DataStax Enterprise 4.7

Documentation

July 10, 2015

Contents

About DataStax Enterprise

DataStax Enterprise delivers Apache Cassandra™ in a database platform that meets the performance and availability demands of Internet-of-Things (IoT), Web, and Mobile applications. It provides enterprises a secure, fast, always-on database that remains operationally simple when scaled in a single data center or across multiple data centers and clouds.

DataStax Enterprise delivers Apache Cassandra™ in a database platform that meets the performance and availability demands of Internet-of-Things (IoT), Web, and Mobile applications. It provides enterprises a secure, fast, always-on database that remains operationally simple when scaled in a single data center or across multiple data centers and clouds.

DataStax Enterprise 4.7 new features

DataStax Enterprise 4.7 introduces a number of new features and enhancements:

DataStax Enterprise	A production-ready version of Cassandra 2.1 built for enterprise deployments, which has been certified and optimized by DataStax for maximum performance and uptime. Support for Oracle Java SE Runtime Environment (JRE) 8 and OpenJDK 7.
DSE Analytics	Automatic high availability for Spark analytics. Support for Spark MLlib common machine learning (ML) functionality. Integrate Spark SQL with JDBC (thriftserver). Production certification of Spark 1.2.
DSE Search	Live indexing increases indexing throughput, enables queries to be made against recently indexed data, reduces latency, and works with all Solr functionality. Fault tolerant, adaptive, distributed search: queries can transparently handle up to RF-1 node failures, and adapt themselves to changes in data consistency and cluster health. DSE Analytics and Search integration allows analytics jobs to be performed using search queries. This provides finer-grained queries of analytics workloads and better performance. Improved paging (cursors) support. Production certification of Solr 4.10.
DSE Advanced Security	Off-server encryption key management using KMIP (Key Management Interoperability Protocol).
DSE Management Services	Support for incremental repair in the OpsCenter Repair Service and the Cassandra nodetool. A faster and less intensive Repair Service improves maintenance of cluster data consistency. Support for Spark performance objects in the Performance Service.
DSE In-Memory	DSE In-Memory improvements expand the amount of data that can be maintained in memory and allow faster read operations on larger volumes of transactional data.

For details, see the DataStax Enterprise 4.7 release notes.

DataStax Sandbox

DataStax Enterprise Sandbox is a packaged and personal virtual machine (VM) image that contains everything you need to get started with DataStax Software. DataStax Sandbox provides an easy way to get up to speed quickly on NoSQL, and learn how to use DataStax Enterprise and its visual management and query tools in the shortest time possible.

Upgrading DataStax Enterprise

See the DataStax Upgrade Guide.

See Upgrading Datastax Enterprise in the *DataStax Upgrade Guide*.

Installing DataStax Enterprise

DataStax Enterprise installation methods include GUI or text mode, unattended command line or properties file, YUM and APT repository, and binary tarball.

DataStax Enterprise installation methods include GUI or text mode, unattended command line or properties file, YUM and APT repository, and binary tarball. If you are new to DataStax Enterprise, use the DataStax Enterprise Essentials installation instructions to install a single node for evaluation.

Installing DataStax Enterprise using GUI or Text mode

DataStax Enterprise production installation or upgrade on any Linux-based platform using a graphical or text interface.

About this task

For a complete list of supported platforms, see DataStax Enterprise Supported Platforms. For other product installations, see Installing OpsCenter and Installing DevCenter.

Before you begin

- Root or sudo access when installing as a system service, or if installing missing system dependencies.
- Latest version of Oracle Java SE Runtime Environment 7 or 8 or OpenJDK 7 is recommended.

  Note: If using Oracle Java 7, you must use at least 1.7.0_25. If using Oracle Java 8, you must use at least 1.8.0_40.
- RedHat-compatible distributions require EPEL (Extra Packages for Enterprise Linux). For RHEL 5.x, see Installing EPEL on RHEL OS 5.x.
- If installing on a 64-bit Oracle Linux distribution, first install the 32-bit versions of glibc libraries.

Also see Recommended production settings and the DataStax Enterprise Reference Architecture white paper.

Table 1: Hardware requirements

Requirement	Minimum	Production
CPUs	2	16
Memory	8GB	24GB
Data directory	20GB	200GB
Commit log directory	20GB	200GB
Saved caches directory	20GB	200GB
Logs directory	20GB	200GB

For a complete list of supported platforms, see DataStax Enterprise Supported Platforms.

About the installer

The location of the cassandra.yaml file depends on the type of installation:

Package installations	`/etc/cassandra/cassandra.yaml`

Tarball installations	`*install_location*/resources/cassandra/conf/cassandra.yaml`

The location of the dse.yaml file depends on the type of installation:

Installer-Services	`/etc/dse/dse.yaml`
Package installations	`/etc/dse/dse.yaml`
Installer-No Services	*install_location*`/resources/dse/conf/dse.yaml`
Tarball installations	*install_location*`/resources/dse/conf/dse.yaml`

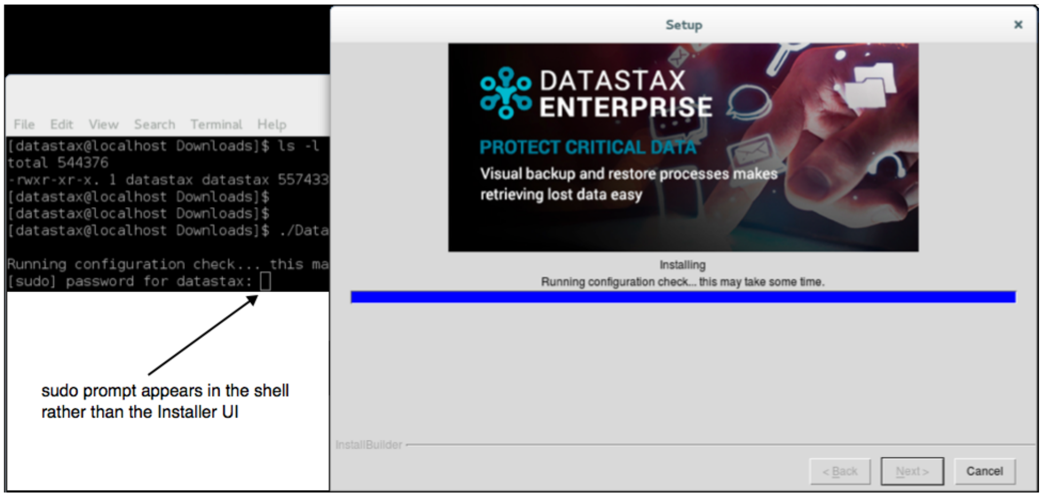
The installer installs DataStax Enterprise and the DataStax Agent. It does not install OpsCenter or DevCenter. The installer sets some but not all cassandra.yaml parameters described in the table below. It does not set dse.yaml properties. You can set the remaining parameters in the following ways:

- Manually after installation.
- Use the unattended install with either command line or the property file options. These options allow you to specify pre-configured `cassandra.yaml` and `dse.yaml` files using `--cassandra_yaml_template filename` and `--dse_yaml_template filename`.

Installing under a user account

- Root or sudo access allows the installer to set up support services on operating systems that support services, such as Debian-based or RHEL-based systems.
- Without root or sudo access, the installer cannot set up support services because it does not have permission to create the services files.

In GUI mode, if gksudo or pkexec, are not installed, the installer may not present a GUI sudo prompt. Subsequently the sudo prompt appears in the shell:



```
[datastax@localhost Downloads]$ ls -l
total 544376
-rwxr-xr-x. 1 datastax datastax 557433
[datastax@localhost Downloads]$
[datastax@localhost Downloads]$
[datastax@localhost Downloads]$ ./Data

Running configuration check... this ma
[sudo] password for datastax: 
```

sudo prompt appears in the shell rather than the Installer UI

Installing
Running configuration check... this may take some time.

File Edit View Search Terminal Help
Setup
DATASTAX ENTERPRISE
PROTECT CRITICAL DATA
Visual backup and restore processes makes retrieving lost data easy
InstallBuilder
< Back
Next >
Cancel

Procedure

Important: DataStax Enterprise 4.7 uses Cassandra 2.1.

1. Download the installer for your computer from the DataStax download page.
   - Linux 64 - `DataStaxEnterprise-4.7.x-linux-x64-installer.run`
   - Mac OS X (Non-production installations only.) See the instructions for installing Mac OS X in Cassandra & DataStax Enterprise Essentials.

2. From the directory where you downloaded the install file, change the permission to executable:

```
$ chmod +x DataStaxEnterprise-4.7.x-linux-x64-installer.run
```

3. To view the installer help:

```
$ ./DataStaxEnterprise-4.7.x-linux-x64-installer.run --help
```

4. Start the installation:

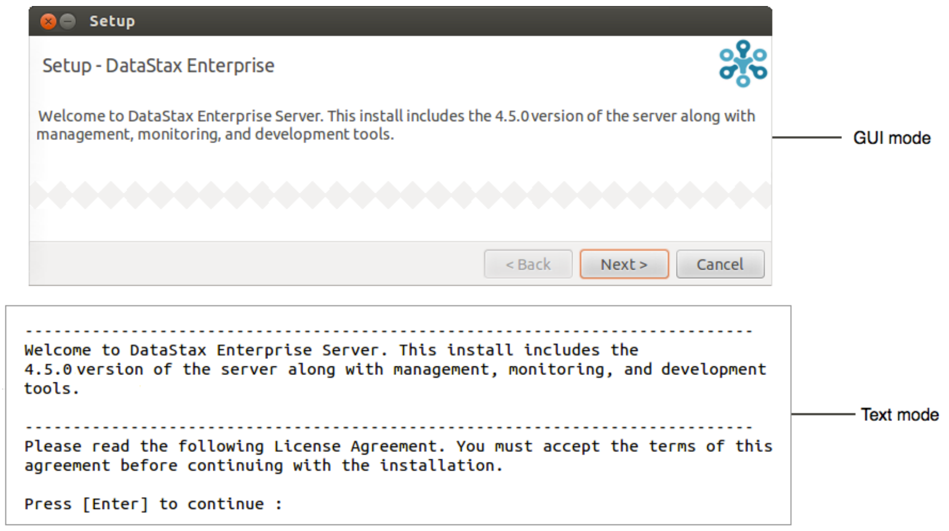
```
$ sudo ./DataStaxEnterprise-4.7.x-linux-x64-installer.run             ##
 Install in GUI mode.
$ sudo ./DataStaxEnterprise-4.7.x-linux-x64-installer.run --mode text ##
 Install in Text mode.
```

Using the install command to set configuration parameters:

To add configuration parameters to the installation, use the installer options described in Installer - unattended. For example:

```
$ sudo ./DataStaxEnterprise-4.7.x-linux-x64-installer.run --prefix /usr/
local/dse --enable_vnodes 0 ## Command line option.
$ sudo ./DataStaxEnterprise-4.7.x-linux-x64-installer.run --optionfile ../
datastax/DC4-analytics.prop ## Property file option.
```

The installer launches.



Welcome to DataStax Enterprise Server. This install includes the 4.5.0 version of the server along with management, monitoring, and development tools.

```
----------------------------------------------------------------------------
Welcome to DataStax Enterprise Server. This install includes the
4.5.0 version of the server along with management, monitoring, and development
tools.

----------------------------------------------------------------------------
Please read the following License Agreement. You must accept the terms of this
agreement before continuing with the installation.

Press [Enter] to continue :
```

5. Follow the instructions in the setup wizard using the following table for guidance:

Screen - Panel	Recommendations and additional information
Setup	Welcome page.
License Agreement	DataStax Enterprise End User License Agreement
Install Options	
Server Installation Directory	If you use the No Services option, you can change the location of the dse directory. If you install as a service, DataStax Enterprise can only be installed in the `/usr/share/dse` directory.
Install Type	Use **Simple Install** for default path names and options. **Advanced Install** allows you to configure additional parameters, including: • Enable/disable virtual nodes (vnodes).

Screen - Panel	Recommendations and additional information
	• Service users and group name for non-root users. • Listen and RPC addresses. • Directory locations. • Storage, SSL Storage, and RPC ports.
Update System	Updates some system packages and dependencies. Does not upgrade or install major components such as Java. Set to **Yes** when run as root user, otherwise set to **No**.
Default Interface	Network interface for the DataStax Enterprise server.
Service Setup	**No Services -** installs the DataStax Enterprise server as a stand-alone process. **Services Only -** installs the DataStax Enterprise server as a service running in the background. **Services and Utilities** (Linux only) - installs the DataStax Enterprise server as a service running in the background and Cassandra utilities, such as cqlsh, sstableloader, sstablescrub, and sstableupgrade to the system path.
Start Services After Install	Select **Yes** to start all services when the installation is complete, or select **No** when additional configuration is needed after installation.
Installation Directories (Advanced installation only)	
Agent Installation Directory	For more information about the Agent, see the DataStax Agent configuration documentation.
Node Setup	
Node Type	The following types of nodes are available: • Cassandra node Transactional and Bring your own Hadoop (BYOH) nodes. • Search node DSE search (Solr) nodes. • Analytics node Spark Only and Spark + Integrated Hadoop (DSE Hadoop) nodes.
Ring Name	Name of the cluster.
Seeds	Cassandra nodes use the seed node list for finding each other and learning the topology of the ring. **Do not make all nodes seed nodes.** See the following: • Internode communications (gossip) • Initializing a multiple node cluster (single data centers) • Initializing a multiple node cluster (multiple data centers)
User Setup (Advanced installation only)	
OS User ID for Service	When starting DataStax Enterprise as a service, the Cassandra and Hadoop tracker services run as this user and group. The service initialization script is located in `/etc/init.d/dse`. Run levels are not set by the package.
OS User Group for Service	
Ring Options (Advanced installation only)	

Screen - Panel	Recommendations and additional information
Enable Vnodes	Enable or disable Virtual nodes.
Listen Address	cassandra.yaml parameter: listen_address
RPC Address	cassandra.yaml parameter: rpc_address
Directory Locations	
Data Directory	cassandra.yaml parameter: data_file_directories
Commitlog Directory	cassandra.yaml parameter: commitlog_directory
Saved Caches Directory	cassandra.yaml parameter: saved_caches_directory
Logs Directory	Log data.
Ports (Advanced installation only)	
Storage Port	cassandra.yaml parameter: storage_port
SSL Storage Port	cassandra.yaml parameter: ssl_storage_port
RPC Port	cassandra.yaml parameter: rpc_port
Setup	
DataStax Agent	The network address of the OpsCenter. The agent provides an interface between DataStax OpsCenter and DataStax Enterprise.
System Configuration	Configuration overview and warnings about potential issues.
Ready to Install	The install wizard installs the software.
Setup finish	Post-installation tasks. View Configuration Recommendations And Warnings opens the Pre-flight check results.

Results

DataStax Enterprise is ready to start or for additional configuration.

The following table shows the location of the installer logs:

Directories	Description
`/usr/share/dse/backups/`*`log_file_dir`*`/copied_config_files.log`	Show Config File Overwrites
`/usr/share/dse/backups/`*`log_file_dir`*`/bitrock_installer.log`	View Installation Log
`/usr/share/dse/backups/`*`log_file_dir`*`/install_dependencies.log`	View Dependency Installation Log
`/usr/share/dse/backups/pfc_results.txt`	View Configuration Recommendations and Warnings (Preflight Check Results)
`/usr/share/dse`	View README
`/usr/share/dse`	Uninstall DataStax Enterprise

What to do next

- Deploying DataStax Enterprise for production.
- Selecting hardware for enterprise implementations.
- Configuring the heap dump directory to avoid server crashes.
- Configuration file locations.
- Starting and stopping DataStax Enterprise.

Unattended DataStax Enterprise installer

Install DataStax Enterprise using the command line or properties file.

About this task

For a complete list of supported platforms, see DataStax Enterprise Supported Platforms. For other product installations, see Installing OpsCenter and Installing DevCenter.

Before you begin

- Root or sudo access when installing as a system service, or if installing missing system dependencies.
- Latest version of Oracle Java SE Runtime Environment 7 or 8 or OpenJDK 7 is recommended.

  Note: If using Oracle Java 7, you must use at least 1.7.0_25. If using Oracle Java 8, you must use at least 1.8.0_40.
- RedHat-compatible distributions require EPEL (Extra Packages for Enterprise Linux). For RHEL 5.x, see Installing EPEL on RHEL OS 5.x.
- If installing on a 64-bit Oracle Linux distribution, first install the 32-bit versions of glibc libraries.

Also see Recommended production settings and the DataStax Enterprise Reference Architecture white paper.

Table 2: Hardware requirements

Requirement	Minimum	Production
CPUs	2	16
Memory	8GB	24GB
Data directory	20GB	200GB
Commit log directory	20GB	200GB
Saved caches directory	20GB	200GB
Logs directory	20GB	200GB

Procedure

Important: DataStax Enterprise 4.7 uses Cassandra 2.1.

1. Download the installer for your computer from the DataStax download page.
   - Linux 64 - `DataStaxEnterprise-4.7.x-linux-x64-installer.run`
   - Mac OS X (Non-production installations only.) See the instructions for installing Mac OS X in Cassandra & DataStax Enterprise Essentials.
2. Change the permission on the file to executable:

```
$ chmod +x DataStaxEnterprise-4.7.x-linux-x64-installer.run
```

3. You can either use the command line or a properties file.

   Command line installation:

   ```
   $ sudo ./DataStaxEnterprise-4.7.x-linux-x64-installer.run --option argument
    --option argument ... --option argument --mode unattended
   ```

   For available options, see the table below. Be sure to add "--" to the option. For example:

   ```
   $ sudo ./DataStaxEnterprise-4.7.x-linux-x64-installer.run --prefix /usr/
   local/dse --enable-components dse,datastax_agent --enable_vnodes 0 --mode
    unattended --prefix /usr/local/dse
   ```

   The installer uses the default value for any --option that is not specified.

   Properties file installation:

   ```
   $ sudo ./DataStaxEnterprise-4.7.x-linux-x64-installer.run --
   optionfile option_file_name --mode unattended
   ```

   where *option_file_name* is the name of the file containing the installation options. For example:

   ```
   $ sudo ./DataStaxEnterprise-4.7.x-linux-x64-installer.run --optionfile ../
   datastax/DC4-analytics.prop --mode unattended
   ```

   Property file format: option=*argument*. For example:

   ```
    enable-components=dse,datastax_agent
    install_type=simple
    update_system=1
   ```

   The property file options are the same as the command line options (without the --).

   Note: You can download a sample_install.prop file from the DataStax Enterprise download page.

Table 3: Unattended install options

Option	Argument	Description
Install options		
prefix	*install_directory*	Install location. Default: `/usr/local/dse`
enable-components	Comma separated list of components: • *dse* • *datastax_agent*	Components to install. Default: *dse,datastax_agent*
cassandra_yaml_template	*file name*	Use this cassandra.yaml file as the template for the node's `cassandra.yaml` file.
dse_yaml_template	*file name*	Use this dse.yaml file as the template

Option	Argument	Description
		for the node's `dse.yaml` file.
cassandra_logs_dir	*directory*	Directory for log files.
do_drain	*0* (no) or *1* (yes)	Drain the node before installing. Default: *1*
install_type	*simple* or *advanced*	Default: *simple*
system_install	Use one of the following: • *no_services* • *services_only* • *services_and_utilities*	Install system services. Default: *services_and_utilities* for root user, *no_services* for others.
update_system	*0* (no) or *1* (yes)	Upgrade any missing system files. Does not upgrade or install major components such as Oracle Java. Default: *1* for root user, *0* for others.
installdir_agent	*directory*	Directory where agent is installed.
node_type	Use one of the following: • *cassandra* • *analytics* • *search*	Type of node. Default: *cassandra*. • Cassandra node Transactional and Bring your own Hadoop (BYOH) nodes. • Search node DSE search (Solr) nodes. • Analytics node Spark Only and Spark + Integrated Hadoop (DSE

Option	Argument	Description
		Hadoop) nodes.
analytics_type	Use one of the following: • *spark_only* • *spark_integrated*	Type of analytics node. • *spark_only* - only enable Spark. • *spark_integrated*- enable Spark + Integrated Hadoop (DSE Hadoop).
cassandra_user	*user name*	User name for running service. Start-up scripts are provided in `/etc/init.d`.
cassandra_group	*group name*	Group name for running service. Start-up scripts are provided in `/etc/init.d`.
start_services	*0* (no) or *1* (yes)	Start services. Default: *1*.
OpsCenter options		
opscenter_address	*IP address*	Address for the OpsCenter server.
cassandra.yaml options (These values override options set in the `cassandra.yaml` template file. See the cassandra_yaml_template above.)		
ring_name	*name*	Name of ring.
enable_vnodes	*0* (no) or *1* (yes)	Enable or disable virtual nodes (vnodes). Default: *1* for Cassandra nodes, *0* for others.
seeds	Comma separated list of seed *IP addresses***Do not make all nodes seed nodes.** See Internode communications (gossip).	Seed list for this node.
interface	*IP address*	Default interface to use for listening on all services.
listen_address	*IP address*	listen_address

Option	Argument	Description
rpc_address	*IP address*	rpc_address
cassandra_data_dir	*directory*	data_file_directories
cassandra_commitlog_dir	*directory*	commitlog_dir
cassandra_saved_caches_dir	*directory*	saved_caches_directory
rpc_port	*port number*	rpc_port
storage_port	*port number*	storage_port
ssl_storage_port	*port number*	ssl_storage_port

The location of the dse.yaml file depends on the type of installation:

Installer-Services	`/etc/dse/dse.yaml`
Package installations	`/etc/dse/dse.yaml`
Installer-No Services	`install_location/resources/dse/conf/dse.yaml`
Tarball installations	`install_location/resources/dse/conf/dse.yaml`

The location of the cassandra.yaml file depends on the type of installation:

Package installations	`/etc/cassandra/cassandra.yaml`
Tarball installations	`install_location/resources/cassandra/conf/cassandra.yaml`

Results

DataStax Enterprise is ready to start or for additional configuration.

The following table shows the location of the installer logs:

Directories	Description
`/usr/share/dse/backups/log_file_dir/copied_config_files.log`	Show Config File Overwrites
`/usr/share/dse/backups/log_file_dir/bitrock_installer.log`	View Installation Log
`/usr/share/dse/backups/log_file_dir/install_dependencies.log`	View Dependency Installation Log
`/usr/share/dse/backups/pfc_results.txt`	View Configuration Recommendations and Warnings (Preflight Check Results)
`/usr/share/dse`	View README
`/usr/share/dse`	Uninstall DataStax Enterprise

What to do next

- Deploying DataStax Enterprise for production.
- Selecting hardware for enterprise implementations.

- Configuring the heap dump directory to avoid server crashes.
- Configuration file locations.
- Starting and stopping DataStax Enterprise.

Other install methods

Installation using YUM or APT packages or binary tarball.

Installing DataStax Enterprise using Yum repositories

Install DataStax Enterprise, DataStax Agent, and OpsCenter using Yum repositories on RHEL-based systems.

Note: To install on SUSE, use the GUI installer or the binary tarball installation.

For a complete list of supported platforms, see DataStax Enterprise Supported Platforms.

To install earlier versions, see Installing earlier versions.

Before you begin

- Yum Package Management application.
- Root or sudo access to the install machine.
- Latest version of Oracle Java SE Runtime Environment 7 or 8 or OpenJDK 7 is recommended.

  Note: If using Oracle Java 7, you must use at least 1.7.0_25. If using Oracle Java 8, you must use at least 1.8.0_40.
- RedHat-compatible distributions require EPEL (Extra Packages for Enterprise Linux). For RHEL 5.x, see Installing EPEL on RHEL OS 5.x.
- If installing on a 64-bit Oracle Linux distribution, first install the 32-bit versions of glibc libraries.

Also see Recommended production settings and the DataStax Enterprise Reference Architecture white paper.

Note: JNA (Java Native Access) is automatically installed.

About this task

The packaged releases create a `cassandra` user. When starting DataStax Enterprise as a service, the Cassandra and Hadoop tracker services run as this user. The service initialization script is located in `/etc/init.d/dse`. Run levels are not set by the package.

Procedure

These steps install DataStax Enterprise, the DataStax Agent, and OpsCenter (optional). After installing, you must configure and start DataStax Enterprise.

Important: DataStax Enterprise 4.7 uses Cassandra 2.1.

In a terminal window:

1. Verify that a required version of Java is installed:

   ```
   $ java -version
   ```

   If not Oracle Java 7, Oracle Java 8, or OpenJDK 7, see Installing the Oracle JRE or the OpenJDK documentation.

   Important: Package management tools do not install Oracle Java.
2. Make sure that the EPEL is installed. See Installing EPEL on RHEL OS 5.x.

3. Add the DataStax Yum repository to a file called `/etc/yum.repos.d/datastax.repo`

   ```
   [datastax]
   name = DataStax Repo for DataStax Enterprise
   baseurl=http://username:password@rpm.datastax.com/enterprise
   enabled=1
   gpgcheck=0
   ```

   where *username* and *password* are the DataStax account credentials from your registration confirmation email.
4. Install either package:
   - `$ sudo yum install dse-full` (Use for all product levels.)
   - `$ sudo yum install dse-full opscenter` (Also installs OpsCenter.)

   For production installations, DataStax recommends installing the OpsCenter separate from the cluster. See the OpsCenter documentation.

   Removing the datastax-agent package also removes the DataStax Enterprise package.

Results

DataStax Enterprise is ready for configuration.

What to do next

- Deploying DataStax Enterprise for production.
- Selecting hardware for enterprise implementations.
- Configuring the heap dump directory to avoid server crashes.
- Configuration file locations.
- Starting and stopping DataStax Enterprise.

Installing DataStax Enterprise using APT repositories

Install DataStax Enterprise, DataStax Agent, and OpsCenter using APT repositories on Debian-based systems.

For a complete list of supported platforms, see DataStax Enterprise Supported Platforms.

Before you begin

- Aptitude Package Management (APT) application.
- Root or sudo access to the install machine.
- Latest version of Oracle Java SE Runtime Environment 7 or 8 or OpenJDK 7 is recommended.

  Note: If using Oracle Java 7, you must use at least 1.7.0_25. If using Oracle Java 8, you must use at least 1.8.0_40.
- Python 2.6+ (if installing OpsCenter).

Also see Recommended production settings and the DataStax Enterprise Reference Architecture white paper.

Note: JNA (Java Native Access) is automatically installed.

About this task

The packaged releases create a `cassandra` user. When starting DataStax Enterprise as a service, the Cassandra and Hadoop tracker services run as this user. The service initialization script is located in `/etc/init.d/dse`. Run levels are not set by the package.

Procedure

These steps install DataStax Enterprise, the DataStax Agent, and OpsCenter (optional). After installing, you must configure and start DataStax Enterprise.

Important: DataStax Enterprise 4.7 uses Cassandra 2.1.

In a terminal window:

1. Verify that a required version of Java is installed:

   ```
   $ java -version
   ```

   If not Oracle Java 7, Oracle Java 8, or OpenJDK 7, see Installing the Oracle JRE or the OpenJDK documentation.

   Important: Package management tools do not install Oracle Java.
2. Add a DataStax repository file called `/etc/apt/sources.list.d/datastax.sources.list`:

   ```
   $ echo "deb http://username:password@debian.datastax.com/enterprise stable
    main" | sudo tee -a /etc/apt/sources.list.d/datastax.sources.list
   ```

   where *username* and *password* are the DataStax account credentials from your registration confirmation email.
3. Add the DataStax repository key:

   ```
   $ curl -L https://debian.datastax.com/debian/repo_key | sudo apt-key add -
   ```

   Note: If you have trouble adding the key, use `http` instead of `https`.
4. Install the packages:

   a) `$ sudo apt-get update`

   b) Install either package:

   - `$ sudo apt-get install dse-full` (Use for all product levels.)
   - `$ sudo apt-get install dse-full opscenter` (Also installs OpsCenter.)

   For production installations, DataStax recommends installing the OpsCenter separate from the cluster. See the OpsCenter documentation.

   Removing the datastax-agent package also removes the DataStax Enterprise package.

Results

DataStax Enterprise is ready for configuration.

What to do next

- Deploying DataStax Enterprise for production.
- Selecting hardware for enterprise implementations.
- Configuring the heap dump directory to avoid server crashes.
- Configuration file locations.
- Starting and stopping DataStax Enterprise.

Installing DataStax Enterprise using the binary tarball

Install DataStax Enterprise on any Linux-based platform.

About this task

For a complete list of supported platforms, see DataStax Enterprise Supported Platforms.

Before you begin

- All Linux platforms:
  - Latest version of Oracle Java SE Runtime Environment 7 or 8 or OpenJDK 7 is recommended.

    Note: If using Oracle Java 7, you must use at least 1.7.0_25. If using Oracle Java 8, you must use at least 1.8.0_40.
- RedHat-compatible distributions:
  - If installing on a 64-bit Oracle Linux distribution, first install the 32-bit versions of glibc libraries.
  - If you are using an earlier RHEL-based Linux distribution, such as CentOS-5, you might need to replace the Snappy compression/decompression library; see the DataStax Enterprise 4.5.0 Release Notes.
  - Before installing, make sure EPEL (Extra Packages for Enterprise Linux) is installed. See Installing EPEL on RHEL OS 5.x.

Also see Recommended production settings and the DataStax Enterprise Reference Architecture white paper.

About this task

The binary tarball runs as a stand-alone process.

Procedure

These steps install DataStax Enterprise, the DataStax Agent, and OpsCenter (optional). After installing, you must configure and start DataStax Enterprise.

Important: DataStax Enterprise 4.7 uses Cassandra 2.1.

In a terminal window:

1. Verify that a required version of Java is installed:

   ```
   $ java -version
   ```

   If not Oracle Java 7, Oracle Java 8, or OpenJDK 7, see Installing the Oracle JRE or the OpenJDK documentation.

   Important: Package management tools do not install Oracle Java.
2. Download and extract the DataStax Enterprise tarball using the *username* and *password* from your DataStax registration confirmation email.

   ```
   $ curl --user username:password -L http://downloads.datastax.com/enterprise/
   dse.tar.gz | tar xz
   ```

   Caution: If you choose to run the above command, your password will be retained in the shell history. To avoid this DataStax recommends using curl with the --netrc or --netrc-file option. Alternately, download the tarball from DataStax downloads.

   where *username* and *password* are the DataStax account credentials from your registration confirmation email.

   The files are downloaded and extracted into the `dse-4.7.x` directory.
3. Download and extract the OpsCenter tarball:

   ```
   $ curl -L http://downloads.datastax.com/community/opscenter.tar.gz | tar xz
   ```

   For production installations, DataStax recommends installing the OpsCenter separate from the cluster. See the OpsCenter documentation.

4. If you do not have root access to the default directories locations, you can define your own directory locations as described in the following steps or change the ownership of the directories:

   - `/var/lib/cassandra`
   - `/var/log/cassandra`
   - `/var/lib/spark`
   - `/var/log/spark`

   ```
   $ sudo mkdir -p /var/lib/cassandra; sudo chown -R  $USER: $GROUP /var/lib/
   cassandra
   $ sudo mkdir -p /var/log/cassandra; sudo chown -R  $USER: $GROUP /var/log/
   cassandra
   $ sudo mkdir -p /var/lib/spark; sudo chown -R  $USER: $GROUP /var/lib/spark
   $ sudo mkdir -p /var/log/spark; sudo chown -R  $USER: $GROUP /var/log/spark
   ```
5. (Optional) If you do not want to use the default data and logging directories, you can define your own directory locations:

   a) Make the directories for data and logging directories:

   ```
   $ mkdir install_location/dse-data
   $ cd dse-data
   $ mkdir commitlog
   $ mkdir saved_caches
   ```
   b) Go the directory containing the cassandra.yaml file:

   ```
   $ cd install_location/resources/cassandra/conf
   ```
   c) Edit the following lines in the `cassandra.yaml` file:

   The location of the cassandra.yaml file depends on the type of installation:

Package installations	`/etc/cassandra/cassandra.yaml`
Tarball installations	*`install_location`*`/resources/cassandra/conf/cassandra.yaml`

   ```
   data_file_directories: install_location/dse-data
   commitlog_directory: install_location/dse-data/commitlog
   saved_caches_directory: install_location/dse-data/saved_caches
   ```

6. (Optional) If you do not want to use the default Spark directories, you can define your own directory locations:

   a) Make the directories for the Spark `lib` and `log` directories.

   b) Edit the spark-env.sh file to match the locations of your Spark `lib` and `log` directories, as described in Configuring Spark nodes.

   The default location of the `spark-env.sh` file depends on the type of installation:

Installer-Services and Package installations	`/etc/dse/spark/spark-env.sh`
Installer-No Services and Tarball installations	*`install_location`*`/resources/spark/conf/spark-env.sh`

Results

DataStax Enterprise is ready for configuration.

What to do next

- Deploying DataStax Enterprise for production.

- Selecting hardware for enterprise implementations.
- Configuring the heap dump directory to avoid server crashes.
- Configuration file locations.
- Starting and stopping DataStax Enterprise.

Installing on cloud providers

Installation on Amazon EC2, CenturyLink, GoGrid, HP cloud, or Microsoft Azure.

Installing a DataStax Enterprise cluster on Amazon EC2

Installing a DataStax Enterprise cluster on Amazon EC2.

About this task

This is a step-by-step guide to using the Amazon Web Services EC2 Management Console to set up a DataStax Enterprise cluster using the DataStax AMI (Amazon Machine Image). Installing via the AMI allows you to quickly deploy a cluster with a pre-configured mixed workload. When you launch the AMI, you can specify the total number of nodes in your cluster and how many nodes should be Real-Time/ Transactional (Cassandra), Analytics (Hadoop), or Search (Solr).

You can also launch a single node using the DataStax AMI and then create the cluster from OpsCenter.

Note: Because Amazon changes the EC2 console intermittently, there may be some differences in screens. For details on each step, read the User guide in the *Amazon Elastic Compute Cloud Documentation*.

For information about upgrading or expanding an existing installation, see Upgrading the DataStax AMI or Expanding a DataStax AMI cluster.

The DataStax AMI does the following:

- Installs the latest version of DataStax Enterprise with an Ubuntu 12.04 LTS (Precise Pangolin), image (Ubuntu Cloud 20140227 release), Kernel 3.8+.
- Installs Oracle Java 7.
- Install metrics tools such as dstat, ethtool, make, gcc, and s3cmd.
- Uses RAID0 ephemeral disks for data storage and commit logs.
- Choice of PV (Para-virtualization) or HVM (Hardware-assisted Virtual Machine) instance types.
- Launches EBS-backed instances for faster start-up, **not** database storage.
- Uses the private interface for intra-cluster communication.
- Starts the nodes in the specified mode (Real-time, Analytics, or Search).
- Sets the seed nodes cluster-wide.
- Installs the DataStax OpsCenter on the first node in the cluster (by default).

Note: The DataStax AMI does not install DataStax Enterprise nodes with virtual nodes enabled.

EC2 clusters spanning multiple regions and availability zones

The DataStax AMI is intended for a single region and availability zone. When creating an EC2 cluster that spans multiple regions and availability zones, use OpsCenter to set up your cluster. You can use any of the supported platforms. It is best practice to use the same platform on all nodes. If your cluster was instantiated using the DataStax AMI, use Ubuntu for the additional nodes. The following topics describe OpsCenter provisioning:

- Provisioning a new cluster
- Adding an existing cluster
- Adding nodes to a cluster

Production considerations

For production Cassandra clusters on EC2, use Large or Extra Large instances with local storage. RAID0 the ephemeral disks, and put both the data directory and the commit log on that volume. This has proved to be better in practice than putting the commit log on the root volume (which is also a shared resource). For more data redundancy, consider deploying your Cassandra cluster across multiple availability zones or using OpsCenter to backup to S3. Also see Production deployment planning.

Note: Hadoop and DSE Search nodes require their own nodes/disks and have specific hardware requirements. See Capacity Planning in the *DataStax Enterprise Reference Architecture* and the Hadoop and Solr documentation.

What to do next

Create an EC2 security group

Creating an EC2 security group

An EC2 Security Group acts as a firewall for designation which protocols and ports are open in your cluster.

About this task

An EC2 Security Group acts as a firewall that allows you to choose which protocols and ports are open in your cluster. You must specify a security group in the same region as your instances.

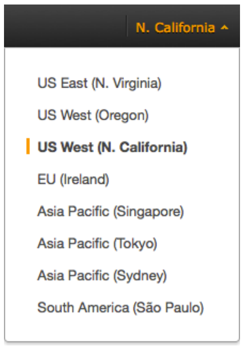
You can specify the protocols and ports either by a range of IP addresses or by security group. To protect your cluster, you should define a security group. Be aware that specifying a Source IP of 0.0.0.0/0 allows every IP address access by the specified protocol and port range.

Procedure

If you need more help, click an informational icon or a link to the *Amazon EC2 User Guide*.

1. Sign in to the AWS console.
2. From the Amazon EC2 console navigation bar, select the same region as where you will launch the DataStax Community AMI.

   Step 1 in Launch the AMI provides a list of the available regions.

3. Open the **Security Groups** page.
4. Create a security group with a name and description of your choice, then save it. It is recommended that you include the region name in the description.

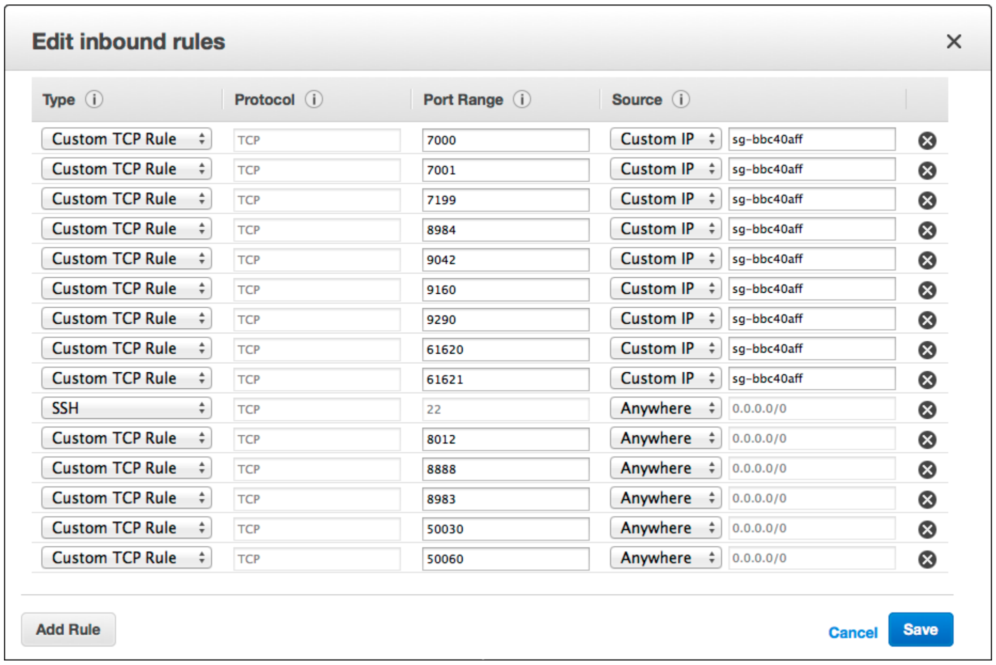
   Note: Creating and saving the securing group allows you to create rules based on the group. After the security group is saved it is available in the **Source** field drop-list.
5. Create rules for the security group using the following table:

Table 4: Ports

Port number	Type	Protocol	Source	Description
For detailed information about ports, see Configuring firewall port access.				
Public facing				
22	SSH	TCP	0.0.0.0/0	SSH (default)
DataStax Enterprise public ports				
4040	Custom TCP Rule	TCP	0.0.0.0/0	Spark application web site port.
7080	Custom TCP Rule	TCP	0.0.0.0/0	Spark Master web site port.
7081	Custom TCP Rule	TCP	0.0.0.0/0	Spark Worker web site port.
8983	Custom TCP Rule	TCP	0.0.0.0/0	Solr port and Demo applications web site port (Portfolio, Search, Search log, Weather Sensors)
8012	Custom TCP Rule	TCP	0.0.0.0/0	Hadoop Job Tracker client port. The Job Tracker listens on this port for job submissions and communications from Task Trackers; allows traffic from each analytics node in a cluster.
8983	Custom TCP Rule	TCP	0.0.0.0/0	Solr port and Demo applications web site port (Portfolio, Search, Search log, Weather Sensors)
50030	Custom TCP Rule	TCP	0.0.0.0/0	Hadoop Job Tracker web site port. The Job Tracker listens on this port for HTTP requests. If initiated from the OpsCenter, these requests are proxied through the opscenterd daemon; otherwise, they come directly from the browser.
50060	Custom TCP Rule	TCP	0.0.0.0/0	Hadoop Task Tracker web site port. Each Task Tracker listens on this port for HTTP requests coming directly from the browser and not proxied by the opscenterd daemon.
OpsCenter public ports				
8888	Custom TCP Rule	TCP	0.0.0.0/0	OpsCenter web site port. The opscenterd daemon listens on this port for HTTP requests coming directly from the browser.
Inter-node ports				
Cassandra inter-node ports				
1024 - 65355 **Cassandra 1.2 or**	Custom TCP Rule	TCP	Your security group	JMX reconnection/loopback ports. Because JMX connects on port 7199, handshakes, and then uses any port within the 1024+ range, use SSH to execute

Port number	Type	Protocol	Source	Description
earlier only				commands remotely to connect to JMX locally or use the DataStax OpsCenter.
7000	Custom TCP Rule	TCP	Your security group	Cassandra inter-node cluster communication port.
7001	Custom TCP Rule	TCP	Your security group	Cassandra SSL inter-node cluster communication port.
7199	Custom TCP Rule	TCP	Your security group	Cassandra JMX monitoring port.
9160	Custom TCP Rule	TCP	Your security group	Cassandra client port (Thrift) port. OpsCenter agents makes Thrift requests to their local node on this port. Additionally, the port can be used by the opscenterd daemon to make Thrift requests to each node in the cluster.
DataStax Enterprise inter-node ports				
7077	Custom TCP Rule	TCP	Your security group	Spark Master inter-node communication port.
8984	Custom TCP Rule	TCP	Your security group	Solr inter-node communication port.
9042	Custom TCP Rule	TCP	Your security group	CQL native clients port.
9290	Custom TCP Rule	TCP	Your security group	Hadoop Job Tracker Thrift port. The Job Tracker listens on this port for Thrift requests coming from the opscenterd daemon.
10000	Custom TCP Rule	TCP	Your security group	Hive server port. **Note:** Use a different port if you run the Hive server and Shark server at the same time.
10000	Custom TCP Rule	TCP	Your security group	Shark server port.
OpsCenter inter-node ports				
61620	Custom TCP Rule	TCP	Your security group	OpsCenter monitoring port. The opscenterd daemon listens on this port for TCP traffic coming from the agent.
61621	Custom TCP Rule	TCP	Your security group	OpsCenter agent port. The agents listen on this port for SSL traffic initiated by OpsCenter.

The completed port rules should look similar to this:



Edit inbound rules

Type	Protocol	Port Range	Source	
Custom TCP Rule	TCP	7000	Custom IP	sg-bbc40aff
Custom TCP Rule	TCP	7001	Custom IP	sg-bbc40aff
Custom TCP Rule	TCP	7199	Custom IP	sg-bbc40aff
Custom TCP Rule	TCP	8984	Custom IP	sg-bbc40aff
Custom TCP Rule	TCP	9042	Custom IP	sg-bbc40aff
Custom TCP Rule	TCP	9160	Custom IP	sg-bbc40aff
Custom TCP Rule	TCP	9290	Custom IP	sg-bbc40aff
Custom TCP Rule	TCP	61620	Custom IP	sg-bbc40aff
Custom TCP Rule	TCP	61621	Custom IP	sg-bbc40aff
SSH	TCP	22	Anywhere	0.0.0.0/0
Custom TCP Rule	TCP	8012	Anywhere	0.0.0.0/0
Custom TCP Rule	TCP	8888	Anywhere	0.0.0.0/0
Custom TCP Rule	TCP	8983	Anywhere	0.0.0.0/0
Custom TCP Rule	TCP	50030	Anywhere	0.0.0.0/0
Custom TCP Rule	TCP	50060	Anywhere	0.0.0.0/0

Warning: The security configuration shown in this example opens up all externally accessible ports to incoming traffic from any IP address (0.0.0.0/0). The risk of data loss is high. If you desire a more secure configuration, see the Amazon EC2 help on security groups.

What to do next

Creating a key pair

Creating a key pair

Amazon EC2 uses public–key cryptography to encrypt and decrypt login information.

About this task

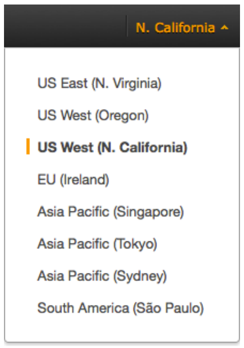
Amazon EC2 uses public–key cryptography to encrypt and decrypt login information. Public–key cryptography uses a public key to encrypt data and the recipient uses the private key to decrypt the data. The public and private keys are known as a *key pair*.

Procedure

You must create a key pair for each region you use.

1. From the Amazon EC2 console navigation bar, select the same region as where you will launch the DataStax Community AMI.

   Step 1 in Launch the AMI provides a list of the available regions.



2. Create the key pair and save it to your home directory.
3. Set the permissions of your private key file so that only you can read it.

   ```
   $ chmod 400 my-key-pair.pem
   ```

What to do next

Launch the AMI

Launching the DataStax AMI

Launching your DataStax Amazon Machine Images.

About this task

After creating the security group, you can launch your AMI instances.

Procedure

If you need more help, click an informational icon or a link to the *Amazon EC2 User Guide*.

1. Launch the AMI using the links in the following table:

   Amazon EC2 offers a number of geographic regions for launching the AMI. Factors for choosing a region include: reduce latency, cost, or regulatory requirements.

Region	AMI
HVM instances	
us-east-1	ami-ada2b6c4
us-west-1	ami-3cf7c979
us-west-2	ami-1cff962c
eu-west-1	ami-7f33cd08
ap-southeast-1	ami-b47828e6
ap-southeast-2	ami-55d54d6f
ap-northeast-1	ami-714a3770
sa-east-1	ami-1dda7800
PV instances	
us-east-1	ami-f9a2b690
us-west-1	ami-32f7c977
us-west-2	ami-16ff9626
eu-west-1	ami-8932ccfe
ap-southeast-1	ami-8c7828de
ap-southeast-2	ami-57d54d6d
ap-northeast-1	ami-6b4a376a
sa-east-1	ami-15da7808

2. In **Step 2: Choose an Instance Type**, choose the appropriate type.

   The recommended instances are:

- Development and light production: **m3.large**
- Moderate production: **m3.xlarge**
- SSD production with light data: **c3.2xlarge**
- Largest heavy production: **m3.2xlarge** (PV) or **i2.2xlarge** (HVM)
- Micro, small, and medium types are not supported.

When the instance is selected, its specifications are displayed:

Currently selected: m3.large (6.5 ECUs, 2 vCPUs, 7.5 GiB memory, 1 x 32 GiB Storage Capacity)

Because Amazon updates instance types periodically, see the following docs to help you determine your hardware and storage requirements:

- Planning an Amazon EC2 cluster
- User guide in the *Amazon Elastic Compute Cloud Documentation*
- What is the story with AWS storage.
- Get in the Ring with Cassandra and EC2.

3. In **Step 3: Configure Instance Details**, configure the instances to suit your requirements:

a) Select the number of instances.

b) Select **Launch into EC2-Classic**.

c) Open **Advanced Details**.

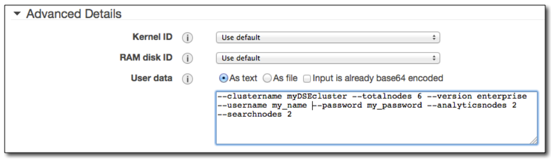
d) Add the following options (as text) to the **User Data** section, according to the type of cluster.

Option	Description
Basic AMI Switches	
--clustername *name*	Required. The name of the cluster.
--totalnodes *#_nodes*	Required. The total number of nodes in the cluster.
--version [enterprise | community]	Required. The version of the cluster. Use enterprise to install the latest version of DataStax Enterprise.
DataStax Enterprise Switches	
--username *username*	Required for DataStax Enterprise. DataStax registration username. Register at DataStax registration.
--password *password*	Required for DataStax Enterprise. DataStax registration password. Register at DataStax registration.
--analyticsnodes #*_node*	Optional for DataStax Enterprise. For mixed-workload clusters, the number of Spark nodes. Default: 0 **Note:** Uses Hadoop in versions earlier than DataStax Enterprise 4.5.
--searchnodes #*_num*	Optional for DataStax Enterprise. For mixed-workload clusters, the number of Search (Solr) nodes. Default: 0
--hadoop	Force Hadoop over Spark on analytics nodes Default: false. uses Spark on 4.5+ **Note:** Uses Spark in DataStax Enterprise 4.5 and later.
Advanced Switches	

Option	Description
--release *version*	Optional. Allows installation of a previous DataStax Enterprise version. For example, `1.0.2-1`. Default: Ignored
--cfsreplicationfactor *#_num*	Optional for DataStax Enterprise. Sets the replication factor for the CFS keyspace. This number must be less than or equal to the number of analytics nodes. Default: 1
--opscenter *Yes*	Optional. By default, DataStax OpsCenter is installed on the first instance. Specify no to disable.
--reflector *url*	Optional. Allows you to use your own reflector. Default: `http://reflector2.datastax.com/reflector2.php`

For example:

```
--clustername myDSEcluster --totalnodes 6 --version enterprise --
username my_name
--password my_password --analyticsnodes 2 --searchnodes 2
```



Kernel ID: Use default
RAM disk ID: Use default
User data: [✓ As text] As file Input is already base64 encoded

```
--clustername myDSEcluster --totalnodes 6 --version enterprise
--username my_name --password my_password --analyticsnodes 2
--searchnodes 2
```

4. Click **Next: Add Storage**, and add volumes as needed.

   The number of instance store devices available to the machine depends on the instance type. EBS volumes are **not** recommended for database storage.
5. Click **Next: Tag Instance** and give a name to your DSE instance, such as `mixed-workload-dse`.

