The Neo4j Operations Manual
v4.4
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This is the operations manual for Neo4j version 4.4, authored by the Neo4j Team.

This manual covers the following areas:

- **Introduction** — Introduction of Neo4j Community and Enterprise Editions.
- **Installation** — Instructions on how to install Neo4j in different deployment contexts.
- **Cloud deployments** — Information on how to deploy Neo4j on cloud platforms.
- **Docker** — Instructions on how to use Neo4j on Docker.
- **Kubernetes** — Instructions on how to use Neo4j on Kubernetes.
- **Configuration** — Instructions on how to configure certain parts of Neo4j.
- **Manage databases** — Instructions on how to manage multiple active databases with Neo4j.
- **Clustering** — Comprehensive descriptions of Neo4j Causal Clustering.
- **Fabric** — Instructions on how to configure and use Neo4j Fabric.
- **Backup and restore** — Instructions on how to back up and restore Neo4j deployments.
- **Authentication and authorization** — Instructions on user management and role-based access control.
- **Security** — Instructions on server security.
- **Monitoring** — Instructions on setting up Neo4j monitoring.
- **Performance** — Instructions on how to go about performance tuning for Neo4j.
- **Tools** — Description of Neo4j tools.
- **Reference** — Listings of all Neo4j configuration parameters.
- **Tutorials** — Step-by-step instructions on various scenarios for setting up Neo4j.
- **Advanced Causal Clustering** — Advanced concepts and actions for Neo4j Causal Clustering.
- **Deprecated security procedures** — Deprecated security procedures.
- **Query routing decisions** — Query routing decisions.

For information on upgrading and migrating Neo4j, see Neo4j Upgrade and Migration Guide.

Who should read this?

This manual is written for:

- the engineer performing the Neo4j production deployment.
- the operations engineer supporting and maintaining the Neo4j production database.
- the enterprise architect investigating database options.
• the infrastructure architect planning the Neo4j production deployment.
Chapter 1. Introduction

This section provides a brief overview of the Neo4j editions, versioning, Cypher language, interaction, and capabilities.

Neo4j is the world’s leading graph database. The architecture is designed for optimal management, storage, and traversal of nodes and relationships. The graph database takes a property graph approach, which is beneficial for both traversal performance and operations runtime. Neo4j offers dedicated memory management and memory-efficient operations.

Neo4j is scalable and can be deployed as a standalone server or across multiple machines in a fault-tolerant cluster for production environments. Other features for production applications include hot backups and extensive monitoring.

There are two editions of Neo4j to choose from, the Community Edition and the Enterprise Edition. The Enterprise Edition includes all that Community Edition has to offer, plus extra enterprise requirements such as backups, clustering, and failover capabilities.

1.1. Community Edition

The Community Edition is a fully functional edition of Neo4j, suitable for single-instance deployments. It has full support for key Neo4j features, such as, ACID-compliant transactions, Cypher, and programming APIs. It is ideal for learning Neo4j, do-it-yourself projects, and applications in small workgroups.

1.2. Enterprise Edition

The Enterprise Edition extends the functionality of Community Edition to include key features for performance and scalability, such as, a clustering architecture and online backup functionality. Additional security features include role-based access control and LDAP support, for example, Active Directory. It is the choice for production systems with requirements for scale and availability, such as, commercial solutions and critical internal solutions.

1.3. Versioning

Neo4j uses semantic versioning (Semantic Versioning Specification 2.0.0). Given a version number MAJOR.MINOR.PATCH, the increment is based on:

- **MAJOR** version - incompatible API changes towards previous MAJOR version.
- **MINOR** version - functionality in a backwards compatible manner.
- **PATCH** release - backwards compatible bug fixes.

Neo4j’s fully managed cloud service Neo4j Aura uses only MAJOR versioning.
1.4. Cypher

Cypher is a declarative query language for graphs. Neo4j uses the property graph approach, where relationships are stored alongside the data in the model, and not computed at query time. Cypher is a powerful, graph-optimized query language that understands, and takes advantage of, these stored connections. When trying to find patterns or insights in data, Cypher queries are often much simpler and easier to write than massive SQL JOINs. Since Neo4j does not have tables, there are no JOINs to worry about.

For more details, see the Cypher Manual → Cypher - The Graph Query Language.

1.5. Interaction

The recommended way of programmatically interacting with the database is either through the official Neo4j Drivers, or through using the Java Reference → Neo4j Java API. Neo4j provides an ACID-compliant transactional backend for your applications.

1.5.1. The official Neo4j Drivers

The official Neo4j Drivers interacts with Neo4j via the Bolt protocol (https://neo4j-drivers.github.io/).

- Neo4j Java Driver
  
  For Spring-powered applications there is also Spring Data Neo4j.

- Neo4j JavaScript Driver
- Neo4j Python Driver
- Neo4j .NET Driver
- Neo4j Go Driver

See the Neo4j Download Center - Drivers for more links.

1.5.2. Other tools

- Neo4j Cypher Shell - Command line tool for Cypher queries. Neo4j Download Center - Cypher Shell.
- Neo4j Browser - Interact with Neo4j, create Cypher queries, and basic visualization capabilities.
- Neo4j Desktop - Developer IDE or Management Environment for Neo4j instances. Neo4j Download Center - Neo4j Desktop.
- Neo4j Bloom - Explore and visualize graph data. Neo4j Download Center - Neo4j Bloom.

1.6. Neo4j feature details
## 1.6.1. Neo4j key features

### Table 1. Key features

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<thead>
<tr>
<th>Feature</th>
<th>Community Edition</th>
<th>Enterprise Edition</th>
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<td>Property graph model</td>
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<td>✓</td>
</tr>
<tr>
<td>Native graph processing &amp; storage</td>
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<td>✓</td>
</tr>
<tr>
<td>ACID-compliant transactions</td>
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</tr>
<tr>
<td>Cypher graph query language</td>
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<td>✓</td>
</tr>
<tr>
<td>Neo4j Browser with syntax highlighting</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Bolt Protocol</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Language drivers for C#, Go, Java, JavaScript &amp; Python</td>
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<td>✓</td>
</tr>
<tr>
<td>High-performance native API</td>
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<td>✓</td>
</tr>
<tr>
<td>High-performance caching</td>
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<tr>
<td>Cost-based query optimizer</td>
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<tr>
<td>Graph algorithms to support AI initiatives</td>
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<td>✓</td>
</tr>
<tr>
<td>Fast writes via native label indexes</td>
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<td>✓</td>
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<tr>
<td>Composite indexes</td>
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<td>✓</td>
</tr>
<tr>
<td>Full-text node &amp; relationship indexes</td>
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<td>✓</td>
</tr>
<tr>
<td>Store copy</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Auto-reuse of space</td>
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<td>✓</td>
</tr>
<tr>
<td>Multiple databases (beyond the system and default databases)</td>
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<td>Slotted and Pipelined Cypher runtimes</td>
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<td>Property-existence constraints</td>
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<td>Node Key constraints</td>
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<td>Role-based access control</td>
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<td>Kerberos security option</td>
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## 1.6.2. Performance and scalability

### Table 2. Performance and scalability features

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<thead>
<tr>
<th>Feature</th>
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<th>Enterprise Edition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Causal Clustering for global scale applications</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Feature</td>
<td>Community Edition</td>
<td>Enterprise Edition</td>
</tr>
<tr>
<td>--------------------------------------------------</td>
<td>-------------------</td>
<td>--------------------</td>
</tr>
<tr>
<td>Enterprise lock manager accesses all cores on server</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Intra-cluster encryption</td>
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<td>✓</td>
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<td>Offline backups</td>
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<td>✓</td>
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<td>Encrypted backups</td>
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<td>✓</td>
</tr>
<tr>
<td>Rolling upgrades</td>
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<tr>
<td>Automatic cache warming</td>
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<td>✓</td>
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<tr>
<td>Routing and load balancing with Neo4j Drivers</td>
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<td>✓</td>
</tr>
<tr>
<td>Advanced monitoring</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Graph size limitations</td>
<td>34 billion nodes, 34 billion relationships, and 68 billion properties</td>
<td>No limit</td>
</tr>
<tr>
<td>Bulk import tool</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Bulk import tool, resumable</td>
<td>✗</td>
<td>✓</td>
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</tbody>
</table>

Chapter 2. Installation

This chapter describes installation of Neo4j in different deployment contexts, such as Linux, macOS, and Windows.

The topics described are:

- **System requirements** — The system requirements for a production deployment of Neo4j.
- **Neo4j Browser** — About Neo4j Browser.
- **Neo4j Desktop** — About Neo4j Desktop.
- **Linux** — Installation instructions for Linux.
- **macOS** — Installation instructions for macOS.
- **Windows** — Installation instructions for Windows.

### Installation-free options

Neo4j AuraDB is a fully managed Neo4j database, hosted in the cloud and requires no installation. For more information, see the AuraDB product page and AuraDB documentation.

Neo4j can be run in a Docker container. For information on running Neo4j on Docker, see Docker.

### 2.1. System requirements

This section provides an overview of the system requirements for running Neo4j in a production environment.

Neo4j can be installed in many environments and for different scopes, therefore system requirements largely depends on the use of the software. This section distinguishes between a personal/development installation, and a server-based installation.

### 2.1.1. Supported platforms

Neo4j is supported on systems with x86_64 and ARM64 architectures, whether they are a physical, virtual, or containerized environments.
2.1.2. Hardware requirements

In terms of hardware requirements, follow these guidelines:

Table 3. Hardware requirement guidelines.

<table>
<thead>
<tr>
<th>CPU</th>
<th>Performance is generally memory or I/O bound for large graphs, and compute bound for graphs that fit in memory.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memory</td>
<td>More memory allows for larger graphs, but it needs to be configured properly to avoid disruptive garbage collection operations.</td>
</tr>
<tr>
<td>Storage</td>
<td>Aside from capacity, the performance characteristics of the disk are the most important when selecting storage:</td>
</tr>
<tr>
<td></td>
<td>• Neo4j workloads tend significantly toward random reads.</td>
</tr>
<tr>
<td></td>
<td>• Select media with low average seek time: SSD over spinning disks.</td>
</tr>
<tr>
<td></td>
<td>• Consult Disks, RAM and other tips for more details.</td>
</tr>
</tbody>
</table>

For personal use and software development:

Table 4. Hardware requirement guidelines for personal use and software development.

<table>
<thead>
<tr>
<th>CPU</th>
<th>Intel Core i3 minimum, Intel Core i7 recommended.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memory</td>
<td>2GB minimum, 16GB or more recommended.</td>
</tr>
<tr>
<td>Storage</td>
<td>10GB SATA Minimum, SSD with SATA Express or NVMe recommended.</td>
</tr>
</tbody>
</table>

For cloud environments:

Table 5. Hardware requirement guidelines for cloud environments.

<table>
<thead>
<tr>
<th>CPU</th>
<th>2vCPU minimum, 16+ recommended, possibly Xeon processors.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memory</td>
<td>2GB minimum, size depends on workloads: in some cases, it is recommended to use instances with memory that fits the size of the graph in use.</td>
</tr>
<tr>
<td>Storage</td>
<td>10GB minimum block storage, attached NVMe SSD recommended.</td>
</tr>
<tr>
<td></td>
<td>Storage size depends on the size of the databases.</td>
</tr>
</tbody>
</table>

For server-based, on-premise environments:

Table 6. Hardware requirement guidelines for server-based, on-premise environments.
2.1.3. Software requirements

For personal use and software development:

Table 7. Software requirements for personal use and software development.

<table>
<thead>
<tr>
<th>Operating System</th>
<th>Supported JDK</th>
</tr>
</thead>
<tbody>
<tr>
<td>MacOS 10.14+</td>
<td>ZuluJDK 11</td>
</tr>
<tr>
<td>Ubuntu Desktop 16.04+</td>
<td>OpenJDK 11, OracleJDK 11, and ZuluJDK 11</td>
</tr>
<tr>
<td>Debian 9+</td>
<td>OpenJDK 11, OracleJDK 11, and ZuluJDK 11</td>
</tr>
<tr>
<td>SuSE 15+</td>
<td>Oracle JDK 11</td>
</tr>
<tr>
<td>Windows 10</td>
<td>OracleJDK 11 and ZuluJDK 11</td>
</tr>
</tbody>
</table>

For cloud environments, and server-based, on-premise environments:

Table 8. Software requirements for cloud environments, and server-based, on-premise environments.

<table>
<thead>
<tr>
<th>Operating System</th>
<th>Supported JDK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ubuntu Server 16.04+</td>
<td>OpenJDK 11, OracleJDK 11, and ZuluJDK 11</td>
</tr>
<tr>
<td>Red Hat Enterprise Linux Server 7.9+, 8.1+</td>
<td>Red Hat OpenJDK 11, Oracle JDK 11, and ZuluJDK 11</td>
</tr>
<tr>
<td>CentOS Server 7, 8</td>
<td>OpenJDK 11</td>
</tr>
<tr>
<td>Amazon Linux AMI 2018.03+</td>
<td>Amazon Corretto 11, OpenJDK 11, and OracleJDK 11</td>
</tr>
<tr>
<td>Windows Server 2016+</td>
<td>OracleJDK 11 and ZuluJDK 11</td>
</tr>
</tbody>
</table>
2.1.4. Filesystem

For proper ACID behavior, the filesystem must support flush (fsync, fdatasync). See Linux file system tuning for a discussion on how to configure the filesystem in Linux for optimal performance.

2.1.5. Java

It is required to have a pre-installed, compatible Java Virtual Machine (JVM), to run a Neo4j instance.

Table 9. Neo4j version and JVM requirements.

<table>
<thead>
<tr>
<th>Neo4j Version</th>
<th>JVM compliance</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.x</td>
<td>Java SE 8 Platform Specification</td>
</tr>
<tr>
<td>4.x</td>
<td>Java SE 11 Platform Specification</td>
</tr>
</tbody>
</table>

Neo4j Desktop is available for developers and personal users. Neo4j Desktop is bundled with a JVM. For more information on how to use Neo4j Desktop and its capabilities, see the Neo4j Desktop documentation.

2.2. Neo4j Browser

This section introduces Neo4j Browser.

Neo4j Browser is a tool for developers to interact with the graph. It is the default interface for both Enterprise and Community Editions of the Neo4j database.

Neo4j Browser is bundled with Neo4j database, including both Neo4j Server and Neo4j Desktop.

For more information on how to use Neo4j Browser and its capabilities, see the Neo4j Browser documentation.

The following web browsers are supported:

- Chrome (Latest version)
- Firefox (Latest version)
- Edge (Latest version)

Internet Explorer web browser is not supported.

2.3. Neo4j Desktop

This section introduces Neo4j Desktop.

Neo4j Desktop is a convenient way for developers to work with local Neo4j databases.
2.4. Linux installation

This section describes how to install Neo4j on Linux using Debian or RPM packages, or from a Tar archive.

This section describes the following:

- **Install Neo4j on Debian and Debian-based distributions**
  - Installation
  - File locations
  - Operation
- **Deploy Neo4j using the Neo4j RPM package**
  - Install on Red Hat, CentOS, Fedora or Amazon Linux
    - Standard installation
    - Non-interactive installation of Neo4j Enterprise Edition
  - Install on SUSE
  - Offline installation
- **Install Neo4j on Linux from a tarball**
  - Unix console application
  - Linux service
  - Setting the number of open files
- **Install Neo4j as a system service**
  - Configuration
  - Controlling the service
  - Log

2.4.1. Debian

This section describes how to install Neo4j on Debian, and Debian-based distributions like Ubuntu, using the Neo4j Debian package.
Installation

To install Neo4j on Debian you need to make sure of the following:

- An OpenJDK Java 11 runtime is installed or available through your package manager.
- The repository containing the Neo4j Debian package is known to the package manager.

Java Prerequisites (Oracle Java, Debian 9+ and Ubuntu 16.04+ only)

Neo4j 4.4 requires the Java 11 runtime. Java 11 is not included in Ubuntu 16.04 LTS or Debian 9 (stretch) and will have to be set up manually prior to installing or upgrading to Neo4j 4.4, as described below.

Debian 9 users can find OpenJDK 11 in backports. Debian 10 and Ubuntu 18.04 onwards already have the Openjdk Java 11 package available through apt.

Oracle Java and Debian

Neo4j is compatible with Oracle Java on Debian/Ubuntu Linux, but should be installed via tarball. The Debian installer may still be used, but it will install OpenJDK Java 11 in addition to any existing Java installations.

This is due to changes in Oracle’s Debian package manifest between Java versions 8 and 11.

Java 11 on Debian 9

Java 11 must be installed before installing Neo4j on Debian 9 (stretch) systems. If you do not already have Java 11 installed, run the following commands to install OpenJDK Java 11:

```
echo "deb http://httpredir.debian.org/debian stretch-backports main" | sudo tee -a /etc/apt/sources.list.d/stretch-backports.list
sudo apt-get update
sudo apt-get install openjdk-11-jre
```

If you already had a different version of Java installed, see Dealing with multiple installed Java versions to make sure Java 11 is the default version. You are now ready to install Neo4j.

Java 11 on Ubuntu 16.04

Add the official OpenJDK package repository to apt:

```
sudo add-apt-repository -y ppa:openjdk-r/ppa
sudo apt-get update
```

You are now ready to install Neo4j, which will install Java 11 automatically if it is not already installed. See Dealing with multiple installed Java versions to make sure you can start Neo4j after install.
Dealing with multiple installed Java versions

It is important that you configure your default Java version to point to Java 11, or Neo4j 4.4.10 will be unable to start. Do so with the `update-java-alternatives` command.

- First list all your installed version of Java with `update-java-alternatives --list`

  Your results may vary, but this is an example of the output:

  ```
  java-1.11.0-openjdk-amd64 1071 /usr/lib/jvm/java-1.11.0-openjdk-amd64
  java-1.8.0-openjdk-amd64 1069 /usr/lib/jvm/java-1.8.0-openjdk-amd64
  ```

- Identify your Java 11 version, in this case it is `java-1.11.0-openjdk-amd64`. Then set it as the default with (replacing `<java11name>` with the appropriate name from above)

  ```
  sudo update-java-alternatives --jre --set <java11name>
  ```

Add the repository

The Debian package is available from https://debian.neo4j.com.

- To use the repository for generally available versions of Neo4j, run:

  ```
  wget -O - https://debian.neo4j.com/neotechnology.gpg.key | sudo apt-key add -
  echo 'deb https://debian.neo4j.com stable latest' | sudo tee -a /etc/apt/sources.list.d/neo4j.list
  sudo apt-get update
  ```

  To avoid the risk of the `apt` package manager accidentally forcing a database upgrade, different major and minor releases of Neo4j are also available separately inside the repository. To install Neo4j this way, specify the major and minor version required, in place of `latest`.

  We recommend the following method for production or business critical installations:

  ```
  wget -O - https://debian.neo4j.com/neotechnology.gpg.key | sudo apt-key add -
  echo 'deb https://debian.neo4j.com stable 4.4' | sudo tee -a /etc/apt/sources.list.d/neo4j.list
  sudo apt-get update
  ```

- Once the repository has been added into `apt`, you can verify which Neo4j versions are available by running:

  ```
  apt list -a neo4j
  ```
In Ubuntu server installations you will also need to make sure that the `universe` repository is enabled. If the `universe` repository is not present, the Neo4j installation will fail with the error `Depends: daemon but it is not installable`.

This can be fixed by running the command:

```
sudo add-apt-repository universe
```

### Install Neo4j

To install Neo4j Community Edition:

```
sudo apt-get install neo4j=1:4.4.10
```

To install Neo4j Enterprise Edition:

```
sudo apt-get install neo4j-enterprise=1:4.4.10
```

Note that the version includes an epoch version component (`1:`), in accordance with the Debian policy on versioning.

Versions of Neo4j that are not yet generally available may differ in naming.

The naming structure of packages are normally composed as `neo4j-enterprise=1:<version>-<release>`. For example, Neo4j Enterprise Edition Milestone Release 3 would be: `neo4j-enterprise=1:4.0.0-beta03mr03`.

Refer to the download page for more information regarding the name of packages.

When installing Neo4j Enterprise Edition, you will be prompted to accept the license agreement. Once the license agreement is accepted installation begins. Your answer to the license agreement prompt will be remembered for future installations on the same system.

To forget the stored answer, and trigger the license agreement prompt on subsequent installation, use `debconf-communicate` to purge the stored answer:

```
echo purge | sudo debconf-communicate neo4j-enterprise
```

### Non-interactive installation of Neo4j Enterprise Edition

For Neo4j Enterprise Edition, the license agreement is presented in an interactive prompt. If you require non-interactive installation of Neo4j Enterprise Edition, you can indicate that you have read and accepted the license agreement using `debconf-set-selections`:

```
14
```
Offline installation

If you cannot reach https://debian.neo4j.com, perhaps due to a firewall, you will need to obtain Neo4j via an alternative machine which has the relevant access, and then move the package manually.

It is important to note that using this method will mean that the offline machine will not receive the dependencies that are that are normally downloaded and installed automatically when using `apt` for installing Neo4j; Cypher Shell and Java (if not installed already):

- The Cypher Shell package can be downloaded from Neo4j Download Center.
- For information on supported versions of Java, see System requirements.

1. Run the following to download the required Debian software package:
   - Neo4j Enterprise Edition:

     ```
     curl -O https://dist.neo4j.org/deb/neo4j-enterprise_4.4.10_all.deb
     ```

     To list all files that the Debian software package (.deb file) installs:

     ```
     dpkg --contents neo4j_4.4.10_all.deb
     ```

   - Neo4j Community Edition:

     ```
     curl -O https://dist.neo4j.org/deb/neo4j_4.4.10_all.deb
     ```

2. Manually move the downloaded Debian package to the offline machine.
3. Run the following on the offline machine to install Neo4j:

   ```
   sudo dpkg -i <deb file name>
   ```

File locations

File locations for all Neo4j packages are documented [here](https://neo4j.com/docs/neo4j-enterprise/4.4/admin-guide/system-configuration/).

Operation

Most Neo4j configuration goes into `neo4j.conf`.

For operating systems using `systemd`, some package-specific options are set in `neo4j.service` and can be edited using `systemctl edit neo4j.service`. 
For operating systems that are not using systemd, some package-specific options are set in /etc/default/neo4j.

<table>
<thead>
<tr>
<th>Environment variable</th>
<th>Default value</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEO4J_SHUTDOWN_TIMEOUT</td>
<td>120</td>
<td>Timeout in seconds when waiting for Neo4j to stop. If it takes longer than this then the shutdown is considered to have failed. This may need to be increased if the system serves long-running transactions.</td>
</tr>
<tr>
<td>NEO4J_ULIMIT_NOFILE</td>
<td>60000</td>
<td>Maximum number of file handles that can be opened by the Neo4j process.</td>
</tr>
</tbody>
</table>

2.4.2. Deploy Neo4j using the Neo4j RPM package

This section describes how to deploy Neo4j using the Neo4j RPM package on Red Hat, CentOS, Fedora, or Amazon Linux distributions.

Install on Red Hat, CentOS, Fedora or Amazon Linux

- If you follow guidelines such as STIG RHEL 8 must mount /tmp with the noexec option, you may have /tmp mounted with the noexec option. This could cause a conflict, as the Neo4j Admin tool uses zstd to compress files. However, Java supports pointing to an alternative temp directory by either setting dbms.jvm.additional=-Djava.io.tmpdir=/path/that/has/exec/permissions in the neo4j.config file, or in the JAVA_OPTS environment variable.

Standard installation

1. Add the repository.

   Use the following as root to add the repository:

   ```
   rpm --import https://debian.neo4j.com/neotechnology.gpg.key
   cat <<EOF > /etc/yum.repos.d/neo4j.repo
   [neo4j]
   name=Neo4j RPM Repository
   baseurl=https://yum.neo4j.com/stable
   enabled=1
   gpgcheck=1
   EOF
   ```

2. Ensure the correct Java version.

   Neo4j 4.4 requires the Java 11 runtime. Most of our supported RPM Linux distributions have Java 11 available by default. There is some minor setup required for Amazon Linux, and for compatibility with Oracle Java 11:
° Java 11 on Amazon Linux:

To enable OpenJDK 11 on Amazon Linux run the shell command:

```
amazon-linux-extras enable java-openjdk11
```

You are now ready to install Neo4j 4.4.10, which will install Java 11 automatically if it is not already installed.

° Oracle Java 11:

Oracle and OpenJDK provide incompatible RPM packages for Java 11. We provide an adapter for Oracle Java 11 which must be installed before Neo4j. The adapter contains no code, but will stop the package manager from installing OpenJDK 11 as a dependency despite an existing Java 11 installation.

This step assumes that you have performed the previous step to set up the yum repository.

a. Download and install the Oracle Java 11 JDK from the Oracle website.

b. Install the adapter:

```
sudo yum install https://dist.neo4j.org/neo4j-java11-adapter.noarch.rpm
```

The SHA-256 of the adapter package can be verified against `https://dist.neo4j.org/neo4j-java11-adapter.noarch.rpm.sha256`.

You are now ready to install Neo4j 4.4.10.

3. Install Neo4j.

° To install Neo4j Community Edition as `root`:

```
yum install neo4j-4.4.10
```

° To install Neo4j Enterprise Edition as `root`:

```
yum install neo4j-enterprise-4.4.10
```

4. Run the following to return the version and edition of Neo4j that has been installed:

```
rpm -qa | grep neo
```

Neo4j supports Security-Enhanced Linux (SELinux), by default.
Non-interactive installation of Neo4j Enterprise Edition

When installing Neo4j Enterprise Edition, you will be required to accept the license agreement before installation is allowed to complete. This is an interactive prompt. If you require non-interactive installation of Neo4j Enterprise Edition, you can indicate that you have read and accepted the license agreement by setting the environment variable `NEO4J_ACCEPT_LICENSE_AGREEMENT` to `yes`:

```bash
NEO4J_ACCEPT_LICENSE_AGREEMENT=yes yum install neo4j-enterprise-4.4.10
```

Install on SUSE

For SUSE-based distributions the steps are as follows:

1. Use the following as `root` to add the repository:

   ```bash
   zypper addrepo --refresh https://yum.neo4j.com/stable neo4j-repository
   ```

2. Install Neo4j.

   - To install Neo4j Community Edition as `root`:

     ```bash
     zypper install neo4j-4.4.10
     ```

   - To install Neo4j Enterprise Edition as `root`:

     ```bash
     zypper install neo4j-enterprise-4.4.10
     ```

Offline installation

If you cannot reach `https://yum.neo4j.com/stable` to install Neo4j using RPM, perhaps due to a firewall, you will need to obtain Neo4j via an alternative machine which has the relevant access, and then move the RPM package manually.

It is important to note that using this method will mean that the offline machine will not receive the dependencies that are normally downloaded and installed automatically when using `yum` for installing Neo4j: Neo4j Cypher Shell and Java.

For information on supported versions of Java, see System requirements.

Downloading the RPM installers

The Cypher Shell RPM package can be downloaded from Neo4j Download Center.

1. Run the following to obtain the required Neo4j RPM package:

   - Neo4j Enterprise Edition:
2. Manually move the downloaded RPM packages to the offline machine.

If using Oracle Java 11, the same dependency issues apply as with the standard installation. You will need to additionally download and install the Java adaptor described in that section:

- To install Neo4j Enterprise Edition as root:

```bash
curl -O https://dist.neo4j.org/neo4j-java11-adapter.noarch.rpm
```

Performing an offline installation

**Offline upgrade from 4.0.0 or later**

- Neo4j 4.0.0 and onwards already require Java 11, so there should be no additional Java setup required.
- Neo4j Cypher Shell must be installed before Neo4j, because it is a dependency.
- Run the following on the offline machine to install Neo4j Cypher Shell and Neo4j simultaneously:

  ```bash
  rpm -U <Cypher Shell RPM file name> <Neo4j RPM file name>
  ```

  This must be one single command, and Neo4j Cypher Shell must be the first package in the command.

**Offline upgrade from 3.5 or earlier**

- Due to dependency conflicts with older versions, for offline upgrades from 3.5 or earlier, Neo4j Cypher Shell and Neo4j must be upgraded simultaneously.
- Before you begin, you will need to have Java 11 pre-installed. For Oracle Java 11 only, you must install the Oracle Java adapter before trying to install Neo4j.
- Run the following on the offline machine to install Neo4j Cypher Shell and Neo4j simultaneously:

  ```bash
  rpm -U <Cypher Shell RPM file name> <Neo4j RPM file name>
  ```

  This must be one single command, and Neo4j Cypher Shell must be the first package in the command.
2.4.3. Linux tarball installation

This section describes how to install Neo4j on Linux from a tarball, and run it as a console application or service. Check System Requirements to see if your setup is suitable.

Unix console application

1. If it is not already installed, get OpenJDK 8 or Oracle Java 8.
2. Download the latest release from Neo4j Download Center.
   Select the appropriate tar.gz distribution for your platform.
3. Make sure to download Neo4j from Neo4j Download Center and always check that the SHA hash of the downloaded file is correct:
   a. To find the correct SHA hash, go to Neo4j Download Center and click on SHA-256 which will be located below your downloaded file.
   b. Using the appropriate commands for your platform, display the SHA-256 hash for the file that you downloaded.
   c. Ensure that the two are identical.
4. Extract the contents of the archive, using `tar -xf <filename>`. For example, `tar -xf neo4j-community-4.4.10-unix.tar.gz`.
5. Place the extracted files in a permanent home on your server. The top level directory is referred to as NEO4J_HOME.
   a. To run Neo4j as a console application, use: `<NEO4J_HOME>/bin/neo4j console`.
   b. To run Neo4j in a background process, use: `<NEO4J_HOME>/bin/neo4j start`.
7. Connect using the username 'neo4j' with default password 'neo4j'. You'll then be prompted to change the password.
8. Stop the server by typing `Ctrl-C` in the console.

Linux service

If you want to run Neo4j as a system service, you can install either the Debian or RPM package.

For more information on configuring and operating the Neo4j system service, see Neo4j system service.

Setting the number of open files

Linux platforms impose an upper limit on the number of concurrently open files per user and session. To check your limit for the current session, run the command `ulimit -n`. The default value is 1024.

```
user@localhost:~$ ulimit -n
1024
```
However, if you experience exceptions on Too many open files or Could not stat() directory, you have to increase the limit to 40000 or more, depending on your usage patterns. This is especially true when many indexes are used, or the server installation sees too many open network connections or sockets.

A quick solution is the command ulimit -n <the-new-limit>, but it will set a new limit only for the root user and will affect only the current session. If you want to set the value system-wide, follow the instructions for your platform.

The following steps set the open file descriptor limit to 60000 for the user neo4j under Ubuntu 16.04 LTS, Debian 8, CentOS 7, or later versions.

Running Neo4j as a service

1. Open the neo4j.service file with root privileges.

   user@localhost:~$ sudo systemctl edit neo4j.service

2. Append the [Service] section to the neo4j.service file.

   [Service]
   LimitNOFILE=60000

Running Neo4j as an interactive user (e.g., for testing purposes)

1. Open the user.conf file with root privileges in a text editor, for example, Vim.

   user@localhost:~$ sudo vi /etc/systemd/user.conf

2. Uncomment and define the value of DefaultLimitNOFILE, found in the [Manager] section.

   [Manager]
   ...
   DefaultLimitNOFILE=60000

3. Open the /etc/security/limits.conf file.

   user@localhost:~$ sudo vi /etc/security/limits.conf

4. Define the following values:

   neo4j   soft    nofile  60000
   neo4j   hard    nofile  60000

5. Reload the systemd settings.
6. Reboot your machine.

2.4.4. Neo4j system service

This article covers configuring and operating the Neo4j system service. It assumes that your system has **systemd**, which is the case for most Linux distributions.

<table>
<thead>
<tr>
<th>Setting the number of open files.</th>
</tr>
</thead>
<tbody>
<tr>
<td>For instructions on how to set the number of concurrent files that a user can have open, see Setting the number of open files.</td>
</tr>
</tbody>
</table>

Configuration

Configuration is stored in `/etc/neo4j/neo4j.conf`. See File locations for a complete catalog of where files are found for the various packages.

Starting the service automatically on system start

If you installed the RPM package and want Neo4j to start automatically on system boot then you need to enable the service. On Debian-based distributions this is done for you at installation time.

```
sudo systemctl enable neo4j
```

Controlling the service

System services are controlled with the `systemctl` command. It accepts a number of commands:

```
sudo systemctl {start|stop|restart} neo4j
```

Service customizations can be placed in a service override file. To edit your specific options, do the following command which will open up an editor of the appropriate file:

```
sudo systemctl edit neo4j
```

Then place any customizations under a `[Service]` section. The following example lists default values which may be interesting to change for some users:

```
[Service]
# The user and group which the service runs as.
User=neo4j
Group=neo4j
# If it takes longer than this then the shutdown is considered to have failed.
# This may need to be increased if the system serves long-running transactions.
TimeoutSec=120
```
You can print the effective service, including possible overrides, with:

```bash
systemctl cat neo4j
```

Remember to restart neo4j if you change any settings.

```bash
systemctl restart neo4j
```

### Log

The neo4j log is written to `journald` which can be viewed using the `journalctl` command:

```bash
journalctl -e -u neo4j
```

`journald` automatically rotates the log after a certain time and by default it commonly does not persist across reboots. Please see `man journald.conf` for further details.

### 2.5. macOS installation

This section describes how to install Neo4j on macOS. Check [System Requirements](#) to see if your setup is suitable.

#### 2.5.1. Unix console application

1. If it is not already installed, get [OpenJDK 8](https://openjdk.java.net) or [Oracle Java 8](https://www.oracle.com/java/technologies/javase-jdk8-downloads.html).

2. Download the latest release from [Neo4j Download Center](https://neo4j.com/download-center/neo4j-community/).

   Select the appropriate tar.gz distribution for your platform.

3. Make sure to download Neo4j from [Neo4j Download Center](https://neo4j.com/download-center/neo4j-community/) and always check that the SHA hash of the downloaded file is correct:

   a. To find the correct SHA hash, go to Neo4j Download Center and click on SHA-256 which will be located below your downloaded file.

   b. Using the appropriate commands for your platform, display the SHA-256 hash for the file that you downloaded.

   c. Ensure that the two are identical.

4. Extract the contents of the archive, using `tar -xf <filename>`. For example, `tar -xf neo4j-community-4.4.10-unix.tar.gz`.

5. Place the extracted files in a permanent home on your server. The top level directory is referred to as `NEO4J_HOME`.

   a. To run Neo4j as a console application, use: `<NEO4J_HOME>/bin/neo4j console`.

   b. To run Neo4j in a background process, use: `<NEO4J_HOME>/bin/neo4j start`. 

7. Connect using the username 'neo4j' with default password 'neo4j'. You’ll then be prompted to change the password.

8. Stop the server by typing Ctrl-C in the console.

When Neo4j runs in console mode, logs are printed to the terminal.

2.5.2. macOS service

Use the standard macOS system tools to create a service based on the neo4j command.

2.5.3. macOS file descriptor limits

The limit of open file descriptors may have to be increased if a database has many indexes or if there are many connections to the database. The currently configured open file descriptor limitation on your macOS system can be inspected with the launchctl limit maxfiles command. The method for changing the limit may differ depending on the version of macOS. Consult the documentation for your operating system in order to find out the appropriate command.

If you raise the limit above 10240, then you must also add the following setting to your neo4j.conf file:

```dbms.jvm.additional=-XX:-MaxFDLimit```

Without this setting, the file descriptor limit for the JVM will not be increased beyond 10240. Note, however, that this only applies to macOS. On all other operating systems, you should always leave the MaxFDLimit JVM setting enabled.

2.6. Windows installation

This section describes how to install Neo4j on Windows. Check System Requirements to see if your setup is suitable.

2.6.1. Windows console application

1. If it is not already installed, get OpenJDK 8 or Oracle Java 8.

2. Download the latest release from Neo4j Download Center.

   Select the appropriate ZIP distribution.

3. Make sure to download Neo4j from Neo4j Download Center and always check that the SHA hash of the downloaded file is correct:

   a. To find the correct SHA hash, go to Neo4j Download Center and click on SHA-256 which will be located below your downloaded file.

   b. Using the appropriate commands for your platform, display the SHA-256 hash for the file that you
4. Right-click the downloaded file, click Extract All.

5. Place the extracted files in a permanent home on your server, for example `D:\neo4j\`. The top level directory is referred to as NEO4J_HOME.
   a. To run Neo4j as a console application, use: `<NEO4J_HOME>\bin\neo4j console`.
   b. To install Neo4j as a service use: `<NEO4J_HOME>\bin\neo4j install-service`.
   c. For additional commands and to learn about the Windows PowerShell module included in the Zip file, see Windows PowerShell module.


7. Connect using the username 'neo4j' with default password 'neo4j'. You'll then be prompted to change the password.

8. Stop the server by typing `Ctrl-C` in the console.

### 2.6.2. Windows service

Neo4j can also be run as a Windows service. Install the service with `bin\neo4j install-service`, and start it with `bin\neo4j start`.

The available commands for `bin\neo4j` are: `help`, `start`, `stop`, `restart`, `status`, `install-service`, `uninstall-service`, and `update-service`.

> When installing a new release of Neo4j, you must first run `bin\neo4j uninstall-service` on any previously installed versions.

### Java options

When Neo4j is installed as a service, Java options are stored in the service configuration. Changes to these options after the service is installed will not take effect until the service configuration is updated. For example, changing the setting `dbms.memory.heap.max_size` in `neo4j.conf` will not take effect until the service is updated and restarted. To update the service, run `bin\neo4j update-service`. Then restart the service to run it with the new configuration.

The same applies to the path to where Java is installed on the system. If the path changes, for example when upgrading to a new version of Java, it is necessary to run the `update-service` command and restart the service. Then the new Java location will be used by the service.
2.6.3. Windows PowerShell module

The Neo4j PowerShell module allows administrators to:

- Install, start and stop Neo4j Windows® Services.
- Start tools, such as Neo4j Admin and Cypher Shell.

The PowerShell module is installed as part of the ZIP file distributions of Neo4j.

System requirements

- Requires PowerShell v2.0 or above.
- Supported on either 32 or 64 bit operating systems.

Managing Neo4j on Windows

On Windows, it is sometimes necessary to Unblock a downloaded ZIP file before you can import its contents as a module. If you right-click on the ZIP file and choose "Properties" you will get a dialog which includes an "Unblock" button, which will enable you to import the module.

Running scripts has to be enabled on the system. This can, for example, be achieved by executing the following from an elevated PowerShell prompt:

Set-ExecutionPolicy -ExecutionPolicy RemoteSigned

For more information, see About execution policies.
The PowerShell module will display a warning if it detects that you do not have administrative rights.

How do I import the module?

The module file is located in the bin directory of your Neo4j installation, i.e. where you unzipped the downloaded file. For example, if Neo4j was installed in C:\Neo4j then the module would be imported like this:

```
Import-Module C:\Neo4j\bin\Neo4j-Management.psd1
```

This will add the module to the current session.

Once the module has been imported you can start an interactive console version of a Neo4j Server like this:

```
Invoke-Neo4j console
```

To stop the server, issue Ctrl-C in the console window that was created by the command.

How do I get help about the module?

Once the module is imported you can query the available commands like this:

```
Get-Command -Module Neo4j-Management
```

The output should be similar to the following:

```
CommandType     Name                                Version    Source
-------------    -----------                            --------    ------
Function        Invoke-Neo4j                        4.4.10      Neo4j-Management
Function        Invoke-Neo4jAdmin                   4.4.10      Neo4j-Management
Function        Invoke-Neo4jBackup                  4.4.10      Neo4j-Management
Function        Invoke-Neo4jImport                  4.4.10      Neo4j-Management
Function        Invoke-Neo4jShell                   4.4.10      Neo4j-Management
```

The module also supports the standard PowerShell help commands.

```
Get-Help Invoke-Neo4j
```

Run the following to see examples of help commands:

```
Get-Help Invoke-Neo4j -examples
```

Example usage

- List of available commands:
  
  ```
  Invoke-Neo4j
  ```
• Current status of the Neo4j service:

```powershell
Invoke-Neo4j status
```

• Install the service with verbose output:

```powershell
Invoke-Neo4j install-service -Verbose
```

• Available commands for administrative tasks:

```powershell
Invoke-Neo4jAdmin
```

Common PowerShell parameters

The module commands support the common PowerShell parameter of `Verbose`. 
Chapter 3. Cloud deployments

This chapter describes the different options for deploying Neo4j in the cloud.

The topics covered are:

- Neo4j on AWS — Deploying Neo4j on AWS.
- Neo4j on Google Cloud Platform — Deploying Neo4j on Google Cloud Platform (GCP).
- Neo4j on Microsoft Azure — Deploying Neo4j on Microsoft Azure.

Other cloud deployment options

Neo4j Aura is a fully managed Neo4j database, hosted in the cloud and requires no installation. For more information, see the Aura product and support pages.

Neo4j can be run in a Docker container. For information on running Neo4j on Docker, see Docker.

3.1. Neo4j on AWS

This chapter describes how to deploy Neo4j on AWS directly from the AWS Marketplace.

You can deploy Neo4j on AWS directly from the AWS Marketplace. Neo4j provides Amazon CloudFormation templates for Neo4j Enterprise standalone and Neo4j cluster. They are public, and you can find them at https://github.com/neo4j-partners/amazon-cloud-formation-neo4j. The Neo4j AWS Marketplace listing uses the marketplace template to deploy Neo4j. It can set up Neo4j DBMS, Graph Data Science, and Bloom.

3.1.1. Neo4j CloudFormation template

CloudFormation is a recipe that tells AWS how to deploy a whole set of interrelated resources.

The Neo4j CloudFormation templates have the following properties:

- Deploying one or three EC2 VMs in a specified region.
- Deploying EC2 VMs in multiple availability zones within a region so that your entire DBMS does not go down if one goes down.
- Deploying a new virtual private cloud (VPC) and installing Neo4j in it. This way, you can control network access by tuning your VPC and security rules.

3.1.2. Deploy Neo4j Enterprise (standalone or cluster)

To deploy a Neo4j Enterprise standalone or a Neo4j cluster, create a CloudFormation stack by launching the Neo4j CloudFormation template in AWS.
1. Log in to the AWS management console.

2. In the search field, look for marketplace and select AWS Marketplace Subscriptions.


4. From the list, click Neo4j Enterprise Edition.

5. Click the Continue to Subscribe button. You need a subscription to be able to launch Neo4j on AWS.

6. Click the Continue to Configuration button. The window Configure this software opens. The default configurations launch the latest version of Neo4j.

7. Click the Continue to Launch button. The window Launch this software opens.

8. From the Choose Action dropdown menu, select Launch CloudFormation to load the Neo4j CloudFormation template, and click Launch.

9. Fill in the following information to configure your Neo4j deployment:
   a. The Create stack window specifies the template you are going to use. Here, you do not need to do anything.

b. The Specify stack details window contains various parameters that control your Neo4j and infrastructure:
   - **Stack name** - the name of your stack.
   - (Optional) Parameters for installing GDS or Bloom.
   - **Password** - password for Neo4j.
   - **Node Count** - the number of Neo4j instances. If you want to launch a standalone, select 1, and if you are going to launch a cluster, select 3.
   - **Instance Type** - the AWS instance type you want to launch, which controls your database.
- Disk Size - the size in GB of EBS volume on each instance node. The default is 100.
- SSH CIDR - the address range from which EC2 instances are accessible on port 22. You can set it to 0.0.0.0/0 to allow any IP on the internet to contact your instance(s). If you want to lock it down to just your company’s IP block, this is where you must specify that.

c. (Optional) On the Configure stack options window, you can specify tags to apply to the resources in your stack, stack permissions, as well as some advanced options.

d. On the Review <stack-name> window, review the stack configurations that you have selected. If you are happy with them, tick I acknowledge that AWS CloudFormation might create IAM resources.
e. Click the button Create stack.
The CloudFormation stack will deploy AWS resources for your Neo4j DBMS.

3.1.3. Verify that Neo4j is up

When the CloudFormation stack is created, navigate to the Outputs tab and click the Neo4jLoadBalancerURL.

The URL takes you to Neo4j Browser, where you can use your credentials to log in to Neo4j.

3.1.4. Clean up the resources and remove your stack

Select the CloudFormation stack you want to remove and click the Delete button. The stack deletion cleans up all AWS resources deployed by it.

3.2. Neo4j on Google Cloud Platform

This chapter describes the different options for deploying and running Neo4j on Google Cloud Platform.

There are several options for running Neo4j on GCP, depending on what you want to do.

- Single instances (VM-based) — Launching a single instance from an image.
3.2.1. Single instances (VM-based)

This chapter describes how to launch a single instance from an image on GCP.

Prerequisites

- You know how to run and operate Neo4j locally.
- You know how to access cloud-hosted Neo4j from your application. See the Driver Manual.
- You have installed and set up Google Cloud SDK to be able to use the `gcloud` command-line tool.
- You have authenticated your `gcloud` CLI, to interact with your GCP projects.

Create a firewall rule to access your instance

Create a firewall rule to be able to access your instance when it is launched:

```
gcloud compute firewall-rules create allow-neo4j-bolt-http-https 
  --allow tcp:7473,tcp:7474,tcp:7687 
  --source-ranges 0.0.0.0/0 
  --target-tags neo4j
```

1. Create a firewall rule with the name `allow-neo4j-bolt-http-https`.
2. Allow traffic on ports:
   - `7473` (HTTPS, for Neo4j Browser and HTTP API).
   - `7474` (HTTP, for Neo4j Browser and HTTP API).
   - `7687` (Bolt Protocol).
3. The ranges, provided with the `--source-ranges` argument, allow the entire Internet to contact your new instance.
4. The `--target-tags` argument specifies that this rule applies only to VMs tagged with `neo4j`. When you launch your instance, you have to apply that tag to it.

Create a Google compute instance from the Neo4j public image

1. List all available Neo4j public images.

   The images are published in a GCP project called `launcher-public`, so by listing images in that project, you can see what is available.

   `launcher-public` images

```
gcloud compute images list --project launcher-public
```
launcher-public images — filtered on Neo4j 4.X versions

gcloud compute images list --project launcher-public | grep --extended-regexp "neo4j-(community|enterprise)-1-4-." 

For example, the image neo4j-enterprise-1-4-2-2-apoc includes Neo4j Enterprise 4.2.2 with the APOC plugin.

2. Create a new instance.

You create and launch an instance by using the following gcloud commands:

```
gcloud config set project <project-id> ①
gcloud compute instances create my-neo4j-instance --image-project launcher-public \ ② --image <neo4j-image-name> \ ③ --tags neo4j ④
```

① Set your project configuration to ensure you know where you are launching your instance.
② Launch an image found in the provided public project launcher-public.
③ Replace <neo4j-image-name> with the image name you want to launch.
④ The --tags argument allows you to configure the correct network permissions.

By default, Google blocks all external access to the network services unless you open them.

3. Note the EXTERNAL_IP.

When the launch is successful, you get the following result:

Example output

<table>
<thead>
<tr>
<th>NAME</th>
<th>ZONE</th>
<th>MACHINE_TYPE</th>
<th>PREEMPTIBLE</th>
<th>INTERNAL_IP</th>
<th>EXTERNAL_IP</th>
<th>STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>my-neo4j-instance</td>
<td>europe-north1-a</td>
<td>n1-standard-1</td>
<td></td>
<td>192.0.2.0</td>
<td>203.0.113.0</td>
<td>RUNNING</td>
</tr>
</tbody>
</table>

Note the IP address in the EXTERNAL_IP column, this is for the Neo4j server.

The gcloud tool comes with many command-line options. For more details on how to deal with machine type, memory, available storage, etc., consult the Google Cloud documentation.

Access your new instance

Navigate to http://[EXTERNAL_IP]:7474/browser or https://[EXTERNAL_IP]:7473/browser, log in with the default username neo4j and password neo4j, and change the password, when prompted.
Neo4j 3.X versions include a self-signed certificate for TLS. Because you do not have a hostname or a valid SSL certificate configured by default, your browser will warn you that the certificate is not trusted.

Neo4j 4.X versions do not include any certificate for TLS. You can configure the certificate later.

Access your instance via SSH

You can run the following command to SSH into the instance:

```bash
ssh gcloud compute ssh my-neo4j-instance
```

Inside the VM, you can check the status of the `neo4j` service:

```bash
systemctl sudo systemctl status neo4j
```

```
● neo4j.service - Neo4j Graph Database
   Loaded: loaded (/etc/systemd/system/neo4j.service; enabled; vendor preset: enabled)
   Active: active (running) since Thu 2021-01-01 13:01:02 UTC; 40min ago
   Main PID: 937 (java)
   Tasks: 62 (limit: 4401)
   CGroup: /system.slice/neo4j.service
         └─937 /usr/bin/java -cp /var/lib/neo4j/plugins:/etc/neo4j:/usr/share/neo4j/lib/*:/var/lib/neo4j/plugins/* -XX:+UseG1GC -XX:-OmitStackTraceInFastThrow
```

Delete your instance

You can run the following command to delete your instance:

```bash
gcloud compute instances delete my-neo4j-instance
```

3.2.2. Causal Clusters (VM-based)

This chapter describes how to deploy and run Neo4j Causal Cluster from the GCP Marketplace.

Neo4j Enterprise is registered in GCP Marketplace.

Prerequisites

- You have a Neo4j Enterprise license.
- You are familiar with the Causal Cluster architecture.
You know how to access cloud-hosted Neo4j from your application. See the Driver Manual.

Deploy Neo4j via the GCP Marketplace

Deploy Neo4j Enterprise from the Google Cloud Launcher console following the interactive prompts.

Once the deploy finishes, save the URL, username, and password.

Start using Neo4j Browser

Use your browser to access the cloud-based database URL, and log in with the initial username and password provided. You may see an SSL warning screen because the out-of-the-box deployment uses an unsigned SSL certificate. The initial password is set to a strong, random password and is saved as a metadata entry on the VMs.

To verify that the cluster has formed correctly, run the following Cypher statement:

```
CALL dbms.cluster.overview()
```

The result is one leader and minimum two followers. The IP addresses and endpoints must be the same as the ones for your running instances, displayed by the Compute Engine.

Access your instance via SSH

Cluster members are regular Google Compute Engine VMs. Therefore, you can access any of them via SSH from the Deployment Manager screen, or by running the following command in the Google Cloud CLI:

```
gcloud compute ssh my-cluster-deploy-vm-1
```

Your cluster default configuration

The following notes are provided on your default cluster configuration.

- Ports 7687 (bolt) and 7473 (HTTPS access) are the only ports exposed to the entire internet. Consider narrowing the access to these ports to only your needed networks. External unencrypted HTTP access is disabled by default.
- Ports 5000, 6000, and 7000 are enabled only for internal network access (10.0.0.8), between the cluster nodes.
- Because cloud VMs can start and stop with different IP addresses, the configuration of these VMs is driven by a file in /etc/neo4j/neo4j.template. Configuration changes must be made to the template, not to the /etc/neo4j/neo4j.conf file, which is overwritten with the template substitutions at every startup. The template allows you to configure aspects of the cluster with the VMs metadata. The template’s behavior and layout match the usual neo4j.conf file.

What’s next

- Visit Clustering for more information on how to configure your cluster.
• Add users and change passwords as necessary.
• Consider creating DNS entries with Google to be able to address your cluster with client applications under a single hostname.

Terminating the deployment

You can use the deployment manager to delete the deployment. To ensure data safety, the disks that back the VMs are not removed when you delete the cluster deployment.

3.2.3. Neo4j deployments automation on Google Cloud Platform (GCP)

This chapter describes how to automate Neo4j deployments on GCP.

Automate Neo4j deployment when you want to integrate Neo4j into your CI/CD pipeline to be able to create/destroy instances temporarily, or to spin up a sample instance.

Prerequisites

• You have installed and set up Google Cloud SDK to be able to use the gcloud command-line tool.
• You have authenticated your gcloud CLI, to make sure it can interact with your GCP projects.

Google Cloud Deployment Manager

Neo4j provides Deployment Manager templates for Neo4j Causal Cluster (highly available clusters), and VM images for Neo4j Enterprise standalone. Deployment Manager is a recipe that tells GCP how to deploy a whole set of interrelated resources. By deploying all of this as a stack you can keep all of your resources together, and delete just one thing when you are done.

Creating a Deployment Manager stack

Depending on what Neo4j edition you want to deploy, you create a Deployment Manager stack by running a bash script.

Each script contains the following configurations:

• The URL of the Neo4j stack template that tells GCP what to deploy.
• Various parameters that control how much hardware you want to use.
• MACHINE - the GCP machine type you want to launch, which controls how much hardware you will be giving to your database.
• DISK_TYPE and DISK_SIZE - controls whether Neo4j uses standard spinning magnetic platters (pd-standard) or SSD disks (pd-ssd), and how many GB of storage you want to allocate. Note that with some disk sizes, GCP warns that the root partition type may need to be resized if the underlying OS does not support the disk size. This warning can be ignored, because the underlying OS will recognize any disk size.
• ZONE - specifies where to deploy Neo4j.
Deploying Neo4j Enterprise Edition with a Causal Cluster

To deploy Neo4j Enterprise Edition with a Causal Cluster, use the Causal Cluster template.

```
#!/bin/bash
export NAME=neo4j-cluster
PROJECT=my-gcp-project-ID
MACHINE=n1-standard-2
DISK_TYPE=pd-ssd
DISK_SIZE=64
ZONE=us-east1-b
CORES=3
READ_REPLICAS=0
NEO4J_VERSION=4.4.10
OUTPUT=$(gcloud deployment-manager deployments create $NAME
  --project $PROJECT
  --template "$TEMPLATE_URL"
  --properties "zone:'$ZONE',clusterNodes:'$CORES',readReplicas:'$READ_REPLICAS',bootDiskSizeGb:'$DISK_SIZE',bootDiskType:'$DISK_TYPE',machineType:'$MACHINE'"
)
echo $OUTPUT
PASSWORD=$(echo $OUTPUT | perl -ne 'm/password\s+([\s]+)/; print $1; ')
IP=$(echo $OUTPUT | perl -ne 'm/vm1URL\s+https://([\s]+):/; print $1; ')
echo NEO4J_URI=bolt+routing://$IP
echo NEO4J_PASSWORD=$PASSWORD
echo STACK_NAME=$NAME
```

After you configure the parameters of what you are deploying, you call to `gcloud deployment-manager deployments create` to do the work. The variable `OUTPUT` contains all the information about your deployment. Then, you use `perl` to pull out the password and IP address of your new deployment, because it will have a strong randomly assigned password.

This command blocks and does not succeed until the entire stack is deployed and ready. This means that by the time you get the IP address back, your Neo4j is up. If you lose these stack outputs (IP, password, and so on), you can find them in your Deployment Manager window within the GCP console.

To delete your deployment, take note of the `STACK_NAME` and use the utility script:

```
#!/bin/bash
PROJECT=my-gcp-project-ID
if [ -z $1 ]; then
  echo "Usage: call me with deployment name"
  exit 1
fi
gcloud -q deployment-manager deployments delete $1 --project $PROJECT
# OPTIONAL!  Destroy the disk
# gcloud --quiet compute disks delete $(gcloud compute disks list --project $PROJECT --filter="name:'$1'" --uri)
```
When you delete Neo4j stacks on GCP, the GCP disks are left behind, to make it hard for you to accidentally destroy your valuable data. To completely clean up your disks, uncomment the last line of the script.

Deploying Neo4j Enterprise (or Community) Edition in standalone mode

To deploy Neo4j Enterprise Edition in standalone mode, create a simple VM and configure its firewall/security rules. It will not have high-availability failover capabilities, but it is a very fast way to get started.

You choose a random password by running some random bytes through a hash. The script also provides an example of polling and waiting until the VM service comes up, and then changing the Neo4j default password.

The launcher-public project on GCP hosts Neo4j’s VM images for GCP. In the example script, neo4j-enterprise-1-3-5-3-apoc is used, but other versions are also available. By substituting a different image name here, you can use this same technique to run Neo4j Community Edition in standalone mode.
#!/bin/bash
export PROJECT=my-gcp-project-id
export MACHINE=n1-standard-2
export DISK_SIZE=64GB
export ZONE=us-east1-b
export NEO4J_VERSION=4.4.10
export PASSWORD=$(head -n 20 /dev/urandom | md5)
export STACK_NAME=neo4j-standalone
export IMAGE=neo4j-enterprise-1-3-5-3-apoc

# Setup firewalling.
echo "Creating firewall rules"
gcloud compute firewall-rules create "$STACK_NAME"
   --allow tcp:7473,tcp:7687
   --source-ranges 0.0.0.0/0
   --target-tags neo4j
   --project $PROJECT
if [ $? -ne 0 ]; then
    echo "Firewall creation failed. Bailing out"
    exit 1
fi

echo "Creating instance"
OUTPUT=$(gcloud compute instances create $STACK_NAME
   --project $PROJECT
   --image $IMAGE
   --tags neo4j
   --machine-type $MACHINE
   --boot-disk-size $DISK_SIZE
   --boot-disk-type $DISK_TYPE
   --image-project launcher-public)

# Pull out the IP addresses, and toss out the private internal one (10.*)
IP=$(echo $OUTPUT | grep -oE '((1\?\[0-9]\[0-9]\?|2\[0-4]\[0-9]\?|25\[0-5]\?)\.(1\?\[0-9]\[0-9]\?|2\[0-4]\[0-9]\?|25\[0-5]\?)\.(1\?\[0-9]\[0-9]\?|2\[0-4]\[0-9]\?|25\[0-5]\?)\.(1\?\[0-9]\[0-9]\?|2\[0-4]\[0-9]\?|25\[0-5]\?))' | grep --invert-match "^10\.")

echo "Discovered new machine IP at $IP"

# To delete your deployment, take note of the STACK_NAME and use the utility script:

#!/bin/bash
export PROJECT=my-google-project-id
if [ -z $1 ]; then
    echo "Missing argument"
    exit 1
fi

echo "Deleting instance and firewall rules"
gcloud compute instances delete --quiet "$1" --project "$PROJECT" &&
gcloud compute firewall-rules --quiet delete "$1" --project "$PROJECT"
3.3. Neo4j on Microsoft Azure

This chapter describes the different options for deploying and running Neo4j on Microsoft Azure.

There are several options for running Neo4j on Azure, depending on what you want to do.

- **Single instances (VM-based)** — Deploying Neo4j single instances on Azure.
- **Causal Clusters (VM-Based)** — Deploying Neo4j Causal cluster on Azure.
- **Neo4j deployments automation on Azure** — Automating Neo4j deployments on Azure.

3.3.1. Single instances (VM-based)

This chapter describes how to launch a single instance from an image on Azure.

Prerequisites

- You know how to run and operate Neo4j locally.
- You have a Neo4j Enterprise or a trial license for Azure.
- You know how to access cloud-hosted Neo4j from your application. See the Driver Manual.
- You have installed and set up Azure Command Line Interface.

Deploy Neo4j via the Azure Marketplace

Deploy Neo4j Enterprise VM from the Azure Marketplace following the interactive prompts.

> The most important setting to consider are **Size**, which controls the available CPU and memory, and optionally **Disks**, where you configure high-speed SSDs and larger disk capacity sizes. It is recommended to create a new resource group to hold the artifacts of your deployment.

Once the deploy finishes, save the URL, username, and password.

Access your new instance

Navigate to `https://[MY_Azure_IP]:7473` and log in with the username `neo4j` and password `neo4j`. You will be prompted to change the password immediately.

Because you do not have a hostname or a valid SSL certificate configured by default, your browser will warn you that the certificate is not trusted. You can configure the certificate later.
Access your instance via SSH

You can use any SSH client as normal to connect to the public IP of your instance. Use the administrative user credentials (password or SSH key) configured during the launch. This user has `sudo` access on the machine.

Inside the VM, you can check the status of the neo4j service:

```
$ sudo systemctl status neo4j
neo4j.service - Neo4j Graph Database
   Loaded: loaded (/etc/systemd/system/neo4j.service; enabled; vendor preset: enabled)
   Active: active (running) since Wed 2018-03-14 11:19:56 UTC; 15min ago
   Main PID: 1290 (pre-neo4j.sh)
     Tasks: 46
     Memory: 325.7M
     CPU: 20.690s
     CGroup: /system.slice/neo4j.service
   └─1290 /bin/bash /etc/neo4j/pre-neo4j.sh
```

Deleting the instance

You can remove the infrastructure by deleting the entire resource group you created as part of the deployment. If you deployed into an existing resource group, you have to individually delete the resources that are part of the deployment.

3.3.2. Causal Clusters (VM-based)

This chapter describes how to deploy and run Neo4j Causal Cluster on Azure.

Prerequisites

- You have a Neo4j Enterprise or a trial license for Azure.
- You are familiar with the Causal Cluster architecture.
- You know how to access cloud-hosted Neo4j from your application. See the Driver Manual.

Deploy Neo4j from the Azure Marketplace

Deploy Neo4j Enterprise Causal Cluster from the Azure Marketplace following the interactive prompts. Create a new resource group to hold the artifacts of your deployment, as the admin account name is used for SSH access to the machines in your cluster.

Once the deploy finishes, save the URL, username, and password.

At the end of the deployment process, Azure runs a validation. If the validation fails, it might be because you have chosen VMs that are too large and exceed your Azure quota. Choose smaller VMs or increase your VM quota.
Start using Neo4j Browser

Use your browser to access the cloud-based database URL, and log in with the initial username and password provided. You may see an SSL warning screen because the out-of-the-box deployment uses an unsigned SSL certificate.

To verify that the cluster has formed correctly, run the following Cypher statement:

```
CALL dbms.cluster.overview().
```

Access your instance via SSH

You can SSH into any of the machines using the configured hostname and admin credentials.

Your cluster default configuration

The following notes are provided on your default cluster configuration.

- Ports 7687 (bolt) and 7473 (HTTPS access) are the only ports exposed to the entire internet. Consider narrowing the access to these ports to only your needed networks. External unencrypted HTTP access is disabled by default.
- Ports 5000, 6000, and 7000 are enabled only for internal network access (10.0.0.8), between the cluster nodes.

What’s next

- Visit Clustering for more information on how to configure your cluster.
- Add users and change passwords as necessary.
- Consider creating DNS entries with Google to be able to address your cluster with client applications under a single hostname.

Terminating the deployment

You can remove the infrastructure by deleting the entire resource group you created as part of the deployment.

3.3.3. Neo4j deployments automation on Azure

This chapter describes how to automate Neo4j deployments on Azure.

Automate Neo4j deployment when you want to integrate Neo4j into your CI/CD pipeline to be able to create/destroy instances temporarily, or to spin up a sample instance.
Prerequisites

- You have installed the Azure command-line interface.
- You have installed jq tool for working with JSON responses. See the Download jq page.
- You have authenticated your az CLI to be able to interact with your resource groups and use the right subscription by default. For more information on how to change the tool subscription, see the Azure CLI documentation.

Azure Resource Manager

Neo4j provides Azure Resource Manager (ARM) templates for Neo4j Enterprise standalone and Neo4j Causal Cluster (highly-available clusters).

ARM templates are a recipe that tells Azure how to deploy a whole set of interrelated resources. By deploying all of this as a stack you can keep all your resources together, and manage the entire instance by managing this resource group.

Creating an ARM deployment job

Depending on what Neo4j edition you want to deploy, you create ARM Deployment job by running a shell script.

Each script contains the following configurations:

- The URL of the Neo4j stack template that tells Azure what to deploy.
- Various parameters that control how much hardware you want to use.
- **VM_SIZE** – the Azure VM type you want to launch, which controls how much hardware you will be using.
- **DISK_SIZE** and **DISK_TYPE** – controls whether Neo4j uses standard spinning magnetic platters (pd-standard) or SSD disks (pd-ssd), and how many GB of storage you want to allocate.
- **LOCATION** - specifies where to deploy Neo4j.
- Authentication details - the administrative username and password for access to the VMs.

Deploying Neo4j Enterprise Causal Cluster

To deploy Neo4j Enterprise Causal Cluster, use the Causal Cluster template.

You indicate how many core servers and read replicas you want in your cluster by configuring the **CORE_NODES** and **READ_REPLICAS** parameters.

Take note of the **TEMPLATE_BASE** parameter, which contains the Neo4j version you want to launch. This can be adjusted to any version of Neo4j where there are published ARM templates. Create a simple JSON file with your deployment configurations and pass it to ARM. Based on your inputs, ARM produces a set of infrastructure as an output.
As a result, a new resource group is created with all the assets, and you get a URI of a bolt endpoint you can use. Alternatively, go to https://<IP address>:7473/ to access Neo4j Browser for your new clustered instance.

Deploying Neo4j Enterprise Standalone

To deploy Neo4j Enterprise Standalone, create a simple VM and configure its firewall/security rules. It will not have high-availability failover capabilities, but it is a very fast way to get started.
Neo4j provides the VM through an Azure marketplace offer. To refer to the right VM image, you need to know the publisher (that’s Neo4j), the “offer” (Neo4j version series), and SKU (the particular Neo4j version). Because you are not using ARM for this deployment, the script polls and waits until the VM service comes up, and then changes the Neo4j default password. At the top, you can choose a different password for the neo4j user as for a system administrator. Make sure to customize the SUBSCRIPTION variable to make this work.

```bash
#!/bin/bash
export LOCATION=eastus
export SUBSCRIPTION=My-Subscription-Name
export RG=neo4j-standalone-RG
export NAME=neo4j-standalone
export ADMIN_USERNAME=graph-hacker
export ADMIN_PASSWORD=ch00se:A@PASSw0rd
export NEO4J_PASSWORD=ch00se:A@PASSw0rd
export NETWORK_SECURITY_GROUP=neo4j-nsg
export VM_SIZE=Standard_D2_v3
# Can change this to static if desired
export ADDRESS_ALLOCATION=dynamic
# Configuration bits of what you’re launching
# Publisher:Offer:Sku:Version
export PUBLISHER=neo4j
export OFFER=neo4j-enterprise-3_5
export SKU=neo4j_3_5_5_apoc
export VERSION=latest
export IMAGE=${PUBLISHER}:${OFFER}:${SKU}:${VERSION}

echo "Creating resource group named $RG"
az group create
--location $LOCATION
--name $RG
--subscription $SUBSCRIPTION

echo "Creating Network Security Group named $NETWORK_SECURITY_GROUP"
az network nsg create
--resource-group $RG
--location $LOCATION
--name $NETWORK_SECURITY_GROUP

echo "Assigning NSG rules to allow inbound traffic on Neo4j ports..."]
prio=1000
for port in 7473 7474 7687; do
az network nsg rule create
--resource-group $RG
--nsg-name $NETWORK_SECURITY_GROUP
--name neo4j-allow-$port
--protocol tcp
--priority $prio
--destination-port-range $port
prio=$(($prio+1))
done

echo "Creating Neo4j VM named $NAME"
az vm create --name $NAME
--resource-group $RG
--image $IMAGE
--vnet-name $NAME-vnet
--subnet $NAME-subnet
--admin-username "$ADMIN_USERNAME"
--admin-password "$ADMIN_PASSWORD"
--public-ip-address-allocation $ADDRESS_ALLOCATION
--size $VM_SIZE
if [ $? -ne 0 ]; then
echo "VM creation failed"
exit 1
fi
echo "Updating NIC to have your NSG"
# Uses default assigned NIC name
az network nic update
--resource-group "$RG"
--name "$NAME"\VMNic
--network-security-group $NETWORK_SECURITY_GROUP

# Get the IP address of our instance
IP_ADDRESS=$(az vm list-ip-addresses -g "$RG" -n "$NAME" | jq -r '.[0].virtualMachine.network.publicIpAddresses[0].ipAddress')
export NEO4J_URI=bolt://$IP_ADDRESS
```
Cleaning up and removing your deployment

When you are done with your deployment, you can delete the entire resource group by using the following script:

```bash
#!/bin/bash
if [ -z $1 ]; then
echo "Usage: call me with deployment name"
exit 1
fi
STACK_NAME=$1
if [ -f "$STACK_NAME.json" ]; then
  rm -f "$STACK_NAME.json"
fi
az group delete -n "$STACK_NAME" --no-wait --yes
exit $?
```

Chapter 4. Docker

This chapter describes how run Neo4j in a Docker container.

This chapter describes the following:

- **Introduction** — Introduction to running Neo4j in a Docker container.
- **Configuration** — How to configure Neo4j to run in a Docker container.
- **Clustering** — How to set up Causal Clustering when using Docker.
- **Docker specific operations** - Descriptions of various operations that are specific to using Docker.
- **Security** - Information about using encryption with the Docker image.
- **Docker maintenance operations** How to maintain Neo4j when running in a Docker container.
- **Docker specific configuration settings** - A conversion table for the Neo4j configuration settings to Docker format.

Docker does not run natively on macOS or Windows. For running Docker on macOS and Windows, please consult the documentation provided by Docker.

4.1. Introduction

An introduction to how Neo4j runs in a Docker container.

Docker can be downloaded for MacOS, Windows, and Linux operating systems from https://www.docker.com/get-started. There is an official Neo4j image on DockerHub that provides a standard, ready-to-run package of Neo4j. From the DockerHub repo, it is possible to run Community Edition or Enterprise Edition with a variety of Neo4j versions.

4.1.1. Neo4j editions

Tags are available for both Community Edition and Enterprise Edition. Version-specific Enterprise Edition tags have an -enterprise suffix, for example: neo4j:4.4.10-enterprise. Community Edition tags have no suffix, for example neo4j:4.4.10. The latest Neo4j Enterprise Edition release is available as neo4j:enterprise.

All supported tags can be found at https://hub.docker.com/_/neo4j/?tab=tags.

Neo4j Enterprise Edition license

In order to use Neo4j Enterprise Edition, you must accept the license agreement.
4.1.2. Using the Neo4j Docker image

A Neo4j container can be started using the following command:

```
docker run \
  --restart always \
  --publish=7474:7474 --publish=7687:7687 \
  --volume=$HOME/neo4j/data:/data \
  neo4j:4.4.10
```

However, there are several options with the `docker run` command. This table lists some of the options available:

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>--name</code></td>
<td>Name your container to avoid generic ID</td>
<td><code>docker run --name myneo4j neo4j</code></td>
</tr>
<tr>
<td><code>-p</code></td>
<td>Specify which container port to expose</td>
<td><code>docker run -p7687:7687 neo4j</code></td>
</tr>
<tr>
<td><code>-d</code></td>
<td>Detach container to run in background</td>
<td><code>docker run -d neo4j</code></td>
</tr>
<tr>
<td><code>-v</code></td>
<td>Bind mount a volume</td>
<td><code>docker run -v $HOME/neo4j/data:/data neo4j</code></td>
</tr>
<tr>
<td><code>--env</code></td>
<td>Set config as environment variables for Neo4j database</td>
<td><code>docker run --env NEO4J_AUTH=neo4j/test</code></td>
</tr>
<tr>
<td>Option</td>
<td>Description</td>
<td>Example</td>
</tr>
<tr>
<td>-------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>----------------------------------------------</td>
</tr>
<tr>
<td>--restart</td>
<td>Control whether Neo4j containers start automatically when they exit, or when Docker restarts.</td>
<td>docker run --restart always</td>
</tr>
<tr>
<td>--help</td>
<td>Output full list of docker run options</td>
<td>docker run --help</td>
</tr>
</tbody>
</table>

The `--restart always` option sets the Neo4j container (and Neo4j) to restart automatically whenever the Docker daemon is restarted.

If you no longer want to have the container auto-start on machine boot, you can disable this setting using the flag `no`:

```
docker update --restart=no <containerID>
```

For more information on Docker restart policies, see [The official Docker documentation](https://docs.docker.com/reference/run/#restart).

### 4.1.3. Offline installation of Neo4j Docker image

Docker provides the `docker save` command for downloading an image into a `.tar` package so that it can be used offline, or transferred to a machine without internet access.

This is an example command to save the `neo4j:4.4.10` image to a `.tar` file:

```
docker save -o neo4j-4.4.10.tar neo4j:4.4.10
```

To load a docker image from a `.tar` file created by `docker save`, use the `docker load` command. For example:

```
docker load --input neo4j-4.4.10.tar
```

For complete instructions on using the `docker save` and `docker load` commands, refer to:

- [The official docker save documentation](https://docs.docker.com/engine/reference/commandline/save/)
- [The official docker load documentation](https://docs.docker.com/engine/reference/commandline/load/)

### 4.1.4. Using `NEO4J_AUTH` to set an initial password

By default, Neo4j requires authentication and prompts you to login with a username/password of `neo4j/neo4j` at the first connection. You are then prompted to set a new password. For more information about setting the initial password for Neo4j, see [Set an initial password](https://neo4j.com/docs/neo4jServer/latest/security/auth.html).

When using Neo4j in a Docker container, you can set the initial password for the container directly by specifying the `NEO4J_AUTH` in your run directive:
Alternatively, you can disable authentication by specifying `NEO4J_AUTH` to `none`:

```bash
--env NEO4J_AUTH=none
```

Please note that there is currently no way to change the initial username from `neo4j`.

If you have mounted a `/data` volume containing an existing database, setting `NEO4J_AUTH` will have no effect. The Neo4j Docker service will start, but to log in you will need a username and password already associated with the database.

### 4.1.5. Running Neo4j as a non-root user

For security reasons, Neo4j runs as the `neo4j` user inside the container. You can specify which user to run as by invoking docker with the `--user` argument. For example, the following runs Neo4j as your current user:

```bash
docker run \
    --publish=7474:7474 --publish=7687:7687 \
    --volume=$HOME/neo4j/data:/data \
    --volume=$HOME/neo4j/logs:/logs \
    --user="$(id -u):$(id -g)" \
    neo4j:4.4.10
```

The folders that you want to mount must exist before starting Docker, otherwise Neo4j will fail to start due to permissions errors.

### 4.2. Configuration

This chapter describes how to configure Neo4j to run in a Docker container.

The default configuration provided by this image is intended for learning about Neo4j, but must be modified to make it suitable for production use. In particular, the default memory assignments to Neo4j are very limited (`NEO4J_dbms_memory_pagecache_size=512M` and `NEO4J_dbms_memory_heap_max_size=512M`), to allow multiple containers to be run on the same server. You can read more about configuring Neo4j in the Docker specific configuration settings.

There are three ways to modify the configuration:

- Set environment variables.
- Mount a `/conf` volume.
- Build a new image.

Which one to choose depends on how much you need to customize the image.
4.2.1. Environment variables

Pass environment variables to the container when you run it.

```
docker run 
  --detach 
  --publish=7474:7474 --publish=7687:7687 
  --volume=$HOME/neo4j/data:/data 
  --volume=$HOME/neo4j/logs:/logs 
  --env NEO4J_dbms_memory_pagecache_size=4G 
  neo4j:4.4.10
```

Any configuration value (see Configuration settings) can be passed using the following naming scheme:

- Prefix with NEO4J_.
- Underscores must be written twice: _ is written as __.
- Periods are converted to underscores: . is written as __.

As an example, `dbms.tx_log.rotation.size` could be set by specifying the following argument to Docker:

```
--env NEO4J_dbms_tx__log_rotation_size
```

Variables which can take multiple options, such as `dbms_jvm_additional`, must be defined just once, and include a concatenation of the multiple values. For example:

```
--env NEO4J_dbms_jvm_additional=-Dcom.sun.management.jmxremote.authenticate=true 
                        -Dcom.sun.management.jmxremote.ssl=false 
                        -Dcom.sun.management.jmxremote.password.file=$HOME/conf/jmx.password 
                        -Dcom.sun.management.jmxremote.access.file=$HOME/conf/jmx.access 
                        -Dcom.sun.management.jmxremote.port=3637
```

4.2.2. Mounting the /conf volume

To make arbitrary modifications to the Neo4j configuration, provide the container with a /conf volume.

```
docker run 
  --detach 
  --publish=7474:7474 --publish=7687:7687 
  --volume=$HOME/neo4j/data:/data 
  --volume=$HOME/neo4j/logs:/logs 
  --volume=$HOME/neo4j/conf:/conf 
  neo4j:4.4.10
```

Any configuration files in the /conf volume will override files provided by the image. So if you want to change one value in a file you must ensure that the rest of the file is complete and correct. Environment variables passed to the container by Docker will still override the values in configuration files in /conf volume.

If you use a configuration volume you must make sure to listen on all network interfaces. This can be done by setting `dbms.default_listen_address=0.0.0.0`.

To dump an initial set of configuration files, run the image with the `dump-config` command.
4.2.3. Customize a Neo4j Docker image

To customize a Neo4j Docker image, you create a custom Dockerfile based on a Neo4j image (using the `FROM` instruction), build that image, and run a container based on it.

It is recommended to specify an explicit version of the base Neo4j Docker image. For available Neo4j Docker images, see [https://hub.docker.com/_/neo4j](https://hub.docker.com/_/neo4j).

Additionally, you can pass `EXTENSION_SCRIPT` as an environment variable, pointing to a location in a folder you need to mount. You can use this script to perform an additional initialization or configuration of the environment, for example, loading credentials or dynamically setting `neo4j.conf` settings, etc. The Neo4j image `ENTRYPOINT` script will check for the presence of an `EXTENSION_SCRIPT` environment variable. If set, it will first execute the `ENTRYPOINT` code, then the extension script specified, and finally, it will start Neo4j.

The following is an example of how to create a custom Dockerfile based on a Neo4j image, build the image, and run a container based on it. It also shows how to use the `EXTENSION_SCRIPT` feature.

```bash
# Create a custom Dockerfile based on a Neo4j image:

FROM neo4j:4.4.10-enterprise
COPY extension_script.sh /extension_script.sh
ENV EXTENSION_SCRIPT=/extension_script.sh

# Build the custom image:

docker build --file /example/Dockerfile --tag neo4j:4.4.10-enterprise-custom-container-1 /example

# Create and run a container based on the custom image:

```

The recommended best practices and methods for building efficient Docker images can be found at the Docker documentation + Best practices for writing Dockerfiles.

4.3. Clustering [Enterprise edition]

How to deploy a Causal Cluster setup in a containerized environment without an orchestration tool.
The examples on this page make use of both command expansion and DNS discovery method. For more information, see:

- Command expansion
- Discovery using DNS with multiple records

4.3.1. Deploy a Causal Cluster with Docker Compose

You can deploy a Causal Cluster using Docker Compose. Docker Compose is a management tool for Docker containers. You use a YAML file to define the infrastructure of all your Causal Cluster members in one file. Then, by running the single command `docker-compose up`, you create and start all the members without the need to invoke each of them individually. For more information about Docker Compose, see the Docker Compose official documentation.

Prerequisites

- Verify that you have installed Docker Compose. For more information, see the Install Docker Compose official documentation.

Procedure

1. Create a configuration file `neo4j.conf` which will be shared across core and replica members and make it readable and writable for the user (eg. `chmod 640 neo4j.conf`)
2. Prepare your `docker-compose.yml` file using the following example. For more information, see the Docker Compose official Service configuration reference.
Example 2. Example docker-compose.yml file

```yaml
version: '3.8'

# Custom top-level network
networks:
  neo4j-internal:

services:

  core1:
    # Docker image to be used
    image: ${NEO4J_DOCKER_IMAGE}
    # Hostname
    hostname: core1
    # Service-level network, which specifies the networks, from the list of the top-level networks (in this case only neo4j-internal), that the server will connect to.
    networks:
      neo4j-internal:
        aliases:
          - neo4j-network
    # The ports that will be accessible from outside the container - HTTP (7474) and Bolt (7687).
    ports:
      - "7474:7474"
      - "7687:7687"
    # Uncomment the volumes to be mounted to make them accessible from outside the container.
    volumes:
      - ./neo4j.conf:/conf/neo4j.conf # This is the main configuration file.
      - ./data/core1:/var/lib/neo4j/data
      - ./logs/core1:/var/lib/neo4j/logs
      - ./conf/core1:/var/lib/neo4j/conf
      - ./import/core1:/var/lib/neo4j/import
      # - ./metrics/core1:/var/lib/neo4j/metrics
      # - ./licenses/core1:/var/lib/neo4j/licenses
      # - ./ssl/core1:/var/lib/neo4j/ssl
    # Passes the following environment variables to the container
    environment:
      - NEO4J_ACCEPT_LICENSE_AGREEMENT
      - NEO4J_AUTH
      - EXTENDED_CONF
      - NEO4J_EDITION
      - NEO4J_dbms_mode=CORE
    # Simple check testing whether the port 7474 is opened.
    # If so, the instance running inside the container is considered as "healthy".
    # This status can be checked using the "docker ps" command.
    healthcheck:
      test: ["CMD-SHELL", "wget --no-verbose --tries=1 --spider localhost:7474 || exit 1"]
    # Set up the user
    user: ${USER_ID}:${GROUP_ID}

  core2:
    image: ${NEO4J_DOCKER_IMAGE}
    hostname: core2
    networks:
      neo4j-internal:
        aliases:
          - neo4j-network
    ports:
      - "7475:7474"
      - "7688:7687"
    volumes:
      - ./neo4j.conf:/conf/neo4j.conf
      - ./data/core2:/var/lib/neo4j/data
      - ./logs/core2:/var/lib/neo4j/logs
      - ./conf/core2:/var/lib/neo4j/conf
      - ./import/core2:/var/lib/neo4j/import
      # - ./metrics/core2:/var/lib/neo4j/metrics
```

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3. Set up the environment variables:

```
  export USER_ID="$(id -u)"
```
° export GROUP_ID="$(id -g)"
° export NEO4J DOCKER_IMAGE=neo4j:4.4-enterprise
° export NEO4J_EDITION=docker_compose
° export EXTENDED_CONF=yes
° export NEO4J_ACCEPT_LICENSE_AGREEMENT=yes
° export NEO4J_AUTH=neo4j/your_password

4. Deploy your Causal Cluster by running `docker-compose up` from your project folder.
6. Authenticate with the default `neo4j/your_password` credentials.
7. Check the status of the cluster by running the following in Neo4j Browser:

   :sysinfo

### 4.3.2. Deploy a Causal Cluster using environment variables

You can set up containers in a cluster to talk to each other using environment variables. Each container must have a network route to each of the others, and the `NEO4J_causal__clustering_expected__core__cluster__size` and `NEO4J_causal__clustering_initial__discovery__members` environment variables must be set for Cores. Read Replicas only need to define `NEO4J_causal__clustering_initial__discovery__members`.

**Causal Cluster environment variables**

The following environment variables are specific to Causal Clustering, and are available in the Neo4j Enterprise Edition:

- **NEO4J_dbms_mode**: the database mode, defaults to SINGLE, set to CORE or READ_REPLICA for Causal Clustering.
- **NEO4J_causal__clustering_expected__core__cluster__size**: the initial cluster size (number of Core instances) at startup.
- **NEO4J_causal__clustering_initial__discovery__members**: the network addresses of an initial set of Core cluster members.
- **NEO4J_causal__clustering_discovery__advertised__address**: hostname/IP address and port to advertise for member discovery management communication.
- **NEO4J_causal__clustering_transaction__advertised__address**: hostname/IP address and port to advertise for transaction handling.
- **NEO4J_causal__clustering_raft__advertised__address**: hostname/IP address and port to advertise for cluster communication.

See [Settings reference](#) for more details of Neo4j Causal Clustering settings.
Set up a Causal Cluster on a single Docker host

Within a single Docker host, you can use the default ports for HTTP, HTTPS, and Bolt. For each container, these ports are mapped to a different set of ports on the Docker host.

Example of a `docker run` command for deploying a cluster with 3 COREs:

```bash
docker network create --driver=bridge cluster
docker run --name=core1 --detach --network=cluster \
  --publish=7474:7474 --publish=7473:7473 --publish=7687:7687 \
  --hostname=core1 \n  --env NEO4J_dbms_mode=CORE \n  --env NEO4J_causal_clustering_expected_core_cluster_size=3 \n  --env NEO4J_causal_clustering_initial_discovery_members=core1:5000,core2:5000,core3:5000 \n  --env NEO4J_ACCEPT_LICENSE AGREEMENT=yes \n  --env NEO4J_dbms_connector_bolt_advertised_address=localhost:7687 \n  --env NEO4J_dbms_connector_http_advertised_address=localhost:7474 \n  neo4j:4.4.10-enterprise
docker run --name=core2 --detach --network=cluster \
  --publish=8474:7474 --publish=8473:7473 --publish=8687:7687 \
  --hostname=core2 \n  --env NEO4J_dbms_mode=CORE \n  --env NEO4J_causal_clustering_expected_core_cluster_size=3 \n  --env NEO4J_causal_clustering_initial_discovery_members=core1:5000,core2:5000,core3:5000 \n  --env NEO4J_ACCEPT_LICENSE AGREEMENT=yes \n  --env NEO4J_dbms_connector_bolt_advertised_address=localhost:8687 \n  --env NEO4J_dbms_connector_http_advertised_address=localhost:8474 \n  neo4j:4.4.10-enterprise
docker run --name=core3 --detach --network=cluster \
  --publish=9474:7474 --publish=9473:7473 --publish=9687:7687 \
  --hostname=core3 \n  --env NEO4J_dbms_mode=CORE \n  --env NEO4J_causal_clustering_expected_core_cluster_size=3 \n  --env NEO4J_causal_clustering_initial_discovery_members=core1:5000,core2:5000,core3:5000 \n  --env NEO4J_ACCEPT_LICENSE AGREEMENT=yes \n  --env NEO4J_dbms_connector_bolt_advertised_address=localhost:9687 \n  --env NEO4J_dbms_connector_http_advertised_address=localhost:9474 \n  neo4j:4.4.10-enterprise
```

Additional instances can be added to the cluster in an ad-hoc fashion.

Example of a `docker run` command for adding a Read Replica to the cluster:

```bash
docker run --name=read-replica1 --detach --network=cluster \
  --publish=10474:7474 --publish=10473:7473 --publish=10687:7687 \
  --hostname=read-replica1 \n  --env NEO4J_dbms_mode=READ_REPLICA \n  --env NEO4J_causal_clustering_initial_discovery_members=core1:5000,core2:5000,core3:5000 \n  --env NEO4J_ACCEPT_LICENSE AGREEMENT=yes \n  --env NEO4J_dbms_connector_bolt_advertised_address=localhost:10687 \n  --env NEO4J_dbms_connector_http_advertised_address=localhost:10474 \n  neo4j:4.4.10-enterprise
```

Set up a Causal Cluster on multiple Docker hosts

To get the Causal Cluster high-availability characteristics, however, it is more sensible to put the cluster nodes on different physical machines.

When each container is running on its own physical machine, and the Docker network is not used, you have to define the advertised addresses to enable the communication between the physical machines.
Each container must also bind to the host machine’s network. For more information about container networking, see the Docker official documentation.

Example of a `docker run` command for invoking a cluster member:

```
docker run --name=neo4j-core --detach \
  --network=host \
  --publish=7474:7474 --publish=7687:7687 \
  --publish=5000:5000 --publish=6000:6000 --publish=7000:7000 \
  --hostname=public-address \
  --env NEO4J_dbms_mode=CORE \
  --env NEO4J_causal_clustering_expected_core_cluster_size=3 \
  --env NEO4J_causal_clustering_initial_discovery_members=core1-public-address:5000,core2-public-address:5000,core3-public-address:5000 \
  --env NEO4J_causal_clustering_discovery_advertised_address=public-address:5000 \
  --env NEO4J_causal_clustering_transaction_advertised_address=public-address:6000 \
  --env NEO4J_causal_clustering_raft_advertised_address=public-address:7000 \
  --env NEO4J_dbms_connectors_default_advertised_address=public-address \
  --env NEO4J_ACCEPT_LICENSE_AGREEMENT=yes \
  --env NEO4J_dbms_connector_bolt_advertised_address=public-address:7687 \
  --env NEO4J_dbms_connector_http_advertised_address=public-address:7474 \
  neo4j:4.4.10-enterprise
```

+ Where `public-address` is the public hostname or ip-address of the machine.

Please note that if you are starting a Read Replica as above, you must publish the discovery port. For example, `--publish=5000:5000`.

In versions prior to Neo4j 4.0, this was only necessary with Core servers.

### 4.4. Docker specific operations

**How to use Neo4j tools when running Neo4j in a Docker container.**

#### 4.4.1. Use Neo4j Admin

The **Neo4j Admin tool** can be run locally within a container using the following command:

```
docker exec --interactive --tty <containerID/name> neo4j-admin <command>
```

To determine the container ID or name, run `docker ps` to list the currently running Docker containers.

For more information about the `neo4j-admin` commands, see **Neo4j Admin tool**.

#### 4.4.2. Use Neo4j Import

The **Neo4j Import tool** can be run locally within a container using the following command:

```
docker exec --interactive --tty <containerID/name> neo4j-admin import <options>
```

For more information about the `neo4j-admin import` syntax and options, see **Syntax** and **Options**.
Prerequisites

- Verify that you have created the folders that you want to mount as volumes to the Neo4j docker container.
- Verify that the CSV files that you want to load into Neo4j are formatted as per CSV header format.
- Verify that you have added the CSV files to the folder that will be mounted to /import in your container.

Import CSV files into the Neo4j Docker container using the Neo4j import tool

This is an example of how to start a container with mounted volumes /data and /import, to ensure the persistence of the data in them, and load the CSV files using the neo4j-admin import command. You can add the flag --rm to automatically remove the container’s file system when the container exits.

```
docker run --interactive --tty --rm \ 
  --publish=7474:7474 --publish=7687:7687 \ 
  --volume=$HOME/neo4j/data:/data \ 
  --volume=$HOME/neo4j/import:/import \ 
  --user="$(id -u):$(id -g)" \ 
  neo4j:4.4.10 \ 
  neo4j-admin import --nodes=Movies=/import/movies_header.csv,/import/movies.csv \ 
  --nodes=Actors=/import/actors_header.csv,/import/actors.csv \ 
  --relationships=ACTED_IN=/import/roles_header.csv,/import/roles.csv
```

4.4.3. Use Neo4j Admin for memory recommendations

The neo4j-admin memrec command with the argument --docker outputs environmental variables that can be passed to a Neo4j docker container. The recommended use is to save the generated environment variables to a file and pass the file to a docker container using the --env-file docker option. The following example shows how neo4j-admin memrec --docker provides a memory recommendation in a docker-friendly format.

Example 3. Invoke neo4j-admin memrec --docker

```
$neo4j-home> bin/neo4j-admin memrec --memory=16g --docker
...
...
# Based on the above, the following memory settings are recommended:
NEO4J_dbms_memory_heap_initial_size=5g
NEO4J_dbms_memory_heap_max_size=5g
NEO4J_dbms_memory_pagecache_size=7g
```

4.4.4. Use Cypher Shell

The Neo4j Cypher Shell tool can be run locally within a container using the following command:

```
docker exec --interactive --tty <containerID/name> cypher-shell <options>
```

For more information about the cypher-shell syntax and options, see Syntax.
Retrieve data from a database in a Neo4j Docker container

The following is an example of how to use the cypher-shell command to retrieve data from the neo4j database.

1. Run a new container, mounting the same volume /data as in the import example.

   ```
   docker run --interactive --tty --name <containerID/name> \
   --publish=7474:7474 --publish=7687:7687 \
   --volume=$HOME/neo4j/data:/data \
   --user="$(id -u):$(id -g)" \
   neo4j:4.4.10
   ```

2. Use the container ID or name to get into the container, and then, run the cypher-shell command and authenticate.

   ```
   docker exec --interactive --tty <containerID/name> cypher-shell -u neo4j -p neo4j
   ```

3. Retrieve some data.

   ```
   neo4j@neo4j> match (n:Actors)-[r]->(m:Movies) return n.name AS Actors, m.title AS Movies, m.year AS MovieYear;
   +-------------------------------------------------------------+
   | Actors               | Movies                   | MovieYear |
   +-------------------------------------------------------------+
   | "Keanu Reeves"      | "The Matrix Revolutions"| 2003      |
   | "Keanu Reeves"      | "The Matrix Reloaded"   | 2003      |
   | "Keanu Reeves"      | "The Matrix"            | 1999      |
   | "Laurence Fishburne"| "The Matrix Revolutions"| 2003      |
   | "Laurence Fishburne"| "The Matrix Reloaded"   | 2003      |
   | "Laurence Fishburne"| "The Matrix"            | 1999      |
   | "Carrie-Anne Moss"  | "The Matrix Revolutions"| 2003      |
   | "Carrie-Anne Moss"  | "The Matrix Reloaded"   | 2003      |
   | "Carrie-Anne Moss"  | "The Matrix"            | 1999      |
   +-------------------------------------------------------------+
   9 rows available after 61 ms, consumed after another 7 ms
   ```

Pass a Cypher script file to a Neo4j Docker container

Because cypher-shell does not support file streams, such as cypher-shell -a localhost -u <username> -p <password> --file myscript.cypher, you can use the commands cat or curl to pipe the contents of your script file into your container. The following are syntax examples of how to use these commands:

Invoke curl with Cypher Shell

```
curl http://mysite.com/config/script.cypher | sudo docker exec --interactive <containerID/name> cypher-shell -u neo4j -p neo4j
```
Invoke cat with Cypher Shell

```
# Prepare the example.cypher script, for instance, containing the query:
match (n:Actors)-[r]->(m:Movies) return n.name AS Actors, m.title AS Movies, m.year AS MovieYear;

# Run the following command:

cat example.cypher | sudo docker exec --interactive <containerID/name> cypher-shell -u neo4j -p neo4j

# The command runs the script and returns the following result:

Actors, Movies, MovieYear
"Keanu Reeves", "The Matrix Revolutions", 2003
"Keanu Reeves", "The Matrix", 1999
"Laurence Fishburne", "The Matrix Revolutions", 2003
"Laurence Fishburne", "The Matrix", 1999
```

These commands take the contents of the script file and pass it into the Docker container. Then, they run `cypher-shell`, authenticate with the provided `<username>` and `<password>`, and execute a cypher example, LOAD CSV dataset, which might be hosted somewhere on a server (with `curl`), create indexes, constraints, or do other administrative operations.

4.4.5. Install user-defined procedures

To install user-defined procedures, mount the `/plugins` volume containing the jars.

```
docker run --publish=7474:7474 --publish=7687:7687 --volume=$HOME/neo4j/plugins:/plugins neo4j:4.4.10
```

4.4.6. Configure Neo4j Labs plugins

The Neo4j Docker image includes a startup script which can automatically download and configure certain Neo4j plugins at runtime.

```
This feature is intended to facilitate using Neo4j Labs plugins in development environments, but it is not recommended for use in production environments.

To use plugins in production with Neo4j Docker containers, see Install user-defined procedures.
```

The `NEO4JLABS_PLUGINS` environment variable can be used to specify the plugins to install using this method. This should be set to a JSON-formatted list of supported plugins.

For example, to install the APOC plugin (`apoc`), you can use the Docker argument:

```
--env NEO4JLABS_PLUGINS='["apoc"]'
```

and run the following command:
For example, to install the APOC plugin (apoc) and the Neo Semantics plugin (n10s), you can use the following Docker argument:

```
--env NEO4JLABS_PLUGINS='["apoc", "n10s"]'
```

Table 11. Supported Neo4j Labs plugins

<table>
<thead>
<tr>
<th>Name</th>
<th>Key</th>
<th>Further information</th>
</tr>
</thead>
<tbody>
<tr>
<td>APOC</td>
<td>apoc</td>
<td><a href="https://neo4j.com/labs/apoc/">https://neo4j.com/labs/apoc/</a></td>
</tr>
<tr>
<td>APOC Core</td>
<td>apoc-core</td>
<td><a href="https://neo4j.com/labs/apoc/">https://neo4j.com/labs/apoc/</a></td>
</tr>
<tr>
<td>Bloom</td>
<td>bloom</td>
<td><a href="https://neo4j.com/docs/bloom-user-guide/current/">https://neo4j.com/docs/bloom-user-guide/current/</a></td>
</tr>
<tr>
<td>Streams</td>
<td>streams</td>
<td><a href="https://neo4j.com/docs/labs/neo4j-streams/current/">https://neo4j.com/docs/labs/neo4j-streams/current/</a></td>
</tr>
<tr>
<td>Graph Data Science</td>
<td>graph-data-science</td>
<td><a href="https://neo4j.com/docs/graph-data-science/current/">https://neo4j.com/docs/graph-data-science/current/</a></td>
</tr>
<tr>
<td>Neo Semantics</td>
<td>n10s</td>
<td><a href="https://neo4j.com/labs/nsmtx-rdf/">https://neo4j.com/labs/nsmtx-rdf/</a></td>
</tr>
</tbody>
</table>

Running Bloom in a Docker container requires Neo4j Docker image 4.2.3-enterprise or later.

4.5. Security

This chapter describes security in Neo4j when running in a Docker container.

4.5.1. SSL Encryption

Neo4j on Docker supports Neo4j's native SSL Framework for setting up secure Bolt and HTTPS communications. To configure these settings in Docker, you either set them in the neo4j.conf file, or pass them to Docker as Docker environment variables.
Set up your certificate folders

1. Verify that you have SSL public certificate(s) and private key(s).

   The certificates must be issued by a trusted certificate authority (CA), such as https://www.openssl.org/ or https://letsencrypt.org/.

   The default file names are private.key and public.crt.

2. Create a local folder to store your certificates.

   For example, $HOME/neo4j/certificates. This folder will be later mounted to /ssl of your container.

3. In your local folder (e.g. $HOME/neo4j/certificates), create a folder for the SSL policy of each of your communication channels that you want to secure. There, you will store your certificates and private keys.

   It is recommended to use different certificates for the different communication channels (bolt and https).

   In the following examples, <scope> substitutes the name of the communication channel.

   `mkdir $HOME/neo4j/certificates/<scope>`

4. In each of your <scope> folders, create a /trusted and a /revoked folder for the trusted and revoked certificates.

   `mkdir $HOME/neo4j/certificates/<scope>/trusted`
   `mkdir $HOME/neo4j/certificates/<scope>/revoked`

5. Finally, you add your certificates to the respective <scope> folder.

   The <scope> folder(s) should now show the following listings:

   `ls $HOME/neo4j/certificates/<scope>
  -r-------- ... private.key
  -rw-r--r-- ... public.crt
  drwxr-xr-x ... revoked
  drwxr-xr-x ... trusted`

Configure SSL via neo4j.conf

In the neo4j.conf file, configure the following settings for the policies that you want to use:
# Https SSL configuration

- `dbms.connector.https.enabled=true`
- `dbms.ssl.policy.https.enabled=true`
- `dbms.ssl.policy.https.base_directory=certificates/https`
- `dbms.ssl.policy.https.private_key=private.key`
- `dbms.ssl.policy.https.public_certificate=public.crt`

# Bolt SSL configuration

- `dbms.ssl.policy.bolt.enabled=true`
- `dbms.ssl.policy.bolt.base_directory=certificates/bolt`
- `dbms.ssl.policy.bolt.private_key=private.key`
- `dbms.ssl.policy.bolt.public_certificate=public.crt`

For more information on configuring SSL policies, see [Configuration](#).

For more information on configuring connectors, see [Configuration options](#).

Example 4. A `docker run` command that launches a container with SSL policy enabled via `neo4j.conf`.

```bash
docker run \ 
  --publish=7473:7473 \ ① 
  --publish=7687:7687 \ 
  --user="$(id -u):$(id -g)" \ ② 
  --volume=$HOME/neo4j/certificates:/ssl \ ③ 
  --volume=$HOME/neo4j/conf:/conf \ ④ 
  neo4j:4.4.10
```

① The port to access the HTTPS endpoint.

② Docker will be started as the current user (assuming the current user has read-access to the certificates).

③ The volume that contains the SSL policies that you want to set up Neo4j to use.

④ The volume that contains the `neo4j.conf` file. In this example, the `neo4j.conf` is in the `$HOME/neo4j/conf` folder of the host.

Configure SSL via Docker environment variables

As an alternative to configuring SSL via the `neo4j.conf` file, you can set an SSL policy by passing its configuration values to the Neo4j Docker container as environment variables. For more information on how to convert the Neo4j settings to the form accepted by Docker, see [Environment variables](#):
Example 5. A `docker run` command that launches a container with SSL policy enabled via Docker environment variables.

```
docker run \
  --publish=7473:7473 \ ①  \
  --publish=7687:7687 \ ①  \
  --user="$(id -u):$(id -g)" \ ②  \
  --volume=$HOME/neo4j/certificates:/ssl \ ③  \
  --env NEO4J_dbms_connectorhttps_enabled=true \ ④  \
  --env NEO4J_dbms_ssl_policyhttps_enabled=true \ ⑤  \
  --env NEO4J_dbms_ssl_policyhttps_base_directory=/ssl/https \ ⑥  
neo4j:4.4.10
```

① The port to access the HTTPS endpoint.
② Docker will be started as the current user (assuming the current user has read-access to the certificates).
③ The volume that contains the SSL policies that you want to set up Neo4j to use.
④ The HTTPS connector is disabled by default. Therefore, you must set `dbms.connector.https.enabled` to `true`, to be able Neo4j to listen for incoming connections on the HTTPS port. However, for the Bolt SSL policy, you do not have to pass this parameter as the Bolt connector is enabled by default.
⑤ The SSL policy that you want to set up for Neo4j.
⑥ The base directory under which SSL certificates and keys are searched for. Note that the value is the docker volume folder `/ssl/https` and not the `/certificate/https` folder of the host.

4.6. Docker maintenance operations

Basic maintenance operations when running Neo4j in a Docker container.

4.6.1. Dump and load a Neo4j database (offline)

The `neo4j-admin dump` and `neo4j-admin load` commands can be run locally to dump and load an offline database.

The following are examples of how to dump and load the default `neo4j` database. Because these commands are run on a stopped database, you have to launch a container for each operation (dump and load), with the `--rm` flag.
Example 6. Invoke `neo4j-admin dump` to dump your database.

```bash
docker run --interactive --tty --rm \
    --volume=$HOME/neo4j/data:/data \ ① \
    --volume=$HOME/neo4j/backups:/backups \ ② \
    neo4j/neo4j-admin:4.4.10 \
    neo4j-admin dump --database=neo4j --to=/backups/<dump-name>.dump
```

① The volume that contains the database that you want to dump.

② The volume that will be used for the dumped database.

Example 7. Invoke `neo4j-admin load` to load your data into the new database.

```bash
docker run --interactive --tty --rm \
    --volume=$HOME/neo4j/data:/data \ ① \
    --volume=$HOME/neo4j/backups:/backups \ ② \
    neo4j/neo4j-admin:4.4.10 \
    neo4j-admin load --database=neo4j --from=/backups/<_dump-name>.dump
```

① The volume that will contain the database, into which you want to load the dumped data.

② The volume that stores the database dump.

Finally, you launch a container with the volume that contains the newly loaded database, and start using it.

For more information on the `neo4j-admin dump` and `load` syntax and options, see `neo4j-admin dump` and `neo4j-admin load`.

For more information on managing volumes, see the official Docker documentation.

4.6.2. Back up and restore a Neo4j database (online) **Enterprise edition**

The Neo4j backup and restore commands can be run locally to backup and restore a live database.

You can also get a `neo4j-admin` image that can be run on a dedicated machine, under the terms of an existing Enterprise licensing agreement.

If Neo4j (a single instance or any member of a Neo4j cluster) is running inside a docker container, you can use `docker exec` to invoke `neo4-admin` from inside the container and take a backup of a database.

**Back up a database using `docker exec`** **Enterprise edition**

To back up a database, you must first mount the host backup folder onto the container. Because Docker does not allow new mounts to be added to a running container, you have to do this when starting the container.
Example 8. A `docker run` command that mounts the host backup folder to a Neo4j container.

```
docker run --name <container name> \  
  --detach \  
  --publish=7474:7474 --publish=7687:7687 \  
  --volume=$HOME/neo4j-enterprise/data:/data \  
  --volume=$HOME/neo4j-enterprise/backups:/backups \  
  --user="$(id -u):$(id -g)" \  
  --env NEO4J_ACCEPT_LICENSE_AGREEMENT=yes \  
  --env NEO4J_dbms_backup_enabled=true \  
  neo4j:4.4.10-enterprise
```

① The volume that contains the database that you want to back up.
② The volume that will be used for the database backup.
③ The environment variable that states that you have accepted the Neo4j Enterprise Edition license agreement.
④ The environment variable that enables online backups.

Example 9. Invoke `neo4j-admin backup` to back up an online database, using `docker exec`:

```
docker exec --interactive --tty <container name> neo4j-admin backup --backup-dir=/backups --database =<database name>
```

For more information on the `neo4j-admin backup` syntax and options, see Back up an online database.

Back up a database using `neo4j-admin image` Enterprise edition

To perform a backup, the cluster needs at least one node with backup enabled and the backup listen address port set and exposed. Ports cannot be exposed on a docker container once it has started, so this must be done when starting the container.
Example 10: A `docker run` command that starts a database configured for backing up.

```bash
docker run \
  --detach \
  --publish=7474:7474 \
  --publish=7687:7687 \
  --publish=6362:6362 \ ① 
  --volume=$HOME/neo4j-enterprise/data:/data \ ② 
  --env NEO4J_ACCEPT_LICENSE_AGREEMENT=yes \ ③ 
  --env NEO4J_dbms_backup_enabled=true \ ④ 
  --env NEO4J_dbms_backup_listen_address=0.0.0.0:6362 \ ⑤ 
  neo4j:4.4.10-enterprise
```

① The `dbms.backup.listen_address` port defined in 5.
② The volume that contains the database that you want to back up.
③ The environment variable that states that you have accepted the Neo4j Enterprise Edition license agreement.
④ The environment variable that enables online backups.
⑤ The environment variable that sets the `dbms.backup.listen_address`.

Once you have a backup enabled cluster node, the `neo4j/neo4j-admin:4.4.10-enterprise` docker image can be used to backup the database.

Example 11: Invoke `neo4j-admin` docker image to backup your database.

```bash
docker run --interactive --tty --rm \
  --volume=$HOME/neo4j-enterprise/backups:/backups \ ① 
  --env NEO4J_ACCEPT_LICENSE_AGREEMENT=yes \ ② 
  neo4j/neo4j-admin:4.4.10-enterprise \
  neo4j-admin backup --database=<database name> \
  --backup-dir=/backups \ 
  --from=<backup node IP address>:6362 \ ③
```

① The volume that will be used for the backup database files.
② The environment variable that states that you have accepted the Neo4j Enterprise Edition license agreement.
③ The IP address of the backup cluster node and the `dbms.backup.listen_address` port.

Restore a database using `docker exec` Enterprise edition

The following are examples of how to restore a database backup on a stopped database in a running Neo4j instance.
Example 12. A `docker run` command that creates a container to be used for restoring a database backup.

```bash
docker run --name <container name> \
  --detach \ 
  --publish=7474:7474 --publish=7687:7687 \ 
  --volume=$HOME/neo4j-enterprise/data:/data \ ① 
  --volume=$HOME/neo4j-enterprise/backups:/backups \ ② 
  --user="$(id -u):$(id -g)" \ 
  --env NEO4J_ACCEPT_LICENSE_AGREEMENT=yes \ ③ 
  neo4j:4.4.10-enterprise
```

① The volume that contains all your databases.
② The volume that contains the database backup.
③ The environment variable that states that you have accepted the Neo4j Enterprise Edition license agreement.

Example 13. Invoke `cypher-shell` to stop the database that you want to use for the backup restore.

```bash
docker exec -it <containerID/name> cypher-shell -u neo4j -p <my-password> -d system "stop database <database name>;"
```


```bash
docker exec --interactive --tty <containerID/name> neo4j-admin restore --from=/backups/<database backup name> --database=<database name>
```

Restore a database using `neo4j-admin` image **Enterprise edition**

The `neo4j-admin restore` action cannot be performed remotely, as it requires access to the `neo4j/data` folder. Consequently, backup files must be copied over to the new machine prior to a restore, and the `neo4j-admin` docker image must be run on the same machine as the database to be restored.

Example 15. A `docker run` command that creates a container to be used for restoring a database backup.

```bash
docker run --name <container name> \
  --detach \ 
  --volume=$HOME/neo4j-enterprise/data:/data \ ① 
  --env NEO4J_ACCEPT_LICENSE_AGREEMENT=yes \ ② 
  neo4j:4.4.10-enterprise
```

① The volume that contains, or will contain, all your database data.
② The environment variable that states that you have accepted the Neo4j Enterprise Edition license agreement.
Example 16. Stop the old database, then restore the backup database using `neo4j/neo4j-admin:4.4.10-enterprise`. Finally start the database again containing the new data.

```bash
docker exec -it <containerID/name> cypher-shell -u neo4j -p <my-password> -d system "stop database <database name>;;"

docker run --interactive --tty --rm \
--volume=$HOME.neo4j-enterprise/data:/data ① \
--volume=$HOME.neo4j-enterprise/backups:/backups ② \
--env NEO4J_ACCEPT_LICENSE_AGREEMENT=yes ③ \
neo4j/neo4j-admin:{neo4j-version-exact}-enterprise \
neo4j-admin restore \
--database=<database name> \
--from=/backups/<database name>

docker exec -it <containerID/name> cypher-shell -u neo4j -p <my-password> -d system "start database <database name>;;"
```

1. The volume that contains, or will contain, all your database data. This must be the same data folder that the `neo4j` database container is using.
2. The volume that contains the database backup.
3. The environment variable that states that you have accepted the Neo4j Enterprise Edition license agreement.

For more information on the `neo4j-admin restore` syntax and options, see [Restore a database backup](#).

Finally, you can use the Cypher Shell tool to verify that your data has been restored.

### 4.6.3. Upgrade Neo4j on Docker

The following is an example of a `docker run` command that launches a container and upgrades a Neo4j database stored in a Docker volume or a host folder.

```bash
docker run \
--publish=7474:7474 --publish=7687:7687 \
--volume=$HOME/neo4j/data:/data ① \
--env NEO4J_dbms_allow_upgrade=true ② \
neo4j:4.4.10 ③
```

1. The volume that contains the database that you want to upgrade.
2. The environment variable that enables the upgrade.
3. The new version of the Neo4j Docker image to which you want to upgrade your database.

The upgrade to a later patch release of Neo4j 4.4 is straightforward — stop the container and then restart it using the later Neo4j docker image. For more details on upgrading, see [Upgrade and Migration Guide](#) → Upgrade to a newer PATCH release.
4.6.4. Monitor Neo4j

Neo4j logging output is written to files in the /logs directory. This directory is mounted as a /logs volume.

For more information about configuring Neo4j, see Configuration.
For more information about the Neo4j log files, see Logging.

Since a docker instance is run as neo4j console, you would not normally expect to see neo4j.log in the /logs directory. However, you can still get it by running:

```bash
docker logs <containerID/name>
```

It is also possible to configure Neo4j to write the logs to a file by setting the configuration NEO4J_dbms_logs_user_stdout__enabled=true as an environment variable.

4.7. Docker specific configuration settings

This chapter provides a conversion table for the Neo4j configuration settings to the Docker format.

The Neo4j configuration settings can be passed to a Docker container using the following naming scheme:

- Prefix with NEO4J_.
- Underscores convert to double underscores: _ is written as __.
- Periods convert to underscores: . is written as _.

For example, browser.post_connect.cmd converts to NEO4J_browser_post__connect__cmd, or in other words, s/./_/g and s/_/__/g.

The following table is a complete reference of the Neo4j configuration settings converted to the Docker-supported format.

For more information on the configuration descriptions, valid values, and default values, see Configuration settings.

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<td>metrics.graphite.enabled</td>
<td>NEO4J_metrics_graphite_enabled</td>
</tr>
<tr>
<td>metrics.graphite.interval</td>
<td>NEO4J_metrics_graphite_interval</td>
</tr>
<tr>
<td>metrics.graphite.server</td>
<td>NEO4J_metrics_graphite_server</td>
</tr>
<tr>
<td>metrics.jmx.enabled</td>
<td>NEO4J_metrics_jmx_enabled</td>
</tr>
<tr>
<td>metrics.jvm.buffers.enabled</td>
<td>NEO4J_metrics_jvm_buffers_enabled</td>
</tr>
<tr>
<td>metrics.jvm.file.descriptors.enabled</td>
<td>NEO4J_metrics_jvm_file_descriptors_enabled</td>
</tr>
<tr>
<td>metrics.jvm.gc.enabled</td>
<td>NEO4J_metrics_jvm_gc_enabled</td>
</tr>
<tr>
<td>metrics.jvm.heap.enabled</td>
<td>NEO4J_metrics_jvm_heap_enabled</td>
</tr>
<tr>
<td>metrics.jvm.memory.enabled</td>
<td>NEO4J_metrics_jvm_memory_enabled</td>
</tr>
<tr>
<td>metrics.jvm.pause_time.enabled</td>
<td>NEO4J_metrics_jvm_pause__time_enabled</td>
</tr>
<tr>
<td>metrics.neo4j.causal_clustering.enabled</td>
<td>NEO4J_metrics_neo4j_causal__clustering_enabled</td>
</tr>
<tr>
<td>metrics.neo4j.checkpointing.enabled</td>
<td>NEO4J_metrics_neo4j_checkpointing_enabled</td>
</tr>
<tr>
<td>metrics.neo4j.counts.enabled</td>
<td>NEO4J_metrics_neo4j_counts_enabled</td>
</tr>
<tr>
<td>metrics.neo4j.data.counts.enabled</td>
<td>NEO4J_metrics_neo4j_data_counts_enabled</td>
</tr>
<tr>
<td>metrics.neo4j.database_operation_count.enabled</td>
<td>NEO4J_metrics_neo4j_database__operation__count_enabled</td>
</tr>
<tr>
<td>metrics.neo4j.logs.enabled</td>
<td>NEO4J_metrics_neo4j_logs_enabled</td>
</tr>
<tr>
<td>metrics.neo4j.pagecache.enabled</td>
<td>NEO4J_metrics_neo4j_pagecache_enabled</td>
</tr>
<tr>
<td>metrics.neo4j.pools.enabled</td>
<td>NEO4J_metrics_neo4j_pools_enabled</td>
</tr>
<tr>
<td>metrics.neo4j.server.enabled</td>
<td>NEO4J_metrics_neo4j_server_enabled</td>
</tr>
<tr>
<td>metrics.neo4j.size.enabled</td>
<td>NEO4J_metrics_neo4j_size_enabled</td>
</tr>
<tr>
<td>metrics.neo4j.tx.enabled</td>
<td>NEO4J_metrics_neo4j_tx_enabled</td>
</tr>
<tr>
<td>metrics.prefix</td>
<td>NEO4J_metrics_prefix</td>
</tr>
<tr>
<td>metrics.prometheus.enabled</td>
<td>NEO4J_metrics_prometheus_enabled</td>
</tr>
<tr>
<td>metrics.prometheus.endpoint</td>
<td>NEO4J_metrics_prometheus_endpoint</td>
</tr>
</tbody>
</table>
Chapter 5. Kubernetes

This chapter describes how to install and operate Neo4j (standalone or cluster) on Kubernetes.

This is the recommended way to run Neo4j on Kubernetes. The Neo4j Helm Charts replace the Labs Helm Charts project at https://neo4j.com/labs. For more information on how to move from the Labs Helm Charts to the Neo4j Helm Charts, see

This chapter describes the following:

- **Introduction** — Introduction to running Neo4j on a Kubernetes cluster using Neo4j Helm Charts.
- **Configure the Neo4j Helm Chart repository** — Configure the Neo4j Helm Chart repository and check for the available charts.
- **Quickstart: Deploy a standalone instance** — Deploy a Neo4j standalone instance to a cloud (GKE, AWS, AKS) or a local (via Docker Desktop for macOS) Kubernetes cluster.
- **Quickstart: Deploy a cluster** — Deploy a Neo4j cluster to a cloud (GKE, AWS, AKS) Kubernetes cluster.
- **Configure a Neo4j deployment** — Configure a Neo4j deployment using a customized values.yaml file.
- **Persistent volumes** — Use persistent volumes with the Neo4j Helm Charts and what types Neo4j supports.
- **Access a Neo4j DBMS** — Access a Neo4j DBMS running on Kubernetes.
- **Access a Neo4j cluster** — Access a Neo4j cluster running on Kubernetes.
- **Import data** — Import data into a Neo4j database.
- **Monitoring** — Monitor a Neo4j deployment running on Kubernetes.
- **Operations** — Maintain a Neo4j deployment running on Kubernetes.
- **Troubleshooting** — Diagnose and troubleshoot a Neo4j deployment running on Kubernetes.

5.1. Introduction

Introduction to running Neo4j on a Kubernetes cluster using Neo4j Helm Charts.

Neo4j supports both a standalone and a cluster deployment of Neo4j on Kubernetes using Neo4j Helm Charts.

Helm (https://helm.sh/) is a “package manager for Kubernetes”. It usually runs on a machine outside of Kubernetes and creates resources in Kubernetes by calling the Kubernetes API. Helm installs and manages applications on Kubernetes using Helm Charts, which are distributed via Helm Chart Repositories.
5.1.1. The Neo4j Helm Chart repository

The Neo4j Helm Chart repository contains helm charts for Neo4j standalone server (neo4j/neo4j-standalone), for both core (neo4j/neo4j-core) and read replica (neo4j/neo4j-read-replica) components of cluster installations, and support charts to simplify configuration and operations. For more details on how to configure the Neo4j Helm Chart repository, see Configure the Neo4j Helm Chart repository. The source code of Neo4j Helm charts is licensed under Apache License 2.0.

5.1.2. Using the Neo4j Helm Chart repository

When using the Neo4j Helm Charts, the user is responsible for defining values.yaml files. The YAML files specify what the users want to achieve with the Helm Charts and the Neo4j configuration. There is no neo4j.conf file in this setup.

The users then run helm install selecting the chart to install and passing in the values.yaml file to customize the behavior. The Helm Charts create Kubernetes entities, which in some cases also spawn outside the resources in the cloud environment where they are run (e.g., cloud load balancers).

For more information about the Helm Charts and the Kubernetes and Cloud resources they instantiate when installed, see Neo4j Helm Charts for standalone server deployment and Neo4j Helm Charts for cluster deployments.

5.2. Configure the Neo4j Helm Chart repository

This section describes how to configure the Neo4j Helm Chart repository and check for the available charts.

To deploy a Neo4j DBMS or cluster on Kubernetes, you have to configure the Neo4j Helm Chart repository.

5.2.1. Prerequisites


5.2.2. Configure the Neo4j Helm Chart repository

1. Add the Neo4j Helm Chart repository.

   ```
   helm repo add neo4j https://helm.neo4j.com/neo4j
   ```

2. Update the repository:

   ```
   helm repo update
   ```
5.2.3. Check for the available Neo4j Helm Charts

```bash
helm search repo neo4j/
```

An example result

<table>
<thead>
<tr>
<th>NAME</th>
<th>CHART VERSION</th>
<th>APP VERSION</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>neo4j/neo4j-cluster-core</td>
<td>4.4.0</td>
<td>4.4.0</td>
<td>Neo4j is the world’s leading graph database</td>
</tr>
<tr>
<td>neo4j/neo4j-cluster-headless-service</td>
<td>4.4.0</td>
<td></td>
<td>Neo4j is the world’s leading graph database</td>
</tr>
<tr>
<td>neo4j/neo4j-cluster-loadbalancer</td>
<td>4.4.0</td>
<td></td>
<td>Neo4j is the world’s leading graph database</td>
</tr>
<tr>
<td>neo4j/neo4j-cluster-read-replica</td>
<td>4.4.0</td>
<td>4.4.0</td>
<td>Neo4j is the world’s leading graph database</td>
</tr>
<tr>
<td>neo4j/neo4j-docker-desktop-pv</td>
<td>4.4.0</td>
<td></td>
<td>Sets up persistent disks suitable for simple de...</td>
</tr>
<tr>
<td>neo4j/neo4j-gcloud-pv</td>
<td>4.4.0</td>
<td></td>
<td>Sets up persistent disks suitable for simple de...</td>
</tr>
<tr>
<td>neo4j/neo4j-standalone</td>
<td>4.4.0</td>
<td>4.4.0</td>
<td>Neo4j is the world’s leading graph database</td>
</tr>
</tbody>
</table>

If you want to see all the versions available, use the option `--versions`.

The utility Helm Charts neo4j/neo4j-docker-desktop-pv and neo4j/neo4j-gcloud-pv can be used as an alternative way of creating persistent volumes in those environments.

5.3. Quickstart: Deploy a standalone instance

This quickstart guide walks through the basics of deploying a Neo4j standalone instance to a cloud or a local Kubernetes cluster using the Neo4j Helm Charts.

The quickstart for deploying a Neo4j standalone server contains the following:

- **Neo4j Helm Charts for standalone server deployments** — A schematic representation of how to use the Neo4j Helm Charts for deploying a standalone server.
- **Prerequisites** — Set up your environment for deploying a Neo4j standalone instance on Kubernetes.
- **Create a persistent volume** — Create a persistent volume for the Neo4j instance.
- **Create a Helm deployment values.yaml file** — Create a Helm deployment values.yaml file with all Neo4j configurations.
- **Install a Neo4j standalone instance** — Install a Neo4j standalone instance using the deployment values.yaml file and the neo4j/neo4j-standalone Helm Chart.
- **Verify the installation** — Verify the Neo4j installation.
- **Uninstall Neo4j and clean up the created resources** — Uninstall Neo4j and clean up the created resources.

5.3.1. Neo4j Helm Charts for standalone server deployments

In the standalone server setup, the user is responsible for defining a single YAML file, containing all the
configurations for the Neo4j standalone instance, and for running the `helm install my-neo4j-release neo4j/neo4j-standalone -f values.yaml` command to deploy the Neo4j DBMS. Then, the Neo4j Helm Chart creates Kubernetes entities needed for running and accessing Neo4j.

The following diagram is a schematic representation of the Helm Chart and the Kubernetes and Cloud resources it instantiates when installed:

**Neo4j standalone server setup**

---

### 5.3.2. Prerequisites

Before you can deploy a Neo4j standalone instance on Kubernetes, you need to:

#### General prerequisites

- Configure the Neo4j Helm Chart repository.
- Obtain a valid license if you want to install Neo4j Enterprise Edition. The Neo4j Community Edition (default for the standalone chart) does not require a license. For more information, see [https://neo4j.com/licensing/](https://neo4j.com/licensing/) or write to licensing@neo4j.com.
- Install the Kubernetes client command-line tool `kubectl` ([https://kubernetes.io/docs/tasks/tools/](https://kubernetes.io/docs/tasks/tools/)).
- Set up a Kubernetes cluster with sufficient CPU and memory for your Neo4j deployment.

This guide works with minimum CPU and memory allocated per Neo4j instance. However, the Neo4j system requirements largely depend on the use of the software. Therefore, for running Neo4j in development or production environments, please refer to **System requirements**.

If you do not have a Kubernetes cluster, you can configure a single-node one as per your environment, see the next section **Environment-specific prerequisites**.
Environment-specific prerequisites

Select the tab as per your Kubernetes environment and complete all prerequisites on it.
1. Install the `gcloud` command-line interface (CLI) ([https://cloud.google.com/sdk/docs/install](https://cloud.google.com/sdk/docs/install)).

2. All the shell commands in this guide assume that the GCP Project, compute zone, and region to use have been set using the `CLOUDSDK_CORE_PROJECT`, `CLOUDSDK_COMPUTE_ZONE`, and `CLOUDSDK_COMPUTE_REGION` environment variables, for example:

   ```
   export CLOUDSDK_CORE_PROJECT="my-neo4j-project"
   export CLOUDSDK_COMPUTE_ZONE="europe-west2-a"
   export CLOUDSDK_COMPUTE_REGION="europe-west2"
   ```

3. If you do not have a Google Kubernetes Engine (GKE) cluster, you can create a single-node one using:

   ```
gcloud container clusters create my-neo4j-gke-cluster --num-nodes=1 --machine-type "e2-standard-2" --release-channel "stable"
```

   `e2-standard-2` is the minimum instance type required for running the examples of this startup guide on GKE.

4. Configure `kubectl` to use your GKE cluster using:

   ```
gcloud container clusters get-credentials my-neo4j-gke-cluster
```

   Fetching cluster endpoint and auth data.
   kubeconfig entry generated for my-neo4j-gke-cluster.
1. Install the **aws** command-line interface (CLI) ([https://docs.aws.amazon.com/cli/latest/userguide/install-cliv2.html](https://docs.aws.amazon.com/cli/latest/userguide/install-cliv2.html)). Make sure you complete the AWS configuration step ([https://docs.aws.amazon.com/cli/latest/userguide/getting-started-quickstart.html](https://docs.aws.amazon.com/cli/latest/userguide/getting-started-quickstart.html)).

2. Install the **eksctl** command-line interface (CLI) ([https://docs.aws.amazon.com/eks/latest/userguide/getting-started-eksctl.html](https://docs.aws.amazon.com/eks/latest/userguide/getting-started-eksctl.html)).

3. All the shell commands in this guide assume that the AWS region and availability zone to use have been set using the `AWS_DEFAULT_REGION` and `AWS_AVAILABILITY_ZONE` environment variables, for example:

   ```bash
   export AWS_DEFAULT_REGION="eu-west-1"
   export AWS_AVAILABILITY_ZONE="eu-west-1c"
   ```

4. If you do not have an AWS Elastic Kubernetes Service (EKS) cluster, you can create a single-node one using the following command:

   ```bash
   eksctl create cluster --name "my-neo4j-eks-cluster" --region "$(AWS_DEFAULT_REGION)" --nodegroup-name "neo4j-nodes" --node-zones "$(AWS_AVAILABILITY_ZONE)" --node-type c4.xlarge --nodes 1 --node-volume-size 10
   ```

5. Configure **kubectl** to use your EKS cluster using:

   ```bash
   aws eks update-kubeconfig --name my-neo4j-eks-cluster
   ```
1. Install the az command-line interface (CLI) ([https://docs.microsoft.com/en-us/cli/azure/install-azure-cli](https://docs.microsoft.com/en-us/cli/azure/install-azure-cli)).

2. Verify that you have a Resource Group with:
   ° An Azure Kubernetes Service (AKS) cluster.
   ° The AKS cluster principal needs to be assigned roles that allow it to manage Microsoft.Compute/disks in the Resource Group.

3. Set the Resource group and the location to use as defaults using:

   ```
   az configure --defaults group=<MyResourceGroup>
   az configure --defaults location=<MyAzureLocation>
   ```

   If you do not have an AKS cluster, follow the steps to create a single-node one.
   1. Create a cluster by running:

   ```
   az aks create --name my-neo4j-aks-cluster --node-count=1
   ```

   2. Configure `kubectl` to use your AKS cluster using:

   ```
   az aks get-credentials --name my-neo4j-aks-cluster --admin
   ```

• Install Docker Desktop for macOS. For more information, see [Docker official documentation](https://docs.microsoft.com/en-us/dotnet/core/).  
• Enable the Docker Desktop Kubernetes engine. For more information, see [Docker official documentation](https://docs.microsoft.com/en-us/dotnet/core/). 
• Verify that you do not have a running instance of Neo4j (e.g., via Neo4j Desktop or Neo4j Browser) to avoid port clashes.

5.3.3. Create a persistent volume

You create a persistent volume to be used for the data volume mount. For more information on persistent volumes and mounts, see [Volume mounts and persistent volumes](https://docs.microsoft.com/en-us/dotnet/core/).
Create a GCP persistent disk using the following command. This is a normal GCP persistent disk and not Kubernetes specific:

```
gcloud compute disks create --size 128Gi --type pd-ssd "my-neo4j-disk"
```

Created [https://www.googleapis.com/compute/v1/projects/my-neo4j-project/zones/europe-west2-a/disks/my-neo4j-disk].

<table>
<thead>
<tr>
<th>NAME</th>
<th>ZONE</th>
<th>SIZE_GB</th>
<th>TYPE</th>
<th>STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>my-neo4j-disk</td>
<td>europe-west2-a</td>
<td>128</td>
<td>pd-ssd</td>
<td>READY</td>
</tr>
</tbody>
</table>

New disks are unformatted. You must format and mount a disk before it can be used. You can find instructions on how to do this at:

https://cloud.google.com/compute/docs/disks/add-persistent-disk#formatting

The message *New disks are unformatted. You must format and mount a disk before it can be used.* should not be a cause for concern, and there is no need to take action to format the disk. If necessary, the disk will be formatted automatically when used in Kubernetes.

Create an AWS EBS disk using the following command. This is a normal AWS EBS disk and not Kubernetes specific:

```
aws ec2 create-volume --availability-zone=${AWS_AVAILABILITY_ZONE} --size=64 --volume-type=gp3 --tag-specifications 'ResourceType=volume,Tags=[{Key=volume,Value=neo4j-k8s}]'
```

Fetch the ID of the disk that was just created.

```
aws ec2 describe-volumes --filters Name=tag:volume,Values=neo4j-k8s --query "Volumes[+].{ID:VolumeId}" --output text
```

vol-0795be227aff63b2a
1. Get the node resource group name by running the following command:

```bash
MC_RG_NAME=$(az aks show --name my-neo4j-aks-cluster --query nodeResourceGroup --output tsv)
```

2. Create an Azure-managed disk for your Neo4j standalone instance using the following commands. This is a normal Azure managed disk and not Kubernetes specific:

```bash
az disk create --name "my-neo4j-disk" --size-gb "64" --sku Premium_LRS --max-shares 1 --resource-group "$MC_RG_NAME"
```

3. Fetch the ID of the disk that was just created, for example:

```bash
az disk show --name "my-neo4j-disk" --query id --resource-group "$MC_RG_NAME"
```

4. Make a note of it.

```bash
*/subscriptions/00000000-0000-0000-0000-000000000000/resourceGroups/MC_myneo4jrg_my-neo4j-aks-cluster_westus2/providers/Microsoft.Compute/disks/my-neo4j-disk*
```

For Docker Desktop for macOS, this Quickstart guide leans on a dynamically provisioned volume. The Neo4j helm command creates a Neo4j StatefulSet that relies on the default Kubernetes StorageClass to dynamically provision a persistent volume. As a consequence, the volume will not survive a Kubernetes restart.

5.3.4. Create a Helm deployment values.yaml file

You create a Helm deployment YAML file containing all the configurations for your Neo4j standalone instance.

Important configuration parameters

`neo4j.resources`

The size of a Neo4j instance is defined by the values of the `neo4j.resources.cpu` and `neo4j.resources.memory` parameters. The minimum is 0.5 CPU and 2GB memory. If invalid or less than the minimum values are provided, Helm will throw an error, for example:

```
Error: template: neo4j-standalone/templates/_helpers.tpl:157:11: executing "neo4j.resources.evaluateCPU" at <fail (printf "Provided cpu value %s is less than minimum. \n %s" ( .Values.neo4j.resources.cpu) (include "neo4j.resources.invalidCPUMessage" .)))>: error calling fail:
Provided cpu value 0.25 is less than minimum.
```

cpu value cannot be less than 0.5 or 500m
For more information, see Configure resource allocation.

**neo4j.password**

The password for the `neo4j` user.

If you do not provide a password, the Neo4j Helm Chart will automatically generate one for you. (Make a note of it.)

| ![Info icon] | You cannot use `neo4j` as the initial password as this is the default password. |

**neo4j.edition** and **neo4j.acceptLicenseAgreement**

By default, the standalone Helm Chart installs Neo4j Community Edition. If you want to install Neo4j Enterprise Edition, set the configuration parameters `edition: "enterprise"` and acknowledge license compliance by setting `neo4j.acceptLicenseAgreement` to "yes".

**volumes.data**

The `volumes.data` parameter maps the `data` volume mount of your Neo4j to the persistent volume that you have created for that instance. See Create a persistent volume.

| ![Info icon] | For details of all Neo4j Helm Chart configuration options, see Configure a Neo4j Helm deployment. |

Create a values.yaml file

Select the tab as per your Kubernetes environment and using the provided example, create a YAML file for your standalone instance.

This guide assumes that the YAML file is named `my-neo4j.values.yaml`. 
neo4j:
  resources:
    cpu: "0.5"
    memory: "2Gi"

# Uncomment to set the initial password
#password: "my-initial-password"

# Uncomment to use enterprise edition
#edition: "enterprise"
#acceptLicenseAgreement: "yes"

volumes:
  data:
    mode: "volume"
  volume:
    gcePersistentDisk:
      pdName: "my-neo4j-disk"

neo4j:
  resources:
    cpu: "0.5"
    memory: "2Gi"

# Uncomment to set the initial password
#password: "my-initial-password"

# Uncomment to use enterprise edition
#edition: "enterprise"
#acceptLicenseAgreement: "yes"

volumes:
  data:
    mode: "volume"
  volume:
    awsElasticBlockStore:
      volumeID: "<volume id>"
      fsType: ext4

neo4j:
  resources:
    cpu: "0.5"
    memory: "2Gi"

# Uncomment to set the initial password
#password: "my-initial-password"

# Uncomment to use enterprise edition
#edition: "enterprise"
#acceptLicenseAgreement: "yes"

volumes:
  data:
    mode: "volume"
  volume:
    azureDisk:
      diskName: "my-neo4j-disk"
      diskURI: "<disk id>"
    kind: Managed
5.3.5. Install a Neo4j standalone instance

Getting everything to work in Kubernetes requires that certain K8s objects have specific names that are referenced elsewhere. Each individual Neo4j instance is a Helm "release" and has a release name. All other names derive from this release name. Release name must consist of lower case alphanumeric characters, - or ., and must start and end with an alphanumeric character. This guide assumes the release name is my-neo4j-release.

1. Install Neo4j using the deployment values.yaml file, created in Create a value.yaml file, and the neo4j/neo4j-standalone Helm Chart:

```bash
ehelm install my-neo4j-release neo4j/neo4j-standalone -f my-neo4j.values.yaml
```

Example output

```
NAME: my-neo4j-release
NAMESPACE: default
STATUS: deployed
REVISION: 1
TEST SUITE: None
NOTES:
Thank you for installing neo4j-standalone.
Your release "my-neo4j-release" has been installed.
To view the progress of the rollout try:
$ kubectl rollout status --watch --timeout=600s statefulset/my-neo4j-release

The neo4j user's password has been set to "bO7YDTVOgs7CS1".
Once rollout is complete you can log in to Neo4j at "neo4j://my-neo4j-release.default.svc.cluster.local:7687". Try:

```
$ kubectl run --rm -it --image "neo4j:4.4.10" cypher-shell \
-- cypher-shell -a "neo4j://my-neo4j-release.default.svc.cluster.local:7687" -u neo4j -p "bO7YDTVOgs7CS1"
```
Graphs are everywhere!
```
2. Run the `kubectl rollout` command provided in the output of `helm install` to watch the Neo4j's rollout until it is complete.

```
kubectl rollout status --watch --timeout=600s statefulset/my-neo4j-release
```

Since you have not passed a password for the `neo4j` user, the Neo4j Helm Chart has set an automatically generated one. You can find it in the Helm install output. Please make a note of it.

5.3.6. Verify the installation
1. Check that the **statefulset** is OK.

   kubectl get statefulsets

<table>
<thead>
<tr>
<th>NAME</th>
<th>READY</th>
<th>AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>my-neo4j-release</td>
<td>1/1</td>
<td>2m11s</td>
</tr>
</tbody>
</table>

2. Check that the pod is **Running**:

   kubectl get pods

<table>
<thead>
<tr>
<th>NAME</th>
<th>READY</th>
<th>STATUS</th>
<th>RESTARTS</th>
<th>AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>my-neo4j-release-0</td>
<td>1/1</td>
<td>Running</td>
<td>0</td>
<td>16m</td>
</tr>
</tbody>
</table>

3. Check that the pod logs look OK:

   kubectl exec my-neo4j-release-0 -- tail -n50 /logs/neo4j.log

   ```
   2021-07-28 12:45:50.267+0000 INFO  Command expansion is explicitly enabled for configuration
   2021-07-28 12:45:50.280+0000 INFO  Starting...
   2021-07-28 12:45:55.680+0000 INFO  ======== Neo4j 4.4.10 ========
   2021-07-28 12:46:00.006+0000 INFO  Bolt enabled on [0:0:0:0:0:0:0:0%0]:7687.
   2021-07-28 12:46:02.478+0000 INFO  Started.
   ```

4. Check that the services look OK:

   kubectl get services

<table>
<thead>
<tr>
<th>NAME</th>
<th>TYPE</th>
<th>CLUSTER-IP</th>
<th>EXTERNAL-IP</th>
<th>PORT(S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>kubernetes</td>
<td>ClusterIP</td>
<td>10.112.0.1</td>
<td>&lt;none&gt;</td>
<td>443/TCP</td>
</tr>
<tr>
<td>my-neo4j-release</td>
<td>ClusterIP</td>
<td>10.112.10.159</td>
<td>&lt;none&gt;</td>
<td>7687/TCP,7474/TCP,7473/TCP</td>
</tr>
<tr>
<td>my-neo4j-release-admin</td>
<td>ClusterIP</td>
<td>10.112.4.73</td>
<td>&lt;none&gt;</td>
<td>6362/TCP,7687/TCP,7474/TCP,7473/TCP</td>
</tr>
</tbody>
</table>

5. In a web browser, open the Neo4j Browser at [http://\<EXTERNAL-IP\>:7474/browser](http://\<EXTERNAL-IP\>:7474/browser).

6. Use the automatically-generated password (as printed in the output of the `helm install` command) or the one you have configured in the `my-neo4j.values.yaml` file.
1. Check that statefulset is OK.

```
kubectl get statefulsets
```

<table>
<thead>
<tr>
<th>NAME</th>
<th>READY</th>
<th>AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>my-neo4j-release</td>
<td>1/1</td>
<td>5m11s</td>
</tr>
</tbody>
</table>

2. Check that the PVC is OK (the STATUS must be Bound):

```
kubectl get pvc
```

<table>
<thead>
<tr>
<th>NAME</th>
<th>STATUS</th>
<th>VOLUME</th>
<th>CAPACITY</th>
<th>ACCESS MODES</th>
</tr>
</thead>
<tbody>
<tr>
<td>data-my-neo4j-release-0</td>
<td>Bound</td>
<td>my-neo4j-release-pv</td>
<td>10Gi</td>
<td>RWO</td>
</tr>
</tbody>
</table>

3. Check that the pod is READY:

```
kubectl get pods
```

<table>
<thead>
<tr>
<th>NAME</th>
<th>READY</th>
<th>STATUS</th>
<th>RESTARTS</th>
<th>AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>my-neo4j-release-0</td>
<td>1/1</td>
<td>Running</td>
<td>0</td>
<td>5m53s</td>
</tr>
</tbody>
</table>

4. Check that the pod logs look OK:

```
kubectl exec my-neo4j-release-0 -- tail -n50 /logs/neo4j.log
```

```
Changed password for user 'neo4j'.
Directories in use:
  home: /var/lib/neo4j
  config: /config/
  logs: /data/logs
  plugins: /var/lib/neo4j/plugins
  import: /var/lib/neo4j/import
  data: /var/lib/neo4j/data
  certificates: /var/lib/neo4j/certificates
  run: /var/lib/neo4j/run
Starting Neo4j.
2021-06-02 17:38:27.791+0000 INFO Command expansion is explicitly enabled for configuration
2021-06-02 17:38:27.819+0000 INFO Starting...
2021-06-02 17:38:31.195+0000 INFO Neo4j 4.4.10 ========
2021-06-02 17:38:34.168+0000 INFO Initializing system graph model for component 'security-users' with version -1 and status UNINITIALIZED
2021-06-02 17:38:34.188+0000 INFO Setting up initial user from 'auth.ini' file: neo4j
2021-06-02 17:38:34.205+0000 INFO Creating new user 'neo4j' (passwordChangeRequired=false, suspended=false)
2021-06-02 17:38:34.214+0000 INFO Setting version for 'security-users' to 2
2021-06-02 17:38:34.223+0000 INFO After initialization of system graph model component 'security-users' have version 2 and status CURRENT
2021-06-02 17:38:34.561+0000 INFO Bolt enabled on 0.0.0.0:7687.
```

5. Check that the services look OK:
kubect1 get services

<table>
<thead>
<tr>
<th>NAME</th>
<th>TYPE</th>
<th>CLUSTER-IP</th>
<th>EXTERNAL-IP</th>
<th>PORT(S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>kubernetes</td>
<td>ClusterIP</td>
<td>10.96.0.1</td>
<td>&lt;none&gt;</td>
<td>443/TCP</td>
</tr>
<tr>
<td>my-neo4j-release</td>
<td>ClusterIP</td>
<td>10.103.103.142</td>
<td>&lt;none&gt;</td>
<td>7687/TCP,7474/TCP,7473/TCP</td>
</tr>
<tr>
<td>my-neo4j-release-admin</td>
<td>ClusterIP</td>
<td>10.99.11.122</td>
<td>&lt;none&gt;</td>
<td>6362/TCP,7687/TCP,7474/TCP,7473/TCP</td>
</tr>
</tbody>
</table>

6. Use port forwarding to get access to the browser:

`kubectl port-forward svc/my-neo4j-release tcp-bolt tcp-http tcp-https`


8. Use the automatically-generated password (as printed in the output of the helm install command) or the one you have set up with the helm install command.

5.3.7. Uninstall Neo4j and clean up the created resources

Uninstall Neo4j Helm deployment

Uninstall the Neo4j Helm deployment.

`helm uninstall my-neo4j-release`

release "my-neo4j-release" uninstalled

Fully remove all the data and resources

Uninstalling the Helm release does not remove the created resources and data. Therefore, after uninstalling the helm deployment, you also have to delete all the data and resources.
1. Display all data associated with the GCP persistent disk by running:

```
gcloud compute disks describe "my-neo4j-disk"
```

```
creationTimestamp: '2021-07-28T04:54:59.385-07:00'
id: '756334900703722364'
kind: compute#disk
labelFingerprint: 42WmSpB8rSM=
lastAttachTimestamp: '2021-07-28T05:45:03.723-07:00'
lastDetachTimestamp: '2021-07-28T06:00:18.793-07:00'
name: my-neo4j-disk
physicalBlockSizeBytes: '4096'
selfLink: https://www.googleapis.com/compute/v1/projects/my-neo4j-project/zones/europe-west2-a/disks/my-neo4j-disk
sizeGb: '128'
type: https://www.googleapis.com/compute/v1/projects/my-neo4j-project/zones/europe-west2-a/diskTypes/pd-ssd
zone: https://www.googleapis.com/compute/v1/projects/my-neo4j-project/zones/europe-west2-a
```

If you re-create Neo4j with the same settings, it will pick up the same disk again, and all the data will still be on it.

Even if the GKE cluster is deleted, the persistent disk with the Neo4j data will still exist.

2. Delete the GCP persistent disk:

```
gcloud compute disks delete my-neo4j-disk
```

The following disks will be deleted:

```
- [my-neo4j-disk] in [europe-west2-a]
```

Do you want to continue (Y/n)?  y

Deleted [https://www.googleapis.com/compute/v1/projects/my-neo4j-project/zones/europe-west2-a/disks/my-neo4j-disk].

If you want to delete the entire GKE Kubernetes cluster, run:

```
gcloud container clusters delete my-neo4j-gke-cluster
```
1. Display all data associated with the AWS EBS disk by running:

```bash
aws ec2 describe-volumes --filters Name=tag:volume,Values=neo4j-k8s --query "Volumes[*].{ID:VolumeId}" --output text
```

If you re-create Neo4j with the same settings, it will pick up the same disk again, and all the data will still be on it.

Even if you delete the EKS cluster, the EBS disk with the Neo4j data will still exist. Note that the disk will be deleted if its Resource Group is deleted.

2. Delete the AWS EBS disk using the volume ID:

```bash
aws ec2 delete-volume --volume-id "<volume id>"
```

If you are sure that you want to delete the entire EKS Kubernetes cluster, run:

```bash
eksctl delete cluster my-neo4j-eks-cluster
```

1. Display all data associated with the Azure managed disk by running:

```bash
az disk show --name "my-neo4j-disk"
```

If you re-create Neo4j with the same settings, it will pick up the same disk again and all the data will still be on it.

Even if you delete the AKS cluster, the managed disk with the Neo4j data will still exist. Note that the disk will be deleted if its Resource Group is deleted.

2. Delete the Azure managed disk:

```bash
az disks delete --name "my-neo4j-disk"
```

If you are sure that you want to delete the entire AKS Kubernetes cluster, run:

```bash
az aks delete --name my-neo4j-aks-cluster
```
1. Check the name of the PersistentVolumeClaim (pvc):

```
kubectl get pvc
```

<table>
<thead>
<tr>
<th>NAME</th>
<th>STATUS</th>
<th>VOLUME</th>
<th>CAPACITY</th>
<th>ACCESS MODES</th>
</tr>
</thead>
<tbody>
<tr>
<td>data-my-neo4j-release-0</td>
<td>Bound</td>
<td>my-neo4j-release-pv</td>
<td>1Ti</td>
<td>RWO</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>manual</td>
</tr>
<tr>
<td>43h</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If you re-create Neo4j with the same settings, it will pick up the PVC again, and all the data is still on it. If you use manually provisioned volumes and delete the PersistentVolumeClaim and the PersistentVolume in Kubernetes, the hostPath directory with the Neo4j data will still exist.

When you use dynamically provisioned volumes and delete the PersistentVolume, the underlying data may or may not be removed, depending on the Docker Desktop version and configuration.

2. To fully remove all the data and resources, delete the PersistentVolumeClaim in Kubernetes. The dynamically provisioned volumes are automatically removed when the PersistentVolumeClaim is deleted.

5.4. Quickstart: Deploy a cluster **Enterprise edition**

This quickstart guide walks through the basics of deploying a Neo4j cluster to a cloud or a local Kubernetes cluster using the Neo4j Helm Charts.

The quickstart for deploying a Neo4j cluster contains the following:

| This guide shows how to deploy a cluster with three core members and one read replica. |

- **Neo4j Helm Charts for cluster deployments** — A schematic representation of how to use the Neo4j Helm Charts for deploying a cluster.
- **Prerequisites** — Set up your environment for deploying a Neo4j cluster on Kubernetes.
- **Create a persistent volume for each cluster member** — Create a persistent volume for each Neo4j cluster member to be used for its data volume mount.
- **Create Helm deployment values files** — Create a Helm deployment values.yaml file for each Neo4j cluster member.
- **Install Neo4j core members** — Install each of your Neo4j core members using its deployment YAML file and the neo4j/neo4j-cluster-core Helm Chart.
- **Install Neo4j read replicas** — Install your Neo4j read replica using its deployment YAML file and the neo4j/neo4j-cluster-read-replica Helm Chart.
- **Verify cluster formation** — Verify that the Neo4j core members and read replica have formed a cluster.
- **Access the Neo4j cluster from inside Kubernetes** — Access the Neo4j cluster from inside Kubernetes using a specific core or the headless service.
- **Access the Neo4j cluster from outside Kubernetes** — Access the Neo4j cluster from outside Kubernetes using a load balancer.
- **Uninstall the Neo4j cluster and clean up the created resources** — Uninstall all Neo4j Helm deployments and clean up the created resources.

### 5.4.1. Neo4j Helm Charts for cluster deployments

Neo4j Helm Charts for cluster deployments support more configuration options than for a standalone server. To offer the flexibility required to cluster users, the Helm Charts for clusters take a modular approach: the typical cluster deployment requires several Helm Charts installation. For example, a cluster with three core nodes requires installing the `neo4j-cluster-core` chart three times. By separating the charts up, users can create a different topology of Neo4j and a different topology in their Kubernetes clusters to suit their needs.

The following diagram is a schematic representation of the Helm Charts involved and the Kubernetes and Cloud resources they instantiate when installed:

**Neo4j cluster setup**

![Diagram of Neo4j cluster setup](image)

The diagram shows an example of a Neo4j cluster setup with three cores and one read replica. The Kubernetes setup includes a headless service for accessing the cluster from inside Kubernetes and a load-balancer service for accessing the cluster from outside Kubernetes. Each component is installed using its own Helm Chart.

### 5.4.2. Prerequisites **Enterprise edition**

Before you can deploy a Neo4j cluster on Kubernetes, you need to:
General prerequisites

- Configure the Neo4j Helm Chart repository.
- Obtain a valid license for Neo4j Enterprise Edition. For more information, see https://neo4j.com/licensing/ or write to licensing@neo4j.com.
- Install the Kubernetes client command-line tool kubectl (https://kubernetes.io/docs/tasks/tools/).
- Set up a Kubernetes cluster with sufficient CPU and memory for your Neo4j deployment.

This guide works with minimum CPU and memory allocated per Neo4j instance. However, the Neo4j system requirements largely depend on the use of the software. Therefore, for running Neo4j in development or production environments, please refer to System requirements.

If you do not have a Kubernetes cluster, you can configure a multi-node one as per your environment, see the next section Environment-specific prerequisites.

Environment-specific prerequisites

Select the tab as per your Kubernetes environment and complete all prerequisites on it.
1. Install the `gcloud` command-line interface (CLI) ([https://cloud.google.com/sdk/docs/install](https://cloud.google.com/sdk/docs/install)).

2. All the shell commands in this guide assume that the GCP Project, compute zone, and region to use, have been set using the `CLOUDSDK_CORE_PROJECT`, `CLOUDSDK_COMPUTE_ZONE`, and `CLOUDSDK_COMPUTE_REGION` environment variables, for example:

   ```
   export CLOUDSDK_CORE_PROJECT="neo4j-helm"
   export CLOUDSDK_COMPUTE_ZONE="europe-west6-c"
   export CLOUDSDK_COMPUTE_REGION="europe-west6"
   export CLOUDSDK_CONTAINER_CLUSTER="my-neo4j-gke-cluster"
   ```

3. If you do not have a Google Kubernetes Engine (GKE) cluster, you can create a multi-node cluster (one node per Neo4j instance) using:

   ```
gcloud container clusters create my-neo4j-gke-cluster --num-nodes=<num> --machine-type "e2-standard-2"
   ```

   `e2-standard-2` is the minimum instance type required for running the examples of this startup guide on GKE.

4. Configure `kubectl` to use your GKE cluster using:

   ```
gcloud container clusters get-credentials my-neo4j-gke-cluster
   ```

   Fetching cluster endpoint and auth data.
   kubeconfig entry generated for my-neo4j-gke-cluster.
1. Install the **aws** command-line interface (CLI) ([https://docs.aws.amazon.com/cli/latest/userguide/install-cliv2.html](https://docs.aws.amazon.com/cli/latest/userguide/install-cliv2.html)). Make sure you complete the AWS configuration step ([https://docs.aws.amazon.com/cli/latest/userguide/getting-started-quickstart.html](https://docs.aws.amazon.com/cli/latest/userguide/getting-started-quickstart.html)).

2. Install the **eksctl** command-line interface (CLI) ([https://docs.aws.amazon.com/eks/latest/userguide/getting-started-eksctl.html](https://docs.aws.amazon.com/eks/latest/userguide/getting-started-eksctl.html)).

3. All the shell commands in this guide assume that the AWS region and availability zone to use, have been set using the `AWS_DEFAULT_REGION` and `AWS_AVAILABILITY_ZONE` environment variables, for example:

```
export AWS_DEFAULT_REGION="eu-west-1"
export AWS_AVAILABILITY_ZONE="eu-west-1c"
```

4. If you do not have an AWS Elastic Kubernetes Service (EKS) cluster, you can create a multi-node cluster (one node per Neo4j instance) using the following command:

```
This command requires that you have a public key named `id_rsa.pub`. If you do not have one, you can generate it by running:

```
ssh-keygen -t rsa -C "your-name@example.com"
```

```
eksctl create cluster --name "my-neo4j-eks-cluster" --region "$AWS_DEFAULT_REGION"
--nodegroup-name "neo4j-nodes" --node-zones "$AWS_AVAILABILITY_ZONE" --nodes-min 1 --nodes-max 4 --node-type c4.xlarge --nodes 4 --node-volume-size 10 --ssh-access --with-oidc
```

5. Configure **kubectl** to use your EKS cluster using:

```
aws eks update-kubeconfig --name my-neo4j-eks-cluster
```

2. Verify that you have a Resource Group with:
   - An Azure Kubernetes Service (AKS) cluster.
   - The AKS cluster principal needs to be assigned roles that allow it to manage Microsoft.Compute/disks in the Resource Group.

3. Set the Resource group and the location to use as defaults using:
   ```
   az configure --defaults group=<MyResourceGroup>
   az configure --defaults location=<MyAzureLocation>
   ```

   If you do not have an AKS cluster, follow the steps to create a multi-node cluster (one node per Neo4j instance).
   1. Create a cluster by running:
      ```
      az aks create --name my-neo4j-aks-cluster --node-count=<num>
      ```
   2. Configure kubectl to use your AKS cluster using:
      ```
      az aks get-credentials --name my-neo4j-aks-cluster --admin
      ```

5.4.3. Create a persistent volume for each cluster member

You create a persistent disk for each cluster member to be used for its data volume mount. For more information on persistent volumes and mounts, see Volume mounts and persistent volumes. In this guide, you attach cloud disks/volumes, e.g., gcePersistentDisk, azureDisk, and awsElasticBlockStore without creating Kubernetes PersistentVolumes.