   Tags enable you to categorize your AWS resources in different ways, such as purpose, owner, or environment.
6. Click **Next: Configure Security Group** and configure as follows:
   a) Choose **Select an existing security group**.
   b) Select the Security Group you created earlier.
   c) Click **Review and Launch**.
7. On the **Step 7: Review Instance Launch** page, make any needed changes.
8. Click **Launch** and then in the **Select an existing key pair or create a new key pair** dialog, do one of the following:
   - Select an existing key pair from the **Select a key pair** drop list.
   - If you need to create a new key pair, click **Choose an existing key pair** drop list and select **Create a new key pair**. Then create the new key pair as described in Creating a key pair.
9. Click **Launch Instances**.

   The AMI image configures your cluster and starts the Cassandra, Hadoop, Solr, and OpsCenter services. The **Launch Status** page is displayed.
10. Click **View Instances**.

What to do next

Connect to your DataStax Enterprise EC2 instance

Connecting to your DataStax Enterprise EC2 instance

Connect to your DataStax Enterprise EC2 instances from a terminal or SSH client.

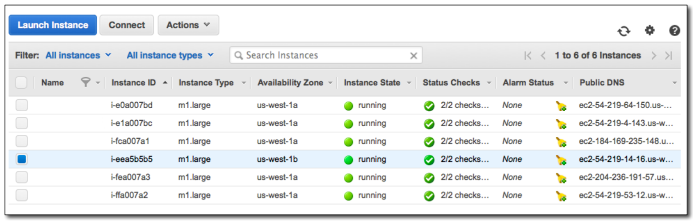
About this task

Once the cluster is launched, you can connect to it from a terminal or SSH client, such as PuTTY. Connect as user `ubuntu` rather than as `root`.

Procedure

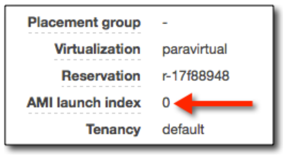
1. If necessary, from the **EC2 Dashboard**, click **Running Instances**.

   You can connect to any node in the cluster. However, one node (Node0) runs OpsCenter and is the Cassandra seed node.



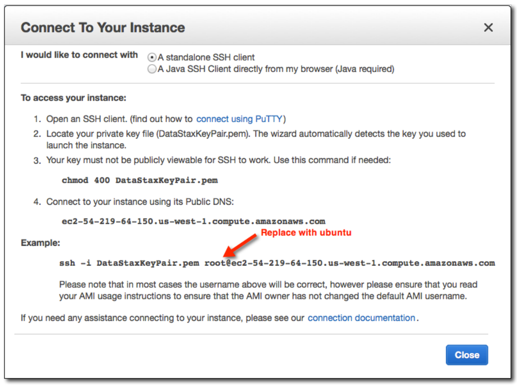
	Name	Instance ID	Instance Type	Availability Zone	Instance State	Status Checks	Alarm Status	Public DNS
☐		i-e0a007bd	m1.large	us-west-1a	running	2/2 checks...	None	ec2-54-219-64-150.us-...
☐		i-e1a007bc	m1.large	us-west-1a	running	2/2 checks...	None	ec2-54-219-4-143.us-w...
☐		i-fca007a1	m1.large	us-west-1a	running	2/2 checks...	None	ec2-184-169-235-148.u...
☑		i-eea5b5b5	m1.large	us-west-1b	running	2/2 checks...	None	ec2-54-219-14-16.us-w...
☐		i-fea007a3	m1.large	us-west-1a	running	2/2 checks...	None	ec2-204-236-191-57.us...
☐		i-ffa007a2	m1.large	us-west-1a	running	2/2 checks...	None	ec2-54-219-53-12.us-w...

2. To find which instance is Node0:
   a) Select an instance.
   b) Select the **Description** tab.
   c) Scroll down the description information until you see **AMI launch index**.



Placement group	-
Virtualization	paravirtual
Reservation	r-17f88948
AMI launch index	0
Tenancy	default

   d) Repeat until you find Node0.
3. To get the public DNS name of a node, select the node to connect to, and then click **Connect**.
4. In **Connect To Your Instance**, select **A standalone SSH client**.
5. Copy the Example command line and change the user from `root` to `ubuntu`, then paste it into your SSH client.



I would like to connect with [✓ A standalone SSH client] A Java SSH Client directly from my browser (Java required)

To access your instance:

1. Open an SSH client. (find out how to connect using PuTTY)
2. Locate your private key file (DataStaxKeyPair.pem). The wizard automatically detects the key you used to launch the instance.
3. Your key must not be publicly viewable for SSH to work. Use this command if needed:

```
chmod 400 DataStaxKeyPair.pem
```

4. Connect to your instance using its Public DNS:

```
ec2-54-219-64-150.us-west-1.compute.amazonaws.com
```

Example:

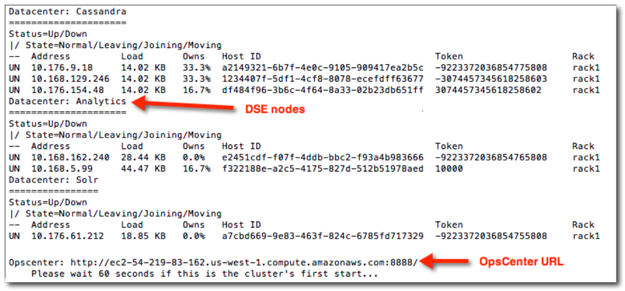
```
ssh -i DataStaxKeyPair.pem root@ec2-54-219-64-150.us-west-1.compute.amazonaws.com
```

Please note that in most cases the username above will be correct, however please ensure that you read your AMI usage instructions to ensure that the AMI owner has not changed the default AMI username.

If you need any assistance connecting to your instance, please see our connection documentation.

The AMI image configures your cluster and starts the Cassandra services.

6. After you have logged into a node and the AMI has completed installing and setting up the nodes, the status is displayed:



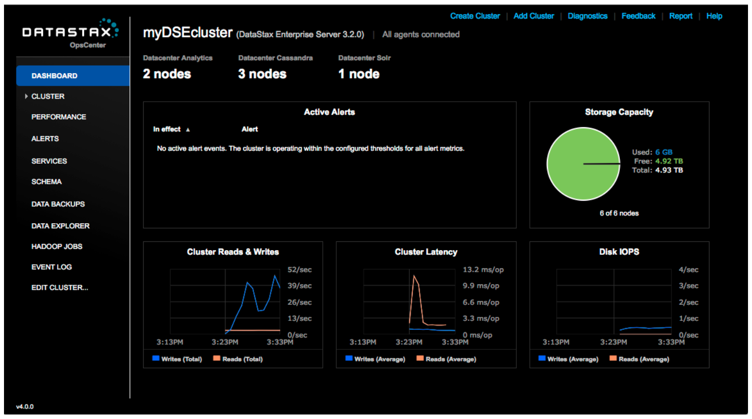
```
Datacenter: Cassandra
=====================
Status=Up/Down
|/ State=Normal/Leaving/Joining/Moving
--  Address         Load       Owns    Host ID                               Token                    Rack
UN  10.176.9.18     14.02 KB   33.3%   a2149321-6b7f-4e0c-9105-909417ea2b5c  -9223372036854775808     rack1
UN  10.168.129.246  14.02 KB   33.3%   1234407f-5df1-4cf8-8078-ecefdff63677  -3074457345618258603     rack1
UN  10.176.154.48   14.02 KB   16.7%   df484f96-3b6c-4f64-8a33-02b23db651ff  3074457345618258602      rack1
Datacenter: Analytics
=====================
Status=Up/Down
|/ State=Normal/Leaving/Joining/Moving
--  Address         Load       Owns    Host ID                               Token                    Rack
UN  10.168.162.240  28.44 KB   0.0%    e2451cdf-f07f-4ddb-bbc2-f93a4b983666  -9223372036854765808     rack1
UN  10.168.5.99     44.47 KB   16.7%   f322188e-a2c5-4175-827d-512b51978aed  10000                    rack1
Datacenter: Solr
================
Status=Up/Down
|/ State=Normal/Leaving/Joining/Moving
--  Address         Load       Owns    Host ID                               Token                    Rack
UN  10.176.61.212   18.85 KB   0.0%    a7cbd669-9e83-463f-824c-6785fd717329  -9223372036854755808     rack1

Opscenter: http://ec2-54-219-83-162.us-west-1.compute.amazonaws.com:8888/
    Please wait 60 seconds if this is the cluster's first start...
```

The URL for the OpsCenter is displayed when you connect to the node containing it; otherwise it is not displayed.

7. If you installed OpsCenter, allow 60 to 90 seconds after the cluster has finished initializing for OpsCenter to start. You can launch OpsCenter using the URL: `http://`*`public_dns_of_first_instance`*`:8888/`

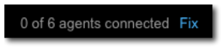
   The Dashboard should show that the agents are connected.



myDSEcluster (DataStax Enterprise Server 3.2.0) | All agents connected

No active alert events. The cluster is operating within the configured thresholds for all alert metrics.

8. If the agents have not automatically connected:
   a) Click the **Fix** link located near the top left of the **Dashboard**.



0 of 6 agents connected Fix

   b) When prompted for credentials for the agent nodes, use the username `ubuntu` and copy and paste the entire contents from your private key (`.pem`).

      The Dashboard shows the agents are connected.

Using OpsCenter to create a cluster on Amazon EC2

Launch a single node using the DataStax AMI and then create a cluster using OpsCenter.

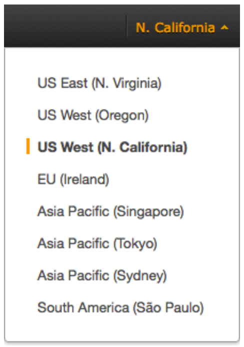
About this task

You can create a cluster using OpsCenter. With this method you first launch a single node using the DataStax AMI, and then create the cluster from OpsCenter.

Procedure

1. Sign in to the AWS console.
2. From the Amazon EC2 console navigation bar, select the same region as where you will launch the DataStax Community AMI.

   Step 1 in Launch the AMI provides a list of the available regions.



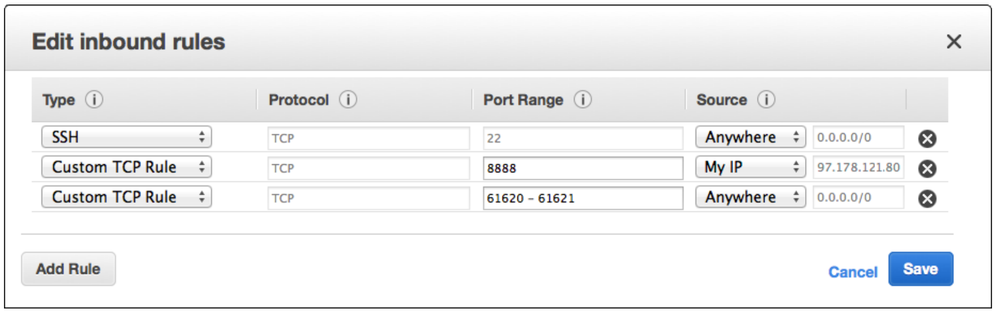
3. Open the **Security Groups** page.
4. Create rules for the security group using the following table:

Table 5: Ports

Port range	Type	Protocol	Source	Description
22	SSH	TCP	0.0.0.0/0	SSH (default)
8888	Custom TCP Rule	TCP	IP address of the machine that connects to OpsCenter or 0.0.0.0/0	OpsCenter web site port. The opscenterd daemon listens on this port for HTTP requests coming directly from the browser.
61620	Custom TCP Rule	TCP	0.0.0.0/0	OpsCenter monitoring port. The opscenterd daemon listens on this port for TCP traffic coming from the agent.
61621	Custom TCP Rule	TCP	0.0.0.0/0	OpsCenter agent port. The agents listen on this port for SSL traffic initiated by OpsCenter.

These rules open the necessary ports so OpsCenter can launch the AMI instances. When launching the cluster, OpsCenter creates it's own security group unless otherwise specified.

The completed port rules should look similar to this:


Edit inbound rules

Type	Protocol	Port Range	Source	
SSH	TCP	22	Anywhere	0.0.0.0/0
Custom TCP Rule	TCP	8888	My IP	97.178.121.80
Custom TCP Rule	TCP	61620 - 61621	Anywhere	0.0.0.0/0

5. Create the key pair, save it to your home directory, and then set its permissions so only you can read it.

```
$ chmod 400 my-key-pair.pem
```

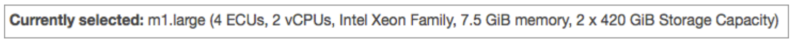
6. Launch the AMI:
   a) Using the following links to launch the AMI:

      Amazon EC2 offers a number of geographic regions for launching the AMI. Factors for choosing a region include: reduce latency, cost, or regulatory requirements.

Region	AMI
us-east-1	ami-f9a2b690
us-west-1	ami-32f7c977
us-west-2	ami-16ff9626
eu-west-1	ami-8932ccfe
ap-southeast-1	ami-8c7828de
ap-southeast-2	ami-57d54d6d
ap-northeast-1	ami-6b4a376a
sa-east-1	ami-15da7808

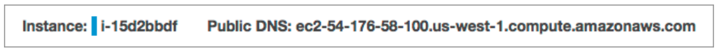
      Note: You can only use PV instances for OpsCenter.
   b) In **Step 2: Choose an Instance Type**, choose m1.large.

      When the instance is selected, its specifications are displayed:


Currently selected: m1.large (4 ECUs, 2 vCPUs, Intel Xeon Family, 7.5 GiB memory, 2 x 420 GiB Storage Capacity)

   c) Click **Next: Configure Instance Details** and set the following.
      - **Number of instances**: `1`
      - **Network**: **Launch into EC2-Classic**
      - **Advanced Details - User data**: `--opscenteronly`
   d) Click **Next** several times until **Step 6: Configure Security Group** page appears.
   e) Choose **Select an existing security group**, and then select your security group.
   f) Click **Review and Launch** and make any needed changes.
   g) Click **Launch**.
   h) In the **Select an existing key pair or create a new key pair** dialog, select the key pair you created from the **Select a key pair** drop-down list.
   i) Click **Launch Instances**.

      The AMI image configures and starts OpsCenter.
   j) Click **View Instances**.
7. After the instance is running and the status checks are complete, you can connect your browser to OpsCenter:
   a) If necessary, from the **EC2 Dashboard**, click **Running Instances**.
   b) Select the instance and use the public DNS for connecting to the OpsCenter.

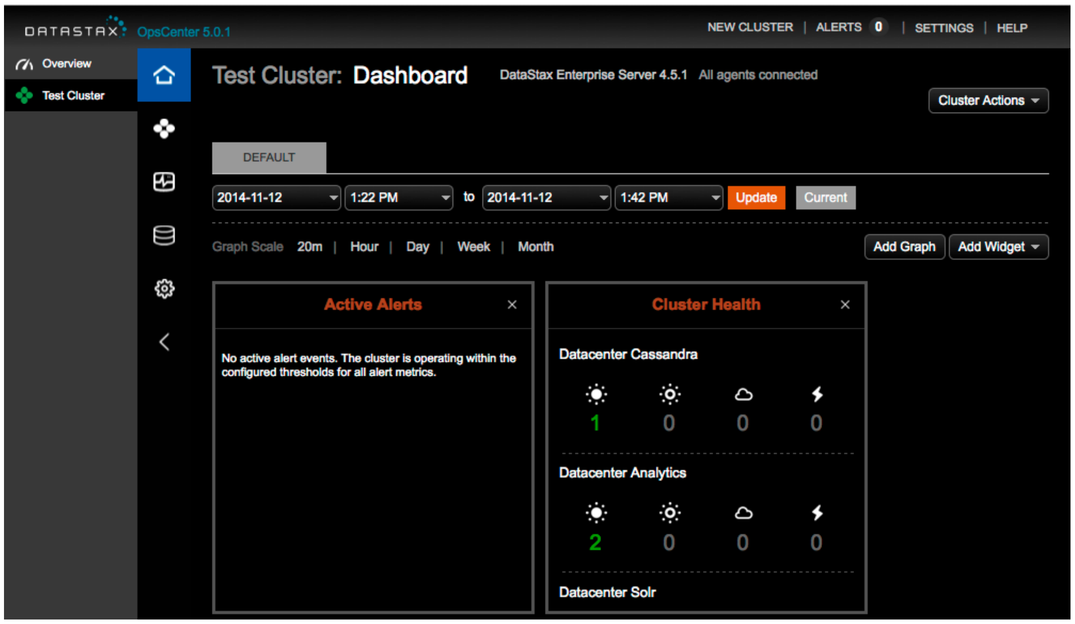

Instance: i-15d2bbdf **Public DNS:** ec2-54-176-58-100.us-west-1.compute.amazonaws.com

   c) Launch OpsCenter using the public DNS. For example: `http://ec2-54-193-159-3.us-west-1.compute.amazonaws.com:8888/`
8. Launch your cluster:
   a) In **Welcome to DataStax OpsCenter**, click **Create Brand New Cluster**.
   b) Fill out the form as appropriate.

Table 6: New cluster fields

Field	Description
Name	My Cluster
Package	The version of DSE or Cassandra to install on the nodes.
DataStax Credentials	*userid* and *password* that were in the email you received from DataStax when registering to download DataStax Enterprise.
Total Nodes	Total number of DSE or Cassandra nodes for the cluster. (Only when provisioning to the cloud.)
# Solr Nodes	Total number of DSE Search (Solr) nodes for the cluster.
# Hadoop Nodes	Total number of Hadoop nodes for the cluster.
# Spark Nodes	For DSE 4.5 and higher clusters, the total number of Spark nodes for the cluster.
Amazon EC2 Credentials	The *access-key-id* and *secret-access-key* to use to authenticate on AWS EC2.
Availability Zone	Which availability zone to use to create the cluster. (The drop-down list is only populated after entering your EC2 credentials.)
Size	Which size image to use.
AMI	Which image to use.
Use OpsCenter specific security group	Determines whether OpsCenter creates its own specific security group or allows you to select one which is available using your EC2 credentials.
Use OpsCenter specific key pair	Determines whether OpsCenter creates its own specific key pair or allows you to select one which is available using your EC2 credentials.

c) Click **Build Cluster**.


DATASTAX OpsCenter 5.0.1
NEW CLUSTER | ALERTS 0 | SETTINGS | HELP
Overview
Test Cluster
Test Cluster: Dashboard
DataStax Enterprise Server 4.5.1 All agents connected
Cluster Actions
DEFAULT
2014-11-12 1:22 PM to 2014-11-12 1:42 PM Update Current
Graph Scale 20m | Hour | Day | Week | Month
Add Graph Add Widget
Active Alerts
No active alert events. The cluster is operating within the configured thresholds for all alert metrics.
Cluster Health
Datacenter Cassandra
1 0 0 0
Datacenter Analytics
2 0 0 0
Datacenter Solr

9. After the cluster is running, change the inbound rules for ports 61620 and 61621 to the OpsCenter Provisioning Security Group:
   a) In the console, click **Security Groups**.
   b) Select **OpsCenter Security Group** > **Actions** > **Edit inbound rules**.
   c) Change the inbound rules to the **OpsCenter Security Group** and then click **Save**.

What to do next

OpsCenter User Guide

Installing and deploying a DataStax Enterprise cluster in CenturyLink Cloud

Installing and deploying a cluster in CenturyLink Cloud.

DataStax Academy provides information about installing and deploying DataStax Enterprise clusters using various cloud providers. The information provided in the Getting Started with DataStax Enterprise in the CenturyLink Cloud documentation includes:

- Detailed steps for deploying DataStax Enterprise-ready nodes using CenturyLink Cloud.
- Instructions for deploying DataStax Enterprise on those nodes using DataStax OpsCenter.

Installing and deploying a DataStax Enterprise cluster using Google Compute Engine

Installing and deploying a DataStax Enterprise cluster using Google Compute Engine.

The DataStax Academy provides information about installing and deploying DataStax Enterprise clusters using various cloud providers. The information provided in the DataStax Enterprise Deployment Guide for Google Compute Engine (GCE) documentation includes:

- Detailed steps for deploying DataStax Enterprise-ready nodes using the Google Compute Engine.
- Instructions for deploying DataStax Enterprise on those nodes using DataStax OpsCenter.
- Deployment considerations when mapping DataStax Enterprise high-availability features to GCE high-availability mechanisms.

Installing and deploying a DataStax Enterprise cluster using GoGrid

Installing and deploying a production (5-node) DataStax Enterprise cluster using GoGrid's 1-Button Deploy.

About this task

Additional introductory documentation is available from GoGrid at:

- GoGrid Cassandra Wiki
- Getting Started

The 1-Button Deploy of DataStax Enterprise does the following:

- Installs the latest version of DataStax Enterprise on 16 GB (raw) servers running Debian 7.5 64bit PVHVM.
- Installs OpsCenter on 8GB SSD.
- Installs Oracle JDK 7.
- Installs Python Driver.
- Uses RAID0 for the DataStax Enterprise disks.
- Enables the Firewall Service - All services are blocked except SSH (22) and ping for public traffic.
- Deploys as DataStax Enterprise as analytics nodes **not** using virtual nodes (vnodes).

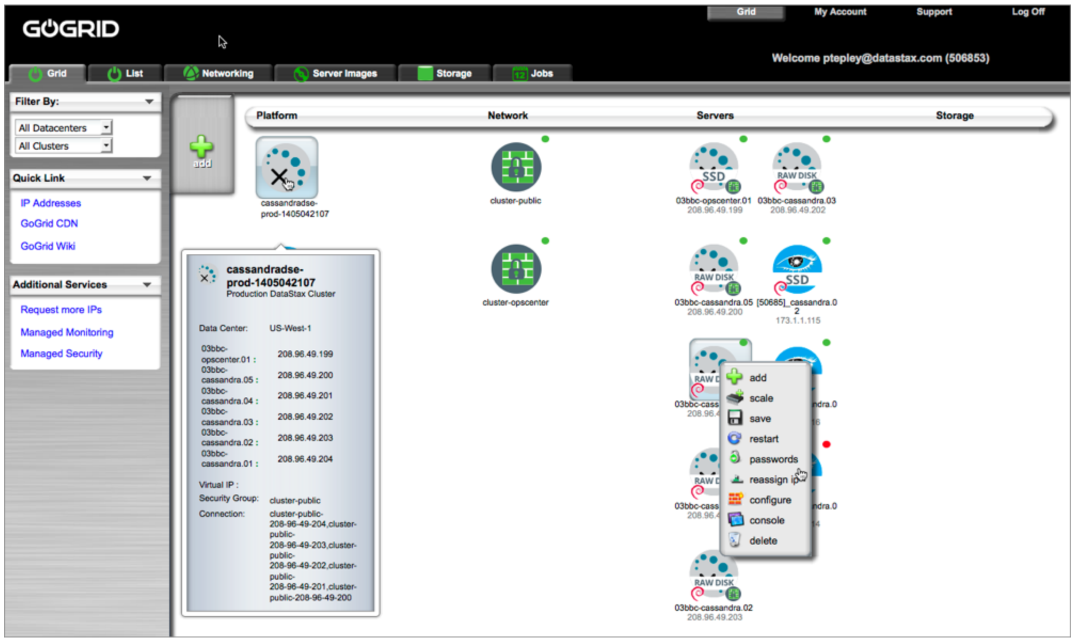
Procedure

1. Register with GoGrid.
2. Fill out the registration form and complete the account verification.

3. Access the management console with the login credentials you received in your email.

   The cluster automatically starts deploying. A green status indicator shows that a server is up and running.

   Hover over any item to view its details or right-click to display a context menu.



cassandradse-prod-1405042107
Production DataStax Cluster

Data Center: US-West-1

03bbc-opscenter.01 : 208.96.49.199
03bbc-cassandra.05 : 208.96.49.200
03bbc-cassandra.04 : 208.96.49.201
03bbc-cassandra.03 : 208.96.49.202
03bbc-cassandra.02 : 208.96.49.203
03bbc-cassandra.01 : 208.96.49.204

Virtual IP :
Security Group: cluster-public
Connection: cluster-public-208-96-49-204,cluster-public-208-96-49-203,cluster-public-208-96-49-202,cluster-public-208-96-49-201,cluster-public-208-96-49-200

4. Login to one of the servers and validate that the servers are configured and communicating:

   Note: You can login to any member of the cluster either with SSH, a third-party client (like PuTTY), or through the GoGrid Console service.

   a) To find your server credentials, right-click the server and select **Passwords**.
   b) From your secure connection client, login to the server with the proper credentials. For example from SSH:

   ```
   $ ssh root@ip_address
   ```

   c) Validate that the cluster is running:

   ```
   $ nodetool status
   ```

   Each node should be listed and it's status and state should be UN (Up Normal) :

   ```
   Datacenter: Analytics
   =====================
   Status=Up/Down
   |/ State=Normal/Leaving/Joining/Moving
   --  Address      Load       Tokens  Owns   Host ID
            Rack
   UN  10.106.69.5  933.91 MB  1       20.0%  518d5137-d6f0-44eb-a696-
   f174a8a38764  rack1
   UN  10.106.69.6  913.69 MB  1       20.0%  fd4fc8ff-
   d54d-42e8-9463-843eb23ac1c2  rack1
   UN  10.106.69.7  925.66 MB  1       20.0%
    609942c2-5482-422e-967f-347f6b13bbdb  rack1
   UN  10.106.69.8  932.12 MB  1       20.0%  4e7e26da-
   b847-4f3f-8471-478df8075504  rack1
   UN  10.106.69.9  926.46 MB  1       20.0%  7995a552-6987-4a9b-
   bfd0-4853cde5ae28  rack1
   ```

What to do next

The following provides information about using and configuring DataStax Enterprise, Cassandra, OpsCenter, GoGrid, and the Cassandra Query Language (CQL):

- DataStax documentation
- Cassandra documentation
- OpsCenter documentation
- GoGrid documentation
- CQL for Cassandra 2.x

Installing and deploying a DataStax Enterprise cluster using Microsoft Azure

Installing and deploying a DataStax Enterprise cluster using Microsoft Azure.

The DataStax Academy provides information about installing and deploying DataStax Enterprise clusters using various cloud providers. The information provided in the Enterprise Deployment for Microsoft Azure Cloud documentation includes:

- Description of technical conventions in Microsoft Azure.
- Detailed steps for deploying DataStax Enterprise-ready nodes.
- Instructions for deploying DataStax Enterprise on those nodes using DataStax OpsCenter.
- Configuring multi-region data centers in Microsoft Azure.

Installing EPEL on RHEL OS 5.x

Install Extra Packages for Enterprise Linux on RHEL OS 5.x.

About this task

Before installing DataStax Enterprise on RHEL OS 5.x, install the Extra Packages for Enterprise Linux (EPEL). EPEL contains important dependent packages that enable installation of Python 2.6.x that is required by DataStax Enterprise.

Note: Only RHEL OS 5.x requires EPEL.

You must install EPEL as root user:

32-bit RHEL and CentOS 5.x

```
# wget http://download.fedoraproject.org/pub/epel/5/i386/epel-
release-5-4.noarch.rpm
# rpm -ivh epel-release-5-4.noarch.rpm
```

64-bit RHEL and CentOS 5.x

```
# wget http://download.fedoraproject.org/pub/epel/5/x86_64/epel-
release-5-4.noarch.rpm
# rpm -ivh epel-release-5-4.noarch.rpm
```

Installing earlier versions of DataStax Enterprise

Steps for installing the same version as other nodes in your cluster.

About this task

DataStax provides binary tarball and packaged versions for installing earlier versions (2.2.x upwards) of DataStax Enterprise.

Note: You must use Oracle JRE 6, not 7, for versions earlier than DataStax Enterprise 3.1. These earlier versions do not support JRE 7.

Installing from the binary tarball

Download the tarball from the Download DataStax Enterprise page and follow the install instructions in the relevant documentation:

- DataStax Enterprise 4.6.x tarball install documentation
- DataStax Enterprise 4.5.x tarball install documentation
- DataStax Enterprise 4.0.x tarball install documentation
- DataStax Enterprise 3.0.x tarball install documentation
- DataStax Enterprise 2.2.x tarball install documentation

Installing the packages on RHEL-based or Debian-based platforms

Follow the install instructions in the relevant documentation and specify the specific version in the install command:

RHEL-based platforms

Format:

```
$ sudo yum -y install dse-full-version-1
```

Example:

```
$ sudo yum -y install dse-full-4.6.7-1
```

Debian-based platforms

Be sure that you have defined the DataStax repository and repository key. See the installation instructions for your version of DataStax Enterprise.

You can use Aptitude or apt-get.

Aptitude

```
$ sudo aptitude install dse-full=version
```

Example:

```
$ sudo aptitude install dse-full=4.6.7-1
```

When prompted, do not accept the first two solutions, and type Y to accept the third solution:

```
The following NEW packages will be installed:
  dse-full{b}
0 packages upgraded, 1 newly installed, 0 to remove and 309 not upgraded.
Need to get 10.3 kB of archives. After unpacking 53.2 kB will be used.
The following packages have unmet dependencies:
 dse-full : Depends: dse (= 4.6.7-1) but it is not going to be installed.
            Depends: dse-hive (= 4.6.7-1) but it is not going to be installed.
            ...
            Depends: dse-libspark (= 4.6.7-1) but it is not going to be
 installed.
The following actions will resolve these dependencies:

Keep the following packages at their current version:
1) dse-full [Not Installed]

Accept this solution? [Y/n/q/?] n
The following actions will resolve these dependencies:
```

```
Install the following packages:
1)  datastax-agent [5.1.3 (stable)]
2)  dse [4.6.7-1 (stable)]
...
16) dse-pig [4.6.7-1 (stable)]

Accept this solution? [Y/n/q/?] n
The following actions will resolve these dependencies:

Install the following packages:
1)  datastax-agent [5.1.2 (stable)]
2)  dse [4.6.7-1 (stable)]
...
16) dse-pig [4.6.7-1 (stable)]

Accept this solution? [Y/n/q/?] Y
The following NEW packages will be installed:
  datastax-agent{a} dse{a} dse-demos{a} dse-full dse-hive{a} dse-
libcassandra{a} dse-libhadoop{a} dse-libhadoop-native{a} dse-libhive{a} dse-
liblog4j{a}
  dse-libmahout{a} dse-libpig{a} dse-libsolr{a} dse-libspark{a} dse-
libsqoop{a} dse-libtomcat{a} dse-pig{a}
0 packages upgraded, 17 newly installed, 0 to remove and 309 not upgraded.
Need to get 554 MB of archives. After unpacking 672 MB will be used.
Do you want to continue? [Y/n/?] Y
```

apt-get

```
$ sudo apt-get install dse-full=version-1 dse=version-1 dse-hive=version-1
 dse-pig=version-1 dse-demos=version-1 dse-libsolr=version-1 dse-
libtomcat=version-1 dse-libsqoop=version-1 dse-liblog4j=version-1 dse-
libmahout=version-1 dse-libhadoop-native=version-1 dse-libcassandra=version-1
 dse-libhive=version-1 dse-libpig=version-1 dse-libhadoop=version-1 dse-
libspark=version
```

Example:

```
$ sudo apt-get install dse-full=4.6.7-1 dse=4.6.7-1 dse-hive=4.6.7-1 dse-
pig=4.6.7-1 dse-demos=4.6.7-1 dse-libsolr=4.6.7-1 dse-libtomcat=4.6.7-1 dse-
libsqoop=4.6.7-1 dse-liblog4j=4.6.7-1 dse-libmahout=4.6.7-1 dse-libhadoop-
native=4.6.7-1 dse-libcassandra=4.6.7-1 dse-libhive=4.6.7-1 dse-libpig=4.6.7-1
 dse-libhadoop=4.6.7-1 dse-libspark=4.6.7-1
```

For additional instructions, see the documentation version for your installation.

Installing glibc on Oracle Linux 6.x and later

To install DSE on Oracle Enterprise Linux 6.x and later, install the 32-bit versions of the glibc libraries.

About this task

To install DataStax Enterprise on Oracle Enterprise Linux 6.x and later, you need to install the 32-bit versions of the glibc libraries. They are not installed by default.

Procedure

1. Make the `yum.repos.d` your current directory.

   ```
   $ cd /etc/yum.repos.d
   ```

2. Download the `public-yum-ol6.repo` package from the repository.

   ```
   $ wget http://public-yum.oracle.com/public-yum-ol6.repo
   ```

3. Check that `glibc.i686` is ready for installation and install it.

   ```
   $ yum list
   $ yum install glibc.i686
   ```

Uninstalling DataStax Enterprise

Launch the uninstaller in the installation directory to uninstall DataStax Enterprise and DataStax Agent.

Select the uninstall method for your type of installation.

Uninstalling from the DataStax Installer

Use this method when you have installed DataStax Enterprise from the DataStax Installer.

1. Go to the server installation directory (default is `/usr/share/dse`).
2. Launch the uninstaller:
   - **Linux:** `$ ./uninstall ## Run the uninstaller as root or sudo if needed`
   - **Mac OS X:** Double-click **uninstaller**.
3. Select the type of uninstall and follow the instructions on the uninstaller.

   Note: If you are going to reinstall DataStax Enterprise with the existing data files, be sure to drain the node and move the files somewhere else before uninstalling.

Using the Unattended Uninstaller

To use this method, you must have installed DataStax Enterprise from the DataStax Installer.

1. Create a configuration file called `uninstall.property` in the same directory as the uninstaller. For example:

   ```
   /usr/share/dse/uninstall.property
   ```

2. In the `uninstall.property` file, set the required properties:
   - `do_drain=`*`1`*`|`*`0`* - drains the node before uninstalling
   - `full_uninstall=`*`1`*`|`*`0`* - uninstalls all components

   where *1*=yes and *0*=no.
3. From the directory containing the uninstaller:

   ```
   $ sudo ./uninstall --mode unattended
   ```

Uninstalling Debian- and RHEL-based packages

Use this method when you have installed DataStax Enterprise using APT or Yum.

1. Stop the DataStax Enterprise and DataStax Agent services:

   ```
   $ nodetool drain -h host name
   $ sudo service dse stop
   $ sudo service datastax-agent stop
   ```
2. Make sure all services are stopped:

   ```
   $ ps auwx | grep dse
   $ ps auwx | grep datastax-agent
   ```

3. If services are still running, use the PID to kill the service:

```
$ bin/dse cassandra-stop -p dse_pid
$ sudo kill datastax_agent_pid
```

4. Remove the installation directories:

   RHEL-based packages:

```
$ sudo yum remove "dse-*" "datastax-*"
```

   Debian-based packages:

```
$ sudo apt-get purge "dse-*" "datastax-*"
```

Uninstalling the binary tarball

Use this method when you have installed DataStax Enterprise using the binary tarball.

1. Stop the node:

```
$ install_location/bin/dse cassandra-stop ## Use sudo if needed
```

2. Stop the DataStax Agent:

```
$ ps auwx | grep datastax-agent
$ kill datastax_agent_pid ## Use sudo if needed
```

3. Make sure all services are stopped:

```
$ ps auwx | grep dse
$ ps auwx | grep datastax-agent
```

4. If services are still running, use the PID to kill the service:

```
$ bin/dse cassandra-stop -p dse_pid
$ sudo kill datastax_agent_pid
```

5. Remove the installation directory.

Starting and stopping DataStax Enterprise

You can start and stop DataStax Enterprise as a service or stand-alone process.

After you install and configure DataStax Enterprise on one or more nodes, start your cluster beginning with the seed nodes. In a mixed-workload DataStax Enterprise cluster, you must start the analytics seed node first.

Packaged installations include startup and stop scripts for running DataStax Enterprise as a service. Binary packages do not.

Starting DataStax Enterprise as a service

Starting the DataStax Enterprise service when DataStax Enterprise was installed from the DataStax Installer with the Services option or from a package.

About this task

Packaged installations provide start-up scripts in `/etc/init.d` for starting DataStax Enterprise as a service.

For Cassandra-only nodes in mixed-workload clusters or BYOH nodes, skip step 1.

The following entries, set the type of node

- HADOOP_ENABLED=1 designates the node as a DSE Hadoop node and starts the Hadoop Job Tracker and Task Tracker services.
- SOLR_ENABLED=1 starts the node as DSE Search node.
- SPARK_ENABLED=1 starts the node as DSE Enterprise Spark node.

Note: No entry is the same as disabling it.

Procedure

1. Edit the `/etc/default/dse` file, and then edit the appropriate line in this file, depending on the type of node you want:
   - Cassandra nodes:

     ```
     HADOOP_ENABLED=0
     SOLR_ENABLED=0
     SPARK_ENABLED=0
     ```
   - BYOH nodes:

     ```
     HADOOP_ENABLED=0
     SOLR_ENABLED=0
     SPARK_ENABLED=0
     ```

     BYOH node run in Cassandra mode.
   - DSE Hadoop nodes:

     ```
     HADOOP_ENABLED=1
     SOLR_ENABLED=0
     SPARK_ENABLED=OPTIONAL
     ```

- DSE Search nodes:

  ```
  SOLR_ENABLED=1
  HADOOP_ENABLED=0
  SPARK_ENABLED=0
  ```

- Spark nodes:

  ```
  SPARK_ENABLED=1
  HADOOP_ENABLED=OPTIONAL
  SOLR_ENABLED=0
  ```

- SearchAnalytics nodes:

  ```
  SPARK_ENABLED=1
  SOLR_ENABLED=1
  ```

2. Start DataStax Enterprise and the DataStax Agent:

   ```
   $ sudo service dse start
   $ sudo service datastax-agent start
   ```

3. To check if your cluster is up and running:

   ```
   $ nodetool status
   ```

   On Enterprise Linux systems, the DataStax Enterprise service runs as a Java process.

Starting DataStax Enterprise as a stand-alone process

Starting the DataStax Enterprise process when DataStax Enterprise was installed from the DataStax Installer with the No Services option or from a tarball.

About this task

If running a mixed-workload cluster (one or more data centers for each type of node), determine which nodes to start as analytics, Cassandra, and DSE Search nodes. Begin with the seed nodes first — analytics seed node, followed by the Cassandra seed node — then start the remaining nodes in the cluster one at a time. For additional information, see Multiple data center deployment.

Attention: Do not start all the nodes at the same time, because this causes contention among nodes to become the Job Tracker.

Procedure

1. From the install directory:

   - Cassandra node: `$ bin/dse cassandra`
   - BYOH node:`$ bin/dse cassandra` - Do not use the -t option to start a BYOH (Bring Your Own Hadoop) node.
   - DSE Hadoop node: `$ bin/dse cassandra -t`
   - DSE Search node: `$ bin/dse cassandra -s` - Do not use the -t option to start a DSE Search node.
   - Spark only node: `$ bin/dse cassandra -k` - Starts Spark trackers on a cluster of analytics nodes.
   - Spark + DSE Hadoop `$ bin/dse cassandra -k -t` - Starts a node in Spark and in Hadoop mode.
   - SearchAnalytics node: `$ bin/dse cassandra -s -k` - Starts a node in SearchAnalytics mode.

2. Start the DataStax agent:

   ```
   $ ./datastax-agent/bin/datastax-agent
   ```

3. To check that your ring is up and running:

   ```
   $ cd install_location
   $ bin/nodetool status
   ```

   If you are running an analytics node, there are several methods for designating the Job Tracker node.

Stopping a DataStax Enterprise node

Stopping DataStax Enterprise and the DataStax Agent on a node.

About this task

To speed up the restart process, before stopping the dse service, run nodetool drain. This step writes the current memtables to disk. When you restart the node, Cassandra does not need to read through the commit log. If you have durable writes set to false, which is unlikely, there is no commit log and you must drain the node to prevent losing data.

To stop the DataStax Enterprise and DataStax Agent services on a node:

```
$ nodetool drain -h host name
$ sudo service dse stop
$ sudo service datastax-agent stop
```

To stop the stand-alone process and DataStax Agent on a node:

Running nodetool drain before using the `cassandra-stop` command to stop a stand-alone process is not necessary because the `cassandra-stop` command drains the node before stopping it.

From the installation location:

```
$ install_location/bin/dse cassandra-stop ## Use sudo if needed
```

In the unlikely event that the cassandra-stop command fails because it cannot find the process DataStax Enterprise Java process ID (PID), the output instructs you to find the DataStax Enterprise Java process ID (PID) manually, and stop the process using its PID number.

```
$ ps auwx | grep dse
$ bin/dse cassandra-stop -p PID ## Use sudo if needed
```

To stop the DataStax Agent:

```
$ ps auwx | grep datastax-agent
$ kill datastax_agent_pid ## Use sudo if needed
```

DataStax Enterprise configuration

Information about configuring DataStax Enterprise.

DataStax Enterprise configuration file (dse.yaml)

`dse.yaml` is the primary DataStax Enterprise configuration file.

The `dse.yaml` file is the primary configuration file for DataStax Enterprise.

For `cassandra.yaml` configuration, see Node and cluster configuration (cassandra.yaml).

DSE In-Memory option

max_memory_to_lock_fraction

max_memory_to_lock_mb

To use the DSE In-Memory, choose one of these options to specify how much system memory to use for all in-memory tables.

- max_memory_to_lock_fraction

  Specify a fraction of the system memory. The default value of 0.20 specifies to use up to 20% of system memory.
- max_memory_to_lock_mb

  Specify a maximum amount of memory in MB.

Hive meta store

hive_meta_store_enabled

Enables or disables the Hive meta store via Cassandra. Default: *true*.

Kerberos support

Use these options for configuring security for a DataStax Enterprise cluster using Kerberos. For instructions, see Kerberos guidelines.

kerberos_options

Note: Encryption using auth-conf is separate and completely independent of SSL encryption. If auth-conf is set in this file and SSL is enabled, the transmitted data is encrypted twice.

- keytab

  `resources/dse/conf/dse.keytab`
- service_principal

  `dse/_HOST@`*`REALM`*
- http_principal

  `HTTP/_HOST@`*`REALM`*
- qop *auth*

  A comma-delimited list of Quality of Protection (qop) values that clients and servers can use for each connection. The valid values are:

  - *auth*

    Default: Authentication only.

- *auth-int*

  Authentication plus integrity protection for all transmitted data.
- *auth-conf*

  Authentication plus integrity protection and encryption of all transmitted data.

  Note: Encryption using auth-conf is separate and completely independent of whether encryption is done using SSL. If both auth-conf and SSL are enabled, the transmitted data is encrypted twice. DataStax recommends choosing one and using it for both encryption and authentication.

LDAP options

To use these options, you must set `com.datastax.bdp.cassandra.auth.LdapAuthenticator` as the authenticator in the cassandra.yaml file. For instructions, see Authenticating with LDAP.

server_host

The host name of the LDAP server. Default: *localhost*

server_port

The port on which the LDAP server listens. Default: *389*

search_dn

The username of the user that is used to search for other users on the LDAP server.

search_password

The password of the `search_dn` user.

use_ssl

Set to `true` to enable SSL connections to the LDAP server. If set to `true`, you may need to change `server_port` to the SSL port of the LDAP server. Default: *false*

use_tls

Set to `true` to enable TLS connections to the LDAP server. If set to `true`, you may need to change the `server_port` to the TLS port of the LDAP server. Default: *false*

truststore_path

The path to the trust store for SSL certificates.

truststore_password

The password to access the trust store.

truststore_type

The type of trust store. Default: *jks*

user_search_base

The search base for your domain, used to look up users. Set the `ou` and `dc` elements for your LDAP domain. Typically this is set to `ou=users,dc=`*`domain`*`,dc=`*`top level domain`*. For example, `ou=users,dc=example,dc=com`.

user_search_filter

The search filter for looking up usernames. Default: *uid={0}*

credentials_validity_in_ms

The duration period in milliseconds for the credential cache. Default: *0*

search_validity_in_seconds

The duration period in milliseconds for the search cache. Default: *0*

connection_pool

- max_active

  The maximum number of active connections to the LDAP server. Default: *8*

- max_idle

  The maximum number of idle connections in the pool awaiting requests. Default: *8*

Scheduler settings for Solr indexes

These settings control the schedulers in charge of querying for and removing expired data.

ttl_index_rebuild_options

- fix_rate_period

  Schedules how often to check for expired data in seconds. Default: *300*
- initial_delay

  Speeds up start-up by delaying the first TTL checks in seconds. Default: *20*
- max_docs_per_batch

  Sets the maximum number of documents to delete per batch by the TTL rebuild thread. Default: *200*

Solr shard transport options

For inter-node communication between DSE Search nodes. Also see Shard transport options for DSE Search communications.

shard_transport_options

These options are specific to netty.

- type

  netty is used for TCP-based communication. It provides lower latency, improved throughput, and reduced resource consumption than http transport, which uses standard a HTTP-based interface for communication. Default: *netty*
- netty_server_port

  The TCP listen port. This setting is mandatory to use the netty transport now or migrate to it later. To use http transport, comment out this setting or change it to *-1*. Default: *8984*
- netty_server_acceptor_threads

  The number of server acceptor threads. Default: *number of available processors*
- netty_server_worker_threads

  The number of server worker threads. Default: *number of available processors * 8*
- netty_client_worker_thread

  The number of client worker threads. Default: *number of available processors * 8*
- netty_client_max_connections

  The maximum number of client connections. Default: *100*
- netty_client_request_timeout

  The client request timeout, in milliseconds. Default: *60000*

HTTP transport settings

The defaults for are the same as Solr, that is 0, meaning no timeout at all. To avoid blocking operations, DataStax strongly recommends to changing these settings to a finite value. These settings are valid across Solr cores:

- http_shard_client_conn_timeout

  HTTP shard client timeouts in milliseconds. Default: *0*
- http_shard_client_socket_timeout

  HTTP shard client socket timeouts in milliseconds. Default: *0*

Solr indexing

DSE Search provides multi-threaded indexing implementation to improve performance on multi-core machines. All index updates are internally dispatched to a per-core indexing thread pool and executed asynchronously, which allows for greater concurrency and parallelism. However, index requests can return a response before the indexing operation is executed.

max_solr_concurrency_per_core

Configures the maximum number of concurrent asynchronous indexing threads per Solr core. If set to 1, DSE Search uses synchronous indexing behavior in a single thread. To achieve optimal performance when using live indexing, ensure that this value is the number of CPU cores. Also see Configuring the available indexing threads. Default: *number of available CPU cores*

back_pressure_threshold_per_core

The total number of queued asynchronous indexing requests per Solr core, computed at Solr commit time. When exceeded, back pressure prevents excessive resources consumption by throttling new incoming requests. Default: *500*

flush_max_time_per_core

The maximum time, in minutes, to wait before flushing asynchronous index updates, which occurs at either at Solr commit time or at Cassandra flush time. To fully synchronize Solr indexes with Cassandra data, ensure that flushing completes successfully by setting this value to a reasonable high value. Default: *5*

load_max_time_per_core

The maximum time in minutes wait for each Solr core to load on startup or create/reload operations, expressed. This advanced option should be changed only if exceptions happen during core loading. Default: *1* (if not specified)

Cassandra disk failure policy

enable_index_disk_failure_policy

DSE Search activates the configured Cassandra disk failure policy if IOExceptions occur during index update operations. Default: *false*

Solr CQL query options

Available options for CQL Solr queries.

solr_data_dir

The directory to store index data. By default, the Solr data is saved in `cassandra_data_dir/solr.data`, or as specified by the dse.solr.data.dir system property.

cql_solr_query_executor_threads

The maximum number of threads for retrieving rows during CQL Solr queries. This value is cross-request and cross-core. Default: number of available processors * 10

cql_solr_query_row_timeout

The maximum time in milliseconds to wait for each row to be read from Cassandra during CQL Solr queries. Default: *10000* milliseconds (10 seconds)

CQL Performance Service options

These settings are used by the Performance Service to configure how it collects performance metrics on Cassandra nodes. They are stored in the dse_perf keyspace and can be queried with CQL using any CQL-based utility, such as cqlsh, DataStax DevCenter, or any application using a Cassandra CQL driver.

cql_slow_log_options

Report distributed sub-queries (query executions on individual shards) that take longer than a specified period of time.

- enabled

Enables (true) or disables (false) log entries for slow queries. Default: false
- cql_slow_log_threshold_ms

  Defines the threshold time. Default: *100* milliseconds
- cql_slow_log_ttl

  Defines the time to keep the slow query log entries. Default: *86400* milliseconds
- async_writers

  Defines the number of server threads to dedicate to writing in the log. More than one server thread might degrade performance. Default: *1*

See Collecting slow queries.

cql_system_info_options

CQL system information tables settings

- enabled

  Default: *false*
- refresh_rate_ms

  Default: *10000* milliseconds

See Collecting system level diagnostics.

resource_level_latency_tracking_options

Data resource latency tracking settings:

- enabled

  Default: *false*
- refresh_rate_ms

  Default: *10000* milliseconds

See Collecting system level diagnostics.

db_summary_stats_options

Database summary statistics settings

- enabled

  Default: *false*
- refresh_rate_ms

  Default: *10000* milliseconds

See Collecting database summary diagnostics.

cluster_summary_stats_options

Cluster summary statistics settings

- enabled

  Default: *false*
- refresh_rate_ms

  Default: *10000* milliseconds

See Collecting cluster summary diagnostics.

histogram_data_options

Column Family Histogram data tables settings

- enabled

Default: *false*
- refresh_rate_ms

  Default: *10000* milliseconds
- retention_count

  Default: *3*

See Collecting table histogram diagnostics.

user_level_latency_tracking_options

User-resource latency tracking settings

- enabled

  Default: *false*
- refresh_rate_ms

  Default: *10000* milliseconds
- top_stats_limit

  Default: *100*

See Collecting user activity diagnostics.