The following examples use core-disk-1, core-disk-2, core-disk-3, and rr-disk-1 as names for the persistent disks.
Create a GCP persistent disk for each cluster member (both cores and read replicas) by executing the following commands. This is a normal GCP persistent disk and not Kubernetes specific:

```
gcloud compute disks create --size 128Gi --type pd-ssd "core-disk-1"
gcloud compute disks create --size 128Gi --type pd-ssd "core-disk-2"
gcloud compute disks create --size 128Gi --type pd-ssd "core-disk-3"
gcloud compute disks create --size 128Gi --type pd-ssd "rr-disk-1"
```

Each of the commands should return the name, zone, size, type, and the status of the corresponding disk, for example:

```
Created [https://www.googleapis.com/compute/v1/projects/neo4j-helm/zones/europe-west6-c/disks/core-disk-1].
NAME         ZONE            SIZE_GB  TYPE    STATUS
core-disk-1  europe-west6-c  128      pd-ssd  READY
New disks are unformatted. You must format and mount a disk before it can be used. You can find instructions on how to do this at:
https://cloud.google.com/compute/docs/disks/add-persistent-disk#formatting
```

```
Created [https://www.googleapis.com/compute/v1/projects/neo4j-helm/zones/europe-west6-c/disks/core-disk-2].
NAME         ZONE            SIZE_GB  TYPE    STATUS
core-disk-2  europe-west6-c  128      pd-ssd  READY
New disks are unformatted. You must format and mount a disk before it can be used. You can find instructions on how to do this at:
https://cloud.google.com/compute/docs/disks/add-persistent-disk#formatting
```

```
Created [https://www.googleapis.com/compute/v1/projects/neo4j-helm/zones/europe-west6-c/disks/core-disk-3].
NAME         ZONE            SIZE_GB  TYPE    STATUS
core-disk-3  europe-west6-c  128      pd-ssd  READY
New disks are unformatted. You must format and mount a disk before it can be used. You can find instructions on how to do this at:
https://cloud.google.com/compute/docs/disks/add-persistent-disk#formatting
```

```
Created [https://www.googleapis.com/compute/v1/projects/neo4j-helm/zones/europe-west6-c/disks/rr-disk-1].
NAME       ZONE            SIZE_GB  TYPE    STATUS
rr-disk-1  europe-west6-c  128      pd-ssd  READY
New disks are unformatted. You must format and mount a disk before it can be used. You can find instructions on how to do this at:
https://cloud.google.com/compute/docs/disks/add-persistent-disk#formatting
```

The message `New disks are unformatted. You must format and mount a disk before it can be used.` should not be a cause for concern, and there is no need to take action to format the disk. If necessary, the disk will be formatted automatically when used in Kubernetes.
1. Create an AWS EBS disk for each cluster member (both cores and read replicas) using the following commands. This is a normal AWS EBS disk and not Kubernetes specific:

```bash
aws ec2 create-volume --availability-zone=${AWS_AVAILABILITY_ZONE} --size=64 --volume-type=gp3 --tag-specifications 'ResourceType=volume,Tags=[{Key=volume,Value=core-disk-1}]
aws ec2 create-volume --availability-zone=${AWS_AVAILABILITY_ZONE} --size=64 --volume-type=gp3 --tag-specifications 'ResourceType=volume,Tags=[{Key=volume,Value=core-disk-2}]
aws ec2 create-volume --availability-zone=${AWS_AVAILABILITY_ZONE} --size=64 --volume-type=gp3 --tag-specifications 'ResourceType=volume,Tags=[{Key=volume,Value=core-disk-3}]
aws ec2 create-volume --availability-zone=${AWS_AVAILABILITY_ZONE} --size=64 --volume-type=gp3 --tag-specifications 'ResourceType=volume,Tags=[{Key=volume,Value=rr-disk-1}]
```

2. Fetch the IDs of the disks that were just created, for example:

```bash
aws ec2 describe-volumes --filters Name=tag:volume,Values=core-disk-1,core-disk-2,core-disk-3,rr-disk-1 --query "Volumes[*].{ID:VolumeId}" --output text
```

3. Make a note of all IDs.

```
vol-081665be3681e384c
vol-000ce1338f430d173
vol-03b099df30ca4f0d3
vol-04f5dffe2a2d7e092
```
1. Get the node resource group name by running the following command:

```
MC_RG_NAME="$(az aks show --name my-neo4j-aks-cluster --query nodeResourceGroup --output tsv)"
```

2. Create an Azure-managed disk for each cluster member (both cores and read replicas) using the following commands. This is a normal Azure managed disk and not Kubernetes specific:

```
az disk create --name "core-disk-1" --size-gb "64" --sku Premium_LRS --max-shares 1
--resource-group "${MC_RG_NAME}"
az disk create --name "core-disk-2" --size-gb "64" --sku Premium_LRS --max-shares 1
--resource-group "${MC_RG_NAME}"
az disk create --name "core-disk-3" --size-gb "64" --sku Premium_LRS --max-shares 1
--resource-group "${MC_RG_NAME}"
az disk create --name "rr-disk-1" --size-gb "64" --sku Premium_LRS --max-shares 1
--resource-group "${MC_RG_NAME}"
```

3. Fetch the IDs of the disks that were just created, for example:

```
az disk show --name "core-disk-1" --query id --resource-group "${MC_RG_NAME}"
```

4. Make a note of all IDs.

```
~/subscriptions/00000000-0000-0000-0000-000000000000/resourceGroups/MC_myneo4jrg_my-neo4j-aks-cluster_westus2/providers/Microsoft.Compute/disks/core-disk-1
```

5.4.4. Create Helm deployment values files

You create a Helm deployment YAML file for each Neo4j cluster member with all the configuration settings and the disk you have created for each particular member in Create a persistent volume for each cluster member.

Important configuration parameters

**neo4j.name**

All Neo4j cluster members (cores or read-replicas) are linked together by the value of the parameter **neo4j.name**. When installed via the Neo4j Helm Charts, they will join the cluster identified by **neo4j.name**. **neo4j.name** is different from the Helm release name, which is used to reference a specific cluster member elsewhere in Kubernetes.

All other names and labels of K8s objects created by the helm charts derive from both **neo4j.name** and release name. If no name is specified, the cluster gets the default name **neo4j-cluster**.

**neo4j.resources**

The size of a Neo4j cluster member is defined by the values of the **neo4j.resources.cpu** and **neo4j.resources.memory** parameters. The minimum for a Neo4j instance is 0.5 CPU and 2GB memory. If invalid or less than the minimum values are provided, Helm will throw an error, for example:
Error: template: neo4j-cluster-core/templates/_helpers.tpl:157:11: executing "neo4j.resources.evaluateCPU" at <fail (printf "Provided cpu value %s is less than minimum. \n %s" (.Values.neo4j.resources.cpu) (include "neo4j.resources.invalidCPUMessage" .))>: error calling fail: Provided cpu value 0.25 is less than minimum. cpu value cannot be less than 0.5 or 500m

For more information, see Configure resource allocation.

**neo4j.password**

The password for the neo4j user. The same password must be set on all cluster members. If you do not provide a password, the Neo4j Helm Chart will automatically generate one for you. (Make a note of it.)

You cannot use neo4j as the initial password as this is the default password.

**neo4j.edition and neo4j.acceptLicenseAgreement**

By default, the cluster Helm Charts install Neo4j Enterprise Edition since clusters are not available in Community Edition. This means that you do not have to explicitly set the configuration parameter edition: to "enterprise", as it would be the case if you want to install a standalone server of Neo4j Enterprise Edition. However, you must acknowledge license compliance by setting neo4j.acceptLicenseAgreement to "yes". For more information on how to obtain a valid license for Neo4j Enterprise Edition, see [https://neo4j.com/licensing/](https://neo4j.com/licencing/) or write to licensing@neo4j.com.

**volumes.data**

The volumes.data parameter maps the data volume mount of each cluster member to the persistent volume that you have created for that member. See Create persistent volumes.

For details of all Neo4j Helm Chart configuration options, see Configure a Neo4j Helm deployment.

Create a values.yaml file for each cluster member

Select the tab as per your Kubernetes environment and using the provided example, create a YAML file for each of your cluster members (both cores and the read replica) with all the configuration settings and the disk you have created for that particular member in Create a persistent volume for each cluster member.

This guide assumes that the YAML files are named core-1.values.yaml, core-2.values.yaml, core-3.values.yaml, and rr-1.values.yaml.
5.4.5. Install Neo4j cluster cores

Getting everything to work in Kubernetes requires that certain K8s objects have specific names that are referenced elsewhere. Each Neo4j instance is a Helm “release” and has a release name. Release name must consist of lower case alphanumeric characters, - or ., and must start and end with an alphanumerical character.
The following example installations use `core-1, core-2, core-3` as release names for the core members.

1. Install each core member individually using the deployment `core-<num>.values.yaml` file created in Create Helm deployment values files and the `neo4j/neo4j-cluster-core` Helm Chart.
   
   a. Install `core-1`.
   
   ```
   helm install core-1 neo4j/neo4j-cluster-core -f core-1.values.yaml
   
   Example output
   ```
   ```
   NAME: core-1
   LAST DEPLOYED: Fri Nov  5 14:32:10 2021
   NAMESPACE: default
   STATUS: deployed
   REVISION: 1
   TEST SUITE: None
   NOTES:
   Thank you for installing neo4j-cluster-core.
   Your release "core-1" has been installed .
   The neo4j user's password has been set to "my-password".
   This release creates a single Neo4j Core instance. It will not become ready until it is able to form a working Neo4j cluster by joining other Neo4j Core instances. To create a working cluster requires at least 3 Core instances.
   Once you have a working Neo4j cluster you must install at least one Neo4j Service before you can connect applications to Neo4j. Available Neo4j services are:
   neo4j-headless-service - for connecting applications running inside Kubernetes to Neo4j
   neo4j-loadbalancer - for connecting applications running outside Kubernetes to Neo4j
   Graphs are everywhere!
   ```
   
   b. Install `core-2`.
   
   ```
   helm install core-2 neo4j/neo4j-cluster-core -f core-2.values.yaml
   ```
Example output

NAME: core-2
LAST DEPLOYED: Fri Nov 5 14:36:14 2021
NAMESPACE: default
STATUS: deployed
REVISION: 1
TEST SUITE: None
NOTES:
Thank you for installing neo4j-cluster-core.

Your release "core-2" has been installed.

The neo4j user's password has been set to "my-password".

This release creates a single Neo4j Core instance. It will not become ready until it is able to form a working Neo4j cluster by joining other Neo4j Core instances. To create a working cluster requires at least 3 Core instances.

Once you have a working Neo4j cluster you must install at least one Neo4j Service before you can connect applications to Neo4j. Available Neo4j services are:

- neo4j-headless-service - for connecting applications running inside Kubernetes to Neo4j
- neo4j-loadbalancer - for connecting applications running outside Kubernetes to Neo4j

Graphs are everywhere!

c. Install core-3.

```
helm install core-3 neo4j/neo4j-cluster-core -f core-3.values.yaml
```

Example output

NAME: core-3
LAST DEPLOYED: Fri Nov 5 14:36:32 2021
NAMESPACE: default
STATUS: deployed
REVISION: 1
TEST SUITE: None
NOTES:
Thank you for installing neo4j-cluster-core.

Your release "core-3" has been installed.

The neo4j user's password has been set to "my-password".

This release creates a single Neo4j Core instance. It will not become ready until it is able to form a working Neo4j cluster by joining other Neo4j Core instances. To create a working cluster requires at least 3 Core instances.

Once you have a working Neo4j cluster you must install at least one Neo4j Service before you can connect applications to Neo4j. Available Neo4j services are:

- neo4j-headless-service - for connecting applications running inside Kubernetes to Neo4j
- neo4j-loadbalancer - for connecting applications running outside Kubernetes to Neo4j

Graphs are everywhere!

If you have not passed a password for the neo4j user, the Neo4j Helm Chart has automatically generated one for you. The password is the same for all cluster members.

You can find it in the Helm install outputs. Make a note of it.

2. Verify that the core members have formed a cluster. See the next section Verify the Neo4j cluster formation.
5.4.6. Verify the Neo4j cluster formation

You check the pods and services to verify that the core members have managed to form a cluster.

1. Check that the pods are READY.

   Typically, it takes a minute or two after the pods are running. They become READY after they form a cluster. You can watch pod status changes by adding the \( -w \) option to the \texttt{kubectl} command (\texttt{kubectl get pods \(-w\)}).

   
   ```
   kubectl get pods
   ```

<table>
<thead>
<tr>
<th>NAME</th>
<th>READY</th>
<th>STATUS</th>
<th>RESTARTS</th>
<th>AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>core-1-0</td>
<td>1/1</td>
<td>Running</td>
<td>0</td>
<td>4m51s</td>
</tr>
<tr>
<td>core-2-0</td>
<td>1/1</td>
<td>Running</td>
<td>0</td>
<td>4m25s</td>
</tr>
<tr>
<td>core-3-0</td>
<td>1/1</td>
<td>Running</td>
<td>0</td>
<td>4m7s</td>
</tr>
</tbody>
</table>

2. You can also check the logs of the pods, for example:

   ```
   kubectl exec core-2-0 -- tail /logs/neo4j.log
   ```

   ```
   2021-11-05 16:07:13.798+0000 INFO  Connected to core-2-internals.default.svc.cluster.local/10.48.1.4:7000 [raft version:4.0]
   2021-11-05 16:07:21.147+0000 INFO  Database 'neo4j' is waiting for a total of 3 core members...
   2021-11-05 16:07:31.245+0000 INFO  This instance bootstrapped the 'neo4j' database.
   2021-11-05 16:07:31.657+0000 INFO  Sending metrics to CSV file at /metrics
   2021-11-05 16:07:31.948+0000 INFO  Bolt enabled on 0.0.0.0:7687.
   2021-11-05 16:07:31.954+0000 INFO  Bolt (Routing) enabled on 0.0.0.0:7688.
   2021-11-05 16:07:33.852+0000 INFO  Connected to core-3-internals.default.svc.cluster.local/10.48.2.5:7000 [raft version:4.0]
   2021-11-05 16:07:33.858+0000 INFO  Connected to core-2-internals.default.svc.cluster.local/10.48.1.4:7000 [raft version:4.0]
   2021-11-05 16:07:37.956+0000 INFO  Started.
   ```

3. Check that the services look good:

   ```
   kubectl get services
   ```
<table>
<thead>
<tr>
<th>NAME</th>
<th>TYPE</th>
<th>CLUSTER-IP</th>
<th>EXTERNAL-IP</th>
<th>PORT(S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>core-1</td>
<td>ClusterIP</td>
<td>10.112.0.8</td>
<td>&lt;none&gt;</td>
<td>7687/TCP, 7474/TCP, 7473/TCP</td>
</tr>
<tr>
<td>core-1-admin</td>
<td>ClusterIP</td>
<td>10.112.6.162</td>
<td>&lt;none&gt;</td>
<td>6362/TCP, 7687/TCP, 7474/TCP, 7473/TCP</td>
</tr>
<tr>
<td>core-1-internals</td>
<td>ClusterIP</td>
<td>None</td>
<td>&lt;none&gt;</td>
<td>6362/TCP, 7687/TCP, 7474/TCP, 7473/TCP</td>
</tr>
<tr>
<td>core-2</td>
<td>ClusterIP</td>
<td>10.112.8.77</td>
<td>&lt;none&gt;</td>
<td>7687/TCP, 7474/TCP, 7473/TCP</td>
</tr>
<tr>
<td>core-2-admin</td>
<td>ClusterIP</td>
<td>10.112.9.168</td>
<td>&lt;none&gt;</td>
<td>6362/TCP, 7687/TCP, 7474/TCP, 7473/TCP</td>
</tr>
<tr>
<td>core-2-internals</td>
<td>ClusterIP</td>
<td>None</td>
<td>&lt;none&gt;</td>
<td>6362/TCP, 7687/TCP, 7474/TCP, 7473/TCP</td>
</tr>
<tr>
<td>core-3</td>
<td>ClusterIP</td>
<td>10.112.8.68</td>
<td>&lt;none&gt;</td>
<td>7687/TCP, 7474/TCP, 7473/TCP</td>
</tr>
<tr>
<td>core-3-admin</td>
<td>ClusterIP</td>
<td>10.112.15.3</td>
<td>&lt;none&gt;</td>
<td>6362/TCP, 7687/TCP, 7474/TCP, 7473/TCP</td>
</tr>
<tr>
<td>core-3-internals</td>
<td>ClusterIP</td>
<td>None</td>
<td>&lt;none&gt;</td>
<td>6362/TCP, 7687/TCP, 7474/TCP, 7473/TCP</td>
</tr>
<tr>
<td>kubernetes</td>
<td>ClusterIP</td>
<td>10.112.0.1</td>
<td>&lt;none&gt;</td>
<td>443/TCP</td>
</tr>
</tbody>
</table>

For more information about the Neo4j services, see [Access a Neo4j cluster](#).

5.4.7. Install the Neo4j read replicas [Enterprise edition](#)

Before you can install the read replica, you need to verify that the core members have formed a cluster. For more information, see [Verify the Neo4j cluster formation](#).

Read Replicas can only be installed after a cluster of at least three cores is formed. Otherwise, the helm install command throws the following error:

```
Error: template: neo4j-cluster-read-replica/templates/neo4j-auth.yaml:5:8: executing "neo4j-cluster-read-replica/templates/neo4j-auth.yaml" at <include "neo4j.checkIfClusterIsPresent" .>: error calling include: template: neo4j-cluster-read-replica/templates/_helpers.tpl:84:11: executing "neo4j.checkIfClusterIsPresent" at <fail "Cannot install Read Replica until a cluster of 3 or more cores is formed">: error calling fail: Cannot install Read Replica until a cluster of 3 or more cores is formed
```

1. Install the Neo4j read replica using `rr-1` as a release name, the deployment `rr-1.values.yaml` file created in [Create value.yaml files](#), and the `neo4j/neo4j-cluster-read-replica` Helm Chart:

```
helm install rr-1 neo4j/neo4j-cluster-read-replica -f rr-1.values.yaml
```
Example output

NAME: rr-1
LAST DEPLOYED: Fri Nov  5 16:15:13 2021
NAMESPACE: default
STATUS: deployed
REVISION: 1
TEST SUITE: None
NOTES:
Thank you for installing neo4j-cluster-read-replica.

Your release "rr-1" has been installed.
The neo4j user's password has been set to "my-password".

This release creates a single Neo4j Read Replica instance. It will not become ready until it is able to join a working Neo4j cluster.

Graphs are everywhere!

2. Verify that the read replica has joined the cluster. See the next section Verify the read replica has joined the cluster.

5.4.8. Verify the read replica has joined the cluster

You check the pods and services to verify that the read replica has joined the cluster, which might take a few minutes. In the end, you should have a cluster with three cores and one read replica:

1. Check that the pods are READY:

```sh
kubectl get pods
```

<table>
<thead>
<tr>
<th>NAME</th>
<th>READY</th>
<th>STATUS</th>
<th>RESTARTS</th>
<th>AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>core-1-0</td>
<td>1/1</td>
<td>Running</td>
<td>0</td>
<td>10m</td>
</tr>
<tr>
<td>core-2-0</td>
<td>1/1</td>
<td>Running</td>
<td>0</td>
<td>10m</td>
</tr>
<tr>
<td>core-3-0</td>
<td>1/1</td>
<td>Running</td>
<td>0</td>
<td>10m</td>
</tr>
<tr>
<td>rr-1-0</td>
<td>1/1</td>
<td>Running</td>
<td>0</td>
<td>5m15s</td>
</tr>
</tbody>
</table>

2. Check that the services look good:

```sh
kubectl get services
```
<table>
<thead>
<tr>
<th>NAME</th>
<th>TYPE</th>
<th>CLUSTER-IP</th>
<th>EXTERNAL-IP</th>
<th>PORT(S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>core-1</td>
<td>ClusterIP</td>
<td>10.112.0.8</td>
<td>&lt;none&gt;</td>
<td>7687/TCP,7474/TCP,7473/TCP</td>
</tr>
<tr>
<td>core-1-admin</td>
<td>ClusterIP</td>
<td>10.112.6.162</td>
<td>&lt;none&gt;</td>
<td>6362/TCP,7687/TCP,7474/TCP,7473/TCP</td>
</tr>
<tr>
<td>core-1-internals</td>
<td>ClusterIP</td>
<td>None</td>
<td>&lt;none&gt;</td>
<td>6362/TCP,7687/TCP,7474/TCP,7473/TCP,7688/TCP,5000/TCP,7000/TCP,6000/TCP</td>
</tr>
<tr>
<td>core-2</td>
<td>ClusterIP</td>
<td>10.112.8.77</td>
<td>&lt;none&gt;</td>
<td>7687/TCP,7474/TCP,7473/TCP</td>
</tr>
<tr>
<td>core-2-admin</td>
<td>ClusterIP</td>
<td>10.112.9.168</td>
<td>&lt;none&gt;</td>
<td>6362/TCP,7687/TCP,7474/TCP,7473/TCP</td>
</tr>
<tr>
<td>core-2-internals</td>
<td>ClusterIP</td>
<td>None</td>
<td>&lt;none&gt;</td>
<td>6362/TCP,7687/TCP,7474/TCP,7473/TCP,7688/TCP,5000/TCP,7000/TCP,6000/TCP</td>
</tr>
<tr>
<td>core-3</td>
<td>ClusterIP</td>
<td>10.112.8.68</td>
<td>&lt;none&gt;</td>
<td>7687/TCP,7474/TCP,7473/TCP</td>
</tr>
<tr>
<td>core-3-admin</td>
<td>ClusterIP</td>
<td>10.112.15.3</td>
<td>&lt;none&gt;</td>
<td>6362/TCP,7687/TCP,7474/TCP,7473/TCP</td>
</tr>
<tr>
<td>core-3-internals</td>
<td>ClusterIP</td>
<td>None</td>
<td>&lt;none&gt;</td>
<td>6362/TCP,7687/TCP,7474/TCP,7473/TCP,7688/TCP,5000/TCP,7000/TCP,6000/TCP</td>
</tr>
<tr>
<td>kubernetes</td>
<td>ClusterIP</td>
<td>10.112.0.1</td>
<td>&lt;none&gt;</td>
<td>443/TCP</td>
</tr>
<tr>
<td>rr-1</td>
<td>ClusterIP</td>
<td>10.112.14.65</td>
<td>&lt;none&gt;</td>
<td>7687/TCP,7474/TCP,7473/TCP</td>
</tr>
<tr>
<td>rr-1-admin</td>
<td>ClusterIP</td>
<td>10.112.9.86</td>
<td>&lt;none&gt;</td>
<td>6362/TCP,7687/TCP,7474/TCP,7473/TCP</td>
</tr>
<tr>
<td>rr-1-internals</td>
<td>ClusterIP</td>
<td>None</td>
<td>&lt;none&gt;</td>
<td>6362/TCP,7687/TCP,7474/TCP,7473/TCP,7688/TCP,6000/TCP</td>
</tr>
</tbody>
</table>

For more information about the Neo4j services, see [Access a Neo4j cluster](#).

### 5.4.9. Access the Neo4j cluster from inside Kubernetes

**Enterprise edition**

By default, client-side routing is used for accessing a Neo4j cluster from inside Kubernetes.

**Access the Neo4j cluster using a specific member**

You run `cypher-shell` in a new pod and point it directly to one of the core members.

1. Run `cypher-shell` in a pod to access, for example, **core-3**:

```
kubectl run --rm -it --image "neo4j:4.4.10-enterprise" cypher-shell \ 
   -- cypher-shell "a "neo4j://core-3.default.svc.cluster.local:7687" -u neo4j -p "my-password"
```

If you don't see a command prompt, try pressing enter.

Connected to Neo4j using Bolt protocol version 4.4 at neo4j://core-3.default.svc.cluster.local:7687 as user neo4j.

Type :help for a list of available commands or :exit to exit the shell.

Note that Cypher queries must end with a semicolon.

2. Run the Cypher command **SHOW DATABASES** to verify that all cluster members are online:

```
SHOW DATABASES;
```
3. Exit cypher-shell. Exiting cypher-shell automatically deletes the pod created to run it.

```
:exit;
```

Bye!
Session ended, resume using 'kubectl attach cypher-shell -c cypher-shell -i -t' command when the pod is running
pod "cypher-shell" deleted

Access the Neo4j cluster using headless service

To allow for an application running inside Kubernetes to access the Neo4j cluster without using a specific core for bootstrapping, you need to install the neo4j-cluster-headless-service Helm Chart. This will create a K8s Service with a DNS entry that includes all the Neo4j cores. You can use the created DNS entry to bootstrap drivers connecting to the cluster as shown in the image:
The headless service is a Kubernetes term for a service that has no ClusterIP. For more information, see the Kubernetes official documentation.

1. Install the headless service using the release name `headless`, `neo4j/neo4j-cluster-headless-service` Helm Chart, and the name of your cluster as a value of the `neo4j.name` parameter.

Alternatively, you can create a `values.yaml` file with all the configurations for the service. To see what options are configurable on the `neo4j/neo4j-cluster-headless-service` Helm Chart, use `helm show values neo4j/neo4j-cluster-headless-service`.

```
helm install headless neo4j/neo4j-cluster-headless-service --set neo4j.name=my-cluster
```

```
NAME: headless
LAST DEPLOYED: Fri Nov  5 16:58:54 2021
NAMESPACE: default
STATUS: deployed
REVISION: 1
TEST SUITE: None
NOTES:
Thank you for installing neo4j-cluster-headless-service.
Your release "headless" has been installed in namespace "default".
Once rollout is complete you can connect to your Neo4j cluster using "neo4j://headless-neo4j.default.svc.cluster.local:7687". Try:

```
$ kubectl run --rm -it --image "neo4j:4.4.10-enterprise" cypher-shell \ 
   -- cypher-shell -a "neo4j://headless-neo4j.default.svc.cluster.local:7687"
```

Graphs are everywhere!

1. Check that the `headless` service is available:

```
kubectl get services | grep head
```

```
NAME | TYPE | CLUSTER-IP | EXTERNAL-IP | PORT(S)
---- | ---- | ---------- | ----------- | ------
headless-neo4j | ClusterIP | None | <none> | 7474/TCP, 7473/TCP, 7687/TCP
```

2. Use `kubectl describe service` to see the service details:

```
kubectl describe service headless-neo4j
```
You should see three “endpoints” for each port in the service — these are the IP addresses of the three Neo4j cores servers. These endpoints are contacted to bootstrap the drivers used by applications running in Kubernetes. The drivers will use them to obtain the initial routing table.

3. Run `cypher-shell` in another pod and connect to the cluster nodes via the headless service:

```
kubectl run --rm -it --image "neo4j:4.4.10-enterprise" cypher-shell \
  -- cypher-shell -a "neo4j://headless-neo4j.default.svc.cluster.local:7687" -u neo4j -p "my-password"
```

If you don’t see a command prompt, try pressing enter.
Connected to Neo4j using Bolt protocol version 4.4 at neo4j://headless-neo4j.default.svc.cluster.local:7687 as user neo4j.
Type :help for a list of available commands or :exit to exit the shell.
Note that Cypher queries must end with a semicolon.

4. Run the Cypher command `SHOW DATABASES` to verify that all cluster members are online.

```
SHOW DATABASES;
```
<table>
<thead>
<tr>
<th>name</th>
<th>aliases</th>
<th>access</th>
<th>address</th>
<th>role</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>requestedStatus</td>
<td>currentStatus</td>
<td>error</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>neo4j</td>
<td>[]</td>
<td>read-write</td>
<td>core-1.default.svc.cluster.local:7687</td>
<td>follower</td>
</tr>
<tr>
<td>online</td>
<td></td>
<td></td>
<td></td>
<td>TRUE</td>
</tr>
<tr>
<td>neo4j</td>
<td>[]</td>
<td>read-write</td>
<td>core-3.default.svc.cluster.local:7687</td>
<td>follower</td>
</tr>
<tr>
<td>online</td>
<td></td>
<td></td>
<td></td>
<td>TRUE</td>
</tr>
<tr>
<td>neo4j</td>
<td>[]</td>
<td>read-write</td>
<td>core-2.default.svc.cluster.local:7687</td>
<td>leader</td>
</tr>
<tr>
<td>online</td>
<td></td>
<td></td>
<td></td>
<td>TRUE</td>
</tr>
<tr>
<td>neo4j</td>
<td>[]</td>
<td>read-write</td>
<td>rr-1.default.svc.cluster.local:7687</td>
<td>read_replica</td>
</tr>
<tr>
<td>online</td>
<td></td>
<td></td>
<td></td>
<td>TRUE</td>
</tr>
<tr>
<td>system</td>
<td>[]</td>
<td>read-write</td>
<td>core-1.default.svc.cluster.local:7687</td>
<td>leader</td>
</tr>
<tr>
<td>online</td>
<td></td>
<td></td>
<td></td>
<td>FALSE</td>
</tr>
<tr>
<td>system</td>
<td>[]</td>
<td>read-write</td>
<td>core-2.default.svc.cluster.local:7687</td>
<td>follower</td>
</tr>
<tr>
<td>online</td>
<td></td>
<td></td>
<td></td>
<td>FALSE</td>
</tr>
<tr>
<td>system</td>
<td>[]</td>
<td>read-write</td>
<td>rr-1.default.svc.cluster.local:7687</td>
<td>read_replica</td>
</tr>
<tr>
<td>online</td>
<td></td>
<td></td>
<td></td>
<td>FALSE</td>
</tr>
</tbody>
</table>

8 rows ready to start consuming query after 4 ms, results consumed after another 42 ms

5. Exit cypher-shell. Exiting cypher-shell automatically deletes the pod created to run it.

:exit;

Bye!
Session ended, resume using 'kubectl attach cypher-shell -c cypher-shell -i -t' command when the pod is running
pod "cypher-shell" deleted

5.4.10. Access the Neo4j cluster from outside Kubernetes

By default, server-side routing is used for accessing a Neo4j cluster from outside Kubernetes.

Access the Neo4j cluster using a load balancer and Cypher Shell

To access a Neo4j cluster from outside Kubernetes, you need to install the neo4j-cluster-loadbalancer service.

1. Install the load balancer service using the release name lb, the neo4j.neo4j-cluster-loadbalancer Helm Chart, and the name of your cluster as a value of the neo4j.name parameter.

Alternatively, you can create a values.yaml file with all the configurations for the service. To see what options are configurable on the neo4j/neomgr-cluster-loadbalancer Helm Chart, use helm show values neo4j/neomgr-cluster-loadbalancer.

```
helm install lb neo4j/neomgr-cluster-loadbalancer --set neo4j.name=my-cluster
```
Thank you for installing neo4j-cluster-loadbalancer.

Your release “lb” has been installed in namespace “default”.

To view the status of your Load Balancer service you can use
$ kubectl get service lb-neo4j

Once your Load Balancer has an External-IP assigned you can connect to your Neo4j cluster using “neo4j://<EXTERNAL-IP>:7687”. Try:
$ cypher-shell -a “neo4j://<EXTERNAL-IP>:7687”

Graphs are everywhere!

2. Check that the lb service is available:

   kubectl get services  | grep lb

   NAME               TYPE           CLUSTER-IP      EXTERNAL-IP     PORT(S)  AGE
   lb-neo4j           LoadBalancer   10.51.248.52    34.65.252.122   7474:31712/TCP,7473:31942/TCP,7687:31649/TCP 3m

3. Use kubectl describe service to see the service details:

   kubectl describe service lb-neo4j
The load-balancer service can send requests to all members of the cluster. You can see that it has four endpoints: three cores and one read-replica.

4. Run cypher-shell from the local machine and connect to the LoadBalancer Ingress address, in the example 34.65.252.122:

```
./cypher-shell -a neo4j://34.65.252.122 -u neo4j -p my-password
```

If you don't see a command prompt, try pressing enter.
Connected to Neo4j using Bolt protocol version 4.4 at neo4j://34.65.252.122:7687 as user neo4j. Type :help for a list of available commands or :exit to exit the shell. Note that Cypher queries must end with a semicolon.

5. Run the Cypher command SHOW DATABASES to verify that all cluster members are online:

```
SHOW DATABASES;
```
You can see that the nodes are advertising their internal addresses, but since you connected without using internal addresses, you use server-side routing.

Access the Neo4j cluster using a load balancer and Neo4j Browser

1. Open a web browser and point it to the **LoadBalancer Ingress** address and port 7474, in this example, http://34.65.252.122:7474/browser.

2. Once connected, verify that all databases are up and running using **SHOW DATABASES** in the Browser Editor:
5.4.11. Uninstall the Neo4j cluster and clean up the created resources

Enterprise edition

Uninstall all Neo4j Helm deployments

1. Uninstall each of the cluster members (both the cores and read replica) and the services using their Helm release names:

   `helm uninstall core-1 core-2 core-3 rr-1 lb headless`

   release "core-1" uninstalled
   release "core-2" uninstalled
   release "core-3" uninstalled
   release "rr-1" uninstalled
   release "lb" uninstalled
   release "headless" uninstalled

Fully remove all the data and resources

Uninstalling the Helm releases does not remove the created resources and data. Therefore, after uninstalling the helm deployments, you also have to delete all the data and resources.
1. Display all data associated with each of the GCP persistent disks you have created, for example:

```bash
gcloud compute disks describe "core-disk-1"
```

If you re-create Neo4j with the same settings, it will pick up the same disk again, and all the data will still be on it.

Even if the GKE cluster is deleted, the persistent disks with the Neo4j data will still exist.

2. Delete each of the GCP persistent disks you have created in Create a persistent volume for each cluster member using the following command and the name of the disk, for example:

```bash
gcloud compute disks delete core-disk-1
```

The following disks will be deleted:
- [core-disk-1] in [europe-west6-c]

Do you want to continue (Y/n)? y

Deleted [https://www.googleapis.com/compute/v1/projects/neo4j-helm/zones/europe-west6-c/disks/core-disk-1].

If you want to delete the entire GKE Kubernetes cluster, run:

```bash
gcloud container clusters delete my-neo4j-gke-cluster
```
1. Display all data associated with the AWS EBS disks by running:

```bash
aws ec2 describe-volumes --filters Name=tag:volume,Values=core-disk-1,core-disk-2,core-disk-3,rr-disk-1 --query "Volumes[*].{ID:VolumeId}" --output text
```

- If you re-create Neo4j with the same settings, it will pick up the same disk again, and all the data will still be on it.
- Even if you delete the EKS cluster, the EBS disks with the Neo4j data will still exist. Note that the disk will be deleted if its Resource Group is deleted.

2. Delete each of the AWS EBS disks you have created in Create a persistent volume for each cluster member using the following command and the volume ID, for example:

```bash
aws ec2 delete-volume --volume-id "<volume id>"
```

- If you are sure that you want to delete the entire EKS Kubernetes cluster, run:

```bash
eksctl delete cluster my-neo4j-eks-cluster
```
1. Display all data associated with the Azure managed disks by running:

```
az disk show --name "core-disk-1"
```

If you re-create Neo4j with the same settings, it will pick up the same disk again and all the data will still be on it.

Even if you delete the AKS cluster, the managed disk with the Neo4j data will still exist. Note that the disk will be deleted if its Resource Group is deleted.

2. Delete each of the Azure managed disks you have created in Create a persistent volume for each cluster member using the following command and the disk name, for example:

```
az disk delete --name "core-disk-1"
```

If you are sure that you want to delete the entire AKS Kubernetes cluster, run:

```
az aks delete --name my-neo4j-aks-cluster
```

5.5. Configure a Neo4j Helm deployment

This section describes how to configure a Neo4j Helm deployment to run in a Kubernetes cluster.

Helm is different from "package managers", such as `apt`, `yum`, and `npm`, because, in addition to installing applications, Helm allows rich configuration of applications. The customized configuration should be expressed declaratively in a YAML formatted file, and then passed during installation.

For more information, see Helm official documentation.

5.5.1. Create a custom values.yaml file

1. Ensure your Neo4j Helm Chart repository is up to date and get the latest charts. For more information, see Configure the Neo4j Helm Chart repository.

2. To see what options are configurable on the Neo4j helm chart that you want to deploy, use `helm show values` and the Helm Chart, such as `neo4j/neo4j-standalone`, `neo4j/neo4j-cluster-core`, `neo4j/neo4j-cluster-read-replica`, `neo4j/neo4j-cluster-headless-service`, and `neo4j/neo4j-cluster-loadbalancer`. For example:
# Default values for Neo4j
# This is a YAML-formatted file.

**neo4j**:

# Name of your cluster
**name**: ""

# If the password is not set or empty a random password will be generated during installation
**password**: ""

# Neo4j Edition to use (community|enterprise)
**edition**: "community"

# set edition: "enterprise" to use Neo4j Enterprise Edition
# To use Neo4j Enterprise Edition you must have a Neo4j license agreement.
# More information is also available at: https://neo4j.com/licensing/
# Email inquiries can be directed to: licensing@neo4j.com
# Set acceptLicenseAgreement: "yes" to confirm that you have a Neo4j license agreement.
**acceptLicenseAgreement**: "no"

# set offlineMaintenanceModeEnabled: true to restart the StatefulSet without the Neo4j process running
# this can be used to perform tasks that cannot be performed when Neo4j is running such as `neo4j-admin dump`
**offlineMaintenanceModeEnabled**: false

# set resources for the Neo4j Container. The values set will be used for both "requests" and "limit".
**resources**:

- **cpu**: "1000m"
- **memory**: "2Gi"

# Volumes for Neo4j

**volumes**:

- **data**:
  
  # REQUIRED: specify a volume mode to use for data
  
  # Valid values are share|selector|defaultStorageClass|volume|volumeClaimTemplate|dynamic
  
  # To get up and running quickly, for development or testing, use "defaultStorageClass" for a dynamically provisioned volume of the default storage class.
  
  **mode**: ""
  
  # Only used if the mode is set to "selector"
  # Will attach to existing volumes that match the selector
  **selector**:

  - **storageClassName**: "manual"
  - **accessModes**: ReadWriteOnce
  - **requests**:
    - **storage**: 100Gi

  # A helm template to generate a label selector to match existing volumes n.b. both storageClassName and label selector must match existing volumes
  **selectorTemplate**:
  
  - **matchLabels**:
    - **app**: "{{ .Values.neo4j.name }}"
    - **helm.neo4j.com/volume-role**: "data"

  # Only used if mode is set to "defaultStorageClass"
  # Dynamic provisioning using the default storageClass
  **defaultStorageClass**:

  - **accessModes**: ReadWriteOnce
  - **requests**:
    - **storage**: 10Gi

  # Only used if the mode is set to "dynamic"
  # Dynamic provisioning using the provided storageClass
  **dynamic**:

  - **storageClassName**: "neo4j"
  - **accessModes**: ReadWriteOnce
requests:
  storage: 100Gi

# Only used if mode is set to "volume"
# Provide an explicit volume to use
volume:
  # If set an init container (running as root) will be added that runs:
  # `chown -R <securityContext.fsUser>:.<securityContext.fsGroup>` AND `chmod -R g+rwx`
  # on the volume. This is useful for some file systems (e.g. NFS) where Kubernetes fsUser or
  # fsGroup settings are not respected
setOwnerAndGroupWritableFilePermissions: false

# Example (using a specific Persistent Volume Claim)
# persistentVolumeClaim:
#   claimName: my-neo4j-pvc

# Only used if mode is set to "volumeClaimTemplate"
# Provide an explicit volumeClaimTemplate to use
volumeClaimTemplate: {}

# provide a volume to use for backups
# n.b. backups will be written to /backups on the volume
# any of the volume modes shown above for data can be used for backups
backups:
  mode: "share" # share an existing volume (e.g. the data volume)
  share: 
    name: "data"

# provide a volume to use for logs
# n.b. logs will be written to /logs/$POD_NAME on the volume
# any of the volume modes shown above for data can be used for logs
logs:
  mode: "share" # share an existing volume (e.g. the data volume)
  share: 
    name: "data"

# provide a volume to use for csv metrics (csv metrics are only available in Neo4j Enterprise Edition)
# n.b. metrics will be written to /metrics/$POD_NAME on the volume
# any of the volume modes shown above for data can be used for metrics
metrics:
  mode: "share" # share an existing volume (e.g. the data volume)
  share: 
    name: "data"

# provide a volume to use for import storage
# n.b. import will be mounted to /import on the underlying volume
# any of the volume modes shown above for data can be used for import
import:
  mode: "share" # share an existing volume (e.g. the data volume)
  share: 
    name: "data"

# provide a volume to use for licenses
# n.b. licenses will be mounted to /licenses on the underlying volume
# any of the volume modes shown above for data can be used for licenses
licenses:
  mode: "share" # share an existing volume (e.g. the data volume)
  share: 
    name: "data"

# Services for Neo4j
services:
  # A ClusterIP service with the same name as the Helm Release name should be used for Neo4j Driver
  # connections originating inside the
  # Kubernetes cluster.
  default:
    # Annotations for the K8s Service object
    annotations: {
    }

  # A LoadBalancer Service for external Neo4j driver applications and Neo4j Browser
  neo4j:
    enabled: true
    # Annotations for the K8s Service object
    annotations: {
    }
spec:
  # Type of service.
  type: LoadBalancer

  # in most cloud environments LoadBalancer type will receive an ephemeral public IP address automatically. If you need to specify a static ip here use:
  # loadBalancerIP: ...

  # ports to include in neo4j service
  ports:
    http:
      #Set this to false to remove HTTP from this service (this does not affect whether http is enabled for the neo4j process)
      enabled: true
    https:
      #Set this to false to remove HTTPS from this service (this does not affect whether https is enabled for the neo4j process)
      enabled: true
    bolt:
      #Set this to false to remove BOLT from this service (this does not affect whether https is enabled for the neo4j process)
      enabled: true

  # A service for admin/ops tasks including taking backups
  # This service is available even if the deployment is not "ready"
  admin:
    # Annotations for the admin service
    annotations: {}
    spec:
      type: ClusterIP

      # n.b. there is no ports object for this service. Ports are autogenerated based on the neo4j configuration

      # A "headless" service for admin/ops and Neo4j cluster-internal communications
      # This service is available even if the deployment is not "ready"
      internals:
        # Annotations for the internals service
        annotations: {}
        spec:
          type: ClusterIP

          # n.b. there is no ports object for this service. Ports are autogenerated based on the neo4j configuration

  # Neo4j Configuration (yaml format)
  config:
    # securityContext defines privilege and access control settings for a Pod or Container. Making sure that you do not run Neo4j as root user.
    securityContext:
      runAsNonRoot: true
      runAsUser: 7474
      runAsGroup: 7474
      fsGroup: 7474
      fsGroupChangePolicy: "Always"

      # Readiness probes are set to know when a container is ready to be used.
      # Because Neo4j uses Java these values are large to distinguish between long Garbage Collection pauses (which don't require a restart) and an actual failure.
      # These values should mark Neo4j as not ready after at most 5 minutes of problems (20 attempts * max 15 seconds between probes)
    readinessProbe:
      failureThreshold: 20
      timeoutSeconds: 10
      periodSeconds: 5

      # Liveness probes are set to know when to restart a container.
      # Because Neo4j uses Java these values are large to distinguish between long Garbage Collection pauses (which don't require a restart) and an actual failure.
      # These values should trigger a restart after at most 10 minutes of problems (40 attempts * max 15 seconds between probes)
    livenessProbe:
      failureThreshold: 40
      timeoutSeconds: 10
      periodSeconds: 5

      # Startup probes are used to know when a container application has started.
      # If such a probe is configured, it disables liveness and readiness checks until it succeeds
      # When restoring Neo4j from a backup, it's important that the startup probe gives time for Neo4j to recover and/or upgrade store files
When using Neo4j clusters, it’s important that the startup probe gives the Neo4j cluster time to form.

```yaml
startupProbe:
  failureThreshold: 1000
  periodSeconds: 5
```

The top-level setting called `ssl` to match the "ssl" from "dbms.ssl.policy"

```yaml
ssl:
  # setting per "connector" matching neo4j config
  bolt:
    privateKey:
      secretName: # we set up the template to grab 'private.key' from this secret
      subPath: # we specify the privateKey value name to get from the secret
    publicCertificate:
      secretName: # we set up the template to grab 'public.crt' from this secret
      subPath: # we specify the publicCertificate value name to get from the secret
  trustedCerts:
    sources: [] # a sources array for a projected volume - this allows someone to (relatively)
    easily mount multiple public certs from multiple secrets for example.
  revokedCerts:
    sources: [] # a sources array for a projected volume
```

HTTPS:

```yaml
https:
  privateKey:
    secretName: # we set up the template to grab 'private.key' from this secret
    subPath: # we specify the privateKey value name to get from the secret
  publicCertificate:
    secretName: # we set up the template to grab 'public.crt' from this secret
    subPath: # we specify the publicCertificate value name to get from the secret
  trustedCerts:
    sources: [] # a sources array for a projected volume
  revokedCerts:
    sources: [] # a sources array for a projected volume
```

# Kubernetes cluster domain suffix

```yaml
clusterDomain: "cluster.local"
```

# Override image settings in Neo4j pod

```yaml
image:
  imagePullPolicy: IfNotPresent
  # set a customImage if you want to use your own docker image
  # customImage: my-image:my-tag
```

# additional environment variables for the Neo4j Container

```yaml
env: {}
```

# Other K8s configuration to apply to the Neo4j pod

```yaml
podSpec:
  # Anti Affinity
  # If set to true then an anti-affinity rule is applied to prevent database pods with the same
  'neo4j.name' running on a single Kubernetes node.
  # If set to false then no anti-affinity rules are applied
  # If set to an object then that object is used for the Neo4j podAntiAffinity
  podAntiAffinity: true

  # Name of service account to use for the Neo4j Pod (optional)
  # this is useful if you want to use Workload Identity to grant permissions to access cloud resources
  e.g. cloud object storage (AWS S3 etc.)
  serviceAccountName: ""

  # How long the Neo4j pod is permitted to keep running after it has been signaled by Kubernetes to stop. Once this timeout elapses the Neo4j process is forcibly terminated.
  # A large value is used because Neo4j takes time to flush in-memory data to disk on shutdown.
  terminationGracePeriodSeconds: 3600

  # initContainers for the Neo4j pod
  initContainers: []

  # additional runtime containers for the Neo4j pod
  containers: []

  # print the neo4j user password set during install to the 'helm install' log
  logInitialPassword: true
```

# JVM configuration for Neo4j

```yaml
jvm:
  # If true any additional arguments are added after the Neo4j default jvm arguments.
  # If false Neo4j default jvm arguments are not used.
```
You can amend any of these settings. Passing that file during installation overrides the default Helm Chart configuration of the Neo4j installation on Kubernetes and the configuration of the Neo4j database itself.

3. Create the `neo4j-values.yaml` file with your preferred configuration. For example:

```yaml
# neo4j-values.yaml
neo4j:
  password: "my-password"
  resources:
    cpu: "2"
    memory: "5Gi"

volumes:
  data:
    mode: "defaultStorageClass"

# Neo4j configuration (yaml format)
config:
  dbms.default_database: "neo4j"
  dbms.config.strict_validation: "true"
```

4. Pass the `neo4j-values.yaml` file during installation.

```
helm install <release-name> neo4j/neo4j-standalone -f neo4j-values.yaml
```

To see the values that have been set for a given release, use `helm get values <release-name>`.

Some examples of possible K8s configurations

- Configure (or disable completely) the Kubernetes LoadBalancer that exposes Neo4j outside the Kubernetes cluster by modifying the `externalService` object in the values.yml file.
- Set the `securityContext` used by Neo4j Pods by modifying the `securityContext` object in the values.yml file.
- Configure manual persistent volume provisioning or set the `StorageClass` to be used as the Neo4j persistent storage.

Some examples of possible Neo4j configurations

- All Neo4j configuration (`neo4j.conf`) settings can be set directly on the `config` object in the values.yaml file.
- Neo4j can be configured to use SSL certificates contained in Kubernetes Secrets by modifying the `ssl` object in the values file.
5.5.2. Set Neo4j configuration

The Neo4j Helm Chart does not use a `neo4j.conf` file. Instead, the Neo4j configuration is set in the Helm deployment’s `values.yaml` file under the `config` object.

The `config` object should contain a string map of `neo4j.conf` setting name to value. For example, this `config` object configures the Neo4j metrics:

```
# Neo4j configuration (yaml format)
config:
  metrics.enabled: "true"
  metrics.namespaces.enabled: "false"
  metrics.csv.interval: "10s"
  metrics.csv.rotation.keep_number: "2"
  metrics.csv.rotation.compression: "NONE"
```

All Neo4j `config` values must be YAML strings. It is important to put quotes around the values, such as "true", "false", and "2", so that they are handled correctly as strings.

All `neo4j.conf` settings are supported except for `dbms.jvm.additional`. Additional JVM settings can be set on the `jvm` object in the Helm deployment `values.yaml` file, as shown in the example:

```
# Jvm configuration for Neo4j
jvm:
  additionalJvmArguments:
    - "-XX:+HeapDumpOnOutOfMemoryError"
    - "-XX:HeapDumpPath=/logs/neo4j.hprof"
```

To find out more about configuring Neo4j and the `neo4j.conf` file, see Configuration and The `neo4j.conf` file.

5.5.3. Set an initial password

You can set an initial password for accessing Neo4j in the `values.yaml` file. If no initial password is set, the Neo4j helm chart will automatically generate one. In cluster deployments, the same password must be set on all cluster members.

```
neo4j:
  # If not set or empty a random password will be generated
  password: ""
```

The password will be printed out in the Helm install output, unless `--set logInitialPassword=false` is used.

The initial Neo4j password is stored in a Kubernetes Secret. The password can be extracted from the Secret using this command:

```
kubectl get secret <release-name>-auth -o yaml | yq -r '.data.NEO4J_AUTH' | base64 -d
```
To change the initial password, follow the steps in Operations - Reset the Neo4j user password.

Once you change the password in Neo4j, the password stored in Kubernetes Secrets will still exist but will no longer be valid.

5.5.4. Configure SSL

The Neo4j SSL Framework can be used with Neo4j Helm Charts. SSL policy objects can be specified for bolt, https, cluster, backup, and fabric. SSL public certificates and private keys to use with a Neo4j Helm deployment must be stored in Kubernetes Secrets.

To enable Neo4j SSL policies, configure the ssl.<policy name> object in the Neo4j Helm deployment’s values.yaml file to reference the Kubernetes Secrets containing the SSL certificates and keys to use. This example shows how to configure the bolt SSL policy:

```
ssl:
bolt:
  privateKey:
    secretName: bolt-cert
    subPath: private.key
  publicCertificate:
    secretName: bolt-cert
    subPath: public.crt
```

When a private key is specified in the values.yaml file, the Neo4j ssl policy is enabled automatically. To disable a policy, add `dbms.ssl.policy.[{ $name }].enabled: "false"` to the config object.

Unencrypted http is not disabled automatically when https is enabled. If https is enabled, add `dbms.connector.http.enabled: "false"` to the config object to disable http.

5.5.5. Configure resource allocation

**CPU and memory**

The resources (CPU, memory) for the Neo4j container are configured by setting neo4j.resources object in the values.yaml file. In the resource requests, you can specify how much CPU and memory the Neo4j container needs, while in the resource limits, you can set a limit on these resources in case the container tries to use more resources than its requests allow.

```
neo4j:
  resources:
    requests:
      cpu: "1000m"
      memory: "2Gi"
    limits:
      cpu: "2000m"
      memory: "4Gi"
```

If no resource requests and resource limits are specified, the values set in the resources object are used for both the Neo4j container’s resource requests and resource limits.
neo4j:
  resources:
    cpu: "2"
    memory: "5Gi"

The minimum for a Neo4j instance is 0.5 CPU and 2GB memory. If invalid or less than the minimum values are provided, Helm will throw an error, for example:

```
 "neo4j.resources.evaluateCPU" at <fail (printf "Provided cpu value %s is less than
 minimum. \n %s" (.Values.neo4j.resources.cpu) (include
 "neo4j.resources.invalidCPUMessage" .))>: error calling fail: Provided cpu value
 0.25 is less than minimum.
 cpu value cannot be less than 0.5 or 500m
```

**JVM heap and page cache**

You configure Neo4j to use the memory provided to the container by setting the parameters `dbms.memory.heap.max_size` and `dbms.memory.pagecache.size`. Combined, they must not exceed the memory configuration of the Neo4j container.

In Kubernetes, running processes in the Neo4j container that exceed the configured memory limit are killed by the underlying operating system. Therefore, it is recommended to allow an additional 1GB of memory headroom so that `heap + pagecache + 1GB < available memory`.

For example, a 5GB container could be configured like this:

```
neo4j:
  resources:
    cpu: "2"
    memory: "5Gi"

# Neo4j configuration (yaml format)
config:
  dbms.memory.heap.initial_size: "3G"
  dbms.memory.heap.max_size: "3G"
  dbms.memory.pagecache.size: "1G"
```

dbms.memory.pagecache.size and dbms.memory.heap.initial_size are not the only settings available in Neo4j to manage memory usage. For full details of how to configure memory usage in Neo4j, see Performance - Memory Configuration.

### 5.5.6. Configure a service account

In some deployment situations, it may be desirable to assign a Kubernetes Service Account to the Neo4j pod. For example, if processes in the pod want to connect to services that require Service Account authorization. To configure the Neo4j pod to use a Kubernetes service account, set `podSpec.serviceAccountName` to the name of the service account to use.

For example:
5.5.7. Configure a custom container image

The helm chart uses the official Neo4j Docker image that matches the version of the Helm Chart. To configure the helm chart to use a different container image, set the `image.customImage` property in the `values.yaml` file.

This can be necessary when public container repositories are not accessible for security reasons. For example, this `values.yaml` file configures Neo4j to use `my-container-repository.io` as the container repository:

```
# neo4j-values.yaml
neo4j:
  password: "my-password"

image:
  customImage: "my-container-repository.io/neo4j:4.4-enterprise"
```

5.5.8. Configure and install APOC core only

APOC core is shipped with Neo4j, but it is not installed in the Neo4j plugins directory. If APOC core is the only plugin that you want to add to Neo4j, it is not necessary to perform plugin installation as described in Install Plugins. Instead, you can configure the helm deployment to use APOC core by upgrading the deployment with this additional setting in the `values.yaml` file:

1. Configure APOC core:

```
config:
  dbms.directories.plugins: "/var/lib/neo4j/labs"
  dbms.security.procedures.unrestricted: "apoc.*"
```

2. Under `apoc_config`, configure the APOC settings you want, for example:

```
apoc_config:
apoc.trigger.enabled: "true"
apoc.jdbc.neo4j.url: "jdbc:foo:bar"
apoc.import.file.enabled: "true"
```

3. Run `helm upgrade` to apply the changes:

```
helm upgrade <release-name> neo4j/neo4j-standalone -f values.yaml
```
4. After the Helm upgrade rollout is complete, verify that APOC core has been configured by running the following Cypher query using `cypher-shell` or Neo4j Browser:

```
RETURN apoc.version()
```

5. Verify the APOC configs using the `apoc.config.list()` procedure:

```
CALL apoc.config.list() YIELD key, value WHERE key = "apoc.jdbc.neo4j.url" RETURN *;
```

5.5.9. Install Plugins

There are two recommended methods for adding Neo4j plugins to Neo4j Helm Chart deployments. You can use:

- a custom container image.
- a plugins volume.

Add plugins using a custom container image

The best method for adding plugins to Neo4j running in Kubernetes is to create a new Docker container image that contains both Neo4j and the Neo4j plugins. This way, you can ensure when building the container that the correct plugin version for the Neo4j version of the container is used, and the resulting image encapsulates all Neo4j runtime dependencies.

Building a Docker container image that is based on the official Neo4j Docker image and does not override the official image’s `ENTRYPOINT` and `COMMAND` is the recommended method to use with the Neo4j Helm Chart, as shown in this example Dockerfile:

```
ARG NEO4J_VERSION
FROM neo4j:{NEO4J_VERSION}

# copy my-plugins into the Docker image
COPY my-plugins/ /var/lib/neo4j/plugins

# install the apoc core plugin that is shipped with Neo4j
RUN cp /var/lib/neo4j/labs/apoc-* /var/lib/neo4j/plugins
```

Once the docker image has been built, push it to a container repository that is accessible to your Kubernetes cluster.

```
CONTAINER_REPOSITORY="my-container-repository.io"
IMAGE_NAME="my-neo4j"

# export this so that it's accessible as a docker build arg
export NEO4J_VERSION=4.4.10-enterprise

docker build --build-arg NEO4J_VERSION --tag ${CONTAINER_REPOSITORY}/${IMAGE_NAME}:${NEO4J_VERSION} .
docker push ${CONTAINER_REPOSITORY}/${IMAGE_NAME}:${NEO4J_VERSION}
```

To use the image that you have created, in the Neo4j Helm deployment’s `values.yaml` file, set `image.customImage` to use the image. For more details, see Configure a custom container image.
Many plugins require additional Neo4j configuration to work correctly. Plugin configuration should be set on the `config` object in the Helm deployment’s `values.yaml` file. In some cases, plugin configuration can cause Neo4j’s strict config validation to fail. Strict config validation can be disabled by setting `dbms.config.strict_validation: "false"`.

Add plugins using a plugins volume

An alternative method for adding Neo4j plugins to a Neo4j Helm deployment uses a `plugins` volume mount. With this method, the plugin jar files are stored on a Persistent Volume that is mounted to the `/plugins` directory of the Neo4j container.

The simplest way to set up a persistent plugins volume is to share the Persistent Volume that is used for storing Neo4j data. This example shows how to configure that in the Neo4j Helm deployment `values.yaml` file:

```yaml
# neo4j-values.yaml
volumes:
  data:
    # your data volume configuration
  plugins:
    mode: "share"
    share:
      name: "data"
```

Details of different ways to configure volume mounts are covered in Mapping volume mounts to persistent volumes.

The Neo4j container now has an empty `/plugins` directory backed by a persistent volume. Plugin jar files can be copied onto the volume using `kubectl cp`. Because it is backed by a persistent volume, plugin files will persist even if the Neo4j pod is restarted or moved.

Neo4j only loads plugins on startup. Therefore, you have to restart the Neo4j pod to load them once all plugins are in place. For example:

```bash
# Copy plugin files into Neo4j container
kubectl cp my-plugins/* <namespace>/<neo4j-pod-name>:/plugins/

# Restart Neo4j
kubectl rollout restart statefulset/<neo4j-statefulset-name>

# Verify plugins are still present after restart
kubectl exec <neo4j-pod-name> -- ls /plugins
```

5.6. Volume mounts and persistent volumes with the Neo4j Helm Charts

This section describes the volume mounts created by the Neo4j Helm Charts and the `PersistentVolume` types that can be used.
5.6.1. Volume mounts

A volume mount is part of a Kubernetes Pod spec that describes how and where a volume is mounted within a container.

The Neo4j Helm Chart creates the following volume mounts:

- backups mounted at /backups
- data mounted at /data
- import mounted at /import
- licenses mounted at /licenses
- logs mounted at /logs
- metrics mounted at /metrics (Neo4j Community Edition does not generate metrics)

It is also possible to specify a plugins volume mount (mounted at /plugins), but this is not created by the default Helm Charts. For more information, see Add plugins using a plugins volume.

5.6.2. Persistent volumes

PersistentVolume (PV) is a storage resource in the Kubernetes cluster that has a lifecycle independent of any individual pod that uses the PV.

PersistentVolumeClaim (PVC) is a request for a storage resource by a user. PVCs consume PV resources. For more information about what PVs are and how they work, see the Kubernetes official documentation.

The type of PV used and its configuration can have a significant effect on the performance of Neo4j. Some PV types are not suitable for use with Neo4j at all.

The volume type used for the data volume mount is particularly important. Neo4j supports the following PV types for the data volume mount:

- awsElasticBlockStore
- azureDisk
- gcePersistentDisk
- hostPath when using Docker Desktop \(^1\).

Neo4j data volume mounts do not support:

- azureFile
- nfs

For volume mounts other than the data volume mount, generally, all PV types are presumed to work.
hostPath, local, and emptyDir types are expected to perform well, provided suitable underlying storage, such as SSD, is used. However, these volume types have operational limitations and are not recommended.

It is also not recommended to use an HDD or cloud storage, such as AWS S3 mounted as a drive.

5.6.3. Mapping volume mounts to persistent volumes

By default, the Neo4j Helm Chart uses a single PV, named data, to support all charts' volume mounts.

The volume used for each volume mount can be changed by modifying the volumes.<volume name> object in the Helm Chart values.

The Neo4j Helm Chart volumes object supports different modes:

**mode: share**

*Description*

The volume mount shares the underlying volume from one of the other volume objects.

*Example*

The logs volume mount uses the data volume (this is the default behavior).

```yaml
volumes:
  logs:
    mode: "share"
    share:
      name: "data"
```

**mode: defaultStorageClass**

*Description*

The volume mount is backed by a PV that Kubernetes dynamically provisions using the default StorageClass.

*Example*

A dynamically provisioned data volume with a size of 10Gi.

```yaml
volumes:
  data:
    mode: "defaultStorageClass"
    defaultStorageClass:
      requests:
        storage: 10Gi
```

For the data volume, if requests.storage is not set, defaultStorageClass will default to a 10Gi volume. For all other volumes, defaultStorageClass.requests.storage must be set explicitly when using defaultStorageClass mode.
mode: dynamic

Description

The volume mount is backed by a PV that Kubernetes dynamically provisions using the specified StorageClass.

Example

A dynamically provisioned import volume with a size of 1Ti using the neo4j storage class.

```
volumes:
  import:
    mode: dynamic
    dynamic:
      storageClassName: "neo4j"
      requests:
        storage: 1Ti
```

For the data volume, if requests.storage is not set, dynamic will default to a 100Gi volume. For all other volumes, dynamic.requests.storage must be set explicitly when using dynamic mode.

mode: volume

Description

A complete Kubernetes volume object can be specified for the volume mount. Generally, volumes specified in this way have to be manually provisioned.

volume can be any valid Kubernetes volume type. This mode can be used in a variety of ways:

- Attach an existing PersistentVolume by name.
- Attach cloud disks/volumes, e.g., gcePersistentDisk, azureDisk, or awsElasticBlockStore without creating Kubernetes PersistentVolumes.
- Attach the contents of a ConfigMap or Secret (as a read-only volume).

For details of how to specify volume objects, see the Kubernetes documentation.

Example - mount an AWS EBS volume

The data volume mount, backed by the specified EBS volume. When this method is used, the EBS volume must already exist.

```
volumes:
  data:
    mode: volume
    volume:
      awsElasticBlockStore:
        volumeID: "vol-0795be227aff63b2a"
        fsType: ext4
```

Set file permissions on mounted volumes

The Neo4j helm chart supports an additional field not present in normal Kubernetes volume objects:
setOwnerAndGroupWritableFilePermissions: true|false. If set to true, an initContainer will be run to
modify the file permissions of the mounted volume, so that the contents can be written and read by the Neo4j process. This is to help with certain volume implementations that are not aware of the SecurityContext set on pods using them.

Example - reference an existing PersistentVolume

The backups volume mount, backed by the specified PVC. When this method is used, the persistentVolumeClaim object must already exist.

```
volumes:
  backups:
    mode: volume
    volume:
      setOwnerAndGroupWritableFilePermissions: true
      persistentVolumeClaim:
        claimName: my-neo4j-pvc
```

**mode: selector**

**Description**

The volume to use is chosen from the existing PVs based on the provided selector object and a PVC, which is dynamically generated.

If no matching PVs exist, the Neo4j pod will be unable to start. To match, a PV must have the specified StorageClass, match the label selectorTemplate, and have sufficient storage capacity to meet the requested storage amount.

**Example**

The data volume, chosen from the available volumes with the neo4j storage class and the label developer: alice.

```
volumes:
  import:
    mode: selector
    selector:
      storageClassName: "neo4j"
      requests:
        storage: 128Gi
      selectorTemplate:
        matchLabels:
          developer: "alice"
```

For the data volume, if requests.storage is not set, selector will default to a 100Gi volume. For all other volumes, selector.requests.storage must be set explicitly when using selector mode.

**mode: volumeClaimTemplate**

**Description**

A complete Kubernetes volumeClaimTemplate object is specified for the volume mount. Generally, volumes specified in this way are dynamically provisioned. For details of how to specify volumeClaimTemplate objects, see the Kubernetes documentation.
In all cases, do not forget to set the `mode` field when customizing the volumes object. If not set, the default `mode` is used, regardless of the other properties set on the `volume` object.

5.6.4. Provision persistent volumes with Neo4j Helm Chart

With the Neo4j Helm Charts, you can provision a PV manually or dynamically, using the default or a custom `StorageClass`.

- Manual provisioning of persistent volumes. **Recommended**
  Must be labeled with an `app` label that matches the release name of your Neo4j Helm deployment.

- Dynamic provisioning using the default `StorageClass`. Recommended only for small-scale development work.

- Dynamic provisioning using a dedicated `StorageClass`.

Provision persistent volumes manually

You provision a PV for Neo4j to use by explicitly creating it (for example, using `kubectl create -f persistentVolume.yaml`) before installing the Neo4j Helm release. If no suitable PV exists, the Neo4j pod will not start.

Why prefer manual provisioning?

- Manual provisioning provides the strongest protection against the automatic removal of volumes containing critical data.

- The performance of Neo4j is very dependent on the latency, IOPS capacity, and throughput of the storage it is using. Manual provisioning is the best way to ensure the underlying storage is configured for Neo4j performance.

- Explicitly configuring the underlying storage before installing Neo4j is worthwhile because changing the underlying storage after installation while preserving the data stored in Neo4j, is difficult and may cause significant Neo4j downtime.

Link a Neo4j Helm release to the manually provisioned volumes

A Neo4j Helm release uses only manually provisioned PVs that have:

- `storageClassName` set to `manual`

- An `app` label — set in their metadata, which matches the name of the Neo4j Helm release.

- Sufficient storage capacity — the PV capacity must be greater than or equal to the value of `volumes.data.selector.requests.storage` set for the Neo4j Helm release (default is `100Gi`).

For example, if the release name is `my-neo4j-release` and the requested storage is `100Gi`, then the PV object must have `storageClassName`, `app` label, and `capacity` as shown in this example:
Then, you install the Neo4j release using the same name:

```bash
helm install "my-neo4j-release" neo4j/neo4j-standalone
```

Configure the Neo4j Helm release for manual provisioning

The Neo4j helm chart uses manual provisioning by default, so it is unnecessary to set any chart values explicitly. The following default values are used for manual provisioning:

```yaml
volumes:
  data:
    mode: "selector"
    selector:
      storageClassName: "manual"
      requests:
        storage: 100Gi
```

With this method, a PVC is dynamically generated for the manually provisioned PV.

An alternative method for manual provisioning is to use a manually provisioned PVC. This is supported by the Neo4j Helm Chart using the `volume` mode. For example, to use a pre-existing PVC called `my-neo4j-pvc` set these values:

```yaml
volumes:
  data:
    mode: "volume"
    volume:
      persistentVolumeClaim:
        claimName: my-neo4j-pvc
```

Configure manual provisioning of persistent volumes

The instructions for manually provisioning PVs vary according to the type of PV being used and the underlying infrastructure. In general, there are two steps:

1. Create the disk/volume to be used for storage in the underlying infrastructure. For example:
   - If using a `gcePersistentDisk` volume — in Google Compute Engine, create the Persistent Disk.
   - If using a `hostPath` volume — on the host node, create the path (directory).
2. Create a PV in Kubernetes that references the underlying resource created in step 1.
   - Ensure that the created PV’s `app` label matches the name of the Neo4j Helm release.
b. Ensure that the created PV’s capacity.storage matches the storage available on the underlying infrastructure.

The performance of Neo4j is very dependent on the latency, IOPS capacity, and throughput of the storage it is using. For the best performance of Neo4j, use the best available disks (e.g., SSD) and set IOPS throttling/quotas to high values. For some cloud providers, IOPS throttling is proportional to the size of the volume. In these cases, the best performance is achieved by setting the size of the volume based on the desired IOPS rather than the amount required for data storage.

Provision a persistent volume

Platform-specific instructions for provisioning PVs can be found in the Create a persistent volume section.

Reuse a persistent volume

After uninstalling the Neo4j Helm Chart, both the PVC and the PV remain and can be reused by a new install of the helm chart. If you delete the PVC, the PV moves into a Released status and will not be reusable.

To be able to reuse the PV by a new install of the Neo4j Helm Chart, remove its connection to the previous PVC:

1. Edit the PV by running the following command:

   kubectl edit pv <pv-name>

2. Remove the section spec.claimRef.

The PV goes back to the Available status and can be reused by a new install of the Neo4j Helm Chart.

Provision persistent volumes dynamically

When using dynamic provisioning, the Neo4j release depends on Kubernetes to create a PV on-demand when Neo4j is installed.

For more information on dynamic provisioning, see the Kubernetes official documentation.

Why use dynamic provisioning?

Dynamic provisioning of PV for Neo4j is a good choice for development and test environments, where the ease of installation is more important than flexibility in managing the underlying storage and preservation of the stored data in all situations. With dynamic provisioning, a Neo4j Helm release uses either a specific Kubernetes StorageClass or the default StorageClass of the running Kubernetes cluster.

Using the default StorageClass is the quickest way to spin up and run Neo4j for simple tests, handling small amounts of data. However, it is not recommended for large amounts of data, as it may lead to
It is recommended to create a dedicated StorageClass for Neo4j so that the underlying storage configuration can be specified to match the Neo4j usage as much as possible.

The `volumes` object in the Neo4j `values.yaml` file is used to configure dynamic provisioning.

Use the default `StorageClass` to dynamically provision persistent volumes

To use the default `StorageClass` and a storage size 100Gi, set the following values:

```yaml
volumes:
  data:
    mode: "defaultStorageClass"
  defaultStorageClass:
    requests:
      storage: 100Gi
```

Use a dedicated `StorageClass` to dynamically provision persistent volumes

To use a dedicated `StorageClass`, you define it in a YAML file and create it using `kubectl create`. The permitted specification values depend on the provisioner being used. Full details of `StorageClass` specification are covered in the Kubernetes official documentation.

`StorageClass` called `neo4j-storage` that has a storage size 100Gi

```yaml
volumes:
  import:
    mode: dynamic
dynamic:
  storageClassName: "neo4j-storage"
  requests:
    storage: 1Ti
```

The performance of Neo4j is very dependent on the latency, IOPS capacity, and throughput of the storage it is using. For the best performance of Neo4j, use the best available disks (e.g., SSD) and set IOPS throttling/quotas to high values. For some cloud providers, IOPS throttling is proportional to the size of the volume. In these cases, the best performance is achieved by setting the size of the volume based on the desired IOPS rather than the amount required for data storage.

5.7. Access a Neo4j standalone server

This section describes how to access a Neo4j DBMS running on Kubernetes.

A Neo4j DBMS is accessible via Kubernetes Services. Neo4j has a number of different interfaces for different application and operational purposes. For more details, see Neo4j ports.
5.7.1. Supported Kubernetes services

The Neo4j Helm chart publishes three K8s services:

- **Neo4j Service** — a ClusterIP service for application `neo4j/bolt` and `http(s)` connections to the Neo4j database, originating from inside the Kubernetes cluster.

- **Admin Service** — a “Headless” (DNS only) service that includes all Neo4j ports. It is only available inside the Kubernetes cluster and access to it should be guarded. The Admin service can be used for Neo4j DBMS administration, performing backups, and collecting metrics.

- **External** — a LoadBalancer service for application `neo4j/bolt` and `http(s)` connections originating from outside the Kubernetes cluster.

<table>
<thead>
<tr>
<th>Neo4j Interface</th>
<th>Default Port</th>
<th>Neo4j Service</th>
<th>Admin Service</th>
<th>External Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolt (neo4j:// and</td>
<td>7687</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>bolt:// protocols)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neo4j Browser HTTP</td>
<td>7474</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Neo4j Browser HTTPS</td>
<td>7473</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Neo4j Cypher HTTP API</td>
<td>7474</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Neo4j Cypher HTTPS API</td>
<td>7473</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Neo4j Backup</td>
<td>6362</td>
<td>No</td>
<td>Yes</td>
<td>No but configurable</td>
</tr>
<tr>
<td>Graphite Monitoring</td>
<td>2003</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Prometheus Metrics</td>
<td>2004</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Java Management</td>
<td>3637</td>
<td>No</td>
<td>No but configurable</td>
<td>No</td>
</tr>
<tr>
<td>Extensions (JMX)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*The Admin service bypasses health checks. This allows it to be used to make connections for administrative purposes when the database is in an unhealthy state. However, you must not use it to connect from applications that require the database to be in a healthy state.*

5.7.2. Applications accessing Neo4j from inside Kubernetes

Access Neo4j using DNS

To access Neo4j from an application in the same Kubernetes cluster use the Neo4j service DNS address `<release-name>.<namespace>.svc.<cluster_domain>`.

The default cluster domain is `cluster.local` and the default namespace is `default`. Generally, the Neo4j service DNS address is `<release-name>.default.svc.cluster.local`.

For example, if using the release name `my-release` in the `default` namespace, the cluster’s DNS address would be `my-release.default.svc.cluster.local`, and the `bolt` address for use with Neo4j drivers would
be neo4j://my-release.default.svc.cluster.local:7687.

Access Neo4j using K8s label selector

Alternatively, the Neo4j service in Kubernetes can be located using Kubernetes service discovery by searching with the label selector: helm.neo4j.com/service=neo4j,helm.neo4j.com/instance=<release-name>.

For example:

```
# install neo4j
helm install "my-release" ...
# lookup installed service
kubectl get service -l helm.neo4j.com/service=neo4j,helm.neo4j.com/instance=my-release
```

Ad-hoc external access using kubectl port-forward

In most cases, it is possible to access the Neo4j service from a developer machine outside the Kubernetes cluster using kubectl port-forward. To access the Neo4j service for http(s) and neo4j/bolt from a developer machine, use the following command:

```
kubectl port-forward svc/<release-name> tcp-bolt tcp-http tcp-https
```

Neo4j is accessible via the Neo4j browser at http://localhost:7474.

5.7.3. Applications accessing Neo4j from outside Kubernetes

To access Neo4j from an application outside the Kubernetes cluster, use the IP address of the external service. The external IP(s) of the LoadBalancer can be found using kubectl:

- Using with the service name <release-name>-external:
  
  ```
  kubectl get service <release-name>-external -ocustom-columns=ip:.status.loadBalancer.ingress[].ip
  ```

- Using a label selector:
  
  ```
  kubectl get service -l helm.neo4j.com/service=external,helm.neo4j.com/name=<release-name> -ocustom -columns=ip:.status.loadBalancer.ingress[].ip
  ```

If the Kubernetes LoadBalancer implementation that you are using supports setting a static IP, the IP address of the LoadBalancer can be configured in the Neo4j Helm release by setting externalService.loadBalancerIP. If a static IP address is not explicitly set, then Kubernetes does not guarantee that a dynamically assigned IP address will not change.

When exposing a Neo4j database on the Internet, it is recommended to use a static IP and configure SSL on the exposed services. For more information, see Configure SSL.

If you have static IPs, you can associate DNS with them and obtain trusted certificates.
The ports that are exposed on the external service can be configured in the Helm release by changing the `externalService` object. The default values are:

```yaml
externalService:
  annotations: {}  # The object can be configured by adding annotations.
  loadBalancerIP: NULL

  ports:
    http:
      enabled: true
    https:
      enabled: true
    bolt:
      enabled: true
    backup:
      enabled: false
```

Disabling / enabling a port on the `externalService` object removes it from the load balancer but does not affect whether it is disabled/enabled in Neo4j.

Backup is not secure unless SSL-with-client-auth is enforced in the Neo4j configuration.

### 5.7.4. Customizing Kubernetes Resources

The Neo4j Helm chart creates various Kubernetes resources. Some of them can be customized by adding extra configuration to the helm deployment values file.

<table>
<thead>
<tr>
<th>Customization</th>
<th>values.yaml field</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Setting a pod securityContext for the Neo4j Pod</td>
<td><code>securityContext</code></td>
<td>PodSecurityContext</td>
</tr>
<tr>
<td>Adding annotations to Services</td>
<td><code>neo4jService.annotations</code></td>
<td>Annotations object for <code>ClusterIP</code> service.</td>
</tr>
<tr>
<td></td>
<td><code>adminService.annotations</code></td>
<td>Annotations object for headless (DNS) service.</td>
</tr>
<tr>
<td></td>
<td><code>externalService.annotations</code></td>
<td>Annotations object for <code>LoadBalancer</code> service.</td>
</tr>
</tbody>
</table>

### 5.7.5. Accessing Neo4j for DBMS administration and monitoring

TheNeo4j Helm chart creates the admin service for the purposes of Neo4j administration. The admin service is a "Headless" service in Kubernetes and does not depend on Neo4j health checks. Therefore, it permits connections to Neo4j even if Neo4j is not healthy. In general, that is not desirable for applications but can be useful for administration and debugging.

**Access Neo4j using DNS**

To access the admin service inside Kubernetes use the DNS address `<release-name>-admin.<namespace>.svc.<cluster domain>`. 
For example, if using the release name `my-release` in the `default` namespace, the cluster's DNS address would be `my-release-admin.default.svc.cluster.local`.

The admin service can be used to access a range of Neo4j interfaces:

- Neo4j Bolt for Neo4j administration via Cypher commands
- Neo4j Backup for taking database backups
- Graphite for metrics collection
- Prometheus for metrics collection
- Java Management Extensions (JMX) for metrics collection and JVM administration

Access Neo4j using `kubectl` for troubleshooting

To get an interactive `cypher-shell` console for troubleshooting, use this command:

```
kubectl run -it --rm --image neo4j:4.4.10 cypher-shell -- cypher-shell -a bolt://my-release-admin.default.svc.cluster.local
```

Generally, the `neo4j://` protocol is used for connecting to Neo4j. For troubleshooting, though, the direct `bolt://` protocol is used because it allows a connection in some situations where a `neo4j://` connection will not succeed.

5.8. Access a Neo4j cluster

This section describes how to access a Neo4j cluster running on Kubernetes.

A Neo4j cluster is accessible via Kubernetes Services. Neo4j has a number of different interfaces for different application and operational purposes. For more details, see Neo4j ports.

5.8.1. Supported Kubernetes services

The Neo4j Helm chart publishes four K8s services:

- **Neo4j Service** — a ClusterIP service for application `neo4j/bolt` and `http(s)` connections to the Neo4j database, originating from inside the Kubernetes cluster.

- **Admin Service** — a "Headless" (DNS only) service that includes all Neo4j ports for admin connections to Neo4j inside Kubernetes. It is only available inside the Kubernetes cluster and access to it should be guarded. The Admin service can be used for Neo4j DBMS administration, performing backups, and collecting metrics.

- **Internal Service** — a "Headless" (DNS only) internal service that includes all Neo4j ports required for causal clustering.

- **External** — a LoadBalancer service for application `neo4j/bolt` and `http(s)` connections originating from outside the Kubernetes cluster. This service is installed using the `neo4j/neo4j-cluster-loadbalancer` Neo4j Helm Chart.
### Table 14. K8s services per Neo4j interface

<table>
<thead>
<tr>
<th>Neo4j Interface</th>
<th>Default Port</th>
<th>Neo4j Service</th>
<th>Admin Service</th>
<th>Internal Service</th>
<th>External Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolt (neo4j:// and bolt:// protocols)</td>
<td>7687</td>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Neo4j Browser HTTP</td>
<td>7474</td>
<td>Yes</td>
<td>Yes*</td>
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<td>Yes</td>
</tr>
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<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Graphite Monitoring</td>
<td>2003</td>
<td>No</td>
<td>No but configurable</td>
<td>No but configurable</td>
<td>No</td>
</tr>
<tr>
<td>Prometheus Metrics</td>
<td>2004</td>
<td>No</td>
<td>No but configurable</td>
<td>No but configurable</td>
<td>No</td>
</tr>
<tr>
<td>Java Management Extensions (JMX)</td>
<td>3637</td>
<td>No</td>
<td>No but configurable</td>
<td>No but configurable</td>
<td>No</td>
</tr>
<tr>
<td>Causal Cluster discovery management</td>
<td>5000</td>
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<td>No</td>
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<td>No</td>
</tr>
<tr>
<td>Causal Cluster transaction</td>
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<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Causal Cluster RAFT</td>
<td>7000</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Causal Cluster routing connector</td>
<td>7688</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

*The Admin service bypasses health checks. This allows it to be used to make connections for administrative purposes when the database is in an unhealthy state. However, you must not use it to connect from applications that require the database to be in a healthy state.

### 5.8.2. Applications accessing Neo4j from inside Kubernetes

#### Access Neo4j using DNS

To access Neo4j from an application in the same Kubernetes cluster use the Neo4j service DNS address `<release-name>.<namespace>.svc.<cluster domain>`.

The default cluster domain is `cluster.local` and the default namespace is `default`. Generally, the Neo4j service DNS address is `<release-name>.default.svc.cluster.local`.

For example, if using the release name `my-release` in the `default` namespace, the cluster’s DNS address
would be `my-release.default.svc.cluster.local`, and the `bolt` address for use with Neo4j drivers would be `neo4j://my-release.default.svc.cluster.local:7687`.

To allow for an application running inside Kubernetes to access the Neo4j cluster, you can also use the Neo4j headless service that is installed via the `neo4j/neo4j-cluster-headless-service` Helm Chart. For more information and a detailed example, see Access the Neo4j cluster using headless service.

Access Neo4j using K8s label selector

Alternatively, the Neo4j service (default) in Kubernetes can be located using Kubernetes service discovery by searching with the label selector: 

```
helm.neo4j.com/service=default/admin/internals,helm.neo4j.com/instance=<release-name>.
```

The following is an example of how to look up the installed services:

```bash
# Neo4j service:
kubectl get service -l helm.neo4j.com/service=default,helm.neo4j.com/instance=my-release
# Admin service:
kubectl get service -l helm.neo4j.com/service=admin,helm.neo4j.com/instance=my-release
# internals service:
kubectl get service -l helm.neo4j.com/service=internals,helm.neo4j.com/instance=my-release
```

Ad-hoc external access using `kubectl port-forward`

In most cases, it is possible to access the Neo4j service from a developer machine outside the Kubernetes cluster using `kubectl port-forward`. To access the Neo4j service for `http(s)` and `neo4j/bolt` from a developer machine, use the following command:

```bash
kubectl port-forward svc/<release-name> tcp-bolt tcp-http tcp-https
```

Neo4j is accessible via the Neo4j browser at `http://localhost:7474`.

5.8.3. Applications accessing Neo4j from outside Kubernetes

To access a Neo4j cluster from outside Kubernetes, you need to install the `neo4j-cluster-loadbalancer` service using the `neo4j/neo4j-cluster-loadbalancer` Helm Chart. For a detailed example, see Access the Neo4j cluster from outside Kubernetes.

5.8.4. Customizing Kubernetes Resources

The Neo4j Helm chart creates various Kubernetes resources. Some of them can be customized by adding extra configuration to the `helm deployment` values file.

Table 15. Supported K8s resources customizations
### Customization

<table>
<thead>
<tr>
<th>Setting a pod securityContext for the Neo4j Pod</th>
<th>values.yaml field</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>securityContext</td>
<td>PodSecurityContext</td>
</tr>
</tbody>
</table>

| Adding annotations to Services                | services.neo4j.annotations | Annotations object for ClusterIP service. |
|                                               | services.admin.annotations| Annotations object for headless (DNS) service. |
|                                               | services.internal.annotations | Annotations object for internal service. |

| Adding annotations to Load Balancer Service   | annotations           | Annotations object for LoadBalancer service. |

### 5.8.5. Accessing Neo4j for DBMS administration and monitoring

The Neo4j Helm chart creates the admin service for the purposes of Neo4j administration. The admin service is a “Headless” service in Kubernetes and does not depend on Neo4j health checks. Therefore, it permits connections to Neo4j even if Neo4j is not healthy. In general, that is not desirable for applications but can be useful for administration and debugging.

#### Access Neo4j using DNS

To access the admin service inside Kubernetes use the DNS address `<release-name>-admin.<namespace>.svc.<cluster domain>`.

For example, if using the release name `my-release` in the default namespace, the cluster’s DNS address would be `my-release-admin.default.svc.cluster.local`.

The admin service can be used to access a range of Neo4j interfaces:

- Neo4j Bolt for Neo4j administration via Cypher commands
- Neo4j Backup for taking database backups
- Graphite for metrics collection
- Prometheus for metrics collection
- Java Management Extensions (JMX) for metrics collection and JVM administration

#### Access Neo4j using `kubectl` for troubleshooting

To get an interactive `cypher-shell` console for troubleshooting, use this command:

```
kubectl run -it --rm --image neo4j:4.4.10 cypher-shell -- cypher-shell -a bolt://my-release-admin.default.svc.cluster.local
```

Generally, the `neo4j://` protocol is used for connecting to Neo4j. For troubleshooting, though, the direct `bolt://` protocol is used because it allows a connection in some situations where a `neo4j://` connection will not succeed.
5.9. Import Data

This section describes how to import data into a Neo4j database on a Kubernetes cluster.

5.9.1. Importing data into Neo4j on Kubernetes

The Neo4j Helm Chart configures a volume mount at /import as the Neo4j import directory, as described in File locations. You place all the files that you want to import in this volume.

To import data from CSV files into Neo4j, use the command `neo4j-admin import` or the Cypher query `LOAD CSV`.

- The `neo4j-admin import` command can be used to do batch imports of large amounts of data into a previously unused database and can only be performed once per database.
- `LOAD CSV` Cypher statement can be used to import small to medium-sized CSV files into an existing database. `LOAD CSV` can be run as many times as needed and does not require an empty database. For a simple example, see Getting Started Guide → Import data.

Depending on your Neo4j configuration, some methods support fetching data to import from a remote location (e.g., using HTTP or fetching from cloud object storage). Therefore, it is not always necessary to place the source data files in the Neo4j import directory.

5.9.2. Configure the import volume mount

The default configuration of the /import volume mount is to share the /data volume mount. Generally, this is sufficient, and it is unnecessary to explicitly configure an import volume in the Helm deployment's `values.yaml` file. For the full details of configuring volume mounts for a Neo4j Helm deployment, see Volume mounts and persistent volumes.

This example shows how to configure /import to use a dynamically provisioned Persistent Volume of the default StorageClass:

```
volumes:
  import:
    mode: "defaultStorageClass"
    defaultStorageClass:
      requests:
        storage: 100Gi
```

5.9.3. Copy files to the import volume using `kubectl cp`

Files can be copied to the import volume using `kubectl cp`. This example shows how to copy a local directory `my-files/` to `/import/files-1` to a Neo4j instance with the release name `my-graph-db` in the namespace `default`. 

---

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Instead of using `kubectl cp`, data can also be loaded onto the `/import` directory by:

- using an additional container or `initContainer` to load data.
- using `kubectl exec` to run commands to load data.
- mounting a volume that is already populated with data.

Data must be placed in the volume’s `/import` directory.

### 5.9.4. Use `neo4j-admin import`

The simplest way to run `neo4j-admin import` is to use `kubectl exec` to run it in the Neo4j container. However, running `neo4j-admin import` to perform a large import in the same container as the Neo4j process may cause resource contention problems, including causing either or both processes to be OOM Killed by the node operating system. To avoid this, either use a separate container or `initContainer` or place the Neo4j Helm deployment in offline maintenance mode to run `neo4j-admin import`.

`neo4j-admin import` cannot be used to replace an existing database while Neo4j is running. To replace an existing database, either `DROP` the database or put the Neo4j Helm deployment into offline maintenance mode before running `neo4j-admin import`.

### 5.9.5. Alternative approach

An alternative approach to importing data into Neo4j is to run a separate Neo4j standalone instance outside Kubernetes, perform the import on that Neo4j instance, and then copy the resulting database into the Kubernetes-based Neo4j instance using the backup and restore or dump and load procedures.

### 5.10. Monitoring

This section describes how to see what is happening with Neo4j running on Kubernetes.

#### 5.10.1. Logging

When using the Helm Chart, Neo4j logging output is written to files in the `/logs` directory. This directory is mounted on a `PersistentVolume` so that logs are persisted if the pod is moved or restarted. For full details of Neo4j logging, see Neo4j logging.

To view the Neo4j user log (`neo4j.log`), use the command `kubectl exec`:

```bash
kubectl exec <neo4j-pod-name> -- tail -f /logs/neo4j.log
```
• To copy the log files from a Neo4j instance, use `kubectl cp`:

Copy all logs

```bash
$ kubectl cp <neo4j-pod-name>:/logs neo4j-logs/
$ ls neo4j-logs
debug.log  neo4j.log  query.log  security.log
```

5.10.2. Log collection

The Neo4j log output can be collected from the log files and sent to a unified location using tools, such as Fluentd (https://www.fluentd.org) or Logstash (https://www.elastic.co/logstash). We recommend running these either as "sidecar" containers in the Neo4j pods or as separate DaemonSets.

• For more information about Pods and the sidecar pattern, see Kubernetes Pod documentation.
• For more information about DaemonSets, see Kubernetes DaemonSet documentation.
• For more information and examples of these logging patterns, see Kubernetes cluster administration documentation.

5.10.3. Metrics

If Neo4j is configured to listen for Graphite, JMX, or Prometheus connections for metrics, those services can be accessed as described in Access a Neo4j Helm release.

The Helm Chart supports standard Neo4j metrics configuration settings, for example:

```yaml
# To listen for Prometheus connections
# Neo4j configuration (yaml format)
config:
  metrics.prometheus.enabled: "true"
  metrics.prometheus.endpoint: "0.0.0.0:2004"

# To publish Graphite connections
# Neo4j configuration (yaml format)
config:
  metrics.graphite.enabled: "true"
  metrics.graphite.interval: "3s"
  metrics.graphite.server: "graphite.default.svc.cluster.local:2003"

# To write CSV metrics
# Neo4j configuration (yaml format)
config:
  metrics.csv.enabled: "true"
  metrics.csv.interval: "10s"

# To enable JMX
# Neo4j configuration (yaml format)
config:
  metrics.jmx.enabled: "true"
```

For more information and examples, see Neo4j metrics.
5.11. Operations

The section describes some operations when running Neo4j in a Kubernetes cluster.

5.11.1. Online Maintenance

Online maintenance does not require stopping the neo4j process. It is performed using the command kubectl exec.

To directly run tasks:

```bash
kubectl exec <release-name>-0 -- neo4j-admin store-info --all /var/lib/neo4j/data/databases --expand-commands
```

All neo4j-admin commands need the --expand-commands flag to run in the Neo4j container. This is because the Neo4j Helm Chart defines the Neo4j configuration using command expansion to dynamically resolve some configuration parameters at runtime.

To run a series of commands, use an interactive shell:

```bash
kubectl exec -it <release-name>-0 -- bash
```

Processes executed using kubectl exec count towards the Neo4j container's memory allocation. Therefore, running tasks that use a significant amount of memory or running Neo4j in an extremely memory-constrained configuration could cause the Neo4j container to be terminated by the underlying Operating System.

5.11.2. Offline Maintenance

You use the Neo4j offline maintenance mode to perform maintenance tasks that require Neo4j to be offline. In this mode, the neo4j process is not running. However, the Neo4j Pod does run, but it never reaches the status READY.

Put the Neo4j instance in offline mode

1. To put the Neo4j instance in offline maintenance mode, you set the offlineMaintenanceModeEnabled: true and upgrade the helm release.

   a. You can do that by using the values.yaml file:

      a. Open your values.yaml file and add offlineMaintenanceModeEnabled: true to the neo4j object:

      ```yaml
      neo4j:
        offlineMaintenanceModeEnabled: true
      ```

      b. Run helm upgrade to apply the changes:
helm upgrade <release-name> neo4j/neo4j-standalone -f values.yaml

Alternatively, you can set neo4j.offlineMaintenanceModeEnabled to true as part of the helm upgrade command:

helm upgrade <release-name> neo4j/neo4j-standalone --version={neo4j-version-exact} --set neo4j.offlineMaintenanceModeEnabled=true

2. Poll kubectl get pods until the pod has restarted (STATUS=Running).

kubectl get pod <release-name>-0

3. Connect to the pod with an interactive shell:

kubectl exec -it "<release-name>-0" -- bash

4. View running java processes:

jps

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The result shows no running java process other than jps itself.

Run task in offline mode

Offline maintenance tasks are performed using the command kubectl exec.

- To directly run tasks:

kubectl exec <release-name>-0 -- neo4j-admin store-info --all /var/lib/neo4j/data/databases --expand -commands

- To run a series of commands, use an interactive shell:

kubectl exec -it <release-name>-0 -- bash

- For long-running commands, use a shell and run tasks using nohup so they continue if the kubectl exec connection is lost:

kubectl exec -it <release-name>-0 -- bash

$ nohup neo4j-admin check-consistency --database=neo4j --expand-commands &>job.out </dev/null

$ tail -f job.out
Put the Neo4j DBMS in online mode

When you finish with the maintenance tasks, return the Neo4j instance to a normal operation:

- You can do that by using the values.yaml file:
  1. Open your values.yaml file and add `offlineMaintenanceModeEnabled: false` to the `neo4j` object:
     ```yaml
     neo4j:
       offlineMaintenanceModeEnabled: false
     ```
  2. Run `helm upgrade` to apply the changes:
     ```shell
     helm upgrade <release-name> neo4j/neo4j-standalone -f values.yaml
     ```
  - Alternatively, you can run `helm upgrade` with the flag set to `false`:
    ```shell
    helm upgrade <release-name> neo4j/neo4j-standalone --version={neo4j-version-exact} --set neo4j.offlineMaintenanceModeEnabled=false
    ```

5.11.3. Reset the neo4j user password

You reset the neo4j user password by disabling authentication and then re-enabling it.

1. In the values.yaml file, set `dbms.security.auth_enabled:` to `false` to disable the authentication:
   ```yaml
   # Neo4j Configuration (yaml format)
   config:
     dbms.security.auth_enabled: "false"
   ```
2. Run the following command to apply the changes:
   ```shell
   helm upgrade <release-name> neo4j/neo4j-standalone -f values.yaml
   ```
   Authentication is now disabled.
3. Connect with `cypher-shell` and set the desired password:
   ```sql
   ALTER USER neo4j SET PASSWORD '<new-password>'
   ```
4. Update the Neo4j configuration to enable authentication:
# Neo4j Configuration (yaml format)

```yaml
config:
  dbms.security.auth_enabled: "true"
```

5. Run the following command to apply the update and re-enable authentication:

```
helm upgrade <release-name> neo4j/neo4j-standalone -f values.yaml
```

Authentication is now enabled, and the Neo4j user password has been reset to the desired password.

5.11.4. Dump and load databases (offline)

You can use the `neo4j-admin dump` command to make a full backup (an archive) of an offline database(s) and `neo4j-admin load` to load it back into a Neo4j deployment. These operations are performed in offline maintenance mode.

**Dump the `neo4j` and `system` databases**

1. Put the Neo4j instance in offline mode.
2. Dump `neo4j` and `system` databases:

   ```
   neo4j-admin dump --expand-commands --database=system --to /backups/system.dump && neo4j-admin dump --expand-commands --database=neo4j --to /backups/neo4j.dump
   ```
3. Put the Neo4j DBMS in online mode.
4. Verify that Neo4j is working by refreshing Neo4j Browser.

   ![For information about the command syntax, options, and usage, see Back up an offline database.](image)

**Load the `neo4j` and `system` databases**

1. Put the Neo4j instance in offline mode.
2. Run `neo4j-admin load` commands:

   ```
   neo4j-admin load --expand-commands --database=system --from /backups/system.dump && neo4j-admin load --expand-commands --database=neo4j --from /backups/neo4j.dump
   ```
3. Put the Neo4j DBMS in online mode.
4. Verify that Neo4j is working by refreshing Neo4j Browser.

   ![For information about the command syntax, options, and usage, see Restore a database dump.](image)
5.11.5. Back up and restore a single database (online) Enterprise edition

You can use the `neo4j-admin backup` command to make a full or incremental backup of an online database(s) and `neo4j-admin restore` to restore it in a live Neo4j DBMS or cluster. These operations are performed in online maintenance mode.

For performing backups, Neo4j uses the Admin Service, which is only available inside the Kubernetes cluster and access to it should be guarded. For more information, see Access the Neo4j cluster from inside Kubernetes and Access the Neo4j cluster from outside Kubernetes.

Back up a single database

The `neo4j-admin backup` command can be run both from the same and a separate pod. However, it uses resources (CPU, RAM) in the Neo4j container (competing with Neo4j itself), because it checks the database consistency at the end of every backup operation. Therefore, it is recommended to run the operation in a separate pod.

In the Neo4j Helm Charts, the backup configurations are set by default to `dbms.backup.enabled=true` and `dbms.backup.listen_address=0.0.0.0:6362`.

Note that the default for Neo4j on-site installations is to listen only on 127.0.0.1, which will not work from other containers, since they would not be able to access the backup port.

Back up a database from a separate pod

1. Create a Neo4j instance pod to get access to the `neo4j-admin` command:

   ```bash
   kubectl run --rm -it --image "neo4j:4.4.10-enterprise" backup -- bash
   ```

2. Run the following command to back up the database you want. In this example, this is the `neo4j` database. The command is the same for standalone instances and Neo4j cluster members.

   ```bash
   bin/neo4j-admin backup --from=my-neo4j-release-admin.default.svc.cluster.local:6362 --database=neo4j --backup-dir=/backups --expand-commands
   ```

Restore a single database

To restore a single offline database or a database backup, you first need to delete the database that you want to replace unless you want to restore the backup as an additional database in your DBMS, then use the restore command of `neo4j-admin` to restore the database backup, and finally, use the Cypher command `CREATE DATABASE name` to create the restored database in the `system` database.
Delete the database that you want to replace

Before you restore the database backup, you have to delete the database that you want to replace with that backup using the Cypher command `DROP DATABASE name` against the `system` database. If you want to restore the backup as an additional database in your DBMS, then you can proceed to the next section.

For Neo4j cluster deployments, you run the Cypher command `DROP DATABASE name` only on one of the cluster members. The command is automatically routed to the leader and from there to the other cluster members.

1. Connect to the Neo4j DBMS:

   ```
   kubectl exec -it <release-name>-0 -- bash
   ```

2. Connect to the `system` database using `cypher-shell`:

   ```
   cypher-shell -u neo4j -p <password> -d system
   ```

3. Drop the database you want to replace with the backup:

   ```
   DROP DATABASE neo4j;
   ```

4. Exit the Cypher Shell command-line console:

   ```
   :exit;
   ```

Restore the database backup

You use the `neo4j-admin restore` command to restore the database backup, and then the Cypher command `CREATE DATABASE name` to create the restored database in the `system` database. For information about the command syntax, options, and usage, see Restore a database backup.

1. Restore the `neo4j` database backup.

   For Neo4j cluster deployments, restore the database backup on each cluster member.

2. Run the `neo4j-admin restore` command:

   ```
   neo4j-admin restore --database=neo4j --from=/backups/neo4j --expand-commands
   ```

3. Connect to the `system` database using `cypher-shell`:

   ```
   cypher-shell -u neo4j -p <password> -d system
   ```
4. Create `neo4j` database.

```
CREATE DATABASE neo4j;
```

For Neo4j cluster deployments, you run the Cypher command `CREATE DATABASE name` only on one of the cluster members.

5. Open the browser at `http://<external-ip>:7474/browser/` and check that all data has been successfully restored.

6. Execute a Cypher command against the `neo4j` database, for example:

```
MATCH (n) RETURN n
```

If you have backed up your database with the option `--include-metadata`, you can manually restore the users and roles metadata. For more information, see Restore a database backup → Example.

To restore the `system` database, follow the steps described in Dump and load databases (offline).

5.11.6. Upgrade the Neo4j DBMS on Kubernetes

To upgrade from Neo4j Community to Enterprise edition, run:

```
helm upgrade <release-name> neo4j/neo4j-standalone --set neo4j.edition=enterprise --set neo4j.acceptNeo4jLicenseAgreement=yes
```

To upgrade to the next patch release of Neo4j, update your Neo4j `values.yaml` file and upgrade the helm release.

1. Open the `values.yaml` file, using the code editor of your choice, and add the following line to the `image` object:

```
image:
  customImage: neo4j:4.4.10
```

2. Run `helm upgrade` to apply the changes:

```
helm upgrade <release-name> neo4j/neo4j-standalone -f values.yaml
```

5.11.7. Migrate Neo4j from the Labs Helm charts to the Neo4j Helm charts (offline)

To migrate your Neo4j deployment from the Labs Helm charts to the Neo4j Helm charts, back up your
standalone instance or cluster created with the Labs Helm charts and restore it in a standalone instance or a cluster created using the Neo4j Helm charts.

Neo4j supports the following migration paths for a single instance and a cluster:

**Single instance**

- From the Labs Helm charts 3.5 or earlier to either Neo4j Helm charts 4.3 or 4.4 — upgrade your Neo4j deployment to whichever version you want to move to using the steps in the [https://neo4j.com/labs/neo4j-helm/1.0.0/](https://neo4j.com/labs/neo4j-helm/1.0.0/) and then migrate from the Labs Helm charts (4.3 or 4.4) to Neo4j Helm charts 4.3 or 4.4 using the steps described here.

- From the Labs Helm charts 4.3 to Neo4j Helm charts 4.3 — follow the steps described here.

- From the Labs Helm charts 4.3 to Neo4j Helm charts 4.4 — follow the steps described here.

**Cluster**

- From the Labs Helm charts 4.3 or 4.4 to Neo4j Helm charts 4.4 — follow the steps described here.

**Back up a Neo4j deployment created with the Labs Helm charts**

To back up your Neo4j deployment created with the Labs Helm charts, follow the steps in the Neo4j-Helm User Guide → Backing up Neo4j Containers.

**Restore your backup into a standalone or a cluster created with the Neo4j Helm charts**

If the backup exists on a cloud provider, you can take one of the following approaches:

**Approach 1**

1. Create a standalone or a cluster using the Neo4j Helm charts with a custom Neo4j image that has all the cloud provider utilities to download the backup from the respective cloud provider storage to your specific mount.

2. Restore the backup following the steps described in Restore a single database.

**Approach 2**

1. Get the backup on your local machine.

2. Copy the backup to the respective mount in your new cluster created using the Neo4j Helm charts, using the command `kubectl cp <local-path> <pod>:<path>`. For example,

   ```bash
   kubectl cp /Users/username/Desktop/backup/4.3.3/neo4j standalone-0:/tmp/
   ```

   where the /tmp directory refers to the mount.

3. Restore the backup following the steps described in Restore a single database.

**5.11.8. Scale a Neo4j deployment**

Neo4j supports both vertical and horizontal scaling.
Vertical scaling

To increase or decrease the resources (CPU, memory) available to a Neo4j instance, change the `neo4j.resources` object in the values.yaml file to set the desired resource usage, and then perform a helm upgrade.

If you change the memory allocated to the Neo4j container, you should also change the Neo4j's memory configuration (`dbms.memory.heap.max_size` and `dbms.memory.pagecache.size` in particular). See Configure Resource Allocation for more details.

For example, if your running Neo4j instance has the following allocated resources:

```yaml
# values.yaml
neo4j:
  resources:
    cpu: "1"
    memory: "3Gi"

# Neo4j Configuration (yaml format)
config:
  dbms.memory.heap.initial_size: "2G"
  dbms.memory.heap.max_size: "2G"
  dbms.memory.pagecache.size: "500m"
```

And, you want to increase them to 2 CPUs and 4 GB of memory (allocating additional memory to the pagecache).

1. Modify the `values.yaml` file to set the desired resource usage:

```yaml
# values.yaml
neo4j:
  resources:
    cpu: "2"
    memory: "4Gi"

# Neo4j Configuration (yaml format)
config:
  dbms.memory.heap.initial_size: "2G"
  dbms.memory.heap.max_size: "2G"
  dbms.memory.pagecache.size: "1G"
```

2. Run `helm upgrade` with the modified deployment `values.yaml` file and the respective Helm Chart (`neo4j/neo4j-standalone`, `neo4j/neo4j-cluster-core`, or `neo4j/neo4j-cluster-read-replica`) to apply the changes. For example:

   ```bash
code
   helm upgrade <release-name> neo4j/neo4j-standalone -f values.yaml
   ```

Horizontal scaling

You can add a new core member or a read replica to the Neo4j cluster to scale out write or read workloads.

1. In the Kubernetes cluster, verify that you have a node that you can use for the new Neo4j cluster member.
2. Create a persistent disk for the new Neo4j cluster member to be used for its data volume mount. For more information, see Create a persistent volume for each cluster member and Volume mounts and persistent volumes.

3. Create a Helm deployment YAML file for the new Neo4j cluster member with all the configuration settings and the disk you have created for it. For more information, see Create Helm deployment values files and Configure a Neo4j Helm deployment.

4. Install the new member using the command `helm install`, the deployment values.yaml file, and the respective Helm Chart (neo4j/neo4j-cluster-core or neo4j/neo4j-cluster-read-replica). For example:

   ```sh
helm install rr-2 neo4j/neo4j-cluster-read-replica -f rr-2.values.yaml
   ```

5.11.9. Use custom images from private registries

Neo4j 4.4.4 introduces the support for using custom images from private registries by adding new or existing imagePullSecrets.

Add an existing imagePullSecret

You can use an existing imagePullSecret for your Neo4j deployment by specifying its name in the values.yaml file. Neo4j Helm charts will check if the provided imagePullSecret exists in the Kubernetes cluster and use it. If a secret with the given name does not exist in the cluster, Helm Charts will throw an error.

Using an already existing secret mysecret

```yaml
# values.yaml
# Override image settings in Neo4j pod
image:
  imagePullPolicy: IfNotPresent
  # set a customImage if you want to use your own docker image
customImage: demo_neo4j_image:v1

#imagePullSecrets list
imagePullSecrets:
- "mysecret"
```

Create and add a new imagePullSecret

You can create a new imagePullSecret for your Neo4j deployment by defining an equivalent imageCredential in the values.yaml file.

Neo4j Helm charts will create a secret with the given name and use it as an imagePullSecret to pull the custom image defined. The following example shows how to define a private docker registry mysecret imageCredential.
Creating and adding `mysecret` as the `imagePullSecret` to the cluster.

```yaml
# values.yaml
# Override image settings in Neo4j pod
image:
  imagePullPolicy: IfNotPresent
  # set a customImage if you want to use your own docker image
  customImage: demo_neo4j_image:v1

#imagePullSecrets list
imagePullSecrets:
  - "mysecret"

#imageCredentials list for which secret of type docker-registry will be created automatically using the details provided
  # registry, username, password, email are compulsory fields for an imageCredential, without any helm chart will throw an error
  # imageCredential name should be part of the imagePullSecrets list or else the respective imageCredential will be ignored and no secret creation will be done
imageCredentials:
  - registry: "https://index.docker.io/v1/
    username: "demouser"
    password: "demopass123"
    email: "demo@company1.com"
    name: "mysecret"
```

5.11.10. Assign Neo4j pods to specific nodes

From version 4.4.5, Neo4j provides support for assigning Neo4j pods to specific nodes using `nodeSelector` labels.

You specify the `nodeSelector` labels in the `values.yaml` file.

If there is no node with the given labels, the Helm chart will throw an error.

### nodeSelector labels in values.yaml

```yaml
#nodeSelector labels
# Ensure the respective labels are present on one of the cluster nodes or else Helm charts will throw an error.
nodeSelector:
  nodeNumber: one
  name: node1
```

5.12. Troubleshooting

Troubleshooting information that can help you diagnose and correct a problem.

5.12.1. Locate and investigate problems with the Neo4j Helm Chart

The rollout of the Neo4j Helm Chart in Kubernetes can be thought of in these approximate steps:

1. Neo4j Pod is created.
2. Neo4j Pod is scheduled to run on a specific Kubernetes Node.
3. All Containers in the Neo4j Pod are created.
4. InitContainers in the Neo4j Pod is run.
5. Containers in the Neo4j Pod are run.

6. Startup and Readiness probes are checked.

After all these steps are completed successfully, the Neo4j StatefulSet, Pod, and Services must be in a ready state. You should be able to connect to and use your Neo4j database.

If the Neo4j Helm Chart is installed successfully, but Neo4j is not starting and reaching a ready state in Kubernetes, then troubleshooting has two steps:

1. Check the state of resources in Kubernetes using kubectl get commands. This will identify which step has failed.
2. Collect the information relevant to that step.

Depending on the failed step, you can collect information from Kubernetes (e.g., using kubectl describe) and from the Neo4j process (e.g., checking the Neo4j debug log).

The following table provides simple steps to get started investigating problems with the Neo4j Helm Chart rollout. For more information on how to debug applications in Kubernetes, see the Kubernetes documentation.

Table 16. Investigating problems with the Neo4j Helm Chart rollout

<table>
<thead>
<tr>
<th>Step</th>
<th>Diagnosis</th>
<th>Further investigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neo4j Pod created</td>
<td>If kubectl get pod &lt;release-name&gt;-0 does not return a single Pod result, there is a problem with the pod creation.</td>
<td>Describe the Neo4j StatefulSet — check the output of kubectl describe statefulset &lt;release-name&gt;.</td>
</tr>
<tr>
<td>Neo4j Pod scheduled</td>
<td>If the state, shown in kubectl get pod &lt;release-name&gt;-0, is stuck in Pending, there is a problem with pod scheduling.</td>
<td>Describe the Neo4j Pod kubectl describe pod &lt;release-name&gt;-0 and check the output.</td>
</tr>
<tr>
<td>Containers in the Neo4j Pod created</td>
<td>If the state, shown in kubectl get pod &lt;release-name&gt;-0, is stuck in Waiting, there is a problem with creating or starting containers.</td>
<td>Describe the Neo4j Pod — check the output of kubectl describe pod &lt;release-name&gt;-0, paying particular attention to Events.</td>
</tr>
<tr>
<td>InitContainers in the Neo4j Pod</td>
<td>If the state, shown in kubectl get pod &lt;release-name&gt;-0, is stuck in Init: (e.g., Init:CrashLoopBackOff, Init:Error etc.), there is a problem with InitContainers. Note that if the pod Status is PodInitializing or Running, then InitContainers have already finished successfully.</td>
<td>Describe the Neo4j Pod — check the output of kubectl describe pod &lt;release-name&gt;-0, paying particular attention to InitContainer (note the InitContainer names) and Events. Fetch InitContainer logs using kubectl logs &lt;pod-name&gt; -c &lt;init-container-name&gt;.</td>
</tr>
</tbody>
</table>
Containers in the Neo4j Pod running  If the state, shown in `kubectl get pod <release-name>-0`, does NOT match any of the states listed above, but the Pod still does not reach `Running`, then there is a problem running containers in the Neo4j Pod.

Describe the Neo4j Pod — check the output of `kubectl describe pod <release-name>-0`, paying particular attention to the Container state (note the Container names) and Events. Fetch Container logs using `kubectl logs <pod-name> -c <init-container-name>`. If the Neo4j Container is starting but exits unexpectedly (e.g., the state is `CrashLoopBackOff`), follow the instructions for Neo4j crashes or restarts unexpectedly.

Startup and Readiness Probes  If the state, shown in `kubectl get pod <release-name>-0`, is `Running`, but the pod does not become ready, there is a problem with Startup or Readiness probes.

Describe the Neo4j Pod — check the output of `kubectl describe pod <release-name>-0`, paying particular attention to Events and probes. Check the pod log `kubectl logs <release-name>-0`, the Neo4j log `kubectl exec <release-name>-0 -- tail -n 100 /logs/neo4j.log`, and the Neo4j debug log `kubectl exec <release-name>-0 -- tail -n 500 /logs/debug.log`.

5.12.2. Neo4j crashes or restarts unexpectedly

If the Neo4j Pod starts but then crashes or restarts unexpectedly, there are a range of possible causes. Known causes include:

- An invalid or incorrect configuration of Neo4j, causing it to shut down shortly after the container is started.
- The Neo4j Java process runs out of memory and exits with `OutOfMemoryException`.
- There has been some disruption affecting the Kubernetes Node where the Neo4j Pod is scheduled, e.g., it is being shut down or has shut down.
- Containers in the Neo4j Pod are shut down by the operating system for using more memory than the resource limit configured for the container (`OOMKilled`).
- Very long Garbage Collection pauses cause the Neo4j Pod `LivenessProbe` to fail, causing Kubernetes to restart Neo4j.

OOMKILLED and OutOfMemoryException appear very similar, but they appear in different places and have different fixes. It is important to be aware of this and be sure of which you are dealing with.

Here are some checks to help troubleshoot crashes and unexpected restarts:

Describe the Neo4j Pod

Use `kubectl` to describe the Neo4j Pod:
Check the Neo4j Container state

Check the State and Last State of the container. This shows how the Last State of a container that has restarted after being OOMKilled appears:

```
kubectl describe pod neo4j-0
```

State: Running  
Started: Mon, 1 Jan 2021 00:02:00 +0000  
Last State: Terminated  
Reason: OOMKilled  
Exit Code: 137  
Started: Mon, 1 Jan 2021 00:00:00 +0000  
Finished: Mon, 1 Jan 2021 00:01:00 +0000

Exit Code: 137 is indicative of OOMKilled if it appears here or in other logs, even if the "OOMKilled" string is not present.

Check recent Events

The `kubectl describe` output shows older events at the top and more recent events at the bottom. Generally, you can ignore older events.

A Killing event that shows that the Neo4j container was killed by the Kubernetes kubectl:

```
kubectl describe pod neo4j-0
```

<table>
<thead>
<tr>
<th>Events:</th>
<th>Type</th>
<th>Reason</th>
<th>Age</th>
<th>From</th>
<th>Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Scheduled</td>
<td>6m30s</td>
<td></td>
<td>default-scheduler</td>
<td>Successfully assigned default/neo4j-0 to k8s-node-a</td>
</tr>
<tr>
<td>Normal</td>
<td>Killing</td>
<td>56s</td>
<td></td>
<td>kubelet, k8s-node-a</td>
<td>Killing container with id docker://neo4j-0-neo4j:Need</td>
</tr>
</tbody>
</table>

It is not clear from this event log alone why Kubernetes decided that the Neo4j container should be killed.

The next steps in this example could be to check:

- if the container was OOMKilled.
- if the container failed Liveness or Startup probes.
- investigate the node to see if there was some reason why it might kill the container, e.g., `kubectl describe node <k8s node>`.
Check Neo4j logs and metrics

The Neo4j Helm Chart configures Neo4j to persist logs and metrics on provided volumes. If no volume is explicitly configured for logs or metrics, they are stored persistently on the Neo4j data volume. This ensures that the logs and metrics outputs from a Neo4j instance that crashes or shuts down unexpectedly are preserved.

Collect data from a running Neo4j Pod

- Download all Neo4j logs from a pod using `kubectl cp` commands:

  ```
  kubectl cp <neo4j-pod-name>:/logs neo4j-logs/
  ```

- If CSV metrics collection is enabled for Neo4j (the default), download all Neo4j metrics from a pod using:

  ```
  kubectl cp <neo4j-pod-name>:/metrics neo4j-metrics/
  ```

Collect data from a not running Neo4j Pod

If the Neo4j Pod is not running or is crashing so frequently that `kubectl cp` is not feasible, the Neo4j deployment should be put into offline maintenance mode to collect logs and metrics.

Check container logs

The logs for the main Neo4j DBMS process are persisted to disk and can be accessed as described in Check Neo4j logs and metrics. However, the logs for Neo4j startup and logs for other Containers in the Neo4j Pod are sent to the container’s `stdout` and `stderr` streams. These container logs can be viewed using `kubectl logs <pod name> -c <container name>`.

Unfortunately, if the container has restarted following a crash or unexpected shutdown, typically, `kubectl logs` shows the logs for the new container instance (following the restart), and the logs for the previous container instance (the instance that shut down unexpectedly) are not available via `kubectl logs`.

To capture the logs for a crashing container, you can try:

- View the container logs in a log collector/aggregator that is connected to your Kubernetes cluster, e.g., Stackdriver, Cloudwatch Logs, Logstash, etc. If you are using a managed Kubernetes platform, this is usually enabled by default.
- Use `kubectl logs --follow` to stream the logs of a running container until it crashes again.

[3] Not recommended because of inconsistencies in Docker Desktop handling of `hostPath` volumes.
Chapter 6. Configuration

This chapter describes the configuration of Neo4j components.

The topics described are:

- The neo4j.conf file — An introduction to the primary configuration file in Neo4j.
- File locations — An overview of where files are stored in the different Neo4j distributions and the necessary file permissions for running Neo4j.
- Ports — An overview of the ports relevant to a Neo4j installation.
- Configure Neo4j connectors — How to configure Neo4j connectors.
- Set initial password — How to set an initial password.
- Password and user recovery — How to recover after a lost admin password.
- Configure dynamic settings — How to configure certain Neo4j parameters while Neo4j is running.
- Transaction logs — The transaction logs record all write operations in the database.

For a complete reference of Neo4j configuration settings, see Configuration settings.

6.1. The neo4j.conf file

Introduction of the neo4j.conf file, and its syntax.

6.1.1. Introduction

The neo4j.conf file is the main source of configuration settings in Neo4j and includes the mappings of configuration setting keys to values. The location of the neo4j.conf file in the different configurations of Neo4j is listed in Default file locations.

Most of the configuration settings in the neo4j.conf file apply directly to Neo4j itself, but there are also other settings related to the Java Runtime (the JVM) on which Neo4j runs. For more information, see the JVM specific configuration settings below. Many of the configuration settings are also used by the neo4j launcher scripts.

6.1.2. Syntax

- The equals sign (=) maps configuration setting keys to configuration values.
- Lines that start with the number sign (#) are handled as comments.
- Empty lines are ignored.
- Configuring a setting in neo4j.conf will overwrite any default values. In case a setting can define a list
of values, and you wish to amend the default values with custom values, you will have to explicitly list the default values along with the new values.

- There is no order for configuration settings, and each setting in the neo4j.conf file must be uniquely specified. If you have multiple configuration settings with the same key, but different values, this can lead to unpredictable behavior.

The only exception to this is `dbms.jvm.additional`. If you set more than one value for `dbms.jvm.additional`, then each setting value will add another custom JVM argument to the java launcher.

### 6.1.3. JVM-specific configuration settings

A Java virtual machine (JVM) is a virtual machine that enables a computer to run Java programs as well as programs written in other languages that are also compiled to Java bytecode. The Java heap is where the objects of a Java program live. Depending on the JVM implementation, the JVM heap size often determines how and for how long time the virtual machine performs garbage collection.

#### Table 17. JVM-specific settings

<table>
<thead>
<tr>
<th>Setting</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>dbms.memory.heap.initial_size</code></td>
<td>Sets the initial heap size for the JVM. By default, the JVM heap size is calculated based on the available system resources.</td>
</tr>
<tr>
<td><code>dbms.memory.heap.max_size</code></td>
<td>Sets the maximum size of the heap for the JVM. By default, the maximum JVM heap size is calculated based on the available system resources.</td>
</tr>
<tr>
<td><code>dbms.jvm.additional</code></td>
<td>Sets additional options for the JVM. The options are set as a string and can vary depending on JVM implementation.</td>
</tr>
</tbody>
</table>

If you want to have good control of the system behavior, it is recommended to set the heap size parameters to the same value to avoid unwanted full garbage collection pauses.

### 6.1.4. List currently active settings

You can use the procedure `dbms.listConfig()` to list the currently active configuration settings and their values.
Example 17. List currently active configuration settings

```sql
CALL dbms.listConfig()
YIELD name, value
WHERE name STARTS WITH 'dbms.default'
RETURN name, value
ORDER BY name
LIMIT 3;
```

<table>
<thead>
<tr>
<th>name</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;dbms.default_advertised_address&quot;</td>
<td>&quot;localhost&quot;</td>
</tr>
<tr>
<td>&quot;dbms.default_database&quot;</td>
<td>&quot;neo4j&quot;</td>
</tr>
<tr>
<td>&quot;dbms.default_listen_address&quot;</td>
<td>&quot;localhost&quot;</td>
</tr>
</tbody>
</table>

See also Dynamic settings for information about dynamic settings.

6.1.5. Command expansion

Command expansion provides an additional capability to configure Neo4j by allowing you to specify scripts that set values sourced from external files. This is especially useful for:

- avoiding setting sensitive information, such as usernames, passwords, keys, etc., in the neo4j.conf file in plain text.
- handling the configuration settings of instances running in environments where the file system is not accessible.

How it works

The scripts are specified in the neo4j.conf file with a \$ prefix and the script to execute within brackets (), i.e., `dbms.setting=$(script_to_execute)`.

The configuration accepts any command that can be executed within a child process by the user who owns and executes the Neo4j server. This also means that, in the case of Neo4j set as a service, the commands are executed within the service.

A generic example would be:

```bash
neo4j.configuration.example=$(/bin/bash echo "expanded value")
```

By providing such a configuration in the neo4j.conf file upon server start with command expansion enabled, Neo4j will evaluate the script and retrieve the value of the configuration settings prior to the instantiation of Neo4j. The values are then passed to the starting Neo4j instance and kept in memory, in the running instance.
You can also use the curl (https://curl.se/docs/manpage.html) command to fetch a token or value for a configuration setting. For example, you can apply an extra level of security by replacing any sensitive information in your neo4j.conf file with a secured reference to a provider of some sort.

Scripts are run by the Neo4j process and are expected to exit with code 0 within a reasonable time. The script output should be of a valid type for the setting. Failure to do so will prevent Neo4j from starting.

Scripts and their syntax differ between operating systems.

Enabling

The Neo4j startup script and the neo4j service can expand and execute the external commands by using the argument `--expand-commands`.

```
bin/neo4j start --expand-commands
```

If the startup script does not receive the `--expand-commands` argument, commands in the configuration file will be treated as invalid settings.

Neo4j performs the following basic security checks on the neo4j.conf file. If they fail, Neo4j will not evaluate the script commands in neo4j.conf, and the Neo4j process will not start.

On Unix (both Linux and Mac OS)

- The neo4j.conf file must only be writeable (but not executable) by its owner.
- The neo4j.conf file must only be readable by its group and owner.
- The Neo4j process must run as a user who is either the owner of the neo4j.conf file or in the group of the neo4j.conf file.

The Linux permissions bitmask for the least restrictive permissions is 640. More restrictive Linux permissions are also allowed. For example, the neo4j.conf file can have no group permissions and only be readable by its owner (400 bitmask).

On Windows

- The neo4j.conf file must only be writeable (but not executable) by the user that the Neo4j process runs as.
- The neo4j.conf file must only be readable by the user that the Neo4j process runs as.

Logging

The execution of scripts is logged in neo4j.log. For each setting that requires the execution of an external command, Neo4j adds an entry into the log file that contains information, for example:

```
... Executing the external script to retrieve the value of <setting>...
```
Error Handling

The scripts' execution may generate two types of errors:

- Errors during the execution — These errors are reported in the debug.log, with a code returned from the external execution. In this case, the execution will stop and the server will not start.
- Errors for incorrect values — The returned value is not the one expected for the setting. In this case, the server will not start.

6.2. File locations

An overview of where files are stored in the different Neo4j distributions, and the necessary file permissions for running Neo4j.

6.2.1. Default file locations

The following table lists the default location of the Neo4j files, per type and distribution.

Table 18. Default file locations

<table>
<thead>
<tr>
<th>File type</th>
<th>Description</th>
<th>Linux / macOS / Docker</th>
<th>Windows</th>
<th>Debian / RPM</th>
<th>Neo4j Desktop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bin</td>
<td>The Neo4j running script and built-in tools, such as, cypher-shell and neo4j-admin.</td>
<td>&lt;neo4j-home&gt;/bin</td>
<td>&lt;neo4j-home&gt;/bin</td>
<td>/usr/bin</td>
<td></td>
</tr>
<tr>
<td>Configuration</td>
<td>The Neo4j configuration settings and the JMX access credentials.</td>
<td>&lt;neo4j-home&gt;/conf/neoj.conf</td>
<td>&lt;neo4j-home&gt;/conf/neoj.conf</td>
<td>/etc/neoj/neoj.conf</td>
<td></td>
</tr>
<tr>
<td>Data</td>
<td>All data-related content, such as databases, transactions, cluster-state (if applicable), dumps, and cypher script files (from the neo4j-admin restore command).</td>
<td>&lt;neo4j-home&gt;/data</td>
<td>&lt;neo4j-home&gt;/data</td>
<td>/var/lib/neoj/data</td>
<td></td>
</tr>
</tbody>
</table>

From the Open dropdown menu of your Neo4j instance, select Terminal, and navigate to <installation-version>/bin.
From the Open dropdown menu of your Neo4j instance, select Terminal, and navigate to <installation-version>/conf/neoj.conf.
From the Open dropdown menu of your Neo4j instance, select Terminal, and navigate to <installation-version>/data.
<table>
<thead>
<tr>
<th>File type</th>
<th>Description</th>
<th>Linux / macOS / Docker</th>
<th>Windows</th>
<th>Debian / RPM</th>
<th>Neo4j Desktop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Import</td>
<td>All CSV files that the command LOAD CSV uses as sources to import data in Neo4j.</td>
<td><code>&lt;neo4j-home&gt;/import</code></td>
<td><code>&lt;neo4j-home&gt;/import</code></td>
<td><code>/var/lib/neo4j/import</code></td>
<td>From the Open dropdown menu of your Neo4j instance, select Terminal, and navigate to <code>&lt;installation-version&gt;/import</code>.</td>
</tr>
<tr>
<td>Labs [^1]</td>
<td>Contains APOC Core.</td>
<td><code>&lt;neo4j-home&gt;/labs</code></td>
<td><code>&lt;neo4j-home&gt;/labs</code></td>
<td><code>/var/lib/neo4j/labs</code></td>
<td>From the Open dropdown menu of your Neo4j instance, select Terminal, and navigate to <code>&lt;installation-version&gt;/labs</code>.</td>
</tr>
<tr>
<td>Lib</td>
<td>All Neo4j dependencies.</td>
<td><code>&lt;neo4j-home&gt;/lib</code></td>
<td><code>&lt;neo4j-home&gt;/lib</code></td>
<td><code>/usr/share/neo4j/lib</code></td>
<td>From the Open dropdown menu of your Neo4j instance, select Terminal, and navigate to <code>&lt;installation-version&gt;/lib</code>.</td>
</tr>
<tr>
<td>Licenses</td>
<td>For storing license files from Neo4j.</td>
<td><code>&lt;neo4j-home&gt;/licenses</code></td>
<td><code>&lt;neo4j-home&gt;/licenses</code></td>
<td><code>/var/lib/neo4j/licenses</code></td>
<td>From the Open dropdown menu of your Neo4j instance, select Terminal, and navigate to <code>&lt;installation-version&gt;/licenses</code>.</td>
</tr>
<tr>
<td>Metrics</td>
<td>The Neo4j built-in metrics for monitoring the Neo4j DBMS and each individual database.</td>
<td><code>&lt;neo4j-home&gt;/metrics</code></td>
<td><code>&lt;neo4j-home&gt;/metrics</code></td>
<td><code>/var/lib/neo4j/metrics</code></td>
<td>From the Open dropdown menu of your Neo4j instance, select Terminal, and navigate to <code>&lt;installation-version&gt;/metrics</code>.</td>
</tr>
</tbody>
</table>
### Plugins

Custom code that extends Neo4j, for example, user-defined procedures, functions, and security plugins.

- **Linux / macOS / Docker**: `<neo4j-home>/plugins`
- **Windows**: `<neo4j-home>/plugins`
- **Debian / RPM**: `/var/lib/neo4j/plugins`
- **Neo4j Desktop**: From the Open dropdown menu of your Neo4j instance, select Terminal, and navigate to `<installation-version>/plugins`.

### Products

The jar files of the Neo4j products: Graph Data Science Library and Bloom. The folder also contains a README.txt file with information on enabling them.

- **Linux / macOS / Docker**: `<neo4j-home>/products`
- **Windows**: `<neo4j-home>/products`
- **Debian / RPM**: `/var/lib/neo4j/products`
- **Neo4j Desktop**: From the Open dropdown menu of your Neo4j instance, select Terminal, and navigate to `<installation-version>/products`.

### Run

The processes IDs.

- **Linux / macOS / Docker**: `<neo4j-home>/run`
- **Windows**: `<neo4j-home>/run`
- **Debian / RPM**: `/var/lib/neo4j/run`
- **Neo4j Desktop**: From the Open dropdown menu of your Neo4j instance, select Terminal, and navigate to `<installation-version>/run`.

### Customize your file locations

The file locations can also be customized by using environment variables and options.

The locations of `<neo4j-home>` and `conf` can be configured using environment variables:

<table>
<thead>
<tr>
<th>Location</th>
<th>Default</th>
<th>Environment variable</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>&lt;neo4j-home&gt;</code></td>
<td>parent of bin</td>
<td>NEO4J_HOME</td>
<td>Must be set explicitly if bin is not a subdirectory.</td>
</tr>
<tr>
<td><code>conf</code></td>
<td><code>&lt;neo4j-home&gt;/conf</code></td>
<td>NEO4J_CONF</td>
<td>Must be set explicitly if it is not a subdirectory of <code>&lt;neo4j-home&gt;</code>.</td>
</tr>
</tbody>
</table>

The rest of the locations can be configured by uncommenting the respective setting in the `conf/neo4j.conf` file and changing the default value.
6.2.3. File permissions

The operating system user that Neo4j server runs as must have the following minimal permissions:

Read only
- conf
- import
- bin
- lib
- plugins
- certificates
- licenses

Read and write
- data
- logs
- metrics
- run

Execute
- all files in bin and tmp

If tmp is set to noexec, we recommend defining in conf/neo4j.conf the following:
```
dbms.jvm.additional=-Djava.io.tmpdir=/home/neo4j
```
Additionally, replace /home/neo4j with a path that has exec permissions.

For /bin/cypher-shell, set this via environment variable: `export JAVA_OPTS=-Djava.io.tmpdir=/home/neo4j` and also replace `/home/neo4j` with a path that has exec permissions.

6.3. Ports

Ports relevant to a Neo4j installation.

An overview of the Neo4j-specific ports. Note that these ports are in addition to those necessary for
ordinary network operation.

Specific recommendations on port openings cannot be made, as the firewall configuration must be performed taking your particular conditions into consideration.

When exposing network services, make sure they are always protected.

The listen address configuration settings will set the network interface and port to listen on. For example the IP-address 127.0.0.1 and port 7687 can be set with the value 127.0.0.1:7687. The table below shows an overview of available Neo4j-specific ports and related configuration settings.

**Table 20. Listen address configuration settings overview**

<table>
<thead>
<tr>
<th>Name</th>
<th>Default port</th>
<th>Related configuration setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backup</td>
<td>6362</td>
<td>dbms.backup.listen_address</td>
</tr>
<tr>
<td>HTTP</td>
<td>7474</td>
<td>dbms.connector.http.listen_address</td>
</tr>
<tr>
<td>HTTPS</td>
<td>7473</td>
<td>dbms.connector.https.listen_address</td>
</tr>
<tr>
<td>Bolt</td>
<td>7687</td>
<td>dbms.connector.bolt.listen_address</td>
</tr>
<tr>
<td>Causal Cluster discovery management</td>
<td>5000</td>
<td>causal_clustering.discovery_listen_address</td>
</tr>
<tr>
<td>Causal Cluster transaction</td>
<td>5000</td>
<td>causal_clustering.transaction_listen_address</td>
</tr>
<tr>
<td>Causal Cluster RAFT</td>
<td>7000</td>
<td>causal_clustering.raft_listen_address</td>
</tr>
<tr>
<td>Causal Cluster routing connector</td>
<td>7688</td>
<td>dbms.routing.listen_address</td>
</tr>
<tr>
<td>Graphite monitoring</td>
<td>2003</td>
<td>metrics.graphite.server</td>
</tr>
<tr>
<td>Prometheus monitoring</td>
<td>2004</td>
<td>metrics.prometheus.endpoint</td>
</tr>
<tr>
<td>JMX monitoring</td>
<td>3637</td>
<td>dbms.jvm.additional= Dcom.sun.management.jmxremote.port=3637</td>
</tr>
<tr>
<td>Remote debugging</td>
<td>5005</td>
<td>dbms.jvm.additional=agentlib:jdwp=transport=dt_socket,server=y,suspend=n,address=:5005</td>
</tr>
</tbody>
</table>

The configuration setting dbms.default_listen_address configures the default network interface to listen for incoming connections.

The advertised address configuration settings are used for routing purposes. An advertised address is composed by a hostname/IP-address and port. For example the IP-address 127.0.0.1 and port 7687 can be set with the value 127.0.0.1:7687. If a host name resolution service has been configured, the advertised address can use a hostname, for example example.com:7687. The table below shows an overview of available Neo4j-specific ports and related configuration settings.

**Table 21. Advertised address configuration settings overview**
<table>
<thead>
<tr>
<th>Name</th>
<th>Default port</th>
<th>Related configuration setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>HTTP</td>
<td>7474</td>
<td>dbms.connector.http.advertised_address</td>
</tr>
<tr>
<td>HTTPS</td>
<td>7473</td>
<td>dbms.connector.https.advertised_address</td>
</tr>
<tr>
<td>Bolt</td>
<td>7687</td>
<td>dbms.connector.bolt.advertised_address</td>
</tr>
<tr>
<td>Causal Cluster discovery management</td>
<td>5000</td>
<td>causal_clustering.discovery_advertised_address</td>
</tr>
<tr>
<td>Causal Cluster transaction</td>
<td>6000</td>
<td>causal_clustering.transaction_advertised_address</td>
</tr>
<tr>
<td>Causal Cluster RAFT</td>
<td>7000</td>
<td>causal_clustering.raft_advertised_address</td>
</tr>
<tr>
<td>Causal Cluster routing connector</td>
<td>7688</td>
<td>dbms.routing.advertised_address</td>
</tr>
</tbody>
</table>

The configuration setting `dbms.default_advertised_address` configures the default hostname/IP-address for advertised address.

### 6.3.1. Backup

**Enterprise edition**

Default port: **6362**

<table>
<thead>
<tr>
<th>Related configuration setting</th>
<th>Default value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>dbms.backup.listen_address</code></td>
<td>127.0.0.1:6362</td>
<td>Network interface and port for the backup server to listen on.</td>
</tr>
<tr>
<td><code>dbms.backup.enabled</code></td>
<td>true</td>
<td>Enable support for running online backups.</td>
</tr>
</tbody>
</table>

In production environments, external access to the backup port should be blocked by a firewall.

For more information, see [Server configuration](#).

### 6.3.2. HTTP

Default port: **7474**

<table>
<thead>
<tr>
<th>Related configuration setting</th>
<th>Default value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>dbms.connector.http.listen_address</code></td>
<td>:7474</td>
<td>Network interface and port for the HTTP connector to listen on.</td>
</tr>
<tr>
<td><code>dbms.connector.http.advertised_address</code></td>
<td>:7474</td>
<td>Advertised hostname/IP-address and port for the HTTP connector.</td>
</tr>
<tr>
<td><code>dbms.connector.http.enabled</code></td>
<td>true</td>
<td>Enable the HTTP connector.</td>
</tr>
</tbody>
</table>
The HTTP connector is enabled by default.
- The network communication is unencrypted.
- Used by Neo4j Browser and the HTTP API.

For more information, see Configure connectors.

6.3.3. HTTPS

Default port: 7473

Table 24. HTTPS connector

<table>
<thead>
<tr>
<th>Related configuration setting</th>
<th>Default value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>dbms.connector.https.listen_address</td>
<td>:7473</td>
<td>Network interface and port for the HTTPS connector to listen on.</td>
</tr>
<tr>
<td>dbms.connector.https.advertised_address</td>
<td>:7473</td>
<td>Advertised hostname/IP-address and port for the HTTPS connector.</td>
</tr>
<tr>
<td>dbms.connector.https.enabled</td>
<td>false</td>
<td>Enable the HTTPS connector.</td>
</tr>
</tbody>
</table>

- The network communication is encrypted.
- Used by Neo4j Browser and the HTTP API.

For more information, see Configure connectors.

6.3.4. Bolt

Default port: 7687

Table 25. Bolt connector

<table>
<thead>
<tr>
<th>Related configuration setting</th>
<th>Default value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>dbms.connector.bolt.listen_address</td>
<td>:7687</td>
<td>Network interface and port for the Bolt connector to listen on.</td>
</tr>
<tr>
<td>dbms.connector.bolt.advertised_address</td>
<td>:7687</td>
<td>Advertised hostname/IP-address and port for the Bolt connector.</td>
</tr>
<tr>
<td>dbms.connector.bolt.enabled</td>
<td>true</td>
<td>Enable the Bolt connector.</td>
</tr>
<tr>
<td>dbms.connector.bolt.tls_level</td>
<td>DISABLED</td>
<td>Encryption level for the Bolt connector.</td>
</tr>
</tbody>
</table>

- By default, the Bolt connector is enabled, but its encryption is turned off.
- Used by Cypher Shell, Neo4j Browser, and the official Neo4j drivers.

For more information, see Configure connectors.
6.3.5. Causal Cluster

By default, the operating mode of a Neo4j instance (dbms.mode) is set to SINGLE.

Table 26. Cluster listen address

<table>
<thead>
<tr>
<th>Name</th>
<th>Default port</th>
<th>Default value</th>
<th>Related configuration setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discovery management</td>
<td>5000</td>
<td>:5000</td>
<td>causal_clustering.discovery_listen_address</td>
</tr>
<tr>
<td>Transaction</td>
<td>6000</td>
<td>:6000</td>
<td>causal_clustering.transaction_listen_address</td>
</tr>
<tr>
<td>RAFT</td>
<td>7000</td>
<td>:7000</td>
<td>causal_clustering.raft_listen_address</td>
</tr>
<tr>
<td>Routing connector</td>
<td>7688</td>
<td>:7688</td>
<td>dbms.routing.listen_address</td>
</tr>
</tbody>
</table>

Table 27. Cluster advertised address

<table>
<thead>
<tr>
<th>Name</th>
<th>Default port</th>
<th>Default value</th>
<th>Related configuration setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discovery management</td>
<td>5000</td>
<td>:5000</td>
<td>causal_clustering.discovery_advertised_address</td>
</tr>
<tr>
<td>Transaction</td>
<td>6000</td>
<td>:6000</td>
<td>causal_clustering.transaction_advertised_address</td>
</tr>
<tr>
<td>RAFT</td>
<td>7000</td>
<td>:7000</td>
<td>causal_clustering.raft_advertised_address</td>
</tr>
<tr>
<td>Routing connector</td>
<td>7688</td>
<td>:7688</td>
<td>dbms.routing.advertised_address</td>
</tr>
</tbody>
</table>

The ports are likely be different in a production installation; therefore the potential opening of ports must be modified accordingly.

For more information, see:

- Deploy a cluster
- Settings reference

6.3.6. Graphite monitoring

Default port: 2003

Table 28. Graphite

<table>
<thead>
<tr>
<th>Related configuration setting</th>
<th>Default value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>metrics.graphite.server</td>
<td>:2003</td>
<td>Hostname/IP-address and port of the Graphite server.</td>
</tr>
<tr>
<td>metrics.graphite.enabled</td>
<td>false</td>
<td>Enable exporting metrics to the Graphite server.</td>
</tr>
</tbody>
</table>

This is an outbound connection that enables a Neo4j instance to communicate with a Graphite server.
For further information, see [metrics-graphite] and the Graphite official documentation.

6.3.7. Prometheus monitoring

Default port: 2004

Table 29. Prometheus

<table>
<thead>
<tr>
<th>Related configuration setting</th>
<th>Default value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>metrics.prometheus.endpoint</td>
<td>localhost:2004</td>
<td>Network interface and port for the Prometheus endpoint to listen on.</td>
</tr>
<tr>
<td>metrics.prometheus.enabled</td>
<td>false</td>
<td>Enable exporting metrics with the Prometheus endpoint.</td>
</tr>
</tbody>
</table>

For more information, see Prometheus.

6.3.8. JMX monitoring

Default port: 3637

Table 30. Java Management Extensions

<table>
<thead>
<tr>
<th>Related configuration setting</th>
<th>Default value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>dbms.jvm.additional=--Dcom.sun.management.jmxremote.port=3637</td>
<td>3637</td>
<td>Additional setting for exposing the Java Management Extensions (JMX).</td>
</tr>
</tbody>
</table>

For further information, see Java Reference → JMX metrics and the official documentation on Monitoring and Management Using JMX.

6.3.9. Remote debugging

Default port: 5005

Table 31. Remote debugging

<table>
<thead>
<tr>
<th>Related configuration setting</th>
<th>Default value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>dbms.jvm.additional=agentlib:jdwp=transport=dt_socket,server=y,suspend=n,address=:5005</td>
<td>:5005</td>
<td>Additional setting for exposing remote debugging.</td>
</tr>
</tbody>
</table>

For more information, see the Java Reference → Setup for remote debugging.

6.4. Configure connectors

How to configure connectors (Bolt, HTTP, and HTTPS) for Neo4j.
6.4.1. Available connectors

The table below lists the available Neo4j connectors:

Table 32. Neo4j connectors and port number

<table>
<thead>
<tr>
<th>Connector name</th>
<th>Protocol</th>
<th>Default port number</th>
</tr>
</thead>
<tbody>
<tr>
<td>dbms.connector.bolt</td>
<td>Bolt</td>
<td>7687</td>
</tr>
<tr>
<td>dbms.connector.http</td>
<td>HTTP</td>
<td>7474</td>
</tr>
<tr>
<td>dbms.connector.https</td>
<td>HTTPS</td>
<td>7473</td>
</tr>
</tbody>
</table>

When configuring the HTTPS or Bolt connector, see also SSL framework for details on how to work with SSL certificates.

6.4.2. Configuration options

The connectors are configured by settings on the format `dbms.connector.<connector-name>.<setting-suffix>`. The available suffixes are described in the table below:

Table 33. Configuration option suffixes for connectors

<table>
<thead>
<tr>
<th>Option name</th>
<th>Default</th>
<th>Setting(s)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>enabled</td>
<td>true [1]</td>
<td>dbms.connector.bolt.enabled, dbms.connector.http.enabled, dbms.connector.https.enabled [2]</td>
<td>This setting allows the client connector to be enabled or disabled. When disabled, Neo4j does not listen for incoming connections on the relevant port.</td>
</tr>
<tr>
<td>listen_address</td>
<td>127.0.0.1:&lt;connector-default-port&gt;</td>
<td>dbms.connector.bolt.listen_address, dbms.connector.https.listen_address, dbms.connector.http.listen_address</td>
<td>This setting specifies how Neo4j listens for incoming connections. It consists of two parts; an IP address (e.g. 127.0.0.1 or 0.0.0.0) and a port number (e.g. 7687), and is expressed in the format <code>&lt;ip-address&gt;:&lt;port-number&gt;</code>. See below for an example of usage.</td>
</tr>
<tr>
<td>advertised_address</td>
<td>localhost:&lt;connector-default-port&gt;</td>
<td>dbms.connector.bolt.advertised_address, dbms.connector.https.advertised_address, dbms.connector.http.advertised_address</td>
<td>This setting specifies the address that clients should use for this connector. This is useful in a Causal Cluster as it allows each server to correctly advertise addresses of the other servers in the cluster. The advertised address consists of two parts; an address (fully qualified domain name, hostname, or IP address) and a port number (e.g. 7687), and is expressed in the format <code>&lt;address&gt;:&lt;port-number&gt;</code>. See below for an example of usage.</td>
</tr>
<tr>
<td>Option name</td>
<td>Default</td>
<td>Setting(s)</td>
<td>Description</td>
</tr>
<tr>
<td>-------------</td>
<td>----------</td>
<td>---------------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>tls_level</td>
<td>DISABLED</td>
<td>dbms.connector.bolt.tls_level</td>
<td>This setting is only applicable to the Bolt connector. It allows the connector to accept encrypted and/or unencrypted connections. The default value is DISABLED, where only unencrypted client connections are to be accepted by this connector, and all encrypted connections will be rejected. Other values are REQUIRED and OPTIONAL. Use REQUIRED when only encrypted client connections are to be accepted by this connector, and all unencrypted connections will be rejected. Use OPTIONAL where either encrypted or unencrypted client connections are accepted by this connector.</td>
</tr>
</tbody>
</table>

Example 18. Specify `listen_address` for the Bolt connector

To listen for Bolt connections on all network interfaces (0.0.0.0) and on port 7000, set the `listen_address` for the Bolt connector:

```
dbms.connector.bolt.listen_address=0.0.0.0:7000
```

Example 19. Specify `advertised_address` for the Bolt connector

If routing traffic via a proxy, or if port mappings are in use, it is possible to specify `advertised_address` for each connector individually. For example, if port 7687 on the Neo4j Server is mapped from port 9000 on the external network, specify the `advertised_address` for the Bolt connector:

```
dbms.connector.bolt.advertised_address=<server-name>:9000
```

6.4.3. Options for Bolt thread pooling

See Bolt thread pool configuration to learn more about Bolt thread pooling and how to configure it on the connector level.

6.4.4. Defaults for addresses

It is possible to specify defaults for the configuration options with `listen_address` and `advertised_address` suffixes, as described below. Setting a default value will apply to all the connectors, unless specifically configured for a certain connector.

```
dbms.default_listen_address
```

This configuration option defines a default IP address of the settings with the `listen_address` suffix for
To listen for Bolt connections on all network interfaces (0.0.0.0) and on port 7000, set the `listen_address` for the Bolt connector:

```bash
dbms.connector.bolt.listen_address=0.0.0.0:7000
```

This is equivalent to specifying the IP address by using the `dbms.default_listen_address` setting, and then specifying the port number for the Bolt connector.

```bash
dbms.default_listen_address=0.0.0.0
 dbms.connector.bolt.listen_address=:7000
```

**dbms.default_advertised_address**

This configuration option defines a default address of the settings with the `advertised_address` suffix for all connectors. If the address part of the `advertised_address` is not specified, it is inherited from the shared setting `dbms.default_advertised_address`.

Example 21. Specify `advertised_address` for the Bolt connector

Specify the address that clients should use for the Bolt connector:

```bash
dbms.connector.bolt.advertised_address=server1:9000
```

This is equivalent to specifying the address by using the `dbms.default_advertised_address` setting, and then specifying the port number for the Bolt connector.

```bash
dbms.default_advertised_address=server1
 dbms.connector.bolt.advertised_address=:9000
```

The default address settings can only accept the hostname or IP address portion of the full socket address. Port numbers are protocol-specific, and can only be added by the protocol-specific connector configuration.

For example, if you configure the default address value to be `example.com:9999`, Neo4j will fail to start and you will get an error in `neo4j.log`.

6.5. Set an initial password

This section describes how to set an initial password for Neo4j.
Use the `set-initial-password` command of `neo4j-admin` to define the password for the native user `neo4j`. This must be performed before starting up the database for the first time.

**Syntax:**

```
neo4j-admin set-initial-password <password> [--require-password-change]
```

**Example 22. Use the `set-initial-password` command of `neo4j-admin`**

Set the password for the native `neo4j` user to 'h6u4%kr' before starting the database for the first time.

```
$neo4j-home> bin/neo4j-admin set-initial-password h6u4%kr
```

**Example 23. Use the `set-initial-password` command of `neo4j-admin` with the optional `--require-password-change` flag**

Set the password for the native `neo4j` user to 'secret' before starting the database for the first time. You will be prompted to change this password to one of your own choice at first login.

```
$neo4j-home> bin/neo4j-admin set-initial-password secret --require-password-change
```

If the password is not set explicitly using this method, it will be set to the default password `neo4j`. In that case, you will be prompted to change the default password at first login.

### 6.6. Password and user recovery

*This section describes how to recover from a lost password, specifically for an admin user, how to recover an admin user if all the admin users have been unassigned the admin role, and how to recreate the built-in admin role if it has been dropped.*

#### 6.6.1. Disable authentication
1. Stop Neo4j:

$ bin/neo4j stop

2. Open the neo4j.conf file and set `dbms.security.auth_enabled` parameter to `false` to disable the authentication:

```
dbms.security.auth_enabled=false
```

It is recommended to block network connections during the recovery phase, so users can connect to Neo4j only via `localhost`. This can be achieved by either:

- Temporarily commenting out the `dbms.default_listen_address` parameter:
  
  ```
  #dbms.default_listen_address=<your_configuration>
  ```

  or

- Providing the specific localhost value:
  
  ```
  dbms.default_listen_address=127.0.0.1
  ```

3. Start Neo4j:

$ bin/neo4j start
1. Stop the cluster (all Core servers and Read Replicas).

```
$ bin/neo4j stop
```

2. On each Core server, open the `neo4j.conf` file and modify the following settings:
   a. Set `dbms.security.auth_enabled` parameter to `false` to disable the authentication:

   ```
   dbms.security.auth_enabled=false
   ```
   b. Disable the HTTP and HTTPS network connections and restrict the `bolt` connector to use only `localhost`. This ensures that no one from outside can access the cluster during the recovery period.

   ```
   #dbms.connector.http.enabled=true
   #dbms.connector.https.enabled=true
   dbms.connector.bolt.listen_address:127.0.0.1
   ```

3. Start all Core servers:

```
$ bin/neo4j start
```

### 6.6.2. Recover a lost password

You can use a client such as Cypher Shell or the Neo4j Browser to connect to the system database and set a new password for the admin user.

In a cluster deployment, you should complete the steps only on one of the Core servers.

1. Complete the steps in Disable authentication as per your deployment.
2. Connect to the system database using Cypher shell. Alternatively, log into Neo4j Browser.

```
$ bin/cypher-shell -d system
```

If you have specified a non-default port for your `bolt` connector, add `-a neo4j://<your-core>:<non-default-bolt-port>` to the `cypher-shell` command to be able to connect to your Core server.

3. Set a new password for the admin user. In this example, the admin user is named `neo4j`.

```
ALTER USER neo4j SET PASSWORD 'mynewpass'
```

4. Exit the `cypher-shell` console:
5. Proceed with the post-recovery steps as per your deployment.

6.6.3. Recover an unassigned admin role

You can use a client such as Cypher Shell or the Neo4j Browser to connect to the system database and grant the admin user role to an existing user.

In a cluster deployment, you should complete the steps only on one of the Core servers.

1. Complete the steps in Disable authentication as per your deployment.

2. Connect to the system database using Cypher shell. Alternatively, log into Neo4j Browser.

   $ bin/cypher-shell -d system

   If you have specified a non-default port for your bolt connector, add -a neo4j://<your-core>:<non-default-bolt-port> to the cypher-shell command to be able to connect to your Core server.

3. Grant the admin user role to an existing user. In this example, the user is named neo4j.

   GRANT ROLE admin TO neo4j

4. Exit the cypher-shell console:

   :exit;

5. Proceed with the post-recovery steps as per your deployment.

6.6.4. Recover the admin role

If you have removed the admin role from your system entirely, you can use a client such as Cypher Shell or the Neo4j Browser to connect to the system database and recreate the role with its original capabilities.

In a cluster deployment, you should complete the steps only on one of the Core servers.

1. Complete the steps in Disable authentication as per your deployment.

2. Connect to the system database using Cypher shell. Alternatively, log into Neo4j Browser.

   $ bin/cypher-shell -d system
3. Recreate the admin role with its original capabilities.

```cypher
CREATE ROLE admin;
GRANT ALL DBMS PRIVILEGES ON DBMS TO admin;
GRANT TRANSACTION MANAGEMENT ON DATABASE * TO admin;
GRANT START ON DATABASE * TO admin;
GRANT STOP ON DATABASE * TO admin;
GRANT MATCH (*) ON GRAPH * TO admin;
GRANT WRITE ON GRAPH * TO admin;
GRANT ALL ON DATABASE * TO admin;
```

4. Grant the admin user role to an existing user.

Before running the `:exit` command, we suggest granting the newly created role to a user. Although this is optional, without this step you will have only collected all admin privileges in a role that no one is assigned to.

To grant the role to a user (assuming your existing user is named `neo4j`), you can run

```
GRANT ROLE admin TO neo4j;
```

5. Exit the `cypher-shell` console:

```
:exit;
```

6. Proceed with the post-recovery steps as per your deployment.

6.6.5. Post-recovery steps
1. Stop Neo4j:

$ bin/neo4j stop

2. Enable the authentication and restore your Neo4j to its original configuration (See Disable authentication).

3. Start Neo4j:

$ bin/neo4j start

---

1. Stop the Core servers.

$ bin/neo4j stop

2. Enable the authentication and restore each Core server to its original configuration (See Disable authentication).

3. Start the cluster (all Core servers and Read Replicas):

$ bin/neo4j start

---

6.7. Dynamic settings

How to change your Neo4j configuration while Neo4j is running, and which settings can be changed.

6.7.1. Introduction

Neo4j Enterprise Edition supports changing some configuration settings at runtime, without restarting the service.

<table>
<thead>
<tr>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changes to the configuration at runtime are not persisted. To avoid losing changes when restarting Neo4j, make sure you update <code>neo4j.conf</code> as well.</td>
</tr>
</tbody>
</table>

In a clustered environment, `CALL dbms.setConfigValue` affects only the cluster member it is run against, and it is not propagated to other members. If you want to change the configuration settings on all cluster members, you have to run the procedure against each of them and update their `neo4j.conf` file. |
6.7.2. Discover dynamic settings

Use the procedure `dbms.listConfig()` to discover which configuration values can be dynamically updated, or consult Dynamic settings reference.

Example 24. Discover dynamic settings

```sql
CALL dbms.listConfig()
YIELD name, dynamic
WHERE dynamic
RETURN name
ORDER BY name
LIMIT 4;
```

<table>
<thead>
<tr>
<th>name</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;dbms.checkpoint.iops.limit&quot;</td>
</tr>
<tr>
<td>&quot;dbms.logs.query.allocation_logging_enabled&quot;</td>
</tr>
<tr>
<td>&quot;dbms.logs.query.enabled&quot;</td>
</tr>
<tr>
<td>&quot;dbms.logs.query.page_logging_enabled&quot;</td>
</tr>
<tr>
<td>----------------------------------------------</td>
</tr>
<tr>
<td>4 rows</td>
</tr>
</tbody>
</table>

6.7.3. Update dynamic settings

An administrator is able to change some configuration settings at runtime, without restarting the service.

Syntax:

`CALL dbms.setConfigValue(setting, value)`

Returns:

Nothing on success.

Exceptions:

Unknown or invalid setting name.

The setting is not dynamic and can not be changed at runtime.

Invalid setting value.

The following example shows how to dynamically enable query logging.

Example 25. Set a config value

```sql
CALL dbms.setConfigValue('dbms.logs.query.enabled', 'info')
```

If an invalid value is passed, the procedure will show a message to that effect.
Example 26. Try to set invalid config value

```sql
CALL dbms.setConfigValue('dbms.logs.query.enabled', 'yes')
```

Failed to invoke procedure `dbms.setConfigValue`: Caused by: org.neo4j.graphdb.config.InvalidSettingException: Bad value 'yes' for setting 'dbms.logs.query.enabled': 'yes' not one of [OFF, INFO, VERBOSE]

To reset a config value to its default, pass an empty string as the value argument.

Example 27. Reset a config value to default

```sql
CALL dbms.setConfigValue('dbms.logs.query.enabled', '')
```

6.7.4. Dynamic settings reference

**causal_clustering.cluster_allow_reads_on_leader**
Configure if the `dbms.routing.getRoutingTable()` procedure should include the leader as read endpoint or return only read replicas/followers.

**causal_clustering.connect_randomly_to_server_group**
Comma separated list of groups to be used by the connect-randomly-to-server-group selection strategy.

**causal_clustering.server_groups**
A list of group names for the server used when configuring load balancing and replication policies.

**dbms.allow_single_automatic_upgrade**
Whether to allow a system graph upgrade to happen automatically in single instance mode (dbms.mode=SINGLE).

**dbms.allow_upgrade**
Whether to allow a store upgrade in case the current version of the database starts against an older version of the store.

**dbms.backup.incremental.strategy**
Strategy for incremental backup.

**dbms.checkpoint.iops.limit**
Limit the number of IOs the background checkpoint process will consume per second.

**dbms.databases.default_to_read_only**
Whether or not any database on this instance are read_only by default.
**dbms.databases.read_only**
List of databases for which to prevent write queries.

**dbms.databases.writable**
List of databases for which to allow write queries.

**dbms.lock.acquisition.timeout**
The maximum time interval within which lock should be acquired. Zero (default) means timeout is disabled.

**dbms.logs.debug.level**
Debug log level threshold.

**dbms.logs.query.allocation_logging_enabled**
Log allocated bytes for the executed queries being logged.

**dbms.logs.query.early_raw_logging_enabled**
Log query text and parameters without obfuscating passwords.

**dbms.logs.query.enabled**
Log executed queries.

**dbms.logs.query.page_logging_enabled**
Log page hits and page faults for the executed queries being logged.

**dbms.logs.query.parameter_full_entities**
Log complete parameter entities including id, labels or relationship type, and properties.

**dbms.logs.query.parameter_logging_enabled**
Log parameters for the executed queries being logged.

**dbms.logs.query.rotation.keep_number**
Maximum number of history files for the query log.

**dbms.logs.query.rotation.size**
The file size in bytes at which the query log will auto-rotate.

**dbms.logs.query.runtime_logging_enabled**
Logs which runtime that was used to run the query.

**dbms.logs.query.threshold**
If the execution of query takes more time than this threshold, the query is logged once completed - provided query logging is set to INFO.

**dbms.logs.query.time_logging_enabled**
Log detailed time information for the executed queries being logged.
**dbms.memory.pagecache.flush.buffer.enabled**

Page cache can be configured to use a temporal buffer for flushing purposes.

**dbms.memory.pagecache.flush.buffer.size_in_pages**

Page cache can be configured to use a temporal buffer for flushing purposes.

**dbms.memory.transaction.database_max_size**

Limit the amount of memory that all transactions in one database can consume, in bytes (or kilobytes with the 'k' suffix, megabytes with 'm' and gigabytes with 'g').

**dbms.memory.transaction.global_max_size**

Limit the amount of memory that all of the running transactions can consume, in bytes (or kilobytes with the 'k' suffix, megabytes with 'm' and gigabytes with 'g').

**dbms.memory.transaction.max_size**

Limit the amount of memory that a single transaction can consume, in bytes (or kilobytes with the 'k' suffix, megabytes with 'm' and gigabytes with 'g').

**dbms.security.ldap.authentication.attribute**

The attribute to use when looking up users. Using this setting requires
**dbms.security.ldap.authentication.search_for_attribute** to be true and thus
**dbms.security.ldap.authorization.system_username** and
**dbms.security.ldap.authorization.system_password** to be configured.

**dbms.security.ldap.authentication.user_dn_template**

LDAP user DN template.

**dbms.security.ldap.authorization.group_membership_attributes**

A list of attribute names on a user object that contains groups to be used for mapping to roles when LDAP authorization is enabled.

**dbms.security.ldap.authorization.group_to_role_mapping**

An authorization mapping from LDAP group names to Neo4j role names.

**dbms.security.ldap.authorization.user_search_base**

The name of the base object or named context to search for user objects when LDAP authorization is enabled.

**dbms.security.ldap.authorization.user_search_filter**

The LDAP search filter to search for a user principal when LDAP authorization is enabled.

**dbms.security.oidc.<provider>.audience**

Expected values of the Audience (aud) claim in the id token.

**dbms.security.oidc.<provider>.auth_endpoint**

The OIDC authorization endpoint.
dbms.security.oidc.<provider>.auth_flow
The OIDC flow to use.

dbms.security.oidc.<provider>.auth_params
Optional additional configuration options used for the authentication request.

dbms.security.oidc.<provider>.authorization.group_to_role_mapping
An authorization mapping from IdP group names to Neo4j role names.

dbms.security.oidc.<provider>.claims.groups
The claim to use as the list of groups in Neo4j.

dbms.security.oidc.<provider>.claims.username
The claim to use as the username in Neo4j.

dbms.security.oidc.<provider>.client_id
Client id needed if token contains multiple Audience (aud) claims.

dbms.security.oidc.<provider>.config
Additional configuration options that the clients may require to authenticate.

dbms.security.oidc.<provider>.get_groups_from_user_info
When turned on, Neo4j gets the groups from the provider user info endpoint.

dbms.security.oidc.<provider>.get_username_from_user_info
When turned on, Neo4j gets the username from the provider user info endpoint.

dbms.security.oidc.<provider>.issuer
The expected value of the iss claim in the id token.

dbms.security.oidc.<provider>.jwks_uri
The location of the JWK public key set for the identity provider.

dbms.security.oidc.<provider>.params
Generic parameters that the clients may require to authenticate.

dbms.security.oidc.<provider>.redirect_uri
The redirect URI the IdP should return the user to when authenticated.

dbms.security.oidc.<provider>.token_endpoint
The OIDC token endpoint.

dbms.security.oidc.<provider>.token_params
Optional additional configuration options used for the token request.

dbms.security.oidc.<provider>.user_info_uri
The identity providers user info uri.
dbms.security.oidc.<provider>.well_known_discovery_uri
The 'well known' OpenID Connect Discovery endpoint used to fetch identity provider settings.

dbms.track_query_allocation
Enables or disables tracking of how many bytes are allocated by the execution of a query.

dbms.track_query_cpu_time
Enables or disables tracking of how much time a query spends actively executing on the CPU.

dbms.transaction.concurrent.maximum
The maximum number of concurrently running transactions.

dbms.transaction.sampling.percentage
Transaction sampling percentage.

dbms.transaction.timeout
The maximum time interval of a transaction within which it should be completed.

dbms.transaction.tracing.level
Transaction creation tracing level.

dbms.tx_log.preallocate
Specify if Neo4j should try to preallocate logical log file in advance.

dbms.tx_log.rotation.retention_policy
Tell Neo4j how long logical transaction logs should be kept to backup the database. For example, "10 days" will prune logical logs that only contain transactions older than 10 days. Alternatively, "100k txs" will keep the 100k latest transactions from each database and prune any older transactions.

dbms.tx_log.rotation.size
Specifies at which file size the logical log will auto-rotate.

dbms.upgrade_max_processors
Max number of processors used when upgrading the store.

fabric.routing.servers
A comma-separated list of Fabric instances that form a routing group.

6.8. Transaction log
The transaction log record all write operations in the database.

- The transaction log record all write operations in the database.
- The transaction log is the "source of truth" in scenarios where the database needs to be recovered.
- The transaction log can be used to provide for incremental backups, as well as for cluster operations.
- For any given configuration, at least the latest non-empty transaction log will be kept.
Each database keeps its own directory with transaction logs. The root directory where the transaction log folders are located is configured by `dbms.directories.transaction.logs.root`.

The transaction log has nothing to do with log monitoring.

### 6.8.1. Transaction logging

The transaction logs record all write operations in the database. This includes additions or modifications to data, as well as the addition or modification of any indexes or constraints.

- The transaction logs are the "source of truth" in scenarios where the database needs to be recovered.
- The transaction logs are used for providing incremental backups, as well as for cluster operations.
- For any given configuration, at least the latest non-empty transaction log will be kept.

An overview of configuration settings for transaction logging:

<table>
<thead>
<tr>
<th>The transaction log configuration</th>
<th>Default value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>dbms.directories.transaction.logs.root</code></td>
<td>transactions</td>
<td>Root location where Neo4j will store transaction logs for configured databases.</td>
</tr>
<tr>
<td><code>dbms.tx_log.preallocate</code></td>
<td>true</td>
<td>Specify if Neo4j should try to preallocate logical log file in advance.</td>
</tr>
<tr>
<td><code>dbms.tx_log.rotation.retention_policy</code></td>
<td>7 days</td>
<td>Make Neo4j keep the logical transaction logs for being able to backup the database. Can be used for specifying the threshold to prune logical logs after.</td>
</tr>
<tr>
<td><code>dbms.tx_log.rotation.size</code></td>
<td>250M</td>
<td>Specifies at which file size the logical log will auto-rotate. Minimum accepted value is 128K (128 KiB).</td>
</tr>
</tbody>
</table>

The retention and rotation policies for the Neo4j transaction logs, and how to configure them.

### 6.8.2. Log location

By default, transaction logs for a database are located at `<neo4j-home>/data/transactions/<database-name>`. Each database keeps its own directory with transaction logs.

The root directory where those folders are located is configured by `dbms.directories.transaction.logs.root`. For maximum performance, it is recommended to configure transaction logs to be stored on a dedicated device.
6.8.3. Log rotation

Log rotation is configured using the parameter `dbms.tx_log.rotation.size`. By default, log switches happen when log sizes surpass 250 MB.

6.8.4. Log retention

<table>
<thead>
<tr>
<th>Error Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manually deleting transaction log files is not supported.</td>
</tr>
</tbody>
</table>

You can control the number of transaction logs that Neo4j keeps using the parameter `dbms.tx_log.rotation.retention_policy`. It is set to 7 days by default, which means Neo4j keeps logical logs that contain any transaction committed within 7 days. The configuration is dynamic, so if you need to update it, you do not have to restart Neo4j for the change to take effect.

Other possible values are:

- **true** or **keep_all** — keep transaction logs indefinitely.

<table>
<thead>
<tr>
<th>Info</th>
</tr>
</thead>
<tbody>
<tr>
<td>This option is not recommended due to the effectively unbounded storage usage. Old transaction logs cannot be safely archived or removed by external jobs since safe log pruning requires knowledge about the most recent successful checkpoint.</td>
</tr>
</tbody>
</table>

- **false** or **keep_none** — keep only the most recent non-empty log.

  Log pruning is called only after checkpoint completion to ensure at least one checkpoint and points to a valid place in the transaction log data. In reality, this means that all transaction logs created between checkpoints will be kept for some time, and only after a checkpoint, the pruning strategy will remove them. For more details on how to speed up checkpointing, see Log pruning. To force a checkpoint, run the procedure `call db.checkpoint()`.

<table>
<thead>
<tr>
<th>Info</th>
</tr>
</thead>
<tbody>
<tr>
<td>This option is not recommended in production Enterprise Edition environments, as incremental backups rely on the presence of the transaction logs since the last backup.</td>
</tr>
</tbody>
</table>

- `<number><optional unit> <type>` where valid units are k, M, and G, and valid types are files, size, txs, entries, hours, and days.

Table 34. Types that can be used to control log retention

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>files</td>
<td>The number of the most recent logical log files to keep.</td>
<td>&quot;10 files&quot;</td>
</tr>
<tr>
<td>size</td>
<td>Max disk size to allow log files to occupy.</td>
<td>&quot;300M size&quot; or &quot;1G size&quot;.</td>
</tr>
<tr>
<td>txs</td>
<td>The number of transactions to keep.</td>
<td>&quot;250k txs&quot; or &quot;5M txs&quot;.</td>
</tr>
<tr>
<td>hours</td>
<td>Keep logs that contain any transaction committed within N hours from the current time.</td>
<td>&quot;10 hours&quot;</td>
</tr>
<tr>
<td>Type</td>
<td>Description</td>
<td>Example</td>
</tr>
<tr>
<td>-------</td>
<td>--------------------------------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>days</td>
<td>Keep logs that contain any transaction committed within N days from the current time.</td>
<td>&quot;50 days&quot;</td>
</tr>
</tbody>
</table>

**Example 28. Configure log retention policy**

This example shows some different ways to configure the log retention policy.

- Keep transaction logs indefinitely:
  
  ```sql
  dbms.tx_log.rotation.retention_policy=true
  ```
  
  or
  
  ```sql
  dbms.tx_log.rotation.retention_policy=keep_all
  ```

- Keep only the most recent non-empty log:
  
  ```sql
  dbms.tx_log.rotation.retention_policy=false
  ```
  
  or
  
  ```sql
  dbms.tx_log.rotation.retention_policy=keep_none
  ```

- Keep logical logs which contain any transaction committed within 30 days:
  
  ```sql
  dbms.tx_log.rotation.retention_policy=30 days
  ```

- Keep logical logs which contain any of the most recent 500 000 transactions:
  
  ```sql
  dbms.tx_log.rotation.retention_policy=500k txs
  ```

### 6.8.5. Log pruning

Transaction log pruning refers to the safe and automatic removal of old, unnecessary transaction log files. The transaction log can be pruned when one or more files fall outside of the configured retention policy.

Two things are necessary for a file to be removed:

- The file must have been rotated.
- At least one checkpoint must have happened in a more recent log file.

Observing that you have more transaction log files than you expected is likely due to checkpoints either not happening frequently enough, or taking too long. This is a temporary condition and the gap between
expected and observed number of log files will be closed on the next successful checkpoint. The interval between checkpoints can be configured using:

<table>
<thead>
<tr>
<th>Checkpoint configuration</th>
<th>Default value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>dbms.checkpoint.interval.time</td>
<td>15m</td>
<td>Configures the time interval between check-points.</td>
</tr>
<tr>
<td>dbms.checkpoint.interval.tx</td>
<td>100000</td>
<td>Configures the transaction interval between check-points.</td>
</tr>
</tbody>
</table>

If your goal is to have the least amount of transaction log data, it can also help to speed up the checkpoint process itself. The configuration parameter `dbms.checkpoint.iops.limit` controls the number of IOs per second the checkpoint process is allowed to use. Setting the value of this parameter to -1 allows unlimited IOPS, which can speed up checkpointing.

Disabling the IOPS limit can cause transaction processing to slow down a bit. For more information, see Checkpoint IOPS limit.

[4] Applicable to all operating systems where Neo4j Desktop is supported.
[6] The data directory is internal to Neo4j and its structure is subject to change between versions without notice.
[8] To view neo4j.log in Docker, use `docker logs <containerID/name>`.
[9] To view the neo4j.log for Debian and RPM, use `journalctl --unit=neo4j`.
[10] When Neo4j is used in embedded mode, the default value is `false`.
Chapter 7. Manage databases

This chapter describes how to create and manage multiple active databases.

This chapter describes the following:

- Introduction
- Administration and configuration
- Queries
- Error handling
- Databases in a Causal Cluster
- Connecting remote databases

7.1. Introduction

Introduction to managing multiple active databases with Neo4j.

7.1.1. Concepts

With Neo4j 4.4 you can create and use more than one active database at the same time.

**DBMS**

Neo4j is a Database Management System, or DBMS, capable of managing multiple databases. The DBMS can manage a standalone server, or a group of servers in a Causal Cluster.

**Instance**

A Neo4j instance is a Java process that is running the Neo4j server code.

**Transaction domain**

A transaction domain is a collection of graphs that can be updated within the context of a single transaction.

**Execution context**

An execution context is a runtime environment for the execution of a request. In practical terms, a request may be a query, a transaction, or an internal function or procedure.

**Database**

A database is an administrative partition of a DBMS. In practical terms, it is a physical structure of files organized within a directory or folder, that has the same name of the database. In logical terms, a database is a container for one or more graphs.

A database defines a transaction domain and an execution context. This means that a transaction cannot span across multiple databases. Similarly, a procedure is called within a database, although its
logic may access data that is stored in other databases.

A default installation of Neo4j 4.4 contains two databases:

- **system** - the system database, containing metadata on the DBMS and security configuration.
- **neo4j** - the default database, a single database for user data. This has a default name of neo4j. A different name can be configured before starting Neo4j for the first time.

**Graph**

This is a data model within a database. In Neo4j 4.0 there is only one graph within each database, and many administrative commands that refer to a specific graph do so using the database name.

In Neo4j Fabric, it is possible to refer to multiple graphs within the same transaction and Cypher query.

The following image illustrates a default installation, including the system database and a single database named neo4j for user data:

![Figure 1. A default Neo4j installation.](image)

**Editions**

The edition of Neo4j determines the number of possible databases:

- Installations of Community Edition can have exactly one user database.
- Installations of Enterprise Edition can have any number of user databases.

All installations include the system database.

**7.1.2. The system database**

All installations include a built-in database named system, which contains meta-data and security configuration.

The system database behaves differently than all other databases. In particular, when connected to this database you can only perform a specific set of administrative functions, as described in detail in Cypher...
Manual → Database management.

Most of the available administrative commands are restricted to users with specific administrative privileges. An example of configuring security privileges is described in Fine-grained access control. Security administration is described in detail in Cypher Manual → Access Control.

The following image illustrates an installation of Neo4j with multiple active databases, named marketing, sales, and hr:

![Image of a multiple database Neo4j installation]

Figure 2. A multiple database Neo4j installation.

7.1.3. The default and home database

If a user connects to Neo4j without specifying a database, they will be connected to a home database. When choosing a home database the server will first use the home database configured for that user. If the connecting user does not have a home database configured, the server will use the default database, which every Neo4j instance has.

The default database is configurable. For details, see configuration parameters.

The following image illustrates an installation of Neo4j containing the three databases for user data, named marketing, sales and hr, and the system database. The default database is sales:
7.1.4. Per-user home databases

Per-user home databases are controlled via the Cypher administration commands.

To set a home database for a user, this user must exist as a record in Neo4j. Therefore, for deployments using auth providers other than native, you create a native user with a matching username and then set a home database for that user. For more information on creating native users and configuring a home database for a user, see Cypher Manual → User Management.

7.2. Administration and configuration

    How to manage multiple active databases.

7.2.1. Administrative commands

<table>
<thead>
<tr>
<th>![Information icon]</th>
<th>Administrative commands should not be used during a rolling upgrade. For more information, see Upgrade and Migration Guide → Upgrade a Causal Cluster.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>For detailed information on Cypher administrative commands, see Cypher Manual → Database management.</td>
</tr>
</tbody>
</table>

Before using administrative commands, it is important to understand the difference between stopped databases, and dropped databases:

- Databases that are stopped with the **STOP** command are completely shutdown, and may be started again through the **START** command. In a Causal Cluster, as long as a database is in a shutdown state, it can not be considered available to other members of the cluster. It is not possible to do online backups against shutdown databases and they need to be taken into special consideration during disaster recovery, as they do not have a running Raft machine while shutdown.
Dropped databases are completely removed and are not intended to be used again at all.

The following Cypher commands are used on the `system` database to manage multiple databases:

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CREATE DATABASE name</td>
<td>Create and start a new database.</td>
</tr>
<tr>
<td>DROP DATABASE name</td>
<td>Drop (remove) an existing database.</td>
</tr>
<tr>
<td>ALTER DATABASE name</td>
<td>Alter (modify) an existing database.</td>
</tr>
<tr>
<td>START DATABASE name</td>
<td>Start a database that has been stopped.</td>
</tr>
<tr>
<td>STOP DATABASE name</td>
<td>Shut down a database.</td>
</tr>
<tr>
<td>SHOW DATABASE name</td>
<td>Show the status of a specific database.</td>
</tr>
<tr>
<td>SHOW DATABASES</td>
<td>Show the name and status of all the databases.</td>
</tr>
<tr>
<td>SHOW DEFAULT DATABASE</td>
<td>Show the name and status of the default database.</td>
</tr>
<tr>
<td>SHOW HOME DATABASE</td>
<td>Show the name and status of the home database for the current user.</td>
</tr>
</tbody>
</table>

Naming rules for databases are as follows:

- Length must be between 3 and 63 characters.
- The first character of a name must be an ASCII alphabetic character.
- Subsequent characters must be ASCII alphabetic or numeric characters, dots or dashes; `[a..z][0..9].-`
- Names are case-insensitive and normalized to lowercase.
- Names that begin with an underscore and with the prefix `system` are reserved for internal use.

All of the above commands are executed as Cypher commands, and the database name is subject to the standard Cypher restrictions on valid identifiers. In particular, the `-` (dash) and `. (dot) characters are not legal in Cypher variables, and therefore names with dashes must be enclosed within back-ticks. For example, `CREATE DATABASE 'main-db'`. Database names are the only identifier for which dots don’t need to be escaped. For example, `main.db` is a valid database name.

It is possible to create an alias to refer to an existing database to avoid these restrictions. For more
For detailed information on Cypher administrative commands, see Cypher Manual → Access Control.

For examples of using the Cypher administrative commands to manage multiple active databases, see Queries.

### 7.2.2. Configuration parameters

Configuration parameters are defined in the `neo4j.conf` file.

The following configuration parameters are applicable for managing databases:

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Description</th>
<th>Default value</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>dbms.default_database</code></td>
<td>Name of the default database for the Neo4j instance. The database is created if it does not exist when the instance starts.</td>
<td>neo4j</td>
</tr>
<tr>
<td></td>
<td>In a clustered setup, the value of <code>dbms.default_database</code> is only used to set the initial default database. To change the default database at a later point, see Change the default database.</td>
<td></td>
</tr>
<tr>
<td><code>dbms.max_databases</code></td>
<td>Maximum number of databases that can be used in a Neo4j single instance or Causal Cluster. The number includes all the online and offline databases. The value is an integer with a minimum value of 2. Enterprise edition</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Once the limit has been reached, it is not possible to create any additional databases. Similarly, if the limit is changed to a number lower than the total number of existing databases, no additional databases can be created.</td>
<td></td>
</tr>
<tr>
<td><code>dbms.databases.default_to_read_only</code></td>
<td>Default mode of all databases. If this setting is set to <code>true</code> all existing and new databases will be in read only mode, and so will prevent write queries.</td>
<td>false</td>
</tr>
<tr>
<td>Parameter name</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>-------------</td>
<td></td>
</tr>
<tr>
<td><strong>dbms.databases.read_only</strong></td>
<td>List of database names for which to prevent write queries. This set can contain also not yet existing databases, but not the system database. Regardless of settings of dbms.databases.default_to_read_only, dbms.databases.read_only and dbms.databases.writable the system database will never will be read-only and will always accept write queries. Another way of preventing writes is to set the database access to read-only using the ALTER DATABASE command. Example configuration: dbms.databases.read_only=[&quot;foo&quot;, &quot;bar&quot;]</td>
<td></td>
</tr>
<tr>
<td><strong>dbms.databases.writable</strong></td>
<td>List of database names for which to accept write queries. This set can contain also not yet existing databases. The value of this setting is ignored if dbms.databases.default_to_read_only is set to false. If a database name is present in both sets, the database will be read-only and prevent write queries. If most of your databases would read-only with a few exceptions, it can be easier to set config.dbms.databases.default_to_read_only to true, and then put the names of the non read-only databases into dbms.databases.writable. Example configuration: dbms.databases.writable=[&quot;foo&quot;, &quot;bar&quot;]</td>
<td></td>
</tr>
</tbody>
</table>
Although it is possible to achieve the same goal, i.e. set a database to read-only, both by using the Cypher command `ALTER DATABASE` and by using configuration parameters in `neo4j.conf`, it is important to understand the difference between the two. `ALTER DATABASE foo SET ACCESS READ ONLY` effectively sets the database `foo` to read-only across the entire DBMS.

Using configuration parameters is more subtle and allows you to configure access on each instance separately, in case of a cluster for example. If you use `dbms.databases.default_to_read_only` all databases on that instance are set to read-only.

If both the Cypher command and the configuration parameters are used and they contain conflicting information, the database in question is set to read-only.

7.3. Queries

Examples of Cypher queries and commands that can be used to create and manage multiple active databases.

For detailed information on Cypher administrative commands, see Cypher Manual → Database management.

All commands and example queries in this section are run in the Neo4j Cypher Shell command-line interface (CLI).

Note that the `cypher-shell` queries are not case-sensitive, but must end with a semicolon.

7.3.1. Show the status of a specific database
Example 29. **SHOW DATABASE**

```bash
neo4j@system> SHOW DATABASE neo4j;
```

**In standalone mode:**

```
+-------------------+-------------------+-----+----------------+-------------------+---+-----+
| name              | address           | role | requestedStatus | currentStatus     | error | default |
+-------------------+-------------------+-----+----------------+-------------------+---+-----+
| "neo4j"           | "localhost:7687"  | "standalone" | "online"       | "online"          | "" | TRUE |
+-------------------+-------------------+-----+----------------+-------------------+---+-----+
```

1 row available after 100 ms, consumed after another 6 ms

**Or in a Causal Cluster:**

```
+-------------------+-------------------+-----+----------------+-------------------+---+-----+
| name              | address           | role | requestedStatus | currentStatus     | error | default |
+-------------------+-------------------+-----+----------------+-------------------+---+-----+
| "neo4j"           | "localhost:7687"  | "leader" | "online"       | "online"          | "" | TRUE   |
| "neo4j"           | "localhost:7688"  | "follower" | "online"      | "online"          | "" | TRUE   |
| "neo4j"           | "localhost:7689"  | "follower" | "online"      | "online"          | "" | TRUE   |
+-------------------+-------------------+-----+----------------+-------------------+---+-----+
```

3 row available after 100 ms, consumed after another 6 ms

7.3.2. Show the status of all databases
Example 30. **SHOW DATABASES**

```
neo4j@system> SHOW DATABASES;
```

In standalone mode:

```
+------------------------------------------------------------------------------------------------+
| name     | address          | role         | requestedStatus | currentStatus | error | default |
+------------------------------------------------------------------------------------------------+
| "neo4j"  | "localhost:7687" | "standalone" | "online"        | "online"      | ""    | TRUE    |
| "system" | "localhost:7687" | "standalone" | "online"        | "online"      | ""    | FALSE   |
+------------------------------------------------------------------------------------------------+
2 rows available after 5 ms, consumed after another 1 ms

Or in a Causal Cluster:

```
+------------------------------------------------------------------------------------------------+
| name     | address          | role         | requestedStatus | currentStatus | error | default |
+------------------------------------------------------------------------------------------------+
| "neo4j"  | "localhost:7687" | "leader"     | "online"        | "online"      | ""    | TRUE    |
| "neo4j"  | "localhost:7688" | "follower"   | "online"        | "online"      | ""    | TRUE    |
| "neo4j"  | "localhost:7689" | "follower"   | "online"        | "online"      | ""    | TRUE    |
| "system" | "localhost:7687" | "follower"   | "online"        | "online"      | ""    | TRUE    |
| "system" | "localhost:7688" | "leader"     | "online"        | "online"      | ""    | TRUE    |
| "system" | "localhost:7689" | "follower"   | "online"        | "online"      | ""    | TRUE    |
+------------------------------------------------------------------------------------------------+
6 rows available after 5 ms, consumed after another 1 ms

Switching between **online** and **offline** states is achieved using the **START DATABASE** and **STOP DATABASE** commands.

### 7.3.3. Show the status of the default database

The config setting `dbms.default_database` defines which database is created and started by default when Neo4j starts. The default value of this setting is **neo4j**.
Example 31. SHOW DEFAULT DATABASE

```
 neo4j@system> SHOW DEFAULT DATABASE;
```

In standalone mode:

```
+-------------------------------------------------------------------------------------+
| name    | address          | role         | requestedStatus | currentStatus | error |
+-------------------------------------------------------------------------------------+
| "neo4j" | "localhost:7687" | "standalone" | "online"        | "online"      | ""    |
+-------------------------------------------------------------------------------------+
```

1 row available after 57 ms, consumed after another 2 ms

Or in a Causal Cluster:

```
+-------------------------------------------------------------------------------------+
| name | address          | role       | requestedStatus | currentStatus | error |
+-------------------------------------------------------------------------------------+
| "neo4j" | "localhost:7687" | "follower" | "online"        | "online"      | ""    |
| "neo4j" | "localhost:7688" | "leader"   | "online"        | "online"      | ""    |
| "neo4j" | "localhost:7689" | "follower" | "online"        | "online"      | ""    |
+-------------------------------------------------------------------------------------+
```

3 row available after 57 ms, consumed after another 2 ms

You can change the default database by using `dbms.default_database`, and restarting the server.

In Community Edition, the default database is the only database available, other than the `system` database.

7.3.4. Create a database [Enterprise edition]
Example 32. CREATE DATABASE

```
neo4j@system> CREATE DATABASE sales;
```

0 rows available after 108 ms, consumed after another 0 ms

```
neo4j@system> SHOW DATABASES;
```

In standalone mode:

```
+------------------------------------------------------------------------------------------------+
<table>
<thead>
<tr>
<th>name</th>
<th>address</th>
<th>role</th>
<th>requestedStatus</th>
<th>currentStatus</th>
<th>error</th>
<th>default</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;neo4j&quot;</td>
<td>&quot;localhost:7687&quot;</td>
<td>&quot;standalone&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>TRUE</td>
</tr>
<tr>
<td>&quot;system&quot;</td>
<td>&quot;localhost:7687&quot;</td>
<td>&quot;standalone&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>FALSE</td>
</tr>
<tr>
<td>&quot;sales&quot;</td>
<td>&quot;localhost:7687&quot;</td>
<td>&quot;standalone&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>FALSE</td>
</tr>
<tr>
<td>-----------</td>
<td>------------------</td>
<td>--------------</td>
<td>-----------------</td>
<td>---------------</td>
<td>-------</td>
<td>---------</td>
</tr>
</tbody>
</table>
```

3 rows available after 4 ms, consumed after another 1 ms

Or in a Causal Cluster:

```
+------------------------------------------------------------------------------------------------+
<table>
<thead>
<tr>
<th>name</th>
<th>address</th>
<th>role</th>
<th>requestedStatus</th>
<th>currentStatus</th>
<th>error</th>
<th>default</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;neo4j&quot;</td>
<td>&quot;localhost:7687&quot;</td>
<td>&quot;leader&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>TRUE</td>
</tr>
<tr>
<td>&quot;neo4j&quot;</td>
<td>&quot;localhost:7688&quot;</td>
<td>&quot;follower&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>TRUE</td>
</tr>
<tr>
<td>&quot;neo4j&quot;</td>
<td>&quot;localhost:7689&quot;</td>
<td>&quot;follower&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>TRUE</td>
</tr>
<tr>
<td>&quot;system&quot;</td>
<td>&quot;localhost:7687&quot;</td>
<td>&quot;follower&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>FALSE</td>
</tr>
<tr>
<td>&quot;system&quot;</td>
<td>&quot;localhost:7688&quot;</td>
<td>&quot;leader&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>FALSE</td>
</tr>
<tr>
<td>&quot;system&quot;</td>
<td>&quot;localhost:7689&quot;</td>
<td>&quot;follower&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>FALSE</td>
</tr>
<tr>
<td>&quot;sales&quot;</td>
<td>&quot;localhost:7687&quot;</td>
<td>&quot;follower&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>FALSE</td>
</tr>
<tr>
<td>&quot;sales&quot;</td>
<td>&quot;localhost:7688&quot;</td>
<td>&quot;follower&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>FALSE</td>
</tr>
<tr>
<td>&quot;sales&quot;</td>
<td>&quot;localhost:7689&quot;</td>
<td>&quot;leader&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>FALSE</td>
</tr>
<tr>
<td>-----------</td>
<td>------------------</td>
<td>------------</td>
<td>-----------------</td>
<td>---------------</td>
<td>-------</td>
<td>-----------</td>
</tr>
</tbody>
</table>
```

9 rows available after 4 ms, consumed after another 1 ms

7.3.5. Switch a database

Example 33. `.use <database-name>`

```
neo4j@system> :use sales
neo4j@sales>
```

7.3.6. Create or replace a database
Example 34. CREATE OR REPLACE DATABASE

```sql
CREATE OR REPLACE DATABASE neo4j @sales>
match (n) return count(n) as countNode;
```

+-----------------+
| countNode       |
| 115             |
+-----------------+

1 row available after 12 ms, consumed after another 0 ms

```sql
CREATE OR REPLACE DATABASE sales;
```

0 rows available after 64 ms, consumed after another 0 ms

```sql
SHOW DATABASES;
```

In standalone mode:

```
+------------------------------------------------------------------------------------------------+
| name     | address          | role         | requestedStatus | currentStatus | error | default |
+------------------------------------------------------------------------------------------------+
| "neo4j"  | "localhost:7687" | "standalone" | "online"        | "online"      | ""    | TRUE    |
| "system" | "localhost:7687" | "standalone" | "online"        | "online"      | ""    | FALSE   |
| "sales"  | "localhost:7687" | "standalone" | "online"        | "online"      | ""    | FALSE   |
+------------------------------------------------------------------------------------------------+
```

3 rows available after 2 ms, consumed after another 2 ms

Or in a Causal Cluster:

```
+------------------------------------------------------------------------------------------------+
| name     | address          | role       | requestedStatus | currentStatus | error | default   |
+------------------------------------------------------------------------------------------------+
| "neo4j"  | "localhost:7687" | "leader"   | "online"        | "online"      | ""    | TRUE      |
| "neo4j"  | "localhost:7688" | "follower" | "online"        | "online"      | ""    | TRUE      |
| "neo4j"  | "localhost:7689" | "follower" | "online"        | "online"      | ""    | TRUE      |
| "system" | "localhost:7687" | "follower" | "online"        | "online"      | ""    | FALSE     |
| "system" | "localhost:7688" | "follower" | "online"        | "online"      | ""    | FALSE     |
| "system" | "localhost:7689" | "follower" | "online"        | "online"      | ""    | FALSE     |
| "sales"  | "localhost:7687" | "follower" | "online"        | "online"      | ""    | FALSE     |
| "sales"  | "localhost:7688" | "follower" | "online"        | "online"      | ""    | FALSE     |
| "sales"  | "localhost:7689" | "leader"   | "online"        | "online"      | ""    | FALSE     |
+------------------------------------------------------------------------------------------------+
```

9 rows available after 2 ms, consumed after another 2 ms

```sql
:use sales
```

```sql
neo4j@sales> match (n) return count(n) as countNode;
```

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7.3.7. Stop a database

Example 35. STOP DATABASE

```
 NEO4J@SYSTEM> STOP DATABASE sales;

 0 rows available after 18 ms, consumed after another 6 ms

NEO4J@SYSTEM> SHOW DATABASES;

In standalone mode:

+---------------------------------------------+-----+----------+----------------+----------------+-----+------+
| name     | address          | role    | requestedStatus | currentStatus  | error | default |
+---------------------------------------------+-----+----------+----------------+----------------+-----+------+
| "neo4j"  | "localhost:7687" | "standalone" | "online"       | "online"       | ""   | TRUE  |
| "system" | "localhost:7687" | "standalone" | "online"       | "online"       | ""   | FALSE |
| "sales"  | "localhost:7687" | "standalone" | "offline"      | "offline"      | ""   | FALSE |
+---------------------------------------------+-----+----------+----------------+----------------+-----+------+

3 rows available after 2 ms, consumed after another 1 ms

Or in a Causal Cluster:

+---------------------------------------------+-----+----------+----------------+----------------+-----+------+
| name     | address          | role       | requestedStatus | currentStatus  | error | default |
+---------------------------------------------+-----+----------+----------------+----------------+-----+------+
| "neo4j"  | "localhost:7687" | "leader"   | "online"       | "online"       | ""   | TRUE  |
| "neo4j"  | "localhost:7688" | "follower" | "online"       | "online"       | ""   | TRUE  |
| "neo4j"  | "localhost:7689" | "follower" | "online"       | "online"       | ""   | TRUE  |
| "system" | "localhost:7687" | "leader"   | "online"       | "online"       | ""   | FALSE |
| "system" | "localhost:7688" | "leader"   | "online"       | "online"       | ""   | FALSE |
| "system" | "localhost:7689" | "leader"   | "online"       | "online"       | ""   | FALSE |
| "sales"  | "localhost:7687" | "unknown"  | "offline"      | "offline"      | ""   | FALSE |
| "sales"  | "localhost:7688" | "unknown"  | "offline"      | "offline"      | ""   | FALSE |
| "sales"  | "localhost:7689" | "unknown"  | "offline"      | "offline"      | ""   | FALSE |
+---------------------------------------------+-----+----------+----------------+----------------+-----+------+

9 rows available after 2 ms, consumed after another 1 ms

NEO4J@SYSTEM> :use sales

Unable to get a routing table for database 'sales' because this database is unavailable
NEO4J@sales[UNAVAILABLE]>
```
7.3.8. Start a database

Example 36. START DATABASE

```
START DATABASE neo4j
```

```
0 rows available after 21 ms, consumed after another 1 ms
```

```
SHOW DATABASES;
```

In standalone mode:

```
+------------------------------------------------------------------------------------------------+
| name     | address          | role         | requestedStatus | currentStatus | error | default |
+------------------------------------------------------------------------------------------------+
| "neo4j"  | "localhost:7687" | "standalone" | "online"        | "online"      | ""    | TRUE    |
| "system" | "localhost:7687" | "standalone" | "online"        | "online"      | ""    | FALSE   |
| "sales"  | "localhost:7687" | "standalone" | "online"        | "online"      | ""    | FALSE   |
+------------------------------------------------------------------------------------------------+
```

3 rows available after 2 ms, consumed after another 1 ms

Or in a Causal Cluster:

```
+------------------------------------------------------------------------------------------------+
| name     | address          | role       | requestedStatus | currentStatus | error | default |
+------------------------------------------------------------------------------------------------+
| "neo4j"  | "localhost:7687" | "leader"   | "online"        | "online"      | ""    | TRUE    |
| "neo4j"  | "localhost:7688" | "follower" | "online"        | "online"      | ""    | TRUE    |
| "neo4j"  | "localhost:7689" | "follower" | "online"        | "online"      | ""    | TRUE    |
| "system" | "localhost:7687" | "follower" | "online"        | "online"      | ""    | FALSE   |
| "system" | "localhost:7688" | "leader"   | "online"        | "online"      | ""    | FALSE   |
| "system" | "localhost:7689" | "follower" | "online"        | "online"      | ""    | FALSE   |
| "sales"  | "localhost:7687" | "follower" | "online"        | "online"      | ""    | FALSE   |
| "sales"  | "localhost:7688" | "follower" | "online"        | "online"      | ""    | FALSE   |
| "sales"  | "localhost:7689" | "leader"   | "online"        | "online"      | ""    | FALSE   |
+------------------------------------------------------------------------------------------------+
```

9 rows available after 2 ms, consumed after another 1 ms

7.3.9. Drop or remove a database

[Enterprise edition]
Example 37. DROP DATABASE

```sql
neo4j@system> DROP DATABASE sales;
0 rows available after 82 ms, consumed after another 1 ms
```

```sql
neo4j@system> SHOW DATABASES;
```

<table>
<thead>
<tr>
<th>name</th>
<th>address</th>
<th>role</th>
<th>requestedStatus</th>
<th>currentStatus</th>
<th>error</th>
<th>default</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;neo4j&quot;</td>
<td>&quot;localhost:7687&quot;</td>
<td>&quot;standalone&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>TRUE</td>
</tr>
<tr>
<td>&quot;system&quot;</td>
<td>&quot;localhost:7687&quot;</td>
<td>&quot;standalone&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>FALSE</td>
</tr>
</tbody>
</table>

2 rows available after 6 ms, consumed after another 0 ms

### 7.4. Error handling

This section describes how to manage errors that you may encounter while managing databases.

When running the database management queries, such as `CREATE DATABASE`, it is possible to encounter errors.

### 7.4.1. Observing errors

Because database management operations are performed asynchronously, these errors may not returned immediately upon query execution. Instead, you must monitor the output of `SHOW DATABASES`; particularly the `error` and `currentStatus` columns.
Example 38. Fail to create a database

```bash
neo4j@system> CREATE DATABASE foo;

0 rows available after 108 ms, consumed after another 0 ms

neo4j@system> SHOW DATABASE foo;
```

In standalone mode:

```
+----------------------------------------------------------------------------------------------------+--------------+
| name   | address          | role         | requestedStatus | currentStatus | error                |
| default |                 |              |                 |               | File system permissions | FALSE   |
+----------------------------------------------------------------------------------------------------+--------------+

1 rows available after 4 ms, consumed after another 1 ms

In a Causal Cluster:

```
+----------------------------------------------------------------------------------------------------+--------------+
| name   | address          | role         | requestedStatus | currentStatus | error                |
| default |                 |              |                 |               | File system permissions | FALSE   |
|         |                 | leader       | online          | online        | ""                   |
| "foo"  | "localhost:7689" | follower     | online          | dirty         | "File system permissions" | FALSE   |
+----------------------------------------------------------------------------------------------------+--------------+

3 row available after 100 ms, consumed after another 6 ms
```

7.4.2. Database states

A database management operation may fail for a number of reasons. For example, if the file system instance has incorrect permissions, or Neo4j itself is misconfigured. As a result, the contents of the `error` column in the `SHOW DATABASE` query results may vary significantly.

However, databases may only be in one of a select number of states:

<table>
<thead>
<tr>
<th>Current state</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>initial</td>
<td>The database has not yet been created.</td>
</tr>
<tr>
<td>Current state</td>
<td>Description</td>
</tr>
<tr>
<td>------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>online</td>
<td>The database is running.</td>
</tr>
<tr>
<td>offline</td>
<td>The database is not running.</td>
</tr>
<tr>
<td>store copying</td>
<td>The database is currently being updated from another instance of Neo4j.</td>
</tr>
<tr>
<td>dropped</td>
<td>The database has been deleted.</td>
</tr>
<tr>
<td>dirty</td>
<td>This state implies an error has occurred. The database's underlying store files may be invalid. For more information, consult the server's logs.</td>
</tr>
<tr>
<td>quarantined</td>
<td>The database is effectively stopped and its state may not be changed until no longer quarantined.</td>
</tr>
<tr>
<td>unknown</td>
<td>This instance of Neo4j doesn't know the state of this database.</td>
</tr>
</tbody>
</table>

Most often, when a database management operation fails, Neo4j attempts to transition the database in question to the offline state. If the system is certain that no store files have yet been created, it transitions the database to initial instead. Similarly, if the system suspects that the store files underlying the database are invalid (incomplete, partially deleted, or corrupt), then it transitions the database to dirty.

While dropped is a valid database state, it is only transiently observable, as database records are removed from SHOW DATABASE results once the DROP operation is complete.

### 7.4.3. Retrying failed operations

Database management operations may be safely retried in the event of failure. However, these retries are not guaranteed to succeed, and errors may persist through several attempts.

If a database is in the quarantined state, retrying the last operation will not work.
Example 39. Retry to start a database

```sql
START DATABASE foo;
```

0 rows available after 108 ms, consumed after another 0 ms

```sql
SHOW DATABASE foo;
```

+----------------------------------------------------------------------------------------------------+
<table>
<thead>
<tr>
<th>name</th>
<th>address</th>
<th>role</th>
<th>requestedStatus</th>
<th>currentStatus</th>
<th>error</th>
</tr>
</thead>
<tbody>
<tr>
<td>default</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+--------+----------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;foo&quot;</td>
<td>&quot;localhost:7687&quot;</td>
<td>&quot;standalone&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;offline&quot;</td>
<td>&quot;Some error message&quot;</td>
</tr>
<tr>
<td>FALSE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
+--------+----------------------------------------------------------|

1 rows available after 4 ms, consumed after another 1 ms

After investigating and addressing the underlying issue, you can start the database again and verify that it is running properly:

```sql
START DATABASE foo;
```

0 rows available after 108 ms, consumed after another 0 ms

```sql
SHOW DATABASE foo;
```

+------------------------------------------------------------------------------------------------+
<table>
<thead>
<tr>
<th>name</th>
<th>address</th>
<th>role</th>
<th>requestedStatus</th>
<th>currentStatus</th>
<th>error</th>
<th>default</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;foo&quot;</td>
<td>&quot;localhost:7687&quot;</td>
<td>&quot;standalone&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>FALSE</td>
</tr>
</tbody>
</table>
+----------+------------------+--------------+-----------------+---------------+-------+---------|

1 rows available after 4 ms, consumed after another 1 ms

If repeated retries of a command have no effect, or if a database is in a dirty state, you may drop and recreate the database, as detailed in Cypher manual → Database management.

When running DROP DATABASE as part of an error handling operation, you can also append DUMP DATA to the command. It produces a database dump that can be further examined and potentially repaired.

7.4.4. Quarantined databases

There are two ways to get a database into a quarantined state:
• By using the `dbms.quarantineDatabase` procedure locally to isolate a specific database. The procedure must be executed on the instance whose copy of the database you want to quarantine. A reason for that can be, for example, when a database is unable to start on a given instance due to a file system permissions issue with the volume where the database is located or when a recently started database begins to log errors. The quarantine state renders the database inaccessible on that instance and prevents its state from being changed, for example, with the `START DATABASE` command.

If running in a cluster, database management commands such as `START DATABASE foo` will still take effect on the instances which have not quarantined `foo`.

• When a database encounters a severe error during its normal run, which prevents it from a further operation, Neo4j stops that database and brings it into a quarantined state. Meaning, it is not possible to restart it with a simple `START DATABASE` command. You have to execute `CALL dbms.quarantineDatabase(databaseName, false)` on the instance with the failing database in order to lift the quarantine.

After lifting the quarantine, the instance will automatically try to bring the database to the desired state.

It is recommended to run the quarantine procedure over the `bolt://` protocol rather than `neo4j://`, which may route requests to unexpected instances.

Syntax:

`CALL dbms.quarantineDatabase(databaseName, setStatus, reason)`

Arguments:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>databaseName</code></td>
<td>String</td>
<td>The name of the database that will be put into or removed from quarantine.</td>
</tr>
<tr>
<td><code>setStatus</code></td>
<td>Boolean</td>
<td><code>true</code> for placing the database into quarantine; <code>false</code> for lifting the quarantine.</td>
</tr>
<tr>
<td><code>reason</code></td>
<td>String</td>
<td>(Optional) The reason for placing the database in quarantine.</td>
</tr>
</tbody>
</table>

Returns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>databaseName</code></td>
<td>String</td>
<td>The name of the database.</td>
</tr>
<tr>
<td><code>quarantined</code></td>
<td>String</td>
<td>Actual state.</td>
</tr>
<tr>
<td><code>result</code></td>
<td>String</td>
<td>Result of the last operation. The result contains the user, the time, and the reason for the quarantine.</td>
</tr>
</tbody>
</table>
The `dbms.quarantineDatabase` procedure replaces `dbms.cluster.quarantineDatabase`, which has been deprecated in Neo4j 4.3 and will be removed with the next major version.

### Quarantine a database

```plaintext
CALL dbms.quarantineDatabase("foo", true);
```

+ databaseName | quarantined | result
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;foo&quot;</td>
<td>TRUE</td>
<td>&quot;By neo4j at 2020-10-15T15:10:41.348Z: No reason given&quot;</td>
</tr>
</tbody>
</table>

3 row available after 100 ms, consumed after another 6 ms

### Check if a database is quarantined

```plaintext
SHOW DATABASE foo;
```

+ name | address          | role     | requestedStatus | currentStatus | error
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;foo&quot;</td>
<td>&quot;localhost:7688&quot;</td>
<td>&quot;unknown&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;quarantined&quot;</td>
<td>&quot;By neo4j at 2020-10-15T15:10:41.348Z: No reason given&quot;</td>
</tr>
<tr>
<td>&quot;foo&quot;</td>
<td>&quot;localhost:7689&quot;</td>
<td>&quot;follower&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
</tr>
<tr>
<td>&quot;foo&quot;</td>
<td>&quot;localhost:7687&quot;</td>
<td>&quot;leader&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
</tr>
</tbody>
</table>

3 row available after 100 ms, consumed after another 6 ms

A quarantined state is persisted for user databases. This means that if a database is quarantined, it will remain so even if that Neo4j instance is restarted. You can remove it only by running the `dbms.quarantineDatabase` procedure on the instance where the quarantined database is located, passing `false` for the `setStatus` parameter.

The one exception to this rule is for the built-in `system` database. Any quarantine for that database is removed automatically after instance restart.

### 7.5. Databases in a Causal Cluster

This section describes how to manage multiple active databases in a Causal Cluster.

Multiple databases in a Causal Cluster are managed the same way as a single instance. Administrators can use the same Cypher commands described in Administrative commands to manage databases. This is based on two main principles:

- All databases are available on all members of a cluster - this applies to Core servers and Read
Replicas.

- Administrative commands must be executed on the system database, on the Leader member of the cluster.

7.5.1. Change the default database

You can use the procedure `dbms.cluster.setDefaultDatabase("newDefaultDatabaseName")` to change the default database of a Causal cluster.

1. Ensure that the database to be set as default exists, otherwise create it using the command `CREATE DATABASE <database-name>`.

2. Show the name and status of the current default database by using the command `SHOW DEFAULT DATABASE`.

3. Stop the current default database using the command `STOP DATABASE <database-name>`.

4. On the Leader member of the cluster, run `CALL` `dbms.cluster.setDefaultDatabase("newDefaultDatabaseName")` against the system database to set the new default database.

5. Optionally, you can start the previous default database as non-default by using `START DATABASE <database-name>`.

7.5.2. Run Cypher administrative commands from Cypher Shell on a Causal Cluster

For the following examples consider a Causal Cluster environment formed by 5 members, 3 Core servers, and 2 Read Replicas:
Example 40. View the members of a Causal Cluster

```
neo4j@neo4j> CALL dbms.cluster.overview();
```

+------------------------------------------+------------------------------------------+-----------------------------+-----------------------------+
| id           | addresses                               | groups                      |                            |
| databases     |                                        |                             |                            |
+------------------------------------------+------------------------------------------+-----------------------------+-----------------------------+
| "8c...3d"    | ["bolt://core01:7687", "http://core01:7474", "https://core01:7473"] | {neo4j: "FOLLOWER", system: "FOLLOWER"} | [ ]                        |
|              |                                        |                             |                            |
| "8f...28"    | ["bolt://core02:7687", "http://core02:7474", "https://core02:7473"] | {neo4j: "LEADER", system: "LEADER"} | [ ]                        |
|              |                                        |                             |                            |
| "e0...4d"    | ["bolt://read01:7687", "http://read01:7474", "https://read01:7473"] | {neo4j: "READ_REPLICA", system: "READ_REPLICA"} | [ ]                        |
|              |                                        |                             |                            |
| "1a...64"    | ["bolt://core03:7687", "http://core03:7474", "https://core03:7473"] | {neo4j: "FOLLOWER", system: "FOLLOWER"} | [ ]                        |
|              |                                        |                             |                            |
| "59...87"    | ["bolt://read02:7687", "http://read02:7474", "https://read02:7473"] | {neo4j: "READ_REPLICA", system: "READ_REPLICA"} | [ ]                        |
+------------------------------------------+------------------------------------------+-----------------------------+-----------------------------+

5 rows available after 5 ms, consumed after another 0 ms

The leader is currently the instance exposing port 7681 for the bolt protocol, and 7471/7481 for the http/https protocol.

Administrators can connect and execute Cypher commands in the following ways:
Example 41. Using the `bolt://` scheme to connect to the Leader:

```
$ bin/cypher-shell -a bolt://localhost:7681 -d system -u neo4j -p neo4j

Connected to Neo4j 4.0.0 at bolt://localhost:7681 as user neo4j.
Type :help for a list of available commands or :exit to exit the shell.
Note that Cypher queries must end with a semicolon.
```

```
neo4j@system> SHOW DATABASES;

+---------------------------+
<table>
<thead>
<tr>
<th>name</th>
<th>status</th>
<th>default</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;neo4j&quot;</td>
<td>&quot;online&quot;</td>
<td>TRUE</td>
</tr>
<tr>
<td>&quot;system&quot;</td>
<td>&quot;online&quot;</td>
<td>FALSE</td>
</tr>
</tbody>
</table>
+-----------+---------+---------+

2 rows available after 34 ms, consumed after another 0 ms
```

```
neo4j@system> CREATE DATABASE data001;

0 rows available after 378 ms, consumed after another 12 ms
Added 1 nodes, Set 4 properties, Added 1 labels
```

```
neo4j@system> SHOW DATABASES;

+-----------------------------+
<table>
<thead>
<tr>
<th>name</th>
<th>status</th>
<th>default</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;neo4j&quot;</td>
<td>&quot;online&quot;</td>
<td>TRUE</td>
</tr>
<tr>
<td>&quot;system&quot;</td>
<td>&quot;online&quot;</td>
<td>FALSE</td>
</tr>
<tr>
<td>&quot;data001&quot;</td>
<td>&quot;online&quot;</td>
<td>FALSE</td>
</tr>
</tbody>
</table>
+-------------+---------+---------+

3 rows available after 2 ms, consumed after another 1 ms
```
Example 42. Using the neo4j:// scheme to connect to any Core member:

```
$ bin/cypher-shell -a neo4j://localhost:7683 -d system -u neo4j -p neo4j
```

Connected to Neo4j 4.0.0 at neo4j://localhost:7683 as user neo4j. Type :help for a list of available commands or :exit to exit the shell. Note that Cypher queries must end with a semicolon.

```
neo4j@system> SHOW DATABASES;
```

```
+--------------------------------+
| name      | status | default |
+--------------------------------+
| "neo4j"   | "online" | TRUE    |
| "system"  | "online" | FALSE   |
| "data001" | "online" | FALSE   |
+--------------------------------+
3 rows available after 0 ms, consumed after another 0 ms

```
neo4j@system> CREATE DATABASE data002;
```

```
0 rows available after 8 ms, consumed after another 1 ms
Added 1 nodes, Set 4 properties, Added 1 labels
```

```
neo4j@system> SHOW DATABASES;
```

```
+--------------------------------+
| name      | status | default |
+--------------------------------+
| "neo4j"   | "online" | TRUE    |
| "system"  | "online" | FALSE   |
| "data001" | "online" | FALSE   |
| "data002" | "online" | FALSE   |
+--------------------------------+
4 rows available after 33 ms, consumed after another 0 ms
```

The neo4j:// scheme is the equivalent to the bolt+routing: scheme available in earlier versions of Neo4j, but it can be used seamlessly with a standalone and clustered DBMS.

### 7.6. Connecting remote databases

**Enterprise edition**

This section describes the steps required to guarantee a secure connection to a remote database.

This feature enables access to one or more graphs on one or more remote standalone servers or clusters by configuring database aliases to remote databases. This alias does not store any data, but it enables users or applications to perform queries on remote databases as if they were on the local DBMS server.
Contrary to fabric databases, which are added in the configuration and not supported directly on clusters, a remote database alias can be modified with Administration Commands on a running system and will be automatically synchronized across all instances of a cluster.

A remote database alias can also be used to provide a single, unique and unchangeable access point to a user. The following steps describe the setup required to define a remote database alias both for the local and remote DBMS, as well as documenting best practices and additional guidance on changes in the configuration.

These steps are also useful in case there are changes in the name of databases or the location of standalone servers and cluster instances.

The fabric database is limited to the use of standalone instances and not the usual causal cluster. For this reason, it requires a more complex deployment architecture. Additionally, DBAs, users, and applications accessing these remote databases are subject to the same security permissions/privileges that are defined on the remote database.

In the following example, a remote alias in DBMS A will connect to a remote database named Db1 in DBMS B.

![Diagram of remote database alias setup]

**Figure 4. Overview of the required remote database alias setup**

A remote alias defines:

- Which user of the remote DBMS B is used.
- Where the remote database is located.
- How to connect to the remote database using driver settings.
• A remote database alias is only accessible by users with appropriate privileges. See DBMS administration for further information.

• Any user with access to a remote database alias will authenticate with the defined identical remote user credentials on DBMS B.

• A remote alias does not restrict the access to Db2. If the remote user should not be able to access Db2, Administrator B must define the appropriate privileges. See Access Control for further information.

• In a cluster, the administration of the remote database alias must be executed on the system database, on the Leader member of the cluster. The remote database alias is available on all members of a cluster - this applies to Core servers and Read Replicas.

• Connecting to a remote DBMS of a different version of Neo4j is not supported.

7.6.1. Configuration needed on the remote DBMS (Administrator B)

Follow these steps to setup the required configuration:

1. Create the user to share with Administrator A. Currently, only user and password-based authentication such as native authentication are supported.

2. Define the permissions for the user as you see fit.

3. Securely transmit the credentials to Administrator A, setting up the link to database Db1.

• If a remote alias target is a cluster, it is recommended to enable Server-side routing to handle leader changes.

• It is recommended to create a custom role to track all users shared on a remote connection, so they remain trackable.

CREATE USER alice SET PASSWORD 'secret'
CREATE ROLE remote
GRANT ACCESS ON DATABASE neo4j TO remote
GRANT MATCH (*) ON GRAPH neo4j TO remote
GRANT ROLE remote TO alice

In this case, Administrator B must do the required setup for the SSL framework and check whether the database accepts non-local connection, if the latter is desired.

# accept non-local connections
dbms.default_listen_address=0.0.0.0

# configure ssl for bolt
dbms.ssl.policy.bolt.enabled=true
dbms.ssl.policy.bolt.base_directory=certificates/bolt
dbms.ssl.policy.bolt.private_key=private.key
dbms.ssl.policy.bolt.public_certificate=public.crt
dbms.ssl.policy.bolt.client_auth=NONE

# enforcing ssl connection
dbms.connector.bolt.tls_level=REQUIRED
7.6.2. Configuration of DBMS with remote database alias (Administrator A)

Firstly, you need to generate an encryption key. In this case, the credentials of a user of DBMS B are reversibly encrypted and stored in the system database of DBMS A. Since the algorithm used is AES/GCM, an AES encryption key needs to be provided. It should have length 256, and be stored in a password-protected keystore of format pkcs12.

The key can be generated by using the following keytool command, which is included in Java Platform, Standard Edition:

```
keytool -genseckey -keyalg aes -keysize 256 -storetype pkcs12 -keystore [keystore-name] -alias [key-name] -storepass [keystore-password]
```

Set configuration

The following configuration is necessary for creating a remote database alias:

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>systemdb.secrets.keystore.path</td>
<td>The absolute path to the keystore file, including the file name.</td>
</tr>
<tr>
<td>systemdb.secrets.keystore.password</td>
<td>The password to the keystore file. Use Command expansion to set the password.</td>
</tr>
<tr>
<td>systemdb.secrets.key.name</td>
<td>The name of the secret key</td>
</tr>
</tbody>
</table>

It is recommended to generate the keystore on the same Java version on which Neo4j is run, as the supported encryption algorithms may vary. For details on the version of Java required by Neo4j, see Java.

To prevent unauthorized access, the keystore file must be stored in a trusted location. This is the main way to protect the encrypted passwords which will be stored on the system database.

It shouldn’t be accessible to any user except for the administrator and neo4j, for whom the keystore file must be readable.

In a cluster Administrator A needs to share the same keystore file over all instances.

For example, these would be valid additions to the config when using the suggested keytool command:

```
systemdb.secrets.keystore.path=/home/secure-folder/keystore-name.pkcs12
systemdb.secrets.keystore.password=$(conf/password.sh)
systemdb.secrets.key.name=key-name
```
Where `password.sh` might look like this:

```bash
#!/bin/bash
echo "\$KEYSTORE_PASSWORD_ENVIRONMENT_VARIABLE"
```

Don’t forget to change the permissions of the configuration file and start Neo4j with the command expansion flag:

```
chmod 640 conf/neo4j.conf
bin/neo4j start --expand-commands
```

### 7.6.3. Managing remote database aliases

You can use the alias commands to manage remote database aliases. In this case, it is strongly recommended to connect to a remote database alias with a secured connection. Please note that only client-side SSL is supported. By default, remote aliases require a secured URI scheme such as `neo4j+s`. This can be disabled by setting the driver setting `ssl_enforced` to `false`.

For example, the following command can be used to create a remote database alias:

```sql
CREATE ALIAS 'remote-neo4j' FOR DATABASE 'neo4j' AT "neo4j+s://location:7687" USER alice PASSWORD 'secret'
```

In order to do so, either database management or alias management privileges are required. The permission to create an alias can be granted like this:

```sql
GRANT CREATE ALIAS ON DBMS TO administrator
```

Grant the access privileges to use the remote database alias:

```sql
GRANT ACCESS ON DATABASE 'remote-neo4j' TO role
```

If a transaction modifies an alias (e.g., changing the database targeted on DBMS B), other transactions concurrently executing against that alias may be aborted and rolled back for safety. This prevents issues such as a transaction executing against multiple target databases for the same alias.

### 7.6.4. Changing the encryption key

If the encryption key in the keystore is changed, the encrypted credentials for existing remote database aliases will need to be updated as they will no longer be readable.

If there is a failure when reading the keystore file, investigate the `debug.log` to find out which parameter is the source of the problem. In case it is not possible to connect to the remote alias after its creation, verify its settings by connecting to the remote database at `https://browser.neo4j.io/` or at your local browser.
7.6.5. User connection to remote database aliases

A user can connect to a remote database alias the same way they would do to a database. This includes:

- Connecting directly to the remote database alias.
- The **Use clause** enables a user to query a remote database alias that they are not directly connected to:

```sql
USE `remote-neo4j` MATCH (n) RETURN *
```

- Connecting to a remote database alias as a home database. This needs to be set by Administrator A. See more about **User Management**.

```sql
ALTER USER alice SET HOME DATABASE `remote-neo4j`
```

Remote alias transactions will not be visible in **SHOW TRANSACTIONS** on DBMS A. However, they can be accessed and terminated on the remote database when connecting with the same user.
This chapter describes the configuration and operation of a Neo4j Causal Cluster.

This chapter describes the following:

- **Introduction** — An overview of the Causal Clustering architecture.
- **Deploy a cluster** — The basics of configuring and deploying a new cluster.
- **Seed a cluster** — How to deploy a Causal Cluster with pre-existing data.
- **Discovery** — How members of a cluster discover each other.
- **Intra-cluster encryption** — How to secure the cluster communication.
- **Internals** — A few internals regarding the operation of the cluster.
- **Settings reference** — A summary of the most important Causal Cluster settings.

Further information:

- For instructions on setting up clustering when running Neo4j in a Docker container, see Clustering on Docker.
- For an example of managing multiple databases in a cluster, see Multiple databases in a cluster.
- For instructions on how you to upgrade your Neo4j cluster, see Upgrade a Causal Cluster.
- For a summary of the facilities that are available for monitoring a Neo4j cluster, see Monitoring (and specifically, Monitoring a cluster).
- For a tutorial on setting up a test cluster locally on a single machine, see Set up a local Causal Cluster.
- For advanced concepts, including the implementation of the Raft Protocol, see Advanced Causal Clustering.

### 8.1. Introduction

Introduction to the Neo4j Causal Clustering architecture.

#### 8.1.1. Overview

Neo4j’s Causal Clustering provides three main features:

1. **Safety**: Core Servers provide a fault tolerant platform for transaction processing which will remain available while a simple majority of those Core Servers are functioning.

2. **Scale**: Read Replicas provide a massively scalable platform for graph queries that enables very large graph workloads to be executed in a widely distributed topology.

3. **Causal consistency**: when invoked, a client application is guaranteed to read at least its own writes.

Together, this allows the end-user system to be fully functional and both read and write to the database in
the event of multiple hardware and network failures and makes reasoning about database interactions straightforward.

In the remainder of this section we will provide an overview of how causal clustering works in production, including both operational and application aspects.

8.1.2. Operational view

From an operational point of view, it is useful to view the cluster as being composed of servers with two different roles, referred to as Primary and Secondary servers.

![Causal Cluster Architecture](image)

Figure 5. Causal Cluster Architecture

The two roles are foundational in any production deployment but are managed at different scales from one another and undertake different roles in managing the fault tolerance and scalability of the overall cluster.

8.1.3. Primary servers

The Primary servers are based on two types on instances:

- **Single instance** is an instance that operates without redundancy within the set of Primary servers and allows read and write operations. Redundancy is achieved by adding Secondary servers, which guarantee causal consistency but they do not safeguard data as Primary servers do. Therefore, clusters based on a Single instance as Primary server are good for read scalability, but they are not fault tolerant. If a fault occurs on the Single instance, there is a potential risk of data loss: it is the responsibility of the application or of the tooling around the cluster to eliminate or minimize such risk.

- **Core instance** is an instance that allows read and write operations and its main responsibility is to safeguard data. Core instances do so by replicating all transactions using the Raft protocol. Raft ensures that the data is safely durable before confirming a transaction commit to the end user application. In practice, this means once a majority of Core instances in a cluster (N/2+1) have accepted the transaction, it is safe to acknowledge the commit to the end user application.
The safety requirement has an impact on write latency. Implicitly, writes are acknowledged by the fastest majority, but as the number of Core instances in the cluster grows, so does the size of the majority needed to acknowledge a write.

In practice, this means that there are relatively few machines in a typical Core instance cluster, enough to provide sufficient fault tolerance for the specific deployment. This is calculated with the formula \( M = 2F + 1 \), where \( M \) is the number of Core instances required to tolerate \( F \) faults. For example:

- In order to tolerate two failed Core instances, you need to deploy a cluster of five Core instances.
- The smallest fault tolerant cluster, a cluster that can tolerate one fault, must have three Core instances.
- It is also possible to create a Causal Cluster consisting of only two Core instances. However, that cluster is not fault-tolerant. If one of the two servers fails, the remaining server becomes read-only.

With Core instances, should the cluster suffer enough Core failures, it can no longer process writes and becomes read-only to preserve safety.

In version 4.4 of Neo4j Causal Cluster, Primary servers cannot be mixed: either one Single instance is the Primary server or a set of Core instances are the Primary servers.

8.1.4. Secondary servers

In version 4.4 of Neo4j Causal Cluster, Secondary servers can only be one type of instance, called Read Replica instances.

Read Replica instances are asynchronously replicated from Primary Servers via transaction log shipping. They will periodically poll an upstream server for new transactions and have these shipped over. Many Read Replicas can be fed data from a relatively small number of Primary Servers, allowing for a large fan out of the query workload for scale.

Read Replicas are read-only, but you should not create one (or convert the `dbms.mode` of a CORE to READ_REPLICA) if you simply desire a neo4j instance which temporarily cannot execute write queries. Instead you should use the `dbms.databases.default_to_read_only` config setting to prevent writes to databases on the instance in question.

Read Replica instances should typically be run in relatively large numbers and treated as disposable. Losing a Read Replica does not impact the cluster’s availability, aside from the loss of its fraction of graph query throughput. It does not affect the fault tolerance capabilities of the cluster.

The main responsibility of Read Replica instances is to scale out read workloads. Read Replica instances act like caches for the graph data and are fully capable of executing arbitrary (read-only) queries and procedures.

When the Primary server is a Single instance, Secondary servers may be part of a Disaster Recovery strategy. Due to its asynchronous nature, Read Replica instances may not provide all transactions committed on the Primary server, but they may be set as a new Primary server in case the Single instance
is no longer available. The change of a Read Replica instance into a Single instance is a manual operation that must be executed by a Database Administrator or by some tooling and it requires careful checks, in order to identify the most up-to-date instance and the status of the other instances.

8.1.5. Causal consistency

While the operational mechanics of the cluster are interesting from an application point of view, it is also helpful to think about how applications will use the database to get their work done. In many applications, it is typically desirable to both read from the graph and write to the graph. Depending on the nature of the workload, it is common to want reads from the graph to take into account previous writes to ensure causal consistency.

Causal consistency is one of numerous consistency models used in distributed computing. It ensures that causally related operations are seen by every instance in the system in the same order. Consequently, client applications are guaranteed to read their own writes, regardless of which instance they communicate with. This simplifies interaction with large clusters, allowing clients to treat them as a single (logical) server.

Causal consistency makes it possible to write to Core Servers (where data is safe) and read those writes from a Read Replica (where graph operations are scaled out). For example, causal consistency guarantees that the write which created a user account will be present when that same user subsequently attempts to log in.
On executing a transaction, the client can ask for a bookmark which it then presents as a parameter to subsequent transactions. Using that bookmark the cluster can ensure that only servers which have processed the client’s bookmarked transaction will run its next transaction. This provides a causal chain which ensures correct read-after-write semantics from the client’s point of view.

Aside from the bookmark everything else is handled by the cluster. The database drivers work with the cluster topology manager to choose the most appropriate Core Servers and Read Replicas to provide high quality of service.

Since Neo4j clusters are causally consistent, in the remainder of this chapter, the terms causal cluster or cluster are used to denote Neo4j installations consisting of primary and secondary servers.

8.2. Deploy a cluster Enterprise edition

How to deploy a new Neo4j Causal Cluster.
8.2.1. Introduction

This section describes how to set up a new cluster. Two scenarios are covered:

1. A four-instance cluster with one Single instance as Primary server and three Read Replica instances as Secondary servers. This scenario is ideal for reporting and analytical workloads.

2. A three-instance cluster with three Core instances as Primary servers. This scenario is ideal for transactional workloads.

Additionally, the process to turn a Secondary server into a standalone instance by detaching it from an existing cluster is also described.

8.2.2. Configure a cluster with Single and Read Replica instances

The following configuration settings are important to consider when deploying a new cluster with a Single instance as a Primary server. See also Settings reference for more detailed descriptions and examples.

![Warning]

This configuration is optimized for best scalability and it is recommended to be used for reporting and analytical workloads. Clusters configured in this way do not provide automatic failover and fault tolerance. In case of fault, if a cluster is not supported by appropriate external tooling, data may be lost.

![Information]

In the current version of Neo4j, the clustering-related parameters use the causal_clustering namespace. This will be replaced with a more suitable namespace in an upcoming release.

Table 35. Important settings for clusters with Single instance as Primary server

<table>
<thead>
<tr>
<th>Option name</th>
<th>Servers</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>dbms.default_advertised_address</td>
<td>All (Primary and Secondary)</td>
<td>The address that other machines are told to connect to. In the typical case, this should be set to the fully qualified domain name or the IP address of this server.</td>
</tr>
<tr>
<td>dbms.mode</td>
<td>Primary</td>
<td>The operating mode of the server instance. The Primary server is set as SINGLE.</td>
</tr>
<tr>
<td></td>
<td>Secondary</td>
<td>The operating mode of the server instance. The Secondary servers are set as READ_REPLICA.</td>
</tr>
<tr>
<td>dbms.clustering.enable=true</td>
<td>Primary</td>
<td>Allows a single instance to form a cluster and is only evaluated when dbms.mode=SINGLE.</td>
</tr>
<tr>
<td>causal_clustering.initial_discovery_members</td>
<td>Secondary</td>
<td>This setting needs to be specified on Read Replica instances and contains the network address for at least the primary instance, but can also include Secondary servers. This parameter must be set to the same value on all cluster members. The behavior of this setting can be modified by configuring the setting causal_clustering.discovery_type. This is described in detail in Discovery.</td>
</tr>
</tbody>
</table>
The following example shows how to set up a cluster with a Single instance as Primary server and three Read Replica instances as Secondary servers.

Example 43. Configure a cluster with a Single instance as Primary server

In this example, one Primary server named single.example.com and three Secondary servers, read_replica01.example.com, read_replica02.example.com and read_replica03.example.com are configured. All instances have Neo4j Enterprise Edition installed. To form a cluster, the neo4j.conf needs to be configured on each server. The Primary server, set as Single instance, is configured as such:

neo4j.conf on single.example.com:

```conf
[dbms]
dbms.mode=SINGLE
dbms.clustering.enable=true
dbms.default_advertised_address=single.example.com
```

The neo4j.conf on the Secondary servers, set as Read Replica instances, is identical across all instances:

neo4j.conf on read_replica01.example.com, read_replica02.example.com and read_replica03.example.com:

```conf
[dbms]
dbms.mode=READ_REPLICA
dbms.default_advertised_address=read_replica<xx>.example.com
causal_clustering.initial_discovery_members=single.example.com:5000
```

Once all neo4j.conf files have been configured, the instances can be started and the cluster is ready. After the cluster has started, it is possible to connect to any of the instances and run `CALL dbms.cluster.overview()` to check the status of the cluster. This shows information about each member of the cluster:

```sql
CALL dbms.cluster.overview();
```

```
+----------------------------------------------------------------------------------------------------+------------------------------------------------------------------------------------+
| id                                     | addresses                                           | groups                                                                 |
+----------------------------------------------------------------------------------------------------+------------------------------------------------------------------------------------+
| "8e4133d7-4de1-469e-88ac-864571cb0a92" | ["bolt://read_replica1.example.com:7687", "http://read_replica1.example.com:7474"] | {neo4j: "READ_REPLICA", system: "READ_REPLICA"} |
| "eb6a4e88-9a5f-405b-b230-5bb6681cc5ec" | ["bolt://read_replica2.example.com:7687", "http://read_replica2.example.com:7474"] | {neo4j: "READ_REPLICA", system: "READ_REPLICA"} |
| "274e36db-d96f-4736-8a99-68851b1bb0b" | ["bolt://read_replica3.example.com:7687", "http://read_replica3.example.com:7474"] | {neo4j: "READ_REPLICA", system: "READ_REPLICA"} |
| "6fd05bc6-760e-4644-bf02-05117a5d777d" | ["bolt://single.example.com:7687", "http://single.example.com:7474"] | {neo4j: "LEADER", system: "LEADER"} |
+----------------------------------------------------------------------------------------------------+------------------------------------------------------------------------------------+
4 rows available after 8 ms, consumed after another 3 ms
```
8.2.3. Configure a cluster with Core instances

The following configuration settings are important to consider when deploying a new cluster with Core instances as Primary servers. See also Settings reference for more detailed descriptions and examples.

This configuration is optimized for fault tolerance, automatic failover and best scalability, and it is recommended to be used for transactional workloads. In many cases and when they are correctly configured, these clusters safeguard data and they do not require any particular external tooling.

Table 36. Important settings for clusters with Core instances as Primary servers

<table>
<thead>
<tr>
<th>Option name</th>
<th>Servers</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>dbms.default_listen_address</td>
<td>All (Primary and Secondary)</td>
<td>The address or network interface this machine uses to listen for incoming messages. Setting this value to 0.0.0.0 makes Neo4j bind to all available network interfaces.</td>
</tr>
<tr>
<td>dbms.default_advertised_address</td>
<td>All (Primary and Secondary)</td>
<td>The address that other machines are told to connect to. In the typical case, this should be set to the fully qualified domain name or the IP address of this server.</td>
</tr>
<tr>
<td>dbms.mode</td>
<td>Primary</td>
<td>The operating mode of the server instance. The Primary servers are set as CORE.</td>
</tr>
<tr>
<td></td>
<td>Secondary</td>
<td>The operating mode of the server instance. The Secondary servers are set as READ_REPLICA.</td>
</tr>
<tr>
<td>causal_clustering.minimum_core_cluster_size_at_formation</td>
<td>Primary</td>
<td>The minimum number of Core instances in the cluster at formation. A cluster will not form without the number of Cores defined by this setting, and this should in general be configured to the full and fixed amount.</td>
</tr>
<tr>
<td>causal_clustering.minimum_core_cluster_size_at_runtime</td>
<td>Primary</td>
<td>The minimum number of Core instances which will exist in the consensus group.</td>
</tr>
<tr>
<td>causal_clustering.initial_discovery_members</td>
<td>All (Primary and Secondary)</td>
<td>The network addresses of an initial set of Core cluster members that are available to bootstrap this Core or Read Replica instance. In the default case, the initial discovery members are given as a comma-separated list of address/port pairs, and the default port for the discovery service is :5000. It is good practice to set this parameter to the same value on all Core Servers. The behavior of this setting can be modified by configuring the setting causal_clustering.discovery_type. This is described in detail in Discovery.</td>
</tr>
</tbody>
</table>

Listen configuration

Listening on 0.0.0.0 makes the ports publicly available. Make sure you understand the security implications and strongly consider setting up encryption.
The following example shows how to set up a simple cluster with three Core servers:

Example 44. Configure a Core-only cluster

In this example, three Core instances named core01.example.com, core02.example.com and core03.example.com are configured. Neo4j Enterprise Edition is installed on all three servers. They are configured by preparing neo4j.conf on each server. Note that they are all identical, except for the configuration of dbms.default_advertised_address:

neo4j.conf on core01.example.com:

```
[...]
dbms.default_listen_address=0.0.0.0
dbms.default_advertised_address=core01.example.com
dbms.mode=CORE
causal_clustering.initial_discovery_members=core01.example.com:5000,core02.example.com:5000,core03.example.com:5000
[...]
```

neo4j.conf on core02.example.com:

```
[...]
dbms.default_listen_address=0.0.0.0
dbms.default_advertised_address=core02.example.com
dbms.mode=CORE
causal_clustering.initial_discovery_members=core01.example.com:5000,core02.example.com:5000,core03.example.com:5000
[...]
```

neo4j.conf on core03.example.com:

```
[...]
dbms.default_listen_address=0.0.0.0
dbms.default_advertised_address=core03.example.com
dbms.mode=CORE
causal_clustering.initial_discovery_members=core01.example.com:5000,core02.example.com:5000,core03.example.com:5000
[...]
```

The Neo4j servers are ready to be started. The startup order does not matter.

After the cluster has started, it is possible to connect to any of the instances and run CALL dbms.cluster.overview() to check the status of the cluster. This shows information about each member of the cluster:

```
CALL dbms.cluster.overview();
```

```
+------------------------------------+------------------------------------+------------------------------------+
| id                                 | addresses                          | databases                          |
| groups |                                |                                    |
+------------------------------------+------------------------------------+------------------------------------+
| "8e07406b-9b03-4311-a63f-85c45af63583" | ["bolt://core1:7687", "http://core1:7474"] | {neo4j: "LEADER", system: "FOLLOWER"} |
+------------------------------------+------------------------------------+------------------------------------+"
8.2.4. Add a Core Server to an existing cluster

Core Servers are added to an existing cluster by starting a new Neo4j instance with the appropriate configuration. The new server will join the existing cluster and become available once it has copied the data from its peers. It may take some time for the new instance to perform the copy if the existing cluster contains large amounts of data.

The setting `causal_clustering.initial_discovery_members` shall be updated on all the servers in the cluster to include the new server.

Example 45. Add a Core Server to an existing cluster

In this example, a Core Server, `core04.example.com`, is added to the cluster created in Configure a Core-only cluster.

Configure the following entries in `neo4j.conf`:

```
neo4j.conf on core04.example.com:

    dbms.default_listen_address=0.0.0.0
    dbms.default_advertised_address=core04.example.com
    dbms.mode=CORE
    causal_clustering.minimum_core_cluster_size_at_formation=3
    causal_clustering.minimum_core_cluster_size_at_runtime=3
    causal_clustering.initial_discovery_members=core01.example.com:5000,core02.example.com:5000,core03.example.com:5000,core04.example.com:5000
```

Note that the configuration is very similar to that of the previous servers. In this example, the new server is not intended to be a permanent member of the cluster, thus it is not included in `causal_clustering.initial_discovery_members` on the other Core members of the cluster.

Now start the new Core Server and let it add itself to the existing cluster.

8.2.5. Add a Secondary server to an existing cluster

In the 4.4 version of Neo4j, all Secondary servers are Read Replica instances. The initial configuration for Read Replica instances is provided via neo4j.conf, as mentioned above in Configure a cluster with Single and Read Replica instances. Since Read Replicas do not participate in cluster quorum decisions, their configuration is shorter; they only need to know the addresses of at least one primary instance which they can bind to in order to discover the cluster.

It is recommended to specify the addresses for all existing primary instances in a cluster when adding a Read Replica. They can then select an appropriate Primary server from which to copy data.
Example 46. Add a Secondary server to an existing cluster with a Single instance as Primary server

In this example, a Read Replica instance, `replica04.example.com`, is added to the cluster created in Configure a cluster with a Single instance as Primary server.

Configure the following entries in `neo4j.conf`:

```
neo4j.conf on replica01.example.com:
```

```
dbms.default_advertised_address=read_replica04.example.com
dbms.mode=READ_REPLICA
causal_clustering.initial_discovery_members=single.example.com:5000
```

Now start the new Read Replica and let it add itself to the existing cluster.

Example 47. Add a Secondary server to an existing cluster with Core servers as Primary servers

In this example, a Read Replica, `replica05.example.com`, is added to the cluster created in Configure a Core-only cluster.

Configure the following entries in `neo4j.conf`:

```
neo4j.conf on replica05.example.com:
```

```
dbms.default_advertised_address=read_replica05.example.com
dbms.mode=READ_REPLICA
causal_clustering.initial_discovery_members=core01.example.com:5000,core02.example.com:5000,core03.example.com:5000
```

Now start the new Read Replica and let it add itself to the existing cluster.

When adding a Secondary server to an existing cluster, only Primary servers need to be listed in `causal_clustering.initial_discovery_members`. It is not necessary to include existing Secondary servers, i.e. other Read Replica instances.

8.2.6. Detach a Secondary server from an existing cluster

It is possible to turn a Secondary server into a standalone instance that thus contains a snapshot of the data in the cluster. This can, in theory, be done for a Core Server as well, but this is not recommended for performance and safety reasons. As mentioned above, in the 4.4 version of Neo4j, all Secondary servers are Read Replica instances.
Example 48. Detach a Read Replica and turn it into a stand alone instance

In this example, a Read Replica, replica01.example.com, is detached from a cluster. See Add a Secondary server to an existing cluster above on how to add a Read Replica to a cluster.

First, check if the Read Replica is as up-to-date as desired. Use SHOW DATABASE to see where the different members of the cluster are in terms of committed transactions compared to the leader.

```
neo4j@system> SHOW DATABASE test00 YIELD name,serverID,address,role,lastCommittedTxn,replicationLag;
```

Note that SHOW DATABASES uses serverID as it lists databases and there may be more than one database per server, while dbms.cluster.overview() uses only id as it is only concerned with servers.

```
+----------------------------------------------------------------------------------------------------+----------------------------------------------------------------------------------------------------+
| name | serverID | address | role | lastCommittedTxn | replicationLag |
|----------------------------------|------------------|-------------------------------|
| test00 | "aeb6debe-d3ea-4644-bd68-304236f3813b" | "core3:7687" | "leader" | 21423 | 0 |
| test00 | "8e07406b-90b3-4311-a63f-85c45af63583" | "core1:7687" | "follower" | 21422 | -1 |
| test00 | "b99ff25e-dc64-4c9c-8a50-ebc1aa0053cf" | "core2:7687" | "follower" | 21423 | 0 |
| test00 | "0bf3f6c1-0f48-47c2-a943-18fa8362c918" | "replica4:7687" | "read_replica" | 21409 | -14 |
| test00 | "0e9c1b28-c8c0-4c65-a1f2-39d326411280" | "replica6:7687" | "read_replica" | 21421 | -2 |
| test00 | "82524236-3058-48a2-b198-6580003475af" | "replica5:7687" | "read_replica" | 21413 | -10 |
```

Based on the results, decide which Read Replica to detach and proceed to shut it down.

Once the Read Replica is shut down, configure the following entry in neo4j.conf:

```
neo4j.conf on replica01.example.com:
```

```
dbms.mode=SINGLE
```

Start the instance again. It is now a standalone instance containing the data committed to it at the time of shutdown.

There is always a chance that the Read Replica is behind the Core Servers at any time (see above on how to check the state of your cluster members). If a transaction is being processed at the time of the shutdown of the Read Replica, this transaction is eventually reflected in the remaining Cluster, but not on the detached Read Replica. A way to ensure that a Read Replica contains a snapshot of a database in the cluster at a point in time, is to pause the read Replica before shutting it down. See dbms.cluster.readReplicaToggle() for more information.
8.2.7. Connect to a Read Replica

It is important to use the correct URI scheme when connecting to a Read Replica since it only allows read sessions/transactions. The following table illustrates the supported URI schemes (the +s indicates that TLS has been configured for the cluster):

<table>
<thead>
<tr>
<th></th>
<th>SSR disabled</th>
<th>SSR enabled</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><code>bolt+s://</code></td>
<td><code>neo4j+s:// read session/tx</code></td>
</tr>
<tr>
<td></td>
<td><code>neo4j+s:// write session/tx</code></td>
<td><code>neo4j+s:// read session/tx</code></td>
</tr>
<tr>
<td>Cypher Shell</td>
<td>✅</td>
<td>✗</td>
</tr>
<tr>
<td>Browser</td>
<td>✅</td>
<td>✗</td>
</tr>
<tr>
<td>Neo4j Driver</td>
<td>✅</td>
<td>✗</td>
</tr>
</tbody>
</table>

In addition to `dbms.routing.enabled=true`, the configuration setting `dbms.routing.default_router` needs to be set to `SERVER` in order to connect to a Read Replica, where applicable. See Server-side routing for more information.

8.3. Seed a cluster [Enterprise edition]

How to seed a new Neo4j Causal Cluster with existing data.

8.3.1. Introduction

Regardless of whether you are just playing around with Neo4j or setting up a production environment, you likely have some existing data that you want to transfer into your newly created Causal cluster. Neo4j supports seeding a cluster from a database dump, a database backup, or from another data source (with the Import tool). For more information about the different backup options and how to use the Neo4j Import tool, see Backup and restore options and Neo4j Admin tool.

The databases that you want to seed and the Neo4j cluster must be of the same version.

The process for seeding a cluster is essentially the same for clusters with Single and Read Replica instances as for clusters with Core (and optional Read Replica) instances. However, using a designated seeder is only applicable to clusters with Core instances. The seeding is usually performed on primary instances only but it is possible to seed a Read Replica instance, yet it is not necessary unless for performance reasons.

8.3.2. Seed a cluster from a database dump (offline)

If you have an existing Neo4j database that you want to use for your new cluster, use `neo4j-admin dump` to create an offline backup. This could be an offline backup from a standalone Neo4j instance or a cluster member (e.g., an existing Read Replica instance).
This scenario is useful in disaster recovery where some servers have retained their data during a catastrophic event.

Moving files and directories manually in or out of a Neo4j installation is not recommended and considered unsupported.

1. Create a new Neo4j Core-only cluster following the instructions in Configure a cluster with Core instances.

2. Delete any databases with names conflicting with the ones in your seeds by using the Cypher command `DROP DATABASE <database-name> against the `system` database.
   The command is automatically routed to the appropriate Core instance and from there to the other cluster members.

   Dropping a database also deletes the users and roles associated with it.

   If you cannot delete the database because Neo4j is not running or because your seeds include the `system` database (which cannot be dropped), you must run `neo4j-admin unbind` as described here.

   1. Run `neo4j-admin unbind` to turn the cluster members into standalone instances by removing their cluster state. Otherwise, the store files you have (post restore) will be out of sync with the cluster state you have for that database, leading to logical corruption.
   2. Remove the store and transaction log files for the database in question. The locations of these files may be configured.

3. Stop each cluster member.

4. Use `neo4j-admin load` to seed each of the Core members in the cluster.

   The examples assume that you are restoring one user database with the default name of `neo4j` and the `system` database, containing the replicated configuration state. Modify the command line arguments to match your exact setup.

   ```
   neo4j-01$ ./bin/neo4j-admin load --from=/path/to/system.dump --database=system
   neo4j-01$ ./bin/neo4j-admin load --from=/path/to/neo4j.dump --database=neo4j
   neo4j-02$ ./bin/neo4j-admin load --from=/path/to/system.dump --database=system
   neo4j-02$ ./bin/neo4j-admin load --from=/path/to/neo4j.dump --database=neo4j
   neo4j-03$ ./bin/neo4j-admin load --from=/path/to/system.dump --database=system
   neo4j-03$ ./bin/neo4j-admin load --from=/path/to/neo4j.dump --database=neo4j
   ```

5. Start each cluster member.

   ```
   neo4j-01$ ./bin/neo4j start
   neo4j-02$ ./bin/neo4j start
   neo4j-03$ ./bin/neo4j start
   ```

   The cluster forms and the replicated Neo4j DBMS deployment comes online.
8.3.3. Seed a cluster from a database backup (online)

These scenarios are useful when you want to restore a database in a running cluster.

If you have a running Neo4j database that you want to seed in a running cluster, use `neo4j-admin backup` to create a database backup. This could be a backup from a standalone Neo4j instance or another cluster member (e.g., an existing Read Replica).

Neo4j supports two types of seeding in a running cluster. You can either transfer the database backup to each Core instance or transfer it only to one Core instance and then use the `CREATE DATABASE` Cypher command to seed the cluster. For more information on the `CREATE DATABASE` syntax and options, see Cypher Manual → Creating databases.

Moving files and directories manually in or out of a Neo4j installation is not recommended and considered unsupported.

Restore a database on each Core instance

Transfer the database backup to each Core instance in the cluster using the `neo4j-admin restore` command and then use `CREATE DATABASE` to restore it. This example uses a user database called `movies1`.

1. To ensure that the `movies1` database does not exist in the cluster, on one of the Core members, use Cypher Shell and run `DROP DATABASE movies1`. Use the `system` database to connect. The command is automatically routed to the appropriate Core instance and from there to the other cluster members.

```
DROP DATABASE movies1;
```

Dropping a database also deletes the users and roles associated with it.

If you cannot drop the database because your seeds include the `system` database (which cannot be dropped), you must run `neo4j-admin unbind`. However, this removes the cluster state of the Core instance and in turn the instance needs to be restarted in order to join the cluster. Thus, you are no longer restoring a database in a running cluster. See Seed a cluster from a database dump (offline) instead for instructions on how to seed an offline cluster.

2. Restore the database on each Core member in the cluster.

```
neo4j@core1$ ./bin/neo4j-admin restore --from=/path/to/movies1-backup-dir --database=movies1
neo4j@core2$ ./bin/neo4j-admin restore --from=/path/to/movies1-backup-dir --database=movies1
neo4j@core3$ ./bin/neo4j-admin restore --from=/path/to/movies1-backup-dir --database=movies1
```

However, restoring a database does not automatically create it.

3. On one of the Core instances, run `CREATE DATABASE movies1` against the `system` database to create the `movies1` database. The command is automatically routed to the appropriate Core instance and from there to the other cluster members.
CREATE DATABASE movies1;

0 rows
ready to start consuming query after 701 ms, results consumed after another 0 ms

4. Verify that the movies1 database is online on all members.

SHOW DATABASES;

<table>
<thead>
<tr>
<th>name</th>
<th>address</th>
<th>role</th>
<th>requestedStatus</th>
<th>currentStatus</th>
<th>error</th>
<th>default</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;neo4j&quot;</td>
<td>&quot;core1:7687&quot;</td>
<td>&quot;leader&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>TRUE</td>
</tr>
<tr>
<td>&quot;neo4j&quot;</td>
<td>&quot;core3:7687&quot;</td>
<td>&quot;follower&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>TRUE</td>
</tr>
<tr>
<td>&quot;movies1&quot;</td>
<td>&quot;core2:7687&quot;</td>
<td>&quot;follower&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>FALSE</td>
</tr>
<tr>
<td>&quot;movies1&quot;</td>
<td>&quot;core3:7687&quot;</td>
<td>&quot;follower&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>FALSE</td>
</tr>
<tr>
<td>&quot;system&quot;</td>
<td>&quot;core1:7687&quot;</td>
<td>&quot;follower&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>FALSE</td>
</tr>
<tr>
<td>&quot;system&quot;</td>
<td>&quot;core3:7687&quot;</td>
<td>&quot;follower&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>FALSE</td>
</tr>
</tbody>
</table>

9 rows available after 3 ms, consumed after another 1 ms

The example uses a user database called movies1 and a cluster that consists of three Core instances. The movies1 database does not exist on any of the cluster members.

If a database with the same name as your backup already exists in your cluster, see step 1 in Restore a database on each Core instance for details on how to drop it.

1. Restore the movies1 database on one of the Core instances. In this example, the core1 member is used.

```
neo4j@core1$ .bin/neo4j-admin restore --from=/path/to/movies1-backup-dir --database=movies1
```

2. Find the server ID of core1 by logging in to Cypher Shell and running dbms.cluster.overview(). Use any database to connect.

```
CALL dbms.cluster.overview();
```
3. On one of the Core instances, use the system database and create the database movies1 using the server ID of core1. The command is automatically routed to the appropriate Core instance and from there to the other cluster members. If the movies1 database is of considerable size, the execution of the command can take some time.

```
CREATE DATABASE movies1 OPTIONS {existingData: 'use', existingDataSeedInstance: '8e07406b-90b3-4311-a63f-85c45af63583'};
```

0 rows ready to start consuming query after 701 ms, results consumed after another 0 ms

4. Verify that the movies1 database is online on all cluster members.

```
SHOW DATABASES;
```

<table>
<thead>
<tr>
<th>name</th>
<th>address</th>
<th>role</th>
<th>requestedStatus</th>
<th>currentStatus</th>
<th>error</th>
<th>default</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;neo4j&quot;</td>
<td>&quot;core1:7687&quot;</td>
<td>&quot;leader&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>TRUE</td>
</tr>
<tr>
<td>&quot;neo4j&quot;</td>
<td>&quot;core1:7687&quot;</td>
<td>&quot;follower&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>TRUE</td>
</tr>
<tr>
<td>&quot;movies1&quot;</td>
<td>&quot;core2:7687&quot;</td>
<td>&quot;follower&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>FALSE</td>
</tr>
<tr>
<td>&quot;movies1&quot;</td>
<td>&quot;core3:7687&quot;</td>
<td>&quot;follower&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>FALSE</td>
</tr>
<tr>
<td>&quot;system&quot;</td>
<td>&quot;core1:7687&quot;</td>
<td>&quot;follower&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>FALSE</td>
</tr>
<tr>
<td>&quot;system&quot;</td>
<td>&quot;core2:7687&quot;</td>
<td>&quot;leader&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>FALSE</td>
</tr>
<tr>
<td>&quot;system&quot;</td>
<td>&quot;core3:7687&quot;</td>
<td>&quot;follower&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>FALSE</td>
</tr>
</tbody>
</table>

9 rows available after 3 ms, consumed after another 1 ms

8.3.4. Seed a cluster using the import tool

To create a cluster based on imported data, it is recommended to first import the data into a standalone Neo4j DBMS and then use an offline backup to seed the cluster.

1. Import the data.
   a. Deploy a standalone Neo4j DBMS.
   b. Import the data using the import tool.

2. Use `neo4j-admin dump` to create an offline backup of the neo4j database.
3. Seed a new cluster using the instructions in Seed a cluster from a database dump (offline).

Skip the system database in this scenario since it is not needed.

8.4. Discovery  Enterprise edition

How members of a cluster discover each other.

8.4.1. Overview

In order to form or connect to a running cluster, a Core Server or a Read Replica needs to know the addresses of some of the Core Servers. This information is used to bind to the Core Servers in order to run the discovery protocol and get the full information about the cluster. The way in which this is best done depends on the configuration in each specific case.

A Single instance used as a Primary server does not need to be configured for discovery. However, discovery_advertised_address and discovery_listen_address can be configured if other addresses than the default are desired.

If the addresses of the other cluster members are known upfront, they can be listed explicitly. This is convenient, but has limitations:

- If Core instances are replaced and the new members have different addresses, the list will become outdated. An outdated list can be avoided by ensuring that the new members can be reached via the same address as the old members, but this is not always practical.
- Under some circumstances the addresses are unknown when configuring the cluster. This can be the case, for example, when using container orchestration to deploy a Causal Cluster.

Additional mechanisms for using DNS are provided for the cases where it is not practical or possible to explicitly list the addresses of cluster members to discover.

The discovery configuration is just used for initial discovery and a running cluster will continuously exchange information about changes to the topology. The behavior of the initial discovery is determined by the parameters causal_clustering.discovery_type and causal_clustering.initial_discovery_members, and is described in the following sections.

Discovery using a list of server addresses

If the addresses of the other cluster members are known upfront, they can be listed explicitly. We use the default causal_clustering.discovery_type=LIST and hard code the addresses in the configuration of each machine. This alternative is illustrated by Configure a Core-only cluster.

Discovery using DNS with multiple records

When using initial discovery with DNS, a DNS record lookup is performed when an instance starts up. Once an instance has joined a cluster, further membership changes are communicated amongst Core
instances as part of the discovery service.

The following DNS-based mechanisms can be used to get the addresses of Core instances for discovery:

causal_clustering.discovery_type=DNS

With this configuration, the initial discovery members will be resolved from DNS A records to find the IP addresses to contact. The value of causal_clustering.initial_discovery_members should be set to a single domain name and the port of the discovery service. For example:

causal_clustering.initial_discovery_members=cluster01.example.com:5000. The domain name should return an A record for every Core instance when a DNS lookup is performed. Each A record returned by DNS should contain the IP address of the Core instance. The configured Primary server will use all the IP addresses from the A records to join or form a cluster.

The discovery port must be the same on all Core instances when using this configuration. If this is not possible, consider using the discovery type SRV instead.

causal_clustering.discovery_type=SRV

With this configuration, the initial discovery members will be resolved from DNS SRV records to find the IP addresses/hostnames and discovery service ports to contact. The value of causal_clustering.initial_discovery_members should be set to a single domain name and the port set to 0. For example: causal_clustering.initial_discovery_members=cluster01.example.com:0. The domain name should return a single SRV record when a DNS lookup is performed. The SRV record returned by DNS should contain the IP address or hostname, and the discovery port, for the Core Servers to be discovered. The configured Primary server will use all the addresses from the SRV record to join or form a cluster.

Discovery in Kubernetes

A special case is when a cluster is running in Kubernetes and each Primary server is running as a Kubernetes service. Then, the addresses of the Core instances can be obtained using the List Service API, as described in the Kubernetes API documentation.

The following settings are used to configure for this scenario:

- Set causal_clustering.discovery_type=K8S.
- Set causal_clustering.kubernetes.label_selector to the label selector for the Causal Cluster services. For more information, see the Kubernetes official documentation.
- Set causal_clustering.kubernetes.service_port_name to the name of the service port used in the Kubernetes service definition for the Core's discovery port. For more information, see the Kubernetes official documentation

With this configuration, causal_clustering.initial_discovery_members is not used and any value assigned to it will be ignored.
• The pod running Neo4j must use a service account which has permission to list services. For further information, see the Kubernetes documentation on RBAC authorization or ABAC authorization.

• The configured causal_clustering.discovery_advertised_address must exactly match the Kubernetes-internal DNS name, which will be of the form <service-name>.<namespace>.svc.cluster.local.

As with DNS-based methods, the Kubernetes record lookup is only performed at startup.

8.5. Intra-cluster encryption

How to secure the cluster communication between server instances.

8.5.1. Introduction

The security solution for cluster communication is based on standard SSL/TLS technology (referred to jointly as SSL). Encryption is in fact just one aspect of security, with the other cornerstones being authentication and integrity. A secure solution will be based on a key infrastructure which is deployed together with a requirement of authentication.

The SSL support in the platform is documented in detail in SSL framework. This section will cover the specifics as they relate to securing a cluster.

Under SSL, an endpoint can authenticate itself using certificates managed by a Public Key Infrastructure (PKI).

It should be noted that the deployment of a secure key management infrastructure is beyond the scope of this manual, and should be entrusted to experienced security professionals. The example deployment illustrated below is for reference purposes only.

8.5.2. Example deployment

The following steps will create an example deployment, and each step is expanded in further detail below.

• Generate and install cryptographic objects
• Configure Causal Clustering with the SSL policy
• Validate the secure operation of the cluster

Generate and install cryptographic objects

The generation of cryptographic objects is for the most part outside the scope of this manual. It will generally require having a PKI with a Certificate Authority (CA) within the organization and they should be
able to advise here. Please note that the information in this manual relating to the PKI is mainly for illustrative purposes.

When the certificates and private keys have been obtained they can be installed on each of the servers. Each server will have a certificate of its own, signed by a CA, and the corresponding private key. The certificate of the CA is installed into the trusted directory, and any certificate signed by the CA will thus be trusted. This means that the server now has the capability of establishing trust with other servers.

![Warning]

Please be sure to exercise caution when using CA certificates in the trusted directory, as any certificates signed by that CA will then be trusted to join the cluster. For this reason, never use a public CA to sign certificates for your cluster. Instead, use an intermediate certificate or a CA certificate which originates from and is controlled by your organization.

In this example we will deploy a mutual authentication setup, which means that both ends of a channel have to authenticate. To enable mutual authentication the SSL policy must have client_auth set to REQUIRE (which is the default). Servers are by default required to authenticate themselves, so there is no corresponding server setting.

If the certificate for a particular server is compromised it is possible to revoke it by installing a Certificate Revocation List (CRL) in the revoked directory. It is also possible to redeploy using a new CA. For contingency purposes, it is advised that you have a separate intermediate CA specifically for the cluster which can be substituted in its entirety should it ever become necessary. This approach would be much easier than having to handle revocations and ensuring their propagation.

Example 49. Generate and install cryptographic objects

In this example we assume that the private key and certificate file are named private.key and public.crt, respectively. If you want to use different names you may override the policy configuration for the key and certificate names/locations. We want to use the default configuration for this server so we create the appropriate directory structure and install the certificate:

```
$neo4j-home> mkdir certificates/cluster
$neo4j-home> mkdir certificates/cluster/trusted
$neo4j-home> mkdir certificates/cluster/revoked
$neo4j-home> cp $some-dir/private.key certificates/cluster
$neo4j-home> cp $some-dir/public.crt certificates/cluster
```

Configure the cluster SSL policy

By default, cluster communication is unencrypted. To configure a Causal Cluster to encrypt its intra-cluster communication, set dbms.ssl.policy.cluster.enabled to true.

An SSL policy utilizes the installed cryptographic objects and additionally allows parameters to be configured. We will use the following parameters in our configuration:

Table 37. Example settings
<table>
<thead>
<tr>
<th>Setting suffix</th>
<th>Value</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>client_auth</td>
<td>REQUIRE</td>
<td>Setting this to REQUIRE effectively enables mutual authentication for servers.</td>
</tr>
<tr>
<td>ciphers</td>
<td>TLS_ECDHE_RSA_WITH_AES_256_CBC_SHA384</td>
<td>We can enforce a particular single strong cipher and remove any doubt about which cipher gets negotiated and chosen. The cipher chosen above offers Perfect Forward Secrecy (PFS) which is generally desirable. It also uses Advanced Encryption Standard (AES) for symmetric encryption which has great support for acceleration in hardware and thus allows performance to generally be negligibly affected.</td>
</tr>
<tr>
<td>tls_versions</td>
<td>TLSv1.2</td>
<td>Since we control the entire cluster we can enforce the latest TLS standard without any concern for backwards compatibility. It has no known security vulnerabilities and uses the most modern algorithms for key exchanges, etc.</td>
</tr>
</tbody>
</table>

In the following example we will create and configure an SSL policy that we will use in our cluster.

**Example 50. Configure the cluster SSL policy**

In this example we assume that the directory structure has been created, and certificate files have been installed, as per the previous example.

We add the following content to our neo4j.conf file:

```plaintext
dbms.ssl.policy.cluster.enabled=true
dbms.ssl.policy.cluster.tls_versions=TLSv1.2
dbms.ssl.policy.cluster.ciphers=TLS_ECDHE_RSA_WITH_AES_256_CBC_SHA384
dbms.ssl.policy.cluster.client_auth=REQUIRE
```

Any user data communicated between instances will now be secured. Please note that an instance which is not correctly setup would not be able to communicate with the others.

Note that the policy must be configured on every server with the same settings. The actual cryptographic objects installed will be mostly different since they do not share the same private keys and corresponding certificates. The trusted CA certificate will be shared however.

**Validate the secure operation of the cluster**

To make sure that everything is secured as intended it makes sense to validate using external tooling such as, for example, the open source assessment tools nmap or OpenSSL.
Example 51. Validate the secure operation of the cluster

In this example we will use the `nmap` tool to validate the secure operation of our cluster. A simple test to perform is a cipher enumeration using the following command:

```
nmap --script ssl-enum-ciphers -p <port> <hostname>
```

The hostname and port have to be adjusted according to our configuration. This can prove that TLS is in fact enabled and that the only the intended cipher suites are enabled. All servers and all applicable ports should be tested.

For testing purposes we could also attempt to utilize a separate testing instance of Neo4j which, for example, has an untrusted certificate in place. The expected result of this test is that the test server is not able to participate in replication of user data. The debug logs will generally indicate an issue by printing an SSL or certificate-related exception.

8.6. Internals of clustering

This section details a few selected internals of a Neo4j Causal Cluster. Understanding the internals is not vital but can be helpful in diagnosing and resolving operational issues.

8.6.1. Elections and leadership

The Core instances used as Primary servers in a cluster use the Raft protocol to ensure consistency and safety. See Advanced Causal Clustering for more information on the Raft protocol. An implementation detail of Raft is that it uses a Leader role to impose an ordering on an underlying log with other instances acting as Followers which replicate the leader’s state. Specifically in Neo4j, this means that writes to the database are ordered by the Core instance currently playing the Leader role for the respective database. If a Neo4j DBMS cluster contains multiple databases, each one of those databases operates within a logically separate Raft group, and therefore each has an individual leader. This means that a Core instance may act both as Leader for some databases, and as Follower for other databases.

If a follower has not heard from the leader for a while, then it can initiate an election and attempt to become the new leader. The follower makes itself a Candidate and asks other Cores to vote for it. If it can get a majority of the votes, then it assumes the leader role. Cores will not vote for a candidate which is less up-to-date than itself. There can only be one leader at any time per database, and that leader is guaranteed to have the most up-to-date log.

Elections are expected to occur during the normal running of a cluster and they do not pose an issue in and of itself. If you are experiencing frequent re-elections and they are disturbing the operation of the cluster then you should try to figure out what is causing them. Some common causes are environmental issues (e.g. a flaky networking) and work overload conditions (e.g. more concurrent queries and transactions than the hardware can handle).
8.6.2. Leadership balancing

Write transactions will always be routed to the leader for the respective database. As a result, unevenly distributed leaderships may cause write queries to be disproportionately directed to a subset of instances. By default, Neo4j avoids this by automatically transferring database leaderships so that they are evenly distributed throughout the cluster. Additionally, Neo4j will automatically transfer database leaderships away from instances where those databases are configured to be read-only using `dbms.databases.read_only` or similar.

8.6.3. Multi-database and the reconciler

Databases operate as independent entities in a Neo4j DBMS, both in standalone and in a cluster. Since a cluster can consist of multiple independent server instances, the effects of administrative operations like creating a new database happen asynchronously and independently for each server. However, the immediate effect of an administrative operation is to safely commit the desired state in the `system` database.

The desired state committed in the `system` database gets replicated and is picked up by an internal component called the reconciler. It runs on every instance and takes the appropriate actions required locally on that instance for reaching the desired state; creating, starting, stopping, and dropping databases.

Every database runs in an independent Raft group and since there are two databases in a fresh cluster, `system` and `neo4j`, this means that it also has two Raft groups. Every Raft group also has an independent leader and thus a particular Core instance could be the leader for one database and a follower for another.

This does not apply to clusters where a Single instance is the Primary server. In such clusters, the Single instance is the leader of all databases and there is no Raft at all.

8.6.4. Server-side routing

Server-side routing is a complement to the client-side routing, performed by a Neo4j Driver.

In a Causal Cluster deployment of Neo4j, Cypher queries may be directed to a cluster member that is unable to run the given query. With server-side routing enabled, such queries will be rerouted internally to a cluster member that is expected to be able to run it. This situation can occur for write-transaction queries when they address a database for which the receiving cluster member is not the leader.

The cluster role for core cluster members is per database. Thus, if a write-transaction query is sent to a cluster member that is not the leader for the specified database (specified either via the Bolt Protocol or by the Cypher syntax: `USE clause`), server-side routing will be performed if properly configured.

Server-side routing is enabled by the DBMS, by setting `dbms.routing.enabled=true` for each cluster member. The listen address (`dbms.routing.listen_address`) and advertised address (`dbms.routing.advertised_address`) also need to be configured for server-side routing communication.

Client connections need to state that server-side routing should be used and this is available for Neo4j Drivers and HTTP API.
Neo4j Drivers can only use server-side routing when the `neo4j://` URI scheme is used. The Drivers will not perform any routing when the `bolt://` URI scheme is used, instead connecting directly to the specified host.

On the cluster-side you must fulfil the following pre-requisites to make server-side routing available:

- Set `dbms.routing.enabled=true` on each member of the cluster.
- Configure `dbms.routing.listen_address`, and provide the advertised address using `dbms.routing.advertised_address` on each member.
- Optionally, you can set `dbms.routing.default_router=SERVER` on each member of the cluster.

The final pre-requisite enforces server-side routing on the clients by sending out a routing table with exactly one entry to the client. Therefore, `dbms.routing.default_router=SERVER` configures a cluster member to make its routing table behave like a standalone instance. The implication is that if a Neo4j Driver connects to this cluster member, then the Neo4j Driver sends all requests to that cluster member. Please note that the default configuration for `dbms.routing.default_router` is `dbms.routing.default_router=CLIENT`. See `dbms.routing.default_router` for more information.

The HTTP-API of each member will benefit from these settings automatically.

The table below shows the criteria by which server-side routing is performed:

**Table 38. Server-side routing criteria**

<table>
<thead>
<tr>
<th>URI scheme</th>
<th>Client-side routing</th>
<th>Request server-side routing</th>
<th>Transaction type</th>
<th>Server - Instance &gt; Role (per database)</th>
<th>Server-side routing enabled</th>
<th>Routes the query</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>neo4j://</code></td>
<td>✔️</td>
<td>✔️</td>
<td>write</td>
<td>Primary - Single</td>
<td>✔️</td>
<td>✗</td>
</tr>
<tr>
<td><code>neo4j://</code></td>
<td>✔️</td>
<td>✔️</td>
<td>read</td>
<td>Primary - Single</td>
<td>✔️</td>
<td>✗</td>
</tr>
<tr>
<td><code>neo4j://</code></td>
<td>✔️</td>
<td>✔️</td>
<td>write</td>
<td>Primary - Core &gt; leader</td>
<td>✔️</td>
<td>✗</td>
</tr>
<tr>
<td><code>neo4j://</code></td>
<td>✔️</td>
<td>✔️</td>
<td>read</td>
<td>Primary - Core &gt; leader</td>
<td>✔️</td>
<td>✗</td>
</tr>
<tr>
<td><code>neo4j://</code></td>
<td>✔️</td>
<td>✔️</td>
<td>write</td>
<td>Primary - Core &gt; follower</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td><code>neo4j://</code></td>
<td>✔️</td>
<td>✔️</td>
<td>read</td>
<td>Primary - Core &gt; follower</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td><code>neo4j://</code></td>
<td>✔️</td>
<td>✔️</td>
<td>write</td>
<td>Secondary - Read Replica</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td><code>neo4j://</code></td>
<td>✔️</td>
<td>✔️</td>
<td>read</td>
<td>Secondary - Read Replica</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td><code>bolt://</code></td>
<td>✗</td>
<td>✗</td>
<td>write</td>
<td>Primary - Single</td>
<td>✔️</td>
<td>✗</td>
</tr>
<tr>
<td><code>bolt://</code></td>
<td>✗</td>
<td>✗</td>
<td>read</td>
<td>Primary - Single</td>
<td>✔️</td>
<td>✗</td>
</tr>
</tbody>
</table>
Server-side routing connector configuration

Rerouted queries are communicated over the Bolt Protocol using a designated communication channel. The receiving end of the communication is configured using the following settings:

- `dbms.routing.enabled`
- `dbms.routing.listen_address`
- `dbms.routing.advertised_address`

Server-side routing driver configuration

Server-side routing uses the Neo4j Java driver to connect to other cluster members. This driver is configured with settings of the format:

- `dbms.routing.driver.*`

The configuration options described in Configuration in the Neo4j Driver manuals have an equivalent in the server-side routing configuration.

Server-side routing encryption

Encryption of server-side routing communication is configured by the cluster SSL policy. For more information, see Cluster Encryption.

8.6.5. Store copy

Store copies are initiated when an instance does not have an up-to-date copy of the database. For example, this is the case when a new instance is joining a cluster (without a seed). It can also happen as a consequence of falling behind the rest of the cluster, for reasons such as connectivity issues or having been shut down. Upon re-establishing connection with the cluster, an instance recognizes that it is too far behind and fetches a new copy from the rest of the cluster.

A store copy is a major operation, which may disrupt the availability of instances in the cluster. Store copies should not be a frequent occurrence in a well-functioning cluster, but rather be an exceptional operation that happens due to specific causes, e.g. network outages or planned maintenance outages. If store copies happen during regular operation, then the configuration of the cluster, or the workload directed at it, might have to be reviewed so that all instances can keep up, and that there is enough of a buffer of Raft logs and transaction logs to handle smaller transient issues.
The protocol used for store copies is robust and configurable. The network requests are directed at an upstream member according to configuration and they are retried despite transient failures. The maximum amount of time to retry every request can be configured with `causal_clustering.store_copy_max_retry_time_per_request`. If a request fails and the maximum retry time has elapsed then it stops retrying and the store copy fails.

Use `causal_clustering.catch_up_client_inactivity_timeout` to configure the inactivity timeout for any particular request.

The default upstream strategy is not applicable to Single instances and it differs for Core and Read Replica instances. Core instances always send the initial request to the leader to get the most up-to-date information about the store. The strategy for the file and index requests for Core instances is to vary every other request to a random Read Replica instance and every other to a random Core instance.

Read Replica instances use the same strategy for store copies as it uses for pulling transactions. The default is to pull from a random Core instance.

If you are running a multi-datacenter cluster, then upstream strategies for both Core and Read Replica instances can be configured. Remember that for Read Replica instances, this also affects from where transactions are pulled. See more in [Configure for multi-data center operations](#).

- Do not transform a Read Replica instance into a Core instance.
- Do not transform a Core instance into a Read Replica instance.

### 8.6.6. On-disk state

The on-disk state of cluster instances is different from that of standalone instances. The biggest difference is the existence of an additional cluster state. Most of the files there are relatively small, but the Raft logs can become quite large depending on the configuration and workload.

It is important to understand that once a database has been extracted from a cluster and used in a standalone deployment, it must not be put back into an operational cluster. This is because the cluster and the standalone deployment now have separate databases, with different and irreconcilable writes applied to them.

- If you try to reinsert a modified database back into the cluster, then the logs and stores will mismatch. Operators should not try to merge standalone databases into the cluster in the optimistic hope that their data will become replicated. That does not happen and instead, it likely leads to unpredictable cluster behavior.

### 8.7. Settings reference

*Enterprise edition*

This section lists the important settings related to running a Neo4j Causal Cluster.
8.7.1. Common server settings

In the current version of Neo4j, the clustering-related parameters use the causal_clustering namespace. This will be replaced with a more suitable namespace in an upcoming release.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Instance type</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>dbms.clustering.enable</code></td>
<td>Single</td>
<td>This setting allows a SINGLE instance to form a cluster with one or more READ_REPLICA instances. Must be set to TRUE on the SINGLE instance only, as the setting is ignored on CORE and READ_REPLICA instances.</td>
</tr>
<tr>
<td><code>dbms.mode</code></td>
<td>All</td>
<td>This setting configures the operating mode of the database. In version 4.4, there are three possible modes:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. SINGLE and READ_REPLICA instances</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. CORE only instances</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. CORE and READ_REPLICA instances</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Example:</strong> <code>dbms.mode=READ_REPLICA</code> defines a Read Replica instance</td>
</tr>
<tr>
<td><code>dbms.read_only</code></td>
<td>-</td>
<td>This setting is not supported.</td>
</tr>
<tr>
<td><code>causal_clustering.minimum_core_cluster_size_at_formation</code></td>
<td>Core</td>
<td>Minimum number of Core instances as Primary servers required to form a Core cluster.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Example:</strong> <code>causal_clustering.minimum_core_cluster_size_at_formation=3</code> specifies that the cluster will form when at least three Core instances have discovered each other.</td>
</tr>
<tr>
<td>Parameter</td>
<td>Instance type</td>
<td>Explanation</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td>---------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>causal_clustering.minimum_core_cluster_size_at_runtime</td>
<td>Core</td>
<td>The minimum size of the dynamically adjusted voting set (which only Core members may be a part of).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Adjustments to the voting set happen automatically as the availability of Core instances changes, due to explicit operations such as starting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or stopping a member, or unintended issues such as network partitions. Please note that this dynamic scaling of the voting set is generally desirable,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>as under some circumstances it can increase the number of instance failures which may be tolerated.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A majority of the voting set must be available before members are voted in or out.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Example:</strong> causal_clustering.minimum_core_cluster_size_at_runtime=3 specifies that the cluster should not try to dynamically adjust below three</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Core instances in the voting set.</td>
</tr>
<tr>
<td>Parameter</td>
<td>Instance type</td>
<td>Explanation</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>---------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>causal_clustering.discovery_type</td>
<td>Core and Read Replica</td>
<td>This setting specifies the strategy that the instance uses to determine the addresses for other instances in the cluster to contact for bootstrapping. Possible values are: LIST, DNS, SRV, and K8S.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>LIST</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Treat causal_clustering.initial_discovery_members as a list of addresses of Core instances to contact for discovery.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>DNS</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Treat causal_clustering.initial_discovery_members as a domain name to resolve via DNS. Expect DNS resolution to provide A records with hostnames or IP addresses of Core instances to contact for discovery, on the port specified by causal_clustering.initial_discovery_members.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>SRV</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Treat causal_clustering.initial_discovery_members as a domain name to resolve via DNS. Expect DNS resolution to provide SRV records with hostnames or IP addresses and ports, of Core instances to contact for discovery.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>K8S</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Access the Kubernetes list service API to derive addresses of Core instances to contact for discovery. Requires causal_clustering.kubernetes.label_selector to be a Kubernetes label selector for Kubernetes services running a Core each and causal_clustering.kubernetes.service_port_name to be a service port name identifying the discovery port of Core services. The value of causal_clustering.initial_discovery_members is ignored for this option.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The value of this setting determines how causal_clustering.initial_discovery_members is interpreted. Detailed information about discovery and discovery configuration options is given in Discovery using DNS with multiple records.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Example:</strong> causal_clustering.discovery_type=DNS combined with causal_clustering.initial_discovery_members=cluster01.example.com:5000 fetch all DNS A records.</td>
</tr>
</tbody>
</table>
### Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Instance type</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>causal_clustering.initial_discovery_members</code></td>
<td>Core and Read Replica</td>
<td>The network addresses of an initial set of Core instance members that are available to bootstrap this Core or Read Replica instance. In the default case, the initial discovery members are given as a comma-separated list of address/port pairs, and the default port for the discovery service is :5000. It is good practice to set this parameter to the same value on all Core instances. The behavior of this setting can be modified by configuring the setting <code>causal_clustering.discovery_type</code>. This is described in detail in <a href="https://neo4j.com/docs/developer-manual/current/config/cluster-scaling/">Discovery using DNS with multiple records</a>. Example: <code>causal_clustering.discovery_type=LIST</code> combined with <code>core01.example.com:5000,core02.example.com:5000,core03.example.com:5000</code> will attempt to reach Neo4j instances listening on <code>core01.example.com</code>, <code>core01.example.com</code>, and <code>core01.example.com</code>; all on port 5000.</td>
</tr>
<tr>
<td><code>causal_clustering.discovery_advertised_address</code></td>
<td>All</td>
<td>The address/port setting that specifies where the instance advertises that it listens for discovery protocol messages from other members of the cluster. If this instance is included in the <code>initial_discovery_members</code> of other cluster members, the value there must exactly match this advertised address. Example: <code>causal_clustering.discovery_advertised_address=192.168.33.21:5001</code> indicates that other cluster members can communicate with this instance using the discovery protocol at host <code>192.168.33.20</code> and port 5001.</td>
</tr>
<tr>
<td>Parameter</td>
<td>Instance type</td>
<td>Explanation</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>---------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>causal_clustering.raft_advertised_address</td>
<td>Core</td>
<td>The address/port setting that specifies where the Neo4j instance advertises to other members of the cluster that it listens for Raft messages within the Core cluster.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Example:</strong> causal_clustering.raft_advertised_address=192.168.33.20:7000 listens for cluster communication in the network interface bound to 192.168.33.20 on port 7000.</td>
</tr>
<tr>
<td>causal_clustering.transaction_advertised_address</td>
<td>All</td>
<td>The address/port setting that specifies where the instance advertises where it listens for requests for transactions in the transaction-shipping catchup protocol.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Example:</strong> causal_clustering.transaction_advertised_address=192.168.33.20:6001 listens for transactions from cluster members on the network interface bound to 192.168.33.20 on port 6001.</td>
</tr>
<tr>
<td>causal_clustering.discovery_listen_address</td>
<td>All</td>
<td>The address/port setting that specifies which network interface and port the Neo4j instance binds to for the cluster discovery protocol.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Example:</strong> causal_clustering.discovery_listen_address=0.0.0.0:5001 will listen for cluster membership communication on any network interface at port 5001.</td>
</tr>
<tr>
<td>causal_clustering.raft_listen_address</td>
<td>Core</td>
<td>The address/port setting that specifies which network interface and port the Neo4j instance binds to for cluster communication. This setting must be set in coordination with the address this instance advertises it listens at in the setting causal_clustering.raft_advertised_address.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Example:</strong> causal_clustering.raft_listen_address=0.0.0.0:7000 listens for cluster communication on any network interface at port 7000.</td>
</tr>
</tbody>
</table>
### 8.7.2. Multi-data center settings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>causal_clustering.multi_dc_license</td>
<td>Enables multi-data center features. Requires appropriate licensing. Example: causal_clustering.multi_dc_license=true will enable the multi-data center features.</td>
</tr>
<tr>
<td>causal_clustering.server_groups</td>
<td>A list of group names for the server used when configuring load balancing and replication policies. Example: causal_clustering.server_groups=us,us-east will add the current instance to the groups us and us-east.</td>
</tr>
<tr>
<td>Parameter</td>
<td>Explanation</td>
</tr>
<tr>
<td>-----------</td>
<td>-------------</td>
</tr>
<tr>
<td><strong>causal_clustering.leadership_priority_group.&lt;database&gt;</strong></td>
<td>The group of servers which should be preferred when selecting leaders for the specified database. If the instance currently acting as leader for this database is not a member of the configured server group, then the cluster will attempt to transfer leadership to an instance which is a member. It is not guaranteed that leadership will always be held by a server in the desired group. For example, if no member of the desired group is available or has up-to-date store contents. The cluster will seek to preserve availability, over respecting the leadership_priority_group setting. To set a default leadership_priority_group for all databases that do not have an explicitly set leadership_priority_group, the &lt;database&gt; can be omitted. See causal_clustering.leadership_priority_group. Example: causal_cluster.leadership_priority_group.foo=us will ensure that if the leader for foo is not held by a server configured with causal_clustering.server_groups=us, the cluster will attempt to transfer leadership to a server which is.</td>
</tr>
<tr>
<td><strong>causal_clustering.upstream_selection_strategy</strong></td>
<td>An ordered list in descending preference of the strategy which Read Replicas use to choose upstream database server from which to pull transactional updates. Example: causal_clustering.upstream_selection_strategy=connect-randomly-within-server-group,typically-connect-to-random-read-replica will configure the behavior so that the Read Replica will first try to connect to any other instance in the group(s) specified in causal_clustering.server_groups. Should we fail to find any live instances in those groups, then we will connect to a random Read Replica. A value of user-defined will enable custom strategy definitions using the setting causal_clustering.user_defined_upstream_strategy.</td>
</tr>
<tr>
<td><strong>causal_clustering.user_defined_upstream_strategy</strong></td>
<td>Defines the configuration of upstream dependencies. Can only be used if causal_clustering.upstream_selection_strategy is set to user-defined. Example: causal_clustering.user_defined_upstream_strategy=groups(north2); groups(north); halt() will look for servers in the north2. If none are available it will look in the north server group. Finally, if we cannot resolve any servers in any of the previous groups, then rule chain will be stopped via halt().</td>
</tr>
<tr>
<td><strong>causal_clustering.load_balancing.plugin</strong></td>
<td>The load balancing plugin to use. One pre-defined plugin named server_policies is available by default. Example: causal_clustering.load_balancing.plugin=server_policies will enable custom policy definitions.</td>
</tr>
<tr>
<td><strong>causal_clustering.load_balancing.config.server_policies.&lt;policy-name&gt;</strong></td>
<td>Defines a custom policy under the name &lt;policy-name&gt;. Note that load balancing policies are cluster-global configurations and should be defined the exact same way on all core machines. Example: causal_clustering.load_balancing.config.server_policies.north1_only=groups(north1)→min(2); halt(); defines a load balancing policy named north1_only. Queries are sent only to servers in the north1 server group, provided there are two of them available. If there are less than two servers in north1, the chain is halted. By default, the load balancer sends read requests only to replicas/followers, which means these two servers must be of that kind. To allow reads on the leader, set to causal_clustering.cluster_allow_reads_on_leader to true.</td>
</tr>
</tbody>
</table>
Chapter 9. Fabric

Enterprise edition

This chapter describes the configuration and operation of Neo4j Fabric.

This chapter describes the following:

- Introduction
- Configuration
- Queries
- Further Considerations
- Sharding data with the copy command

9.1. Introduction

Enterprise edition

An introduction of Neo4j Fabric.

9.1.1. Overview

Fabric, introduced in Neo4j 4.0, is a way to store and retrieve data in multiple databases, whether they are on the same Neo4j DBMS or in multiple DBMSs, using a single Cypher query. Fabric achieves a number of desirable objectives:

- a unified view of local and distributed data, accessible via a single client connection and user session
- increased scalability for read/write operations, data volume and concurrency
- predictable response time for queries executed during normal operations, a failover or other infrastructure changes
- High Availability and No Single Point of Failure for large data volume.

In practical terms, Fabric provides the infrastructure and tooling for:

- Data Federation: the ability to access data available in distributed sources in the form of disjointed graphs.
- Data Sharding: the ability to access data available in distributed sources in the form of a common graph partitioned on multiple databases.

With Fabric, a Cypher query can store and retrieve data in multiple federated and sharded graphs.

If you want to connect a single database to your DBMS that is shared over all instances of your DBMS, consider using Remote Database Aliases instead.
9.1.2. Fabric concepts

The fabric database

A Fabric setup includes a Fabric virtual database, which acts as the entry point to a federated or sharded graph infrastructure. This database is the execution context in which multi-graph queries can be executed. Drivers and client applications access and use the Fabric execution context by naming it as the selected database for a session. For more information, see Databases and execution context in the Neo4j Driver manuals.

The Fabric virtual database (execution context) differs from normal databases in that it cannot store any data, and only relays data stored elsewhere. The Fabric virtual database can be configured on a standalone Neo4j DBMS only, i.e. on a Neo4j DBMS where the configuration setting `dbms.mode` must be set to SINGLE.

The Neo4j Admin commands cannot be applied to the Fabric virtual database. They must be run directly on the databases that are part of the Fabric setup.

Fabric graphs

In a Fabric virtual database, data is organized in the form of graphs. Graphs are seen by client applications as local logical structures, where physically data is stored in one or more databases. Databases accessed as Fabric graphs can be local, i.e in the same Neo4j DBMS, or they can be located in external Neo4j DBMSes. The databases are also accessible by client applications from regular local connections in their respective Neo4j DBMSs.

9.1.3. Deployment examples

Fabric constitutes an extremely versatile environment that provides scalability and availability with no single point of failure in various topologies. Users and developers may use applications that can work on a standalone DBMS as well on a very complex and largely distributed infrastructure without the need to apply any change to the queries accessing the Fabric graphs.

Development deployment

In its simplest deployment, Fabric can be used on a single instance, where Fabric graphs are associated to local databases. This approach is commonly used by software developers to create applications that will be deployed on multiple Neo4j DBMSs, or by power users who intend to execute Cypher queries against local disjoint graphs.
Cluster deployment with no single point of failure

In this deployment Fabric guarantees access to disjoint graphs in high availability with no single point of failure. Availability is reached by creating redundant entry points for the Fabric Database (i.e. two standalone Neo4j DBMSs with the same Fabric configuration) and a minimum Causal Cluster of three members for data storage and retrieval. This approach is suitable for production environments and it can be used by power users who intend to execute Cypher queries against disjoint graphs.
Multi-cluster deployment

In this deployment Fabric provides high scalability and availability with no single point of failure. Disjoint clusters can be sized according to the expected workload and Databases may be colocated in the same cluster or they can be hosted in their own cluster to provide higher throughput. This approach is suitable for production environments where database can be sharded, federated or a combination of the two.
9.2. Configuration

**Enterprise edition**

How to configure Neo4j Fabric.

### 9.2.1. Fabric database setup

Fabric must be set on a standalone Neo4j DBMS: the settings in `neo4j.conf` are identified by the `fabric` namespace. The minimal requirements to setup Fabric are:

- A virtual database name: this is the entry point used by the client applications to access the Fabric environment.
- One or more Fabric graph URI and database: this a reference of a URI and a database for each graph set in the Fabric environment.

**Local development setup example**

Consider a standalone Neo4j DBMS, which has two databases, `db1` and `db2`. Note that all databases except for the default and system must be created using the `CREATE DATABASE` command.

Fabric is enabled by configuring:

```
fabric.database.name=example
```

This configuration enables Fabric and exposes the feature under the virtual database with the name...
example, which is accessible using the default URI, neo4j://localhost:7687. After connecting to the DBMS with the example database selected, you can run queries like the following:

```
USE db1
MATCH (n) RETURN n
UNION
USE db2
MATCH (n) RETURN n
```

**Figure 10. Minimal local Fabric setting in a development setup**

Remote development setup example

This example consists of a setup with three standalone Neo4j DBMSs. One instance acts as the Fabric proxy, configured to enable Fabric. The other two instances contain the databases db1 and db2.

The following configuration enables Fabric on the proxy instance and allows it to access the databases in the other two instances.

```
fabric.database.name=example
fabric.graph.0.uri=neo4j://hostname-of-instance1:7687
fabric.graph.0.database=db1
fabric.graph.1.uri=neo4j://hostname-of-instance2:7687
fabric.graph.1.database=db2
```

This configuration enables Fabric and exposes the feature under the virtual database named example, which is accessible using the default URI, neo4j://localhost:7687. The Fabric graphs are uniquely identified.
by their IDs, 0 and 1.

After connecting to the DBMS with the selected database set to "example", you can run queries like the following:

```
USE example.graph(0)
MATCH (n) RETURN n
UNION
USE example.graph(1)
MATCH (n) RETURN n
```

![Diagram of minimal remote Fabric setting in a development setup]

**Figure 11. Minimal remote Fabric setting in a development setup**

**Naming graphs**

Graphs can be identified by their ID or by a name. A graph can be named by adding an extra configuration setting, `fabric.graph.<ID>.name`.

For example, if the given names are `graphA` (associated to `db1`) and `graphB` (associated to `db2`), the two additional settings will be:

```
fabric.graph.0.name=graphA
fabric.graph.1.name=graphB
```

Giving names to graphs means you can refer to them by name in queries:
Cluster setup with no single point of failure example

In this example, all components are redundant and data is stored in a Causal Cluster. In addition to the settings described in the previous example, a setting with no single point of failure requires the use of the routing servers parameter, which specifies a list of standalone Neo4j DBMSs that expose the same Fabric database and configuration. This parameter is required in order to simulate the same connectivity that client applications use with Causal Cluster, which means, in case of fault of one instance, the client application may revert to another existing instance.

Assume that in this example, the data is stored in three databases: db1, db2 and db3. The configuration of Fabric would be:

```
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>dbms.mode</td>
<td>SINGLE</td>
</tr>
<tr>
<td>fabric.database.name</td>
<td>example</td>
</tr>
<tr>
<td>fabric.routing.servers</td>
<td>server1:7687,server2:7687</td>
</tr>
<tr>
<td>fabric.graph.0.name</td>
<td>graphA</td>
</tr>
<tr>
<td>fabric.graph.0.database</td>
<td>db1</td>
</tr>
<tr>
<td>fabric.graph.1.name</td>
<td>graphB</td>
</tr>
<tr>
<td>fabric.graph.1.database</td>
<td>db2</td>
</tr>
<tr>
<td>fabric.graph.2.name</td>
<td>graphC</td>
</tr>
<tr>
<td>fabric.graph.2.database</td>
<td>db3</td>
</tr>
</tbody>
</table>
```

The configuration above must be added to the `neo4j.conf` file of the Neo4j DBMSs `server1` and `server2`. The parameter `fabric.routing.servers` contains the list of available standalone Neo4j DBMSs hosting the Fabric database. The parameter `fabric.graph.<ID>.uri` can contain a list of URIs, so in case the first server does not respond to the request, the connection can be established to another server that is part of the cluster. The URIs refer to the `neo4j://` schema so that Fabric can retrieve a routing table and can use one of the members of the cluster to connect.
Figure 12. Fabric setting with Causal Cluster and no single point of failure

Cluster routing context

The URIs in the graph settings may include routing contexts, which are described in the Neo4j Driver manuals. This can be used to associate a Fabric graph with a filtered subset of Causal Cluster members, by selecting a routing policy.

As an example, assuming you have a server policy called read_replicas defined in the configuration of the cluster you are targeting, you might set up a Fabric graph that accesses only the read replicas of the cluster.

```
fabric.graph.0.name=graphA
fabric.graph.0.uri=neo4j://core1:7687?policy=read_replicas
fabric.graph.0.database=db1
```

This enables scenarios where queries executed through Fabric are explicitly offloaded to specific instances in clusters.

9.2.2. Authentication and authorization

Credentials

Connections between the Fabric database and the Neo4j DBMSs hosting the data are created using the same credentials that are supplied in the client connection to the Fabric database. It is recommended to maintain a set of user credentials on all the Neo4j DBMSs; if required, a subset of credentials may be set for local access on the remote DBMSs.
User and role administration

User and role administration actions are not automatically propagated to the Fabric environment, therefore security settings must be executed on any DBMS that is part of Fabric.

Privileges on the Fabric database

In order to use all Fabric features, users of Fabric databases need **ACCESS** and **READ** privileges.

9.2.3. Important settings

This section provides general information about Fabric settings and describes the ones important for creating a fabric set-up. For the full list of Fabric configuration options, see **Configuration settings**.

Fabric settings are divided in the following categories:

- **System Settings**: DBMS-level settings.
- **Graph Settings**: definition and configuration of Fabric graphs.
- **Drivers Settings**: configuration of drivers used to access Neo4j DBMSs and databases associated to Fabric graphs.

System settings

**Table 39. Fabric system settings**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>fabric.database.name</td>
<td>Name of the Fabric database. Neo4j Fabric currently supports one Fabric database in a standalone Neo4j DBMS.</td>
</tr>
<tr>
<td>fabric.routing.servers</td>
<td>A comma-separated list of Neo4j DBMSs that share the same Fabric configuration. These DBMSs form a routing group. A client application will route transactions through a Neo4j driver or connector to one of the members of the routing group. A Neo4j DBMS is represented by its Bolt connector address. Example: fabric.routing.servers=server1:7687,server2:7687.</td>
</tr>
</tbody>
</table>

Graph settings

The `<ID>` in the following settings is the integer associated to each Fabric graph.

**Table 40. Fabric graph settings**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>fabric.graph.&lt;ID&gt;.uri</td>
<td>URI of the Neo4j DBMS hosting the database associated to the Fabric graph. Example: <code>neo4j://somewhere:7687</code></td>
</tr>
<tr>
<td>fabric.graph.&lt;ID&gt;.database</td>
<td>Name of the database associated to the Fabric graph.</td>
</tr>
</tbody>
</table>
Drivers settings

Fabric uses the Neo4j Java driver to connect to and access the data stored in Neo4j databases associated to Fabric graphs. This section presents the most important parameters available to configure the driver.

Drivers settings are configured with parameters with names of the format:

\[ \text{fabric.driver.<suffix>} \]

A setting can be global, i.e. be valid for all the drivers used in Fabric, or it can be specific for a given connection to a Neo4j database associated to a graph. The graph-specific setting overrides the global configuration for that graph.

Example 52. Global drivers setting versus graph-specific drivers setting

A drivers setting for Fabric as the following is valid for all the connections established with the Neo4j DBMSs set in Fabric:

\[ \text{fabric.driver.api}=RX \]

A graph-specific connection for the database with ID=6 will override the \text{fabric.driver.api} setting for that database:

\[ \text{fabric.graph.6.driver.api}=ASYNC \]

Table 41. Fabric drivers setting suffixes
### Parameter suffix

<table>
<thead>
<tr>
<th>Parameter suffix</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>ssl_enabled</td>
<td>SSL for Fabric drivers is configured using the fabric SSL policy. This setting can be used to instruct the driver not to use SSL even though the fabric SSL policy is configured. The driver will use SSL if the fabric SSL policy is configured, and this setting is set to true. This parameter can only be used in fabric.graph.&lt;graph ID&gt;.driver.ssl_enabled and not fabric.driver.ssl_enabled.</td>
</tr>
<tr>
<td>api</td>
<td>Determine which driver API to be used. Supported values are RX and ASYNC.</td>
</tr>
</tbody>
</table>

Most driver options described in Configuration in the Neo4j Driver manuals have an equivalent in Fabric configuration.

### 9.3. Queries  Enterprise edition

Examples of Cypher queries and commands that can be used with Neo4j Fabric.

In this section we will look at a few example queries that show how to perform a range of different tasks.

The examples in this section make use of the two Cypher clauses: **USE** and **CALL {}**. The syntax is explained in detail in the Cypher Manual:

- See Cypher Manual → CALL {} for details about the CALL {} clause.
- See Cypher Manual → USE for details about the USE clause.

### 9.3.1. Query a single graph

Example 53. Reading and returning data from a single graph.

```cypher
USE example.graphA
MATCH (movie:Movie)
RETURN movie.title AS title
```

The **USE** clause at the beginning of the query causes the rest of the query to execute against the example.graphA graph.

### 9.3.2. Query multiple graphs
Example 54. Reading and returning data from two named graphs

```
USE example.graphA
MATCH (movie:Movie)
RETURN movie.title AS title
UNION
USE example.graphB
MATCH (movie:Movie)
RETURN movie.title AS title
```

The first part of the `UNION` query executes against the `example.graphA` graph and the second part executes against the `example.graphB` graph.

9.3.3. Query all graphs

Example 55. Reading and returning data from all graphs

```
UNWIND example.graphIds() AS graphId
CALL {
  USE example.graph(graphId)
  MATCH (movie:Movie)
  RETURN movie.title AS title
}
RETURN title
```

We call the built-in function `example.graphIds()` to get the graph IDs for all remote graphs in our Fabric setup. We `UNWIND` the result of that function to get one record per graph ID. The `CALL {}` subquery is executed once per incoming record. We use a `USE` clause in the subquery with a dynamic graph lookup, causing the subquery to execute once against each remote graph. At the end of the main query we simply `RETURN` the title variable.

9.3.4. Query result aggregation

Example 56. Getting the earliest release year of all movies in all graphs

```
UNWIND example.graphIds() AS graphId
CALL {
  USE example.graph(graphId)
  MATCH (movie:Movie)
  RETURN movie.released AS released
}
RETURN min(released) AS earliest
```

From each remote graph we return the released property of each movie. At the end of the main query we aggregate across the full result to calculate the global minimum.

9.3.5. Correlated subquery
Example 57. Correlated subquery

Assume that graphA contains American movies and graphB contains European movies. Find all European movies released in the same year as the latest released American movie:

```cyphe
CALL {
  USE example.graphA
  MATCH (movie:Movie)
  RETURN max(movie.released) AS usLatest
}
CALL {
  USE example.graphB
  WITH usLatest
  MATCH (movie:Movie)
  WHERE movie.released = usLatest
  RETURN movie
}
RETURN movie
```

We query the example.graphA and return the release year of the latest release. We then query the example.graphB. WITH usLatest is an import clause which lets us refer to the usLatest variable inside the subquery. We find all the movies in this graph that fulfill our condition and return them.

It is not possible to switch the current graph in a nested query. For example, the following query is illegal:

Example 58. Illegal correlated subquery

```cyphe
USE example.graphA
MATCH (movie:Movie)
WITH movie.title AS title
CALL {
  USE example.graphB // Cannot swicth from example.graphA
  WITH title
  MATCH (otherMovie:Movie)
  WHERE otherMovie.title STARTS WITH title
  RETURN otherMovie.title AS otherTitle
}
RETURN title, otherTitle
```

This limitation can be circumvented by having subqueries after one another, but without nesting them.

9.3.6. Updating query

Example 59. Create a new movie node

```cyphe
USE example.graphB
CREATE (m:Movie)
SET m.title = 'Léon: The Professional'
SET m.tagline = 'If you want the job done right, hire a professional.'
SET m.released = 1994
```

9.3.7. Mapping functions

Mapping functions are a common Fabric usage pattern. In the previous examples, graphs were identified
by providing static graph names in the query. Fabric may be used in scenarios where graphs are identified by a mapping mechanism that can, for example, identify a key of an object contained in a graph. This can be achieved by using user-defined functions or other functions that may be already available. These functions ultimately return the ID of a graph in Fabric.

Mapping functions are commonly used in sharding scenarios. In Fabric, shards are associated to graphs, hence mapping functions are used to identify a graph, i.e. a shard.

Let’s assume that Fabric is setup in order to store and retrieve data associated to nodes with the label user. User nodes are partitioned in several graphs (shards) in Fabric. Each user has a numerical userId, which is unique in all Fabric. We decide on a simple scheme where each user is located on a graph determined by taking the userId modulo the number of graphs. We create a user-defined function which implements the following pseudo code:

sharding.userIdToGraphId(userId) = userId % NUM_SHARDS

Assuming we have supplied a query parameter $userId with the specific userId that we are interested in, we use our function in this way:

USE example.graph(sharding.userIdToGraphId($userId))
MATCH (u:User) WHERE u.userId = $userId
RETURN u

9.3.8. Fabric built-in functions

Fabric functions are located in a namespace corresponding to a Fabric database in which they are used. The following table provides a description of Fabric built-in functions:

<table>
<thead>
<tr>
<th>Function</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;fabric database name&gt;.graphIds()</td>
<td>Provides a list of IDs of all remote graph configured for the given Fabric database.</td>
</tr>
<tr>
<td>&lt;fabric database name&gt;.graph(graphId)</td>
<td>Maps a graph ID to a Graph. It accepts a graph ID as a parameter and returns a graph representation accepted by USE clause. This function is supported only in USE clauses</td>
</tr>
</tbody>
</table>

9.4. Further considerations

This section presents considerations about Fabric that developers and administrators must be aware of.

DBMS mode

The DBMS hosting the Fabric virtual database cannot be part of a Causal Cluster: it can only be a
DBMS with `dbms.mode=SINGLE`.

### Sharding an existing database

An existing database can be sharded with the help of the `neo4j-admin copy` command. See [Sharding data with the copy command](#) for an example.

### Database compatibility

Fabric is part of Neo4j DBMS and does not require any special installation or plugin. Fabric graphs can be associated to databases available on Neo4j DBMS version 4.1 or 4.2.

### Fabric configuration

The Neo4j DBMSs that host the same Fabric virtual database must have the same configuration settings. The configuration must be kept in-sync and applied by the Database Administrator.

### Security credentials

The Neo4j DBMSs that host the same Fabric virtual database must have the same user credentials. Any change of password on a machine that is part of Fabric, must be kept in-sync and applied to all the Neo4j DBMSs that are part of Fabric.

### Transactions in Fabric

In Fabric, ACID compliance is guaranteed only within a single graph. This means, that the current version of Fabric does not support transactions that span across multiple graphs. To avoid common mistakes that may lead to data corruption, Fabric does not allow write operations on more than one graph within the same transaction. Transactions with queries that read from multiple graphs, or read from multiple graphs and write to a single graph, are allowed.

### Administration commands

Fabric does not support issuing Cypher administration commands, on, or through the Fabric virtual database. Any database management commands, index and constraint management commands or user and security management commands must be issued directly to the DBMSs and databases that are part of the Fabric setup.

### Neo4j embedded

Fabric is not available when Neo4j is used as an embedded database in Java applications. Fabric can be used only in a typical client/server mode, when users connect to a Neo4j DBMS from their client application or tool, via Bolt or HTTP protocol.

#### 9.5. Sharding data with the `copy` command

This section provides an example of how to use `neo4j-admin copy` to filter out data for Fabric.

The `copy` command can be used to filter out data for a Fabric installation. In the following example, a sample database is separated into 3 shards.
Example 60. Use the `copy` command to filter out data for a Fabric installation.

The sample database contains the following data:

```plaintext
(p1 :Person :S2 {id:123, name: "Ava"})
(p2 :Person :S2 {id:124, name: "Bob"})
(p3 :Person :S3 {id:125, name: "Cat", age: 54})
(p4 :Person :S3 {id:126, name: "Dan"})
(t1 :Team :S1 :SAll {id:1, name: "Foo", mascot: "Pink Panther"})
(t2 :Team :S1 :SAll {id:2, name: "Bar", mascot: "Cookie Monster"})
(d1 :Division :SAll {name: "Marketing"})
(p1)-[:MEMBER]->(t1)
(p2)-[:MEMBER]->(t2)
(p3)-[:MEMBER]->(t1)
(p4)-[:MEMBER]->(t2)
```

The data has been prepared using queries to add the labels :S1, :S2, :S3, and :SAll, which denotes the target shard. Shard 1 contains the team data. Shard 2 and Shard 3 contain person data.

1. Create Shard 1 with:

```
$neo4j-home> bin/neo4j-admin copy --from-database=neo4j \\
    --to-database=shard1 \\
    --keep-only-nodes-with-labels=S1,SAll ① \\
    --skip-labels=S1,S2,S3,SAll ②
```

① The `--keep-only-node-with-labels` property is used to filter out everything that does not have the label :S1 or :SAll.

② The `--skip-labels` property is used to exclude the temporary labels you created for the sharding process.

The resulting shard contains the following:

```
(t1 :Team {id:1, name: "Foo", mascot: "Pink Panther"})
(t2 :Team {id:2, name: "Bar", mascot: "Cookie Monster"})
(d1 :Division {name: "Marketing"})
```

2. Create Shard 2:

```
$neo4j-home> bin/neo4j-admin copy --from-database=neo4j \\
    --to-database=shard2 \\
    --keep-only-nodes-with-labels=S2,SAll \\
    --skip-labels=S1,S2,S3,SAll \\
    --keep-only-node-properties=Team.id
```

In Shard 2, you want to keep the :Team nodes as proxy nodes, to be able to link together information from the separate shards. The nodes will be included since they have the label :SAll, but you specify `--keep-only-node-properties` so as to not duplicate the team information from Shard 1.
Observe that --keep-only-node-properties did not filter out Person.name since the :Person label was not mentioned in the filter.

3. Create Shard 3, but with the filter --skip-node-properties, instead of --keep-only-node-properties.

```bash
$neo4j-home> bin/neo4j-admin copy --from-database=neo4j \
   --to-database=shard3 \
   --keep-only-nodes-with-labels=S3,SAll \
   --skip-labels=S1,S2,S3,SAll \
   --skip-node-properties=Team.name,Team.mascot
```

The result is:

(p3 :Person {id:125, name: "Cat", age: 54})
(p4 :Person {id:126, name: "Dan"})
(t1 :Team {id:1})
(t2 :Team {id:2})
(d1 :Division {name: "Marketing"})
(p3)-[:MEMBER]->(t1)
(p4)-[:MEMBER]->(t2)

As demonstrated, you can achieve the same result with both --skip-node-properties and --keep-only-node-properties. In this example, it is easier to use --keep-only-node-properties because only one property should be kept. The relationship property filters works in the same way.
Chapter 10. Backup and restore

This chapter describes how to back up and restore Neo4j.

This chapter describes the following:

- **Backup and restore planning** — What to consider when designing your backup and restore strategy.
- **Backup modes** — The supported backup modes.
- **Back up an online database** — How to back up an online database.
- **Prepare for restore** - How to prepare your backup for restore by applying the latest transactions.
- **Restore a database backup** — How to restore a database backup in a live Neo4j deployment.
- **Back up an offline database** — How to back up an offline database.
- **Restore a database dump** — How to restore a database dump in a live Neo4j deployment.
- **Copy a database store** — How to copy data store from an existing database to a new database.

### 10.1. Backup and restore planning

>This section describes the benefits of backing up Neo4j, what to consider when deciding on your backup and restore strategy, what needs to be backed up, and the different backup modes and options.

There are two main reasons for backing up your Neo4j databases and storing them in a safe, off-site location:

- to be able to quickly recover your data in case of failure, for example related to hardware, human error, or natural disaster.
- to be able to perform routine administrative operations, such as moving a database from one instance to another, upgrading, or reclaiming space.

### 10.1.1. Backup and restore strategy

Depending on your particular deployment and environment, it is important to design an appropriate backup and restore strategy.

There are various factors to consider when deciding on your strategy, such as:

- **Type of environment** – development, test, or production.
- **Data volumes**.
- **Number of databases**.
- Available system resources.
- Downtime tolerance during backup and restore.
- Demands on Neo4j performance during backup and restore. This factor might lead your decision towards performing these operations during an off-peak period.
- Tolerance for data loss in case of failure.
- Tolerance for downtime in case of failure. If you have zero tolerance for downtime and data loss, you might want to consider performing an online or even a scheduled backup.
- Frequency of updates to the database.
- Type of backup and restore method (online or offline), which may depend on whether you want to:
  - perform full backups (online or offline).
  - automatically check the consistency of a database backup (online only).
  - perform incremental backups (online only).
  - use SSL/TLS for the backup network communication (online only).
  - keep your databases as archive files (offline only).
- How many backups you want to keep.
- Where the backups will be stored — drive or remote server, cloud storage, different data center, different location, etc.

| 💡 It is recommended to store your database backups on a separate off-site server (drive or remote) from the database files. This ensures that if for some reason your Neo4j DBMS crashes, you will be able to access the backups and perform a restore. |

- How you will test recovery routines, and how often.

### 10.1.2. Backup and restore options

Neo4j supports backing up and restoring both online and offline databases. It uses Neo4j Admin tool commands, which can be run from a live, as well as from an offline Neo4j DBMS. All neo4j-admin commands must be invoked as the neo4j user to ensure the appropriate file permissions.

- `neo4j-admin backup/restore` (Enterprise only) — used for performing online backup (full and incremental) and restore operations. The database to be backed up must be in online mode. This command is suitable for production environments, where you cannot afford downtime. However, it is more memory intensive and is not supported in Neo4j Aura.

| 💡 When using `neo4j-admin backup` in Causal Cluster, it is recommended to back up from an external instance as opposed to reuse instances that form part of the cluster. |

- `neo4j-admin dump/load` — used for performing offline dump and load operations. The database to be dumped must be in offline mode. This dump command is suitable for environments, where downtime is not a factor. It is faster than the backup command, and produces an archive file, which occupies less space than a normal database structure.
• **neo4j-admin copy** — used for copying an offline database or backup. This command can be used for cleaning up database inconsistencies, reclaiming unused space, and migrating Neo4j 3.5.any directly to any 4.x version of Neo4j, including the latest version, skipping the intermediate steps. For a detailed example, see Upgrade and Migration Guide → Tutorial: Back up and copy a database in a standalone instance.

![Warning] File system copy-and-paste of databases is not supported.

![Info] In Fabric deployments, the Neo4j Admin commands `backup`, `restore`, `dump`, `load`, `copy`, and `check-consistency` are not supported for use on the Fabric virtual database. They must be run directly on the databases that are part of the Fabric setup.

Table 43. The following table describes the commands capabilities and usage.

<table>
<thead>
<tr>
<th>Capability/ Usage</th>
<th>neo4j-admin backup</th>
<th>neo4j-admin dump</th>
<th>neo4j-admin restore</th>
<th>neo4j-admin load</th>
<th>neo4j-admin copy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neo4j Edition</td>
<td>Enterprise</td>
<td>all</td>
<td>Enterprise</td>
<td>all</td>
<td>Enterprise</td>
</tr>
<tr>
<td>Live Neo4j DBMS</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Offline Neo4j DBMS</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Run against a user database</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Run against the <strong>system</strong> database</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>Run against the <strong>fabric</strong> database</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>Perform full backups</td>
<td>✓</td>
<td>✓</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Perform incremental backups</td>
<td>✓</td>
<td>✗</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Applied to an online database</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>Applied to an offline database</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Can be run remotely (support SSL)</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Command input</td>
<td>database</td>
<td>database</td>
<td>database backup</td>
<td>archive (.dump)</td>
<td>database or database backup</td>
</tr>
<tr>
<td>Command output</td>
<td>database</td>
<td>archive (.dump)</td>
<td>database</td>
<td>database</td>
<td>database; no schema store</td>
</tr>
<tr>
<td>Capability/ Usage</td>
<td>neo4j-admin backup</td>
<td>neo4j-admin dump</td>
<td>neo4j-admin restore</td>
<td>neo4j-admin load</td>
<td>neo4j-admin copy</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>--------------------</td>
<td>------------------</td>
<td>---------------------</td>
<td>-----------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Run consistency check after completion</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>Clean up database inconsistencies</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Compact data store</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
</tr>
</tbody>
</table>

### 10.1.3. Databases to backup

A Neo4j DBMS can host multiple databases. Both Neo4j Community and Enterprise Editions have a default user database, called `neo4j`, and a system database, which contains configurations, e.g., operational states of databases, security configuration, schema definitions, login credentials, and roles. In the Enterprise Edition, you can also create additional user databases. Each of these databases are backed up independently of one another.