Spark Performance Service options

These settings are used by the Performance Service. See Monitoring Spark with Spark Performance Objects.

spark_cluster_info_options

- enabled

  Default: *false*
- refresh_rate_ms

  Default: *10000* milliseconds

spark_application_info_options

- enabled

  Default: *false*
- refresh_rate_ms

  Default: *10000* milliseconds
- driver

  The driver option controls the metrics collected by the Spark Driver.

Solr Performance Service options

These settings are used by the Performance Service. See Collecting Solr performance statistics.

solr_indexing_error_log_options

- enabled

  Default: *false*
- ttl_seconds

  Default: *604800* seconds
- async_writers

  Default: *1*

See Collecting indexing errors.

solr_slow_sub_query_log_options

- enabled

  Default: *false*
- ttl_seconds

  Default: *604800* seconds
- async_writers

  Default: *1*
- threshold_ms

  Default: *100*

See Collecting slow Solr queries.

solr_update_handler_metrics_options

- enabled

  Default: *false*
- ttl_seconds

  Default: *604800* seconds
- refresh_rate_ms

  Default: *60000* milliseconds

See Collecting handler statistics.

solr_index_stats_options

- enabled

  Default: *false*
- ttl_seconds

  Default: *604800*
- refresh_rate_ms

  Default: *60000*

See Collecting index statistics.

solr_cache_stats_options

- enabled

  Default: *false*
- ttl_seconds

  Default: *604800*
- refresh_rate_ms

  Default: *60000*

See Collecting cache statistics.

solr_latency_snapshot_options

- enabled

  Default: *false*
- ttl_seconds

  Default: *604800* seconds

- refresh_rate_ms

  Default: *60000* milliseconds

See Collecting Solr performance statistics.

node_health_options

- enabled

  Default: *false*
- ttl_seconds

  Default: *60000* seconds

Encryption settings

Settings for encrypting passwords and sensitive system tables.

system_key_directory

The directory where global encryption keys, called system keys, are kept. Keys used for SSTable encryption must be distributed to all nodes, DataStax Enterprise must be able to read and write to this directory, and have 700 permissions and belong to the dse user. Default: `/etc/dse/conf`

For details, see Configuring encryption using off-server encryption keys and Configuring encryption using local encryption keys.

config_encryption_active

When set to true (default: *false*), the following configuration values **must** be encrypted:

`dse.yaml`

- ldap_options.search_password
- ldap_options.truststore_password

cassandra.yaml

- server_encryption_options.keystore_password
- server_encryption_options.truststore_password
- client_encryption_options.keystore_password
- client_encryption_options.truststore_password
- ldap_options.truststore_password

config_encryption_key_name

The name of the system key for encrypting and decrypting stored passwords in the configuration files. To encrypt keyfiles, use dsetool createsystemkey. When config_encryption_active is *true*, you must provide a valid key with this name for the system_key_directory option. Default: *system_key*

system_info_encryption

If enabled, system tables that contain sensitive information, such as system.hints, system.batchlog, and system.paxos, are encrypted. If enabling system table encryption on a node with existing data, run nodetool upgradesstables -a on the listed tables. When tracing is enabled, sensitive information is written into the tables in the system_traces keyspace. Configure those tables to encrypt their data by using an encrypting compressor.

- enabled

  Default: *false*
- cipher_algorithm

  Default: *AES*
- secret_key_strength

  Default: *128*

- chunk_length_kb

  Default: *64*
- key_name

  The name of the keys file that is created to encrypt system tables. This file is created in *system_key_directory*/system/*key_name*. Comment out when using key_provider: KmipKeyProviderFactory Default: *system_table_keytab*
- key_provider

  Use KMIP off-server encryption. Default: *KmipKeyProviderFactory*
- kmip_host

  The *kmip_groupname* that is defined in `dse.yaml` that describes the KMIP key server or group of KMIP key servers.

Hive options

hive_options

Retries setting when Hive inserts data to Cassandra table.

- insert_max_retries

  Maximum number of retries. Default: *6*
- insert_retry_sleep_period

  Period of time in milliseconds between retries. Default: *50*

Audit logging settings

To get the maximum information from data auditing, turn on data auditing on every node. See Configuring and using data auditing and Configuring audit logging to a logback log file.

audit_logging_options

- enabled

  Default: *false*
- Available loggers:
  - CassandraAuditWriter

    Logs audit information to a Cassandra table. This logger can be run either synchronously or asynchronously. Audit logs are stored in the dse_audit.audit_log table. When run synchronously, a query will not execute until it has been written to the audit log table successfully. If there is a failure between when an audit event is written and it's query is executed, the audit logs may contain queries that were never executed. Also see Configuring audit logging to a Cassandra table.
  - SLF4JAuditWriter

    Logs audit information to the SLF4JAuditWriter logger. Audit logging configuration settings are in the logback.xml file.

    The location of the `logback.xml` file depends on the type of installation:

Installer-Services and Package installations	`/etc/dse/cassandra/conf/logback.xml`
Installer-No Services and Tarball installations	`*install_location*/resources/cassandra/conf/logback.xml`

- included_categories or excluded_categories

  Comma separated list of audit event categories to be included or excluded from the audit log. Categories are: QUERY, DML, DDL, DCL, AUTH, ADMIN. Specify either included or excluded categories. Specifying both is an error.

- included_keyspaces or excluded_keyspaces

  Comma separated list of keyspaces to be included or excluded from the audit log. Specify either included or excluded keyspaces. Specifying both is an error.
- retention_time

  The amount of time, in hours, that audit events are retained by supporting loggers. Currently, only the CassandraAuditWriter supports retention time. Values of 0 or less retain events forever. Default: 0
- cassandra_audit_writer_options

  Sets the mode the writer runs in. When run synchronously, a query is not executed until the audit event is successfully written. When run asynchronously, audit events are queued for writing to the audit table, but are not necessarily logged before the query executes. A pool of writer threads consumes the audit events from the queue, and writes them to the audit table in batch queries. While this substantially improves performance under load, if there is a failure between when a query is executed, and its audit event is written to the table, the audit table may be missing entries for queries that were executed.

  - mode

    Default: *sync*
  - batch_size (async mode only)

    Must be greater than 0. The maximum number of events the writer will dequeue before writing them out to the table. If you're seeing warnings in your logs about batches being too large, decrease this value. Increasing batch_size_warn_threshold_in_kb in cassandra.yaml is also an option. Make sure you understand the implications before doing so. Default: *50*
  - flush_time (async mode only)

    The maximum amount of time in milliseconds before an event is removed from the queue by a writer before being written out. This prevents events from waiting too long before being written to the table when there are not a lot of queries happening. Default: *500*
  - num_writers (async mode only)

    The number of worker threads asynchronously logging events to the CassandraAuditWriter. Default: *10*
  - queue_size

    The size of the queue feeding the asynchronous audit log writer threads. When there are more events being produced than the writers can write out, the queue will fill up, and newer queries will block until there is space on the queue. If a value of 0 is used, the queue size will be unbounded, which can lead to resource exhaustion under heavy query load. Default: *10000*
  - write_consistency

    The consistency level used to write audit events. Default: *QUORUM*

The location of the cassandra.yaml file depends on the type of installation:

Package installations	`/etc/cassandra/cassandra.yaml`
Tarball installations	`*install_location*/resources/cassandra/conf/cassandra.yaml`

KMIP encryption options

Options for KMIP encryption keys and communication between the DataStax Enterprise node and the KMIP key server or key servers.

kmip_hosts

Configure options for a *kmip_groupname* section for each KMIP key server or group of KMIP key servers. Using separate key server configuration settings allows use of different key servers to encrypt table data, and eliminates the need to enter key server configuration information in DDL statements and other configurations.

kmip_groupname

A user-defined name for a group of options to configure a KMIP server or servers, key settings, and certificates.

- hosts

  A comma-separated list of hosts[:port] for the KMIP key server. There is no load balancing. In failover scenarios, failover occurs in the same order that servers are listed. For example: `hosts: kmip1.yourdomain.com, kmip2.yourdomain.com`
- keystore_path

  The path to a java keystore that identifies the DSE node to the KMIP key server. For example: `/path/to/keystore.jks`
- keystore_type

  The type of key store. The default value is `jks`.
- keystore_password

  The password to access the key store.
- truststore_path

  The path to a java truststore that identifies the KMIP key server to the DSE node. For example: `/path/to/truststore.jks`
- truststore_type

  The type of trust store.
- truststore_password

  The password to access the trust store.
- key_cache_milli

  Milliseconds to locally cache the encryption keys that are read from the KMIP hosts. The longer the encryption keys are cached, the fewer requests are made to the KMIP key server, but the longer it takes for changes, like revocation, to propagate to the DSE node. Default: 300000.
- timeout

  Socket timeout in milliseconds. Default: 1000.

Configuring and using virtual nodes

A description of vnodes and using them in different types of data centers. Also steps for disabling vnodes.

About this task

Virtual nodes simplify many tasks in Cassandra, such as eliminating the need to determine the partition range (calculate and assign tokens), rebalancing the cluster when adding or removing nodes, and replacing dead nodes. For a complete description of virtual nodes and how they work, see About virtual nodes, and the Virtual nodes in Cassandra 1.2 blog.

Attention: DataStax Enterprise turns off virtual nodes (vnodes) by default. DataStax does not recommend turning on vnodes for DSE Hadoop or BYOH nodes. Before turning vnodes on for Hadoop, understand the implications of doing so DataStax Enterprise does support turning on vnodes for Spark nodes.

Guidelines for using virtual nodes

In the cassandra.yaml file, uncomment num_tokens and leave the initial_token parameter unset. Guidelines for using virtual nodes include:

- Determining the num_tokens value:

The initial recommended value for num_tokens is 256. For more guidance, see Setting up virtual nodes.

- Migrating existing clusters:

  To upgrade existing clusters to virtual nodes, see Enabling virtual nodes on an existing production cluster.
- Using a vnodes in a mixed architecture deployment:

  Cassandra supports using virtual node-enabled and non-virtual node data centers. For example, a single cluster with:

  - A cassandra-only data center running OLTP.
  - A analytics data center without vnodes
  - A search data center with vnodes.

Disabling virtual nodes

Important: If you do not use virtual nodes, you must make sure that each node is responsible for roughly an equal amount of data. To ensure that each node is responsible for an equal amount of data, assign each node an initial-token value and calculate the tokens for each data center as described in Generating tokens. You can also use the default Murmur3Partitioner and calculate the tokens as described in Generating tokens.

Procedure

1. In the cassandra.yaml file, set num_tokens to 1.

   ```
   num_tokens: 1
   ```

   The location of the cassandra.yaml file depends on the type of installation:

Package installations	`/etc/cassandra/cassandra.yaml`
Tarball installations	*`install_location`*`/resources/cassandra/conf/cassandra.yaml`

2. Uncomment the initial_token property and set it to 1 or to the value of a generated token for a multi-node cluster.

Default file locations for Installer-Services and package installations

Locations when installing from the DataStax All-in-One Installer with Services option or package installations.

The default location of the files depend on how DataStax Enterprise is installed. The DataStax All-in-One Installer installs files differently depending on whether Services or No Services option is selected during installation. When Services is selected, the files are located in the same locations as package installations. When No Services are selected, the files are located in the same locations as the tarball installations.

Directories for cassanda.yaml and dse.yaml

Directories	Description
`/etc/dse/cassandra`	cassanda.yaml is the main configuration file for Cassandra.
`/etc/dse`	dse.yaml is the main configuration file for DataStax Enterprise.

BYOH directories

Directories	Description
`/etc/dse`	byoh-env.sh is the BYOH configuration file to: • Set up the DataStax Enterprise environment • Define the BYOH environment variables

Cassandra directories

Directories	Description
`/var/lib/cassandra`	commitlog, data, saved_caches
`/var/log/cassandra`	audit.log, output.log, solrvalidation.log, system.log
`/var/run/cassandra`	
`/usr/share/dse/cassandra`	Cassandra environment settings
`/usr/share/dse/cassandra/lib`	
`/usr/bin`	
`/usr/sbin`	
`/etc/dse/cassandra/`	Cassandra configuration
`/etc/init.d`	
`/etc/security/limits.d`	
`/etc/default/`	
`/usr/share/doc/dse-libcassandra`	Notices and `cqlshrc` samples

DataStax Enterprise Installer directories

Directories	Description
`/usr/share/dse/backups/`*`log_file_dir/`*`copied_config_files.log`	Show Config File Overwrites
`/usr/share/dse/backups/`*`log_file_dir/`*`bitrock_installer.log`	View Installation Log
`/usr/share/dse/backups/`*`log_file_dir/`*`install_dependencies.log`	View Dependency Installation Log
`/usr/share/dse/backups/pfc_results.txt`	View Configuration Recommendations and Warnings (Preflight Check Results)
`/usr/share/dse`	View README
`/usr/share/dse`	Uninstall DataStax Enterprise

DSE Hadoop directories

Directories	Description
`/etc/dse/hadoop`	Hadoop configuration
`/usr/share/dse/resources/hadoop`	Hadoop environment settings

Directories	Description
`/usr/share/portfolio_manager`	Hadoop Portfolio Manager demo

Hive directories

Directories	Description
`/etc/dse/hive`	Hive configuration
`/usr/share/dse/resources/hive`	Hive environment settings

Mahout directories

Directories	Description
`/etc/dse/mahout`	Mahout properties
`/usr/share/dse/resources/mahout`	Mahout environment settings
`/usr/share/demos/mahout`	Mahout demo

Pig directories

Directories	Description
`/etc/dse/pig`	Pig configuration
`/usr/share/dse/resources/pig`	Pig environment settings
`/usr/share/demos/pig`	Pig demo

Solr directories

Directories	Description
`/usr/share/dse/resources/solr/conf`	Solr configuration
`/usr/share/dse/solr`	Solr driver
`/usr/share/dse/demos/wikipedia`	Search - Wikipedia demo

Spark directories

Directories	Description
`/etc/dse/spark`	spark-env.sh is the Spark configuration file
`/usr/share/dse/spark/work`	Spark work directory
`/usr/share/dse/spark/logs`	Spark Master and Worker logs
`/usr/share/dse/demos/spark`	Spark Portfolio Manager demo

Shark directories

Directories	Description
`/etc/dse/shark`	`shark-env.sh` is the Shark configuration file
`/usr/share/dse/resources/shark`	Shark environment settings

Sqoop directories

Directories	Description
`/etc/dse/sqoop`	Sqoop configuration
`/usr/share/dse/resources/sqoop`	Sqoop environment settings
`/usr/share/dse/demos/sqoop`	Sqoop demo

Logback-appender directories

Directories	Description
`/etc/dse/cassandra`	`logback.xml` is the logback configuration file

Tomcat server logs for DSE Search

Directories	Description
`/var/log/tomcat`	Default log location. You can change the location of the Tomcat server logs for DSE Search.

OpsCenter directories

Directories	Description
`/var/lib/opscenter`	SSL certificates for encrypted agent/dashboard communications
`/var/log/opscenter`	Log directory
`/var/run/opscenter`	Runtime
`/usr/share/opscenter`	JAR, agent, web application, and binary files
`/etc/opscenter`	opscenterd.conf is the OpsCenter configuration file
`/etc`	init.d contains the service startup script
`/etc/security`	`limits.d` sets OpsCenter user limits

DataStax Agent directories

Directories	Description
`/var/lib/datastax-agent/ssl`	SSL certificates for encrypted agent and dashboard communications
`/var/lib/datastax-agent/conf`	Configuration
`/var/log/datastax-agent`	Log directory
`/var/run/datastax-agent`	Runtime
`/usr/share/datastax-agent`	JAR, agent, web application, and binary files
`/etc/init.d`	Service startup script

Default file locations for Installer-No Services and tarball installations

Locations when installing from the DataStax All-in-One Installer with No Services selected or tarball installations.

The default location of the files depend on how DataStax Enterprise is installed. The DataStax All-in-One Installer installs files differently depending on whether Services or No Services option is selected during installation. When Services is selected, the files are located in the same locations as package installations. When No Services are selected, the files are located in the same locations as the tarball installations.

Note: The default *install_location* depends whether you installed using the DataStax All-in-One Installer or from the binary tarball:

- Installer-No Services: `/usr/share/dse`
- Tarball installation: The `location` where you extracted DataStax Enterprise.

Directories for cassanda.yaml and dse.yaml

Directories	Description
`install_location/resources/cassandra/conf`	`cassanda.yaml` is the main configuration file for Cassandra.
`install_location/resources/dse/conf`	`dse.yaml` is the main configuration file for DataStax Enterprise.

BYOH directories

Directories	Description
`install_location/bin`	byoh-env.sh is the BYOH configuration file to: • Set up the DataStax Enterprise environment • Define the BYOH environment variables
`install_location/resources/byoh/conf`	BYOH configuration

Cassandra directories

Directories	Description
`install_location/resources/cassandra/bin`	Cassandra commands and utilities, such as nodetool, cqlsh, sstablekeys, and sstableloader
`install_location/resources/cassandra/conf`	Cassandra configuration

DSE Hadoop directories

Directories	Description
`install_location/resources/hadoop/conf`	Hadoop configuration
`install_location/demos/portfolio_manager`	Hadoop Portfolio Manager demo

Hive directories

Directories	Description
install_location/resources/hive/conf	Hive configuration

Mahout directories

Directories	Description
install_location/resources/mahout/conf	Mahout properties
install_location/demos/mahout	Mahout demo

Pig directories

Directories	Description
install_location/resources/pig/conf	Pig configuration
install_location/demos/pig	Pig demo

Solr directories

Directories	Description
install_location/resources/solr/conf	Solr configuration
install_location/resources/dse/lib	Solr driver
install_location/demos/wikipedia	Search - Wikipedia demo

Spark directories

Directories	Description
install_location/resources/spark/conf	spark-env.sh is the Spark configuration file
install_location/resources/spark/work	Spark work directory
install_location/resources/spark/logs	Spark Master and Worker logs
install_location/demos/spark	Spark Portfolio Manager demo

Shark directories

Directories	Description
install_location/resources/shark	shark-env.sh is the Shark configuration file

Sqoop directories

Directories	Description
install_location/resources/sqoop/conf	Sqoop configuration
install_location/demos/sqoop	Sqoop demo

Logback-appender directories

Directories	Description
`install_location/resources`	`logback.xml` is the logback configuration file

Tomcat server logs for DSE Search

Directories	Description
`/var/log/tomcat`	Default log location. You can change the location of the Tomcat server logs for DSE Search.

OpsCenter directories

Directories	Description
`install_location/opscenter/agent`	Agent installation
`install_location/opscenter/bin`	Startup and configuration
`install_location/opscenter/content`	Web application
`install_location/opscenter/conf`	Configuration
`install_location/opscenter/doc`	License
`install_location/opscenter/lib and /src`	Library
`install_location/opscenter/log`	OpsCenter log
`install_location/opscenter/ssl`	SSL files for OpsCenter to agent communications

DataStax Agent directories

Directories	Description
`install_location/datastax-agent/ssl`	SSL certificates for encrypted agent and dashboard communications

Configuring the Tomcat log location

Steps to change the location of the Tomcat server logs for DSE Search.

About this task

The default location of the Tomcat server logs for DSE Search is `/var/log/tomcat`.

Procedure

To change this location, edit one of these files:

- Set the TOMCAT_LOGS environment variable in the `dse.in.sh` file.
- Set the locations in `resources/tomcat/conf/logging.properties`.

DSE Analytics

DataStax Enterprise analytics includes integration with Apache Spark, Shark, BYOH (bring your own Hadoop), and DSE Hadoop.

DataStax Enterprise analytics includes integration with Apache Spark, Shark, BYOH (bring your own Hadoop), and DSE Hadoop.

About DSE Analytics

DataStax Enterprise serves the analytics market with significant features for analyzing huge databases.

DataStax Enterprise targets the analytics market with significant features for analyzing huge databases:

- Apache Spark

  A fast alternative to Hadoop. Spark is a distributed, parallel, batch data processing engine based on the Resilient Distributed Datasets (RDD) concept instead of MapReduce upon which Hadoop is based.
- Shark

  A Hive-like language built on top of Spark. The connection of Spark to Cassandra executes performant analytical queries independent of Hadoop. Shark's Hive-like language simplifies the transition for Hive users. The connection of Spark to Cassandra provides faster data analysis than the typical MapReduce job.
- BYOH

  A bring your own Hadoop (BYOH) model gives organizations, who are already running late models of Hadoop implemented by Cloudera or Hortonworks, a way to use these implementations with DataStax Enterprise. This model provides better performance through custom, better-tuned Hadoop than previous DataStax Enterprise versions.
- Improved integration of Apache Sqoop

  You can import RDBMS data to Cassandra and export Cassandra CQL data to an RDBMS.
- DSE Hadoop

  Hadoop is integrated with DataStax Enterprise and has the following Hive and Pig tools:

  - Support for the native protocol in Hive.
  - Auto-creation of Hive databases and external tables for each CQL keyspace and table.
  - A cql3.partition.key property that maps Hive tables to CQL compound primary keys and composite partition keys.
  - Support for HiveServer2.
  - Integration of the HiveServer2 Beeline command shell.
  - Support for expiring data in columns by setting TTL (time to live) on Hive tables.
  - Support for expiring data by setting the TTL on Pig data using the `cql://` URL, which includes a prepared statement. See step 10 of the library demo.

DSE Analytics features

- No single point of failure

  DSE Hadoop supports a peer-to-peer, distributed cluster for running MapReduce jobs. Being peers, any node in the cluster can load data files, and any analytics node can assume the responsibilities of Job Tracker for MapReduce jobs.
- Job Tracker management

DSE Hadoop can automatically select Job Tracker and reserve Job Tracker nodes that take over in the event of a problem that would affect availability. The Job Tracker and reserve Job Tracker nodes can also be explicitly set.

- Multiple Job Trackers

  You can run one or more Job Tracker services across multiple data centers and create multiple keyspaces per data center. Using this capability has performance, data replication, and other benefits.
- Hadoop MapReduce using multiple Cassandra File Systems (CFS)

  Cassandra File System (CFS) is a Hadoop Distributed File System (HDFS)-compatible storage layer. DataStax Enterprise replaces HDFS with CFS to run MapReduce jobs on Cassandra's peer-to-peer, fault-tolerant, and scalable architecture. You can create additional CFS to organize and optimize data.
- Analytics without ETL

  Using DSE Hadoop, you run MapReduce jobs directly against data in Cassandra. You can perform real-time and analytics workloads at the same time without one workload affecting the performance of the other. Starting some cluster nodes as Hadoop analytics nodes and others as pure Cassandra real-time nodes automatically replicates data between nodes.
- Hive Support

  Hive, a data warehouse system, facilitates data summarization, ad hoc queries, and the analysis of large data sets that are stored in Hadoop-compatible file systems. Any JDBC compliant user interface connects to Hive from the server. Using the Cassandra-enabled Hive MapReduce client in DataStax Enterprise, you project a relational structure onto Hadoop data in CFS, and query the data using a SQL-like language.
- Pig Support

  The Cassandra-enabled Pig MapReduce client that is included with DSE Hadoop is a high-level platform for creating MapReduce programs used with Hadoop. You can analyze large data sets by running jobs in MapReduce mode and Pig programs directly on data that is stored in Cassandra.
- Mahout support

  Apache Mahout, included with DSE Hadoop, offers machine learning libraries. Machine learning improves a system, such as the system that recreates the Google Priority Inbox, based on past experience or examples.

DSE Analytics and Search integration

DSE SearchAnalytics clusters can use DSE Search queries within DSE Analytics jobs.

An integrated DSE SearchAnalytics cluster allows analytics jobs to be performed using search queries. This allows finer-grained control over the types of queries used in analytics workloads, and better performance because the amount of data that is processed is reduced.

Nodes started as stand-alone processes or services in SearchAnalytics mode allow you to create analytics queries that use Solr indexes. These queries return RDDs used by Spark jobs to analyze the returned data.

The following code shows how to use a Solr query from the DSE Spark console.

```
val table = sc.cassandraTable("music","solr")
val result =
 table.select("id","artist_name").where("solr_query='artist_name:Miles*'").collect
```

For a more complete example, see Running the Wikipedia demo with SearchAnalytics.

Planning a DSE SearchAnalytics cluster

DSE SearchAnalytics clusters should be created as a new cluster in a data center, as described in Single data center deployment per workload type. The name of the data center is set to `SearchAnalytics` when using the `DseSimpleSnitch`. Existing search or analytics nodes should not be retroactively modified to be SearchAnalytics nodes.

SearchAnalytics nodes may consume more resources than search or analytics nodes. Because the resource requirements of the nodes greatly depends on the type of query patterns you are using, we recommend doing load-testing to ensure your hardware has enough CPU and memory for the additional resource overhead required by Spark and Solr.

Limitations of DSE SearchAnalytics clusters

While you will be able to query Solr indexes from Spark in a SearchAnalytics data center, you will get none of the benefits of workload isolation in that data center. DataStax recommends that you do not run real-time Solr queries against SearchAnalytics nodes if Spark jobs are being run on them.

SearchAnalytics clusters are considered experimental, and should not be run in production environments.

About the Cassandra File System

A Hive or Pig analytics job requires a Hadoop file system to function. For use with DSE Hadoop, DataStax Enterprise provides a replacement for the Hadoop Distributed File System (HDFS) called the Cassandra File System (CFS).

About this task

A Hive or Pig analytics job requires a Hadoop file system to function. DataStax Enterprise provides a replacement for the Hadoop Distributed File System (HDFS) called the Cassandra File System (CFS), which serves this purpose. When an analytics node starts up, DataStax Enterprise creates a default CFS rooted at cfs:/ and an archive file system named `cfs-archive`, which is rooted at cfs-archive:/. Cassandra creates a keyspace for the cfs-archive file system, and every other CFS file system. The keyspace name is similar to the file system name except the hyphen in the name is replaced by an underscore. For example, the cfs-archive file system keyspace is cfs_archive. You need to increase the replication factor of default CFS keyspaces to prevent problems when running Hadoop jobs.

Configuring a CFS superuser

A CFS superuser is the DSE daemon user, the user who starts DataStax Enterprise. A cassandra superuser, set up using the CQL CREATE USER command, is also a CFS superuser.

A CFS superuser can modify files in the CFS without any restrictions. Files that a superuser adds to the CFS are password-protected.

Deleting files from the CFS

Cassandra does not immediately remove deleted data from disk when you use the `dse hadoop fs -rm` *`file`* command. Instead, Cassandra treats the deleted data like any data that is deleted from Cassandra. A tombstone is written to indicate the new data status. Data marked with a tombstone exists for a configured time period (defined by the gc_grace_seconds value set on the table). When the grace period expires, the compaction process permanently deletes the data. You do not have to manually remove expired data.

Managing the CFS consistency level

The default read and write consistency level for CFS is LOCAL_QUORUM or QUORUM, depending on the keyspace replication strategy, SimpleStrategy or NetworkTopologyStrategy, respectively. You can change the consistency level by specifying a value for dse.consistencylevel.read and dse.consistencylevel.write properties in the `core-site.xml` file.

Using multiple Cassandra File Systems

You can use more than one CFS. Some typical reasons for using an additional CFS are:

- To isolate Hadoop-related jobs
- To configure keyspace replication by job
- To segregate file systems in different physical data centers
- To separate Hadoop data in some other way

Creating an additional CFS

Procedure

1. Open the core-site.xml file for editing.

   The default location of the `core-site.xml` file depends on the type of installation:

Installer-Services and Package installations	`/etc/dse/hadoop/conf/core-site.xml`
Installer-No Services and Tarball installations	*`install_location`*`/resources/hadoop/conf/core-site.xml`

2. Add one or more property elements to `core-site.xml` using this format:

```
<property>
  <name>fs.cfs-<filesystemname>.impl</name>
  <value>com.datastax.bdp.hadoop.cfs.CassandraFileSystem</value>
</property>
```

3. Save the file and restart Cassandra.

   DataStax Enterprise creates the new CFS.
4. To access the new CFS, construct a URL using the following format:

```
cfs-<filesystemname>:<path>
```

   For example, assuming the new file system name is NewCassandraFS use the dse commands to put data on the new CFS.

```
dse hadoop fs -put /tmp/giant_log.gz cfs-NewCassandraFS://cassandrahost/
tmp

dse hadoop fs distcp hdfs:/// cfs-NewCassandraFS:///
```

Configuring DSE Analytics

Guidelines and steps to configure DSE Analytics.

Guidelines and steps to configure all DSE Analytics nodes.

Setting the replication factor

Guidelines and steps to set the replication factor on DSE Analytics nodes.

About this task

The Cassandra File System (CFS) is a Hadoop Distributed File System (HDFS)-compatible storage layer. DataStax Enterprise replaces HDFS with CFS to run MapReduce jobs on Cassandra's peer-to-peer, fault-tolerant, and scalable architecture. CFS is a fundamental piece of infrastructure for all DSE Analytics nodes. For CFS, the three keyspaces are:

- cfs
- cfs_archive
- HiveMetaStore

The default replication factor for the HiveMetaStore, cfs, and cfs_archive system keyspaces is 1.

- A replication factor of 1 using the default data center Analytics is suitable only for development and testing of a single node, but not for a production environment.
- For production clusters, increase the replication factor to at least 3.

The number of nodes in the cluster determines the replication factor, as discussed in Choosing keyspace replication options. To change the replication factors of these keyspaces:

Procedure

1. Change the replication factor of the cfs and cfs_archive keyspaces from 1 to 3, for example:

```
ALTER KEYSPACE cfs
  WITH REPLICATION = {'class' : 'NetworkTopologyStrategy', 'dc1' : 3};


ALTER KEYSPACE cfs_archive
    WITH REPLICATION= {'class' : 'NetworkTopologyStrategy', 'dc1' : 3};
```

2. If you use Hive, update the HiveMetaStore keyspace to increase the replication from 1 to 3, for example:

```
ALTER KEYSPACE "HiveMetaStore"
    WITH REPLICATION= {'class' : 'NetworkTopologyStrategy', 'dc1' : 3};
```

3. Run nodetool repair to avoid having missing data problems or data unavailable exceptions.

What to do next

Ensure that you appropriately configure replication for your environment.

Job Trackers for DSE Hadoop and external Hadoop

Job Trackers are used for analytics nodes that analyze data using Hadoop, including DSE Hadoop and external Hadoop systems.

About this task

Job Trackers are used for analytics nodes that analyze data using Hadoop, including DSE Hadoop and external Hadoop systems.

For each MapReduce job that is submitted to the Job Tracker, DataStax Enterprise schedules a series of tasks on the analytics nodes. One Task Tracker service per node handles the map and reduce tasks that are scheduled for that node. Within a data center, the Job Tracker monitors the execution and status of distributed tasks that comprise a MapReduce job.

Note: If the Job Tracker is not manually set after you enable the automatic Job Tracker setting using the dsetool utility, the Job Tracker is reassigned when the reserve tracker is set.

Using multiple Job Tracker services

You can use multiple Job Tracker nodes in a cluster, one per data center. In deployments that have multiple data centers far away from each other, using multiple Job Trackers and multiple file systems can improve performance by taking advantage of data locality on each cluster.

Tasks related to the Job Tracker are:

- Setting the Job Tracker node
- Managing the Job Tracker using dsetool commands
- Changing the Job Tracker client port

Setting the Job Tracker node

Steps to set the Job Tracker node for all DSE Analytics nodes.

There are several ways to set the Job Tracker node for all DSE Analytics nodes.

- You can configure the Cassandra seeds list. From the IP addresses in the seeds list in the cassandra.yaml file, the first analytics node in the list in each data center is nominated to be the Job Tracker when you start the analytics node.
- You can start up an analytics node using the -j option on a tarball or GUI/Text No Services installation. This option designates the node being started as the Job Tracker node.

  ```
  $ install_location/bin/dse cassandra -t -j
  ```

  You can also use this method on a packaged installation to designate the Job Tracker when starting the analytics node as a standalone process instead of a service.
- You can use the `dsetool setjt` command to explicitly set the Job Tracker nodes.
- You can use the `dsetool autojt` to have DataStax enterprise automatically select Job Trackers.

The location of the cassandra.yaml file depends on the type of installation:

Package installations	`/etc/cassandra/cassandra.yaml`
Tarball installations	`install_location/resources/cassandra/conf/cassandra.yaml`

Hive clients automatically select the correct Job Tracker node on startup. You configure and manage the Job Tracker node for an analytics node using dsetool commands.

About the reserve Job Tracker

DataStax Enterprise nominates a node in the cluster as a reserve Job Tracker for a data center. The reserve Job Tracker becomes the Job Tracker when, for some reason, there is no local node in the data center that can function as Job Tracker.

The `dsetool setrjt` command sets the reserve Job Tracker.

Managing the Job Tracker using dsetool commands

Examples for using dsetool commands to identify and manage Job Tracker nodes.

About this task

Several dsetool commands are useful for managing Job Tracker nodes:

- `dsetool autojt` *datacenter*

If you do not specify the data center name, the command elects Job Trackers for all data centers. Automatically manage Job Tracker selection and remove manual selections. If the current manually selected tracker is up, the manually selected Job Tracker continues to be used.
- `dsetool jobtracker`

  Returns the Job Tracker hostname and port to your location in the data center where you issued the command.
- `dsetool setjt` *node IP*

  Moves the Job Tracker, or the Spark Master, and notifies the Task Tracker nodes of the change.
- `dsetool setrjt` *node IP*

  Moves the reserve Job Tracker and notifies the Task Tracker nodes of the change..
- `dsetool listjt`

  Lists all Job Tracker nodes grouped by their local data center.
- `dsetool ring`

  Lists the nodes and types of the nodes in the ring and the following Job Tracker status:

  - (JT) the active Job Tracker
  - (PT) an inactive primary tracker, when the primary tracker is down
  - (RT) an inactive reserve tracker, when the reserve tracker is up while there is a primary tracker

More dsetool commands and options are described later.

Listing Job Trackers example

To determine which nodes in your DataStax Enterprise cluster are Job Tracker nodes, run the following command:

- **Installer-Services and Package installations:**

  ```
  $ dsetool jobtracker
  ```
- **Installer-No Services and Tarball installations:**

  ```
  $ install_location/bin/dsetool jobtracker
  ```

Moving the Job Tracker node example

If your primary Job Tracker node fails, move the Job Tracker to another analytics node in the cluster. In-progress MapReduce jobs fail when you move the Job Tracker node or when the node goes down.

Procedure

1. Log in to a DataStax Enterprise analytics node.
2. Run the `dsetool setjt` command and specify the IP address of the new Job Tracker node in your DataStax Enterprise cluster. For example, to move the Job Tracker to node 110.82.155.4:

   - **Installer-Services and Package installations:**

     ```
     $ dsetool setjt 110.82.155.4
     ```
   - Installer-No Services and Tarball installations:

     ```
     $ install_location/bin/dsetool setjt 110.82.155.4
     ```
3. Allow 20 seconds for all of the analytics nodes to detect the change and restart their Task Tracker processes.
4. In a browser, connect to the new Job Tracker node and confirm that it is up and running. For example (change the IP to reflect your Job Tracker node IP):

   ```
   http://110.82.155.4:50030
   ```

5. If you are running Hive or Pig MapReduce clients, restart them to pick up the new Job Tracker node information.

Changing the Job Tracker client port

Steps to change the port where the Job Tracker listens for client messages.

About this task

By default, the Job Tracker listens on port 8012 for client messages. To use a port other than the default port 8012, configure the mapred.job.tracker property.

Procedure

1. Open the mapred-site.xml file for editing.

   The default location of the `mapred-site.xml` file depends on the type of installation:

Installer-Services and Package installations	`/etc/dse/hadoop/mapred-site.xml`
Installer-No Services and Tarball installations	*`install_location`*`/resources/hadoop/conf/mapred-site.xml`

2. Locate the mapred.job.tracker property:

   ```
   <!-- Auto detect the dse job tracker -->
   <property>
     <name>mapred.job.tracker</name>
     <value>${dse.job.tracker}</value>
     <description>
       The address of the job tracker
     </description></pre></stepxmp>
   ```

3. In the mapred.job.tracker property, change the placeholder *${dse.job.tracker}* value to the port number that you want to use. For example, change the port number from the default to 8013:

   ```
   <!-- Auto detect the dse job tracker -->
         <property>
           <name>mapred.job.tracker</name>
           <value>8013</value>
           <description>
             The address of the job tracker
           </description>
   ```

Analyzing data using Spark

Spark is the default mode when you start an analytics node in a packaged installation. Spark runs locally on each node.

Spark introduction

Information about Spark architecture and capabilities.

Spark is the default mode when you start an analytics node in a packaged installation. Spark runs locally on each node and executes in memory when possible. Spark uses multiple threads instead of multiple processes to achieve parallelism on a single node, avoiding the memory overhead of several JVMs.

Apache Spark integration includes:

- Spark streaming
- Spark Java API support

- Spark Python API (PySpark) support
- Spark SQL support

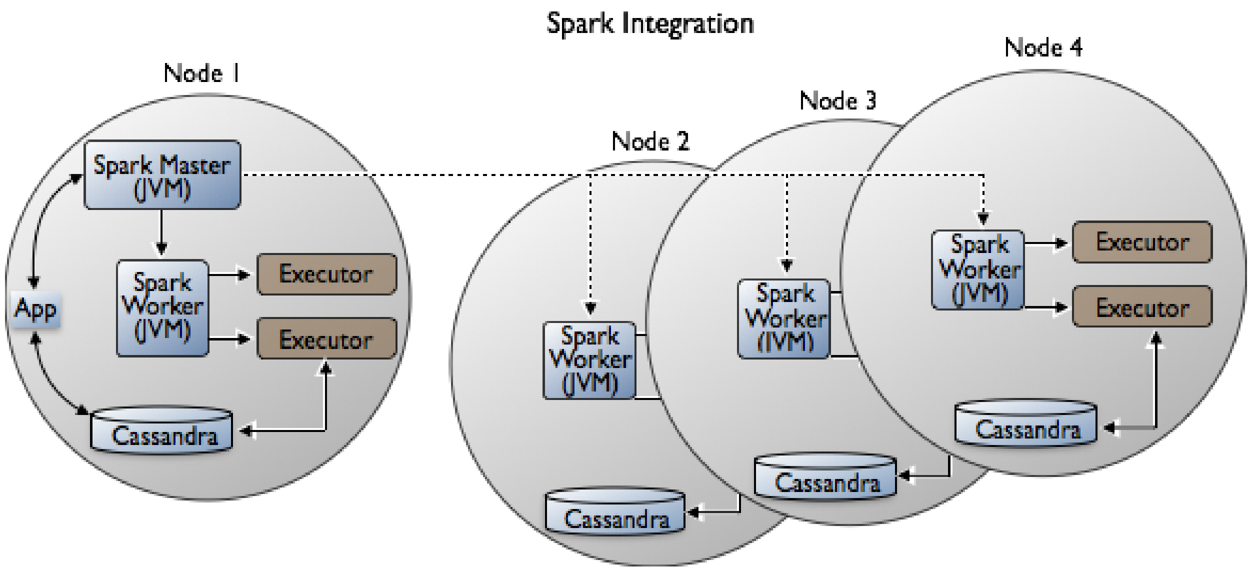
Spark offers performance improvements over previous versions of DataStax Enterprise Analytics using Hadoop. Spark runs locally on each node and executes in memory when possible. Based on Spark's Resilient Distributed Datasets (RDD), Spark can employ RAM for dataset persistence. Spark stores files for chained iteration in memory as opposed to using temporary storage in HDFS, as Hadoop does. Contrary to Hadoop, Spark utilizes multiple threads instead of multiple processes to achieve parallelism on a single node, avoiding the memory overhead of several JVMs. Spark is the default mode when you start an analytics node in a packaged installation.

You use Spark SQL and Apache Shark to query data that is stored in Cassandra clusters, and execute the queries using Spark. From a usage perspective, Spark SQL and Shark, which is being replaced by Spark SQL, are counterparts to Hive. Typically, queries run faster in Spark SQL than in Hive.

Spark architecture

Spark processing resembles Hadoop processing. A Spark Master controls the workflow, and a Spark Worker launches executors responsible for executing part of the job submitted to the Spark Master. Spark architecture is slightly more complex than Hadoop architecture, as described in the Apache documentation. Spark supports multiple applications. A single application can spawn multiple jobs and the jobs run in parallel. An application reserves some resources on every node and these resources are not freed until the application finishes. For example, every session of Spark shell or Shark shell is an application that reserves resources. By default, the scheduler tries allocate the application to the highest number of different nodes. For example, if the application declares that it needs four cores and there are ten servers, each offering two cores, the application most likely gets four executors, each on a different node, each consuming a single core. However, the application can get also two executors on two different nodes, each consuming two cores. The user can configure the application scheduler. Contrary to Hadoop trackers, Spark Workers / Spark Master are spawned as separate processes and are very lightweight. Workers spawn other memory heavy processes that are dedicated to handling queries. Memory settings for those additional processes are fully controlled by the administrator.

In deployment, one analytics node runs the Spark Master, and Spark Workers run on each of the analytics nodes. The Spark Master comes with automatic high availability. Spark executors use native integration to access data in local Cassandra nodes through the Open Source Spark-Cassandra Connector.



Shark uses Hadoop Input/Output formats to access Cassandra data. As you run Spark/Shark, you can access data in the Hadoop Distributed File System (HDFS) or the Cassandra File System (CFS) by using the URL for one or the other.

About the highly available Spark Master

The Spark Master High Availability mechanism uses a special table in the dse_system keyspace to store information required to recover Spark workers and the application. Unlike the high availability mechanism mentioned in Spark documentation, DataStax Enterprise does not use ZooKeeper.

If you enable password authentication in Cassandra, DataStax Enterprise creates special users. The Spark Master process accesses Cassandra through the special users, one per analytics node. The user names begin with the name of the node, followed by an encoded node identifier. The password is randomized.

Do not remove these users or change the passwords because doing so breaks the high availability mechanism.

In DataStax Enterprise, you manage the Spark Master location as you manage the Hadoop Job Tracker. By running a cluster in Spark plus Hadoop mode, the Job Tracker and Spark Master will always work on the same node.

If the original Spark Master fails, the reserved one automatically takes over. You can use the `dsetool setrjt` command to set the reserve Spark Master.

Software components

Software components for a single analytics DataStax Enterprise node are:

- Spark Worker, on all nodes
- Cassandra File System (CFS)
- Cassandra

Unsupported features

The following Spark features and APIs are not supported:

- GraphX
- ODBC

Writing to blob columns from Spark is not supported. Reading columns of all types is supported; however, you must convert collections of blobs to byte arrays before serializing.

Configuring Spark

Setting Spark properties for DataStax Enterprise and Cassandra.

Configuring Spark nodes

Configure Spark nodes in data centers that are separate from nodes running other types of workloads, such as Cassandra real-time and DSE Search.

Spark nodes need to be configured in separate data centers from nodes running other types of workloads, such as Cassandra real-time and DSE Search. To isolate Spark traffic to a subset of dedicated nodes, follow workload isolation guidelines. In separate data centers, you can run Spark and Shark alongside integrated Hadoop or BYOH. However, you cannot run BYOH and integrated Hadoop on the same node.

DataStax recommends using the default values of Spark environment variables unless you need to increase the memory settings due to an `OutOfMemoryError` condition or garbage collection taking too long. The configuration options that you might want to change are in the dse.yaml and spark-env.sh files.

The location of the dse.yaml file depends on the type of installation:

Installer-Services	`/etc/dse/dse.yaml`
Package installations	`/etc/dse/dse.yaml`
Installer-No Services	*`install_location`*`/resources/dse/conf/dse.yaml`
Tarball installations	*`install_location`*`/resources/dse/conf/dse.yaml`

The default location of the `spark-env.sh` file depends on the type of installation:

Installer-Services and Package installations	`/etc/dse/spark/spark-env.sh`
Installer-No Services and Tarball installations	*`install_location`*`/resources/spark/conf/spark-env.sh`

Some of the options you can change to manage Spark performance or operations are:

- Spark directories
- Log directories
- Spark memory and cores

Spark directories

After you start up a Spark cluster, DataStax Enterprise creates a Spark work directory for each Spark Worker on worker nodes. A worker node can have more than one worker, configured by the SPARK_WORKER_INSTANCES option in spark-env.sh. If SPARK_WORKER_INSTANCES is undefined, a single worker will be started. The work directory contains the standard output and standard error of executors and other application specific data stored by Spark Worker and executors; it is writable only by the Cassandra user.

By default, the Spark parent work directory is located in `/var/lib/spark/work`, with each worker in a subdirectory named `worker-`*`number`*, where the number starts at 0. To change the parent worker directory, configure SPARK_WORKER_DIR in the `spark-env.sh` file.

The Spark RDD directory is the directory where RDDs are placed when executors decide to spill them to disk. This directory might contain the data from the database or the results of running Spark applications. If the data in the directory is confidential, prevent access by unauthorized users. The RDD directory might contain a significant amount of data, so configure its location on a fast disk. The directory is writable only by the Cassandra user. The default location of the Spark RDD directory is `/var/lib/spark/rdd`. The directory should be located on a fast disk. To change the RDD directory, configure SPARK_LOCAL_DIRS in the `spark-env.sh` file.

Log directories

The Spark logging directory is the directory where the Spark components store individual log files. DataStax Enterprise places logs in the following locations:

- Executor logs:
  - *`SPARK_WORKER_DIR`*`/worker-`*`n`*`/`*`application_id`*`/`*`executor_id`*`/stderr`
  - *`SPARK_WORKER_DIR`*`/worker-`*`n`*`/`*`application_id`*`/`*`executor_id`*`/stdout`
- Spark Master/Worker logs:
  - Spark Master: the global `system.log`
  - Spark Worker: `SPARK_WORKER_LOG_DIR/worker-`*`n`*`/worker.log`

    SPARK_WORKER_LOG_DIR is set to `/var/log/spark/worker` by default.
- Spark Shell and application logs: console

Configure logging options, such as log levels, in the following files:

- Executors: `logback-spark-executor.xml`
- Spark Master: logback.xml
- Spark Worker: `logback-spark-server.xml`
- Spark Shell, Spark applications: `logback-spark.xml`

The location of the `logback.xml` file depends on the type of installation:

Installer-Services and Package installations	`/etc/dse/cassandra/conf/logback.xml`
Installer-No Services and Tarball installations	*`install_location`*`/resources/cassandra/conf/logback.xml`

Log configuration files are located in the same directory as `spark-env.sh`.

Spark memory and cores

Spark memory options affect different components of the Spark ecosystem:

- Spark Worker memory

  The SPARK_WORKER_MEMORY option configures the total amount of memory that you can assign to all executors that a single Spark Worker runs on the particular node.
- Application executor memory

  You can configure the amount of memory that each executor can consume for the application. Spark uses a 512MB default. Use either the spark.executor.memory option, described in "Spark 1.2.1 Available Properties", or the `--executor-memory <mem>` argument to the dse spark command.

Application memory

You can configure additional Java options that should be applied by the worker when spawning an executor for the application. Use the spark.executor.extraJavaOptions property, described in "Spark 1.2.1 Available Properties". For example: `spark.executor.extraJavaOptions -XX:+PrintGCDetails -Dkey=value -Dnumbers="one two three"`

Management of cores

You can manage the number of cores by configuring these options.

- Spark Worker cores

  The SPARK_WORKER_CORES option configures the number of cores offered by Spark Worker for use by executors. A single executor can borrow more than one core from the worker. The number of cores used by the executor relates to the number of parallel tasks the executor might perform. The number of cores offered by the cluster is the sum of cores offered by all the workers in the cluster.
- Application cores

  In the Spark configuration object of your application, you configure the number of application cores that the application requests from the cluster using either the spark.cores.max configuration property or the `--total-executor-cores <cores>` argument to the dse spark command.

Refer to Spark documentation for a detailed description about memory and core allocation.

DataStax Enterprise can control the memory and cores offered by particular Spark Workers in semi-automatic fashion. The initial_spark_worker_resources parameter in dse.yaml file specifies the fraction of system resources available to the Spark Worker. The available resources are calculated in the following way:

- `Spark Worker memory = initial_spark_worker_resources * (total system memory - memory assigned to Cassandra)`
- `Spark Worker cores = initial_spark_worker_resources * total system cores`

The lowest values you can assign to Spark Worker memory and cores are 64Mb and 1 core, respectively. If the results are lower, no exception is thrown and the values are automatically limited. The range of the initial_spark_worker_resources value is 0.01 to 1. If the range is not specified, the default value 0.7 is used.

This mechanism is used by default to set the Spark Worker memory and cores. To override the default, uncomment and edit one or both SPARK_WORKER_MEMORY and SPARK_WORKER_CORES options in the `spark-env.sh` file.

Deploying nodes for Spark jobs

Before starting up nodes on a tarball installation, you need permission to access the default Spark directory locations: `/var/lib/spark` and `/var/log/spark`. Change ownership of these directories as follows:

```
$ sudo mkdir -p /var/lib/spark; sudo chown -R  $USER: $GROUP /var/lib/spark
$ sudo mkdir -p /var/log/spark; sudo chown -R  $USER: $GROUP /var/log/spark
```

In multiple data center clusters, use a virtual data center to isolate Spark jobs. Running Spark jobs consume resources that can affect latency and throughput. To isolate Spark traffic to a subset of dedicated nodes, follow workload isolation guidelines.

DataStax Enterprise supports the use of Cassandra virtual nodes (vnodes) with Spark.

Setting Cassandra-specific properties

Use the Spark Cassandra Connector options to configure DataStax Enterprise Spark.

Spark integration uses the Spark Cassandra Connector 1.2 under the hood. You can use the configuration options defined in that project to configure DataStax Enterprise Spark. Spark recognizes system properties having the *spark.* prefix and adds the properties to the configuration object implicitly upon creation. You can avoid adding system properties to the configuration object by passing false for the loadDefaults parameter in the SparkConf constructor.