It is very important to back up each of your databases, including the system database, in a safe location.

### 10.1.4. Additional files to back up

The following files must be backed up separately from the databases:

- The `neo4j.conf` file. If you have a cluster deployment, you should back up the configuration file for each cluster member.
- All the files used for encryption, i.e., private key, public certificate, and the contents of the trusted and revoked directories. The locations of these are described in SSL framework. If you have a cluster, you should back up these files for each cluster member.
- If using custom plugins, make sure that you have the plugins in a safe location.

### 10.1.5. Storage considerations

For any backup, it is important that you store your data separately from the production system, where there are no common dependencies, and preferably off-site. If you are running Neo4j in the cloud, you may use a different availability zone or even a separate cloud provider. Since backups are kept for a long time, the longevity of archival storage should be considered as part of backup planning.

### 10.2. Backup modes

This section describes the backup modes.

The backup client can operate in two different modes – a full backup and an incremental backup.
10.2.1. Full backup

A full backup is always required initially for the very first backup into a target location.

The full backup can be run against both an online (using `neo4j-admin backup`) and an offline (using `neo4j-admin dump`) database.

Example 61. Full backup against an online database

```
$neo4j-home> export HEAP_SIZE=2G
$neo4j-home> mkdir /mnt/backups
$neo4j-home> bin/neo4j-admin backup --from=192.168.1.34 --backup-dir=/mnt/backups/neo4j --database=neo4j --pagecache=4G
Doing full backup...
2017-02-01 14:09:09.510+0000 INFO [o.n.c.s.StoreCopyClient] Copying neostore.nodestore.db.labels
2017-02-01 14:09:09.537+0000 INFO [o.n.c.s.StoreCopyClient] Copied neostore.nodestore.db.labels 8.00 kB
2017-02-01 14:09:09.538+0000 INFO [o.n.c.s.StoreCopyClient] Copying neostore.nodestore.db
2017-02-01 14:09:09.540+0000 INFO [o.n.c.s.StoreCopyClient] Copied neostore.nodestore.db 16.00 kB
... 
```

For more information about online backup options and how to control memory usage, see Back up an online database.

For more information about performing a full backup against an offline database, see Back up an offline database.

10.2.2. Incremental backup

After the initial full backup, the subsequent backups attempt to use the incremental mode, where just the delta of the transaction logs since the last backup are transferred and applied onto the target location. If the required transaction logs are not available on the backup server, then the backup client falls back on performing a full backup instead, unless `--fallback-to-full` is disabled.

The incremental backup can be run only against an online database.

Example 62. Incremental backup against an online database

```
$neo4j-home> export HEAP_SIZE=2G
$neo4j-home> bin/neo4j-admin backup --from=192.168.1.34 --backup-dir=/mnt/backups/neo4j --database=neo4j --pagecache=4G
Destination is not empty, doing incremental backup...
Backup complete.
```

For more information about online backup options and how to control memory usage, see Back up an online database.
This section describes how to back up an online database.

Remember to plan your backup carefully and to back up each of your databases, including the system database.

10.3.1. Command

A Neo4j database can be backed up in online mode using the backup command of neo4j-admin. The command must be invoked as the neo4j user to ensure the appropriate file permissions.

Usage

The neo4j-admin backup command can be used for performing both full and incremental backups of an online database. The command can be run both locally and remotely. By default, neo4j-admin backup also checks the database consistency at the end of every backup operation. However, it uses a significant amount of resources, such as memory and CPU. Therefore, it is recommended to perform the backup on a separate dedicated machine. The neo4j-admin backup command also supports SSL/TLS. For more information, see Online backup configurations.

neo4j-admin backup is not supported in Neo4j Aura.

neo4j-admin backup is not supported for use on the Fabric virtual database. It must be run directly on the databases that are part of the Fabric setup.

Syntax

```
neo4j-admin backup --backup-dir=<path>
    [-v] [-x] [-f <host:port>]
    [-d <database>]
    [-f<true/false>]
    [-p=<size>]
    [-c<true/false>]
    [-r=<path>]
    [-g<true/false>]
    [-i<true/false>]
    [-s<true/false>]
    [-l<true/false>]
    [-a<true/false>]
    [-m<all/users/roles>]
    [-r<true/false>]
    [-p<true/false>]
```

Please note that the following options have been deprecated:

```
[--check-label-scan-store=<true/false>]
[--check-property-owners=<true/false>]
```

Values for these settings will be ignored.

## Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>--backup-dir</code></td>
<td></td>
<td>Target directory.</td>
</tr>
<tr>
<td><code>--verbose</code></td>
<td></td>
<td>Enable verbose output.</td>
</tr>
<tr>
<td><code>--expand-commands</code></td>
<td></td>
<td>Allow command expansion in config value evaluation.</td>
</tr>
<tr>
<td><code>--from</code></td>
<td>localhost:6362</td>
<td>Host and port of Neo4j.</td>
</tr>
<tr>
<td><code>--database</code></td>
<td>neo4j</td>
<td>Name of the remote database to back up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The value can contain * and ? for globbing, in which cases, all matching</td>
</tr>
<tr>
<td></td>
<td></td>
<td>databases will be backed up.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>With a single * as a value, you can back up all the databases of the</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DBMS.</td>
</tr>
<tr>
<td><code>--fallback-to-full</code></td>
<td>true</td>
<td>If an incremental backup fails, backup will move the old backup to &lt;name&gt;.err.&lt;N&gt; and fallback on a full backup instead.</td>
</tr>
<tr>
<td><code>--pagecache</code></td>
<td>8m</td>
<td>The size of the page cache to use for the backup process.</td>
</tr>
<tr>
<td><code>--check-consistency</code></td>
<td>true</td>
<td>Run a consistency check against the database backup.</td>
</tr>
<tr>
<td>Option</td>
<td>Default</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------</td>
<td>---------</td>
<td>-------------</td>
</tr>
<tr>
<td>--report-dir</td>
<td>.</td>
<td>Directory where consistency report will be written.</td>
</tr>
<tr>
<td>--check-graph</td>
<td>true</td>
<td>Perform consistency checks between nodes, relationships, properties, types, and tokens.</td>
</tr>
<tr>
<td>--check-indexes</td>
<td>true</td>
<td>Perform consistency checks on indexes.</td>
</tr>
<tr>
<td>--check-index-structure</td>
<td>true</td>
<td>Perform structure checks on indexes.</td>
</tr>
<tr>
<td>--check-label-scan-store</td>
<td>true</td>
<td>This option is deprecated, and its value is ignored.</td>
</tr>
<tr>
<td>--check-property-owners</td>
<td>false</td>
<td>This option is deprecated, and its value is ignored.</td>
</tr>
<tr>
<td>--additional-config</td>
<td></td>
<td>Configuration file to provide additional or override the existing configuration settings in the neo4j.conf file.</td>
</tr>
<tr>
<td>Option</td>
<td>Default</td>
<td>Description</td>
</tr>
<tr>
<td>------------------------</td>
<td>---------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>--include-metadata</td>
<td></td>
<td>Include metadata in the backup. Metadata contains security settings related to the database. Cannot be used for backing up the system database.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- roles - commands to create the roles and privileges (for both database and graph) that affect the use of the database.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- users - commands to create the users that can use the database and their role assignments.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- all - include roles and users.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The metadata script can be found in the backup directory &lt;database&gt;/tools/metadata_script.cypher.</td>
</tr>
</tbody>
</table>
### Option

<table>
<thead>
<tr>
<th>Option</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>--prepare-restore</td>
<td>true</td>
<td>Perform the recovery of the backup store by applying the latest pulled transactions. If disabled, the backup will be faster, but a recovery of the backup store will be required at a later time before restoring the data. For more information on how to do that, see Prepare a database for restoring.</td>
</tr>
<tr>
<td>--parallel-recovery</td>
<td>false</td>
<td>Allow multiple threads to apply transactions to a backup in parallel. For some databases and workloads, this may reduce execution times significantly. parallel-recovery is an experimental option. Consult Neo4j support before use.</td>
</tr>
</tbody>
</table>

**Exit codes**

Depending on whether the backup was successful or not, neo4j-admin backup exits with different codes. The error codes include details of what error was encountered.

Table 44. Neo4j Admin backup exit codes when backing up one database
<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Success.</td>
</tr>
<tr>
<td>1</td>
<td>Backup failed.</td>
</tr>
<tr>
<td>2</td>
<td>Backup succeeded but consistency check failed.</td>
</tr>
<tr>
<td>3</td>
<td>Backup succeeded but consistency check found inconsistencies.</td>
</tr>
</tbody>
</table>

Table 45. Neo4j Admin backup exit codes when backing multiple databases

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>All databases are backed up successfully.</td>
</tr>
<tr>
<td>1</td>
<td>One or several backup failed.</td>
</tr>
</tbody>
</table>

10.3.2. Online backup configurations

Server configuration

The table below lists the basic server parameters relevant to backups. Note that, by default, the backup service is enabled but only listens on localhost (127.0.0.1). This needs to be changed if backups are to be taken from another machine.

Make this change only if you need the remote backup. If your network is not adequately isolated, this change might expose your system to threats.

Table 46. Server parameters for backups

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>dbms.backup.enabled</td>
<td>true</td>
<td>Enable support for running online backups.</td>
</tr>
<tr>
<td>dbms.backup.listen_address</td>
<td>127.0.0.1:6362</td>
<td>Listening server for online backups.</td>
</tr>
</tbody>
</table>

It is not recommended to use an NFS mount for backup purposes as this is likely to corrupt and slow down the backup.

Make sure to follow the Security Configurations in order to prevent unauthorized users from accessing the DBMS by having access to the backup server.

Memory configuration

The following options are available for configuring the memory allocated to the backup client:

Configure heap size for the backup

`HEAP_SIZE` configures the maximum heap size allocated for the backup process. This is done by setting
the environment variable `HEAP_SIZE` before starting the operation. If not specified, the Java Virtual Machine chooses a value based on the server resources.

**Configure page cache for the backup**

The page cache size can be configured by using the `--pagecache` option of the `neo4j-admin backup` command. If not explicitly defined, the page cache defaults to 8MB.

<table>
<thead>
<tr>
<th>💡 You should give the Neo4J page cache as much memory as possible, as long as it satisfies the following constraint:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neo4J page cache + OS page cache &lt; available RAM, where 2 to 4GB should be dedicated to the operating system’s page cache.</td>
</tr>
<tr>
<td>For example, if your current database has a Total mapped size of 128GB as per the debug.log, and you have enough free space (meaning you have left aside 2 to 4 GB for the OS), then you can set <code>--pagecache</code> to 128GB.</td>
</tr>
</tbody>
</table>

**Computational resources configurations**

**Consistency checking**

Checking the consistency of the backup is a major operation which may consume significant computational resources, such as, memory, CPU, I/O. When backing up an online database, the consistency checker is invoked at the end of the process by default. Therefore, it is highly recommended to perform the backup and consistency check on a dedicated machine, which has sufficient free resources, to avoid adversely affecting the running server.

Alternatively, you can decouple the backup operation from the consistency check (using the `neo4j-admin backup` option `--check-consistency=false`) and schedule that part of the workflow to happen at a later point in time, on a dedicated machine. Consistency checking a backup is vital for safeguarding and ensuring the quality of the data, and should not be underestimated.

|💡 To avoid running out of resources on the running server, it is recommended to perform the backup on a separate dedicated machine.|

**Transaction log files**

The transaction log files, which keep track of recent changes, are rotated and pruned based on a provided configuration. For example, setting `dbms.tx_log.rotation.retention_policy=3` files keeps 3 transaction log files in the backup. Because recovered servers do not need all of the transaction log files that have already been applied, it is possible to further reduce storage size by reducing the size of the files to the bare minimum. This can be done by setting `dbms.tx_log.rotation.size=1M` and `dbms.tx_log.rotation.retention_policy=3` files. You can use the `--additional-config` parameter to override the configurations in the neo4j.conf file.

|⚠️ Removing transaction logs manually can result in a broken backup. |
Security configurations

Securing your backup network communication with an SSL policy and a firewall protects your data from unwanted intrusion and leakage. When using the `neo4j-admin backup` command, you can configure the backup server to require SSL/TLS, and the backup client to use a compatible policy. For more information on how to configure SSL in Neo4j, see SSL framework.

For a detailed list of recommendations regarding security in Neo4j, see Security checklist.

The following table provides details on how the configured SSL policies map to the configured ports.

<table>
<thead>
<tr>
<th>Topology</th>
<th>Backup target address on database server</th>
<th>SSL policy setting on database server</th>
<th>SSL policy setting on backup client</th>
<th>Default port</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standalone instance</td>
<td><code>dbms.backup.listen_address</code></td>
<td><code>dbms.ssl.policy.backup</code></td>
<td><code>dbms.ssl.policy.backup</code></td>
<td>6362</td>
</tr>
<tr>
<td>Causal cluster</td>
<td><code>dbms.ssl.policy.cluster causal_clustering.transaction_listen_address</code></td>
<td><code>dbms.ssl.policy.cluster</code></td>
<td><code>dbms.ssl.policy.backup</code></td>
<td>6000</td>
</tr>
</tbody>
</table>

It is very important to ensure that there is no external access to the port specified by the setting `dbms.backup.listen_address`. Failing to protect this port may leave a security hole open by which an unauthorized user can make a copy of the database onto a different machine. In production environments, external access to the backup port should be blocked by a firewall.

Cluster configurations

In a cluster topology, it is possible to take a backup from any server, and each server has two configurable ports capable of serving a backup. These ports are configured by `dbms.backup.listen.address` and `causal_clustering.transaction_listen_address` respectively. Functionally, they are equivalent for backups, but separating them can allow some operational flexibility, while using just a single port can simplify the configuration. It is generally recommended to select Read Replicas to act as backup servers, since they are more numerous than Core members in typical cluster deployments. Furthermore, the possibility of performance issues on a Read Replica, caused by a large backup, will not affect the performance or redundancy of the Core members. If a Read Replica is not available, then a Core can be selected based on factors, such as its physical proximity, bandwidth, performance, and liveness.

To avoid taking a backup from a cluster member that is lagging behind, you can look at the transaction IDs by exposing Neo4j metrics or via Neo4j Browser. To view the latest processed transaction IDs (and other metrics) in Neo4j Browser, type `:sysinfo` at the prompt.
10.3.3. Examples

The following are examples of how to back up a single database, e.g., the default database neo4j, and multiple databases, using the neo4j-admin backup command. The target directory /mnt/backups/neo4j must exist before calling the command and the database(s) must be online.

Example 63. Use neo4j-admin backup to back up a single database.

```
bin/neo4j-admin backup --backup-dir=/mnt/backups/neo4j --database=neo4j
```

To backup several databases that match database pattern you can use name globbing. For example, to backup all databases that start with n you should run:

Example 64. Use neo4j-admin backup to back up multiple databases.

```
neo4j-admin backup --from=192.168.1.34 --backup-dir=/mnt/backups/neo4j --database=n* --pagecache=4G
```

For a detailed example on how to back up and restore a database in a Causal cluster, see Back up and restore a database in Causal Cluster.

10.4. Prepare a database for restoring [Enterprise edition]

This section describes how to apply the latest transactions pulled at the backup time but not yet applied to the store.

10.4.1. Command

If the --prepare-restore option is disabled when you back up your database, your store may not contain the latest transactions pulled at backup time. In this case, you have to run the --neo4j-admin prepare-restore command to apply those transactions to the store, before you can restore your data.

Syntax

```
neo4j-admin prepare-restore --target=<path>[,<path>...]... [--verbose] [--expand-commands] [--parallel-recovery]
```

Options
<table>
<thead>
<tr>
<th>Option</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>--target</code></td>
<td></td>
<td>A path to the backup that is going to be prepared for restoring. A path can contain asterisks or question marks in the last subpath but must not contain commas. Multiple paths are separated by a comma.</td>
</tr>
<tr>
<td><code>--verbose</code></td>
<td></td>
<td>Enable verbose output.</td>
</tr>
<tr>
<td><code>--expand-commands</code></td>
<td></td>
<td>Allow command expansion in config value evaluation.</td>
</tr>
<tr>
<td><code>--parallel-recovery</code></td>
<td>false</td>
<td>Allow multiple threads to apply transactions to a backup in parallel. For some databases and workloads, this may reduce execution times significantly.</td>
</tr>
</tbody>
</table>

**parallel-recovery** is an experimental option. Consult Neo4j support before use.

10.4.2. Example

The following is an example of preparing your database backup, created in the section Back up an online database, for restoring, using the `neo4j-admin prepare-restore` command.

```
bin/neo4j-admin prepare-restore --target=/mnt/backups/neo4j
```

10.5. Restore a database backup **Enterprise edition**

This section describes how to restore a database backup or an offline database in a live Neo4j deployment.

10.5.1. Command

A database backup or an offline database can be restored using the `restore` command of `neo4j-admin`.
You must create the database (using `CREATE DATABASE` against the `system` database) after the restore operation finishes, unless you are replacing an existing database. `neo4j-admin restore` must be invoked as the `neo4j` user to ensure the appropriate file permissions. For more information, see Administrative commands.

If the `--prepare-restore` option is disabled when backing up your database, you must first perform the `neo4j-admin prepare-restore` command before you can restore your database. This is to apply the latest transactions pulled at the backup time but not yet applied to the store. For more information, see Prepare a database for restoring.

Syntax

```
neo4j-admin restore  --from=<path>[,<path>...]  
[--verbose]
[--expand-commands]
[--database=<database>]
[--force]
[--move]
[--to-data-directory=<path>]
[--to-data-tx-directory=<path>]
```

Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>--from</code></td>
<td></td>
<td>A path or multiple paths to the database backup(s) for restore. A path can contain asterisks or question marks in the last subpath but must not contain commas. Commas are used to separate multiple paths.</td>
</tr>
<tr>
<td><code>--verbose</code></td>
<td></td>
<td>Enables verbose output.</td>
</tr>
<tr>
<td><code>--expand-commands</code></td>
<td></td>
<td>Allows command expansion in config value evaluation.</td>
</tr>
<tr>
<td><code>--database</code></td>
<td><code>neo4j</code></td>
<td>Name for the restored database.</td>
</tr>
<tr>
<td><code>--force</code></td>
<td></td>
<td>Replaces an existing database.</td>
</tr>
<tr>
<td>Option</td>
<td>Default</td>
<td>Description</td>
</tr>
<tr>
<td>------------------------</td>
<td>---------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>--move</strong></td>
<td></td>
<td>Moves the backup files to the destination, rather than copying. This makes the restoring process faster and with no need for extra disk space. However, for this procedure to work properly, backup and database files must be on the same filesystem. In case they are not, the command will only copy the files and delete the backup, resulting in no performance benefits.</td>
</tr>
<tr>
<td><strong>--to-data-directory</strong></td>
<td></td>
<td>Base directory for databases. Usage of this option is only allowed if the <strong>--from</strong> parameter points to one directory.</td>
</tr>
<tr>
<td><strong>--to-data-tx-directory</strong></td>
<td></td>
<td>Base directory for transaction logs. Usage of this option is only allowed if the <strong>--from</strong> parameter points to one directory.</td>
</tr>
</tbody>
</table>

### 10.5.2. Example

The following is an example of how to perform an online restore of the database backup created in the section Back up an online database, using the `neo4j-admin restore` command.

```
bin/neo4j-admin restore --from=/mnt/backups/neo4j --database=neo4j --force
```

Unless you are replacing an existing database, you must create the database (using `CREATE DATABASE` against the `system` database) after the restore operation finishes.

If you have backed up a database with the option `--include-metadata`, you can manually restore the users and roles metadata.

From the `<neo4j-home>` directory, you run the Cypher script `data/scripts/databasename/restore_metadata.cypher`, which the `neo4j-admin restore` command outputs, using Cypher Shell:

**Using cat (UNIX)**

```
cat data/scripts/databasename/restore_metadata.cypher | bin/cypher-shell -u user -p password -a ip_address:port -d system --param "database => 'databasename'"
```
Using `type` (Windows)

```bash
type data\scripts\databasename\restore_metadata.cypher | bin\cypher-shell.bat -u user -p password -a ip_address:port -d system --param "database => 'databasename'"
```

For a detailed example on how to back up and restore a database in a Causal cluster, see `Back up and restore a database in Causal Cluster`.

`neo4j-admin restore` cannot be applied to the Fabric virtual database. It must be run directly on the databases that are part of the Fabric setup.

### 10.6. Back up an offline database

This section describes how to back up an offline database.

Remember to plan your backup carefully and to back up each of your databases, including the `system` database.

### 10.6.1. Command

A Neo4j database can be backed up in offline mode using the `dump` command of `neo4j-admin`.

#### Usage

The `neo4j-admin dump` command can be used for performing a full backup of an offline database. It dumps a database into a single-file archive, called `<database>.dump`. Alternatively, `neo4j-admin dump` can stream `dump` to standard output, enabling the output to be piped to another program, for example to `neo4j-admin load`.

The command can be run only locally from an online or an offline Neo4j DBMS.

It does not support SSL/TLS.

#### Syntax

```
neo4j-admin dump --to=<destination-path> 
[--verbose] 
[--expand-commands] 
[--database=<database>]
```

#### Options
<table>
<thead>
<tr>
<th>Option</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>--to</td>
<td></td>
<td>Destination (file or folder) of database dump, or - for standard output.</td>
</tr>
<tr>
<td>--verbose</td>
<td></td>
<td>Enable verbose output.</td>
</tr>
<tr>
<td>--expand-commands</td>
<td></td>
<td>Allow command expansion in config value evaluation.</td>
</tr>
<tr>
<td>--database</td>
<td>neo4j</td>
<td>Name of the database to dump.</td>
</tr>
</tbody>
</table>

10.6.2. Example

The following is an example of how to create a dump of the default database neo4j, called neo4j-<timestamp>.dump, using the neo4j-admin dump command. The target directory /dumps/neo4j must exist before running the command and the database must be offline.

```
bin/neo4j-admin dump --database=neo4j --to=/dumps/neo4j/neo4j-<timestamp>.dump
```

Neo4j-admin dump cannot be applied to the Fabric virtual database. It must be run directly on the databases that are part of the Fabric setup.

10.7. Restore a database dump

This section describes how to restore a database dump in a live Neo4j deployment.

A database dump can be loaded to a Neo4j instance using the load command of neo4j-admin.

10.7.1. Command

The neo4j-admin load command loads a database from an archive created with the neo4j-admin dump command. Alternatively, neo4j-admin load can accept dump from standard input, enabling it to accept input from neo4j-admin dump or another source.

The command can be run from an online or an offline Neo4j DBMS.

If you are replacing an existing database, you have to shut it down before running the command. If you are not replacing an existing database, you must create the database (using CREATE DATABASE against the system database) after the load operation finishes.

neo4j-admin load must be invoked as the neo4j user to ensure the appropriate file permissions.
Syntax

```
neo4j-admin load --from=<archive-path>
    [--verbose]
    [--expand-commands]
    [--database=<database>]
    [--force]
    [--info]
```

Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>--from</td>
<td></td>
<td>Path to archive created with the neo4j-admin dump command, or - to use standard input.</td>
</tr>
<tr>
<td>--verbose</td>
<td></td>
<td>Enable verbose output.</td>
</tr>
<tr>
<td>--expand-commands</td>
<td></td>
<td>Allow command expansion in config value evaluation.</td>
</tr>
<tr>
<td>--database</td>
<td>neo4j</td>
<td>Name for the loaded database.</td>
</tr>
<tr>
<td>--force</td>
<td></td>
<td>Replace an existing database.</td>
</tr>
<tr>
<td>--info</td>
<td></td>
<td>Print meta-data information about the archive file, such as, file count, byte count, and format of the load file.</td>
</tr>
</tbody>
</table>

10.7.2. Example

The following is an example of how to load the dump of the neo4j database created in the section Back up an offline database, using the neo4j-admin load command. When replacing an existing database, you have to shut it down before running the command.

```
bin/neo4j-admin load --from=/dumps/neo4j/neo4j-<timestamp>.dump --database=neo4j --force
```

Unless you are replacing an existing database, you must create the database (using CREATE DATABASE against the system database) after the load operation finishes.
When using the `load` command to seed a Causal Cluster, and a previous version of the database exists, you must delete it (using `DROP DATABASE`) first. Alternatively, you can stop the Neo4j instance and unbind it from the cluster using `neo4j-admin unbind` to remove its cluster state data. If you fail to DROP or unbind before loading the dump, that database’s store files will be out of sync with its cluster state, potentially leading to logical corruptions. For more information, see [Seed a cluster from a database backup](online).

`neo4j-admin load` cannot be applied to the Fabric virtual database. It must be run directly on the databases that are part of the Fabric setup.

### 10.8. Copy a database store [Enterprise edition](online)

This section describes how to copy the data store of an existing offline database to a new database.

A user database or backup can be copied to a Neo4j instance using the `copy` command of `neo4j-admin`.

`neo4j-admin copy` is not supported for use on the system database.

In Fabric deployments, `neo4j-admin copy` cannot be applied to the Fabric virtual database. It must be run directly on the databases that are part of the Fabric setup.
It is important to note that `neo4j-admin copy` is an IOPS-intensive process. Using this process for upgrading or migration purposes can have significant performance implications, depending on your disc specification. It is therefore not appropriate for all use cases.

Estimating the processing time

Estimations for how long the `neo4j-admin copy` command will take can be made based upon the following:

- Neo4j, like many other databases, do IO in 8K pages.
- Your disc manufacturer will have a value for the maximum IOPS it can process.

For example, if your disc manufacturer has provided a maximum of 5000 IOPS, you can reasonably expect up to 5000 such page operations a second. Therefore, the maximal theoretical throughput you can expect is 40MB/s (or 144 GB/hour) on that disc. You may then assume that the best-case scenario for running `neo4j-admin copy` on that 5000 IOPS disc is that it will take at least 1 hour to process a 144 GB database. [1]

However, it is important to remember that the process must read 144 GB from the source database, and must also write to the target store (assuming the target store is of comparable size). Additionally, there are internal processes during the copy that will read/modify/write the store multiple times. Therefore, with an additional 144 GB of both read and write, the best-case scenario for running `neo4j-admin copy` on a 5000 IOPS disc is that it will take at least 3 hours to process a 144 GB database.

Finally, it is also important to consider that in almost all Cloud environments, the published IOPS value may not be the same as the actual value, or be able to continuously maintain the maximum possible IOPS. The real processing time for this example could be well above that estimation of 3 hours.

For detailed information about supported methods of upgrade and migration, see the Neo4j Upgrade and Migration Guide.

10.8.1. Command

`neo4j-admin copy` copies the data store of an existing offline database to a new database.

Usage

The `neo4j-admin copy` command can be used to clean up database inconsistencies, compact stores, and do a direct migration from Neo4j 3.5 to any 4.x version. It can process an optional set of filters, which you can use to remove any unwanted data before copying the database. The command also reclaims the unused space of a database and creates a defragmented copy of that database or backup in the destination Neo4j instance.
neo4j-admin copy copies the data store without the schema (indexes and constraints). However, if the database has a schema defined, the command will output Cypher statements, which you can run to recreate the indexes and constraints.

For a detailed example of how to reclaim unused space, see Reclaim unused space.
For a detailed example of how to back up a 3.5 database and use the neo4j-admin copy command to compact its store and migrate it to a 4.x Neo4j standalone instance, see Upgrade and Migration Guide → Tutorial: Back up and copy a database in a standalone instance.

neo4j-admin copy preserves the node IDs; however, the relationships get new IDs.

Syntax

```
neo4j-admin copy  [--verbose]
  [--from-database=<database>]
  [--from-path=<path>]
  --to-database=<database>
  [--from-pagecache=<size>]
  [--to-pagecache=<size>]
```

Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>--verbose</td>
<td>Enable verbose output.</td>
</tr>
<tr>
<td>--from-database</td>
<td>The database name to copy from.</td>
</tr>
<tr>
<td>--from-path</td>
<td>The path to the database to copy from. It can be used to target databases</td>
</tr>
<tr>
<td></td>
<td>outside of the installation, e.g., backups.</td>
</tr>
<tr>
<td>--from-path-tx</td>
<td>The path to the transaction log files. Use if the command cannot determine</td>
</tr>
<tr>
<td></td>
<td>where they are located.</td>
</tr>
<tr>
<td>Option</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><code>--to-database</code></td>
<td>The destination database name.</td>
</tr>
<tr>
<td><code>--neo4j-home-directory=&lt;path&gt;</code></td>
<td>Path to the home directory for the copied database.</td>
</tr>
<tr>
<td></td>
<td>Default: The same as the database copied from.</td>
</tr>
<tr>
<td><code>--force</code></td>
<td>Force the command to proceed even if the integrity of the database can not be verified.</td>
</tr>
<tr>
<td><code>--compact-node-store</code></td>
<td>Enforce node store compaction.</td>
</tr>
<tr>
<td></td>
<td>By default, the node store is not compacted on copy since it changes the node IDs.</td>
</tr>
<tr>
<td><code>--to-format</code></td>
<td>Set the format for the new database.</td>
</tr>
<tr>
<td></td>
<td>Valid values are <code>same</code>, <code>standard</code>, <code>high_limit</code>, and <code>aligned</code>. The <code>high_limit</code> format is only available in Enterprise Edition. If you go from <code>high_limit</code> to <code>standard</code>, there is no validation that the data will fit.</td>
</tr>
<tr>
<td></td>
<td>Default: The format of the source database.</td>
</tr>
<tr>
<td><code>--delete-nodes-with-labels</code></td>
<td>A comma-separated list of labels.</td>
</tr>
<tr>
<td></td>
<td>All nodes that have ANY of the specified labels will be deleted. Any node matching any of the labels will be ignored during copy.</td>
</tr>
<tr>
<td><code>--keep-only-node-properties</code></td>
<td>A list of property keys to keep for nodes with the specified label.</td>
</tr>
<tr>
<td></td>
<td>Any labels not explicitly mentioned will keep their properties. Cannot be combined with <code>--skip-properties</code> or <code>--skip-node-properties</code>.</td>
</tr>
<tr>
<td><code>--keep-only-nodes-with-labels</code></td>
<td>A list of labels.</td>
</tr>
<tr>
<td></td>
<td>All nodes that have any of the specified labels will be kept. Cannot be combined with <code>--delete-nodes-with-labels</code>.</td>
</tr>
<tr>
<td>Option</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><code>--keep-only-relationship-properties</code></td>
<td>A list of property keys to keep for relationships with the specified type. Any relationship types not explicitly mentioned will keep their properties. Cannot be combined with <code>--skip-properties</code> or <code>--skip-relationship-properties</code>.</td>
</tr>
<tr>
<td><code>--skip-labels</code></td>
<td>A comma-separated list of labels to ignore during the copy.</td>
</tr>
<tr>
<td><code>--skip-node-properties</code></td>
<td>A list of property keys to ignore for nodes with the specified label. Cannot be combined with <code>--skip-properties</code> or <code>--keep-only-node-properties</code>.</td>
</tr>
<tr>
<td><code>--skip-properties</code></td>
<td>A comma-separated list of property keys to ignore during the copy. Cannot be combined with <code>--skip-node-properties</code>, <code>--keep-only-node-properties</code>, <code>--skip-relationship-properties</code>, and <code>--keep-only-relationship-properties</code>.</td>
</tr>
<tr>
<td><code>--skip-relationships</code></td>
<td>A comma-separated list of relationship types to ignore during the copy.</td>
</tr>
<tr>
<td><code>--skip-relationship-properties</code></td>
<td>A list of property keys to ignore for relationships with the specified type. Cannot be combined with <code>--skip-properties</code> or <code>--keep-only-relationship-properties</code>.</td>
</tr>
<tr>
<td><code>--from-pagecache</code></td>
<td>The size of the page cache to use for reading.</td>
</tr>
<tr>
<td><code>--to-pagecache</code></td>
<td>The size of the page cache to use for writing.</td>
</tr>
</tbody>
</table>

You can use the `--from-pagecache` and `--to-pagecache` options to speed up the copy operation by specifying how much cache to allocate when reading the source and writing the destination. As a rule of thumb, `--to-pagecache` should be around 1-2GB since it mostly does sequential writes. The `--from-pagecache` should then be assigned whatever memory you can spare since Neo4j does random reads from the source.
10.8.2. Examples

Example 65. Use `neo4j-admin copy` to copy the data store of the database `neo4j`.

1. Stop the database named `neo4j`:

   ```
   STOP DATABASE neo4j
   ```

2. Copy the data store from `neo4j` to a new database called `copy`:

   ```
   bin/neo4j-admin copy --from-database=neo4j --to-database=copy
   ```

3. Run the following command to verify that database has been successfully copied.

   ```
   ls -al ../data/databases
   ```

   Copying a database does not automatically create it. Therefore, it will not be visible if you do `SHOW DATABASES` at this point.

4. Create the copied database.

   ```
   CREATE DATABASE copy
   ```

5. Verify that the `copy` database is online.

   ```
   SHOW DATABASES
   ```

6. If your original database has a schema defined, change your active database to `copy` and recreate the schema using the `neo4j-admin copy` output.

   ```
   The console output is saved to logs/neo4j-admin-copy-<timestamp>.log.
   ```
Example 66. Use `neo4j-admin copy` to filter the data you want to copy.

The command can perform some basic forms of processing. You can filter the data that you want to copy by removing nodes, labels, properties, and relationships.

```
bin/neo4j-admin copy --from-database=neo4j --to-database=copy --delete-nodes-with-labels="Cat,Dog"
```

The command creates a copy of the database `neo4j` but without the nodes with the labels `:Cat` and `:Dog`.

Labels are processed independently, i.e., the filter deletes any node with a label `:Cat`, `:Dog`, or both.

For a detailed example of how to use `neo4j-admin copy` to filter out data for a Fabric installation, see [Sharding data with the copy command](#).

[12] The calculations are based on $\text{MB/s} = (\text{IOPS} \times B) \div 10^6$, where $B$ is the block size in bytes; in the case of Neo4j, this is 8000. GB/hour can then be calculated from $(\text{MB/s} \times 3600) \div 1000$.  

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Chapter 11. Authentication and authorization

This chapter describes authentication and authorization in Neo4j.

Ensure that your Neo4j deployment adheres to your company’s information security guidelines by setting up the appropriate authentication and authorization rules.

This section describes the following:

- Introduction
- Built-in roles
- Fine-grained access control
- Integration with LDAP directory services
- Integration with Single Sign-On (SSO) services
- Manage procedure and user-defined function permissions
- Terminology

The functionality described in this section is applicable to Enterprise Edition. A limited set of user management functions are also available in Community Edition. Native roles overview gives a quick overview of these.

11.1. Introduction

This section provides an overview of authentication and authorization in Neo4j.

Authentication is the process of ensuring that a user is who the user claims to be, while authorization pertains to checking whether the authenticated user is allowed to perform a certain action. Authorization is managed using role-based access control (RBAC). Permissions that define access control are assigned to roles, which are in turn assigned to users.

Neo4j has the following auth providers, that can perform user authentication and authorization:

Native auth provider

Neo4j provides a native auth provider that stores user and role information in the system database. The following parameters control this provider:
**dbms.security.auth_enabled** (Default: true) — Enable auth requirement to access Neo4j.

If you need to disable authentication, for example, to recover an admin user password or assign a user to the admin role, make sure you block all network connections during the recovery phase so users can connect to Neo4j only via localhost. For more information, see Password and user recovery.

**dbms.security.auth_lock_time** (Default: 5s) — The amount of time a user account is locked after a configured number of unsuccessful authentication attempts.

**dbms.security.auth_max_failed_attempts** (Default: 3) — The maximum number of unsuccessful authentication attempts before imposing a user lock for a configured amount of time.

When triggered, Neo4j logs an error containing a timestamp and the message failed to log in: too many failed attempts in the security.log.

The Cypher commands to manage users, roles, and permissions are described in detail in Cypher Manual → Administration. Various scenarios that illustrate the use of the native auth provider are available in Fine-grained access control.

**LDAP auth provider**

Another way of controlling authentication and authorization is through external security software such as Active Directory or OpenLDAP, which is accessed via the built-in LDAP connector. A description of the LDAP plugin using Active Directory is available in Integration with LDAP directory services.

**Single Sign-On provider**

Some clients wish to centrally manage authentication and authorization for their systems in an identity provider which provides single sign-on for their other systems. Neo4j supports the popular OpenID Connect mechanism for integrating with identity providers and configuration for that is described in Integration with Single Sign-On Services.

**Custom-built plugin auth providers**

For clients with specific requirements not satisfied with either native or LDAP, Neo4j provides a plugin option for building custom integrations. It is recommended that this option is used as part of a custom delivery as negotiated with Neo4j Professional Services. The plugin is described in Java Reference → Authentication and authorization plugins.

**Kerberos authentication and single sign-on**

In addition to LDAP, Native and custom providers, Neo4j supports Kerberos for authentication and single sign-on. Kerberos support is provided via the Neo4j Kerberos Add-On.

11.2. Built-in roles **Enterprise edition**

This section describes the roles that come pre-defined with Neo4j.

Neo4j provides built-in roles with default privileges. The built-in roles and the default privileges are:
PUBLIC
• Access to the home database.
• Allows executing procedures with the users own privileges.
• Allows executing user-defined functions with the users own privileges.

reader
• Access to all databases.
• Traverse and read on the data graph (all nodes, relationships, properties).

editor
• Access to all databases.
• Traverse, read, and write on the data graph.
• Write access limited to creating and changing existing property keys, node labels, and relationship types of the graph. In other words, the editor role cannot add to the schema but can only make changes to already existing objects.

publisher
• Access to all databases.
• Traverse, read, and write on the data graph.

architect
• Access to all databases.
• Traverse, read, and write on the data graph.
• Create/drop/show indexes and constraints along with any other future schema constructs.

admin
• Access to all databases.
• Traverse, read, and write on the data graph.
• Create/drop/show indexes and constraints along with any other future schema constructs.
• Allows executing procedures with the users own privileges or boosted privileges.
• Allows executing admin procedures.
• Allows executing user-defined functions with the users own privileges or boosted privileges.
• View/terminate queries.
• Manage databases, users, roles, and privileges.

All users will be assigned the PUBLIC role, which by default does not give any rights or capabilities regarding the data, not even read privileges. A user may have more than one assigned role, and the union of these determine what action(s) on the data may be undertaken by the user. For instance, a user assigned to the reader role will be able to execute procedures because all users are also assigned to the PUBLIC role, which enables that capability.

When an administrator suspends or deletes another user, the following rules apply:
• Administrators can suspend or delete any other user (including other administrators), but not themselves.
• The user will no longer be able to log back in (until re-activated by an administrator if suspended).
• There is no need to remove assigned roles from a user prior to deleting the user.

Deleting a user will not automatically terminate associated connections, sessions, transactions, or queries.

The set of actions on the data and database prescribed by each role are described below. The subset of the functionality which is available with Community Edition is also included:

Table 48: Native roles overview

<table>
<thead>
<tr>
<th>Action</th>
<th>reader</th>
<th>editor</th>
<th>publisher</th>
<th>architect</th>
<th>admin</th>
<th>PUBLIC</th>
<th>Available in Community Edition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change own password</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>View own details</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Read data</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Execute procedures</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Execute functions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Execute admin procedures</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>View own queries</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Terminate own queries</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Write/update/delete existing data</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Create new types of properties key</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Create new types of nodes labels</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Create new types of relationship types</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Create/drop/show index/constraint</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Create/delete user</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Action</td>
<td>reader</td>
<td>editor</td>
<td>publisher</td>
<td>architect</td>
<td>admin</td>
<td>PUBLIC</td>
<td>Available in Community Edition</td>
</tr>
<tr>
<td>--------------------------------------------------</td>
<td>--------</td>
<td>--------</td>
<td>-----------</td>
<td>-----------</td>
<td>-------</td>
<td>--------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>Change another user's name</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Change another user's password</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Change another user's home database</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suspend/activate user</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Create/drop roles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change role names</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Assign/remove role to/from user</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Create/drop/alter databases</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Start/stop databases</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Manage database access</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Access home database</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Access all databases</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>View all users</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>View all roles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>View all roles for a user</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>View all users for a role</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>View all queries</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>View all databases</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>View own privileges</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
11.3. Fine-grained access control [Enterprise edition]

Describes an example that illustrates various aspects of security and fine-grained access control.

11.3.1. The data model

Consider a healthcare database, as could be relevant in a medical clinic or hospital. A simple version of this might contain only three labels, representing three entity types:

(:Patient)

Nodes of this type represent patients that visit the clinic because they have some symptoms. Information specific to the patient can be captured in properties:

- name
- ssn
- address
- dateOfBirth

(:Symptom)

A medical database contains a catalog of known illnesses and associated symptoms, which can be described using properties:

- name
- description

(:Disease)

A medical database contains a catalog of known illnesses and associated symptoms, which can be
described using properties:

- name
- description

These entities will be modelled as nodes, and connected using relationships of the following types:

(:Patient)-[:HAS]→(:Symptom)

When a patient reports to the clinic, they will describe their symptoms to the nurse or the doctor. The nurse or doctor will then enter this information into the database in the form of connections between the patient node and a graph of known symptoms. Possible properties of interest on this relationship could be:

- date - date when symptom was reported

(:Symptom)-[:OF]→(:Disease)

The graph of known symptoms is part of a graph of diseases and their symptoms. The relationship between a symptom and a disease can include a probability factor for how likely or common it is for people with that disease to express that symptom. This will make it easier for the doctor to make a diagnosis using statistical queries.

- probability - probability of symptom matching disease

(:Patient)-[:DIAGNOSIS]→(:Disease)

The doctor can use the graph of diseases and their symptoms to perform an initial investigation into the most likely diseases to match the patient. Based on this, and their own assessment of the patient, they may make a diagnosis which they would persist to the graph through the addition of this relationship with appropriate properties:

- by: doctor's name
- date: date of diagnosis
- description: additional doctors' notes
The database would be used by a number of different user types, with different needs for access.

- **Doctors** who need to perform diagnosis on patients.
- **Nurses** who need to treat patients.
- **Receptionists** who need to identify and record patient information.
- **Researchers** who need to perform statistical analysis of medical data.
- **IT administrators** who need to administer the database, creating and assigning users.

### 11.3.2. Security

When building an application for a specific domain, it is common to model the different users within the application itself. However, when working with a database that provides rich user management with roles and privileges, it is possible to model these entirely within the database security model (for more information, see Cypher Manual → Access control). This results in separation of concerns for the access control to the data and the data itself. We will show two approaches to using Neo4j security features to support the healthcare database application. First, a simple approach using built-in roles, and then a more advanced approach using fine-grained privileges for sub-graph access control.

Our healthcare example involves five users of the database:

- Alice the doctor
- Daniel the nurse
- Bob the receptionist
- Charlie the researcher
- Tina the IT administrator

![Figure 13. Healthcare use case](image)
These users can be created using the `CREATE USER` command (from the `system` database):

**Example 67. Creating users**

```sql
CREATE USER charlie SET PASSWORD $secret1 CHANGE NOT REQUIRED;
CREATE USER alice SET PASSWORD $secret2 CHANGE NOT REQUIRED;
CREATE USER daniel SET PASSWORD $secret3 CHANGE NOT REQUIRED;
CREATE USER bob SET PASSWORD $secret4 CHANGE NOT REQUIRED;
CREATE USER tina SET PASSWORD $secret5 CHANGE NOT REQUIRED;
```

At this point the users have no ability to interact with the database, so we need to grant those capabilities using roles. There are two different ways of doing this, either by using the built-in roles, or through more fine-grained access control using privileges and custom roles.

### 11.3.3. Access control using built-in roles

Neo4j comes with a number of built-in roles that cover a number of common needs:

- **PUBLIC** - All users have this role, can by default access the home database and run all procedures and user-defined functions.
- **reader** - Can read data from all databases.
- **editor** - Can read and update all databases, but not expand the schema with new labels, relationship types or property names.
- **publisher** - Can read and edit, as well as add new labels, relationship types and property names.
- **architect** - Has all the capabilities of the publisher as well as the ability to manage indexes and constraints.
- **admin** - Can perform architect actions as well as manage databases, users, roles and privileges.

Charlie is a researcher and will not need write access to the database, and so he is assigned the `reader` role. Alice the doctor, Daniel the nurse and Bob the receptionist all need to update the database with new patient information, but do not need to expand the schema with new labels, relationship types, property names or indexes. We assign them all the `editor` role. Tina is the IT administrator that installs and manages the database. In order to create all other users, Tina is assigned the `admin` role.

**Example 68. Granting roles**

```sql
GRANT ROLE reader TO charlie;
GRANT ROLE editor TO alice;
GRANT ROLE editor TO daniel;
GRANT ROLE editor TO bob;
GRANT ROLE admin TO tina;
```

A limitation of this approach is that it does allow all users to see all data in the database, and in many real-world scenarios it would be preferable to restrict the users’ access. In this example, we would want to restrict the researcher from being able to read any of the patients’ personal information, and the receptionist should only be able to see the patient records and nothing more.
These, and more restrictions, could be coded into the application layer. However, it is possible and more secure to enforce these kinds of fine-grained restrictions directly within the Neo4j security model, by creating custom roles and assigning specific privileges to those roles.

Since we will be creating new custom roles, the first thing to do is revoke the current roles from the users:

Example 69. Revoking roles

```sql
REVOKE ROLE reader FROM charlie;
REVOKE ROLE editor FROM alice;
REVOKE ROLE editor FROM daniel;
REVOKE ROLE editor FROM bob;
REVOKE ROLE admin FROM tina;
```

Now the users are once again unable to do anything, and so we need to start over by building the set of new privileges based on a complete understanding of what we want each user to be able to do.

11.3.4. Sub-graph access control using privileges

With the concept of privileges, we can take much more control over what each user is capable of doing. We start by identifying each type of user:

**Doctor**

- Should be able to read and write most of the graph. We would, however, like to prevent the doctor from reading the patient’s address. We would also like to make sure the doctor can save diagnoses to the database, but not expand the schema of the database with new concepts.

**Receptionist**

- Should be able to read and write all patient data, but not be able to see the symptoms, diseases or diagnoses.

**Researcher**

- Should be able to perform statistical analysis on all data, except patients’ personal information, and as such should not be able to read most patient properties. To illustrate two different ways of setting up the same effective privileges, we will create two roles and compare them.

**Nurse**

- The nurse should be able to perform all tasks that both the doctor and the receptionist can do. At first one might be tempted to simply grant both those roles, but this does not work as expected. We will demonstrate why below, and instead create a dedicated `nurse` role.

**Junior nurse**

- The senior nurse above is able to save diagnoses just as a doctor can. However, we might wish to have nurses that are not allowed to make that update to the graph. While we could build another role from scratch, this could more easily be achieved by combining the `nurse` role with a new `disableDiagnoses` role that specifically restricts that activity.
IT administrator

This role is very similar to the built-in admin role, except that we wish to restrict access to the patients SSN, as well as prevent the administrator from performing the very critical action of saving a diagnosis, something specific to medical professionals. To achieve this, we can create this role by copying the built-in admin role and modifying the privileges of that copy.

User manager

It is possible that we would like the IT administrator to be less powerful than described above. We can create a new role from scratch, granting only the specific administrative capabilities we actually desire.

Before we create the new roles and assign them to Alice, Bob, Daniel, Charlie and Tina, we should define the privileges of each role. Since all users need ACCESS privilege to the healthcare database, we can add this to the PUBLIC role instead of all the individual roles:

```
GRANT ACCESS ON DATABASE healthcare TO PUBLIC;
```

Privileges of itadmin

This role can be created as a copy of the built-in admin role:

```
CREATE ROLE itadmin AS COPY OF admin;
```

Then all we need to do is deny the two specific actions this role is not supposed to do:

- Should not be able to read any patients social security number.
- Should not be able to perform medical diagnosis.

```
DENY READ {ssn} ON GRAPH healthcare NODES Patient TO itadmin;
DENY CREATE ON GRAPH healthcare RELATIONSHIPS DIAGNOSIS TO itadmin;
```

The complete set of privileges available to users assigned the itadmin role can be viewed using the following command:
SHOW ROLE itadmin PRIVILEGES AS COMMANDS;

+-------------------------------------------------------------------------+
| command                                                                 |
+-------------------------------------------------------------------------+
| "GRANT ACCESS ON DATABASE * TO `itadmin"                              |
| "GRANT MATCH (+) ON GRAPH * NODE * TO `itadmin"                        |
| "GRANT MATCH (+) ON GRAPH * RELATIONSHIP * TO `itadmin"               |
| "GRANT WRITE ON GRAPH * TO `itadmin"                                  |
| "GRANT INDEX MANAGEMENT ON DATABASE * TO `itadmin"                    |
| "GRANT CONSTRAINT MANAGEMENT ON DATABASE * TO `itadmin"               |
| "GRANT NAME MANAGEMENT ON DATABASE * TO `itadmin"                     |
| "GRANT START ON DATABASE * TO `itadmin"                                |
| "GRANT STOP ON DATABASE * TO `itadmin"                                 |
| "GRANT TRANSACTION MANAGEMENT (*) ON DATABASE * TO `itadmin"          |
| "GRANT ALL DBMS PRIVILEGES ON DBMS TO `itadmin"                        |
| "DENY CREATE ON GRAPH 'healthcare' NODE Patient TO `itadmin"          |
| "DENY READ {ssn} ON GRAPH `healthcare` NODE Patient TO `itadmin"       |
+-------------------------------------------------------------------------+

Priviliges that were granted or denied earlier can be revoked using the REVOKE command. See the Cypher Manual → The REVOKE command.

In order for the IT administrator tina to be provided these privileges, she must be assigned the new role itadmin.

neo4j@system> GRANT ROLE itadmin TO tina;

To demonstrate that Tina is not able to see the patients SSN, we can login to healthcare as tina and run the query:

MATCH (n:Patient) WHERE n.dateOfBirth < date('1972-06-12') RETURN n.name, n.ssn, n.address, n.dateOfBirth;

+--------------------------------------------------------------------+
<table>
<thead>
<tr>
<th>n.name</th>
<th>n.ssn</th>
<th>n.address</th>
<th>n.dateOfBirth</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Mary Stone&quot;</td>
<td>NULL</td>
<td>&quot;1 secret way, downtown&quot;</td>
<td>1970-01-15</td>
</tr>
<tr>
<td>&quot;Ally Anderson&quot;</td>
<td>NULL</td>
<td>&quot;1 secret way, downtown&quot;</td>
<td>1970-08-20</td>
</tr>
<tr>
<td>&quot;Sally Stone&quot;</td>
<td>NULL</td>
<td>&quot;1 secret way, downtown&quot;</td>
<td>1970-03-12</td>
</tr>
<tr>
<td>&quot;Jane Stone&quot;</td>
<td>NULL</td>
<td>&quot;1 secret way, downtown&quot;</td>
<td>1970-07-21</td>
</tr>
<tr>
<td>&quot;Ally Svensson&quot;</td>
<td>NULL</td>
<td>&quot;1 secret way, downtown&quot;</td>
<td>1971-08-15</td>
</tr>
<tr>
<td>&quot;Jane Svensson&quot;</td>
<td>NULL</td>
<td>&quot;1 secret way, downtown&quot;</td>
<td>1972-05-12</td>
</tr>
<tr>
<td>&quot;Ally Svensson&quot;</td>
<td>NULL</td>
<td>&quot;1 secret way, downtown&quot;</td>
<td>1971-07-30</td>
</tr>
</tbody>
</table>
+--------------------------------------------------------------------+

The results make it seem as if these nodes do not even have an ssn field. This is a key feature of the security model, that users cannot tell the difference between data that is not there, and data that is hidden using fine-grained read privileges.

Now remember that we also denied the administrator from saving diagnoses, because that is a critical medical function reserved for only doctors and senior medical staff. We can test this by trying to create
**DIAGNOSIS relationships:**

```
MATCH (n:Patient), (d:Disease)
CREATE (n)-[:DIAGNOSIS]->(d);
```

Create relationship with type 'DIAGNOSIS' is not allowed for user 'tina' with roles [PUBLIC, itadmin].

```
While restrictions on reading data do not result in errors and only make it appear as if
the data is not there, restrictions on updating, i.e. writing to the graph will produce an
appropriate error when the user attempts to perform an update they are not permitted to
do.
```

### Privileges of researcher

Charlie the researcher was previously our only read-only user. We could do something similar to what we
did with the *itadmin* role, by copying and modifying the *reader* role. However, we would like to explicitly
illustrate how to build a role from scratch. There are various possibilities for building this role using the
concepts of either granting or denying a list of privileges:

- **Denying privileges:**

  We could grant the role the ability to find all nodes and read all properties (much like the *reader* role)
  and then deny read access to the *Patient* properties we want to restrict the researcher from seeing,
such as *name*, *SSN* and *address*. This approach is simple but suffers from one problem. If *Patient* nodes
  are assigned additional properties, after we have restricted access, these new properties will
  automatically be visible to the researcher, which may not be desirable.

  **Example 70. Denying specific privileges**

  ```
  // First create the role
  CREATE ROLE researcherB;
  // Then grant access to everything
  GRANT MATCH (*)&
  ON GRAPH healthcare
  TO researcherB;
  // And deny read on specific node properties
  DENY READ {name, address, ssn}
  ON GRAPH healthcare
  NODES Patient
  TO researcherB;
  // And finally deny traversal of the doctors diagnosis
  DENY TRAVERSE
  ON GRAPH healthcare
  RELATIONSHIPS DIAGNOSIS
  TO researcherB;
  ```

- **Granting privileges:**

  An alternative is to only provide specific access to the properties we wish the researcher to see. Then,
  the addition of new properties will not automatically make them visible to the researcher. In this case,
  adding new properties to a *Patient* will not mean that the researcher can see them by default. If we
  wish to have them visible, we need to explicitly grant read access.
Example 71. Granting specific privileges

```sql
// Create the role first
CREATE ROLE researcherW

// We allow the researcher to find all nodes
GRANT TRAVERSE
    ON GRAPH healthcare
    NODES *
    TO researcherW;

// Now only allow the researcher to traverse specific relationships
GRANT TRAVERSE
    ON GRAPH healthcare
    RELATIONSHIPS HAS, OF
    TO researcherW;

// Allow reading of all properties of medical metadata
GRANT READ (*)
    ON GRAPH healthcare
    NODES Symptom, Disease
    TO researcherW;

// Allow reading of all properties of the disease-symptom relationship
GRANT READ (*)
    ON GRAPH healthcare
    RELATIONSHIPS OF
    TO researcherW;

// Only allow reading dateOfBirth for research purposes
GRANT READ {dateOfBirth}
    ON GRAPH healthcare
    NODES Patient
    TO researcherW;
```

In order to test that Charlie now has the privileges we have specified, we assign him to the researcherB role (with specifically denied privileges):

```sql
GRANT ROLE researcherB TO charlie;
```

We can use a version of the `SHOW PRIVILEGES` command to see Charlie's access rights, combining those from researcherB and PUBLIC:

```sql
neo4j@system> SHOW USER charlie PRIVILEGES AS COMMANDS;
```

```
+-----------------------------------------------------------------------+
| command                                                               |
+-----------------------------------------------------------------------+
| "GRANT ACCESS ON HOME DATABASE TO $role"                              |
| "GRANT ACCESS ON DATABASE 'healthcare' TO $role"                      |
| "GRANT EXECUTE PROCEDURE * ON DBMS TO $role"                          |
| "GRANT EXECUTE FUNCTION * ON DBMS TO $role"                           |
| "GRANT MATCH (*) ON GRAPH 'healthcare' NODE * TO $role"               |
| "GRANT MATCH (*) ON GRAPH 'healthcare' RELATIONSHIP * TO $role"        |
| "DENY TRAVERSE ON GRAPH 'healthcare' RELATIONSHIP DIAGNOSIS TO $role" |
| "DENY READ {address} ON GRAPH 'healthcare' NODE Patient TO $role"     |
| "DENY READ {name} ON GRAPH 'healthcare' NODE Patient TO $role"        |
| "DENY READ {ssn} ON GRAPH 'healthcare' NODE Patient TO $role"         |
+-----------------------------------------------------------------------+
```

Now when Charlie logs into the healthcare database and tries to run a command similar to the one used by the itadmin above, we will see different results:
MATCH (n:Patient)
WHERE n.dateOfBirth < date('1972-06-12')
RETURN n.name, n.ssn, n.address, n.dateOfBirth;

<table>
<thead>
<tr>
<th>n.name</th>
<th>n.ssn</th>
<th>n.address</th>
<th>n.dateOfBirth</th>
</tr>
</thead>
<tbody>
<tr>
<td>NULL</td>
<td>NULL</td>
<td>NULL</td>
<td>1971-05-31</td>
</tr>
<tr>
<td>NULL</td>
<td>NULL</td>
<td>NULL</td>
<td>1971-04-17</td>
</tr>
<tr>
<td>NULL</td>
<td>NULL</td>
<td>NULL</td>
<td>1971-12-27</td>
</tr>
<tr>
<td>NULL</td>
<td>NULL</td>
<td>NULL</td>
<td>1970-02-13</td>
</tr>
<tr>
<td>NULL</td>
<td>NULL</td>
<td>NULL</td>
<td>1971-02-04</td>
</tr>
<tr>
<td>NULL</td>
<td>NULL</td>
<td>NULL</td>
<td>1971-05-10</td>
</tr>
<tr>
<td>NULL</td>
<td>NULL</td>
<td>NULL</td>
<td>1971-02-21</td>
</tr>
</tbody>
</table>

Only the date of birth is available, so Charlie the researcher may perform statistical analysis, for example. Another query Charlie could try is to find the ten diseases a patient younger than 25 is most likely to be diagnosed with, listed by probability:

WITH datetime() - duration({years:25}) AS timelimit
MATCH (n:Patient)
WHERE n.dateOfBirth > date(timeLimit)
MATCH (n)-[h:HAS]->(s:Symptom)<-[o:OF]-(d:Disease)
WITH d.name AS disease, o.probability AS prob
RETURN disease, sum(prob) AS score ORDER BY score DESC LIMIT 10;

<table>
<thead>
<tr>
<th>disease</th>
<th>score</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Acute Argitis&quot;</td>
<td>95.0595287286318</td>
</tr>
<tr>
<td>&quot;Chronic Someitis&quot;</td>
<td>88.7220337139605</td>
</tr>
<tr>
<td>&quot;Chronic Placeboitis&quot;</td>
<td>88.43609533058974</td>
</tr>
<tr>
<td>&quot;Acute Whatitis&quot;</td>
<td>83.23493746472457</td>
</tr>
<tr>
<td>&quot;Acute Otheritis&quot;</td>
<td>82.46129768949129</td>
</tr>
<tr>
<td>&quot;Chronic Otheritis&quot;</td>
<td>82.0365063794025</td>
</tr>
<tr>
<td>&quot;Acute Placeboitis&quot;</td>
<td>77.34207326583929</td>
</tr>
<tr>
<td>&quot;Acute Yellowitis&quot;</td>
<td>76.43519967463832</td>
</tr>
<tr>
<td>&quot;Chronic Whatitis&quot;</td>
<td>73.7396870128234</td>
</tr>
<tr>
<td>&quot;Chronic Yellowitis&quot;</td>
<td>71.58791287376775</td>
</tr>
</tbody>
</table>

Now if we revoke the researcherB and instead grant the researcherW role to Charlie, and re-run these queries, we will see the same results.

Privileges that were granted or denied earlier can be revoked using the REVOKE command. See the Cypher Manual → The REVOKE command.

Privileges of doctor

Doctors should be given the ability to read and write almost everything. We would, however, like to remove the ability to read the patients' address property. This role can be built from scratch by assigning full read and write access, and then specifically denying access to the address property:
CREATE ROLE doctor;
GRANT TRAVERSE ON GRAPH healthcare TO doctor;
GRANT READ (*) ON GRAPH healthcare TO doctor;
GRANT WRITE ON GRAPH healthcare TO doctor;
DENY READ (address) ON GRAPH healthcare NODES Patient TO doctor;
DENY SET PROPERTY (address) ON GRAPH healthcare NODES Patient TO doctor;

To allow Alice to have these privileges, we grant her this new role:

```sql
neo4j@system> GRANT ROLE doctor TO alice;
```

To demonstrate that Alice is not able to see patient addresses, we log in as alice to healthcare and run the query:

```sql
MATCH (n:Patient)
WHERE n.dateOfBirth < date('1972-06-12')
RETURN n.name, n.ssn, n.address, n.dateOfBirth;
```

<table>
<thead>
<tr>
<th>n.name</th>
<th>n.ssn</th>
<th>n.address</th>
<th>n.dateOfBirth</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Jack Anderson&quot;</td>
<td>1234647</td>
<td>NULL</td>
<td>1970-07-23</td>
</tr>
<tr>
<td>&quot;Joe Svensson&quot;</td>
<td>1234659</td>
<td>NULL</td>
<td>1972-06-07</td>
</tr>
<tr>
<td>&quot;Mary Jackson&quot;</td>
<td>1234568</td>
<td>NULL</td>
<td>1971-10-19</td>
</tr>
<tr>
<td>&quot;Jack Jackson&quot;</td>
<td>1234503</td>
<td>NULL</td>
<td>1971-05-04</td>
</tr>
<tr>
<td>&quot;Ally Smith&quot;</td>
<td>1234590</td>
<td>NULL</td>
<td>1971-12-07</td>
</tr>
<tr>
<td>&quot;Ally Stone&quot;</td>
<td>1234606</td>
<td>NULL</td>
<td>1970-03-29</td>
</tr>
<tr>
<td>&quot;Mark Smith&quot;</td>
<td>1234610</td>
<td>NULL</td>
<td>1971-03-30</td>
</tr>
</tbody>
</table>

As we can see, the doctor has the expected privileges, including being able to see the SSN, but not the address of each patient.

The doctor is also able to see all other node types:

```sql
MATCH (n) WITH labels(n) AS labels
RETURN labels, count(*);
```

<table>
<thead>
<tr>
<th>labels</th>
<th>count(*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>[&quot;Patient&quot;]</td>
<td>101</td>
</tr>
<tr>
<td>[&quot;Symptom&quot;]</td>
<td>10</td>
</tr>
<tr>
<td>[&quot;Disease&quot;]</td>
<td>12</td>
</tr>
</tbody>
</table>

In addition, the doctor can traverse the graph, finding symptoms and diseases connected to patients:

```sql
MATCH (n:Patient)-[:HAS]->(s:Symptom)-[:OF]->(d:Disease)
WHERE n.ssn = 1234657
RETURN n.name, d.name, count(s) AS score ORDER BY score DESC;
```
The resulting table shows which are the most likely diagnoses based on symptoms. The doctor can use this table to facilitate further questioning and testing of the patient in order to decide on the final diagnosis.

<table>
<thead>
<tr>
<th>n.name</th>
<th>d.name</th>
<th>score</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Sally Anderson&quot;</td>
<td>&quot;Chronic Otheritis&quot;</td>
<td>4</td>
</tr>
<tr>
<td>&quot;Sally Anderson&quot;</td>
<td>&quot;Chronic Yellowitis&quot;</td>
<td>3</td>
</tr>
<tr>
<td>&quot;Sally Anderson&quot;</td>
<td>&quot;Chronic Placeboitis&quot;</td>
<td>3</td>
</tr>
<tr>
<td>&quot;Sally Anderson&quot;</td>
<td>&quot;Acute Whatitis&quot;</td>
<td>2</td>
</tr>
<tr>
<td>&quot;Sally Anderson&quot;</td>
<td>&quot;Acute Yellowitis&quot;</td>
<td>2</td>
</tr>
<tr>
<td>&quot;Sally Anderson&quot;</td>
<td>&quot;Chronic Someitis&quot;</td>
<td>2</td>
</tr>
<tr>
<td>&quot;Sally Anderson&quot;</td>
<td>&quot;Chronic Argitis&quot;</td>
<td>2</td>
</tr>
<tr>
<td>&quot;Sally Anderson&quot;</td>
<td>&quot;Chronic Whatitis&quot;</td>
<td>2</td>
</tr>
<tr>
<td>&quot;Sally Anderson&quot;</td>
<td>&quot;Acute Someitis&quot;</td>
<td>1</td>
</tr>
<tr>
<td>&quot;Sally Anderson&quot;</td>
<td>&quot;Acute Argitis&quot;</td>
<td>1</td>
</tr>
<tr>
<td>&quot;Sally Anderson&quot;</td>
<td>&quot;Acute Otheritis&quot;</td>
<td>1</td>
</tr>
</tbody>
</table>

Once the doctor has investigated further, they would be able to decide on the diagnosis and save that result to the database:

```sql
WITH
datetime((epochmillis:timestamp()) AS now
WITH now, date(now) as today
MATCH (p:Patient)
  WHERE p.ssn = 1234657
MATCH (d:Disease)
  WHERE d.name = "Chronic Placeboitis"
MERGE (p)-[:DIAGNOSIS {by: 'Alice'}]->(d)
  ON CREATE SET i.created_at = now, i.updated_at = now, i.date = today
  ON MATCH SET i.updated_at = now
RETURN p.name, d.name, i.by, i.date, duration.between(i.created_at, i.updated_at) AS updated;
```

This allows this doctor to record their diagnosis as well as take note of previous diagnoses:

<table>
<thead>
<tr>
<th>p.name</th>
<th>d.name</th>
<th>i.by</th>
<th>i.date</th>
<th>updated</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Sally Anderson&quot;</td>
<td>&quot;Chronic Placeboitis&quot;</td>
<td>&quot;Alice&quot;</td>
<td>2020-05-29</td>
<td>P0MDT213.076000000S</td>
</tr>
</tbody>
</table>

In order to create the `DIAGNOSIS` relationship for the first time, it is required to have the privilege to create new types. This is also true of the property names `doctor`, `created_at` and `updated_at`. This can be fixed by either granting the doctor `NAME MANAGEMENT` privileges or by pre-creating the missing types. The latter would be more precise and can be achieved by running, as an administrator, the procedures `db.createRelationshipType` and `db.createProperty` with appropriate arguments.

**Privileges of receptionist**

Receptionists should only be able to manage patient information. They are not allowed to find or read any other parts of the graph. In addition, they should be able to create and delete patients, but not any other nodes:
CREATE ROLE receptionist;
GRANT MATCH (**) ON GRAPH healthcare NODES Patient TO receptionist;
GRANT CREATE ON GRAPH healthcare NODES Patient TO receptionist;
GRANT DELETE ON GRAPH healthcare NODES Patient TO receptionist;
GRANT SET PROPERTY (**) ON GRAPH healthcare NODES Patient TO receptionist;

It would have been simpler to grant global WRITE privileges. However, this would have the unfortunate side effect of allowing the receptionist the ability to create other nodes, like new Symptom nodes, even though they would subsequently be unable to find or read those same nodes. While there are use cases for being able to create data you cannot read, that is not desired for this model.

With these privileges, if Bob tries to read the entire database, he will still only see the patients:

MATCH (n) WITH labels(n) AS labels
RETURN labels, count(*);

+------------------------+
| labels      | count(*) |
|------------------------|
| ["Patient"] | 101      |
+------------------------+

However, Bob is able to see all fields of the Patient records:

MATCH (n:Patient)
WHERE n.dateOfBirth < date('1972-06-12')
RETURN n.name, n.ssn, n.address, n.dateOfBirth;

+----------------------------------------------------------------------+
<table>
<thead>
<tr>
<th>n.name</th>
<th>n.ssn</th>
<th>n.address</th>
<th>n.dateOfBirth</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Mark Stone&quot;</td>
<td>1234666</td>
<td>&quot;1 secret way, downtown&quot;</td>
<td>1970-08-04</td>
</tr>
<tr>
<td>&quot;Sally Jackson&quot;</td>
<td>1234633</td>
<td>&quot;1 secret way, downtown&quot;</td>
<td>1970-10-21</td>
</tr>
<tr>
<td>&quot;Bob Stone&quot;</td>
<td>1234581</td>
<td>&quot;1 secret way, downtown&quot;</td>
<td>1972-02-16</td>
</tr>
<tr>
<td>&quot;Ally Anderson&quot;</td>
<td>1234582</td>
<td>&quot;1 secret way, downtown&quot;</td>
<td>1970-05-13</td>
</tr>
<tr>
<td>&quot;Mark Svensson&quot;</td>
<td>1234594</td>
<td>&quot;1 secret way, downtown&quot;</td>
<td>1970-01-16</td>
</tr>
<tr>
<td>&quot;Bob Anderson&quot;</td>
<td>1234597</td>
<td>&quot;1 secret way, downtown&quot;</td>
<td>1970-09-23</td>
</tr>
<tr>
<td>&quot;Jack Svensson&quot;</td>
<td>1234599</td>
<td>&quot;1 secret way, downtown&quot;</td>
<td>1971-02-13</td>
</tr>
<tr>
<td>&quot;Mark Jackson&quot;</td>
<td>1234618</td>
<td>&quot;1 secret way, downtown&quot;</td>
<td>1970-03-28</td>
</tr>
<tr>
<td>&quot;Jack Jackson&quot;</td>
<td>1234623</td>
<td>&quot;1 secret way, downtown&quot;</td>
<td>1971-04-02</td>
</tr>
</tbody>
</table>
+----------------------------------------------------------------------+

We have granted Bob the receptionist the ability to delete patient nodes. This will allow him to delete any new patients he has just created, but will not allow him the ability to delete patients that have already received diagnoses, because those are connected to parts of the graph the receptionist cannot see. Let's demonstrate both these scenarios:
CREATE (n:Patient {
  ssn: 87654321,
  name: 'Another Patient',
  email: 'another@example.com',
  address: '1 secret way, downtown',
  dateOfBirth: date('2001-01-20')
})
RETURN n.name, n.dateOfBirth;

<table>
<thead>
<tr>
<th>n.name</th>
<th>n.dateOfBirth</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Another Patient&quot;</td>
<td>2001-01-20</td>
</tr>
</tbody>
</table>

The receptionist is able to modify any patient record:

MATCH (n:Patient)
WHERE n.ssn = 87654321
SET n.address = '2 streets down, uptown'
RETURN n.name, n.dateOfBirth, n.address;

<table>
<thead>
<tr>
<th>n.name</th>
<th>n.dateOfBirth</th>
<th>n.address</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Another Patient&quot;</td>
<td>2001-01-20</td>
<td>&quot;2 streets down, uptown&quot;</td>
</tr>
</tbody>
</table>

The receptionist is also able to delete this recently created patient because it is not connected to any other records:

MATCH (n:Patient)
WHERE n.ssn = 87654321
DETACH DELETE n;

However, if the receptionist attempts to delete a patient that has existing diagnoses, this will fail:

MATCH (n:Patient)
WHERE n.ssn = 1234610
DETACH DELETE n;

org.neo4j.graphdb.ConstraintViolationException: Cannot delete node<42>, because it still has relationships. To delete this node, you must first delete its relationships.

The reason this fails is that Bob can find the (:Patient) node, but does not have sufficient traverse rights to find nor delete the outgoing relationships from it. Either he needs to ask Tina the itadmin for help for this task, or we can add more privileges to the receptionist role:

GRANT TRAVERSE ON GRAPH healthcare NODES Symptom, Disease TO receptionist;
GRANT TRAVERSE ON GRAPH healthcare RELATIONSHIPS HAS, DIAGNOSIS TO receptionist;
GRANT DELETE ON GRAPH healthcare RELATIONSHIPS HAS, DIAGNOSIS TO receptionist;
Privileges of nurses

As previously described, nurses have the capabilities of both doctors and receptionists. As such it would be tempting to assign them both the doctor and the receptionist roles. However, this might not have the effect you would expect. If those two roles were created with GRANT privileges only, combining them would be simply cumulative. But it turns out the doctor contains some DENY privileges, and these always overrule GRANT. This means that the nurse will still have the same restrictions as a doctor, which is not what we wanted.

To demonstrate this, let's give it a try:

```
neo4j@system> GRANT ROLE doctor, receptionist TO daniel;
```

Now we can see that the user 'Daniel' has a combined set of privileges:

```
SHOW USER daniel PRIVILEGES AS COMMANDS;
```

```
+--------------------------------------------------+
| command                                                                                       |
| "GRANT ACCESS ON HOME DATABASE TO $role"                                                      |
| "GRANT ACCESS ON DATABASE 'healthcare' TO $role"                                              |
| "GRANT EXECUTE PROCEDURE * ON DBMS TO $role"                                                  |
| "GRANT EXECUTE FUNCTION * ON DBMS TO $role"                                                   |
| "GRANT TRAVERSE ON GRAPH 'healthcare' NODE * TO $role"                                        |
| "GRANT TRAVERSE ON GRAPH 'healthcare' RELATIONSHIP * TO $role"                                |
| "GRANT READ (*) ON GRAPH 'healthcare' NODE * TO $role"                                       |
| "GRANT READ (*) ON GRAPH 'healthcare' RELATIONSHIP * TO $role"                                |
| "GRANT MATCH (*) ON GRAPH 'healthcare' NODE Patient TO $role"                                |
| "GRANT WRITE ON GRAPH 'healthcare' TO $role"                                                  |
| "GRANT SET PROPERTY (*) ON GRAPH 'healthcare' NODE Patient TO $role"                         |
| "GRANT CREATE ON GRAPH 'healthcare' NODE Patient TO $role"                                   |
| "GRANT DELETE ON GRAPH 'healthcare' NODE Patient TO $role"                                   |
| "DENY READ {address} ON GRAPH 'healthcare' NODE Patient TO $role"                            |
| "DENY SET PROPERTY {address} ON GRAPH 'healthcare' NODE Patient TO $role"                    |
+--------------------------------------------------+
```

Now the intention is that a nurse can perform the actions of a receptionist. This would mean they should be able to read and write the address field of the Patient nodes.

```
MATCH (n:Patient)
WHERE n.dateOfBirth < date('1972-06-12')
RETURN n.name, n.ssn, n.address, n.dateOfBirth;
```
Clearly the address field is invisible. This is due to the DENIED privileges we could see in the table earlier. If we tried to write to the address field we would receive an error. This is not the intended behavior. We have two choices to correct otherwise:

- We could redefine the doctor role with only grants, requiring that we define each Patient property we wish the doctor to be able to read.
- We can redefine the nurse role with the actual intended behavior.

It turns out that the latter choice is by far the simplest. The nurse is essentially the doctor without the address restrictions:

```
CREATE ROLE nurse
GRANT TRAVERSE ON GRAPH healthcare TO nurse;
GRANT READ { * } ON GRAPH healthcare TO nurse;
GRANT WRITE ON GRAPH healthcare TO nurse;
```

Now let’s assign this role to Daniel and test the new behavior:

```
REVOKE ROLE doctor FROM daniel;
REVOKE ROLE receptionist FROM daniel;
GRANT ROLE nurse TO daniel;
```

When the improved nurse Daniel takes another look at the patient records, he will see the address fields:

```
MATCH (n:Patient)
WHERE n.dateOfBirth < date('1972-06-12')
RETURN n.name, n.ssn, n.address, n.dateOfBirth;
```

Now Daniel can see the previously hidden address field. The other main action we want the nurse to be
able to perform, is the primary doctor action of saving a diagnosis to the database:

```
WITH date(datetime({epochmillis:timestamp()}) AS today
MATCH (p:Patient)
  WHERE p.ssn = 1234657
MATCH (d:Disease)
  WHERE d.name = "Chronic Placeboitis"
MERGE (p)-[:DIAGNOSIS {by: 'Daniel'}]->(d)
  ON CREATE SET i.date = today
RETURN p.name, d.name, i.by, i.date;
```

Performing an action otherwise reserved for the doctor role involves more responsibility for the nurse. Perhaps it is not desirable to entrust all nurses with this option, which is why we can divide the nurses into senior and junior nurses. Daniel is currently a senior nurse.

Privileges of junior nurses

When we tried to create the senior nurse by combining the doctor and receptionist roles, that did not work out. As previously mentioned, it would work to combine two roles if the intention is to increase capabilities and the roles were created with GRANT privileges only. It is also possible to combine two roles if the intention is to reduce capabilities and the combination brings in DENY privileges.

Consider this case, we would like a junior nurse to be able to perform the same actions as a senior nurse, but not be able to save diagnoses. We could create a special role that contains specifically only the additional restrictions:

```
CREATE ROLE disableDiagnoses;
DENY CREATE ON GRAPH healthcare RELATIONSHIPS DIAGNOSIS TO disableDiagnoses;
```

Now let's assign this role to Daniel and test the new behaviour:

```
GRANT ROLE disableDiagnoses TO daniel;
```

If we look at what privileges Daniel now has, it will be the combination of the two roles nurse and disableDiagnoses:
.neo4j> SHOW USER daniel PRIVILEGES AS COMMANDS;

+---------------------------------------------------------------------+
| command                                                             |
+---------------------------------------------------------------------+
| "GRANT ACCESS ON HOME DATABASE TO $role"                            |
| "GRANT ACCESS ON DATABASE 'healthcare' TO $role"                   |
| "GRANT EXECUTE PROCEDURE * ON DBMS TO $role"                       |
| "GRANT EXECUTE FUNCTION * ON DBMS TO $role"                        |
| "GRANT TRAVERSE ON GRAPH 'healthcare' NODE * TO $role"             |
| "GRANT TRAVERSE ON GRAPH 'healthcare' RELATIONSHIP * TO $role"      |
| "GRANT READ {*} ON GRAPH 'healthcare' NODE * TO $role"             |
| "GRANT READ {*} ON GRAPH 'healthcare' RELATIONSHIP * TO $role"      |
| "GRANT WRITE ON GRAPH 'healthcare' TO $role"                       |
| "DENY CREATE ON GRAPH 'healthcare' RELATIONSHIP DIAGNOSIS TO $role" |
+---------------------------------------------------------------------+

Daniel can still see address fields, and can even perform the diagnosis investigation that the doctor can perform:

MATCH (n:Patient)-[:HAS]->(s:Symptom)-[:OF]->(d:Disease)
WHERE n.ssn = 1234650
RETURN n.ssn, n.name, d.name, count(s) AS score ORDER BY score DESC;

<table>
<thead>
<tr>
<th>n.ssn</th>
<th>n.name</th>
<th>d.name</th>
<th>score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1234650</td>
<td>&quot;Mark Smith&quot;</td>
<td>&quot;Chronic Whatitis&quot;</td>
<td>3</td>
</tr>
<tr>
<td>1234650</td>
<td>&quot;Mark Smith&quot;</td>
<td>&quot;Chronic Someitis&quot;</td>
<td>3</td>
</tr>
<tr>
<td>1234650</td>
<td>&quot;Mark Smith&quot;</td>
<td>&quot;Acute Someitis&quot;</td>
<td>2</td>
</tr>
<tr>
<td>1234650</td>
<td>&quot;Mark Smith&quot;</td>
<td>&quot;Chronic Otheritis&quot;</td>
<td>2</td>
</tr>
<tr>
<td>1234650</td>
<td>&quot;Mark Smith&quot;</td>
<td>&quot;Chronic Yellowitis&quot;</td>
<td>2</td>
</tr>
<tr>
<td>1234650</td>
<td>&quot;Mark Smith&quot;</td>
<td>&quot;Chronic Placeboitis&quot;</td>
<td>2</td>
</tr>
<tr>
<td>1234650</td>
<td>&quot;Mark Smith&quot;</td>
<td>&quot;Acute Otheritis&quot;</td>
<td>2</td>
</tr>
<tr>
<td>1234650</td>
<td>&quot;Mark Smith&quot;</td>
<td>&quot;Chronic Argitis&quot;</td>
<td>2</td>
</tr>
<tr>
<td>1234650</td>
<td>&quot;Mark Smith&quot;</td>
<td>&quot;Acute Placeboitis&quot;</td>
<td>2</td>
</tr>
<tr>
<td>1234650</td>
<td>&quot;Mark Smith&quot;</td>
<td>&quot;Acute Yellowitis&quot;</td>
<td>1</td>
</tr>
<tr>
<td>1234650</td>
<td>&quot;Mark Smith&quot;</td>
<td>&quot;Acute Argitis&quot;</td>
<td>1</td>
</tr>
<tr>
<td>1234650</td>
<td>&quot;Mark Smith&quot;</td>
<td>&quot;Acute Whatitis&quot;</td>
<td>1</td>
</tr>
</tbody>
</table>

But when he tries to save a diagnosis to the database, he will be denied:

WITH date(datetime({epochmillis:timestamp()})) AS today
MATCH (p:Patient)
WHERE p.ssn = 1234650
MATCH (d:Disease)
WHERE d.name = "Chronic Placeboitis"
MERGE (p)-[i:DIAGNOSIS {by: 'Daniel'}]->(d)
ON CREATE SET i.date = today
RETURN p.name, d.name, i.by, i.date;

Create relationship with type 'DIAGNOSIS' is not allowed for user 'daniel' with roles [PUBLIC, disableDiagnoses, nurse].

Promoting Daniel back to senior nurse will be as simple as revoking the role that introduced the restriction:
Building a custom administrator role

Originally we created the itadmin role by copying the built-in admin role and adding restrictions. However, we have also shown cases where having denys can be less convenient than only having grants. So can we instead build the administrator role from the ground up?

Let’s review the purpose of this role. The intention is that Tina, the administrator, can create new users and assign them to the product roles. We can create a new role called userManager and grant it the appropriate privileges:

```
CREATE ROLE userManager;
GRANT USER MANAGEMENT ON DBMS TO userManager;
GRANT ROLE MANAGEMENT ON DBMS TO userManager;
GRANT SHOW PRIVILEGE ON DBMS TO userManager;
```

We need to revoke the itadmin role from Tina and grant her the userManager role instead:

```
REVOKE ROLE itadmin FROM tina;
GRANT ROLE userManager TO tina
```

The three privileges we’ve granted will allow:

- **USER MANAGEMENT** allows creating, updating and dropping users
- **ROLE MANAGEMENT** allows creating, updating, and dropping roles as well as assigning roles to users
- **SHOW PRIVILEGE** allows listing the users privileges

Listing Tina’s new privileges should show a much shorter list than when she was a more powerful administrator:

```
neo4j@system> SHOW USER tina PRIVILEGES AS COMMANDS;
+--------------------------------------------------+
<table>
<thead>
<tr>
<th>command</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;GRANT ACCESS ON HOME DATABASE TO $role&quot;</td>
</tr>
<tr>
<td>&quot;GRANT ACCESS ON DATABASE 'healthcare' TO $role&quot;</td>
</tr>
<tr>
<td>&quot;GRANT EXECUTE PROCEDURE * ON DBMS TO $role&quot;</td>
</tr>
<tr>
<td>&quot;GRANT EXECUTE FUNCTION * ON DBMS TO $role&quot;</td>
</tr>
<tr>
<td>&quot;GRANT ROLE MANAGEMENT ON DBMS TO $role&quot;</td>
</tr>
<tr>
<td>&quot;GRANT USER MANAGEMENT ON DBMS TO $role&quot;</td>
</tr>
<tr>
<td>&quot;GRANT SHOW PRIVILEGE ON DBMS TO $role&quot;</td>
</tr>
</tbody>
</table>
+--------------------------------------------------+
```
We have not granted any other privilege management privileges. How much power this role should have would depend on the requirements of the system. Refer to the section Cypher Manual → The admin role for a complete list of privileges to consider.

Now Tina should be able to create new users and assign them to roles:

```
CREATE USER sally SET PASSWORD 'secret' CHANGE REQUIRED;
GRANT ROLE receptionist TO sally;
SHOW USER sally PRIVILEGES AS COMMANDS;
```

<table>
<thead>
<tr>
<th>command</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;GRANT ACCESS ON HOME DATABASE TO $role&quot;</td>
</tr>
<tr>
<td>&quot;GRANT ACCESS ON DATABASE 'healthcare' TO $role&quot;</td>
</tr>
<tr>
<td>&quot;GRANT EXECUTE PROCEDURE * ON DBMS TO $role&quot;</td>
</tr>
<tr>
<td>&quot;GRANT EXECUTE FUNCTION * ON DBMS TO $role&quot;</td>
</tr>
<tr>
<td>&quot;GRANT MATCH (*) ON GRAPH 'healthcare' NODE Patient TO $role&quot;</td>
</tr>
<tr>
<td>&quot;GRANT SET PROPERTY {*} ON GRAPH 'healthcare' NODE Patient TO $role&quot;</td>
</tr>
<tr>
<td>&quot;GRANT CREATE ON GRAPH 'healthcare' NODE Patient TO $role&quot;</td>
</tr>
<tr>
<td>&quot;GRANT DELETE ON GRAPH 'healthcare' NODE Patient TO $role&quot;</td>
</tr>
</tbody>
</table>

11.4. Integration with LDAP directory services

This section describes Neo4j support for integrating with LDAP systems.

- Introduction
- LDAP configuration parameters
- Set Neo4j to use LDAP
- Map the LDAP groups to the Neo4j roles
- Configure Neo4j to use Active Directory
  - Configure Neo4j to support LDAP user ID authentication
  - Configure Neo4j to support attribute authentication
  - Configure Neo4j to support sAMAccountName authentication by setting user_dn_template
- Configure Neo4j to use OpenLDAP
- Verify the LDAP configuration
- The auth cache
- Available methods of encryption
  - Use LDAP with encryption via StartTLS
  - Use LDAP with encrypted LDAPS
11.4.1. Introduction

Neo4j supports LDAP, which allows for integration with Active Directory (AD), OpenLDAP, or other LDAP-compatible authentication services. This means that you use the LDAP service for managing federated users, while the native Neo4j user and role administration are completely turned off.

The following configuration settings are important to consider when configuring LDAP. For a more detailed overview of the LDAP configuration options, see Configuration settings.

11.4.2. LDAP dynamic configuration settings

The following configuration settings can be updated while the database is running, see Dynamic settings. Altering any of these settings clears the authentication and authorization cache.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>dbms.security.ldap.authentication.user_dn_template</code></td>
<td><code>uid={0},ou=users,dc=example,dc=com</code></td>
<td>Convert usernames into LDAP-specific fully qualified names required for logging in.</td>
</tr>
<tr>
<td><code>dbms.security.ldap.authorization.user_search_base</code></td>
<td><code>ou=users,dc=example,dc=com</code></td>
<td>Set the base object or named context to search for user objects.</td>
</tr>
<tr>
<td><code>dbms.security.ldap.authorization.user_search_filter</code></td>
<td><code>(&amp;(objectClass=*)(uid={0}))</code></td>
<td>Set an LDAP search filter for a user principal.</td>
</tr>
<tr>
<td><code>dbms.security.ldap.authorization.group_membership_attributes</code></td>
<td><code>memberOf</code></td>
<td>List attribute names on a user object that contains groups to be used for mapping to roles. Common values: <code>memberOf</code> and <code>gidNumber</code>.</td>
</tr>
<tr>
<td><code>dbms.security.ldap.authorization.to_role_mapping</code></td>
<td></td>
<td>List an authorization mapping from groups to the pre-defined built-in roles <code>admin</code>, <code>architect</code>, <code>publisher</code>, <code>editor</code>, and <code>reader</code>, or to any other custom-defined roles.</td>
</tr>
<tr>
<td><code>dbms.security.ldap.authentication.attribute</code></td>
<td><code>samaccountname</code></td>
<td>Set the attribute to search for users with a system account.</td>
</tr>
<tr>
<td><code>dbms.security.ldap.authorization.access_permitted_group</code></td>
<td></td>
<td>Set an LDAP group of users with access rights. Users passing authentication are mapped to at least the <code>PUBLIC</code> role in addition to any roles assigned by the <code>group to role mapping</code> and have access to the database that those roles provide. If this attribute is set, users not part of this LDAP group will fail authentication, even if their credentials are correct.</td>
</tr>
</tbody>
</table>

All settings are defined at server startup time in the default configuration file `neo4j.conf` or can be modified at runtime using `dbms.setConfigValue()`.

• Use a self-signed certificate (SSL) in a test environment
11.4.3. Set Neo4j to use LDAP

First, you configure Neo4j to use LDAP as an authentication and authorization provider.

1. Uncomment the setting `dbms.security.auth_enabled=false` and change its value to `true` to turn on the security feature.

2. Uncomment the settings `dbms.security.authentication_providers` and `dbms.security.authorization_providers` and change their value to `ldap`. This way, the LDAP connector is used as a security provider for both authentication and authorization.

11.4.4. Map the LDAP groups to the Neo4j roles

To access the user and role management procedures, you have to map the LDAP groups to the Neo4j built-in and custom-defined roles. To do that, you need to know what privileges the Neo4j roles have, and based on these privileges, to create the mapping to the groups defined in the LDAP server. The map must be formatted as a semicolon separated list of key-value pairs, where the key is a comma-separated list of the LDAP group names and the value is a comma-separated list of the corresponding role names. For example, `group1=role1;group2=role2;group3=role3,role4,role5;group4,group5=role6`.

Example 72. Example of LDAP groups to Neo4j roles mapping

```
"cn=Neo4j Read Only,cn=users,dc=example,dc=com" = reader;   \ ①
"cn=Neo4j Read-Write,cn=users,dc=example,dc=com" = editor,publisher;  \ ②
"cn=Neo4j Create Data,cn=users,dc=example,dc=com",*cn=Neo4j Create Data."cn=users,dc=example,dc=com" = publisher; \ ③
"cn=Neo4j Create Data,cn=users,dc=example,dc=com","cn=Neo4j Schema Manager,cn=users,dc=example,dc=com" = architect;   \ 
"cn=Neo4j Administrator,cn=users,dc=example,dc=com" = admin;  \ 
"cn=Neo4j Procedures,cn=users,dc=neo4j,dc=com" = rolename ④
```

① Mapping of an LDAP group to a Neo4j built-in role.

② Mapping of an LDAP group to two Neo4j built-in roles.

③ Mapping of two LDAP groups to a Neo4j built-in role.

④ Mapping of an LDAP group to a custom-defined role. Custom-defined roles, such as `rolename`, must be explicitly created using the `CREATE ROLE rolename` command before they can be used to grant privileges. See the Cypher Manual → Creating roles.

11.4.5. Configure Neo4j to use Active Directory

You configure Neo4j to use the LDAP security provider to access and manage your Active Directory. There are three alternative ways to do that depending on your specific use case.

Configure Neo4j to support LDAP user ID authentication

This option allows users to log in with their LDAP user ID.

In the `neo4j.conf` file, uncomment and configure the following settings:
1. Configure LDAP to point to the AD server:

```
dbms.security.ldap.host=ldap://myactivedirectory.example.com
```

2. Provide details on the user structure of the LDAP directory:

```
dbms.security.ldap.authentication.user_dn_template=cn={0},cn=Users,dc=example,dc=com
dbms.security.ldap.authorization.user_search_base=cn=Users,dc=example,dc=com
dbms.security.ldap.authorization.user_search_filter=(&(objectClass=*)(cn={0}))
```

3. Map the groups in the LDAP system to the Neo4j built-in and custom roles. See Map the LDAP groups to the Neo4j roles.

Configure Neo4j to support attribute authentication

This is an alternative configuration for Active Directory that allows users to log in by providing an attribute to search for, by default `sAMAccountName`. The attribute has to be unique to be used as a lookup. You create a system account that has read-only access to the parts of the LDAP directory that you want. However, it does not need to have access rights to Neo4j or any other systems.

In the `neo4j.conf` file, uncomment and configure the following settings:

1. Configure LDAP to point to the AD server:

```
dbms.security.ldap.host=ldap://myactivedirectory.example.com
```

2. Provide details on the user structure of the LDAP directory (replacing `myattribute` with the actual attribute name):

```
dbms.security.ldap.authorization.user_search_base=cn=Users,dc=example,dc=com
dbms.security.ldap.authorization.user_search_filter=(&(objectClass=*)(myattribute={0}))
```

3. Map the groups in the LDAP system to the Neo4j built-in and custom roles. See Map the LDAP groups to the Neo4j roles.

4. Configure Neo4j to use a system account with read access to all users and groups in the LDAP server.
   a. Set `dbms.security.ldap.authorization.use_system_account` value to `true`.
   b. Set `dbms.security.ldap.authorization.system_username` value to the full Distinguished Name (DN) as the `dbms.security.ldap.authentication.user_dn_template` will not be applied to this username. For example,

```
dbms.security.ldap.authorization.system_username=cn=search-account,cn=Users,dc=example,dc=com
```
   c. Configure the LDAP system account password.

```
dbms.security.ldap.authorization.system_password=mypassword
```
d. Configure which attribute to search for by adding the following lines to the neo4j.conf file (replacing myattribute with the actual attribute name):

```
  dbms.security.ldap.authentication.search_for_attribute=true
  dbms.security.ldap.authentication.attribute=myattribute
```

e. (Optional) Create an LDAP group to restrict authentication against the database to a subset of LDAP users:

```
  dbms.security.ldap.authorization.access_permitted_group=cn=Neo4j Access,cn=users,dc=example,dc=com
```

Earlier Neo4j versions only supported samaccountname as a search attribute. This could be configured with `dbms.security.ldap.authentication.use_samaccountname`. That setting has been deprecated and replaced by `dbms.security.ldap.authentication.search_for_attribute`.

Configure Neo4j to support sAMAccountName authentication by setting `user_dn_template`

This is an alternative configuration for Active Directory that allows all users from the specified domain to log in using sAMAccountName. With this option, you do not have to create a system account and store a system username/password in the config file. Instead, you set `{0}@example.com` as a value of the `user_dn_template` to enable the authentication to start at the root domain. This way, the whole tree is checked to find the user, regardless of where it is located within the LDAP directory tree.

In the neo4j.conf file, uncomment and configure the following settings:

1. Configure LDAP to point to the AD server:

```
  dbms.security.ldap.host=ldap://myactivedirectory.example.com
```

2. Provide details on the user structure of the LDAP directory:

```
  dbms.security.ldap.authentication.user_dn_template={0}@example.com
  dbms.security.ldap.authorization.user_search_base=dc=example,dc=com
  dbms.security.ldap.authorization.user_search_filter=((&(objectClass=user)(sAMAccountName={0})))
  dbms.security.ldap.authorization.group_membership_attributes=memberOf
```

3. Map the groups in the LDAP system to the Neo4j built-in and custom roles. For more information, see Map the LDAP groups to the Neo4j roles.

The setting `dbms.security.ldap.authentication.search_for_attribute` should be set to the default value of false.

11.4.6. Configure Neo4j to use OpenLDAP

You configure the LDAP security provider to access and manage your OpenLDAP directory service.
In the neo4j.conf file, uncomment and configure the following settings:

1. Configure LDAP to point to the OpenLDAP server:

   ```
   dbms.security.ldap.host=myopenldap.example.com
   ```

2. Provide details on the user structure of the LDAP directory:

   ```
   dbms.security.ldap.authentication.user_dn_template=cn={0},ou=users,dc=example,dc=com
   dbms.security.ldap.authorization.user_search_base=ou=users,dc=example,dc=com
   dbms.security.ldap.authorization.user_search_filter=(&objectClass=*)(uid={0})
   dbms.security.ldap.authorization.group_membership_attributes=gidNumber
   ```

3. (Optional) Create an LDAP group to restrict authentication against the database to a subset of LDAP users:

   ```
   dbms.security.ldap.authorization.access_permitted_group=501
   ```

4. Map the groups in the LDAP system to the Neo4j built-in and custom roles. For more information, see Map the LDAP groups to the Neo4j roles.

11.4.7. Verify the LDAP configuration

You can verify that your LDAP configuration is correct, and that the LDAP server responds, by using the LDAP command-line tool `ldapsearch`.

The `ldapsearch` command accepts the LDAP configuration setting values as input and verifies both the authentication (using the simple mechanism) and authorization of a user. See the `ldapsearch official documentation` for more advanced usage and how to use SASL authentication mechanisms.

1. Verify the authentication and authorization of a user. For example, john.

   * With `dbms.security.ldap.authorization.use_system_account=false` (default):

     ```
     # ldapsearch -v -H ldap://<dbms.security.ldap.host> -x -D <dbms.security.ldap.authentication.user_dn_template : replace {0}> -W -b <dbms.security.ldap.authorization.user_search_base> "<dbms.security.ldap.authorization.user_search_filter : replace {0}>" <dbms.security.ldap.authorization.group_membership_attributes>
     ldapsearch -v -H ldap://myactivedirectory.example.com:389 -x -D cn=john,cn=Users,dc=example,dc=com -W -b cn=Users,dc=example,dc=com "(&(objectClass=*)(cn=john))" memberOf
     ```

   * With `dbms.security.ldap.authorization.use_system_account=true`:

     ```
     # ldapsearch -v -H ldap://<dbms.security.ldap.host> -x -D <dbms.security.ldap.authorization.system_username> -w <dbms.security.ldap.authorization.system_password> -b <dbms.security.ldap.authorization.user_search_base> "<dbms.security.ldap.authorization.user_search_filter : replace {0}>" <dbms.security.ldap.authorization.group_membership_attributes>
     ldapsearch -v -H ldap://myactivedirectory.example.com:389 -x -D cn=search-account,cn=Users,dc=example,dc=com -w mypassword -b cn=Users,dc=example,dc=com "(&(objectClass=*)(cn=john))" memberOf
     ```
2. Verify that the value of the returned membership attribute is a group that is mapped to a role in `dbms.security.ldap.authorization.group_to_role_mapping`.

```ldif
# extended LDIF
#
# LDAPv3
# base <cn=Users,dc=example,dc=com> with scope subtree
# filter: (cn=john)
# requesting: memberOf
#
# john, Users, example.com
dn: CN=john,CN=Users,DC=example,DC=com
memberOf: CN=Neo4j Read Only,CN=Users,DC=example,DC=com
```

**11.4.8. The auth cache**

The auth cache is the mechanism by which Neo4j caches the result of authentication via the LDAP server in order to aid performance. It is configured with the parameters `dbms.security.ldap.authentication.cache_enabled` and `dbms.security.auth_cache_ttl`.

```sql
# Turn on authentication caching to ensure performance.

dbms.security.ldap.authentication.cache_enabled=true
dbms.security.auth_cache_ttl=10m
```

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>dbms.security.ldap.authentication.cache_enabled</code></td>
<td>true</td>
<td>Determines whether or not to cache the result of authentication via the LDAP server. Whether authentication caching should be enabled or not must be considered in view of your company’s security guidelines.</td>
</tr>
</tbody>
</table>
### dbms.security.auth_cache_ttl

- **Default value**: 600 seconds
- **Description**: Is the time to live (TTL) for cached authentication and authorization info. Setting the TTL to 0 disables all auth caching. A short TTL requires more frequent re-authentication and re-authorization, which can impact performance. A very long TTL means that changes to the users settings on an LDAP server may not be reflected in the Neo4j authorization behaviour in a timely manner.

Valid units are ms, s, m; default unit is s.

An administrator can clear the auth cache to force the re-querying of authentication and authorization information from the federated auth provider system. Use Neo4j Browser or Neo4j Cypher Shell to execute this statement:

```
CALL dbms.security.clearAuthCache()
```

### 11.4.9. Available methods of encryption

Specifying the `dbms.security.ldap.host` parameter configures using LDAP without encryption. Not specifying the protocol or port results in `ldap` being used over the default port 389.

```
dbms.security.ldap.host=myactivedirectory.example.com
```

Use LDAP with encryption via StartTLS

To configure Active Directory with encryption via StartTLS, set the following parameters:

```
dbms.security.ldap.host=ldap://myactivedirectory.example.com
```

Use LDAP with encrypted LDAPS

To configure Active Directory with encrypted LDAPS, set `dbms.security.ldap.host` to one of the following. If you do not specify the port, the default one 636 is used.

```
dbms.security.ldap.host=ldaps://myactivedirectory.example.com
```

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11.4.10. Use a self-signed certificate (SSL) in a test environment

Production environments should always use an SSL certificate issued by a Certificate Authority for secure access to the LDAP server. However, there are scenarios, for example in test environments, where you may want to use an SSL certificate on the LDAP server.

To configure an SSL certificate on LDAP server, enter the details of the certificate using `dbms.jvm.additional` in `neo4j.conf`. The path to the certificate file `MyCert.jks` is an absolute path to the Neo4j server.

```
dbms.jvm.additional=-Djavax.net.ssl.keyStore=/path/to/MyCert.jks
dbms.jvm.additional=-Djavax.net.ssl.keyStorePassword=mypassword
dbms.jvm.additional=-Djavax.net.ssl.trustStore=/path/to/MyCert.jks
dbms.jvm.additional=-Djavax.net.ssl.trustStorePassword=mypassword
```

11.5. Integration with Single Sign-On Services

This section describes Neo4j support for integrating with SSO identity providers using OpenID Connect. For examples with different providers and troubleshooting, see the SSO configuration tutorial.

11.5.1. Introduction

Neo4j supports OpenID Connect (OIDC), which allows for integration with many identity providers including Okta, Microsoft Azure Active Directory, and Google. This integration permits federated users, managed by the identity provider, to access Neo4j instead of, or in addition to the native users and roles.

11.5.2. OIDC configuration settings

Neo4j supports multiple OIDC identity providers at the same time, as such each provider configuration must be assigned a prefix to differentiate it from others. In the configuration examples below the provider-specific prefix is represented by `<provider>`, which should be replaced with a name representing your provider. For example, if you are using Okta as your identity provider you might use `okta` in the place of `<provider>` below.

The following configuration settings are important to consider when configuring single sign-on. For a more detailed overview of the single sign-on configuration options, see Configuration settings. These settings can also be updated while the database is running, see Dynamic settings for more information on how to do this. Altering any of these settings causes users to re-authenticate as their permissions may have changed as a result.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>dbms.security.oidc.&lt;provider&gt;.display_name</code></td>
<td></td>
<td>The display name for the provider. This is displayed in clients such as Neo4j Browser and Bloom.</td>
</tr>
<tr>
<td>Parameter name</td>
<td>Default value</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------------------------------------</td>
<td>---------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td><code>dbms.security.oidc.&lt;provider&gt;.auth_flow</code></td>
<td>pkce</td>
<td>The OIDC auth_flow for clients such as Neo4j Browser and Bloom to use. Supported values are pkce and implicit.</td>
</tr>
<tr>
<td><code>dbms.security.oidc.&lt;provider&gt;.well_known_discovery_uri</code></td>
<td></td>
<td>The OpenID Connect Discovery URL for the provider.</td>
</tr>
<tr>
<td><code>dbms.security.oidc.&lt;provider&gt;.auth_endpoint</code></td>
<td></td>
<td>URL of the provider’s Authorization Endpoint.</td>
</tr>
<tr>
<td><code>dbms.security.oidc.&lt;provider&gt;.auth_params</code></td>
<td></td>
<td>Optional parameters that clients may require with the Authorization Endpoint. The map is a semicolon-separated list of key-value pairs. For example: k1=v1;k2=v2.</td>
</tr>
<tr>
<td><code>dbms.security.oidc.&lt;provider&gt;.token_endpoint</code></td>
<td></td>
<td>URL of the provider’s OAuth 2.0 Token Endpoint.</td>
</tr>
<tr>
<td><code>dbms.security.oidc.&lt;provider&gt;.token_params</code></td>
<td></td>
<td>Option parameters that clients may require with the Token Endpoint. The map is a semicolon-separated list of key-value pairs. For example: k1=v1;k2=v2.</td>
</tr>
<tr>
<td><code>dbms.security.oidc.&lt;provider&gt;.jwks_uri</code></td>
<td></td>
<td>URL of the provider’s JSON Web Key Set.</td>
</tr>
<tr>
<td><code>dbms.security.oidc.&lt;provider&gt;.user_info_uri</code></td>
<td></td>
<td>URL of the provider’s UserInfo Endpoint.</td>
</tr>
<tr>
<td><code>dbms.security.oidc.&lt;provider&gt;.issuer</code></td>
<td></td>
<td>URL that the provider asserts as its issuer identifier. This will be checked against the <code>iss</code> claim in the token.</td>
</tr>
<tr>
<td><code>dbms.security.oidc.&lt;provider&gt;.audience</code></td>
<td></td>
<td>The expected value for the <code>aud</code> claim.</td>
</tr>
<tr>
<td><code>dbms.security.oidc.&lt;provider&gt;.client_id</code></td>
<td></td>
<td>The <code>client_id</code> of this client as issued by the provider.</td>
</tr>
<tr>
<td><code>dbms.security.oidc.&lt;provider&gt;.params</code></td>
<td></td>
<td>Option parameters that clients may require. The map is a semicolon-separated list of key-value pairs. For example: k1=v1;k2=v2.</td>
</tr>
<tr>
<td><code>dbms.security.oidc.&lt;provider&gt;.config</code></td>
<td></td>
<td>Option additional configuration that clients may require. The map is a semicolon-separated list of key-value pairs. For example: k1=v1;k2=v2.</td>
</tr>
<tr>
<td><code>dbms.security.oidc.&lt;provider&gt;.get_groups_from_user_info</code></td>
<td>false</td>
<td>Whether to fetch the groups claim from the user info endpoint on the identity provider. The default is false, to read the claim from the token.</td>
</tr>
<tr>
<td><code>dbms.security.oidc.&lt;provider&gt;.get_username_from_user_info</code></td>
<td>false</td>
<td>Whether to fetch the username claim from the user info endpoint on the identity provider. The default is false, to read the claim from the token.</td>
</tr>
<tr>
<td><code>dbms.security.oidc.&lt;provider&gt;.claims.username</code></td>
<td>sub</td>
<td>The claim to use for the database username.</td>
</tr>
<tr>
<td><code>dbms.security.oidc.&lt;provider&gt;.claims.groups</code></td>
<td></td>
<td>The claim to use for the database roles.</td>
</tr>
<tr>
<td><code>dbms.security.oidc.&lt;provider&gt;.authorization.group_to_role_mapping</code></td>
<td></td>
<td>List an authorization mapping from groups to the pre-defined built-in roles admin, architect, publisher, editor, and reader, or to any custom-defined roles.</td>
</tr>
</tbody>
</table>
11.5.3. Configure Neo4j to use OpenID Connect

First, you configure Neo4j to use OpenID Connect as an authentication and authorization provider.

1. Uncomment the setting `dbms.security.auth_enabled=false` and change its value to `true` to enable the security feature.

2. Uncomment the settings `dbms.security.authentication_providers` and `dbms.security.authorization_providers` and change their value to `oidc-<provider>`, where `<provider>` maps to the provider name used in the configuration settings. This way, the OIDC connector is used as a security provider for both authentication and authorization. These configuration values are comma-separated lists, so if you wish to continue to use native authentication and authorization alongside SSO, then these providers can be added to the existing native provider:

Example 73. Configuration

```
{dbms.security.authentication_providers=oidc-newsso,oidc-oldsso/native
 dbms.security.authorization_providers=oidc-newsso,oidc-oldsso/native}
```

This example has two OpenID Connect providers configured, as well as Neo4j native authorization and authentication.

11.5.4. Map the Identity Provider Groups to the Neo4j Roles

Before identity provider managed groups can be used with Neo4j, you have to decide on an approach for mapping identity provider groups to Neo4j roles. The simplest approach is to create identity provider groups with the same names as Neo4j roles. If you decide to go this way, no mapping configuration is necessary. Assuming, however, that identity provider groups do not directly map 1:1 to the desired Neo4j roles, it is necessary to map the identity provider groups to the Neo4j built-in and custom-defined roles. To do that, you need to know what privileges the Neo4j roles have, and based on these privileges, create the mapping to the groups defined in the identity provider. The map must be formatted as a semicolon-separated list of key-value pairs, where the key is a comma-separated list of the identity provider group names and the value is a comma-separated list of the corresponding role names. For example, `group1=role1;group2=role2;group3=role3,role4,role5;group4,group5=role6`. 
Example 74. Example of identity provider groups to Neo4j roles mapping

```
dbms.security.oidc.mysso.authorization.group_to_role_mapping=
    neo4j_readonly   = reader;  
    neo4j_rw         = editor,publisher;  
    neo4j_rw,neo4j_create = publisher;  
    neo4j_create,neo4j_schema = architect;  
    neo4j_dba        = admin;  
    neo4j_exec       = rolename  
```

① Mapping of an identity provider group to a Neo4j built-in role.
② Mapping of an identity provider group to two Neo4j built-in roles.
③ Mapping of two identity provider groups to a Neo4j built-in role.
④ Mapping of an identity provider group to a custom-defined role. Custom-defined roles, such as `rolename`, must be explicitly created using the `CREATE ROLE rolename` command before they can be used to grant privileges. See the Cypher Manual → Creating roles.

11.5.5. Configure Neo4j to use an OpenID Connect Identity Provider

This option allows users to log in through an OIDC compliant identity provider by offering a token from the provider instead of a username and password. Typically, these tokens take the form of a signed JSON Web Token (JWT). In the configuration examples below, we are using `mysso` as our provider name. It is recommended to use a name describing the provider that is being integrated.

OpenID Connect Using JWT Claims

In this configuration, Neo4j receives a JWT from the identity provider containing claims representing the database username (e.g. email), and the Neo4j roles.

1. Set a Display Name

   In the `neo4j.conf` file, uncomment and configure the following settings:

   ```
   dbms.security.oidc.mysso.display_name=SSO Provider
   ```

   This is displayed on a button on the login page of clients such as Neo4j Browser and Bloom, so that users can identify the provider they are using to login.

2. Configure Discovery:

   Uncomment and configure the following settings:

   ```
   dbms.security.oidc.mysso.well_known_discovery_uri=https://my-idp.example.com/.well-known/openid-configuration
   ```

   The `well_known_discovery` endpoint of the identity provider supplies the OpenID Provider Metadata to allow Neo4j to interact with a provider. It is also possible to configure the provider settings manually:
Manual settings always take priority over those retrieved from the discovery endpoint.

3. Configure Audience:

Provide the expected value for the audience (aud) claim:

\[
\text{dbms.security.oidc.mysso.claims.audience=myaudience}
\]

In some situations there may be multiple values for the aud claim. In this situation, the id_token should contain an authorized party (azp) claim containing the client id, which is configured as follows:

\[
\text{dbms.security.oidc.mysso.claims.client_id=myclientid}
\]

4. Configure Claims:

Provide the name of the claims that map to the database username and roles. username is expected to be a string claim and roles is expected to be a list of strings.

\[
\begin{align*}
\text{dbms.security.oidc.mysso.claims.username} &= \text{sub} \\
\text{dbms.security.oidc.mysso.claims.groups} &= \text{roles}
\end{align*}
\]

5. Optionally, map the groups in the OIDC groups claim to the Neo4j built-in and custom roles. See Map the Identity Provider Groups to the Neo4j Roles.

OpenID Connect Fetching Claims from Provider

In this configuration, Neo4j receives a token from the identity provider and uses that token to call back to the identity provider using its UserInfo endpoint to retrieve claims for the database username and Neo4j roles.

1. Configure as for JWT Claims.

Configure Neo4j for OpenID Connect Using JWT Claims.

2. Configure the claims to fetch from the UserInfo endpoint:

\[
\begin{align*}
\text{dbms.security.oidc.mysso.get_username_from_user_info} &= \text{true} \\
\text{dbms.security.oidc.mysso.get_groups_from_user_info} &= \text{true}
\end{align*}
\]

It is possible to fetch just the username, just the groups, or both from the userinfo endpoint.
11.5.6. Use a self-signed certificate (SSL) in a test environment

Production environments should always use an SSL certificate issued by a Certificate Authority for secure access to the identity provider. However, there are scenarios, for example in test environments, where you may want to use a self-signed SSL certificate on the identity provider server.

To configure a self-signed SSL certificate used on an identity provider server, enter the details of a Java keystore containing the relevant certificates using `dbms.jvm.additional` in `neo4j.conf`. The path to the certificate file `MyCert.jks` is an absolute path to the Neo4j server.

```
dbms.jvm.additional=-Djavax.net.ssl.keyStore=/path/to/MyCert.jks
dbms.jvm.additional=-Djavax.net.ssl.keyStorePassword=mypassword
dbms.jvm.additional=-Djavax.net.ssl.trustStore=/path/to/MyCert.jks
dbms.jvm.additional=-Djavax.net.ssl.trustStorePassword=mypassword
```

11.6. Manage procedure and user-defined function permissions

**Enterprise edition**

This section describes how access control works with procedures and user-defined functions in Neo4j.

11.6.1. Introduction

To be able to run a procedure or user-defined function, the user needs to have the corresponding execute privilege. Procedures and user-defined functions are executed according to the same security rules as regular Cypher statements, e.g. a procedure performing writes will fail if called by a user that only has read privileges.

Procedures and user-defined functions can also be run with privileges exceeding the users own privileges. This is called execution boosting. The elevated privileges only apply within the procedure or user-defined function; any operation performed outside will still use the users original privileges.

The steps below assume that the procedure or user-defined function is already developed and installed.

Please refer to [Java Reference → Extending Neo4j](#) for a description on creating and using user-defined procedures and functions.

11.6.2. Manage procedure permissions

Procedure permissions can be managed using the native execute privileges. These control whether the user is allowed to both execute a procedure, and which set of privileges apply during the execution.

A procedure may be run using the `EXECUTE PROCUREMENT` privilege.

This allows the user to execute procedures that match the `globbed procedures`.
Example 75. Grant privilege to execute procedure

```
GRANT EXECUTE PROCEDURE db.schema.visualization ON DBMS TO visualizer
```

This will allow any user with the visualizer role to execute the `db.schema.visualization`. E.g. a user that also have the following privileges:

```
GRANT TRAVERSE ON GRAPH * NODES A, B TO role
GRANT TRAVERSE ON GRAPH * RELATIONSHIP R1 TO role
```

When calling the `db.schema.visualization` procedure that user will only see the A and B nodes and R1 relationships, even though there might exist other nodes and relationships.

A procedure may also be executed with elevated privileges using the `EXECUTE BOOSTED PROCEDURE` privilege.

This allows the user to successfully execute procedures that would otherwise fail during execution with their assigned roles. The user is given full privileges for the procedure, during the execution of the procedure only.

Example 76. Grant privilege to execute procedure with elevated privileges

```
GRANT EXECUTE BOOSTED PROCEDURE db.schema.visualization ON DBMS TO visualizer
```

This will allow any user with the visualizer role to execute the `db.schema.visualization` with elevated privileges. When calling the `db.schema.visualization` procedure that user will see all nodes and relationships that exist in the graph, even though they have no traversal privileges.

11.6.3. Manage user-defined function permissions

User-defined function permissions can be managed using the `native execute privileges`. These control if the user is both allowed to execute a user-defined function, and which set of privileges apply during the execution.

A user-defined function may be executed using the `EXECUTE USER DEFINED FUNCTION` privilege.

This allows the user to execute user-defined functions that match the `globbed user-defined function`.
Example 77. Grant privilege to execute user-defined function

```sql
GRANT EXECUTE USER DEFINED FUNCTION apoc.any.properties ON DBMS TO custom
```

This will allow any user with the `custom` role to execute the `apoc.any.properties`. E.g. a user that also have the following privilege:

```sql
GRANT MATCH {visibleProp} ON GRAPH * NODES A TO role
```

When calling the user-defined function `MATCH (a:A) RETURN apoc.any.properties(a) AS properties`, they will only see the `visibleProp` even though there might exist other properties.

A user-defined function may also be executed with elevated privileges using the `EXECUTE BOOSTED USER DEFINED FUNCTION` privilege.

This allows the user to successfully execute user-defined functions that would otherwise fail during execution with their assigned roles. The user is given full privileges for the user-defined function, during the execution of the function only.

Example 78. Grant privilege to execute user-defined function with elevated privileges

```sql
GRANT EXECUTE BOOSTED USER DEFINED FUNCTION apoc.any.properties ON DBMS TO custom
```

This will allow any user with the `custom` role to execute the `apoc.any.properties` with elevated privileges. E.g. a user that also have the following privileges:

```sql
GRANT TRAVERSE ON GRAPH * NODES A TO role
```

When calling the user-defined function `MATCH (a:A) RETURN apoc.any.properties(a) AS properties`, they will see all properties that exist on the matched nodes even though they have no read privileges.

11.6.4. Manage procedure and user-defined function permissions from config setting [Deprecated]

It is possible to grant boosting for procedures and user-defined functions through config settings. These settings will be translated to temporary `execute boosted procedure` and `execute boosted function` privileges that cannot be revoked.

`dbms.security.procedures.default_allowed`

The setting `dbms.security.procedures.default_allowed` defines a single role that is allowed to execute any procedure or user-defined function that is not matched by the `dbms.security.procedures.roles` configuration.
Example 79. Configure a default role that can execute procedures and user-defined functions

Assume that we have the following configuration:

```
dbms.security.procedures.default_allowed=superAdmin
```

This will create the following temporary privileges:

- GRANT EXECUTE BOOSTED PROCEDURE * ON DBMS TO superAdmin
- GRANT EXECUTE BOOSTED USER DEFINED FUNCTION * ON DBMS TO superAdmin
- If the setting `dbms.security.procedures.roles` has some roles to name defined, then for any procedure/function not also granted to the superAdmin role, create temporary privileges:
  - DENY EXECUTE BOOSTED PROCEDURE name ON DBMS TO superAdmin
  - DENY EXECUTE BOOSTED USER DEFINED FUNCTION name ON DBMS TO superAdmin

**dbms.security.procedures.roles**

The `dbms.security.procedures.roles` setting provides fine-grained control over procedures and user-defined functions.

Example 80. Configure roles for the execution of specific procedures and user-defined functions

Assume that we have the following configuration:

```
dbms.security.procedures.default_allowed=superAdmin
dbms.security.procedures.roles=apoc.coll.*:Collector;apoc.trigger.add:TriggerHappy,superAdmin
```

This will have create the following temporary privileges:

- GRANT EXECUTE BOOSTED PROCEDURE apoc.coll.* ON DBMS TO Collector
- GRANT EXECUTE BOOSTED USER DEFINED FUNCTION apoc.coll.* ON DBMS TO Collector
- GRANT EXECUTE BOOSTED PROCEDURE apoc.trigger.add ON DBMS TO TriggerHappy, superAdmin
- GRANT EXECUTE BOOSTED USER DEFINED FUNCTION apoc.trigger.add ON DBMS TO TriggerHappy, superAdmin
- GRANT EXECUTE BOOSTED PROCEDURE * ON DBMS TO superAdmin
- GRANT EXECUTE BOOSTED USER DEFINED FUNCTION * ON DBMS TO superAdmin
- DENY EXECUTE BOOSTED PROCEDURE apoc.coll.* ON DBMS TO superAdmin
- DENY EXECUTE BOOSTED USER DEFINED FUNCTION apoc.coll.* ON DBMS TO superAdmin

11.7. Terminology **Enterprise edition**

This section lists the relevant terminology related to authentication and authorization in Neo4j.
The following terms are relevant to role-based access control within Neo4j:

active user
A user who is active within the system and can perform actions prescribed by any assigned roles on the data. This is in contrast to a suspended user.

administrator
This is a user who has been assigned the admin role.

current user
This is the currently logged-in user invoking the commands described in this chapter.

password policy
The password policy is a set of rules of what makes up a valid password. For Neo4j, the following rules apply:

- The password cannot be the empty string.
- When changing passwords, the new password cannot be the same as the previous password.

role
This is a collection of actions — such as read and write — permitted on the data.

suspended user
A user who has been suspended is not able to access the database in any capacity, regardless of any assigned roles.

user
- A user is composed of a username and credentials, where the latter is a unit of information, such as a password, verifying the identity of a user.
- A user may represent a human, an application etc.
Chapter 12. Security

This chapter covers important security aspects in Neo4j.

Ensure your physical data security by following industry best practices with regard to server and network security.

This chapter includes the following:

- Securing extensions
- SSL framework
- Credentials handling in Neo4j Browser
- Security checklist

Additionally, logs can be useful for continuous analysis, or for specific investigations. Facilities are available for producing security event logs as well as query logs as described in Monitoring.

![Information icon] Refer to Authentication and authorization for information on how to manage users and their authentication and authorization.

12.1. Securing extensions

This section describes how to use allow listing to ensure the security of custom-written additions in Neo4j.

Neo4j can be extended by writing custom code which can be invoked directly from Cypher, as described in Java Reference → User-defined procedures and Java Reference → User-defined functions. This section describes how to ensure the security of these additions.

12.1.1. Allow listing

Allow listing can be used to allow the loading of only a few extensions from a larger library.

The configuration setting `dbms.security.procedures.allowlist` is used to name certain procedures that should be available from a library. It defines a comma-separated list of procedures that are to be loaded. The list may contain both fully qualified procedure names, and partial names with the wildcard `*`. 
Example 81. Allow listing

In this example we wish to allow the use of the method `apoc.load.json` as well as all the methods under `apoc.coll`. We do not want to make available any additional extensions from the `apoc` library, other than the ones matching these criteria.

```sql
# Example allow listing
dbms.security.procedures.allowlist=apoc.coll.*,apoc.load.*
```

There are a few things that should be noted about `dbms.security.procedures.allowlist`:

- If using this setting, no extensions other than those listed will be loaded. In particular, if it is set to the empty string, no extensions will be loaded.
- The default of the setting is `*`. This means that if you do not explicitly give it a value (or no value), all libraries in the `plugins` directory will be loaded.

12.2. SSL framework

Describes how to set up SSL within your environment, how to view, validate, and test the certificates.

The SSL framework provides support for securing the following Neo4j communication channels using standard SSL/TLS technology:

- **bolt** (port - 7687)
- **https** (port - 7473)
- **cluster** (ports - 5000, 6000, and 7000)
- **backups** (port - 6362)

12.2.1. SSL providers

The secure networking in Neo4j is provided through the Netty library, which supports both the native JDK SSL provider as well as Netty-supported OpenSSL derivatives.

Follow these steps to use OpenSSL:

- Install a suitable dependency into the `plugins/` folder of Neo4j.

| --- |
- Set `dbms.netty.ssl.provider=OPENSSL`.
- Restart Neo4j

Most supported versions of Neo4j use Netty 41.77.Final, which requires tcnative 2.0.52. Only Neo4j 3.5 still uses older versions of Netty. See the table below for detailed information:

<table>
<thead>
<tr>
<th>Neo4j version</th>
<th>Netty version</th>
<th>tcnative version</th>
<th>Direct link</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.0</td>
<td>4.1.77.Final</td>
<td>2.0.52.Final. Both netty-tcnative-boringssl-static and netty-tcnative-classes are required</td>
<td><a href="https://search.maven.org/artifact/io.netty/netty-tcnative-boringssl-static/2.0.52.Final/jar">link</a> <a href="https://search.maven.org/artifact/io.netty/netty-tcnative-classes/2.0.52.Final/jar">link</a></td>
</tr>
<tr>
<td>4.4.9</td>
<td>4.1.77.Final</td>
<td>2.0.52.Final</td>
<td><a href="https://search.maven.org/artifact/io.netty/netty-tcnative-boringssl-static/2.0.52.Final/jar">link</a> <a href="https://search.maven.org/artifact/io.netty/netty-tcnative-classes/2.0.52.Final/jar">link</a></td>
</tr>
<tr>
<td>4.3.15</td>
<td>4.1.77.Final</td>
<td>2.0.52.Final</td>
<td><a href="https://search.maven.org/artifact/io.netty/netty-tcnative-boringssl-static/2.0.52.Final/jar">link</a> <a href="https://search.maven.org/artifact/io.netty/netty-tcnative-classes/2.0.52.Final/jar">link</a></td>
</tr>
<tr>
<td>3.5.34</td>
<td>3.9.9.Final + 4.1.68.Final</td>
<td>2.0.42.Final</td>
<td><a href="https://search.maven.org/artifact/io.netty/netty-tcnative/2.0.42.Final/jar">link</a></td>
</tr>
</tbody>
</table>

Using OpenSSL can significantly improve performance, especially for AES-GCM-cryptos, e.g. TLS_ECDHE_RSA_WITH_AES_128_GCM_SHA256.

### 12.2.2. Certificates

The SSL configuration requires SSL **certificates** to be issued by Certificate Authority (CA). All Certificates and the private key must be in **PEM** format.

If the same certificates are used across all instances of the cluster, make sure that when generating the certificates to include the DNS names of all the cluster instances in the certificates. Multi-host and wildcard certificates are also supported.

The instructions on this page assume that you have already obtained the required certificates from the CA.

### Validate the key and the certificate

If you need, you can validate the key file and the certificate as follows:

Validate the key

```bash
openssl rsa -in private.key -check
```
Validate certificate in the PEM format

PEM - $openssl x509 -in public.crt -text -noout
DER - $openssl x509 -in certificate.der -inform der -text -noout

Transform the certificates

Neo4j requires all SSL certificates to be in the PEM format. If your certificate is in the DER format, you must transform it into PEM format.

Transform DER format certificate to PEM format

openssl x509 -in cert.crt -inform der -outform pem -out cert.pem

Transform PEM format certificate to DER format

openssl x509 -in cert.crt -outform der -out cert.der

12.2.3. Connectors

Before enabling SSL support, you must ensure the following connector configurations to avoid errors:

- Set `dbms.connector.https.enabled` to `true` when using HTTPS.
- Set `dbms.connector.bolt.tls_level` to `REQUIRED` or `OPTIONAL` when using Bolt.

For more information on configuring connectors, see Configure connectors.

12.2.4. Configuration

The SSL policies are configured by assigning values to parameters of the following format:

dbms.ssl.policy.<scope>.<setting-suffix>

- `scope` is the name of the communication channel, such as `bolt`, `https`, `cluster`, `backup`, and `fabric`.
- `setting-suffix` can be any of the following:

<table>
<thead>
<tr>
<th>Setting suffix</th>
<th>Description</th>
<th>Default value</th>
</tr>
</thead>
<tbody>
<tr>
<td>enabled</td>
<td>Setting this to <code>true</code> enables this policy.</td>
<td><code>false</code></td>
</tr>
<tr>
<td>base_directory</td>
<td>The base directory under which <code>&lt;term-ssl-cryptographic-objects, cryptographic objects&gt;</code> are searched for by default.</td>
<td><code>certificates/&lt;scope&gt;</code></td>
</tr>
<tr>
<td>private_key</td>
<td>The private key used for authenticating and securing this instance.</td>
<td><code>private.key</code></td>
</tr>
<tr>
<td>Setting suffix</td>
<td>Description</td>
<td>Default value</td>
</tr>
<tr>
<td>------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>private_key_password</td>
<td>The passphrase to decode the private key. Only applicable for encrypted private keys.</td>
<td></td>
</tr>
<tr>
<td>public_certificate</td>
<td>A public certificate matching the private key signed by a CA.</td>
<td>public.crt</td>
</tr>
<tr>
<td>trusted_dir</td>
<td>A directory populated with certificates of trusted parties.</td>
<td>trusted/</td>
</tr>
<tr>
<td>revoked_dir</td>
<td>A directory populated with certificate revocation lists (CRLs).</td>
<td>revoked/</td>
</tr>
</tbody>
</table>

**Advanced**

<table>
<thead>
<tr>
<th>Setting suffix</th>
<th>Description</th>
<th>Default value</th>
</tr>
</thead>
<tbody>
<tr>
<td>verify_hostname</td>
<td>Enabling this setting turns on client-side hostname verification. After receiving the server’s public certificate, the client compares the address it uses against the certificate Common Name (CN) and Subject Alternative Names (SAN) fields. If the address does not match those fields, the client disconnects.</td>
<td>false</td>
</tr>
<tr>
<td>ciphers</td>
<td>A comma-separated list of cipher suites allowed during cipher negotiation. Valid values depend on the current JRE and SSL provider. For Ciphers supported by the Oracle JRE, see the Oracle official documentation.</td>
<td>Java platform default allowed cipher suites.</td>
</tr>
<tr>
<td>tls_versions</td>
<td>A comma-separated list of allowed TLS versions.</td>
<td>TLSv1.2</td>
</tr>
<tr>
<td>client_auth</td>
<td>Whether or not clients must be authenticated. Setting this to <code>REQUIRE</code> enables mutual authentication for servers. Other possible values are <code>NONE</code> and <code>OPTIONAL</code>.</td>
<td>OPTIONAL for <code>bolt</code> and <code>https</code>; <code>REQUIRE</code> for <code>cluster</code> and <code>backup</code>.</td>
</tr>
<tr>
<td>trust_all</td>
<td>Setting this to <code>true</code> results in all clients and servers to be trusted and the content of the <code>trusted_dir</code> directory to be ignored. Use this only as a mean of debugging, since it does not offer security.</td>
<td>false</td>
</tr>
</tbody>
</table>

For security reasons, Neo4j does not automatically create any of these directories. Therefore, the creation of an SSL policy requires the appropriate file system structure to be set up manually. Note that the existence of the directories, the certificate file, and the private key are mandatory. Ensure that only the Neo4j user can read the private key.

Each policy needs to be explicitly enabled by setting:
Configure SSL over Bolt

Bolt protocol is based on the PackStream serialization and supports the Cypher type system, protocol versioning, authentication, and TLS via certificates. For Neo4j clusters, Bolt provides smart client routing with load balancing and failover. Bolt connector is used by Cypher Shell, Neo4j Browser, and by the officially supported language drivers. Bolt connector is enabled by default but its encryption is disabled. To enable the encryption over Bolt, create the folder structure and place the key file and the certificates under those. Then, you need to configure the SSL Bolt policies in the neo4j.conf file.

1. Enable the Bolt connector to enable SSL over Bolt:

```
dbms.connector.bolt.enabled=true (default is true)
```

2. Set up the bolt folder under certificates.
   a. Create a directory bolt under <neo4j-home>/certificates folder:

```
mkdir certificates/bolt
```

   b. Create a directory trusted and revoked under <neo4j-home>/certificates/bolt folder:

```
mkdir certificates/bolt/trusted
mkdir certificates/bolt/revoked
```

3. Place the certificates private.key and the public.crt files under <neo4j-home>/certificates/bolt folder:

```
cp /path/to/certs/private.key certificates/bolt
cp /path/to/certs/public.crt certificates/bolt
```

4. Place the public.crt file under the <neo4j-home>/certificates/bolt/trusted folder.

```
cp /path/to/certs/public.crt certificates/bolt/trusted
```

5. (Optional) If a particular certificate is revoked, then place it under <neo4j-home>/certificates/bolt/revoked folder.

```
cp /path/to/certs/public.crt certificates/bolt/revoked
```

The folder structure should look like this with the right file permissions and the groups and ownerships:

<table>
<thead>
<tr>
<th>Path</th>
<th>Directory/File</th>
<th>Owner</th>
<th>Group</th>
<th>Permission</th>
<th>Unix/Linux View</th>
</tr>
</thead>
<tbody>
<tr>
<td>/data/neo4j/certificates/bolt</td>
<td>Directory</td>
<td>neo4j</td>
<td>neo4j</td>
<td>0755</td>
<td>drwxr-xr-x</td>
</tr>
<tr>
<td>/data/neo4j/certificates/bolt/public.crt</td>
<td>File</td>
<td>neo4j</td>
<td>neo4j</td>
<td>0644</td>
<td>-rw-r-r--</td>
</tr>
</tbody>
</table>
6. Set the Bolt SSL configuration in `neo4j.conf`.
   a. Set the SSL Bolt policy to `true`:
      
      ```
      dbms.ssl.policy.bolt.enabled=true
      ```
   
   b. Set the appropriate certificates path and the right key and cert files:
      
      ```
      dbms.ssl.policy.bolt.base_directory=certificates/bolt
      dbms.ssl.policy.bolt.private_key=private.key
      dbms.ssl.policy.bolt.public_certificate=public.crt
      ```
      
      If the certificate is a different path outside of NEO4J_HOME, then set the absolute path for the certificates directory.
   
   c. Set the Bolt client authentication to `NONE` to disable the mutual authentication:
      
      ```
      dbms.ssl.policy.bolt.client_auth=NONE
      ```
   
   d. Set the Bolt TLS level to allow the connector to accept encrypted and/or unencrypted connections:
      
      ```
      dbms.connector.bolt.tls_level=REQUIRED (default is DISABLED)
      ```
      
      In Neo4j version 3.5, the default value is `OPTIONAL`. In the Neo4j 4.x versions, the default value is `DISABLED`, where only unencrypted client connections are to be accepted by this connector, and all encrypted connections will be rejected. Use `REQUIRED` when only encrypted client connections are to be accepted by this connector, and all unencrypted connections will be rejected. Use `OPTIONAL` where either encrypted or unencrypted client connections are accepted by this connector.

7. Test the SSL connection to the specified host and Bolt port and view the certificate:
   
   ```
   openssl s_client -connect my_domain.com:7687
   ```
Connect with SSL over Bolt

Each of the neo4j and bolt URI schemes permit variants that contain extra encryption and trust information. The +s variants enable encryption with a full certificate check. The +ssc variants enable encryption with no certificate check. This latter variant is designed specifically for use with self-signed certificates.

<table>
<thead>
<tr>
<th>URI Scheme</th>
<th>Routing</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>neo4j</td>
<td>Yes</td>
<td>Unsecured</td>
</tr>
<tr>
<td>neo4j+s</td>
<td>Yes</td>
<td>Secured with full certificate</td>
</tr>
<tr>
<td>neo4j+ssc</td>
<td>Yes</td>
<td>Secured with self-signed certificate</td>
</tr>
<tr>
<td>bolt</td>
<td>No</td>
<td>Unsecured</td>
</tr>
<tr>
<td>bolt+s</td>
<td>No</td>
<td>Secured with full certificate</td>
</tr>
<tr>
<td>bolt+ssc</td>
<td>No</td>
<td>Secured with self-signed certificate</td>
</tr>
</tbody>
</table>

Once SSL is enabled over Bolt, you can connect to the Neo4j DBMS using neo4j+s or bolt+s:

**Cypher Shell**

```
cypher-shell -a neo4j+s://<Server DNS or IP>:<Bolt port>
```

**Neo4j Browser**

From the Connect URL dropdown menu, select the URI scheme you want to use (neo4j+s or bolt+s).

> URI schemes ending +ssc are not supported by Neo4j Browser since the browser’s OS handles certificate trust. If it is necessary to connect to a Neo4j instance using a self-signed certificate from Neo4j Browser, first visit a web page that uses the self-signed certificate in order to prompt the browser to request that certificate trust be granted. Once that trust has been granted, you can connect with URI schemes ending +s.

Configure SSL over HTTPS

HTTP(s) is used by the Neo4j Browser and the HTTP API. HTTPS (secure HTTP) is set to encrypt network communications. To enable the encryption over HTTPS, create the folder structure and place the key file and the certificates under those. Then, you need to configure the SSL HTTPS policies in the neo4j.conf file and disable the HTTP connector.

1. Enable the HTTPS connector to enable SSL over HTTPS:

   ```
   dbms.connector.https.enabled=true (default is false)
   ```

2. Set up the https folder under certificates.
a. Create a directory https under <neo4j-home>/certificates folder:

```
mkdir certificates/https
```

b. Create a directory trusted and revoked under <neo4j-home>/certificates/https folder:

```
mkdir certificates/https/trusted
mkdir certificates/https/revoked
```

3. Place the certificates private.key and the public.crt files under <neo4j-home>/certificates/https folder:

```
cp /path/to/certs/private.key certificates/https
cp /path/to/certs/public.crt certificates/https
```

4. Place the public.crt file under the <neo4j-home>/certificates/https/trusted folder.

```
 cp /path/to/certs/public.crt certificates/https/trusted
```

5. (Optional) If a particular certificate is revoked, then place it under <neo4j-home>/certificates/https/revoked folder.

```
cp /path/to/certs/public.crt certificates/https/revoked
```

The folder structure should look like this with the right file permissions and the groups and ownerships:

<table>
<thead>
<tr>
<th>Path</th>
<th>Directory/File</th>
<th>Owner</th>
<th>Group</th>
<th>Permission</th>
<th>Unix/Linux View</th>
</tr>
</thead>
<tbody>
<tr>
<td>/data/neo4j/certificates/https</td>
<td>Directory</td>
<td>neo4j</td>
<td>neo4j</td>
<td>0755</td>
<td>drwxr-xr-x</td>
</tr>
<tr>
<td>/data/neo4j/certificates/https/public.crt</td>
<td>File</td>
<td>neo4j</td>
<td>neo4j</td>
<td>0644</td>
<td>-rw-r--r--</td>
</tr>
<tr>
<td>/data/neo4j/certificates/https/private.key</td>
<td>File</td>
<td>neo4j</td>
<td>neo4j</td>
<td>0400</td>
<td>---------</td>
</tr>
<tr>
<td>/data/neo4j/certificates/https/trusted</td>
<td>Directory</td>
<td>neo4j</td>
<td>neo4j</td>
<td>0755</td>
<td>drwxr-xr-x</td>
</tr>
<tr>
<td>/data/neo4j/certificates/https/trusted/public.crt</td>
<td>File</td>
<td>neo4j</td>
<td>neo4j</td>
<td>0644</td>
<td>-rw-r--r--</td>
</tr>
<tr>
<td>/data/neo4j/certificates/https/revoked</td>
<td>Directory</td>
<td>neo4j</td>
<td>neo4j</td>
<td>0755</td>
<td>drwxr-xr-x</td>
</tr>
</tbody>
</table>

The owner/group should be configured to the user/group that will be running the neo4j service. Default user/group is neo4j/neo4j.

6. Set the HTTPS SSL configuration in neo4j.conf.
   a. Set the SSL HTTPS policy to true:

```
dbms.ssl.policy.https.enabled=true
```
b. Set the appropriate certificates path and the right key and cert files:

```
dbms.ssl.policy.https.base_directory=certificates/https
dbms.ssl.policy.https.private_key=private.key
dbms.ssl.policy.https.public_certificate=public.crt
```

If the certificate is a different path outside of NEO4J_HOME, then set the absolute path for the certificates directory.

c. Set the HTTPS client authentication to **NONE** to disable the mutual authentication:

```
dbms.ssl.policy.https.client_auth=NONE
```

d. Disable HTTP connector:

```
dbms.connector.http.enabled=false
```

7. Test the SSL connection to the specified host and HTTPS port and view the certificate:

```
openssl s_client -connect my_domain.com:7473
```

Configure SSL for intra-cluster communications

Intra-cluster encryption is the security solution for the cluster communication. The Neo4j cluster communicates on 3 ports:

- 5000 - Discovery management
- 6000 - Transactions
- 7000 - Raft communications

To set up intra-cluster encryption, on each server create the folder structure and place the key file and the certificates under those. Then, you need to configure the SSL cluster policies in the neo4j.conf file and test that the intra-cluster communication is encrypted.

1. Set up the cluster folder under certificates.
   a. Create a directory **cluster** under `<neo4j-home>/certificates_` folder:

   ```
   mkdir certificates/cluster
   ```

   b. Create a directory **trusted** and **revoked** under `<neo4j-home>/certificates/cluster` folder:

   ```
   mkdir certificates/cluster/trusted
   mkdir certificates/cluster/revoked
   ```

2. Place the certificates **private.key** and the **public.crt** files under `<neo4j-home>/certificates/cluster` folder:
3. Place the public.crt file under the `<neo4j-home>/certificates/cluster/trusted` folder.

   ```bash
cp /path/to/certs/public.crt certificates/cluster/trusted
   ```

   If each server has a certificate of its own, signed by a CA, then each server’s public certificate has to be put in the trusted folder on each instance of the cluster. Thus, the servers are able to establish trust relationships with each other.

4. (Optional) If a particular certificate is revoked, then place it under `<neo4j-home>/certificates/cluster/revoked` folder.

   ```bash
cp /path/to/certs/public.crt certificates/cluster/revoked
   ```

The folder structure should look like this with the right file permissions and the groups and ownerships:

<table>
<thead>
<tr>
<th>Path</th>
<th>Directory/File</th>
<th>Owner</th>
<th>Group</th>
<th>Permission</th>
<th>Unix/Linux View</th>
</tr>
</thead>
<tbody>
<tr>
<td>/data/neo4j/certificates/cluster</td>
<td>Directory</td>
<td>neo4j</td>
<td>neo4j</td>
<td>0755</td>
<td>drwxr-xr-x</td>
</tr>
<tr>
<td>/data/neo4j/certificates/cluster/public.crt</td>
<td>File</td>
<td>neo4j</td>
<td>neo4j</td>
<td>0644</td>
<td>-rw-r--r--</td>
</tr>
<tr>
<td>/data/neo4j/certificates/cluster/private.key</td>
<td>File</td>
<td>neo4j</td>
<td>neo4j</td>
<td>0400</td>
<td>-r--------</td>
</tr>
<tr>
<td>/data/neo4j/certificates/cluster/trusted</td>
<td>Directory</td>
<td>neo4j</td>
<td>neo4j</td>
<td>0755</td>
<td>drwxr-xr-x</td>
</tr>
<tr>
<td>/data/neo4j/certificates/cluster/trusted/public.crt</td>
<td>File</td>
<td>neo4j</td>
<td>neo4j</td>
<td>0644</td>
<td>-rw-r--r--</td>
</tr>
<tr>
<td>/data/neo4j/certificates/cluster/revoked</td>
<td>Directory</td>
<td>neo4j</td>
<td>neo4j</td>
<td>0755</td>
<td>drwxr-xr-x</td>
</tr>
</tbody>
</table>

   The owner/group should be configured to the user/group that will be running the neo4j service. Default user/group is neo4j/neo4j.

5. Set the cluster SSL configuration in `neo4j.conf`.
   a. Set the cluster SSL policy to `true`:

   ```ini
   dbms.ssl.policy.cluster.enabled=true
   ```

   b. Set the appropriate certificates path and the right key and cert files:

   ```ini
dbms.ssl.policy.cluster.base_directory=certificates/cluster
dbms.ssl.policy.cluster.private_key=private.key
dbms.ssl.policy.cluster.public_certificate=public.crt
```
If the certificate is a different path outside of NEO4J_HOME, then set the absolute path for the certificates directory.

c. Set the cluster client authentication to REQUIRE to enable the mutual authentication, which means that both ends of a channel have to authenticate:

```plaintext
dbms.ssh.policy.cluster.client_auth=REQUIRE
```

The policy must be configured on every server with the same settings. The actual cryptographic objects installed will be mostly different since they do not share the same private keys and corresponding certificates. The trusted CA certificate will be shared however.

d. Verify that the intra-cluster communication is encrypted. You may use an external tooling, such as Nmap (https://nmap.org/download.html):

```plaintext
nmap --script ssl-enum-ciphers -p <port> <hostname>
```

The hostname and port have to be adjusted according to your configuration. This can prove that TLS is in fact enabled and that only the intended cipher suites are enabled. All servers and all applicable ports should be tested. If the intra-cluster encryption is enabled, the output should indicate the port is open and it is using TLS with the ciphers used.

For more details on securing the communication between the cluster servers, see Intra-cluster encryption.

Configure SSL for backup communication

In a single instance, by default the backup communication happens on port 6362. In a cluster topology, it is possible to take a backup from any server, and each server has two configurable ports capable of serving a backup. These ports are configured by `dbms.backup.listen.address` (port 6362) and `causal_clustering.transaction_listen_address` (port 6000) respectively. If the intra-cluster encryption is enabled and the backup communication is using port 6000, then your communication channels are already encrypted. The following steps assumes that your backup is set up on a different port.

To set up SSL for backup communication, create the folder structure and place the key file and the certificates under those. Then, you need to configure the SSL backup policies in the neo4j.conf file.

1. Set up the backup folder under certificates.
   a. Create a directory `backup` under `<neo4j-home>/certificates` folder:

```plaintext
mkdir certificates/backup
```
   
b. Create a directory `trusted` and `revoked` under `<neo4j-home>/certificates/backup` folder:
2. Place the certificates private.key and the public.crt files under <neo4j-home>/certificates/backup folder:

```bash
cp /path/to/certs/private.key certificates/backup
cp /path/to/certs/public.crt certificates/backup
```

3. Place the public.crt file under the <neo4j-home>/certificates/backup/trusted folder.

```bash
cp /path/to/certs/public.crt certificates/backup/trusted
```

4. (Optional) If a particular certificate is revoked, then place it under <neo4j-home>/certificates/backup/revoked folder.

```bash
cp /path/to/certs/public.crt certificates/backup/revoked
```

The folder structure should look like this with the right file permissions and the groups and ownerships:

<table>
<thead>
<tr>
<th>Path</th>
<th>Directory/File</th>
<th>Owner</th>
<th>Group</th>
<th>Permission</th>
<th>Unix/Linux View</th>
</tr>
</thead>
<tbody>
<tr>
<td>/data/neo4j/certificates/backup</td>
<td>Directory</td>
<td>neo4j</td>
<td>neo4j</td>
<td>0755</td>
<td>drwxr-xr-x</td>
</tr>
<tr>
<td>/data/neo4j/certificates/backup/public.crt</td>
<td>File</td>
<td>neo4j</td>
<td>neo4j</td>
<td>0644</td>
<td>-rw-r-r--</td>
</tr>
<tr>
<td>/data/neo4j/certificates/backup/private.key</td>
<td>File</td>
<td>neo4j</td>
<td>neo4j</td>
<td>0400</td>
<td>-r--------</td>
</tr>
<tr>
<td>/data/neo4j/certificates/backup/trusted</td>
<td>Directory</td>
<td>neo4j</td>
<td>neo4j</td>
<td>0755</td>
<td>drwxr-xr-x</td>
</tr>
<tr>
<td>/data/neo4j/certificates/backup/trusted/public.crt</td>
<td>File</td>
<td>neo4j</td>
<td>neo4j</td>
<td>0644</td>
<td>-rw-r-r--</td>
</tr>
<tr>
<td>/data/neo4j/certificates/backup/revoked</td>
<td>Directory</td>
<td>neo4j</td>
<td>neo4j</td>
<td>0755</td>
<td>drwxr-xr-x</td>
</tr>
</tbody>
</table>

The owner/group should be configured to the user/group that will be running the neo4j service. Default user/group is neo4j/neo4j.

5. Set the backup SSL configuration in neo4j.conf.

   a. Set the backup SSL policy to `true`:

   ```
   dbms.ssl.policy.backup.enabled=true
   ```

   b. Set the appropriate certificates path and the right key and cert files:

   ```
   dbms.ssl.policy.backup.base_directory=certificates/backup
   dbms.ssl.policy.backup.private_key=private.key
   dbms.ssl.policy.backup.public_certificate=public.crt
   ```
If the certificate is a different path outside of NEO4J_HOME, then set the absolute path for the certificates directory.

c. Set the backup client authentication to **REQUIRE** to enable the mutual authentication, which means that both ends of a channel have to authenticate:

```
dbms.ssl.policy.backup.client_auth=REQUIRE
```

### Other configurations for SSL

#### Using encrypted private key

To use an encrypted private key, configure the following settings. The private key password must be clear text format without any quotes.

**Bolt**

```
dbms.ssl.policy.bolt.private_key_password=<clear text password>
```

**HTTPS**

```
dbms.ssl.policy.https.private_key_password=<password>
```

**Intra-cluster encryption**

```
dbms.ssl.policy.cluster.private_key_password=<password>
```

**Backup**

```
dbms.ssl.policy.backup.private_key_password=<password>
```

If hardcoding of clear text private key password is not feasible due to security constraints, it can be set up to use dynamic password pickup:

```
dbms.ssl.policy.bolt.private_key_password=$(/opt/neo4j/aes-256-cbc -a -d -in /opt/neo4j/etc/neo4j/cert让他们 neo4j_cert_pwd.enc -kfile /opt/neo4j/var/lib/neo4j/certificates/bolt/neo4j.cert)
```

Using a dynamic command requires Neo4j to be started with the **--expand-commands** option. For more information, see Command expansion.

#### Using specific cipher

There are cases where Neo4j Enterprise requires the use of specific ciphers for encryptions. One can set up a Neo4j configuration by specifying the list of cipher suits that will be allowed during cipher negotiation. Valid values depend on the current JRE and SSL provider. For Oracle JRE here is the list of supported ones
Bolt

```
@ Bolt

```

```
@ HTTPS

```

```
@ Intra-cluster encryption

```

```
@ Backup

```

```
Using OCSP stapling

From version 4.2, Neo4j supports OCSP stapling, which is implemented on the server side, and can be configured in the neo4j.config file. OCSP stapling is also available for Java Bolt driver and HTTP AP.

On the server side in the neo4j.conf file, configure the following settings:

1. Set the SSL Bolt policy to true:

   ```
   dbms.ssl.policy.bolt.enabled=true
   ```

2. Enable the OCSP stapling for Bolt:

   ```
   dbms.connector.bolt.ocsp_stapling_enabled=true (default = false)
   ```

```
12.2.5. SSL logs

All information related to SSL can be found in the debug.log file. You can also enable additional debug logging for SSL by adding the following configuration to the neo4j.conf file and restarting Neo4j.

```
@ dbms.jvm.additional=-Djavax.net.debug=ssl:handshake
```
12.2.6. Terminology

The following terms are relevant to SSL support within Neo4j:

Certificate Authority (CA)

A trusted entity that issues electronic documents that can verify the identity of a digital entity. The term commonly refers to globally recognized CAs, but can also include internal CAs that are trusted inside of an organization. The electronic documents are digital certificates. They are an essential part of secure communication, and play an important part in the Public Key Infrastructure.

Certificate Revocation List (CRL)

In the event of a certificate being compromised, that certificate can be revoked. This is done by means of a list (located in one or several files) spelling out which certificates are revoked. The CRL is always issued by the CA which issues the corresponding certificates.

cipher

An algorithm for performing encryption or decryption. In the most general implementation of encryption of Neo4j communications, we make implicit use of ciphers that are included as part of the Java platform. The configuration of the SSL framework also allows for the explicit declaration of allowed ciphers.

communication channel

A means for communicating with the Neo4j database. Available channels are:

- Bolt client traffic
- HTTPS client traffic
- intra-cluster communication
- backup traffic

cryptographic objects

A term denoting the artifacts private keys, certificates and CRLs.

configuration parameters

These are the parameters defined for a certain ssl policy in neo4j.conf.

certificate

SSL certificates are issued by a trusted certificate authority (CA). The public key can be obtained and used by anyone to encrypt messages intended for a particular recipient. The certificate is commonly stored in a file named <file name>.crt. This is also referred to as the public key.

SAN

SAN is an acronym for Subject Alternative Names. It is an extension to certificates that one can include optionally. When presented with a certificate that includes SAN entries, it is recommended that the address of the host is checked against this field. Verifying that the hostname matches the certificate
SAN helps prevent attacks where a rogue machine has access to a valid key pair.

SSL
SSL is an acronym for Secure Sockets Layer, and is the predecessor of TLS. It is common to refer to SSL/TLS as just SSL. However, the modern and secure version is TLS, and this is also the default in Neo4j.

SSL policy
An SSL policy in Neo4j consists of a digital certificate and a set of configuration parameters defined in neo4j.conf.

private key
The private key ensures that encrypted messages can be deciphered only by the intended recipient. The private key is commonly stored in a file named <file name>.key. It is important to protect the private key to ensure the integrity of encrypted communication.

Public Key Infrastructure (PKI)
A set of roles, policies, and procedures needed to create, manage, distribute, use, store, and revoke digital certificates and manage public-key encryption.

public key
The public key can be obtained and used by anyone to encrypt messages intended for a particular recipient. This is also referred to as the certificate.

TLS protocol
The cryptographic protocol that provides communications security over a computer network. The Transport Layer Security (TLS) protocol and its predecessor, the Secure Sockets Layer (SSL) protocol are both frequently referred to as "SSL".

TLS version
A version of the TLS protocol.

12.3. Browser credentials handling
This section explains how to control how credentials are handled in Neo4j Browser.

Neo4j Browser has two mechanisms for avoiding users having to repeatedly enter their Neo4j credentials.

First, while the Browser is open in a web browser tab, it ensures that the existing database session is kept alive. This is subject to a timeout. The timeout is configured in the setting browser.credential_timeout. The timeout is reset whenever there is user interaction with the Browser.

Second, the Browser can also cache the user’s Neo4j credentials locally. When credentials are cached, they are stored unencrypted in the web browser’s local storage. If the web browser tab is closed and then re-opened, the session is automatically re-established using the cached credentials. This local storage is also subject to the timeout configured in the setting browser.credential_timeout. In addition, caching credentials in browser local storage can be disabled altogether. To disable credentials caching, set
browser.retain_connection_credentials=false in the server configuration.

If the user issues a :server disconnect command then any existing session is terminated and the credentials are cleared from local storage.

---

For more information on how to administer and use Neo4j Browser, see the Neo4j Browser manual → Browser operations.

12.4. Security checklist

This section provides a summary of recommendations regarding security in Neo4j.

Below is a simple checklist highlighting the specific areas within Neo4j that may need some extra attention in order to ensure the appropriate level of security for your application.

1. Deploy Neo4j on safe servers in safe networks:
   a. Use subnets and firewalls.
   b. Only open up for the necessary ports. For a list of relevant ports see Ports.
      In particular, ensure that there is no external access to the port specified by the setting `dbms.backup.listen_address`. Failing to protect this port may leave a security hole open by which an unauthorized user can make a copy of the database onto a different machine.

2. Protect data-at-rest:
   a. Use volume encryption (e.g. Bitlocker).
   b. Manage access to database dumps (refer to Back up an offline database) and backups (refer to Back up an online database).
   c. Manage access to data files and transaction logs by ensuring the correct file permissions on the Neo4j files. Refer to File permissions for instructions on permission levels.