You pass settings for Spark, Spark Shell, and other DSE Spark built-in applications using the intermediate application spark-submit, described in Spark 1.2 documentation.

Configuring the Spark shell

You pass Spark configuration arguments using the following syntax:

```
dse spark [submission arguments] [application arguments]
```

- Submission arguments:
  - --properties-file <path-to-properties-file>

    The location of the properties file having the configuration settings. By default, Spark loads the settings from conf/spark-defaults.conf.
  - --executor-memory <memory>.

    How much memory to allocate on each machine for the application. You can provide the memory argument in JVM format using either the k, m, or g suffix.
  - --total-executor-cores <cores>

    The total number of cores the application uses
  - --conf name=value

    An arbitrary Spark option to the Spark configuration prefixed by *spark.*
  - --help

    Shows a help message that displays all options except DataStax Enterprise Spark shell options.
  - -- jars <additional-jars>

    A comma-separated list of paths to additional jar files.

    - --verbose

      Displays which arguments are recognized as Spark configuration options and which are forwarded to the Spark Shell.
- Spark shell application arguments:
    - -i <file>

      Runs a script from the specified file.

Configuring Spark applications

You pass the Spark submission arguments using the following syntax:

```
dse spark-submit [submission arguments] <application file> [application
 arguments]
```

- All the submission arguments listed in the previous section, and additionally:
-
    - -- class <class-name>

      The full name of the application main class
    - -- name <name>

      The application name as displayed in the Spark web-app
    - -- py-files <files>

      A comma-separated list of the .zip, .egg or .py files, which will be set on PYTHONPATH for Python applications
    - -- files <files>

      A comma-separated list files that are distributed among the executors and available for the application.
    - -- master <master URL>

      The URL of the Spark Master.
- Application file, a JAR or `.py` file that contains the application being run.

  Passed without any control argument; acts as a separator between Spark configuration arguments and custom application arguments.

In general, Spark submission arguments are translated into system properties `-Dname=value` and other VM params like classpath. The application arguments are passed directly to the application.

Spark configuration object

Use the `com.datastax.bdp.spark.DseSparkContext` class to create a Spark context object to connect to DSE clusters. The `DseSparkContext` class is functionally the same as `org.apache.spark.SparkContext`.

```
import com.datastax.bdp.spark.DseSparkContext
import org.apache.spark.SparkConf

object ConfigurationExample extends App {

  def createSparkContext() = {
    val conf = new SparkConf()
     /* set the app name here or by using the --name option when
        you submit the app */
      .setAppName("Configuration example")
      .forDse

    new DseSparkContext(conf)
  }
```

```
    val sc = createSparkContext()

    // ...

    sc.stop()
  }
```

Property list

The following key Cassandra-specific properties are recognized:

spark.cassandra.keyspace
The default keyspace for Spark SQL.

spark.cassandra.connection.native.port
Default = 9042. Port for native client protocol connections.

spark.cassandra.connection.rpc.port
Default = 9160. Port for thrift connections.

spark.cassandra.connection.host
The host name or IP address to which the Thrift RPC service and native transport is bound. The rpc_address property in the cassandra.yaml, which is localhost by default, determines the default value of this property.

Read properties

spark.cassandra.input.split.size
Default = 100000. Approximate number of rows in a single Spark partition. The higher the value, the fewer Spark tasks are created. Increasing the value too much may limit the parallelism level.

spark.cassandra.input.page.row.size
Default = 1000. Number of rows being fetched per roundtrip to Cassandra. Increasing this value increases memory consumption. Decreasing the value increases the number of roundtrips.

spark.cassandra.input.consistency.level
Default = LOCAL_ONE. Consistency level to use when reading.

Write properties

You can set the following properties in SparkConf to fine tune the saving process.

spark.cassandra.output.batch.size.bytes
Default = auto. Number of bytes per single batch. The default, auto, means the connector adjusts the number of bytes based on the amount of data.

spark.cassandra.output.consistency.level
Default = LOCAL_ONE. Consistency level to use when writing.

spark.cassandra.output.concurrent.writes
Default = 5. Maximum number of batches executed in parallel by a single Spark task.

spark.cassandra.output.batch.size.rows
Default = 64K. The maximum total size of the batch in bytes.

Connector 1.2 documentation describes additional, low-level properties.

Using Spark with DataStax Enterprise

DataStax Enterprise integrates with Apache Spark to allow distributed analytic applications to run using Cassandra data.

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Starting Spark

How you start Spark depends on the installation and if want to run in Hadoop mode or SearchAnalytics mode:

How you start Spark depends on the installation and if you want to run in Hadoop mode or SearchAnalytics mode:

Installer-Services and Package installations

To start the Spark trackers on a cluster of analytics nodes, edit the `/etc/default/dse` file to set SPARK_ENABLED to 1.

When you start DataStax Enterprise as a service, the node is launched as a Spark node.

To start a node in Spark and Hadoop mode, edit the `/etc/default/dse` file to set HADOOP_ENABLED and SPARK_ENABLED to 1.

Spark and Hadoop mode should be used only for development purposes.

To start a node in SearchAnalytics mode, edit the `/etc/default/dse` file to set SPARK_ENABLED and SEARCH_ENABLED to 1.

SearchAnalytics mode is experimental, and not recommended for production clusters.

Installer-No Services and Tarball installations:

To start the Spark trackers on a cluster of analytics nodes, use the -k option:

```
$ dse cassandra -k
```

To start a node in Spark and Hadoop mode, use the -k and -t options:

```
$ dse cassandra -k -t
```

Spark and Hadoop mode should only be used for development purposes.

Nodes started with -t or -k are automatically assigned to the default Analytics data center if you do not configure a data center in the snitch property file.

To start a node in SearchAnalytics mode, use the -k and -s options.

```
$ dse cassandra -k -s
```

SearchAnalytics mode is experimental, and not recommended for production clusters.

Starting the node with the Spark or Hadoop option starts a node that is designated as the Job Tracker, as shown by the Analytics(JT) workload in the output of the `dsetool ring` command:

```
$ dsetool ring

Note: Ownership information does not include topology, please specify a
 keyspace.
Address          DC           Rack   Workload      Status  State    Load
 Owns   Token
10.160.137.165   Analytics    rack1  Analytics(JT)    Up    Normal   87.04 KB
 33.33% -9223372036854775808
10.168.193.41    Analytics    rack1  Analytics(TT)    Up    Normal   92.91 KB
 33.33% -3074457345618258603
```

```
10.176.83.32     Analytics    rack1  Analytics(TT)    Up   Normal   94.9 KB
 33.33% 3074457345618258602
```

The default location of the `dsetool` command depends on the type of installation:

Package installations	`/usr/bin/dsetool`
Installer-Services installations	`/usr/bin/dsetool`
Installer-No Services and Tarball installations	`*install_location*/bin/dsetool`

If you use `sudo` to start DataStax Enterprise, remove the `~./spark` directory before you restart the cluster :

```
$ sudo rm -r ~/.spark
```

Launching Spark

After starting a Spark node, use `dse` commands to launch Spark.

The default location of the `dse` tool depends on the type of installation:

Package installations	`/usr/bin/dse`
Installer-Services installations	`/usr/bin/dse`
Installer-No Services and Tarball installations	`*install_location*/bin/dse`

You can use Cassandra specific properties to start Spark. Spark binds to the listen_address that is specified in cassandra.yaml.

The location of the cassandra.yaml file depends on the type of installation:

Package installations	`/etc/cassandra/cassandra.yaml`
Tarball installations	`*install_location*/resources/cassandra/conf/cassandra.yaml`

DataStax Enterprise supports these commands for launching Spark on the DataStax Enterprise command line:

dse spark

Enters interactive Spark shell, offers basic autocompletion.

```
$ dse spark
```

dse spark-submit

Launches applications on a cluster like spark-submit. Replaces the deprecated `dse spark-class` command. Using this interface you can use Spark cluster managers without the need for separate configurations for each application. The syntax is:

```
$ dse spark-submit --class <class name> <jar file> <other_options>
```

For example, if you write a class that defines an option named d, enter the command as follows:

```
$ dse spark-submit --class com.datastax.HttpSparkStream target/
HttpSparkStream.jar -d $NUM_SPARK_NODES
```

Note: The directory in which you run the `dse` Spark commands must be writable by the current user.

To use a user name and password to run an application, use the following syntax:

```
$ dse -u <username> -p <password> spark[-submit]
```

Running Spark commands against a remote cluster

To run Spark commands against a remote cluster, you must copy your Hadoop configuration files from one of the remote nodes to the local client machine.

About this task

To run Spark commands against a remote cluster, you must copy your Hadoop configuration files from one of the remote nodes to the local client machine.

The default location of the Hadoop configuration files depends on the type of installation:

Installer-Services and Package installations	`/etc/dse/hadoop/`
Installer-No Services and Tarball installations	*`install_location`*`/resources/hadoop/conf/`

To run a driver application remotely, there must be full public network communication between the remote nodes and the client machine.

Procedure

1. Copy the files from the remote node to the local machine.

   On a services or package install of DataStax Enterprise:

   ```
   $ cd /etc/dse/hadoop
   $ scp adminuser@node1:/etc/dse/hadoop/* .
   ```
2. Optional: Edit the copied XML configuration files to ensure that the IP address for the Cassandra nodes is a publicly accessible IP address.
3. Run the Spark command against the remote node.

   ```
   $ dse spark-submit submit options myApplication.jar
   ```

   To set the driver host to a publicly accessible IP address, pass in the spark.driver.host option.

   ```
   $ dse spark-submit --conf spark.driver.host=IP address myApplication.jar
   ```

Accessing Cassandra from Spark

DataStax Enterprise integrates Spark with Cassandra. Cassandra tables are fully usable from Spark without Shark.

DataStax Enterprise integrates Spark with Cassandra. Cassandra tables are fully usable from Spark without Shark.

Accessing Cassandra from a Spark application

To access Cassandra from a Spark application, follow instructions in the Spark example Portfolio Manager demo using Spark.

Accessing Cassandra from the Spark shell

DataStax Enterprise uses the Spark Cassandra Connector to provide Cassandra integration for Spark. By running the Spark shell in DataStax Enterprise, you have access to the enriched Spark Context object (sc) for accessing Cassandra directly.

To access Cassandra from the Spark Shell, just run the `dse spark` command and follow instructions in subsequent sections.

```
 $ dse spark
```

```
Welcome to
      ____              __
     / __/__  ___ _____/ /__
    _\ \/ _ \/ _ `/ __/  '_/
   /___/ .__/\_,_/_/ /_/\_\   version 0.9.1
      /_/

Using Scala version 2.10.3 (Java HotSpot(TM) 64-Bit Server VM, Java
 1.7.0_25)
Type in expressions to have them evaluated.
Type :help for more information.
Creating SparkContext...
2014-06-26 22:52:05.295 java[94799:1703] Unable to load realm info from
 SCDynamicStore
Created spark context..
Spark context available as sc.
Type in expressions to have them evaluated.
Type :help for more information.

scala>
```

Using the Spark context

To get a Spark RDD that represents a Cassandra table, load data from a Cassandra table into Spark using the sc-dot (sc.) syntax to call the cassandraTable method on the Spark context.

To get a Spark RDD that represents a Cassandra table, load data from a Cassandra table into Spark using the sc-dot (sc.) syntax to call the `cassandraTable` method on the Spark context, where `sc` represents the Spark API `SparkContext` class.

```
sc.cassandraTable ( "keyspace", "table name" )
```

Cassandra data is mapped into Scala objects and DataStax Enterprise returns a `CassandraRDD[CassandraRow]`. To use the Spark API for creating an application that runs outside DataStax Enterprise, import `com.datastax.spark.connector.SparkContextCassandraFunctions`.

The following example shows how to load a Cassandra table into Spark and read the table in Cassandra from Spark.

1. Create this keyspace and table in Cassandra using `cqlsh`. Use the Analytics data center to create the keyspace.

   ```
   CREATE KEYSPACE test WITH REPLICATION = {'class' :
    'NetworkTopologyStrategy', 'Analytics' : 1};

   CREATE TABLE test.words (word text PRIMARY KEY, count int);
   ```

   This example assumes you start a single-node cluster in Spark mode.
2. Load data into the words table.

   ```
   INSERT INTO test.words (word, count) VALUES ('foo', 10);
   INSERT INTO test.words (word, count) VALUES ('bar', 20);
   ```

3. Assuming you started the node in Spark mode, start the Spark shell. Do not use `sudo` to start the shell.

   ```
   $ bin/dse spark
   ```

   The Welcome to Spark output and scala prompt appears.

4. Use the `showSchema` command to view the user keyspaces and tables in Cassandra.

   ```
   :showSchema
   ```

   Information about all user keyspaces appears.

   ```
   ========================================
    Keyspace: HiveMetaStore
   ========================================
    Table: MetaStore
   ----------------------------------------
    - key    : String              (partition key column)
    - entity : String              (clustering column)
    - value  : java.nio.ByteBuffer


   ========================================
    Keyspace: test
   ========================================
    Table: words
   ----------------------------------------
    - word   : String              (partition key column)
    - count  : Int

   scala> :showSchema test
   ========================================
    Keyspace: test
   ========================================
    Table: words
   ----------------------------------------
    - word  : String (partition key column)
    - count : Int

   scala> :showSchema test words
   ========================================
    Keyspace: test
   ========================================
    Table: words
   ----------------------------------------
    - word  : String (partition key column)
    - count : Int
   ```
5. Get information about only the test keyspace.

   ```
   :showSchema test
   ```

   ```

   ========================================
    Keyspace: test
   ========================================
    Table: words
   ----------------------------------------
    - word  : String (partition key column)
    - count : Int
   ```
6. Get information about the words table.

   ```
   :showSchema test words
   ```

   ```
   ========================================
    Keyspace: test
   ========================================
    Table: words
   ```

```
----------------------------------------
 - word  : String (partition key column)
 - count : Int
```

7. Define a base RDD to point to the data in the test.words table.

```
 val rdd = sc.cassandraTable("test", "words")
```

```
rdd:
 com.datastax.spark.connector.rdd.CassandraRDD[com.datastax.spark.connector.
CassandraRow] = CassandraRDD[0] at RDD at CassandraRDD.scala:47
```

   The RDD is returned in the rdd value. To read the Cassandra table, use this command.

```
 rdd.toArray.foreach(println)
```

```
CassandraRow{word: bar, count: 20}
CassandraRow{word: foo, count: 10}
```

Now, you can use methods on the returned RDD to query the test.words table.

Python support for loading cassandraTables

Python supports loading cassandraTables from a Spark streaming context and saving a DStream to Cassandra.

Reading column values

You can read columns in a Cassandra table using the get methods of the `CassandraRow` object. The get methods access individual column values by column name or column index. Type conversions are applied on the fly. Use `getOption` variants when you expect to receive Cassandra null values.

Continuing with the previous example, follow these steps to access individual column values.

1. Store the first item of the rdd in the firstRow value.

```
 val firstRow = rdd.first
```

```

firstRow: com.datastax.spark.connector.CassandraRow = CassandraRow{word:
 foo, count: 10}
```

2. Get the column names.

```
 rdd.columnNames
```

```
res3: com.datastax.spark.connector.ColumnSelector = AllColumns
```

3. Use a generic get to query the table by passing the return type directly.

```
 firstRow.get[Int]("count")
```

```
res4: Int = 10
```

```
 firstRow.get[Long]("count")
```

```
res5: Long = 10
```

```
 firstRow.get[BigInt]("count")
```

```
res6: BigInt = 10
```

```
firstRow.get[java.math.BigInteger]("count")
```

```
res7: java.math.BigInteger = 10
```

```
firstRow.get[Option[Int]]("count")
```

```
res8: Option[Int] = Some(10)
```

```
firstRow.get[Option[BigInt]]("count")
```

```
res9: Option[BigInt] = Some(10)
```

Reading collections

You can read collection columns in a Cassandra table using the get methods of the `CassandraRow` object. The get methods access the collection column and returns a corresponding Scala collection.

Assuming you set up the test keyspace earlier, follow these steps to access a Cassandra collection.

1. In the test keyspace, set up a collection set using `cqlsh`.

   ```
   CREATE TABLE test.users (
     username text PRIMARY KEY, emails SET<text>);

   INSERT INTO test.users (username, emails)
     VALUES ('someone', {'someone@email.com', 's@email.com'});
   ```

2. If Spark is not running, start the Spark shell. Do not use `sudo` to start the shell.

   ```
   $ bin/dse spark
   ```

   The Welcome to Spark output and scala prompt appears.
3. Define a CassandraRDD[CassandraRow] to access the collection set.

   ```
   val row = sc.cassandraTable("test", "users").toArray.apply(0)
   ```

   ```
   row: com.datastax.spark.connector.CassandraRow = CassandraRow{username:
    someone,
   emails: {s@email.com,someone@email.com}}
   ```
4. Query the collection set in Cassandra from Spark.

   ```
   row.getList[String]("emails")
   ```

   ```
   res2: Vector[String] = Vector(s@email.com, someone@email.com)
   ```

   ```
   row.get[List[String]]("emails")
   ```

   ```
   res3: List[String] = List(s@email.com, someone@email.com)
   ```

   ```
   row.get[Seq[String]]("emails")
   ```

```
res4: Seq[String] = List(s@email.com, someone@email.com)
```

```
 row.get[IndexedSeq[String]]("emails")
```

```
res5: IndexedSeq[String] = Vector(s@email.com, someone@email.com)
```

```
 row.get[Set[String]]("emails")
```

```
res6: Set[String] = Set(s@email.com, someone@email.com)
```

```
 row.get[String]("emails")
```

```
res7: String = {s@email.com,someone@email.com}
```

Restricting the number of fetched columns

For performance reasons, you should not fetch columns you don't need. You can achieve this with the `select` method:

To restrict the number of fetched columns:

```
 val row = sc.cassandraTable("test", "users").select("username").toArray
```

```
row: Array[com.datastax.spark.connector.CassandraRow] =
 Array(CassandraRow{username: someone})
```

Mapping rows to tuples and case classes

Instead of mapping your Cassandra rows to objects of the `CassandraRow` class, you can directly unwrap column values into tuples of the desired type.

To map rows to tuples:

```
 sc.cassandraTable[(String, Int)]("test", "words").select("word",
  "count").toArray
```

```
res9: Array[(String, Int)] = Array((bar,20), (foo,10))
```

```
 sc.cassandraTable[(Int, String)]("test", "words").select("count",
  "word").toArray
```

```
res10: Array[(Int, String)] = Array((20,bar), (10,foo))
```

Define a case class with properties of the same name as the Cassandra columns. For multi-word column identifiers, separate each word using an underscore in Cassandra, and use camel case abbreviation on the Scala side.

To map rows to case classes:

```
 case class WordCount(word: String, count: Int)
```

```
defined class WordCount
```

```
 scala> sc.cassandraTable[WordCount]("test", "words").toArray
```

```
res14: Array[WordCount] = Array(WordCount(bar,20), WordCount(foo,20))
```

You can name columns in Cassandra using these conventions:

- Use the underscore convention and lowercase letters. (Recommended)
- Use the camel case convention, exactly the same as properties in Scala.

The following examples show valid column names.

Table 7: Recommended naming convention

Cassandra column name	Scala property name
count	count
column_1	column1
user_name	userName
user_address	UserAddress

Table 8: Alternative naming convention

Cassandra column name	Scala property name
count	count
column1	column1
userName	userName
UserAddress	UserAddress

Mapping rows to objects with a user-defined function

Invoke `as` on the `CassandraRDD` to map every row to an object of a different type. Contrary to map, `as` expects a function having the same number of arguments as the number of columns to be fetched. Invoking `as` in this way performs type conversions. Using `as` to directly create objects of a particular type eliminates the need to create `CassandraRow` objects and also decreases garbage collection pressure.

To map columns using a user-defined function:

```
 val table = sc.cassandraTable("test", "words")
```

```
table:
 com.datastax.spark.connector.rdd.CassandraRDD[com.datastax.spark.connector.
CassandraRow] = CassandraRDD[9] at RDD at CassandraRDD.scala:47
```

```
 val total = table.select("count").as((c: Int) => c).sum
```

```
total: Double = 30.0
```

```
 val frequencies = table.select("word", "count").as((w: String, c: Int) =>
  (w, c / total)).toArray
```

```
frequencies: Array[(String, Double)] = Array((bar,0.6666666666666666),
 (foo,0.3333333333333333))
```

Filtering rows on the server

To filter rows, you can use the filter transformation provided by Spark. Filter transformation fetches all rows from Cassandra first and then filters them in Spark. Some CPU cycles are wasted serializing and deserializing objects excluded from the result. To avoid this overhead, `CassandraRDD` has a method that passes an arbitrary CQL condition to filter the row set on the server.

This example shows how to use Spark to filter rows on the server.

1. Download and unzip the CQL commands for this example. The commands in this file perform the following tasks:
   - Create a cars table in the test keyspace.
   - Index the color column.
   - Insert some data into the table
2. Run the `test_cars.cql` file using `cqlsh` or DevCenter. For example using `cqlsh`:

   ```
   $ cqlsh -f test_cars.cql
   ```
3. Filter the rows using Spark:

   ```
    sc.cassandraTable("test", "cars").select("id", "model").where("color = ?",
     "black").toArray.foreach(println)
   ```

   ```
   CassandraRow{id: AS-8888, model: Aston Martin DB9 Volante}
   CassandraRow{id: KF-334L, model: Ford Mondeo}
   CassandraRow{id: MT-8787, model: Hyundai x35}
   CassandraRow{id: MZ-1038, model: Mazda CX-9}
   CassandraRow{id: DG-2222, model: Dodge Avenger}
   CassandraRow{id: DG-8897, model: Dodge Charger}
   CassandraRow{id: BT-3920, model: Bentley Continental GT}
   CassandraRow{id: IN-9964, model: Infinity FX}
   ```

   ```
    sc.cassandraTable("test", "cars").select("id", "model").where("color = ?",
     "silver").toArray.foreach(println)
   ```

   ```
   CassandraRow{id: FR-8877, model: Ferrari FF}
   CassandraRow{id: FR-8877, model: Ferrari FF}
   CassandraRow{id: HD-1828, model: Honda Accord}
   CassandraRow{id: WX-2234, model: Toyota Yaris}
   ```

Saving data to Cassandra

With DataStax Enterprise, you can save almost any RDD to Cassandra. Before you use the RDD in a standalone application, import com.datastax.spark.connector.

With DataStax Enterprise, you can save almost any RDD to Cassandra. Unless you do not provide a custom mapping, the object class of the RDD must be a tuple or have property names corresponding to Cassandra column names. To save the RDD, call the saveToCassandra method with a keyspace name, table name, and optionally, a list of columns. Before attempting to use the RDD in a standalone application, import com.datastax.spark.connector.

Saving a collection of tuples

The following example shows how to save a collection of tuples to Cassandra.

```
scala> val collection = sc.parallelize(Seq(("cat", 30), ("fox", 40)))
collection: org.apache.spark.rdd.RDD[(String, Int)] =
 ParallelCollectionRDD[6] at parallelize at <console>:22

scala> collection.saveToCassandra("test", "words", SomeColumns("word",
 "count"))
```

```
scala>
```

At the last scala prompt in this example, no output means that the data was saved to Cassandra.

In cqlsh, query the words table to select all the contents.

```
SELECT * FROM test.words;

 word | count
------+-------
  bar |    20
  foo |    10
  cat |    30
  fox |    40

(4 rows)
```

Saving a collection of case class objects to Cassandra

The following example shows how to save a collection of case class objects.

```
scala> case class WordCount(word: String, count: Long)
defined class WordCount

scala> val collection = sc.parallelize(Seq(WordCount("dog", 50),
 WordCount("cow", 60)))
collection: org.apache.spark.rdd.RDD[WordCount] = ParallelCollectionRDD[0]
 at parallelize at <console>:24

scala> collection.saveToCassandra("test", "words", SomeColumns("word",
 "count"))

scala>
```

In cqlsh, query the words table to select all the contents.

```
SELECT * FROM test.words;

 word | count
------+-------
 bar |    20
 foo |    10
 cat |    30
 fox |    40
 dog |    50
 cow |    60
```

Using non-default property-name to column-name mappings

Mapping rows to tuples and case classes work out-of-the box, but in some cases, you might need more control over Cassandra-Scala mapping. For example, Java classes are likely to use the JavaBeans naming convention, where accessors are named with *get*, *is* or *set* prefixes. To customize column-property mappings, put an appropriate ColumnMapper[YourClass] implicit object in scope. Define such an object in a companion object of the class being mapped. The ColumnMapper affects both loading and saving data. DataStax Enterprise includes a few ColumnMapper implementations.

Working with JavaBeans

To work with Java classes, use JavaBeanColumnMapper. Make sure objects are serializable; otherwise Spark cannot send them over the network. The following example shows how to use the JavaBeanColumnMapper.

To use JavaBean style accessors:

```
scala> :paste
// Entering paste mode (ctrl-D to finish)
```

Paste this import command and class definition:

```
    import com.datastax.spark.connector.mapper.JavaBeanColumnMapper
    class WordCount extends Serializable {
      private var _word: String = ""
      private var _count: Int = 0
      def setWord(word: String) { _word = word }
      def setCount(count: Int) { _count = count }
      override def toString = _word + ":" + _count
    }
    object WordCount {
      implicit object Mapper extends JavaBeanColumnMapper[WordCount]
    }
```

Enter CTRL D to exit paste mode. The output is:

```
    // Exiting paste mode, now interpreting.

    import com.datastax.spark.connector.mapper.JavaBeanColumnMapper
    defined class WordCount
    defined module WordCount

    scala>
```

Query the WordCount object.

```
sc.cassandraTable[WordCount]("test", "words").toArray
res18: Array[WordCount] = Array(cow:60, bar:20, foo:10, cat:30, fox:40,
 dog:50)
```

To save the data, you need to define getters.

Manually specifying a property-name to column-name relationship

If for some reason you want to associate a property with a column of a different name, pass a column translation map to the DefaultColumnMapper or JavaBeanColumnMapper.

To change column names:

```
scala> :paste
// Entering paste mode (ctrl-D to finish)

import com.datastax.spark.connector.mapper.DefaultColumnMapper
case class WordCount(w: String, c: Int)
object WordCount { implicit object Mapper extends
DefaultColumnMapper[WordCount](Map("w" -> "word", "c" -> "count")) }
```

Enter CTRL D.

```
// Exiting paste mode, now interpreting.
```

```
import com.datastax.spark.connector.mapper.DefaultColumnMapper
defined class WordCount
defined module WordCount
```

Continue entering these commands:

```
scala> sc.cassandraTable[WordCount]("test", "words").toArray
res21: Array[WordCount] = Array(WordCount(cow,60), WordCount(bar,20),
 WordCount(foo,10), WordCount(cat,30), WordCount(fox,40), WordCount(dog,50))

scala>
 sc.parallelize(Seq(WordCount("bar",20),WordCount("foo",40))).saveToCassandra("test",
 "words", SomeColumns("word", "count"))

scala>
```

Writing custom ColumnMappers

To define column mappings for your classes, create an appropriate implicit object implementing ColumnMapper[YourClass] trait.

Using the Cassandra context

The Cassandra context is removed in DataStax Enterprise 4.7. Instead, use the Spark context to create a CassandraRDD.

The Cassandra context is removed in DataStax Enterprise 4.7. Instead, use the Spark context to create a CassandraRDD.

Monitoring Spark with the web interface

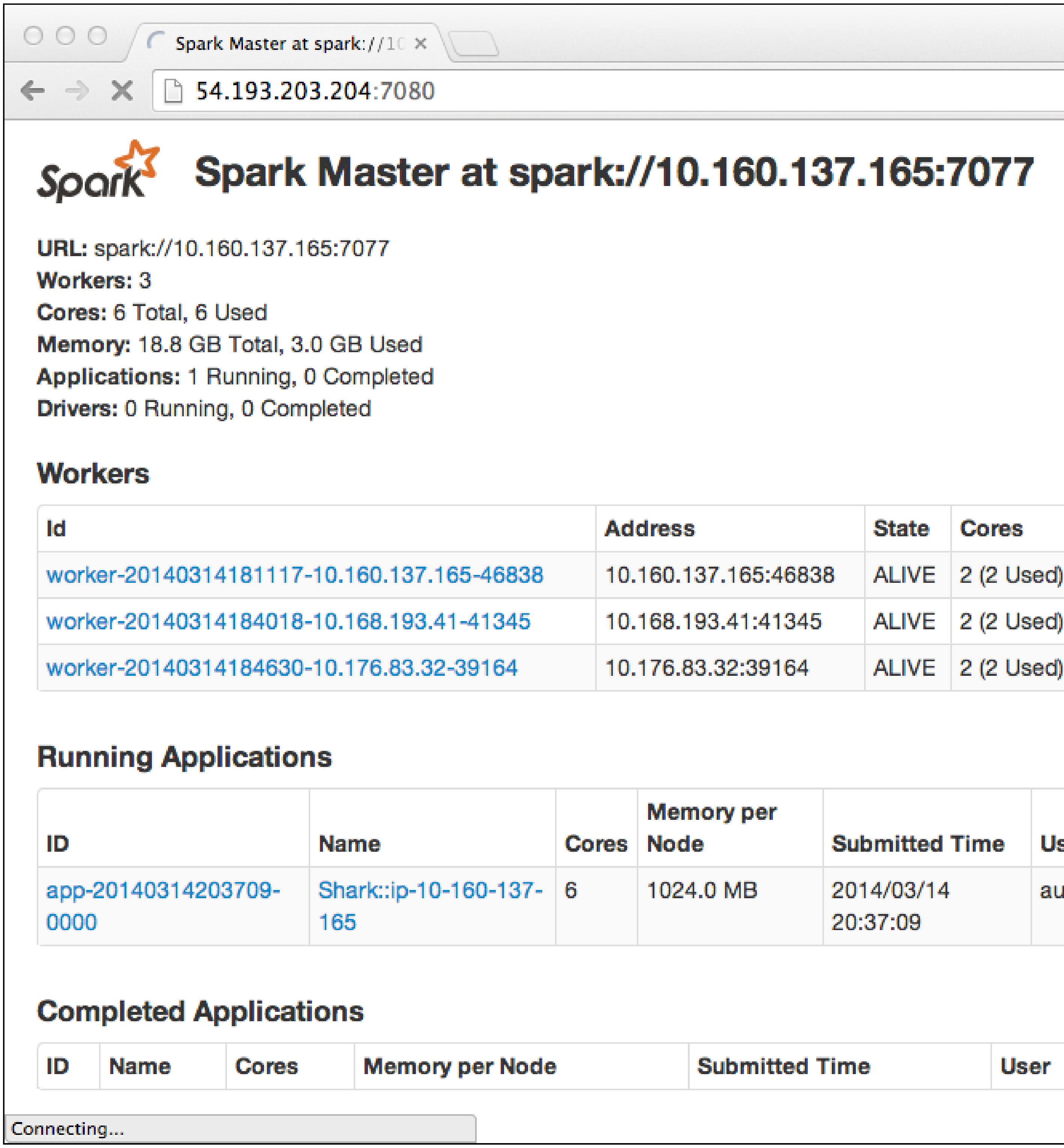
A Spark web interface is bundled with DataStax Enterprise. The Spark web interface facilitates monitoring, debugging, and managing Spark and Shark.

A Spark web interface, bundled with DataStax Enterprise, facilitates monitoring, debugging, and managing Spark and Shark.

Using the Spark web interface

To use the Spark web interface:

- Enter the public IP address of the Spark Master node in a browser followed by port number 7080.
- To change the port, modify the `spark-env.sh` configuration file.



Spark Master at spark://10.160.137.165:7077

URL: spark://10.160.137.165:7077
Workers: 3
Cores: 6 Total, 6 Used
Memory: 18.8 GB Total, 3.0 GB Used
Applications: 1 Running, 0 Completed
Drivers: 0 Running, 0 Completed

Workers

Id	Address	State	Cores
worker-20140314181117-10.160.137.165-46838	10.160.137.165:46838	ALIVE	2 (2 Used)
worker-20140314184018-10.168.193.41-41345	10.168.193.41:41345	ALIVE	2 (2 Used)
worker-20140314184630-10.176.83.32-39164	10.176.83.32:39164	ALIVE	2 (2 Used)

Running Applications

ID	Name	Cores	Memory per Node	Submitted Time	Us
app-20140314203709-0000	Shark::ip-10-160-137-165	6	1024.0 MB	2014/03/14 20:37:09	au

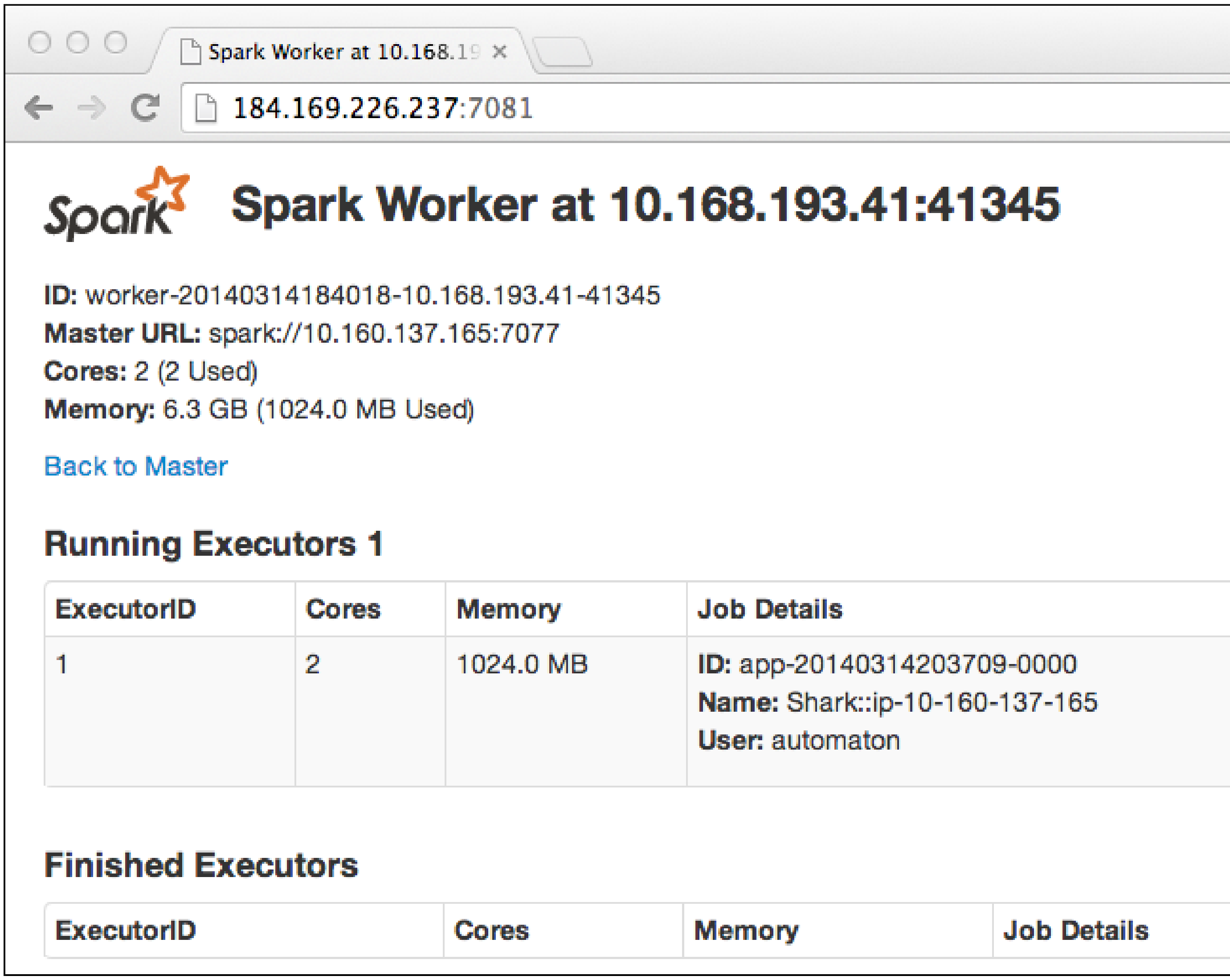
Completed Applications

ID	Name	Cores	Memory per Node	Submitted Time	User

Spark Worker nodes and debugging logs

- In the Spark Master node page, click the ID of a worker node, in this example worker-20140314184018-10.168.193.41-41345. The Spark Worker page for the node appears. In this web interface, you see detailed information about apps that are running. For example, while running Shark queries in the earlier example, the Spark Worker shows details about the Shark job.

In this example, the Workers section lists three registered nodes. The misleading summary information in the top left corner of the page covers alive and dead workers.



Spark Worker at 10.168.193.41:41345

ID: worker-20140314184018-10.168.193.41-41345
Master URL: spark://10.160.137.165:7077
Cores: 2 (2 Used)
Memory: 6.3 GB (1024.0 MB Used)

Back to Master

Running Executors 1

ExecutorID	Cores	Memory	Job Details
1	2	1024.0 MB	**ID:** app-20140314203709-0000 **Name:** Shark::ip-10-160-137-165 **User:** automaton

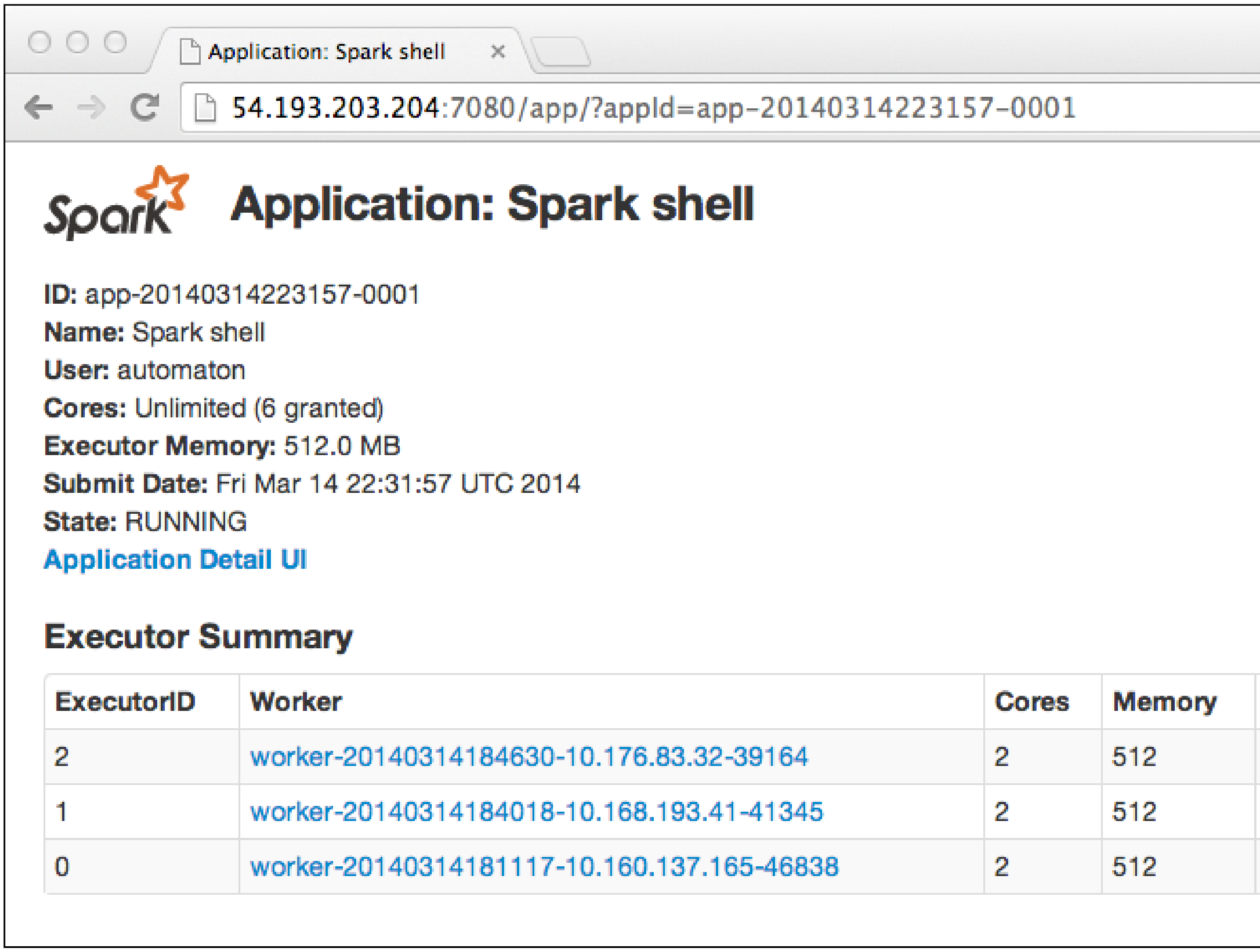
Finished Executors

ExecutorID	Cores	Memory	Job Details

- To get debugging information, click the **stdout** or **stderr** links in the Logs column.

Application: Spark shell

After starting a Spark context, you can see the status of the worker, which can be useful for debugging. The interface also shows the memory that is required for apps that are running, so you can adjust which apps you run to meet your needs.



Application: Spark shell

ID: app-20140314223157-0001
Name: Spark shell
User: automaton
Cores: Unlimited (6 granted)
Executor Memory: 512.0 MB
Submit Date: Fri Mar 14 22:31:57 UTC 2014
State: RUNNING
Application Detail UI

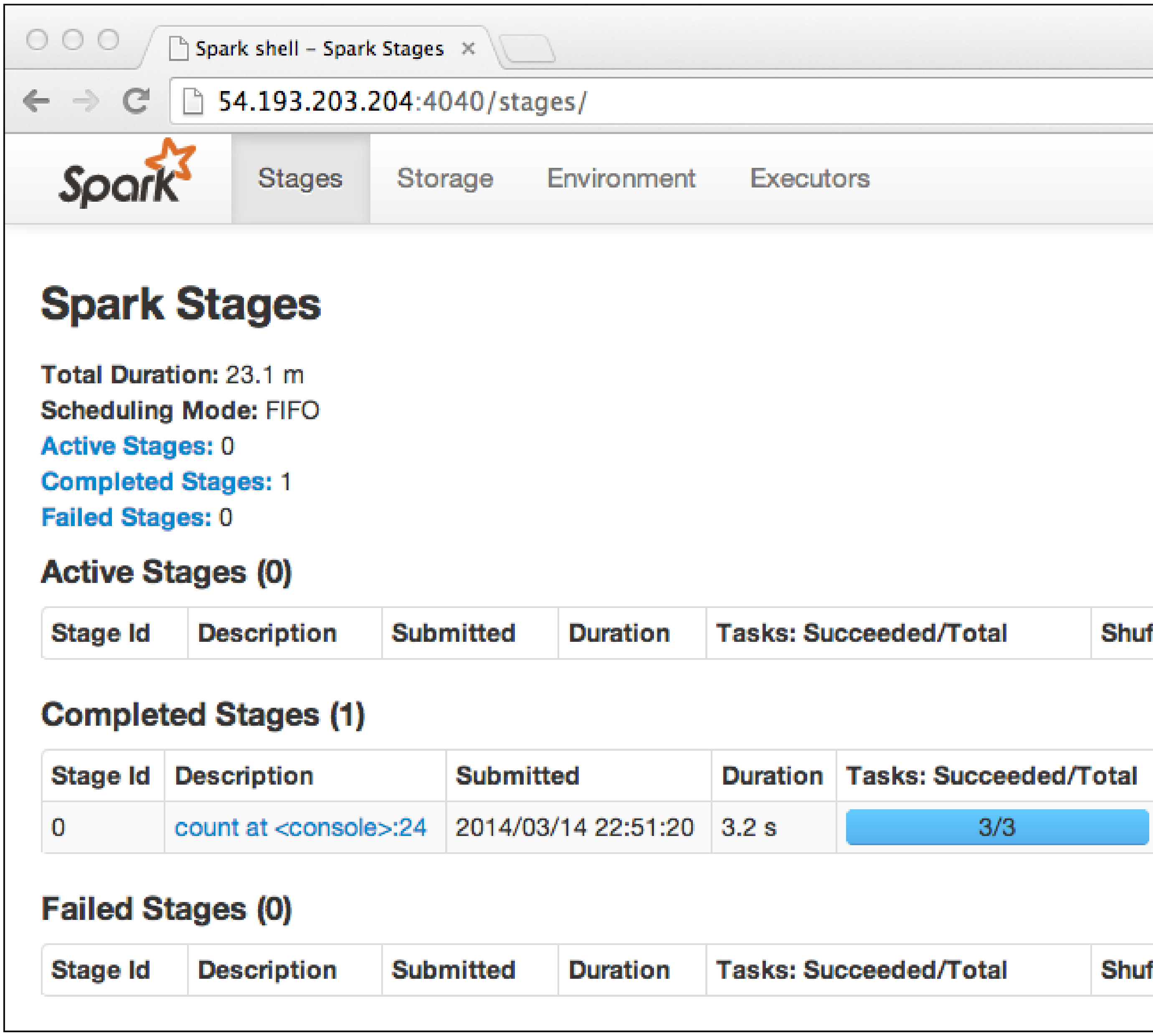
Executor Summary

ExecutorID	Worker	Cores	Memory
2	worker-20140314184630-10.176.83.32-39164	2	512
1	worker-20140314184018-10.168.193.41-41345	2	512
0	worker-20140314181117-10.160.137.165-46838	2	512

Spark Stages: Application progress

- To see the progress of applications that are running, click the name of application to see every query that was executed with detailed information about how the data got distributed that might be valuable for debugging.
- On a port, not necessarily port 4040 as shown here, you can view Spark stages.

  When you run multiple applications at the same time Spark tries to use subsequent ports starting at 4040, for example 4040, 4041, and so on.



Spark Stages

Total Duration: 23.1 m
Scheduling Mode: FIFO
Active Stages: 0
Completed Stages: 1
Failed Stages: 0

Active Stages (0)

Stage Id	Description	Submitted	Duration	Tasks: Succeeded/Total	Shuf

Completed Stages (1)

Stage Id	Description	Submitted	Duration	Tasks: Succeeded/Total
0	count at <console>:24	2014/03/14 22:51:20	3.2 s	3/3

Failed Stages (0)

Stage Id	Description	Submitted	Duration	Tasks: Succeeded/Total	Shuf

Spark supported types

Spark supported CQL types are mapped to Scala types.

This table maps CQL types to Scala types. All CQL types are supported by the DataStax Enterprise Spark integration. Other type conversions might work, but cause loss of precision or not work for all values. Most types are convertible to strings. You can convert strings that conform to the CQL standard to numbers, dates, addresses or uuids. You can convert maps to or from sequences of key-value tuples.

Table 9: Supported types

CQL Type	Scala Type
ascii	String
bigint	Long
blob	ByteBuffer, Array

CQL Type	Scala Type
boolean	Boolean
counter	Long
decimal	BigDecimal, java.math.BigDecimal
double	Double
float	Float
inet	java.net.InetAddress
int	Int
list	Vector, List, Iterable, Seq, IndexedSeq, java.util.List
map	Map, TreeMap, java.util.HashMap
set	Set, TreeSet, java.util.HashSet
text, varchar	String
timestamp	Long, java.util.Date, java.sql.Date, org.joda.time.DateTime
timeuuid	java.util.UUID
uuid	java.util.UUID
varint	BigInt, java.math.BigInteger
nullable values	Option

Using Spark SQL to query data

Spark SQL allows you to execute Spark queries using a variation of the SQL language. Spark SQL includes APIs for Scala and Java.

Spark SQL basics

In DataStax Enterprise, Spark SQL allows you to perform relational queries over data stored in Cassandra clusters, and executed using Spark. Spark SQL is a unified relational query language for transversing over Spark Resilient Distributed Datasets (RDDs), and supports a variation of the SQL language used in relational databases. It is intended as a replacement for Shark and Hive, including the ability to run Hive QL queries over RDDs. You can use traditional Spark applications in conjunction with Spark SQL queries to analyze large data sets.

The `SqlContext` class and its subclasses are the entry point for running relational queries in Spark. `SqlContext` instances are created from a `SparkContext` instance. The `CassandraSQLContext` class is a subclass of `SqlContext` and allows you to run these queries against a Cassandra data source.

Spark SQL uses a special type of RDD called `SchemaRDD`, and are similar to tables in a traditional relational database. A `SchemaRDD` consists of object data and a schema that describes the data types of the objects. You can create `SchemaRDD` instances from existing Spark RDDs. Once a `SchemaRDD` has been applied to a `SqlContext`, it can be registered as a table, and SQL queries can be run against it.

Starting the Spark SQL shell

The Spark SQL shell allows you to interactively perform Spark SQL queries. To start the shell, run `dse spark-sql`:

```
$ dse spark-sql
```

Querying Cassandra data using Spark SQL in Scala

You can execute Spark SQL queries in Scala by starting the Spark shell. When you start Spark, DataStax Enterprise sets the context to allow you to run Spark SQL queries against Cassandra tables.

About this task

When you start Spark, DataStax Enterprise sets the context to allow you to run Spark SQL queries against Cassandra tables. Use the `setKeyspace` method to connect to a Cassandra keyspace, and then use the `sql` method to execute the query.

Procedure

1. Start the Spark shell.

   ```
   $ dse spark
   ```
2. Set the keyspace you'd like to query using the `setKeyspace` method.

   ```
   csc.setKeyspace("my_keyspace_name")
   ```
3. Use the `sql` method to pass in the query, storing the result in a variable.

   ```
   val results = csc.sql("SELECT * from my_keyspace_name.my_table")
   ```
4. Use the returned data.