3. Protect data-in-transit:
   a. For remote access to the Neo4j database, only open up for encrypted Bolt or HTTPS.
   b. Use SSL certificates issued from a trusted Certificate Authority.
      i. For configuring your Neo4j installation to use encrypted communication, refer to SSL framework.
      ii. If using Causal Clustering, configure and use encryption for intra-cluster communication. For details, see Intra-cluster encryption.
      iii. If using Causal Clustering, configure and use encryption for backups. This ensures that only servers with the specified SSL policy and SSL certificates will be able to access the server and perform the backup.
      iv. For configuring your Bolt and/or HTTPS connectors, refer to Configure connectors.
      v. If using LDAP, configure your LDAP system with encryption via StartTLS; see Use LDAP with encryption via StartTLS.
4. Be on top of the security for custom extensions:
   a. Validate any custom code that you deploy (procedures and unmanaged extensions) and ensure that they do not expose any parts of the product or data unintentionally.
   b. Survey the settings `dbms.security.procedures.unrestricted` and `dbms.security.procedures.allowlist` to ensure that they exclusively contain intentionally exposed extensions.

5. Ensure the correct file permissions on the Neo4j files.

6. Protect against the execution of unauthorized extensions by restricting access to the `bin`, `lib`, and `plugins` directories. Only the operating system user that Neo4j runs as should have permissions to those files. Refer to File permissions for instructions on permission levels.

7. If `LOAD CSV` is enabled, ensure that it does not allow unauthorized users to import data. How to configure `LOAD CSV` is described in Cypher Manual → LOAD CSV.

8. Use Neo4j authentication. The setting `dbms.security.auth_enabled` controls native authentication. The default value is `true`, which enables the native auth provider.

9. Survey your `neo4j.conf` file for ports relating to deprecated functions such as remote JMX (controlled by the parameter setting `dbms.jvm.additional=-Dcom.sun.management.jmxremote.port=3637`).

10. Review Browser credentials handling to determine whether the default credentials handling in Neo4j Browser complies with your security regulations. Follow the instructions to configure it if necessary.

11. Use the latest patch version of Neo4j.
Chapter 13. Performance

This chapter describes factors that affect operational performance, and how to tune Neo4j for optimal throughput.

The topics described in this chapter are:

- **Memory configuration** — How to configure memory settings for efficient operations.
- **Index configuration** — How to configure indexes.
- **Garbage collector** — How to configure the Java Virtual Machine’s garbage collector.
- **Bolt thread pool configuration** — How to configure the Bolt thread pool.
- **Linux file system tuning** — How to configure the Linux file system.
- **Disks, RAM and other tips** — Disks, RAM and other tips.
- **Statistics and execution plans** — How schema statistics and execution plans affect Cypher query performance.
- **Space reuse** — Data deletion and storage space reuse.

13.1. Memory configuration

This section describes the different aspects of Neo4j memory configuration and use.

13.1.1. Overview

The RAM of the Neo4j server has a number of usage areas, with some sub-areas:
OS memory

Some memory must be reserved for running the processes of the operating system itself. It is not possible to explicitly configure the amount of RAM that should be reserved for the operating system, as this is what RAM remains available after configuring Neo4j. If you do not leave enough space for the OS, it will start to swap memory to disk, which will heavily affect performance.

1GB is a good starting point for a server that is dedicated to running Neo4j. However, there are cases where the amount reserved for the OS is significantly larger than 1GB, such as servers with exceptionally large RAM.

JVM Heap

The JVM heap is a separate dynamic memory allocation that Neo4j uses to store instantiated Java objects. The memory for the Java objects are managed automatically by a garbage collector. Particularly important is that a garbage collector automatically handles the deletion of unused objects. For more information on how the garbage collector works and how to tune it, see Tuning of the garbage collector.

The heap memory size is determined by the parameters `dbms.memory.heap.initial_size` and `dbms.memory.heap.max_size`. It is recommended to set these two parameters to the same value to avoid unwanted full garbage collection pauses.

Generally, to aid performance, you should configure a large enough heap to sustain concurrent operations.

Native memory

Native memory, sometimes referred to as off-heap memory, is memory directly allocated by Neo4j from the OS. This memory will grow dynamically as needed and is not subject to the garbage collector.
DBMS
The database management system, or DBMS, contains the global components of the Neo4j instance. For example, the bolt server, logging service, monitoring service, etc.

Database
Each database in the system comes with an overhead. In deployments with multiple databases, this overhead needs to be accounted for.

Transaction
When executing a transaction, Neo4j holds not yet committed data, the result, and intermediate states of the queries in memory. The size needed for this is very dependent on the nature of the usage of Neo4j. For example, long-running queries, or very complicated queries, are likely to require more memory. Some parts of the transactions can optionally be placed off-heap, but for the best performance, it is recommended to keep the default with everything on-heap.

This memory group can be limited with the setting `dbms.memory.transaction.global_max_size`.

Page cache
The page cache is used to cache the Neo4j data stored on disk. The caching of graph data and indexes into memory helps avoid costly disk access and result in optimal performance.

The parameter for specifying how much memory Neo4j is allowed to use for the page cache is: `dbms.memory.pagecache.size`.

Network buffers
Direct buffers are used by Neo4j to send and receive data. Direct byte buffers are important for improving performance because they allow native code and Java code to share data without copying it. However, they are expensive to create, which means byte buffers are usually reused once they are created.

Other shared buffers
This includes unspecified shared direct buffers.

JVM overhead
The JVM will require some memory to function correctly. For example, this can be:

- **Thread stacks** – Each thread has its own call stack. The stack stores primitive local variables and object references along with the call stack (list of method invocations) itself. The stack is cleaned up as stack frames move out of context, so there is no GC performed here.
- **Metaspace** – Metaspace stores the java class definitions and some other metadata.
- **Code cache** – The JIT compiler stores the native code it generates in the code cache to improve performance by reusing it.

For more details and means of limiting the memory used by the JVM please consult your JVM documentation.
13.1.2. Considerations

Always use explicit configuration

To have good control of the system behavior, it is recommended to always define the page cache and heap size parameters explicitly in `neo4j.conf`. Otherwise, Neo4j computes some heuristic values at startup based on the available system resources.

Initial memory recommendation

Use the `neo4j-admin memrec` command to get an initial recommendation for how to distribute a certain amount of memory. The values may need to be adjusted to cater for each specific use case.

Inspect the memory settings of all databases in a DBMS

The `neo4j-admin memrec` command is useful for inspecting the current distribution of data and indexes.

Example 82. Use `neo4j-admin memrec` to inspect the memory settings of all your databases

Estimate the total size of the database files.

```
$neo4j-home> bin/neo4j-admin memrec
...

# Total size of lucene indexes in all databases: 6690m
# Total size of data and native indexes in all databases: 17050m
```

You can see that the Lucene indexes take up approximately 6.7GB of data, and that the data volume and native indexes combined take up approximately 17GB.

Using this information, you can do a sanity check of your memory configuration:

- Compare the value for data volume and native indexes to the value of `dbms.memory.pagecache.size`.
- For cases when off-heap transaction state is used, estimate transactional workload and how much memory is left to the value of `dbms.tx_state.max_off_heap_memory`.
- Compare the value for Lucene indexes to how much memory is left after assigning `dbms.memory.pagecache.size` and `dbms.memory.heap.initial_size`.

In some production systems the access to memory is limited and must be negotiated between different areas. Therefore, it is recommended to perform a certain amount of testing and tuning of these settings to figure out the optimal division of the available memory.

Limit transaction memory usage recommendation

The measured heap usage of all transactions is only an estimate and the actual heap utilization may be slightly larger or slightly smaller than the estimated value. In some cases, limitations of the estimation algorithm to detect shared objects at a deeper level of the memory graph could lead to overestimations. This is because a conservative estimate is given based on aggregated estimations of memory usage, where the identities of all contributing objects are not known, and cannot be assumed to be shared. For
example, when you use \texttt{UNWIND} on a very large list, or expand a variable length or shortest path pattern, where many relationships are shared between the computed result paths.

In these cases, if you experience problems with a query that gets terminated, you can execute the same query with the \texttt{transaction memory limit} disabled. If the actual heap usage is not too large, it might succeed without triggering an out-of-memory error.

13.1.3. Capacity planning

In many use cases, it is advantageous to try to cache as much of the data and indexes as possible. The following examples illustrate methods for estimating the page cache size, depending on whether you are already running in production or planning for a future deployment:

Example 83. Estimate page cache for the existing Neo4j databases

First, estimate the total size of data and indexes, and then multiply with some factor, for example 20%, to allow for growth.

```bash
$neo4j-home> bin/neo4j-admin memrec
... ...
# Total size of lucene indexes in all databases: 6690m
# Total size of data and native indexes in all databases: 35050m
```

You can see that the data volume and native indexes combined take up approximately 35GB. In your specific use case, you estimate that 20% will provide sufficient head room for growth.

\[
dbms.memory.pagecache.size = 1.2 \times (35GB) = 42GB
\]

You configure the page cache by adding the following to `neo4j.conf`:

```bash
dbms.memory.pagecache.size=42GB
```
When planning for a future database, it is useful to run an import with a fraction of the data, and then multiply the resulting store size delta by that fraction plus some percentage for growth.

1. Run the `memrec` command to see the total size of the data and indexes in all current databases.

```
$neo4j-home> bin/neo4j-admin memrec
...
...
# Total size of lucene indexes in all databases: 6690m
# Total size of data and native indexes in all databases: 35050m
```

2. Import 1/100th of the data and again measure the data volume and native indexes of all databases.

```
$neo4j-home> bin/neo4j-admin memrec
...
...
# Total size of lucene indexes in all databases: 6690m
# Total size of data and native indexes in all databases: 35400m
```

You can see that the data volume and native indexes combined take up approximately 35.4GB.

3. Multiply the resulting store size delta by that fraction.

```
35.4GB - 35GB = 0.4GB * 100 = 40GB
```

4. Multiply that number by 1.2 to size up the result, and allow for 20% growth.

```
dbms.memory.pagecache.size = 1.2 * (40GB) = 48GB
```

5. Configure the page cache by adding the following to `neo4j.conf`:

```
dbms.memory.pagecache.size=48G
```

### 13.1.4. Limit transaction memory usage

By using the `dbms.memory.transaction.global_max_size` setting you can configure a global maximum memory usage for all of the transactions running on the server. This setting must be configured low enough so that you do not run out of memory. If you are experiencing `OutOfMemory` messages during high transaction load, try to lower this limit.

Neo4j also offers the following settings to provide fairness, which can help improve stability in multi-tenant deployments.

- The setting `dbms.memory.transaction.database_max_size` limits the transaction memory usage per database.
- The setting `dbms.memory.transaction.max_size` constrains each transaction.
When any of the limits are reached, the transaction is terminated without affecting the overall health of the database.

To help configure these settings you can use the following commands to list the current usage:

```sql
CALL dbms.listPools()
CALL dbms.listTransactions()
CALL dbms.listQueries()
```

Or alternatively, you can enable `dbms.logs.query.allocation_logging_enabled` and monitor the memory usage of each query in the query.log.

By default, transaction sizes are unconstrained. However, in a Cluster deployment, where an instance is configured as either a Single, Core or a Read Replica, the maximum amount of memory each transaction is permitted to use is 2GB. Consequently, if your configuration contains `dbms.mode=SINGLE`, `dbms.mode=CORE`, or `dbms.mode=READ_REPLICA`, the largest value permitted for the `dbms.memory.transaction.max_size` setting is also 2GB.

13.2. Index configuration

How to configure indexes to enhance performance in search, and to enable full-text search.

13.2.1. Introduction

In Neo4j there are four different index types: b-tree, full-text, text, and token lookup.

All four types of indexes can be created and dropped using Cypher and they can also all be used to index both nodes and relationships. The token lookup index is the only index present by default in the database.

B-tree, text and full-text indexes provide mapping from a property value to an entity (node or relationship). Token lookup indexes are different and provide mapping from labels to nodes, or from relationships types to relationships, instead of between properties and entities.

Users are not required to know the difference between the various indexes in order to use them, since Cypher’s query planner decides which index to use in which situation.

For for information on the available indexes and their configuration aspects, see below. For further details on creating, querying and dropping indexes, see Cypher Manual → Indexes for search performance and Cypher Manual → Indexes to support full-text search.

The type of an index can be identified according to the table below:

<table>
<thead>
<tr>
<th>Index type</th>
<th>Cypher command</th>
<th>Core API</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-tree index</td>
<td><code>SHOW INDEXES#BTREE</code></td>
<td><code>org.neo4j.graphdb.schema.IndexType#B TREE</code></td>
</tr>
</tbody>
</table>
### 13.2.2. B-tree indexes

B-tree indexes are deprecated, partially replaced for now, and will be fully replaced in 5.0 by the future indexes. In 4.4, b-tree indexes are still the correct alternative to use except for when the `lucene+native-3.0` provider is used. A new text index type has been introduced to handle the case `lucene+native-3.0` covered for single property strings.

B-tree indexes are good for exact look-ups on all types of values, range scans, full scans, and prefix searches. They can be backed by two different index providers, `native-btree-1.0` and `lucene+native-3.0`. If not explicitly set, `native-btree-1.0` will be used.

#### Limitations

There are a few limitations for b-tree indexes, which are listed below together with suggested workarounds.

#### Limitations for queries using `CONTAINS` and `ENDS WITH`

The index provider `native-btree-1.0` has limited support for `ENDS WITH` and `CONTAINS` queries. These queries are not able to do an optimized search as per queries that use `STARTS WITH`, `=`, and `<-->`. Instead, the index result is a stream of an index scan with filtering.

`ENDS WITH` and `CONTAINS` queries are natively supported by text indexes and these types of queries are handled by a text index in a more performant way compared to a b-tree index. Even though the deprecated index provider `lucene+native-3.0` can also be used for these types of queries, it provides no extra value over a text index and it will be removed in 5.0.

- For details about execution plans, refer to Cypher Manual → Execution plans.
- For details about string operators, refer to Cypher Manual → Operators.

#### Limitations on key size

The index provider `native-btree-1.0` has a key size limit of around 8kB.
If a transaction reaches the key size limit for one or more of its changes, that transaction fails before committing any changes. If the limit is reached during index population, the resulting index is in a failed state, and as such is not usable for any queries.

If this is an issue, you can use the index provider `lucene+native-3.0` instead. This provider has a key size limit for single property strings of around 32kB.

Workarounds to address limitations

To work around problems with key size or performance issues related to `ENDS WITH` or `CONTAINS`, the text index type or the deprecated index provider `lucene+native-3.0` can be used. This only works for single-property string indexes.

Alternatively, this can still be done using any of the following methods:

- **Use `lucene+native-3.0` in OPTIONS clause in create command**

  Note that this option uses the `lucene+native-3.0` index provider that has been deprecated and will be removed in a future release.

  The Cypher commands for index creation, unique property constraint creation, and node key creation contains an optional OPTIONS clause. This clause can be used to specify index provider.

  For details on indexes, see Cypher Manual → Indexes for search performance. For details on constraints, see Cypher manual → Constraints.

- **Use a built-in procedure**

  Note that this option uses built-in procedures that have been deprecated, and will be removed in a future release. These have been replaced with the Cypher commands in Option 1.

  The built-in procedures `db.createIndex`, `db.createUniquePropertyConstraint`, and `db.createNodeKey` can be used to specify index provider on index creation, unique property constraint creation, and node key creation.

  For details on constraints, see Cypher manual → Constraints, and for more information on built-in procedures, see Procedures.

- **Change the config**

  Note that this option uses the index setting `dbms.index.default_schema_provider`, which has been deprecated and will be removed in a future release. It will be a fully internal concern which index provider an index is using.

  1. Configure the setting `dbms.index.default_schema_provider` to the one required.
2. Restart Neo4j.

3. Drop and recreate the relevant index.

4. Change `dbms.index.default_schema_provider` back to the original value.

5. Restart Neo4j.

The recommended way to set index provider for an index is to use the `OPTIONS` clause for index creation, unique property constraint creation, and node key creation. For more information, see Cypher Manual → Indexes for search performance and Cypher manual → Constraints.

**Index migration**

When upgrading a 3.5 store to 4.4.10, all indexes are upgraded to the latest index version, and rebuilt automatically, with the exception for the indexes that were previously using Lucene for single-property strings. They are upgraded to a fallback version which still uses Lucene for those properties. Note that they still need to be rebuilt. For more information, see Upgrade and Migration Guide → Neo4j indexes.

**Procedures to create index and index backed constraint**

Indexes and constraints are best created through Cypher, but can still be created through the deprecated procedures described in the example below. Index provider and index settings can both be specified using the optional `OPTIONS` clause for the Cypher commands.

**Example 85. Example of procedures to create index and index backed constraint**

The following procedures provide the option to specify both index provider and index settings (optional). Note that settings keys need to be escaped with back-ticks if they contain dots.

Use `db.createIndex` procedure to create an index:

```
CALL db.createIndex("MyIndex", ["Person"], ["name"], "native-btree-1.0", {
`spatial.cartesian.max`: [100.0, 100.0],
`spatial.cartesian.min`: [-100.0, -100.0]
})
```

If a settings map is not provided, the settings are picked up from the Neo4j config file, the same way as when creating an index or constraint through Cypher.

```
CALL db.createIndex("MyIndex", ["Person"], ["name"], "native-btree-1.0")
```

Use `db.createUniquePropertyConstraint` to create a node property uniqueness constraint (the example is without settings map, left out for abbreviation):

```
CALL db.createUniquePropertyConstraint("MyIndex", ["Person"], ["name"], "native-btree-1.0")
```

Use `db.createNodeKey` to create node key constraint (the example is without settings map, left out for abbreviation):

```
CALL db.createNodeKey("MyIndex", ["Person"], ["name"], "native-btree-1.0")
```
13.2.3. Text indexes

Text indexes are a type of single-property index and only index properties with string values, unlike b-tree indexes. They are specifically designed to deal with `ENDS WITH` or `CONTAINS` queries efficiently. They are used through Cypher and they support a smaller set of string queries. Even though text indexes do support other text queries, `ENDS WITH` or `CONTAINS` queries are the only ones for which this index type provides an advantage over a b-tree index.

For more information on the queries a text index can be used for, refer to Cypher Manual → Query Tuning → The use of indexes. For more information on the different index types, refer to Cypher Manual → Indexes for search performance.

Limitations

Text indexes only index single property strings. If the property to index can contain several value types, but string-specific queries are also performed, it is possible to have both a b-tree and a text index on the same schema.

The index has a key size limit for single property strings of around 32kB. If a transaction reaches the key size limit for one or more of its changes, that transaction fails before committing any changes. If the limit is reached during index population, the resulting index is in a failed state, and as such is not usable for any queries.

13.2.4. Full-text indexes

Full-text indexes are optimized for indexing and searching text. They make it possible to write queries that match within the contents of indexed string properties. In other words, they are used for queries that demand an understanding of language and they only index string data. They must also be queried explicitly via procedures, as Cypher does not make plans that rely on them.

An example of a use case for full-text indexes is parsing a book for a certain term and taking advantage of the knowledge that the book is written in a certain language. The use of an analyzer for that language enables the exclusion of words that are not relevant for the search (for example "if" and "and"), and include conjugations of words that are.

Another use case example is indexing the various address fields and text data in a corpus of emails. Indexing this data using the `email` analyzer makes it possible to find all emails that are sent from, or to, or mentions, an email account.

In contrast to b-tree and text indexes, full-text indexes are queried using built-in procedures. They are however created and dropped using Cypher. The use of full-text indexes does require familiarity with how the indexes operate.

Full-text indexes are powered by the Apache Lucene indexing and search library. A full description on how to create and use full-text indexes is provided in the Cypher Manual → Indexes to support full-text search.
Configuration

The following options are available for configuring full-text indexes:

dbms.index.fulltext.default_analyzer

The name of the analyzer that the full-text indexes should use by default. This setting only has effect when a full-text index is created, and will be remembered as an index-specific setting from then on.

The list of possible analyzers is available through the `db.index.fulltext.listAvailableAnalyzers()` Cypher procedure.

Unless otherwise specified, the default analyzer is `standard-no-stop-words`, which is the same as the `StandardAnalyzer` from Lucene, except no stop-words are filtered out.

dbms.index.fulltext.eventually_consistent

Used to declare whether full-text indexes should be eventually consistent, or not. This setting only has effect when a full-text index is created, and is remembered as an index-specific setting from then on.

Indexes are normally fully consistent, and the committing of a transaction does not return until both the store and the indexes have been updated. Eventually consistent full-text indexes, on the other hand, are not updated as part of commit, but instead have their updates queued up and applied in a background thread. This means that there can be a short delay between committing a change, and that change becoming visible via any eventually consistent full-text indexes. This delay is just an artifact of the queueing, and is usually quite small since eventually consistent indexes are updated "as soon as possible".

By default, this is turned off, and full-text indexes are fully consistent.

dbms.index.fulltext.eventually_consistent_index_update_queue_max_length

Eventually consistent full-text indexes have their updates queued up and applied in a background thread, and this setting determines the maximum size of that update queue. If the maximum queue size is reached, then committing transactions block and wait until there is more room in the queue, before adding more updates to it.

This setting applies to all eventually consistent full-text indexes, and they all use the same queue. The maximum queue length must be at least 1 index update, and must be no more than 50 million due to heap space usage considerations.

The default maximum queue length is 10,000 index updates.

13.2.5. Token lookup indexes

Token lookup indexes, as the name suggests, are used to look up nodes with a specific label or relationships of a specific type. A token lookup index is always created over all labels or relationship types, respectively, and hence there can only be a maximum of two token lookup indexes in a database - one for nodes and one for relationships.

Token lookup indexes are introduced in 4.3 and whereas relationship type lookup index is a new concept, node label lookup index is not. The latter evolved from the label scan store, which has been present in
various forms for a long time. Node label lookup index provides the same functionality as the former label scan store, but has additional features that are common for all indexes, such as the ability to be created and dropped using non-blocking population.

Use and Significance

Token lookup indexes are the most important indexes that can be present in a database. They are essential for both Cypher queries and Core API operations. More importantly, their presence speeds up the population of other indexes significantly, node label lookup index for node b-tree and full-text indexes and relationship type lookup index for the corresponding relationship indexes.

The node label lookup index is important for queries that match a node by one or more labels. It can be used even when matching labels and properties of a node, if there are no suitable b-tree indexes available. This is essential considering that no b-tree indexes are defined by default. In other words, a node label lookup index is often the best way to approach a query that matches labels, unless the user has defined a more appropriate b-tree index. Accordingly, the relationship type lookup index does the same for relationships and their types.

Most queries are executed by matching nodes and expanding their relationships, and hence the node label lookup index is slightly more significant than the relationship type lookup index.

Since these indexes are important for both query execution and index population, a lot of consideration should be taken before dropping them.

Both node and relationship type lookup index are present by default in all databases created in 4.3 and onwards. Please see the next section for details on databases created in earlier versions.

Databases created before 4.3

Databases created before 4.3 get only a node label lookup index when used in a DBMS of version 4.3 or later, by default. This is to preserve backwards compatibility and performance characteristics of such databases.

If needed, such databases can get a relationship type lookup index by creating it explicitly through Cypher.

Creating relationship type lookup index on a large database can take significant amount of time as all relationships need to be scanned when populating such index.

When used in a DBMS of version 4.3 or later, databases created before 4.3 automatically get a node label lookup index, which is created by converting the former label scan store and naming it __org_neo4j_schema_index_label_scan_store_converted_to_token_index. This index name is reserved from 4.3 onwards, and an error is returned if you attempt to create a user-defined index with this name. Similarly, in the unlikely situation that an index with such name was created in previous versions, it must be dropped and recreated with a different name before upgrading to 4.3.

The following table summarizes which of token lookup indexes and label scan store are present by default in various versions. Note that the table represents only the default indexes and that the relationship type lookup index can be created explicitly through Cypher if needed.
### 13.2.6. Future indexes

Two new index types, range and point index, will be introduced in 5.0. They will, together with the text index, replace the deprecated b-tree indexes.

Like the b-tree index, the range index will index all types of values and be good for exact lookups on all types of values, range scans, full scans, and prefix searches. The difference is that range index will not support spatial queries and therefore will not have the same config options. It will still index the point values to support full scans, but if spatial queries are needed, a point index should be created.

The point index is a highly specialized single-property index that is optimized for spatial queries. It only indexes point values and exact lookups are the only non-spatial query it supports.

These indexes can be created on the same combination of property and label/relationship type if the functionality of both is needed.

It is possible to create and drop these index types, but they cannot be used in queries yet. They are introduced now to allow a smoother migration to 5.0 later. See Cypher Manual → Indexes for search performance → Future indexes for the new syntax.

### 13.3. Tuning of the garbage collector

This section discusses the effect of the Java Virtual Machine’s garbage collector with regards to Neo4j performance.

The heap is separated into an old generation and a young generation. New objects are allocated in the young generation, and then later moved to the old generation, if they stay live (in use) for long enough. When a generation fills up, the garbage collector performs a collection, during which all other threads in the process are paused. The young generation is quick to collect since the pause time correlates with the live set of objects. In the old generation, pause times roughly correlates with the size of the heap. For this reason, the heap should ideally be sized and tuned such that transaction and query state never makes it to the old generation.

The heap size is configured with the `dbms.memory.heap.max_size` (in MBs) setting in the `neo4j.conf` file. The initial size of the heap is specified by the `dbms.memory.heap.initial_size` setting, or with the `–Xms??m` flag, or chosen heuristically by the JVM itself if left unspecified. The JVM will automatically grow the heap as needed, up to the maximum size. The growing of the heap requires a full garbage collection cycle. It is recommended to set the initial heap size and the maximum heap size to the same value. This
way the pause that happens when the garbage collector grows the heap can be avoided.

If the new generation is too small, short-lived objects may be moved to the old generation too soon. This is called premature promotion and will slow the database down by increasing the frequency of old generation garbage collection cycles. If the new generation is too big, the garbage collector may decide that the old generation does not have enough space to fit all the objects it expects to promote from the new to the old generation. This turns new generation garbage collection cycles into old generation garbage collection cycles, again slowing the database down. Running more concurrent threads means that more allocations can take place in a given span of time, in turn increasing the pressure on the new generation in particular.

The Compressed OOPs feature in the JVM allows object references to be compressed to use only 32 bits. The feature saves a lot of memory but is only available for heaps up to 32 GB. The maximum applicable size varies from platform and JVM version. The `-XX:+UseCompressedOops` option can be used to verify whether the system can use the Compressed OOPs feature. If it cannot, this will be logged in the default process output stream.

How to tune the specific garbage collection algorithm depends on both the JVM version and the workload. It is recommended to test the garbage collection settings under realistic load for days or weeks. Problems like heap fragmentation can take a long time to surface.

To gain good performance, these are the things to look into first:

- Make sure the JVM is not spending too much time performing garbage collection. The goal is to have a large enough heap to make sure that heavy/peak load will not result in so called GC-trashing. Performance can drop as much as two orders of magnitude when GC-trashing happens. Having too large heap may also hurt performance so you may have to try some different heap sizes.
- Neo4j needs enough heap memory for the transaction state and query processing, plus some head-room for the garbage collector. As heap memory requirements are so workload-dependent, it is common to see heap memory configurations from 1 GB, up to 32 GB.

Edit the following properties:

<table>
<thead>
<tr>
<th>Property Name</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>dbms.memory.heap.initial_size</td>
<td>initial heap size (in MB)</td>
</tr>
<tr>
<td>dbms.memory.heap.max_size</td>
<td>maximum heap size (in MB)</td>
</tr>
<tr>
<td>dbms.jvm.additional</td>
<td>additional literal JVM parameter</td>
</tr>
</tbody>
</table>

13.4. Bolt thread pool configuration

This section discusses the thread pool infrastructure built into Bolt connectors, and how it can be configured.
The Bolt connector is backed by a thread pool on the server side. The thread pool is constructed as part of the server startup process.

13.4.1. How thread pooling works

The Bolt thread pool has a minimum and a maximum capacity. It starts with a minimum number of threads available, and grows up to the maximum count depending on the workload. Threads that sit idle for longer than a specified time period are stopped and removed from the pool in order to free up resources. However, the size of the pool will never go below the minimum.

Each connection being established is assigned to the connector’s thread pool. Idle connections do not consume any resources on the server side, and they are monitored against messages arriving from the client. Each message arriving on a connection triggers the scheduling of a connection on an available thread in the thread pool. If all the available threads are busy, and there is still space to grow, a new thread is created and the connection is handed over to it for processing. If the pool capacity is filled up, and no threads are available to process, the job submission is rejected and a failure message is generated to notify the client of the problem.

The default values assigned to the Bolt thread pool will fit most workloads, so it is generally not necessary to configure the connection pool explicitly. If the maximum pool size is set too low, an exception will be thrown with an error message indicating that there are no available threads to serve. The message will also be written to neo4j.log.

Any connection with an active explicit, or implicit, transaction will stick to the thread that starts the transaction, and will not return that thread to the pool until the transaction is closed. Therefore, in applications that are making use of explicit transactions, it is important to close the transactions appropriately. To learn more about transactions, refer to the Neo4j Driver manuals.

13.4.2. Configuration options

The following configuration options are available for configuring the Bolt connector:

Table 51. Thread pool options

<table>
<thead>
<tr>
<th>Option name</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>dbms.connector.bolt.thread_pool_min_size</td>
<td>5</td>
<td>The minimum number of threads that will always be up even if they are idle.</td>
</tr>
<tr>
<td>dbms.connector.bolt.thread_pool_max_size</td>
<td>400</td>
<td>The maximum number of threads that will be created by the thread pool.</td>
</tr>
<tr>
<td>dbms.connector.bolt.thread_pool_keep_alive</td>
<td>5m</td>
<td>The duration that the thread pool will wait before killing an idle thread from the pool. However, the number of threads will never go below dbms.connector.bolt.thread_pool_min_size.</td>
</tr>
</tbody>
</table>
13.4.3. How to size your Bolt thread pool

Select values for thread pool sizing based on your workload. Since each active transaction will borrow a thread from the pool until the transaction is closed, it is basically the minimum and maximum active transaction at any given time that determine the values for pool configuration options. You can use the monitoring capabilities (see Monitoring) of the database to discover more about your workload.

Configure `dbms.connector.bolt.thread_pool_min_size` based on your minimum or average workload. Since there will always be this many amount of threads in the thread pool, sticking with lower values may be more resource-friendly than having too many idle threads waiting for job submissions.

Configure `dbms.connector.bolt.thread_pool_max_size` based on your maximum workload. This should basically be set after the maximum number of active transactions that is expected on the server. You should also account for non-transaction operations that will take place on the thread pool, such as connection and disconnection of clients.

Example 86. Configure the thread pool for a Bolt connector

In this example we configure the Bolt thread pool to be of minimum size 5, maximum size 100, and have a keep-alive time of 10 minutes.

```
$ dbms.connector.bolt.thread_pool_min_size=10
$ dbms.connector.bolt.thread_pool_max_size=100
$ dbms.connector.bolt.thread_pool_keep_alive=10m
```

13.5. Linux file system tuning

This section covers Neo4j I/O behavior, and how to optimize for operations on disk.

Databases often produce many small and random reads when querying data, and few sequential writes when committing changes. For maximum performance, it is recommended to store database and transaction logs on separate physical devices.

Often, recommended practice is to disable file and directory access time updates. This way, the file system won’t have to issue writes that update this meta-data, thus improving write performance.

Since databases can put a high and consistent load on a storage system for a long time, it is recommended to use a file system that has good aging characteristics. The EXT4 and XFS file systems are both supported.

A high read and write I/O load can also degrade SSD performance over time. The first line of defense against SSD wear is to ensure that the working dataset fits in RAM. A database with a high write workload will, however, still cause wear on SSDs. The simplest way to combat this is to over-provision; use SSDs that are at least 20% larger than you strictly need them to be.

⚠️ Neo4j does not recommend and support the usage of NFS or NAS as database storage.
13.6. Disks, RAM and other tips

This section provides an overview of performance considerations for disk and RAM when running Neo4j.

As with any persistence solution, performance depends a lot on the persistence media used. In general, the faster storage you have, and the more of your data you can fit in RAM, the better performance you will get.

13.6.1. Storage

There are many performance characteristics to consider for your storage solutions. The performance can vary hugely in orders of magnitude. Generally, having all your data in RAM achieves maximum performance.

If you have multiple disks or persistence media available, it may be a good idea to divide the store files and transaction logs across those disks. Keeping the store files on disks with low seek time can do wonders for read operations.

Use tools like `dstat` or `vmstat` to gather information when your application is running. If the swap or paging numbers are high, that is a sign that the database does not quite fit in memory. In this case, database access can have high latencies.

To achieve maximum performance, it is recommended to provide Neo4j with as much RAM as possible to avoid hitting the disk.

13.6.2. Page cache

When Neo4j starts up, its page cache is empty and needs to warm up. The pages, and their graph data contents, are loaded into memory on demand as queries need them. This can take a while, especially for large stores. It is not uncommon to see a long period with many blocks being read from the drive, and high IO wait times. This will show up in the page cache metrics as an initial spike in page faults. The page fault spike is then followed by a gradual decline of page fault activity, as the probability of queries needing a page that is not yet in memory drops.

13.6.3. Active page cache warmup [Enterprise edition]

Neo4j Enterprise Edition has a feature called active page cache warmup, which is enabled by default via the `dbms.memory.pagecache.warmup.enable` configuration setting.

**How it works**

It shortens the page fault spike and makes the page cache warm up faster. This is done by periodically recording cache profiles of the store files while the database is running. These profiles contain information about what data is and is not in memory and are stored in the `data/databases/mydatabase/profiles` directory. When Neo4j is restarted next time, it looks for these cache profiles and loads the same data that was in memory when the profile was created. The profiles are also copied as part of the online backup and
cluster store-copy operations and help warm up new databases that join a cluster.

The setting should remain enabled for most scenarios. However, when the workload changes after the database restarts, the setting can be disabled to avoid spending time fetching data that will be directly evicted.

Configuration options

Load the entire database into memory

It is also possible to configure `dbms.memory.pagecache.warmup.preload` to load the entire database data into memory. This is useful when the size of the database store is smaller than the available memory for the page cache. When enabled, it disables warmup by profile and prefetches data into the page cache as part of the startup.

Load specified files into memory

The files that you want to prefetched can be filtered using the `dbms.memory.pagecache.warmup.preload.allowlist` setting. It takes a regular expression as a value to match the files.

Example 87. Load only the nodes and relationships

For example, if you want to load only the nodes and relationships, you can use the regex `.*\(node|relationship\).*` to match the name of the store files. The active page cache warmup will prefetch the content of the following files:

```plaintext
neostore.nodestore.db
neostore.nodestore.db.id
neostore.nodestore.db.labels
neostore.nodestore.db.labels.id
neostore.relationshipgroupstore.db
neostore.relationshipgroupstore.db.id
neostore.relationshipstore.db
neostore.relationshipstore.db.id
neostore.relationshiptypestore.db
neostore.relationshiptypestore.db.id
neostore.relationshiptypestore.db.names
neostore.relationshiptypestore.db.names.id
```

And can be verified using unix `grep`:

```plaintext
ls neo4j/ | grep -E '.*(node|relationship).*
```

Configure the profile frequency for the page cache

The profile frequency is the rate at which the profiles are re-generated. More frequent means more accurate. A profile contains information about those parts of the files that are currently loaded into memory. By default, it is set to `dbms.memory.pagecache.warmup.profile.interval=1m`. It takes some time to generate these profiles, and therefore `1m` is a good interval. If the workload is very stable, then the profile will not change much. Accordingly, if the workload changes often, the profile will thus often become outdated.
13.6.4. Checkpoint IOPS limit

Neo4j flushes its page cache in the background as part of its checkpoint process. This will show up as a period of elevated write IO activity. If the database is serving a write-heavy workload, the checkpoint can slow the database down by reducing the IO bandwidth that is available to query processing. Running the database on a fast SSD, which can service a lot of random IOs, significantly reduces this problem. If a fast SSD is not available in your environment, or if it is insufficient, then an artificial IOPS limit can be placed on the checkpoint process. The `dbms.checkpoint.iops.limit` restricts the IO bandwidth that the checkpoint process is allowed to use. Each IO is, in the case of the checkpoint process, an 8 KiB write. An IOPS limit of 600, for instance, would thus only allow the checkpoint process to write at a rate of roughly 5 MiB per second. This will, on the other hand, make checkpoints take longer to complete. A longer time between checkpoints can cause more transaction log data to accumulate, and can lengthen recovery times. See the transaction logs section for more details on the relationship between checkpoints and log pruning. The IOPS limit can be changed at runtime, making it possible to tune it until you have the right balance between IO usage and checkpoint time.

13.7. Statistics and execution plans

This section describes how to configure the Neo4j statistics collection and the query replanning in the Cypher query engine.

When a Cypher query is issued, it gets compiled to an execution plan that can run and answer the query. The Cypher query engine uses the available information about the database, such as schema information about which indexes and constraints exist in the database. Neo4j also uses statistical information about the database to optimize the execution plan. For more information, see Cypher Manual → Query tuning and Cypher Manual → Execution plans.

13.7.1. Configure statistics collection

The Cypher query planner depends on accurate statistics to create efficient plans. Therefore, these statistics are kept up-to-date as the database evolves.

For each database in the DBMS, Neo4j collects the following statistical information and keeps it up-to-date:

For graph entities
- The number of nodes with a certain label.
- The number of relationships by type.
- The number of relationships by type between nodes with a specific label.

These numbers are updated whenever you set or remove a label from a node.

For database schema
- Selectivity per index.

To produce a selectivity number, Neo4j runs a full index scan in the background. Because this could
potentially be a very time-consuming operation, a full index scan is triggered only when the changed data reaches a specified threshold.

### Automatic statistics collection

You can control whether and how often statistics are collected automatically by configuring the following settings:

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>dbms.index_sampling.background_enabled</code></td>
<td>true</td>
<td>Enable the automatic (background) index sampling.</td>
</tr>
<tr>
<td><code>dbms.index_sampling.update_percentage</code></td>
<td>5</td>
<td>Percentage of index updates of total index size required before sampling of a given index is triggered.</td>
</tr>
</tbody>
</table>

### Manual statistics collection

You can manually trigger index resampling by using the built-in procedures `db.resampleIndex()` and `db.resampleOutdatedIndexes()`.

**db.resampleIndex()**

Trigger resampling of a specified index.

```
CALL db.resampleIndex("indexName")
```

**db.resampleOutdatedIndexes()**

Trigger resampling of all outdated indexes.

```
CALL db.resampleOutdatedIndexes()
```

### 13.7.2. Configure the replanning of execution plans

Execution plans are cached and are not replanned until the statistical information used to produce the plan changes.

### Automatic replanning

You can control how sensitive the replanning should be to database updates by configuring the following settings:
<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>cypher.statistics_divergence_threshold</td>
<td>0.75</td>
<td>The threshold for statistics above which a plan is considered stale. When the changes to the underlying statistics of an execution plan meet the specified threshold, the plan is considered stale and is replanned. Change is calculated as $\frac{</td>
</tr>
<tr>
<td>cypher.min_replan_interval</td>
<td>10s</td>
<td>The minimum amount of time between two query replanning executions. After this time, the graph statistics are evaluated, and if they have changed more than the value set in <code>cypher.statistics_divergence_threshold</code>, the query is replanned. Each time the statistics are evaluated, the divergence threshold is reduced until it reaches 10% after about 7h. This ensures that even moderately changing databases see query replanning after a sufficiently long time interval.</td>
</tr>
</tbody>
</table>

**Manual replanning**

You can manually force the database to replan the execution plans that are already in the cache by using the following built-in procedures:

**db.clearQueryCaches()**

Clear all query caches. Does not change the database statistics.

```cypher
CALL db.clearQueryCaches()
```

**db.prepareForReplanning()**

Completely recalculates all database statistics to be used for any subsequent query planning.

The procedure triggers an index resampling, waits for it to complete, and clears all query caches. Afterwards, queries are planned based on the latest database statistics.

```cypher
CALL db.prepareForReplanning()
```

You can use Cypher replanning to specify whether you want to force a replan, even if the plan is valid according to the planning rules, or skip replanning entirely should you wish to use a valid plan that already exists.

For more information, see:

- Cypher manual → Cypher replanning
- Cypher manual → Execution plans
13.8. Space reuse

This section describes how Neo4j handles data deletion and storage space.

Neo4j uses logical deletes to remove data from the database to achieve maximum performance and scalability. A logical delete means that all relevant records are marked as deleted, but the space they occupy is not immediately returned to the operating system. Instead, it is subsequently reused by the transactions creating data.

Marking a record as deleted requires writing a record update command to the transaction log, as when something is created or updated. Therefore, when deleting large amounts of data, this leads to a storage usage growth of that particular database, because Neo4j writes records for all deleted nodes, their properties, and relationships to the transaction log.

Transactions are eventually pruned out of the transaction log, bringing the storage usage of the log back down to the expected level. The store files, on the other hand, do not shrink when data is deleted. The space that the deleted records take up is kept in the store files. Until the space is reused, the store files are sparse and fragmented, but the performance impact of this is usually minimal.

13.8.1. ID files

Neo4j uses .id files for managing the space that can be reused. These files contain the set of IDs for all the deleted records in their respective files. The ID of the record uniquely identifies it within the store file. For instance, the neostore.nodestore.db.id contains the IDs of all deleted nodes.

These .id files are maintained as part of the write transactions that interact with them. When a write transaction commits a deletion, the record's ID is buffered in memory. The buffer keeps track of all overlapping unfinished transactions. When they complete, the ID becomes available for reuse.

The buffered IDs are flushed to the .id files as part of the checkpointing. Concurrently, the .id file changes (the ID additions and removals) are inferred from the transaction commands. This way, the recovery process ensures that the .id files are always in-sync with their store files. The same process also ensures that clustered databases have precise and transactional space reuse.

13.8.2. Reclaim unused space

You can use the neo4j-admin copy command to create a defragmented copy of your database. The copy command creates and entirely new and independent database. If you want to run that database in a
cluster, you have to re-seed the existing cluster, or seed a new cluster from that copy.
Example 88. Example of database compaction using neo4j-admin copy

The following is a detailed example on how to check your database store usage and how to reclaim space.

Let’s use the Cypher Shell command-line tool to add 100k nodes and then see how much store they occupy.

1. In a running Neo4j standalone instance, log in to the Cypher Shell command-line tool with your credentials.

   $neo4j-home/bin$/ ./cypher-shell -u neo4j -p <password>

   Connected to Neo4j at neo4j://localhost:7687 as user neo4j.
   Type :help for a list of available commands or :exit to exit the shell.
   Note that Cypher queries must end with a semicolon.

2. Add 100k nodes to the neo4j database using the following command:

   neo4j@neo4j> foreach (x in range (1,100000) | create (n:testnode1 {id:x}));

   0 rows available after 1071 ms, consumed after another 0 ms
   Added 100000 nodes, Set 100000 properties, Added 100000 labels

3. Check the allocated ID range:

   neo4j@neo4j> MATCH (n:testnode1) RETURN ID(n) as ID order by ID limit 5;

   +----+
   | ID |
   +----+
   | 0  |
   | 1  |
   | 2  |
   | 3  |
   | 4  |
   +----+

   5 rows available after 171 ms, consumed after another 84 ms

4. Run call db.checkpoint() procedure to force a checkpoint.

   neo4j@neo4j> call db.checkpoint();

   +------------------+
   | success | message |
   +------------------+
   | TRUE    | "Checkpoint completed." |
   +------------------+

   1 row available after 18 ms, consumed after another 407 ms
5. In Neo4j Browser, run `:sysinfo` to check the total store size of neo4j.

The reported output for the store size is 791.92 KiB, ID Allocation: Node ID 100000, Property ID 100000.

6. Delete the above created nodes.

   ```
   neo4j@neo4j> Match (n) detach delete n;
   ```

7. Run `call db.checkpoint()` procedure again.

   ```
   neo4j@neo4j> call db.checkpoint();
   +-----------------------------------+
   | success | message                 |
   +-----------------------------+
   | TRUE        | "Checkpoint completed." |
   +-----------------------------+
   1 row available after 18 ms, consumed after another 407 ms
   ```

8. In Neo4j Browser, run `:sysinfo` to check the total store size of neo4j.

   The reported output for the store size is 31.01 MiB, ID Allocation: Node ID 100000, Property ID 100000.

   By default, a checkpoint flushes any cached updates in pagecache to store files. Thus, the allocated IDs remain unchanged, and the store size increases or does not alter (if the instance restarts) despite the deletion. In a production database, where numerous load/deletes are frequently performed, the result is a significant unused space occupied by store files.

   To reclaim that unused space, you can use the `neo4j-admin copy` command to create a defragmented copy of your database. Use the `system` database and stop the `neo4j` database before running the command.

   1. Invoke the `neo4j-admin copy` command to create a copy of your `neo4j` database.

   ```
   $neo4j-home/bin$> ./neo4j-admin copy --to-database=neo4jcopy1 --from-database=neo4j --force --verbose
   ```
Starting to copy store, output will be saved to: $neo4j_home/logs/neo4j-admin-copy-2020-11-04.11.30.57.log
2020-10-23 11:40:00.749+0000 INFO [StoreCopy] ### Copy Data ###
2020-10-23 11:40:00.750+0000 INFO [StoreCopy] Source: $neo4j_home/data/databases/neo4j (page cache 8m) (page cache 8m)
2020-10-23 11:40:00.750+0000 INFO [StoreCopy] Target: $neo4j_home/data/databases/neo4jcopy1 (page cache 8m)
2020-10-23 11:40:00.750+0000 INFO [StoreCopy] Empty database created, will start importing readable data from the source.
2020-10-23 11:40:02.397+0000 INFO [o.n.i.b.ImportLogic] Import starting
Nodes, started 2020-11-04 11:31:00.088+0000
[<Nodes:>?? 7.969MiB--------------------]
100K Δ 100K
Done in 632ms
Prepare node index, started 2020-11-04 11:31:00.735+0000
[<DETECT:7.969MiB------------------------]
0 Δ 0
Done in 79ms
Relationships, started 2020-11-04 11:31:00.819+0000
[<Relationships:>?? 7.969MiB---------------------------]
0 Δ 0
Done in 37ms
Node Degrees, started 2020-11-04 11:31:01.162+0000
[<*>:??---------------------------------------------]
0 Δ 0
Done in 12ms
Relationship --> Relationship 1/1, started 2020-11-04 11:31:01.207+0000
[<*>:??---------------------------------------------]
0 Δ 0
Done in 0ms
RelationshipGroup 1/1, started 2020-11-04 11:31:01.232+0000
[<*>:??---------------------------------------------]
0 Δ 0
Done in 10ms
Node --> Relationship, started 2020-11-04 11:31:01.245+0000
[<*>:??---------------------------------------------]
0 Δ 0
Done in 10ms
Relationship <-- Relationship 1/1, started 2020-11-04 11:31:01.287+0000
[<*>:??---------------------------------------------]
0 Δ 0
Done in 0ms
Count groups, started 2020-11-04 11:31:01.549+0000
[<*>:??---------------------------------------------]
0 Δ 0
Done in 0ms
Node --> Group, started 2020-11-04 11:31:01.579+0000
[<*>:??---------------------------------------------]
0 Δ 0
Done in 0ms
Node counts and label index build, started 2020-11-04 11:31:01.986+0000
[<*>:??---------------------------------------------]
0 Δ 0
Done in 11ms
Relationship counts, started 2020-11-04 11:31:02.034+0000
[<*>:??---------------------------------------------]
0 Δ 0
Done in 0ms
IMPORT DONE in 3s 345ms.
Imported:
  0 nodes
  0 relationships
  0 properties
Peak memory usage: 7.969MiB
2020-11-04 11:31:02.835+0000 INFO [o.n.i.b.ImportLogic] Import completed successfully, took 3s 345ms. Imported:
  0 nodes
  0 relationships
  0 properties
2020-11-04 11:31:03.330+0000 INFO [StoreCopy] Import summary: Copying of 100704 records took 5 seconds (20140 rec/s). Unused Records 100704 (100%) Removed Records 0 (0%)
2020-11-04 11:31:03.330+0000 INFO [StoreCopy] Trying to extract schema...
The example resulted in a compact and consistent store (any inconsistent nodes, properties, relationships are not copied over to the newly created store).

2. Use the `system` database and create the `neo4jcopy1` database.

```
neo4j@system> create database neo4jcopy1;
```

0 rows available after 60 ms, consumed after another 0 ms

3. Verify that the `neo4jcopy1` database is online.

```
neo4j@system> show databases;
```

```
+------------------------------------------------------------------------------------------------+
| name   | address     | role       | requestedStatus | currentStatus | error |                                                                 |
+------------------------------------------------------------------------------------------------+
| default | localhost:7687 | standalone | offline         | offline       | ""   | TRUE                                                                 |
| neo4j   | localhost:7687 | standalone | offline         | offline       | ""   |                                                                 |
| neo4jcopy1 | localhost:7687 | standalone | online          | online        | ""   | FALSE                                                                |
| system  | localhost:7687 | standalone | online          | online        | ""   |                                                                 |
+------------------------------------------------------------------------------------------------+

3 rows available after 2 ms, consumed after another 1 ms

4. In Neo4j Browser, run `:sysinfo` to check the total store size of neo4jcopy1.

The reported output for the store size after the compaction is 800.68 KiB, ID Allocation: Node ID 0, Property ID 0.
Chapter 14. Monitoring

This chapter describes the tools that are available for monitoring Neo4j.

Neo4j provides mechanisms for continuous analysis through the output of metrics as well as the inspection and management of currently-executing queries.

Logs can be harvested for continuous analysis, or for specific investigations. Facilities are available for producing security event logs as well as query logs. The query management functionality is provided for specific investigations into query performance. Monitoring features are also provided for ad-hoc analysis of a Causal Cluster.

This chapter describes the following:

- Monitor the logs
- Metrics
  - Essential metrics
  - Enable metrics logging
  - Connect monitoring tools
  - Metrics reference
- Manage queries
  - List all running queries
  - List all active locks for a query
  - Terminate queries
- Manage transactions
  - Configure transaction timeout
  - Configure lock acquisition timeout
  - List all running transactions
- Manage connections
  - List all network connections
  - Terminate multiple network connections
  - Terminate a single network connection
- Manage background jobs
  - Listing active background jobs
  - Listing failed job executions
- Monitor a Causal Cluster
  - Procedures for monitoring a Causal Cluster
  - Monitor cluster endpoints for status information
Monitor the state of individual databases

14.1. Logging

This section describes the logging mechanisms in Neo4j, including general log files, error messages, and severity levels.

14.1.1. Log files

Neo4j provides logs for monitoring purposes. The root directory where the general log files are located is configured by `dbms.directories.logs`. The default format of the log files is configured by `dbms.logs.default_format`. For more information on where files are located, see `File locations`.

The following table describes the Neo4j general log files and the information they contain.

Table 52. Neo4j logs for monitoring

<table>
<thead>
<tr>
<th>Filename</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>neo4j.log</td>
<td>The user log</td>
<td>Logs general information about Neo4j. Not written for Debian and RPM packages.</td>
</tr>
<tr>
<td>debug.log</td>
<td>The debug log</td>
<td>Logs information that is useful when debugging problems with Neo4j.</td>
</tr>
<tr>
<td>http.log</td>
<td>The HTTP log</td>
<td>Logs information about the HTTP API.</td>
</tr>
<tr>
<td>gc.log</td>
<td>The garbage collection log</td>
<td>Logs information provided by the JVM.</td>
</tr>
<tr>
<td>query.log</td>
<td>The query log</td>
<td>Logs information about queries that run longer than a specified threshold.</td>
</tr>
<tr>
<td>security.log</td>
<td>The security log</td>
<td>Logs information about security events.</td>
</tr>
<tr>
<td>service-error.log</td>
<td>The windows service log</td>
<td>Logs information about errors encountered when installing or running the Windows service.</td>
</tr>
</tbody>
</table>

Table 53. Log paths

<table>
<thead>
<tr>
<th>Configuration setting</th>
<th>Default value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>dbms.directories.logs</td>
<td>logs</td>
<td>Path to the logs directory.</td>
</tr>
</tbody>
</table>
### Configuration setting

<table>
<thead>
<tr>
<th>Configuration setting</th>
<th>Default value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>dbms.logs.user.path</code></td>
<td>neo4j.log</td>
<td>Path to the user log file.</td>
</tr>
<tr>
<td><code>dbms.logs.debug.path</code></td>
<td>debug.log</td>
<td>Path to the debug log file.</td>
</tr>
<tr>
<td><code>dbms.logs.http.path</code></td>
<td>http.log</td>
<td>Path to the HTTP log file.</td>
</tr>
<tr>
<td><code>dbms.logs.query.path</code></td>
<td>query.log</td>
<td>Path to the query log file.</td>
</tr>
<tr>
<td><code>dbms.logs.security.path</code></td>
<td>security.log</td>
<td>Path to the security log file.</td>
</tr>
</tbody>
</table>

#### 14.1.2. Log format

**Table 54. Log formats**

<table>
<thead>
<tr>
<th>Configuration setting</th>
<th>Default value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>dbms.logs.default_format</code></td>
<td>PLAIN</td>
<td>The default log format for all logs. Valid options are PLAIN and JSON.</td>
</tr>
<tr>
<td><code>dbms.logs.user.format</code></td>
<td>Inherits from <code>dbms.logs.default_format</code></td>
<td>The log format for the user log. Valid options are PLAIN and JSON.</td>
</tr>
<tr>
<td><code>dbms.logs.query.format</code></td>
<td>Inherits from <code>dbms.logs.default_format</code></td>
<td>The log format for the query log. Valid options are PLAIN and JSON.</td>
</tr>
<tr>
<td><code>dbms.logs.debug.format</code></td>
<td>Inherits from <code>dbms.logs.default_format</code></td>
<td>The log format for the debug log. Valid options are PLAIN and JSON.</td>
</tr>
<tr>
<td><code>dbms.logs.security.format</code></td>
<td>Inherits from <code>dbms.logs.default_format</code></td>
<td>The log format for the security log. Valid options are PLAIN and JSON.</td>
</tr>
</tbody>
</table>

#### 14.1.3. Log configurations

There are a number of configuration options to enable/disable logging, decide how to rotate the logs, and how many of the logs to keep around.

**User log (neo4j.log)**

**Table 55. User log configurations**
### The user log configuration

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Default value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>dbms.logs.user.format</code></td>
<td>Inherits from <code>dbms.logs.default_format</code></td>
<td>The log format for the user log.</td>
</tr>
<tr>
<td><code>dbms.logs.user.rotation.delay</code></td>
<td>5m</td>
<td>The minimum time interval after the last rotation of the user log before it may be rotated again.</td>
</tr>
<tr>
<td><code>dbms.logs.user.rotation.keep_number</code></td>
<td>7</td>
<td>The maximum number of history files for the user log.</td>
</tr>
<tr>
<td><code>dbms.logs.user.rotation.size</code></td>
<td>0B</td>
<td>The threshold size for rotation of the user log. If set to 0, the log rotation is disabled.</td>
</tr>
<tr>
<td><code>dbms.logs.user.stdout_enabled</code></td>
<td>true</td>
<td>Send user logs to the process stdout. If disabled, the logs are sent to the user log.</td>
</tr>
</tbody>
</table>

The following information is available in the JSON format:

#### Table 56. JSON format log entries

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>time</code></td>
<td>The timestamp of the log message.</td>
</tr>
<tr>
<td><code>level</code></td>
<td>The log level.</td>
</tr>
<tr>
<td><code>message</code></td>
<td>The log message.</td>
</tr>
<tr>
<td><code>stacktrace</code></td>
<td>Included when there is a stacktrace associated with the log message.</td>
</tr>
</tbody>
</table>

### Debug log

The debug log logs problems, errors, stacktraces, etc.

#### Table 57. Debug log configurations

<table>
<thead>
<tr>
<th>The debug log configuration</th>
<th>Default value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>dbms.logs.debug.level</code></td>
<td>INFO</td>
<td>Log level threshold for the debug log.</td>
</tr>
<tr>
<td><code>dbms.logs.debug.format</code></td>
<td>Inherits from <code>dbms.logs.default_format</code></td>
<td>The log format for the debug log.</td>
</tr>
<tr>
<td><code>dbms.logs.debug.rotation.delay</code></td>
<td>5m</td>
<td>The minimum time interval after the last rotation of the debug log before it may be rotated again.</td>
</tr>
</tbody>
</table>
The debug log configuration

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Default value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>dbms.logs.debug.rotation.keep_number</td>
<td>7</td>
<td>The maximum number of history files for the debug log.</td>
</tr>
<tr>
<td>dbms.logs.debug.rotation.size</td>
<td>20M</td>
<td>The threshold size for rotation of the debug log.</td>
</tr>
</tbody>
</table>

The following table lists all message types raised by Neo4j and their severity level:

Table 58. Message types

<table>
<thead>
<tr>
<th>Message type</th>
<th>Severity level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>INFO</td>
<td>Low severity</td>
<td>Report status information and errors that are not severe.</td>
</tr>
<tr>
<td>DEBUG</td>
<td>Low severity</td>
<td>Report details on the raised errors and possible solutions.</td>
</tr>
<tr>
<td>WARN</td>
<td>Low severity</td>
<td>Report errors that need attention but are not severe.</td>
</tr>
<tr>
<td>ERROR</td>
<td>High severity</td>
<td>Report errors that prevent the Neo4j server from running and must be addressed immediately.</td>
</tr>
</tbody>
</table>

To set the log level threshold for the debug log, use the configuration setting dbms.logs.debug.level.

The following information is available in the JSON format:

Table 59. JSON format log entries

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>time</td>
<td>The timestamp of the log message.</td>
</tr>
<tr>
<td>level</td>
<td>The log level.</td>
</tr>
<tr>
<td>category</td>
<td>The class the message was logged from.</td>
</tr>
<tr>
<td>message</td>
<td>The log message.</td>
</tr>
<tr>
<td>stacktrace</td>
<td>Included when there is a stacktrace associated with the log message.</td>
</tr>
</tbody>
</table>

Garbage collection log

Table 60. Garbage collection log configurations

<table>
<thead>
<tr>
<th>The garbage collection log configuration</th>
<th>Default value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>dbms.logs.gc.enabled</td>
<td>false</td>
<td>Enable garbage collection logging.</td>
</tr>
<tr>
<td>dbms.logs.gc.options</td>
<td></td>
<td>Garbage collection logging options.</td>
</tr>
<tr>
<td>dbms.logs.gc.rotation.keep_number</td>
<td>0</td>
<td>The maximum number of history files for the garbage collection log.</td>
</tr>
</tbody>
</table>
The garbage collection log configuration

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Default value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>dbms.logs.gc.rotation.size</code></td>
<td></td>
<td>The threshold size for rotation of the garbage collection log.</td>
</tr>
</tbody>
</table>

HTTP log

Table 61. HTTP log configurations

<table>
<thead>
<tr>
<th>The HTTP log configuration</th>
<th>Default value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>dbms.logs.http.enabled</code></td>
<td><code>false</code></td>
<td>Enable HTTP logging.</td>
</tr>
<tr>
<td><code>dbms.logs.http.rotation.keep_number</code></td>
<td><code>5</code></td>
<td>The maximum number of history files for the HTTP log.</td>
</tr>
<tr>
<td><code>dbms.logs.http.rotation.size</code></td>
<td><code>20M</code></td>
<td>The threshold size for rotation of the HTTP log.</td>
</tr>
</tbody>
</table>

Security log  

Neo4j provides security event logging that records all security events.

For native user management, the following actions are recorded:

- Login attempts — by default, both successful and unsuccessful logins are recorded.
- All administration commands run against the system database.
- All security procedures run against the system database.
- Authorization failures from role-based access control.

Rotation of the security events log can be configured in the `neo4j.conf` configuration file.

The following configuration settings are available for the security log:

Table 62. Security log configurations

<table>
<thead>
<tr>
<th>The security log configuration</th>
<th>Default value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>dbms.logs.security.level</code></td>
<td><code>INFO</code></td>
<td>Security log level threshold.</td>
</tr>
<tr>
<td><code>dbms.logs.security.format</code></td>
<td>Inherits from dbms.logs.default_format</td>
<td>The log format for the security log.</td>
</tr>
<tr>
<td><code>dbms.logs.security.path</code></td>
<td><code>security.log</code></td>
<td>The name of the security log file.</td>
</tr>
<tr>
<td><code>dbms.logs.security.rotation.size</code></td>
<td><code>20M</code></td>
<td>The file size at which the security event log auto-rotates.</td>
</tr>
<tr>
<td><code>dbms.logs.security.rotation.delay</code></td>
<td><code>300s</code></td>
<td>The minimum time interval after the last security log rotation occurred before the security log may be rotated again.</td>
</tr>
<tr>
<td>The security log configuration</td>
<td>Default value</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>---------------</td>
<td>-------------</td>
</tr>
<tr>
<td>dbms.logs.security.rotation.keep_number</td>
<td>7</td>
<td>The number of historical log files kept.</td>
</tr>
</tbody>
</table>

If using LDAP as the authentication method, some cases of LDAP misconfiguration are also logged, as well as LDAP server communication events and failures.

If many programmatic interactions are expected, it is advised to disable the logging of successful logins by setting the `dbms.security.log_successful_authentication` parameter in the `neo4j.conf` file:

```
dbms.security.log_successful_authentication=false
```

The following information is available in the JSON format:

**Table 63. JSON format log entries**

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>time</td>
<td>The timestamp of the log message.</td>
</tr>
<tr>
<td>level</td>
<td>The log level.</td>
</tr>
<tr>
<td>type</td>
<td>It is always <code>security</code>.</td>
</tr>
<tr>
<td>source</td>
<td>Connection details.</td>
</tr>
<tr>
<td>database</td>
<td>The database name the command is executed on.</td>
</tr>
<tr>
<td>username</td>
<td>The user connected to the security event. This field is deprecated by <code>executingUser</code>.</td>
</tr>
<tr>
<td>executingUser</td>
<td>The name of the user triggering the security event. Either same as <code>authenticatedUser</code> or an impersonated user.</td>
</tr>
<tr>
<td>authenticatedUser</td>
<td>The name of the user who authenticated and is connected to the security event.</td>
</tr>
<tr>
<td>message</td>
<td>The log message.</td>
</tr>
<tr>
<td>stacktrace</td>
<td>Included if there is a stacktrace associated with the log message.</td>
</tr>
</tbody>
</table>

Example of the security log in plain format:
Query log

Query logging is enabled by default and is controlled by the setting `dbms.logs.query.enabled`. It helps you analyze long-running queries and does not impact system performance. The default is to log all queries, but it is recommended to log for queries exceeding a certain threshold.

The following configuration settings are available for the query log:

Table 64. Query log enabled setting

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFF</td>
<td>Completely disable logging.</td>
</tr>
<tr>
<td>INFO</td>
<td>Log at the end of queries that have either succeeded or failed. The <code>dbms.logs.query.threshold</code> parameter is used to determine the threshold for logging a query. If the execution of a query takes longer than this threshold, the query is logged. Setting the threshold to 0s results in all queries being logged.</td>
</tr>
<tr>
<td>VERBOSE</td>
<td>Log all queries at both start and finish, regardless of <code>dbms.logs.query.threshold</code>. Default</td>
</tr>
</tbody>
</table>

The name of the query log file is `query.log` by default. For more information, see `dbms.logs.query.path`.

You can configure the rotation of the query log in the `neo4j.conf` file.

The following configuration settings are available for the query log file:

Table 65. Query log configurations
<table>
<thead>
<tr>
<th>The query log configuration</th>
<th>Default value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>dbms.logs.query.allocation_logging_enabled</code></td>
<td>true</td>
<td>Log allocated bytes for the executed queries being logged. The logged number is cumulative over the duration of the query. That means the value may be larger for memory intense or long-running queries than the current memory allocation. Requires <code>dbms.track_query_allocation=true</code>.</td>
</tr>
<tr>
<td><code>dbms.logs.query.early_raw_logging_enabled</code></td>
<td>false</td>
<td>Log query text and parameters without obfuscating passwords. This allows queries to be logged earlier before parsing starts.</td>
</tr>
<tr>
<td><code>dbms.logs.query.enabled</code></td>
<td>VERBOSE</td>
<td>Log executed queries.</td>
</tr>
<tr>
<td><code>dbms.logs.query.format</code></td>
<td>Inherits from <code>dbms.logs.default_format</code></td>
<td>The log format for the query log. For logging detailed time information requires <code>dbms.track_query_cpu_time=true</code>.</td>
</tr>
<tr>
<td><code>dbms.logs.query.max_parameter_length</code></td>
<td>2147483647</td>
<td>This configuration option allows you to set a maximum parameter length to include in the log. Parameters exceeding this length will be truncated and appended with ... This applies to each parameter in the query.</td>
</tr>
<tr>
<td>The query log configuration</td>
<td>Default value</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------------------------------------------------</td>
<td>--------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td><code>dbms.logs.query.obfuscate_literals</code></td>
<td><code>false</code></td>
<td>If true, obfuscates all query literals before writing to the log. This is useful when Cypher queries expose sensitive information.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>azole labels, relationship types, and map property keys are still shown. Changing the setting does not affect cached queries. Therefore, if you want the switch to have an immediate effect, you must also clear the query cache; <code>CALL db.clearQueryCache()</code>.</td>
</tr>
<tr>
<td><code>dbms.logs.query.page_logging_enabled</code></td>
<td><code>false</code></td>
<td>Log page hits and page faults for the executed queries being logged.</td>
</tr>
<tr>
<td><code>dbms.logs.query.parameter_full_entities</code></td>
<td><code>false</code></td>
<td>Log complete parameter entities including ID, labels or relationship type, and properties. If <code>false</code>, only the entity ID is logged. This only takes effect if <code>dbms.logs.query.parameter_logging_enabled=true</code>.</td>
</tr>
<tr>
<td><code>dbms.logs.query.parameterLoggingEnabled</code></td>
<td><code>true</code></td>
<td>Log parameters for the executed queries being logged. You can disable this configuration setting if you do not want to display sensitive information.</td>
</tr>
<tr>
<td>The query log configuration</td>
<td>Default value</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
<td>---------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>dbms.logs.query.plan_description_enabled</td>
<td>false</td>
<td>This configuration option allows you to log the query plan for each query. The query plan shows up as a description table and is useful for debugging purposes. Every time a Cypher query is run, it generates and uses a plan for the execution of the code. The plan generated can be affected by changes in the database, such as adding a new index. As a result, it is not possible to historically see what plan was used for the original query execution.</td>
</tr>
<tr>
<td>dbms.logs.query.rotation.keep_number</td>
<td>7</td>
<td>The maximum number of history files for the query log.</td>
</tr>
<tr>
<td>dbms.logs.query.rotation.size</td>
<td>20M</td>
<td>The file size in bytes at which the query log auto-rotates.</td>
</tr>
<tr>
<td>dbms.logs.query.runtime_logging_enabled</td>
<td>true</td>
<td>Logs which runtime that was used to run the query.</td>
</tr>
<tr>
<td>dbms.logs.query.threshold</td>
<td>0s</td>
<td>If the query execution takes longer than this threshold, the query is logged once completed (provided query logging is set to INFO). A threshold of 0 seconds logs all queries.</td>
</tr>
<tr>
<td>The query log configuration</td>
<td>Default value</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------------------------------------------------</td>
<td>---------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>dbms.logs.query.time_logging_enabled</td>
<td>false</td>
<td>Log detailed time information for the executed queries being logged, such as (planning: 92, waiting: 0). Enabling dbms.track_query_cpu_time=true as well, adds the CPU time used by current transaction in milliseconds, e.g., (planning: 95, cpu: 96, waiting: 0).</td>
</tr>
<tr>
<td>dbms.logs.query.transaction.enabled</td>
<td>OFF</td>
<td>Track the start and end of a transaction within the query log. Log entries are written to the query log. They include the transaction ID for a specific query and the start and end of a transaction. You can also choose a level of logging (OFF, INFO, or VERBOSE). If INFO is selected, you must exceed the time before the log is written (dbms.logs.query.transaction.threshold).</td>
</tr>
<tr>
<td>dbms.logs.query.transaction.threshold</td>
<td>0s</td>
<td>If the transaction is open for longer than this threshold (duration of time), the transaction is logged once completed, provided transaction logging is set to INFO. Defaults to 0 seconds, which means all transactions are logged. This can be useful when identifying where there is a significant time lapse after query execution and transaction commits, especially in performance analysis around locking.</td>
</tr>
</tbody>
</table>
The query log configuration

<table>
<thead>
<tr>
<th>The query log configuration</th>
<th>Default value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>dbms.logs.query.transaction_id.enabled</td>
<td>false</td>
<td>This configuration option allows the administrator to request the transaction ID is included with the query ID in all query log entries. Queries are run as part of a transaction. For simple queries, there is usually a 1:1 correlation. In application usage, however, a transaction can include many queries, especially if retries are required in the event of connection instability.</td>
</tr>
</tbody>
</table>

Example 89. Configure for simple query logging

In this example, the query logging is set to INFO, and all other query log parameters are at their defaults.

```
    dbms.logs.query.enabled=INFO
```

Below is an example of the query log with this basic configuration:

```
2017-11-22 14:31 ... INFO  9 ms: bolt-session bolt johndoe neo4j-javascript/1.4.1
2017-11-22 14:31 ... INFO  0 ms: bolt-session bolt johndoe neo4j-javascript/1.4.1
2017-11-22 14:32 ... INFO  3 ms: server-session http 127.0.0.1 /db/data/cypher neo4j - CALL dbms.procedures() - {}
2017-11-22 14:32 ... INFO  1 ms: server-session http 127.0.0.1 /db/data/cypher neo4j - CALL dbms.showCurrentUs...
2017-11-22 14:32 ... INFO  0 ms: bolt-session bolt johndoe neo4j-javascript/1.4.1
2017-11-22 14:32 ... INFO  0 ms: bolt-session bolt johndoe neo4j-javascript/1.4.1
2017-11-22 14:32 ... INFO  2 ms: bolt-session bolt johndoe neo4j-javascript/1.4.1
2017-11-22 14:32 ... INFO  0 ms: bolt-session bolt johndoe neo4j-javascript/1.4.1
```

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Example 90. Configure for query logging with more details

In this example, the query log is enabled, as well as some additional logging:

```
dbms.logs.query.enabled=INFO
dbms.logs.query.allocation_logging_enabled=true
dbms.logs.query.page_logging_enabled=true
dbms.logs.query.parameter_logging_enabled=true
dbms.logs.query.time_logging_enabled=true
dbms.logs.query.threshold=<appropriate value>
```

The following sample query is run on the Movies database:

```
MATCH (n:Person {name:'Tom Hanks'})-[[:ACTED_IN]->(n1:Movie)<-[:DIRECTED]->(n2:Person {name:"Tom Hanks")}) RETURN n1.title
```

The corresponding query log in `<file>query.log` is:

```
2017-11-23 12:44:56.973+0000 INFO  1550 ms: (planning: 20, cpu: 920, waiting: 10) - 13792 B - 15 page hits, 0 page faults - bolt-session    bolt    neo4j   neo4j-javascript/1.4.1
client/127.0.0.1:58189  server/127.0.0.1:7687>  neo4j - match (n:Person {name:'Tom Hanks'})-[[:ACTED_IN]->(n1:Movie)<-[:DIRECTED]->(n2:Person {name:"Tom Hanks")}) return n1.title; - {} - {} 
```

An obvious but essential point of note when examining parameters of a particular query is to ensure you analyze only the entries relevant to that specific query plan, as opposed to, e.g., CPU, time, bytes, and so on for each log entry in sequence.

Following is a breakdown of resource usage parameters with descriptions corresponding to the above query:

```
2017-11-23 12:44:56.973+0000
Log timestamp.

INFO
Log category.

1550 ms
Total elapsed cumulative wall time spent in query execution. It is the total of planning time + CPU + waiting + any other processing time, e.g., taken to acquire execution threads. This figure is cumulative for every time a CPU thread works on executing the query.

Planning
Refers to the time the Cypher engine takes to create a query plan. Plans may be cached for repetitive queries, and therefore, planning times for such queries will be shorter than those for previously unplanned ones. In the example, this contributed 20ms to the total execution time of 1550ms.

CPU time
Refers to the time taken by the individual threads executing the query, e.g., a query is submitted at 08:00. It uses CPU for 720ms, but then the CPU swaps out to another query, so the first query is no longer using the CPU. Then, after 100ms, it gets/uses the CPU again for 200ms (more results
to be loaded, requested by the client via the Driver), then the query completes at 08:01:30, so the total duration is 1550ms (includes some round-trip time for 2 round-trips), and CPU is 720+200=920ms.

Waiting
Time a query spent waiting before execution (in ms), for example, if an existing query has a lock which the new query must wait to release. In the example, this contributed 10ms to the total execution time of 1550ms.

It is important to note that the client requests data from the server only when its record buffer is empty (one round-trip from the server may end up with several records), and the server stops pushing data into outgoing buffers if the client does not read them in a timely fashion. Therefore, it depends on the size of the result set. If it is relatively small and fits in a single round-trip, the client receives all the results at once, and the server finishes processing without any client-side effect. Meanwhile, if the result set is large, the client-side processing time will affect the overall time, as it is directly connected to when new data is requested from the server.

13792 B
The allocated bytes for the executed queries being logged. This is the amount of HEAP memory used during the life of the query. The logged number is cumulative over the duration of the query, i.e., for memory intense or long-running queries the value may be larger than the current memory allocation.

15 page hits
Page hit means the result was returned from page cache as opposed to disk. In this case, page cache was hit 15 times.

0 page faults
Page fault means that the query result data was not in the dbms.memory.pagecache, and therefore, had to be fetched from the file system. In this case, query results were returned entirely from the 8 page cache hits mentioned above, so there were 0 hits on the disk required.

bolt-session
The session type.

bolt
The Browser ↔ database communication protocol used by the query.

neo4j
The process ID.

neo4j-javascript/1.4.1
The Driver version.

client/127.0.0.1:52935
The query client outbound IP:port used.

server/127.0.0.1:7687>
The server listening IP:port used.
The executed query.

The last two parenthesis {} {} are for the query parameters and txMetaData.

Attach metadata to a transaction

You can attach metadata to a transaction and have it printed in the query log using the built-in procedure tx.setMetaData.

Neo4j Drivers also support attaching metadata to a transaction. For more information, see the respective Driver's manual.

Every graph app should follow a convention for passing metadata with the queries that it sends to Neo4j:

```json
{
    app: "neo4j-browser_v4.4.0", ①
type: "system" ②
}
```

① `app` can be a user-agent styled-name plus version.

② `type` can be one of:

- `system` — a query automatically run by the app.
- `user-direct` — a query the user directly submitted to/through the app.
- `user-action` — a query resulting from an action the user performed.
- `user-transpiled` — a query that has been derived from the user input.

This is typically done programmatically but can also be used with the Neo4j dev tools.

In general, you start a transaction on a user database and attach a list of metadata to it by calling tx.setMetaData. You can also use the procedure CALL tx.getMetaData() to show the metadata of the current transaction. These examples use the MovieGraph dataset from the Neo4j Browser guide.
Example 91. Using cypher-shell, attach metadata to a transaction

```
neo4j@neo4j> :begin
neo4j@neo4j# CALL tx.setMetaData({app: 'neo4j-cypher-shell_v.4.4.0', type: 'user-direct', user: 'jsmith'});
0 rows
ready to start consuming query after 2 ms, results consumed after another 0 ms
neo4j@neo4j# CALL tx.getMetaData();
+--------------------------------------------------------------------------+
| metadata                                                                 |
+--------------------------------------------------------------------------+
| {app: "neo4j-cypher-shell_v.4.4.0", type: "user-direct", user: "jsmith"} |
+--------------------------------------------------------------------------+
1 row
ready to start consuming query after 37 ms, results consumed after another 2 ms
neo4j@neo4j# MATCH (n:Person) RETURN n LIMIT 5;
+----------------------------------------------------+
| n                                                  |
+----------------------------------------------------+
| (:Person {name: "Keanu Reeves", born: 1964})       |
| (:Person {name: "Carrie-Anne Moss", born: 1967})   |
| (:Person {name: "Laurence Fishburne", born: 1961}) |
| (:Person {name: "Hugo Weaving", born: 1960})       |
| (:Person {name: "Lilly Wachowski", born: 1967})    |
+----------------------------------------------------+
5 rows
ready to start consuming query after 2 ms, results consumed after another 1 ms
neo4j@neo4j# :commit
```

Example result in the query.log file

```
2021-07-30 14:43:17.176+0000 INFO  id:225 - 2 ms: 136 B - bolt-session bolt    neo4j-cypher-shell/v4.4.0       client/127.0.0.1:54026  server/127.0.0.1:7687>  neo4j - neo4j - MATCH (n:Person) RETURN n  LIMIT 5; - {} - runtime=pipelined - {app: 'neo4j-cypher-shell_v.4.4.0', type: 'user-direct', user: 'jsmith'}
```

Example 92. Using Neo4j Browser, attach metadata to a transaction

```
CALL tx.setMetaData({app: 'neo4j-browser_v.4.4.0', type: 'user-direct', user: 'jsmith'});
MATCH (n:Person) RETURN n LIMIT 5
```

Example result in the query.log file

```
2021-07-30 14:51:39.457+0000 INFO  Query started: id:328 - 0 ms: 0 B - bolt-session bolt    neo4j-browser/v4.4.0        client/127.0.0.1:53666  server/127.0.0.1:7687>  neo4j - neo4j - MATCH (n:Person) RETURN n  LIMIT 5 - {} - runtime=null - {type: 'system', app: 'neo4j-browser_v4.4.0'}
```
Example 93. Using Neo4j Bloom, attach metadata to a transaction

```groovy
CALL tx.setMetaData({app: 'neo4j-browser_v.1.7.0', type: 'user-direct', user: 'jsmith'})

MATCH (n:Person) RETURN n LIMIT 5
```

Example result in the query.log file

```
2021-07-30 15:09:54.048+0000 INFO  id:95 - 1 ms: 72 B - bolt-session   bolt   neo4j-bloom/v1.7.0
  client/127.0.0.1:54693   server/127.0.0.1:11003> neo4j - neo4j - RETURN TRUE - {} - runtime=pipelined
  - {app: 'neo4j-bloom_v1.7.0', type: 'system'}
```

In Neo4j Browser and Bloom, the user-provided metadata is always replaced by the system metadata.

JSON format

The following information is available in the JSON format:

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>time</td>
<td>The timestamp of the log message.</td>
</tr>
<tr>
<td>level</td>
<td>The log level.</td>
</tr>
<tr>
<td>type</td>
<td>Valid options are <code>query</code> and <code>transaction</code>.</td>
</tr>
<tr>
<td>stacktrace</td>
<td>Included when there is a stacktrace associated with the log message.</td>
</tr>
</tbody>
</table>

If the type of the log entry is `query`, these additional fields are available:

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>event</td>
<td>Valid options are <code>start</code>, <code>fail</code>, and <code>success</code>.</td>
</tr>
<tr>
<td>id</td>
<td>The query ID. Included when <code>dbms.logs.query.enabled</code> is <code>VERBOSE</code>.</td>
</tr>
<tr>
<td>elapsedTimeMs</td>
<td>The elapsed time in milliseconds.</td>
</tr>
<tr>
<td>planning</td>
<td>Milliseconds spent on planning. Included when <code>dbms.logs.query.time_logging_enabled</code> is <code>true</code>.</td>
</tr>
<tr>
<td>Name</td>
<td>Description</td>
</tr>
<tr>
<td>---------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>cpu</td>
<td>Milliseconds spent actively executing on the CPU. Included when <code>dbms.logs.query.time_logging_enabled</code> and <code>dbms.track_query_cpu_time=true</code> are true.</td>
</tr>
<tr>
<td>waiting</td>
<td>Milliseconds spent waiting on locks or other queries, as opposed to actively running this query. Included when <code>dbms.logs.query.time_logging_enabled</code> is true.</td>
</tr>
<tr>
<td>allocatedBytes</td>
<td>Number of bytes allocated by the query. Included when <code>dbms.logs.query.allocation_logging_enabled</code> is true.</td>
</tr>
<tr>
<td>pageHits</td>
<td>Number of page hits. Included when <code>dbms.logs.query.page_logging_enabled</code> is true.</td>
</tr>
<tr>
<td>pageFaults</td>
<td>Number of page faults. Included when <code>dbms.logs.query.page_logging_enabled</code> is true.</td>
</tr>
<tr>
<td>source</td>
<td>Connection details.</td>
</tr>
<tr>
<td>database</td>
<td>The database name on which the query is run.</td>
</tr>
<tr>
<td>username</td>
<td>The user running the query. This field is deprecated by <code>executingUser</code>.</td>
</tr>
<tr>
<td>executingUser</td>
<td>The name of the user executing the query. Either same as <code>authenticatedUser</code> or an impersonated user.</td>
</tr>
<tr>
<td>authenticatedUser</td>
<td>The name of the user who authenticated and is executing the query.</td>
</tr>
<tr>
<td>query</td>
<td>The query text.</td>
</tr>
<tr>
<td>queryParameters</td>
<td>The query parameters. Included when <code>dbms.logs.query.parameter_logging_enabled</code> is true.</td>
</tr>
<tr>
<td>runtime</td>
<td>The runtime used to run the query. Included when <code>dbms.logs.query.runtime_logging_enabled</code> is true.</td>
</tr>
<tr>
<td>annotationData</td>
<td>Metadata attached to the transaction.</td>
</tr>
<tr>
<td>failureReason</td>
<td>Reason for failure. Included when applicable.</td>
</tr>
</tbody>
</table>
### Name | Description
--- | ---
`transactionId` | The transaction ID of the running query. Included when `dbms.logs.query.transaction_id.enabled` is `true`.
`queryPlan` | The query plan. Included when `dbms.logs.query.plan_description_enabled` is `true`.

If the type of the log entry is `transaction`, the following additional fields are available:

**Table 68. JSON format log entries**

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>event</code></td>
<td>Valid options are <code>start</code>, <code>rollback</code>, and <code>commit</code>.</td>
</tr>
<tr>
<td><code>database</code></td>
<td>The database name on which the transaction is run.</td>
</tr>
<tr>
<td><code>username</code></td>
<td>The user connected to the transaction. This field is deprecated by <code>executingUser</code>.</td>
</tr>
<tr>
<td><code>executingUser</code></td>
<td>The name of the user connected to the transaction. Either same as <code>authenticatedUser</code> or an impersonated user.</td>
</tr>
<tr>
<td><code>authenticatedUser</code></td>
<td>The name of the user who authenticated and is connected to the transaction.</td>
</tr>
<tr>
<td><code>transactionId</code></td>
<td>ID of the transaction.</td>
</tr>
</tbody>
</table>

### 14.2. Metrics [Enterprise edition](#)

This chapter describes some essential metrics to monitor in Neo4j, how to enable their logging, and how to view them.

You can configure Neo4j to log many different metrics to help you keep your applications running smoothly. By default, this data can be retrieved from CSV files or exposed over JMX MBeans, but you can also export them to third-party monitoring tools, such as **Graphite** and **Prometheus**.

Reading the **Performance** section is recommended to better understand the metrics.

This section describes the following:

- **Essential metrics** — Some of the important metrics most Neo4j administrators need to monitor.
- **Enable metrics logging** — How to configure Neo4j to log metrics data.
• **Expose metrics** — How to view data using JMX, CSV files, or other third-party monitoring tools.

• **Metrics reference** — Neo4j available metrics.

14.2.1. Essential metrics **Enterprise edition**

*This chapter describes some essential metrics to monitor in Neo4j.*

To ensure your applications are running smoothly, it is good to monitor:

- The **server load** — the strain on the machine hosting Neo4j.
- The **Neo4j load** — the strain on Neo4j.
- The **cluster health** — to ensure the cluster is working as expected.
- The **workload** of a Neo4j instance.

Reading the **Performance** section is recommended to better understand the metrics.

**Server load metrics**

Monitoring the hardware resources shows the strain on the server running Neo4j.

You can use utilities, such as the **collectd** daemon or **systemd** on Linux, to gather information about the system. These metrics can help with capacity planning as your workload grows.

<table>
<thead>
<tr>
<th>Metric name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU usage</td>
<td>If this is reaching 100%, you may need additional CPU capacity.</td>
</tr>
<tr>
<td>Used memory</td>
<td>This metric tells you if you are close to using all available memory on the server. Make sure your peaks are at 95% or below to reduce the risk of running out of memory. For more information, see Memory configuration.</td>
</tr>
<tr>
<td>Free disk space</td>
<td>Observe the rate of your data growth so you can plan for additional storage before you run out. This applies to all disks that Neo4j is writing to. You might also choose to write the log files to a different disk.</td>
</tr>
</tbody>
</table>

**Neo4j load metrics**

The Neo4j load metrics monitor the strain that Neo4j is being put under. They can help with capacity planning.
<table>
<thead>
<tr>
<th>Metric name</th>
<th>Metric</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heap usage</td>
<td><code>vm.heap.used</code> and <code>vm.heap.total</code></td>
<td>If Neo4j consistently uses 100% of the heap, increase the initial and max heap size. For more information, see <a href="#">Memory configuration</a>.</td>
</tr>
<tr>
<td>Page cache</td>
<td><code>page_cache.hit_ratio</code> and <code>page_cache.usage_ratio</code></td>
<td>When a request misses the page cache, the data must be fetched from a much slower disk. Ideally, the hit_ratio should be above 98% most of the time. This shows how much of the allocated memory to the page cache is used. If this is at 100%, consider increasing the page cache size.</td>
</tr>
<tr>
<td>JVM garbage collection</td>
<td><code>vm.gc.time.%s</code></td>
<td>The proportion of time the JVM spends reclaiming the heap instead of doing other work. This metric can spike when the database is running low on memory. If this happens, it can halt processing and cause query execution errors. Consider increasing the size of your database if this appears to be the case.</td>
</tr>
<tr>
<td>Metric name</td>
<td>Metric</td>
<td>Description</td>
</tr>
<tr>
<td>-------------</td>
<td>--------</td>
<td>-------------</td>
</tr>
</tbody>
</table>
| Checkpoint time | neo4j.<db>.check_point.duration | You should monitor the checkpoint duration to ensure it does not start to approach the interval between checkpoints. If this happens, consider the following steps to improve checkpointing performance:  
  - Raise the `dbms.checkpoint.iops.limit` to make checkpoints faster, but only if there is enough IOPS budget available to avoid slowing the commit process.  
  - `dbms.memory.pagecache.flush.buffer-enabled` / `dbms.memory.pagecache.flush.buffer.size_in_pages` make checkpoints faster by writing batches of data in a way that plays well with the underlying disk (with a nice multiple to the block size).  
  - Change the checkpointing policy (`dbms.checkpoint.*`, `dbms.checkpoint.interval.time`) to more frequent/smaller checkpoints, continuous checkpointing, or checkpoint by volume or `tx` count. For more information, see Checkpoint IOPS limit and Log pruning. |

### Neo4j cluster health metrics

The cluster health metrics indicate the health of a cluster member at a glance. It is important to know which instance is the leader. The leader has a different load pattern from the followers, which should exhibit similar load patterns.

<table>
<thead>
<tr>
<th>Metric name</th>
<th>Metric</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leader</td>
<td>neo4j.causal_clustering.core.is_leader</td>
<td>Track this for each Core cluster member. It will report 0 if it is not the leader and 1 if it is the leader. The sum of all of these should always be 1. However, there will be transient periods in which the sum can be more than 1 because more than one member thinks it is the leader.</td>
</tr>
<tr>
<td>Metric name</td>
<td>Metric</td>
<td>Description</td>
</tr>
<tr>
<td>-------------</td>
<td>--------</td>
<td>-------------</td>
</tr>
<tr>
<td>Transaction workload</td>
<td>neo4j.transaction.last_committed_tx_id</td>
<td>The ID of the last committed transaction. Track this for each Neo4j instance. In a cluster setup, track this for each Core cluster member and Read Replica. It might break into separate charts. It should show one line, ever increasing, and if one of the lines levels off or falls behind, it is clear that this member is no longer replicating data, and action is needed to rectify the situation.</td>
</tr>
</tbody>
</table>

**Workload metrics**

These metrics are useful for monitoring the workload of a Neo4j instance. The absolute values of these depend on the sort of workload you expect.

<table>
<thead>
<tr>
<th>Metric name</th>
<th>Metric</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolt connections</td>
<td>&lt;prefix&gt;.bolt.connections_running</td>
<td>The number of connections that are currently executing cypher and returning results.</td>
</tr>
<tr>
<td>Total nodes/relationships</td>
<td>neo4j.count.node and neo4j.count.relationship</td>
<td>(Not enabled by default) Total number of distinct relationship types. Total number of distinct property names. Total number of relationships. Total number of nodes.</td>
</tr>
<tr>
<td>Throughput</td>
<td>&lt;db&gt;.db.query.execution.latency.millis</td>
<td>This metric produces a histogram of 99th and 95th percentile transaction latencies. Useful for identifying spikes or increases in the data load.</td>
</tr>
</tbody>
</table>

For the full list of all available metrics in Neo4j, see Metrics reference Enterprise edition.

14.2.2. Enable metrics logging **Enterprise edition**

This chapter describes how to enable the metrics that you want to monitor.

A subset of all available metrics is enabled by default. See metrics.filter. The list was last updated in version 4.2.

You can enable/disable metrics using the configuration setting metrics.enabled. You can also use the setting metrics.filter to enable only the metrics that you want. The metrics must be specified as a
comma-separated list of globbing patterns. The following example enables all checkpoint metrics and the pagecache eviction metric:

```yaml
# Setting for enabling all supported metrics. (Default is true) Setting this to false disables all metrics.
metrics.enabled=true

# Setting for exposing metrics.
metrics.filter=*check_point*,neo4j.page_cache.evictions
```

When specifying a complete metric name, you should take into account whether `metrics.namespaces.enabled` is set.

All metrics are logged to CSV files in the `/metrics` folder.

14.2.3. Expose metrics Enterprise edition

This chapter describes how to expose the metrics using the default and third-party monitoring tools.

Neo4j supports the following ways of exposing data for monitoring purposes:

- CSV files — retrieve metrics from CSV files (true by default).
- JMX MBeans — expose metrics over JMX MBeans (true by default).
- Graphite — send metrics to Graphite or any monitoring tool based on the Graphite protocol (false by default).
- Prometheus — publish metrics for polling as Prometheus endpoint (false by default).

**CSV files**

Export metrics to CSV files.

Add the following settings to `neo4j.conf` in order to enable export of metrics into local .CSV files:

```yaml
# Enable the CSV exporter. Default is 'true'.
metrics.csv.enabled=true

# Directory path for output files.
# Default is a "metrics" directory under NEO4J_HOME.
#dbms.directories.metrics='/local/file/system/path'
# How often to store data. Default is 30 seconds.
metrics.csv.interval=30s

# The maximum number of CSV files that will be saved. Default is 7.
metrics.csv.rotation.keep_number=7

# The file size at which the csv files will auto-rotate. Default is 10M.
metrics.csv.rotation.size=10M

# Compresses the metric archive files.
metrics.csv.rotation.compression=zip
```

`metrics.csv.rotation.compression` selects the compression scheme to use on the files after rotation. Since CSV files are highly compressible, it is recommended to enable compression of the files to save disk space.
JMX MBeans

From version 4.2.2 onwards, the JMX metrics are exposed by default over JMX MBeans.

Graphite

Send metrics to Graphite or any monitoring tool based on the Graphite protocol.

Add the following settings to `neo4j.conf` in order to enable integration with Graphite:

```ini
# Enable the Graphite integration. Default is 'false'.
metrics.graphite.enabled=true
# The IP and port of the Graphite server on the format <hostname or IP address>:<port number>.
# The default port number for Graphite is 2003.
metrics.graphite.server=localhost:2003
# How often to send data. Default is 30 seconds.
metrics.graphite.interval=30s
# Prefix for Neo4j metrics on Graphite server.
metrics.prefix=Neo4j_1
```

Start Neo4j and connect to Graphite via a web browser in order to monitor your Neo4j metrics.

> If you configure the Graphite server to be a hostname or DNS entry you should be aware that the JVM resolves hostnames to IP addresses and by default caches the result indefinitely for security reasons. This is controlled by the value of `networkaddress.cache.ttl` in the JVM Security properties. See https://docs.oracle.com/javase/8/docs/technotes/guides/net/properties.html for more information.

Prometheus

Publish metrics for polling as Prometheus endpoint.

Add the following settings to `neo4j.conf` in order to enable the Prometheus endpoint.

```ini
# Enable the Prometheus endpoint. Default is 'false'.
metrics.prometheus.enabled=true
# The IP and port the endpoint will bind to in the format <hostname or IP address>:<port number>.
# The default is localhost:2004.
metrics.prometheus.endpoint=localhost:2004
```

When Neo4j is fully started, a Prometheus endpoint will be available at the configured address.

14.2.4. Metrics reference

This section includes metrics that are primarily to allow Neo4j experts to fine-tune specific issues.

You should use caution when interpreting unfamiliar metrics. Reading the Performance section is recommended to better understand the metrics.
Types of metrics

Neo4j has the following types of metrics:

- Global — covers the whole Neo4j DBMS.
- Per database — covers an individual database.

Global metrics

Global metrics cover the whole database management system, and represents the status of the system as a whole.

Global metrics have the following name format: `<user-configured-prefix>.<metric-name>` if `metrics.namespaces.enabled` is `false`, or `<user-configured-prefix>.dbms.<metric-name>` if the setting is `true`.

Metrics of this type are reported as soon as the database management system is available. For example, all JVM related metrics are global. In particular, the `neo4j.vm.thread.count` metric has a default user-configured-prefix `neo4j` and the metric name is `vm.thread.count`.

By default, global metrics include:

- Bolt metrics
- Page cache metrics
- GC metrics
- Thread metrics
- Database operation metrics
- Web Server metrics
- JVM metrics

Database metrics

Each database metric is reported for a particular database only. Database metrics are only available during the lifetime of the database. When a database becomes unavailable, all of its metrics become unavailable also.

Database metrics have the following name format: `<user-configured-prefix>.<database-name>.<metric-name>` if `metrics.namespaces.enabled` is `false`, or `<user-configured-prefix>.database.<database-name>.<metric-name>` if the setting is `true`.

For example, any transaction metric is a database metric. In particular, the `neo4j.mydb.transaction.started` metric has a default user-configured-prefix `neo4j` and is a metric for the `mydb` database.

By default, database metrics include:
- Transaction metrics
- Checkpoint metrics
- Log rotation metrics
- Database data metrics
- Cypher metrics
- Causal clustering metrics

General-purpose metrics

Table 69. Bolt metrics

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;prefix&gt;.bolt.sessions_started</td>
<td>The total number of Bolt sessions created by users since startup. This includes both succeeded and failed sessions (deprecated, use connections_opened instead). Useful for monitoring load via the Bolt drivers in combination with other metrics. (counter)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.bolt.connections_opened</td>
<td>The total number of Bolt connections opened since startup. This includes both succeeded and failed connections. Useful for monitoring load via the Bolt drivers in combination with other metrics. (counter)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.bolt.connections_closed</td>
<td>The total number of Bolt connections closed since startup. This includes both properly and abnormally ended connections. Useful for monitoring load via Bolt drivers in combination with other metrics. (counter)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.bolt.connections_running</td>
<td>The total number of Bolt connections that are currently executing Cypher and returning results. Useful to track the overall load on Bolt connections. This is limited to the number of Bolt worker threads that have been configured via dbms.connector.bolt.thread_pool_max_size. Reaching this maximum indicated the server is running at capacity. (gauge)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.bolt.connections_idle</td>
<td>The total number of Bolt connections that are not currently executing Cypher or returning results. (gauge)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.bolt.messages_received</td>
<td>The total number of messages received via Bolt since startup. Useful to track general message activity in combination with other metrics. (counter)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.bolt.messages_started</td>
<td>The total number of messages that have started processing since being received. A received message may have begun processing until a Bolt worker thread becomes available. A large gap being observed between between bolt.messages_received and bolt.messages_started could indicate the server is running at capacity. (counter)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.bolt.messages_done</td>
<td>The total number of Bolt messages that have completed processing whether successfully or unsuccessfully. Useful for tracking overall load. (counter)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.bolt.messages_failed</td>
<td>The total number of messages that have failed while processing. A high number of failures may indicate an issue with server and further investigation of the logs is recommended. (counter)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.bolt.accumulated_queue_time</td>
<td>(unsupported feature) When internal.server.bolt.thread_pool_queue_size is enabled, the total time in milliseconds that a Bolt message waits in the processing queue before a Bolt worker thread becomes available to process it. Sharp increases in this value indicate that server is running at capacity. If internal.server.bolt.thread_pool_queue_size is disabled, the value should be 0, meaning that messages are directly handed off to worker threads. (counter)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.bolt.accumulated_processing_time</td>
<td>The total amount of time in milliseconds that worker threads have been processing messages. Useful for monitoring load via Bolt drivers in combination with other metrics. (counter)</td>
</tr>
</tbody>
</table>
Table 70. Database checkpointing metrics

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;prefix&gt;.check_point.events</td>
<td>The total number of check point events executed so far. (counter)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.check_point.total_time</td>
<td>The total time, in milliseconds, spent in check pointing so far. (counter)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.check_point.duration</td>
<td>The duration, in milliseconds, of the last check point event. Checkpoints should generally take several seconds to several minutes. Long checkpoints can be an issue, as these are invoked when the database stops, when a hot backup is taken, and periodically as well. Values over 30 minutes or so should be cause for some investigation. (gauge)</td>
</tr>
</tbody>
</table>

Table 71. Cypher metrics

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;prefix&gt;.cypher.replan_events</td>
<td>The total number of times Cypher has decided to re-plan a query. Neo4j caches 1000 plans by default. Seeing sustained replanning events or large spikes could indicate an issue that needs to be investigated. (counter)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.cypher.replan_wait_time</td>
<td>The total number of seconds waited between query replans. (counter)</td>
</tr>
</tbody>
</table>

Table 72. Database data count metrics

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;prefix&gt;.neo4j.count.relationship</td>
<td>The total number of relationships in the database. (gauge)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.neo4j.count.node</td>
<td>The total number of nodes in the database. A rough metric of how big your graph is. And if you are running a bulk insert operation you can see this tick up. (gauge)</td>
</tr>
</tbody>
</table>

Table 73. Database neo4j pools metrics

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;prefix&gt;.pool.&lt;pool&gt;.&lt;database&gt;.used_heap</td>
<td>Used or reserved heap memory in bytes. (gauge)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.pool.&lt;pool&gt;.&lt;database&gt;.used_native</td>
<td>Used or reserved native memory in bytes. (gauge)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.pool.&lt;pool&gt;.&lt;database&gt;.total_used</td>
<td>Sum total used heap and native memory in bytes. (gauge)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.pool.&lt;pool&gt;.&lt;database&gt;.total_size</td>
<td>Sum total size of capacity of the heap and/or native memory pool. (gauge)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.pool.&lt;pool&gt;.&lt;database&gt;.free</td>
<td>Available unused memory in the pool, in bytes. (gauge)</td>
</tr>
</tbody>
</table>

Table 74. Database operation count metrics

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;prefix&gt;.db.operation.count.create</td>
<td>Count of successful database create operations. (counter)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.db.operation.count.start</td>
<td>Count of successful database start operations. (counter)</td>
</tr>
</tbody>
</table>
### Table 75. Database data metrics

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>&lt;prefix&gt;.db.operation.count.stop</code></td>
<td>Count of successful database stop operations. (counter)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.db.operation.count.drop</code></td>
<td>Count of successful database drop operations. (counter)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.db.operation.count.failed</code></td>
<td>Count of failed database operations. (counter)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.db.operation.count.recovered</code></td>
<td>Count of database operations which failed previously but have recovered. (counter)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>&lt;prefix&gt;.ids_in_use.relationship_type</code></td>
<td>The total number of different relationship types stored in the database. Informational, not an indication of any issue. Spikes or large increases indicate large data loads, which could correspond with some behavior you are investigating. (gauge)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.ids_in_use.property</code></td>
<td>The total number of different property names used in the database. Informational, not an indication of any issue. Spikes or large increases indicate large data loads, which could correspond with some behavior you are investigating. (gauge)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.ids_in_use.relationship</code></td>
<td>The total number of relationships stored in the database. Informational, not an indication of any issue. Spikes or large increases indicate large data loads, which could correspond with some behavior you are investigating. (gauge)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.ids_in_use.node</code></td>
<td>The total number of nodes stored in the database. Informational, not an indication of any issue. Spikes or large increases indicate large data loads, which could correspond with some behavior you are investigating. (gauge)</td>
</tr>
</tbody>
</table>

### Table 76. Global neo4j pools metrics

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>&lt;prefix&gt;.dbms.pool.&lt;pool&gt;.used_heap</code></td>
<td>Used or reserved heap memory in bytes. (gauge)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.dbms.pool.&lt;pool&gt;.used_native</code></td>
<td>Used or reserved native memory in bytes. (gauge)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.dbms.pool.&lt;pool&gt;.total_used</code></td>
<td>Sum total used heap and native memory in bytes. (gauge)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.dbms.pool.&lt;pool&gt;.total_size</code></td>
<td>Sum total size of capacity of the heap and/or native memory pool. (gauge)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.dbms.pool.&lt;pool&gt;.free</code></td>
<td>Available unused memory in the pool, in bytes. (gauge)</td>
</tr>
</tbody>
</table>

### Table 77. Database page cache metrics

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>&lt;prefix&gt;.page_cache.eviction_exceptions</code></td>
<td>The total number of exceptions seen during the eviction process in the page cache. (counter)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.page_cache.flushes</code></td>
<td>The total number of page flushes executed by the page cache. (counter)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.page_cache.merges</code></td>
<td>The total number of page merges executed by the page cache. (counter)</td>
</tr>
<tr>
<td>Name</td>
<td>Description</td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.page_cache.unpins</code></td>
<td>The total number of page unpins executed by the page cache. (counter)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.page_cache.pins</code></td>
<td>The total number of page pins executed by the page cache. (counter)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.page_cache.evictions</code></td>
<td>The total number of page evictions executed by the page cache. (counter)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.page_cache.evictions.cooperative</code></td>
<td>The total number of cooperative page evictions executed by the page cache due to low available pages. (counter)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.page_cache.page_faults</code></td>
<td>The total number of page faults happened in the page cache. If this continues to rise over time, it could be an indication that more page cache is needed. (counter)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.page_cache.hits</code></td>
<td>The total number of page hits happened in the page cache. (counter)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.page_cache.hit_ratio</code></td>
<td>The ratio of hits to the total number of lookups in the page cache. Performance relies on efficiently using the page cache, so this metric should be in the 98-100% range consistently. If it is much lower than that, then the database is going to disk too often. (gauge)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.page_cache.usage_ratio</code></td>
<td>The ratio of number of used pages to total number of available pages. This metric shows what percentage of the allocated page cache is actually being used. If it is 100%, then it is likely that the hit ratio will start dropping, and you should consider allocating more RAM to page cache. (gauge)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.page_cache.bytes_read</code></td>
<td>The total number of bytes read by the page cache. (counter)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.page_cache.bytes_written</code></td>
<td>The total number of bytes written by the page cache. (counter)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.page_cache.iops</code></td>
<td>The total number of IO operations performed by page cache.</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.page_cache.throttled.times</code></td>
<td>The total number of times page cache flush IO limiter was throttled during ongoing IO operations.</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.page_cache.throttled.millis</code></td>
<td>The total number of millis page cache flush IO limiter was throttled during ongoing IO operations.</td>
</tr>
</tbody>
</table>

**Table 78. Query execution metrics**

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>&lt;prefix&gt;.db.query.execution.success</code></td>
<td>Count of successful queries executed. (meter)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.db.query.execution.failure</code></td>
<td>Count of failed queries executed. (meter)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.db.query.execution.latency.millis</code></td>
<td>Execution time in milliseconds of queries executed successfully. (histogram)</td>
</tr>
</tbody>
</table>

**Table 79. Database store size metrics**

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>&lt;prefix&gt;.store.size.total</code></td>
<td>The total size of the database and transaction logs, in bytes. The total size of the database helps determine how much cache page is required. It also helps compare the total disk space used by the data store and how much is available. (gauge)</td>
</tr>
</tbody>
</table>
### Name Description

<prefix>.store.size.database  The size of the database, in bytes. The total size of the database helps determine how much cache page is required. It also helps compare the total disk space used by the data store and how much is available. (gauge)

---

Table 80. Database transaction log metrics

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;prefix&gt;.log.rotation_events</td>
<td>The total number of transaction log rotations executed so far. (counter)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.log.rotation_total_time</td>
<td>The total time, in milliseconds, spent in rotating transaction logs so far. (counter)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.log.rotation_duration</td>
<td>The duration, in milliseconds, of the last log rotation event. (gauge)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.log.appended_bytes</td>
<td>The total number of bytes appended to transaction log. (counter)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.log.flushes</td>
<td>The total number of transaction log flushes. (counter)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.log.append_batch_size</td>
<td>The size of the last transaction append batch. (gauge)</td>
</tr>
</tbody>
</table>

---

Table 81. Database transaction metrics

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;prefix&gt;.transaction.started</td>
<td>The total number of started transactions. (counter)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.transaction.peak_concurrent</td>
<td>The highest peak of concurrent transactions. This is a useful value to understand. It can help you with the design for the highest load scenarios and whether the Bolt thread settings should be altered. (counter)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.transaction.active</td>
<td>The number of currently active transactions. Informational, not an indication of any issue. Spikes or large increases could indicate large data loads, or just high read load. (gauge)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.transaction.active_read</td>
<td>The number of currently active read transactions. (gauge)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.transaction.active_write</td>
<td>The number of currently active write transactions. (gauge)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.transaction.committed</td>
<td>The total number of committed transactions. Informational, not an indication of any issue. Spikes or large increases indicate large data loads, or just high read load. (counter)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.transaction.committed_read</td>
<td>The total number of committed read transactions. Informational, not an indication of any issue. Spikes or large increases indicate high read load. (counter)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.transaction.committed_write</td>
<td>The total number of committed write transactions. Informational, not an indication of any issue. Spikes or large increases indicate large data loads, which could correspond with some behavior you are investigating. (counter)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.transaction.rollback</td>
<td>The total number of rolled back transactions. (counter)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.transaction.rollback_read</td>
<td>The total number of rolled back read transactions. (counter)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.transaction.rollback_write</td>
<td>The total number of rolled back write transactions. Seeing a lot of writes rolled back may indicate various issues with locking, transaction timeouts, etc. (counter)</td>
</tr>
<tr>
<td>Name</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.transaction.terminated</code></td>
<td>The total number of terminated transactions. (counter)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.transaction.terminated_read</code></td>
<td>The total number of terminated read transactions. (counter)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.transaction.terminated_write</code></td>
<td>The total number of terminated write transactions. (counter)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.transaction.last_committed_tx_id</code></td>
<td>The ID of the last committed transaction. Track this for each instance. (Cluster) Track this for each</td>
</tr>
<tr>
<td></td>
<td>Core cluster member, and each Read Replica. Might break into separate charts. It should show one</td>
</tr>
<tr>
<td></td>
<td>line, ever increasing, and if one of the lines levels off or falls behind, it is clear that this member</td>
</tr>
<tr>
<td></td>
<td>is no longer replicating data and action is needed to rectify the situation. (counter)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.transaction.last_closed_tx_id</code></td>
<td>The ID of the last closed transaction. (counter)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.transaction.tx_size_heap</code></td>
<td>The transactions' size on heap in bytes. (histogram)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.transaction.tx_size_native</code></td>
<td>The transactions' size in native memory in bytes. (histogram)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>&lt;prefix&gt;.server.threads.jetty.idle</code></td>
<td>The total number of idle threads in the jetty pool. (gauge)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.server.threads.jetty.all</code></td>
<td>The total number of threads (both idle and busy) in the jetty pool. (gauge)</td>
</tr>
</tbody>
</table>
Chapter 15. Metrics specific to Causal Clustering

Table 83. CatchUp Metrics

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;prefix&gt;.causal_clustering.catchup.tx_pull_requests_received</td>
<td>TX pull requests received from read replicas. (counter)</td>
</tr>
</tbody>
</table>

Table 84. Discovery core metrics

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;prefix&gt;.causal_clustering.core.discovery.replicated_data</td>
<td>Size of replicated data structures. (gauge)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.causal_clustering.core.discovery.cluster.members</td>
<td>Discovery cluster member size. (gauge)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.causal_clustering.core.discovery.cluster.unreachable</td>
<td>Discovery cluster unreachable size. (gauge)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.causal_clustering.core.discovery.cluster.converged</td>
<td>Discovery cluster convergence. (gauge)</td>
</tr>
</tbody>
</table>

Table 85. Raft core metrics

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;prefix&gt;.causal_clustering.core.append_index</td>
<td>The append index of the Raft log. Each index represents a write transaction (possibly internal) proposed for commitment. The values mostly increase, but sometimes they can decrease as a consequence of leader changes. The append index should always be less than or equal to the commit index. (gauge)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.causal_clustering.core.commit_index</td>
<td>The commit index of the Raft log. Represents the commitment of previously appended entries. Its value increases monotonically if you do not unbind the cluster state. The commit index should always be bigger than or equal to the append index. (gauge)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.causal_clustering.core.applied_index</td>
<td>The applied index of the Raft log. Represents the application of the committed Raft log entries to the database and internal state. The applied index should always be bigger than or equal to the commit index. The difference between this and the commit index can be used to monitor how up-to-date the follower database is. (gauge)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.causal_clustering.core.term</td>
<td>The Raft Term of this server. It increases monotonically if you do not unbind the cluster state. (gauge)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.causal_clustering.core.tx_retries</td>
<td>Transaction retries. (counter)</td>
</tr>
<tr>
<td>&lt;prefix&gt;.causal_clustering.core.is_leader</td>
<td>Is this server the leader? Track this for each Core cluster member. It will report 0 if it is not the leader and 1 if it is the leader. The sum of all of these should always be 1. However, there will be transient periods in which the sum can be more than 1 because more than one member thinks it is the leader. Action may be needed if the metric shows 0 for more than 30 seconds. (gauge)</td>
</tr>
<tr>
<td>Name</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.causal_clustering.core.in_flight_cache.total_bytes</code></td>
<td>In-flight cache total bytes. (gauge)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.causal_clustering.core.in_flight_cache.max_bytes</code></td>
<td>In-flight cache max bytes. (gauge)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.causal_clustering.core.in_flight_cache.element_count</code></td>
<td>In-flight cache element count. (gauge)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.causal_clustering.core.in_flight_cache.max_elements</code></td>
<td>In-flight cache maximum elements. (gauge)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.causal_clustering.core.in_flight_cache.hits</code></td>
<td>In-flight cache hits. (counter)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.causal_clustering.core.in_flight_cache.misses</code></td>
<td>In-flight cache misses. (counter)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.causal_clustering.core.raft_log_entry_prefetch_buffer.lag</code></td>
<td>Raft Log Entry Prefetch Lag. (gauge)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.causal_clustering.core.raft_log_entry_prefetch_buffer.bytes</code></td>
<td>Raft Log Entry Prefetch total bytes. (gauge)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.causal_clustering.core.raft_log_entry_prefetch_buffer.size</code></td>
<td>Raft Log Entry Prefetch buffer size. (gauge)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.causal_clustering.core.raft_log_entry_prefetch_buffer.async_put</code></td>
<td>Raft Log Entry Prefetch buffer async puts. (gauge)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.causal_clustering.core.raft_log_entry_prefetch_buffer.sync_put</code></td>
<td>Raft Log Entry Prefetch buffer sync puts. (gauge)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.causal_clustering.core.message_processing_delay</code></td>
<td>Delay between Raft message receive and process. (gauge)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.causal_clustering.core.message_processing_timer</code></td>
<td>Timer for Raft message processing. (counter, histogram)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.causal_clustering.core.replication_new</code></td>
<td>The total number of Raft replication requests. It increases with write transactions (possibly internal) activity. (counter)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.causal_clustering.core.replication_attempt</code></td>
<td>The total number of Raft replication requests attempts. It is bigger or equal than the replication requests. (counter)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.causal_clustering.core.replication_fail</code></td>
<td>The total number of Raft replication attempts that have failed. (counter)</td>
</tr>
</tbody>
</table>
### Table 86. Read Replica Metrics

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>&lt;prefix&gt;.causal_clustering.core.replication.maybe</code></td>
<td>Raft Replication maybe count. (counter)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.causal_clustering.core.replication.success</code></td>
<td>The total number of Raft replication requests that have succeeded. (counter)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.causal_clustering.core.last_leader_message</code></td>
<td>The time elapsed since the last message from a leader in milliseconds. Should reset periodically. (gauge)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.causal_clustering.read_replica.pull_updates</code></td>
<td>The total number of pull requests made by this instance. (counter)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.causal_clustering.read_replica.pull_update_highest_tx_id_requested</code></td>
<td>The highest transaction id requested in a pull update by this instance. (counter)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.causal_clustering.read_replica.pull_update_highest_tx_id_received</code></td>
<td>The highest transaction id that has been pulled in the last pull updates by this instance. (counter)</td>
</tr>
</tbody>
</table>
Chapter 16. Java Virtual Machine Metrics

The JVM metrics show information about garbage collections (for example, the number of events and time spent collecting), memory pools and buffers, and the number of active threads running. They are environment dependent and therefore, may vary on different hardware and with different JVM configurations. The metrics about the JVM’s memory usage expose values that are provided by the MemoryPoolMXBeans and BufferPoolMXBeans. The memory pools are memory managed by the JVM, for example, `neo4j.vm.memory.pool.g1_survivor_space`. Therefore, if necessary, you can tune them using the JVM settings. The buffer pools are space outside of the memory managed by the garbage collector. Neo4j allocates buffers in those pools as it needs them. You can limit this memory using JVM settings, but there is never any good reason for you to set them.

Table 87. JVM file descriptor metrics.

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>&lt;prefix&gt;.vm.file.descriptors.count</code></td>
<td>The current number of open file descriptors. (gauge)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.vm.file.descriptors.maximum</code></td>
<td>(OS setting) The maximum number of open file descriptors. It is recommended to be set to 40K file handles, because of the native and Lucene indexing Neo4j uses. If this metric gets close to the limit, you should consider raising it. (gauge)</td>
</tr>
</tbody>
</table>

Table 88. GC metrics.

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>&lt;prefix&gt;.vm.gc.time.&lt;gc&gt;</code></td>
<td>Accumulated garbage collection time in milliseconds. Long GCs can be an indication of performance issues, or potentially instability. If this approaches the heartbeat timeout in a cluster, it may cause unwanted leader switches. (counter)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.vm.gc.count.&lt;gc&gt;</code></td>
<td>Total number of garbage collections. (counter)</td>
</tr>
</tbody>
</table>

Table 89. JVM Heap metrics.

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>&lt;prefix&gt;.vm.heap.committed</code></td>
<td>Amount of memory (in bytes) guaranteed to be available for use by the JVM. (gauge)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.vm.heap.used</code></td>
<td>Amount of memory (in bytes) currently used. This is the amount of heap space currently used at a given point in time. Monitor this to identify if you are maxing out consistently, in which case, you should increase initial and max heap size, or if you are underutilizing, you should decrease the initial and max heap sizes. (gauge)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.vm.heap.max</code></td>
<td>Maximum amount of heap memory (in bytes) that can be used. This is the amount of heap space currently used at a given point in time. Monitor this to identify if you are maxing out consistently, in which case, you should increase initial and max heap size, or if you are underutilizing, you should decrease the initial and max heap sizes. (gauge)</td>
</tr>
</tbody>
</table>

Table 90. JVM memory buffers metrics.
### Name Description

- `<prefix>.vm.memory.buffer.<bufferpool>.count` Estimated number of buffers in the pool. (gauge)
- `<prefix>.vm.memory.buffer.<bufferpool>.used` Estimated amount of memory used by the pool. (gauge)
- `<prefix>.vm.memory.buffer.<bufferpool>.capacity` Estimated total capacity of buffers in the pool. (gauge)

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>&lt;prefix&gt;.vm.memory.pool.&lt;pool&gt;</code></td>
<td>Estimated amount of memory in bytes used by the pool. (gauge)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>&lt;prefix&gt;.vm.pause_time</code></td>
<td>Accumulated detected VM pause time. (gauge)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>&lt;prefix&gt;.vm.thread.count</code></td>
<td>Estimated number of active threads in the current thread group. (gauge)</td>
</tr>
<tr>
<td><code>&lt;prefix&gt;.vm.thread.total</code></td>
<td>The total number of live threads including daemon and non-daemon threads. (gauge)</td>
</tr>
</tbody>
</table>

### 16.1. Manage queries

This section describes facilities for query management.

#### 16.1.1. List all running queries

The procedure for listing queries, `dbms.listQueries()`, is replaced by the command for listing transactions, `SHOW TRANSACTIONS`. This command returns information about the currently executing query in the transaction. For more information on the command, see the Cypher manual → SHOW TRANSACTIONS command.

#### 16.1.2. List all active locks for a query

An administrator is able to view all active locks held by the transaction executing the query with the `queryId`.

Syntax:
CALL dbms.listActiveLocks(queryId)

Returns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>mode</td>
<td>String</td>
<td>Lock mode corresponding to the transaction.</td>
</tr>
<tr>
<td>resourceType</td>
<td>String</td>
<td>Resource type of the locked resource</td>
</tr>
<tr>
<td>resourceId</td>
<td>Integer</td>
<td>Resource id of the locked resource.</td>
</tr>
</tbody>
</table>

Example 94. Viewing active locks for a query

The following example shows the active locks held by transaction executing query with id query-614

```sql
CALL dbms.listActiveLocks( "query-614" )
```

```
+mode  +resourceType  +resourceId+
| "SHARED" | "SCHEMA"  | 0          |
+----------+-----------+------------+
1 row
```

The following example shows the active locks for all currently executing queries by yielding the queryId from dbms.listQueries procedure

```sql
CALL dbms.listQueries() YIELD queryId, query, database
CALL dbms.listActiveLocks( queryId ) YIELD resourceType, resourceId, mode
RETURN queryId, query, resourceType, resourceId, mode, database
```

```
+queryId    +query                    +resourceType +resourceId +mode       +database      |
| "query-614" | match (n), (m), (o), (p), (q) return count(*)"      | "SCHEMA"    | 0          | "SHARED"  | "myDb"        |
| "query-684" | CALL dbms.listQueries() YIELD ...                      | "SCHEMA"    | 0          | "SHARED"  | "myOtherDb"   |
+------------+----------------------------------+-----------+------------+-----------+---------------+
2 rows
```

16.1.3. Terminate queries

The procedures for terminating queries, dbms.killQueries(queryIds) and dbms.killQuery(queryId), are replaced by the command for terminating transactions, TERMINATE TRANSACTIONS transactionIds. These commands use the transactionId instead of the queryId, which can be found using the SHOW TRANSACTIONS command.

The TERMINATE TRANSACTION privilege determines what transactions can be terminated. However, the current user can always terminate all of their own transactions.
Syntax:

```
TERMINATE TRANSACTIONS transactionIds
```

Argument:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>transactionIds</td>
<td>Comma-separated strings</td>
<td>The IDs of all the transactions to be terminated.</td>
</tr>
<tr>
<td>transactionIds</td>
<td>Single string parameter</td>
<td>The ID of the transaction to be terminated.</td>
</tr>
<tr>
<td>transactionIds</td>
<td>List parameter</td>
<td>The IDs of all the transactions to be terminated.</td>
</tr>
</tbody>
</table>

For more information on the command, see the Cypher manual → TERMINATE TRANSACTIONS command.

16.2. Manage transactions

This section describes facilities for transaction management.

16.2.1. Configure transaction timeout

It is recommended to configure Neo4j to terminate transactions whose execution time has exceeded the configured timeout.

- Set `dbms.transaction.timeout` to some positive time interval value (e.g., `10s`) denoting the default transaction timeout. Setting `dbms.transaction.timeout` to 0 — which is the default value — disables the feature.
- You can also set this dynamically on each instance (Read Replicas only if required) using the procedure `dbms.setConfigValue('dbms.transaction.timeout','10s')`.

Example 95. Configure transaction timeout

Set the timeout to ten seconds.

```
dbms.transaction.timeout=10s
```

Configuring transaction timeout has no effect on transactions executed with custom timeouts (e.g., via the Java API or Neo4j Drivers), as the custom timeout overrides the value set for `dbms.transaction.timeout`. Note that the timeout value can only be overridden to a value that is smaller than that configured by `dbms.transaction.timeout`.

The transaction timeout feature is also known as the transaction guard.
16.2.2. Configure lock acquisition timeout

An executing transaction may get stuck while waiting for some lock to be released by another transaction. To kill that transaction and remove the lock, set the `dbms.lock.acquisition.timeout` to some positive time interval value (e.g., 10s) denoting the maximum time interval within which any particular lock should be acquired, before failing the transaction. Setting `dbms.lock.acquisition.timeout` to 0 — which is the default value — disables the lock acquisition timeout.

This feature cannot be set dynamically.

**Example 96. Configure lock acquisition timeout**

Set the timeout to ten seconds.
```
dbms.lock.acquisition.timeout=10s
```

16.2.3. List all running transactions

The procedure for viewing transactions, `dbms.listTransactions()`, is replaced by the command for showing transactions, `SHOW TRANSACTIONS`. Both the command and procedure returns the transactions that are currently executing within the instance.

The `SHOW TRANSACTION` privilege determines what transactions are returned by the command. However, the current user can always view all of their own currently executing transactions.

**Syntax:**
```
SHOW TRANSACTIONS
```

For more information on this command, see the Cypher manual → SHOW TRANSACTIONS command.

16.3. Manage connections

*This section describes facilities for connection management.*

16.3.1. List all network connections

An administrator is able to view all network connections within the database instance. Alternatively, the current user may view all of their own network connections.

The procedure `dbms.listConnections` lists all accepted network connections for all configured connectors, including Bolt, HTTP, and HTTPS. Some listed connections might never perform authentication. For example, HTTP GET requests to the Neo4j Browser endpoint fetches static resources and does not need to authenticate. However, connections made using Neo4j Browser require the user to provide credentials and perform authentication. For more information on Neo4j Browser connections, see the Neo4j Browser documentation.
Syntax:

CALL dbms.listConnections()

Table 94. Data retrieved from a database

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>connectionId</td>
<td>String</td>
<td>This is the ID of the network connection.</td>
</tr>
<tr>
<td>connectTime</td>
<td>String</td>
<td>This is the time at which the connection was started.</td>
</tr>
<tr>
<td>connector</td>
<td>String</td>
<td>Name of the connector that accepted the connection.</td>
</tr>
<tr>
<td>username</td>
<td>String</td>
<td>This is the username of the user who initiated the connection. This field will be null if the transaction was issued using embedded API. It can also be null if connection did not perform authentication.</td>
</tr>
<tr>
<td>userAgent</td>
<td>String</td>
<td>Name of the software that is connected. For HTTP and HTTPS connections, this information is extracted from the User-Agent request header. For Bolt connections, the user agent is available natively and is supplied in an initialization message.</td>
</tr>
<tr>
<td>serverAddress</td>
<td>String</td>
<td>The server address this connection is connected to.</td>
</tr>
<tr>
<td>clientAddress</td>
<td>String</td>
<td>The client address of the connection.</td>
</tr>
</tbody>
</table>

Table 95. Default userAgent string formats

<table>
<thead>
<tr>
<th>Neo4j client agent</th>
<th>userAgent default string format</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cypher Shell</td>
<td>&quot;neo4j-cypher-shell/v${version}&quot;</td>
<td>&quot;neo4j-cypher-shell/v4.3.0&quot;</td>
</tr>
<tr>
<td>Neo4j Browser</td>
<td>&quot;neo4j-browser/v${version}&quot;</td>
<td>&quot;neo4j-browser/v4.3.0&quot;</td>
</tr>
<tr>
<td>Neo4j Bloom</td>
<td>&quot;neo4j-bloom/v${version}&quot;</td>
<td>&quot;neo4j-bloom/v1.7.0&quot;</td>
</tr>
<tr>
<td>Neo4j Java Driver</td>
<td>&quot;neo4j-java/x.y.z&quot;</td>
<td>&quot;neo4j-java/1.6.3&quot;</td>
</tr>
<tr>
<td>Neo4j .Net Driver</td>
<td>&quot;neo4j-dotnet/x.y&quot;</td>
<td>&quot;neo4j-dotnet/4.3&quot;</td>
</tr>
<tr>
<td>Neo4j Go Driver</td>
<td>&quot;Go Driver/x.y&quot;</td>
<td>&quot;Go Driver/4.3&quot;</td>
</tr>
<tr>
<td>Neo4j Python Driver</td>
<td>&quot;neo4j-python/x.y Python/x.y.z-a-b (operating-system)&quot;</td>
<td>&quot;neo4j-python/4.3 Python/3.7.6 (linux)&quot;</td>
</tr>
<tr>
<td>Neo4j JavaScript Driver</td>
<td>&quot;neo4j-javascript/x.y.z&quot;</td>
<td>&quot;neo4j-javascript/4.3.0&quot;</td>
</tr>
</tbody>
</table>
Example 97. List all network connections

The following example shows that the user 'alwood' is connected using Java driver and a Firefox web browser. The procedure call yields specific information about the connection, namely connectionId, connectTime, connector, username, userAgent, and clientAddress.

```
CALL dbms.listConnections() YIELD connectionId, connectTime, connector, username, userAgent, clientAddress
```

<table>
<thead>
<tr>
<th>&quot;connectionId&quot;</th>
<th>&quot;connectTime&quot;</th>
<th>&quot;connector&quot;</th>
<th>&quot;username&quot;</th>
<th>&quot;userAgent&quot;</th>
<th>&quot;clientAddress&quot;</th>
<th>&quot;status&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;bolt-21&quot;</td>
<td>&quot;2018-10-10T12:11:42.276Z&quot;</td>
<td>&quot;bolt&quot;</td>
<td>&quot;alwood&quot;</td>
<td>&quot;neo4j-java/1.6.3&quot;</td>
<td>&quot;127.0.0.1:53929&quot;</td>
<td>&quot;Running&quot;</td>
</tr>
<tr>
<td>&quot;http-11&quot;</td>
<td>&quot;2018-10-10T12:37:19.014Z&quot;</td>
<td>&quot;http&quot;</td>
<td>null</td>
<td>&quot;Mozilla/5.0 (Macintosh; Intel macos 10.13; rv:62.0) Gecko/20100101 Firefox/62.0&quot;</td>
<td>&quot;127.0.0.1:54118&quot;</td>
<td>&quot;Running&quot;</td>
</tr>
</tbody>
</table>

2 rows

16.3.2. Terminate multiple network connections

An administrator is able to terminate within the instance all network connections with any of the given IDs. Alternatively, the current user may terminate all of their own network connections with any of the given IDs.

Syntax:

```
CALL dbms.killConnections(connectionIds)
```

Arguments:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ids</td>
<td>List&lt;String&gt;</td>
<td>This is a list of the IDs of all the connections to be terminated.</td>
</tr>
</tbody>
</table>

Returns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>connectionId</td>
<td>String</td>
<td>This is the ID of the terminated connection.</td>
</tr>
<tr>
<td>username</td>
<td>String</td>
<td>This is the username of the user who initiated the (now terminated) connection.</td>
</tr>
<tr>
<td>message</td>
<td>String</td>
<td>A message stating whether the connection was successfully found.</td>
</tr>
</tbody>
</table>
Considerations:

Bolt connections are stateful. Termination of a Bolt connection results in termination of the ongoing query/transaction.

Termination of an HTTP/HTTPS connection can terminate the ongoing HTTP/HTTPS request.

Example 98. Terminate multiple network connections

The following example shows that the administrator has terminated the connections with IDs 'bolt-37' and 'https-11', started by the users 'joesmith' and 'annebrown', respectively. The administrator also attempted to terminate the connection with ID 'http-42' which did not exist.

```
CALL dbms.killConnections(['bolt-37', 'https-11', 'http-42'])
```

<table>
<thead>
<tr>
<th>&quot;connectionId&quot;</th>
<th>&quot;username&quot;</th>
<th>&quot;message&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>bolt-37</td>
<td>joesmith</td>
<td>Connection found</td>
</tr>
<tr>
<td>https-11</td>
<td>annebrown</td>
<td>Connection found</td>
</tr>
<tr>
<td>http-42</td>
<td>n/a</td>
<td>No connection found with this id</td>
</tr>
</tbody>
</table>

3 rows

16.3.3. Terminate a single network connection

An administrator is able to terminate within the instance any network connection with the given ID. Alternatively, the current user may terminate their own network connection with the given ID.

Syntax:

```
CALL dbms.killConnection(connectionId)
```

Arguments:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>id</td>
<td>String</td>
<td>This is the ID of the connection to be terminated.</td>
</tr>
</tbody>
</table>

Returns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>connectionId</td>
<td>String</td>
<td>This is the ID of the terminated connection.</td>
</tr>
<tr>
<td>username</td>
<td>String</td>
<td>This is the username of the user who initiated the (now terminated) connection.</td>
</tr>
<tr>
<td>message</td>
<td>String</td>
<td>A message stating whether the connection was successfully found.</td>
</tr>
</tbody>
</table>
Considerations:

Bolt connections are stateful. Termination of a Bolt connection results in termination of the ongoing query/transaction.

Termination of an HTTP/HTTPS connection can terminate the ongoing HTTP/HTTPS request.

Example 99. Terminate a single network connection

The following example shows that the user 'joesmith' has terminated his connection with the ID 'bolt-4321'.

```sql
CALL dbms.killConnection('bolt-4321')
```

<table>
<thead>
<tr>
<th>&quot;connectionId&quot;</th>
<th>&quot;username&quot;</th>
<th>&quot;message&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;bolt-4321&quot;</td>
<td>&quot;joesmith&quot;</td>
<td>&quot;Connection found&quot;</td>
</tr>
</tbody>
</table>

1 row

The following example shows the output when trying to kill a connection with an ID that does not exist.

```sql
CALL dbms.killConnection('bolt-987')
```

<table>
<thead>
<tr>
<th>&quot;connectionId&quot;</th>
<th>&quot;username&quot;</th>
<th>&quot;message&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;bolt-987&quot;</td>
<td>&quot;n/a&quot;</td>
<td>&quot;No connection found with this id&quot;</td>
</tr>
</tbody>
</table>

1 row

16.4. Manage background jobs [Enterprise edition]

This section describes facilities for listing both active and failed background jobs.

There are many types of background jobs performed in the DBMS, many of which are triggered as system jobs by the DBMS itself without any user action. For example, important background jobs include checkpoint or index population. The former is triggered by the DBMS, and the latter can be a result of a user creating or modifying an index definition.

Background jobs are of the following types:

- **IMMEDIATE** - a one-time action, triggered and run in the background.
- **DELAYED** - a one-time action, run in the background at a given point in the future.
- **PERIODIC** - a recurring action, run in the background at a given time interval.

The DBMS provides a way to show active and failed background jobs. Active jobs are those that are
currently running, or are scheduled to be delayed or periodic jobs. If a background job fails, or fails to start, the details of the failure are stored in the failed jobs list. Please note that only the last 100 jobs are stored in the failed jobs list, and that this list is not persistent, so it is cleared with a DBMS restart.

Additionally, it should be noted that a single periodic job can contribute multiple times to the failed jobs list.

16.4.1. Listing active background jobs

An administrator can list background jobs active on an instance:

Syntax:

```
CALL dbms.scheduler.jobs()
```

Returns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>jobId</td>
<td>String</td>
</tr>
<tr>
<td>ID of the job. Can be used to keep track of an active job, and to link a job to a failed job run.</td>
<td></td>
</tr>
<tr>
<td>group</td>
<td>String</td>
</tr>
<tr>
<td>A job is a member of a job group. For example, INDEX_POPULATION, LOG_ROTATION or RAFT_SERVER.</td>
<td></td>
</tr>
<tr>
<td>submitted</td>
<td>String</td>
</tr>
<tr>
<td>A timestamp for when the job was submitted, in ISO-8601 format.</td>
<td></td>
</tr>
<tr>
<td>database</td>
<td>String</td>
</tr>
<tr>
<td>Jobs can have either a database or a DBMS scope:</td>
<td></td>
</tr>
<tr>
<td>• For database, this column will display the name of the database.</td>
<td></td>
</tr>
<tr>
<td>• For DBMS, this column will be blank.</td>
<td></td>
</tr>
<tr>
<td>submitter</td>
<td>String</td>
</tr>
<tr>
<td>Jobs are either triggered as a result of user action, or as a system job by the DBMS itself. This column will contain a username for jobs triggered by users, or is otherwise blank.</td>
<td></td>
</tr>
<tr>
<td>description</td>
<td>String</td>
</tr>
<tr>
<td>A short description of a job that, unlike currentStateDescription, does not change during the running of the job.</td>
<td></td>
</tr>
<tr>
<td>Name</td>
<td>Type</td>
</tr>
<tr>
<td>--------------</td>
<td>------------</td>
</tr>
<tr>
<td>type</td>
<td>String</td>
</tr>
<tr>
<td>Type of the job. The values can be <strong>IMMEDIATE</strong>, <strong>DELAYED</strong> or <strong>PERIODIC</strong>.</td>
<td></td>
</tr>
<tr>
<td>scheduledAt</td>
<td>String</td>
</tr>
<tr>
<td>A timestamp for when a <strong>DELAYED</strong> or <strong>PERIODIC</strong> job will be run, in ISO-8601 format. This column is not applicable to <strong>IMMEDIATE</strong> jobs, and will be blank for that job type.</td>
<td></td>
</tr>
<tr>
<td>period</td>
<td>String</td>
</tr>
<tr>
<td>A period of a <strong>PERIODIC</strong> job, in format <code>hh:mm:ss.sss</code>.</td>
<td></td>
</tr>
<tr>
<td>state</td>
<td>String</td>
</tr>
<tr>
<td>A state of the job. Since this procedure lists only active jobs, they can be either in <strong>SCHEDULED</strong> or <strong>EXECUTING</strong> state. <strong>SCHEDULED</strong> state is applicable only to <strong>DELAYED</strong> or <strong>PERIODIC</strong> jobs, and means that the job is scheduled for a given time in the future.</td>
<td></td>
</tr>
<tr>
<td>currentStateDescription</td>
<td>String</td>
</tr>
<tr>
<td>If a job supports reposting its progress, the progress will be reported in this column in a free-form format, specific for each job.</td>
<td></td>
</tr>
</tbody>
</table>

### 16.4.2. Listing failed job executions

An administrator can list job executions failed on an instance:

**Syntax:**

```sql
CALL calling dbms.scheduler.failedJobs()
```

**Returns:**

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>jobId</td>
<td>String</td>
</tr>
<tr>
<td>ID of the failed job.</td>
<td></td>
</tr>
<tr>
<td>group</td>
<td>String</td>
</tr>
<tr>
<td>A job is a member of a job group. For example, <strong>INDEX_POPULATION</strong>, <strong>LOG_ROTATION</strong> or <strong>RAFT_SERVER</strong>.</td>
<td></td>
</tr>
</tbody>
</table>
Jobs can have either a database or a DBMS scope:

- For database, this column will display the name of the database.
- For DBMS, this column will be blank.

Jobs are either triggered as a result of user action, or as a system job by the DBMS itself. This column will contain a username for jobs triggered by users, or is otherwise blank.

A short description of a job that, unlike `currentStateDescription`, does not change during the running of the job.

Type of the job. The values can be `IMMEDIATE`, `DELAYED` or `PERIODIC`.

A timestamp for when the job was submitted, in ISO-8601 format.

A timestamp for when the failed execution started, in ISO-8601 format.

A timestamp for when the execution failed, in ISO-8601 format.

A short description of the failure. If the failure description is insufficient, more information can be found in logs.


This section covers additional facilities available for monitoring a Neo4j Causal Cluster.

In addition to specific metrics as described in previous sections, Neo4j Causal Clusters provide an
infrastructure that operators will wish to monitor. The procedures can be used to inspect the cluster state and to understand its current condition and topology. Additionally, there are HTTP endpoints for checking health and status.

This section describes the following:

- Procedures for monitoring a Causal Cluster
  - Find out the role of a cluster member
  - Gain an overview over the instances in the cluster
  - Get routing recommendations
- Endpoints for status information
  - Adjusting security settings for Causal Clustering endpoints
  - Unified endpoints

16.5.1. Procedures for monitoring a Causal Cluster

This section covers procedures for monitoring a Neo4j Causal Cluster.

A number of procedures are available that provide information about a cluster.

Find out the role of a cluster member

The procedure `dbms.cluster.role(databaseName)` can be called on every instance in a Causal Cluster to return the role of the instance. Each instance holds multiple databases and participates in multiple independent Raft groups. The role returned by the procedure is for the database denoted by the `databaseName` parameter.

**Syntax:**

`CALL dbms.cluster.role(databaseName)`

**Arguments:**

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>databaseName</td>
<td>String</td>
<td>The name of the database to get the cluster role for.</td>
</tr>
</tbody>
</table>

**Returns:**

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>role</td>
<td>String</td>
<td>This is the role of the current instance, which can be LEADER, FOLLOWER, or READ_REPLICA.</td>
</tr>
</tbody>
</table>

**Considerations:**
While this procedure is useful in and of itself, it serves as basis for more powerful monitoring procedures.

Example 100. Check the role of this instance

The following example shows how to find out the role of the current instance for database neo4j, which in this case is FOLLOWER.

```
CALL dbms.cluster.role("neo4j")
```

<table>
<thead>
<tr>
<th>role</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOLLOWER</td>
</tr>
</tbody>
</table>

Gain an overview over the instances in the cluster

The procedure `dbms.cluster.overview()` provides an overview of cluster topology by returning details on all the instances in the cluster.

Syntax:

```
CALL dbms.cluster.overview()
```

Returns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>id</td>
<td>String</td>
<td>This is id of the instance.</td>
</tr>
<tr>
<td>addresses</td>
<td>List</td>
<td>This is a list of all the addresses for the instance.</td>
</tr>
<tr>
<td>groups</td>
<td>List</td>
<td>This is a list of all the server groups which an instance is part of.</td>
</tr>
<tr>
<td>databases</td>
<td>Map</td>
<td>This is a map of all databases with corresponding roles which the instance is hosting. The keys in the map are database names. The values are roles of this instance in the corresponding Raft groups, which can be LEADER, FOLLOWER, or READ_REPLICA.</td>
</tr>
</tbody>
</table>
Example 101. Get an overview of the cluster

The following example shows how to explore the cluster topology.

```
CALL dbms.cluster.overview()
```

<table>
<thead>
<tr>
<th>id</th>
<th>addresses</th>
<th>groups</th>
<th>databases</th>
</tr>
</thead>
</table>

Get routing recommendations

From the application point of view it is not interesting to know about the role a member plays in the cluster. Instead, the application needs to know which instance can provide the wanted service. The procedure `dbms.routing.getRoutingTable(routingContext, databaseName)` provides this information.

Syntax:

```
CALL dbms.routing.getRoutingTable(routingContext, databaseName)
```

Arguments:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>routingContext</td>
<td>Map</td>
<td>The routing context used for multi-data center deployments. It should be used in combination with multi-data center load balancing.</td>
</tr>
<tr>
<td>databaseName</td>
<td>String</td>
<td>The name of the database to get the routing table for.</td>
</tr>
</tbody>
</table>
Example 102. Get routing recommendations

The following example shows how discover which instances in the cluster can provide which services for database neo4j.

```sql
CALL dbms.routing.getRoutingTable({}, "neo4j")
```

The procedure returns a map between a particular service, READ, WRITE and ROUTE, and the addresses of instances that provide this service. It also returns a Time To Live (TTL) in seconds as a suggestion on how long the client could cache the response.

The result is not primarily intended for human consumption. Expanding it this is what it looks like.

```json
{
  "ttl": 300,
  "servers": [
    {
      "addresses": ["neo20:7687"],
      "role": "WRITE"
    },
    {
      "role": "READ"
    },
    {
      "addresses": ["neo20:7687", "neo21:7687", "neo22:7687"],
      "role": "ROUTE"
    }
  ]
}
```

16.5.2. Monitor cluster endpoints for status information

This section describes HTTP endpoints for monitoring the health of a Neo4j Causal Cluster.

A Causal Cluster exposes some HTTP endpoints which can be used to monitor the health of the cluster. In this section we will describe these endpoints and explain their semantics.

Adjusting security settings for Causal Clustering endpoints

If authentication and authorization is enabled in Neo4j, the Causal Clustering status endpoints will also require authentication credentials. The setting `dbms.security.auth_enabled` controls whether the native auth provider is enabled. For some load balancers and proxy servers, providing authentication credentials with the request is not an option. For those situations, consider disabling authentication of the Causal Clustering status endpoints by setting `dbms.security.causal_clustering_status_auth_enabled=false` in `neo4j.conf`.

Unified endpoints

A unified set of endpoints exist, both on Core Servers and on Read Replicas, with the following behavior:

- `/db/<databasename>/cluster/writable` — Used to direct write traffic to specific instances.
• /db/<databasename>/cluster/read-only — Used to direct read traffic to specific instances.

• /db/<databasename>/cluster/available — Available for the general case of directing arbitrary request types to instances that are available for processing read transactions.

• /db/<databasename>/cluster/status — Gives a detailed description of this instance’s view of its status within the cluster, for the given database.

• /dbms/cluster/status — Gives a detailed description of this instance’s view of its status within the cluster, for all databases. Useful for monitoring and coordinating rolling upgrades. See Status endpoints for further details.

Every /db/<databasename>/* endpoint targets a specific database. The databaseName path parameter represents the name of the database. By default, a fresh Neo4j installation with two databases system and neo4j will have the following cluster endpoints:

- http://localhost:7474/dbms/cluster/status
- http://localhost:7474/db/system/cluster/writable
- http://localhost:7474/db/system/cluster/read-only
- http://localhost:7474/db/system/cluster/available
- http://localhost:7474/db/system/cluster/status
- http://localhost:7474/db/neo4j/cluster/writable
- http://localhost:7474/db/neo4j/cluster/read-only
- http://localhost:7474/db/neo4j/cluster/available
- http://localhost:7474/db/neo4j/cluster/status

Table 96. Unified HTTP endpoint responses

<table>
<thead>
<tr>
<th>Endpoint</th>
<th>Instance state</th>
<th>Returned code</th>
<th>Body text</th>
</tr>
</thead>
<tbody>
<tr>
<td>/db/&lt;databasename&gt;/cluster/writable</td>
<td>Leader</td>
<td>200 OK</td>
<td>true</td>
</tr>
<tr>
<td></td>
<td>Follower</td>
<td>404 Not Found</td>
<td>false</td>
</tr>
<tr>
<td></td>
<td>Read Replica</td>
<td>404 Not Found</td>
<td>false</td>
</tr>
<tr>
<td>/db/&lt;databasename&gt;/cluster/read-only</td>
<td>Leader</td>
<td>404 Not Found</td>
<td>false</td>
</tr>
<tr>
<td></td>
<td>Follower</td>
<td>200 OK</td>
<td>true</td>
</tr>
<tr>
<td></td>
<td>Read Replica</td>
<td>200 OK</td>
<td>true</td>
</tr>
<tr>
<td>Endpoint</td>
<td>Instance state</td>
<td>Returned code</td>
<td>Body text</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>----------------</td>
<td>---------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>/db/&lt;databasename&gt;/cluster/available</td>
<td>Leader</td>
<td>200 OK</td>
<td>true</td>
</tr>
<tr>
<td></td>
<td>Follower</td>
<td>200 OK</td>
<td>true</td>
</tr>
<tr>
<td></td>
<td>Read Replica</td>
<td>200 OK</td>
<td>true</td>
</tr>
<tr>
<td>/db/&lt;databasename&gt;/cluster/status</td>
<td>Leader</td>
<td>200 OK</td>
<td>JSON - See Status endpoint for details.</td>
</tr>
<tr>
<td></td>
<td>Follower</td>
<td>200 OK</td>
<td>JSON - See Status endpoint for details.</td>
</tr>
<tr>
<td></td>
<td>Read Replica</td>
<td>200 OK</td>
<td>JSON - See Status endpoint for details.</td>
</tr>
<tr>
<td>/dbms/cluster/status</td>
<td>Leader</td>
<td>200 OK</td>
<td>JSON - See Status endpoint for details.</td>
</tr>
<tr>
<td></td>
<td>Follower</td>
<td>200 OK</td>
<td>JSON - See Status endpoint for details.</td>
</tr>
<tr>
<td></td>
<td>Read Replica</td>
<td>200 OK</td>
<td>JSON - See Status endpoint for details.</td>
</tr>
</tbody>
</table>
Example 103. Use a Causal Clustering monitoring endpoint

From the command line, a common way to ask those endpoints is to use curl. With no arguments, curl will do an HTTP GET on the URI provided and will output the body text, if any. If you also want to get the response code, just add the -v flag for verbose output. Here are some examples:

- Requesting writable endpoint on a Core Server that is currently elected leader with verbose output:

```bash
#> curl -v localhost:7474/db/neo4j/cluster/writable
* About to connect() to localhost port 7474 (#0)
* Trying ::1...
* Connected to localhost (::1) port 7474 (#0)
> GET /db/neo4j/cluster/writable HTTP/1.1
> User-Agent: curl/7.24.0 (x86_64-apple-darwin12.0) libcurl/7.24.0 OpenSSL/0.9.8r zlib/1.2.5
> Host: localhost:7474
> Accept: */*
>
< HTTP/1.1 200 OK
< Content-Type: text/plain
< Access-Control-Allow-Origin: *
< Transfer-Encoding: chunked
< Server: Jetty(9.4.17)
<
* Connection #0 to host localhost left intact
true* Closing connection #0
```

Status endpoints

The status endpoint, available at /db/<databasename>/cluster/status, is to be used to assist with rolling upgrades. For more information, see Upgrade and Migration Guide → Upgrade a Causal Cluster.

Typically, you will want to have some guarantee that a Core is safe to shutdown for each database before removing it from a cluster. Counter intuitively, a core being safe to shutdown means that a majority of the other cores are healthy, caught up, and have recently heard from that database's leader. The status endpoints provide the following information in order to help resolve such issues.

Several of the fields in status endpoint responses refer to details of Raft, the algorithm used in Neo4j Causal Clusters to provide highly available transactions. When using multiple databases, each database implements Raft independently. Therefore, details such as leader and raftCommandsPerSecond are database specific.
Example 104. Example status response

```json
{
  "lastAppliedRaftIndex": 0,
  "votingMembers": ["30edc1c4-519c-4030-8348-7cb7af44f591", "80a7fb7b-c966-4ee7-88a9-35db8b4d68fe", "f9301218-1f4d-4938-b9bb-a03453e1f779"],
  "memberId": "80a7fb7b-c966-4ee7-88a9-35db8b4d68fe",
  "leader": "30edc1c4-519c-4030-8348-7cb7af44f591",
  "millisSinceLastLeaderMessage": 84545,
  "participatingInRaftGroup": true,
  "core": true,
  "isHealthy": true,
  "raftCommandsPerSecond": 124
}
```

Table 97. Status endpoint descriptions

<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Optional</th>
<th>Example</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>core</td>
<td>boolean</td>
<td>no</td>
<td>true</td>
<td>Used to distinguish between Core Servers and Read Replicas.</td>
</tr>
<tr>
<td>lastAppliedRaftIndex</td>
<td>number</td>
<td>no</td>
<td>4321</td>
<td>Every transaction in a cluster is associated with a raft index.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Gives an indication of what the latest applied raft log index is.</td>
</tr>
<tr>
<td>participatingInRaftGroup</td>
<td>boolean</td>
<td>no</td>
<td>false</td>
<td>A participating member is able to vote. A Core is considered participating when it is part of the voter membership and has kept track of the leader.</td>
</tr>
<tr>
<td>votingMembers</td>
<td>string[]</td>
<td>no</td>
<td>[]</td>
<td>A member is considered a voting member when the leader has been receiving communication with it. List of member's memberId that are considered part of the voting set by this Core.</td>
</tr>
<tr>
<td>isHealthy</td>
<td>boolean</td>
<td>no</td>
<td>true</td>
<td>Reflects that the local database of this member has not encountered a critical error preventing it from writing locally.</td>
</tr>
<tr>
<td>memberId</td>
<td>string</td>
<td>no</td>
<td>30edc1c4-519c-4030-8348-7cb7af44f591</td>
<td>Every member in a cluster has its own unique member id to identify it. Use memberId to distinguish between Core and Read Replica.</td>
</tr>
<tr>
<td>leader</td>
<td>string</td>
<td>yes</td>
<td>80a7fb7b-c966-4ee7-88a9-35db8b4d68fe</td>
<td>Follows the same format as memberId, but if it is null or missing, then the leader is unknown.</td>
</tr>
<tr>
<td>millisSinceLastLeaderMessage</td>
<td>number</td>
<td>yes</td>
<td>1234</td>
<td>The number of milliseconds since the last heartbeat-like leader message. Not relevant to Read Replicas, and hence is not included.</td>
</tr>
<tr>
<td>raftCommandsPerSecond</td>
<td>number</td>
<td>yes</td>
<td>124</td>
<td>An estimate of the average Raft state machine throughput over a sampling window configurable via causal_clustering.status_throughput_window setting.</td>
</tr>
</tbody>
</table>
After an instance has been switched on, you can access the status endpoint in order to make sure all the guarantees listed in the table below are met.

To get the most accurate view of a cluster it is strongly recommended to access the status endpoint on all core members and compare the result. The following table explains how results can be compared.

Table 98. Measured values, accessed via the status endpoint

<table>
<thead>
<tr>
<th>Name of check</th>
<th>Method of calculation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>allServersAreHealthy</td>
<td>Every Core's status endpoint indicates isHealthy==true.</td>
<td>We want to make sure the data across the entire cluster is healthy. Whenever any Cores are false indicates a larger problem.</td>
</tr>
<tr>
<td>allVotingSetsAreEqual</td>
<td>For any 2 Cores (A and B), status endpoint A's votingMembers== status endpoint B's votingMembers.</td>
<td>When the voting begins, all the Cores are equal to each other, and you know all members agree on membership.</td>
</tr>
<tr>
<td>allVotingSetsContainAtLeastTargetCluster</td>
<td>For all Cores (S), excluding Core Z (to be switched off), every member in S contains S in their voting set. Membership is determined by using the memberId and votingMembers from the status endpoint.</td>
<td>Sometimes network conditions will not be perfect and it may make sense to switch off a different Core to the one we originally wanted to switch off. If you run this check for all Cores, the ones that match this condition can be switched off (providing other conditions are also met).</td>
</tr>
<tr>
<td>hasOneLeader</td>
<td>For any 2 Cores (A and B), A.leader == B.leader &amp;&amp; leader!=null.</td>
<td>If the leader is different then there may be a partition (alternatively, this could also occur due to bad timing). If the leader is unknown, that means the leader messages have actually timed out.</td>
</tr>
<tr>
<td>noMembersLagging</td>
<td>For Core A with lastAppliedRaftIndex = min, and Core B with lastAppliedRaftIndex = max, B.lastAppliedRaftIndex- A.lastAppliedRaftIndex&lt;raftIndexLagThreshold.</td>
<td>If there is a large difference in the applied indexes between Cores, then it could be dangerous to switch off a Core.</td>
</tr>
</tbody>
</table>

Combined status endpoints

When using the status endpoints to support a rolling upgrade, you need to assess whether a Core is safe to shutdown for all databases. To avoid having to issue a separate request to each /db/<databasename>/cluster/status endpoint, you can use the /dbms/cluster/status instead.

This endpoint returns a json array, the elements of which contain the same fields as the single database version, along with fields for for databaseName and databaseUuid.
16.6. Monitor individual database states

This section covers the use of SHOW DATABASES, and other related Cypher commands.

In addition to the system-wide metrics and logs described in previous sections, operators may wish to monitor the state of individual databases being hosted within a Neo4j instance. The SHOW DATABASES command may be used for this purpose.

16.6.1. Listing Databases

First ensure that you are executing queries against the system database, either by running the command :use system (if using the Cypher shell or Neo4j Browser) or by creating a session against the system database using a Neo4j driver. Subsequently, run the SHOW DATABASES command.

Syntax:
SHOW DATABASES

Returns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>name</td>
<td>String</td>
<td>The human-readable name of the database.</td>
</tr>
<tr>
<td>address</td>
<td>String</td>
<td>The bolt address of the Neo4j instance hosting the database.</td>
</tr>
<tr>
<td>role</td>
<td>String</td>
<td>The cluster role which the Neo4j instance fulfils for this database.</td>
</tr>
<tr>
<td>requestedStatus</td>
<td>String</td>
<td>The state that an operator has requested the database to be in.</td>
</tr>
<tr>
<td>currentStatus</td>
<td>String</td>
<td>The state the database is actually in on this Neo4j instance.</td>
</tr>
<tr>
<td>error</td>
<td>String</td>
<td>Error encountered by the Neo4j instance when transitioning the database to requestedStatus, if any.</td>
</tr>
<tr>
<td>default</td>
<td>String</td>
<td>Whether this database is the default for this DBMS.</td>
</tr>
</tbody>
</table>
### Example 106. Listing databases in standalone Neo4j

When executing `SHOW DATABASES` against a standalone instance of Neo4j, you should see output like the following:

<table>
<thead>
<tr>
<th>name</th>
<th>address</th>
<th>role</th>
<th>requestedStatus</th>
<th>currentStatus</th>
<th>error</th>
<th>default</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;neo4j&quot;</td>
<td>&quot;localhost:7687&quot;</td>
<td>&quot;standalone&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>true</td>
</tr>
<tr>
<td>&quot;system&quot;</td>
<td>&quot;localhost:7687&quot;</td>
<td>&quot;standalone&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>false</td>
</tr>
<tr>
<td>&quot;foo&quot;</td>
<td>&quot;localhost:7687&quot;</td>
<td>&quot;standalone&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;offline&quot;</td>
<td>&quot;An error occurred! Unable to start database ...&quot;</td>
<td>false</td>
</tr>
</tbody>
</table>

Note that the `role` and `address` columns are primarily intended to distinguish between the states of a given database, across multiple Neo4j instances deployed in a Causal Cluster. In a standalone deployment where you have a single Neo4j instance, your `address` field should be the same for every database, and your `role` field should always be "standalone".

If an error occurred whilst creating (or stopping, dropping etc.) a database, you should see output like the following:

<table>
<thead>
<tr>
<th>name</th>
<th>address</th>
<th>role</th>
<th>requestedStatus</th>
<th>currentStatus</th>
<th>error</th>
<th>default</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;neo4j&quot;</td>
<td>&quot;localhost:7687&quot;</td>
<td>&quot;standalone&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>true</td>
</tr>
<tr>
<td>&quot;system&quot;</td>
<td>&quot;localhost:7687&quot;</td>
<td>&quot;standalone&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>false</td>
</tr>
<tr>
<td>&quot;foo&quot;</td>
<td>&quot;localhost:7687&quot;</td>
<td>&quot;standalone&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;offline&quot;</td>
<td>&quot;An error occurred! Unable to start database ...&quot;</td>
<td>false</td>
</tr>
</tbody>
</table>

Note that for failed databases, the `currentStatus` and `requestedStatus` are different. This can imply an error. For example:

- a database may take a while to transition from "offline" to "online", due to performing recovery.
- during normal operation, the `currentStatus` of a database may be transiently different from its `requestedStatus`, due to a necessary automatic process, such as one Neo4j instance copying store files from another.

The possible statuses are "initial", "online", "offline", "store copying", and "unknown".
When running `SHOW DATABASES` against a Neo4j Causal Cluster you might see output like the following:

<table>
<thead>
<tr>
<th>name</th>
<th>address</th>
<th>role</th>
<th>requestedStatus</th>
<th>currentStatus</th>
<th>error</th>
<th>default</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;neo4j&quot;</td>
<td>&quot;localhost:2003 1&quot;</td>
<td>&quot;follower&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>true</td>
</tr>
<tr>
<td>&quot;neo4j&quot;</td>
<td>&quot;localhost:2001 0&quot;</td>
<td>&quot;follower&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>true</td>
</tr>
<tr>
<td>&quot;neo4j&quot;</td>
<td>&quot;localhost:2000 5&quot;</td>
<td>&quot;leader&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>true</td>
</tr>
<tr>
<td>&quot;neo4j&quot;</td>
<td>&quot;localhost:2003 4&quot;</td>
<td>&quot;read_replica&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>true</td>
</tr>
<tr>
<td>&quot;system&quot;</td>
<td>&quot;localhost:2003 1&quot;</td>
<td>&quot;follower&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>false</td>
</tr>
<tr>
<td>&quot;system&quot;</td>
<td>&quot;localhost:2001 0&quot;</td>
<td>&quot;follower&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>false</td>
</tr>
<tr>
<td>&quot;system&quot;</td>
<td>&quot;localhost:2000 5&quot;</td>
<td>&quot;leader&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>false</td>
</tr>
<tr>
<td>&quot;system&quot;</td>
<td>&quot;localhost:2003 4&quot;</td>
<td>&quot;read_replica&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>false</td>
</tr>
<tr>
<td>&quot;foo&quot;</td>
<td>&quot;localhost:2003 1&quot;</td>
<td>&quot;leader&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>false</td>
</tr>
<tr>
<td>&quot;foo&quot;</td>
<td>&quot;localhost:2001 0&quot;</td>
<td>&quot;follower&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>false</td>
</tr>
<tr>
<td>&quot;foo&quot;</td>
<td>&quot;localhost:2000 5&quot;</td>
<td>&quot;follower&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>false</td>
</tr>
<tr>
<td>&quot;foo&quot;</td>
<td>&quot;localhost:2003 4&quot;</td>
<td>&quot;read_replica&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>false</td>
</tr>
</tbody>
</table>

Note that `SHOW DATABASES` does not return 1 row per database. Instead, it returns 1 row per database, per Neo4j instance in the cluster. Therefore, if you have a 4-instance cluster, hosting 3 databases, you will have 12 rows.

If an error occurred whilst creating (or stopping, dropping etc.) a database, you should see output like the following:

<table>
<thead>
<tr>
<th>name</th>
<th>address</th>
<th>role</th>
<th>requestedStatus</th>
<th>currentStatus</th>
<th>error</th>
<th>default</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;neo4j&quot;</td>
<td>&quot;localhost:2003 1&quot;</td>
<td>&quot;follower&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>true</td>
</tr>
<tr>
<td>&quot;neo4j&quot;</td>
<td>&quot;localhost:2001 0&quot;</td>
<td>&quot;follower&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>true</td>
</tr>
</tbody>
</table>
### Note that different instances may have different roles for each database.

If a database is offline on a particular Neo4j instance, either because it was stopped by an operator or an error has occurred, its cluster role is "unknown". This is because the cluster role of a given instance/database combination cannot be assumed in advance. This differs from standalone Neo4j instances, where the role of that instance for each database can always be assumed to be "standalone".

The possible roles are "standalone", "leader", "follower", "read_replica", and "unknown".

### 16.6.2. Listing a single database

The number of rows returned by `SHOW DATABASES` can be quite large, especially when run in a cluster. You can filter the rows returned by database name (e.g. "foo") by using the command `SHOW DATABASE foo`.

**Syntax:**

```sql
SHOW DATABASE databaseName
```
Arguments:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>databaseName</td>
<td>String</td>
<td>The name of the database whose status to report</td>
</tr>
</tbody>
</table>

Returns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>name</td>
<td>String</td>
<td>The human-readable name of the database.</td>
</tr>
<tr>
<td>address</td>
<td>String</td>
<td>The bolt address of the Neo4j instance hosting the database.</td>
</tr>
<tr>
<td>role</td>
<td>String</td>
<td>The cluster role which the Neo4j instance fulfills for this database.</td>
</tr>
<tr>
<td>requestedStatus</td>
<td>String</td>
<td>The state that an operator has requested the database to be in.</td>
</tr>
<tr>
<td>currentStatus</td>
<td>String</td>
<td>The state the database is actually in on this Neo4j instance.</td>
</tr>
<tr>
<td>error</td>
<td>String</td>
<td>Error encountered by Neo4j instance when transitioning the database to requestedStatus, if any.</td>
</tr>
<tr>
<td>default</td>
<td>String</td>
<td>Whether this database is the default for this DBMS.</td>
</tr>
</tbody>
</table>
When running `SHOW DATABASE foo` in a Neo4j Causal Cluster, you should see output like the following:

<table>
<thead>
<tr>
<th>name</th>
<th>address</th>
<th>role</th>
<th>requestedStatus</th>
<th>currentStatus</th>
<th>error</th>
<th>default</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;foo&quot;</td>
<td>&quot;localhost:2003 1&quot;</td>
<td>&quot;unknown&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;initial&quot;</td>
<td>&quot;An error occurred! Unable to start database ...&quot;</td>
<td>false</td>
</tr>
<tr>
<td>&quot;foo&quot;</td>
<td>&quot;localhost:2001 0&quot;</td>
<td>&quot;leader&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>false</td>
</tr>
<tr>
<td>&quot;foo&quot;</td>
<td>&quot;localhost:2000 5&quot;</td>
<td>&quot;follower&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>false</td>
</tr>
<tr>
<td>&quot;foo&quot;</td>
<td>&quot;localhost:2003 4&quot;</td>
<td>&quot;unknown&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;initial&quot;</td>
<td>&quot;An error occurred! Unable to start database ...&quot;</td>
<td>false</td>
</tr>
</tbody>
</table>
Chapter 17. Tools

This chapter describes the Neo4j tools — Neo4j CLI, Neo4j Admin, and Cypher Shell.

This chapter comprises the following topics:

- **Neo4j CLI tool** — A description of the Neo4j database server CLI tool.
- **Neo4j Admin tool** — A description of the Neo4j Admin tool.
  - **Consistency checker** — How to check the consistency of a Neo4j database using Neo4j Admin.
  - **Neo4j Admin report** — How to collect the most common information needed for remote assessments.
  - **Display store information** — How to display information about a database store.
  - **Memory recommendations** — How to get an initial recommendation for Neo4j memory settings.
  - **Import** — How to import data into Neo4j using the command `neo4j-admin import`.
  - **Unbind a Core Server** — How to remove cluster state data from a Neo4j server.
  - **Push to Neo4j AuraDB** — How to push an existing Neo4j graph to Neo4j AuraDB.
- **Cypher Shell** — How to use the Cypher Shell.

17.1. Neo4j CLI tool

This section describes the Neo4j database server CLI tool.

The Neo4j CLI tool is a tool for managing a Neo4j database server. It is a command-line tool that is installed as part of the product and can be executed with a number of commands. Neo4j CLI tool is located in the `bin` directory.

17.1.1. Syntax and commands

**General synopsis**

The `neo4j` tool has the following general synopsis:

```
neo4j <command>
```

**Available commands**

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>console</td>
<td>Start server in console.</td>
</tr>
<tr>
<td>start</td>
<td>Start server as a daemon.</td>
</tr>
<tr>
<td>Command</td>
<td>Description</td>
</tr>
<tr>
<td>------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>stop</td>
<td>Stop the server daemon.</td>
</tr>
<tr>
<td>restart</td>
<td>Restart the server daemon.</td>
</tr>
<tr>
<td>status</td>
<td>Get the status of the server.</td>
</tr>
<tr>
<td>version, --version</td>
<td>Print version information and exit.</td>
</tr>
<tr>
<td>help, --help</td>
<td>Display help information about the specified command. For example, running <code>./bin/neo4j --help start</code> outputs the usage, description, and all available options of the <code>start</code> command:</td>
</tr>
</tbody>
</table>

```
Usage: Neo4j start [-expand-commands] [-verbose]
Start server as a daemon.
- -expand-commands    Allow command expansion in config value evaluation.
- -verbose            Prints additional information.
```

Command expansion can be enabled by adding a customised script to the `neo4j.conf` file, and then including the `--expand-commands` argument to the Neo4j startup script.

For more information, see Command expansion.

17.1.2. Environment variables

Neo4j CLI tool can also use the following environment variables:

<table>
<thead>
<tr>
<th>Environment variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEO4J_DEBUG</td>
<td>Set to anything to enable debug output.</td>
</tr>
<tr>
<td>NEO4J_HOME</td>
<td>Neo4j home directory.</td>
</tr>
<tr>
<td>NEO4J_CONF</td>
<td>Path to the directory that contains <code>neo4j.conf</code>.</td>
</tr>
<tr>
<td>HEAP_SIZE</td>
<td>Set JVM maximum heap size during command execution. Takes a number and a unit, for example, 512m.</td>
</tr>
<tr>
<td>JAVA_OPTS</td>
<td>Additional JVM arguments. Refer to JVM documentation about the exact format. This variable is incompatible with <code>HEAP_SIZE</code> and takes precedence over <code>HEAP_SIZE</code>.</td>
</tr>
</tbody>
</table>
17.2. Neo4j Admin tool

Describes the Neo4j Admin tool.

17.2.1. Introduction

Neo4j Admin is the primary tool for managing a Neo4j DBMS. It is a command-line tool that is installed as part of the product and can be executed with a number of commands. Some of the commands are described in more detail in separate sections.

The Neo4j Admin commands must be invoked with the same user as Neo4j runs as. This guarantees that Neo4j will have full rights to start and work with the database files you use.

17.2.2. Syntax and commands

Syntax

Neo4j Admin is located in the bin directory and is invoked as:

```
neo4j-admin [-hV] [COMMAND]
```

- `-h, --help` — Show the `neo4j-admin` help message and exit.
- `-V, --version` — Print the `neo4j-admin` version information and exit.

Commands
<table>
<thead>
<tr>
<th>Functionality area</th>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>help &lt;command&gt;</td>
<td>Display help information about the specified command.</td>
</tr>
<tr>
<td></td>
<td>check-consistency</td>
<td>Check the consistency of a database.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For details, see Consistency checker.</td>
</tr>
<tr>
<td></td>
<td>report</td>
<td>Produce a zip/tar of the most common information needed for remote assessments.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For details, see Neo4j Admin report.</td>
</tr>
<tr>
<td></td>
<td>store-info</td>
<td>Print information about a Neo4j database store.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For details, see Display store information.</td>
</tr>
<tr>
<td></td>
<td>memrec</td>
<td>Print Neo4j heap and pagecache memory settings recommendations.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For details, see Memory recommendations.</td>
</tr>
<tr>
<td></td>
<td>import</td>
<td>Import from a collection of CSV files or a pre-3.0 database.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For details, see Import.</td>
</tr>
<tr>
<td></td>
<td>copy</td>
<td>Copy data from an existing database to a new database.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For details, see Copy a database store.</td>
</tr>
<tr>
<td></td>
<td>push-to-cloud</td>
<td>Dump a local offline database, and imports it into a specified Neo4j AuraDB instance. The target location is your Neo4j Aura Bolt URI.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For details, see Push to cloud.</td>
</tr>
<tr>
<td>Authentication</td>
<td>set-default-admin</td>
<td>Set the default admin user when no roles are present.</td>
</tr>
<tr>
<td></td>
<td>set-initial-password</td>
<td>Set the initial password of the initial admin user (neo4j).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>For details, see Set an initial password.</td>
</tr>
</tbody>
</table>
### 17.2.3. Environment variables

### 17.2.4. Environment variables

The Neo4j Admin tool can also use the following environment variables:

<table>
<thead>
<tr>
<th>Environment variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEO4J_DEBUG</td>
<td>Set to anything to enable debug output.</td>
</tr>
<tr>
<td>NEO4J_HOME</td>
<td>Neo4j home directory.</td>
</tr>
</tbody>
</table>
### Environment variable

<table>
<thead>
<tr>
<th>Environment variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEO4J_CONF</td>
<td>Path to the directory that contains neo4j.conf.</td>
</tr>
<tr>
<td>HEAP_SIZE</td>
<td>Set JVM maximum heap size during command execution. Takes a number and a unit, for example, 512m.</td>
</tr>
<tr>
<td>JAVA_OPTS</td>
<td>Additional JVM arguments.</td>
</tr>
</tbody>
</table>

By default, dbms.jvm.additional settings specified in the configuration file are used when invoking Admin commands. Even though this is a default behavior, it might lead to problems when an Admin command is invoked on the same machine running DBMS. Since the command reuses JVM memory settings configured for the DBMS, the machine might not have enough memory to run both tasks simultaneously. Even if it does, Admin commands require nowhere near as much memory as the DBMS, so this default behavior is wasteful in most cases.

Still, memory consumption might not be the only issue. For instance, if the DBMS JVM is configured to open an administration port for JMX or debugging, Admin commands will try to open the same port and thus conflict with a running DBMS. If the default behavior described above is problematic, Admin commands can be instructed to ignore dbms.jvm.additional from the configuration file by simply using JAVA_OPTS with any non-empty value, for example: JAVA_OPTS=-Xmx512m neo4j-admin .... Setting JAVA_OPTS to any non-empty value will make the invoked Admin command completely ignore all dbms.jvm.additional settings in the configuration file.

### 17.2.5. Exit codes

When neo4j-admin finishes as expected, it returns an exit code of 0. A non-zero exit code means something undesired happened during command execution. The non-zero exit code can contain further information about the error, such as the backup command’s exit codes.

### 17.2.6. Consistency checker

Describes the Neo4j consistency checker.

The consistency of a database or a backup can be checked using the check-consistency argument to the neo4j-admin tool. The neo4j-admin tool is located in the bin directory. If checking the consistency of a database, note that it has to be stopped first or else the consistency check will result in an error.

It is not recommended to use an NFS to check the consistency of a database or a backup as this slows the process down significantly.

### Syntax
Please note that the following options have been deprecated:

```
[--check-label-scan-store=<true/false>]
[--check-property-owners=<true/false>]
```

Values for these settings will be ignored.

## Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>--database</code></td>
<td><code>neo4j</code></td>
<td>Name of database.</td>
</tr>
<tr>
<td><code>--backup</code></td>
<td></td>
<td>Path to backup to check consistency of. Cannot be used together with <code>--database</code>.</td>
</tr>
<tr>
<td><code>--additional-config</code></td>
<td></td>
<td>Configuration file to supply additional configuration in.</td>
</tr>
<tr>
<td><code>--verbose</code></td>
<td><code>false</code></td>
<td>Enable verbose output.</td>
</tr>
<tr>
<td><code>--check-graph</code></td>
<td><code>true</code></td>
<td>Perform checks between nodes, relationships, properties, types and tokens.</td>
</tr>
<tr>
<td><code>--check-indexes</code></td>
<td><code>true</code></td>
<td>Perform checks on indexes by comparing content with the store.</td>
</tr>
<tr>
<td><code>--check-index-structure</code></td>
<td><code>true</code></td>
<td>Perform physical structure check on indexes. No comparison with the store takes place.</td>
</tr>
<tr>
<td><code>--check-label-scan-store</code></td>
<td><code>true</code></td>
<td>This option is deprecated and its value will be ignored.</td>
</tr>
<tr>
<td>Option</td>
<td>Default</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------------</td>
<td>---------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>--check-property-owners</td>
<td>false</td>
<td>This option is deprecated and its value will be ignored.</td>
</tr>
</tbody>
</table>

### Output

If the consistency checker does not find errors, it will exit cleanly and not produce a report. If the consistency checker finds errors, it will exit with an exit code of 1 and write a report file with a name on the format `inconsistencies-YYYY-MM-DD.HH24.MI.SS.report`. The location of the report file is the current working directory, or as specified by the parameter `report-dir`.

### Example 109. Run the consistency checker

Run with the **--database** option to check the consistency of a database. Note that the database must be stopped first.

```
$ neo4j-home> bin/neo4j-admin check-consistency --database=neo4j
2019-11-13 12:42:14.479+0000 INFO [o.n.k.i.s.f.RecordFormatSelector] Selected RecordFormat:StandardV4_0[SF4.0.b] record format from store /data/databases/neo4j
Index structure consistency check
                      10%
                      20%
                      30%
                      40%
                      50%
                      60%
                      70%
                      80%
                      90%
                     100%
Full Consistency Check
                      10%
                      20%
                      30%
                      40%
                      50%
                      60%
                      70%
                      80%
                      90%
 .Checking node and relationship counts
                      10%
                      20%
                      30%
                      40%
                      50%
                      60%
                      70%
                      80%
                      90%
                     100%
```

Run with the **--backup** option to check the consistency of a backup.

```
bin/neo4j-admin check-consistency --backup backup/neo4j-backup
```
17.2.7. Neo4j Admin report

This chapter describes the report command of Neo4j Admin.

Use the report command of neo4j-admin to gather information about a Neo4j installation and save it to an archive.

```
neo4j-admin report [--force] [--list] [--verbose] [--pid=<pid>] [--to=<path>] [<classifier>...]
```

The intended usage of the report tool is to simplify the support process by collecting the relevant information in a standard way. This tool does not send any information automatically. To share this information with the Neo4j Support organization, you have to send it manually.

### Table 99. Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>--to</td>
<td>reports/</td>
<td>Specify to target directory where the report should be written to.</td>
</tr>
<tr>
<td>--list</td>
<td></td>
<td>List available classifiers.</td>
</tr>
<tr>
<td>--verbose</td>
<td></td>
<td>Instruct the tool to print more verbose output.</td>
</tr>
<tr>
<td>--force</td>
<td></td>
<td>Disable the available disk space check.</td>
</tr>
<tr>
<td>--pid</td>
<td></td>
<td>Specify process id of a running Neo4j instance. Only applicable when used together with the Online classifiers. See the Classifiers table.</td>
</tr>
</tbody>
</table>

By default, the tool tries to estimate the final size of the report and uses that to assert that there is enough disk space available for it. If there is not enough available space, the tool aborts. However, this estimation is pessimistic and does not consider the compression. Therefore, if you are confident that you do have enough disk space, you can disable this check with the option --force.

### Table 100. Classifiers

<table>
<thead>
<tr>
<th>Classifier</th>
<th>Online</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>all</td>
<td></td>
<td>Include all of the available classifiers.</td>
</tr>
<tr>
<td>ccstate</td>
<td></td>
<td>Include the current cluster state.</td>
</tr>
<tr>
<td>config</td>
<td></td>
<td>Include the neo4j.conf file.</td>
</tr>
<tr>
<td>Classifier</td>
<td>Online</td>
<td>Description</td>
</tr>
<tr>
<td>------------</td>
<td>--------</td>
<td>-------------</td>
</tr>
<tr>
<td>heap</td>
<td>✓</td>
<td>Include a heap dump.</td>
</tr>
<tr>
<td>logs</td>
<td></td>
<td>Include log files, e.g., <code>debug.log</code>, <code>neo4j.log</code>, etc.</td>
</tr>
<tr>
<td>metrics</td>
<td></td>
<td>Include the collected metrics.</td>
</tr>
<tr>
<td>plugins</td>
<td></td>
<td>Include a text view of the plugin directory (no files are collected).</td>
</tr>
<tr>
<td>ps</td>
<td></td>
<td>Include a list of running processes.</td>
</tr>
<tr>
<td>raft</td>
<td></td>
<td>Include the raft log.</td>
</tr>
<tr>
<td>sysprop</td>
<td>✓</td>
<td>Include a list of Java system properties.</td>
</tr>
<tr>
<td>threads</td>
<td>✓</td>
<td>Include a thread dump of the running instance.</td>
</tr>
<tr>
<td>tree</td>
<td></td>
<td>Include a text view of the folder structure of the data directory (no files are collected).</td>
</tr>
<tr>
<td>tx</td>
<td></td>
<td>Include transaction logs.</td>
</tr>
</tbody>
</table>

The classifiers marked as Online work only when you have a running Neo4j instance that the tool can find.

If no classifiers are specified, the following classifiers are used: logs, config, plugins, tree, metrics, threads, sysprop, and ps.

The reporting tool does not read any data from your database. However, the heap, the raft logs, and the transaction logs may contain data. Additionally, even though the standard `neo4j.conf` file does not contain password information, for specific configurations, it may have this type of information. Therefore, be aware of your organization’s data security rules before using the classifiers heap, tx, raft, and config.

This tool uses the Java Attach API to gather data from a running Neo4j instance. Therefore, it requires the Java JDK to run properly.

Example 110. Invoke `neo4j-admin report` against a running Neo4j instance using the default classifiers

The following command gathers information about a Neo4j instance using the default classifiers and saves it to the default location:

```
$neo4j-home> bin/neo4j-admin report --pid=47369
```
Example 111. Invoke `neo4j-admin report` against a running Neo4j instance using all classifiers

The following command gathers information about a Neo4j instance using all classifiers and saves it to a specified location:

```
$neo4j-home> bin/neo4j-admin report --pid=47369 --to=./report all
```

Example 112. Invoke `neo4j-admin report` against running Neo4j to gather only logs and thread dumps

The following command gathers only logs and thread dumps from a running Neo4j instance and saves it to a specified location:

```
$neo4j-home> bin/neo4j-admin report --pid=47369 --to=./report threads logs
```

17.2.8. Display store information

This chapter describes the `neo4j-admin store-info` command.

The `neo4j-admin store-info` command outputs information about the store format for a given database store.

1. The store format version.
2. When the store format version was introduced.
3. Whether the store format needs to be migrated to a newer version.

The store format can be set with the `dbms.record_format` configuration setting.

The store formats are:

- `aligned`
- `standard`
- `high_limit` [Enterprise edition]

Syntax

The `neo4j-admin store-info` command is located in the `bin` directory. It is invoked against an offline database store or a backup as follows:

```
neo4j-admin store-info [--all] [--structured] [--verbose] <path>
```

`<path>` — Path to database store, or databases directory if `--all` option is used.
Options

Table 101. Options

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>--verbose</td>
<td>Enable verbose output.</td>
</tr>
<tr>
<td>--structured</td>
<td>Return result structured as JSON.</td>
</tr>
<tr>
<td>--all</td>
<td>Return store format info for all databases at provided path.</td>
</tr>
</tbody>
</table>

Examples

Example 113. Invoke `neo4j-admin store-info` against a database store

```
bin/neo4j-admin store-info data/databases/mygraph.db
```

Output:

```
Store format version:         SF4.0.0
Store format introduced in:   4.0.0
```

Example 114. Invoke `neo4j-admin store-info` against a database backup

You can run the `store-info` command to see if the store format of the backup that you want to restore, is compatible with your running Neo4j instance. For example, if you want to restore the database backup `/tmp/3518/mygraph.db` into a 4.x Neo4j instance:

```
bin/neo4j-admin store-info /tmp/3518/mygraph.db
```

Output:

```
Store format version:         vE.H.4 ①
Store format introduced in:   3.4.0 ②
Store format superseded in:   4.0.0 ③
```

① The store format version reveals that the database is configured to use the `high_limit`, see `dbms.record_format`.

② The store format version was introduced in Neo4j 3.4.0.

③ The store format of the current instance is 4.0.0, which means that a format migration must be performed if you want to restore this backup into the current instance.

For more information on how to migrate a single database, see Upgrade and Migration Guide → Tutorial: Back up and copy a database in a standalone instance.
Example 115. Invoke `neo4j-admin store-info` against a root containing several databases

The command can also be invoked against a root directory containing several databases, as follows:

```
neo4j-admin store-info <path> --all
```

```
bin/neo4j-admin store-info data/databases --all
```

Output:

```
<table>
<thead>
<tr>
<th>Database name</th>
<th>Database in use</th>
<th>Store format version</th>
<th>Store format introduced</th>
<th>Last committed transaction id</th>
<th>Store needs recovery</th>
<th>Database name</th>
<th>Database in use</th>
</tr>
</thead>
<tbody>
<tr>
<td>foo</td>
<td>false</td>
<td>SF4.0.0</td>
<td>4.0.0</td>
<td>2</td>
<td>true</td>
<td>bar</td>
<td>true</td>
</tr>
</tbody>
</table>
```

When the command is invoked against several databases, if some are online they will simply report as `in use` and exclude all other information.

Example 116. Invoke `neo4j-admin store-info` against a database and output JSON

If you are parsing the results of this command you may use the `--structured` option to receive the output as JSON. All the same fields are included and all values are strings.

```
bin/neo4j-admin store-info data/databases/foo --structured
```

Output:

```
{"databaseName":"foo","inUse":"false","storeFormat":"SF4.0.0","storeFormatIntroduced":"4.0.0","lastCommittedTransaction":"2","recoveryRequired":"true"}
```

Store format — aligned

Table 102. Store versions — aligned

<table>
<thead>
<tr>
<th>Store Format Name</th>
<th>Store Format Version</th>
<th>Neo4j Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALIGNED_V4_3</td>
<td>AF4.3.0</td>
<td>4.3.0</td>
</tr>
<tr>
<td>ALIGNED_V4_1</td>
<td>AF4.1.a</td>
<td>4.1.0</td>
</tr>
</tbody>
</table>

Table 103. Store limits — aligned
### Store format — standard

#### Table 104. Store versions — standard

<table>
<thead>
<tr>
<th>Store Format Name</th>
<th>Store Format Version</th>
<th>Neo4j Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>STANDARD_V4_3</td>
<td>SF4.3.0</td>
<td>4.3.0</td>
</tr>
<tr>
<td>STANDARD_V4_0</td>
<td>SF4.0.0</td>
<td>4.0.0</td>
</tr>
<tr>
<td>STANDARD_V3_4</td>
<td>v0.A.9</td>
<td>3.4.0</td>
</tr>
</tbody>
</table>

#### Table 105. Store limits — standard

<table>
<thead>
<tr>
<th>Name</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Property keys</td>
<td>$2^{24}$ (16 777 216)</td>
</tr>
<tr>
<td>Nodes</td>
<td>$2^{35}$ (34 359 738 368)</td>
</tr>
<tr>
<td>Relationships</td>
<td>$2^{35}$ (34 359 738 368)</td>
</tr>
<tr>
<td>Properties</td>
<td>$2^{36}$ (68 719 476 736)</td>
</tr>
<tr>
<td>Labels</td>
<td>$2^{32}$ (4 294 967 296)</td>
</tr>
<tr>
<td>Relationship types</td>
<td>$2^{16}$ (65 536)</td>
</tr>
<tr>
<td>Relationship groups</td>
<td>$2^{35}$ (34 359 738 368)</td>
</tr>
</tbody>
</table>

### Store format — high_limit

#### Table 106. Store versions — high_limit

<table>
<thead>
<tr>
<th>Store Format Name</th>
<th>Store Format Version</th>
<th>Neo4j Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIGH_LIMIT_V4_3_0</td>
<td>HL4.3.0</td>
<td>4.3.0</td>
</tr>
<tr>
<td>HIGH_LIMIT_V4_0_0</td>
<td>HL4.0.0</td>
<td>4.0.0</td>
</tr>
<tr>
<td>HIGH_LIMIT_V3_4_0</td>
<td>vE.H.4</td>
<td>3.4.0</td>
</tr>
<tr>
<td>HIGH_LIMIT_V3_2_0</td>
<td>vE.H.3</td>
<td>3.2.0</td>
</tr>
<tr>
<td>HIGH_LIMIT_V3_1_0</td>
<td>vE.H.2</td>
<td>3.1.0</td>
</tr>
<tr>
<td>HIGH_LIMIT_V3_0_6</td>
<td>vE.H.0b</td>
<td>3.0.6</td>
</tr>
</tbody>
</table>
17.2.9. Memory recommendations

This chapter describes the memrec command of Neo4j Admin.

Use the memrec command of neo4j-admin to get an initial recommendation on how to configure memory parameters for Neo4j:

```
neo4j-admin memrec --memory=<memory dedicated to Neo4j>, --verbose, --docker
```

The command gives heuristic memory setting recommendations for the Neo4j JVM heap and pagecache. The heuristic is based on the total memory of the system the command is running on, or on the amount of memory specified with the `--memory` argument. The heuristic assumes that the system is dedicated to running Neo4j. If this is not the case, then use the `--memory` argument to specify how much memory can be expected to be dedicated to Neo4j. The default output is formatted as such that it can be copy-pasted into neo4j.conf. The argument `--docker` outputs environmental variables that can be passed to a Neo4j docker container. For a detailed example, see Use Neo4j Admin for memory recommendations.

### Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>--memory=&lt;size&gt;</code></td>
<td>The memory capacity of the machine.</td>
<td>The amount of memory to allocate to Neo4j. Valid units are: k, K, m, M, g, G.</td>
</tr>
<tr>
<td><code>--verbose</code></td>
<td></td>
<td>Enable verbose output.</td>
</tr>
<tr>
<td><code>--docker</code></td>
<td></td>
<td>Enable output formatted as environmental variables that can be passed to a Neo4j docker container.</td>
</tr>
</tbody>
</table>

### Considerations

The `neo4j-admin memrec` command calculates a valid starting point for Neo4j memory settings, based on
the provided memory. The specific conditions for your use case may warrant adjustment of these values. See Memory configuration for a description of the memory settings in Neo4j.

Example 117. Use the memrec command of neo4j-admin

The following example illustrates how neo4j-admin memrec provides a recommendation on how to use 16g of memory:

```bash
$neo4j-home> bin/neo4j-admin memrec --memory=16g

# Based on the above, the following memory settings are recommended:
dbms.memory.heap.initial_size=5g
dbms.memory.heap.max_size=5g
dbms.memory.pagecache.size=7g
```

For an example on how to use the neo4j-admin memrec command, see Inspect the memory settings of all databases in a DBMS.

17.2.10. Import

This section describes how to perform batch imports of data into Neo4j using the command line tool neo4j-admin import.

There are two ways to import data from CSV files into Neo4j: via neo4j-admin import or LOAD CSV.

With the neo4j-admin import command, you can do batch imports of large amounts of data into a previously unused database database from CSV files. The command can be performed only once per database. By default, this database is set to neo4j, but you can use the --database=<database> option to import your data into a different database.

The user running neo4j-admin import must have WRITE capabilities into dbms.directories.data and dbms.directories.log.

With LOAD CSV, you can import small to medium-sized CSV files into an existing database. LOAD CSV can be run as many times as needed and does not require an empty database.

However, using the import command of neo4j-admin is generally faster since it is run against a stopped and empty database. This section describes the neo4j-admin import option.

For information on LOAD CSV, see the Cypher Manual → LOAD CSV.

For in-depth examples of using the command neo4j-admin import, refer to the Tutorials → Neo4j Admin import.

To create a cluster based on imported data, see Seed a cluster using the import tool.

These are some things you need to keep in mind when creating your input files:
• Fields are comma-separated by default but a different delimiter can be specified.
• All files must use the same delimiter.
• Multiple data sources can be used for both nodes and relationships.
• A data source can optionally be provided using multiple files.
• A separate file with a header that provides information on the data fields, must be the first specified file of each data source.
• Fields without corresponding information in the header will not be read.
• UTF-8 encoding is used.
• By default, the importer trims extra whitespace at the beginning and end of strings. Quote your data to preserve leading and trailing whitespaces.

Indexes and constraints
Indexes and constraints are not created during the import. Instead, you have to add these afterwards (see Cypher Manual → Indexes).

Syntax
The syntax for importing a set of CSV files is:

```
neo4j-admin import [--expand-commands]
[--verbose]
[--auto-skip-subsequent-headers=[true/false]]
[--cache-on-heap=[true/false]]
[--force=[true/false]]
[--high-io=[true/false]]
[--ignore-empty-strings=[true/false]]
[--ignore-extra-columns=[true/false]]
[--legacy-style-quoting=[true/false]]
[--multiline-fields=[true/false]]
[--normalize-types=[true/false]]
[--skip-bad-entries-logging=[true/false]]
[--skip-bad-relationships=[true/false]]
[--skip-duplicate-nodes=[true/false]]
[--trim-strings=[true/false]]
[--additional-config=<path>]
[--array-delimiter=<char>]
[--bad-tolerance=<num>]
[--database=<database>]
[--delimiter=<char>]
[--id-type=STRING|INTEGER|ACTUAL]
[--input-encoding=<character-set>]
[--max-memory=<size>]
[--processors=<num>]
[--quote=<char>]
[--read-buffer-size=<size>]
[--report-file=<path>]
--nodes=[<label>[::<label>]...<files>...]
[--nodes=[<label>[::<label>]...<files>...]
[--relationships=[<type>=<files>]...]
```

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Example 118. Import data from CSV files

Assume that you have formatted your data as per CSV header format so that you have it in six different files:

1. movies_header.csv
2. movies.csv
3. actors_header.csv
4. actors.csv
5. roles_header.csv
6. roles.csv

The following command imports the three datasets:

```bash
neo4j_home$ bin/neo4j-admin import --nodes import/movies_header.csv,import/movies.csv
   --nodes import/actors_header.csv,import/actors.csv
   --relationships import/roles_header.csv,import/roles.csv
```

Example 119. Import data from CSV files using regular expression

Assume that you want to include a header and then multiple files that matches a pattern, e.g. containing numbers. In this case a regular expression can be used. It is guaranteed that groups of digits will be sorted in numerical order, as opposed to lexicographic order.

For example:

```bash
neo4j_home$ bin/neo4j-admin import --nodes import/node_header.csv,import/node_data_\d+.csv
```

Example 120. Import data from CSV files using a more complex regular expression

For regular expression patterns containing commas, which is also the delimiter between files in a group, the pattern can be quoted to preserve the pattern.

For example:

```bash
neo4j_home$ bin/neo4j-admin import --nodes import/node_header.csv,'import/node_data_\d{1,5}.csv'
```

If importing to a database that has not explicitly been created prior to the import, it must be created subsequently in order to be used.

Options

Table 108. `neo4j-admin import` options
- `--expand-commands`  
  Allow command expansion in config value evaluation.

Some of the options below are marked as Advanced. These options should not be used for experimentation.

For more information, please contact Neo4j Professional Services.
--verbose
Enable verbose output.

--auto-skip-subsequent-headers
Automatically skip accidental header lines in subsequent files in file groups with more than one file.
Default: false

--cache-on-heap[=<true/false>] Advanced
Determines whether or not to allow allocating memory for the cache on heap.
If false, then caches will still be allocated off-heap, but the additional free memory inside the JVM will not be allocated for the caches.
Use this to have better control over the heap memory.
Default: false

--force[=<true/false>]
Force deletes any existing database files prior to the import.
Default: false

Use --force=true to delete all files of a specified database and then import new data. For example:

- When using Neo4j Community Edition.
  Since the Community Edition only supports one database and does not support DROP DATABASE name, the only way to re-import data using neo4j-admin import is to use --force=true.
- When you first want to see how the data would get imported and maybe do some tweaking before you import your actual data. For example, you can first import a small batch of data (e.g., 1000 rows) and examine it. And then, tweak your actual data (e.g., 10 million rows) and use the option --force=true to re-import it.

--high-io[=<true/false>]
Ignore environment-based heuristics, and specify whether the target storage subsystem can support parallel IO with high throughput.
Typically this is true for SSDs, large raid arrays and network-attached storage.
Default: false

--ignore-empty-strings[=<true/false>]
Determines whether or not empty string fields, such as ",", from input source are ignored (treated as null).
Default: false

--ignore-extra-columns[=<true/false>]
If unspecified columns should be ignored during the import.
Default: `false`

`--legacy-style-quoting[=<true/false>]`

Determines whether or not backslash-escaped quote e.g. `\"` is interpreted as inner quote.

Default: `false`

`--multiline-fields[=<true/false>]`

Determines whether or not fields from input source can span multiple lines, i.e. contain newline characters.

Setting `--multiline-fields=true` can severely degrade performance of the importer. Therefore, use it with care, especially with large imports.

Default: `false`

`--normalize-types[=<true/false>]`

Determines whether or not to normalize property types to Cypher types, e.g. `int` becomes `long` and `float` becomes `double`.

Default: `true`

`--skip-bad-entries-logging[=<true/false>]`

Determines whether or not to skip logging bad entries detected during import.

Default: `false`

`--skip-bad-relationships[=<true/false>]`

Determines whether or not to skip importing relationships that refer to missing node IDs, i.e. either start or end node ID/group referring to node that was not specified by the node input data.

Skipped relationships will be logged, containing at most the number of entities specified by `--bad-tolerance`, unless otherwise specified by the `--skip-bad-entries-logging` option.

Default: `false`

`--skip-duplicate-nodes[=<true/false>]`

Determines whether or not to skip importing nodes that have the same ID/group.

In the event of multiple nodes within the same group having the same ID, the first encountered will be imported, whereas consecutive such nodes will be skipped.

Skipped nodes will be logged, containing at most the number of entities specified by `--bad-tolerance`, unless otherwise specified by the `--skip-bad-entries-logging` option.

Default: `false`

`--trim-strings[=<true/false>]`

Determines whether or not strings should be trimmed for whitespaces.

Default: `false`
--additional-config=<config-file-path>
Path to a configuration file that contain additional configuration options.

--array-delimiter=<char>
Determines the array delimiter within a value in CSV data.

- ASCII character — e.g. `--array-delimiter=";"`
- \ID — unicode character with ID, e.g. `--array-delimiter="\59"`
- U+XXXX — unicode character specified with 4 HEX characters, e.g. `--array-delimiter="U+20AC"`
- \t — horizontal tabulation (HT), e.g. `--array-delimiter="\t"`

For horizontal tabulation (HT), use \t or the unicode character ID \9.

Unicode character ID can be used if prepended by \.

Default: ;

--bad-tolerance=<num>
Number of bad entries before the import is considered failed.

This tolerance threshold is about relationships referring to missing nodes. Format errors in input data are still treated as errors.

Default: 1000

--database=<name>
Name of the database to import.

Default: neo4j

--delimiter=<char>
Determines the delimiter between values in CSV data.

- ASCII character — e.g. `--delimiter=","`
- \ID — unicode character with ID, e.g. `--delimiter="\44"`
- U+XXXX — unicode character specified with 4 HEX characters, e.g. `--delimiter="U+20AC"`
- \t — horizontal tabulation (HT), e.g. `--delimiter="\t"`

For horizontal tabulation (HT), use \t or the unicode character ID \9.

Unicode character ID can be used if prepended by \.

Default: ,
--id-type=<STRING|INTEGER|ACTUAL>
Each node must provide a unique ID in order to be used for creating relationships during the import.

Possible values are:

- **STRING** — arbitrary strings for identifying nodes.
- **INTEGER** — arbitrary integer values for identifying nodes.
- **ACTUAL** — actual node IDs. (Advanced)

Default: STRING

--input-encoding=<character-set>
Character set that input data is encoded in.

Default: UTF-8

--max-memory=<size>
Maximum memory that neo4j-admin can use for various data structures and caching to improve performance.

Values can be plain numbers such as 10000000, or 20G for 20 gigabyte. It can also be specified as a percentage of the available memory, for example 70%.

Default: 90%

--processors=<num> Advanced
Max number of processors used by the importer.

Defaults to the number of available processors reported by the JVM. There is a certain amount of minimum threads needed, so for that reason there is no lower bound for this value.

For optimal performance, this value shouldn't be greater than the number of available processors.

--quote=<char>
Character to treat as quotation character for values in CSV data.

Quotes can be escaped as per RFC 4180 by doubling them, for example "" would be interpreted as a literal "".

You cannot escape using \\.

Default: "

--read-buffer-size=<size>
Size of each buffer for reading input data.

It has to at least be large enough to hold the biggest single value in the input data. Value can be a plain number or byte units string, e.g. 128k, 1m.

Default: 4m
--report-file=<filename>
File in which to store the report of the csv-import.

Default: import.report

The location of the import log file can be controlled using the --report-file option. If you run large imports of CSV files that have low data quality, the import log file can grow very large. For example, CSV files that contain duplicate node IDs, or that attempt to create relationships between non-existent nodes, could be classed as having low data quality. In these cases, you may wish to direct the output to a location that can handle the large log file.

If you are running on a UNIX-like system and you are not interested in the output, you can get rid of it altogether by directing the report file to /dev/null.

If you need to debug the import, it might be useful to collect the stack trace. This is done by using --verbose option.

--nodes=[<label>:]<files>...
Node CSV header and data.

- Multiple files will be logically seen as one big file from the perspective of the importer.
- The first line must contain the header.
- Multiple data sources like these can be specified in one import, where each data source has its own header.
- Files can also be specified using regular expressions.

For an example, see Import data from CSV files using regular expression.

--relationships=[<type>=]<files>...
Relationship CSV header and data.

- Multiple files will be logically seen as one big file from the perspective of the importer.
- The first line must contain the header.
- Multiple data sources like these can be specified in one import, where each data source has its own header.
- Files can also be specified using regular expressions.

For an example, see Import data from CSV files using regular expression.

@<arguments-file-path>
File containing all arguments, used as an alternative to supplying all arguments on the command line directly.

Each argument can be on a separate line, or multiple arguments per line and separated by space.

Arguments containing spaces must be quoted.
Heap size for the import

You want to set the maximum heap size to a relevant value for the import. This is done by defining the `HEAP_SIZE` environment parameter before starting the import. For example, 2G is an appropriate value for smaller imports.

If doing imports in the order of magnitude of 100 billion entities, 20G will be an appropriate value.

Record format

If your import data will result in a graph that is larger than 34 billion nodes, 34 billion relationships, or 68 billion properties you will need to configure the importer to use the high limit record format. This is achieved by setting the parameters `dbms.record_format=high_limit` and `dbms.allow_upgrade=true` in a configuration file, and supplying that file to the importer with `--additional-config`. The format is printed in the `debug.log` file.

The `high_limit` format is available for Enterprise Edition only.

CSV header format

The header file of each data source specifies how the data fields should be interpreted. You must use the same delimiter for the header file and for the data files.

The header contains information for each field, with the format `<name>:<field_type>`. The `<name>` is used for properties and node IDs. In all other cases, the `<name>` part of the field is ignored.

Node files

Files containing node data can have an ID field, a LABEL field as well as properties.

ID

Each node must have a unique ID if it is to be connected by any relationships created in the import. The IDs are used to find the correct nodes when creating relationships. Note that the ID has to be unique across all nodes in the import; even for nodes with different labels. The unique ID can be persisted in a property whose name is defined by the `<name>` part of the field definition `<name>:ID`. If no such property name is defined, the unique ID will be used for the purpose of the import but not be available for reference later. If no ID is specified, the node will be imported but it will not be able to be connected by any relationships during the import. When a property name is provided, the type of that property can only be configured globally via the `--id-type` option, and can’t be specified with a `<field_type>` in the header field (as is possible for properties).

LABEL

Read one or more labels from this field. Like array values, multiple labels are separated by `;`, or by the character specified with `--array-delimiter`. 
Example 121. Define nodes files

You define the headers for movies in the movies_header.csv file. Movies have the properties movieId, year and title. You also specify a field for labels.

```
movieId:ID,title,year:int,:LABEL
```

You define three movies in the movies.csv file. They contain all the properties defined in the header file. All the movies are given the label Movie. Two of them are also given the label Sequel.

```
tt0133093,"The Matrix",1999,Movie
tt0234215,"The Matrix Reloaded",2003,Movie;Sequel
tt0242653,"The Matrix Revolutions",2003,Movie;Sequel
```

Similarly, you also define three actors in the actors_header.csv and actors.csv files. They all have the properties personId and name, and the label Actor.

```
personId:ID,name,:LABEL
```

```
keanu,"Keanu Reeves",Actor
laurence,"Laurence Fishburne",Actor
carrieanne,"Carrie-Anne Moss",Actor
```

Relationship files

Files containing relationship data have three mandatory fields and can also have properties. The mandatory fields are:

**TYPE**

The relationship type to use for this relationship.

**START_ID**

The ID of the start node for this relationship.

**END_ID**

The ID of the end node for this relationship.

The START_ID and END_ID refer to the unique node ID defined in one of the node data sources, as explained in the previous section. None of these take a name, e.g. if <name>:START_ID or <name>:END_ID is defined, the <name> part will be ignored. Nor do they take a <field_type>, e.g. if :START_ID:int or :END_ID:int is defined, the :int part does not have any meaning in the context of type information.
Example 122. Define relationships files

In this example you assume that the two nodes files from the previous example are used together with the following relationships file.

You define relationships between actors and movies in the files roles_header.csv and roles.csv. Each row connects a start node and an end node with a relationship of relationship type ACTED_IN. Notice how you use the unique identifiers personId and movieId from the nodes files above. The name of character that the actor is playing in this movie is stored as a role property on the relationship.

```
:START_ID,role,:END_ID,:TYPE
keanu,"Neo",tt0133093,ACTED_IN
keanu,"Neo",tt0234215,ACTED_IN
keanu,"Neo",tt0242653,ACTED_IN
laurence,"Morpheus",tt0133093,ACTED_IN
laurence,"Morpheus",tt0234215,ACTED_IN
laurence,"Morpheus",tt0242653,ACTED_IN
carrieanne,"Trinity",tt0133093,ACTED_IN
carrieanne,"Trinity",tt0234215,ACTED_IN
carrieanne,"Trinity",tt0242653,ACTED_IN
```

Properties

For properties, the <name> part of the field designates the property key, while the <field_type> part assigns a data type (see below). You can have properties in both node data files and relationship data files.

Data types

Use one of int, long, float, double, boolean, byte, short, char, string, point, date, localtime, time, localdatetime, datetime, and duration to designate the data type for properties. If no data type is given, this defaults to string. To define an array type, append [] to the type. By default, array values are separated by ;. A different delimiter can be specified with --array-delimiter. Boolean values are true if they match exactly the text true. All other values are false. Values that contain the delimiter character need to be escaped by enclosing in double quotation marks, or by using a different delimiter character with the --delimiter option.

Example 123. Header format with data types

```
:ID,name,joined:date,active:boolean,points:int
user01,Joe Soap,2017-05-05,true,10
user02,Jane Doe,2017-08-21,true,15
user03,Moe Know,2018-02-17,false,7
```

Special considerations for the point data type

A point is specified using the Cypher syntax for maps. The map allows the same keys as the input to the Cypher Manual → Point function. The point data type in the header can be amended with a map of default values used for all values of that column, e.g. point{crs: 'WGS-84'}. Specifying the header this
way allows you to have an incomplete map in the value position in the data file. Optionally, a value in a data file may override default values from the header.

Example 124. Property format for point data type

This example illustrates various ways of using the point data type in the import header and the data files.

You are going to import the name and location coordinates for cities. First, you define the header as:

```
:ID,name,location:point{crs:WGS-84}
```

You then define cities in the data file.

- The first city’s location is defined using latitude and longitude, as expected when using the coordinate system defined in the header.
- The second city uses x and y instead. This would normally lead to a point using the coordinate reference system cartesian. Since the header defines crs:WGS-84, that coordinate reference system will be used.
- The third city overrides the coordinate reference system defined in the header, and sets it explicitly to WGS-84-3D.

```
:ID,name,location:point{crs:WGS-84}
city01,"Malmö","{latitude:55.6121514, longitude:12.9950357}"  
city02,"London","{y:51.507222, x:-0.1275}"  
city03,"San Mateo","{latitude:37.554167, longitude:-122.313056, height: 100, crs:'WGS-84-3D'}"
```

Note that all point maps are within double quotation marks " in order to prevent the enclosed , character from being interpreted as a column separator. An alternative approach would be to use --delimiter='\t' and reformat the file with tab separators, in which case the " characters are not required.

```
:ID name location:point{crs:WGS-84}  
city01 Malmö  {latitude:55.6121514, longitude:12.9950357}  
city02 London  {y:51.507222, x:-0.1275}  
city03 San Mateo  {latitude:37.554167, longitude:-122.313056, height: 100, crs:'WGS-84-3D'}
```

Special considerations for temporal data types

The format for all temporal data types must be defined as described in Cypher Manual → Temporal instants syntax and Cypher Manual → Durations syntax. Two of the temporal types, Time and DateTime, take a time zone parameter which might be common between all or many of the values in the data file. It is therefore possible to specify a default time zone for Time and DateTime values in the header, for example: time{timezone:+02:00} and: datetime{timezone:Europe/Stockholm}. If no default time zone is specified, the default time zone is determined by the db.temporal.timezone configuration setting. The default time zone can be explicitly overridden in the values in the data file.
Example 125. Property format for temporal data types

This example illustrates various ways of using the `datetime` data type in the import header and the data files.

First, you define the header with two `DateTime` columns. The first one defines a time zone, but the second one does not:

```
:ID,date1:datetime(timezone:Europe/Stockholm),date2:datetime
```

You then define dates in the data file.

- The first row has two values that do not specify an explicit timezone. The value for `date1` will use the `Europe/Stockholm` time zone that was specified for that field in the header. The value for `date2` will use the configured default time zone of the database.
- In the second row, both `date1` and `date2` set the time zone explicitly to be `Europe/Berlin`. This overrides the header definition for `date1`, as well as the configured default time zone of the database.

```
1,2018-05-10T10:30,2018-05-10T12:30
```

Using ID spaces

By default, the import tool assumes that node identifiers are unique across node files. In many cases the ID is only unique across each entity file, for example when your CSV files contain data extracted from a relational database and the ID field is pulled from the primary key column in the corresponding table. To handle this situation you define ID spaces. ID spaces are defined in the `ID` field of node files using the syntax `ID(<ID space identifier>)`. To reference an ID of an ID space in a relationship file, you use the syntax `START_ID(<ID space identifier>)` and `END_ID(<ID space identifier>)`. 
Define a **Movie-ID** ID space in the *movies_header.csv* file.

<table>
<thead>
<tr>
<th>movieId:ID(Movie-ID),title,year:int,:LABEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,&quot;The Matrix&quot;,1999,Movie</td>
</tr>
<tr>
<td>2,&quot;The Matrix Reloaded&quot;,2003,Movie;Sequel</td>
</tr>
<tr>
<td>3,&quot;The Matrix Revolutions&quot;,2003,Movie;Sequel</td>
</tr>
</tbody>
</table>

Define an **Actor-ID** ID space in the header of the *actors_header.csv* file.

<table>
<thead>
<tr>
<th>personId:ID(Actor-ID),name,:LABEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,&quot;Keanu Reeves&quot;,Actor</td>
</tr>
<tr>
<td>2,&quot;Laurence Fishburne&quot;,Actor</td>
</tr>
<tr>
<td>3,&quot;Carrie-Anne Moss&quot;,Actor</td>
</tr>
</tbody>
</table>

Now use the previously defined ID spaces when connecting the actors to movies.

<table>
<thead>
<tr>
<th>:START_ID(Actor-ID),role,:END_ID(Movie-ID),:TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,&quot;Neo&quot;,1,ACTED_IN</td>
</tr>
<tr>
<td>1,&quot;Neo&quot;,2,ACTED_IN</td>
</tr>
<tr>
<td>1,&quot;Neo&quot;,3,ACTED_IN</td>
</tr>
<tr>
<td>2,&quot;Morpheus&quot;,1,ACTED_IN</td>
</tr>
<tr>
<td>2,&quot;Morpheus&quot;,2,ACTED_IN</td>
</tr>
<tr>
<td>2,&quot;Morpheus&quot;,3,ACTED_IN</td>
</tr>
<tr>
<td>3,&quot;Trinity&quot;,1,ACTED_IN</td>
</tr>
<tr>
<td>3,&quot;Trinity&quot;,2,ACTED_IN</td>
</tr>
<tr>
<td>3,&quot;Trinity&quot;,3,ACTED_IN</td>
</tr>
</tbody>
</table>

**Skipping columns**

**IGNORE**

If there are fields in the data that you wish to ignore completely, this can be done using the **IGNORE** keyword in the header file. **IGNORE** must be prepended with a `:`.

**Example 127. Skip a column**

In this example, you are not interested in the data in the third column of the nodes file and wish to skip over it. Note that the **IGNORE** keyword is prepended by a `:`.

<table>
<thead>
<tr>
<th>personId:ID,name,:IGNORE,:LABEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>keanu,&quot;Keanu Reeves&quot;,&quot;male&quot;,Actor</td>
</tr>
<tr>
<td>laurence,&quot;Laurence Fishburne&quot;,&quot;male&quot;,Actor</td>
</tr>
<tr>
<td>carrieanne,&quot;Carrie-Anne Moss&quot;,&quot;female&quot;,Actor</td>
</tr>
</tbody>
</table>
If all your superfluous data is placed in columns located to the right of all the columns that you wish to import, you can instead use the command line option --ignore-extra-columns.

Import compressed files

The import tool can handle files compressed with `zip` or `gzip`. Each compressed file must contain a single file.

Example 128. Perform an import using compressed files

```bash
neo4j_home$ ls import
actors-header.csv actors.csv.zip movies-header.csv movies.csv.gz roles-header.csv roles.csv.gz

```

Resuming a stopped or cancelled import

An import that is stopped or fails before completing can be resumed from a point closer to where it was stopped. An import can be resumed from the following points:

- Linking of relationships
- Post-processing

17.2.11. Unbind a Core Server

This section describes how to remove cluster state data from a Neo4j server.

Command

The cluster state of a Causal Cluster member can be removed by using the following command:

Syntax

```
```

Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>--verbose</td>
<td></td>
<td>Enable verbose output.</td>
</tr>
<tr>
<td>Option</td>
<td>Default</td>
<td>Description</td>
</tr>
<tr>
<td>------------------------</td>
<td>---------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>--expand-commands</td>
<td></td>
<td>Allow command expansion in config value evaluation.</td>
</tr>
<tr>
<td>--archive-cluster-state</td>
<td>false</td>
<td>Enable or disable the cluster state archiving.</td>
</tr>
<tr>
<td>--archive-path</td>
<td></td>
<td>Destination (file or folder) of the cluster state archive.</td>
</tr>
</tbody>
</table>

Limitations

The Neo4j server process must be shut down before running the `neo4j-admin unbind` command.

Examples of usage

You can use the `neo4j-admin unbind` command to:

- Turn a cluster member into a standalone server:

  To start the Neo4j server in single (standalone) mode after unbinding it from the cluster, first set `dbms.mode=SINGLE` in `neo4j.conf`.

- Seed a Causal Cluster with existing store files:

  To seed a new cluster using the store files of another cluster, you must first run `neo4j-admin unbind` on each server. For more information about seeding Causal Clusters, see Seed a cluster.

  If a cluster holds a previous version of any of the databases being seeded, you must DROP those databases before seeding. Alternatively, you can stop every instance, unbind them from the cluster using `neo4j-admin unbind` and then forcefully restore the correct seeds (backups) for the databases in question. If you do not DROP or unbind before seeding, either with `neo4j-admin restore` or `neo4j-admin load`, the database’s store files and cluster state will be out of sync, potentially leading to logical corruptions.

- Recover a Causal Cluster:

  In the event of serious failures you may need to recover an entire Causal Cluster from backups. Before restoring those backups, you must first run `neo4j-admin unbind` on each server. For more information about recovering databases from online backups, see Restore a database backup.

  From Neo4j version 4.0.0 onwards, you must run the `neo4j-admin unbind` command on both Read Replicas and Core members.

Archive cluster state

To archive the cluster state, from the `<neo4j-home>` folder, run the `neo4j-admin unbind` command with the arguments `--archive-cluster-state=true` and `--archive-path=<destination-folder>`.
bin/neo4j-admin unbind --archive-path=/path/to/archive-folder --archive-cluster-state=true

The default resultant file is named:

unbound_cluster_state.<YYYYMMDDHH24MM>.zip

17.2.12. Push to cloud Aura

This section describes the push-to-cloud command of the Neo4j Admin tool.

The `neo4j-admin push-to-cloud` command enables you to dump a local Neo4j database and import it into a Neo4j Aura instance.

Syntax

```
neo4j-admin push-to-cloud [--overwrite] [--verbose] --bolt-uri=<boltURI> 
[--database=<database>] [--dump=<dump>] 
[--dump-to=<tmpDumpFile>] [--password=<password>] 
[--username=<username>]
```

Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>--database</td>
<td>neo4j</td>
<td>Name of the database to push.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>This argument cannot be used together with --dump.</td>
</tr>
<tr>
<td>--dump</td>
<td></td>
<td>Path to an existing database dump for upload, in the format /path/to/my-neo4j-database-dump-file.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>This argument cannot be used together with --database.</td>
</tr>
<tr>
<td>--dump-to</td>
<td></td>
<td>Optional. Target path for temporary database dump file to be uploaded, in the format /path/to/temp-file.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Used in combination with the --database argument.</td>
</tr>
<tr>
<td>--bolt-uri</td>
<td></td>
<td>Bolt URI of the target database. For example, neo4j://mydatabaseid.databases.neo4j.io.</td>
</tr>
<tr>
<td>Option</td>
<td>Default</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>---------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>--username</td>
<td>Optional.</td>
<td>Username of the target database to push this database to. If you do not provide a username, you will be prompted to provide one. Alternatively, the NEO4J_USERNAME environment variable can be used.</td>
</tr>
<tr>
<td>--password</td>
<td>Optional.</td>
<td>Password of the target database to push this database to. If you do not provide a password, you will be prompted to provide one. Alternatively, the NEO4J_PASSWORD environment variable can be used.</td>
</tr>
<tr>
<td>--overwrite</td>
<td>Optional.</td>
<td>Overwrite the data in the target database.</td>
</tr>
<tr>
<td>--verbose</td>
<td>Optional.</td>
<td>Enable verbose output.</td>
</tr>
</tbody>
</table>

Limitations

- A Neo4j Aura database must already be provisioned and running.
- Your local database must be stopped before you run the push-to-cloud command with the --database argument. The push-to-cloud function cannot be used with a source database which is currently in use.
- If used with a running source database, it will exit and print an error.

Output

If the push-to-cloud function completes successfully, it will exit with the following log line:

```
"Your data was successfully pushed to cloud and is now running".
```

If the push-to-cloud function encounters an error at any point, you will be provided with instructions on how to try again, or to contact Neo4j Aura support.

Example

Run with the --database option to dump a specific database name. Note that the local database must be stopped first.
17.3. Cypher Shell

Describes Neo4j Cypher Shell command-line interface (CLI) and how to use it.

17.3.1. About Cypher Shell CLI

Cypher Shell is a command-line tool that comes with the Neo4j distribution. It can also be downloaded from Neo4j Download Center and installed separately.

Cypher Shell CLI is used to run queries and perform administrative tasks against a Neo4j instance. By default, the shell is interactive, but you can also use it for scripting, by passing cypher directly on the command line or by piping a file with cypher statements (requires PowerShell on Windows). It communicates via the Bolt protocol.

17.3.2. Syntax

The Cypher Shell CLI is located in the bin directory if installed as part of the product.

Syntax:
Arguments:

<table>
<thead>
<tr>
<th>Argument</th>
<th>Type</th>
<th>Description</th>
<th>Default value</th>
</tr>
</thead>
<tbody>
<tr>
<td>-h, --help</td>
<td>Optional argument</td>
<td>Show help message and exit.</td>
<td></td>
</tr>
<tr>
<td>-a ADDRESS</td>
<td>Connection argument</td>
<td>Address and port to connect to.</td>
<td>neo4j://localhost:7687</td>
</tr>
<tr>
<td>-u USERNAME</td>
<td>Connection argument</td>
<td>Username to connect as. It can also be specified by the environment variable</td>
<td></td>
</tr>
<tr>
<td>-p PASSWORD</td>
<td>Connection argument</td>
<td>Password to connect with. It can also be specified by the environment variable</td>
<td></td>
</tr>
<tr>
<td>--encryption</td>
<td>Connection argument</td>
<td>Whether the connection to Neo4j should be encrypted; must be consistent with</td>
<td>default</td>
</tr>
<tr>
<td>{true,false,default}</td>
<td></td>
<td>Neo4j’s configuration.</td>
<td></td>
</tr>
<tr>
<td>-d DATABASE</td>
<td>Connection argument</td>
<td>Database to connect to. It can also be specified by the environment variable</td>
<td></td>
</tr>
<tr>
<td>--database DATABASE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Argument</td>
<td>Type</td>
<td>Description</td>
<td>Default value</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-----------------</td>
<td>------------------------------------------------------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td><strong>--format</strong> {auto,verbose,plain}</td>
<td>Optional argument</td>
<td>Desired output format.</td>
<td>auto (default): displays results in tabular format if you use the shell interactively and with minimal formatting if you use it for scripting. verbose: displays results in tabular format and prints statistics. plain: displays data with minimal formatting.</td>
</tr>
<tr>
<td><strong>--P PARAM</strong></td>
<td>Optional argument</td>
<td>Add a parameter to this session. For example, -P &quot;number ⇒ 3&quot; or -P &quot;country ⇒ 'Spain'&quot;. This argument can be specified multiple times.</td>
<td></td>
</tr>
<tr>
<td><strong>--param PARAM</strong></td>
<td>Optional argument</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>--debug</strong></td>
<td>Optional argument</td>
<td>Print additional debug information.</td>
<td>false</td>
</tr>
<tr>
<td><strong>--non-interactive</strong></td>
<td>Optional argument</td>
<td>Force non-interactive mode; only useful if auto-detection fails (e.g. Windows).</td>
<td>false</td>
</tr>
<tr>
<td><strong>--sample-rows SAMPLE-ROWS</strong></td>
<td>Optional argument</td>
<td>Number of rows sampled to compute table widths (only for format=VERBOSE).</td>
<td>1000</td>
</tr>
<tr>
<td><strong>--wrap {true,false}</strong></td>
<td>Optional argument</td>
<td>Wrap table column values if column is too narrow (only for format=VERBOSE).</td>
<td>true</td>
</tr>
<tr>
<td><strong>-v</strong></td>
<td>Optional argument</td>
<td>Print version of cypher-shell and exit.</td>
<td>false</td>
</tr>
<tr>
<td><strong>--version</strong></td>
<td>Optional argument</td>
<td>Print version of the Neo4j Driver used and exit.</td>
<td>false</td>
</tr>
<tr>
<td>Argument</td>
<td>Type</td>
<td>Description</td>
<td>Default value</td>
</tr>
<tr>
<td>---------------------------</td>
<td>--------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>-f FILE</td>
<td>Optional argument</td>
<td>Pass a file with cypher statements to be executed. After the statements have been executed cypher-shell shuts down.</td>
<td></td>
</tr>
<tr>
<td>--file FILE</td>
<td>Optional argument</td>
<td>Change Neo4j user password and exit</td>
<td>false</td>
</tr>
<tr>
<td>--change-password</td>
<td>Optional argument</td>
<td>Exit and report failure on first error when reading from file.</td>
<td></td>
</tr>
<tr>
<td>--fail-fast</td>
<td>Optional argument</td>
<td>Exit and report failures at end of input when reading from file.</td>
<td>This is the default behavior.</td>
</tr>
<tr>
<td>--fail-at-end</td>
<td>Optional argument</td>
<td>An optional string of cypher to execute and then exit.</td>
<td></td>
</tr>
<tr>
<td>cypher</td>
<td>Positional argument</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

17.3.3. Running Cypher Shell within the Neo4j distribution

You can connect to a live Neo4j DBMS by running cypher-shell and passing in a username and a password argument:

```
bin/cypher-shell -u neo4j -p <password>
```

The output is the following:

```
Connected to Neo4j at neo4j://localhost:7687 as user neo4j.
Type :help for a list of available commands or :exit to exit the shell.
Note that Cypher queries must end with a semicolon.
```

17.3.4. Running Cypher Shell from a different server

You can also install the Cypher Shell tool on a different server (without Neo4j) and connect to a Neo4j DBMS. Cypher Shell requires a JDK and Java 11.

- DEB/RPM distributions both install OpenJDK if it is not already installed. The cypher-shell files are available in the same DEB/RPM Linux repositories as Neo4j.
- The TAR distribution contains only the cypher-shell files, so you must install the JDK manually.
1. Download Cypher Shell from Neo4j Download Center.

2. Connect to a Neo4j DBMS by running the `cypher-shell` command providing the Neo4j address, a username, and a password:

   ```
cypher-shell/cypher-shell -a neo4j://IP-address:7687 -u neo4j -p <password>
   ```

   The output is the following:

   ```
   Connected to Neo4j at neo4j://IP-address:7687 as user neo4j.
   Type :help for a list of available commands or :exit to exit the shell.
   Note that Cypher queries must end with a semicolon.
   ```

17.3.5. Available commands

Once in the interactive shell, run the following command to display all available commands:

Example 129. Running `help`

```
:help
```

The output is the following:

```plaintext
Available commands:
:begin      Open a transaction
:commit     Commit the currently open transaction
:connect    Connects to a database
:disconnect Disconnects from database
:exit       Exit the logger
:help       Show this help message
:history    Print a list of the last commands executed
:param      Set the value of a query parameter
:params     Print all currently set query parameters and their values
:rollback   Rollback the currently open transaction
:source     Interactively executes cypher statements from a file
:use        Set the active database

For help on a specific command type:
:help command
```

17.3.6. Running Cypher statements

You can run Cypher statements in the following ways:

- Typing Cypher statements directly into the interactive shell.
- Running Cypher statements from a file with the interactive shell.
- Running Cypher statements from a file as a `cypher-shell` argument.

The examples in this section use the `MATCH (n) RETURN n LIMIT 5` Cypher statement and will return 5 nodes from the database.
Example 130. Typing a Cypher statement directly into the interactive shell

```
MATCH (n) RETURN n LIMIT 5;
```

Example 131. Running Cypher statements from a file with the interactive shell

You can use the :source command followed by the file name to run the Cypher statements in that file when in the Cypher interactive shell:

```
:source example.cypher
```

Example 132. Running Cypher statements from a file as a cypher-shell argument.

You can pass a file containing Cypher statements as an argument when running cypher-shell. The examples here use the --format plain flag for a simple output.

Using `cat` (UNIX)

```
cat example.cypher | bin/cypher-shell -u neo4j -p <password> --format plain
```

Using `type` (Windows)

```
type example.cypher | bin/cypher-shell.bat -u neo4j -p <password> --format plain
```

17.3.7. Query parameters

Cypher Shell CLI supports querying based on parameters. This is often used while scripting.
Example 133. Use parameters within Cypher Shell

1. Set the parameter thisAlias to Robin using the :param keyword:

   :param thisAlias => 'Robin'

2. Check the parameter using the :params keyword:

   :params
   :param thisAlias => 'Robin'

3. Now use the parameter thisAlias in a Cypher query:

   CREATE (:Person {name : 'Dick Grayson', alias : $thisAlias });

   Added 1 nodes, Set 2 properties, Added 1 labels

4. Verify the result:

   MATCH (n) RETURN n;

   +-----------------------------------------------------------------+
   | n                                                               |
   +-----------------------------------------------------------------+
   | (:Person {name: "Bruce Wayne", alias: "Batman"})               |
   | (:Person {name: "Selina Kyle", alias: ["Catwoman", "The Cat"]}) |
   | (:Person {name: "Dick Grayson", alias: "Robin"})               |
   +-----------------------------------------------------------------+
   3 rows available after 2 ms, consumed after another 2 ms

17.3.8. Transactions

Cypher Shell supports explicit transactions. Transaction states are controlled using the keywords :begin, :commit, and :rollback.
Example 134. Use fine-grained transaction control

The example uses the dataset from the built-in Neo4j Browser guide, called MovieGraph. For more information, see the [Neo4j Browser documentation](#).

1. Run a query that shows there is only one person in the database, who is born in 1964.

   ```cypher
   MATCH (n:Person) WHERE n.born=1964 RETURN n.name AS name;
   +----------------+
   | name           |
   +----------------+
   | "Keanu Reeves" |
   +----------------+
   1 row
   ready to start consuming query after 9 ms, results consumed after another 0 ms
   ```

2. Start a transaction and create another person born in the same year:

   ```cypher
   :begin
   neo4j# CREATE (:Person {name : 'Edward Mygma', born:1964});
   0 rows
   ready to start consuming query after 38 ms, results consumed after another 0 ms
   Added 1 nodes, Set 2 properties, Added 1 labels
   ```

3. If you open a second Cypher Shell session and run the query from step 1, you will notice no changes from the latest `CREATE` statement.

   ```cypher
   MATCH (n:Person) WHERE n.born=1964 RETURN n.name AS name;
   +----------------+
   | name           |
   +----------------+
   | "Keanu Reeves" |
   +----------------+
   1 row
   ready to start consuming query after 9 ms, results consumed after another 0 ms
   ```

4. Go back to the first session and commit the transaction.

   ```cypher
   neo4j# :commit
   ```

5. Now, if you run the query from step 1, you will see that Edward Mygma has been added to the database.

   ```cypher
   MATCH (n:Person) WHERE n.born=1964 RETURN n.name AS name;
   ```
17.3.9. Procedures

Cypher Shell supports running any procedures for which the current user is authorized.

Example 135. Call the dbms.showCurrentUser procedure

```cypher
CALL dbms.showCurrentUser();
```

<table>
<thead>
<tr>
<th>username</th>
<th>roles</th>
<th>flags</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;neo4j&quot;</td>
<td>[&quot;admin&quot;]</td>
<td>[]</td>
</tr>
</tbody>
</table>

1 row available after 66 ms, consumed after another 2 ms

17.3.10. Supported operating systems

You can use the Cypher Shell CLI via cmd on Windows systems, and bash on Unix systems.

Other shells may work as intended, but there is no test coverage to guarantee compatibility.

Appendix A: Reference

This section provides a complete reference to the Neo4j configuration settings and procedures.

This appendix contains the following:

- Configuration settings
- Procedures

17.A.1. Configuration settings

This section provides a complete reference to the Neo4j configuration settings.

Configuration settings can be set in neo4j.conf. Refer to The neo4j.conf file for details on how to use
configuration settings.

All settings

- **browser.allow_outgoing_connections**: Configure the policy for outgoing Neo4j Browser connections.
- **browser.credential_timeout**: Configure the Neo4j Browser to time out logged in users after this idle period.
- **browser.post_connect_cmd**: Commands to be run when Neo4j Browser successfully connects to this server.
- **browser.remote_content_hostname_whitelist**: Whitelist of hosts for the Neo4j Browser to be allowed to fetch content from.
- **browser.retain_connection_credentials**: Configure the Neo4j Browser to store or not store user credentials.
- **browser.retain_editor_history**: Configure the Neo4j Browser to store or not store user editor history.
- **causal_clustering.catch_up_client_inactivity_timeout**: The catch up protocol times out if the given duration elapses with no network activity.
- **causal_clustering.catchup_batch_size**: The maximum batch size when catching up (in unit of entries).
- **causal_clustering.cluster_allow_reads_on_followers**: Configure if the dbms.routing.getRoutingTable() procedure should include followers as read endpoints or return only read replicas.
- **causal_clustering.cluster_allow_reads_on_leader**: Configure if the dbms.routing.getRoutingTable() procedure should include the leader as read endpoint or return only read replicas/followers.
- **causal_clustering.cluster_binding_timeout**: The time allowed for a database on a Neo4j server to either join a cluster or form a new cluster with the other Neo4j Core Servers provided by causal_clustering.initial_discovery_members.
- **causal_clustering.cluster_topology_refresh**: Time between scanning the cluster to refresh current server’s view of topology.
- **causal_clustering.command_applier_parallelism**: Limits amount of global threads for applying commands.
- **causal_clustering.connect_randomly_to_server_group**: Comma separated list of groups to be used by the connect-randomly-to-server-group selection strategy.
- **causal_clustering.delete_store_before_store_copy**: Deletes the old store (on cores and replicas) before performing a store copy (instead of deleting it after).
- **causal_clustering.discovery_advertised_address**: Advertised cluster member discovery management communication.
- **causal_clustering.discovery_listen_address**: Host and port to bind the cluster member discovery management communication.
- **causal_clustering.discovery_type**: Configure the discovery type used for cluster name resolution.
- **causal_clustering.election_failure_detection_window**: The rate at which leader elections happen.
- **causal_clustering.enable_pre_voting**: Enable pre-voting extension to the Raft protocol (this is breaking and must match between the core cluster members).
- **causal_clustering.global_session_tracker_state_size**: The maximum file size before the global session
• **causal_clustering.handshake_timeout**: Time out for protocol negotiation handshake.
• **causal_clustering.in_flight_cache.max_bytes**: The maximum number of bytes in the in-flight cache.
• **causal_clustering.in_flight_cache.max_entries**: The maximum number of entries in the in-flight cache.
• **causal_clustering.in_flight_cache.type**: Type of in-flight cache.
• **causal_clustering.initial_discovery_members**: A comma-separated list of other members of the cluster to join.
• **causal_clustering.join_catch_up_max_lag**: Maximum amount of lag accepted for a new follower to join the Raft group.
• **causal_clustering.join_catch_up_timeout**: Time out for a new member to catch up.
• **causal_clustering.kubernetes.address**: Address for Kubernetes API.
• **causal_clustering.kubernetes.ca_crt**: File location of CA certificate for Kubernetes API.
• **causal_clustering.kubernetes.cluster_domain**: Kubernetes cluster domain.
• **causal_clustering.kubernetes.label_selector**: LabelSelector for Kubernetes API.
• **causal_clustering.kubernetes.namespace**: File location of namespace for Kubernetes API.
• **causal_clustering.kubernetes.service_port_name**: Service port name for discovery for Kubernetes API.
• **causal_clustering.kubernetes.token**: File location of token for Kubernetes API.
• **causal_clustering.last_applied_state_size**: The maximum file size before the storage file is rotated (in unit of entries).
• **causal_clustering.leader_election_timeout**: This setting is moved and enhanced into
  causal_clustering.leader_failure_detection_window and
causal_clustering.election_failure_detection_window.
• **causal_clustering.leader_failure_detection_window**: The time window within which the loss of the leader is detected and the first re-election attempt is held. The window should be significantly larger than typical communication delays to make conflicts unlikely.
• **causal_clustering.leadership_balancing**: Which strategy to use when transferring database leaderships around a cluster.
• **causal_clustering.leadership_priority_group**: The name of a server_group whose members should be prioritized as leaders.
• **causal_clustering.load_balancing.plugin**: The load balancing plugin to use.
• **causal_clustering.load_balancing.shuffle**: Enables shuffling of the returned load balancing result.
• **causal_clustering.log_shipping_max_lag**: The maximum lag allowed before log shipping pauses (in unit of entries).
• **causal_clustering.log_shipping_retry_timeout**: Retry time for log shipping to followers after a stall.
• **causal_clustering.max_raft_channels**: The maximum number of TCP channels between two nodes to operate the raft protocol. Each database gets allocated one channel, but a single channel can be used by more than one database.
• **causal_clustering.middleware.logging.level**: The level of middleware logging.
• **causal_clustering.minimum_core_cluster_size_at_formation**: Minimum number of Core machines initially required to form a cluster.

• **causal_clustering.minimum_core_cluster_size_at_runtime**: The minimum size of the dynamically adjusted voting set (which only core members may be a part of).

• **causal_clustering.multi_dc_license**: Enable multi-data center features.

• **causal_clustering.protocol_implementations.catchup**: Catchup protocol implementation versions that this instance will allow in negotiation as a comma-separated list.

• **causal_clustering.protocol_implementations.compression**: Network compression algorithms that this instance will allow in negotiation as a comma-separated list.

• **causal_clustering.protocol_implementations.raft**: Raft protocol implementation versions that this instance will allow in negotiation as a comma-separated list.

• **causal_clustering.pull_interval**: Interval of pulling updates from cores.

• **causal_clustering.raft_advertised_address**: Advertised hostname/IP address and port for the RAFT server.

• **causal_clustering.raft_handler_parallelism**: Limits amount of global threads shared by raft groups for handling batching of messages and timeout events.

• **causal_clustering.raft_in_queue_max_batch_bytes**: Largest batch processed by RAFT in bytes.

• **causal_clustering.raft_in_queue_max_bytes**: Maximum number of bytes in the RAFT in-queue.

• **causal_clustering.raft_listen_address**: Network interface and port for the RAFT server to listen on.

• **causal_clustering.raft_log_entry_prefetch_buffer.max_entries**: The maximum number of entries in the raft log entry prefetch buffer.

• **causal_clustering.raft_log_implementation**: RAFT log implementation.

• **causal_clustering.raft_log_prune_strategy**: RAFT log pruning strategy that determines which logs are to be pruned.

• **causal_clustering.raft_log_pruning_frequency**: RAFT log pruning frequency.

• **causal_clustering.raft_log_reader_pool_size**: RAFT log reader pool size.

• **causal_clustering.raft_log_rotation_size**: RAFT log rotation size.

• **causal_clustering.raft_membership_state_size**: The maximum file size before the membership state file is rotated (in unit of entries).

• **causal_clustering.raft_term_state_size**: The maximum file size before the term state file is rotated (in unit of entries).

• **causal_clustering.raft_vote_state_size**: The maximum file size before the vote state file is rotated (in unit of entries).

• **causal_clustering.refuse_to_be_leader**: Deprecated, use dbms.databases.default_to_read_only.

• **causal_clustering.replicated_lease_state_size**: The maximum file size before the replicated lease state file is rotated (in unit of entries).

• **causal_clustering.replication_leader_await_timeout**: The duration for which the replicator will await a new leader.
- **causal_clustering.replication_retry_timeout_base**: The initial timeout until replication is retried.
- **causal_clustering.replication_retry_timeout_limit**: The upper limit for the exponentially incremented retry timeout.
- **causal_clustering.server_groups**: A list of group names for the server used when configuring load balancing and replication policies.
- **causal_clustering.state_machine_apply_max_batch_size**: The maximum number of operations to be batched during applications of operations in the state machines.
- **causal_clustering.state_machine_flush_window_size**: The number of operations to be processed before the state machines flush to disk.
- **causal_clustering.status_throughput_window**: Sampling window for throughput estimate reported in the status endpoint.
- **causal_clustering.store_copy_chunk_size**: Store copy chunk size.
- **causal_clustering.store_copy_max_retry_time_per_request**: Maximum retry time per request during store copy.
- **causal_clustering.store_copy_parallelism**: Limits amount of global threads for store copy.
- **causal_clustering.transaction_advertised_address**: Advertised hostname/IP address and port for the transaction shipping server.
- **causal_clustering.transaction_listen_address**: Network interface and port for the transaction shipping server to listen on.
- **causal_clustering.unknown_address_logging_throttle**: Throttle limit for logging unknown cluster member address.
- **causal_clustering.upstream_selection_strategy**: An ordered list in descending preference of the strategy which read replicas use to choose the upstream server from which to pull transactional updates.
- **causal_clustering.user_defined_upstream_strategy**: Configuration of a user-defined upstream selection strategy.
- **clients.allow_telemetry**: Configure client applications such as Browser and Bloom to send Product Analytics data.
- **cypher.default_language_version**: Set this to specify the default parser (language version).
- **cypher.forbid_exhaustive_shortestpath**: This setting is associated with performance optimization.
- **cypher.forbid_shortestpath_common_nodes**: This setting is associated with performance optimization.
- **cypher.hints_error**: Set this to specify the behavior when Cypher planner or runtime hints cannot be fulfilled.
- **cypher.lenient_create_relationship**: Set this to change the behavior for Cypher create relationship when the start or end node is missing.
- **cypher.min_replan_interval**: The minimum time between possible cypher query replanning events.
- **cypher.planner**: Set this to specify the default planner for the default language version.
- **cypher.statistics_divergence_threshold**: The threshold for statistics above which a plan is considered stale.
If any of the underlying statistics used to create the plan have changed more than this value, the plan will be considered stale and will be replanned. * `db.temporal.timezone`: Database timezone for temporal functions. * `dbms.allow_single_automatic_upgrade`: Whether to allow a system graph upgrade to happen automatically in single instance mode (dbms.mode=SINGLE). * `dbms.allow_upgrade`: Whether to allow a store upgrade in case the current version of the database starts against an older version of the store. * `dbms.backup.enabled`: Enable support for running online backups. * `dbms.backup.incremental.strategy`: Strategy for incremental backup. * `dbms.backup.listen_address`: Network interface and port for the backup server to listen on. * `dbms.checkpoint`: Configures the general policy for when check-points should occur. * `dbms.checkpoint.interval.time`: Configures the time interval between check-points. * `dbms.checkpoint.interval.tx`: Configures the transaction interval between check-points. * `dbms.checkpoint.interval.volume`: Configures the volume of transaction logs between check-points. * `dbms.checkpoint.iops.limit`: Limit the number of IOs the background checkpoint process will consume per second. * `dbms.clustering.enable`: Enable discovery service and a catchup server to be started on an Enterprise Standalone Instance 'dbms.mode=SINGLE', and with that allow for Read Replicas to connect and pull transaction from it. * `dbms.config.strict_validation`: A strict configuration validation will prevent the database from starting up if unknown configuration options are specified in the neo4j settings namespace (such as dbms., cypher., etc). * `dbms.connector.bolt.advertised_address`: Advertised address for this connector. * `dbms.connector.bolt.connection.keep_alive`: The maximum time to wait before sending a NOOP on connections waiting for responses from active ongoing queries. The minimum value is 1 millisecond. * `dbms.connector.bolt.connection.keep_alive_for_requests`: The type of messages to enable keep-alive messages for (ALL, STREAMING or OFF). * `dbms.connector.bolt.connection.keep_alive_probes`: The total amount of probes to be missed before a connection is considered stale. The minimum for this value is 1. * `dbms.connector.bolt.connection.keep_alive_streaming_scheduling_interval`: The interval between every scheduled keep-alive check on all connections with active queries. * `dbms.connector.bolt.enabled`: Enable the bolt connector. * `dbms.connector.bolt.listen_address`: Address the connector should bind to. * `dbms.connector.bolt.ocsp_stapling_enabled`: Enable server OCSP stapling for bolt and http connectors. * `dbms.connector.bolt.thread_pool_keep_alive`: The maximum time an idle thread in the thread pool bound to this connector will wait for new tasks. * `dbms.connector.bolt.thread_pool_max_size`: The maximum number of threads allowed in the thread pool bound to this connector. * `dbms.connector.bolt.thread_pool_min_size`: The number of threads to keep in the thread pool bound to this connector, even if they are idle. * `dbms.connector.bolt.tls_level`: Encryption level to require this connector to use. * `dbms.connector.bolt.unsupported_thread_pool_shutdown_wait_time`: The maximum time to wait for the thread pool to finish processing its pending jobs and shutdown. * `dbms.connector.http.advertised_address`: Advertised address for this connector. * `dbms.connector.http.enabled`: Enable the http connector. * `dbms.connector.http.listen_address`: Address the connector should bind to. * `dbms.connector.https.advertised_address`: Advertised address for this connector. * `dbms.connector.https.enabled`: Enable the https connector. * `dbms.connector.https.listen_address`: Address the connector should bind to. * `dbms.databases.default_to_read_only`: Whether or not any database on this instance are read_only by default. * `dbms.databases.read_only`: List of databases for which to prevent write queries. * `dbms.databases.writable`: List of databases for which to allow write queries. * `dbms.db.timezone`: Database timezone. * `dbms.default_advertised_address`: Default hostname or IP address the server uses to advertise itself. * `dbms.default_database`: Name of the default database (aliases are not supported). * `dbms.default_listen_address`: Default network interface to listen for incoming connections. * `dbms.directories.cluster_state`: Directory to hold cluster state including Raft log. * `dbms.directories.data`: Path of the data directory. * `dbms.directories.dumps.root`: Root location where Neo4j will store database
purposes. * dbms.logs.query.rotation.keep_number: Maximum number of history files for the query log. * dbms.logs.query.rotation.size: The file size in bytes at which the query log will auto-rotate. * dbms.logs.query.runtime_logging_enabled: Logs which runtime that was used to run the query. * dbms.logs.query.threshold: If the execution of query takes more time than this threshold, the query is logged once completed - provided query logging is set to INFO. * dbms.logs.query.time_logging_enabled: Log detailed time information for the executed queries being logged, such as (planning: 92, waiting: 0). * dbms.logs.query.transaction.enabled: Log the start and end of a transaction. * dbms.logs.query.transaction.threshold: If the transaction is open for more time than this threshold, the transaction is logged once completed - provided transaction logging (dbms.logs.query.transaction.enabled) is set to INFO. * dbms.logs.query.transaction_id.enabled: Log transaction ID for the executed queries. * dbms.logs.security.format: Log format to use for security log. * dbms.logs.security.level: Security log level threshold. * dbms.logs.security.path: Path to the security log file. * dbms.logs.security.rotation.delay: Minimum time interval after last rotation of the security log before it may be rotated again. * dbms.logs.security.rotation.keep_number: Maximum number of history files for the security log. * dbms.logs.security.rotation.size: Threshold for rotation of the security log. * dbms.logs.user.format: Log format to use for user log. * dbms.logs.user.path: Path to the user log file. * dbms.logs.user.rotation.delay: Minimum time interval after last rotation of the user log (neo4j.log) before it may be rotated again. * dbms.logs.user.rotation.keep_number: Maximum number of history files for the user log (neo4j.log). * dbms.logs.user.rotation.size: Threshold for rotation of the user log (neo4j.log). * dbms.logs.user.stdout_enabled: Send user logs to the process stdout. * dbms.max_databases: The maximum number of databases. * dbms.memory.heap.initial_size: Initial heap size. * dbms.memory.heap.max_size: Maximum heap size. * dbms.memory.off_heap.block_cache_size: Defines the size of the off-heap memory blocks cache. * dbms.memory.off_heap.max_cacheable_block_size: Defines the maximum size of an off-heap memory block that can be cached to speed up allocations. * dbms.memory.off_heap.max_size: The maximum amount of off-heap memory that can be used to store transaction state data; it's a total amount of memory shared across all active transactions. * dbms.memory.pagecache.directio: Use direct I/O for page cache. * dbms.memory.pagecache.flush.buffer.enabled: Page cache can be configured to use a temporal buffer for flushing purposes. * dbms.memory.pagecache.flush.buffer.size_in_pages: Page cache can be configured to use a temporal buffer for flushing purposes. * dbms.memory.pagecache.scan.prefetchers: The maximum number of worker threads to use for pre-fetching data when doing sequential scans. * dbms.memory.pagecache.size: The amount of memory to use for mapping the store files, in bytes (or kilobytes with the 'k' suffix, megabytes with 'm' and gigabytes with 'g'). * dbms.memory.pagecache.swapper: This setting is not used anymore. * dbms.memory.pagecache.warmup.enable: Page cache can be configured to perform usage sampling of loaded pages that can be used to construct active load profile. * dbms.memory.pagecache.warmup.preload: Page cache warmup can be configured to prefetch files, preferably when cache size is bigger than store size. * dbms.memory.pagecache.warmup.preload.allowlist: Page cache warmup prefetch file allowlist regex. * dbms.memory.pagecache.warmup.preload.whitelist: Page cache warmup prefetch file whitelist regex. * dbms.memory.pagecache.warmup.profile.interval: The profiling frequency for the page cache. * dbms.memory.tracking.enable: Enable off heap and on heap memory tracking. * dbms.memory.transaction.database_max_size: Limit the amount of memory that all transactions in one database can consume, in bytes (or kilobytes with the 'k' suffix, megabytes with 'm' and gigabytes with 'g'). * dbms.memory.transaction.global_max_size: Limit the amount of memory that all of the running transactions can consume, in bytes (or kilobytes with the 'k' suffix, megabytes with 'm' and gigabytes with 'g'). * dbms.memory.transaction.max_size: Limit the amount of memory that a single transaction can consume, in bytes (or kilobytes with the 'k' suffix, megabytes with 'm' and gigabytes with
* dbms.mode: Configure the operating mode of the database — ‘SINGLE’ for stand-alone operation, ‘CORE’ for operating as a core member of a Causal Cluster, or ‘READ_REPLICA’ for operating as a read replica member of a Causal Cluster. * dbms.netty.ssl.provider: Netty SSL provider. * dbms.panic.shutdown_on_panic: If there is a Database Management System Panic (an irrecoverable error) should the neo4j process shut down or continue running. * dbms.query_cache_size: The number of cached Cypher query execution plans per database. * dbms.read_only: Only allow read operations from this Neo4j instance. * dbms.reconciler.max_backoff: Defines the maximum amount of time to wait before retrying after the dbms fails to reconcile a database to its desired state. * dbms.reconciler.max_parallelism: Defines the level of parallelism employed by the reconciler. * dbms.reconciler.may_retry: Defines whether the dbms may retry reconciling a database to its desired state. * dbms.reconciler.min_backoff: Defines the minimum amount of time to wait before retrying after the dbms fails to reconcile a database to its desired state. * dbms.record_format: Database record format. * dbms.recovery.fail_on_missing_files: If true, Neo4j will abort recovery if transaction log files are missing. * dbms.relationship_grouping_threshold: Relationship count threshold for considering a node to be dense. * dbms.rest.transaction.idle_timeout: Timeout for idle transactions in the REST endpoint. * dbms.routing.advertised_address: The advertised address for the intra-cluster routing connector. * dbms.routing.client_side.enforce_for_domains: Always use client side routing (regardless of the default router) for neo4j:// protocol connections to these domains. * dbms.routing.default_router: Use server side routing by default for neo4j:// protocol connections. * dbms.routing.driver.api: Determines which driver API will be used. * dbms.routing.driver.connection.connect_timeout: Socket connection timeout. A timeout of zero is treated as an infinite timeout and will be bound by the timeout configured on the operating system level. * dbms.routing.driver.connection.max_lifetime: Pooled connections older than this threshold will be closed and removed from the pool. Setting this option to a low value will cause a high connection churn and might result in a performance hit. It is recommended to set maximum lifetime to a slightly smaller value than the one configured in network equipment (load balancer, proxy, firewall, etc. * dbms.routing.driver.connection.pool.acquisition_timeout: Maximum amount of time spent attempting to acquire a connection from the connection pool. This timeout only kicks in when all existing connections are being used and no new connections can be created because maximum connection pool size has been reached. Error is raised when connection can’t be acquired within configured time. Negative values are allowed and result in unlimited acquisition timeout. * dbms.routing.driver.connection.pool.idle_test: Pooled connections that have been idle in the pool for longer than this timeout will be tested before they are used again, to ensure they are still alive. If this option is set too low, an additional network call will be incurred when acquiring a connection, which causes a performance hit. If this is set high, no longer live connections might be used which might lead to errors. Hence, this parameter tunes a balance between the likelihood of experiencing connection problems and performance. Normally, this parameter should not need tuning. Value 0 means connections will always be tested for validity. * dbms.routing.driver.connection.pool.max_size: Maximum total number of connections to be managed by a connection pool. The limit is enforced for a combination of a host and user. * dbms.routing.driver.logging.level: Sets level for driver internal logging. * dbms.routing.enabled: Enable intra-cluster routing using an additional bolt connector. * dbms.routing.listen_address: The address the routing connector should bind to. * dbms.routing_ttl: How long callers should cache the response of the routing procedure dbms.getRoutingTable(). * dbms.security.allow_csv_import_from_file_urls: Determines if Cypher will allow using file URLs when loading data using LOAD CSV. * dbms.security.auth_cache_max_capacity: The maximum capacity for authentication and authorization caches (respectively). * dbms.security.auth_cache_ttl: The time to live (TTL) for cached authentication and authorization info when using external auth providers (LDAP or plugin). * dbms.security.auth_cache_use_ttl: Enable time-based eviction of the authentication and authorization info.
cache for external auth providers (LDAP or plugin). * \texttt{dbms.security.auth\_enabled}: Enable auth requirement to access Neo4j. * \texttt{dbms.security.auth\_lock\_time}: The amount of time user account should be locked after a configured number of unsuccessful authentication attempts. * \texttt{dbms.security.auth\_max\_failed\_attempts}: The maximum number of unsuccessful authentication attempts before imposing a user lock for the configured amount of time, as defined by \texttt{dbms.security.auth\_lock\_time}. The locked out user will not be able to log in until the lock period expires, even if correct credentials are provided. *

\texttt{dbms.security.authorization\_providers}: A list of security authorization providers containing the users and roles. * \texttt{dbms.security.ldap.authorization.attribute}: The attribute to use when looking up users. Using this setting requires \texttt{dbms.security.ldap.authorization.search\_for\_attribute\_for\_attribute} to be true and thus \texttt{dbms.security.ldap.authorization.system\_username} and \texttt{dbms.security.ldap.authorization.system\_password} to be configured. * \texttt{dbms.security.ldap.connection\_timeout}: The timeout for establishing an LDAP connection. * \texttt{dbms.security.ldap.host}: URL of LDAP server to use for authentication and authorization. * \texttt{dbms.security.ldap.http\_auth\_allowlist}: Defines an allowlist of http paths where Neo4j authentication is not required. * \texttt{dbms.security.ldap.http\_auth\_whitelist}: Defines a whitelist of http paths where Neo4j authentication is not required. * \texttt{dbms.security.ldap.http\_strict\_transport\_security}: Value of the HTTP Strict-Transport-Security (HSTS) response header. * \texttt{dbms.security.ldap.read\_timeout}: The timeout for an LDAP read request (i.e. *)
dbms.security.ldap.referral: The LDAP referral behavior when creating a connection.
* dbms.security.ldap.use_starttls: Use secure communication with the LDAP server using opportunistic TLS.
* dbms.security.log_successful_authentication: Set to log successful authentication events to the security log. * dbms.security.oidc.<provider>.audience: Expected values of the Audience (aud) claim in the id token.
* dbms.security.oidc.<provider>.auth_params: Optional additional configuration options used for the authentication request. * dbms.security.oidc.<provider>.authorization.group_to_role_mapping: An authorization mapping from IdP group names to Neo4j role names. * dbms.security.oidc.<provider>.claims.groups: The claim to use as the list of groups in Neo4j. *
* dbms.security.oidc.<provider>.claims.username: The claim to use as the username in Neo4j. *
* dbms.security.oidc.<provider>.client_id: Client id needed if token contains multiple Audience (aud) claims. * dbms.security.oidc.<provider>.config: Additional configuration options that the clients may require to authenticate. * dbms.security.oidc.<provider>.display_name: The user-facing name of the provider as provided by the discovery endpoint to clients (Bloom, Browser etc.). *
* dbms.security.oidc.<provider>.get_groups_from_user_info: When turned on, Neo4j gets the groups from the provider user info endpoint. * dbms.security.oidc.<provider>.get_username_from_user_info: When turned on, Neo4j gets the username from the provider user info endpoint. *
* dbms.security.oidc.<provider>.issuer: The expected value of the iss claim in the id token. *
* dbms.security.oidc.<provider>.jwks_uri: The location of the JVK public key set for the identity provider. * dbms.security.oidc.<provider>.params: Generic parameters that the clients may require to authenticate. *
* dbms.security.oidc.<provider>.redirect_uri: The redirect URI the IdP should return the user to when authenticated. * dbms.security.oidc.<provider>.token_endpoint: The OIDC token endpoint. *
* dbms.security.oidc.<provider>.token_params: Optional additional configuration options used for the token request. * dbms.security.oidc.<provider>.user_info_uri: The identity providers user info uri. *
* dbms.security.oidc.<provider>.well_known_discovery_uri: The 'well known' OpenID Connect Discovery endpoint used to fetch identity provider settings. * dbms.security.procedures.allowlist: A list of procedures (comma separated) that are to be loaded. * dbms.security.procedures.default_allowed: The default role that can execute all procedures and user-defined functions that are not covered by the * dbms.security.procedures.roles setting. * dbms.security.procedures.roles: This provides a finer level of control over which roles can execute procedures than the dbms.security.procedures.default_allowed setting. * dbms.security.procedures.unrestricted: A list of procedures and user defined functions (comma separated) that are allowed full access to the database. * dbms.security.procedures.whitelist: A list of procedures (comma separated) that are to be loaded. * dbms.shutdown_transaction_end_timeout: The maximum amount of time to wait for running transactions to complete before allowing initiated database shutdown to continue. * dbms.store.files.preallocate: Specify if Neo4j should try to preallocate store files as they grow. * dbms.threads.worker_count: Number of Neo4j worker threads. *
* dbms.track_query_allocation: Enables or disables tracking of how many bytes are allocated by the execution of a query. * dbms.track_query_cpu_time: Enables or disables tracking of how much time a query spends actively executing on the CPU. * dbms.transaction.bookmark_ready_timeout: The maximum amount of time to wait for the database state represented by the bookmark. *
* dbms.transaction.concurrent.maximum: The maximum number of concurrently running transactions. * dbms.transaction.monitor.check.interval: Configures the time interval between transaction monitor checks. *
* dbms.transaction.sampling.percentage: Transaction sampling percentage. * dbms.transaction.timeout: The maximum time interval of a transaction within which it should be completed. *
* dbms.transaction.tracing.level: Transaction creation tracing level. * dbms.tx_log.buffer.size: On serialization of transaction logs, they will be temporary stored in the byte buffer that will be flushed at the end of the
transaction or at any moment when buffer will be full. * `dbms.tx_log.preallocate`: Specify if Neo4j should try to preallocate logical log file in advance. * `dbms.tx_log.rotation.retention_policy`: Tell Neo4j how long logical transaction logs should be kept to backup the database. For example, "10 days" will prune logical logs that only contain transactions older than 10 days. Alternatively, "100k txs" will keep the 100k latest transactions from each database and prune any older transactions. * `dbms.tx_log.rotation.size`: Specifies at which file size the logical log will auto-rotate. * `dbms.tx_state.memory_allocation`: Defines whether memory for transaction state should be allocated on- or off-heap. * `dbms.unmanaged_extension_classes`: Comma-separated list of `<classname>=<mount point>` for unmanaged extensions. * `dbms.upgrade_max_processors`: Max number of processors used when upgrading the store. * `dbms.windows_service_name`: Name of the Windows Service managing Neo4j when installed using `neo4j install-service`. * `fabric.database.name`: Name of the Fabric database. * `fabric.driver.api`: Determines which driver API will be used. * `fabric.driver.connection.connect_timeout`: Socket connection timeout. A timeout of zero is treated as an infinite timeout and will be bound by the timeout configured on the operating system level. * `fabric.driver.connection.max_lifetime`: Pooled connections older than this threshold will be closed and removed from the pool. Setting this option to a low value will cause a high connection churn and might result in a performance hit. It is recommended to set maximum lifetime to a slightly smaller value than the one configured in network equipment (load balancer, proxy, firewall, etc.). * `fabric.driver.connection.pool.acquisition_timeout`: Maximum amount of time spent attempting to acquire a connection from the connection pool. This timeout only kicks in when all existing connections are being used and no new connections can be created because maximum connection pool size has been reached. Error is raised when connection can’t be acquired within configured time. Negative values are allowed and result in unlimited acquisition timeout. * `fabric.driver.connection.pool.idle_test`: Pooled connections that have been idle in the pool for longer than this timeout will be tested before they are used again, to ensure they are still alive. If this option is set too low, an additional network call will be incurred when acquiring a connection, which causes a performance hit. If this is set high, no longer live connections might be used which might lead to errors. Hence, this parameter tunes a balance between the likelihood of experiencing connection problems and performance. Normally, this parameter should not need tuning. Value 0 means connections will always be tested for validity. * `fabric.driver.connection.pool.max_size`: Maximum total number of connections to be managed by a connection pool. The limit is enforced for a combination of a host and user. * `fabric.driver.logging.level`: Sets level for driver internal logging. * `fabric.graph.<graph ID>.database`: Name of the database associated to the Fabric graph. * `fabric.graph.<graph ID>.driver.api`: Determines which driver API will be used. * `fabric.graph.<graph ID>.driver.connection.connect_timeout`: Socket connection timeout. A timeout of zero is treated as an infinite timeout and will be bound by the timeout configured on the operating system level. This setting can be used as a graph-specific override of the global setting ‘`fabric.driver.connection.connect_timeout’’. * `fabric.graph.<graph ID>.driver.connection.max_lifetime`: Pooled connections older than this threshold will be closed and removed from the pool. Setting this option to a low value will cause a high connection churn and might result in a performance hit. It is recommended to set maximum lifetime to a slightly smaller value than the one configured in network equipment (load balancer, proxy, firewall, etc.). * `fabric.graph.<graph ID>.driver.connection.pool.acquisition_timeout`: Maximum amount of time spent attempting to acquire a connection from the connection pool. This timeout only kicks in when all existing connections are being used and no new connections can be created because maximum connection pool size has been reached. Error is raised when connection can’t be acquired within configured time. Negative values are allowed and result in unlimited acquisition timeout. * `fabric.graph.<graph ID>.driver.connection.pool.idle_test`: Pooled connections that have been idle in the pool for longer than this timeout will be tested before they are used again, to ensure they are still alive. If this option is set too low, an additional network call will be incurred when acquiring a connection, which causes a performance hit. If this is set high, no longer live connections
might be used which might lead to errors. Hence, this parameter tunes a balance between the likelihood of experiencing connection problems and performance. Normally, this parameter should not need tuning. Value 0 means connections will always be tested for validity. This setting can be used as a graph-specific override of the global setting 'fabric.driver.connection.pool.idle_test'.

- **fabric.graph.<graph ID>.driver.connection.pool.max_size**: Maximum total number of connections to be managed by a connection pool. The limit is enforced for a combination of a host and user.
- **fabric.graph.<graph ID>.driver.logging.leaked_sessions**: Enables logging of leaked driver session.
- **fabric.graph.<graph ID>.driver.logging.level**: Sets level for driver internal logging. This setting can be used as a graph-specific override of the global setting 'fabric.driver.logging.level'.
- **fabric.graph.<graph ID>.driver.ssl_enabled**: SSL for Fabric drivers is configured using 'fabric' SSL policy. This setting can be used to instruct the driver not to use SSL even though 'fabric' SSL policy is configured. The driver will use SSL if 'fabric' SSL policy is configured and this setting is set to 'true'.
- **fabric.graph.<graph ID>.name**: Name assigned to the Fabric graph.
- **fabric.graph.<graph ID>.uri**: URI of the Neo4j DBMS hosting the database associated to the Fabric graph.
- **fabric.routing.servers**: A comma-separated list of Fabric instances that form a routing group.
- **fabric.routing.ttl**: The time to live (TTL) of a routing table for fabric routing group.
- **fabric.stream.buffer.low_watermark**: Number of records in prefetching buffer that will trigger prefetching again.
- **fabric.stream.buffer.size**: Maximal size of a buffer used for pre-fetching result records of remote queries. To compensate for latency to remote databases, the Fabric execution engine pre-fetches records needed for local executions. This limit is enforced per fabric query.
- **fabric.stream.concurrent**: Maximal concurrency within Fabric queries. Limits the number of iterations of each subquery that are executed concurrently.
- **metrics.bolt.messages.enabled**: Enable reporting metrics about Bolt Protocol message processing.
- **metrics.csv.enabled**: Set to true to enable exporting metrics to CSV files.
- **metrics.csv.interval**: The reporting interval for the CSV files.
- **metrics.csv.rotation.compression**: Decides what compression to use for the csv history files.
- **metrics.csv.rotation.keep_number**: Maximum number of history files for the csv files.
- **metrics.csv.rotation.size**: The file size in bytes at which the csv files will auto-rotate.
- **metrics.cypher.replanning.enabled**: Enable reporting metrics about number of occurred replanning events.
- **metrics.enabled**: Enable metrics.
- **metrics.filter**: Specifies which metrics should be enabled by using a comma separated list of globbing patterns.
- **metrics.graphite.enabled**: Set to true to enable exporting metrics to Graphite.
- **metrics.graphite.interval**: The reporting interval for Graphite.
- **metrics.graphite.server**: The hostname or IP address of the Graphite server.
- **metrics.jmx.enabled**: Set to true to enable the JMX metrics endpoint.
- **metrics.jvm.buffers.enabled**: Enable reporting metrics about the buffer pools.
- **metrics.jvm.file.descriptors.enabled**: Enable reporting metrics about the number of open file descriptors.
- **metrics.jvm.gc.enabled**: Enable reporting metrics about the duration of garbage collections.
- **metrics.jvm.heap.enabled**: Enable reporting metrics about the heap memory usage.
- **metrics.jvm.memory.enabled**: Enable reporting metrics about the memory usage.
- **metrics.jvm.pause_time.enabled**: Enable reporting metrics about the VM pause time.
- **metrics.jvm.threads.enabled**: Enable reporting metrics about the current number of threads running.
- **metrics.namespaces.enabled**: Enable metrics namespaces that separates the global and database specific metrics.
- **metrics.neo4j.causal_clustering.enabled**: Enable reporting metrics about Causal Clustering mode.
- **metrics.neo4j.checkpointing.enabled**: Enable reporting metrics about Neo4j check pointing; when it occurs and how much time it takes to complete.
- **metrics.neo4j.counts.enabled**: Enable reporting metrics about approximately how many entities are in the database; nodes, relationships, properties, etc.
- **metrics.neo4j.data.counts.enabled**: Enable reporting metrics about number of entities in the database.
- **metrics.neo4j.database_operation_count.enabled**: Enable reporting metrics for Neo4j dbms operations; how many times databases have been created, started, stopped or dropped, and how many attempted operations have failed and recovered later.
- **metrics.neo4j.logs.enabled**: Enable reporting metrics about the Neo4j transaction logs.
page cache; page faults, evictions, flushes, exceptions, etc. * metrics.neo4j.pools.enabled: Enable reporting metrics about Neo4j memory pools. * metrics.neo4j.server.enabled: Enable reporting metrics about Server threading info. * metrics.neo4j.size.enabled: Enable reporting metrics about the store size of each database. * metrics.neo4j.tx.enabled: Enable reporting metrics about transactions; number of transactions started, committed, etc. * metrics.prefix: A common prefix for the reported metrics field names. * metrics.prometheus.enabled: Set to true to enable the Prometheus endpoint. * metrics.prometheus.endpoint: The hostname and port to use as Prometheus endpoint. * systemdb.secrets.key.name: Name of the 256 length AES encryption key, which is used for the symmetric encryption. * systemdb.secrets.keystore.password: Password for accessing the keystore holding a 256 length AES encryption key, which is used for the symmetric encryption. * systemdb.secrets.keystore.path: Location of the keystore holding a 256 length AES encryption key, which is used for the symmetric encryption of secrets held in system database.

Table 109. browser.allow_outgoing_connections

<table>
<thead>
<tr>
<th>Description</th>
<th>Configure the policy for outgoing Neo4j Browser connections.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>browser.allow_outgoing_connections, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td>true</td>
</tr>
</tbody>
</table>

Table 110. browser.credential_timeout

<table>
<thead>
<tr>
<th>Description</th>
<th>Configure the Neo4j Browser to time out logged in users after this idle period. Setting this to 0 indicates no limit.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>browser.credential_timeout, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)</td>
</tr>
<tr>
<td>Default value</td>
<td>0s</td>
</tr>
</tbody>
</table>

Table 111. browser.post_connect_cmd

<table>
<thead>
<tr>
<th>Description</th>
<th>Commands to be run when Neo4j Browser successfully connects to this server. Separate multiple commands with semi-colon.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>browser.post_connect_cmd, a string</td>
</tr>
<tr>
<td>Default value</td>
<td></td>
</tr>
</tbody>
</table>

Table 112. browser.remote_content_hostname_whitelist

<table>
<thead>
<tr>
<th>Description</th>
<th>Whitelist of hosts for the Neo4j Browser to be allowed to fetch content from.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>browser.remote_content_hostname_whitelist, a string</td>
</tr>
<tr>
<td>Default value</td>
<td>guides.neo4j.com,localhost</td>
</tr>
</tbody>
</table>
Table 113. browser.retain_connection_credentials

<table>
<thead>
<tr>
<th>Description</th>
<th>Configure the Neo4j Browser to store or not store user credentials.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>browser.retain_connection_credentials, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td>true</td>
</tr>
</tbody>
</table>

Table 114. browser.retain_editor_history

<table>
<thead>
<tr>
<th>Description</th>
<th>Configure the Neo4j Browser to store or not store user editor history.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>browser.retain_editor_history, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td>true</td>
</tr>
</tbody>
</table>

Table 115. causal_clustering.catch_up_client_inactivity_timeout

<table>
<thead>
<tr>
<th>Description</th>
<th>The catch up protocol times out if the given duration elapses with no network activity. Every message received by the client from the server extends the time out duration.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.catch_up_client_inactivity_timeout, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)</td>
</tr>
<tr>
<td>Default value</td>
<td>10m</td>
</tr>
</tbody>
</table>

Table 116. causal_clustering.catchup_batch_size

<table>
<thead>
<tr>
<th>Description</th>
<th>The maximum batch size when catching up (in unit of entries)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.catchup_batch_size, an integer</td>
</tr>
<tr>
<td>Default value</td>
<td>64</td>
</tr>
</tbody>
</table>

Table 117. causal_clustering.cluster_allow_reads_on_followers

<table>
<thead>
<tr>
<th>Description</th>
<th>Configure if the dbms.routing.getRoutingTable() procedure should include followers as read endpoints or return only read replicas. Note: if there are no read replicas in the cluster, followers are returned as read end points regardless the value of this setting. Defaults to true so that followers are available for read-only queries in a typical heterogeneous setup.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.cluster_allow_reads_on_followers, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td>true</td>
</tr>
</tbody>
</table>
Table 118. causal_clustering.cluster_allow_reads_on_leader

<table>
<thead>
<tr>
<th>Description</th>
<th>Configure if the <code>dbms.routing.getRoutingTable()</code> procedure should include the leader as read endpoint or return only read replicas/followers. Note: leader is returned as read endpoint if no other member is present all.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>causal_clustering.cluster_allow_reads_on_leader</code>, a boolean</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td><code>false</code></td>
</tr>
</tbody>
</table>

Table 119. causal_clustering.cluster_binding_timeout

<table>
<thead>
<tr>
<th>Description</th>
<th>The time allowed for a database on a Neo4j server to either join a cluster or form a new cluster with the other Neo4j Core Servers provided by <code>causal_clustering.initial_discovery_members</code>.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>causal_clustering.cluster_binding_timeout</code>, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)</td>
</tr>
<tr>
<td>Default value</td>
<td><code>10m</code></td>
</tr>
</tbody>
</table>

Table 120. causal_clustering.cluster_topology_refresh

<table>
<thead>
<tr>
<th>Description</th>
<th>Time between scanning the cluster to refresh current server’s view of topology.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>causal_clustering.cluster_topology_refresh</code>, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s) which is minimum 1s</td>
</tr>
<tr>
<td>Default value</td>
<td><code>5s</code></td>
</tr>
</tbody>
</table>

Table 121. causal_clustering.command_applier_parallelism

<table>
<thead>
<tr>
<th>Description</th>
<th>Limits amount of global threads for applying commands.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>causal_clustering.command_applier_parallelism</code>, an integer which is minimum 1</td>
</tr>
<tr>
<td>Default value</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 122. causal_clustering.connect_randomly_to_server_group

<p>| Description | Comma separated list of groups to be used by the connect-randomly-to-server-group selection strategy. The connect-randomly-to-server-group strategy is used if the list of strategies (<code>causal_clustering.upstream_selection_strategy</code>) includes the value <code>connect-randomly-to-server-group</code>. |</p>
<table>
<thead>
<tr>
<th>Valid values</th>
<th>causal_clustering.connect_randomly_to_server_group, a ',' separated list with elements of type 'a string identifying a Server Group'.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td></td>
</tr>
</tbody>
</table>

| Table 123. causal_clustering.delete_store_before_store_copy                   |
| Description                                                                  | Deletes the old store (on cores and replicas) before performing a store copy (instead of deleting it after).                  |
| Valid values                                                                 | causal_clustering.delete_store_before_store_copy, a boolean                                                                   |
| Default value                                                                | true                                                                                                                          |

| Table 124. causal_clustering.discovery_advertised_address                     |
| Description                                                                  | Advertised cluster member discovery management communication.                                                                    |
| Valid values                                                                 | causal_clustering.discovery_advertised_address, a socket address in the format 'hostname:port', 'hostname' or ':port'. If missing port or hostname it is acquired from dbms.default_advertised_address |
| Default value                                                                | :5000                                                                                                                         |

| Table 125. causal_clustering.discovery_listen_address                        |
| Description                                                                  | Host and port to bind the cluster member discovery management communication.                                                    |
| Valid values                                                                 | causal_clustering.discovery_listen_address, a socket address in the format 'hostname:port', 'hostname' or ':port'. If missing port or hostname it is acquired from dbms.default_listen_address |
| Default value                                                                | :5000                                                                                                                         |

| Table 126. causal_clustering.discovery_type                                   |
| Description                                                                  | Configure the discovery type used for cluster name resolution.                                                                  |

Valid values

causal_clustering.discovery_type, one of [DNS, LIST, SRV, K8S] which depends on dbms.mode. If dbms.mode one of [CORE, READ_REPLICA] then it may require different settings depending on the discovery type: DNS requires [causal_clustering.initial_discovery_members], LIST requires [causal_clustering.initial_discovery_members], SRV requires [causal_clustering.initial_discovery_members], K8S requires [causal_clustering.kubernetes.label_selector, causal_clustering.kubernetes.service_port_name] otherwise it depends on dbms.mode. If dbms.mode one of [SINGLE] then it depends on dbms.clustering.enable. If dbms.clustering.enable is true then it may require different settings depending on the discovery type: DNS requires [causal_clustering.initial_discovery_members], LIST requires [causal_clustering.initial_discovery_members], SRV requires [causal_clustering.initial_discovery_members], K8S requires [causal_clustering.kubernetes.label_selector, causal_clustering.kubernetes.service_port_name] otherwise it is unconstrained.

Default value

LIST

Table 127. causal_clustering.election_failure_detection_window

<table>
<thead>
<tr>
<th>Description</th>
<th>The rate at which leader elections happen. Note that due to election conflicts it might take several attempts to find a leader. The window should be significantly larger than typical communication delays to make conflicts unlikely.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.election_failure_detection_window, a duration-range &lt;min-max&gt; (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)</td>
</tr>
<tr>
<td>Default value</td>
<td>3s-6s</td>
</tr>
</tbody>
</table>

Table 128. causal_clustering.enable_pre_voting

<table>
<thead>
<tr>
<th>Description</th>
<th>Enable pre-voting extension to the Raft protocol (this is breaking and must match between the core cluster members)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.enable_pre_voting, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td>true</td>
</tr>
</tbody>
</table>

Table 129. causal_clustering.global_session_tracker_state_size

<table>
<thead>
<tr>
<th>Description</th>
<th>The maximum file size before the global session tracker state file is rotated (in unit of entries)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.global_session_tracker_state_size, an integer</td>
</tr>
<tr>
<td>Default value</td>
<td>1000</td>
</tr>
</tbody>
</table>
### Table 130. causal_clustering.handshake_timeout

<table>
<thead>
<tr>
<th>Description</th>
<th>Time out for protocol negotiation handshake. This configuration is applicable to: Raft (communication between CORE instances only), Catchup (communication between any instances: CORE → CORE, RR → CORE, RR → RR, CORE → RR, including RR → SINGLE in a replica-only cluster). Backup (communication between any instance and a backup client that lives in the neo4j-admin command, such as BackupClient → SINGLE, BackupClient → CORE, BackupClient → RR).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.handshake_timeout, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)</td>
</tr>
<tr>
<td>Default value</td>
<td>20s</td>
</tr>
</tbody>
</table>

### Table 131. causal_clustering.in_flight_cache.max_bytes

<table>
<thead>
<tr>
<th>Description</th>
<th>The maximum number of bytes in the in-flight cache. This parameter limits the amount of memory that can be consumed by cache. If the bytes limit is reached, cache size will be limited even if max_entries is not exceeded.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.in_flight_cache.max_bytes, a byte size (valid multipliers are B, KiB, KB, K, kB, kb, k, MiB, MB, M, mB, mb, m, GiB, GB, G, gB, gb, g, TiB, TB, PiB, PB, EiB, EB)</td>
</tr>
<tr>
<td>Default value</td>
<td>2.00GiB</td>
</tr>
</tbody>
</table>

### Table 132. causal_clustering.in_flight_cache.max_entries

<table>
<thead>
<tr>
<th>Description</th>
<th>The maximum number of entries in the in-flight cache. Increasing size will require more memory but might improve performance in high load situations.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.in_flight_cache.max_entries, an integer</td>
</tr>
<tr>
<td>Default value</td>
<td>1024</td>
</tr>
</tbody>
</table>

### Table 133. causal_clustering.in_flight_cache.type

<table>
<thead>
<tr>
<th>Description</th>
<th>Type of in-flight cache. CONSECUTIVE should be used for production instances, NONE will disable cache which might be useful in specific support cases. UNBOUNDED is for internal use only.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.in_flight_cache.type, one of [NONE, CONSECUTIVE, UNBOUNDED]</td>
</tr>
<tr>
<td>Default value</td>
<td>CONSECUTIVE</td>
</tr>
</tbody>
</table>

### Table 134. causal_clustering.initial_discovery_members

528
### Table 135. causal_clustering.join_catch_up_max_lag

<table>
<thead>
<tr>
<th>Description</th>
<th>Maximum amount of lag accepted for a new follower to join the Raft group.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.join_catch_up_max_lag, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)</td>
</tr>
<tr>
<td>Default value</td>
<td>10s</td>
</tr>
</tbody>
</table>

### Table 136. causal_clustering.join_catch_up_timeout

<table>
<thead>
<tr>
<th>Description</th>
<th>Time out for a new member to catch up.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.join_catch_up_timeout, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)</td>
</tr>
<tr>
<td>Default value</td>
<td>10m</td>
</tr>
</tbody>
</table>

### Table 137. causal_clustering.kubernetes.address

<table>
<thead>
<tr>
<th>Description</th>
<th>Address for Kubernetes API.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.kubernetes.address, a socket address in the format 'hostname:port', 'hostname' or ':port'</td>
</tr>
<tr>
<td>Default value</td>
<td>kubernetes.default.svc:443</td>
</tr>
</tbody>
</table>

### Table 138. causal_clustering.kubernetes.ca_crt

<table>
<thead>
<tr>
<th>Description</th>
<th>File location of CA certificate for Kubernetes API.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.kubernetes.ca_crt, a path</td>
</tr>
<tr>
<td>Default value</td>
<td>/var/run/secrets/kubernetes.io/serviceaccount/ca.crt</td>
</tr>
</tbody>
</table>

### Table 139. causal_clustering.kubernetes.cluster_domain

<table>
<thead>
<tr>
<th>Description</th>
<th>Kubernetes cluster domain.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.kubernetes.cluster_domain, a string</td>
</tr>
<tr>
<td>Table 140. causal_clustering.kubernetes.label_selector</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><strong>Description</strong></td>
<td>LabelSelector for Kubernetes API.</td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
<td>causal_clustering.kubernetes.label_selector, a string</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 141. causal_clustering.kubernetes.namespace</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
<td>File location of namespace for Kubernetes API.</td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
<td>causal_clustering.kubernetes.namespace, a path</td>
</tr>
<tr>
<td><strong>Default value</strong></td>
<td>/var/run/secrets/kubernetes.io/serviceaccount/namespace</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 142. causal_clustering.kubernetes.service_port_name</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
<td>Service port name for discovery for Kubernetes API.</td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
<td>causal_clustering.kubernetes.service_port_name, a string</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 143. causal_clustering.kubernetes.token</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
<td>File location of token for Kubernetes API.</td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
<td>causal_clustering.kubernetes.token, a path</td>
</tr>
<tr>
<td><strong>Default value</strong></td>
<td>/var/run/secrets/kubernetes.io/serviceaccount/token</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 144. causal_clustering.last_applied_state_size</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
<td>The maximum file size before the storage file is rotated (in unit of entries)</td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
<td>causal_clustering.last_applied_state_size, an integer</td>
</tr>
<tr>
<td><strong>Default value</strong></td>
<td>1000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 145. causal_clustering.leader_election_timeout</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
<td>This setting is moved and enhanced into causal_clustering.leader_failure_detection_window and causal_clustering.election_failure_detection_window.</td>
</tr>
<tr>
<td>Valid values</td>
<td>causal_clustering.leader_election_timeout, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Default value</td>
<td>7s</td>
</tr>
<tr>
<td>Deprecated</td>
<td>The causal_clustering.leader_election_timeout configuration setting has been deprecated.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 146. causal_clustering.leader_failure_detection_window</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
</tr>
<tr>
<td>Valid values</td>
</tr>
<tr>
<td>Default value</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 147. causal_clustering.leadership_balancing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
</tr>
<tr>
<td>Valid values</td>
</tr>
<tr>
<td>Default value</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 148. causal_clustering.leadership_priority_group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
</tr>
<tr>
<td>Valid values</td>
</tr>
</tbody>
</table>
### Table 149. causal_clustering.load_balancing.plugin

<table>
<thead>
<tr>
<th>Description</th>
<th>The load balancing plugin to use.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Valid values</strong></td>
<td>causal_clustering.load_balancing.plugin, a string which depends on dbms.mode. If dbms.mode one of [CORE] then it specified load balancer plugin exist. otherwise it is unconstrained.</td>
</tr>
<tr>
<td><strong>Default value</strong></td>
<td>server_policies</td>
</tr>
</tbody>
</table>

### Table 150. causal_clustering.load_balancing.shuffle

<table>
<thead>
<tr>
<th>Description</th>
<th>Enables shuffling of the returned load balancing result.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Valid values</strong></td>
<td>causal_clustering.load_balancing.shuffle, a boolean</td>
</tr>
<tr>
<td><strong>Default value</strong></td>
<td>true</td>
</tr>
</tbody>
</table>

### Table 151. causal_clustering.log_shipping_max_lag

<table>
<thead>
<tr>
<th>Description</th>
<th>The maximum lag allowed before log shipping pauses (in unit of entries)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Valid values</strong></td>
<td>causal_clustering.log_shipping_max_lag, an integer</td>
</tr>
<tr>
<td><strong>Default value</strong></td>
<td>256</td>
</tr>
</tbody>
</table>

### Table 152. causal_clustering.log_shipping_retry_timeout

<table>
<thead>
<tr>
<th>Description</th>
<th>Retry time for log shipping to followers after a stall.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Valid values</strong></td>
<td>causal_clustering.log_shipping_retry_timeout, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)</td>
</tr>
<tr>
<td><strong>Default value</strong></td>
<td>5s</td>
</tr>
</tbody>
</table>

### Table 153. causal_clustering.max_raft_channels

<table>
<thead>
<tr>
<th>Description</th>
<th>The maximum number of TCP channels between two nodes to operate the raft protocol.Each database gets allocated one channel, but a single channel can be used by more than one database.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Valid values</strong></td>
<td>causal_clustering.max_raft_channels, an integer</td>
</tr>
<tr>
<td><strong>Default value</strong></td>
<td>8</td>
</tr>
</tbody>
</table>
### Table 154. causal_clustering.middleware.logging.level

<table>
<thead>
<tr>
<th>Description</th>
<th>The level of middleware logging.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.middleware.logging.level, one of [DEBUG, INFO, WARN, ERROR, NONE]</td>
</tr>
<tr>
<td>Default value</td>
<td>WARN</td>
</tr>
</tbody>
</table>

### Table 155. causal_clustering.minimum_core_cluster_size_at_formation

<table>
<thead>
<tr>
<th>Description</th>
<th>Minimum number of Core machines initially required to form a cluster. The cluster will form when at least this many Core members have discovered each other.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.minimum_core_cluster_size_at_formation, an integer which is minimum 2</td>
</tr>
<tr>
<td>Default value</td>
<td>3</td>
</tr>
</tbody>
</table>

### Table 156. causal_clustering.minimum_core_cluster_size_at_runtime

<table>
<thead>
<tr>
<th>Description</th>
<th>The minimum size of the dynamically adjusted voting set (which only core members may be a part of). Adjustments to the voting set happen automatically as the availability of core members changes, due to explicit operations such as starting or stopping a member, or unintended issues such as network partitions. Note that this dynamic scaling of the voting set is generally desirable as under some circumstances it can increase the number of instance failures which may be tolerated. A majority of the voting set must be available before voting in or out members.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.minimum_core_cluster_size_at_runtime, an integer which is minimum 2 and depends on dbms.mode. If dbms.mode one of [CORE] then it Must be set less than or equal to value of 'causal_clustering.minimum_core_cluster_size_at_formation' otherwise it is unconstrained.</td>
</tr>
<tr>
<td>Default value</td>
<td>3</td>
</tr>
</tbody>
</table>

### Table 157. causal_clustering.multi_dc_license

<table>
<thead>
<tr>
<th>Description</th>
<th>Enable multi-data center features. Requires appropriate licensing.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.multi_dc_license, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td>false</td>
</tr>
</tbody>
</table>

### Table 158. causal_clustering.protocol_impementations.catchup
## Description

Catchup protocol implementation versions that this instance will allow in negotiation as a comma-separated list. Order is not relevant: the greatest value will be preferred. An empty list will allow all supported versions. Example value: "1.1, 1.2, 2.1, 2.2"

### Valid values

causal_clustering.protocol_implementations.catchup, a ',' separated list with elements of type 'an application protocol version'.

### Default value


## Table 159. causal_clustering.protocol_implementations.compression

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network compression algorithms that this instance will allow in negotiation as a comma-separated list. Listed in descending order of preference for incoming connections. An empty list implies no compression. For outgoing connections this merely specifies the allowed set of algorithms and the preference of the remote peer will be used for making the decision. Allowable values: [Gzip, Snappy, Snappy_validating, LZ4, LZ4_high_compression, LZ_validating, LZ4_high_compression_validating]</td>
</tr>
</tbody>
</table>

### Valid values

causal_clustering.protocol_implementations.compression, a ',' separated list with elements of type 'a string'.

### Default value


## Table 160. causal_clustering.protocol_implementations.raft

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raft protocol implementation versions that this instance will allow in negotiation as a comma-separated list. Order is not relevant: the greatest value will be preferred. An empty list will allow all supported versions. Example value: &quot;1.0, 1.3, 2.0, 2.1&quot;</td>
</tr>
</tbody>
</table>

### Valid values

causal_clustering.protocol_implementations.raft, a ',' separated list with elements of type 'an application protocol version'.

### Default value


## Table 161. causal_clustering.pull_interval

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interval of pulling updates from cores.</td>
</tr>
</tbody>
</table>

### Valid values

causal_clustering.pull_interval, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)

### Default value

1s

## Table 162. causal_clustering.raft_advertised_address

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raft protocol advertised address.</td>
</tr>
</tbody>
</table>

534
<table>
<thead>
<tr>
<th>Description</th>
<th>Advertised hostname/IP address and port for the RAFT server.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.raft_advertised_address, a socket address in the format 'hostname:port', 'hostname' or ':port'. If missing port or hostname it is acquired from dbms.default_advertised_address</td>
</tr>
<tr>
<td>Default value</td>
<td>:7000</td>
</tr>
</tbody>
</table>

**Table 163. causal_clustering.raft_handler_parallelism**

<table>
<thead>
<tr>
<th>Description</th>
<th>Limits amount of global threads shared by raft groups for handling bathing of messages and timeout events.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.raft_handler_parallelism, an integer which is minimum 1</td>
</tr>
<tr>
<td>Default value</td>
<td>8</td>
</tr>
</tbody>
</table>

**Table 164. causal_clustering.raft_in_queue_max_batch_bytes**

<table>
<thead>
<tr>
<th>Description</th>
<th>Largest batch processed by RAFT in bytes.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.raft_in_queue_max_batch_bytes, a byte size (valid multipliers are B, KiB, KB, kB, k, MiB, MB, mB, m, GiB, GB, G, gB, gb, g, TiB, TB, PiB, PB, EiB, EB)</td>
</tr>
<tr>
<td>Default value</td>
<td>8.00MiB</td>
</tr>
</tbody>
</table>

**Table 165. causal_clustering.raft_in_queue_max_bytes**

<table>
<thead>
<tr>
<th>Description</th>
<th>Maximum number of bytes in the RAFT in-queue.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.raft_in_queue_max_bytes, a byte size (valid multipliers are B, KiB, KB, kB, k, MiB, MB, mB, m, GiB, GB, G, gB, gb, g, TiB, TB, PiB, PB, EiB, EB)</td>
</tr>
<tr>
<td>Default value</td>
<td>2.00GiB</td>
</tr>
</tbody>
</table>

**Table 166. causal_clustering.raft_listen_address**

<table>
<thead>
<tr>
<th>Description</th>
<th>Network interface and port for the RAFT server to listen on.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.raft_listen_address, a socket address in the format 'hostname:port', 'hostname' or ':port'. If missing port or hostname it is acquired from dbms.default.Listen_address</td>
</tr>
<tr>
<td>Default value</td>
<td>:7000</td>
</tr>
</tbody>
</table>

**Table 167. causal_clustering.raft_log_entry_prefetch_buffer.max_entries**
<table>
<thead>
<tr>
<th>Description</th>
<th>The maximum number of entries in the raft log entry prefetch buffer.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.raft_log_entry_prefetch_buffer.max_entries, an integer</td>
</tr>
<tr>
<td>Default value</td>
<td>1024</td>
</tr>
</tbody>
</table>

Table 168. causal_clustering.raft_log_implementation

<table>
<thead>
<tr>
<th>Description</th>
<th>RAFT log implementation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.raft_log_implementation, a string</td>
</tr>
<tr>
<td>Default value</td>
<td>SEGMENTED</td>
</tr>
</tbody>
</table>

Table 169. causal_clustering.raft_log_prune_strategy

<table>
<thead>
<tr>
<th>Description</th>
<th>RAFT log pruning strategy that determines which logs are to be pruned. Neo4j only prunes log entries up to the last applied index, which guarantees that logs are only marked for pruning once the transactions within are safely copied over to the local transaction logs and safely committed by a majority of cluster members. Possible values are a byte size or a number of transactions (e.g., 200K txs).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.raft_log_prune_strategy, a string</td>
</tr>
<tr>
<td>Default value</td>
<td>lg size</td>
</tr>
</tbody>
</table>

Table 170. causal_clustering.raft_log_pruning_frequency

<table>
<thead>
<tr>
<th>Description</th>
<th>RAFT log pruning frequency.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.raft_log_pruning_frequency, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)</td>
</tr>
<tr>
<td>Default value</td>
<td>10m</td>
</tr>
</tbody>
</table>

Table 171. causal_clustering.raft_log_reader_pool_size

<table>
<thead>
<tr>
<th>Description</th>
<th>RAFT log reader pool size.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.raft_log_reader_pool_size, an integer</td>
</tr>
<tr>
<td>Default value</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 172. causal_clustering.raft_log_rotation_size

<table>
<thead>
<tr>
<th>Description</th>
<th>RAFT log rotation size.</th>
</tr>
</thead>
</table>
Valid values | causal_clustering.raft_log_rotation_size, a byte size (valid multipliers are B, KiB, KB, K, kB, k, MiB, MB, M, mB, mb, m, GiB, GB, G, gB, gb, g, TiB, TB, PiB, PB, EiB, EB) which is minimum 1.00KiB
---|---
Default value | 250.00MiB

Table 173. causal_clustering.raft_membership_state_size

<table>
<thead>
<tr>
<th>Description</th>
<th>The maximum file size before the membership state file is rotated (in unit of entries)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.raft_membership_state_size, an integer</td>
</tr>
<tr>
<td>Default value</td>
<td>1000</td>
</tr>
</tbody>
</table>

Table 174. causal_clustering.raft_term_state_size

<table>
<thead>
<tr>
<th>Description</th>
<th>The maximum file size before the term state file is rotated (in unit of entries)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.raft_term_state_size, an integer</td>
</tr>
<tr>
<td>Default value</td>
<td>1000</td>
</tr>
</tbody>
</table>

Table 175. causal_clustering.raft_vote_state_size

<table>
<thead>
<tr>
<th>Description</th>
<th>The maximum file size before the vote state file is rotated (in unit of entries)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.raft_vote_state_size, an integer</td>
</tr>
<tr>
<td>Default value</td>
<td>1000</td>
</tr>
</tbody>
</table>

Table 176. causal_clustering.refuse_to_be_leader

<table>
<thead>
<tr>
<th>Description</th>
<th>Deprecated, use dbms.databases.default_to_read_only</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.refuse_to_be_leader, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td>false</td>
</tr>
<tr>
<td>Deprecated</td>
<td>The causal_clustering.refuse_to_be_leader configuration setting has been deprecated.</td>
</tr>
</tbody>
</table>

Table 177. causal_clustering.replicated_lease_state_size

<p>| Description | The maximum file size before the replicated lease state file is rotated (in unit of entries) |</p>
<table>
<thead>
<tr>
<th>Valid values</th>
<th>causal_clustering.replicated_lease_state_size, an integer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default value</td>
<td>1000</td>
</tr>
</tbody>
</table>

**Table 178. causal_clustering.replication_leader_await_timeout**

<table>
<thead>
<tr>
<th>Description</th>
<th>The duration for which the replicator will await a new leader.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.replication_leader_await_timeout, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)</td>
</tr>
<tr>
<td>Default value</td>
<td>10s</td>
</tr>
</tbody>
</table>

**Table 179. causal_clustering.replication_retry_timeout_base**

<table>
<thead>
<tr>
<th>Description</th>
<th>The initial timeout until replication is retried. The timeout will increase exponentially.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.replication_retry_timeout_base, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)</td>
</tr>
<tr>
<td>Default value</td>
<td>10s</td>
</tr>
</tbody>
</table>

**Table 180. causal_clustering.replication_retry_timeout_limit**

<table>
<thead>
<tr>
<th>Description</th>
<th>The upper limit for the exponentially incremented retry timeout.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.replication_retry_timeout_limit, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)</td>
</tr>
<tr>
<td>Default value</td>
<td>1m</td>
</tr>
</tbody>
</table>

**Table 181. causal_clustering.server_groups**

<table>
<thead>
<tr>
<th>Description</th>
<th>A list of group names for the server used when configuring load balancing and replication policies.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.server_groups, a ',' separated list with elements of type 'a string identifying a Server Group'</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td></td>
</tr>
</tbody>
</table>

**Table 182. causal_clustering.state_machine_apply_max_batch_size**
<table>
<thead>
<tr>
<th>Table 183. causal_clustering.state_machine_apply_max_batch_size</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong> The maximum number of operations to be batched during applications of operations in the state machines.</td>
</tr>
<tr>
<td><strong>Valid values</strong> causal_clustering.state_machine_apply_max_batch_size, an integer</td>
</tr>
<tr>
<td><strong>Default value</strong> 16</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 184. causal_clustering.state_machine_flush_window_size</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong> The number of operations to be processed before the state machines flush to disk.</td>
</tr>
<tr>
<td><strong>Valid values</strong> causal_clustering.state_machine_flush_window_size, an integer</td>
</tr>
<tr>
<td><strong>Default value</strong> 4096</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 185. causal_clustering.status_throughput_window</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong> Sampling window for throughput estimate reported in the status endpoint.</td>
</tr>
<tr>
<td><strong>Valid values</strong> causal_clustering.status_throughput_window, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s) which is in the range 1s to 5m</td>
</tr>
<tr>
<td><strong>Default value</strong> 5s</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 186. causal_clustering.store_copy_chunk_size</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong> Store copy chunk size.</td>
</tr>
<tr>
<td><strong>Valid values</strong> causal_clustering.store_copy_chunk_size, an integer which is in the range 4096 to 1048576</td>
</tr>
<tr>
<td><strong>Default value</strong> 32768</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 187. causal_clustering.store_copy_max_retry_time_per_request</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong> Maximum retry time per request during store copy. Regular store files and indexes are downloaded in separate requests during store copy. This configures the maximum time failed requests are allowed to resend.</td>
</tr>
<tr>
<td><strong>Valid values</strong> causal_clustering.store_copy_max_retry_time_per_request, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)</td>
</tr>
<tr>
<td><strong>Default value</strong> 20m</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 187. causal_clustering.store_copy_parallelism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 188. causal_clustering.transaction_advertised_address</td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
</tr>
<tr>
<td>Description</td>
</tr>
<tr>
<td>Advertised hostname/IP address and port for the transaction shipping server.</td>
</tr>
<tr>
<td>Valid values</td>
</tr>
<tr>
<td>causal_clustering.transaction_advertised_address, a socket address in the format 'hostname:port', 'hostname' or ':port'. If missing port or hostname it is acquired from dbms.default_advertised_address</td>
</tr>
<tr>
<td>Default value</td>
</tr>
<tr>
<td>:6000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 189. causal_clustering.transaction_listen_address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
</tr>
<tr>
<td>Network interface and port for the transaction shipping server to listen on. Please note that it is also possible to run the backup client against this port so always limit access to it via the firewall and configure an ssl policy.</td>
</tr>
<tr>
<td>Valid values</td>
</tr>
<tr>
<td>causal_clustering.transaction_listen_address, a socket address in the format 'hostname:port', 'hostname' or ':port'. If missing port or hostname it is acquired from dbms.default_listen_address</td>
</tr>
<tr>
<td>Default value</td>
</tr>
<tr>
<td>:6000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 190. causal_clustering.unknown_address_logging_throttle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
</tr>
<tr>
<td>Throttle limit for logging unknown cluster member address.</td>
</tr>
<tr>
<td>Valid values</td>
</tr>
<tr>
<td>causal_clustering.unknown_address_logging_throttle, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)</td>
</tr>
<tr>
<td>Default value</td>
</tr>
<tr>
<td>10s</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 191. causal_clustering.upstream_selection_strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
</tr>
<tr>
<td>An ordered list in descending preference of the strategy which read replicas use to choose the upstream server from which to pull transactional updates.</td>
</tr>
<tr>
<td>Valid values</td>
</tr>
<tr>
<td>causal_clustering.upstream_selection_strategy, a ',' separated list with elements of type 'a string'.</td>
</tr>
<tr>
<td>Default value</td>
</tr>
<tr>
<td>default</td>
</tr>
</tbody>
</table>
Table 192. causal_clustering.user_defined_upstream_strategy

<table>
<thead>
<tr>
<th>Description</th>
<th>Configuration of a user-defined upstream selection strategy. The user-defined strategy is used if the list of strategies (causal_clustering.upstream_selection_strategy) includes the value user_defined.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>causal_clustering.user_defined_upstream_strategy, a string</td>
</tr>
<tr>
<td>Default value</td>
<td></td>
</tr>
</tbody>
</table>

Table 193. clients.allow_telemetry

<table>
<thead>
<tr>
<th>Description</th>
<th>Configure client applications such as Browser and Bloom to send Product Analytics data.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>clients.allow_telemetry, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td>true</td>
</tr>
</tbody>
</table>

Table 194. cypher.default_language_version

<table>
<thead>
<tr>
<th>Description</th>
<th>Set this to specify the default parser (language version).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>cypher.default_language_version, one of [default, 3.5, 4.3, 4.4]</td>
</tr>
<tr>
<td>Default value</td>
<td>default</td>
</tr>
</tbody>
</table>

Table 195. cypher.forbid_exhaustive_shortestpath

<table>
<thead>
<tr>
<th>Description</th>
<th>This setting is associated with performance optimization. Set this to true in situations where it is preferable to have any queries using the 'shortestPath' function terminate as soon as possible with no answer, rather than potentially running for a long time attempting to find an answer (even if there is no path to be found). For most queries, the 'shortestPath' algorithm will return the correct answer very quickly. However there are some cases where it is possible that the fast bidirectional breadth-first search algorithm will find no results even if they exist. This can happen when the predicates in the WHERE clause applied to 'shortestPath' cannot be applied to each step of the traversal, and can only be applied to the entire path. When the query planner detects these special cases, it will plan to perform an exhaustive depth-first search if the fast algorithm finds no paths. However, the exhaustive search may be orders of magnitude slower than the fast algorithm. If it is critical that queries terminate as soon as possible, it is recommended that this option be set to true, which means that Neo4j will never consider using the exhaustive search for shortestPath queries. However, please note that if no paths are found, an error will be thrown at run time, which will need to be handled by the application.</th>
</tr>
</thead>
</table>

### Table 196. `cypher.forbid_shortestpath_common_nodes`

<table>
<thead>
<tr>
<th>Description</th>
<th>This setting is associated with performance optimization. The shortest path algorithm does not work when the start and end nodes are the same. With this setting set to <code>false</code> no path will be returned when that happens. The default value of <code>true</code> will instead throw an exception. This can happen if you perform a shortestPath search after a cartesian product that might have the same start and end nodes for some of the rows passed to shortestPath. If it is preferable to not experience this exception, and acceptable for results to be missing for those rows, then set this to <code>false</code>. If you cannot accept missing results, and really want the shortestPath between two common nodes, then re-write the query using a standard Cypher variable length pattern expression followed by ordering by path length and limiting to one result.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>cypher.forbid_shortestpath_common_nodes</code>, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td><code>true</code></td>
</tr>
</tbody>
</table>

### Table 197. `cypher.hints_error`

<table>
<thead>
<tr>
<th>Description</th>
<th>Set this to specify the behavior when Cypher planner or runtime hints cannot be fulfilled. If true, then non-conformance will result in an error, otherwise only a warning is generated.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>cypher.hints_error</code>, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td><code>false</code></td>
</tr>
</tbody>
</table>

### Table 198. `cypher.lenient_create_relationship`

<table>
<thead>
<tr>
<th>Description</th>
<th>Set this to change the behavior for Cypher create relationship when the start or end node is missing. By default this fails the query and stops execution, but by setting this flag the create operation is simply not performed and execution continues.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>cypher.lenient_create_relationship</code>, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td><code>false</code></td>
</tr>
</tbody>
</table>

### Table 199. `cypher.min_replan_interval`

---

542
| **Description** | The minimum time between possible cypher query replanning events. After this time, the graph statistics will be evaluated, and if they have changed by more than the value set by `cypher.statistics_divergence_threshold`, the query will be replanned. If the statistics have not changed sufficiently, the same interval will need to pass before the statistics will be evaluated again. Each time they are evaluated, the divergence threshold will be reduced slightly until it reaches 10% after 7h, so that even moderately changing databases will see query replanning after a sufficiently long time interval. |
| **Valid values** | `cypher.min_replan_interval`, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s) |
| **Default value** | 10s |

**Table 200. cypher.planner**

| **Description** | Set this to specify the default planner for the default language version. |
| **Valid values** | `cypher.planner`, one of [DEFAULT, COST] |
| **Default value** | DEFAULT |

**Table 201. cypher.statistics_divergence_threshold**

| **Description** | The threshold for statistics above which a plan is considered stale. If any of the underlying statistics used to create the plan have changed more than this value, the plan will be considered stale and will be replanned. Change is calculated as \( \frac{\text{abs}(a-b)}{\text{max}(a,b)} \). This means that a value of 0.75 requires the database to quadruple in size before query replanning. A value of 0 means that the query will be replanned as soon as there is any change in statistics and the replan interval has elapsed. This interval is defined by `cypher.min_replan_interval` and defaults to 10s. After this interval, the divergence threshold will slowly start to decline, reaching 10% after about 7h. This will ensure that long running databases will still get query replanning on even modest changes, while not replanning frequently unless the changes are very large. |
| **Valid values** | `cypher.statistics_divergence_threshold`, a double which is in the range 0.0 to 1.0 |
| **Default value** | 0.75 |

**Table 202. db.temporal.timezone**
<table>
<thead>
<tr>
<th>Description</th>
<th>Database timezone for temporal functions. All Time and DateTime values that are created without an explicit timezone will use this configured default timezone.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>db.temporal.timezone, a string describing a timezone, either described by offset (e.g. +02:00) or by name (e.g. Europe/Stockholm)</td>
</tr>
<tr>
<td>Default value</td>
<td>Z</td>
</tr>
</tbody>
</table>

**Table 203. dbms.allow_single_automatic_upgrade**

<table>
<thead>
<tr>
<th>Description</th>
<th>Whether to allow a system graph upgrade to happen automatically in single instance mode (dbms.mode=SINGLE). Default is true. In clustering environments no automatic upgrade will happen (dbms.mode=CORE or dbms.mode=READ_REPLICA). If set to false, or when in a clustering environment, it is necessary to call the procedure dbms.upgrade() to complete the upgrade.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.allow_single_automatic_upgrade, a boolean</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td>true</td>
</tr>
</tbody>
</table>

**Table 204. dbms.allow_upgrade**

<table>
<thead>
<tr>
<th>Description</th>
<th>Whether to allow a store upgrade in case the current version of the database starts against an older version of the store.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.allow_upgrade, a boolean</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td>false</td>
</tr>
</tbody>
</table>

**Table 205. dbms.backup.enabled**

<table>
<thead>
<tr>
<th>Description</th>
<th>Enable support for running online backups.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.backup.enabled, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td>true</td>
</tr>
</tbody>
</table>

**Table 206. dbms.backup.incremental.strategy**
<table>
<thead>
<tr>
<th>Description</th>
<th>Strategy for incremental backup. START_TIME means that this server will send transactions until the time of when the backup started has been reached. UNBOUNDED will keep sending until all committed transactions have been sent, even if they were committed after the backup job started.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.backup.incremental.strategy, one of [UNBOUNDED, START_TIME]</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td>UNBOUNDED</td>
</tr>
</tbody>
</table>

Table 207. dbms.backup.listen_address

<table>
<thead>
<tr>
<th>Description</th>
<th>Network interface and port for the backup server to listen on.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.backup.listen_address, a socket address in the format 'hostname:port', 'hostname' or ':port'</td>
</tr>
<tr>
<td>Default value</td>
<td>127.0.0.1:6362</td>
</tr>
</tbody>
</table>

Table 208. dbms.checkpoint

<table>
<thead>
<tr>
<th>Description</th>
<th>Configures the general policy for when check-points should occur. The default policy is the 'periodic' check-point policy, as specified by the 'dbms.checkpoint.interval.tx' and 'dbms.checkpoint.interval.time' settings. The Neo4j Enterprise Edition provides two alternative policies: The first is the 'continuous' check-point policy, which will ignore those settings and run the check-point process all the time. The second is the 'volumetric' check-point policy, which makes a best-effort at check-pointing often enough so that the database doesn't get too far behind on deleting old transaction logs in accordance with the 'dbms.tx_log.rotation.retention_policy' setting.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.checkpoint, one of [PERIODIC, CONTINUOUS, VOLUME, VOLUMETRIC]</td>
</tr>
<tr>
<td>Default value</td>
<td>PERIODIC</td>
</tr>
</tbody>
</table>

Table 209. dbms.checkpoint.interval.time
Description
Configures the time interval between check-points. The database will not check-point more often than this (unless check pointing is triggered by a different event), but might check-point less often than this interval, if performing a check-point takes longer time than the configured interval. A check-point is a point in the transaction logs, which recovery would start from. Longer check-point intervals typically mean that recovery will take longer to complete in case of a crash. On the other hand, a longer check-point interval can also reduce the I/O load that the database places on the system, as each check-point implies a flushing and forcing of all the store files.

Valid values
dbms.checkpoint.interval.time, a duration (Valid units are: `ns`, `μs`, `ms`, `s`, `m`, `h` and `d`; default unit is `s`)

Default value
15m

Table 210. dbms.checkpoint.interval.tx

Description
Configures the transaction interval between check-points. The database will not check-point more often than this (unless check pointing is triggered by a different event), but might check-point less often than this interval, if performing a check-point takes longer time than the configured interval. A check-point is a point in the transaction logs, which recovery would start from. Longer check-point intervals typically mean that recovery will take longer to complete in case of a crash. On the other hand, a longer check-point interval can also reduce the I/O load that the database places on the system, as each check-point implies a flushing and forcing of all the store files. The default is '100000' for a check-point every 100000 transactions.

Valid values
dbms.checkpoint.interval.tx, an integer which is minimum 1

Default value
100000

Table 211. dbms.checkpoint.interval.volume

Description
Configures the volume of transaction logs between check-points. The database will not check-point more often than this (unless check pointing is triggered by a different event), but might check-point less often than this interval, if performing a check-point takes longer time than the configured interval. A check-point is a point in the transaction logs, which recovery would start from. Longer check-point intervals typically mean that recovery will take longer to complete in case of a crash. On the other hand, a longer check-point interval can also reduce the I/O load that the database places on the system, as each check-point implies a flushing and forcing of all the store files.