   ```
   results.collect().foreach(println)
   ```

   ```
   CassandraRow{type_id: 1, value: 9685.807}
   CassandraRow{type_id: 2, value: -9775.808}
   ```

Querying Cassandra data using Spark SQL in Java

You can execute Spark SQL queries in Java applications that traverse over Cassandra column families. Java applications that query Cassandra data using Spark SQL require a Spark configuration instance and Spark context instance.

Java applications that query Cassandra data using Spark SQL first need a Spark configuration instance and Spark context instance.

Create the Spark configuration object by calling the `enrichSparkConf` method of `com.datastax.bdp.spark.DseSparkConfHelper`, creating a new default `SparkConf` object. `DseSparkConfHelper` is found in dse.jar. The returned `SparkConf` instance is automatically configured for your cluster, including the Spark Master and Cassandra host. This can then be used to create a new `com.datastax.bdp.spark.DseSparkContext` object. `DseSparkContext` automatically adjusts your configuration for DataStax Enterprise. It is also located in `dse.jar`.

The default location of the `dse.jar` file depends on the type of installation:

Installer-Services and Package installations	`/usr/share/dse/dse.jar`
Installer-No Services and Tarball installations	*`install_location`*`/lib/dse.jar`

This Spark context object is used to create a Cassandra-aware Spark SQL context object to connect to Cassandra. This object is an instance of `org.apache.spark.sql.cassandra.CassandraSQLContext`.

```
// create a new configuration
SparkConf conf = DseSparkConfHelper.enrichSparkConf(new SparkConf())
                .setAppName( "My application");
// create a Spark context
DseSparkContext sc = new DseSparkContext(conf);
// create a Cassandra Spark SQL context
```

```
CassandraSQLContext cassandraSQLContext = new CassandraSQLContext(sc);
```

Once the Spark SQL context has been created, you can use it to register RDDs and execute Spark SQL queries. Queries are executed by calling the `CassandaSQLContext.sql` method. You can register an RDD as a table by calling `SchemaRDD.registerTempTable` to perform further Spark SQL queries on the results.

```
SchemaRDD employees = cassandraContext.sql("SELECT * FROM
 company.employees");
employees.registerTempTable("employees");
SchemaRDD managers = cassandraContext.sql("SELECT name FROM employees WHERE
 role == 'Manager' ");
```

The returned RDD objects support the standard RDD operations.

```
List<String> managerNames = managers.map(new Function<Row, String>() {
    public String call(Row row) {
        return "Name: " + row.getString(0);
    }
}).collect();
```

Supported syntax of Spark SQL

Spark SQL supports a subset of the SQL-92 language.

The following syntax defines a `SELECT` query.

```
SELECT [DISTINCT] [column names]|[wildcard]
FROM [kesypace name.]table name
[JOIN clause table name ON join condition]
[WHERE condition]
[GROUP BY column name]
[HAVING conditions]
[ORDER BY column names [ASC | DSC]]
```

A `SELECT` query using joins has the following syntax.

```
SELECT statement
FROM statement
[JOIN | INNER JOIN | LEFT JOIN | LEFT SEMI JOIN | LEFT OUTER JOIN | RIGHT
 JOIN | RIGHT OUTER JOIN | FULL JOIN | FULL OUTER JOIN]
ON join condition
```

Several select clauses can be combined in a `UNION`, `INTERSECT`, or `EXCEPT` query.

```
SELECT statement 1
[UNION | UNION ALL | UNION DISTINCT | INTERSECT | EXCEPT]
SELECT statement 2
```

Note: Select queries run on new columns return `''`, or empty results, instead of None.

The following syntax defines an `INSERT` query.

```
INSERT [OVERWRITE] INTO [keyspace name.]table name [(columns)]
VALUES values
```

The following syntax defines a `CACHE TABLE` query.

```
CACHE TABLE table name [AS table alias]
```

You can remove a table from the cache using a `UNCACHE TABLE` query.

```
UNCACHE TABLE table name
```

Keywords in Spark SQL

The following keywords are reserved in Spark SQL.

ALL
AND
AS
ASC
APPROXIMATE
AVG
BETWEEN
BY
CACHE
CAST
COUNT
DESC
DISTINCT
FALSE
FIRST
LAST
FROM
FULL
GROUP
HAVING
IF
IN
INNER
INSERT
INTO
IS
JOIN
LEFT
LIMIT
MAX
MIN
NOT
NULL
ON
OR
OVERWRITE
LIKE
RLIKE
UPPER
LOWER
REGEXP
ORDER
OUTER

RIGHT
SELECT
SEMI
STRING
SUM
TABLE
TIMESTAMP
TRUE
UNCACHE
UNION
WHERE
INTERSECT
EXCEPT
SUBSTR
SUBSTRING
SQRT
ABS

Running HiveQL queries using Spark SQL

Spark SQL supports queries that are written using HiveQL, a SQL-like language that produces queries that are converted to Spark jobs.

About this task

Spark SQL supports queries written using HiveQL, a SQL-like language that produces queries that are converted to Spark jobs. HiveQL is more mature and supports more complex queries than Spark SQL. To construct a HiveQL query, first create a new `HiveContext` instance, and then submit the queries by calling the `sql` method on the `HiveContext` instance.

See the Hive Language Manual for the full syntax of HiveQL.

Note: Creating indexes with `DEFERRED REBUILD` is not supported in Spark SQL.

Procedure

1. Start the Spark shell.

```
$ bin/dse spark
```

2. Use the provided `HiveContext` instance hc to create a new query in HiveQL by calling the `sql` method on the hc object..

```
scala> val results = hc.sql("SELECT * FROM my_keyspace.my_table")
```

Getting started with Spark Streaming

Spark Streaming allows you to consume live data streams from sources, including Akka, Kafka, and Twitter. This data can then be analyzed by Spark applications, and the data can be stored in Cassandra. This example uses Scala.

About this task

Spark Streaming allows you to consume live data streams from sources, including Akka, Kafka, and Twitter. This data can then be analyzed by Spark applications, and the data can be stored in Cassandra.

You use Spark Streaming by creating a `org.apache.spark.streaming.StreamingContext` instance based on your Spark configuration. You then create a `DStream` instance, or a *discretionized stream*, an object that represents an input stream. `DStream` objects are created by calling one of the methods of `StreamingContext`, or using a utility class from external libraries to connect to other sources like Twitter.

The data you consume and analyze is saved to Cassandra by calling one of the `saveToCassandra` methods on the stream object, passing in the keyspace name, the table name, and optionally the column names and batch size.

The following Scala example demonstrates how to connect to a text input stream at a particular IP address and port, count the words in the stream, and saves the results to Cassandra.

Procedure

1. Create a new StreamingContext object based on an existing SparkConf configuration object, specifying the interval in which streaming data will be divided into batches by passing in a batch duration.

   ```
   val sparkConf = ....
   val ssc = new StreamingContext(sparkConf, Seconds(1))
   ```

   Spark allows you to specify the batch duration in milliseconds, seconds, and minutes.
2. Import the Cassandra-specific functions for `StreamingContext`, `DStream`, and RDD objects.

   ```
   import com.datastax.spark.connector.streaming._
   ```

3. Create the `DStream` object that will connect to the IP and port of the service providing the data stream.

   ```
   val lines = ssc.socketTextStream(server IP address, server port number)
   ```

4. Count the words in each batch and save the data to the Cassandra table.

   ```
   val words = lines.flatMap(_.split(" "))
   val pairs = words.map(word => (word, 1))
   val wordCounts = pairs.reduceByKey(_ + _)
                         .saveToCassandra("streaming_test", "words_table",
    SomeColumns("word", "count"))
   ```

5. Start the computation.

   ```
   ssc.start()
   ssc.awaitTermination()
   ```

Example

In the following example, you will start a service using the nc utility that repeats strings, then consume the output of that service using Spark Streaming.

In a terminal window, enter the following command to start the service:

```
$ nc -lk 9999
one two two three three three four four four four someword
```

In a different terminal start a Spark shell.

```
$ bin/dse spark
```

In the Spark shell enter the following:

```
 import org.apache.spark._
 import org.apache.spark.streaming._
 import org.apache.spark.streaming.StreamingContext._
 import com.datastax.spark.connector.streaming._
 import com.datastax.spark.connector.cql.CassandraConnector
```

```
 val conf =  new
  SparkConf().setMaster( "local[2]").setAppName( "NetworkWordCount")

 val ssc =  new StreamingContext(conf, Seconds(1))

 val lines = ssc.socketTextStream( "localhost", 9999)

 val words = lines.flatMap(_.split( " "))

 val pairs = words.map(word => (word, 1))


 CassandraConnector(conf).withSessionDo { session =>
      |   session.execute(s "CREATE KEYSPACE IF NOT EXISTS streaming_test
  WITH REPLICATION = {'class': 'SimpleStrategy', 'replication_factor': 1 }")
      |   session.execute(s "CREATE TABLE IF NOT EXISTS
  streaming_test.words_table (word TEXT PRIMARY KEY, count COUNTER)")
      |   session.execute(s "TRUNCATE streaming_test.words_table")
      | }

 val wordCounts = pairs.reduceByKey(_ + _)

 wordCounts.saveToCassandra( "streaming_test",  "words_table",
  SomeColumns( "word",  "count"))

 wordCounts.print()

 ssc.start()

 ssc.awaitTermination()
 exit()
```

Using `cqlsh` connect to the `streaming_test` keyspace and run a query to show the results.

```
$ cqlsh -k streaming_test
cqlsh:streaming_test> select * from words_table;

 word     | count
----------+-------
    three |     3
      one |     1
      two |     2
     four |     4
 someword |     1
```

What to do next

See the Spark Streaming Programming Guide for more information, API documentation, and examples.

Getting started with the Spark Cassandra Connector Java API

The Spark Cassandra Connector Java API allows you to create Java applications that use Spark to analyze Cassandra data.

The Spark Cassandra Connector Java API allows you to create Java applications that use Spark to analyze Cassandra data.

Using the Java API in SBT build files

Add the following library dependency to the `build.sbt` or other SBT build file.

```
libraryDependencies + =" com.datastax.spark " %%" spark-cassandra-connector-
java_2.10 " %" 1.2.1 " withSources() withJavadoc()
```

Using the Java API in Maven build files

Add the following dependencies to the `pom.xml` file:

```
<dependencies>
    <dependency>
        <groupId>com.datastax.spark</groupId>
        <artifactId>spark-cassandra-connector-java_2.10</artifactId>
        <version>1.1.1</version>
    </dependency>
    ...
</dependencies>
```

To use the helper classes included in dse.jar in your applications, copy dse.jar to the *project directory*/`lib` and add the following to your `pom.xml`:

```
<dependency>
    <groupId>com.datastax</groupId>
    <artifactId>dse</artifactId>
    <version>version number</version>
    <scope>system</scope>
    <systemPath>${project.basedir}/lib/dse-version number.jar</systemPath>
</dependency>
```

Alternately, you can manually install dse.jar in your local repository.

```
$ mvn install:install-file -Dfile=path/dse-version number.jar -
DgroupId=com.datastax -DartifactId=dse -Dversion=version number -
Dpackaging=jar
```

And then add the dependency to `pom.xml`:

```
<dependency>
    <groupId>com.datastax</groupId>
    <artifactId>dse</artifactId>
    <version>version number</version>
</dependency>
```

Accessing Cassandra data in Java applications

To perform Spark actions on Cassandra table data, you first obtain a `CassandraJavaRDD` object, a subclass of the JavaRDD class. The `CassandraJavaRDD` is the Java language equivalent of the `CassandraRDD` object used in Scala applications.

To create the `CassandraJavaRDD` object, you need to create a Spark configuration object, which is then used to create a Spark context object.

Create the Spark configuration object by calling the `enrichSparkConf` method of `com.datastax.bdp.spark.DseSparkConfHelper`, creating a new default `SparkConf` object. `DseSparkConfHelper` is found in dse.jar. The returned `SparkConf` instance is automatically configured for your cluster, including the Spark Master and Cassandra host. This can then be used to create a new `com.datastax.bdp.spark.DseSparkContext` object. `DseSparkContext` automatically adjusts your configuration for DataStax Enterprise. It is also located in `dse.jar`.

```
SparkConf conf = DseSparkConfHelper.enrichSparkConf(new SparkConf())
                .setAppName( "My application");
DseSparkContext sc = new DseSparkContext(conf);
```

The default location of the `dse.jar` file depends on the type of installation:

Installer-Services and Package installations	`/usr/share/dse/dse.jar`
Installer-No Services and Tarball installations	*`install_location`*`/lib/dse.jar`

Use the static methods of the `com.datastax.spark.connector.japi.CassandraJavaUtil` class to get and manipulate `CassandraJavaRDD` instances. To get a new `CassandraJavaRDD` instance, call one of the `javaFunctions` methods in `CassandraJavaUtil`, pass in a context object, and then call the `cassandraTable` method and pass in the keyspace, table name, and mapping class.

```
JavaRDD<String> cassandraRdd = CassandraJavaUtil.javaFunctions(sc)
        .cassandraTable("my_keyspace",
 "my_table", .mapColumnTo(String.class))
        .select("my_column");
```

Mapping Cassandra column data to Java types

You can specify the Java type of a single column from a table row by specifying the type in when creating the `CassandraJavaRDD<T>` instance and calling the `mapColumnTo` method and passing in the type. Then call the `select` method to set the column name in Cassandra.

```
JavaRDD<Integer> cassandraRdd = CassandraJavaUtil.javaFunctions(sc)
        .cassandraTable("my_keyspace",
 "my_table", .mapColumnTo(Integer.class))
        .select("column1");
```

JavaBeans classes can be mapped using the `mapRowTo` method. The JavaBeans property names should correspond to the column names following the default mapping rules. For example, the `firstName` property will map by default to the `first_name` column name.

```
JavaRDD<Person> personRdd = CassandraJavaUtil.javaFunctions(sc)
                .cassandraTable("my_keyspace", "my_table",
 mapRowTo(Person.class));
```

`CassandraJavaPairRDD<T, T>` instances are extensions of the `JavaPairRDD` class, and have mapping readers for rows and columns similar to the previous examples. These pair RDDs typically are used for key/value pairs, where the first type is the key and the second type is the value.

When mapping a single column for both the key and the value, call `mapColumnTo` and specify the key and value types, then the `select` method and pass in the key and value column names.

```
CassandraJavaPairRDD<Integer, String> pairRdd =
 CassandraJavaUtil.javaFunctions(sc)
        .cassandraTable("my_keyspace", "my_table",
 mapColumnTo(Integer.class), mapColumnTo(String.class))
        select("id", "first_name");
```

Use the mapRowTo method to map row data to a Java type. For example, to create a pair RDD instance with the primary key and then a JavaBeans object:

```
CassandraJavaPairRDD<Integer, Person> idPersonRdd =
 CassandraJavaUtil.javaFunctions(sc)
        .cassandraTable("my_keyspace", "my_table",
 mapColumnTo(Integer.class), mapRowTo(Person.class))
        .select("id", "first_name", "last_name", "birthdate", "email");
```

Saving data to Cassandra

To save data from an RDD to Cassandra call the `writerBuilder` method on the `CassandraJavaRDD` instance, passing in the keyspace, table name, and optionally type mapping information for the column or row.

```
CassandraJavaUtil.javaFunctions(personRdd)
               .writerBuilder("my_keyspace", "my_table",
 mapToRow(Person.class)).saveToCassandra();
```

Getting started with PySpark

DataStax Enterprise supports the Spark Python API (PySpark) that exposes the Spark programming model to Python. You can use PySpark interactively from the command line.

DataStax Enterprise supports the Spark Python API (PySpark) that exposes the Spark programming model to Python. You can use PySpark interactively from the command line.

Limitations

- Predicate pushdown and column selection is not supported in this release.
- Blobs cannot be used as set or map keys.

Data types

The following table lists CQL and corresponding Python data types.

Table 10: CQL-Python data mapping

CQL Type	Python Type	CQL Description
null	None	
ascii	str/unicodr	US-ASCII character string
bigint	long	64-bit signed long
blob	bytearray	Arbitrary bytes (no validation), expressed as hexadecimal
boolean	bool	true or false
counter	long	Distributed counter value (64-bit long)
decimal	decimal	Variable-precision decimal Java type
double	float	64-bit IEEE-754 floating point Java type
float	float	32-bit IEEE-754 floating point

CQL Type	Python Type	CQL Description
		Java type
inet	str/unicode	IP address string in IPv4 or IPv6 format, used by the python-cql driver and CQL native protocols
int	int	32-bit signed integer
list	list	A collection of one or more ordered elements
map	dict	A JSON-style array of literals: { literal : literal, literal : literal ... }
set	set	A collection of one or more elements
text	str/unicode	UTF-8 encoded string
timestamp	datetime.datetime	Date plus time, encoded as 8 bytes since epoch
timeuuid	str/unicode	Type 1 UUID only
uuid	str/unicode	A UUID in standard UUID format
varchar	str/unicode	UTF-8 encoded string
varint	long	Arbitrary-precision integer Java type

On the Python side, both `str/unicode` and `uuid.UUID` types that represent UUIDs are properly mapped to Cassandra `uuid` or `timeuuid` type when saved as RDDs. However, Cassandra uuids are converted to str/unicode when read from Python.

PySpark prerequisites

The prerequisites for starting PySpark are:

- Python 2.6 or 2.7
- Start a DataStax Enterprise node in Spark mode.

Insert Cassandra data

1. Start cqlsh.

```
$ cqlsh
Connected to Test Cluster at 127.0.0.1:9160.
[cqlsh 4.1.1 | Cassandra 2.1.0.0 | DSE 4.7.0 | CQL spec 3.1.1 | Thrift
 protocol 19.39.0]
Use HELP for help.
```

2. In cqlsh, create a keyspace and two tables in Cassandra using the Analytics data center name.

```
CREATE KEYSPACE IF NOT EXISTS test WITH REPLICATION = {'class':
 'NetworkTopologyStrategy', 'Analytics' : 1};
USE test;
CREATE TABLE kv (key int PRIMARY KEY, value text);
CREATE TABLE kv2 (key int PRIMARY KEY, value text);
```

3. Insert data into kv table only.

   ```
   INSERT INTO kv (key, value) VALUES (1, 'abc');
   INSERT INTO kv (key, value) VALUES (2, 'def');
   ```

   The schema for both tables and the data for table kv exists in Cassandra before starting PySpark.

Access the data using PySpark

1. Start PySpark using one of the following commands:

   - Installer-Services and Package installations:

     ```
     dse pyspark
     ```

   - Installer-No Services and Tarball installations:

     ```
     install_location/bin/dse pyspark
     ```

   Note: The directory in which you run the `dse` Spark commands must be writable by the current user.

   The Spark prompt will appear.
2. Call the `cassandraTable` method to obtain an RDD representing the Cassandra table `test.kv`.

   ```
   rdd = sc.cassandraTable("test", "kv")
   ```

   Cassandra rows are converted to Python objects of class `pyspark.sql.Row`, which allows for dictionary-like lookup of column values as well as directly formatting the rows as object fields.
3. Query Cassandra.

   ```
   rdd.first()
   Row(key=2, value=u'def')
   rdd.first().key
   2
   rdd.first().value
   u'def'
   rdd.first()[0]
   2
   rdd.first()[1]
   u'def'
   rdd.collect()
   [Row(key=2, value=u'def'), Row(key=1, value=u'abc')]
   rdd.filter(lambda row: row.key > 1).collect()
   [Row(key=2, value=u'def')]
   ```

4. Call `saveToCassandra` and pass a keyspace, table, and optionally a list of columns on any RDD of dictionary or `pysparksql.Row` objects. For example, save the `key` columns from the `kv` table to the `kv2` table.

   ```
   rdd = sc.cassandraTable("test", "kv")
   rdd.saveToCassandra("test", "kv2", ["key"])
   ```

5. In `cqlsh`, confirm that the keys from `kv1` were added to table `kv2`.

   ```
   SELECT  * FROM  kv2;

    key | value
   -----+-------
      1 |  null
   ```

```
      2 |  null

        (2 rows)
```

6. In PySpark, copy all columns from table `kv` to table `kv2`.

   ```
   rdd.saveToCassandra("test", "kv2")
   ```

7. In `cqlsh`, take a look at the `kv2` table to confirm that `kv2` has both keys and values now.

   ```
   SELECT * FROM kv2;

    key | value
   -----+-------
      1 |   abc
      2 |   def

   (2 rows)
   ```

Insert new data into Cassandra from PySpark

1. Distribute the current Python collection to form an RDD. The source RDD does not need to be in Cassandra.

   ```
   otherRdd = sc.parallelize([{ "key": 3, "value": "foobar" }])
   ```

2. Save `otherRdd` to the `kv2` table in Cassandra.

   ```
   otherRdd.saveToCassandra("test", "kv2")
   ```

   These steps add the key 3 and the value `foobar` to table `k2`.
3. In `cqlsh`, select all the data from `kv2` to confirm the addition of the data.

   ```
   SELECT * FROM kv2;

    key | value
   -----+--------
      1 |    abc
      2 |    def
      3 | foobar

   (3 rows)
   ```

Run a Python script using dse `spark-submit`

You run a Python script using the `spark-submit` command. For example, create the following file and save it as `standalone.py`:

```
#standalone.py

from pyspark import SparkContext, SparkConf

conf = SparkConf().setAppName("Stand Alone Python Script")
sc = SparkContext(conf=conf)
x = sc.cassandraTable("test","kv").collect()
print x
```

DataStax Enterprise sets the `cassandra.connection.host` environment variable, eliminating the need to set the variable in the Python file. Assuming you set up the `kv` table in the last example, execute standalone.py. On Linux, for example, from the installation directory, execute standalone.py as follows:

```
$ bin/dse spark-submit /<path>/standalone.py
```

Run Python jobs independently

If you create test-suites with nose or other tools that run raw Python code, you cannot explicitly call dse spark-submit. You can execute Python scripts independent of DataStax Enterprise using one or the other of these methods.

- Set the PYTHONPATH environment variable to the path of the DataStax Enterprise integrated python executable, as shown in the next section.
- Use an initialization file that you modify to describe your environment and then run, as shown in the example later.

These methods work with the DataStax Enterprise integrated Spark, not the open source version.

Configure PYTHONPATH to run jobs

This procedure uses the PYTHONPATH environment variable to find and use PySpark to execute a Python job.

Run a Python job using PYTHONPATH

1. Set the PYTHONPATH environment variable to the location of the Python executable in your DataStax Enterprise Spark environment.

   The default Python location depends on the type of installation:

Installer-Services and Package installations	/usr/share/dse/spark/python
Installer-No Services and Tarball installations	*install_location*/resources/spark/python

2. Run the Python script. For example, run the standalone.py file that you created in "Running a python script using dse spark-submit."

   ```
   $ python /<path>/standalone.py
   ```

   The output is:

   ```
   [Row(key=1, value=u'abc'), Row(key=2, value=u'def')]
   ```

Create an initialization file to run a Python job

You can create an initialization file to run Python jobs independent of DataStax Enterprise.

Use the __name__.py convention to name the initialization file. For example, name the file __init__.py.

An initialization file on a tarball installation might look like this:

```
import os
from os import getenv
from os.path import join
import sys
from subprocess import check_output

HOME = getenv("HOME")
DSE_HOME = getenv("DSE_HOME",join(HOME,"dse-4.7.0"))
SPARK_HOME = join(DSE_HOME,"resources","spark")
os.environ['SPARK_HOME']=SPARK_HOME
```

```
PYSPARK_DIR = join(DSE_HOME,"resources","spark","python")
ADD_PATH = [ PYSPARK_DIR ]
for PATH in ADD_PATH:
  if PATH not in sys.path:
    sys.path.insert(1,PATH)
```

Use this sample initialization file as a guide to modify the file to match the operating system and DataStax Enterprise environment. For example:

- Use `HOME` or `USERPROFILE`, depending on the operating system.
- Change the `DSE_HOME` definition to match the location of the DataStax Enterprise installation.
- Modify `SPARK_HOME` to match the location of Spark resources:
    - Installer-Services and Package installations: `SPARK_HOME = join(DSE_HOME,"resources","spark")` matches `/etc/dse/spark`
    - Installer-No Services and Tarball installations: `SPARK_HOME = join(DSE_HOME,"resources","spark")` matches the *`install_location`*`/resources/spark` location.

Use the initialization file to run jobs

This procedure uses the initialization file shown in the last section to set up a number of environment variables and execute a sample Python job.

1. Create a directory and subdirectory for storing the python scripts. For example, create a directory named `example` that has a subdirectory named `connector`.
2. Create the example initialization file. For example, create the `__init__.py` file shown in the last section, and save it to `example/connector` directory.
3. Create scripts to configure Spark and query the `kv` table in Cassandra from Spark. For example, create the a script named `connector.py` and save it to the `example/connector` directory.

    ```
    #connector.py

    from pyspark import SparkContext, SparkConf

    def getSC():
        conf = SparkConf().setAppName("Stand Alone Python Script")
        sc = SparkContext(conf=conf)
        return sc
    ```

4. Create another script named `moduleexample.py`, for example, to print the results. Save `moduleexample.py` to the `example` directory.

    ```
    #!/usr/local/bin/python

    from connector.connector import getSC

    sc = getSC()
    print sc.cassandraTable("test","kv").collect()
    ```

    The example directory now contains these files:

    - `moduleexample.py`
    - `connector/_init_.py`
    - `connector/connector.py`
5. Execute the Python job as the same user that launched DataStax Enterprise.

    ```
    $ python example/moduleexample.py
    ```

The output of the kv table appears.

```
[Row(key=1, value=u'abc'), Row(key=2, value=u'def')]
```

Using Shark to query data

Shark stores metadata in the Cassandra keyspace called HiveMetaStore. External tables are not stored unless explicitly requested. Shark depends on Hive for parsing and for some optimization translations.

Shark stores metadata in the Cassandra keyspace called HiveMetaStore. External tables are not stored unless explicitly requested. Shark depends on Hive for parsing and for some optimization translations. You can use Shark just as you use Hive. The following example assumes that you ran the Portfolio Manager demo using Hadoop to generate the data for the example. For more examples, refer to Hive documentation. The backend implementation of Hive and Shark differ, but the user interface and query language are interchangeable for the most part.

Note: DataStax Enterprise does not support SharkServer2.

Limitations

- Adding the short cut "_cached" suffix to Shark table names does not work in Shark 1.1. Use TBLPROPERTIES ("shark.cache" = "true") instead.

  See the Spark User Guide.
- When you create a table that includes `TBLPROPERTIES ("shark.cache" = "true")`, the table continues to exist after the session ends, which is reasonable for sharkserver.

  For other Shark jobs, you should drop the table when the session ends. Do not design applications to depend on this persistence between sessions.
- The Shark JavaAPI does not work with Spark 1.1.

  The workaround is change the Spark serializer to Kryo. Configure the spark.serializer org.apache.spark.serializer.KryoSerializer as described in "Spark 1.1.0 Available Properties". Using `dse spark-submit` reads configuration options, including spark.serializer from the `spark-defaults.conf` file.
- When using the `Distribute By` syntax to distribute the rows among reducers, also use the `Sort By` syntax to guarantee sorting.

  For example:

  ```
  select p_mfgr, p_brand, s, round(sum(s) over w1 ,2) as s1 from
   mfgr_price_view
    window w1 as (distribute by p_mfgr sort by p_brand rows between 2
   preceding and current row);
  ```

After starting a Spark node, use `dse` commands to launch Shark. You can use the Cassandra specific properties (-Dname=value) to start Shark.

DataStax Enterprise supports these commands for launching Shark on the Datastax Enterprise command line:

dse shark

Launches the Shark shell.

dse shark --service sharkserver -p <port>

Launches the Shark server

Starting and stopping a Shark client

If you do not need to keep Shark memory tables persistent between sessions, start a Shark standalone client, use this dse command on the dse command line. On Ubuntu, for example:

```
$ dse shark
```

Use the -skipRddReload flag to skip reloading data into memory tables when you start Shark.

The shark command line prompt appears:

```
Starting the Shark Command Line Client

    shark>
```

To stop the Shark client:

```
shark> exit;
```

You can also start a Shark as a server to provide Shark service to clients.

Starting the Shark server

You can keep Shark memory tables persistent and run applications between sessions if you use the Shark server instead of the client. To start the Shark server:

```
$ dse shark --service sharkserver -p <port number>
```

For example:

```
$ dse shark --service sharkserver -p 10000
```

Connect a Shark client to the server:

```
$ dse shark -h localhost -p 10000
    [localhost:10000] shark>
```

Using Shark

1. Start DataStax Enterprise in Spark mode.
2. Start Shark.

   ```
   $ dse shark
   Starting the Shark Command Line Client
   . . .
   2014-03-14 20:37:09.315:INFO:oejs.AbstractConnector:Started
    SelectChannelConnector@0.0.0.0:4040
   Reloading cached RDDs from previous Shark sessions... (use -skipRddReload
    flag to skip reloading)
   ```

3. Enter these queries to analyze the portfolio data.

   ```
   shark> USE PortfolioDemo;
   OK
   Time taken: 0.384 seconds

   shark> DESCRIBE StockHist;
   ```

Output is:

```
OK
key                     string                  from deserializer
column1                 string                  from deserializer
value                   double                  from deserializer
Time taken: 0.208 seconds
```

4. Continue querying the data by selecting the count from the Stocks table and then select ten stocks, ordered by value.

```
shark> SELECT count(*) FROM Stocks;
OK
2759
Time taken: 9.899 seconds

shark> SELECT * FROM Stocks ORDER BY value DESC LIMIT 10;
OK
XIN price 99.95643836954761
JQC price 99.92873883263657
SBH price 99.87928626341066
CCJ price 99.83980527070464
QXM price 99.72161816290533
DPC price 99.70004934561737
AVT price 99.69106570398871
ANW price 99.69009660302422
PMO price 99.67491825839043
WMT price 99.67281873305834
Time taken: 2.204 seconds
```

5. Use the Explain command in Shark to get specific Hive and Shark information.

```
shark> EXPLAIN SELECT * FROM Stocks ORDER BY value DESC LIMIT 10;
```

After listing some Hive information in the abstract syntax tree, you see the Shark query plan. At this point, Spark Worker page lists the Shark application that you are running.

```
shark> exit;
```

6. Exit Shark.

Starting and stopping the Spark SQL JDBC server

The Spark SQL Thrift JDBC server provides a JDBC interface for client connections to Cassandra.

About this task

The Spark SQL Thrift JDBC server provides a JDBC interface for client connections to Cassandra. The server is an extension of the HiveServer2 server, and uses the same configuration options. Use the

By default, the server listens on port 10000 on the localhost interface on node from which it was started.

Note: The Spark SQL Thrift server also provides a ODBC interface, but DataStax recommends using the Databricks ODBC driver for Apache Shark.

Procedure

1. Start DataStax Enterprise with Spark enabled as a service or in a standalone installation.

   Note: To run index queries, start the node with both Spark and Hadoop enabled. Running in this mode is experimental and not supported.
2. Start the server by entering the `dse start-spark-sql-thriftserver` command as a user with permissions to write to the Spark directories.

To override the default settings for the server, pass in the configuration property using the --hiveconf option. Refer to the HiveServer2 documentation for a complete list of configuration properties.

```
$ dse start-spark-sql-thriftserver
```

To start the server on port 10001, use the --hiveconf hive.server2.thrift.port=10001 option when starting the server.

```
$ dse start-spark-sql-thriftserver --hiveconf hive.server2.thrift.port=10001
```

If you have enabled authentication, use the cassandra.username and cassandra.password properties.

```
$ dse start-spark-sql-thriftserver --hiveconf cassandra.username=user --
hiveconf cassandra.password=password
```

To enable virtual columns, pass in the enableVirtualColumns=true option when starting the server.

```
$ dse start-spark-sql-thirftserver --hiveconf enableVirtualColumns=true
```

3. To stop the server, enter the `dse stop-spark-sql-thriftserver` command.

```
$ dse stop-spark-sql-thriftserver
```

What to do next

You can now connect your application by using JDBC to the server at the URI: `jdbc:hive2://`*`hostname`*`:`*`port number`*. See Connecting to the Spark SQL JDBC server using Beeline for a test using the Beeline console.

Databricks ODBC driver for Apache Shark

The Databricks ODBC Driver with SQL Connector for Apache Shark is used for direct SQL and HiveQL access to Apache Hadoop / Shark distributions, enabling Business Intelligence (BI), analytics, and reporting on Hadoop-based data.

The Databricks ODBC Driver with SQL Connector for Apache Shark is used for direct SQL and HiveQL access to Apache Hadoop / Shark distributions, enabling Business Intelligence (BI), analytics, and reporting on Hadoop-based data. The driver efficiently transforms an application’s SQL query into the equivalent form in HiveQL. Hive Query Language is a subset of SQL-92. If an application is Hive-aware, then the driver is configurable to pass the query through. The driver interrogates Shark to obtain schema information to present to a SQL-based application. Queries, including joins, are translated from SQL to HiveQL.

Installing the driver on Windows

Install the Databricks ODBC Driver with SQL Connector for Apache Shark on Windows for direct SQL and HiveQL access to Apache Hadoop / Shark distributions.

About this task

To install the ODBC driver for Spark on Windows.

Before you begin

- One of the following Windows operating systems (32- and 64-bit editions are supported):
  - Windows XP with SP3
  - Windows Vista
  - Windows 7 Professional
  - Windows Server 2008 R2
- 25 MB of available disk space
- Administrator privileges on the computer you install the driver

- The driver is suitable for use with all versions of Apache Shark

To install the ODBC driver for Spark on a Windows platform:

Procedure

1. Download the driver from Client Libraries and CQL Drivers.
2. Double-click the downloaded file and follow the wizard's instructions.

Configuring the driver

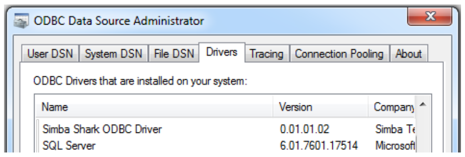
Steps to configure the Shark ODBC driver.

About this task

Configure the Shark ODBC driver:

Procedure

1. Click **Start Program Files** > **Simba Shark ODBC Driver 0.1 (32-bit)** > **32-bit ODBC Administrator**.
2. Click the **Drivers** tab to verify that the driver is present.



ODBC Drivers that are installed on your system:

Name	Version	Company
Simba Shark ODBC Driver	0.01.01.02	Simba Te
SQL Server	6.01.7601.17514	Microsoft

3. Create either a User or System DSN (data source name) for your ODBC connection.
   a) Click the **User DSN** or **System DSN** tab.
   b) Click **Add** > **Simba Shark ODBC Driver** > **Finish**.

      Note: This topic assumes you have installed the 32-bit Shark ODBC driver. Some graphical controls may be different with the 64-bit version installed.
   c) In **Simba Shark ODBC Driver Setup**, enter the following:

Data Source Name	The name for your DSN. For example Test Shark.
Description	Optional.
Host	IP or host name of your Shark server.
Port	Listening port for the Shark service.
Database	By default, all tables reside within the default database.

   d) Click **Test**.

      The test results are displayed.
4. To configure the advanced options, see Appendix C in the *Simba ODBC Driver with SQL Connector for Apache Shark*.

Using the driver

After configuring the ODBC data source, you can connect and pull data from Shark using any compliant BI tool

About this task

After configuring the ODBC data source, you can connect and pull data from Shark using any compliant BI tool. For example, to retrieve data using Microsoft Excel:

Procedure

1. Start Microsoft Excel.
2. Select **Data** > **From Other Sources** > **From Data Connection Wizard** to view the **Data Connection Wizard** to select your new ODBC data source.
3. In **Welcome to the Data Connection Wizard**, select **ODBC DSN** > **Next**.
4. In **Connect to OBDC Data Source**, select **Test Shark** > **Next**.
5. Select a table (or construct a query) to retrieve the data, and then click **Finish**.
   The current spreadsheet displays the data.

Installing the driver on Linux

Install the Databricks ODBC Driver with SQL Connector for Apache Shark on Linux for direct SQL and HiveQL access to Apache Hadoop / Shark distributions.

About this task

To install the ODBC driver for Spark on Linux.

Before you begin

- System Requirements
  - Red Hat® Enterprise Linux® (RHEL) 5.0, CentOS 5.0 or SUSE Linux Enterprise Server (SLES) 11. Both 32 and 64-bit editions are supported.
  - 45 MB of available disk space.
  - An installed ODBC driver manager (either of the following):
    - iODBC 3.52.7 or above
    - unixODBC 2.2.12 or above
- The driver requires a Hadoop cluster with the Spark service installed and running.
- The driver is suitable for use with all versions of Spark.

Procedure

1. Download the driver from Client Libraries and CQL Drivers.
2. Decompress and unarchive the file you downloaded.

   ```
   $ tar zxvf SimbaSharkODBC-32bit-0.1.0.0001-1.i686.tar.gz
   ```
3. Add the driver's `lib` directory to your system's `LD_LIBRARY_PATH` environmental variable.

Spark examples

DSE includes Spark example applications that demonstrate different Spark features.

DSE includes Spark example applications that demonstrate different Spark features.

Portfolio Manager demo using Spark

The Portfolio Manager demo runs an application that is based on a financial use case. You run scripts that create a portfolio of stocks.

About this task

The Portfolio Manager demo runs an application that is based on a financial use case. You run scripts that create a portfolio of stocks. On the Cassandra OLTP (online transaction processing) side, each portfolio contains a list of stocks, the number of shares purchased, and the purchase price. The demo's pricer utility simulates real-time stock data. Each portfolio gets updated based on its overall value and the percentage of gain or loss compared to the purchase price. The utility also generates 100 days of historical market data (the end-of-day price) for each stock. On the DSE OLAP (online analytical processing) side, a Spark

Scala job calculates the greatest historical 10 day loss period for each portfolio, which is an indicator of the risk associated with a portfolio. This information is then fed back into the real-time application to allow customers to better gauge their potential losses.

Procedure

To run the demo:

Note: DataStax Demos do not work with either LDAP or internal authorization (username/password) enabled.

1. Install a single Demo node using the DataStax Installer in GUI or Text mode with the following settings:
    - **Install Options** page - **Default Interface: 127.0.0.1** (You must use this IP for the demo.)
    - **Node Setup** page - **Node Type: Analytics**
    - **Analytic Node Setup** page - **Analytics Type: Spark + Integrated Hadoop**
2. Start DataStax Enterprise if you haven't already:
    - **Installer-Services and Package installations:**

      ```
      $ sudo service dse start
      ```
    - **Installer-No Services and Tarball installations:**

      ```
      $ install_location/bin/dse cassandra -k ## Starts node in Spark mode
      ```

      The default *install_location* is `/usr/share/dse`.
3. Go to the Portfolio Manager demo directory.

   The default location of the Portfolio Manager demo depends on the type of installation:

Installer-Services and Package installations	`/usr/share/dse/demos/portfolio_manager`
Installer-No Services and Tarball installations	`install_location/demos/portfolio_manager`

4. Run the bin/pricer utility to generate stock data for the application:
    - To see all of the available options for this utility:

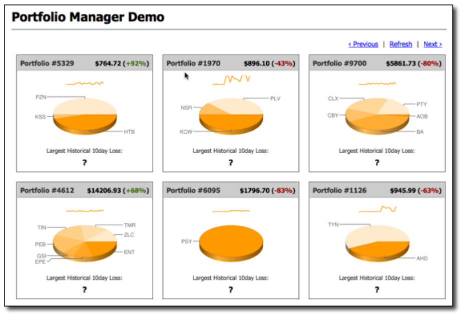
      ```
      $ bin/pricer --help
      ```
    - Start the pricer utility:

      ```
      $ bin/pricer -o INSERT_PRICES
      $ bin/pricer -o UPDATE_PORTFOLIOS
      $ bin/pricer -o INSERT_HISTORICAL_PRICES -n 100
      ```

   The pricer utility takes several minutes to run.
5. Start the web service:

   ```
   $ cd website
   $ sudo ./start
   ```
6. Open a browser and go to `http://localhost:8983/portfolio`.

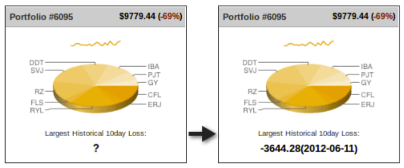
   The real-time Portfolio Manager demo application is displayed.


Portfolio Manager Demo
‹ Previous | Refresh | Next ›
Portfolio #5329 $764.72 (+92%)
Portfolio #1970 $896.10 (-43%)
Portfolio #9700 $5861.73 (-80%)
Portfolio #4612 $14206.93 (+68%)
Portfolio #6095 $1796.70 (-83%)
Portfolio #1126 $945.99 (-63%)
Largest Historical 10day Loss:
?

7. Open another terminal.
8. Start Spark by running the `10-day-loss.sh` script.
   - Installer-Services: `$ cd /usr/share/dse/demos/spark; ./10-day-loss.sh`
   - Package installations: `$ cd /usr/share/dse-demos/spark; ./10-day-loss.sh`
   - Installer-No Services and Tarball installations: `$` *`install_location`*`/demos/spark/10-day-loss.sh`

   The Spark application takes several minutes to run.
9. After the job completes, refresh the **Portfolio Manager** web page.

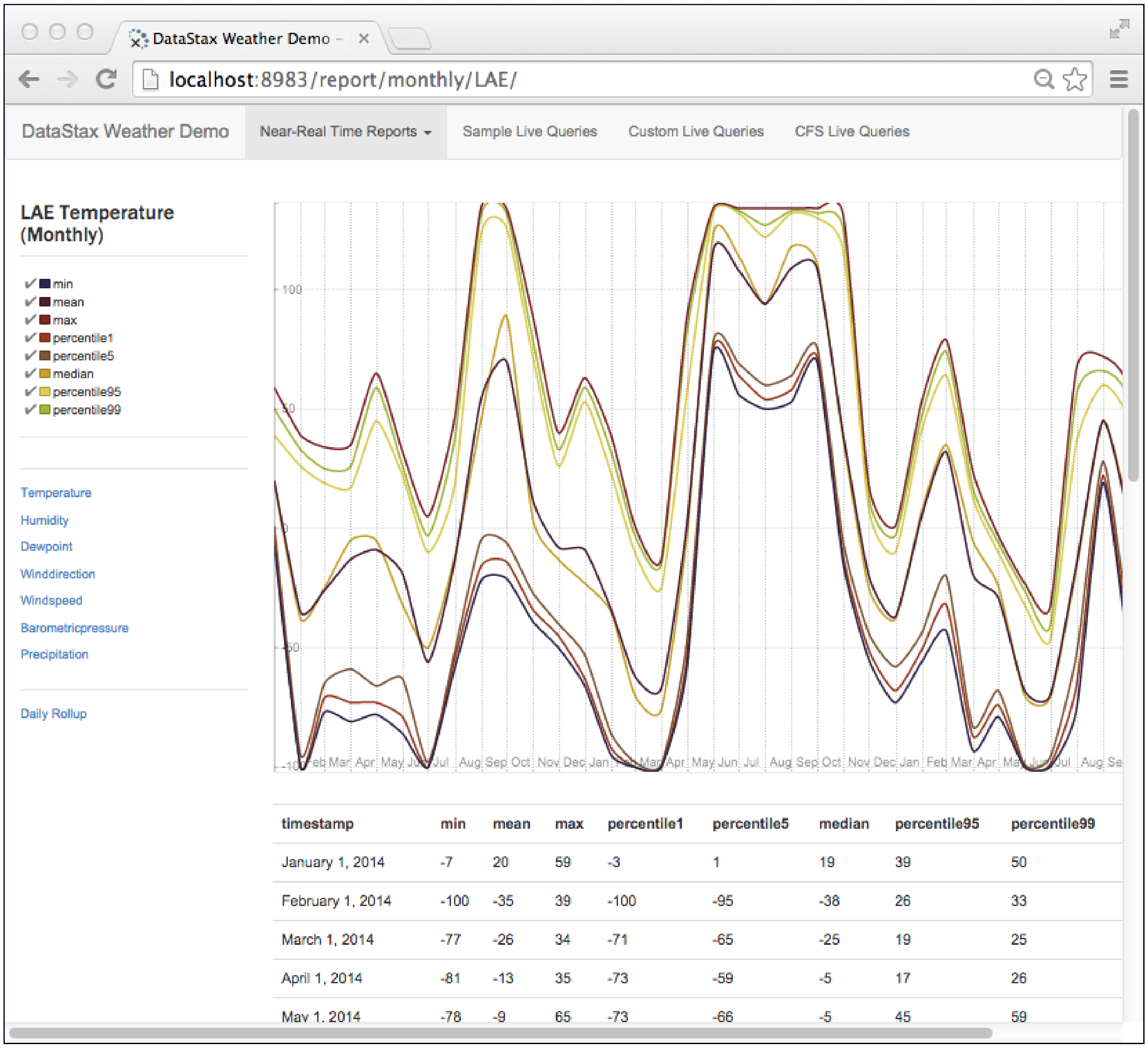
   The results of the Largest Historical 10 day Loss for each portfolio are displayed.


Portfolio #6095 $9779.44 (-69%)
DDT
SVJ
RZ
FLS
RYL
IBA
PJT
GY
CFL
ERJ
Largest Historical 10day Loss:
?
Portfolio #6095 $9779.44 (-69%)
Largest Historical 10day Loss:
-3644.28(2012-06-11)

Running the Weather Sensor demo

The Weather Sensor demo compares how long it takes to run Hive versus Shark queries against aggregated data for a number of weather sensors in various cities.

Using the Weather Sensor demo, you can compare how long it takes to run Hive versus Shark queries against aggregated data for a number of weather sensors in various cities. For example, you can view reports using different metrics, such as temperature or humidity, and get a daily rollup.



timestamp	min	mean	max	percentile1	percentile5	median	percentile95	percentile99
January 1, 2014	-7	20	59	-3	1	19	39	50
February 1, 2014	-100	-35	39	-100	-95	-38	26	33
March 1, 2014	-77	-26	34	-71	-65	-25	19	25
April 1, 2014	-81	-13	35	-73	-59	-5	17	26
May 1, 2014	-78	-9	65	-73	-66	-5	45	59

You run customize Shark or Hive queries using different metrics and different dates. In addition to querying CQL tables, you time Shark and Hive queries against data in the Cassandra File System (CFS).

Note: DataStax Demos do not work with either LDAP or internal authorization (username/password) enabled.

Prerequisites

Before running the demo, install the following source code and tools if you do not already have them:

- Python 2.7
    - Debian and Ubuntu

      ```
      $ sudo apt-get install python2.7-dev
      ```

    - RedHat or CentOS

      ```
      $ sudo yum install python27
      ```

    - Mac OSX already has Python installed.
- pip installer tool
    - Debian and Ubuntu

      ```
      $ sudo apt-get install
            python-pip
      ```
    - RedHat or CentOS

      ```
      $ sudo yum install python-pip
      ```
    - Mac OS X

      ```
      $ sudo easy_install pip
      ```

If you installed DataStax Enterprise using a tarball or the GUI-no services, set the PATH environment variable to the DataStax Enterprise installation/bin startup directory.

```
export PATH=$PATH:~/install_location/bin/
```

Start DataStax Enterprise and import data

You start DataStax Enterprise in Spark and Hadoop mode, and then run a script that creates the schema for weather sensor data model. The script also imports aggregated data from CSV files into Cassandra CQL tables. The script uses a `hadoop fs` command to put the CSV files into the Cassandra File System.

1. Start DataStax Enterprise in Hadoop and Spark mode.
2. Run the create-and-load CQL script in the weather_sensors/resources directory. On Linux, for example:

   ```
   $ cd install_location/demos/weather_sensors
   $ bin/create-and-load
   ```

   The output confirms that the script imported the data into CQL and copied files to CFS.

   ```
   . . .
   10 rows imported in 0.019 seconds.
   2590 rows imported in 2.211 seconds.
   76790 rows imported in 33.522 seconds.
   + echo 'Copy csv files to Hadoop...'
   Copy csv files to Hadoop...
   + dse hadoop fs -mkdir /datastax/demos/weather_sensors/
   ```

If an error occurs, set the PATH to the installation/bin directory correctly, as described in Prerequisites, and retry.

Starting Shark and Hive

You start the Shark and Hive services on specific ports to avoid conflicts. Start these services using your local user account. For example, do not use sudo.

1. Start the Shark service on port 5588. On Linux, for example:

   ```
   $ cd install_location
   $ bin/dse shark --service sharkserver -p 5588
   ```
2. Open a new terminal and start the Hive service in DSE on port 5587.

   ```
   $ bin/dse hive --service hiveserver -p 5587
   ```

If you see a message saying, "The blist library is not available, so a pure python list-based set will," just ignore it.