Valid values
dbms.checkpoint.interval.volume, a byte size (valid multipliers are `B`, `KiB`, `KB`, `K`, `kB`, `k`, `MiB`, `MB`, `M`, `mB`, `mb`, `m`, `GiB`, `GB`, `G`, `gB`, `gb`, `g`, `TiB`, `TB`, `T`, `tB`, `PB`, `PB`, `Pi`, `PB`, `Ei`, `EB`) which is minimum 1.00KiB
Default value | 250.00 MiB
---|---

Table 212. dbms.checkpoint.iops.limit

<table>
<thead>
<tr>
<th>Description</th>
<th>Limit the number of IOs the background checkpoint process will consume per second. This setting is advisory, is ignored in Neo4j Community Edition, and is followed to best effort in Enterprise Edition. An IO is in this case a 8 KiB (mostly sequential) write. Limiting the write IO in this way will leave more bandwidth in the IO subsystem to service random-read IOs, which is important for the response time of queries when the database cannot fit entirely in memory. The only drawback of this setting is that longer checkpoint times may lead to slightly longer recovery times in case of a database or system crash. A lower number means lower IO pressure, and consequently longer checkpoint times. Set this to -1 to disable the IOPS limit and remove the limitation entirely; this will let the checkpointer flush data as fast as the hardware will go. Removing the setting, or commenting it out, will set the default value of 600.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.checkpoint.iops.limit, an integer</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td>600</td>
</tr>
</tbody>
</table>

Table 213. dbms.clustering.enable

<table>
<thead>
<tr>
<th>Description</th>
<th>Enable discovery service and a catchup server to be started on an Enterprise Standalone Instance 'dbms.mode=SINGLE', and with that allow for Read Replicas to connect and pull transaction from it. When 'dbms.mode' is clustered (CORE, READ_REPLICA) this setting is not recognized.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.clustering.enable, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td>false</td>
</tr>
<tr>
<td>Deprecated</td>
<td>The dbms.clustering.enable configuration setting has been deprecated.</td>
</tr>
</tbody>
</table>

Table 214. dbms.config.strict_validation

<table>
<thead>
<tr>
<th>Description</th>
<th>A strict configuration validation will prevent the database from starting up if unknown configuration options are specified in the neo4j settings namespace (such as dbms., cypher., etc).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.config.strict_validation, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td>false</td>
</tr>
</tbody>
</table>
**Table 215. dbms.connector.bolt.advertised_address**

<table>
<thead>
<tr>
<th>Description</th>
<th>Advertised address for this connector.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Valid values</strong></td>
<td>dbms.connector.bolt.advertised_address, a socket address in the format 'hostname:port', 'hostname' or ':port'. If missing port or hostname it is acquired from dbms.default_advertised_address</td>
</tr>
<tr>
<td><strong>Default value</strong></td>
<td>:7687</td>
</tr>
</tbody>
</table>

**Table 216. dbms.connector.bolt.connection_keep_alive**

<table>
<thead>
<tr>
<th>Description</th>
<th>The maximum time to wait before sending a NOOP on connections waiting for responses from active ongoing queries. The minimum value is 1 millisecond.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Valid values</strong></td>
<td>dbms.connector.bolt.connection_keep_alive, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s) which is minimum 1ms</td>
</tr>
<tr>
<td><strong>Default value</strong></td>
<td>1m</td>
</tr>
</tbody>
</table>

**Table 217. dbms.connector.bolt.connection_keep_alive_streaming_scheduling_interval**

<table>
<thead>
<tr>
<th>Description</th>
<th>The interval between every scheduled keep-alive check on all connections with active queries. Zero duration turns off keep-alive service.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Valid values</strong></td>
<td>dbms.connector.bolt.connection_keep_alive_streaming_scheduling_interval, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s) which is minimum 0s</td>
</tr>
<tr>
<td><strong>Default value</strong></td>
<td></td>
</tr>
<tr>
<td>Table 220. dbms.connector.bolt.enabled</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Description</strong></td>
<td>Enable the bolt connector.</td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
<td>dbms.connector.bolt.enabled, a boolean</td>
</tr>
<tr>
<td><strong>Default value</strong></td>
<td>true</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 221. dbms.connector.bolt.listen_address</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 222. dbms.connector.bolt.ocsp_stapling_enabled</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 223. dbms.connector.bolt.thread_pool_keep_alive</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 224. dbms.connector.bolt.thread_pool_max_size</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
<tr>
<td>Table 225. dbms.connector.bolt.thread_pool_min_size</td>
</tr>
<tr>
<td>---------------------------------------------------</td>
</tr>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 226. dbms.connector.bolt.tls_level</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 227. dbms.connector.bolt.unsupported_thread_pool_shutdown_wait_time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 228. dbms.connector.http.advertised_address</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 229. dbms.connector.http.enabled</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 230. dbms.connector.http.listen_address</th>
</tr>
</thead>
<tbody>
<tr>
<td>550</td>
</tr>
<tr>
<td>Table 231. dbms.connector.http.listen_address</td>
</tr>
<tr>
<td>---------------------------------------------</td>
</tr>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 232. dbms.connector.https.advertised_address</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 233. dbms.connector.https.enabled</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 234. dbms.databases.default_to_read_only</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td>Table 235. dbms.databases.read_only</td>
</tr>
<tr>
<td>-------------------------------------</td>
</tr>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Dynamic</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 236. dbms.databases.writable</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Dynamic</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 237. dbms.db.timezone</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>

Table 238. dbms.default_advertised_address
<table>
<thead>
<tr>
<th>Description</th>
<th>Default hostname or IP address the server uses to advertise itself.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.default_advertised_address, a socket address in the format 'hostname:port', 'hostname' or ':port' which has no specified port</td>
</tr>
<tr>
<td>Default value</td>
<td>localhost</td>
</tr>
</tbody>
</table>

| Table 239. dbms.default_database                                             |
| Description                                                                 | Name of the default database (aliases are not supported).           |
| Valid values                                                               | dbms.default_database, A valid database name containing only alphabetic characters, numbers, dots and dashes with a length between 3 and 63 characters, starting with an alphabetic character but not with the name 'system' |
| Default value                                                              | neo4j                                                               |

| Table 240. dbms.default_listen_address                                      |
| Description                                                                 | Default network interface to listen for incoming connections. To listen for connections on all interfaces, use "0.0.0.0". |
| Valid values                                                               | dbms.default_listen_address, a socket address in the format 'hostname:port', 'hostname' or ':port' which has no specified port |
| Default value                                                              | localhost                                                           |

| Table 241. dbms.directories.cluster_state                                  |
| Description                                                                 | Directory to hold cluster state including Raft log.                |
| Valid values                                                               | dbms.directories.cluster_state, a path. If relative it is resolved from dbmsdirectories.data |
| Default value                                                              | cluster-state                                                       |

| Table 242. dbms.directories.data                                           |
| Description                                                                 | Path of the data directory. You must not configure more than one Neo4j installation to use the same data directory. |
| Valid values                                                               | dbmsdirectories.data, a path. If relative it is resolved from dbmsdirectories.neo4j.home |
| Default value                                                              | data                                                                |
Table 243. dbms.directories.dumps.root

<table>
<thead>
<tr>
<th>Description</th>
<th>Root location where Neo4j will store database dumps optionally produced when dropping said databases.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.directories.dumps.root, a path. If relative it is resolved from dbms.directories.data</td>
</tr>
<tr>
<td>Default value</td>
<td>dumps</td>
</tr>
</tbody>
</table>

Table 244. dbms.directories.import

<table>
<thead>
<tr>
<th>Description</th>
<th>Sets the root directory for file URLs used with the Cypher LOAD CSV clause. This should be set to a directory relative to the Neo4j installation path, restricting access to only those files within that directory and its subdirectories. For example the value &quot;import&quot; will only enable access to files within the 'import' folder. Removing this setting will disable the security feature, allowing all files in the local system to be imported. Setting this to an empty field will allow access to all files within the Neo4j installation folder.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.directories.import, a path. If relative it is resolved from dbms.directories.neo4j_home</td>
</tr>
</tbody>
</table>

Table 245. dbms.directories.lib

<table>
<thead>
<tr>
<th>Description</th>
<th>Path of the lib directory.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.directories.lib, a path. If relative it is resolved from dbms.directories.neo4j_home</td>
</tr>
<tr>
<td>Default value</td>
<td>lib</td>
</tr>
</tbody>
</table>

Table 246. dbms.directories.licenses

<table>
<thead>
<tr>
<th>Description</th>
<th>Path of the licenses directory.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.directories.licenses, a path. If relative it is resolved from dbms.directories.neo4j_home</td>
</tr>
<tr>
<td>Default value</td>
<td>licenses</td>
</tr>
</tbody>
</table>

Table 247. dbms.directories.logs

<table>
<thead>
<tr>
<th>Description</th>
<th>Path of the logs directory.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Table 248. dbms.directories.logs</td>
<td></td>
</tr>
<tr>
<td>----------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Description</strong></td>
<td></td>
</tr>
<tr>
<td>The target location of the CSV files: a path to a directory wherein a CSV file per reported field will be written.</td>
<td></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
<td></td>
</tr>
<tr>
<td>dbms.directories.logs, a path. If relative it is resolved from dbms.directories.neo4j_home</td>
<td></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
<td></td>
</tr>
<tr>
<td>logs</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 249. dbms.directories.metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td>The target location of the CSV files: a path to a directory wherein a CSV file per reported field will be written.</td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td>dbms.directories.metrics, a path. If relative it is resolved from dbms.directories.neo4j_home</td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
<tr>
<td>metrics</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 249. dbms.directories.neo4j_home</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td>Root relative to which directory settings are resolved.</td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td>dbms.directories.neo4j_home, a path which is absolute</td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
<tr>
<td>Defaults to current working directory</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 250. dbms.directories.plugins</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td>Location of the database plugin directory. Compiled Java JAR files that contain database procedures will be loaded if they are placed in this directory.</td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td>dbms.directories.plugins, a path. If relative it is resolved from dbms.directories.neo4j_home</td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
<tr>
<td>plugins</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 251. dbms.directories.run</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td>Path of the run directory. This directory holds Neo4j's runtime state, such as a pidfile when it is running in the background. The pidfile is created when starting neo4j and removed when stopping it. It may be placed on an in-memory filesystem such as tmpfs.</td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td>dbms.directories.run, a path. If relative it is resolved from dbms.directories.neo4j_home</td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
<tr>
<td>run</td>
</tr>
</tbody>
</table>

<p>| Table 252. dbms.directories.script.root |</p>
<table>
<thead>
<tr>
<th>Table 253. <code>dbms.directories.transaction.logs.root</code></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 254. <code>dbms.dynamic.setting.allowlist</code></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 255. <code>dbms.dynamic.setting.whitelist</code></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
<tr>
<td><strong>Deprecated</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 256. <code>dbms.filewatcher.enabled</code></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
</tbody>
</table>
Valid values | dbms.filewatcher.enabled, a boolean
--- | ---
Default value | true

**Table 257. dbms.http_enabled_modules**

<table>
<thead>
<tr>
<th>Description</th>
<th>Defines the set of modules loaded into the Neo4j web server. Options include TRANSACTIONAL_ENDPOINTS, BROWSER, UNMANAGED_EXTENSIONS and ENTERPRISE_MANAGEMENT_ENDPOINTS (if applicable).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.http_enabled_modules, a ',' separated set with elements of type 'one of [TRANSACTIONAL_ENDPOINTS, UNMANAGED_EXTENSIONS, BROWSER, ENTERPRISE_MANAGEMENT_ENDPOINTS]'</td>
</tr>
<tr>
<td>Default value</td>
<td>TRANSACTIONAL_ENDPOINTS,UNMANAGED_EXTENSIONS,BROWSER,ENTERPRISE_MANAGEMENT_ENDPOINTS</td>
</tr>
</tbody>
</table>

**Table 258. dbms.import.csv.buffer_size**

<table>
<thead>
<tr>
<th>Description</th>
<th>The size of the internal buffer in bytes used by <code>LOAD CSV</code>. If the csv file contains huge fields this value may have to be increased.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.import.csv.buffer_size, a long which is minimum 1</td>
</tr>
<tr>
<td>Default value</td>
<td>2097152</td>
</tr>
</tbody>
</table>

**Table 259. dbms.import.csv.legacy_quote_escaping**

<table>
<thead>
<tr>
<th>Description</th>
<th>Selects whether to conform to the standard <a href="https://tools.ietf.org/html/rfc4180">https://tools.ietf.org/html/rfc4180</a> for interpreting escaped quotation characters in CSV files loaded using <code>LOAD CSV</code>. Setting this to <code>false</code> will use the standard, interpreting repeated quotes &quot;&quot;&quot;&quot; as a single in-lined quote, while <code>true</code> will use the legacy convention originally supported in Neo4j 3.0 and 3.1, allowing a backslash to include quotes in-lined in fields.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.import.csv.legacy_quote_escaping, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td>true</td>
</tr>
</tbody>
</table>

**Table 260. dbms.index.default_schema_provider**
Index provider to use for newly created schema indexes. An index provider may store different value types in separate physical indexes. native-btree-1.0: All value types and arrays of all value types, even composite keys, are stored in one native index. lucene+native-3.0: Like native-btree-1.0 but single property strings are stored in Lucene. A native index has faster updates, less heap and CPU usage compared to a Lucene index. A native index has some limitations around key size and slower execution of CONTAINS and ENDS WITH string index queries, compared to a Lucene index. Deprecated: Which index provider to use will be a fully internal concern.

**Valid values**

<table>
<thead>
<tr>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>dbms.index.default_schema_provider, a string</td>
</tr>
</tbody>
</table>

**Default value**

native-btree-1.0

**Deprecated**

The dbms.index.default_schema_provider configuration setting has been deprecated.

### Table 261. dbms.index.fulltext.default_analyzer

**Description**

The name of the analyzer that the fulltext indexes should use by default.

**Valid values**

<table>
<thead>
<tr>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>dbms.index.fulltext.default_analyzer, a string</td>
</tr>
</tbody>
</table>

**Default value**

standard-no-stop-words

### Table 262. dbms.index.fulltext.eventually_consistent

**Description**

Whether or not fulltext indexes should be eventually consistent by default or not.

**Valid values**

<table>
<thead>
<tr>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>dbms.index.fulltext.eventually_consistent, a boolean</td>
</tr>
</tbody>
</table>

**Default value**

false

### Table 263. dbms.index.fulltext.eventually_consistent_index_update_queue_max_length

**Description**

The eventually_consistent mode of the fulltext indexes works by queueing up index updates to be applied later in a background thread. This newBuilder sets an upper bound on how many index updates are allowed to be in this queue at any one point in time. When it is reached, the commit process will slow down and wait for the index update applier thread to make some more room in the queue.

**Valid values**

<table>
<thead>
<tr>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>dbms.index.fulltext.eventually_consistent_index_update_queue_max_length, an integer which is in the range 1 to 5000000</td>
</tr>
</tbody>
</table>

**Default value**

10000
Table 264. `dbms.index_sampling.background_enabled`

<table>
<thead>
<tr>
<th>Description</th>
<th>Enable or disable background index sampling.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.index_sampling.background_enabled</code>, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td><code>true</code></td>
</tr>
</tbody>
</table>

Table 265. `dbms.index_sampling.sample_size_limit`

<table>
<thead>
<tr>
<th>Description</th>
<th>Index sampling chunk size limit.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.index_sampling.sample_size_limit</code>, an integer which is in the range 1048576 to 2147483647</td>
</tr>
<tr>
<td>Default value</td>
<td><code>8388608</code></td>
</tr>
</tbody>
</table>

Table 266. `dbms.index_sampling.update_percentage`

<table>
<thead>
<tr>
<th>Description</th>
<th>Percentage of index updates of total index size required before sampling of a given index is triggered.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.index_sampling.update_percentage</code>, an integer which is minimum 0</td>
</tr>
<tr>
<td>Default value</td>
<td><code>5</code></td>
</tr>
</tbody>
</table>

Table 267. `dbms.index_searcher_cache_size`

<table>
<thead>
<tr>
<th>Description</th>
<th>The maximum number of open Lucene index searchers.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.index_searcher_cache_size</code>, an integer which is minimum 1</td>
</tr>
<tr>
<td>Default value</td>
<td><code>2147483647</code></td>
</tr>
<tr>
<td>Deprecated</td>
<td>The <code>dbms.index_searcher_cache_size</code> configuration setting has been deprecated.</td>
</tr>
</tbody>
</table>

Table 268. `dbms.jvm.additional`

<table>
<thead>
<tr>
<th>Description</th>
<th>Additional JVM arguments. Argument order can be significant. To use a Java commercial feature, the argument to unlock commercial features must precede the argument to enable the specific feature in the config value string. For example, to use Flight Recorder, <code>-XX:+UnlockCommercialFeatures</code> must come before <code>-XX:+FlightRecorder</code>.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.jvm.additional</code>, one or more jvm arguments</td>
</tr>
</tbody>
</table>
Table 269. `dbms.lock.acquisition.timeout`

<table>
<thead>
<tr>
<th>Description</th>
<th>The maximum time interval within which lock should be acquired. Zero (default) means timeout is disabled.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.lock.acquisition.timeout</code>, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td>0s</td>
</tr>
</tbody>
</table>

Table 270. `dbms.logs.debug.format`

<table>
<thead>
<tr>
<th>Description</th>
<th>Log format to use for debug log.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.logs.debug.format</code>, one of [PLAIN, JSON]. If unset the value is inherited from <code>dbms.logs.default_format</code></td>
</tr>
</tbody>
</table>

Table 271. `dbms.logs.debug.level`

<table>
<thead>
<tr>
<th>Description</th>
<th>Debug log level threshold.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.logs.debug.level</code>, one of [DEBUG, INFO, WARN, ERROR, NONE]</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td>INFO</td>
</tr>
</tbody>
</table>

Table 272. `dbms.logs.debug.path`

<table>
<thead>
<tr>
<th>Description</th>
<th>Path to the debug log file.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.logs.debug.path</code>, a path. If relative it is resolved from <code>dbms.directories.logs</code></td>
</tr>
<tr>
<td>Default value</td>
<td><code>debug.log</code></td>
</tr>
</tbody>
</table>

Table 273. `dbms.logs.debug.rotation.delay`

<table>
<thead>
<tr>
<th>Description</th>
<th>Minimum time interval after last rotation of the debug log before it may be rotated again.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.logs.debug.rotation.delay</code>, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)</td>
</tr>
<tr>
<td>Default value</td>
<td>5m</td>
</tr>
</tbody>
</table>
The `dbms.logs.debug.rotation.delay` configuration setting has been deprecated.

**Table 274. dbms.logs.debug.rotation.keep_number**

<table>
<thead>
<tr>
<th>Description</th>
<th>Maximum number of history files for the debug log.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.logs.debug.rotation.keep_number</code>, an integer which is minimum 1</td>
</tr>
<tr>
<td>Default value</td>
<td>7</td>
</tr>
</tbody>
</table>

**Table 275. dbms.logs.debug.rotation.size**

<table>
<thead>
<tr>
<th>Description</th>
<th>Threshold for rotation of the debug log.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.logs.debug.rotation.size</code>, a byte size (valid multipliers are B, KiB, KB, K, kB, k, MiB, MB, m, MB, mb, m, GiB, GB, G, gB, gb, g, TiB, TB, PiB, PB, PiB, PB, PiB, PB) which is in the range 0B to 8388608.00TiB</td>
</tr>
<tr>
<td>Default value</td>
<td>20.00MiB</td>
</tr>
</tbody>
</table>

**Table 276. dbms.logs.default_format**

<table>
<thead>
<tr>
<th>Description</th>
<th>Default log format. Will apply to all logs unless overridden.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.logs.default_format</code>, one of [PLAIN, JSON]</td>
</tr>
<tr>
<td>Default value</td>
<td>PLAIN</td>
</tr>
</tbody>
</table>

**Table 277. dbms.logs.gc.enabled**

<table>
<thead>
<tr>
<th>Description</th>
<th>Enable GC Logging.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.logs.gc.enabled</code>, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td>false</td>
</tr>
</tbody>
</table>

**Table 278. dbms.logs.gc.options**

<table>
<thead>
<tr>
<th>Description</th>
<th>GC Logging Options.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.logs.gc.options</code>, a string</td>
</tr>
<tr>
<td>Default value</td>
<td><code>-Xlog:gc*,safepoint,age=trace</code></td>
</tr>
</tbody>
</table>

**Table 279. dbms.logs.gc.rotation.keep_number**
<table>
<thead>
<tr>
<th>Table 280. <code>dbms.logs.gc.rotation.size</code></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 281. <code>dbms.logs.http.enabled</code></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 282. <code>dbms.logs.http.format</code></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 283. <code>dbms.logs.http.path</code></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 284. <code>dbms.logs.http.rotation.keep_number</code></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>
### Table 285. `dbms.logs.http.rotation.size`

<table>
<thead>
<tr>
<th>Description</th>
<th>Size of each HTTP log that is kept.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.logs.http.rotation.size</code>, a byte size (valid multipliers are B, KiB, KB, k, MiB, MB, mB, mb, m, GiB, GB, G, gB, gb, g, TiB, TB, PiB, PB, EiB, EB) which is in the range 0B to 8388608.00TiB</td>
</tr>
<tr>
<td>Default value</td>
<td>20.00MiB</td>
</tr>
</tbody>
</table>

### Table 286. `dbms.logs.query.allocation_logging_enabled`

<table>
<thead>
<tr>
<th>Description</th>
<th>Log allocated bytes for the executed queries being logged. The logged number is cumulative over the duration of the query, i.e. for memory intense or long-running queries the value may be larger than the current memory allocation. Requires <code>dbms.track_query_allocation=true</code></th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.logs.query.allocation_logging_enabled</code>, a boolean</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td>true</td>
</tr>
</tbody>
</table>

### Table 287. `dbms.logs.query.early_raw_logging_enabled`

<table>
<thead>
<tr>
<th>Description</th>
<th>Log query text and parameters without obfuscating passwords. This allows queries to be logged earlier before parsing starts.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.logs.query.early_raw_logging_enabled</code>, a boolean</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td>false</td>
</tr>
</tbody>
</table>

### Table 288. `dbms.logs.query.enabled`
Log executed queries. Valid values are OFF, INFO, or VERBOSE.

OFF
  no logging.

INFO
  log queries at the end of execution, that take longer than the configured threshold, `dbms.logs.query.threshold`.

VERBOSE
  log queries at the start and end of execution, regardless of `dbms.logs.query.threshold`.

Log entries are written to the query log (`dbms.logs.query.path`).
This feature is available in the Neo4j Enterprise Edition.

<table>
<thead>
<tr>
<th>Valid values</th>
<th>dbms.logs.query.enabled, one of [OFF, INFO, VERBOSE]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td>VERBOSE</td>
</tr>
</tbody>
</table>

Table 289. dbms.logs.query.format

<table>
<thead>
<tr>
<th>Description</th>
<th>Log format to use for the query log.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.logs.query.format, one of [PLAIN, JSON]. If unset the value is inherited from dbms.logs.default_format</td>
</tr>
</tbody>
</table>

Table 290. dbms.logs.query.max_parameter_length

<table>
<thead>
<tr>
<th>Description</th>
<th>Sets a maximum character length use for each parameter in the log. This only takes effect if <code>dbms.logs.query.parameter_logging_enabled</code> = true.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.logs.query.max_parameter_length, an integer</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td>2147483647</td>
</tr>
</tbody>
</table>

Table 291. dbms.logs.query.obfuscate_literals
<table>
<thead>
<tr>
<th>Description</th>
<th>Obfuscates all literals of the query before writing to the log. Note that node labels, relationship types and map property keys are still shown. Changing the setting will not affect queries that are cached. So, if you want the switch to have immediate effect, you must also call <code>CALL db.clearQueryCaches()</code>.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.logs.query.obfuscate_literals</code>, a boolean</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td>false</td>
</tr>
</tbody>
</table>

Table 292. `dbms.logs.query.page_logging_enabled`

<table>
<thead>
<tr>
<th>Description</th>
<th>Log page hits and page faults for the executed queries being logged.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.logs.query.page_logging_enabled</code>, a boolean</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td>false</td>
</tr>
</tbody>
</table>

Table 293. `dbms.logs.query.parameter_full_entities`

<table>
<thead>
<tr>
<th>Description</th>
<th>Log complete parameter entities including id, labels or relationship type, and properties. If false, only the entity id will be logged. This only takes effect if <code>dbms.logs.query.parameter_logging_enabled = true</code>.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.logs.query.parameter_full_entities</code>, a boolean</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td>false</td>
</tr>
</tbody>
</table>

Table 294. `dbms.logs.query.parameter_logging_enabled`

<table>
<thead>
<tr>
<th>Description</th>
<th>Log parameters for the executed queries being logged.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.logs.query.parameter_logging_enabled</code>, a boolean</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td>true</td>
</tr>
</tbody>
</table>

Table 295. `dbms.logs.query.path`
<table>
<thead>
<tr>
<th>Description</th>
<th>Path to the query log file.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.logs.query.path, a path. If relative it is resolved from dbms.directories.logs</td>
</tr>
<tr>
<td>Default value</td>
<td>query.log</td>
</tr>
</tbody>
</table>

**Table 296. dbms.logs.query.plan_description_enabled**

<table>
<thead>
<tr>
<th>Description</th>
<th>Log query plan description table, useful for debugging purposes.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.logs.query.plan_description_enabled, a boolean</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td>false</td>
</tr>
</tbody>
</table>

**Table 297. dbms.logs.query.rotation.keep_number**

<table>
<thead>
<tr>
<th>Description</th>
<th>Maximum number of history files for the query log.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.logs.query.rotation.keep_number, an integer which is minimum 1</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td>7</td>
</tr>
</tbody>
</table>

**Table 298. dbms.logs.query.rotation.size**

<table>
<thead>
<tr>
<th>Description</th>
<th>The file size in bytes at which the query log will auto-rotate. If set to zero then no rotation will occur. Accepts a binary suffix k, m or g.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.logs.query.rotation.size, a byte size (valid multipliers are B, KiB, KB, K, kB, kb, k, MiB, MB, M, mB, mb, m, GiB, GB, G, gB, gb, g, TiB, TB, PiB, PB, EiB, EB) which is in the range 0B to 8388608.00TiB</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td>20.00MiB</td>
</tr>
</tbody>
</table>

**Table 299. dbms.logs.query.runtime_logging_enabled**

<table>
<thead>
<tr>
<th>Description</th>
<th>Logs which runtime that was used to run the query.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.logs.query.runtime_logging_enabled, a boolean</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td>true</td>
</tr>
</tbody>
</table>

**Table 300. dbms.logs.query.threshold**

| Description | If the execution of query takes more time than this threshold, the query is logged once completed - provided query logging is set to INFO. Defaults to 0 seconds, that is all queries are logged. |
| Valid values | dbms.logs.query.threshold, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s) |
| Dynamic | true |
| Default value | 0s |

**Table 301. dbms.logs.query.time_logging_enabled**

| Description | Log detailed time information for the executed queries being logged, such as (planning: 92, waiting: 0). |
| Valid values | dbms.logs.query.time_logging_enabled, a boolean |
| Dynamic | true |
| Default value | false |

**Table 302. dbms.logs.query.transaction.enabled**

| Description | Log the start and end of a transaction. Valid values are 'OFF', 'INFO', or 'VERBOSE'. OFF: no logging. INFO: log start and end of transactions that take longer than the configured threshold, dbms.logs.query.transaction.threshold. VERBOSE: log start and end of all transactions. Log entries are written to the query log (dbms.logs.query.path). This feature is available in the Neo4j Enterprise Edition. |
| Valid values | dbms.logs.query.transaction.enabled, one of [OFF, INFO, VERBOSE] |
| Dynamic | true |
| Default value | OFF |

**Table 303. dbms.logs.query.transaction.threshold**
If the transaction is open for more time than this threshold, the transaction is logged once completed - provided transaction logging (dbms.logs.query.transaction.enabled) is set to INFO. Defaults to 0 seconds (all transactions are logged).

**Valid values**
dbms.logs.query.transaction.threshold, a duration (Valid units are: \textit{ns}, \textit{μs}, \textit{ms}, \textit{s}, \textit{m}, \textit{h} and \textit{d}; default unit is \textit{s})

**Dynamic**
true

**Default value**
0s

**Table 304. dbms.logs.query.transaction_id.enabled**

<table>
<thead>
<tr>
<th>Description</th>
<th>Log transaction ID for the executed queries.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Valid values</strong></td>
<td>dbms.logs.query.transaction_id.enabled, a boolean</td>
</tr>
<tr>
<td><strong>Dynamic</strong></td>
<td>true</td>
</tr>
<tr>
<td><strong>Default value</strong></td>
<td>false</td>
</tr>
</tbody>
</table>

Table 305. dbms.logs.security.format

<table>
<thead>
<tr>
<th>Description</th>
<th>Log format to use for security log.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Valid values</strong></td>
<td>dbms.logs.security.format, one of {PLAIN, JSON}. If unset the value is inherited from dbms.logs.default_format</td>
</tr>
</tbody>
</table>

Table 306. dbms.logs.security.level

<table>
<thead>
<tr>
<th>Description</th>
<th>Security log level threshold.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Valid values</strong></td>
<td>dbms.logs.security.level, one of {DEBUG, INFO, WARN, ERROR, NONE}</td>
</tr>
<tr>
<td><strong>Default value</strong></td>
<td>INFO</td>
</tr>
</tbody>
</table>

Table 307. dbms.logs.security.path

<table>
<thead>
<tr>
<th>Description</th>
<th>Path to the security log file.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Valid values</strong></td>
<td>dbms.logs.security.path, a path. If relative it is resolved from dbms.directories.logs</td>
</tr>
<tr>
<td><strong>Default value</strong></td>
<td>security.log</td>
</tr>
</tbody>
</table>
### Table 308. `dbms.logs.security.rotation.delay`

<table>
<thead>
<tr>
<th>Description</th>
<th>Minimum time interval after last rotation of the security log before it may be rotated again.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.logs.security.rotation.delay</code>, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)</td>
</tr>
<tr>
<td>Default value</td>
<td>5m</td>
</tr>
<tr>
<td>Deprecated</td>
<td>The <code>dbms.logs.security.rotation.delay</code> configuration setting has been deprecated.</td>
</tr>
</tbody>
</table>

### Table 309. `dbms.logs.security.rotation.keep_number`

<table>
<thead>
<tr>
<th>Description</th>
<th>Maximum number of history files for the security log.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.logs.security.rotation.keep_number</code>, an integer which is minimum 1</td>
</tr>
<tr>
<td>Default value</td>
<td>7</td>
</tr>
</tbody>
</table>

### Table 310. `dbms.logs.security.rotation.size`

<table>
<thead>
<tr>
<th>Description</th>
<th>Threshold for rotation of the security log.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.logs.security.rotation.size</code>, a byte size (valid multipliers are B, KiB, KB, K, kB, k, MiB, MB, M, mB, mb, m, GiB, GB, G, gB, gb, g, TiB, TB, PiB, PB, EiB, EB) which is in the range 0B to 8388608.00TiB</td>
</tr>
<tr>
<td>Default value</td>
<td>20.00MiB</td>
</tr>
</tbody>
</table>

### Table 311. `dbms.logs.user.format`

<table>
<thead>
<tr>
<th>Description</th>
<th>Log format to use for user log.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.logs.user.format</code>, one of [PLAIN, JSON]. If unset the value is inherited from <code>dbms.logs.default_format</code></td>
</tr>
</tbody>
</table>

### Table 312. `dbms.logs.user.path`

<table>
<thead>
<tr>
<th>Description</th>
<th>Path to the user log file. Note that if <code>dbms.logs.user.stdout_enabled</code> is enabled this setting will be ignored.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.logs.user.path</code>, a path. If relative it is resolved from <code>dbms.directories.logs</code></td>
</tr>
<tr>
<td>Default value</td>
<td><code>neo4j.log</code></td>
</tr>
</tbody>
</table>
### Table 313. dbms.logs.user.rotation.delay

<table>
<thead>
<tr>
<th>Description</th>
<th>Minimum time interval after last rotation of the user log (neo4j.log) before it may be rotated again. Note that if dbms.logs.user.stdout_enabled is enabled this setting will be ignored.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.logs.user.rotation.delay, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)</td>
</tr>
<tr>
<td>Default value</td>
<td>5m</td>
</tr>
<tr>
<td>Deprecated</td>
<td>The dbms.logs.user.rotation.delay configuration setting has been deprecated.</td>
</tr>
</tbody>
</table>

### Table 314. dbms.logs.user.rotation.keep_number

<table>
<thead>
<tr>
<th>Description</th>
<th>Maximum number of history files for the user log (neo4j.log). Note that if dbms.logs.user.stdout_enabled is enabled this setting will be ignored.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.logs.user.rotation.keep_number, an integer which is minimum 1</td>
</tr>
<tr>
<td>Default value</td>
<td>7</td>
</tr>
</tbody>
</table>

### Table 315. dbms.logs.user.rotation.size

<table>
<thead>
<tr>
<th>Description</th>
<th>Threshold for rotation of the user log (neo4j.log). If set to 0, log rotation is disabled. Note that if dbms.logs.user.stdout_enabled is enabled this setting will be ignored.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.logs.user.rotation.size, a byte size (valid multipliers are B, KiB, KB, K, kB, k, MiB, MB, M, mB, mb, m, GiB, GB, G, gB, gb, g, TiB, TB, T, PB, P, PB, EiB, EB) which is in the range 0B to 8388608.00TiB</td>
</tr>
<tr>
<td>Default value</td>
<td>0B</td>
</tr>
</tbody>
</table>

### Table 316. dbms.logs.user.stdout_enabled

<table>
<thead>
<tr>
<th>Description</th>
<th>Send user logs to the process stdout. If this is disabled then logs will instead be sent to the file neo4j.log located in the logs directory.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.logs.user.stdout_enabled, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td>true</td>
</tr>
</tbody>
</table>

### Table 317. dbms.max_databases

| Description | The maximum number of databases. |
Table 318. dbms.memory.heap.initial_size

<table>
<thead>
<tr>
<th>Description</th>
<th>Initial heap size. By default it is calculated based on available system resources.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.memory.heap.initial_size, a byte size (valid multipliers are B, KiB, KB, K, KB, kb, k, MiB, MB, mB, mb, m, GiB, GB, G, GB, gb, g, TiB, TB, PiB, PB, EiB, EB)</td>
</tr>
</tbody>
</table>

Table 319. dbms.memory.heap.max_size

<table>
<thead>
<tr>
<th>Description</th>
<th>Maximum heap size. By default it is calculated based on available system resources.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.memory.heap.max_size, a byte size (valid multipliers are B, KiB, KB, K, KB, kb, k, MiB, MB, mB, mb, m, GiB, GB, G, GB, gb, g, TiB, TB, PiB, PB, EiB, EB)</td>
</tr>
</tbody>
</table>

Table 320. dbms.memory.off_heap.block_cache_size

<table>
<thead>
<tr>
<th>Description</th>
<th>Defines the size of the off-heap memory blocks cache. The cache will contain this number of blocks for each block size that is power of two. Thus, maximum amount of memory used by blocks cache can be calculated as 2 * dbms.memory.off_heap.max_cacheable_block_size * dbms.memory.off_heap.block_cache_size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.memory.off_heap.block_cache_size, an integer which is minimum 16</td>
</tr>
<tr>
<td>Default value</td>
<td>128</td>
</tr>
</tbody>
</table>

Table 321. dbms.memory.off_heap.max_cacheable_block_size

<table>
<thead>
<tr>
<th>Description</th>
<th>Defines the maximum size of an off-heap memory block that can be cached to speed up allocations. The value must be a power of 2.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.memory.off_heap.max_cacheable_block_size, a byte size (valid multipliers are B, KiB, KB, K, KB, kb, k, MiB, MB, mB, mb, m, GiB, GB, G, GB, gb, g, TiB, TB, PiB, PB, EiB, EB) which is minimum 4.00KiB and is power of 2</td>
</tr>
<tr>
<td>Default value</td>
<td>512.00KiB</td>
</tr>
</tbody>
</table>

Table 322. dbms.memory.off_heap.max_size
### dbms.memory.off_heap.max_size

**Description**
The maximum amount of off-heap memory that can be used to store transaction state data; it's a total amount of memory shared across all active transactions. Zero means 'unlimited'. Used when `dbms.tx_state.memory_allocation` is set to 'OFF_HEAP'.

**Valid values**
dbms.memory.off_heap.max_size, a byte size (valid multipliers are B, KiB, KB, K, kB, kb, k, MiB, MB, M, mB, mb, m, GiB, GB, G, gB, gb, g, TiB, TB, PiB, PB, EiB, EB) which is minimum 0B

**Default value**
2.00GiB

---

### dbms.memory.pagecache.directio

**Description**
Use direct I/O for page cache. Setting is supported only on Linux and only for a subset of record formats that use platform aligned page size.

**Valid values**
dbms.memory.pagecache.directio, a boolean

**Default value**
false

---

### dbms.memory.pagecache.flush.buffer.enabled

**Description**
Page cache can be configured to use a temporal buffer for flushing purposes. It is used to combine, if possible, sequence of several cache pages into one bigger buffer to minimize the number of individual IOPS performed and better utilization of available I/O resources, especially when those are restricted.

**Valid values**
dbms.memory.pagecache.flush.buffer.enabled, a boolean

**Dynamic**
true

**Default value**
false

---

### dbms.memory.pagecache.flush.buffer.size_in_pages

**Description**
Page cache can be configured to use a temporal buffer for flushing purposes. It is used to combine, if possible, sequence of several cache pages into one bigger buffer to minimize the number of individual IOPS performed and better utilization of available I/O resources, especially when those are restricted. Use this setting to configure individual file flush buffer size in pages (8KiB). To be able to utilize this buffer during page cache flushing, buffered flush should be enabled.

**Valid values**
dbms.memory.pagecache.flush.buffer.size_in_pages, an integer which is in the range 1 to 512
## Table 326. `dbms.memory.pagecache.scan.prefetchers`

**Description**

The maximum number of worker threads to use for pre-fetching data when doing sequential scans. Set to '0' to disable pre-fetching for scans.

**Valid values**

`dbms.memory.pagecache.scan.prefetchers`, an integer which is in the range 0 to 255

**Default value**

4

## Table 327. `dbms.memory.pagecache.size`

**Description**

The amount of memory to use for mapping the store files, in bytes (or kilobytes with the 'k' suffix, megabytes with 'm' and gigabytes with 'g'). If Neo4j is running on a dedicated server, then it is generally recommended to leave about 2-4 gigabytes for the operating system, give the JVM enough heap to hold all your transaction state and query context, and then leave the rest for the page cache. If no page cache memory is configured, then a heuristic setting is computed based on available system resources.

**Valid values**

`dbms.memory.pagecache.size`, a string

## Table 328. `dbms.memory.pagecache.swapper`

**Description**

This setting is not used anymore.

**Valid values**

`dbms.memory.pagecache.swapper`, a string

**Deprecated**

The `dbms.memory.pagecache.swapper` configuration setting has been deprecated.

## Table 329. `dbms.memory.pagecache.warmup.enable`

**Description**

Page cache can be configured to perform usage sampling of loaded pages that can be used to construct active load profile. According to that profile pages can be reloaded on the restart, replication, etc. This setting allows disabling that behavior. This feature is available in Neo4j Enterprise Edition.

**Valid values**

`dbms.memory.pagecache.warmup.enable`, a boolean

**Default value**

true

## Table 330. `dbms.memory.pagecache.warmup.preload`
Page cache warmup can be configured to prefetch files, preferably when cache size is bigger than store size. Files to be prefetched can be filtered by 'dbms.memory.pagecache.warmup.preload.allowlist'. Enabling this disables warmup by profile.

<table>
<thead>
<tr>
<th>Description</th>
<th>Page cache warmup prefetch file allowlist regex. By default matches all files.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.memory.pagecache.warmup.preload.allowlist, a string</td>
</tr>
<tr>
<td>Default value</td>
<td>.*</td>
</tr>
</tbody>
</table>

Table 331. dbms.memory.pagecache.warmup.preload.allowlist

Page cache warmup prefetch file whitelist regex. By default matches all files. Deprecated, use 'dbms.memory.pagecache.warmup.preload.allowlist'.

Table 332. dbms.memory.pagecache.warmup.preload.whitelist

The dbms.memory.pagecache.warmup.preload.whitelist configuration setting has been deprecated.

<table>
<thead>
<tr>
<th>Description</th>
<th>Page cache warmup prefetch file whitelist regex. By default matches all files.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.memory.pagecache.warmup.preload.whitelist, a string</td>
</tr>
<tr>
<td>Default value</td>
<td>.*</td>
</tr>
<tr>
<td>Deprecated</td>
<td>The dbms.memory.pagecache.warmup.preload.whitelist configuration setting has been deprecated.</td>
</tr>
</tbody>
</table>

The profiling frequency for the page cache. Accurate profiles allow the page cache to do active warmup after a restart, reducing the mean time to performance. This feature is available in Neo4j Enterprise Edition.

Table 333. dbms.memory.pagecache.warmup.profile.interval

<table>
<thead>
<tr>
<th>Description</th>
<th>The profiling frequency for the page cache. Accurate profiles allow the page cache to do active warmup after a restart, reducing the mean time to performance. This feature is available in Neo4j Enterprise Edition.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.memory.pagecache.warmup.profile.interval, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)</td>
</tr>
<tr>
<td>Default value</td>
<td>1m</td>
</tr>
</tbody>
</table>

Table 334. dbms.memory.tracking.enable

Enable off heap and on heap memory tracking. Should not be set to false for clusters.
<table>
<thead>
<tr>
<th>Valid values</th>
<th>dbms.memory.tracking.enable, a boolean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default value</td>
<td>true</td>
</tr>
</tbody>
</table>

**Table 335. dbms.memory.transaction.database_max_size**

<table>
<thead>
<tr>
<th>Description</th>
<th>Limit the amount of memory that all transactions in one database can consume, in bytes (or kilobytes with the 'k' suffix, megabytes with 'm' and gigabytes with 'g'). Zero means 'unlimited'.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.memory.transaction.database_max_size, a byte size (valid multipliers are B, KiB, KB, k, kb, k, MiB, MB, M, mb, m, GiB, GB, G, gb, g, TiB, TB, PiB, PB, EiB, EB) which is minimum 10.00MiB or is 0B</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td>0B</td>
</tr>
</tbody>
</table>

**Table 336. dbms.memory.transaction.global_max_size**

<table>
<thead>
<tr>
<th>Description</th>
<th>Limit the amount of memory that all of the running transactions can consume, in bytes (or kilobytes with the 'k' suffix, megabytes with 'm' and gigabytes with 'g'). Zero means 'unlimited'.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.memory.transaction.global_max_size, a byte size (valid multipliers are B, KiB, KB, k, kb, k, MiB, MB, M, mb, m, GiB, GB, G, gb, g, TiB, TB, PiB, PB, EiB, EB) which is minimum 10.00MiB or is 0B</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td>0B</td>
</tr>
</tbody>
</table>

**Table 337. dbms.memory.transaction.max_size**

<table>
<thead>
<tr>
<th>Description</th>
<th>Limit the amount of memory that a single transaction can consume, in bytes (or kilobytes with the 'k' suffix, megabytes with 'm' and gigabytes with 'g'). Zero means 'largest possible value'. When dbms.mode=CORE or dbms.mode=SINGLE and dbms.clustering.enable=true this is '2G', in other cases this is 'unlimited'.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.memory.transaction.max_size, a byte size (valid multipliers are B, KiB, KB, k, kb, k, MiB, MB, M, mb, m, GiB, GB, G, gb, g, TiB, TB, PiB, PB, EiB, EB) which is minimum 10.00MiB or is 0B</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td>0B</td>
</tr>
</tbody>
</table>
Valid values  
dbms.memory.transaction.max_size, a byte size (valid multipliers are \(B\), \(KiB\), \(KB\), \(kB\), \(k\), \(MiB\), \(MB\), \(mB\), \(m\), \(GiB\), \(GB\), \(gB\), \(g\), \(TiB\), \(TB\), \(PiB\), \(PB\), \(EiB\), \(EB\)) which is minimum 1.00MiB or is 0B and depends on dbms.mode. If dbms.mode one of [CORE] then it is maximum 2.00GiB otherwise it depends on dbms.mode. If dbms.mode one of [SINGLE] then it depends on dbms.clustering.enable. If dbms.clustering.enable is true then it is maximum 2.00GiB otherwise it is unconstrained. otherwise it is unconstrained.

| Dynamic | true |

| Default value | 0B |

Table 338. dbms.mode

| Description | Configure the operating mode of the database — ‘SINGLE’ for stand-alone operation, ‘CORE’ for operating as a core member of a Causal Cluster, or ‘READ_REPLICA’ for operating as a read replica member of a Causal Cluster. Only SINGLE mode is allowed in Community. |

| Valid values | dbms.mode, one of [SINGLE, CORE, READ_REPLICA] |

| Default value | SINGLE |

Table 339. dbms.netty.ssl.provider

| Description | Netty SSL provider. |

| Valid values | dbms.netty.ssl.provider, one of [JDK, OPENSSL, OPENSSL_REFCNT] |

| Default value | JDK |

Table 340. dbms.panic.shutdown_on_panic

| Description | If there is a Database Management System Panic (an irrecoverable error) should the neo4j process shut down or continue running. Following a DbMS panic it is likely that a significant amount of functionality will be lost. Recovering full functionality will require a Neo4j restart. This feature is available in Neo4j Enterprise Edition. |

| Valid values | dbms.panic.shutdown_on_panic, a boolean |

| Default value | false except for Neo4j Enterprise Edition deployments running on Kubernetes where it is true. |

Table 341. dbms.query_cache_size
The number of cached Cypher query execution plans per database. The max number of query plans that can be kept in cache is the number of databases * \texttt{dbms.query_cache_size}. With 10 databases and \texttt{dbms.query_cache_size}=1000, the caches can keep 10000 plans in total on the instance, assuming that each DB receives queries that fill up its cache.

| Valid values | \texttt{dbms.query_cache_size}, an integer which is minimum 0 |
| Default value | 1000 |

Table 342. \texttt{dbms.read_only}

| Description | Only allow read operations from this Neo4j instance. This mode still requires write access to the directory for lock purposes. Replaced by: \texttt{dbms.databases.default_to_read_only}, \texttt{dbms.databases.read_only}, \texttt{dbms.databases.writable}. |
| Valid values | \texttt{dbms.read_only}, a boolean |
| Default value | \texttt{false} |
| Deprecated | The \texttt{dbms.read_only} configuration setting has been deprecated. |

Table 343. \texttt{dbms.reconciler.max_backoff}

| Description | Defines the maximum amount of time to wait before retrying after the dbms fails to reconcile a database to its desired state. |
| Valid values | \texttt{dbms.reconciler.max_backoff}, a duration (Valid units are: \texttt{ns}, \texttt{μs}, \texttt{ms}, \texttt{s}, \texttt{m}, \texttt{h} and \texttt{d}; default unit is \texttt{s}) which is minimum \texttt{1m} |
| Default value | \texttt{1h} |

Table 344. \texttt{dbms.reconciler.max_parallelism}

| Description | Defines the level of parallelism employed by the reconciler. By default the parallelism equals the number of available processors or 8 (whichever is smaller). If configured as 0, the parallelism of the reconciler will be unbounded. |
| Valid values | \texttt{dbms.reconciler.max_parallelism}, an integer which is minimum 0 |
| Default value | 8 |

Table 345. \texttt{dbms.reconciler.may_retry}
<table>
<thead>
<tr>
<th>Description</th>
<th>Defines whether the dbms may retry reconciling a database to its desired state.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Valid values</strong></td>
<td><strong>dbms.reconciler.may_retry</strong>, a boolean</td>
</tr>
<tr>
<td><strong>Default value</strong></td>
<td><strong>false</strong></td>
</tr>
</tbody>
</table>

Table 346. dbms.reconciler.min_backoff

<table>
<thead>
<tr>
<th>Description</th>
<th>Defines the minimum amount of time to wait before retrying after the dbms fails to reconcile a database to its desired state.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Valid values</strong></td>
<td><strong>dbms.reconciler.min_backoff</strong>, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s) which is minimum 1s</td>
</tr>
<tr>
<td><strong>Default value</strong></td>
<td><strong>2s</strong></td>
</tr>
</tbody>
</table>

Table 347. dbms.record_format

<table>
<thead>
<tr>
<th>Description</th>
<th>Database record format. Valid values are blank(no value, default), standard, aligned, or high_limit. Specifying a value will force new databases to that format and existing databases to migrate if dbms.allow_upgrade=true is specified. The aligned format is essentially the standard format with some minimal padding at the end of pages such that a single record will never cross a page boundary. The high_limit format is available for Enterprise Edition only. It is required if you have a graph that is larger than 34 billion nodes, 34 billion relationships, or 68 billion properties. A change of the record format is irreversible. Certain operations may suffer from a performance penalty of up to 10%, which is why this format is not switched on by default. However, if you want to change the configured record format value, you must also set dbms.allow_upgrade=true, because the setting implies a one-way store format migration.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Valid values</strong></td>
<td><strong>dbms.record_format</strong>, a string</td>
</tr>
<tr>
<td><strong>Default value</strong></td>
<td>Blank (no value). New databases will use aligned. Existing databases will stay on their current format</td>
</tr>
</tbody>
</table>

Table 348. dbms.recovery.fail_on_missing_files

<table>
<thead>
<tr>
<th>Description</th>
<th>If true, Neo4j will abort recovery if transaction log files are missing. Setting this to false will allow Neo4j to create new empty missing files for the already existing database, but the integrity of the database might be compromised.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Valid values</strong></td>
<td><strong>dbms.recovery.fail_on_missing_files</strong>, a boolean</td>
</tr>
<tr>
<td><strong>Default value</strong></td>
<td><strong>true</strong></td>
</tr>
</tbody>
</table>

Table 349. dbms.relationship_grouping_threshold
<table>
<thead>
<tr>
<th>Table 350. dbms.relationship_grouping_threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 350. dbms.rest.transaction.idle_timeout</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 351. dbms.routing.advertised_address</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 352. dbms.routing.client_side.enforce_for_domains</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Dynamic</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 353. dbms.routing.default_router</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>
Table 354. dbms.routing.driver.api

<table>
<thead>
<tr>
<th>Description</th>
<th>dbms.routing.driver.api will be used. ASYNC must be used when the remote instance is 3.5.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.routing.driver.api, one of [RX, ASYNC]</td>
</tr>
<tr>
<td>Default value</td>
<td>RX</td>
</tr>
</tbody>
</table>

Table 355. dbms.routing.driver.connection.connect_timeout

<table>
<thead>
<tr>
<th>Description</th>
<th>Socket connection timeout. A timeout of zero is treated as an infinite timeout and will be bound by the timeout configured on the operating system level.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.routing.driver.connection.connect_timeout, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)</td>
</tr>
<tr>
<td>Default value</td>
<td>5s</td>
</tr>
</tbody>
</table>

Table 356. dbms.routing.driver.connection.max_lifetime

<table>
<thead>
<tr>
<th>Description</th>
<th>Pooled connections older than this threshold will be closed and removed from the pool. Setting this option to a low value will cause a high connection churn and might result in a performance hit. It is recommended to set maximum lifetime to a slightly smaller value than the one configured in network equipment (load balancer, proxy, firewall, etc. can also limit maximum connection lifetime). Zero and negative values result in lifetime not being checked.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.routing.driver.connection.max_lifetime, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)</td>
</tr>
<tr>
<td>Default value</td>
<td>1h</td>
</tr>
</tbody>
</table>

Table 357. dbms.routing.driver.connection.pool.acquisition_timeout

<table>
<thead>
<tr>
<th>Description</th>
<th>Maximum amount of time spent attempting to acquire a connection from the connection pool. This timeout only kicks in when all existing connections are being used and no new connections can be created because maximum connection pool size has been reached. Error is raised when connection can’t be acquired within configured time. Negative values are allowed and result in unlimited acquisition timeout. Value of 0 is allowed and results in no timeout and immediate failure when connection is unavailable.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.routing.driver.connection.pool.acquisition_timeout, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)</td>
</tr>
<tr>
<td>Default value</td>
<td>1m</td>
</tr>
</tbody>
</table>
Table 358. `dbms.routing.driver.connection.pool.idle_test`

<table>
<thead>
<tr>
<th>Description</th>
<th>Pooled connections that have been idle in the pool for longer than this timeout will be tested before they are used again, to ensure they are still alive. If this option is set too low, an additional network call will be incurred when acquiring a connection, which causes a performance hit. If this is set high, no longer live connections might be used which might lead to errors. Hence, this parameter tunes a balance between the likelihood of experiencing connection problems and performance. Normally, this parameter should not need tuning. Value 0 means connections will always be tested for validity.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.routing.driver.connection.pool.idle_test</code>, a duration (Valid units are: ns, µs, ms, s, m, h and d; default unit is s)</td>
</tr>
<tr>
<td>Default value</td>
<td>No connection liveliness check is done by default.</td>
</tr>
</tbody>
</table>

Table 359. `dbms.routing.driver.connection.pool.max_size`

<table>
<thead>
<tr>
<th>Description</th>
<th>Maximum total number of connections to be managed by a connection pool. The limit is enforced for a combination of a host and user. Negative values are allowed and result in unlimited pool. Value of 0 is not allowed.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.routing.driver.connection.pool.max_size</code>, an integer</td>
</tr>
<tr>
<td>Default value</td>
<td>Unlimited</td>
</tr>
</tbody>
</table>

Table 360. `dbms.routing.driver.logging.level`

<table>
<thead>
<tr>
<th>Description</th>
<th>Sets level for driver internal logging.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.routing.driver.logging.level</code>, one of [DEBUG, INFO, WARN, ERROR, NONE]</td>
</tr>
<tr>
<td>Default value</td>
<td>Value of <code>dbms.logs.debug.level</code></td>
</tr>
</tbody>
</table>

Table 361. `dbms.routing.enabled`

<table>
<thead>
<tr>
<th>Description</th>
<th>Enable intra-cluster routing using an additional bolt connector.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.routing.enabled</code>, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td><code>false</code></td>
</tr>
</tbody>
</table>

Table 362. `dbms.routing.listen_address`

| Description | The address the routing connector should bind to. |
Valid values: `dbms.routing.listen_address`, a socket address in the format 'hostname:port', 'hostname' or ':port'. If missing port or hostname it is acquired from `dbms.default_listen_address`

**Default value:** :7688

### Table 363. `dbms.routing_ttl`

<table>
<thead>
<tr>
<th>Description</th>
<th>How long callers should cache the response of the routing procedure <code>dbms.routing.getRoutingTable()</code></th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.routing_ttl</code>, a duration (Valid units are: <code>ns</code>, <code>μs</code>, <code>ms</code>, <code>s</code>, <code>m</code>, <code>h</code> and <code>d</code>; default unit is <code>s</code>) which is minimum 1s</td>
</tr>
<tr>
<td>Default value</td>
<td>5m</td>
</tr>
</tbody>
</table>

### Table 364. `dbms.security.allow_csv_import_from_file_urls`

<table>
<thead>
<tr>
<th>Description</th>
<th>Determines if Cypher will allow using file URLs when loading data using <code>LOAD CSV</code>. Setting this value to <code>false</code> will cause Neo4j to fail <code>LOAD CSV</code> clauses that load data from the file system.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.security.allow_csv_import_from_file_urls</code>, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td><code>true</code></td>
</tr>
</tbody>
</table>

### Table 365. `dbms.security.auth_cache_max_capacity`

<table>
<thead>
<tr>
<th>Description</th>
<th>The maximum capacity for authentication and authorization caches (respectively).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.security.auth_cache_max_capacity</code>, an integer</td>
</tr>
<tr>
<td>Default value</td>
<td>10000</td>
</tr>
</tbody>
</table>

### Table 366. `dbms.security.auth_cache_ttl`

<table>
<thead>
<tr>
<th>Description</th>
<th>The time to live (TTL) for cached authentication and authorization info when using external auth providers (LDAP or plugin). Setting the TTL to 0 will disable auth caching. Disabling caching while using the LDAP auth provider requires the use of an LDAP system account for resolving authorization information.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.security.auth_cache_ttl</code>, a duration (Valid units are: <code>ns</code>, <code>μs</code>, <code>ms</code>, <code>s</code>, <code>m</code>, <code>h</code> and <code>d</code>; default unit is <code>s</code>)</td>
</tr>
<tr>
<td>Default value</td>
<td>10m</td>
</tr>
</tbody>
</table>

### Table 367. `dbms.security.auth_cache_use_ttl`

---

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<table>
<thead>
<tr>
<th>Description</th>
<th>Enable time-based eviction of the authentication and authorization info cache for external auth providers (LDAP or plugin). Disabling this setting will make the cache live forever and only be evicted when <code>dbms.security.auth_cache_max_capacity</code> is exceeded.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.security.auth_cache_use_ttl</code>, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td><code>true</code></td>
</tr>
</tbody>
</table>

Table 368. `dbms.security.auth_enabled`

<table>
<thead>
<tr>
<th>Description</th>
<th>Enable auth requirement to access Neo4j.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.security.auth_enabled</code>, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td><code>true</code></td>
</tr>
</tbody>
</table>

Table 369. `dbms.security.auth_lock_time`

<table>
<thead>
<tr>
<th>Description</th>
<th>The amount of time user account should be locked after a configured number of unsuccessful authentication attempts. The locked out user will not be able to log in until the lock period expires, even if correct credentials are provided. Setting this configuration option to a low value is not recommended because it might make it easier for an attacker to brute force the password.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.security.auth_lock_time</code>, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s) which is minimum 0s</td>
</tr>
<tr>
<td>Default value</td>
<td>5s</td>
</tr>
</tbody>
</table>

Table 370. `dbms.security.auth_max_failed_attempts`

<table>
<thead>
<tr>
<th>Description</th>
<th>The maximum number of unsuccessful authentication attempts before imposing a user lock for the configured amount of time, as defined by <code>dbms.security.auth_lock_time</code>. The locked out user will not be able to log in until the lock period expires, even if correct credentials are provided. Setting this configuration option to values less than 3 is not recommended because it might make it easier for an attacker to brute force the password.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.security.auth_max_failed_attempts</code>, an integer which is minimum 0</td>
</tr>
<tr>
<td>Default value</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 371. `dbms.security.authentication_providers`
### dbms.security.authentication_providers

**Description**
A list of security authentication providers containing the users and roles. This can be any of the built-in native or ldap providers, or it can be an externally provided plugin, with a custom name prefixed by plugin-<AUTH_PROVIDER_NAME>. They will be queried in the given order when login is attempted.

**Valid values**
dbms.security.authentication_providers, a ',' separated list with elements of type 'a string'.

**Default value**
native

#### Table 372. dbms.security.authorization_providers

**Description**
A list of security authorization providers containing the users and roles. This can be any of the built-in native or ldap providers, or it can be an externally provided plugin, with a custom name prefixed by plugin-<AUTH_PROVIDER_NAME>. They will be queried in the given order when login is attempted.

**Valid values**
dbms.security.authorization_providers, a ',' separated list with elements of type 'a string'.

**Default value**
native

#### Table 373. dbms.security.causal_clustering_status_auth_enabled

**Description**
Require authorization for access to the Causal Clustering status endpoints.

**Valid values**
dbms.security.causal_clustering_status_auth_enabled, a boolean

**Default value**
true

#### Table 374. dbms.security.http_access_control_allow_origin

**Description**
Value of the Access-Control-Allow-Origin header sent over any HTTP or HTTPS connector. This defaults to '*', which allows broadest compatibility. Note that any URI provided here limits HTTP/HTTPS access to that URI only.

**Valid values**
dbms.security.http_access_control_allow_origin, a string

**Default value**
*

#### Table 375. dbms.security.http_auth_allowlist

**Description**
Defines an allowlist of http paths where Neo4j authentication is not required.

**Valid values**
dbms.security.http_auth_allowlist, a ',' separated list with elements of type 'a string'.

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### Table 376. `dbms.security.http_auth_whitelist`  
**Description**  
Defines a whitelist of http paths where Neo4j authentication is not required. Deprecated, use `dbms.security.http_auth_allowlist`  
**Valid values**  
`dbms.security.http_auth_whitelist`, a ',' separated list with elements of type 'a string'.  
**Default value**  
`/','browser.*`  
**Deprecated**  
The `dbms.security.http_auth_whitelist` configuration setting has been deprecated.

### Table 377. `dbms.security.http_strict_transport_security`  
**Description**  
Value of the HTTP Strict-Transport-Security (HSTS) response header. This header tells browsers that a webpage should only be accessed using HTTPS instead of HTTP. It is attached to every HTTPS response. Setting is not set by default so 'Strict-Transport-Security' header is not sent. Value is expected to contain directives like 'max-age', 'includeSubDomains' and 'preload'.  
**Valid values**  
`dbms.security.http_strict_transport_security`, a string

### Table 378. `dbms.security.ldap.authentication.attribute`  
**Description**  
The attribute to use when looking up users. Using this setting requires `dbms.security.ldap.authentication.search_for_attribute` to be true and thus `dbms.security.ldap.authorization.system_username` and `dbms.security.ldap.authorization.system_password` to be configured.  
**Valid values**  
`dbms.security.ldap.authentication.attribute`, a string which matches the pattern `[A-Za-z0-9-]*` (has to be a valid LDAP attribute name, only containing letters [A-Za-z], digits [0-9] and hyphens [-].)  
**Dynamic**  
true  
**Default value**  
samaccountname

### Table 379. `dbms.security.ldap.authentication.cache_enabled`
<table>
<thead>
<tr>
<th>Description</th>
<th>Determines if the result of authentication via the LDAP server should be cached or not. Caching is used to limit the number of LDAP requests that have to be made over the network for users that have already been authenticated successfully. A user can be authenticated against an existing cache entry (instead of via an LDAP server) as long as it is alive (see <code>dbms.security.auth_cache_ttl</code>). An important consequence of setting this to <code>true</code> is that Neo4j then needs to cache a hashed version of the credentials in order to perform credentials matching. This hashing is done using a cryptographic hash function together with a random salt. Preferably a conscious decision should be made if this method is considered acceptable by the security standards of the organization in which this Neo4j instance is deployed.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.security.ldap.authentication.cache_enabled</code>, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td><code>true</code></td>
</tr>
</tbody>
</table>

**Table 380. dbms.security.ldap.authentication.mechanism**

<table>
<thead>
<tr>
<th>Description</th>
<th>LDAP authentication mechanism. This is one of <code>simple</code> or a SASL mechanism supported by JNDI, for example <code>DIGEST-MD5</code>. <code>simple</code> is basic username and password authentication and SASL is used for more advanced mechanisms. See RFC 2251 LDAPv3 documentation for more details.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.security.ldap.authentication.mechanism</code>, a string</td>
</tr>
<tr>
<td>Default value</td>
<td><code>simple</code></td>
</tr>
</tbody>
</table>

**Table 381. dbms.security.ldap.authentication.search_for_attribute**

<table>
<thead>
<tr>
<th>Description</th>
<th>Perform authentication by searching for an unique attribute of a user. Using this setting requires <code>dbms.security.ldap.authorization.system_username</code> and <code>dbms.security.ldap.authorization.system_password</code> to be configured.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.security.ldap.authentication.search_for_attribute</code>, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td><code>false</code></td>
</tr>
</tbody>
</table>

**Table 382. dbms.security.ldap.authentication.use_samaccountname**

<table>
<thead>
<tr>
<th>Description</th>
<th>Perform authentication by searching for an unique attribute of a user. This setting is deprecated and has been replaced with <code>dbms.security.ldap.authentication.search_for_attribute</code>.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.security.ldap.authentication.use_samaccountname</code>, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td><code>false</code></td>
</tr>
</tbody>
</table>
The `dbms.security.ldap.authentication.use_samaccountname` configuration setting has been deprecated.

Table 383. `dbms.security.ldap.authentication.user_dn_template`  
<table>
<thead>
<tr>
<th>Description</th>
<th>LDAP user DN template. An LDAP object is referenced by its distinguished name (DN), and a user DN is an LDAP fully-qualified unique user identifier. This setting is used to generate an LDAP DN that conforms with the LDAP directory’s schema from the user principal that is submitted with the authentication token when logging in. The special token <code>{0}</code> is a placeholder where the user principal will be substituted into the DN string.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.security.ldap.authentication.user_dn_template</code>, a string which Must be a string containing <code>{0}</code> to understand where to insert the runtime authentication principal.</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td><code>uid={0},ou=users,dc=example,dc=com</code></td>
</tr>
</tbody>
</table>

Table 384. `dbms.security.ldap.authorization.access_permitted_group`  
<table>
<thead>
<tr>
<th>Description</th>
<th>The LDAP group to which a user must belong to get any access to the system. Set this to restrict access to a subset of LDAP users belonging to a particular group. If this is not set, any user to successfully authenticate via LDAP will have access to the PUBLIC role and any other roles assigned to them via <code>dbms.security.ldap.authorization.group_to_role_mapping</code>.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.security.ldap.authorization.access_permitted_group</code>, a string</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td></td>
</tr>
</tbody>
</table>

Table 385. `dbms.security.ldap.authorization.group_membership_attributes`  
<table>
<thead>
<tr>
<th>Description</th>
<th>A list of attribute names on a user object that contains groups to be used for mapping to roles when LDAP authorization is enabled.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.security.ldap.authorization.group_membership_attributes</code>, a ',' separated list with elements of type 'a string'. which Can not be empty</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td><code>memberOf</code></td>
</tr>
</tbody>
</table>
### Table 386. `dbms.security.ldap.authorization.group_to_role_mapping`

<table>
<thead>
<tr>
<th>Description</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>An authorization mapping from LDAP group names to Neo4j role names. The map</td>
<td>should be formatted as a semicolon separated list of key-value pairs, where the key is the LDAP group</td>
</tr>
<tr>
<td>should be formatted as a semicolon separated list of key-value pairs, where</td>
<td>name and the value is a comma separated list of corresponding role names. For example: group1=role1;</td>
</tr>
<tr>
<td>the key is the LDAP group name and the value is a comma separated list of</td>
<td>group2=role2;group3=role3,role4,role5 You could also use whitespaces and quotes around group names to</td>
</tr>
<tr>
<td>corresponding role names. For example: group1=role1;group2=role2;group3=role3,</td>
<td>make this mapping more readable, for example:</td>
</tr>
<tr>
<td>role4,role5 You could also use whitespaces and quotes around group names to</td>
<td></td>
</tr>
<tr>
<td>make this mapping more readable, for example:</td>
<td></td>
</tr>
</tbody>
</table>
|                                                                            | `dbms.security.ldap.authorization.group_to_role_mapping=
|                                                                            | "cn=Neo4j Read Only,cn=users,dc=example,dc=com" = reader; \                                         |
|                                                                            | "cn=Neo4j Read-Write,cn=users,dc=example,dc=com" = publisher; \                                      |
|                                                                            | "cn=Neo4j Schema Manager,cn=users,dc=example,dc=com" = architect; \                                 |
|                                                                            | "cn=Neo4j Administrator,cn=users,dc=example,dc=com" = admin                                           |

<table>
<thead>
<tr>
<th>Valid values</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><code>dbms.security.ldap.authorization.group_to_role_mapping</code>, a string which must</td>
<td>besemicolon separated list of key-value pairs or empty</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dynamic</th>
<th>true</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Default value</th>
<th></th>
</tr>
</thead>
</table>

### Table 387. `dbms.security.ldap.authorization.system_password`

<table>
<thead>
<tr>
<th>Description</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>An LDAP system account password to use for authorization searches when</td>
<td></td>
</tr>
<tr>
<td><code>dbms.security.ldap.authorization.use_system_account</code> is true.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Valid values</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><code>dbms.security.ldap.authorization.system_password</code>, a secure string</td>
<td></td>
</tr>
</tbody>
</table>

### Table 388. `dbms.security.ldap.authorization.system_username`

<table>
<thead>
<tr>
<th>Description</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>An LDAP system account username to use for authorization searches when</td>
<td></td>
</tr>
<tr>
<td><code>dbms.security.ldap.authorization.use_system_account</code> is true. Note that the</td>
<td><code>dbms.security.ldap.authentication.user_dn_template</code> will not be applied to this username, so you</td>
</tr>
<tr>
<td><code>dbms.security.ldap.authentication.user_dn_template</code> will not be applied to</td>
<td>may have to specify a full DN.</td>
</tr>
<tr>
<td>this username, so you may have to specify a full DN.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Valid values</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><code>dbms.security.ldap.authorization.system_username</code>, a string</td>
<td></td>
</tr>
</tbody>
</table>

### Table 389. `dbms.security.ldap.authorization.use_system_account`

<table>
<thead>
<tr>
<th>Description</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Perform LDAP search for authorization info using a system account instead of the user’s own account. If this is set to `false` (default), the search for group membership will be performed directly after authentication using the LDAP context bound with the user’s own account. The mapped roles will be cached for the duration of `dbms.security.auth_cache_ttl`, and then expire, requiring re-authentication. To avoid frequently having to re-authenticate sessions you may want to set a relatively long auth cache expiration time together with this option. NOTE: This option will only work if the users are permitted to search for their own group membership attributes in the directory. If this is set to `true`, the search will be performed using a special system account user with read access to all the users in the directory. You need to specify the username and password using the settings `dbms.security.ldap.authorization.system_username` and `dbms.security.ldap.authorization.system_password` with this option. Note that this account only needs read access to the relevant parts of the LDAP directory and does not need to have access rights to Neo4j, or any other systems.

| Valid values | `dbms.security.ldap.authorization.use_system_account`, a boolean |
| Default value | `false` |

Table 390. `dbms.security.ldap.authorization.user_search_base`

| Description | The name of the base object or named context to search for user objects when LDAP authorization is enabled. A common case is that this matches the last part of `dbms.security.ldap.authentication.user_dn_template`. |
| Valid values | `dbms.security.ldap.authorization.user_search_base`, a string which Can not be empty |
| Dynamic | true |
| Default value | `ou=users,dc=example,dc=com` |

Table 391. `dbms.security.ldap.authorization.user_search_filter`

| Description | The LDAP search filter to search for a user principal when LDAP authorization is enabled. The filter should contain the placeholder token `{0}` which will be substituted for the user principal. |
| Valid values | `dbms.security.ldap.authorization.user_search_filter`, a string |
| Dynamic | true |
| Default value | `(&(objectClass=*)(uid={0}))` |

Table 392. `dbms.security.ldap.connection_timeout`
The timeout for establishing an LDAP connection. If a connection with the LDAP server cannot be established within the given time the attempt is aborted. A value of 0 means to use the network protocol’s (i.e., TCP’s) timeout value.

**Valid values**
dbms.security.ldap.connection_timeout, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)

**Default value** 30s

**Table 393. dbms.security.ldap.host**

URL of LDAP server to use for authentication and authorization. The format of the setting is `<protocol>://<hostname>:<port>`, where hostname is the only required field. The supported values for protocol are ldap (default) and ldaps. The default port for ldap is 389 and for ldaps 636. For example: ldaps://ldap.example.com:10389. You may want to consider using STARTTLS (dbms.security.ldap.use_starttls) instead of LDAPS for secure connections, in which case the correct protocol is ldap.

**Valid values** dbms.security.ldap.host, a string

**Default value** localhost

**Table 394. dbms.security.ldap.read_timeout**

The timeout for an LDAP read request (i.e. search). If the LDAP server does not respond within the given time the request will be aborted. A value of 0 means wait for a response indefinitely.

**Valid values** dbms.security.ldap.read_timeout, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)

**Default value** 30s

**Table 395. dbms.security.ldap.referral**

The LDAP referral behavior when creating a connection. This is one of follow, ignore or throw. * follow automatically follows any referrals * ignore ignores any referrals * throw throws an exception, which will lead to authentication failure.

**Valid values** dbms.security.ldap.referral, a string

**Default value** follow

**Table 396. dbms.security.ldap.use_starttls**
Use secure communication with the LDAP server using opportunistic TLS. First an initial insecure connection will be made with the LDAP server, and a STARTTLS command will be issued to negotiate an upgrade of the connection to TLS before initiating authentication.

<table>
<thead>
<tr>
<th>Valid values</th>
<th>dbms.security.ldap.use_starttls, a boolean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default value</td>
<td>false</td>
</tr>
</tbody>
</table>

Table 397. dbms.security.log_successful_authentication

Set to log successful authentication events to the security log. If this is set to false only failed authentication events will be logged, which could be useful if you find that the successful events spam the logs too much, and you do not require full auditing capability.

<table>
<thead>
<tr>
<th>Valid values</th>
<th>dbms.security.log_successful_authentication, a boolean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default value</td>
<td>true</td>
</tr>
</tbody>
</table>

Table 398. dbms.security.oidc.<provider>.audience

Expected values of the Audience (aud) claim in the id token.

<table>
<thead>
<tr>
<th>Valid values</th>
<th>dbms.security.oidc.&lt;provider&gt;.audience, a ',' separated list with elements of type 'a string'. which Can not be empty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
</tbody>
</table>

Table 399. dbms.security.oidc.<provider>.auth_endpoint

The OIDC authorization endpoint. If this is not supplied Neo4j will attempt to discover it from the well_known_discovery_uri.

<table>
<thead>
<tr>
<th>Valid values</th>
<th>dbms.security.oidc.&lt;provider&gt;.auth_endpoint, a URI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
</tbody>
</table>

Table 400. dbms.security.oidc.<provider>.auth_flow

The OIDC flow to use. This is exposed to clients via the discovery endpoint.

<table>
<thead>
<tr>
<th>Valid values</th>
<th>dbms.security.oidc.&lt;provider&gt;.auth_flow, one of [PKCE, IMPLICIT]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>---------</td>
<td>------</td>
</tr>
<tr>
<td>Default value</td>
<td>PKCE</td>
</tr>
</tbody>
</table>

Table 401. `dbms.security.oidc.<provider>.auth_params`

**Description**
Optional additional configuration options used for the authentication request. The map is a semicolon separated list of key-value pairs. For example: `k1=v1;k2=v2`.

**Valid values**
`dbms.security.oidc.<provider>.auth_params`, A simple key value map pattern `k1=v1;k2=v2`

**Dynamic**
true

**Default value**
`
`

Table 402. `dbms.security.oidc.<provider>.authorization.group_to_role_mapping`

**Description**
An authorization mapping from IdP group names to Neo4j role names. The map should be formatted as a semicolon separated list of key-value pairs, where the key is the IdP group name and the value is a comma separated list of corresponding role names. For example: `group1=role1;group2=role2;group3=role3,role4,role5` You could also use whitespaces and quotes around group names to make this mapping more readable, for example:

```python
dbms.security.oidc.<provider>.authorization.group_to_role_mapping="\n"Neo4j Read Only" = reader; \n"Neo4j Read-Write" = publisher; \n"Neo4j Schema Manager" = architect; \n"Neo4j Administrator" = admin
```

**Valid values**
`dbms.security.oidc.<provider>.authorization.group_to_role_mapping`, a string which must be semicolon separated list of key-value pairs or empty

**Dynamic**
true

Table 403. `dbms.security.oidc.<provider>.claims.groups`

**Description**
The claim to use as the list of groups in Neo4j. These could be Neo4j roles directly, or can be mapped using `dbms.security.oidc.<provider>.authorization.group_to_role_mapping`.

**Valid values**
`dbms.security.oidc.<provider>.claims.groups`, a string

**Dynamic**
true
**Table 404. dbms.security.oidc.<provider>.claims.username**

<table>
<thead>
<tr>
<th>Description</th>
<th>The claim to use as the username in Neo4j. This would typically be sub, but in some situations it may be desirable to use something else such as email.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.security.oidc.&lt;provider&gt;.claims.username, a string</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td>sub</td>
</tr>
</tbody>
</table>

**Table 405. dbms.security.oidc.<provider>.client_id**

<table>
<thead>
<tr>
<th>Description</th>
<th>Client id needed if token contains multiple Audience (aud) claims.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.security.oidc.&lt;provider&gt;.client_id, a string</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
</tbody>
</table>

**Table 406. dbms.security.oidc.<provider>.config**

<table>
<thead>
<tr>
<th>Description</th>
<th>Additional configuration options that the clients may require to authenticate. The map is a semicolon separated list of key-value pairs. For example: k1=v1;k2=v2.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.security.oidc.&lt;provider&gt;.config, A simple key value map pattern k1=v1;k2=v2</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td>{}</td>
</tr>
</tbody>
</table>

**Table 407. dbms.security.oidc.<provider>.display_name**

<table>
<thead>
<tr>
<th>Description</th>
<th>The user-facing name of the provider as provided by the discovery endpoint to clients (Bloom, Browser etc.).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.security.oidc.&lt;provider&gt;.display_name, a string</td>
</tr>
</tbody>
</table>

**Table 408. dbms.security.oidc.<provider>.get_groups_from_user_info**

<table>
<thead>
<tr>
<th>Description</th>
<th>When turned on, Neo4j gets the groups from the provider user info endpoint.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.security.oidc.&lt;provider&gt;.get_groups_from_user_info, a boolean</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
</tbody>
</table>
### Table 409. dbms.security.oidc.<provider>.get_username_from_user_info

<table>
<thead>
<tr>
<th>Description</th>
<th>When turned on, Neo4j gets the username from the provider user info endpoint.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.security.oidc.&lt;provider&gt;.get_username_from_user_info, a boolean</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td>false</td>
</tr>
</tbody>
</table>

### Table 410. dbms.security.oidc.<provider>.issuer

<table>
<thead>
<tr>
<th>Description</th>
<th>The expected value of the iss claim in the id token.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.security.oidc.&lt;provider&gt;.issuer, a string</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
</tbody>
</table>

### Table 411. dbms.security.oidc.<provider>.jwks_uri

<table>
<thead>
<tr>
<th>Description</th>
<th>The location of the JWK public key set for the identity provider. If this is not supplied Neo4j will attempt to discover it from the well_known_discovery_uri.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.security.oidc.&lt;provider&gt;.jwks_uri, a URI</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
</tbody>
</table>

### Table 412. dbms.security.oidc.<provider>.params

<table>
<thead>
<tr>
<th>Description</th>
<th>Generic parameters that the clients may require to authenticate. The map is a semicolon separated list of key-value pairs. For example: k1=v1;k2=v2.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.security.oidc.&lt;provider&gt;.params, A simple key value map pattern k1=v1;k2=v2</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td>{}</td>
</tr>
</tbody>
</table>

### Table 413. dbms.security.oidc.<provider>.redirect_uri

<table>
<thead>
<tr>
<th>Description</th>
<th>The redirect URI the IdP should return the user to when authenticated.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Valid values</strong></td>
<td><code>dbms.security.oidc.&lt;provider&gt;.redirect_uri</code>, a URI</td>
</tr>
<tr>
<td>---------------------</td>
<td>---------------------------------------------------</td>
</tr>
<tr>
<td><strong>Dynamic</strong></td>
<td>true</td>
</tr>
<tr>
<td><strong>Deprecated</strong></td>
<td>The <code>dbms.security.oidc.&lt;provider&gt;.redirect_uri</code> configuration setting has been deprecated.</td>
</tr>
</tbody>
</table>

Table 414. `dbms.security.oidc.<provider>.token_endpoint`

<table>
<thead>
<tr>
<th><strong>Description</strong></th>
<th>The OIDC token endpoint. If this is not supplied Neo4j will attempt to discover it from the <code>well_known_discovery_uri</code>.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Valid values</strong></td>
<td><code>dbms.security.oidc.&lt;provider&gt;.token_endpoint</code>, a URI</td>
</tr>
<tr>
<td><strong>Dynamic</strong></td>
<td>true</td>
</tr>
</tbody>
</table>

Table 415. `dbms.security.oidc.<provider>.token_params`

<table>
<thead>
<tr>
<th><strong>Description</strong></th>
<th>Optional additional configuration options used for the token request. The map is a semicolon separated list of key-value pairs. For example: <code>k1=v1;k2=v2</code>.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Valid values</strong></td>
<td><code>dbms.security.oidc.&lt;provider&gt;.token_params</code>, A simple key value map pattern <code>k1=v1;k2=v2</code></td>
</tr>
<tr>
<td><strong>Dynamic</strong></td>
<td>true</td>
</tr>
<tr>
<td><strong>Default value</strong></td>
<td><code>{}</code></td>
</tr>
</tbody>
</table>

Table 416. `dbms.security.oidc.<provider>.user_info_uri`

<table>
<thead>
<tr>
<th><strong>Description</strong></th>
<th>The identity providers user info uri.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Valid values</strong></td>
<td><code>dbms.security.oidc.&lt;provider&gt;.user_info_uri</code>, a URI</td>
</tr>
<tr>
<td><strong>Dynamic</strong></td>
<td>true</td>
</tr>
</tbody>
</table>

Table 417. `dbms.security.oidc.<provider>.well_known_discovery_uri`

<table>
<thead>
<tr>
<th><strong>Description</strong></th>
<th>The ‘well known’ OpenID Connect Discovery endpoint used to fetch identity provider settings.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Valid values</strong></td>
<td><code>dbms.security.oidc.&lt;provider&gt;.well_known_discovery_uri</code>, a URI</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 418. `dbms.security.procedures.allowlist`

<table>
<thead>
<tr>
<th>Description</th>
<th>A list of procedures (comma separated) that are to be loaded. The list may contain both fully-qualified procedure names, and partial names with the wildcard <code>*</code>. If this setting is left empty no procedures will be loaded.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.security.procedures.allowlist</code>, a ',' separated list with elements of type 'a string'.</td>
</tr>
<tr>
<td>Default value</td>
<td><code>*</code></td>
</tr>
</tbody>
</table>

### Table 419. `dbms.security.procedures.default_allowed`

| Description                                                                 | The default role that can execute all procedures and user-defined functions that are not covered by the `dbms.security.procedures.roles` setting. This setting (if not empty string) will be translated to 'GRANT EXECUTE BOOSTED PROCEDURE *' and 'GRANT EXECUTE BOOSTED FUNCTION *' for that role. If `dbms.security.procedures.roles` is not empty, any procedure or function that this role is not mapped to will result in a 'DENY EXECUTE BOOSTED PROCEDURE name' and 'DENY EXECUTE BOOSTED FUNCTION name' for this role. Any privilege mapped in this way cannot be revoked, instead the config must be changed and will take effect after a restart. Deprecated: Replaced by EXECUTE PROCEDURE, EXECUTE BOOSTED PROCEDURE, EXECUTE FUNCTION and EXECUTE BOOSTED FUNCTION privileges. |
| Valid values                                                                | `dbms.security.procedures.default_allowed`, a string                                                                                                       |
| Default value                                                               |                                                                                                                                                    |
| Deprecated                                                                  | The `dbms.security.procedures.default_allowed` configuration setting has been deprecated.                                                            |

### Table 420. `dbms.security.procedures.roles`
This provides a finer level of control over which roles can execute procedures than the `dbms.security.procedures.default_allowed` setting. For example: 

\[
\text{dbms.security.procedures.roles} = \text{apoc.convert.*:reader;apoc.load.json*:write}\n\text{r;apoc.trigger.add:TriggerHappy}
\]

will allow the role `reader` to execute all procedures in the `apoc.convert` namespace, the role `writer` to execute all procedures in the `apoc.load` namespace that starts with `json` and the role `TriggerHappy` to execute the specific procedure `apoc.trigger.add`. Procedures not matching any of these patterns will be subject to the `dbms.security.procedures.default_allowed` setting. This setting (if not empty string) will be translated to 'GRANT EXECUTE BOOSTED PROCEDURE name' and 'GRANT EXECUTE BOOSTED FUNCTION name' privileges for the mapped roles. Any privilege mapped in this way cannot be revoked, instead the config must be changed and will take effect after a restart. Deprecated: Replaced by EXECUTE PROCEDURE, EXECUTE BOOSTED PROCEDURE, EXECUTE FUNCTION and EXECUTE BOOSTED FUNCTION privileges.

<table>
<thead>
<tr>
<th>Valid values</th>
<th>dbms.security.procedures.roles, a string</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default value</td>
<td></td>
</tr>
<tr>
<td>Deprecated</td>
<td>The <code>dbms.security.procedures.roles</code> configuration setting has been deprecated.</td>
</tr>
</tbody>
</table>

Table 421. `dbms.security.procedures.unrestricted`

A list of procedures and user defined functions (comma separated) that are allowed full access to the database. The list may contain both fully-qualified procedure names, and partial names with the wildcard `*`. Note that this enables these procedures to bypass security. Use with caution.

<table>
<thead>
<tr>
<th>Valid values</th>
<th>dbms.security.procedures.unrestricted, a ',' separated list with elements of type 'a string'</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default value</td>
<td></td>
</tr>
</tbody>
</table>

Table 422. `dbms.security.procedures.whitelist`

A list of procedures (comma separated) that are to be loaded. The list may contain both fully-qualified procedure names, and partial names with the wildcard `*`. If this setting is left empty no procedures will be loaded. Deprecated, use `dbms.security.procedures.allowlist`.

<table>
<thead>
<tr>
<th>Valid values</th>
<th>dbms.security.procedures.whitelist, a ',' separated list with elements of type 'a string'</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default value</td>
<td>*</td>
</tr>
</tbody>
</table>
## Deprecated

The `dbms.security.procedures.whitelist` configuration setting has been deprecated.

### Table 423. `dbms.shutdown_transaction_end_timeout`

<table>
<thead>
<tr>
<th>Description</th>
<th>The maximum amount of time to wait for running transactions to complete before allowing initiated database shutdown to continue.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.shutdown_transaction_end_timeout</code>, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)</td>
</tr>
<tr>
<td>Default value</td>
<td>10s</td>
</tr>
</tbody>
</table>

### Table 424. `dbms.store.files.preallocate`

<table>
<thead>
<tr>
<th>Description</th>
<th>Specify if Neo4j should try to preallocate store files as they grow.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.store.files.preallocate</code>, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td><code>true</code></td>
</tr>
</tbody>
</table>

### Table 425. `dbms.threads.worker_count`

<table>
<thead>
<tr>
<th>Description</th>
<th>Number of Neo4j worker threads. This setting is only valid for REST, and does not influence bolt-server. It sets the amount of worker threads for the Jetty server used by neo4j-server. This option can be tuned when you plan to execute multiple, concurrent REST requests, with the aim of getting more throughput from the database. Your OS might enforce a lower limit than the maximum value specified here.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.threads.worker_count</code>, an integer which is in the range 1 to 44738</td>
</tr>
<tr>
<td>Default value</td>
<td>Number of available processors, or 500 for machines which have more than 500 processors.</td>
</tr>
</tbody>
</table>

### Table 426. `dbms.track_query_allocation`

<table>
<thead>
<tr>
<th>Description</th>
<th>Enables or disables tracking of how many bytes are allocated by the execution of a query. If enabled, calling <code>dbms.listQueries</code> will display the allocated bytes. This can also be logged in the query log by using <code>dbms.logs.query.allocation_logging_enabled</code>.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.track_query_allocation</code>, a boolean</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
</tbody>
</table>
Table 427. `dbms.track_query_cpu_time`

<table>
<thead>
<tr>
<th>Description</th>
<th>Enables or disables tracking of how much time a query spends actively executing on the CPU. Calling <code>dbms.listQueries</code> will display the time. This can also be logged in the query log by using <code>dbms.logs.query.time_logging_enabled</code>.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.track_query_cpu_time</code>, a boolean</td>
</tr>
<tr>
<td>Dynamic</td>
<td><code>true</code></td>
</tr>
<tr>
<td>Default value</td>
<td><code>false</code></td>
</tr>
</tbody>
</table>

Table 428. `dbms.transaction.bookmark_ready_timeout`

<table>
<thead>
<tr>
<th>Description</th>
<th>The maximum amount of time to wait for the database state represented by the bookmark.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.transaction.bookmark_ready_timeout</code>, a duration (Valid units are: ns, µs, ms, s, m, h and d; default unit is s) which is minimum 1s</td>
</tr>
<tr>
<td>Dynamic</td>
<td><code>true</code></td>
</tr>
<tr>
<td>Default value</td>
<td><code>30s</code></td>
</tr>
</tbody>
</table>

Table 429. `dbms.transaction.concurrent.maximum`

<table>
<thead>
<tr>
<th>Description</th>
<th>The maximum number of concurrently running transactions. If set to 0, limit is disabled.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.transaction.concurrent.maximum</code>, an integer</td>
</tr>
<tr>
<td>Dynamic</td>
<td><code>true</code></td>
</tr>
<tr>
<td>Default value</td>
<td><code>1000</code></td>
</tr>
</tbody>
</table>

Table 430. `dbms.transaction.monitor.check.interval`

<table>
<thead>
<tr>
<th>Description</th>
<th>Configures the time interval between transaction monitor checks. Determines how often monitor thread will check transaction for timeout.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>dbms.transaction.monitor.check.interval</code>, a duration (Valid units are: ns, µs, ms, s, m, h and d; default unit is s)</td>
</tr>
<tr>
<td>Default value</td>
<td><code>2s</code></td>
</tr>
</tbody>
</table>
### Table 431. dbms.transaction.sampling.percentage

**Description**
Transaction sampling percentage.

**Valid values**
dbms.transaction.sampling.percentage, an integer which is in the range 1 to 100

**Dynamic**
true

**Default value**
5

### Table 432. dbms.transaction.timeout

**Description**
The maximum time interval of a transaction within which it should be completed.

**Valid values**
dbms.transaction.timeout, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)

**Dynamic**
true

**Default value**
0s

### Table 433. dbms.transaction.tracing.level

**Description**
Transaction creation tracing level.

**Valid values**
dbms.transaction.tracing.level, one of [DISABLED, SAMPLE, ALL]

**Dynamic**
true

**Default value**
DISABLED

### Table 434. dbms.tx_log.buffer.size

**Description**
On serialization of transaction logs, they will be temporary stored in the byte buffer that will be flushed at the end of the transaction or at any moment when buffer will be full.

**Valid values**
dbms.tx_log.buffer.size, a long which is minimum 131072

**Default value**
By default the size of byte buffer is based on number of available cpu’s with minimal buffer size of 512KB. Every another 4 cpu’s will add another 512KB into the buffer size. Maximal buffer size in this default scheme is 4MB taking into account that we can have one transaction log writer per database in multi-database env. For example, runtime with 4 cpus will have buffer size of 1MB; runtime with 8 cpus will have buffer size of 1MB 512KB; runtime with 12 cpus will have buffer size of 2MB.

### Table 435. dbms.tx_log.preallocate

---

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**Table 436. dbms.tx_log.preallocate**

<table>
<thead>
<tr>
<th>Description</th>
<th>Specify if Neo4j should try to preallocate logical log file in advance.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.tx_log.preallocate, a boolean</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td>true</td>
</tr>
</tbody>
</table>

**Table 437. dbms.tx_log.rotation.retention_policy**

<table>
<thead>
<tr>
<th>Description</th>
<th>Tell Neo4j how long logical transaction logs should be kept to backup the database. For example, &quot;10 days&quot; will prune logical logs that only contain transactions older than 10 days. Alternatively, &quot;100k txs&quot; will keep the 100k latest transactions from each database and prune any older transactions.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.tx_log.rotation.retention_policy, a string which matches the pattern ^(true</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td>7 days</td>
</tr>
</tbody>
</table>

**Table 438. dbms.tx_log.rotation.size**

<table>
<thead>
<tr>
<th>Description</th>
<th>Specifies at which file size the logical log will auto-rotate. Minimum accepted value is 128 KiB.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.tx_log.rotation.size, a byte size (valid multipliers are B, KiB, KB, K, kB, k, MiB, MB, M, mB, mb, m, GiB, GB, G, gB, gb, g, TiB, TB, PiB, PB, EiB, EB) which is minimum 128.00KiB</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td>250.00MiB</td>
</tr>
</tbody>
</table>

**Table 438. dbms.tx_state.memory_allocation**

<table>
<thead>
<tr>
<th>Description</th>
<th>Defines whether memory for transaction state should be allocated on- or off-heap. Note that for small transactions you can gain up to 25% write speed by setting it to ON_HEAP.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Valid values</th>
<th>dbms.tx_state.memory_allocation, one of [ON_HEAP, OFF_HEAP]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default value</td>
<td>OFF_HEAP</td>
</tr>
</tbody>
</table>

Table 439. dbms.unmanaged_extension_classes

<table>
<thead>
<tr>
<th>Description</th>
<th>Comma-separated list of &lt;classname&gt;=&lt;mount point&gt; for unmanaged extensions.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.unmanaged_extension_classes, a ',' separated list with elements of type '&lt;classname&gt;=&lt;mount point&gt; string'.</td>
</tr>
<tr>
<td>Default value</td>
<td></td>
</tr>
</tbody>
</table>

Table 440. dbms.upgrade_max_processors

<table>
<thead>
<tr>
<th>Description</th>
<th>Max number of processors used when upgrading the store. Defaults to the number of processors available to the JVM. There is a certain amount of minimum threads needed so for that reason there is no lower bound for this value. For optimal performance this value shouldn't be greater than the number of available processors.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.upgrade_max_processors, an integer which is minimum 0</td>
</tr>
<tr>
<td>Dynamic</td>
<td>true</td>
</tr>
<tr>
<td>Default value</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 441. dbms.windows_service_name

<table>
<thead>
<tr>
<th>Description</th>
<th>Name of the Windows Service managing Neo4j when installed using neo4j install-service. Only applicable on Windows OS. Note: This must be unique for each individual installation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>dbms.windows_service_name, a string</td>
</tr>
<tr>
<td>Default value</td>
<td>neo4j</td>
</tr>
</tbody>
</table>

Table 442. fabric.database.name

<table>
<thead>
<tr>
<th>Description</th>
<th>Name of the Fabric database. Only one Fabric database is currently supported per Neo4j instance.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>fabric.database.name, A valid database name containing only alphabetic characters, numbers, dots and dashes with a length between 3 and 63 characters, starting with an alphabetic character but not with the name 'system'</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Table 443. fabric.driver.api</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 444. fabric.driver.connection.connect_timeout</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 445. fabric.driver.connection.max_lifetime</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 446. fabric.driver.connection.pool.acquisition_timeout</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>
Table 447. fabric.driver.connection.pool.idle_test

<table>
<thead>
<tr>
<th>Description</th>
<th>Pooled connections that have been idle in the pool for longer than this timeout will be tested before they are used again, to ensure they are still alive. If this option is set too low, an additional network call will be incurred when acquiring a connection, which causes a performance hit. If this is set high, no longer live connections might be used which might lead to errors. Hence, this parameter tunes a balance between the likelihood of experiencing connection problems and performance. Normally, this parameter should not need tuning. Value 0 means connections will always be tested for validity.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>fabric.driver.connection.pool.idle_test, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)</td>
</tr>
<tr>
<td>Default value</td>
<td>No connection liveliness check is done by default.</td>
</tr>
</tbody>
</table>

Table 448. fabric.driver.connection.pool.max_size

<table>
<thead>
<tr>
<th>Description</th>
<th>Maximum total number of connections to be managed by a connection pool. The limit is enforced for a combination of a host and user. Negative values are allowed and result in unlimited pool. Value of 0 is not allowed.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>fabric.driver.connection.pool.max_size, an integer</td>
</tr>
<tr>
<td>Default value</td>
<td>Unlimited</td>
</tr>
</tbody>
</table>

Table 449. fabric.driver.logging.level

<table>
<thead>
<tr>
<th>Description</th>
<th>Sets level for driver internal logging.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>fabric.driver.logging.level, one of [DEBUG, INFO, WARN, ERROR, NONE]</td>
</tr>
<tr>
<td>Default value</td>
<td>Value of dbms.logs.debug.level</td>
</tr>
</tbody>
</table>

[[config_fabric.graph.-graph ID-.database]] .fabric.graph.<graph ID>.database

<table>
<thead>
<tr>
<th>Description</th>
<th>Name of the database associated to the Fabric graph.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>fabric.graph.&lt;graph ID&gt;.database, a string</td>
</tr>
<tr>
<td>Default value</td>
<td>The default database on the target DBMS. Typically 'Neo4j'</td>
</tr>
</tbody>
</table>

[[config_fabric.graph.-graph ID-.driver.api]] .fabric.graph.<graph ID>.driver.api
<table>
<thead>
<tr>
<th><strong>Description</strong></th>
<th>Determines which driver API will be used. ASYNC must be used when the remote instance is 3.5 This setting can be used as a graph-specific override of the global setting 'fabric.driver.api'</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Valid values</strong></td>
<td>fabric.graph.&lt;graph ID&gt;.driver.api, one of [RX, ASYNC]</td>
</tr>
</tbody>
</table>

[[config_fabric.graph.-graph ID-.driver.connection.connect_timeout]] .fabric.graph.<graph ID>.driver.connection.connect_timeout

<table>
<thead>
<tr>
<th><strong>Description</strong></th>
<th>Socket connection timeout. A timeout of zero is treated as an infinite timeout and will be bound by the timeout configured on the operating system level. This setting can be used as a graph-specific override of the global setting 'fabric.driver.connection.connect_timeout'</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Valid values</strong></td>
<td>fabric.graph.&lt;graph ID&gt;.driver.connection.connect_timeout, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)</td>
</tr>
</tbody>
</table>

[[config_fabric.graph.-graph ID-.driver.connection.max_lifetime]] .fabric.graph.<graph ID>.driver.connection.max_lifetime

<table>
<thead>
<tr>
<th><strong>Description</strong></th>
<th>Pooled connections older than this threshold will be closed and removed from the pool. Setting this option to a low value will cause a high connection churn and might result in a performance hit. It is recommended to set maximum lifetime to a slightly smaller value than the one configured in network equipment (load balancer, proxy, firewall, etc. can also limit maximum connection lifetime). Zero and negative values result in lifetime not being checked. This setting can be used as a graph-specific override of the global setting 'fabric.driver.connection.max_lifetime'</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Valid values</strong></td>
<td>fabric.graph.&lt;graph ID&gt;.driver.connection.max_lifetime, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)</td>
</tr>
</tbody>
</table>

[[config_fabric.graph.-graph ID-.driver.connection.pool.acquisition_timeout]] .fabric.graph.<graph ID>.driver.connection.pool.acquisition_timeout

<table>
<thead>
<tr>
<th><strong>Description</strong></th>
<th>Maximum amount of time spent attempting to acquire a connection from the connection pool. This timeout only kicks in when all existing connections are being used and no new connections can be created because maximum connection pool size has been reached. Error is raised when connection can’t be acquired within configured time. Negative values are allowed and result in unlimited acquisition timeout. Value of 0 is allowed and results in no timeout and immediate failure when connection is unavailable. This setting can be used as a graph-specific override of the global setting 'fabric.driver.connection.pool.acquisition_timeout'</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>fabric.graph.&lt;graph ID&gt;.driver.connection.pool.acquisition_timeout, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)</td>
</tr>
<tr>
<td>--------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Description</td>
<td>Pooled connections that have been idle in the pool for longer than this timeout will be tested before they are used again, to ensure they are still alive. If this option is set too low, an additional network call will be incurred when acquiring a connection, which causes a performance hit. If this is set high, no longer live connections might be used which might lead to errors. Hence, this parameter tunes a balance between the likelihood of experiencing connection problems and performance. Normally, this parameter should not need tuning. Value 0 means connections will always be tested for validity. This setting can be used as a graph-specific override of the global setting 'fabric.driver.connection.pool.idle_test'</td>
</tr>
<tr>
<td>Valid values</td>
<td>fabric.graph.&lt;graph ID&gt;.driver.connection.pool.idle_test, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)</td>
</tr>
<tr>
<td>Description</td>
<td>Maximum total number of connections to be managed by a connection pool. The limit is enforced for a combination of a host and user. Negative values are allowed and result in unlimited pool. Value of 0 is not allowed. This setting can be used as a graph-specific override of the global setting 'fabric.driver.connection.pool.max_size'</td>
</tr>
<tr>
<td>Valid values</td>
<td>fabric.graph.&lt;graph ID&gt;.driver.connection.pool.max_size, an integer</td>
</tr>
<tr>
<td>Description</td>
<td>Enables logging of leaked driver session.</td>
</tr>
<tr>
<td>Valid values</td>
<td>fabric.graph.&lt;graph ID&gt;.driver.logging.leaked_sessions, a boolean</td>
</tr>
<tr>
<td>Description</td>
<td>Sets level for driver internal logging. This setting can be used as a graph-specific override of the global setting 'fabric.driver.logging.level'</td>
</tr>
</tbody>
</table>
Valid values  
| fabric.graph.<graph ID>.driver.logging.level, one of [DEBUG, INFO, WARN, ERROR, NONE] |

[[config_fabric.graph.-graph ID-.driver.ssl_enabled]] .fabric.graph.<graph ID>.driver.ssl_enabled

**Description**  
SSL for Fabric drivers is configured using 'fabric' SSL policy. This setting can be used to instruct the driver not to use SSL even though 'fabric' SSL policy is configured. The driver will use SSL if 'fabric' SSL policy is configured and this setting is set to 'true'.

**Valid values**  
fabric.graph.<graph ID>.driver.ssl_enabled, a boolean

**Default value**  
true

[[config_fabric.graph.-graph ID-.name]] .fabric.graph.<graph ID>.name

**Description**  
Name assigned to the Fabric graph. The name can be used in Fabric queries.

**Valid values**  
fabric.graph.<graph ID>.name, A valid graph name. Containing only alphabetic characters, numbers, dots and dashes, with a length between 3 and 63 characters. It should be starting with an alphabetic character. The name 'graph' is reserved.

[[config_fabric.graph.-graph ID-.uri]] .fabric.graph.<graph ID>.uri

**Description**  
URI of the Neo4j DBMS hosting the database associated to the Fabric graph. Example: neo4j://somewhere:7687 A comma separated list of URIs is acceptable. This is useful when the Fabric graph is hosted on a cluster and more than one bootstrap address needs to be provided in order to avoid a single point of failure. The provided addresses will be considered as an initial source of a routing table. Example: neo4j://core-1:1111,neo4j://core-2:2222.

**Valid values**  
fabric.graph.<graph ID>.uri, a ',' separated list with elements of type 'a URI'.

**Table 450. fabric.routing.servers**

**Description**  
A comma-separated list of Fabric instances that form a routing group. A driver will route transactions to available routing group members. A Fabric instance is represented by its Bolt connector address.

**Valid values**  
fabric.routing.servers, a ',' separated list with elements of type 'a socket address in the format 'hostname:port', 'hostname' or ':port'.
<table>
<thead>
<tr>
<th>Table 451. fabric.routing.ttl</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 452. fabric.stream.buffer.low_watermark</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 453. fabric.stream.buffer.size</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 454. fabric.stream.concurrency</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>

<p>| Table 455. metrics.bolt.messages.enabled |</p>
<table>
<thead>
<tr>
<th>Description</th>
<th>Valid values</th>
<th>Default value</th>
<th>Deprecated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enable reporting metrics about Bolt Protocol message processing. Deprecated - use metrics.filter instead.</td>
<td>metrics.bolt.messages.enabled, a boolean</td>
<td>false</td>
<td>The metrics.bolt.messages.enabled configuration setting has been deprecated.</td>
</tr>
<tr>
<td>Table 456. metrics.csv.enabled</td>
<td>Description: Set to true to enable exporting metrics to CSV files.</td>
<td>Valid values: metrics.csv.enabled, a boolean</td>
<td>Default value: true</td>
</tr>
<tr>
<td>Table 457. metrics.csv.interval</td>
<td>Description: The reporting interval for the CSV files. That is, how often new rows with numbers are appended to the CSV files.</td>
<td>Valid values: metrics.csv.interval, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s) which is minimum 1ms</td>
<td>Default value: 30s</td>
</tr>
<tr>
<td>Table 458. metrics.csv.rotation.compression</td>
<td>Description: Decides what compression to use for the csv history files.</td>
<td>Valid values: metrics.csv.rotation.compression, one of [NONE, ZIP, GZ]</td>
<td>Default value: NONE</td>
</tr>
<tr>
<td>Table 459. metrics.csv.rotation.keep_number</td>
<td>Description: Maximum number of history files for the csv files.</td>
<td>Valid values: metrics.csv.rotation.keep_number, an integer which is minimum 1</td>
<td>Default value: 7</td>
</tr>
<tr>
<td>Table 460. metrics.csv.rotation.size</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Description</td>
<td>The file size in bytes at which the csv files will auto-rotate. If set to zero then no rotation will occur. Accepts a binary suffix k, m or g.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
<td>metrics.csv.rotation.size, a byte size (valid multipliers are B, KiB, KB, k, MiB, MB, M, mB, mb, m, GiB, GB, G, gB, gb, g, TiB, TB, PiB, PB, EiB, EB) which is in the range 0B to 8388608.00TiB</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
<td>10.00MiB</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 461. metrics.cypher.replanning.enabled**

<table>
<thead>
<tr>
<th>Description</th>
<th>Enable reporting metrics about number of occurred replanning events. Deprecated - use metrics.filter instead.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Valid values</strong></td>
<td>metrics.cypher.replanning.enabled, a boolean</td>
</tr>
<tr>
<td><strong>Default value</strong></td>
<td>false</td>
</tr>
<tr>
<td><strong>Deprecated</strong></td>
<td>The metrics.cypher.replanning.enabled configuration setting has been deprecated.</td>
</tr>
</tbody>
</table>

**Table 462. metrics.enabled**

<table>
<thead>
<tr>
<th>Description</th>
<th>Enable metrics. Setting this to false will to turn off all metrics.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Valid values</strong></td>
<td>metrics.enabled, a boolean</td>
</tr>
<tr>
<td><strong>Default value</strong></td>
<td>true</td>
</tr>
</tbody>
</table>

**Table 463. metrics.filter**

<table>
<thead>
<tr>
<th>Description</th>
<th>Specifies which metrics should be enabled by using a comma separated list of globbing patterns. Only the metrics matching the filter will be enabled. For example <em>check_point</em>,neo4j.page_cache.evictions will enable any checkpoint metrics and the pagecache eviction metric.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Valid values</strong></td>
<td>metrics.filter, a ',' separated list with elements of type 'A simple globbing pattern that can use * and ?.'</td>
</tr>
<tr>
<td><strong>Default value</strong></td>
<td><em>bolt.connections</em>,<em>bolt.messages_received</em>,<em>bolt.messages_started</em>,*dbms.pool.bolt.free, <em>dbms.pool.bolt.total_size</em>,*dbms.pool.bolt.total_used,*dbms.pool.bolt.used_heap,*causal_clustering.core.is_leader,*causal_clustering.core.last_leader_message,*causal_clustering.core.replication_attempt,*causal_clustering.core.replication_fail,*check_point.duratio n,*check_point.total_time,*cypher.replan_events,*ids_in_use,<em>pool.transaction.</em>.total_used,<em>pool.transaction.</em>.used_heap,<em>pool.transaction.</em>.used_native,*store.size,*transact ion.active_read,*transaction.active_write,*transaction.committed,*transaction.last_committed_ts_id,*transaction.peak_concurrent,<em>transaction.rollback</em>,<em>page_cache.hit</em>,*page_cache.page_faults,*page_cache.usage_ratio,*vm.file.descriptors.count,<em>vm.gc.time,</em>,*vm.heap.used,*vm.memory.buffer.direct.used,*vm.memory.pool.g1_eden_space,*vm.memory.pool.g1_old_gen,*vm.pause_time,<em>vm.thread</em>,<em>db.query.execution</em></td>
</tr>
</tbody>
</table>
Table 464. **metrics.graphite.enabled**

<table>
<thead>
<tr>
<th>Description</th>
<th>Set to <strong>true</strong> to enable exporting metrics to Graphite.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><strong>metrics.graphite.enabled</strong>, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td><strong>false</strong></td>
</tr>
</tbody>
</table>

Table 465. **metrics.graphite.interval**

<table>
<thead>
<tr>
<th>Description</th>
<th>The reporting interval for Graphite. That is, how often to send updated metrics to Graphite.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><strong>metrics.graphite.interval</strong>, a duration (Valid units are: ns, μs, ms, s, m, h and d; default unit is s)</td>
</tr>
<tr>
<td>Default value</td>
<td><strong>30s</strong></td>
</tr>
</tbody>
</table>

Table 466. **metrics.graphite.server**

<table>
<thead>
<tr>
<th>Description</th>
<th>The hostname or IP address of the Graphite server.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><strong>metrics.graphite.server</strong>, a socket address in the format 'hostname:port', 'hostname' or ':port'. If missing port or hostname it is acquired from dbms.default_listen_address</td>
</tr>
<tr>
<td>Default value</td>
<td><strong>:2003</strong></td>
</tr>
</tbody>
</table>

Table 467. **metrics.jmx.enabled**

<table>
<thead>
<tr>
<th>Description</th>
<th>Set to <strong>true</strong> to enable the JMX metrics endpoint.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><strong>metrics.jmx.enabled</strong>, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td><strong>true</strong></td>
</tr>
</tbody>
</table>

Table 468. **metrics.jvm.buffers.enabled**

<table>
<thead>
<tr>
<th>Description</th>
<th>Enable reporting metrics about the buffer pools. Deprecated - use <strong>metrics.filter</strong> instead.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><strong>metrics.jvm.buffers.enabled</strong>, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td><strong>false</strong></td>
</tr>
<tr>
<td>Deprecated</td>
<td>The <strong>metrics.jvm.buffers.enabled</strong> configuration setting has been deprecated.</td>
</tr>
</tbody>
</table>
Table 469. metrics.jvm.file.descriptors.enabled

<table>
<thead>
<tr>
<th>Description</th>
<th>Enable reporting metrics about the number of open file descriptors. Deprecated - use metrics.filter instead.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>metrics.jvm.file.descriptors.enabled, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td>false</td>
</tr>
<tr>
<td>Deprecated</td>
<td>The metrics.jvm.file.descriptors.enabled configuration setting has been deprecated.</td>
</tr>
</tbody>
</table>

Table 470. metrics.jvm.gc.enabled

<table>
<thead>
<tr>
<th>Description</th>
<th>Enable reporting metrics about the duration of garbage collections. Deprecated - use metrics.filter instead.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>metrics.jvm.gc.enabled, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td>false</td>
</tr>
<tr>
<td>Deprecated</td>
<td>The metrics.jvm.gc.enabled configuration setting has been deprecated.</td>
</tr>
</tbody>
</table>

Table 471. metrics.jvm.heap.enabled

<table>
<thead>
<tr>
<th>Description</th>
<th>Enable reporting metrics about the heap memory usage. Deprecated - use metrics.filter instead.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>metrics.jvm.heap.enabled, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td>false</td>
</tr>
<tr>
<td>Deprecated</td>
<td>The metrics.jvm.heap.enabled configuration setting has been deprecated.</td>
</tr>
</tbody>
</table>

Table 472. metrics.jvm.memory.enabled

<table>
<thead>
<tr>
<th>Description</th>
<th>Enable reporting metrics about the memory usage. Deprecated - use metrics.filter instead.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>metrics.jvm.memory.enabled, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td>false</td>
</tr>
<tr>
<td>Deprecated</td>
<td>The metrics.jvm.memory.enabled configuration setting has been deprecated.</td>
</tr>
</tbody>
</table>

Table 473. metrics.jvm.pause_time.enabled
<table>
<thead>
<tr>
<th>Description</th>
<th>Enable reporting metrics about the VM pause time. Deprecated - use <code>metrics.filter</code> instead.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>metrics.jvm.pause_time.enabled</code>, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td><code>false</code></td>
</tr>
<tr>
<td>Deprecated</td>
<td>The <code>metrics.jvm.pause_time.enabled</code> configuration setting has been deprecated.</td>
</tr>
</tbody>
</table>

**Table 474. metrics.jvm.threads.enabled**

<table>
<thead>
<tr>
<th>Description</th>
<th>Enable reporting metrics about the current number of threads running. Deprecated - use <code>metrics.filter</code> instead.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>metrics.jvm.threads.enabled</code>, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td><code>false</code></td>
</tr>
<tr>
<td>Deprecated</td>
<td>The <code>metrics.jvm.threads.enabled</code> configuration setting has been deprecated.</td>
</tr>
</tbody>
</table>

**Table 475. metrics.namespaces.enabled**

<table>
<thead>
<tr>
<th>Description</th>
<th>Enable metrics namespaces that separates the global and database specific metrics. If enabled all database specific metrics will have field names starting with <code>&lt;metrics_prefix&gt;.database.&lt;database_name&gt;</code> and all global metrics will start with <code>&lt;metrics_prefix&gt;.dbms</code>. For example <code>neo4j.page_cache.hits</code> will become <code>neo4j.dbms.page_cache.hits</code> and <code>neo4j.system.log.rotation_events</code> will become <code>neo4j.database.system.log.rotation_events</code>.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>metrics.namespaces.enabled</code>, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td><code>false</code></td>
</tr>
</tbody>
</table>

**Table 476. metrics.neo4j.causal_clustering.enabled**

<table>
<thead>
<tr>
<th>Description</th>
<th>Enable reporting metrics about Causal Clustering mode. Deprecated - use <code>metrics.filter</code> instead.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>metrics.neo4j.causal_clustering.enabled</code>, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td><code>false</code></td>
</tr>
<tr>
<td>Deprecated</td>
<td>The <code>metrics.neo4j.causal_clustering.enabled</code> configuration setting has been deprecated.</td>
</tr>
</tbody>
</table>
### Table 477. metrics.neo4j.checkpointing.enabled

<table>
<thead>
<tr>
<th>Description</th>
<th>Enable reporting metrics about Neo4j checkpointing; when it occurs and how much time it takes to complete. Deprecated - use <code>metrics.filter</code> instead.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>metrics.neo4j.checkpointing.enabled, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td><code>false</code></td>
</tr>
<tr>
<td>Deprecated</td>
<td>The <code>metrics.neo4j.checkpointing.enabled</code> configuration setting has been deprecated.</td>
</tr>
</tbody>
</table>

### Table 478. metrics.neo4j.counts.enabled

<table>
<thead>
<tr>
<th>Description</th>
<th>Enable reporting metrics about approximately how many entities are in the database; nodes, relationships, properties, etc. Deprecated - use <code>metrics.filter</code> instead.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>metrics.neo4j.counts.enabled, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td><code>false</code></td>
</tr>
<tr>
<td>Deprecated</td>
<td>The <code>metrics.neo4j.counts.enabled</code> configuration setting has been deprecated.</td>
</tr>
</tbody>
</table>

### Table 479. metrics.neo4j.data.counts.enabled

<table>
<thead>
<tr>
<th>Description</th>
<th>Enable reporting metrics about number of entities in the database. Deprecated - use <code>metrics.filter</code> instead.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>metrics.neo4j.data.counts.enabled, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td><code>false</code></td>
</tr>
<tr>
<td>Deprecated</td>
<td>The <code>metrics.neo4j.data.counts.enabled</code> configuration setting has been deprecated.</td>
</tr>
</tbody>
</table>

### Table 480. metrics.neo4j.database_operation_count.enabled

<table>
<thead>
<tr>
<th>Description</th>
<th>Enable reporting metrics for Neo4j dbms operations; how many times databases have been created, started, stopped or dropped, and how many attempted operations have failed and recovered later. Deprecated - use <code>metrics.filter</code> instead.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td>metrics.neo4j.database_operation_count.enabled, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td><code>false</code></td>
</tr>
<tr>
<td>Deprecated</td>
<td>The <code>metrics.neo4j.database_operation_count.enabled</code> configuration setting has been deprecated.</td>
</tr>
<tr>
<td>-------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>

Table 481. `metrics.neo4j.logs.enabled`  
<table>
<thead>
<tr>
<th>Description</th>
<th>Enable reporting metrics about the Neo4j transaction logs. Deprecated - use <code>metrics.filter</code> instead.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>metrics.neo4j.logs.enabled</code>, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td><code>false</code></td>
</tr>
<tr>
<td>Deprecated</td>
<td>The <code>metrics.neo4j.logs.enabled</code> configuration setting has been deprecated.</td>
</tr>
</tbody>
</table>

Table 482. `metrics.neo4j.pagecache.enabled`  
<table>
<thead>
<tr>
<th>Description</th>
<th>Enable reporting metrics about the Neo4j page cache; page faults, evictions, flushes, exceptions, etc. Deprecated - use <code>metrics.filter</code> instead.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>metrics.neo4j.pagecache.enabled</code>, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td><code>false</code></td>
</tr>
<tr>
<td>Deprecated</td>
<td>The <code>metrics.neo4j.pagecache.enabled</code> configuration setting has been deprecated.</td>
</tr>
</tbody>
</table>

Table 483. `metrics.neo4j.pools.enabled`  
<table>
<thead>
<tr>
<th>Description</th>
<th>Enable reporting metrics about Neo4j memory pools. Deprecated - use <code>metrics.filter</code> instead.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>metrics.neo4j.pools.enabled</code>, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td><code>false</code></td>
</tr>
<tr>
<td>Deprecated</td>
<td>The <code>metrics.neo4j.pools.enabled</code> configuration setting has been deprecated.</td>
</tr>
</tbody>
</table>

Table 484. `metrics.neo4j.server.enabled`  
<table>
<thead>
<tr>
<th>Description</th>
<th>Enable reporting metrics about Server threading info. Deprecated - use <code>metrics.filter</code> instead.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid values</td>
<td><code>metrics.neo4j.server.enabled</code>, a boolean</td>
</tr>
<tr>
<td>Default value</td>
<td><code>false</code></td>
</tr>
<tr>
<td>Table 485. metrics.neo4j.size.enabled</td>
<td></td>
</tr>
<tr>
<td>--------------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Description</strong></td>
<td>Enable reporting metrics about the store size of each database. Deprecated - use <code>metrics.filter</code> instead.</td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
<td><code>metrics.neo4j.size.enabled</code>, a boolean</td>
</tr>
<tr>
<td><strong>Default value</strong></td>
<td><code>false</code></td>
</tr>
<tr>
<td><strong>Deprecated</strong></td>
<td>The <code>metrics.neo4j.size.enabled</code> configuration setting has been deprecated.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 486. metrics.neo4j.tx.enabled</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
<tr>
<td><strong>Deprecated</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 487. metrics.prefix</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 488. metrics.prometheus.enabled</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Valid values</strong></td>
</tr>
<tr>
<td><strong>Default value</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 489. metrics.prometheus.endpoint</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
</tbody>
</table>
Valid values  metrics.prometheus.endpoint, a socket address in the format 'hostname:port', 'hostname' or ':port'. If missing port or hostname it is acquired from dbms.default_listen_address

Default value  localhost:2004

<table>
<thead>
<tr>
<th>Table 490. systemdb.secrets.key.name</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
</tbody>
</table>

| Valid values | systemdb.secrets.key.name, a string |
| Dynamic | true |
| Default value | aesKey |

<table>
<thead>
<tr>
<th>Table 491. systemdb.secrets.keystore.password</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
</tbody>
</table>

| Valid values | systemdb.secrets.keystore.password, a secure string |
| Dynamic | true |

<table>
<thead>
<tr>
<th>Table 492. systemdb.secrets.keystore.path</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
</tbody>
</table>

| Valid values | systemdb.secrets.keystore.path, a path |
| Dynamic | true |

17.A.2. Procedures

This section provides a complete reference to the Neo4j procedures.

Procedures, editions, and modes

Available procedures depend on the type of installation you have:
• Neo4j Enterprise Edition provides a larger set of procedures than Neo4j Community Edition.

• Cluster members have procedures that are not available in standalone mode.

To check which procedures are available in your Neo4j DBMS, use the Cypher command `SHOW PROCEDURES`:

Example 136. List available procedures

```cypher
SHOW PROCEDURES
```

Some procedures can only be run by users with `Admin` privileges. These are labeled with `Admin only`.

For more information, see Cypher Manual → Manage Privileges.

List of procedures

Table 493. Neo4j procedures

<table>
<thead>
<tr>
<th>Name</th>
<th>Community Edition</th>
<th>Enterprise Edition</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>db.awaitIndex()</code></td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td><code>db.awaitIndexes()</code></td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td><code>db.checkpoint()</code></td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td><code>db.clearQueryCaches()</code></td>
<td>Yes</td>
<td>Yes</td>
<td>Admin only</td>
</tr>
<tr>
<td><code>db.constraints()</code></td>
<td>Yes</td>
<td>Yes</td>
<td>Deprecated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>In 4.1. signature changed to <code>db.constraints() :: (name :: STRING?, description :: STRING?, details :: STRING?)</code>. Replaced by: <code>SHOW CONSTRAINTS</code>.</td>
</tr>
<tr>
<td><code>db.createIndex()</code></td>
<td>Yes</td>
<td>Yes</td>
<td>Deprecated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Replaced by: <code>CREATE INDEX</code>.</td>
</tr>
<tr>
<td><code>db.createLabel()</code></td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td><code>db.createNodeKey()</code></td>
<td>No</td>
<td>Yes</td>
<td>Deprecated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Replaced by: <code>CREATE CONSTRAINT _ IS NODE KEY</code>.</td>
</tr>
<tr>
<td><code>db.createProperty()</code></td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td><code>db.createRelationshipType()</code></td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td><code>db.createUniquePropertyConstraint()</code></td>
<td>Yes</td>
<td>Yes</td>
<td>Deprecated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Replaced by: <code>CREATE CONSTRAINT _ IS UNIQUE</code>.</td>
</tr>
<tr>
<td><code>db.index.fulltext.awaitEventuallyConsistentIndexRefresh()</code></td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Name</td>
<td>Community Edition</td>
<td>Enterprise Edition</td>
<td>Comment</td>
</tr>
<tr>
<td>--------------------------------------------------</td>
<td>-------------------</td>
<td>--------------------</td>
<td>----------------------------------------------</td>
</tr>
<tr>
<td>db.index.fulltext.createNodeIndex()</td>
<td>Yes</td>
<td>Yes</td>
<td>Deprecated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Replaced by: CREATE FULLTEXT INDEX ...</td>
</tr>
<tr>
<td>db.index.fulltext.createRelationshipIndex()</td>
<td>Yes</td>
<td>Yes</td>
<td>Deprecated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Replaced by: CREATE FULLTEXT INDEX ...</td>
</tr>
<tr>
<td>db.index.fulltext.drop()</td>
<td>Yes</td>
<td>Yes</td>
<td>Deprecated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Replaced by: DROP INDEX ...</td>
</tr>
<tr>
<td>db.index.fulltext.listAvailableAnalyzers()</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>db.index.fulltext.queryNodes()</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>In 4.1, signature changed to</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>db.index.fulltext.queryNodes(indexName :: STRING?, queryString :: STRING?, options = () :: MAP?) :: (node :: NODE?, score :: FLOAT?).</td>
</tr>
<tr>
<td>db.index.fulltext.queryRelationships()</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>In 4.1, signature changed to</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>db.index.fulltext.queryRelationships(indexName :: STRING?, queryString :: STRING?, options = () :: MAP?) :: (relationship :: RELATIONSHIP?, score :: FLOAT?).</td>
</tr>
<tr>
<td>db.indexDetails()</td>
<td>Yes</td>
<td>Yes</td>
<td>Deprecated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Replaced by: SHOW INDEXES YIELD *.</td>
</tr>
<tr>
<td>db.indexes()</td>
<td>Yes</td>
<td>Yes</td>
<td>Deprecated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Replaced by: SHOW INDEXES.</td>
</tr>
<tr>
<td>db.info()</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>db.labels()</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>db.listLocks()</td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Admin only</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>in 4.2, signature changed to</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>db.listLocks() :: (mode :: STRING?, resourceType :: STRING?, resourceId :: INTEGER?, transactionId :: STRING?).</td>
</tr>
<tr>
<td>db.ping()</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>db.prepareForReplanning()</td>
<td>Yes</td>
<td>Yes</td>
<td>Admin only</td>
</tr>
<tr>
<td>db.propertyKeys()</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>db.relationshipTypes()</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>db.resampleIndex()</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>db.resampleOutdatedIndexes()</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>db.schema.nodeTypeProperties()</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>db.schema.relTypeProperties()</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>db.schema.visualization()</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Name</td>
<td>Community Edition</td>
<td>Enterprise Edition</td>
<td>Comment</td>
</tr>
<tr>
<td>-----------------------------------------------------------</td>
<td>-------------------</td>
<td>--------------------</td>
<td>----------------------------------------------</td>
</tr>
<tr>
<td>db.schemaStatements()</td>
<td>Yes</td>
<td>Yes</td>
<td>Deprecated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Replaced by: SHOW INDEXES YIELD * and SHOW CONSTRAINTS YIELD *.</td>
</tr>
<tr>
<td>db.stats.clear()</td>
<td>Yes</td>
<td>Yes</td>
<td>Admin only</td>
</tr>
<tr>
<td>db.stats.collect()</td>
<td>Yes</td>
<td>Yes</td>
<td>Admin only</td>
</tr>
<tr>
<td>db.stats.retrieve()</td>
<td>Yes</td>
<td>Yes</td>
<td>Admin only</td>
</tr>
<tr>
<td>db.stats.retrieveAllAnonymized()</td>
<td>Yes</td>
<td>Yes</td>
<td>Admin only</td>
</tr>
<tr>
<td>db.stats.status()</td>
<td>Yes</td>
<td>Yes</td>
<td>Admin only</td>
</tr>
<tr>
<td>db.stats.stop()</td>
<td>Yes</td>
<td>Yes</td>
<td>Admin only</td>
</tr>
<tr>
<td>dbms.cluster.routing.getRoutingTable()</td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>dbms.cluster.overview()</td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>dbms.cluster.protocols()</td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>dbms.cluster.quarantineDatabase()</td>
<td>No</td>
<td>Yes</td>
<td>Deprecated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Replaced by: dbms.quarantineDatabase().</td>
</tr>
<tr>
<td>dbms.cluster.readReplicaToggle()</td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>dbms.cluster.role()</td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>dbms.cluster.setDefaultDatabase()</td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>dbms.components()</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>dbms.database.state()</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>dbms.functions()</td>
<td>Yes</td>
<td>Yes</td>
<td>Deprecated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>In 4.2, signature changed to dbms.functions() :: (name :: STRING?, signature :: STRING?, category :: STRING?, description :: STRING?, aggregating :: BOOLEAN?, defaultBuiltInRoles :: LIST? OF STRING?). Replaced by: SHOW FUNCTIONS.</td>
</tr>
<tr>
<td>dbms.info()</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>dbms.killConnection()</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>dbms.killConnections()</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>dbms.killQueries()</td>
<td>Yes</td>
<td>Yes</td>
<td>Deprecated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Replaced by: TERMINATE TRANSACTIONS.</td>
</tr>
<tr>
<td>dbms.killQuery()</td>
<td>Yes</td>
<td>Yes</td>
<td>Deprecated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Replaced by: TERMINATE TRANSACTIONS.</td>
</tr>
<tr>
<td>dbms.killTransaction()</td>
<td>Yes</td>
<td>Yes</td>
<td>Deprecated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Replaced by: TERMINATE TRANSACTIONS.</td>
</tr>
<tr>
<td>dbms.killTransactions()</td>
<td>Yes</td>
<td>Yes</td>
<td>Deprecated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Replaced by: TERMINATE TRANSACTIONS.</td>
</tr>
<tr>
<td>Name</td>
<td>Community Edition</td>
<td>Enterprise Edition</td>
<td>Comment</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>-------------------</td>
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<td>------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>dbms.listActiveLocks()</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>dbms.listConfig()</td>
<td>Yes</td>
<td>Yes</td>
<td>Admin only</td>
</tr>
<tr>
<td>dbms.listConnections()</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>dbms.listPools()</td>
<td>No</td>
<td>Yes</td>
<td>Deprecated</td>
</tr>
<tr>
<td>dbms.listQueries()</td>
<td>Yes</td>
<td>Yes</td>
<td>Deprecated. In 4.1, the queryId procedure format changed to no longer include the database name. For example, mydb-query-123 became query-123. Replaced by: SHOW TRANSACTIONS.</td>
</tr>
<tr>
<td>dbms.listTransactions()</td>
<td>Yes</td>
<td>Yes</td>
<td>Deprecated. In 4.1, signature changed to dbms.listTransactions() :: (transactionId :: STRING?, username :: STRING?, metaData :: MAP?, startTime :: STRING?, protocol :: STRING?, clientAddress :: STRING?, requestUri :: STRING?, currentQueryId :: STRING?, currentQuery :: STRING?, activeLockCount :: INTEGER?, status :: STRING?, resourceInformation :: MAP?, elapsedTimeMillis :: INTEGER?, cpuTimeMillis :: INTEGER?, waitTimeMillis :: INTEGER?, idleTimeMillis :: INTEGER?, allocatedBytes :: INTEGER?, allocatedDirectBytes :: INTEGER?, pageHits :: INTEGER?, pageFaults :: INTEGER?, connectionId :: STRING?, initializationStackTrace :: STRING?, database :: STRING?, estimatedUsedHeapMemory :: INTEGER?). Replaced by: SHOW TRANSACTIONS.</td>
</tr>
<tr>
<td>dbms.procedures()</td>
<td>Yes</td>
<td>Yes</td>
<td>Deprecated. Replaced by: SHOW PROCEDURES.</td>
</tr>
<tr>
<td>dbms.quarantineDatabase()</td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>dbms.queryJmx()</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>dbms.routing.getRoutingTable()</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>dbms.scheduler.failedJobs()</td>
<td>No</td>
<td>Yes</td>
<td>Admin only</td>
</tr>
<tr>
<td>dbms.scheduler.groups()</td>
<td>No</td>
<td>Yes</td>
<td>Admin only</td>
</tr>
<tr>
<td>dbms.scheduler.jobs()</td>
<td>No</td>
<td>Yes</td>
<td>Admin only</td>
</tr>
<tr>
<td>dbms.scheduler.profile()</td>
<td>No</td>
<td>Yes</td>
<td>Admin only</td>
</tr>
<tr>
<td>dbms.security.activateUser()</td>
<td>No</td>
<td>Yes</td>
<td>Deprecated. In 4.1, mode changed to write. Replaced by: ALTER USER.</td>
</tr>
<tr>
<td>Name</td>
<td>Community Edition</td>
<td>Enterprise Edition</td>
<td>Comment</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>-------------------</td>
<td>--------------------</td>
<td>----------------------------------------------</td>
</tr>
<tr>
<td>dbms.security.addRoleToUser()</td>
<td>No</td>
<td>Yes</td>
<td>Deprecated, Admin only</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>In 4.1, mode changed to write. Replaced by: GRANT ROLE TO USER.</td>
</tr>
<tr>
<td>dbms.security.changePassword()</td>
<td>Yes</td>
<td>Yes</td>
<td>Deprecated, Admin only</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>In 4.1, mode changed to write. Replaced by: ALTER CURRENT USER SET PASSWORD.</td>
</tr>
<tr>
<td>dbms.security.changeUserPassword()</td>
<td>No</td>
<td>Yes</td>
<td>Deprecated, Admin only</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>In 4.1, mode changed to write. Replaced by: ALTER USER.</td>
</tr>
<tr>
<td>dbms.security.clearAuthCache()</td>
<td>No</td>
<td>Yes</td>
<td>Admin only</td>
</tr>
<tr>
<td>dbms.security.createRole()</td>
<td>No</td>
<td>Yes</td>
<td>Deprecated, Admin only</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>In 4.1, mode changed to write. Replaced by: CREATE ROLE.</td>
</tr>
<tr>
<td>dbms.security.createUser()</td>
<td>Yes</td>
<td>Yes</td>
<td>Deprecated, Admin only</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>In 4.1, mode changed to write. Replaced by: CREATE USER.</td>
</tr>
<tr>
<td>dbms.security.deleteRole()</td>
<td>No</td>
<td>Yes</td>
<td>Deprecated, Admin only</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>In 4.1, mode changed to write. Replaced by: DROP ROLE.</td>
</tr>
<tr>
<td>dbms.security.deleteUser()</td>
<td>Yes</td>
<td>Yes</td>
<td>Deprecated, Admin only</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>In 4.1, mode changed to write. Replaced by: DROP USER.</td>
</tr>
<tr>
<td>dbms.security.listRoles()</td>
<td>Yes</td>
<td>Yes</td>
<td>Deprecated, Admin only</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>In 4.1, mode changed to read. Replaced by: SHOW ROLES.</td>
</tr>
<tr>
<td>dbms.security.listRolesForUser()</td>
<td>No</td>
<td>Yes</td>
<td>Deprecated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>In 4.1, mode changed to read. Replaced by: SHOW USERS.</td>
</tr>
<tr>
<td>dbms.security.listUsers()</td>
<td>Yes</td>
<td>Yes</td>
<td>Deprecated, Admin only</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>In 4.1, mode changed to read. Replaced by: SHOW USERS.</td>
</tr>
<tr>
<td>dbms.security.listUsersForRole()</td>
<td>No</td>
<td>Yes</td>
<td>Deprecated, Admin only</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>In 4.1, mode changed to read. Replaced by: SHOW ROLES WITH USERS.</td>
</tr>
<tr>
<td>dbms.security.removeRoleFromUser()</td>
<td>No</td>
<td>Yes</td>
<td>Deprecated, Admin only</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>In 4.1, mode changed to write. Replaced by: REVOKE ROLE FROM USER.</td>
</tr>
<tr>
<td>dbms.security.suspendUser()</td>
<td>No</td>
<td>Yes</td>
<td>Deprecated, Admin only</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>In 4.1, mode changed to write. Replaced by: ALTER USER.</td>
</tr>
<tr>
<td>dbms.setConfigValue()</td>
<td>No</td>
<td>Yes</td>
<td>Admin only</td>
</tr>
<tr>
<td>Name</td>
<td>Community Edition</td>
<td>Enterprise Edition</td>
<td>Comment</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-------------------</td>
<td>--------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>dbms.showCurrentUser()</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>dbms.upgrade()</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>dbms.upgradeStatus()</td>
<td>Yes</td>
<td>Yes</td>
<td>Admin only</td>
</tr>
<tr>
<td>tx.getMetaData()</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>tx.setMetaData()</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>

### Procedure descriptions

#### Table 494. db.awaitIndex()

<table>
<thead>
<tr>
<th>Description</th>
<th>Wait for an index to come online.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example</td>
<td>CALL db.awaitIndex(&quot;MyIndex&quot;, 300)</td>
</tr>
</tbody>
</table>

| Signature | db.awaitIndex(indexName :: STRING?, timeOutSeconds = 300 :: INTEGER?) :: VOID |
| Mode      | READ |

#### Table 495. db.awaitIndexes()

<table>
<thead>
<tr>
<th>Description</th>
<th>Wait for all indexes to come online.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example</td>
<td>CALL db.awaitIndexes(300)</td>
</tr>
</tbody>
</table>

| Signature | db.awaitIndexes(timeOutSeconds = 300 :: INTEGER?) :: VOID |
| Mode      | READ |

#### Table 496. db.checkpoint()  

| Description | Initiate and wait for a new check point, or wait any already on-going check point to complete.  
Note that this temporarily disables the dbms.checkpoint.iops.limit setting in order to make the check point complete faster. This might cause transaction throughput to degrade slightly, due to increased IO load. |
|-------------|--------------------------------------------------------------------------------------------------|

| Signature | db.checkpoint() :: (success :: BOOLEAN?, message :: STRING?) |
| Mode      | DBMS |

#### Table 497. db.clearQueryCaches()  

| Description | Clears all query caches. |

<p>| Signature | db.clearQueryCaches() :: (value :: STRING?) |</p>
<table>
<thead>
<tr>
<th>Mode</th>
<th>DBMS</th>
</tr>
</thead>
</table>

**Table 498. db.constraints()**  
**Description**  
List all constraints in the database.  
**Signature**  
db.constraints() :: (name :: STRING?, description :: STRING?, details :: STRING?)  
**Mode**  
READ  
**Replaced by**  
SHOW CONSTRAINTS. For more information, see Database administration.

**Table 499. db.createIndex()**  
**Description**  
Create a named schema index with specified index provider and configuration (optional).  
Yield: name, labels, properties, providerName, status  
**Signature**  
db.createIndex(indexName :: STRING?, labels :: LIST? OF STRING?, properties :: LIST? OF STRING?, providerName :: STRING?, config = {} :: MAP?) :: (name :: STRING?, labels :: LIST? OF STRING?, properties :: LIST? OF STRING?, providerName :: STRING?, status :: STRING?)  
**Mode**  
SCHEMA  
**Replaced by**  
CREATE INDEX. For more information, see Database administration.

**Table 500. db.createLabel()**  
**Description**  
Create a label  
**Signature**  
db.createLabel(newLabel :: STRING?) :: VOID  
**Mode**  
WRITE

**Table 501. db.createNodeKey()**  
**Description**  
Create a named node key constraint. Backing index will use specified index provider and configuration (optional).  
Yield: name, labels, properties, providerName, status  
**Signature**  
db.createNodeKey(constraintName :: STRING?, labels :: LIST? OF STRING?, properties :: LIST? OF STRING?, providerName :: STRING?, config = {} :: MAP?) :: (name :: STRING?, labels :: LIST? OF STRING?, properties :: LIST? OF STRING?, providerName :: STRING?, status :: STRING?)  
**Mode**  
SCHEMA  
**Replaced by**  
CREATE CONSTRAINT ... IS NODE KEY. For more information, see Database administration.

**Table 502. db.createProperty()**
### Table 503. db.createRelationshipType()

<table>
<thead>
<tr>
<th>Description</th>
<th>Create a RelationshipType</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature</td>
<td><code>db.createRelationshipType(newRelationshipType :: STRING?) :: VOID</code></td>
</tr>
<tr>
<td>Mode</td>
<td>WRITE</td>
</tr>
</tbody>
</table>

### Table 504. db.createUniquePropertyConstraint()

<table>
<thead>
<tr>
<th>Description</th>
<th>Create a named unique property constraint. Backing index will use specified index provider and configuration (optional). Yield: name, labels, properties, providerName, status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature</td>
<td><code>db.createUniquePropertyConstraint(constraintName :: STRING?, labels :: LIST? OF STRING?, properties :: LIST? OF STRING?, providerName :: STRING?, config = {} :: MAP?) :: (name :: STRING?, labels :: LIST? OF STRING?, properties :: LIST? OF STRING?, providerName :: STRING?, status :: STRING?)</code></td>
</tr>
<tr>
<td>Mode</td>
<td>SCHEMA</td>
</tr>
<tr>
<td>Replaced by</td>
<td><code>CREATE CONSTRAINT ... IS UNIQUE</code>. For more information, see Database administration.</td>
</tr>
</tbody>
</table>

### Table 505. db.index.fulltext.awaitEventuallyConsistentIndexRefresh()

<table>
<thead>
<tr>
<th>Description</th>
<th>Wait for the updates from recently committed transactions to be applied to any eventually-consistent full-text indexes.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature</td>
<td><code>db.index.fulltext.awaitEventuallyConsistentIndexRefresh() :: VOID</code></td>
</tr>
<tr>
<td>Mode</td>
<td>READ</td>
</tr>
</tbody>
</table>

### Table 506. db.index.fulltext.createNodeIndex()

<table>
<thead>
<tr>
<th>Description</th>
<th>Create a node full-text index for the given labels and properties. The optional 'config' map parameter can be used to supply settings to the index. Supported settings are 'analyzer', for specifying what analyzer to use when indexing and querying. Use the <code>db.index.fulltext.listAvailableAnalyzers</code> procedure to see what options are available. And 'eventually_consistent' which can be set to 'true' to make this index eventually consistent, such that updates from committing transactions are applied in a background thread.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature</td>
<td><code>db.index.fulltext.createNodeIndex() :: VOID</code></td>
</tr>
<tr>
<td>Mode</td>
<td>READ</td>
</tr>
</tbody>
</table>

| Replaced by       | `CREATE INDEX ... ON NODE ...` or `CREATE INDEX ... ON NODE ... USING FULLTEXT ...` or `CREATE INDEX ... ON NODE ... USING FULLTEXT` or `CREATE INDEX ... ON NODE ... USING FULLTEXT`, depending on the labels, properties, and eventually_consistent setting. For more information, see Database administration. |

**Note:** The `db.createUniquePropertyConstraint` method is deprecated. Use `CREATE CONSTRAINT ... IS UNIQUE` instead.
Signature  
\texttt{db.index.fulltext.createNodeIndex(indexName :: STRING?, labels :: LIST? OF STRING?, properties :: LIST? OF STRING?, config = {} :: MAP?) :: VOID}  

Mode  
\texttt{SCHEMA}  

Replaced by  
CREATE FULLTEXT INDEX

**Table 507. db.index.fulltext.createRelationshipIndex()**  
\texttt{db.index.fulltext.createRelationshipIndex(indexName :: STRING?, relationshipTypes :: LIST? OF STRING?, properties :: LIST? OF STRING?, config = {} :: MAP?) :: VOID}  

Description  
Create a relationship full-text index for the given relationship types and properties.

The optional 'config' map parameter can be used to supply settings to the index. Supported settings are 'analyzer', for specifying what analyzer to use when indexing and querying. Use the \texttt{db.index.fulltext.listAvailableAnalyzers} procedure to see what options are available. And 'eventually_consistent' which can be set to 'true' to make this index eventually consistent, such that updates from committing transactions are applied in a background thread.

Signature  
\texttt{db.index.fulltext.createRelationshipIndex(indexName :: STRING?, relationshipTypes :: LIST? OF STRING?, properties :: LIST? OF STRING?, config = {} :: MAP?) :: VOID}  

Mode  
\texttt{SCHEMA}  

Replaced by  
CREATE FULLTEXT INDEX ...  

**Table 508. db.index.fulltext.drop()**  
\texttt{db.index.fulltext.drop(indexName :: STRING?) :: VOID}  

Description  
Drop the specified index.

Signature  
\texttt{db.index.fulltext.drop(indexName :: STRING?) :: VOID}  

Mode  
\texttt{SCHEMA}  

Replaced by  
DROP INDEX ...

**Table 509. db.index.fulltext.listAvailableAnalyzers()**  
\texttt{db.index.fulltext.listAvailableAnalyzers() :: (analyzer :: STRING?, description :: STRING?, stopwords :: LIST? OF STRING?)}  

Description  
List the available analyzers that the full-text indexes can be configured with.

**Table 510. db.index.fulltext.queryNodes()**  
\texttt{db.index.fulltext.queryNodes() :: VOID}  

Description  
Query the given full-text index.

Returns the matching nodes, and their Lucene query score, ordered by score.

Valid keys for the options map are: 'skip' to skip the top N results; 'limit' to limit the number of results returned.
### Table 511. `db.index.fulltext.queryNodes()`

**Description**
Query the given full-text index.

Returns the matching relationships, and their Lucene query score, ordered by score.

Valid keys for the options map are: 'skip' to skip the top N results; 'limit' to limit the number of results returned.

**Signature**
```
Signature db.index.fulltext.queryNodes(indexName :: STRING?, queryString :: STRING?, options = {} :: MAP?) :: (node :: NODE?, score :: FLOAT?)
```

| Mode | READ |

### Table 512. `db.index.fulltext.queryRelationships()`

**Description**
Query the given full-text index.

Returns the matching relationships, and their Lucene query score, ordered by score.

**Signature**
```
Signature db.index.fulltext.queryRelationships(indexName :: STRING?, queryString :: STRING?, options = {} :: MAP?) :: (relationship :: RELATIONSHIP?, score :: FLOAT?)
```

| Mode | READ |

### Table 513. `db.indexDetails()`

**Description**
Detailed description of specific index.

**Signature**
```
Signature db.indexDetails(indexName :: STRING?) :: (id :: INTEGER?, name :: STRING?, state :: STRING?, populationPercent :: FLOAT?, uniqueness :: STRING?, type :: STRING?, entityType :: STRING?, labelsOrTypes :: LIST? OF STRING?, properties :: LIST? OF STRING?, provider :: STRING?, indexConfig :: MAP?, failureMessage :: STRING?)
```

| Mode | READ |

**Replaced by**
SHOW INDEXES YIELD *

### Table 514. `db.indexes()`

**Description**
List all indexes in the database.

**Signature**
```
Signature db.indexes() :: (id :: INTEGER?, name :: STRING?, state :: STRING?, populationPercent :: FLOAT?, uniqueness :: STRING?, type :: STRING?, entityType :: STRING?, labelsOrTypes :: LIST? OF STRING?, properties :: LIST? OF STRING?, provider :: STRING?)
```

| Mode | READ |

**Replaced by**
SHOW INDEXES

### Table 515. `db.info()`

**Description**
Provides information regarding the database.

**Signature**
```
Signature db.info() :: (id :: STRING?, name :: STRING?, creationDate :: STRING?)
```

| Mode | READ |

### Table 516. `db.labels()`
<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Signature</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>516. db.listLocks()</td>
<td>List all locks at this database.</td>
<td>db.listLocks() :: (mode :: STRING?, resourceType :: STRING?, resourceId :: INTEGER?, transactionId :: STRING?)</td>
<td>DBMS</td>
</tr>
<tr>
<td>517. db.ping()</td>
<td>This procedure can be used by client side tooling to test whether they are correctly connected to a database. The procedure is available in all databases and always returns true. A faulty connection can be detected by not being able to call this procedure.</td>
<td>db.ping() :: (success :: BOOLEAN?)</td>
<td>READ</td>
</tr>
<tr>
<td>518. db.prepareForReplanning()</td>
<td>Triggers an index resample and waits for it to complete, and after that clears query caches. After this procedure has finished queries will be planned using the latest database statistics.</td>
<td>db.prepareForReplanning(timeOutSeconds = 300 :: INTEGER?) :: VOID</td>
<td>READ</td>
</tr>
<tr>
<td>519. db.propertyKeys()</td>
<td>List all property keys in the database.</td>
<td>db.propertyKeys() :: (propertyKey :: STRING?)</td>
<td>READ</td>
</tr>
<tr>
<td>520. db.relationshipTypes()</td>
<td>List all available relationship types in the database.</td>
<td>db.relationshipTypes() :: (relationshipType :: STRING?)</td>
<td>READ</td>
</tr>
<tr>
<td>521. db.resampleIndex()</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Schedule resampling of an index.

Example: CALL db.resampleIndex("MyIndex")

**Signature**

```java
db.resampleIndex(indexName :: STRING?) :: VOID
```

**Mode**

READ

---

Schedule resampling of all outdated indexes.

**Signature**

```java
db.resampleOutdatedIndexes() :: VOID
```

**Mode**

READ

---

Show the derived property schema of the nodes in tabular form.

**Signature**

```java
db.schema.nodeTypeProperties() :: (nodeType :: STRING?, nodeLabels :: LIST? OF STRING?,
propertyName :: STRING?, propertyTypes :: LIST? OF STRING?, mandatory :: BOOLEAN?)
```

**Mode**

READ

---

Show the derived property schema of the relationships in tabular form.

**Signature**

```java
db.schema.relTypeProperties() :: (relType :: STRING?, propertyName :: STRING?, propertyTypes
:: LIST? OF STRING?, mandatory :: BOOLEAN?)
```

**Mode**

READ

---

Visualize the schema of the data.

**Signature**

```java
db.schema.visualization() :: (nodes :: LIST? OF NODE?, relationships :: LIST? OF
RELATIONSHIP?)
```

**Mode**

READ

---

List all statements for creating and dropping existing indexes and constraints. Note that only index types introduced before Neo4j 4.3 are included.

**Signature**

```java
db.schemaStatements() :: (name :: STRING?, type :: STRING?, createStatement :: STRING?,
dropStatement :: STRING?)
```

**Mode**

READ
### Table 527. db.stats.clear()

| Description | Clear collected data of a given data section.  
| Valid sections are 'QUERIES' |
| Signature | `db.stats.clear(section :: STRING?) :: (section :: STRING?, success :: BOOLEAN?, message :: STRING?)` |
| Mode | READ |

### Table 528. db.stats.collect()

| Description | Start data collection of a given data section.  
| Valid sections are 'QUERIES' |
| Signature | `db.stats.collect(section :: STRING?, config = {} :: MAP?) :: (section :: STRING?, success :: BOOLEAN?, message :: STRING?)` |
| Mode | READ |

### Table 529. db.stats.retrieve()

| Description | Retrieve statistical data about the current database.  
| Valid sections are 'GRAPH COUNTS', 'TOKENS', 'QUERIES', 'META' |
| Signature | `db.stats.retrieve(section :: STRING?, config = {} :: MAP?) :: (section :: STRING?, data :: MAP?)` |
| Mode | READ |

### Table 530. db.stats.retrieveAllAnonymized()

| Description | Retrieve all available statistical data about the current database, in an anonymized form. |
| Signature | `db.stats.retrieveAllAnonymized(graphToken :: STRING?, config = {} :: MAP?) :: (section :: STRING?, data :: MAP?)` |
| Mode | READ |

### Table 531. db.stats.status()

| Description | Retrieve the status of all available collector daemons, for this database. |
| Signature | `db.stats.status() :: (section :: STRING?, status :: STRING?, data :: MAP?)` |
| Mode | READ |
### Table 532. `db.stats.stop() [Admin only]`

<table>
<thead>
<tr>
<th>Description</th>
<th>Stop data collection of a given data section. Valid sections are 'QUERIES'</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature</td>
<td><code>db.stats.stop(section :: STRING?) :: (section :: STRING?, success :: BOOLEAN?, message :: STRING?)</code></td>
</tr>
<tr>
<td>Mode</td>
<td>READ</td>
</tr>
</tbody>
</table>

### Table 533. `dbms.cluster.routing.getRoutingTable()`

<table>
<thead>
<tr>
<th>Description</th>
<th>Returns endpoints of this instance.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature</td>
<td><code>dbms.cluster.routing.getRoutingTable(context :: MAP?, database = null :: STRING?) :: (ttl :: INTEGER?, servers :: LIST? OF MAP?)</code></td>
</tr>
<tr>
<td>Mode</td>
<td>DBMS</td>
</tr>
</tbody>
</table>

### Table 534. `dbms.cluster.overview()` [Enterprise edition]

<table>
<thead>
<tr>
<th>Description</th>
<th>Overview of all currently accessible cluster members, their databases and roles.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature</td>
<td><code>dbms.cluster.overview() :: (id :: STRING?, addresses :: LIST? OF STRING?, databases :: MAP?, groups :: LIST? OF STRING?)</code></td>
</tr>
<tr>
<td>Mode</td>
<td>READ</td>
</tr>
</tbody>
</table>

### Table 535. `dbms.cluster.protocols()` [Enterprise edition]

<table>
<thead>
<tr>
<th>Description</th>
<th>Overview of installed protocols. Note that this can only be executed on a cluster core member.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature</td>
<td><code>dbms.cluster.protocols() :: (orientation :: STRING?, remoteAddress :: STRING?, applicationProtocol :: STRING?, applicationProtocolVersion :: INTEGER?, modifierProtocols :: STRING?)</code></td>
</tr>
<tr>
<td>Mode</td>
<td>READ</td>
</tr>
</tbody>
</table>

### Table 536. `dbms.cluster.quarantineDatabase()` [Enterprise edition]  [Deprecated]

<table>
<thead>
<tr>
<th>Description</th>
<th>Place a database in quarantine or remove thereof.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature</td>
<td><code>dbms.cluster.quarantineDatabase(databaseName :: STRING?, setStatus :: BOOLEAN?, reason = No reason given :: STRING?) :: (databaseName :: STRING?, quarantined :: BOOLEAN?, result :: STRING?)</code></td>
</tr>
<tr>
<td>Mode</td>
<td>DBMS</td>
</tr>
<tr>
<td>Replaced by</td>
<td><code>dbms.quarantineDatabase()</code></td>
</tr>
</tbody>
</table>

### Table 537. `dbms.cluster.readReplicaToggle()` [Enterprise edition]

<table>
<thead>
<tr>
<th>Description</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature</td>
<td></td>
</tr>
<tr>
<td>Mode</td>
<td></td>
</tr>
</tbody>
</table>

631
The toggle can pause or resume the pulling of new transactions for a specific database. If paused, the Read Replica does not pull new transactions from the other cluster members for the specific database. The Read Replica is still available for reads, you can perform a backup, etc.

**What is it for?**

You can perform a point in time backup, as the backup will contain only the transactions up to the point where the transaction pulling was paused.

1. Connect directly to the Read Replica cluster member. (Neo4j Driver use `bolt://` or use the HTTP API).
2. Pause transaction pulling for the specified database.
3. Create a point in time backup, see [Back up an online database](#).

If connected directly to a Read Replica, Data Scientists can execute analysis on a specific database that is paused, the data will not unexpectedly change while performing the analysis.

This procedure can only be executed on a Read Replica cluster member.

### Pause transaction pulling for database `neo4j`

```sql
CALL dbms.cluster.readReplicaToggle('neo4j', true)
```

### Resume transaction pulling for database `neo4j`

```sql
CALL dbms.cluster.readReplicaToggle('neo4j', false)
```

**Signature**

```sql
dbms.cluster.readReplicaToggle(databaseName :: STRING?, pause :: BOOLEAN?) :: (state :: STRING?)
```

**Mode**

```
READ
```

**Table 538. dbms.cluster.role()**

<table>
<thead>
<tr>
<th>Description</th>
<th>The role of this instance in the cluster for the specified database.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Signature</strong></td>
<td><code>dbms.cluster.role(database :: STRING?) :: (role :: STRING?)</code></td>
</tr>
<tr>
<td><strong>Mode</strong></td>
<td><code>READ</code></td>
</tr>
</tbody>
</table>

**Table 539. dbms.cluster.setDefaultDatabase()**

<table>
<thead>
<tr>
<th>Description</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Signature</strong></td>
<td><code>dbms.cluster.setDefaultDatabase(databaseName :: STRING?) :: (state :: STRING?)</code></td>
</tr>
<tr>
<td><strong>Mode</strong></td>
<td><code>READ</code></td>
</tr>
</tbody>
</table>
Change the default database to the provided value.

The database must exist and the old default database must be stopped.

For more information see Change the default database.

Note that this can only be executed on a cluster core member.