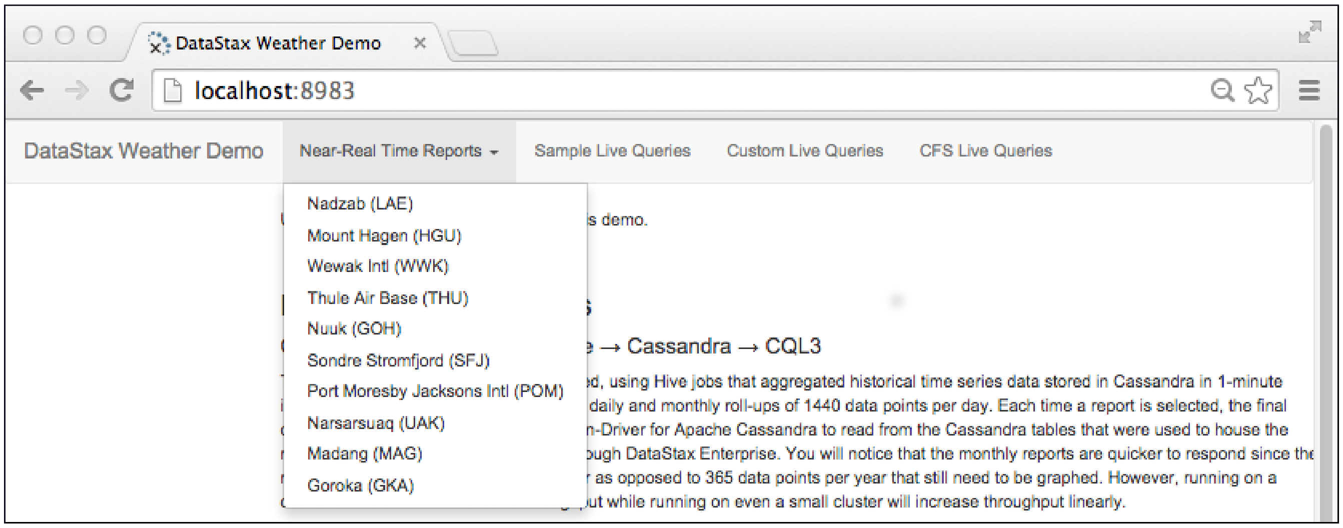
Start the web app and query the data

1. Open another terminal and start the Python service that controls the web interface:

```
$ cd install_location/demos/weather_sensors
$ python web/weather.py
```

2. Open a browser and go to the following URL: `http://localhost:8983/`

   The weather sensors app appears. Select Near Real-Time Reports on the horizontal menu. A drop-down listing weather stations appears:



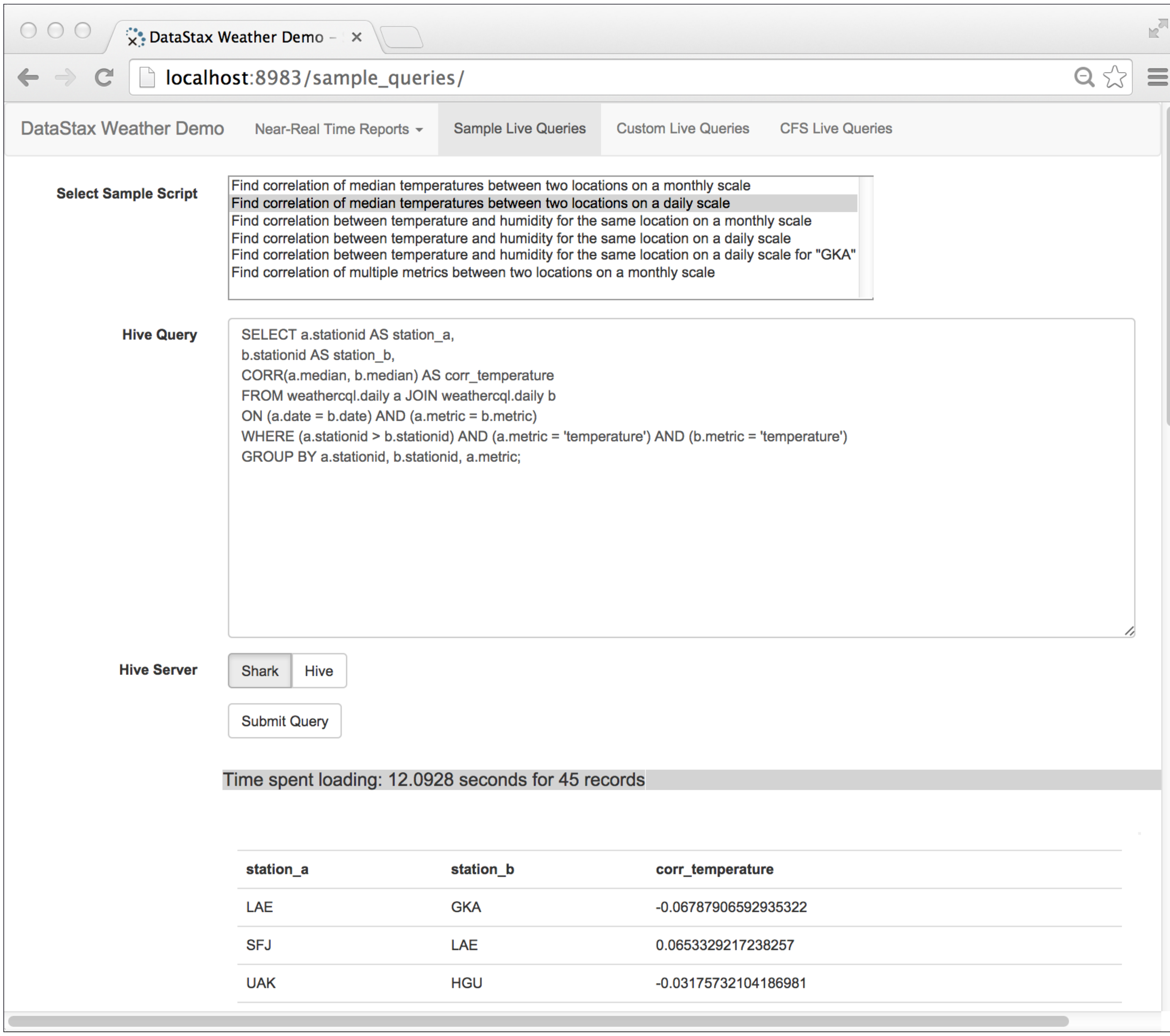
s demo.

→ Cassandra → CQL3

d, using Hive jobs that aggregated historical time series data stored in Cassandra in 1-minute
daily and monthly roll-ups of 1440 data points per day. Each time a report is selected, the final
n-Driver for Apache Cassandra to read from the Cassandra tables that were used to house the
ough DataStax Enterprise. You will notice that the monthly reports are quicker to respond since the
as opposed to 365 data points per year that still need to be graphed. However, running on a
ut while running on even a small cluster will increase throughput linearly.

3. Select a weather station from the drop-down, view the graph, and select different metrics from the vertical menu on the left side of the page.
4. On the horizontal menu, click Sample Live Queries, then select a sample script. Click the Shark button, then click Submit.

   The time spent loading results using Spark appears.



Select Sample Script

- Find correlation of median temperatures between two locations on a monthly scale
- Find correlation of median temperatures between two locations on a daily scale
- Find correlation between temperature and humidity for the same location on a monthly scale
- Find correlation between temperature and humidity for the same location on a daily scale
- Find correlation between temperature and humidity for the same location on a daily scale for "GKA"
- Find correlation of multiple metrics between two locations on a monthly scale

Hive Query

```
SELECT a.stationid AS station_a,
b.stationid AS station_b,
CORR(a.median, b.median) AS corr_temperature
FROM weathercql.daily a JOIN weathercql.daily b
ON (a.date = b.date) AND (a.metric = b.metric)
WHERE (a.stationid > b.stationid) AND (a.metric = 'temperature') AND (b.metric = 'temperature')
GROUP BY a.stationid, b.stationid, a.metric;
```

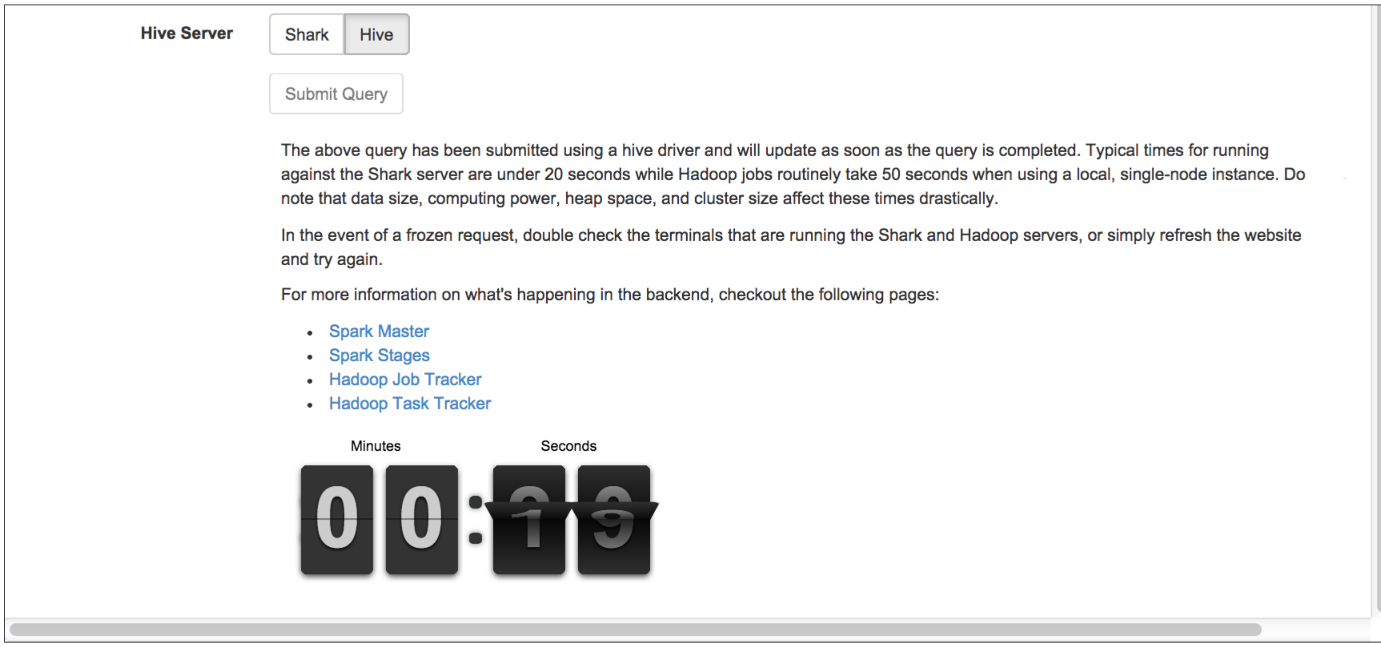
Hive Server [✓ Shark] Hive

Submit Query

Time spent loading: 12.0928 seconds for 45 records

station_a	station_b	corr_temperature
LAE	GKA	-0.06787906592935322
SFJ	LAE	0.0653329217238257
UAK	HGU	-0.03175732104186981

5. Click the Hive button to see the time spent loading results in Hive.



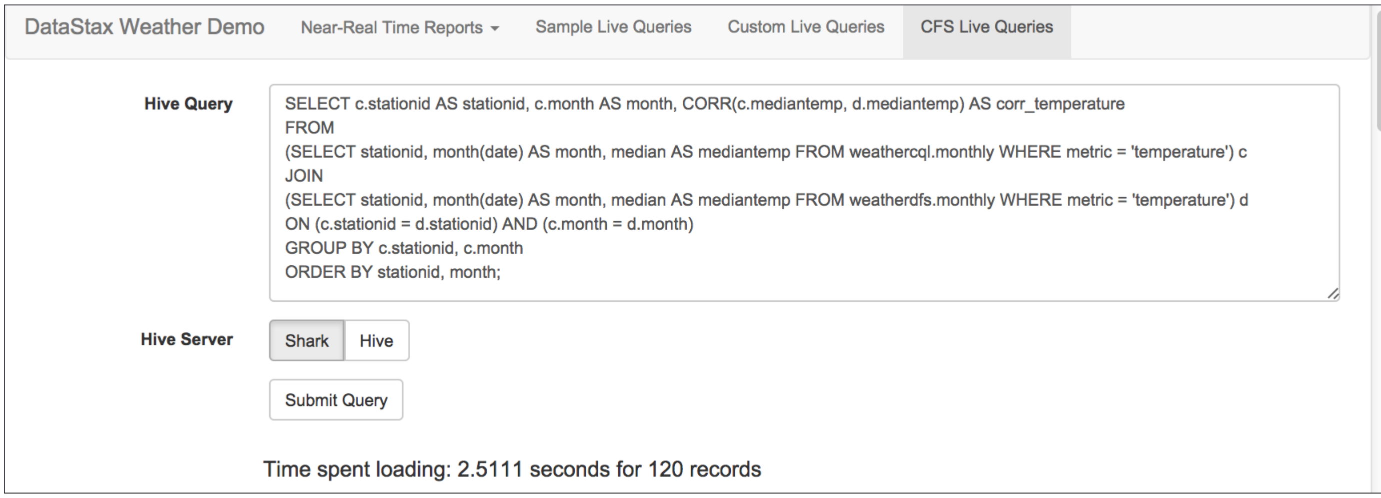
The above query has been submitted using a hive driver and will update as soon as the query is completed. Typical times for running against the Shark server are under 20 seconds while Hadoop jobs routinely take 50 seconds when using a local, single-node instance. Do note that data size, computing power, heap space, and cluster size affect these times drastically.

In the event of a frozen request, double check the terminals that are running the Shark and Hadoop servers, or simply refresh the website and try again.

For more information on what's happening in the backend, checkout the following pages:

- Spark Master
- Spark Stages
- Hadoop Job Tracker
- Hadoop Task Tracker

6. From the horizontal menu, click Custom Live Queries. Click a Week Day, and then a metric, such as Wind Direction. Click Recalculate Query. The query reflects the selections you made.
7. From the horizontal menu, click CFS Live Queries. Click Shark. The time spent loading results from CFS using Shark appears.



```
SELECT c.stationid AS stationid, c.month AS month, CORR(c.mediantemp, d.mediantemp) AS corr_temperature
FROM
(SELECT stationid, month(date) AS month, median AS mediantemp FROM weathercql.monthly WHERE metric = 'temperature') c
JOIN
(SELECT stationid, month(date) AS month, median AS mediantemp FROM weatherdfs.monthly WHERE metric = 'temperature') d
ON (c.stationid = d.stationid) AND (c.month = d.month)
GROUP BY c.stationid, c.month
ORDER BY stationid, month;
```

Time spent loading: 2.5111 seconds for 120 records

Clean up

To remove all generated data, run the following commands:

```
$ cd install_location/demos/weather_sensors
$ bin/cleanup
```

To remove the keyspace from the cluster, run the following command:

```
$ echo "DROP KEYSPACE weathercql;" | cqlsh
```

Running the Wikipedia demo with SearchAnalytics

The Wikipedia Solr demo can be run on a SearchAnalytics node to retrieve Spark RDDs using Solr queries.

About this task

The following instructions describe how to use Solr queries in the Spark console on SearchAnalytics nodes using the Wikipedia demo.

Before you begin

You must have created a new SearchAnalytics cluster as described in the single data center deployment scenario.

Procedure

1. Start the node or nodes in SearchAnalytics mode.
   - Packages/Services: See Starting DataStax Enterprise as a service.
   - Tarball/No Services: See Starting DataStax Enterprise as a stand-alone process.
2. Ensure that the cluster is running correctly by running dsetool. The node type should be `SearchAnalytics`.

   ```
   $ dsetool ring
   ```

   The default location of the `dsetool` command depends on the type of installation:

Package installations	`/usr/bin/dsetool`
Installer-Services installations	`/usr/bin/dsetool`
Installer-No Services and Tarball installations	*`install_location`*`/bin/dsetool`

3. In a terminal, go to the Wikipedia demo directory.

   The default wikipedia demo location depends on the type of installation:

Installer-No Services and Tarball installations	*`install_location`*`/demos/wikipedia`
Installer-Services and Package installations	`/usr/share/dse/demos/wikipedia`

   ```
   $ cd /usr/share/dse/demos/wikipedia
   ```
4. Add the schema by running the `1-add-schema.sh` script.

   ```
   $ ./1-add-schema.sh
   ```
5. Create the Solr indexes.

   ```
   $ ./2-index.sh
   ```
6. Start the Spark console.

   ```
   $ dse spark
   ```
7. Create an RDD based on the `wiki.solr` table.

   ```
   scala> val table = sc.cassandraTable("wiki","solr")
   ```

   ```
   table:
    com.datastax.spark.connector.rdd.CassandraTableScanRDD[com.datastax.spark.connector.C
    = CassandraTableScanRDD[0] at RDD at CassandraRDD.scala:15
   ```
8. Run a query using the title Solr index and collect the results.

```
scala> val result =
 table.select("id","title").where("solr_query='title:Boroph*'").collect
```

```
result:
    Array[com.datastax.spark.connector.CassandraRow] = Array(
        CassandraRow{id: 23729958, title: Borophagus parvus},
        CassandraRow{id: 23730195, title: Borophagus dudleyi},
        CassandraRow{id: 23730528, title: Borophagus hilli},
        CassandraRow{id: 23730810, title: Borophagus diversidens},
        CassandraRow{id: 23730974, title: Borophagus littoralis},
        CassandraRow{id: 23731282, title: Borophagus orc},
        CassandraRow{id: 23731616, title: Borophagus pugnator},
        CassandraRow{id: 23732450, title: Borophagus secundus})
```

What to do next

For details on using Solr query syntax in CQL, see Using CQL Solr queries in DSE Search.

Running the Spark MLlib demo application

The Spark MLlib demo application demonstrates how to run machine-learning analytic jobs using Spark and Cassandra.

About this task

The Spark MLlib demo application demonstrates how to run machine-learning analytic jobs using Spark and Cassandra. The demo solves the classic iris flower classification problem, using the iris flower data set. The application will use the iris flower data set to build a Naive Bayes classifier that will recognize a flower based on four feature measurements.

Before you begin

We strongly recommend that you install the BLAS library on your machines before running Spark MLlib jobs. For instructions on installing the BLAS library on your platform, see https://github.com/fommil/netlib-java/blob/master/README.md#machine-optimised-system-libraries.

The BLAS library is not distributed with DataStax Enterprise due to licensing restrictions, but improves MLlib performance significantly.

You must have the Gradle build tool installed to build the demo. See https://gradle.org/ for details on installing Gradle on your OS.

Procedure

1. Start the nodes in Analytics mode.
   - Installer-Services and Package installations: See Starting DataStax Enterprise as a service.
   - Installer-No Services and Tarball installations: See Starting DataStax Enterprise as a stand-alone process.
2. In a terminal, go to the `spark-mlib` directory located in the Spark demo directory.

   The default location of the Spark demo depends on the type of installation:

Installer-Services and Package installations	`/usr/share/dse/demos/spark`
Installer-No Services and Tarball installations	*`install_location`*`/demos/spark`
3. Build the application using the `gradle` build tool.

   ```
   $ gradle
   ```
4. Use `spark-submit` to submit the application JAR.

The Spark MLlib demo application reads the `Spark demo directory/spark-mllib/iris.csv` file on each node. This file must be accessible in the same location on each node. If some nodes do not have the same local file path, set up a shared network location accessible to all the nodes in the cluster.

To run the application where each node has access to the same local location of `iris.csv`.

```
$ dse spark-submit NaiveBayesDemo.jar
```

To specify a shared location of `iris.csv`:

```
$ dse spark-submit NaiveBayesDemo.jar /mnt/shared/iris.csv
```

Importing a Text File into a CQL Table

This example shows how to use Spark to import a local or CFS (Cassandra File System)-based text file into an existing CQL table.

About this task

This example shows how to use Spark to import a local or CFS (Cassandra File System)-based text file into an existing CQL table. You use the saveToCassandra method present in Cassandra RDDs to save arbitrary RDD to Cassandra.

Procedure

1. Create a keyspace and a CQL table in Cassandra. For example, use cqlsh.

```
CREATE KEYSPACE int_ks WITH replication =
  {'class': 'NetworkTopologyStrategy', 'Analytics':1};
USE int_ks;
CREATE TABLE int_compound ( pkey int, ckey1 int, data1 int , PRIMARY KEY
 (pkey,ckey1));
```

2. Insert data into the table

```
INSERT INTO int_compound ( pkey, ckey1, data1 ) VALUES ( 1, 2, 3 );
INSERT INTO int_compound ( pkey, ckey1, data1 ) VALUES ( 2, 3, 4 );
INSERT INTO int_compound ( pkey, ckey1, data1 ) VALUES ( 3, 4, 5 );
INSERT INTO int_compound ( pkey, ckey1, data1 ) VALUES ( 4, 5, 1 );
INSERT INTO int_compound ( pkey, ckey1, data1 ) VALUES ( 5, 1, 2 );
```

3. Create a text file named normalfill.csv that contains this data.

```
6,7,8
7,8,6
8,6,7
```

4. Put the CSV file in the CFS. For example, on Linux:

```
$ bin/dse hadoop fs -put <mypath>/normalfill.csv /
```

5. Start the Spark shell.
6. Verify that Spark can access the int_ks keyspace:

```
scala> :showSchema int_ks
========================================
 Keyspace: int_ks
========================================
 Table: int_compound
----------------------------------------
 - pkey  : Int (partition key column)
 - ckey1 : Int (clustering column)
```

```
  - data1 : Int
```

int_ks appears in the list of keyspaces.

7. Read in the file from the CassandraFS, splitting it on the comma delimiter. Transform each element into an Integer.

```
scala> val normalfill = sc.textFile("/normalfill.csv").map(line =>
 line.split(",").map(_.toInt));
normalfill: org.apache.spark.rdd.RDD[Array[Int]] = MappedRDD[2] at map at
 <console>:22
```

   Alternatively, read in the file from the local file system.

```
scala> val file = sc.textFile("file:///<local-path>/normalfill.csv")
file: org.apache.spark.rdd.RDD[String] = MappedRDD[4] at textFile at
 <console>:22
```

8. Check that Spark can find and read the CSV file.

```
scala> normalfill.take(1);
res2: Array[Array[Int]] = Array(Array(6, 7, 8))
```

9. Save the new data to Cassandra.

```
scala> normalfill.map(line => (line(0), line(1),
 line(2))).saveToCassandra(
 "int_ks", "int_compound", Seq("pkey", "ckey1", "data1"))

scala>
```

   The step produces no output.

10. Check that the data was saved in Cassandra using cqlsh.

```
SELECT * FROM int_ks.int_compound;

 pkey | ckey1 | data1
------+-------+-------
    5 |     1 |     2
    1 |     2 |     3
    8 |     6 |     7
    2 |     3 |     4
    4 |     5 |     1
    7 |     8 |     6
    6 |     7 |     8
    3 |     4 |     5

  (8 rows)
```

Connecting to the Spark SQL JDBC server using Beeline

Use Shark Beeline to test the Spark SQL JDBC server.

About this task

You can use Shark Beeline to test the Spark SQL JDBC server.

Procedure

1. Start DataStax Enterprise with Spark enabled as a service or in a standalone installation.

Note: To run index queries, start the node with both Spark and Hadoop enabled. Running in this mode is experimental and not supported.

2. Start the server by entering the `dse start-spark-sql-thriftserver` command as a user with permissions to write to the Spark directories.

   To override the default settings for the server, pass in the configuration property using the --hiveconf option. Refer to the HiveServer2 documentation for a complete list of configuration properties.

   ```
   $ dse start-spark-sql-thriftserver
   ```

   To start the server on port 10001, use the --hiveconf hive.server2.thrift.port=10001 option when starting the server.

   ```
   $ dse start-spark-sql-thriftserver --hiveconf hive.server2.thrift.port=10001
   ```

   If you have enabled authentication, use the cassandra.username and cassandra.password properties.

   ```
   $ dse start-spark-sql-thriftserver --hiveconf cassandra.username=user --
   hiveconf cassandra.password=password
   ```

   To enable virtual columns, pass in the enableVirtualColumns=true option when starting the server.

   ```
   $ dse start-spark-sql-thirftserver --hiveconf enableVirtualColumns=true
   ```
3. Start the Beeline shell.

   ```
   $ dse beeline
   ```
4. Connect to the server using the JDBC URI for your server.

   ```
   beeline> !connect jdbc:hive2://localhost:10000
   ```
5. Connect to a keyspace and run a query from the Beehive shell.

   ```
   0: jdbc:hive2://localhost:10000> use test;
   0: jdbc:hive2://localhost:10000> select * from test;
   ```

Analyzing data using DSE Hadoop

You can run analytics on Cassandra data using Hadoop that is integrated into DataStax Enterprise. The Hadoop component in DataStax Enterprise enables analytics to be run across the DataStax Enterprise distributed, shared-nothing architecture.

About DSE Hadoop

The Hadoop component in DataStax Enterprise enables analytics to be run across DataStax Enterprise's distributed, shared-nothing architecture. Instead of using the Hadoop Distributed File System (HDFS), DataStax Enterprise uses Cassandra File System (CFS) keyspaces for the underlying storage layer.

About this task

You can run analytics on Cassandra data using Hadoop, which is integrated into DataStax Enterprise. The Hadoop component in DataStax Enterprise is not meant to be a full Hadoop distribution, but rather enables analytics to be run across DataStax Enterprise's distributed, shared-nothing architecture. Instead of using the Hadoop Distributed File System (HDFS), DataStax Enterprise uses Cassandra File System (CFS) keyspaces for the underlying storage layer. This provides replication, data location awareness, and takes full advantage of Cassandra's peer-to-peer architecture. DSE Hadoop uses an embedded Apache Hadoop 1.0.4 to eliminate the need to install a separate Hadoop cluster. This is the fastest and easiest option for analyzing Cassandra data using Hadoop.

Unless using DSE Analytics and Search integration, DSE Hadoop workloads are isolated from other workloads that might run in your cluster, Cassandra and Search, never accessing nodes outside of the Analytics data center. Therefore, you can run heavy data analysis without affecting performance of your realtime-transactional system.

DataStax Enterprise supports internal authentication for analyzing data using the following Hadoop components:

- MapReduce
- Hive for running HiveQL queries on Cassandra data
- Pig for exploring very large data sets
- Apache Mahout for machine learning applications

To get started using DSE Hadoop, run the Portfolio Manager demo.

DataStax Enterprise turns off virtual nodes (vnodes) by default. Before turning vnodes on, understand the implications of doing so.

Performance enhancement

DataStax Enterprise optimizes performance reading MapReduce files in the Cassandra File System (CFS) by storing files in the page cache, making the files available on the next read.

Starting a DSE Hadoop node

The way you start up a DSE Hadoop node depends on the type of installation:

- **Installer-Services and Package installations:**
  1. Enable Hadoop mode by setting `HADOOP_ENABLED=1` in `/etc/default/dse`.
  2. Use this command to start the service:

     ```
     $ sudo service dse start
     ```
- **Installer-No Services and Tarball installations:**

  From the installation directory:

  ```
  $ bin/dse cassandra -t
  ```

Stopping a DSE Hadoop node

The way you stop a DSE Hadoop node depends on the type of installation:

- **Installer-No Services and Tarball installations:**
  1. From the install directory:

     ```
     $ bin/dse cassandra-stop
     ```
  2. Check that the dse process has stopped.

     ```
     $ ps auwx | grep dse
     ```

     If the dse process stopped, the output should be minimal, for example:

     ```
     jdoe  12390 0.0 0.0  2432768   620 s000  R+ 2:17PM   0:00.00 grep dse
     ```

If the output indicates that the dse process is not stopped, rerun the cassandra-stop command using the process ID (PID) from the top of the output.

```
bin/dse cassandra-stop PID
```

- **Installer-Services and Package installations:**

  ```
  $ sudo service dse stop
  ```

Hadoop getting started tutorial

A tutorial to use DSE Hadoop that is embedded in DataStax Enterprise.

About this task

In this tutorial, you download a text file containing a State of the Union speech and run a classic MapReduce job that counts the words in the file and creates a sorted list of word/count pairs as output. The mapper and reducer are provided in a JAR file. Download the State of the Union speech now.

This tutorial assumes that you started an analytics node on Linux. Also, the tutorial assumes you have permission to perform Hadoop and other DataStax Enterprise operations, for example, or that you preface commands with sudo if necessary.

Procedure

1. Unzip the downloaded `obama.txt.zip` file into a directory of your choice on your file system.

   This file will be the input for the MapReduce job.
2. Create a directory in the Cassandra File System (CFS) for the input file using the dse command version of the familiar `hadoop fs` command. For example, on Installer-No Services and Tarball installations:

   ```
   $ cd install_location
   $ bin/dse hadoop fs -mkdir /user/hadoop/wordcount/input
   ```

3. Copy the input file that you downloaded to the CFS.

   ```
   $ bin/dse hadoop fs -copyFromLocal
     path/obama.txt
     /user/hadoop/wordcount/input
   ```

4. Check the version number of the `hadoop-examples-version.jar` file, located in:
   - Installer-Services installations: /usr/share/dse/hadoop/lib
   - Installer-No Services installations: *install_location*/resources/hadoop
   - Package installations: /usr/share/dse/hadoop/lib
   - Tarball installations: *install_location*/resources/hadoop
5. Get usage information about how to run the MapReduce job from the jar file.

   ```
   $ bin/dse hadoop jar /install_location/resources/hadoop/hadoop-
   examples-1.0.4.13.jar wordcount
   ```

   The output is:

   ```
   2013-10-02 12:40:16.983 java[9505:1703] Unable to load realm info from
    SCDynamicStore
   Usage: wordcount <in> <out>
   ```

   If you see the SCDynamic Store message, just ignore it. The internet provides information about the message.

6. Run the Hadoop word count example in the JAR.

```
$ bin/dse hadoop jar
  /install_location/resources/hadoop/hadoop-examples-1.0.4.13.jar
 wordcount
  /user/hadoop/wordcount/input
  /user/hadoop/wordcount/output
```

The output is:

```
13/10/02 12:40:36 INFO input.FileInputFormat: Total input paths to
 process : 0
13/10/02 12:40:36 INFO mapred.JobClient: Running job:
 job_201310020848_0002
13/10/02 12:40:37 INFO mapred.JobClient:  map 0% reduce 0%
. . .
13/10/02 12:40:55 INFO mapred.JobClient:     FILE_BYTES_WRITTEN=19164
13/10/02 12:40:55 INFO mapred.JobClient:   Map-Reduce Framework
```

7. List the contents of the output directory on the CFS.

```
$ bin/dse hadoop fs -ls /user/hadoop/wordcount/output
```

The output looks something like this:

```
Found 3 items
-rwxrwxrwx   1 root wheel      0 2013-10-02 12:58 /user/hadoop/wordcount/
output/_SUCCESS
drwxrwxrwx   - root wheel      0 2013-10-02 12:57 /user/hadoop/wordcount/
output/_logs
-rwxrwxrwx   1 root wheel  24528 2013-10-02 12:58 /user/hadoop/wordcount/
output/part-r-00000
```

8. Using the output file name from the directory listing, get more information using the dsetool utility.

```
$ bin/dsetool checkcfs /user/hadoop/wordcount/output/part-r-00000
```

The output is:

```
Path: cfs://127.0.0.1/user/hadoop/wordcount/output/part-r-00000
  INode header:
    File type: FILE
    User: root
    Group: wheel
    Permissions: rwxrwxrwx (777)
    Block size: 67108864
    Compressed: true
    First save: true
    Modification time: Wed Mar 02 12:58:05 PDT 2014
  INode:
    Block count: 1
    Blocks:                               subblocks   length   start
 end
      (B) f2fa9d90-2b9c-11e3-9ccb-73ded3cb6170:   1    24528       0
 24528
          f3030200-2b9c-11e3-9ccb-73ded3cb6170:        24528       0
 24528
    Block locations:
    f2fa9d90-2b9c-11e3-9ccb-73ded3cb6170: [localhost]
  Data:
    All data blocks ok.
```

9. Finally, look at the output of the MapReduce job--the list of word/count pairs using a familiar Hadoop command.

   ```
   $ bin/dse hadoop fs -cat /user/hadoop/wordcount/output/part-r-00000
   ```

   The output is:

   ```
   "D."  1
   "Don't  1
   "I  4
   . . .
   ```

Analytics node configuration

Steps to configure analytic nodes for DSE Hadoop.

About this task

Important configuration changes, excluding those related to the Job Tracker, are:

- Disabling virtual nodes
- Setting the replication factor
- Configuring the verbosity of log messages
- Connecting to non-standard Cassandra native port

Advanced users can also configure DataStax Enterprise to run jobs remotely.

DataStax Enterprise turns off virtual nodes (vnodes) by default because using vnodes causes a sharp increase in the Hadoop task scheduling latency. This increase is due to the number of Hadoop splits, which cannot be lower than the number of vnodes in the analytics data center. Using vnodes, instead of N splits for tiny data, you have, for example, 256 * N splits, where N number of physical nodes in the cluster. This may raise job latency from tens of seconds to single or even tens of minutes. This increase in job latency is relatively insignificant when running jobs for hours to analyze huge quantities of data that inherently has lots of splits anyway. In this case, vnodes are perfectly fine. You can use vnodes for any Cassandra-only cluster, a Cassandra-only data center, a Spark data center, or a Search-only data center in a mixed Hadoop/Search/Cassandra deployment.

Note: To you use vnodes on DSE Search nodes, DataStax recommends from 64 to 256 vnodes. Using vnodes increases performance overhead by approximately 30%.

Setting the replication factor

Change the default replication factor to a production-appropriate value of at least 3.

Configuring the verbosity of log messages

To adjust the verbosity of log messages for Hadoop map/reduce tasks, add the following settings to the logback.xml file on each analytic node:

```
logback.logger.org.apache.hadoop.mapred=WARN
logback.logger.org.apache.hadoop.filecache=WARN
```

The location of the `logback.xml` file depends on the type of installation:

Installer-Services and Package installations	`/etc/dse/cassandra/conf/logback.xml`
Installer-No Services and Tarball installations	*`install_location`*`/resources/cassandra/conf/logback.xml`

Connecting to non-standard Cassandra native port

If the Cassandra native port was changed to a port other than the default port 9042, you must change the cassandra.input.native.port configuration setting for Hive and Hadoop to use the non-default port. The following examples change the Cassandra native port protocol connections to use port 9999.

- Inside the Hive shell, set the port after starting DSE Hive:

  ```
  $ dse hive
  hive> set cassandra.input.native.port=9999;
  ```
- General Hive, add cassandra.input.native.port to the hive-site.xml file:

  The default location of the `hive-site.xml` file depends on the type of installation:

Installer-Services and Package installations	`/etc/dse/hive/hive-site.xml`
Installer-No Services and Tarball installations	*`install_location`*`/resources/hive/conf/hive-site.xml`

  ```
  <property>
      <name>cassandra.input.native.port</name>
      <value>9999</value>
  </property>
  ```
- For Hadoop, add cassandra.input.native.port to the core-site.xml file:

  The default location of the `core-site.xml` file depends on the type of installation:

Installer-Services and Package installations	`/etc/dse/hadoop/conf/core-site.xml`
Installer-No Services and Tarball installations	*`install_location`*`/resources/hadoop/conf/core-site.xml`

  ```
  <property>
      <name>cassandra.input.native.port</name>
      <value>9999</value>
  </property>
  ```

Configuration for running jobs on a remote cluster

This information is intended for advanced users.

Procedure

To connect to external addresses:

1. Make sure that the hostname resolution works properly on the localhost for the remote cluster nodes.
2. Copy the `dse-core-default.xml` and `dse-mapred-default.xml` files from any working remote cluster node to your local Hadoop conf directory.
3. Run the job using `dse hadoop`.
4. To override the Job Tracker location or if DataStax Enterprise cannot automatically detect the Job Tracker location, define the HADOOP_JT environment variable before running the job:

   ```
   $ export HADOOP_JT=jobtracker host:jobtracker port dse hadoop jar ....
   ```
5. If you need to connect to many different remote clusters from the same host:
   a) Before starting the job, copy the remote Hadoop conf directories fully to the local node (into different locations).
   b) Select the appropriate location by defining HADOOP_CONF_DIR.

Changing the Hadoop log directory

Add the HADOOP_LOG_DIR environment variable to the `dse-env.sh` file to recognize changes to the default log directory used by the Hadoop component that is integrated into DataStax Enterprise.

About this task

You must add the HADOOP_LOG_DIR environment variable to the `dse-env.sh` file to enable DataStax Enterpriseto recognize changes to the default log directory used by the Hadoop component integrated into DataStax Enterprise.

Note: If you change the default Hadoop log directory environment variable in `hadoop-env.sh` and restart DataStax Enterprise, the change is not recognized.

Procedure

1. In the dse-env.sh file, comments describe where to add the command to configure the environment variable. For example:

   The default location of the `dse-env.sh` file depends on the type of installation:

Installer-Services and Package installations	`/etc/dse/dse-env.sh`
Installer-No Services and Tarball installations	*`install_location`*`/bin/dse-env.sh`

```
#!/bin/sh

# Add any environment overrides you need here. This is where users
# may set third-party variables such as HADOOP_LOG_DIR

export HADOOP_LOG_DIR=/var/log/hadoop/new_log_location

# ==================================
# don't change after this.
if [ -r "`dirname "$0"`/dse.in.sh" ]; then
. . .
```

2. Restart DataStax Enterprise after configuring the new log location.

   In a packaged installation, DataStax Enterprise loads the environment variable change using `/usr/share/dse/dse.in.sh` after you restart the node.

Portfolio Manager demo using DSE Hadoop

Steps to run a tutorial for the Hadoop component that is integrated into DataStax Enterprise to create and manage a portfolio of stocks.

About this task

The use case is a financial application where users can actively create and manage a portfolio of stocks. On the Cassandra OLTP (online transaction processing) side, each portfolio contains a list of stocks, the number of shares purchased, and the purchase price. The demo's pricer utility simulates real-time stock data where each portfolio updates based on its overall value and the percentage of gain or loss compared to the purchase price. This utility also generates 100 days of historical market data (the end-of-day price) for each stock. On the DSE OLAP (online analytical processing) side, a Hive MapReduce job calculates the greatest historical 10 day loss period for each portfolio, which is an indicator of the risk associated with a portfolio. This information is then fed back into the real-time application to allow customers to better gauge their potential losses.

Procedure

To run the demo:

Note: DataStax Demos do not work with either LDAP or internal authorization (username/password) enabled.

1. Install a single Demo node using the DataStax Installer in GUI or Text mode with the following settings:
   - **Install Options** page - **Default Interface: 127.0.0.1** (You must use this IP for the demo.)
   - **Node Setup** page - **Node Type: Analytics**
   - **Analytic Node Setup** page - **Analytics Type: Spark + Integrated Hadoop**
2. Start DataStax Enterprise if you haven't already:
   - **Installer-Services and Package installations:**

     ```
     $ sudo service dse start
     ```
   - **Installer-No Services and Tarball installations:**

     ```
     install_location/bin/dse cassandra -k -t ## Starts node in Spark and
      Hadoop mode
     ```

     ```
     install_location/bin/dse cassandra -t ## Starts node in Hadoop mode
     ```

     The default *install_location* is `/usr/share/dse`.
3. Go to the Portfolio Manager demos directory.

   The default location of the Portfolio Manager demo depends on the type of installation:

Installer-Services and Package installations	`/usr/share/dse/demos/portfolio_manager`
Installer-No Services and Tarball installations	*`install_location`*`/demos/portfolio_manager`

4. Run the bin/pricer utility to generate stock data for the application:
   - To see all of the available options for this utility:

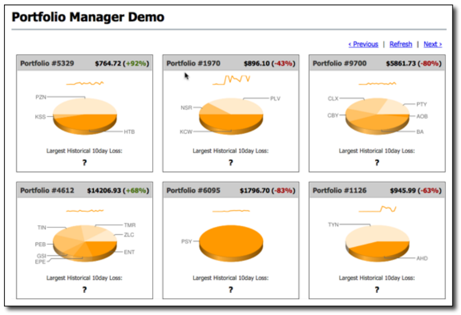
     ```
     $ bin/pricer --help
     ```
   - Start the pricer utility:

     ```
     $ bin/pricer -o INSERT_PRICES
     $ bin/pricer -o UPDATE_PORTFOLIOS
     $ bin/pricer -o INSERT_HISTORICAL_PRICES -n 100
     ```

   The pricer utility takes several minutes to run.
5. Start the web service:

   ```
   $ cd website
   $ sudo ./start
   ```
6. Open a browser and go to `http://localhost:8983/portfolio`.

   The real-time Portfolio Manager demo application is displayed.

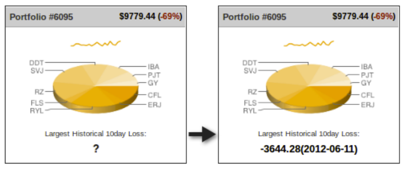

Portfolio Manager Demo
‹ Previous | Refresh | Next ›
Portfolio #5329 $764.72 (+92%)
PZN
KSS
HTB
Largest Historical 10day Loss:
?
Portfolio #1970 $896.10 (-43%)
NSR
PLV
KCW
Largest Historical 10day Loss:
?
Portfolio #9700 $5861.73 (-80%)
CLX
CBY
PTY
AOB
BA
Largest Historical 10day Loss:
?
Portfolio #4612 $14206.93 (+68%)
TIN
PEB
GSI
EPE
TMR
ZLC
ENT
Largest Historical 10day Loss:
?
Portfolio #6095 $1796.70 (-83%)
PSY
Largest Historical 10day Loss:
?
Portfolio #1126 $945.99 (-63%)
TYN
AHD
Largest Historical 10day Loss:
?

7. Open another terminal.
8. Start Hive and run the MapReduce job for the demo in Hive.
   - Installer-Services: `$ dse hive -f /usr/share/dse/demos/portfolio_manager/10_day_loss.q`
   - Package installations: `$ dse hive -f /usr/share/dse-demos/portfolio_manager/10_day_loss.q`
   - Installer-No Services and Tarball installations: `$` *`install_location`*`/bin/dse hive -f` *`install_location`*`/demos/portfolio_manager/10_day_loss.q`

   The MapReduce job takes several minutes to run.
9. To watch the progress in the Job Tracker node, open the following URL in a browser.

   `http://localhost:50030/jobtracker.jsp`
10. After the job completes, refresh the **Portfolio Manager** web page.

    The results of the Largest Historical 10 day Loss for each portfolio are displayed.


Portfolio #6095 $9779.44 (-69%)
DDT
SVJ
RZ
FLS
RYL
IBA
PJT
GY
CFL
ERJ
Largest Historical 10day Loss:
?
Portfolio #6095 $9779.44 (-69%)
Largest Historical 10day Loss:
-3644.28(2012-06-11)

Using common Hadoop commands

Common Hadoop commands perform functions in the Cassandra File System (CFS) that correspond to open source, HDFS file system shell commands.

Use common hadoop commands to perform functions in the Cassandra File System (CFS) that correspond to open source, HDFS file system shell commands. The format of the URI for the CFS is:

```
[cfs-name:][//[host]] path
```

- If cfs-name is missing, cfs, which means to access the CFS, is used.
- If host is missing, the address of the local node is used.
- If host is given, the path must start with /

For example, the following paths point to the same path in the CFS:

```
/tmp
///tmp
cfs:/tmp
cfs:///tmp
cfs://localhost/tmp
//localhost/tmp
```

Execute hadoop fs commands on the command line in these directories:

- Installer-Services and Package installations:

  ```
  $ dse hadoop fs option
  ```
- Installer-No Services and Tarball installations:

  ```
  $ install_location/bin/dse hadoop fs option
  ```

For example, using this syntax, you can load MapReduce input from the local file system into the Cassandra File System on Linux.

```
$ dse hadoop fs -mkdir /user/hadoop/wordcount/input

$ dse hadoop fs -copyFromLocal $HADOOP_EXAMPLE/data/state_of_union/
state_of_union.txt
   /user/hadoop/wordcount/input
```

To list all options for performing command hadoop HDFS commands:

```
$ dse hadoop fs -help
```

The DSE command reference lists other commands.

Using the cfs-archive to store huge files

The Cassandra File System (CFS) consists of two layers: cfs and cfs-archive. Using cfs-archive is recommended for long-term storage of huge files.

About this task

The Cassandra File System (CFS) consists of two layers, cfs and cfs-archive that you access using these Hadoop shell commands and URIs:

- cfs:// for the cassandra layer
- cfs-archive:// for the cassandra archive layer

Using cfs-archive is highly recommended for long-term storage of huge files, such as those having terabytes of data. On the contrary, using cfs is not recommended because the data on this layer undergoes the compaction process periodically, as it should. Hadoop uses the cfs layer for many small files and temporary data, which need to be cleaned up after deletions occur. When you use the cfs layer instead of the cfs-archive layer, compaction of huge files can take too long, for example, days. Files stored on the cfs-archive layer, on the other hand, do not undergo compaction automatically. You can manually start compaction using the nodetool compact command.

Example: Store a file on cfs-archive

This example shows how to store a file on cfs-archive using the Hadoop shell commands from the DataStax Enterprise installation directory on Linux:

1. Create a directory on the cfs-archive layer. You must use an additional forward slash, as described earlier:

   ```
   bin/dse hadoop fs -mkdir cfs-archive:///20140401
   ```
2. Use the Hadoop shell put command and an absolute path name to store the file on the cfs-archive layer.

   ```
   bin/dse hadoop fs -put big_archive.csv cfs-archive:///20140401/
   big_archive.csv
   ```

3. Check that the file is stored in on the cfs-archive.

   ```
   bin/dse hadoop fs -ls cfs-archive:///20140401/
   ```

Example: Migrate a file from SQL to text on cfs-archive

This example shows how to migrate the data from the MySQL table the archive directory cfs-archive/npa_nxx.

1. Run the sqoop demo.
2. Use the dse command in the bin directory to migrate the data from the MySQL table to text files in the npa_nxx directory of cfs-archive. Specify the IP address of the host in the --target-dir option.

   ```
   $ sudo ./dse sqoop import --connect
       jdbc:mysql://127.0.0.1/npa_nxx_demo
       --username root
       --password <password>
       --table npa_nxx
       --target-dir cfs-archive://127.0.0.1/npa_nxx
   ```

Using Hive with DSE Hadoop

Use Hive with DSE Hadoop to eliminate boilerplate MapReduce code and enjoy productivity gains. DataStax Enterprise includes a Cassandra-enabled Hive MapReduce client. Use Hive to query Cassandra data using an SQL-like language called HiveQL.

About this task

DataStax Enterprise includes a Cassandra-enabled Hive MapReduce client. Hive is a data warehouse system for Hadoop that projects a relational structure onto data that is stored in Hadoop-compatible file systems. You use Hive to query Cassandra data using an SQL-like language called HiveQL.

You start the Hive client on an analytics node and run MapReduce queries directly on data stored in Cassandra. Using the DataStax Enterprise ODBC driver for Hive, a JDBC compliant user interface can connect to Hive from the Hive server.

Why Hive

By using Hive, you typically eliminate boilerplate MapReduce code and enjoy productivity gains. The large base of SQL users can master HiveQL quickly. Hive has a large set of standard functions, such as mathematical and string functions. You can use Hive for queries that Cassandra as a NoSQL database does not support, such as joins. DataStax Enterprise support of Hive facilitates the migration of data to DataStax Enterprise from a Hive warehouse. Hive capabilities are extensible through a Hive user-defined function (UDF), which DataStax Enterprise supports.

Typical uses for Hive are:

- Reporting

  User engagement and impression click count applications
- Ad hoc analysis
- Machine learning

  Advertising optimization

Hive in DataStax Enterprise

DSE Analytics nodes store Hive table structures in the Cassandra File System (CFS) instead of in a Hadoop Distributed File System (HDFS). You *layer* a Hive table definition onto a directory in the file system or use Hive to query a CQL table. The Hive table definition describes the layout of the data and is stored in the HiveMetaStore keyspace. DataStax Enterprise implements the Hive metastore as the HiveMetaStore keyspace within Cassandra. Unlike open source Hive, there is no need to run the metastore as a standalone database to support multiple users.

The consistency level of Hadoop nodes is ONE by default, but when processing Hive queries, if DataStax Enterprise can guarantee that all replicas are in the same data center, the consistency level of LOCAL_ONE is used.

There are two types of Hive tables: external tables and managed tables.

Automatically created external tables

DataStax Enterprise automatically creates a Hive external table for each existing CQL table when you attempt to use the keyspace/table name in Hive. Exception: After upgrading, you need to enable auto-creation of tables.

About custom external tables

You can create a custom external table using TBLPROPERTIES and SERDEPROPERTIES when the auto-created table does not suit your needs. The external table data source is external to Hive, located in CQL. When you drop a Hive external table, only the table metadata stored in the HiveMetaStore keyspace is removed. The data persists in CQL.

Restoring tables after upgrading

You need to map custom external tables to the new release format after upgrading to DataStax Enterprise 4.7. DataStax Enterprise provides the `hive-metastore-migrate` tool for mapping the tables to the new format. The tool is in the hive-metastore-<version>.jar in `resources/hive/lib`.

Use the hive-metastore-migrate tool only *after* upgrading and only on a *stable* cluster.

To use the hive-metastore-migrate tool, perform steps in this order:

1. Upgrade DataStax Enterprise.
2. Check that the cluster is stable after upgrading.
3. Call the `hive-metastore-migrate` tool using the following options:

Hive-metastore-migrate tool options

- -from <from>

  Source release number
- -help

  Print hive-metastore-migrate command usage
- -host <host>

  Host name
- -password <password>

  Password
- -port <port>

  Port number
- -to <to>

  Destination release number
- -user <user>

  User name

This example show how to call use to map Hive custom tables created in DataStax Enterprise 4.5.0 to the format required for a later release, for example 4.7.1:

```
bin/dse hive-metastore-migrate --to 4.7.1  --from 4.5.0
```

In this example, the old Hive tables in 4.5.0 format are mapped to the new 4.7.1 release format.

The `hive-metastore-migrate` tool copies the metadata to a row key using a prefix, for example 4.5.0_, that you specify using the -to option. The tool inserts data for a row key only if there is no data for that row/column.

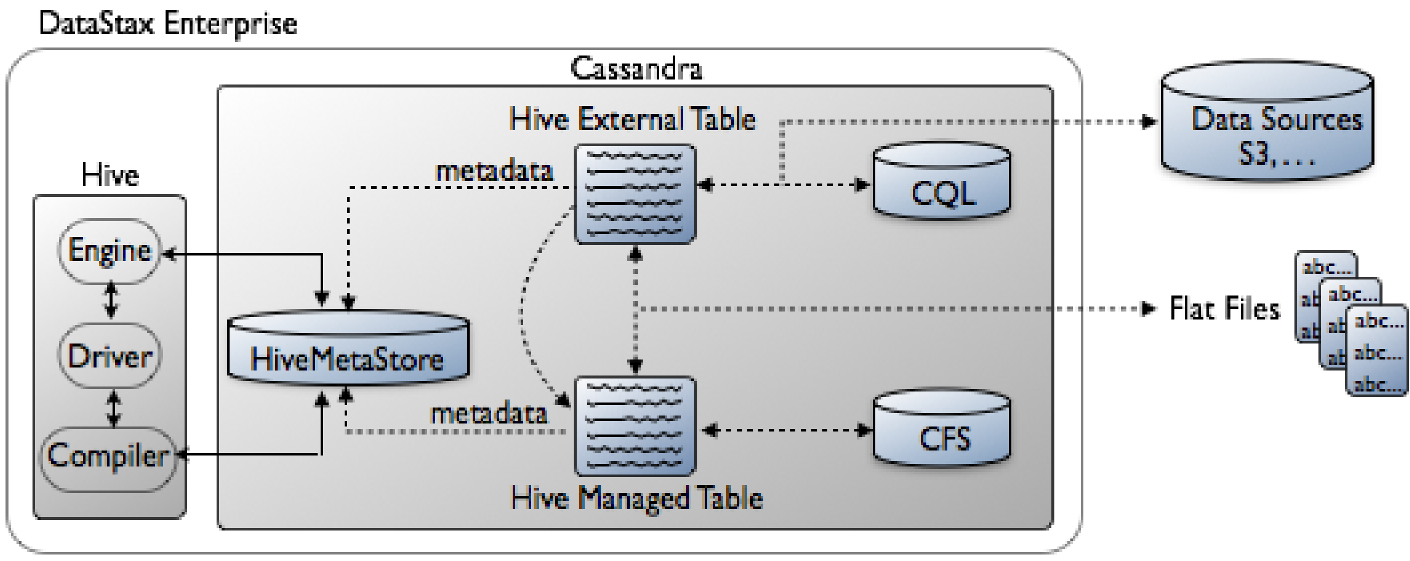
Enabling automatic generation of external tables after upgrading

Automatic generation of external tables is disabled. To enable automatic generation of external tables, start Hive and run one of these commands at the Hive prompt to enable automatic generation of external tables:

- SHOW databases
- USE <database name>

Managed tables

Instead of an external table, you can use a Hive managed table. Hive manages storing and deleting the data in this type of table. DataStax Enterprise stores Hive managed table data in the Cassandra File System (CFS). The data source for the Hive managed table can be a flat file that you put on the CFS `using a dse hadoop -fs` command or the file can be elsewhere, such as on an operating system file system. To load the managed file, use the LOAD [LOCAL] DATA INPATH, INSERT INTO, or INSERT OVERWRITE Hive commands. You use Hive external tables to access Cassandra or other data sources, such as Amazon S3. Like the Hive managed table, you can populate the external table from flat files on the local hard drive, as well as dumped the data from Hive to a flat file. You can also copy an external table, which represents a Cassandra table, into a Hive managed table stored in CFS. The following diagram shows the architecture of Hive in DataStax Enterprise.



Hive metastore configuration

The HiveMetaStore in DataStax Enterprise supports multiple users and requires no configuration except increasing the default replication factor of the keyspace. The default replication for system keyspaces is 1. This replication factor is suitable for development and testing, not for a production environment. To avoid production problems, alter the replication factor of these system keyspaces from 1 to at least 3.

- HiveMetaStore
- cfs
- cfs_archive keyspaces

To prevent missing data problems or data unavailable exceptions after altering keyspaces that contain any data, run nodetool repair as shown in these examples.

Supported Hive features

The Hive component in DataStax Enterprise includes querying capabilities, data type mapping, and performance enhancements. The following Hive 0.12 features are supported:

- Windowing functions
  - RANK
  - LEAD/LAG
  - ROW_NUMBER
  - FIRST_VALUE, LAST_VALUE
- Aggregate OVER functions with PARTITION BY and ORDER BY

DataStax Enterprise supports most CQL and Cassandra internal data types. DataStax provides a Hive user-defined function (UDF) for working with unsupported types, such as blob:

```
org.apache.hadoop.hive.cassandra.ql.udf.UDFStringToCassandraBinary
```

This UDF converts from Hive Strings to native Cassandra types. Due to limitations in Hive, the UDF can be used only to convert Hive Strings to string primitives, not collections that are arrays and maps of strings. It is not possible to use the UDF to convert, for example, an array of strings representing inet addresses to an array of InetAddress columns in Cassandra.

Running Hive

With DSE Hadoop, run Hive as a server or as a client. DataStax Enterprise supports Apache HiveServer and Apache HiveServer2. HiveServer is an optional service for remote clients to submit programmatic requests to Hive.

About this task

You can run Hive as a server or as a client. DataStax Enterprise supports Apache HiveServer and Apache HiveServer2. HiveServer is an optional service for remote clients to submit programmatic requests to Hive. HiveServer2 is an improved version of HiveServer that supports multi-client concurrency and other features.You can use the Beeline command shell with HiveServer2.

Use a Hive client on a node in the cluster under these conditions:

- To connect to the Hive server running on another node
- To use Hive in a single-node cluster

Start a Hive client

You can start a Hive client on any analytics node and run MapReduce queries directly on data already stored in Cassandra. You run Hive as a client to perform the examples in this document.

Procedure

1. Start DataStax Enterprise as an analytics (Hadoop) node.
   - Installer-Services and Package installations:
     1. Enable Hadoop mode by setting this option in `/etc/default/dse`:

        ```
        HADOOP_ENABLED=1
        ```

2. Use this command to start the service:

   ```
   $ sudo service dse start
   ```

- Installer-No Services and Tarball installations:

  From the installation directory:

  ```
  $ bin/dse cassandra -t
  ```

2. Start a Hive client.

- Installer-Services and Package installations:

  ```
  $ dse hive
  ```

- Installer-No Services and Tarball installations:

  ```
  $ install_location/bin/dse hive
  ```

The hive prompt appears and you can now enter HiveQL shell commands.

Browsing through Cassandra tables in Hive

If a keyspace and table exists in Cassandra, you can query the keyspace and table in Hive.

If a keyspace and table exists in Cassandra, you can query the keyspace and table in Hive. For example, create a keyspace in Cassandra using cqlsh. Add some data to the table using cqlsh, and then access the data in Hive.

```
cqlsh> CREATE KEYSPACE cassandra_keyspace WITH replication =
         {'class': 'NetworkTopologyStrategy', 'Analytics': 1};
cqlsh> USE cassandra_keyspace;
cqlsh:cassandra_keyspace> CREATE TABLE exampletable
                            ( key int PRIMARY KEY , data text );
cqlsh:cassandra_keyspace> INSERT INTO exampletable (key, data )
                            VALUES ( 1, 'This data can be read
                              automatically in hive');
cqlsh:cassandra_keyspace> quit;
```

At this point, you can start Hive and query the keyspace and table in Hive.

```
hive> USE cassandra_keyspace;
hive> SHOW TABLES;
      OK
      exampletable
hive> SELECT * FROM exampletable;
      OK
      1 This data can be read automatically in hive
```

Creating or altering CQL data from Hive

Use a Hive external table to create or alter CQL data from Hive. A counterpart to the Hive database/ external table must pre-exist in Cassandra as an keyspace/table.

You need to use a Hive external table to create or alter CQL data from Hive. A counterpart to the Hive database/external table must pre-exist in Cassandra as an keyspace/table. When you use a Hive database name that matches a Cassandra keyspace name, DataStax Enterprise automatically generates a Hive external table for each table in the keyspace. If the auto-created external table does not suit your needs, you create a custom external table using different TBL and SERDEPROPERTIES. Use the `CREATE EXTERNAL TABLE` statement to create such a table.

To use Hive with legacy tables, such as those created using Thrift or the CLI, see DataStax Enterprise 3.0 documentation. Thrift applications require that you configure Cassandra for connection to your application using the rpc connections instead of the default native_transport connection.

Creating a custom external table

This example assumes you created the cassandra_keyspace and exampletable in "Browsing through Cassandra tables in Hive". A Hive example table is auto-created when you run the `USE cassandra_keyspace` command on the Hive command line. To use a Hive database or table of a different name than the auto-created ones, but with the same or a similar schema, customize the auto-created external table as shown in this example. The example uses the Hive database named bigdata instead cassandra_keyspace, and the example uses a table named MyHiveTable instead of exampletable. The example specifies the CQL keyspace and table names in the external table definition using the TBLPROPERTIES clause to use the CQL-defined schema.

Creating an custom external table

```
hive> CREATE DATABASE bigdata;
hive> USE bigdata;
hive> CREATE EXTERNAL TABLE MyHiveTable
        ( key int,  data string )
        STORED BY 'org.apache.hadoop.hive.cassandra.cql3.CqlStorageHandler'
        TBLPROPERTIES ( "cassandra.ks.name" = "cassandra_keyspace" ,
          "cassandra.cf.name" = "exampletable" );
```

Inspecting an auto-created, external table (DataStax Enterprise 4.0.4 and later)

In Hive, you can use the `SHOW CREATE TABLE <CQL table name>` command to see the schema of a auto-created external table. The output of this command can help you construct a custom Hive external table definition. Assuming you created the table in "Browsing through Cassandra tables in Hive", use the SHOW CREATE TABLE command to see the schema of exampletable.

```
hive> SHOW CREATE TABLE exampletable;
OK
CREATE EXTERNAL TABLE exampletable(
  key int COMMENT 'from deserializer',
  data string COMMENT 'from deserializer')
ROW FORMAT SERDE
  'org.apache.hadoop.hive.cassandra.cql3.serde.CqlColumnSerDe'
STORED BY
  'org.apache.hadoop.hive.cassandra.cql3.CqlStorageHandler'
WITH SERDEPROPERTIES (
  'serialization.format'='1',
  'cassandra.columns.mapping'='key,data')
LOCATION
  'cfs://127.0.0.1/user/hive/warehouse/cassandra_keyspace.db/exampletable'
TBLPROPERTIES (
  'cassandra.partitioner'='org.apache.cassandra.dht.Murmur3Partitioner',
  'cql3.partition.key'='key',
  'cassandra.ks.name'='cassandra_keyspace',
  'cassandra.cf.name'='exampletable',
  'auto_created'='true')
Time taken: 0.028 seconds, Fetched: 18 row(s)
```

Updating metadata in Hive when altering tables

When you run ALTER TABLE, the metadata in Hive is not updated and subsequent Hive and SparkSQL queries fail.

Workaround

1. Enter the hive shell:

   ```
   $ dse hive
   ```

2. In the hive shell, drop the table:

   ```
   hive> DROP TABLE your_keyspace.your_table;
   ```

3. To allow Hive to refresh the metadata:

   ```
   hive> USE your_keyspace;
   ```

Hive to Cassandra type mapping

In the Hive CREATE EXTERNAL TABLE statement, use the Hive data type that corresponds to the Cassandra data type.

In the Hive CREATE EXTERNAL TABLE statement, use the Hive data type that corresponds to the Cassandra data type. The following table maps CQL, Cassandra internal storage engine (used by legacy tables), and Hive data types:

CQL	Cassandra Internal	Hive
ascii	AsciiType	string
bigint	LongType	bigint
boolean	BooleanType	boolean
counter	CounterColumnType	bigint
decimal	DecimalType	decimal
double	DoubleType	double
float	FloatType	float
inet	InetAddressType	binary
int	Int32Type	int
text	UTF8Type	string
timestamp	TimestampType	date
timestamp	TimestampType	timestamp
timeuuid	TimeUUIDType	binary
uuid	UUIDType	binary
varint	IntegerType	binary
varchar	UTF8Type	varchar
other	other	binary

The InetAddressType stores the raw IP address in network byte order.

Using TBLPROPERTIES and SERDEPROPERTIES

In an external table definition, the TBLPROPERTIES clause maps the Hive database to a CQL table and can include MapReduce properties, Cassandra database configuration, and native protocol properties for the table. The SERDEPROPERTIES clause specifies the properties used when serializing/deserializing data passed between the Hive table and Cassandra.

In an external table definition, the TBLPROPERTIES clause maps the Hive database to a CQL table and can include MapReduce properties, Cassandra database configuration, and native protocol properties for the table. The SERDEPROPERTIES clause specifies the properties used when serializing/deserializing data passed between the Hive table and Cassandra. You can add a WITH SERDEPROPERTIES clause to map meaningful column names in Hive to the Cassandra partition key, column names, and column values. You can change these properties on the fly. Using the Hive SET command, you can configure properties in the hive session. The settings become effective for the next query.

The following table lists general properties used in the TBLPROPERTIES or SERDEPROPERTIES clause or both. The subsequent section lists additional, optional properties for use with the DataStax Java Driver. The TBL/SERDE column of the following table lists how to declare properties in the table definition, as a TBLPROPERTIES (TBL), a SERDEPROPERTIES (SERDE) or both.

Table 11: General TBL and SERDE properties

General Property	TBL/SERDE	Description
cassandra.cf.name	both	Cassandra table name
cassandra.columns.mapping	both	Mapping of Hive to legacy Cassandra columns
cassandra.consistency.level	both	Consistency level - default ONE
cassandra.cql3.type	both	CQL types
cassandra.host	both	IP of a Cassandra node to connect to
cassandra.input.split.size	both	MapReduce split size
cassandra.ks.name	both	Cassandra keyspace name
cassandra.partitioner	both	Partitioner (default = configured partitioner)
cassandra.port	both	Cassandra RPC port - default 9160
cql3.output.query	TBL	A prepared statement for storing alterations to a CQL users table
cql3.partition.key	both	CQL partition key, a comma-separated list of partition and clustering keys
cql3.pushdown.enable	TBL	True (default) enable pushdown predicate
cql3.update.columns	both	Used with INSERT INTO SELECT

Required table properties

When you create an external table in Hive, you need to specify these properties:

- cassandra.ks.name
- cassandra.cf.name

Other frequently-used properties are:

- cql3.output.query
- cql3.partition.key (DataStax Enterprise 4.0.4 and later)

You use the `SHOW CREATE TABLE <CQL table name>` command at the Hive prompt to see the auto-created external table. The output helps you see how to format the cql3.partition.key in your custom external table. For example, the output of a table having following CQL composite partition key, has the 'cql3.partition.key'='key,event_id' Hive property syntax:

```
PRIMARY KEY ((key, event_id), num_responses)
```

Required storage handler

Also required in the external table definition is the CQL storage handler: `org.apache.hadoop.hive.cassandra.cql3.CqlStorageHandler`. The storage handler accesses and stores Cassandra data back to Cassandra.

About the cassandra.input.split.size

The cassandra.input.split.size property configures the number of CQL partitions processed per mapper (64k rows per split). The default is 64 * 1024. If your tables have large partitions (many distinct values of clustering columns for the same partitioning key), do *not* use the default. Use a lower setting.

Partitioner use by Hive

You do not need to specify cassandra.partitioner. Your configured partitioner is used by Hive. For example, Hive uses this property value if you use the Cassandra 2.1 default partitioner:

```
"cassandra.partitioner" = "org.apache.cassandra.dht.Murmur3Partitioner"
```

Creating or altering CQL data from Hive and MapReduce performance show examples of using some of these properties.

Optional native protocol properties

DataStax Enterprise supports the following optional properties for the native protocol.

- cassandra.input.native.port
- cassandra.input.native.core.connections.per.host
- cassandra.input.native.max.connections.per.host
- cassandra.input.native.min.simult.reqs.per.connection
- cassandra.input.native.max.simult.reqs.per.connection
- cassandra.input.native.connection.timeout
- cassandra.input.native.read.connection.timeout
- cassandra.input.native.receive.buffer.size
- cassandra.input.native.send.buffer.size
- cassandra.input.native.solinger
- cassandra.input.native.tcp.nodelay
- cassandra.input.native.reuse.address
- cassandra.input.native.keep.alive
- cassandra.input.native.auth.provider
- cassandra.input.native.ssl.trust.store.path
- cassandra.input.native.ssl.key.store.path
- cassandra.input.native.ssl.trust.store.password
- cassandra.input.native.ssl.key.store.password
- cassandra.input.native.ssl.cipher.suites

Using a managed table to load local data

If you do not need to store data in a Cassandra table, use a managed table instead of an external table. The data can be located in the Cassandra File System (CFS) or on the file system.

If you do not need to store data in a Cassandra table, use a managed table instead of an external table. The data can be located in the Cassandra File System (CFS) or on the file system. You load the data into the managed table as shown in this example:

1. Create a managed table:

```
hive>  CREATE TABLE invites (foo INT, bar STRING )
       PARTITIONED BY  (ds STRING );
```

2. Load data into a table using the LOAD DATA command. The HiveQL Manual provides more information about the HiveQL syntax.

   For example, on the Mac OS X:

```
hive>  LOAD DATA LOCAL INPATH '<install_location>/resources/hive/
examples/files/kv2.txt' OVERWRITE INTO TABLE invites PARTITION  ( ds =
 '2008-08-15' );

hive>  LOAD DATA LOCAL INPATH  '<install_location>/resources/hive/
examples/files/kv3.txt' OVERWRITE INTO TABLE invites PARTITION  ( ds =
 '2008-08-08' );

hive>  SELECT count (* ), ds FROM invites GROUP BY ds;
```

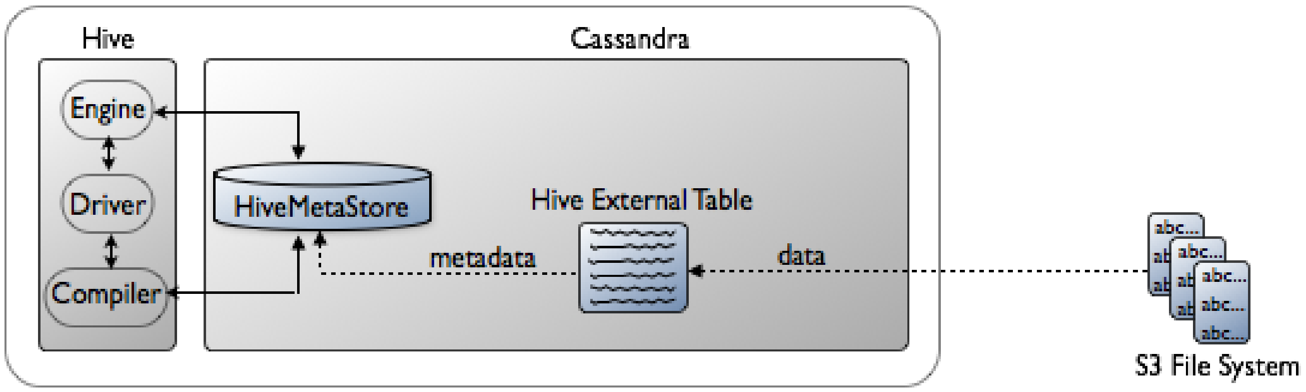
Note: The paths to the Hive example files shown in the example LOAD commands above are for the tarball distribution.

Using an external file system

You can map a file in an external file system, such as S3 native file system to a table in Hive.

About this task

You can map a file in an external file system, such as S3 native file system to a table in Hive. The DSE Hadoop cluster continues to use the Cassandra File System (CFS). The data source is external to Hive, located in S3 for example. You create a Hive external table for querying the data in an external file system. When you drop the external table, only the table metadata that is stored in the HiveMetaStore keyspace is removed. The data persists in the external file system.



First, set up the `hive-site.xml` and `core-site.xml` files, and then create an external table as described in this procedure.

Procedure

1. Open the hive-site.xml file for editing.

The default location of the `hive-site.xml` file depends on the type of installation:

Installer-Services and Package installations	`/etc/dse/hive/hive-site.xml`
Installer-No Services and Tarball installations	*`install_location`*`/resources/hive/conf/hive-site.xml`

2. Add a property to `hive-site.xml` to set the default file system to be the native S3 block file system. Use `fs.default.name` as the name of the file system and the location of the bucket as the value. For example, if the S3 bucket name is mybucket:

```
<property>
  <name>fs.default.name</name>
  <value>s3n://mybucket</value>
</property>
```

3. Save the file.
4. Open the core-site.xml file for editing.

   The default location of the `core-site.xml` file depends on the type of installation:

Installer-Services and Package installations	`/etc/dse/hadoop/conf/core-site.xml`
Installer-No Services and Tarball installations	*`install_location`*`/resources/hadoop/conf/core-site.xml`

5. Add these properties to core-site.xml to specify the access key ID and the secret access key credentials for accessing the native S3 block filesystem:

```
<property>
  <name>fs.s3n.awsAccessKeyId</name>
  <value>ID</value>
</property>

<property>
  <name>fs.s3n.awsSecretAccessKey</name>
  <value>Secret</value>
</property>
```

6. Save the file and restart Cassandra.
7. Create a directory in `s3n://mybucket` named, for example, `mydata_dir`.
8. Create a data file named `mydata.txt`, for example. Delimit fields using =.

```
"key1"=100
"key2"=200
"key3"=300
```

9. Put the data file you created in `s3n://mybucket/mydata_dir`.
10. Using cqlsh, create a keyspace and a CQL table schema to accommodate the data on S3.

```
cqlsh> CREATE KEYSPACE s3_counterpart WITH replication =
         {'class': 'NetworkTopologyStrategy', 'Analytics': 1};
cqlsh> USE s3_counterpart;
cqlsh:s3_counterpart> CREATE TABLE mytable
                            ( key text PRIMARY KEY , data int );
```

11. Start Hive, and on the Hive command line, create an external table for the data on S3. Specify the S3 file name as shown in this example.

```
hive> CREATE EXTERNAL TABLE mytable (key STRING, value INT) ROW FORMAT
 DELIMITED FIELDS TERMINATED BY '=' STORED AS TEXTFILE LOCATION 's3n://
mybucket/mydata_dir/';
```

Now, having the S3 data in Hive, you can query the data using Hive.

12. Select all the data in the file on S3.

```
SELECT * from mytable;
OK
key1  100
key2  200
key3  300
```

Creating a Hive CQL output query

One of the Hive external table properties (TBLPROPERTIES) is the cql3.output.query. The value of this property is a prepared statement that the MapReduce job uses to insert data into the corresponding Cassandra table.

One of the Hive external table properties (TBLPROPERTIES) is the cql3.output.query. The value of this property is a prepared statement that the MapReduce job uses to insert data into the corresponding Cassandra table. The prepared query is identical to the CQL statement for altering the table except the binding of the ? is done by Hive. The ? are bound to the hive columns in the order specified in the external table schema.

You can set TTL (time to live) on data in a column using the cql3.output.query property.

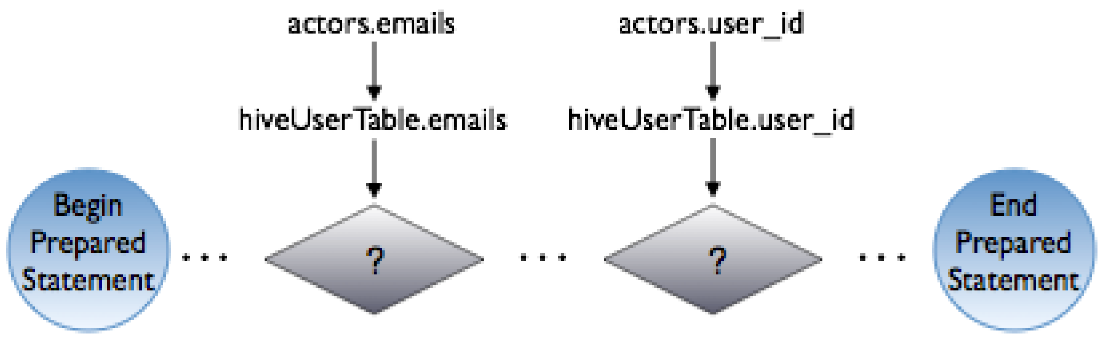
In the example of using a collection set, the external table definition determines the bind variables, '?'s, needed in the prepared statements:

```
hive> CREATE EXTERNAL TABLE hiveUserTable
   (emails array<string>,user_id string)
   . . .
```

This external table schema specifes the second column to be the user_id; therefore, this `INSERT` statement takes the columns emails, user_id from the Cassandra actors table and maps the data into the Hive emails and user_id columns:

```
hive> INSERT INTO TABLE hiveUserTable SELECT emails,user_id FROM actors;
```

The following diagram shows the relationship between the tables and the bind variables:



The hiveUserTable includes this prepared query:

```
"cql3.output.query" =
  "update cql3ks.users set emails = emails + ? WHERE user_id = ?");
```

The Hive `INSERT` statement starts the MapReduce job that uses the key value from the actors table in the 'WHERE (user_id) =' clause of prepared statement.

Another example, an abstract one, updates a table having three columns (x,y,z) using a prepared statement. The query looks like this internally:

```
create external table ( x,y,z ) Stored by  ....
(cql3.output.query = "Update cassX = ?(x) cassY=?(y) where cassZ= ?(z))"
```

Setting TTL on column data

You can set the TTL on data in an external table. Decoded the following example of how to set TTL using the cql3.output.query looks like this:

```
UPDATE users USING TTL 432000 SET 'password' = 'ch@ngem3a' WHERE KEY =
 'jsmith';
```

To set TTL on data in an auto-created table, configure a property named cql.output.query.ttl for the CQL table. Set the property as you would set the comment property. This action sets the TTL for the entire record.

Example: Work with an unsupported data type

DataStax Enterprise provides a user defined function (UDF) for converting Hive binary data into string representations of CQL types.

DataStax Enterprise provides a user defined function (UDF) for converting Hive binary data into string representations of CQL types. Hive cannot auto-create an external table that maps to the unsupported types, such as Cassandra blobs. You have to create a custom external table in Hive and map these types to binary. To read the data in Hive, use a provided UDF to convert the data.

Create the keyspace and two tables in cqlsh

This example first creates a keyspace and two tables in cqlsh and inserts data of every supported type into the tables.

1. Start cqlsh. For example, on Linux.

    ```
    ./cqlsh
    ```

2. In cqlsh, create a keyspace:

    ```
    cqlsh> CREATE KEYSPACE cql3ks WITH replication =
          { 'class': 'NetworkTopologyStrategy',
          'Analytics': '1' };
    ```

3. Using cqlsh, create a table in the cql3ks keyspace having columns of every CQL data type.

    ```
    cqlsh> USE cql3ks;

    cql3ks> CREATE TABLE genericAdd (
                key ascii PRIMARY KEY, a bigint, b blob, c boolean,
                d decimal, e double, f float, g inet, h int, i text,
                j timestamp, k uuid, l timeuuid, m varint);
    ```

4. Insert some data into the table.

    ```
    cql3ks> INSERT INTO genericAdd (
    ```

```
          key,a,b,c,d,e,f,g,h,i,j,k,l,m)
          VALUES ('KeyOne', 100005, 0xBEEFFEED, true, 3.5,-1231.4,
          3.14, '128.2.4.1', 42, 'SomeText', '2008-10-03',
          e3d81c40-1961-11e3-8ffd-0800200c9a66,
          f078d660-1961-11e3-8ffd-0800200c9a66, 1000000);
```

5. Create a second table, genericToAdd, containing every data type and insert different data into the table.

```
cql3ks> CREATE TABLE genericToAdd (
          id int PRIMARY KEY, key ascii, a bigint, b blob, c boolean,
          d decimal, e double, f float, g inet, h int, i text,
          j timestamp, k uuid, l timeuuid, m varint);
```

6. Insert some data into the second table.

```
cql3ks> INSERT INTO genericToAdd (
          id,key,a,b,c,d,e,f,g,h,i,j,k,l,m)
          VALUES (1,'Oneness',1, 0x11111111, true, 1.11,-1111.1,1.11,
          '111.1.1.1', 11,'11111','1999-11-01',
          e3d81c40-1961-11e3-8ffd-0800200c9a66,
          f078d660-1961-11e3-8ffd-0800200c9a66, 1);
```

Create an external table in Hive

Next, create an *external* table in Hive that maps to the table in Cassandra. You cannot use the auto-created table because Hive cannot represent the blob type in a comprehensible format. After creating the custom external table, you can perform alterations of the CQL tables from Hive. You insert data from the second CQL table into the first CQL table from Hive. Using a UDF, you query the external table in Hive. You need to use the UDF because the data is of the unsupported blob type.

1. Create a table in Hive that includes a cql3.output.query property that has the value of a prepared statement for inserting the data from the second, genericToAdd, table into the first, genericAdd, table.

   The last couple of lines in the following statement need to be free of line breaks. If you copy/paste this statement directly from the documentation and do not remove line breaks, an error occurs in the subsequent step.

```
hive> CREATE EXTERNAL TABLE hive_genericadd ( key string, a bigint,
 b binary, c boolean, d decimal, e double, f float, g binary, h
 int, i string, j timestamp, k binary, l binary, m binary) STORED BY
 'org.apache.hadoop.hive.cassandra.cql3.CqlStorageHandler' TBLPROPERTIES
 ( "cassandra.ks.name" = "cql3ks", "cassandra.cf.name" = "genericadd",
 "cql3.partition.key"="key",
"cql3.output.query" = "INSERT INTO cql3ks.genericadd
 (key,a,b,c,d,e,f,g,h,i,j,k,l,m) VALUES (?,?,?,?,?,?,?,?,?,?,?,?,?,?)");
```

2. Use the `INSERT` statement to start the MapReduce job that inserts the data from the second CQL table into the first one.

```
hive> INSERT INTO TABLE hive_genericadd SELECT
 key,a,b,c,d,e,f,g,h,i,j,k,l,m FROM cql3ks.generictoadd;
```

   The MapReduce job runs.

```
Total MapReduce jobs = 1
Launching Job 1 out of 1
. . .
Job 0: Map: 2   HDFS Read: 0 HDFS Write: 0 SUCCESS
Total MapReduce CPU Time Spent: 0 msec
OK
Time taken: 33.278 seconds
```

3. Create an alias for the UDF provided by DataStax.

   ```
   hive> CREATE TEMPORARY FUNCTION c_to_string AS
    'org.apache.hadoop.hive.cassandra.ql.udf.UDFCassandraBinaryToString';
   ```

4. Select the data of the unsupported blob type from the Hive table by calling the UDF.

   ```
   hive> select c_to_string(b, 'blob') from hive_genericadd;
   ```

The MapReduce job runs, and the output correctly displays the values:

```
Total MapReduce jobs = 1
. . .
Job 0: Map: 2   HDFS Read: 0 HDFS Write: 0 SUCCESS
Total MapReduce CPU Time Spent: 0 msec
OK
beeffeed
11111111
```

INSERT INTO SELECT statement

DataStax Enterprise supports the INSERT INTO SELECT statement in Hive.

About this task

DataStax Enterprise supports the INSERT INTO SELECT statement in Hive. You set a TBL and SERDE property, and use INSERT INTO SELECT to copy data from one table and insert it into another, or the same, table.

Supported TBL and SERDE properties include the following SERDE property:

```
cql3.update.columns
```

You use cql3.update.columns in conjunction with the CQL output query property, cql3.output.query.

The following example shows how to configure these properties and use the INSERT INTO SELECT statement in Hive to insert selective columns from a table into another row of the same Cassandra table. The SELECT statement requires values for each column in the target table. Using fake values satisfies this requirement.

Procedure

1. Start cqlsh and create a Cassandra keyspace and table.

   ```
   cqlsh> CREATE KEYSPACE mykeyspace WITH replication = {'class':
    'SimpleStrategy', 'replication_factor': 3};
   cqlsh> USE mykeyspace;
   cqlsh> CREATE TABLE mytable (a INT PRIMARY KEY, b INT, c INT, d INT);
   cqlsh> INSERT INTO mytable (a, b, c, d) VALUES (1, 2, 3, 4);
   ```

2. Start the Hive client.
3. In Hive, use the auto-created database and external table, and select all the data in the table.

   ```
   hive> USE mykeyspace;
   hive> SELECT * FROM mytable;
   ```

   Output is:

   ```
   OK 1 2 3 4 Time taken: 0.138 seconds, Fetched: 1 row(s)
   ```

4. In Hive, alter the external table to configure the prepared statement as the value of the Hive CQL output query. The prepared statement in this example takes values inserted into columns a and b in mytable and maps them to columns b and a, respectively, for insertion into the new row.

   ```
   hive> ALTER TABLE mytable SET TBLPROPERTIES ('cql3.output.query' = 'update
    mykeyspace.mytable set b = ? where a = ?');
   ```

   ```
   hive> ALTER TABLE mytable SET SERDEPROPERTIES ('cql3.update.columns' =
    'b,a');
   ```

5. In Hive, execute an INSERT INTO SELECT statement to insert a row of data into mytable. For example, use 4 and 9 as the values to insert into the first two positions (a, b) of the row. The CQL output query will reverse these positions. Use two type-compatible fake values in addition to the values 4 and 9 that you want to insert. In this example, the fake values are an int, 9999, and a column name, d.

   ```
   hive> INSERT INTO TABLE mytable SELECT 4, 9, 9999, d FROM mytable;
   ```

   The MapReduce job runs:

   ```
   Total MapReduce jobs = 1
   Launching Job 1 out of 1
   Number of reduce tasks is set to 0 since there's no reduce operator
   . . .
   MapReduce Jobs Launched:
   Job 0: Map: 2   HDFS Read: 0 HDFS Write: 0 SUCCESS
   Total MapReduce CPU Time Spent: 0 msec
   OK
   Time taken: 31.867 seconds
   ```

6. Check that 4 and 9, and only those values, were inserted:

   ```
   hive> SELECT * FROM mytable;
   ```

   ```
   The fake values are inserted as NULL and only the values specified by the
    CQL output query are inserted. The output query mapped 4 to column b and
    9 to column a.
   ```

   ```
   OK
   1        2       3       4
   9        4       NULL    NULL
   Time taken: 0.131 seconds, Fetched: 2 row(s)
   ```

Example: Use a CQL composite partition key

Example steps to create a CQL table, and then create an external table in Hive that maps to the CQL table.

About this task

This example first creates a CQL table, and then creates an external table in Hive that maps to the CQL table. You cannot use the auto-created external table because Hive does not support the timeuuid or varint types used in the CQL table. You need to declare these types binary in the external table definition. The Hive table uses a SERDE property and declares a single key followed by the column declarations that correspond to columns in the CQL table. Finally, the example queries the CQL table from Hive.

Procedure

1. In cqlsh, add a table to the cql3ks keyspace created earlier. Create a table that uses a composite partition key.

   ```
   cql3ks> CREATE TABLE event_table (
   ```

```
              key ascii, factor float, event_type text, event_date timestamp,
              event_id timeuuid, num_responses varint,
              PRIMARY KEY ((key, event_id), num_responses)
            );
```

2. Insert data into the table.

```
cql3ks> INSERT INTO event_table (
          key, factor, event_type, event_date, event_id, num_responses)
          VALUES ('KeyOne', 3.14, 'Q3-launch', '2014-09-03',
          f078d660-1961-11e3-8ffd-0800200c9a66, 1000000
        );
```

3. Create a custom external table in Hive named mapped_table that maps to the CQL event_table.

```
hive> CREATE EXTERNAL TABLE mapped_table(
        key string, factor float, event_type string,
        event_date timestamp, event_id binary, num_responses binary)
        STORED BY
 'org.apache.hadoop.hive.cassandra.cql3.CqlStorageHandler'
        WITH SERDEPROPERTIES( "cassandra.ks.name" = "cql3ks",
        "cassandra.cf.name" = "event_table",
 'cql3.partition.key'='key,event_id',
        "cassandra.cql3.type" = "ascii, float, text, timestamp, timeuuid,
 varint"
      );
```

4. Trigger a MapReduce job to query the table in Hive.

```
hive> SELECT COUNT(*) FROM mapped_table;
```

The output is:

```
Total MapReduce jobs = 1
Launching Job 1 out of 1
. . .
MapReduce Jobs Launched:
Job 0: Map: 2  Reduce: 1   HDFS Read: 0 HDFS Write: 0 SUCCESS
Total MapReduce CPU Time Spent: 0 msec
OK
1
Time taken: 39.929 seconds
```

Using CQL collections

Hive supports writing to CQL table collections.

About this task

Hive supports writing to CQL tables, including tables of collections. To store data to a CQL table from Hive, use prepared statements as shown in these examples:

Prepared statements for a list

```
UPDATE users SET top_places = ?  where user_id = ?
UPDATE users SET top_places = [ 'rivendell', 'rohan' ] WHERE user_id =
 'frodo';

UPDATE users SET top_places = ? + top_places  where user_id = ?
UPDATE users SET top_places = [ 'the shire' ] + top_places WHERE user_id =
 'frodo';

UPDATE users SET top_places = top_places - ?  where user_id = ?
UPDATE users SET top_places = top_places - ['riddermark'] WHERE user_id =
 'frodo';
```

About this task

Prepared statement for a map

Prepared statements for a set are similar to those for a list.

```
UPDATE users SET todo = ? where user_id = ?
UPDATE users
     SET todo = { '2012-9-24' : 'enter mordor',
                  '2012-10-2 12:00' : 'throw ring into mount doom' }
     WHERE user_id = 'frodo';
```

The following queries are handled as a regular value instead of tuples:

```
UPDATE users SET top_places[2] = ?  where user_id = ?
UPDATE users SET top_places[2] = 'riddermark' WHERE user_id = 'frodo';

UPDATE users SET todo[?] = ?  where user_id = ?
UPDATE users SET todo['2012-10-2 12:10'] = 'die' WHERE user_id = 'frodo';
```

Example: Alter a set collection

Items in a CQL collection are mapped to the Hive types shown in the Hive to Cassandra type mapping table. The CQL data types not supported in Hive, such as blob, can be used if you transform the fields of that type using a DataStax-provided UDF.

In cqlsh, you create two tables that contain a collection sets and insert data into the tables. In Hive, you create a custom external table that maps to the first CQL table, and then insert data from the second CQL table to the first CQL table. Finally, in cqlsh, you query the second CQL table to verify that the insertion was made.

1. In cqlsh, create the users table shown in the CQL documentation that contains a set collection column, and insert data into the table:

```
cqlsh> CREATE TABLE cql3ks.users (
         user_id text PRIMARY KEY,
         first_name text,
         last_name text,
         emails set <text>
       );


cqlsh> INSERT INTO cql3ks.users (user_id, first_name, last_name, emails)
         VALUES('frodo', 'Frodo', 'Baggins',
         {'f@baggins.com', 'baggins@gmail.com'});
```

2. Create a second table that contains data about actors:

```
cqlsh> CREATE TABLE cql3ks.actors (
         user_id text PRIMARY KEY,
         first_name text,
         last_name text,
         emails set<text>
       );

cqlsh> INSERT INTO cql3ks.actors (user_id, first_name, last_name, emails)
       VALUES ('ejwood', 'Elijah', 'Wood', {'ejwood@hobbit.com'});
```

3. In Hive, create a custom external table named hiveUserTable that maps to the CQL users table. The last couple of lines in the following statement need to be free of line breaks.

   ```
   hive> CREATE EXTERNAL TABLE hiveUserTable (emails array<string>,user_id
    string) STORED BY
    'org.apache.hadoop.hive.cassandra.cql3.CqlStorageHandler'
    TBLPROPERTIES( "cassandra.ks.name" = "cql3ks", "cassandra.cf.name" =
    "users", "cql3.partition.key"="user_id", "cql3.output.query" = "update
    cql3ks.users set emails = emails + ? WHERE user_id = ?");
   ```
4. Add the data from the CQL actors table to the users table:

   ```
   hive> INSERT INTO TABLE hiveUserTable SELECT emails,user_id FROM
    cql3ks.actors;
   ```

   The MapReduce job runs and alters the table.
5. Check that the CQL table contains Elijah Wood's email address:

   ```
   cql3ks> SELECT * FROM cql3ks.users;

    user_id | emails                                                     |
    first_name | last_name
   ---------+---------------------------------------------------------
   +------------+-----------
     ejwood |                                       {ejwood@hobbit.com} |
       null |      null
      frodo | {baggins@gmail.com, f@baggins.com, fb@friendsofmordor.org} |
      Frodo |   Baggins
   ```

Using a custom UDF

You can include your own Java code in a user-defined function (UDF) and invoke it using a query.

About this task

If the Hive built-in functions do not provide the capability you need, you can include your own Java code in a user-defined function (UDF) and invoke it using a query. DataStax provides a UDF for working with unsupported data types, for example. The example in this section uses a JAR that converts text from lowercase to uppercase. After downloading the JAR from the Hadoop tutorial examples repository and setting up the UDF in Hive, you create a Hive table. You insert data into the table from a text file installed with DataStax Enterprise. The contents of the file look like this:

```
238^Aval_238
86^Aval_86
311^Aval_311
27^Aval_27
165^Aval_165
. . .
```

When you execute a SELECT statement, you invoke the UDF to convert text in the file from lowercase to uppercase: val to VAL.

Procedure

1. Download the JAR for this example.
2. On the command line, add the JAR to the root Hadoop directory in the Cassandra File System (CFS) using Hadoop shell commands. For example:

   ```
   dse hadoop fs -copyFromLocal local-path-to-jar/myudfs.jar /tmp
   ```

Substitute the path to the downloaded job in your environment for *local-path-to-jar*.

3. Start a Hive client, and at the Hive prompt, add the JAR file to the Hadoop distributed cache, which copies files to task nodes to use when the files run:

   ```
   hive> add jar cfs:///tmp/myudfs.jar;
   ```

   The output on the Mac OS X is:

   ```
   converting to local cfs:///tmp/myudfs.jar
   Added /private/tmp/johndoe/hive_resources/myudfs.jar to class path
   Added resource: /private/tmp/johndoe/hive_resources/myudfs.jar
   ```
4. At the Hive prompt, create an alias for the UDF associated with the JAR.

   ```
   hive> CREATE TEMPORARY FUNCTION myUpper AS 'org.hue.udf.MyUpper';
   ```
5. Create a Hive table for text data.

   ```
   hive> CREATE TABLE udftest (foo INT, bar STRING);
   ```
6. Insert data into the table, substituting the path to the DataStax Enterprise installation in your environment for the *install_location*. For example, on Mac OS X:

   ```
   hive> LOAD DATA LOCAL INPATH
           'install_location/resources/hive/examples/files/kv1.txt'
           OVERWRITE INTO TABLE udftest;
   ```
7. Convert the lowercase text in the table, the instances of *val*, to uppercase by invoking the UDF by its alias in the SELECT statement.

   ```
   hive> SELECT myUpper(bar) from udftest;
   ```

   The mapper output looks like this:

   ```
   . . .
   MapReduce Jobs Launched:
   Job 0: Map: 1   HDFS Read: 0 HDFS Write: 0 SUCCESS
   Total MapReduce CPU Time Spent: 0 msec
   OK
   VAL_238-gg
   VAL_86-gg
   VAL_311-gg
   . . .
   ```

Using pushdown predicates

To minimize the amount of data to be processed, enable pushdown predicates using cql3.pushdown.enable in the TBLPROPERTIES clause of a Hive query.

About this task

Pushdown predicates resolve expressions as early as possible in the processing pipeline to minimize the amount of data to be processed. You enable pushdown predicates using the cql3.pushdown.enable property in the TBLPROPERTIES clause of a Hive query. True enables the feature and false (the default) disables it. Processing of operations on columns of the following types are affected by the setting:

Cassandra type	Hive type
UTF8Type	string

Cassandra type	Hive type
AsciiType	string
CounterColumnType	long
DateType	timestamp
LongType	long
DoubleType	double
FloatType	float
BooleanType	boolean
Int32Type	int

Recommended usage

When the indexed row is small, enable pushdown predicates; otherwise, disable the feature to avoid a timeout exception or Out-Of-Memory (OOM) condition.

Limitations

DataStax Enterprise supports pushdown predicates for indexes only. Primary keys are not supported.

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Using the Hive count function

For the cassandra.consistency.level general property in Hive TBLPROPERTIES, set the consistency level to ALL before you issue a Hive SELECT expression that contains the count function.

About this task

Using the Hive TBLPROPERTIES cassandra.consistency.level, set the consistency level to ALL before issuing a Hive `SELECT` expression containing the `count` function. Using ALL ensures that when you ping one node for a scan of all keys, the node is fully consistent with the rest of the cluster. Using a consistency level other than ALL can return resultsets having fewer rows than expected because replication has not finished propagating the rows to all nodes. A count that is higher than expected can occur because tombstones have not yet been propagated to all nodes.

To get accurate results from the count function using a consistency level other than ALL:

- Repair all nodes.
- Prevent new data from being added or deleted.

Spatial analytics support

DataStax Enterprise integrates some components of GIS Tools for Hadoop.

DataStax Enterprise integrates some components of GIS Tools for Hadoop. The GIS Tools for Hadoop open source project provides several libraries for performing spatial analytics. DataStax Enterprise incorporates the Hive Spatial library of the Spatial Framework for Hadoop and includes a custom tool for importing data in Enclosed JSON format from ArcGIS to a Cassandra table.

DataStax Enterprise supports Environmental Systems Research Institute (ESRI) data types, which map to the following Cassandra CQL types:

ESRI Type	Description	CQL Type
esriFieldTypeSmallInteger	Integer	Int
esriFieldTypeInteger	Long integer	Bigint
esriFieldTypeSingle	Single-precision floating-point number	Float/decimal
esriFieldTypeDouble	Double-precision floating-point number	Double/decimal
esriFieldTypeString	Character string	Text
esriFieldTypeDate	Date	Date
esriFieldTypeOID	Long integer representing an object identifier	Bigint
esriFieldTypeGeometry	Geometry	Blob
esriFieldTypeBlob	Binary large object	Blob
esriFieldTypeRaster	Raster	N/A
esriFieldTypeGUID	Globally unique identifier	Text
esriFieldTypeGlobalID	ESRI global ID	Text
esriFieldTypeXML	XML document	N/A

The DataStax Enterprise custom ESRI import tool supports the Enclosed JSON format. The syntax for using the tool is:

```
esri-import -keyspace <keyspace name> -table <table name> -dir <path to
 files> [options]
```

Options are:

-dir <path>
: Directory of ESRI data files

-exclude <files>
: Files to exclude

-file <files>
: Included files

-help
: esri-import command usage help

-host <host>
: Host name of node

-port <port>
: Port number on the host node

The example of analyzing data shows how to use the GIS tools for Hadoop.

Example: Analyzing spatial data

Use DataStax Enterprise with the integrated GIS Tools for Hadoop and custom ESRI-import tool.

About this task

This example shows how to use DataStax Enterprise with the integrated GIS Tools for Hadoop and custom ESRI-import tool for the following tasks:

- Create a CQL table to accommodate ESRI earthquake data.
- Load ESRI earthquake data from a CSV file into Cassandra.
- Load county geographic information from a JSON file into Hive.
- Analyze the data to determine the location of earthquakes.

The example assumes that you started DataStax Enterprise as a Hadoop-enabled analytics node.

Procedure

1. Download the CSV and JSON files from the DataStax web site for this example.
2. Unzip the file into a directory.

   The gis.zip file contains earthquakes.csv and california-counties.json.
3. In cqlsh, create and use a keyspace.

   ```
   cqlsh> CREATE KEYSPACE gis WITH replication = {'class':
    'NetworkTopologyStrategy', 'Analytics': 1 };

   cqlsh> USE gis;
   ```
4. Create a schema for the earthquake data in earthquakes.csv.

   ```
   cqlsh:gis> CREATE TABLE earthquakes (
                datetime text PRIMARY KEY,
                latitude double,
                longitude double,
   ```

```
                    depth double,
                    magnitude double,
                    magtype text,
                    nbstations int,
                    gap double,
                    distance double,
                    rms double,
                    source text,
                    eventid int
                  );
```

Although the earthquake dates are in ISO 8601 format, the schema uses the text type for the datetime column because 1898 - 2011 is outside the timestamp type range.

5. Copy the data in the CSV file to the table using the path that you chose for the CSV file.

```
cqlsh:gis> COPY earthquakes (datetime, latitude, longitude, depth,
 magnitude, magtype, nbstations, gap, distance, rms, source, eventid) FROM
 'path/earthquakes.csv' WITH HEADER = 'true';
```

6. Start a Hive client.
7. From Hive, access the gis database in Cassandra.

```
hive> USE gis;
```

8. In Hive, create a managed table named counties that defines a schema for the California counties data.

```
hive> CREATE TABLE IF NOT EXISTS counties (
        Area string,
        Perimeter string,
        State string,
        County string,
        Name string,
        BoundaryShape binary
      )
      ROW FORMAT SERDE 'com.esri.hadoop.hive.serde.JsonSerde'

      STORED AS INPUTFORMAT 'com.esri.json.hadoop.EnclosedJsonInputFormat'
      OUTPUTFORMAT
 'org.apache.hadoop.hive.ql.io.HiveIgnoreKeyTextOutputFormat';
```

9. Load the ESRI county data into the table. Use the path to the california-counties.json file you downloaded.

```
hive> LOAD DATA LOCAL INPATH 'path/california-counties.json' OVERWRITE
 INTO TABLE counties;
```

The output looks something like this:

```
Copying data from file:/Users/me/builds/dse-4.x/bin/california-
counties.json
Copying file: file:/Users/me/builds/dse-4.x/bin/california-counties.json
Loading data to table gis.counties
Table gis.counties stats: [num_partitions: 0, num_files: 1, num_rows: 0,
 total_size: 1028330, raw_data_size: 0]
OK
```

10. In Hive, create temporary functions for the geometry API calls.

    ```
    hive> create temporary function ST_Point as
     'com.esri.hadoop.hive.ST_Point';

    hive> create temporary function ST_Contains as
     'com.esri.hadoop.hive.ST_Contains';
    ```

11. Join the counties and earthquake tables, and query the data to determine the number of earthquakes in each county.

    ```
    hive> SELECT counties.name, count(*) cnt FROM counties
            JOIN earthquakes
            WHERE ST_Contains(counties.boundaryshape,
     ST_Point(earthquakes.longitude, earthquakes.latitude))
            GROUP BY counties.name
            ORDER BY cnt desc;
    ```

    The MapReduce job runs, and the output appears.