<table>
<thead>
<tr>
<th>Description</th>
<th>Change the default database to the provided value. The database must exist and the old default database must be stopped. For more information see Change the default database. Note that this can only be executed on a cluster core member.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature</td>
<td>dbms.cluster.setDefaultDatabase(databaseName :: STRING?) :: (result :: STRING?)</td>
</tr>
<tr>
<td>Mode</td>
<td>WRITE</td>
</tr>
</tbody>
</table>

### Table 540. dbms.components()

<table>
<thead>
<tr>
<th>Description</th>
<th>List DBMS components and their versions.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature</td>
<td>dbms.components() :: (name :: STRING?, versions :: LIST? OF STRING?, edition :: STRING?)</td>
</tr>
<tr>
<td>Mode</td>
<td>DBMS</td>
</tr>
</tbody>
</table>

### Table 541. dbms.database.state()

<table>
<thead>
<tr>
<th>Description</th>
<th>The actual status of the database with the provided name on this neo4j instance.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature</td>
<td>dbms.database.state(databaseName :: STRING?) :: (role :: STRING?, address :: STRING?, status :: STRING?, error :: STRING?)</td>
</tr>
<tr>
<td>Mode</td>
<td>READ</td>
</tr>
</tbody>
</table>

### Table 542. dbms.functions()

<table>
<thead>
<tr>
<th>Description</th>
<th>List all functions in the DBMS.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature</td>
<td>dbms.functions() :: (name :: STRING?, signature :: STRING?, category :: STRING?, description :: STRING?, aggregating :: BOOLEAN?, defaultBuiltInRoles :: LIST? OF STRING?)</td>
</tr>
<tr>
<td>Mode</td>
<td>DBMS</td>
</tr>
<tr>
<td>Replaced by</td>
<td>SHOW FUNCTIONS</td>
</tr>
</tbody>
</table>

### Table 543. dbms.info()

<table>
<thead>
<tr>
<th>Description</th>
<th>Provides information regarding the DBMS.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature</td>
<td>dbms.info() :: (id :: STRING?, name :: STRING?, creationDate :: STRING?)</td>
</tr>
<tr>
<td>Mode</td>
<td>DBMS</td>
</tr>
</tbody>
</table>

### Table 544. dbms.killConnection()

<table>
<thead>
<tr>
<th>Description</th>
<th>Kill network connection with the given connection id.</th>
</tr>
</thead>
</table>


<table>
<thead>
<tr>
<th>Table 545. dbms.killConnections()</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Signature</strong></td>
</tr>
<tr>
<td><strong>Mode</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 546. dbms.killQueries()</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Signature</strong></td>
</tr>
<tr>
<td><strong>Mode</strong></td>
</tr>
<tr>
<td><strong>Replaced by</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 547. dbms.killQuery()</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Signature</strong></td>
</tr>
<tr>
<td><strong>Mode</strong></td>
</tr>
<tr>
<td><strong>Replaced by</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 548. dbms.killTransaction()</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Signature</strong></td>
</tr>
<tr>
<td><strong>Mode</strong></td>
</tr>
<tr>
<td><strong>Replaced by</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 549. dbms.killTransactions()</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Signature</strong></td>
</tr>
</tbody>
</table>
### Table 550. dbms.listActiveLocks()

<table>
<thead>
<tr>
<th>Description</th>
<th>List the active lock requests granted for the transaction executing the query with the given query id.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature</td>
<td>dbms.listActiveLocks(queryId :: STRING?) :: (mode :: STRING?, resourceType :: STRING?, resourceId :: INTEGER?)</td>
</tr>
<tr>
<td>Mode</td>
<td>DBMS</td>
</tr>
</tbody>
</table>

### Table 551. dbms.listConfig()

<table>
<thead>
<tr>
<th>Description</th>
<th>List the currently active config of Neo4j.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature</td>
<td>dbms.listConfig(searchString = :: STRING?) :: (name :: STRING?, description :: STRING?, value :: STRING?, dynamic :: BOOLEAN?)</td>
</tr>
<tr>
<td>Mode</td>
<td>DBMS</td>
</tr>
</tbody>
</table>

### Table 552. dbms.listConnections()

<table>
<thead>
<tr>
<th>Description</th>
<th>List all accepted network connections at this instance that are visible to the user.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature</td>
<td>dbms.listConnections() :: (connectionId :: STRING?, connectTime :: STRING?, connector :: STRING?, username :: STRING?, userAgent :: STRING?, serverAddress :: STRING?, clientAddress :: STRING?)</td>
</tr>
<tr>
<td>Mode</td>
<td>DBMS</td>
</tr>
</tbody>
</table>

### Table 553. dbms.listPools()

<table>
<thead>
<tr>
<th>Description</th>
<th>List all memory pools, including sub pools, currently registered at this instance that are visible to the user.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature</td>
<td>dbms.listPools() :: (pool :: STRING?, databaseName :: STRING?, heapMemoryUsed :: STRING?, heapMemoryUsedBytes :: STRING?, nativeMemoryUsed :: STRING?, nativeMemoryUsedBytes :: STRING?, freeMemory :: STRING?, freeMemoryBytes :: STRING?, totalPoolMemory :: STRING?, totalPoolMemoryBytes :: STRING?)</td>
</tr>
<tr>
<td>Mode</td>
<td>DBMS</td>
</tr>
</tbody>
</table>

### Table 554. dbms.listQueries()

<table>
<thead>
<tr>
<th>Description</th>
<th>List all queries currently executing at this instance that are visible to the user.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature</td>
<td>dbms.listQueries() :: (queryId :: STRING?, username :: STRING?, metaData :: MAP?, query :: STRING?, parameters :: MAP?, planner :: STRING?, runtime :: STRING?, indexes :: LIST? OF MAP?, startTime :: STRING?, clientAddress :: STRING?, requestUri :: STRING?, resourceInformation :: MAP?, activeLockCount :: INTEGER?, elapsedTimeMillis :: INTEGER?, cpuTimeMillis :: INTEGER?, waitTimeMillis :: INTEGER?, idleTimeMillis :: INTEGER?, allocatedBytes :: INTEGER?, pageHits :: INTEGER?, pageFaunts :: INTEGER?, connectionId :: STRING?, database :: STRING?)</td>
</tr>
<tr>
<td>Mode</td>
<td>DBMS</td>
</tr>
</tbody>
</table>
### Table 555. dbms.listTransactions()

<table>
<thead>
<tr>
<th>Description</th>
<th>List all transactions currently executing at this instance that are visible to the user.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature</td>
<td><code>dbms.listTransactions() :: (transactionId :: STRING?, username :: STRING?, metaData :: MAP?, startTime :: STRING?, protocol :: STRING?, clientAddress :: STRING?, requestUri :: STRING?, currentQueryId :: STRING?, currentQuery :: STRING?, activeLockCount :: INTEGER?, status :: STRING?, resourceInformation :: MAP?, elapsedTimeMillis :: INTEGER?, cpuTimeMillis :: INTEGER?, waitTimeMillis :: INTEGER?, idleTimeMillis :: INTEGER?, allocatedBytes :: INTEGER?, allocatedDirectBytes :: INTEGER?, pageHits :: INTEGER?, pageFaults :: INTEGER?, connectionId :: STRING?, initializationStackTrace :: STRING?, database :: STRING?, estimatedUsedHeapMemory :: INTEGER?)</code></td>
</tr>
</tbody>
</table>

**Mode**

| DBMS |

**Replaced by**

| SHOW TRANSACTIONS |

### Table 556. dbms.procedures()

<table>
<thead>
<tr>
<th>Description</th>
<th>List all procedures in the DBMS.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature</td>
<td><code>dbms.procedures() :: (name :: STRING?, signature :: STRING?, description :: STRING?, mode :: STRING?, defaultBuiltInRoles :: LIST? OF STRING?, worksOnSystem :: BOOLEAN?)</code></td>
</tr>
</tbody>
</table>

**Mode**

| DBMS |

**Replaced by**

| SHOW PROCEDURES |

### Table 557. dbms.quarantineDatabase

<table>
<thead>
<tr>
<th>Description</th>
<th>Place a database in quarantine or remove thereof.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature</td>
<td><code>dbms.quarantineDatabase(databaseName :: STRING?, setStatus :: BOOLEAN?, reason = No reason given :: STRING?) :: (databaseName :: STRING?, quarantined :: BOOLEAN?, result :: STRING?)</code></td>
</tr>
</tbody>
</table>

**Mode**

| DBMS |

### Table 558. dbms.queryJmx()

<table>
<thead>
<tr>
<th>Description</th>
<th>Query JMX management data by domain and name. Valid queries should use the syntax outlined in the javax.management.ObjectName API documentation. For instance, use &quot;<em>:::</em>&quot; to find all JMX beans.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature</td>
<td><code>dbms.queryJmx(query :: STRING?) :: (name :: STRING?, description :: STRING?, attributes :: MAP?)</code></td>
</tr>
</tbody>
</table>

**Mode**

<p>| DBMS |</p>
<table>
<thead>
<tr>
<th>Table 559. dbms.routing.getRoutingTable()</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Signature</strong></td>
</tr>
<tr>
<td><strong>Mode</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 560. dbms.scheduler.failedJobs()</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Signature</strong></td>
</tr>
<tr>
<td><strong>Mode</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 561. dbms.scheduler.groups()</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Signature</strong></td>
</tr>
<tr>
<td><strong>Mode</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 562. dbms.scheduler.jobs()</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Signature</strong></td>
</tr>
<tr>
<td><strong>Mode</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 563. dbms.scheduler.profile()</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Signature</strong></td>
</tr>
<tr>
<td><strong>Mode</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 564. dbms.security.activateUser()</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Signature</strong></td>
</tr>
<tr>
<td><strong>Mode</strong></td>
</tr>
<tr>
<td>Table 565. dbms.security.addRoleToUser()</td>
</tr>
<tr>
<td>----------------------------------------</td>
</tr>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Signature</strong></td>
</tr>
<tr>
<td><strong>Mode</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 566. dbms.security.changePassword()</th>
<th>Admin only</th>
<th>Deprecated</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
<td>Change the current user’s password.</td>
<td></td>
</tr>
<tr>
<td><strong>Signature</strong></td>
<td><code>dbms.security.changePassword(password :: STRING?, requirePasswordChange = false :: BOOLEAN?) :: VOID</code></td>
<td></td>
</tr>
<tr>
<td><strong>Mode</strong></td>
<td>WRITE</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 567. dbms.security.changeUserPassword()</th>
<th>Enterprise edition</th>
<th>Admin only</th>
<th>Deprecated</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
<td>Change the given user’s password.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Signature</strong></td>
<td><code>dbms.security.changeUserPassword(username :: STRING?, newPassword :: STRING?, requirePasswordChange = true :: BOOLEAN?) :: VOID</code></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mode</strong></td>
<td>WRITE</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 568. dbms.security.clearAuthCache()</th>
<th>Enterprise edition</th>
<th>Admin only</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
<td>Clears authentication and authorization cache.</td>
<td></td>
</tr>
<tr>
<td><strong>Signature</strong></td>
<td><code>dbms.security.clearAuthCache() :: VOID</code></td>
<td></td>
</tr>
<tr>
<td><strong>Mode</strong></td>
<td>DBMS</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 569. dbms.security.createRole()</th>
<th>Enterprise edition</th>
<th>Admin only</th>
<th>Deprecated</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
<td>Create a new role.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Signature</strong></td>
<td><code>dbms.security.createRole(roleName :: STRING?) :: VOID</code></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mode</strong></td>
<td>WRITE</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 570. dbms.security.createUser()</th>
<th>Admin only</th>
<th>Deprecated</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
<td>Create a new user.</td>
<td></td>
</tr>
<tr>
<td><strong>Signature</strong></td>
<td><code>dbms.security.createUser(username :: STRING?, password :: STRING?, requirePasswordChange = true :: BOOLEAN?) :: VOID</code></td>
<td></td>
</tr>
<tr>
<td><strong>Mode</strong></td>
<td>WRITE</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 571. dbms.security.deleteRole()</th>
<th>Enterprise edition</th>
<th>Admin only</th>
<th>Deprecated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Delete the specified role. Any role assignments will be removed.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Signature</td>
<td><code>dbms.security.deleteRole(roleName :: STRING?) :: VOID</code></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mode</td>
<td>WRITE</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 572. `dbms.security.deleteUser()`  
Admin only  
Deprecated

| Description | Delete the specified user. |
| Signature | `dbms.security.deleteUser(username :: STRING?) :: VOID` |
| Mode | WRITE |

### Table 573. `dbms.security.listRoles()`  
Enterprise edition  
Admin only  
Deprecated

| Description | List all available roles. |
| Signature | `dbms.security.listRoles() :: (role :: STRING?, users :: LIST? OF STRING?)` |
| Mode | READ |

### Table 574. `dbms.security.listRolesForUser()`  
Enterprise edition  
Deprecated

| Description | List all roles assigned to the specified user. |
| Signature | `dbms.security.listRolesForUser(username :: STRING?) :: (value :: STRING?)` |
| Mode | READ |

### Table 575. `dbms.security.listUsers()`  
Admin only  
Deprecated

| Description | List all native users. |
| Signature | `dbms.security.listUsers() :: (username :: STRING?, roles :: LIST? OF STRING?, flags :: LIST? OF STRING?)` |
| Mode | READ |

### Table 576. `dbms.security.listUsersForRole()`  
Enterprise edition  
Admin only  
 Deprecated

| Description | List all users currently assigned the specified role. |
| Signature | `dbms.security.listUsersForRole(roleName :: STRING?) :: (value :: STRING?)` |
| Mode | READ |

### Table 577. `dbms.security.removeRoleFromUser()`  
Enterprise edition  
Admin only  
Deprecated

| Description | Unassign a role from the user. |
| Signature | `dbms.security.removeRoleFromUser(roleName :: STRING?, username :: STRING?) :: VOID` |
Table 578. `dbms.security.suspendUser()` **Enterprise edition** **Admin only** **Deprecated**

**Description**  
Suspend the specified user.

**Signature**  
dbms.security.suspendUser(username :: STRING?) :: VOID

**Mode**  
WRITE

Table 579. `dbms.setConfigValue()` **Enterprise edition** **Admin only**

**Description**  
Update a given setting value. Passing an empty value results in removing the configured value and falling back to the default value. Changes do not persist and are lost if the server is restarted. In a clustered environment, `dbms.setConfigValue` affects only the cluster member it is run against.

**Signature**  
dbms.setConfigValue(setting :: STRING?, value :: STRING?) :: VOID

**Mode**  
DBMS

Table 580. `dbms.showCurrentUser()`

**Description**  
Show the current user.

**Signature**  
dbms.showCurrentUser() :: (username :: STRING?, roles :: LIST? OF STRING?, flags :: LIST? OF STRING?)

**Mode**  
DBMS

Table 581. `dbms.upgrade()` **Admin only**

**Description**  
Upgrade the system database schema if it is not the current schema.

**Signature**  
dbms.upgrade() :: (status :: STRING?, upgradeResult :: STRING?)

**Mode**  
WRITE

Table 582. `dbms.upgradeStatus()` **Admin only**

**Description**  
Report the current status of the system database sub-graph schema.

**Signature**  
dbms.upgradeStatus() :: (status :: STRING?, description :: STRING?, resolution :: STRING?)

**Mode**  
READ

Table 583. `tx.getMetaData()`

**Description**  
Provides attached transaction metadata.

**Signature**  
tx.getMetaData() :: (metadata :: MAP?)
<table>
<thead>
<tr>
<th>Mode</th>
<th>DBMS</th>
</tr>
</thead>
</table>

### Table 584. `tx.setMetaData()`

<table>
<thead>
<tr>
<th>Description</th>
<th>Attaches a map of data to the transaction. The data will be printed when listing queries, and inserted into the query log.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature</td>
<td><code>tx.setMetaData(data :: MAP?) :: VOID</code></td>
</tr>
<tr>
<td>Mode</td>
<td>DBMS</td>
</tr>
</tbody>
</table>

### Appendix B: Tutorials

This appendix contains tutorials that further describe usages of Neo4j.

The following step-by-step tutorials cover common operational tasks or otherwise exemplify working with Neo4j.

- **Set up a local Causal Cluster** — This tutorial walks through the basics of setting up a Neo4j Causal Cluster.
- **Back up and restore a database in Causal Cluster** — This tutorial provides a detailed example of how to back up and restore a database in a running Causal Cluster.
- **Neo4j Admin import** — This tutorial provides detailed examples to illustrate the capabilities of importing data from CSV files with the command `neo4j-admin import`.
- **SSO configuration** — This tutorial presents examples and solutions to common problems when configuring SSO.
- **Set up and use Fabric** — This tutorial walks through the basics of setting up and using Neo4j Fabric.

#### 17.B.1. Set up a local Causal Cluster [Enterprise edition](#)

This tutorial walks through the basics of setting up a Neo4j Causal Cluster. The result is a local cluster of six instances: three Cores and three Read Replicas.

### Introduction

In this tutorial, you will learn how to deploy a Causal Cluster locally on a single machine.

- Keep in mind that a cluster on a single machine has no fault tolerance and is therefore not suitable for production use.

A typical Causal Cluster consists of three Core instances and three Read Replicas. The Core instances are responsible for keeping the data safe, and the Read Replicas are responsible for scaling the capacity of the cluster. For details on the number of servers required for a Causal Cluster, see [Primary servers](#).
The Core of the Causal Cluster is intended to remain stable over time. The roles within the Core may change as needed, but the Core itself is long-lived and stable. Read Replicas live at the edge of the cluster and can be brought up and taken down without affecting the Core. They can be added as needed to increase the operational capacity of the cluster as a whole.

For more information about Causal Clustering architecture, configuration, and operation, see Clustering.

Download Neo4j

You download Neo4j and prepare your local environment.

1. Create a local working directory.
2. Download a copy of the Neo4j Enterprise Edition from the Neo4j download site.
3. Unpack Neo4j in the working directory.

Set up the Core servers

You create and configure three Core instances.

Configure and start the first Core instance

You create and configure the first Core instance.

1. Make a copy of the neo4j-enterprise-4.4.10 directory and name it core-01.
   You have to keep the original directory for setting up the other Core instances and Read Replicas. The core-01 directory will contain the first Core instance.
2. Open the Neo4j configuration file, conf/neo4j.conf, and configure the following settings:
   
   ![Image of a table with settings]
   
   If you cannot find the configuration file, see File locations.

   a. Locate and uncomment the setting dbms.mode=CORE.
   b. Locate and uncomment the setting causal_clustering.minimum_core_cluster_size_at_formation=3.
   c. Locate and uncomment the setting causal_clustering.minimum_core_cluster_size_at_runtime=3.
   d. Locate and uncomment the setting causal_clustering.initial_discovery_members=localhost:5000,localhost:5001,localhost:5002.
   e. Locate and uncomment the setting causal_clustering.discovery_listen_address=:5000.
   f. Locate and uncomment the setting causal_clustering.transaction_listen_address=:6000.
   g. Locate and uncomment the setting causal_clustering.raft_listen_address=:7000.
   h. Locate and uncomment the setting dbms.connector.bolt.listen_address=:7687.
   i. Locate and uncomment the setting dbms.connector.http.listen_address=:7474.
   j. Locate and uncomment the setting dbms.connector.https.listen_address, and change the value.

   ![Image of a table with settings]
to :6474.

k. Locate and uncomment the setting dbms.backup.listen_address=0.0.0.0:6362.

3. Save the file.

4. Open a command-line tool and navigate to core-01 directory.

5. Run the following command to start core-01:

```
core-01$ ./bin/neo4j start
```

Create and configure the second Core instance

You create and configure the second Core instance.

1. Make a new copy of the neo4j-enterprise-4.4.10 directory and name it core-02.

2. Overwrite core-02/conf/neo4j.conf with the just modified core-01/conf/neo4j.conf. Then in the new core-02 directory, open the conf/neo4j.conf file and configure the following settings:

   a. Locate the setting causal_clustering.discovery_listen_address and change the value to :5001.

   b. Locate the setting causal_clustering.transaction_listen_address and change the value to :6001.

   c. Locate the setting causal_clustering.raft_listen_address and change the value to :7001.

   d. Locate the setting dbms.connector.bolt.listen_address and change the value to :7688.

   e. Locate the setting dbms.connector.http.listen_address and change the value to :7475.

   f. Locate the setting dbms.connector.https.listen_address and change the value to :6475.

   g. Locate the setting dbms.backup.listen_address and change the value to 0.0.0.0:6363.

3. Save the file.

4. Open a command-line tool and navigate to core-02 directory.

5. Run the following command to start core-02:

```
core-02$ ./bin/neo4j start
```

Create and configure the third Core instance

You create and configure the third Core instance.

1. Make a new copy of the neo4j-enterprise-4.4.10 directory and name it core-03.

2. Overwrite core-03/conf/neo4j.conf with the just modified core-02/conf/neo4j.conf. Then in the new core-03 directory, open the conf/neo4j.conf file and configure the following settings:

   a. Locate the setting causal_clustering.discovery_listen_address and change the value to :5002.

   b. Locate the setting causal_clustering.transaction_listen_address and change the value to :6475.
c. Locate the setting `causal_clustering.raft_liste...change the value to `:7002`.

d. Locate the setting `dbms.connector.bolt.listen_address` and change the value to `:7689`.

e. Locate the setting `dbms.connector.http.listen_address` and change the value to `:7476`.

f. Locate the setting `dbms.connector.https.listen_address` and change the value to `:6476`.

g. Locate the setting `dbms.backup.listen_address` and change the value to `0.0.0.0:6364`.

3. Save the file.

4. Open a command-line tool and navigate to `core-03` directory.

5. Run the following command to start `core-03`:

   ```bash
core-03$ ./bin/neo4j start
   ```

   **Startup Time**
   
   To follow along with the startup of a server, check the messages in `<instance-home>/logs/neo4j.log`:
   
   - On a Unix system, run the command `tail -n100 logs/neo4j.log`.
   - On Windows Server, run `Get-Content .\logs\neo4j.log -Tail 10 -Wait`.

   While an instance is joining the cluster, the server may appear unavailable. In the case where an instance is joining a cluster with lots of data, it may take a number of minutes for the new instance to download the data from the cluster and become available.

Check the status of the cluster

The minimal cluster of three Core servers is operational and is ready to serve requests.

Connect to any of the three Core instances to check the cluster status.


2. Authenticate with the default `neo4j/neo4j` credentials, and set a new password when prompted.

3. Check the status of the cluster by running the following in Neo4j Browser:

   ```cypher
   :sysinfo
   ```
4. Run the following query to create nodes and relationships.

```
UNWIND range(0, 100) AS value
MERGE (person1:Person {id: value})
MERGE (person2:Person {id: toInteger(100.0 * rand())})
MERGE (person1)-[:FRIENDS]->(person2)
```

5. Open a new tab and point your web browser to a follower, for example, core-02 at http://localhost:7475.

6. Authenticate with the credentials you have set up for core-01.

7. Run the following query to verify that the data has been replicated:

```
MATCH path = (person:Person)-[:FRIENDS]->(friend)
RETURN path
LIMIT 10
```

Set up the Read Replicas

Because the Read Replicas do not participate in quorum decisions, their configuration is simpler than the configuration of the Core servers.

You configure a Read Replica by setting the address of a Core instance that it can bind to in order to discover the cluster. For details, see Discovery protocol.

After the initial discovery, the Read Replicas can choose a Core instance from which to catch up. For details, see Catchup protocol.

Configure and start the first Read Replica

You create and configure the first Read Replica.

1. Make a copy of the neo4j-enterprise-4.4.10 directory and name it replica-01.

2. In the new replica-01 directory, open the conf/neo4j.conf file and configure the following settings:

   a. Locate and uncomment the setting dbms.mode, and change the value to READ_REPLICA.
b. Locate and uncomment the setting
   
   `causal_clustering.initial_discovery_members=localhost:5000,localhost:5001,localhost:5002`.

c. Locate and uncomment the setting `causal_clustering.discovery_listen_address`, and change the value to `:5003`.

d. Locate and uncomment the setting `causal_clustering.transaction_listen_address`, and change the value to `:6003`.

e. Locate and uncomment the setting `dbms.connector.bolt.listen_address`, and change the value to `:7690`.

f. Locate and uncomment the setting `dbms.connector.http.listen_address`, and change the value to `:7477`.

g. Locate and uncomment the setting `dbms.connector.https.listen_address`, and change the value to `:6477`.

h. Locate and uncomment the setting `dbms.backup.listen_address`, and change the values to `0.0.0.0:6365`.

3. Save the file.

4. Open a command-line tool and navigate to `replica-01` directory.

5. Run the following command to start `replica-01`:

   ```bash
   replica-01$ ./bin/neo4j start
   ```

**Configure and start the second Read Replica**

You create and configure the second Read Replica.

1. Make a new copy of the `neo4j-enterprise-4.4.10` directory and name it `replica-02`.

2. Overwrite `replica-02/conf/neo4j.conf` with the just modified `replica-01/conf/neo4j.conf`. Then in the new `replica-02` directory, open the `conf/neo4j.conf` file and configure the following settings:

   a. Locate the setting `causal_clustering.discovery_listen_address` and change the value to `:5004`.

   b. Locate the setting `causal_clustering.transaction_listen_address` and change the value to `:6004`.

   c. Locate the setting `dbms.connector.bolt.listen_address` and change the value to `:7691`.

   d. Locate the setting `dbms.connector.http.listen_address` and change the value to `:7478`.

   e. Locate the setting `dbms.connector.https.listen_address` and change the value to `:6478`.

   f. Locate the setting `dbms.backup.listen_address` and change the value to `0.0.0.0:6366`.

3. Save the file.

4. Open a command-line tool and navigate to `replica-02` directory.

5. Run the following command to start `replica-02`:
Configure and start the third Read Replica

You create and configure the third Read Replica.

1. Make a new copy of the neo4j-enterprise-4.4.10 directory and name it replica-03.
2. Overwrite replica-03/conf/neo4j.conf with the just modified replica-02/conf/neo4j.conf. Then in the new replica-03 directory, open the conf/neo4j.conf file and configure the following settings:
   a. Locate the setting causal_clustering.discovery_listen_address and change the value to :5005.
   b. Locate the setting causal_clustering.transaction_listen_address and change the value to :6005.
   c. Locate the setting dbms.connector.bolt.listen_address and change the value to :7692.
   d. Locate the setting dbms.connector.http.listen_address and change the value to :7479.
   e. Locate the setting dbms.connector.https.listen_address and change the value to :6479.
   f. Locate the setting dbms.backup.listen_address and change the value to 0.0.0.0:6367.
3. Save the file.
4. Open a command-line tool and navigate to replica-03 directory.
5. Run the following command to start replica-03:

```
replica-03$ ./bin/neo4j start
```

Check the status of the cluster

Your cluster of three Core servers and three Read Replicas is operational and is ready to serve requests.

In your core-01 browser, check the cluster status by running the following in Neo4j Browser:

```
:syinfo
```
Example 138. A cluster of three Core instances and three Read Replicas.

<table>
<thead>
<tr>
<th>Name</th>
<th>Address</th>
<th>Role</th>
<th>Status</th>
<th>Default</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>neo4j</td>
<td>localhost:7689</td>
<td>follower</td>
<td>online</td>
<td>true</td>
<td>-</td>
</tr>
<tr>
<td>neo4j</td>
<td>localhost:7688</td>
<td>follower</td>
<td>online</td>
<td>true</td>
<td>-</td>
</tr>
<tr>
<td>neo4j</td>
<td>localhost:7687</td>
<td>leader</td>
<td>online</td>
<td>true</td>
<td>-</td>
</tr>
<tr>
<td>neo4j</td>
<td>localhost:7692</td>
<td>read_replica</td>
<td>online</td>
<td>true</td>
<td>-</td>
</tr>
<tr>
<td>neo4j</td>
<td>localhost:7691</td>
<td>read_replica</td>
<td>online</td>
<td>true</td>
<td>-</td>
</tr>
<tr>
<td>neo4j</td>
<td>localhost:76890</td>
<td>read_replica</td>
<td>online</td>
<td>true</td>
<td>-</td>
</tr>
<tr>
<td>system</td>
<td>localhost:7689</td>
<td>follower</td>
<td>online</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>system</td>
<td>localhost:7688</td>
<td>follower</td>
<td>online</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>system</td>
<td>localhost:7687</td>
<td>leader</td>
<td>online</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>system</td>
<td>localhost:7692</td>
<td>read_replica</td>
<td>online</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>system</td>
<td>localhost:7691</td>
<td>read_replica</td>
<td>online</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>system</td>
<td>localhost:7690</td>
<td>read_replica</td>
<td>online</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

1. Open a new tab and point your web browser to a Read Replica, for example, replica-01 at http://localhost:7477.
2. Login with neo4j and the previously set password and use the bolt:// schema.
3. Run the following query to verify that the data has been replicated:

   ```
   MATCH path = (person:Person)-[:FRIENDS]-(friend)
   RETURN path
   LIMIT 10
   ```

17.B.2. Back up and restore a database in Causal Cluster Enterprise edition

This tutorial provides a detailed example of how to back up and restore a database in a running Causal Cluster.

The following example assumes that you want to restore a database backup, which has users and roles associated with it, in a running Causal Cluster with three core servers. For more information on how to set up a Causal Cluster with three cores, see Set up a local Causal Cluster.

In a Neo4j DBMS, every database is backed up individually. Therefore, it is very important to plan your backup strategy for each of them. For more detailed information on how to design an appropriate backup strategy for your setup, see Backup and restore.
Prepare to back up your database

Before you perform the backup, it is good to take a note of the data and metadata of the database that you want to restore. You can use this information to later verify that the restore is successful and to recreate the database users and roles. In this example, the database is called movies1 and uses the Movie Graph dataset from the Neo4j Browser → Favorites → Example Graphs.

This tutorial uses the Linux or macOS tarball installation. It assumes that your current work directory is the <neo4j-home> directory of the tarball installation.

1. In the Neo4j instance, where the database is running, log in to the Cypher Shell command-line console with your credentials. For more information about the Cypher Shell command-line interface (CLI) and how to use it, see Cypher Shell.

   ```
   bin/cypher-shell -u neo4j -p <password>
   ```

   Connected to Neo4j at neo4j://localhost:7687 as user neo4j.
   Type :help for a list of available commands or :exit to exit the shell.
   Note that Cypher queries must end with a semicolon.

2. Change the active database to movies1.

   ```
   :use movies1
   ```

3. Run a query to count the number of nodes in the database.

   ```
   MATCH (n) RETURN count(n) AS countNode;
   ```

   +-----------+
   | countNode |
   | 171       |
   +-----------+
   1 row available after 22 ms, consumed after another 1 ms

4. Run a query to count the number of relationships.

   ```
   MATCH (n)-[r]->() RETURN count(r) AS countRelationships;
   ```

   +------------------+
   | countRelationships |
   | 253               |
   +------------------+
   1 row available after 29 ms, consumed after another 0 ms

5. Change the active database to system, and run a query to see if there are any custom roles, associated with this database, and their privileges.
SHOW ALL PRIVILEGES AS COMMANDS;

<table>
<thead>
<tr>
<th>command</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;GRANT ACCESS ON HOME DATABASE TO 'PUBLIC'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT EXECUTE FUNCTION ON DBMS TO 'PUBLIC'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT EXECUTE PROCEDURE * ON DBMS TO 'PUBLIC'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT ACCESS ON DATABASE * TO 'admin'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT MATCH {x} ON GRAPH * RELATIONSHIP * TO 'admin'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT WRITE ON GRAPH * TO 'admin'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT NAME MANAGEMENT ON DATABASE * TO 'admin'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT INDEX MANAGEMENT ON DATABASE * TO 'admin'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT CONSTRAINT MANAGEMENT ON DATABASE * TO 'admin'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT START ON DATABASE * TO 'admin'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT STOP ON DATABASE * TO 'admin'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT TRANSACTION MANAGEMENT (*) ON DATABASE * TO 'admin'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT ALL DBMS PRIVILEGES ON DBMS TO 'admin'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT ACCESS ON DATABASE * TO 'architect'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT MATCH {x} ON GRAPH * NODE * TO 'architect'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT MATCH {x} ON GRAPH * RELATIONSHIP * TO 'architect'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT WRITE ON GRAPH * TO 'architect'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT NAME MANAGEMENT ON DATABASE * TO 'architect'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT INDEX MANAGEMENT ON DATABASE * TO 'architect'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT CONSTRAINT MANAGEMENT ON DATABASE * TO 'architect'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT ACCESS ON DATABASE * TO 'publisher'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT MATCH {x} ON GRAPH * NODE * TO 'publisher'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT MATCH {x} ON GRAPH * RELATIONSHIP * TO 'publisher'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT WRITE ON GRAPH * TO 'publisher'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT NAME MANAGEMENT ON DATABASE * TO 'publisher'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT INDEX MANAGEMENT ON DATABASE * TO 'publisher'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT CONSTRAINT MANAGEMENT ON DATABASE * TO 'publisher'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT ACCESS ON DATABASE * TO 'editor'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT MATCH {x} ON GRAPH * NODE * TO 'editor'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT MATCH {x} ON GRAPH * RELATIONSHIP * TO 'editor'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT WRITE ON GRAPH * TO 'editor'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT ACCESS ON DATABASE * TO 'reader'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT MATCH {x} ON GRAPH * NODE * TO 'reader'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT MATCH {x} ON GRAPH * RELATIONSHIP * TO 'reader'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT ACCESS ON DATABASE * TO 'myrole'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT MATCH {x} ON GRAPH * NODE * TO 'myrole'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT MATCH {x} ON GRAPH * RELATIONSHIP * TO 'myrole'&quot;</td>
</tr>
<tr>
<td>&quot;GRANT WRITE ON GRAPH movies1 TO 'myrole'&quot;</td>
</tr>
</tbody>
</table>

39 rows available after 868 ms, consumed after another 80 ms

The result shows that there is one custom role `myrole`.

6. Run a query to see all users associated with this role.

SHOW USERS;

<table>
<thead>
<tr>
<th>user</th>
<th>roles</th>
<th>passwordChangeRequired</th>
<th>suspended</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;neo4j&quot;</td>
<td>[&quot;admin&quot;, &quot;PUBLIC&quot;]</td>
<td>FALSE</td>
<td>FALSE</td>
</tr>
<tr>
<td>&quot;user1&quot;</td>
<td>[&quot;myrole&quot;, &quot;PUBLIC&quot;]</td>
<td>TRUE</td>
<td>FALSE</td>
</tr>
</tbody>
</table>

2 rows available after 36 ms, consumed after another 2 ms

7. Exit the Cypher Shell command-line console.

:exit
Back up your database

Now you are ready to back up the database.

Run the following command to back up the database in your targeted folder. If the folder where you want to place your backup does not exist, you have to create it. In this example, it is called /tmp/4.4.10.

To perform the backup, run the following command:

```
bin/neo4j-admin backup --backup-dir=/tmp/4.4.10 --database=movies1 --include-metadata=all
```

The option `--include-metadata=all` creates a cypher script, which you can later use to restore the database’s users, roles, and privileges.

For details on performing a backup and the different command options, see Back up an online database.

Delete the database that you want to replace

Before you restore the database backup, you have to delete the database that you want to replace with that backup. If you want to restore the backup as an additional database in your DBMS, then you can proceed to Restore the database backup on all cluster members directly.

On one of the cluster members, run the Cypher command `DROP DATABASE` to delete the database that you want to replace. The command is automatically routed to the leader and from there to the other cluster members.

Dropping a database also deletes the users and roles associated with it.

1. In the Cypher Shell command-line console on one of the cluster members, change the active database to `system`, and run the command `DROP DATABASE` to delete the database that you want to replace. In this example, the database is called `movies`.

```
DROP DATABASE movies;
```

If you are unable to delete the database (e.g., because Neo4j is not running), you must run `neo4j-admin unbind` first instead. If you fail to do this, the store files you have (post restore) will be out of sync with the cluster state you have for that database, leading to logical corruption.

2. You can run `SHOW DATABASES` to verify that the database `movies` does not exist.

```
SHOW DATABASES;
```
3. Exit the Cypher Shell command-line console.

:exit

Restore the database backup on all cluster members

On each cluster member, run the following command to restore the database backup. For details on performing a restore and the different command options, see Restore a database backup.

```
bin/neo4j-admin restore --from=/tmp/4.4.10/movies1 --database=movies1
```

You need to execute $HOME/path/to/core-member/data/scripts/movies1/restore_metadata.cypher. To execute the file use cypher-shell command with parameter `movies1` restorePath=/tmp/{neo4j-version-exact}/movies1, restoreStatus=successful, reason=

Then, on each cluster member, run the following command to verify that the database movies1 exists:

```
ls -al data/databases
```

```
total 0
    drwxr-xr-x 7 username  staff  224 17 Nov 15:50 .
    drwxr-xr-x 8 username  staff  256 17 Nov 15:50 ..
    drwxr-xr-x 40 username  staff 1280 17 Nov 15:50 movies1
    drwxr-xr-x 37 username  staff 1184 16 Nov 15:00 neo4j
    -rw-r--r-- 1 username  staff  0 16 Nov 15:00 store_lock
    drwxr-xr-x 38 username  staff 1216 16 Nov 15:00 system
```

However, restoring a database does not automatically create it. Therefore, it will not be visible if you do SHOW DATABASES in Cypher Shell or Neo4j Browser.

Create the database backup on the cluster leader

You create the database backup only on one of your cluster members using the command CREATE DATABASE. The command is automatically routed to the leader and from there to the other cluster members.

1. In the Cypher Shell command-line console on one of the cluster members, use the `system` database and create the database `movies1`.

```cypher
CREATE DATABASE movies1;
```
2. Verify that the movies1 database is online on all members.

```sql
SHOW DATABASES;
```

<table>
<thead>
<tr>
<th>name</th>
<th>address</th>
<th>role</th>
<th>requestedStatus</th>
<th>currentStatus</th>
<th>error</th>
<th>default</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;movies1&quot;</td>
<td>&quot;localhost:7688&quot;</td>
<td>&quot;follower&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>FALSE</td>
</tr>
<tr>
<td>&quot;movies1&quot;</td>
<td>&quot;localhost:7687&quot;</td>
<td>&quot;leader&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>FALSE</td>
</tr>
<tr>
<td>&quot;movies1&quot;</td>
<td>&quot;localhost:7689&quot;</td>
<td>&quot;follower&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>FALSE</td>
</tr>
<tr>
<td>&quot;neo4j&quot;</td>
<td>&quot;localhost:7688&quot;</td>
<td>&quot;leader&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>TRUE</td>
</tr>
<tr>
<td>&quot;neo4j&quot;</td>
<td>&quot;localhost:7687&quot;</td>
<td>&quot;follower&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>TRUE</td>
</tr>
<tr>
<td>&quot;neo4j&quot;</td>
<td>&quot;localhost:7689&quot;</td>
<td>&quot;follower&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>TRUE</td>
</tr>
<tr>
<td>&quot;system&quot;</td>
<td>&quot;localhost:7688&quot;</td>
<td>&quot;leader&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>FALSE</td>
</tr>
<tr>
<td>&quot;system&quot;</td>
<td>&quot;localhost:7687&quot;</td>
<td>&quot;follower&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>FALSE</td>
</tr>
<tr>
<td>&quot;system&quot;</td>
<td>&quot;localhost:7689&quot;</td>
<td>&quot;follower&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;&quot;</td>
<td>FALSE</td>
</tr>
</tbody>
</table>

9 rows available after 3 ms, consumed after another 1 ms

3. Exit the Cypher Shell command-line console.

```sql
:exit
```

Recreate the database users and roles

On one of the cluster members, run the restore cypher script `restore_metadata.cypher` to create the database and recreate all users and roles of the database backup. The command is automatically routed to the leader and from there to the other cluster members.

Using `cat` (UNIX)

```bash
cat data/scripts/movies1/restore_metadata.cypher | bin/cypher-shell -u neo4j -p password -a localhost:7688 -d system --param "database => 'movies1'"
```

Using `type` (Windows)

```bash
type data\scripts\movies1\restore_metadata.cypher | bin\cypher-shell.bat -u neo4j -p password -a localhost:7688 -d system --param "database => 'movies1'"
```

Follow the steps from 1 to 6 of section Prepare to back up your database to verify that all data and metadata of the database backup have been successfully restored on all cluster members.

17.B.3. Neo4j Admin import

This tutorial provides detailed examples to illustrate the capabilities of importing data from CSV files with the command `neo4j-admin import`. 653
The `neo4j-admin import` command does not create a database, the command only imports data and make it available for the database. The database must not exist before the `neo4j-admin import` command has been executed, and the database should be created afterwards. The command will exit with an error message if the database already exists.

Relationships are created by connecting node IDs, each node should have a unique ID to be able to be referenced when creating relationships between nodes. In the following examples, the node IDs are stored as properties on the nodes. If you do not want the IDs to persist as properties after the import completes, then do not specify a property name in the `:ID` field.

The examples show how to import data in a standalone Neo4j DBMS. They use:

- The Neo4j tarball (Unix console application).
- `$NEO4J_HOME` as the current working directory.
- The default database `neo4j`.
- The import directory of the Neo4j installation to store all the CSV files. However, the CSV files can be located in any directory of your file system.
- UNIX styled paths.
- The `neo4j-admin import` command.

To create a cluster based on imported data, see [Seed a cluster using the import tool](#).

### Handy tips:

- The details of CSV file header format can be found at [CSV header format](#).
- To show available databases, use the Cypher query `SHOW DATABASES` against the `system` database.
- To remove a database, use the Cypher query `DROP DATABASE database_name` against the `system` database.
- To create a database, use the Cypher query `CREATE DATABASE database_name` against the `system` database.

### Import a small data set

In this example, you will import a small data set containing nodes and relationships. The data set is split into three CSV files, where each file has a header row describing the data.

The data
The data set contains information about movies, actors, and roles. Data for movies and actors are stored as nodes and the roles are stored as relationships.

The files you want to import data from are:

- `movies.csv`
- `actors.csv`
- `roles.csv`

Each movie in `movies.csv` has an ID, a title and a year, stored as properties in the node. All the nodes in `movies.csv` also have the label Movie. A node can have several labels, as you can see in `movies.csv` there are nodes that also have the label Sequel. The node labels are optional, they are very useful for grouping nodes into sets where all nodes that have a certain label belongs to the same set.

`movies.csv`

<table>
<thead>
<tr>
<th>movieId</th>
<th>ID</th>
<th>title</th>
<th>year</th>
<th>label</th>
</tr>
</thead>
<tbody>
<tr>
<td>tt0133093</td>
<td>&quot;The Matrix&quot;,1999,Movie</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tt0234215</td>
<td>&quot;The Matrix Reloaded&quot;,2003,Movie;Sequel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tt0242653</td>
<td>&quot;The Matrix Revolutions&quot;,2003,Movie;Sequel</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The actors data in `actors.csv` consist of an ID and a name, stored as properties in the node. The ID in this case a shorthand of the actors name. All the nodes in `actors.csv` have the label Actor.

`actors.csv`

<table>
<thead>
<tr>
<th>personId</th>
<th>ID</th>
<th>name</th>
<th>label</th>
</tr>
</thead>
<tbody>
<tr>
<td>keanu</td>
<td>&quot;Keanu Reeves&quot;,Actor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>laurence</td>
<td>&quot;Laurence Fishburne&quot;,Actor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>carrieanne</td>
<td>&quot;Carrie-Anne Moss&quot;,Actor</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The roles data in `roles.csv` have only one property, role. Roles are represented by relationship data that connects actor nodes with movie nodes.

There are three mandatory fields for relationship data:

1. :START_ID — ID refering to a node.
2. :END_ID — ID refering to a node.

In order to create a relationship between two nodes, the IDs defined in `actors.csv` and `movies.csv` are used for the :START_ID and :END_ID fields. You also need to provide a relationship type (in this case ACTED_IN) for the :TYPE field.
Importing the data

- Paths to node data is defined with the `--nodes` option.
- Paths to relationship data is defined with the `--relationships` option.

The call to `neo4j-admin import` would look like this:

```
bin/neo4j-admin import --database=neo4j --nodes=import/movies.csv --nodes=import/actors.csv --relationships=import/roles.csv
```

Query the data

To query the data. Start Neo4j.

```
The default username and password is neo4j and neo4j.
```

```
bin/neo4j start
```

To query the imported data in the graph, try a simple Cypher query.

```
bin/cypher-shell --database=neo4j "MATCH (n) RETURN count(n) as nodes"
```

Stop Neo4j.

```
bin/neo4j stop
```

CSV file delimiters

You can customize the configuration options that the import tool uses (see Options) if your data does not fit the default format.
The details of CSV file header format can be found at [CSV header format](#).

The data

The following CSV files have:

- `--delimiter=;`
- `--array-delimiter=|`
- `--quote='`

movies2.csv

<table>
<thead>
<tr>
<th>movieId</th>
<th>title</th>
<th>year</th>
<th>type</th>
</tr>
</thead>
<tbody>
<tr>
<td>tt0133093</td>
<td>'The Matrix'</td>
<td>1999</td>
<td>Movie</td>
</tr>
<tr>
<td>tt0234215</td>
<td>'The Matrix Reloaded'</td>
<td>2003</td>
<td>Movie</td>
</tr>
<tr>
<td>tt0242653</td>
<td>'The Matrix Revolutions'</td>
<td>2003</td>
<td>Movie</td>
</tr>
</tbody>
</table>

actors2.csv

<table>
<thead>
<tr>
<th>personId</th>
<th>name</th>
<th>type</th>
</tr>
</thead>
<tbody>
<tr>
<td>keanu</td>
<td>'Keanu Reeves'</td>
<td>Actor</td>
</tr>
<tr>
<td>laurence</td>
<td>'Laurence Fishburne'</td>
<td>Actor</td>
</tr>
<tr>
<td>carrieanne</td>
<td>'Carrie-Anne Moss'</td>
<td>Actor</td>
</tr>
</tbody>
</table>

roles2.csv

<table>
<thead>
<tr>
<th>START_ID</th>
<th>role</th>
<th>END_ID</th>
<th>type</th>
</tr>
</thead>
<tbody>
<tr>
<td>keanu</td>
<td>'Neo'</td>
<td>tt0133093</td>
<td>ACTED_IN</td>
</tr>
<tr>
<td>keanu</td>
<td>'Neo'</td>
<td>tt0234215</td>
<td>ACTED_IN</td>
</tr>
<tr>
<td>keanu</td>
<td>'Neo'</td>
<td>tt0242653</td>
<td>ACTED_IN</td>
</tr>
<tr>
<td>laurence</td>
<td>'Morpheus'</td>
<td>tt0133093</td>
<td>ACTED_IN</td>
</tr>
<tr>
<td>laurence</td>
<td>'Morpheus'</td>
<td>tt0234215</td>
<td>ACTED_IN</td>
</tr>
<tr>
<td>laurence</td>
<td>'Morpheus'</td>
<td>tt0242653</td>
<td>ACTED_IN</td>
</tr>
<tr>
<td>carrieanne</td>
<td>'Trinity'</td>
<td>tt0133093</td>
<td>ACTED_IN</td>
</tr>
<tr>
<td>carrieanne</td>
<td>'Trinity'</td>
<td>tt0234215</td>
<td>ACTED_IN</td>
</tr>
<tr>
<td>carrieanne</td>
<td>'Trinity'</td>
<td>tt0242653</td>
<td>ACTED_IN</td>
</tr>
</tbody>
</table>

Importing the data

The call to `neo4j-admin import` would look like this:

```
bin/neo4j-admin import --database=neo4j --delimiter=; --array-delimiter=| --quote=''
--nodes=import/movies2.csv --nodes=import/actors2.csv --relationships=import/roles2.csv
```

Using separate header files

When dealing with very large CSV files, it is more convenient to have the header in a separate file. This makes it easier to edit the header as you avoid having to open a huge data file just to change it. The header file must be specified before the rest of the files in each file group.

The import tool can also process single file compressed archives, for example:
The data

You will use the same data set as in the previous example but with the headers in separate files.

movies3-header.csv

<table>
<thead>
<tr>
<th>movieId</th>
<th>ID, title, year:int,</th>
<th>:LABEL</th>
</tr>
</thead>
</table>

movies3.csv

| tt0133093 | The Matrix, 1999, Movie |
| tt0234215 | The Matrix Reloaded, 2003, Movie; Sequel |
| tt0242653 | The Matrix Revolutions, 2003, Movie; Sequel |

actors3-header.csv

<table>
<thead>
<tr>
<th>personId</th>
<th>ID, name,</th>
<th>:LABEL</th>
</tr>
</thead>
</table>

actors3.csv

| keanu | Keanu Reeves, Actor |
| laurence | Laurence Fishburne, Actor |
| carrieanne | Carrie-Anne Moss, Actor |

roles3-header.csv

<table>
<thead>
<tr>
<th>:START_ID, role, :END_ID, :TYPE</th>
</tr>
</thead>
</table>

roles3.csv

| keanu, Neo, tt0133093, ACTED_IN |
| keanu, Neo, tt0234215, ACTED_IN |
| keanu, Neo, tt0242653, ACTED_IN |
| laurence, Morpheus, tt0133093, ACTED_IN |
| laurence, Morpheus, tt0234215, ACTED_IN |
| laurence, Morpheus, tt0242653, ACTED_IN |
| carrieanne, Trinity, tt0133093, ACTED_IN |
| carrieanne, Trinity, tt0234215, ACTED_IN |
| carrieanne, Trinity, tt0242653, ACTED_IN |

Importing the data

The call to `neo4j-admin import` would look as follows:

- The header line for a file group, whether it is the first line of a file in the group or a dedicated header file, must be the first line in the file group.
Multiple input files

In addition to using a separate header file you can also provide multiple nodes or relationships files. Files within such an input group can be specified with multiple match strings, delimited by `,`, where each match string can be either the exact file name or a regular expression matching one or more files. Multiple matching files will be sorted according to their characters and their natural number sort order for file names containing numbers.

The data

movies4-header.csv

movieId:ID,title,year:int,:LABEL

movies4-part1.csv

tt0133093,"The Matrix",1999,Movie
tt0234215,"The Matrix Reloaded",2003,Movie;Sequel

movies4-part2.csv

tt0242653,"The Matrix Revolutions",2003,Movie;Sequel

actors4-header.csv

personId:ID,name,:LABEL

actors4-part1.csv

keanu,"Keanu Reeves",Actor
laurence,"Laurence Fishburne",Actor

actors4-part2.csv

carrieanne,"Carrie-Anne Moss",Actor

roles4-header.csv

:START_ID,role,:END_ID,:TYPE
roles4-part1.csv

keanu,"Neo",tt0133093,ACTED_IN
keanu,"Neo",tt0234215,ACTED_IN
laurence,"Morpheus",tt0133093,ACTED_IN
laurence,"Morpheus",tt0234215,ACTED_IN

roles4-part2.csv

laurence,"Morpheus",tt0242653,ACTED_IN
carrieanne,"Trinity",tt0133093,ACTED_IN
carrieanne,"Trinity",tt0234215,ACTED_IN
carrieanne,"Trinity",tt0242653,ACTED_IN

Importing the data

The call to `neo4j-admin import` would look like this:

```
bin/neo4j-admin import --database=neo4j --nodes=import/movies4-header.csv,import/movies4-part1.csv,import/movies4-part2.csv --nodes=import/actors4-header.csv,import/actors4-part1.csv,import/actors4-part2.csv --relationships=import/roles4-header.csv,import/roles4-part1.csv,import/roles4-part2.csv
```

Regular expressions

File names can be specified using regular expressions in order to simplify using the command line when there are many data source files. Each file name that matches the regular expression will be included.

If using separate header files, for the import to work correctly, the header file must be the first in the file group. When using regular expressions to specify the input files, the list of files will be sorted according to the names of the files that match the expression. The matching is aware of numbers inside the file names and will sort them accordingly, without the need for padding with zeros.

Example 139. Match order

For example, let’s assume that you have the following files:

- movies4-header.csv
- movies4-data1.csv
- movies4-data2.csv
- movies4-data12.csv

If you use the regular expression `movies4.*`, the sorting will place the header file last and the import will fail. A better alternative would be to name the header file explicitly and use a regular expression that only matches the names of the data files. For example: `--nodes "import/movies4-header.csv,movies-data.*"` will accomplish this.
Importing the data using regular expressions, the call to `neo4j-admin import` can be simplified to:

```
bin/neo4j-admin import --database=neo4j --nodes="import/movies4-header.csv,import/movies4-part.*" --nodes="import/actors4-header.csv,import/actors4-part.*" --relationships="import/roles4-header.csv,import/roles4-part.*"
```

The use of regular expressions should not be confused with file globbing.

The expression `./*` means: "zero or more occurrences of any character except line break". Therefore, the regular expression `movies4.*` will list all files starting with `movies4`. Conversely, with file globbing, `ls movies4.*` will list all files starting with `movies4`.

Another important difference to pay attention to is the sorting order. The result of a regular expression matching will place the file `movies4-part2.csv` before the file `movies4-part12.csv`. If doing `ls movies4-part*` in a directory containing the above listed files, the file `movies4-part12.csv` will be listed before the file `movies4-part2.csv`.

Using the same label for every node

If you want to use the same node label(s) for every node in your nodes file you can do this by specifying the appropriate value as an option to `neo4j-admin import`. There is then no need to specify the `:LABEL` column in the header file and each row (node) will apply the specified labels from the command line option.

Example 140. Specify node labels option

```
--nodes=LabelOne:LabelTwo=import/example-header.csv,import/example-data1.csv
```

It is possible to apply both the label provided in the file and the one provided on the command line to the node.

The data

In this example you want to have the label `Movie` on every node specified in `movies5a.csv`, and you put the labels `Movie` and `Sequel` on the nodes specified in `sequels5a.csv`.

**movies5a.csv**

```
movieId:ID,title,year:int
tt0133093,"The Matrix",1999
```

**sequels5a.csv**

```
movieId:ID,title,year:int
tt0234215,"The Matrix Reloaded",2003
tt0242653,"The Matrix Revolutions",2003
```
Importing the data

The call to `neo4j-admin import` would look like this:

```shell
bin/neo4j-admin import --database=neo4j --nodes=Movie=import/movies5a.csv --nodes=Movie:Sequel=import/sequels5a.csv --nodes=Actor=import/actors5a.csv --relationships=import/roles5a.csv
```

Using the same relationship type for every relationship

If you want to use the same relationship type for every relationship in your relationships file this can be done by specifying the appropriate value as an option to `neo4j-admin import`.

Example 141. Specify relationship type option

```bash
--relationships=TYPE=import/example-header.csv,import/example-data1.csv
```

If you provide a relationship type both on the command line and in the relationships file, the one in the file will be applied.

The data

In this example you want the relationship type `ACTED_IN` to be applied on every relationship specified in `roles5b.csv`.

```csv
movies5b.csv
```

```csv
movieId:ID,title.year:int,:LABEL
tt0133093,"The Matrix",1999,Movie
tt0234215,"The Matrix Reloaded",2003,Movie;Sequel
tt0242653,"The Matrix Revolutions",2003,Movie;Sequel
```
Importing the data

The call to `neo4j-admin import` would look like this:

```
bin/neo4j-admin import --database=neo4j --nodes=import/movies5b.csv --nodes=import/actors5b.csv
--relationships=ACTED_IN=import/roles5b.csv
```

Properties

Nodes and relationships can have properties. The property type are specified in the CSV header row, see CSV header format.

The data

The following example creates a small graph containing one actor and one movie connected by one relationship.

There is a `roles` property on the relationship which contains an array of the characters played by the actor in a movie:

```
movies6.csv

mid:ID,title,year:int,:LABEL
tt0099892,"Joe Versus the Volcano",1990,Movie
```
Importing the data

The call to `neo4j-admin import` would look like this:

```shell
bin/neo4j-admin import --database=neo4j --nodes=import/movies6.csv --nodes=import/actors6.csv
--relationships=import/roles6.csv
```

ID space

The import tool makes the assumption that identifiers are unique across node files. This may not be the case for data sets which use sequential, auto incremented or otherwise colliding identifiers. Those data sets can define ID spaces where identifiers are unique within their respective ID space.

In cases where the node ID is only unique within files, using ID spaces is a way to ensure uniqueness across all nodes files. See Using ID spaces.

Each node processed by `neo4j-admin import` must provide an ID if it is to be connected in any relationships. The node ID is used to find the start node and end node when creating a relationship.

Example 142. ID space

To define a ID space `Movie-ID` for `movieId:ID` the syntax will be `movieId:ID(Movie-ID)`. 

The data

For example, if movies and people both use sequential identifiers, then you would define Movie and Actor ID spaces.

movies7.csv

```csv
movieId:ID(Movie-ID),title,year:int,:LABEL
1,"The Matrix",1999,Movie
2,"The Matrix Reloaded",2003,Movie;Sequel
3,"The Matrix Revolutions",2003,Movie;Sequel
```

actors7.csv

```csv
personId:ID(Actor-ID),name,:LABEL
1,"Keanu Reeves",Actor
2,"Laurence Fishburne",Actor
3,"Carrie-Anne Moss",Actor
```

You also need to reference the appropriate ID space in your relationships file so it knows which nodes to
connect together.

roles7.csv

<table>
<thead>
<tr>
<th>:START_ID(Actor-ID),role,:END_ID(Movie-ID)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,&quot;Neo&quot;,1</td>
</tr>
<tr>
<td>1,&quot;Neo&quot;,2</td>
</tr>
<tr>
<td>1,&quot;Neo&quot;,3</td>
</tr>
<tr>
<td>2,&quot;Morpheus&quot;,1</td>
</tr>
<tr>
<td>2,&quot;Morpheus&quot;,2</td>
</tr>
<tr>
<td>2,&quot;Morpheus&quot;,3</td>
</tr>
<tr>
<td>3,&quot;Trinity&quot;,1</td>
</tr>
<tr>
<td>3,&quot;Trinity&quot;,2</td>
</tr>
<tr>
<td>3,&quot;Trinity&quot;,3</td>
</tr>
</tbody>
</table>

Importing the data

The call to `neo4j-admin import` would look like this:

```shell
bin/neo4j-admin import --database=neo4j --nodes=import/movies7.csv --nodes=import/actors7.csv --relationships=ACTED_IN=import/roles7.csv
```

Skip relationships referring to missing nodes

The import tool has no tolerance for bad entities (relationships or nodes) and will fail the import on the first bad entity. You can specify explicitly that you want it to ignore rows that contain bad entities.

There are two different types of bad input:

1. Bad relationships.
2. Bad nodes.

Relationships that refer to missing node IDs, either for :START_ID or :END_ID are considered bad relationships. Whether or not such relationships are skipped is controlled with the `--skip-bad-relationships` flag, which can have the values `true` or `false` or no value, which means `true`. The default is `false`, which means that any bad relationship is considered an error and will fail the import. For more information, see the `--skip-bad-relationships` option.

The data

In the following example there is a missing `emil` node referenced in the roles file.

movies8a.csv

<table>
<thead>
<tr>
<th>movield:ID,title,year:int,:LABEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>tt0133093,&quot;The Matrix&quot;,1999,Movie</td>
</tr>
<tr>
<td>tt0234215,&quot;The Matrix Reloaded&quot;,2003,Movie;Sequel</td>
</tr>
<tr>
<td>tt0242653,&quot;The Matrix Revolutions&quot;,2003,Movie;Sequel</td>
</tr>
</tbody>
</table>
actors8a.csv

<table>
<thead>
<tr>
<th>PersonId</th>
<th>Name</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>keanu</td>
<td>Keanu Reeves</td>
<td>Actor</td>
</tr>
<tr>
<td>laurence</td>
<td>Laurence Fishburne</td>
<td>Actor</td>
</tr>
<tr>
<td>carrieanne</td>
<td>Carrie-Anne Moss</td>
<td>Actor</td>
</tr>
</tbody>
</table>

roles8a.csv

<table>
<thead>
<tr>
<th>START_ID</th>
<th>Role</th>
<th>END_ID</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>keanu</td>
<td>Neo</td>
<td>tt0133093</td>
<td>ACTED_IN</td>
</tr>
<tr>
<td>keanu</td>
<td>Neo</td>
<td>tt0234215</td>
<td>ACTED_IN</td>
</tr>
<tr>
<td>keanu</td>
<td>Neo</td>
<td>tt0242653</td>
<td>ACTED_IN</td>
</tr>
<tr>
<td>laurence</td>
<td>Morpheus</td>
<td>tt0133093</td>
<td>ACTED_IN</td>
</tr>
<tr>
<td>laurence</td>
<td>Morpheus</td>
<td>tt0234215</td>
<td>ACTED_IN</td>
</tr>
<tr>
<td>laurence</td>
<td>Morpheus</td>
<td>tt0242653</td>
<td>ACTED_IN</td>
</tr>
<tr>
<td>carrieanne</td>
<td>Trinity</td>
<td>tt0133093</td>
<td>ACTED_IN</td>
</tr>
<tr>
<td>carrieanne</td>
<td>Trinity</td>
<td>tt0234215</td>
<td>ACTED_IN</td>
</tr>
<tr>
<td>carrieanne</td>
<td>Trinity</td>
<td>tt0242653</td>
<td>ACTED_IN</td>
</tr>
<tr>
<td>emil</td>
<td>Emil</td>
<td>tt0133093</td>
<td>ACTED_IN</td>
</tr>
</tbody>
</table>

Importing the data

The call to `neo4j-admin import` would look like this:

```shell
bin/neo4j-admin import --database=neo4j --nodes=import/movies8a.csv --nodes=import/actors8a.csv --relationships=import/roles8a.csv
```

Since there was a bad relationship in the input data, the import process will fail completely.

Let's see what happens if you append the `--skip-bad-relationships` flag:

```shell
bin/neo4j-admin import --database=neo4j --skip-bad-relationships --nodes=import/movies8a.csv --nodes=import/actors8a.csv --relationships=import/roles8a.csv
```

The data files are successfully imported and the bad relationship is ignored. An entry is written to the `import.report` file.

ignore bad relationships

InputRelationship:
- source: roles8a.csv:11
- properties: [role, Emil]
- startNode: emil (global id space)
- endNode: tt0133093 (global id space)
- type: ACTED_IN
- referring to missing node emil

Skip nodes with same ID

Nodes that specify `:ID` which has already been specified within the ID space are considered bad nodes. Whether or not such nodes are skipped is controlled with `--skip-duplicate-nodes` flag which can have...
the values true or false or no value, which means true. The default is false, which means that any duplicate node is considered an error and will fail the import. For more information, see the --skip-duplicate-nodes option.

The data

In the following example there is a node ID, laurence, that is specified twice within the same ID space.

actors8b.csv

```csv
personId:ID, name, :LABEL
keanu,"Keanu Reeves",Actor
laurence,"Laurence Fishburne",Actor
carrieanne,"Carrie-Anne Moss",Actor
laurence,"Laurence Harvey",Actor
```

Importing the data

The call to neo4j-admin import would look like this:

```
shell
bin/neo4j-admin import --database=neo4j --nodes=import/actors8b.csv
```

Since there was a bad node in the input data, the import process will fail completely.

Let's see what happens if you append the --skip-duplicate-nodes flag:

```
shell
bin/neo4j-admin import --database=neo4j --skip-duplicate-nodes --nodes=import/actors8b.csv
```

The data files are successfully imported and the bad node is ignored. An entry is written to the import.report file.

ignore bad nodes

ID 'laurence' is defined more than once in global ID space, at least at actors8b.csv:3 and actors8b.csv:5

17.B.4. Set up and use Fabric Enterprise edition

This tutorial walks through the basics of setting up and using Neo4j Fabric.

Neo4j Fabric is a tool for storing and retrieving data in multiple databases, located in one or many Neo4j DBMS(s), with a single Cypher query.

In this tutorial, you will learn how to:

- Model your data for Fabric
Model your data for Fabric

Northwind data

The example data in this tutorial is based on the Northwind dataset, created by Microsoft. It contains the sales data of a fictitious small company called “Northwind Traders”. The data includes customers, products, customer orders, warehouse stock, shipping, suppliers, employees, and sales territories.

For more information on how Northwind (a relational dataset) is modeled into a graph, run :guide northwind-graph in Neo4j Browser to play the built-in guide Northwind Graph. See the Neo4j Browser documentation.

The model

The Northwind graph model consists of the following data:

- **Node labels**
  - :Product
  - :Category
  - :Supplier
  - :Order
  - :Customer

- **Relationship types**
  - :SUPPLIES
  - :PART_OF
  - :ORDERS
  - :PURCHASED
Remodeling the Northwind dataset

In this scenario, you imagine that data privacy constraints require customers' data to be stored in their original region. For simplicity, there are two regions: the Americas (AME) and Europe (EU). The first step is to remodel the Northwind dataset, so that customer data can be separated from the Product catalog, which has no privacy constraints. You create two graphs: one for the Product catalog, which includes :Product, :Category, :Supplier, :PART_OF, :SUPPLIES, and one partitioned graph in two databases for the Customer orders in EU and AME, with :Product, :Order, :Customer, :PURCHASED, and :ORDERS.
This way, the Product and Customer data are in two disjointed graphs, with different labels and relationship types. This is called Data Federation. To query across them, you have to federate the graphs, because relationships cannot span across them. This is done by using a proxy node modeling pattern: nodes with the :Product label must be present in both federated domains. In the Product catalog graph, nodes with the :Product label contain all the data related to a product, while in the Customer graphs, the same label is associated to a proxy node, which only contains productID. The productID property allows you to link data across the graphs in this federation.

Since the Customer data is for two regions (EU and AME), you have to partition it into two databases. The resulting two graphs have the same model (same labels, same relationship types), but different data. This is called Data Sharding.
Figure 18. Data Sharding

In general, there are a couple of main use cases that require sharding. The most common is scalability, i.e., different shards can be deployed on different servers, splitting the load on different resources. Another reason could be data regulations: different shards can be deployed on servers, residing in different locations, and managed independently.

Configure Fabric with three databases

Now that you have a new multi-database model defined, you can start to configure the Fabric infrastructure.

Create three databases

You need three databases: db0 for the Product catalog, db1 for the EU customer data, and db2 for the AME customers.

1. Start the Neo4j DBMS.

   bin/neo4j start

2. Check all available databases.

   ls -al /data/databases/

   total 0
   drwxr-xr-x@ 5 username staff  160 9 Jun 12:53 .
   drwxr-xr-x@ 5 username staff  160 9 Jun 12:53 ..
   drwxr-xr-x 37 username staff 1184 9 Jun 12:53 neo4j
   -rw-r--r-- 1 username staff   0 9 Jun 12:53 store_lock
   drwxr-xr-x 38 username staff 1216 9 Jun 12:53 system

3. Connect to the Neo4j DBMS using cypher-shell with the default credentials and change the password when prompted. For more information about the Cypher Shell command-line interface (CLI) and how to use it, see Cypher Shell.
bin/cypher-shell -u neo4j -p neo4j

Password change required
new password: *****
Connected to Neo4j 4.1.x at neo4j://localhost:7687 as user neo4j.
Type :help for a list of available commands or :exit to exit the shell.
Note that Cypher queries must end with a semicolon.

4. Run the command `SHOW DATABASES` to list all available databases.

```
SHOW DATABASES;
```

```
+------------------------------------------------------------------------------------------------+
<table>
<thead>
<tr>
<th>name</th>
<th>address</th>
<th>role</th>
<th>requestedStatus</th>
<th>currentStatus</th>
<th>error</th>
<th>default</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;neo4j&quot;</td>
<td>&quot;localhost:7687&quot;</td>
<td>&quot;standalone&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td></td>
<td>TRUE</td>
</tr>
<tr>
<td>&quot;system&quot;</td>
<td>&quot;localhost:7687&quot;</td>
<td>&quot;standalone&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td></td>
<td>FALSE</td>
</tr>
</tbody>
</table>
+------------------------------------------------------------------------------------------------+
2 rows available after 102 ms, consumed after another 11 ms

5. Run the command `CREATE DATABASE <database-name>` to create the databases.

```
CREATE DATABASE db0;
```

```
0 rows available after 137 ms, consumed after another 0 ms
```

```
CREATE DATABASE db1;
```

```
0 rows available after 14 ms, consumed after another 0 ms
```

```
CREATE DATABASE db2;
```

```
0 rows available after 10 ms, consumed after another 0 ms
```

6. Again run the command `SHOW DATABASES` to verify that the new databases have been created.

```
SHOW DATABASES;
```

```
+------------------------------------------------------------------------------------------------+
<table>
<thead>
<tr>
<th>name</th>
<th>address</th>
<th>role</th>
<th>requestedStatus</th>
<th>currentStatus</th>
<th>error</th>
<th>default</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;db0&quot;</td>
<td>&quot;localhost:7687&quot;</td>
<td>&quot;standalone&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td></td>
<td>FALSE</td>
</tr>
<tr>
<td>&quot;db1&quot;</td>
<td>&quot;localhost:7687&quot;</td>
<td>&quot;standalone&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td></td>
<td>FALSE</td>
</tr>
<tr>
<td>&quot;db2&quot;</td>
<td>&quot;localhost:7687&quot;</td>
<td>&quot;standalone&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td></td>
<td>FALSE</td>
</tr>
<tr>
<td>&quot;neo4j&quot;</td>
<td>&quot;localhost:7687&quot;</td>
<td>&quot;standalone&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td></td>
<td>TRUE</td>
</tr>
<tr>
<td>&quot;system&quot;</td>
<td>&quot;localhost:7687&quot;</td>
<td>&quot;standalone&quot;</td>
<td>&quot;online&quot;</td>
<td>&quot;online&quot;</td>
<td></td>
<td>FALSE</td>
</tr>
</tbody>
</table>
+------------------------------------------------------------------------------------------------+
5 rows available after 8 ms, consumed after another 7 ms
Configure Fabric

You set up Fabric by configuring the fabric database and the graph names and IDs in the `neo4j.conf` file. In this example, the Fabric database is called `fabricnw`.

1. Navigate to the `<neo4j-home>/conf/` folder and open the `neo4j.conf` file.
2. Add the following lines and save it.

```plaintext
# Fabric tutorial

fabric.database.name=fabricnw

fabric.graph.0.uri=neo4j://localhost:7687
fabric.graph.0.name=product
fabric.graph.0.database=db0

fabric.graph.1.uri=neo4j://localhost:7687
fabric.graph.1.name=customerEU
fabric.graph.1.database=db1

fabric.graph.2.uri=neo4j://localhost:7687
fabric.graph.2.name=customerAME
fabric.graph.2.database=db2
```

3. Navigate back to the `<neo4j-home>` folder and restart the Neo4j DBMS.

   `bin/neo4j restart`

4. Connect to the Neo4j DBMS using `cypher-shell` and your credentials.

   `bin/cypher-shell -u neo4j -p your-password`

5. Run the command `SHOW DATABASES` to verify that the Fabric database has been configured and is online.

   `SHOW DATABASES;`
Import data in your databases

You can use the command `LOAD CSV WITH HEADERS FROM` to import data in the databases.

Load the Product catalog in db0

1. Run the following Cypher query to change the active database to db0, and add the product data.

```cypher
:use db0;

LOAD CSV WITH HEADERS FROM "http://data.neo4j.com/northwind/products.csv" AS row
CREATE (n:Product)
SET n = row,
   n.unitPrice = toFloat(row.unitPrice),
   n.unitsInStock = toInteger(row.unitsInStock),
   n.unitsOnOrder = toInteger(row.unitsOnOrder),
   n.reorderLevel = toInteger(row.reorderLevel),
   n.discontinued = (row.discontinued <> "0");

LOAD CSV WITH HEADERS FROM "http://data.neo4j.com/northwind/categories.csv" AS row
CREATE (n:Category)
SET n = row;

LOAD CSV WITH HEADERS FROM "http://data.neo4j.com/northwind/suppliers.csv" AS row
CREATE (n:Supplier)
SET n = row;

CREATE INDEX FOR (p:Product) ON (p.productID);
CREATE INDEX FOR (c:Category) ON (c.categoryID);
CREATE INDEX FOR (s:Supplier) ON (s.supplierID);

MATCH (p:Product).c:Category
WHERE p.categoryID = c.categoryID
CREATE (p)-[:PART_OF]->(c);

MATCH (p:Product).s:Supplier
WHERE p.supplierID = s.supplierID
CREATE (s)-[:SUPPLIES]->(p);
```

2. Press Enter.

3. Verify that the product data is loaded in db0.

```cypher
MATCH (s:Supplier)-[:SUPPLIES]->(p:Product)-[:PART_OF]->(c:Category)
RETURN s.companyName AS Supplier, p.productName AS Product, c.categoryName AS Category
LIMIT 5;
```
Load EU customers and related orders in db1

1. Run the following Cypher query to change the active database to db1, and add the EU customers and orders.

```
:use db1;
:param europe => ['Germany', 'UK', 'Sweden', 'France', 'Spain', 'Switzerland', 'Austria', 'Italy', 'Portugal', 'Ireland', 'Belgium', 'Norway', 'Denmark', 'Finland'];

LOAD CSV WITH HEADERS FROM "http://data.neo4j.com/northwind/customers.csv" AS row
WITH row
WHERE row.country IN $europe
CREATE (n:Customer)
SET n = row;
CREATE INDEX FOR (c:Customer) ON (c.customerID);

LOAD CSV WITH HEADERS FROM "http://data.neo4j.com/northwind/orders.csv" AS row
WITH row
MATCH (c:Customer)
WHERE row.customerID = c.customerID
CREATE (o:Order)
SET o = row;
CREATE INDEX FOR (o:Order) ON (o.orderID);

MATCH (c:Customer), (o:Order)
WHERE c.customerID = o.customerID
CREATE (c)-[:PURCHASED]->(o);

LOAD CSV WITH HEADERS FROM "http://data.neo4j.com/northwind/products.csv" AS row
CREATE (n:Product)
SET n.productID = row.productID;
CREATE INDEX FOR (p:Product) ON (p.productID);

LOAD CSV WITH HEADERS FROM "http://data.neo4j.com/northwind/order-details.csv" AS row
MATCH (p:Product), (o:Order)
WHERE p.productID = row.productID AND o.orderID = row.orderID
CREATE (o)-[details:ORDERS]->(p)
SET details.quantity = toInteger(row.quantity);
```

2. Press Enter.

3. Verify that the EU Customer orders data is loaded in db1.

```
MATCH (c:Customer)-[:PURCHASED]->(o:Order)-[:ORDERS]->(p:Product)
RETURN c.companyName AS Customer, c.country AS CustomerCountry, o.orderID AS Order, p.productId AS Product
LIMIT 5;
```
Load AME customers and related orders in db2

1. Run the following Cypher query to change the active database to db2 and add the AME customers and orders.

   ```cypher
   :use db2;
   :
   
   :param americas => ['Mexico', 'Canada', 'Argentina', 'Brazil', 'USA', 'Venezuela'];
   LOAD CSV WITH HEADERS FROM "http://data.neo4j.com/northwind/customers.csv" AS row
   WITH row
   WHERE row.country IN $americas
   CREATE (n:Customer)
   SET n = row;
   CREATE INDEX FOR (c:Customer) ON (c.customerID);
   
   LOAD CSV WITH HEADERS FROM "http://data.neo4j.com/northwind/orders.csv" AS row
   WITH row
   MATCH (c:Customer)
   WHERE row.customerID = c.customerID
   CREATE (o:Order)
   SET o = row;
   CREATE INDEX FOR (o:Order) ON (o.orderID);
   
   MATCH (c:Customer), (o:Order)
   WHERE c.customerID = o.customerID
   CREATE (c)-[:PURCHASED]->(o),
   LOAD CSV WITH HEADERS FROM "http://data.neo4j.com/northwind/products.csv" AS row
   CREATE (n:Product)
   SET n.productID = row.productID;
   CREATE INDEX FOR (p:Product) ON (p.productID);
   
   LOAD CSV WITH HEADERS FROM "http://data.neo4j.com/northwind/order-details.csv" AS row
   MATCH (p:Product), (o:Order)
   WHERE p.productID = row.productID AND o.orderID = row.orderID
   CREATE (o)-[details:ORDERS]->(p)
   SET details.quantity = toInteger(row.quantity);
   ```

2. Press Enter.

3. Verify that the AME Customer orders data is loaded in db2.

   ```cypher
   MATCH (c:Customer)-[:PURCHASED]->(o:Order)-[:ORDERS]->(p:Product)
   RETURN c.companyName AS Customer, c.country AS CustomerCountry, o.orderID AS Order, p.productID AS Product
   LIMIT 5;
   ```
Retrieve data with a single Cypher query

Fabric allows you to retrieve data from all your databases with a single Cypher query.

As the databases `db0`, `db1`, `db2` in this tutorial are part of the same Neo4j DBMS, you can also access them directly, using their database names. This is especially useful when you want to set up Fabric locally for development or testing purposes. In this case, you only have to add `fabric.database.name=fabricnw` to the `neo4j.conf` file, and use queries as the following one.

```cypher
:use fabricnw

USE db1
MATCH (c:Customer)
WHERE c.customerID STARTS WITH 'A'
RETURN c.customerID AS name, c.country AS country
UNION
USE db2
MATCH (c:Customer)
WHERE c.customerID STARTS WITH 'A'
RETURN c.customerID AS name, c.country AS country
LIMIT 5;
```

However, if your databases `db0`, `db1`, `db2` are located in other Neo4j DBMSs, on completely different servers for example, then you must update the URI settings to connect to them.

In this tutorial, you will try the Fabric capabilities as if the data is deployed on different servers.

Query a single database

You can retrieve data from a single database by using the cypher clause `USE` and the name of the Fabric graph. When querying a single database, you do not have to change the active database to Fabric.
USE fabricnw.product
MATCH (p:Product)
RETURN p.productName AS product
LIMIT 5;

+--------------------------------+
<table>
<thead>
<tr>
<th>product</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Chai&quot;</td>
</tr>
<tr>
<td>&quot;Chang&quot;</td>
</tr>
<tr>
<td>&quot;Aniseed Syrup&quot;</td>
</tr>
<tr>
<td>&quot;Chef Anton's Cajun Seasoning&quot;</td>
</tr>
<tr>
<td>&quot;Chef Anton's Gumbo Mix&quot;</td>
</tr>
</tbody>
</table>
+--------------------------------+
5 rows available after 6 ms, consumed after another 21 ms

Query across multiple shards
Use Fabric to query both shards and get customers whose name starts with A.

When you want to retrieve data from multiple databases, you have to change the active database to fabricnw.

:use fabricnw

USE fabricnw.customerAME
MATCH (c:Customer)
WHERE c.customerID STARTS WITH 'A'
RETURN c.customerID AS name, c.country AS country
UNION
USE fabricnw.customerEU
MATCH (c:Customer)
WHERE c.customerID STARTS WITH 'A'
RETURN c.customerID AS name, c.country AS country
LIMIT 5;

+---------------------+
<table>
<thead>
<tr>
<th>name</th>
<th>country</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;ANATR&quot;</td>
<td>&quot;Mexico&quot;</td>
</tr>
<tr>
<td>&quot;ANTON&quot;</td>
<td>&quot;Mexico&quot;</td>
</tr>
<tr>
<td>&quot;ALFKI&quot;</td>
<td>&quot;Germany&quot;</td>
</tr>
<tr>
<td>&quot;AROUT&quot;</td>
<td>&quot;UK&quot;</td>
</tr>
</tbody>
</table>
+---------------------+
4 rows available after 25 ms, consumed after another 56 ms

Or, using a more common Fabric idiom:

UNWIND [1,2]AS gid
CALL {
    USE fabricnw.graph(gid)
    MATCH (c:Customer)
    WHERE c.customerID STARTS WITH 'A'
    RETURN c.customerID AS name, c.country AS country
}
RETURN name, country
LIMIT 5;
Query across federation and shards

Finally, a more complex query that uses all 3 databases to find all customers who have bought discontinued products in the Meat/Poultry category.

```
CALL {
  USE fabricnw.product
  MATCH (p:Product{discontinued:true})-[[:PART_OF]]->(c:Category{categoryName:'Meat/Poultry'})
  RETURN COLLECT(p.productID) AS pids
}
WITH *, [g IN fabricnw.graphIds() WHERE g<>0] AS gids
UNWIND gids AS gid
CALL {
  USE fabricnw.graph(gid)
  WITH pids
  UNWIND pids as pid
  MATCH (p:Product{productID:pid})<-[:ORDERS]-(:Order)<-[:PURCHASED]-(c:Customer)
  RETURN DISTINCT c.customerID AS customer, c.country AS country
}
RETURN customer, country
LIMIT 20;
```

<table>
<thead>
<tr>
<th>customer</th>
<th>country</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;RICSU&quot;</td>
<td>&quot;Switzerland&quot;</td>
</tr>
<tr>
<td>&quot;PERIC&quot;</td>
<td>&quot;Mexico&quot;</td>
</tr>
<tr>
<td>&quot;WARTH&quot;</td>
<td>&quot;Finland&quot;</td>
</tr>
<tr>
<td>&quot;WELLI&quot;</td>
<td>&quot;Brazil&quot;</td>
</tr>
<tr>
<td>&quot;DRACD&quot;</td>
<td>&quot;Germany&quot;</td>
</tr>
<tr>
<td>&quot;RATTC&quot;</td>
<td>&quot;USA&quot;</td>
</tr>
<tr>
<td>&quot;HUNGO&quot;</td>
<td>&quot;Ireland&quot;</td>
</tr>
<tr>
<td>&quot;QUEDE&quot;</td>
<td>&quot;Brazil&quot;</td>
</tr>
<tr>
<td>&quot;SEVES&quot;</td>
<td>&quot;UK&quot;</td>
</tr>
<tr>
<td>&quot;ANTON&quot;</td>
<td>&quot;Mexico&quot;</td>
</tr>
<tr>
<td>&quot;BERGS&quot;</td>
<td>&quot;Sweden&quot;</td>
</tr>
<tr>
<td>&quot;SAVEA&quot;</td>
<td>&quot;USA&quot;</td>
</tr>
<tr>
<td>&quot;AROUT&quot;</td>
<td>&quot;UK&quot;</td>
</tr>
<tr>
<td>&quot;FAMIA&quot;</td>
<td>&quot;Brazil&quot;</td>
</tr>
<tr>
<td>&quot;WANDK&quot;</td>
<td>&quot;Germany&quot;</td>
</tr>
<tr>
<td>&quot;WHITC&quot;</td>
<td>&quot;USA&quot;</td>
</tr>
<tr>
<td>&quot;ISLAT&quot;</td>
<td>&quot;UK&quot;</td>
</tr>
<tr>
<td>&quot;LONEP&quot;</td>
<td>&quot;USA&quot;</td>
</tr>
<tr>
<td>&quot;QUICK&quot;</td>
<td>&quot;Germany&quot;</td>
</tr>
<tr>
<td>&quot;HILAA&quot;</td>
<td>&quot;Venezuela&quot;</td>
</tr>
</tbody>
</table>

20 rows available after 51 ms, consumed after another 2 ms
First, fabricnw calls database db0 to retrieve all discontinued products in the Meat/Poultry category. Then, using the returned product IDs, it queries both db1 and db2 in parallel and gets the customers who have purchased these products and their country.

The end

You have just learned how to store and retrieve data from multiple databases using a single Cypher query. For more details on the Neo4j Fabric, see Fabric.


Detailed examples of how to configure Single Sign-On (SSO) for several identity providers. It also presents frequently asked questions and solutions to common problems encountered when configuring SSO.

Neo4j supports SSO authentication and authorization through identity providers implementing the OpenID Connect (OIDC) standard.

The following configurations are crafted for a Neo4j Browser served on http://localhost:7474/browser/ (the default URL when starting the database on localhost).

Therefore, when reproducing them in the identity providers, you must modify the redirect URI to include the URI serving your Neo4j Browser application. For example:

<code>http://localhost:7474/browser/?idp_id={provider}&auth_flow_step=redirect_uri</code>

SSO works in the following way:

1. The server (Neo4j DBMS) contacts the identity provider (Okta, Azure, Google, etc.) and fetches the JSON Web Keys (JWKs) from the provider.
2. The client (e.g., Bloom, Neo4j Browser, etc.) asks the user for credentials and contacts the identity provider.
3. The identity provider responds with a JSON Web Token (JWT), a JSON file containing fields (claims) relative to the user (email, audience, groups, etc.).
4. The client provides the server with the JWT, and the server verifies its signature with the JWKs.

Okta

This example shows how to configure Okta for authentication and authorization using access tokens.

1. Configure the client with the appropriate redirect URI. You can skip the group assignments in this step:
2. Take note of the Client ID and the Okta domain. You will need them later when configuring the Okta parameters and the Well-known OpenID Connect endpoint in the neo4j.conf file:
3. Create groups in Okta, assign users to them (the user can be added to a group either on user creation or editing the group), and map them in the `neo4j.conf` to native groups:

Figure 21. Okta OIDC client configuration

4. Configure the default authorization server (the one that shows `api://default` as audience) to return the `groups` claim in access tokens:

Figure 22. Okta OIDC server groups
5. Configure Neo4j to use Okta authentication by configuring the following settings in the `neo4j.conf` file:

```ini
[dbms.security]
dbms.security.authentication_providers=oidc-okta
dbms.security.authorization_providers=oidc-okta
dbms.security.oidc.okta.display_name=Okta
dbms.security.oidc.okta.auth_flow=pkce
dbms.security.oidc.okta.well_known_discovery_uri=https://dev-21056049.okta.com/oauth2/default/.well-known/openid-configuration
dbms.security.oidc.okta.audience=api://default
dbms.security.oidc.okta.claims.username=sub
dbms.security.oidc.okta.claims.groups=groups
dbms.security.oidc.okta.params=client_id=0oa3oq6uw3u50Bf8y5d7;response_type=code;scope=openid profile email
dbms.security.oidc.okta.authorization.group_to_role_mapping= "engineers" = admin; "collaborators" = reader
```
The *token_type_principal* and the *token_type_authentication* are omitted, meaning access tokens are used instead.

6. Log in with your Okta SSO credentials using the email of an *engineer* role user that results in an *admin* role in the database:

![Okta OIDC successful login](image)

**Figure 25. Okta OIDC successful login**

**Azure Active Directory (AAD)**

This example shows how to configure AAD for authentication and authorization using ID tokens.

1. Log in to the [Azure portal](https://portal.azure.com).
2. Navigate to Azure Active Directory > Overview.
3. From the Add dropdown menu, select **App registration** and fill in the following information to create your SSO application:
Figure 26. Azure OIDC client creation

The redirect URI http://localhost:7474/browser/?idp_id=azure&auth_flow_step=redirect_uri is the URI that will accept returned token responses after successful authentication.

4. Click Register.

5. After the successful app creation, on the app’s Overview page, find the Application (client) ID value and record it for later.

6. Navigate to Endpoints and take note of the domain. It will be used later when configuring the well-known OpenIDC connect endpoint in the neo4j.conf file.

Figure 27. Azure OIDC client config

7. There are two options to follow at this stage. The first one is to create groups in the Azure AD console, assign users to them, and map them in the neo4j.conf to native roles. In this case, the groups claim in the JWT will contain the ID of the group, so you have to map that ID to the desired native role later on:
a. On the Active Directory page, navigate to Groups and then select New group.

b. Fill in the required information.

![Image](sso-configuration-tutorials/oidc-azure-app-roles.png) [title="Azure OIDC app roles config"]

**Figure 28. Azure OIDC server groups**

8. Configure the server to return `groupMembershipClaims` in identity tokens, modifying the Manifest of the registered application:

![Image](sso-configuration-tutorials/oidc-azure-app-roles.png) [title="Azure OIDC server claims"]

**Figure 29. Azure OIDC server claims**

9. Another way to achieve the authorization of SSO is via the app’s home page. The previous step described how to create groups in the Azure AD console, but this has a caveat: you can only have a maximum of 200 groups in a JWT. Navigate to App roles and add the Neo4j roles to the Azure active directory. They will be later used when mapping the group ID to the desired native role in the `neo4j.conf` file.

You can choose to follow only the group method or the app roles. No need to perform both steps.

+ image::sso-configuration-tutorials/oidc-azure-app-roles.png[title="Azure OIDC app roles config"]

1. Configure Neo4j to use Azure authentication by configuring the following settings in the `neo4j.conf` file:
2. Log in with your Azure SSO credentials using the email of an `engineer` role user that results in an `admin` role in the database:

![Figure 30. Azure OIDC successful login](image)

```
Remember to always set an email in contact info, otherwise login may not work properly at this stage.
```

Google

This example shows how to use Google OpenID Connect for authentication using ID tokens in conjunction with native authorization.

1. Configure the client and the redirect URI:
SSO authorization does not work with Google, as the JWT returned by Google does not contain information about the groups that a user belongs to, and cannot be configured to. Therefore, it is recommended to use native (or another flavor) authorization by creating a native version of the user in Neo4j.

2. The role assigned to the email used to log in with SSO, in this case, alice@neo4j-test.com, must have **GRANT ROLE** permissions in the database (native authentication temporarily enabled):

   ```sql
   CREATE USER 'alice@neo4j-test.com' SET PASSWORD 'pass';
   GRANT ROLE admin to 'alice@neo4j-test.com';
   ```

3. Configure Neo4j to use Google authentication by configuring the following settings in the neo4j.conf file:
dbms.security.authentication_providers=oidc-google
dbms.security.authorization_providers=native
dbms.security.oidc.google.display_name=Google
dbms.security.oidc.google.auth_flow=pkce
dbms.security.oidc.google.well_known_discovery_uri=https://accounts.google.com/.well-known/openid-configuration
dbms.security.oidc.google.issuer=345461137297-v9brpjgbvbn35s59f65tktevod3rn.apps.googleusercontent.com
dbms.security.oidc.google.claims.username=email
dbms.security.oidc.google.params=client_id=345461137297-v9brpjgbvbn35s59f65tktevod3rn.apps.googleusercontent.com;response_type=code;scope=openid profile email
dbms.security.oidc.google.token_params=client_secret=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
dbms.security.oidc.google.config=token_type_principal=id_token;token_type_authentication=id_token

4. Log in with your Google SSO credentials using the email address and get the admin role when doing so:

![Login Screen](image)

Figure 33. Azure OIDC successful login

The native authentication is disabled to prevent someone from logging in to alice@neo4j-test.com with the set password.

**FAQ**

When should pkce be used as auth flow?

Assuming the client (Neo4j Browser or Bloom) can be accessed through the public internet, always use pkce auth-flow rather than implicit because the latter requires the client’s secret to be available to the public client. In general, if both flows are available, it is recommended to opt for pkce because it is more secure than implicit.
Is Google authentication secure if it has a client secret listed in the config?

Yes. Google uses the pkce flow, but identity providers sometimes also use a client secret to ensure the client asking for a token is the one using it (pkce does not guarantee that). The client secret does not add any additional security as it is public but the pkce flow provides sufficient security.

Could not parse JWT of type "access_token"

When getting the message FAILED to get credentials: Could not parse JWT of type "access_token" on Browser, it probably means the provider only accepts ID tokens.

![Figure 34. Failed to parse JWT of type access_token](image)

Change to ID tokens in your neo4j.conf:

```
dbms.security.oidc.{{provider}}.config = token_type_principal=id_token;token_type_authentication=id_token
```

When should identity tokens vs. access tokens be used?

It is generally safer to use access tokens when possible due to being shorter-lived. If authorization permissions change on the identity provider, Neo4j will fail authorization. Neo4j Browser will try to reconnect and reflect the changed permissions faster than if ID tokens were used.

How to debug further problems with the configuration

Apart from the logs available in logs/debug.log and logs/security.log in the Neo4j path, you can also use the web-development console in your web browser when doing the SSO authentication flow with Bloom or Neo4j Browser. However, this could reveal potential problems as the one presented below with an example identity provider and the Cross-Origin Request policy:
The solution involves adding the redirect domain to the list of allowed domains in the provider (in this case, localhost:8080):

Appendix C: Advanced Causal Clustering

This appendix describes advanced features of Neo4j Causal Clustering.

This section includes information about advanced deployments and configuration options for multi-data center operations.

- **Causal Clustering lifecycle** — A walk-through of the lifecycle of a cluster.
- **Multi-data center** — Overview of the multi-data center section.
  - Licensing for multi-data center operations — Information about licensing for multi-data center operations.
  - Multi-data center design — Patterns for multi-data center deployments.
  - Multi-data center operations — Configuration options for multi-data center deployments.
  - Multi-data center load balancing — Configuration options for making client applications aware of
multi-data center topologies.

- Data center disaster recovery — How to recover a cluster to full working capability after data center loss.
- Embedded usage — How to embed a Neo4j Causal Cluster in your application.

For details on the configuration and operation of a Neo4j Causal Cluster, see Clustering.

For descriptions of settings related to running a Neo4j Causal Cluster, see Settings reference.


This section describes the lifecycle of a Neo4j Causal Cluster.

This section includes:

- Introduction
- Discovery protocol
- Core membership
- Read Replica membership
- Transacting via the Raft protocol
- Catchup protocol
- Read Replica shutdown
- Core shutdown

Introduction

In this section we will develop some deeper knowledge of how the cluster operates. By developing our understanding of how the cluster works we will be better equipped to design, deploy, and troubleshoot our production systems.

Our in-depth tour will follow the lifecycle of a cluster. We will boot a Core cluster and pick up key architectural foundations as the cluster forms and transacts. We will then add in Read Replicas and show how they bootstrap join the cluster and then catchup and remain caught up with the Core Servers. We will then see how backup is used in live cluster environments before shutting down Read Replicas and Core Servers.

Discovery protocol

The discovery protocol is the first step in forming a Causal Cluster. It takes in some information about existing Core cluster servers, and uses this to initiate a network join protocol.
Using this information, the server will either join an existing cluster or form one of its own.

The discovery protocol takes information from `causal_clustering.initial_discovery_members` in `neo4j.conf`, which lists which IP addresses and ports that form the cluster on startup. Detailed information about discovery and discovery configuration options is given in the Initial discovery of cluster members section. When consuming this information, the server will try to handshake with the other listed servers. On successful handshake with another server (or servers), the current server will discover the whole current topology.

The discovery protocol continues to run throughout the lifetime of the Causal Cluster and is used to maintain the current state of available servers and to help clients route queries to an appropriate server via the client-side drivers.

**Core membership**

If it is a Core Server that is performing discovery, once it has made a connection to the one of the existing Core Servers, it then joins the Raft protocol. Each database is replicated by a logically separate Raft group,
so the process below is repeated for every one.

Raft is a distributed algorithm for maintaining a consistent log across multiple shared-nothing servers designed by Diego Ongaro for his 2014 Ph.D. thesis. See the Raft thesis for details.

Raft handles cluster membership by making it a normal part of keeping a distributed log in sync. Joining a cluster involves the insertion of a cluster membership entry into the Raft log which is then reliably replicated around the existing cluster. Once that entry is applied to enough members of the Raft consensus group (those machines running the specific instance of the algorithm), they update their view of the cluster to include the new server. Thus membership changes benefit from the same safety properties as other data transacted via Raft (see Transacting via the Raft protocol for more information).

The new Core Server must also catch up its own Raft logs with respect to the other Core Servers as it initializes its internal Raft instance. This is the normal case when a cluster is first booted and has performed few operations. There will be a delay before the new Core Server becomes available if it also needs to catch up (as per Catchup protocol) graph data from other servers. This is the normal case for a long lived cluster where the servers holds a great deal of graph data.

Where a joining Neo4j instance has databases whose names match databases which already exist in the cluster, the database stores on the joining instance must be the same as their counterparts on cluster members (although they are allowed to be in previous states). For example, if a cluster contains a database named products, a new instance may join with a backup of products, but not a database named products with different contents. A new instance may also join a cluster if it does not contain any matching databases.

The described catchup process is repeated for each database which exists in the cluster.

Read Replica membership

When a Read Replica performs discovery, once it has made a connection to any of the available Core clusters it proceeds to add itself into a shared whiteboard.
This whiteboard provides a view of all live Read Replicas and is used both for routing requests from database drivers that support end-user applications and for monitoring the state of the cluster.

The Read Replicas are not involved in the Raft protocol, nor are they able to influence cluster topology. Hence a shared whiteboard outside of Raft comfortably scales to very large numbers of Read Replicas.

The whiteboard is kept up to date as Read Replicas join and leave the cluster, even if they fail abruptly rather than leaving gracefully.

Transacting via the Raft protocol

Once bootstrapped, each Core Server spends its time processing database transactions. Updates are reliably replicated around Core Servers via the Raft protocol. Updates appear in the form of a (committed) Raft log entry containing transaction commands which is subsequently applied to update the database.

One of Raft’s primary design goals is to be easily understandable so that there are fewer places for tricky bugs to hide in implementations. As a side-effect, it is also possible for database operators to reason about their Core Servers in their Causal Clusters.

The Raft Leader for the current term (a logical clock) appends the transaction (an 'entry' in Raft terminology) to the head of its local log and asks the other instances to do the same. When the Leader can see that a majority instances have appended the entry, it can be considered committed into the Raft log.

The client application can now be informed that the transaction has safely committed since there is sufficient redundancy in the system to tolerate any (non-pathological) faults.
The Raft protocol describes three roles that an instance can be playing: Leader, Follower, and Candidate. These are transient roles and any Core Server can expect to play them throughout the lifetime of a cluster. While it is interesting from a computing science point of view to understand those states, operators should not be overly concerned: they are an implementation detail.

As each database operates within a logically separate Raft group, a core server can have multiple roles: one for each database. For example, it may be the Leader for database `system` and at the same time be a Follower for database `neo4j`.

For safety, within any Raft protocol instance there is only one Leader able to make forward progress in any given term. The Leader bears the responsibility for imposing order on Raft log entries and driving the log forward with respect to the Followers.

Followers maintain their logs with respect to the current Leader’s log. Should any participant in the cluster suspect that the Leader has failed (not receiving new entries or heartbeats), then they can instigate a leadership election by entering the Candidate state. In Neo4j Core Servers this failure detection window is set by default above 20s to enable more stable leaders.

Whichever instance is in the best state (including the existing Leader, if it remains available) can emerge from the election as Leader. The "best state" for a Leader is decided by highest term, then by longest log, then by highest committed entry.

The ability to fail over roles without losing data allows forward progress even in the event of faults. Even where Raft instances fail, the protocol can rapidly piece together which of the remaining instances is best placed to take over from the failed instance (or instances) without data loss. This is the essence of a non-blocking consensus protocol which allows Neo4j Causal Clustering to provide continuous availability to applications.

Catchup protocol

Read Replicas spend their time concurrently processing graph queries and applying a stream of transactions from the Core Servers to update their local graph store.

![Figure 39. Transactions shipped from Core to Read Replica.](image)

Updates from Core Servers to Read Replicas are propagated by transaction shipping. Transaction shipping is instigated by Read Replicas frequently polling any of the Core Servers specifying the ID of the last
transaction they received and processed. The frequency of polling is an operational choice.

| Neo4j transaction IDs are strictly monotonic integer values (they always increase). This makes it possible to determine whether or not a transaction has been applied to a Read Replica by comparing its last processed transaction ID with that of a Core Server. |

If there is a large difference between an Read Replica’s transaction history and that of a Core Server, polling may not result in any transactions being shipped. This is quite expected, for example when a new Read Replica is introduced to a long-running cluster or where a Read Replica has been down for some significant period of time. In such cases the catchup protocol will realize the gap between the Core Servers and Read Replica is too large to fill via transaction shipping and will fall back to copying the database store directly from Core Server to Read Replica. Since we are working with a live system, at the end of the database store copy the Core Server’s database is likely to have changed. The Read Replica completes the catchup by asking for any transactions missed during the copy operation before becoming available.

| A very slow database store copy could conceivably leave the Read Replica too far behind to catch up via transaction log shipping as the Core Server has substantially moved on. In such cases the Read Replica server repeats the catchup protocol. In pathological cases the operator can intervene to snapshot, restore, or file copy recent store files from a fast backup. |

Read Replica shutdown

On clean shutdown, a Read Replica will invoke the discovery protocol to remove itself from the shared whiteboard overview of the cluster. It will also ensure that the database is cleanly shutdown and consistent, immediately ready for future use.

On an unclean shutdown such as a power outage, the Core Servers maintaining the overview of the cluster will notice that the Read Replica’s connection has been abruptly been cut. The discovery machinery will initially hide the Read Replica’s whiteboard entry, and if the Read Replica does not reappear quickly its modest memory use in the shared whiteboard will be reclaimed.

On unclean shutdown it is possible the Read Replica will not have entirely consistent store files or transaction logs. On subsequent reboot the Read Replica will rollback any partially applied transactions such that the database is in a consistent state.

Core shutdown

A shutdown of a Core Server, like Core Server booting, is handled via the Raft protocol. When a member is shutdown, either cleanly or by force, it will eventually be voted out from the Raft group. All remaining instances accept that the cluster has grown smaller, and is therefore less fault tolerant. For any databases where the leaver was playing the Leader role, each of those leaderships will be transferred to other Core Servers. Once the new Leader is established, the Core cluster continues albeit with less redundancy.

If more members than the current fault tolerance leaves the cluster within a very short time period, the cluster cannot proceed and will lose quorum. However, if members are gradually lost, the cluster may have time to reduce the size of the cluster. A Core cluster of 5 members reduced to 3 can still continue operate normally with a fault tolerance reduced from 2 to 0. After the Raft protocol votes out the lost members
which reduces the cluster size to 3, our fault tolerance has been increased from 0 to 1, and can lose yet another member and keep operating. This is because the Raft protocol has had time to vote out the lost members, and changed the cluster size of 5 (fault tolerance of 2) to 3 (fault tolerance of 1).

Raft may only reduce a cluster size to the configured causal_clustering.minimum_core_cluster_size_at_runtime. Once the cluster has reached this size, it will stop voting out members.

17.C.2. Multi-data center

This section introduces the multi-data center functionality in Neo4j.

Some use cases present high needs for availability, redundancy, locality of client applications, or simply scale. In these cases it is important that the cluster is aware of its physical topology so that it can optimize for workload. This makes configuring a single cluster to span multiple data centers a necessary proposition.

The following sections are dedicated to describing the different aspects of multi-data center operations of a Causal Cluster.

- Licensing for multi-data center operations
- Multi-data center design
  - Introduction
  - Core Server deployment scenarios
  - Allowing Read Replicas to catch up from other Read Replicas
- Multi-data center operations
  - Enable multi-data center operations
  - Server groups
  - Strategy plugins
- Multi-data center load balancing
  - Introduction
  - Prerequisite configuration
  - The load balancing framework
  - Load balancing examples
- Data center disaster recovery
  - Data center loss scenario
  - Procedure for recovering from data center loss
Licensing for multi-data center operations

Multi-data center functionality is intended for very demanding users of Neo4j who typically operate under a commercial database license. As a result, multi-data center functionality is licensed separately from the single-data center Causal Clustering features.

In order to confirm that you are operating under a suitable license, you must explicitly set the following in `neo4j.conf`:

```
causal_clustering.multi_dc_license=true
```

Without this configuration, all of the multi-data center features will remain disabled.

17.C.3. Multi-data center design

This section describes common patterns for multi-data center deployments that can act as building blocks for your own multi-data center production environments.

This section describes the following:

- Introduction
- Core Server deployment scenarios
- Allowing Read Replicas to catch up from other Read Replicas
  - Hierarchical Read Replica deployment
  - Catch up (mostly) from peer Read Replicas
  - Maintaining causal consistency in scale-out topologies

Introduction

This section is based on a series of examples to illustrate the different considerations we should take into account when designing our Causal Cluster for a multi-data center environment. We’ll come to understand the weaknesses and benefits of common multi-data center deployment scenarios. Each scenario is presented at a high architectural level for clarity. In subsequent sections we will go into more detail on how such deployments are configured.

Core Server deployment scenarios

We will start with the conceptually simplest multi-data center scenario where we deploy the same number and kind of instances into each DC. This is a homogeneous deployment because each data center is identical to the other.
Example 143. Homogeneous three data center deployment

In diagram above we have three data centers, each identically equipped with a single Core Server and a small number of Read Replicas.

Since Raft only requires a majority of the instances to acknowledge a write before it is safely committed, the latency of the commit path for this pattern involves only the two fastest data centers. As such the cost of committing to this setup is two WAN messages: one to send the transaction and one ACK message. In a non-failure case the other data center will not be far behind and will apply the transaction as well.

Within each of the data centers we can increase machine-level redundancy by adding more Core instances. For example we could add two more machines in each data center so that we can tolerate the spontaneous loss of up to four machines anywhere in the cluster or a single data center as a whole.

To recap the strengths and weaknesses of this deployment pattern:

- We can lose an entire data center without losing availability and, depending on the number of...
machines in each data center, we may still be able to tolerate the loss of individual servers regardless of which data center they are in.

- The commit path for transactions is short, just two WAN messages exchanged.
- While the loss of majority data centers will need to be recovered, the operational procedure is identical irrespective of which of the data centers are lost.

As will be shown in the section on multi-data center configuration the Read Replicas can be biased to catchup from their data center-local Core Servers to minimize catchup latency. Data center-local client applications would also likely be routed to those same Read Replicas both for topological locality and scaling. More details are available in the section on multi-data center load balancing.

In the two data center case, our first instinct is to balance the available servers for operational consistency. An example of a homogeneous deployment across two data centers with two Core instances in each is illustrated in the diagram below:

Example 144. Homogeneous two data center deployment

Figure 42. Homogeneous deployment across two data centers

The problem with this configuration is that while architecturally simple, it does not play to the strengths of the Raft protocol which is based on majority consensus. In the non-failure case, we incur two WAN messages to commit any transaction because a majority commit implies at least one response from the non-local data center instances. Worse, if we lose either data center the cluster will become read-only because it is impossible to achieve a majority.

As seen in the example above, the homogeneous deployment over two data centers does not take full advantage of the strengths of Causal Clustering. However it guarantees that the full Raft log will be present in either data center in the case of total data center loss.

The opposite of spreading Core Servers around our data centers, is to have them all hosted in a single one. This may be for technical or governance reasons, but either way has the advantage of LAN commit latencies for writes.

While our Core Servers are colocated, we spread out our Read Replicas close to the client applications to enable fan-out scaling.
Example 145. Core Servers and Read Replicas segregated by data center

The diagram below shows an example of a heterogeneous deployment directing writes to one data center, and reads to all. This pattern provides high survivability for data because of geo-replication. It also provides locality for client applications. However, if the Core Server data center is lost, we must immediately instigate recovery and turn one of the remaining Read Replica data centers into a new Core cluster.

It is possible that none of the Read Replicas have received all of the confirmed transactions prior to losing Data Center 1. While this is a convenient pattern for geo-replication, its semantics are best-effort. Cluster designers must take this aspect under consideration when deciding on recovery strategy.

![Heterogeneous deployment separating Read Replicas from the Core cluster](image)

Figure 43. Heterogeneous deployment separating Read Replicas from the Core cluster

An operational tweak to this approach would be to host a Core Server in Data Center 2 and 3 as the starting point for recovery. During normal operations, these extra Core Servers should be configured with `causal_clustering.refuse_to_be_leader=true`. Should we lose Data Center 1, then we can use one of these Core Servers to quickly bootstrap a new Core cluster and return to full service rapidly.

To recap the strengths of this deployment pattern:

- Core Servers commit at LAN latencies if using the setup with Core Servers exclusively in one data center.
- Read Replicas provide scale and locality for client applications.
- Geo-replication provides high survivability for data.

Allowing Read Replicas to catch up from other Read Replicas

With an understanding of the basic multi-data center patterns at our disposal, we can refine our deployment models to embrace local catchup within data centers. This means that any server, including Read Replicas, can act as a source of transactions for Read Replica server. When catching up from data center-local instances we aim to amortize the cost of WAN traffic catchup across many local replications.

Allowing Read Replicas to choose a data center-local Core Server or even another Read Replica gives us a great deal of design freedom, and importantly allows us to scale to truly huge numbers of Read Replicas. Using this feature we might choose to fan-out Read Replicas so that the catchup load on the Core Servers grows (approximately) logarithmically rather than linearly.
Hierarchical Read Replica deployment

The primary motivation for Read Replicas catching up from other Read Replicas is to allow for fan-out scale. To achieve a fan-out we arrange the Read Replicas in a hierarchy, with each layer of the hierarchy being broader than the one above.

Figure 44. Fan out from Core Servers for scale at log cost

An illustrative hierarchy is presented in the diagram above. The Core Servers supply transactions to a relatively small number of Read Replicas at the first tier. This results in a relatively modest load on the Core Servers, freeing up resources to focus on the commit path. Those Read Replicas in the first tier in turn feed a larger number of Read Replicas in the second tier. This pattern can be reasonably extended to several tiers to provide enormous fan-out.
At each tier we expand the scalability of the Read Replicas, but we add another level of catchup latency. By careful measurement we can ascertain the appropriate depth and breadth of the hierarchy to match the application requirements.

We should also take care that each tier in the hierarchy has sufficient redundancy so that failures do not compromise transmission of data from the Core Servers. A strategy for keeping Read Replicas current in the presence of failures is to occasionally have them subvert the hierarchy. That is, if a given Read Replica occasionally goes to its grandparents or even directly to the Core Servers then we can avoid pathologically high replication latencies under fault conditions.

Catch up (mostly) from peer Read Replicas

Another strategy for Read Replica catchup is to treat them all as peers and have peer-to-peer catchup. This avoids the need to manage tiers of replicas to maintain availability since the Read Replicas catch up from one another in a mesh.

![Peer-to-peer Read Replica catchup](image)

*Figure 45. Peer-to-peer Read Replica catchup*

Having a reduced load on the Core Servers allows us to scale out. For example if only one in ten catchup requests goes to the Core Servers, we could expand the number of Read Replicas by approximately a factor of 10.

To avoid groups of orphans in the mesh, Read Replicas will occasionally catch up directly from Core Servers. Having Read Replicas catch up with Core Servers ensures that no Read Replica is left behind indefinitely, placing an upper bound on replication latency. While this places some load on the Core Servers, it is far less than if all catch up attempts from Read Replicas were directed to a Core Server.

The upper bound on replication latency for this mode of operation is the number of catchup attempts served by Read Replicas before trying core. The average replication latency will be half the number of attempts to replicate. This is because on average half the Read Replicas will be ahead and half behind any given Read Replica.
Connecting to a random Core Server on failure to retrieve updates from other sources is the default behavior of Read Replicas.

Maintaining causal consistency in scale-out topologies

Causal consistency is always maintained, even in extreme situations with chains of Read Replicas catching up from other upstream Read Replicas. The key trade-off to understand, as so often in distributed systems, is that of latency for scale.

In Fan out from Core Servers for scale at log cost, we see that number of hops required for a transaction to propagate to the lowest tier is 2: the highest latency in this topology. Equally we see how the bottommost tier has far more members than any other tier giving it scale advantages.

Correspondingly, in the middle tier we have better latency (one hop) but less scale. At the top most tier (Core Servers) we have very little latency (just the Raft commit path) but the fewest available servers. This means we should target queries at the most appropriate tier based on latency, scale, and locality.

Summary on latency versus scalability:

- Issuing read queries to a Core Server generally has the lowest latency in principle but may have the highest contention.
- Issuing read queries to a Read Replica topologically closest to Core Servers typically has higher latency but also higher scalability.
- Issuing read queries to a Read Replica topologically further from Core Servers typically has the highest latency but also the highest scalability.

In large systems like the scale-out hierarchy above, we are conventionally used to having relaxed or eventual consistency semantics. With Neo4j multi-data center setups, that is also possible. Where we don’t care about causality we can read from any Read Replica and accept that we might see older values. However the causal consistency semantics are maintained.
Figure 46. Each tier in the Read Replicas is further behind the source of truth, but offers greater scale-out

As we can see in diagram above, even if the client binds to a Read Replica that is multiple hops/data centers away from the source of truth, causal consistency is maintained. While the query may be suspended while the necessary transaction propagates to the Read Replica, the benefit is that there will be more Read Replicas available and so overall client throughput is higher than with a single-tier configuration.


This section shows how to configure Neo4j servers so that they are topology/data center-aware. It describes the precise configuration needed to achieve a scalable multi-data center deployment.
This section describes the following:

- Enable multi-data center operations
- Server groups
- Strategy plugins
  - Configuring upstream selection strategy using pre-defined strategies
  - Configuring user-defined strategies
  - Building upstream strategy plugins using Java
  - Favoring data centers

Enable multi-data center operations

Before doing anything else, we must enable the multi-data center functionality. This is described in Licensing for multi-data center operations.

<table>
<thead>
<tr>
<th>Licensing for multi-data center</th>
</tr>
</thead>
<tbody>
<tr>
<td>The multi-data center functionality is separately licensed and must be specifically enabled.</td>
</tr>
</tbody>
</table>

Server groups

In order to optimize the use of our Causal Cluster servers according to our specific requirements, we sort them into Server Groups. Server Group membership can map to data centers, availability zones, or any other significant topological elements from the operator’s domain. Server Groups can also overlap.

Server Groups are defined as a key that maps onto a set of servers in a Causal Cluster. Server Group membership is defined on each server using the causal_clustering.server_groups parameter in neo4j.conf. Each server in a Causal Cluster can belong to zero or more server groups.
Example 146. Definition of Server Group membership

The membership of a server group or groups can be set in neo4j.conf as in the following examples:

```
# Add the current instance to the groups 'us' and 'us-east'
causal_clustering.server_groups=us,us-east
```

```
# Add the current instance into the group 'london'
causal_clustering.server_groups=london
```

```
# Add the current instance into the group 'eu'
causal_clustering.server_groups=eu
```

We must be aware that membership of each server group is explicit. For example, a server in the gb-
london group is not automatically part of some gb or eu group unless that server is explicitly added to
those groups. That is, any (implied) relationship between groups is reified only when those groups
are used as the basis for requesting data from upstream systems.

Server Groups are not mandatory, but unless they are present, we cannot set up specific upstream
transaction dependencies for servers. In the absence of any specified server groups, the cluster defaults to
its most pessimistic fall-back behavior: each Read Replica will catch up from a random Core Server.

Strategy plugins

Strategy plugins are sets of rules that define how Read Replicas contact servers in the cluster in order to
synchronize transaction logs. Neo4j comes with a set of pre-defined strategies, and also provides a Design
Specific Language, DSL, to flexibly create user-defined strategies. Finally, Neo4j supports an API which
advanced users may use to enhance upstream recommendations.

Once a strategy plugin resolves a satisfactory upstream server, it is used for pulling transactions to update
the local Read Replica for a single synchronization. For subsequent updates, the procedure is repeated so
that the most preferred available upstream server is always resolved.

Configuring upstream selection strategy using pre-defined strategies

Neo4j ships with the following pre-defined strategy plugins. These provide coarse-grained algorithms for
choosing an upstream instance:

<table>
<thead>
<tr>
<th>Plugin name</th>
<th>Resulting behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td>connect-to-random-core-server</td>
<td>Connect to any Core Server selecting at random from those currently available.</td>
</tr>
<tr>
<td>typically-connect-to-random-read-replica</td>
<td>Connect to any available Read Replica, but around 10% of the time connect to any random Core Server.</td>
</tr>
<tr>
<td>Plugin name</td>
<td>Resulting behavior</td>
</tr>
<tr>
<td>-------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>connect-randomly-to-server-group</td>
<td>Connect at random to any available Read Replica in any of the server groups specified in the comma-separated list causal_clustering.connect-randomly-to-server-group.</td>
</tr>
<tr>
<td>leader-only</td>
<td>Connect only to the current Raft leader of the Core Servers.</td>
</tr>
<tr>
<td>connect-randomly-within-server-group</td>
<td>Connect at random to any available Read Replica in any of the server groups to which this server belongs. Deprecated, please use connect-randomly-to-server-group.</td>
</tr>
</tbody>
</table>

Pre-defined strategies are used by configuring the causal_clustering.upstream_selection_strategy option. Doing so allows us to specify an ordered preference of strategies to resolve an upstream provider of transaction data. We provide a comma-separated list of strategy plugin names with preferred strategies earlier in that list. The upstream strategy is chosen by asking each of the strategies in list-order whether they can provide an upstream server from which transactions can be pulled.

**Example 147. Define an upstream selection strategy**

Consider the following configuration example:

```plaintext
causal_clustering.upstream_selection_strategy=connect-randomly-to-server-group,typically-connect-to-random-read-replica
```

With this configuration the instance will first try to connect to any other instance in the group(s) specified in causal_clustering.connect-randomly-to-server-group. Should we fail to find any live instances in those groups, then we will connect to a random Read Replica.

![Order of evaluation diagram](image)

**Figure 47. The first satisfactory response from a strategy will be used.**

To ensure that downstream servers can still access live data in the event of upstream failures, the last resort of any instance is always to contact a random Core Server. This is equivalent to ending the causal_clustering.upstream_selection_strategy configuration with connect-to-random-core-server.

**Configuring user-defined strategies**

Neo4j Causal Clusters support a small DSL for the configuration of client-cluster load balancing. This is
described in detail in Policy definitions and Filters. The same DSL is used to describe preferences for how an instance binds to another instance to request transaction updates.

The DSL is made available by selecting the user-defined strategy as follows:

```
causal_clustering.upstream_selection_strategy=user-defined
```

Once the user-defined strategy has been specified, we can add configuration to the causal_clustering.user_defined_upstream_strategy setting based on the server groups that have been set for the cluster.

We will describe this functionality with two examples:
For illustrative purposes we propose four regions: north, south, east, and west and within each region we have a number of data centers such as north1 or west2. We configure our server groups so that each data center maps to its own server group. Additionally we will assume that each data center fails independently from the others and that a region can act as a supergroup of its constituent data centers. So an instance in the north region might have configuration like `causal_clustering.server_groups=north2,north` which puts it in two groups that match to our physical topology as shown in the diagram below.

![Diagram showing mapping of regions and data centers onto server groups](image)

**Figure 48. Mapping regions and data centers onto server groups**

Once we have our server groups, our next task is to define some upstream selection rules based on them. For our design purposes, let’s say that any instance in one of the north region data centers prefers to catchup within the data center if it can, but will resort to any northern instance otherwise. To configure that behavior we add:

```
causal_clustering.user_defined_upstream_strategy=groups(north2); groups(north); halt()
```

The configuration is in precedence order from left to right. The `groups()` operator yields a server group from which to catch up. In this case only if there are no servers in the north2 server group will we proceed to the `groups(north)` rule which yields any server in the north server group. Finally, if we cannot resolve any servers in any of the previous groups, then we will stop the rule chain via `halt()`.

Note that the use of `halt()` will end the rule chain explicitly. If we don’t use `halt()` at the end of the rule chain, then the `all()` rule is implicitly added. `all()` is expansive: it offers up all servers and so increases the likelihood of finding an available upstream server. However `all()` is indiscriminate and the servers it offers are not guaranteed to be topologically or geographically local, potentially increasing the latency of synchronization.

The example above shows a simple hierarchy of preferences. But we can be more sophisticated if we so choose. For example we can place conditions on the server groups from which we catch up.
Example 149. User-defined strategy with conditions

In this example we wish to roughly qualify cluster health before choosing from where to catch up. For this we use the \texttt{min()} filter as follows:

\begin{verbatim}
causal_clustering.user_defined_upstream_strategy =
groups(north2)->min(3), groups(north)->min(3);
all();
\end{verbatim}

\texttt{groups(north2)->min(3)} states that we want to catch up from the \texttt{north2} server group if it has three available machines, which we here take as an indicator of good health. If \texttt{north2} can't meet that requirement (is not healthy enough) then we try to catch up from any server across the \texttt{north} region provided there are at least three of them available as per \texttt{groups(north)->min(3)}. Finally, if we cannot catch up from a sufficiently healthy \texttt{north} region, then we’ll (explicitly) fall back to the whole cluster with \texttt{all()}.

The \texttt{min()} filter is a simple but reasonable indicator of server group health.

Building upstream strategy plugins using Java

Neo4j supports an API which advanced users may use to enhance upstream recommendations in arbitrary ways: load, subnet, machine size, or anything else accessible from the JVM. In such cases we are invited to build our own implementations of \texttt{org.neo4j.causalclustering.readreplica.UpstreamDatabaseSelectionStrategy} to suit our own needs, and register them with the strategy selection pipeline just like the pre-packaged plugins.

We have to override the \texttt{org.neo4j.causalclustering.readreplica.UpstreamDatabaseSelectionStrategy#upstreamDatabase()} method in our code. Overriding that class gives us access to the following items:

\begin{tabular}{|l|l|}
\hline
\textbf{Resource} & \textbf{Description} \\
\hline
\texttt{org.neo4j.causalclustering.discovery.TopologyService} & This is a directory service which provides access to the addresses of all servers and server groups in the cluster. \\
\texttt{org.neo4j.kernel.configuration.Config} & This provides the configuration from \texttt{neo4j.conf} for the local instance. Configuration for our own plugin can reside here. \\
\texttt{org.neo4j.causalclustering.identity.MemberId} & This provides the unique cluster MemberId of the current instance. \\
\hline
\end{tabular}

Once our code is written and tested, we have to prepare it for deployment. \texttt{UpstreamDatabaseSelectionStrategy} plugins are loaded via the Java Service Loader. This means when we package our code into a jar file, we'll have to create a file \texttt{META-INF/services/org.neo4j.causalclustering.readreplica.UpstreamDatabaseSelectionStrategy} in which we write the fully qualified class name(s) of the plugins, e.g. \texttt{org.example.myplugins.PreferServersWithHighIOPS}.

To deploy this jar into the Neo4j server we copy it into the \texttt{plugins} directory and restart the instance.
Favoring data centers

In a multi-DC scenario, while it remains a rare occurrence, it is possible to bias where writes for the specified database should be directed. We can apply `causal_clustering.leadership_priority_group` to specify a group of servers which should have priority when selecting the leader for a given database. The priority group can be set on one or multiple databases and it means that the cluster will attempt to keep the leadership for the configured database on an instance tagged with the configured server group.

A database for which `leadership_priority_group` has been configured will be excluded from the automatic balancing of leaderships across a cluster. It is therefore recommended to not use this configuration unless it is necessary.

17.C.5. Multi-data center load balancing

This section describes the topology-aware load balancing options available for client applications in a multi-data center Neo4j deployment. It describes how to configure the load balancing for the cluster so that client applications can direct its workload at the most appropriate cluster members, such as those nearby.

This section describes the following:

- Introduction
- Prerequisite configuration
  - Enable multi-data center operations
  - Server groups
  - Cores for reading
- The load balancing framework
  - Policy definitions
  - Policy names
  - Filters
- Load balancing examples

<table>
<thead>
<tr>
<th>Enabling load balancing</th>
</tr>
</thead>
<tbody>
<tr>
<td>The load balancing functionality is part of the separately licensed multi-data center package and must be specifically enabled. See Licensing for multi-data center operations for details.</td>
</tr>
</tbody>
</table>

Introduction

When deploying a multi-data center cluster we often wish to take advantage of locality to reduce latency and improve performance. For example, we would like our graph-intensive workloads to be executed in the local data center at LAN latencies rather than in a faraway data center at WAN latencies. Neo4j’s enhanced load balancing for multi-data center scenarios facilitates precisely this and can also be used to
define fall-back behaviors. This means that failures can be planned for upfront and persistent overload conditions be avoided.

The load balancing system is a cooperative system where the driver asks the cluster on a recurring basis where it should direct the different classes of its workload (e.g. writes and reads). This allows the driver to work independently for long stretches of time, yet check back from time to time to adapt to changes like for example a new server having been added for increased capacity. There are also failure situations where the driver will ask again immediately, for example when it cannot use any of its allocated servers.

This is mostly transparent from the perspective of a client. On the server side we configure the load balancing behaviors and expose them under a named load balancing policy which the driver can bind to.

All server-side configuration is performed on the Core Servers.

Use load balancing from Neo4j drivers

This chapter describes how to configure a Causal Cluster to use custom load balancing policies Once enabled and configured, the custom load balancing feature is used by drivers to route traffic as intended. See the Neo4j Driver manuals for instructions on how to configure drivers to use custom load balancing.

Prerequisite configuration

Enable multi-data center operations

In order to configure a cluster for load balancing we must enable the multi-data center functionality. This is described in Licensing for multi-data center operations.

Server groups

In common with server-to-server catchup, load balancing across multiple data centers is predicated on the server group concept. Servers can belong to one or more potentially overlapping server groups, and decisions about where to route requests from client to cluster member are parameterized based on that configuration. For details on server group configuration, refer to Server groups.

Cores for reading

Depending on the deployment and the available number of servers in the cluster different strategies make sense for whether or not the reading workload should be routed to the Core Servers. The following configuration will allow the routing of read workload to Core Servers. Valid values are true and false.

causal_clustering.cluster_allow_reads_on_followers=true

The load balancing framework

The load balancing system is based on a plugin architecture for future extensibility and for allowing user
customizations. The current version ships with exactly one such canned plugin called the server policies plugin.

The server policies plugin is selected by setting the following property:

```
causal_clustering.load_balancing.plugin=server_policies
```

Under the server policies plugin, a number of load balancing policies can be configured server-side and be exposed to drivers under unique names. The drivers, in turn, must on instantiation select an appropriate policy by specifying its name. Common patterns for naming policies are after geographical regions or intended application groups.

It is of crucial importance to define the exact same policies on all core machines since this is to be regarded as cluster-wide configuration and failure to do so will lead to surprising behavior. Similarly, policies which are in active use should not be removed or renamed since it will break applications trying to use these policies. It is perfectly acceptable and expected however that policies be modified under the same name.

If a driver asks for a policy name which is not available, then it will not be able to use the cluster. A driver which does not specify any name at all will get the behavior of the default policy as configured. The default policy, if left unchanged, distributes the load across all servers. It is possible to change the default policy to any behavior that a named policy can have.

A misconfigured driver or load balancing policy will result in suboptimal routing choices or even prevent successful interactions with the cluster entirely.

The details of how to write a custom plugin is not documented here. Please get in contact with Neo4j Professional Services if you think that you need a custom plugin.

Policy definitions

The configuration of load balancing policies is transparent to client applications and expressed via a simple DSL. The syntax consists of a set of rules which are considered in order. The first rule to produce a non-empty result will be the final result.

```
rule1; rule2; rule3
```

Each rule in turn consists of a set of filters which limit the considered servers, starting with the complete set. Note that the evaluation of each rule starts fresh with the complete set of available servers.

There is a fixed set of filters which compose a rule and they are chained together using arrows

```
filter1 => filter2 => filter3
```

If there are any servers still left after the last filter then the rule evaluation has produced a result and this will be returned to the driver. However, if there are no servers left then the next rule will be considered. If no rule is able to produce a usable result then the driver will be signalled a failure.
Policy names

The policies are configured under the namespace of the server policies plugin and named as desired. Policy names can contain alphanumeric characters and underscores, and they are case sensitive. Below is the property key for a policy with the name `mypolicy`.

```bash
causal_clustering.load_balancing.config.server_policies.mypolicy=
```

The actual policy is defined in the value part using the DSL.

The `default` policy name is reserved for the default policy. It is possible to configure this policy like any other and it will be used by driver clients which do not specify a policy.

Additionally, any number of policies can be created using unique policy names. The policy name can suggest a particular region or an application for which it is intended to be used.

Filters

There are four filters available for specifying rules, detailed below. The syntax is similar to a method call with parameters.

- `groups(name1, name2, ...)`
  - Only servers which are part of any of the specified groups will pass the filter.
  - The defined names must match those of the server groups.
- `min(count)`
  - Only the minimum amount of servers will be allowed to pass (or none).
  - Allows overload conditions to be managed.
- `all()`
  - No need to specify since it is implicit at the beginning of each rule.
  - Implicitly the last rule (override this behavior using `halt`).
- `halt()`
  - Only makes sense as the last filter in the last rule.
  - Will stop the processing of any more rules.

The groups filter is essentially an OR-filter, e.g. `groups(A,B)` which will pass any server in either A, B or both (the union of the server groups). An AND-filter can also be created by chaining two filters as in `groups(A) -> groups(B)`, which will only pass servers in both groups (the intersect of the server groups).

Load balancing examples

In our discussion on multi-data center clusters we introduced a four region, multi-data center setup. We used the cardinal compass points for regions and numbered data centers within those regions. We'll use the same hypothetical setup here too.
Figure 49. Mapping regions and data centers onto server groups

We configure the behavior of the load balancer in the property `causal_clustering.load_balancing.config.server_policies.<policy-name>`. The rules we specify will allow us to fine tune how the cluster routes requests under load.

In the examples we will make use of the line continuation character `\` for better readability. It is valid syntax in `neo4j.conf` as well and it is recommended to break up complicated rule definitions using this and a new rule on every line.

The most restrictive strategy would be to insist on a particular data center to the exclusion of all others:

**Example 150. Specific data center only**

```plaintext
causal_clustering.load_balancing.config.server_policies.north1_only=\ 
groups(north1)->min(2); halt();
```

In this case we’re stating that we are only interested in sending queries to servers in the `north1` server group, which maps onto a specific physical data center, provided there are two of them available. If we cannot provide at least two servers in `north1` then we should `halt()`, i.e. not try any other data center.

While the previous example demonstrates the basic form of our load balancing rules, we can be a little more expansive:
Example 151. Specific data center preferably

```java
causal_clustering.load_balancing.config.server_policies.north1=
  groups(north1)->min(2);
```

In this case if at least two servers are available in the north1 data center then we will load balance across them. Otherwise we will use any server in the whole cluster, falling back to the implicit, final all() rule.

The previous example considered only a single data center before resorting to the whole cluster. If we have a hierarchy or region concept exposed through our server groups we can make the fall back more graceful:

Example 152. Gracefully falling back to neighbors

```java
causal_clustering.load_balancing.config.server_policies.north_app1=
  groups(north1,north2)->min(2);
  groups(north);
  all();
```

In this case we’re saying that the cluster should load balance across the north1 and north2 data centers provided there are at least two machines available across them. Failing that, we’ll resort to any instance in the north region, and if the whole of the north is offline we’ll resort to any instances in the cluster.

17.C.6. Data center disaster recovery

This section describes how to recover your Neo4j Causal Cluster following a data center failure. Specifically it covers safely turning a small number of surviving instances from a read-only state back into a fully operational cluster of read/write instances.

This section describes the following:

- Data center loss scenario
- Procedure for recovering from data center loss

Data center loss scenario

This section describes how to recover a multi-data center deployment which owing to external circumstances has reduced the cluster below half of its members. It is most easily typified by a 2x2 deployment with 2 data centers each containing two instances. This deployment topology can either arise because of other data center failures, or be a deliberate choice to ensure the geographic survival of data for catastrophe planning. However, by distributing an instance over three data centers instead, you could avoid having the cluster lose quorum through a single data center failure. For example, in a 1x1x1 deployment.
Under normal operation this provides a stable majority quorum where the fastest three out of four machines will execute users' transactions, as we see highlighted in Two Data Center Deployment with Four Core Instances, role="middle.

However if an entire data center becomes offline because of some disaster, then a majority quorum cannot be formed in this case.

Neo4j Core clusters are based on the Raft consensus protocol for processing transactions. The Raft protocol requires a majority of cluster members to agree in order to ensure the safety of the cluster and data. As such, the loss of a majority quorum results in a read-only situation for the remaining cluster members.

When data center is lost abruptly in a disaster rather than having the instances cleanly shut down, the surviving members still believe that they are part of a larger cluster. This is different from even the case of rapid failures of individual instances in a live data center which can often be detected by the underlying cluster middleware, allowing the cluster to automatically reconfigure.

Conversely if we lose a data center, there is no opportunity for the cluster to automatically reconfigure. The loss appears instantaneous to other cluster members. However, because each remaining machine has only a partial view of the state of the cluster (its own), it is not safe to allow any individual machine to make an arbitrary decision to reform the cluster.

In this case we are left with two surviving machines which cannot form a quorum and thus make progress.

But, from a birds’s eye view, it’s clear we have surviving machines which are sufficient to allow a non-fault tolerant cluster to form under operator supervision.
Groups of individual cluster members (e.g. those in a single data center) may become isolated from the cluster during network partition for example. If they arbitrarily reformed a new, smaller cluster there is a risk of split-brain. That is from the clients' point of view there may be two or more smaller clusters that are available for reads and writes depending on the nature of the partition. Such situations lead to divergence that is tricky and laborious to reconcile and so best avoided.

To be safe, an operator or other out-of-band agent (e.g. scripts triggered by well-understood, trustworthy alerts) that has a trusted view on the whole of the system estate must make that decision. In the surviving data center, the cluster can be rebooted into a smaller configuration whilst retaining all data committed to that point. While end users may experience unavailability during the switch over, no committed data will be lost.

Procedure for recovering from data center loss

The following procedure for performing recovery of a data center should not be done lightly. It assumes that we are completely confident that a disaster has occurred and our previously data center-spanning cluster has been reduced to a read-only cluster in a single data center, where there is no possible way to repair a connection to the lost instances. Further it assumes that the remaining cluster members are fit to provide a seed from which a new cluster can be created from a data quality point of view.

Having acknowledged the above, the procedure for returning the cluster to full availability following catastrophic loss of all but one data centers can be done using one of the following options, depending on your infrastructure.

Please note that the main difference between the options is that Option 2 will allow read-availability during recovery.

Option 1.

If you are unable to add instances to the current data-center, and can only use the current read-only cluster, the following steps are recommended:

1. Verify that a catastrophe has occurred, and that access to the surviving members of the cluster in the surviving data center is possible. Then for each instance:
   a. Stop the instance with `bin/neo4j stop` or shut down the service.
   b. Change the configuration in `neo4j.conf` such that the `causal_clustering.initial_discovery_members` property contains the DNS names or IP addresses of the other surviving instances.
   c. Optional: you may need to update `causal_clustering.minimum_core_cluster_size_at_formation`, depending on the current size of the cluster (in the current example, two cores).
   d. Unbind the instance using `neo4j-admin unbind`.
   e. Start the instance with `bin/neo4j start` or start the `neo4j` service.

Option 2.

If it is possible to create a new cluster while the previous read-only cluster is still running, then the following steps will enable you to keep read-availability during recovery:
1. Verify that a catastrophe has occurred, and that access to the surviving members of the cluster in the surviving data center is possible.

2. Perform an online backup of the currently running, read-only, cluster.

3. Seed a new cluster (in the current example, two new cores) using the backup from the read-only cluster, as described in Seed a cluster.

4. When the new cluster is up, load balance your workload over to the new cluster.

5. Shutdown the old, read-only, cluster.

Once your chosen recovery procedure is completed for each instance, they will form a cluster that is available for reads and writes. It is recommended at this point that other cluster members are incorporated into the cluster to improve its load handling and fault tolerance. See Deploy a cluster for details of how to configure instances to join the cluster from scratch.

17.4. Embedded usage

This section describes how to embed a Neo4j Causal Cluster in your application.

For users coming to Causal Clustering from Neo4j HA embedded, there are a small number of changes required. The Neo4j routing driver is used for routing and load balancing queries in server deployments (other setups are possible with 3rd party load balancers).

The driver also handles bookmarks, which are essential for causal consistency, and as such is a fundamental part of the Causal Clustering architecture. In an embedded deployment the driver can be used either for routing queries externally from another application into the embedded cluster, or using an embedded driver internally within the cluster.

The workload must be comprised, in its entirety, of Cypher statements. If your workload depends on the Java Core API for writing, then you have to package those pieces as procedures which are (remotely) invoked using Cypher, via the driver. Read-only queries can still access the Core API directly.

For a detailed tutorial on how to embed Neo4j in your Java application, see Neo4j Java Reference → Including Neo4j in your project.

Appendix D: Deprecated security procedures

This appendix describes deprecated procedures for security management.

This appendix describes deprecated procedures for security management:

- Enterprise Edition
- Community Edition
The procedures described in this appendix have been deprecated and will be removed in a future release.

It is strongly recommended to migrate to the security features as described in Cypher Manual + Access Control

See also a worked example in Fine-grained access control.


This section describes deprecated procedures for native user and role management for Neo4j Enterprise Edition.

A subset of this functionality is also available in Community Edition. The table below includes an indication of which functions this is valid for. Refer to Community Edition for a complete description.

In Neo4j, native user and role management are managed by using built-in procedures through Cypher. This section gives a list of all the security procedures for user management along with some simple examples. Use Neo4j Browser or Neo4j Cypher Shell to run the examples provided.

The following table lists the available procedures:

<table>
<thead>
<tr>
<th>Procedure name</th>
<th>Description</th>
<th>Executable by role(s)</th>
<th>Available in Community Edition</th>
</tr>
</thead>
<tbody>
<tr>
<td>dbms.security.activateUser</td>
<td>Activate a suspended user</td>
<td>admin</td>
<td></td>
</tr>
<tr>
<td>dbms.security.addRoleToUser</td>
<td>Assign a role to the user</td>
<td>admin</td>
<td></td>
</tr>
<tr>
<td>dbms.security.changePassword</td>
<td>Change the current user's password</td>
<td>reader, editor, publisher, architect, admin</td>
<td></td>
</tr>
<tr>
<td>dbms.security.changeUserPassword</td>
<td>Change the given user's password</td>
<td>admin</td>
<td></td>
</tr>
<tr>
<td>dbms.security.createRole</td>
<td>Create a new role</td>
<td>admin</td>
<td></td>
</tr>
<tr>
<td>dbms.security.createUser</td>
<td>Create a new user</td>
<td>admin</td>
<td></td>
</tr>
<tr>
<td>dbms.security.deleteRole</td>
<td>Delete the specified role. Any role assignments will be removed</td>
<td>admin</td>
<td></td>
</tr>
<tr>
<td>Procedure name</td>
<td>Description</td>
<td>Executable by role(s)</td>
<td>Available in Community Edition</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>------------------------------</td>
<td>-----------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>dbms.security.deleteUser</td>
<td>Delete the specified user</td>
<td>admin</td>
<td>☑</td>
</tr>
<tr>
<td>dbms.security.listRoles</td>
<td>List all available roles</td>
<td>admin</td>
<td></td>
</tr>
<tr>
<td>dbms.security.listRolesForUser</td>
<td>List all roles assigned to the specified user</td>
<td>admin</td>
<td></td>
</tr>
<tr>
<td>dbms.security.listUsers</td>
<td>List all local users</td>
<td>admin</td>
<td>☑</td>
</tr>
<tr>
<td>dbms.security.listUsersForRole</td>
<td>List all users currently assigned the specified role</td>
<td>admin</td>
<td></td>
</tr>
<tr>
<td>dbms.security.removeRoleFromUser</td>
<td>Unassign a role from the user</td>
<td>admin</td>
<td></td>
</tr>
<tr>
<td>dbms.security.suspendUser</td>
<td>Suspend the specified user</td>
<td>admin</td>
<td></td>
</tr>
</tbody>
</table>

Activate a suspended user

An administrator is able to activate a suspended user so that the user is once again able to access the data in their original capacity.

Syntax:

```
CALL dbms.security.activateUser(username, requirePasswordChange)
```

Arguments:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>username</td>
<td>String</td>
<td>This is the username of the user to be activated.</td>
</tr>
<tr>
<td>requirePasswordChange</td>
<td>Boolean</td>
<td>This is optional, with a default of true. If this is true, (i) the user will be forced to change their password when they next log in, and (ii) until the user has changed their password, they will be forbidden from performing any other operation.</td>
</tr>
</tbody>
</table>

Exceptions:

| The current user is not an administrator. |
The username does not exist in the system.
The username matches that of the current user (i.e. activating the current user is not permitted).

Considerations:
This is an idempotent procedure.

Example 153. Activate a suspended user

The following example activates a user with the username 'jackgreen'. When the user 'jackgreen' next logs in, he will be required to change his password.

CALL dbms.security.activateUser('jackgreen')

Assign a role to the user

An administrator is able to assign a role to any user in the system, thus allowing the user to perform a series of actions upon the data.

Syntax:

CALL dbms.security.addRoleToUser(roleName, username)

Arguments:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>roleName</td>
<td>String</td>
<td>This is the name of the role to be assigned to the user.</td>
</tr>
<tr>
<td>username</td>
<td>String</td>
<td>This is the username of the user who is to be assigned the role.</td>
</tr>
</tbody>
</table>

Exceptions:

The current user is not an administrator.
The username does not exist in the system.
The username contains characters other than alphanumeric characters and the '_' character.
The role name does not exist in the system.
The role name contains characters other than alphanumeric characters and the '_' character.

Considerations:
This is an idempotent procedure.
Example 154. Assign a role to the user

The following example assigns the role **publisher** to the user with username 'johnsmith'.

```
CALL dbms.security.addRoleToUser('publisher', 'johnsmith')
```

Change the current user's password

The procedure `dbms.security.changePassword(newPassword, requirePasswordChange)` has been entirely removed since the corresponding Cypher administration command also requires the old password, and thus is more secure. Please use `ALTER CURRENT USER SET PASSWORD FROM 'oldPassword' TO 'newPassword'`, documented in the Cypher Manual, instead.

Change the given user’s password

An administrator is able to change the password of any user within the system. Alternatively, the current user may change their own password.

**Syntax:**

```
CALL dbms.security.changeUserPassword(username, newPassword, requirePasswordChange)
```

**Arguments:**

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>username</td>
<td>String</td>
<td>This is the username of the user whose password is to be changed.</td>
</tr>
<tr>
<td>newPassword</td>
<td>String</td>
<td>This is the new password for the user.</td>
</tr>
<tr>
<td>requirePasswordChange</td>
<td>Boolean</td>
<td>This is optional, with a default of true. If this is true, (i) the user will be forced to change their password when they next log in, and (ii) until the user has changed their password, they will be forbidden from performing any other operation.</td>
</tr>
</tbody>
</table>

**Exceptions:**

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>The current user is not an administrator and the username does not match that of the current user.</td>
</tr>
<tr>
<td>The username does not exist in the system.</td>
</tr>
<tr>
<td>The password is the empty string.</td>
</tr>
<tr>
<td>The password is the same as the user’s previous password.</td>
</tr>
</tbody>
</table>

**Considerations:**

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
</table>

725
This procedure may be invoked by the current user to change their own password, irrespective of whether or not the current user is an administrator.

This procedure may be invoked by an administrator to change another user's password.

In addition to changing the user's password, this will terminate with immediate effect all of the user's sessions and roll back any running transactions.

Example 155. Change a given user's password

The following example changes the password of the user with the username 'joebloggs' to 'h6u4%kr'. When the user 'joebloggs' next logs in, he will be required to change his password.

CALL dbms.security.changeUserPassword('joebloggs', 'h6u4%kr')

Create a new role

An administrator is able to create custom roles in the system.

Syntax:

CALL dbms.security.createRole(roleName)

Arguments:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>roleName</td>
<td>String</td>
<td>This is the name of the role to be created.</td>
</tr>
</tbody>
</table>

Exceptions:

- The current user is not an administrator.
- The role name already exists in the system.
- The role name is empty.
- The role name contains characters other than alphanumeric characters and the '_' character.
- The role name matches one of the native roles: reader, publisher, architect, and admin.

Example 156. Create a new role

The following example creates a new custom role.

CALL dbms.security.createRole('operator')
Create a new user

An administrator is able to create a new user. This action ought to be followed by assigning a role to the user, which is described here.

Syntax:

```
CALL dbms.security.createUser(username, password, requirePasswordChange)
```

Arguments:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>username</td>
<td>String</td>
<td>This is the user's username.</td>
</tr>
<tr>
<td>password</td>
<td>String</td>
<td>This is the user's password.</td>
</tr>
<tr>
<td>requirePasswordChange</td>
<td>Boolean</td>
<td>This is optional, with a default of true. If this is true, (i) the user will be forced to change their password when they log in for the first time, and (ii) until the user has changed their password, they will be forbidden from performing any other operation.</td>
</tr>
</tbody>
</table>

Exceptions:

<table>
<thead>
<tr>
<th>Exception Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>The current user is not an administrator.</td>
</tr>
<tr>
<td>The username either contains characters other than the ASCII characters between ! and ~, or contains : and ..</td>
</tr>
<tr>
<td>The username is already in use within the system.</td>
</tr>
<tr>
<td>The password is the empty string.</td>
</tr>
</tbody>
</table>

Example 157. Create a new user

The following example creates a user with the username 'johnsmith' and password 'h6u4%kr'. When the user 'johnsmith' logs in for the first time, he will be required to change his password.

```
CALL dbms.security.createUser('johnsmith', 'h6u4%kr')
```

Delete the specified role

An administrator is able to delete roles from the system.

Syntax:

```
CALL dbms.security.deleteRole(roleName)
```

Arguments:
Delete the specified role

The following example deletes the custom role 'operator' from the system.

CALL dbms.security.deleteRole('operator')

Delete the specified user

An administrator is able to delete permanently a user from the system. It is not possible to undo this action, so, if in any doubt, consider suspending the user instead.

Syntax:

CALL dbms.security.deleteUser(username)

Arguments:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>username</td>
<td>String</td>
<td>This is the username of the user to be deleted.</td>
</tr>
</tbody>
</table>

Exceptions:

The current user is not an administrator.

The username does not exist in the system.

The username matches that of the current user (i.e. deleting the current user is not permitted).
Deleting a user will terminate with immediate effect all of the user’s sessions and roll back any running transactions. As it is not possible for the current user to delete themselves, there will always be at least one administrator in the system.

Example 159. Delete the specified user

The following example deletes a user with the username 'janebrown'.

```
CALL dbms.security.deleteUser('janebrown')
```

List all available roles

An administrator is able to view all assigned users for each role in the system.

**Syntax:**

```
CALL dbms.security.listRoles()
```

**Returns:**

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>role</td>
<td>String</td>
<td>This is the name of the role.</td>
</tr>
<tr>
<td>users</td>
<td>List&lt;String&gt;</td>
<td>This is a list of the usernames of all users who have been assigned the role.</td>
</tr>
</tbody>
</table>

**Exceptions:**

The current user is not an administrator.

Example 160. List all available roles

The following example shows, for each role in the system, the name of the role and the usernames of all assigned users.

```
CALL dbms.security.listRoles()
```

```
+-----------------+-------------------+
| role            | users             |
+-----------------+-------------------+
| "reader"        | ["bill"]         |
| "architect"     | []                |
| "admin"         | ["neo4j"]        |
| "publisher"     | ["john","bob"]  |
+-----------------+-------------------+
4 rows
```
List all roles assigned to the specified user

Any active user is able to view all of their assigned roles. An administrator is able to view all assigned roles for any user in the system.

Syntax:

```
CALL dbms.security.listRolesForUser(username)
```

Arguments:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>username</td>
<td>String</td>
<td>This is the username of the user.</td>
</tr>
</tbody>
</table>

Returns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>value</td>
<td>String</td>
<td>This returns all roles assigned to the requested user.</td>
</tr>
</tbody>
</table>

Exceptions:

- The current user is not an administrator and the username does not match that of the current user.
- The username does not exist in the system.

Considerations:

- This procedure may be invoked by the current user to view their roles, irrespective of whether or not the current user is an administrator.
- This procedure may be invoked by an administrator to view the roles for another user.

Example 161. List all roles assigned to the specified user

The following example lists all the roles for the user with username 'johnsmith', who has the roles reader and publisher.

```
CALL dbms.security.listRolesForUser('johnsmith')
```

```
+-------------+
<table>
<thead>
<tr>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;reader&quot;</td>
</tr>
<tr>
<td>&quot;publisher&quot;</td>
</tr>
</tbody>
</table>
+-------------+  
2 rows
```
List all local users

An administrator is able to view the details of every user in the system.

Syntax:

CALL dbms.security.listUsers()

Returns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>username</td>
<td>String</td>
<td>This is the user's username.</td>
</tr>
<tr>
<td>roles</td>
<td>List&lt;String&gt;</td>
<td>This is a list of roles assigned to the user.</td>
</tr>
<tr>
<td>flags</td>
<td>List&lt;String&gt;</td>
<td>This is a series of flags indicating whether the user is suspended or needs to change their password.</td>
</tr>
</tbody>
</table>

Exceptions:

The current user is not an administrator.

Example 162. List all local users

The following example shows, for each user in the system, the username, the roles assigned to the user, and whether the user is suspended or needs to change their password.

```
CALL dbms.security.listUsers()
```

```
+--------------------+-----------------+--------------------------------------+
<table>
<thead>
<tr>
<th>username</th>
<th>roles</th>
<th>flags</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;neo4j&quot;</td>
<td>[&quot;admin&quot;]</td>
<td>[]</td>
</tr>
<tr>
<td>&quot;anne&quot;</td>
<td>[]</td>
<td>[&quot;password_change_required&quot;]</td>
</tr>
<tr>
<td>&quot;bill&quot;</td>
<td>[&quot;reader&quot;]</td>
<td>[&quot;is_suspended&quot;]</td>
</tr>
<tr>
<td>&quot;john&quot;</td>
<td>[&quot;architect&quot;,&quot;publisher&quot;]</td>
<td>[]</td>
</tr>
</tbody>
</table>
+--------------------+-----------------+--------------------------------------+
4 rows
```

List all users currently assigned the specified role

An administrator is able to view all assigned users for a role.

Syntax:

CALL dbms.security.listUsersForRole(roleName)

Arguments:
<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>roleName</td>
<td>String</td>
<td>This is the name of the role.</td>
</tr>
</tbody>
</table>

Returns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>value</td>
<td>String</td>
<td>This returns all assigned users for the requested role.</td>
</tr>
</tbody>
</table>

Exceptions:

- The current user is not an administrator.
- The role name does not exist in the system.

Example 163. List all users currently assigned the specified role

The following example lists all the assigned users - 'bill' and 'anne' - for the role **publisher**.

```sql
CALL dbms.security.listUsersForRole('publisher')
```

```
+--------+
| value  |
+--------+
| "bill" |
| "anne" |
+--------+
2 rows
```

Unassign a role from the user

An administrator is able to remove a role from any user in the system, thus preventing the user from performing upon the data any actions prescribed by the role.

Syntax:

```sql
CALL dbms.security.removeRoleFromUser(roleName, username)
```

Arguments:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>roleName</td>
<td>String</td>
<td>This is the name of the role which is to be removed from the user.</td>
</tr>
<tr>
<td>username</td>
<td>String</td>
<td>This is the username of the user from which the role is to be removed.</td>
</tr>
</tbody>
</table>

Exceptions:
The current user is not an administrator.
The username does not exist in the system.
The role name does not exist in the system.
The username is that of the current user and the role is admin.

Considerations:

If the username is that of the current user and the role name provided is admin, an error will be thrown; i.e. the current user may not be demoted from being an administrator.

As it is not possible for the current user to remove the admin role from themselves, there will always be at least one administrator in the system.

This is an idempotent procedure.

Example 164. Unassign a role from the user

The following example removes the role publisher from the user with username 'johnsmith'.

```
CALL dbms.security.removeRoleFromUser('publisher', 'johnsmith')
```

Suspend the specified user

An administrator is able to suspend a user from the system. The suspended user may be activated at a later stage.

Syntax:

```
CALL dbms.security.suspendUser(username)
```

Arguments:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>username</td>
<td>String</td>
<td>This is the username of the user to be suspended.</td>
</tr>
</tbody>
</table>

Exceptions:

The current user is not an administrator.
The username does not exist in the system.
The username matches that of the current user (i.e. suspending the current user is not permitted).

Considerations:

Suspending a user will terminate with immediate effect all of the user’s sessions and roll back any running transactions.

All of the suspended user’s attributes — assigned roles and password — will remain intact.
A suspended user will not be able to log on to the system.

As it is not possible for the current user to suspend themselves, there will always be at least one active administrator in the system.

This is an idempotent procedure.

Example 165. Suspend the specified user

The following example suspends a user with the username 'billjones'.

```
CALL dbms.security.suspendUser('billjones')
```


This section describes deprecated procedures for user and password management for Neo4j Community Edition.

User and password management for Community Edition is a subset of the functionality available in Enterprise Edition. The following is true for user management in Community Edition:

- It is possible to create multiple users.
- All users assume the privileges of an admin for the available functionality.

Users are managed by using built-in procedures through Cypher. This section gives a list of all the security procedures for user management along with some simple examples. Use Neo4j Browser or Neo4j Cypher Shell to run the examples provided. Unless stated otherwise, all arguments to the procedures described in this section must be supplied.

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>dbms.security.changePassword</td>
<td>Change the current user's password</td>
</tr>
<tr>
<td>dbms.security.createUser</td>
<td>Add a user</td>
</tr>
<tr>
<td>dbms.security.deleteUser</td>
<td>Delete a user</td>
</tr>
<tr>
<td>dbms.security.listUsers</td>
<td>List all users</td>
</tr>
</tbody>
</table>

Change the current user's password

The procedure `dbms.security.changePassword(newPassword, requirePasswordChange)` has been entirely removed since the corresponding Cypher administration command also requires the old password, and thus is more secure. Please use `ALTER CURRENT USER SET PASSWORD FROM 'oldPassword' TO 'newPassword'`, documented in the Cypher Manual, instead.
Add a user

The current user is able to add a user to the system.

Syntax:

CALL dbms.security.createUser(username, password, requirePasswordChange)

Arguments:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>username</td>
<td>String</td>
<td>This is the user's username.</td>
</tr>
<tr>
<td>password</td>
<td>String</td>
<td>This is the user's password.</td>
</tr>
<tr>
<td>requirePasswordChange</td>
<td>Boolean</td>
<td>This is optional, with a default of true. If this is true, (i) the user will be forced to change their password when they log in for the first time, and (ii) until the user has changed their password, they will be forbidden from performing any other operation.</td>
</tr>
</tbody>
</table>

Exceptions:

- The username either contains characters other than the ASCII characters between ! and ~, or contains : and ..
- The username is already in use within the system.
- The password is the empty string.

Example 166. Add a user

The following example creates a user with the username 'johnsmith' and password 'h6u4%kr'. When the user 'johnsmith' logs in for the first time, he will be required to change his password.

CALL dbms.security.createUser('johnsmith', 'h6u4%kr', true)

Delete a user

The current user is able to delete permanently a user from the system.

Syntax:

CALL dbms.security.deleteUser(username)

Arguments:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>username</td>
<td>String</td>
<td>This is the username of the user to be deleted.</td>
</tr>
</tbody>
</table>
Exceptions:

The username does not exist in the system.

The username matches that of the current user (i.e. deleting the current user is not permitted).

Considerations:

Deleting a user will terminate with immediate effect all of the user’s sessions and roll back any running transactions.

As it is not possible for the current user to delete themselves, there will always be at least one user in the system.

Example 167. Delete a user

The following example deletes a user with the username ‘janebrown’.

```
CALL dbms.security.deleteUser('janebrown')
```

List all native users

The current user is able to view the details of every user in the system.

Syntax:

```
CALL dbms.security.listUsers()
```

Returns:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>username</td>
<td>String</td>
<td>This is the user’s username.</td>
</tr>
<tr>
<td>flags</td>
<td>List&lt;String&gt;</td>
<td>This is a flag indicating whether the user needs to change their password.</td>
</tr>
</tbody>
</table>

Example 168. List all users

The following example shows the username for each user in the system, and whether the user needs to change their password.

```
CALL dbms.security.listUsers()
```

```
+-----------------+------------------+
<table>
<thead>
<tr>
<th>username</th>
<th>flags</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;neo4j&quot;</td>
<td>[]</td>
</tr>
<tr>
<td>&quot;anne&quot;</td>
<td>[&quot;password_change_required&quot;]</td>
</tr>
<tr>
<td>&quot;bill&quot;</td>
<td>[]</td>
</tr>
</tbody>
</table>
+-----------------+------------------+
3 rows
```
Appendix E: Query routing decisions

This appendix describes in detail how queries are routed to databases for execution.

17.E.1. Introduction

A query that arrives at a Neo4j server, over the bolt protocol from a driver, undergoes query routing. Query routing is the process of deciding with which Cypher executor (database) and at which physical location the query should be executed.

17.E.2. Routing decision tree

Before the query is executed, these are the decisions taken during query routing:

Step 1: Determine the name of the target database

Pick the first of these that has a value:

1. Cypher USE clause
   - Note that administration commands implicitly have USE system.
2. Driver session database
3. Home or default database

Step 2: Reuse open transaction

- If there is an already open transaction to the target database, local or remote, then proceed to step 6.
- If not, then proceed to step 3.

Step 3: Determine the type of the target database (execution context type)

- If the target database is a database in this DBMS, then the context type is Internal.
- If the target database is the Fabric virtual database, then the context type is Fabric.
  - This also allows the query to target multiple databases.
- If the target database is a Fabric graph, then the context type is External.

Step 4: Determine the location of execution

- If context type is Internal, then ...
  - if the URI scheme is bolt:// (routing disabled), then location is Local.
  - if transaction mode is READ, then location is Local.
  - if transaction mode is WRITE, then ...
    - if the local member is the leader for the database, then location is Local.
    - if the another member is the leader for the database, then ...
      - if Server-side routing is enabled, then location is Remote (using the routing advertised...
address of that member).

- if not, then fail.

- If context type is Fabric, then location is Local (for this part of the query).

- If context type is External, then location is Remote (using the URI and database given in the configuration).

Step 5: Open a transaction

- If location is Local, then open a transaction to the database on this member.

- If location is Remote, then open a driver transaction to the database using the URI determined in step 4.

Step 6: Execute query

- Execute the query in the open transaction.

17.E.3. Illustrated routing decision tree
Figure 52. Illustrated routing decision tree
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