    ```
    Kern 36
    San Bernardino 35
    Imperial 28
    Inyo 20
    Los Angeles 18
    Monterey 14
    Riverside 14
    Santa Clara 12
    Fresno 11
    San Benito 11
    San Diego 7
    Santa Cruz 5
    San Luis Obispo 3
    Ventura 3
    Orange 2
    San Mateo 1
    ```

Handling schema changes

If you change a table in Cassandra after creating an external table in Hive that maps to that table in Cassandra, a runtime exception can occur. Use a workaround when changes that occur to the table in Cassandra get out of synch with the mapped table in Hive.

About this task

If you change a table in Cassandra, using CQL for example, after creating an external table in Hive that maps to that table in Cassandra, a runtime exception can occur. Changes that occur to the table in Cassandra get out of synch with the mapped table in Hive. The workaround is:

Procedure

1. In Hive, drop the table.

   ```
   hive> drop table mytable;
   ```

2. Run `SHOW TABLES`.

   ```
   hive> show tables;
   ```

   Now, the table in Hive contains the updated data.

MapReduce performance tuning

DataStax Enterprise includes a Cassandra-enabled Hive MapReduce client. Change settings to enable improved MadReduce performance.

About this task

You can change performance settings in the following ways:

- In an external table definition, using the TBLPROPERTIES or SERDEPROPERTIES clauses.
- Using the Hive SET command. For example: `SET mapred.reduce.tasks=32;`
- In the mapred-site.xml file.

  Note: Restart the analytics nodes after you make changes to `mapred-site.xml`.

The default location of the `mapred-site.xml` file depends on the type of installation:

Installer-Services and Package installations	`/etc/dse/hadoop/mapred-site.xml`
Installer-No Services and Tarball installations	*`install_location`*`/resources/hadoop/conf/mapred-site.xml`

Performance changes using `mapred-site.xml`

Speeding up map reduce jobs

Increase your mappers to one per CPU core by setting mapred.tasktracker.map.tasks.maximum.

Increasing the number of map tasks to maximize performance

You can increase the number of map tasks in these ways:

- Turn off map output compression in the `mapred-site.xml` file to lower memory usage.
- The cassandra.input.split.size property specifies rows to be processed per mapper. The default size is 64k rows per split. You can decrease the split size to create more mappers.

Out of Memory Errors

When your mapper or reduce tasks fail, reporting Out of Memory (OOM) errors, turn the mapred.map.child.java.opts setting in Hive to:

```
SET mapred.child.java.opts="-server -Xmx512M"
```

Loading balancing using the Fair Scheduler

The Hadoop Fair Scheduler assigns resources to jobs to balance the load, so that each job gets roughly the same amount of CPU time.

To enable the fair scheduler, uncomment a section in the `mapred-site.xml` that looks something like this:

```
<property>
  <name>mapred.jobtracker.taskScheduler</name>
  <value>org.apache.hadoop.mapred.FairScheduler</value>
</property>
. . .
  <value>dse-3.0.2/dse/resources/hadoop/conf/fair-scheduler.xml</value>
</property>
```

You might need to change the value element shown here. If the Fair Scheduler file has a different name, change the name of the file to fair-scheduler.xml. Specify the absolute path to the file.

The default location of the `fair-scheduler.xml` file depends on the type of installation:

Installer-Services and Package installations	`/etc/dse/hadoop/fair-scheduler.xml`
Installer-No Services and Tarball installations	`install_location/resources/hadoop/conf/fair-scheduler.xml`

DataStax Enterprise also supports the Capacity Scheduler.

Starting the Hive server

A node in the analytics cluster acts as the Hive server. To start the Hive server, run the start command from a node in the Hadoop cluster.

About this task

A node in the analytics cluster can act as the Hive server. Other nodes connect to Hive through the JDBC driver. To start the Hive server, choose a node in the Hadoop cluster and run this command:

Installer-Services and Package installations:

```
$ dse hive --service hiveserver
```

Installer-No Services and Tarball installations:

```
$ install_location/bin/dse hive  --service hiveserver
```

Starting the HiveServer2

DataStax Enterprise integrates Apache HiveServer2, an improved version of HiveServer that supports multi-client concurrency and other features.

To start HiveServer2, run this command:

```
dse hive --service hiveserver2
```

After starting HiveServer2, use the Beeline command shell to connect to the server and run Hive queries.

Using Beeline

DataStax Enterprise supports the HiveServer2 Beeline command shell, a JDBC client. After starting HiveServer2, open another terminal window, start Beeline, connect to HiveServer2, and run Hive queries.

DataStax Enterprise supports the HiveServer2 Beeline command shell, a JDBC client. HiveServer2, an improved Hive server, uses Beeline as the command-line interface. After starting HiveServer2, open another terminal window, start Beeline, connect to HiveServer2, and run Hive queries.

1. In a terminal window, start HiveServer2:
   - Installer-Services and Package installations:

     ```
     $ dse hive --service hiveserver2
     ```
   - Installer-No Services and Tarball installations:

     ```
     $ install_location/bin/dse hive  --service hiveserver2
     ```
2. In another terminal window, start Beeline. On Linux, for example:

   ```
   $ install_directory/bin/dse beeline
   ```

   The beeline prompt appears.

   ```
   2014-06-19 06:37:22.758 java[46121:1a03] Unable to load realm info from
    SCDynamicStore
   ```

```
Beeline version 0.12.0.3-SNAPSHOT by Apache Hive
beeline>
```

3. Connect to the server. On a single-node, development cluster for example:

   ```
   beeline> !connect jdbc:hive2://localhost
   ```

   The HiveServer2 prompt appears.

   ```
   scan complete in 24ms
   Connecting to jdbc:hive2://localhost
   Enter username for jdbc:hive2://localhost:
   ```

4. Enter the DataStax Enterprise user name.

   The password prompt appears.

   ```
   Enter password for jdbc:hive2://localhost:
   ```

5. Enter the password.

   The hive2 prompt appears.

   ```
   Connected to: Hive (version 0.12.0.3-SNAPSHOT)
   Driver: Hive (version 0.12.0.3-SNAPSHOT)
   Transaction isolation: TRANSACTION_REPEATABLE_READ
   0: jdbc:hive2://localhost>
   ```

6. Run Hive queries.

Recreating Hive metadata after decommissioning a node

After removing/decommissioning a node that stored the Hive metadata, truncate the Hive metadata table, then recreate the table.

After removing/decommissioning a node that stored the Hive metadata, truncate the Hive metadata table, then recreate the table. In the hive-site.xml file, set the parameters as shown in the following example to specify a different keyspace and table for the Hive metastore:

The default location of the `hive-site.xml` file depends on the type of installation:

Installer-Services and Package installations	`/etc/dse/hive/hive-site.xml`
Installer-No Services and Tarball installations	`*install_location*/resources/hive/conf/hive-site.xml`

```
<property>
    <name>cassandra.connection.metaStoreKeyspaceName</name>
    <value>newKeyspaceName</value>
  </property>
  <property>
    <name>cassandra.connection.metaStoreColumnFamilyName</name>
    <value>MetaStore</value>
  </property>
```

This action is necessary to prevent an exception in `SemanticAnalyzer.genFileSinkPlan`.

DataStax ODBC driver for Hive on Windows

The DataStax ODBC Driver for Hive provides Windows users access to the information that is stored in DSE Hadoop.

About this task

The DataStax ODBC Driver for Hive provides Windows users access to the information stored in the Hadoop distribution bundled into DataStax Enterprise. This driver allows you to access the data stored on your DataStax Enterprise Hadoop nodes using business intelligence (BI) tools, such as Tableau and Microsoft Excel. The driver is compliant with the latest ODBC 3.52 specification and automatically translates any SQL-92 query into HiveQL.

Before you begin

- Windows® 7 Professional or Windows® 2008 R2. Both 32- and 64-bit editions are supported.
- Microsoft Visual C++ 2010 runtime.
- A cluster with a Hadoop node running the Hive server. See Starting the Hive server.

To install the DataStax ODBC driver on a Windows platform:

Procedure

1. Download the driver from Client Libraries and CQL Drivers.
2. Double-click the downloaded file and follow the wizard instructions.

Configuring the driver

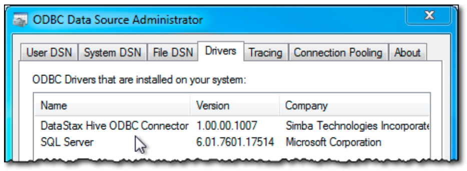
Set up the DataStax Hive ODBC driver for access by your BI tool.

About this task

Set up the DataStax ODBC driver for access by your BI tool.

Procedure

1. Click **Start Program Files** > **DataStax Hive ODBC Connector** > **ODBC Driver Manager**.
2. Click the **Drivers** tab to verify that the driver is present.



ODBC Drivers that are installed on your system:

Name	Version	Company
DataStax Hive ODBC Connector	1.00.00.1007	Simba Technologies Incorporate
SQL Server	6.01.7601.17514	Microsoft Corporation

3. Create either a User or System DSN (data source name) for your BI tool connection.
   a) Click the **User DSN** or **System DSN** tab.
   b) Click **Add** > **DataStax Hive ODBC Connector** > **Finish**.
   c) In **DataStax Hive ODBC Connector Setup**, enter the following:

Data Source Name	The name for your DSN.
Description	Optional.
Host	IP or hostname of your Hive server.
Port	Listening port for the Hive service.

Database	By default, all tables reside within the default database. To check for the appropriate database, use the show databases Hive command.

d) Click **Test**.

The test results are displayed.

Note: If your DataStax Enterprise cluster is on Amazon EC2, you must open the listing port for the Hive Server. For more information, refer to Creating an EC2 security group for DataStax Enterprise.

4. To configure the advanced options, see Appendix C in the *DataStax Hive ODBC Connector User Guide for Windows*:

   Start > **Program Files** > **DataStax Hive ODBC Connector** > **User's Guide**

Using the DataStax ODBC driver for Hive

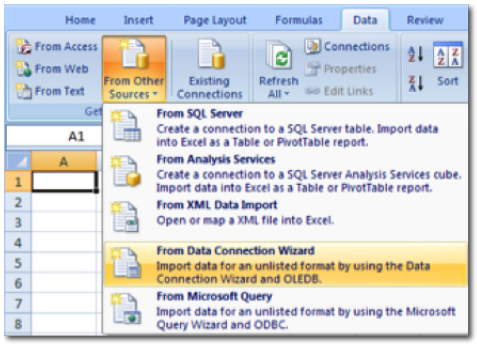
After configuring the ODBC data source for Hive, connect and pull data from Hive using any compliant BI tool.

About this task

After configuring the ODBC data source for Hive, you can connect and pull data from Hive using any compliant BI tool. For example, to retrieve data using Microsoft Excel:

Procedure

1. Use the data connection wizard to select your new ODBC data source:



From SQL Server
Create a connection to a SQL Server table. Import data into Excel as a Table or PivotTable report.

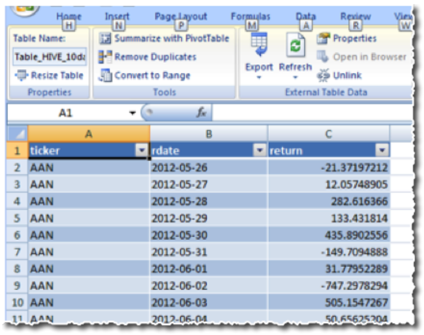
From Analysis Services
Create a connection to a SQL Server Analysis Services cube. Import data into Excel as a Table or PivotTable report.

From XML Data Import
Open or map a XML file into Excel.

From Data Connection Wizard
Import data for an unlisted format by using the Data Connection Wizard and OLEDB.

From Microsoft Query
Import data for an unlisted format by using the Microsoft Query Wizard and ODBC.

2. In **Connect to OBDC Data Source**, select **DSE2 Hive** > **Next**.
3. Select one or more data objects (or construct a query) to retrieve the data, and then click **Finish**.



	A	B	C
1	ticker	rdate	return
2	AAN	2012-05-26	-21.37197212
3	AAN	2012-05-27	12.05748905
4	AAN	2012-05-28	282.616366
5	AAN	2012-05-29	133.431814
6	AAN	2012-05-30	435.8902556
7	AAN	2012-05-31	-149.7094888
8	AAN	2012-06-01	31.77952289
9	AAN	2012-06-02	-747.2978294
10	AAN	2012-06-03	505.1547267
11	AAN	2012-06-04	50.65625204

Results

After the ODBC query is executed and the data is retrieved, a Hive MapReduce job runs on the server:

```
Total MapReduce jobs = 1
Launching Job 1 out of 1
Number of reduce tasks is set to 0 since there's no reduce operator
Starting Job = job_201208230939_0006,
   Tracking URL = http://localhost:50030/jobdetails.jsp?
jobid=job_201208230939_0006
Kill Command = ./dse hadoop job
   -Dmapred.job.tracker=127.0.0.1:8012 -kill job_201208230939_0006
Hadoop job information for Stage-1: number of mappers: 1; number of
 reducers: 0
2012-08-23 12:44:39,795 Stage-1 map = 0%,  reduce = 0%
2012-08-23 12:44:42,824 Stage-1 map = 100%,  reduce = 0%
2012-08-23 12:44:44,833 Stage-1 map = 100%,  reduce = 100%
Ended Job = job_201208230939_0006
MapReduce Jobs Launched:
Job 0: Map: 1   HDFS Read: 0 HDFS Write: 0 SUCCESS
Total MapReduce CPU Time Spent: 0 msec
```

Using Mahout

DataStax Enterprise integrates Apache Mahout, a Hadoop component that offers machine learning libraries.

About this task

DataStax Enterprise integrates Apache Mahout, a Hadoop component that offers machine learning libraries. Mahout facilitates building intelligent applications that learn from data and user input. Machine learning use cases are many and some, such as the capability of web sites to recommend products to visitors based on previous visits, are notorious.

Currently, Mahout jobs that use Lucene features are not supported.

Running the Mahout demo

The DataStax Enterprise installation includes a Mahout demo. The demo determines with some percentage of certainty which entries in the input data remained statistically in control and which have not. The input data is time series historical data. Using the Mahout algorithms, the demo classifies the data into categories based on whether it exhibited relatively stable behavior over a period of time. The demo produces a file of classified results. This procedure describes how to run the Mahout demo.

Procedure

Note: DataStax Demos do not work with either LDAP or internal authorization (username/password) enabled.

1. After installing DataStax Enterprise, start an analytics node.
2. Go to the demos/mahout directory.

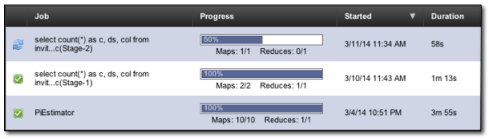
   The default location of the `demos/mahout` directory depends on the type of installation:

Installer-Services and Package installations	`/usr/share/dse/demos/mahout`
Installer-No Services and Tarball installations	`*install_location*/demos/mahout`

3. Run the script in the `demos` directory. For example, on Linux:

```
./run_mahout_example.sh
```

If you are running OpsCenter, you can now view the Hadoop job progress:



	Job	Progress	Started ▼	Duration
	select count(*) as c, ds, col from invit...c(Stage-2)	50% Maps: 1/1 Reduces: 0/1	3/11/14 11:34 AM	58s
✓	select count(*) as c, ds, col from invit...c(Stage-1)	100% Maps: 2/2 Reduces: 1/1	3/10/14 11:43 AM	1m 13s
✓	PiEstimator	100% Maps: 10/10 Reduces: 1/1	3/4/14 10:51 PM	3m 55s

When the demo completes, a message appears on the standard output about the location of the output file. For example:

```
The output is in /tmp/clusteranalyze.txt
```

Using Mahout commands in DataStax Enterprise

Run Mahout commands on the dse command line.

About this task

You can run Mahout commands on the dse command line. For example on Mac OS X, to get a list of which commands are available:

```
$ cd install_location
$ bin/dse mahout
```

The list of commands appears.

Mahout command line help

You use one of these commands as the first argument plus the help option:

```
$ cd install_location
$ bin/dse mahout arff.vector --help
```

The output is help on the arff.vector command.

Add Mahout classes to the class path, execute Hadoop command

You use Hadoop shell commands to work with Mahout. Using this syntax first adds Mahout classes to the class path, and then executes the Hadoop command:

```
$ cd install_location
$ bin/dse mahout hadoop fs -text mahout_file | more
```

The Apache web site offers an in-depth tutorial.

Using Pig

DataStax Enterprise includes a Cassandra File System (CFS) enabled Apache Pig Client to provide a high-level programming environment for MapReduce coding.

About this task

DataStax Enterprise includes a Cassandra File System (CFS) enabled Apache Pig Client. Pig is a high-level programming environment for MapReduce coding. You can explore big data sets using the Pig Latin data flow language for programmers. Relations, which are similar to tables, are constructed of tuples, which correspond to the rows in a table. Unlike a relational database table, Pig relations do not require every tuple to contain the same number of fields. Fields in the same position (column) need not be of the same type. Using Pig, you can devise logic for data transformations, such as filtering data and grouping relations. The transformations occur during the MapReduce phase.

Configure the Job Tracker node for the node running Pig as you would for any analytics (Hadoop) node. Use the dsetool commands to manage the Job Tracker. After configuration, Pig clients automatically select the correct Job Tracker node on startup. Pig programs are compiled into MapReduce jobs, executed in parallel by Hadoop, and run in a distributed fashion on a local or remote cluster.

Support for TTL

You can set the TTL (time to live) on Pig data. You use the cql:// URL, which includes a prepared statement shown in step 10 of the library demo.

Support for CQL collections

Pig in DataStax Enterprise supports CQL collections. Pig-supported types must be used.

Running the Pig demo

Examples demonstrate how to use Pig to work with CQL tables.

About this task

Three examples demonstrate how to use Pig to work with CQL tables.

- How to save Pig relations from/to Cassandra

  Pig uses a single tuple.
- How to work with a Cassandra compound primary key in Pig

  Pig uses three tuples, one for the partition key and two for the two clustering columns.
- How to use Pig to set up logic for exploring library data

  This example from the Cassandra and Pig tutorial shows how to copy public library data into Cassandra, add logic to save the data to a Pig relation, execute programs by running MapReduce jobs, and view results in a Cassandra table.

Start Pig

Procedure

Note: DataStax Demos do not work with either LDAP or internal authorization (username/password) enabled.

1. Start DataStax Enterprise as an analytics (Hadoop) node:
   - **Installer-Services and Package installations:**
     1. Set HADOOP_ENABLED=1 in `/etc/default/dse`.
     2. Start an analytics node:

        ```
        $ sudo service dse start
        ```
   - **Installer-No Services and Tarball installations:**

     ```
     $ DSE_install_location/bin/dse cassandra -t
     ```
2. Start the Pig shell:
   - Installer-Services and Package installations: `$ dse pig`
   - Installer-No Services and Tarball installations: `$ *DSE_install_location*/bin/dse pig`

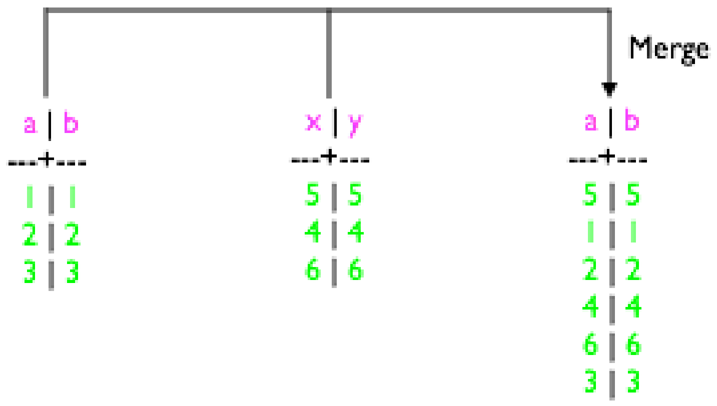
   The Pig grunt prompt appears, and you can now enter Pig commands.

Example: Save Pig relations from/to Cassandra

How to merge the data from two CQL tables having simple primary keys using Pig.

About this task

For Pig to access data in Cassandra, the target keyspace and table must already exist. Pig can save data from a Pig relation to a table in Cassandra and from a Cassandra table to a pig relation, but it cannot create the table. This example shows how to merge the data from two CQL tables having simple primary keys using Pig.



A subsequent example shows how to merge data from CQL tables having compound primary keys into one CQL table using Pig.

Procedure

1. Start cqlsh.
2. Using cqlsh, create and use a keyspace named, for example, cql3ks.

```
cqlsh> CREATE KEYSPACE cql3ks WITH replication =
         {'class': 'SimpleStrategy', 'replication_factor': 1 };

cqlsh> USE cql3ks;
```

3. Create a two-column (a and b) Cassandra table named simple_table1 and another two-column (x and y) table named simple_table2. Insert data into the tables.

```
cqlsh:cql3ks> CREATE TABLE simple_table1 (a int PRIMARY KEY, b int);
cqlsh:cql3ks> CREATE TABLE simple_table2 (x int PRIMARY KEY, y int);
cqlsh:cql3ks> INSERT INTO simple_table1 (a,b) VALUES (1,1);
cqlsh:cql3ks> INSERT INTO simple_table1 (a,b) VALUES (2,2);
cqlsh:cql3ks> INSERT INTO simple_table1 (a,b) VALUES (3,3);
cqlsh:cql3ks> INSERT INTO simple_table2 (x, y) VALUES (4,4);
cqlsh:cql3ks> INSERT INTO simple_table2 (x, y) VALUES (5,5);
cqlsh:cql3ks> INSERT INTO simple_table2 (x, y) VALUES (6,6);
```

4. Using Pig, add logic to load the data (4, 5, 6) from the Cassandra simple_table2 table into a Pig relation.

```
grunt> moretestvalues= LOAD 'cql://cql3ks/simple_table2/' USING
 CqlNativeStorage;
```

5. Convert the simple_table2 table data to a tuple. The key column is a chararray, 'a'.

```
grunt> insertformat= FOREACH moretestvalues GENERATE
         TOTUPLE(TOTUPLE('a',x)),TOTUPLE(y);
```

6. Save the relation to the Cassandra simple_table1 table.

```
grunt> STORE insertformat INTO
       'cql://cql3ks/simple_table1?output_query=UPDATE
+cql3ks.simple_table1+set+b+%3D+%3F'
       USING CqlNativeStorage;
```

Pig uses a URL-encoded prepared statement to store the relation to Cassandra. The cql:// URL is followed by an output_query, which specifies which key should be used in the command. The rest of the arguments, the "?"s, for the prepared statement are filled in by the values related to that key in Pig.

7. On the cqlsh command line, check that the simple_table1 table now contains its original values plus the values from the simple_table2 table:

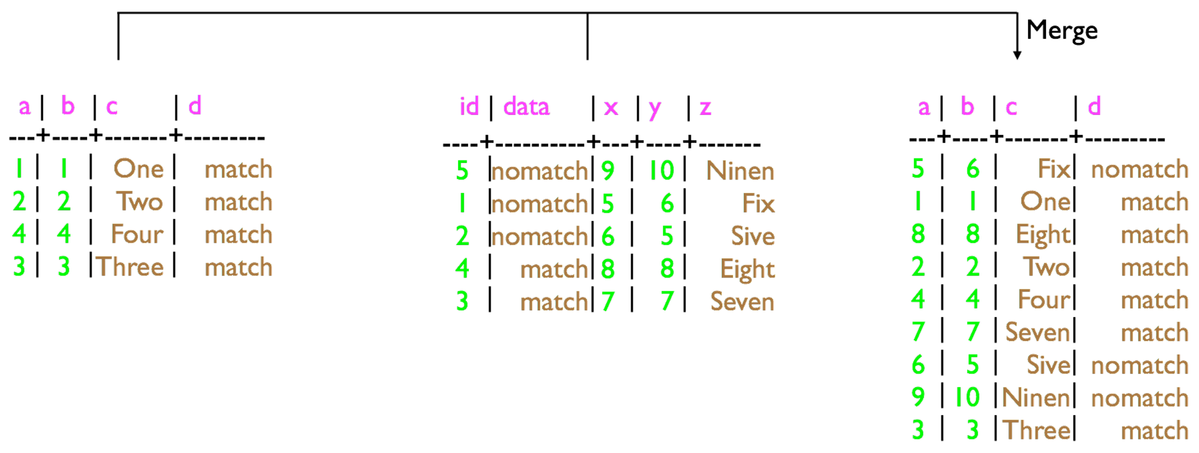
```
cqlsh:cql3ks> SELECT * FROM simple_table1;




a | b
--+--
5 | 5
1 | 1
2 | 2
4 | 4
6 | 6
3 | 3
```

Example: Handle a compound primary key

Work with CQL tables in Pig. The tables use compound primary keys. You create the tables in cqlsh and merge them using Pig.

About this task

This example, like the previous one, shows you how to work with CQL tables in Pig. The previous example used tables having a simple primary key. The tables in this example use compound primary keys. You create the tables in cqlsh and merge them using Pig.



```
a | b |c      |d
---+----+-------+---------
1 | 1 |  One |   match
2 | 2 |  Two |   match
4 | 4 | Four |   match
3 | 3 |Three |   match
```

```
id | data     | x | y  | z
----+----------+---+----+-------
5  |nomatch| 9 | 10 | Ninen
1  |nomatch| 5 |  6 |   Fix
2  |nomatch| 6 |  5 |  Sive
4  |   match| 8 |  8 | Eight
3  |   match| 7 |  7 | Seven
```

```
a | b  |c      | d
---+----+-------+---------
5 |  6 |   Fix| nomatch
1 |  1 |  One|    match
8 |  8 | Eight|   match
2 |  2 |  Two|    match
4 |  4 | Four|    match
7 |  7 |Seven|    match
6 |  5 |  Sive| nomatch
9 | 10 |Ninen| nomatch
3 |  3 |Three|    match
```

Procedure

1. Create a four-column (a, b, c, d) Cassandra table named table1 and another five-column (id, x, y, z, data) table named table2.

   ```
   cqlsh:cql3ks> CREATE TABLE table1 (
                   a int,
                   b int,
                   c text,
                   d text,
                   PRIMARY KEY (a,b,c)
                 );
   cqlsh:cql3ks> CREATE TABLE table2 (
                   id int PRIMARY KEY,
                   x int,
                   y int,
                   z text,
                   data text
                 );
   ```

2. Insert data into the tables.

   ```
   cqlsh:cql3ks> INSERT INTO table1 (a, b , c , d )
                   VALUES ( 1,1,'One','match');
   cqlsh:cql3ks> INSERT INTO table1 (a, b , c , d )
                   VALUES ( 2,2,'Two','match');
   cqlsh:cql3ks> INSERT INTO table1 (a, b , c , d )
                   VALUES ( 3,3,'Three','match');
   cqlsh:cql3ks> INSERT INTO table1 (a, b , c , d )
                   VALUES ( 4,4,'Four','match');
   cqlsh:cql3ks> INSERT INTO table2 (id, x, y, z,data)
                   VALUES (1,5,6,'Fix','nomatch');
   cqlsh:cql3ks> INSERT INTO table2 (id, x, y, z,data)
                   VALUES (2,6,5,'Sive','nomatch');
   cqlsh:cql3ks> INSERT INTO table2 (id, x, y, z,data)
                   VALUES (3,7,7,'Seven','match');
   cqlsh:cql3ks> INSERT INTO table2 (id, x, y, z,data)
                   VALUES (4,8,8,'Eight','match');
   cqlsh:cql3ks> INSERT INTO table2 (id, x, y, z,data)
                   VALUES (5,9,10,'Ninen','nomatch');
   ```

3. Using Pig, add logic to load the data from the Cassandra table2 to a Pig relation.

   ```
   grunt> moredata = load 'cql://cql3ks/table2' USING CqlNativeStorage;
   ```

4. Convert the data to a tuple.

   ```
   grunt> insertformat = FOREACH moredata GENERATE TOTUPLE
            (TOTUPLE('a',x),TOTUPLE('b',y),
            TOTUPLE('c',z)),TOTUPLE(data);
   ```

   During the actual data processing, the data is formatted as follows:

   ```
   ((PartitionKey_Name,Value),(ClusteringKey_1_name,Value)...)
   (ArgValue1,ArgValue2,ArgValue3,...)
   ```

5. Save the Pig relation to the Cassandra table1 table. The data from table 1 and table 2 will be merged.

   ```
   grunt> STORE insertformat INTO 'cql://cql3ks/table1?output_query=UPDATE
   %20cql3ks.table1%20SET%20d%20%3D%20%3F' USING CqlNativeStorage;
   ```

The cql:// URL includes a prepared statement, described later, that needs to be copied/pasted as a continuous string (no spaces or line breaks).

6. In cqlsh, query table1 to check that the data from table1 and table2 have been merged.

```
cqlsh:cql3ks> SELECT * FROM table1;



 a | b  | c     | d
---+----+-------+---------
5 |  6 |   Fix | nomatch
1 |  1 |   One |   match
8 |  8 | Eight |   match
2 |  2 |   Two |   match
4 |  4 |  Four |   match
7 |  7 | Seven |   match
6 |  5 |  Sive | nomatch
9 | 10 | Ninen | nomatch
3 |  3 | Three |   match
```

Example: Explore library data

Install library data that is encoded in UTF-8 format and use a pig script.

About this task

This example uses library data from the Institute of Library and Museum Services, encoded in UTF-8 format. Download the formatted data for this example now.

DataStax Enterprise installs files in the following directory that you can use to run through this example using a pig script instead of running Pig commands manually.

- Installer-Services and Package installations: `/usr/share/demos/pig/cql`
- Installer-No Services and Tarball installations: `*install-location*/demos/pig/cql`

Using the files is optional. To use the files, copy/paste the commands in steps 2-3 from the `library-populate-cql.txt` file and execute steps 7-10 automatically by running the library-cql.pig script.

Procedure

1. Unzip `libdata.csv.zip` and give yourself permission to access the downloaded file. On the Linux command line, for example:

```
$ chmod 777 libdata.csv
```

2. Create and use a keyspace called libdata.

```
cqlsh:libdata> CREATE KEYSPACE libdata WITH replication =
                 {'class': 'SimpleStrategy', 'replication_factor': 1 };

cqlsh:libdata> USE libdata;
```

3. Create a table for the library data that you downloaded.

```
cqlsh:libdata> CREATE TABLE libout ("STABR" TEXT, "FSCSKEY" TEXT,
 "FSCS_SEQ" TEXT,
                 "LIBID" TEXT, "LIBNAME" TEXT, "ADDRESS" TEXT, "CITY"
 TEXT,
                 "ZIP" TEXT, "ZIP4" TEXT, "CNTY" TEXT, "PHONE" TEXT,
 "C_OUT_TY" TEXT,
                        "C_MSA" TEXT, "SQ_FEET" INT, "F_SQ_FT" TEXT, "L_NUM_BM"
 INT,
                        "F_BKMOB" TEXT, "HOURS" INT, "F_HOURS" TEXT, "WKS_OPEN"
 INT,
                        "F_WKSOPN" TEXT, "YR_SUB" INT, "STATSTRU" INT, "STATNAME"
 INT,
                        "STATADDR" INT, "LONGITUD" FLOAT, "LATITUDE" FLOAT,
 "FIPSST" INT,
                        "FIPSCO" INT, "FIPSPLAC" INT, "CNTYPOP" INT, "LOCALE"
 TEXT,
                        "CENTRACT" FLOAT, "CENBLOCK" INT, "CDCODE" TEXT,
 "MAT_CENT" TEXT,
                        "MAT_TYPE" INT, "CBSA" INT, "MICROF" TEXT,
                        PRIMARY KEY ("FSCSKEY", "FSCS_SEQ"));
```

4. Import data into the libout table from the `libdata.csv` file that you downloaded.

```
cqlsh:libdata> COPY libout
 ("STABR","FSCSKEY","FSCS_SEQ","LIBID","LIBNAME",
                        "ADDRESS","CITY","ZIP","ZIP4","CNTY","PHONE","C_OUT_TY",
                        "C_MSA","SQ_FEET","F_SQ_FT","L_NUM_BM","F_BKMOB","HOURS",

 "F_HOURS","WKS_OPEN","F_WKSOPN","YR_SUB","STATSTRU","STATNAME",

 "STATADDR","LONGITUD","LATITUDE","FIPSST","FIPSCO","FIPSPLAC",

 "CNTYPOP","LOCALE","CENTRACT","CENBLOCK","CDCODE","MAT_CENT",
                        "MAT_TYPE","CBSA","MICROF") FROM 'libdata.csv' WITH
 HEADER=TRUE;
```

In the FROM clause of the COPY command, use the path to `libdata.csv` in your environment.

5. Check that the libout table contains the data you copied from the downloaded file.

```
cqlsh:libdata> SELECT count(*) FROM libdata.libout LIMIT 20000;

  count
 -------
  17598
```

6. Create a table to hold results of Pig relations.

```
cqlsh:libdata> CREATE TABLE libsqft (
                        year INT,
                        state TEXT,
                        sqft BIGINT,
                        PRIMARY KEY (year, state)
                      );
```

7. Using Pig, add a plan to load the data from the Cassandra libout table to a Pig relation.

```
grunt> libdata = LOAD 'cql://libdata/libout' USING CqlNativeStorage();
```

8. Add logic to remove data about outlet types other than books-by-mail (BM). The C_OUT_TY column uses BM and other abbreviations to identify these library outlet types:

   - CE–Central Library
   - BR–Branch Library
   - BS–Bookmobile(s)
   - BM–Books-by-Mail Only

```
grunt> book_by_mail = FILTER libdata BY C_OUT_TY == 'BM';
grunt> DUMP book_by_mail;
```

9. Add logic to filter out the library data that has missing building size data, define the schema for libdata_buildings, and group data by state. The STABR column contains the state codes. GROUP creates the state_grouped relation. Pig gives the grouping field the default alias *group*. Process each row to generate a derived set of rows that aggregate the square footage of each state *group*.

```
grunt> libdata_buildings = FILTER libdata BY SQ_FEET > 0;
grunt> state_flat = FOREACH libdata_buildings GENERATE STABR AS
 State,SQ_FEET AS SquareFeet;
grunt> state_grouped = GROUP state_flat BY State;
grunt> state_footage = FOREACH state_grouped GENERATE
                         group as State,SUM(state_flat.SquareFeet)
                         AS TotalFeet:int;
grunt> DUMP state_footage;
```

The MapReduce job completes successfully and the output shows the square footage of the buildings.

```
. . .
(UT,1510353)
(VA,4192931)
(VI,31875)
(VT,722629)
(WA,3424639)
(WI,5661236)
(WV,1075356)
(WY,724821)
```

10. Add logic to filter the data by year, state, and building size, and save the relation to Cassandra using the cql:// URL. The URL includes a prepared statement, described later.

```
grunt> insert_format= FOREACH state_footage GENERATE

 TOTUPLE(TOTUPLE('year',2011),TOTUPLE('state',State)),TOTUPLE(TotalFeet);
grunt> STORE insert_format INTO 'cql://libdata/libsqft?output_query=UPDATE
%20libdata.
         libsqft%20USING%20TTL%20300%20SET%20sqft%20%3D%20%3F' USING
 CqlNativeStorage;
```

The prepared statement includes a TTL that causes the data to expire in 5 minutes. Decoded the prepared statement looks like this:

```
UPDATE libdata.libsqft USING TTL 300 SET sqft = ?
```

11. In CQL, query the libsqft table to see the Pig results now stored in Cassandra.

```
cqlsh> SELECT * FROM libdata.libsqft;


 year | state | sqft
------+-------+----------
 2011 |    AK |   570178
 2011 |    AL |  2792246

 . . .

 2011 |    WV |  1075356
 2011 |    WY |   724821
```

Data access using storage handlers

To execute Pig programs directly on data that is stored in Cassandra, use one of the DataStax Enterprise storage handlers.

The DataStax Enterprise Pig driver uses the Cassandra File System (CFS) instead of the Hadoop distributed file system (HDFS). Apache Cassandra, on the other hand, includes a Pig driver that uses the Hadoop Distributed File System (HDFS).

To execute Pig programs directly on data stored in Cassandra, you use one of the DataStax Enterprise storage handlers:

Table Format	Storage Handler	URL	Description
CQL	CqlNativeStorage()	cql://	Use with DataStax Enterprise 4.7.
CQL	CqlStorage()	cql://	Deprecated.
storage engine	CassandraStorage()	cassandra://	Use with Cassandra tables in the storage engine (CLI/ Thrift) format.

The CqlStorage handler is deprecated and will be removed in a future Cassandra release. Use the CqlNativeStorage handler and the cql:// url for new pig applications. DataStax recommends migrating all tables to CqlNativeStorage as soon as possible in preparation for the removal of the CqlStorage handler.

Migrating compact tables with clustering columns to CqlNativeStorage format

The CqlNativeStorage handler uses native paging through the DataStax Java driver to communicate with the underlying Cassandra cluster. Use applications having compact tables with clustering columns in the CqlStorage format, you need to migrate tables to the CqlNativeStorage format. Attempting to run Pig commands on compact tables in the CqlStorage format results in an exception. You can, however, run Pig commands on non-compact tables in the CqlStorage format.

To migrate tables from CqlStorage to CqlNativeStorage format:

1. Identify Pig functions that interact with compact tables in CqlStorage format. For example, suppose you identify a command that adds logic to load the data to a Pig relation from the compact table tab in keyspace ks.

```
x = LOAD 'cql://ks/tab' USING CqlStorage();       -- Old function
```

2. Change CqlStorage() to USING CqlNativeStorage().

```
x = LOAD 'cql://ks/tab' USING CqlNativeStorage(); -- New function
```

URL format for CqlNativeStorage

The URL format for CqlNativeStorage is:

```
cql://[username:password@]<keyspace>/<table>[?
  [page_size=<size>]
  [&columns=<col1,col2>]
  [&output_query=<prepared_statement_query>]
  [&cql_input=<prepared_statement_query>]
  [&where_clause=<clause>]
  [&split_size=<size>]
  [&partitioner=<partitioner>]
  [&use_secondary=true|false]]
  [&init_address=<host>]
  [&native_port=<port>]]
```

Where:

- page_size -- the number of rows per page

- columns -- the select columns of CQL query
- output_query -- the CQL query for writing in a prepared statement format
- input_cql -- the CQL query for reading in a prepared statement format
- where_clause -- the where clause on the index columns, which needs URL encoding
- split_size -- number of rows per split
- partitioner -- Cassandra partitioner
- use_secondary -- to enable pig filter partition push down
- init_address -- the IP address of the target node
- native_port -- the listen address of the target node

URL format for CqlStorage

The URL format for CqlStorage is:

```
cql://[username:password@]<keyspace>/<table>[?
  [page_size=<size>]
  [&columns=<col1,col2>]
  [&output_query=<prepared_statement_query>]
  [&where_clause=<clause>]
  [&split_size=<size>]
  [&partitioner=<partitioner>]
  [&use_secondary=true|false]]
  [&init_address=<host>]
  [&rpc_port=<port>]]
```

Where:

- page_size -- the number of rows per page
- columns -- the select columns of CQL query
- output_query -- the CQL query for writing in a prepared statement format
- where_clause -- the where clause on the index columns, which needs URL encoding
- split_size -- number of rows per split
- partitioner -- Cassandra partitioner
- use_secondary -- to enable pig filter partition push down
- init_address -- the IP address of the target node
- rpc_port -- the listen address of the target node

Working with legacy Cassandra tables

Use the CassandraStorage() handler and cfs:// URL to work with Cassandra tables that are in the storage engine (CLI/Thrift) format in Pig. Legacy tables are created using Thrift, CLI, or using the WITH COMPACT STORAGE directive in CQL. Thrift applications require that you configure Cassandra for connection to your application using the rpc connections instead of the default native transport for CassandraStorage connection.

The URL format for CassandraStorage is:

```
cassandra://[username:password@]<keyspace>/<columnfamily>[?
slice_start=<start>&slice_end=<end>
   [&reversed=true]
   [&limit=1]
   [&allow_deletes=true]
   [&widerows=true]
   [&use_secondary=true]
   [&comparator=<comparator>]
   [&split_size=<size>]
   [&partitioner=<partitioner>]
   [&init_address=<host>]
   [&rpc_port=<port>]]
```

CQL data access

Use the CqlNativeStorage handler with the input_cql statement or use the output_query statement to pull Cassandra data into a Pig relation.

Use the CqlNativeStorage handler with the input_cql statement or the output_query statement. To access data in the CassandraFS, the target keyspace and table must already exist. Data in a Pig relation can be stored in a Cassandra table, but Pig will not create the table.

The Pig LOAD function pulls Cassandra data into a Pig relation through the storage handler as shown in this examples:

```
<pig_relation_name> = LOAD 'cql://<keyspace>/<table>'
    USING CqlNativeStorage();
```

DataStax Enterprise supports these Pig data types:

- int
- long
- float
- double
- boolean
- chararray

The Pig LOAD statement pulls Cassandra data into a Pig relation through the storage handler. The format of the Pig LOAD statement is:

```
<pig_relation_name> = LOAD 'cql://<keyspace>/<table>'
                        USING CqlNativeStorage();
```

The Pig demo examples include using the LOAD command.

LOAD schema

The LOAD Schema is:

```
(colname:colvalue, colname:colvalue, … )
```

where each colvalue is referenced by the Cassandra column name.

CQL pushdown filter

Optimize the processing of the data by moving filtering expressions in Pig as close to the data source as possible.

DataStax Enterprise includes a CqlStorage URL option, use_secondary. Setting the option to true optimizes the processing of the data by moving filtering expressions in Pig as close to the data source as possible. To use this capability:

- Create an index for the Cassandra table.

  For Pig pushdown filtering, the secondary index must have the same name as the column being indexed.
- Include the use_secondary option with a value of true in the url format for the storage handler. The option name reflects the term that used to be used for a Cassandra index: secondary index. For example:

  ```
  newdata = LOAD 'cql://ks/cf_300000_keys_50_cols?use_secondary=true' USING
   CqlNativeStorage();
  ```

Saving a Pig relation to Cassandra

The Pig STORE command pushes data from a Pig relation to Cassandra through the CqlNativeStorage handler.

The Pig STORE command pushes data from a Pig relation to Cassandra through the CqlNativeStorage handler:

```
STORE <relation_name> INTO 'cql://<keyspace>/<column_family>?<prepared
 statement>'
  USING CqlNativeStorage();
```

Store schema

The input schema for Store is:

```
(value, value, value)
```

where each value schema has the name of the column and value of the column value.

The output schema for Store is:

```
(((name, value), (name, value)), (value ... value), (value ... value))
```

where the first tuple is the map of partition key and clustering columns. The rest of the tuples are the list of bound values for the output in a prepared CQL query.

Creating a URL-encoded prepared statement

Pig demo examples set up a prepared CQL query using the output_query statement.

About this task

The Pig demo examples show the steps required for setting up a prepared CQL query using the output_query statement:

Procedure

1. **Format the data**

   The example of saving Pig relations from/to Cassandra shows the output schema: the name of the simple_table1 table primary key 'a', represented as a chararray in the relation is paired with a value in the simple_table2 table. In this case, the key for simple_table1 table is only a partitioning key, and only a single tuple is needed.

   The Pig statement to add (moredata) fields to a tuple is:

   ```
   grunt> insertformat= FOREACH morevalues GENERATE
            TOTUPLE(TOTUPLE('a',x)),TOTUPLE(y);
   ```

   The example of exploring library data works with more complicated data, a partition key and clustering column:

   ```
   grunt> insertformat = FOREACH moredata GENERATE

    TOTUPLE(TOTUPLE('a',x),TOTUPLE('b',y),TOTUPLE('c',z)),TOTUPLE(data);
   ```

2. **Construct the prepared query**

   The output query portion of the cql:// URL is the prepared statement. The prepared statement must be url-encoded to make special characters readable by Pig.

The example of saving Pig relations from/to Cassandra shows how to construct a prepared query:

```
'cql://cql3ks/simple_table1?output_query=UPDATE+cql3ks.simple_table1+set+b
+%3D+%3F'
```

The key values of the simple_table1 table are automatically transformed into the 'WHERE (key) =' clause to form the output_query portion of a prepared statement.

3. **Execute the query**

   To update the simple_table1 table using the values in the simple_table2 (4-6), the prepared statement is executed using these WHERE clauses when the MapReduce job runs:

```
... WHERE a = 5
... WHERE a = 4
... WHERE a = 6
```

   This output_query in Pig statement forms the '...' url-encoded portion of the prepared statement:

```
grunt> STORE insertformat INTO
         'cql://cql3ks/simple_table1?output_query=UPDATE
+cql3ks.simple_table1+set+b+%3D+%3F'
         USING CqlNativeStorage;
```

   Decoded the UPDATE statement is:

```
UPDATE cql3ks.simple_table1 SET b = ?
```

   The prepared statement represents these queries:

```
UPDATE cql3ks.test SET b = 5 WHERE a = 5;
UPDATE cql3ks.test set b = 4 WHERE a = 4;
UPDATE cql3ks.test set b = 6 WHERE a = 6;
```

Analyzing data using external Hadoop systems

DataStax Enterprise works with external Hadoop systems in a bring your own Hadoop (BYOH) model. Use BYOH when you want to run DSE with a separate Hadoop cluster, from a different vendor.

About BYOH

DataStax Enterprise works with external Hadoop systems in a bring your own Hadoop (BYOH) model. Use BYOH to run DSE Analytics with a separate Hadoop cluster from a different vendor.

Hadoop is a software framework for distributed processing of large data sets using MapReduce programs. DataStax Enterprise works with these external Hadoop systems in a bring your own Hadoop (BYOH) model. Use BYOH to run DSE Analytics with a separate Hadoop cluster, from a different vendor. Supported vendors are:

- Hadoop 2.x data warehouse implementations Cloudera 4.5, 4.6, 5.0.x, and 5.2.x
- Hortonworks 1.3.3, 2.0.x, 2.1, and 2.2

You can use Hadoop in one of the following modes:

- External Hadoop

  Uses the Hadoop distribution provided by Cloudera (CDH) or Hortonworks (HDP).
- Internal Hadoop

  Uses the DSE Hadoop integrated with DataStax Enterprise.

For legacy purposes, DataStax Enterprise includes DSE Hadoop 1.0.4 with built-in Hadoop trackers.

Use cases for BYOH are:

- Bi-directional data movement between Cassandra in DataStax Enterprise and the Hadoop Distributed File System (HDFS)
- Hive queries against Cassandra data in DataStax Enterprise
- Data combination (joins) between Cassandra and HDFS data
- ODBC access to Cassandra data through Hive

Components

This table compares DSE Hadoop with the external Hadoop system in the BYOH model:

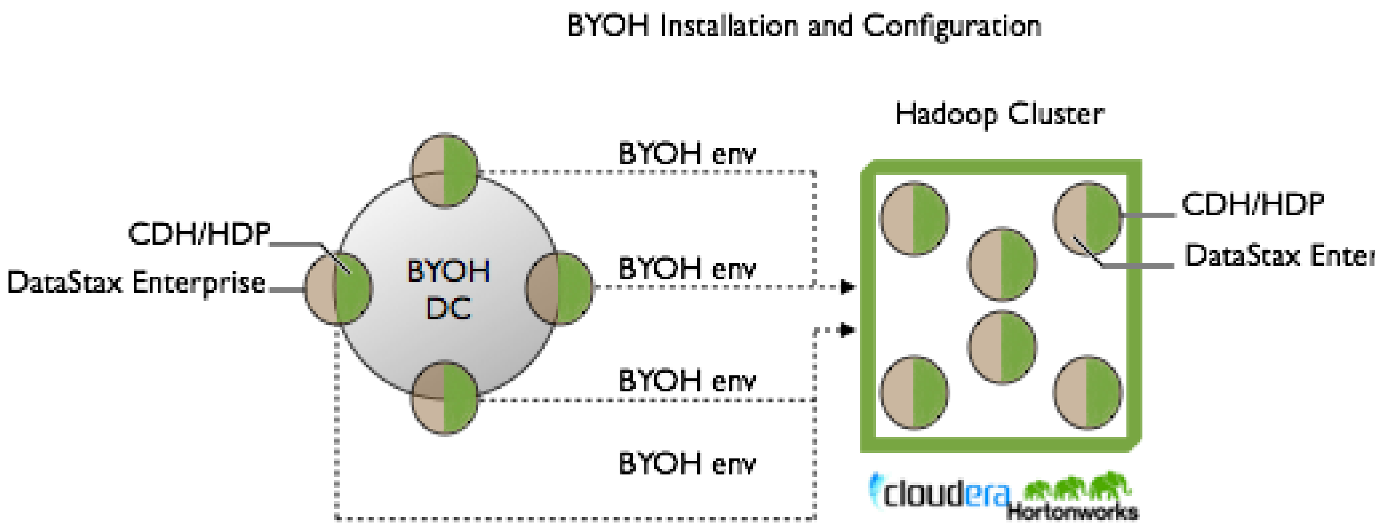
Table 12: Comparison of DSE Hadoop and the BYOH model

Component	DSE-integrated Hadoop owner	BYOH owner	DSE interaction
Job Tracker	DSE Cluster	Hadoop Cluster	Optional
Task Tracker	DSE Cluster	Hadoop Cluster	Co-located with BYOH nodes
Pig	Distributed with DSE	Distribution chosen by operator	Can launch from Task Trackers
Hive	Distributed with DSE	Distribution chosen by operator	Can launch from Task Trackers
HDFS/CFS	CFS	HDFS	Block storage

BYOH installation and configuration

The procedure for installing and configuring DataStax Enterprise for BYOH is straight-forward.

1. Ensure that you meet the prerequisites.
2. Install DataStax Enterprise on all nodes in the Cloudera or Hortonworks cluster and on additional nodes outside the Hadoop cluster.
3. Install several Cloudera or Hortonworks components on the additional nodes and deploy those nodes in a virtual BYOH data center.
4. Configure DataStax Enterprise BYOH environment variables on each node in the BYOH data center to point to the Hadoop cluster, as shown in the following diagram:



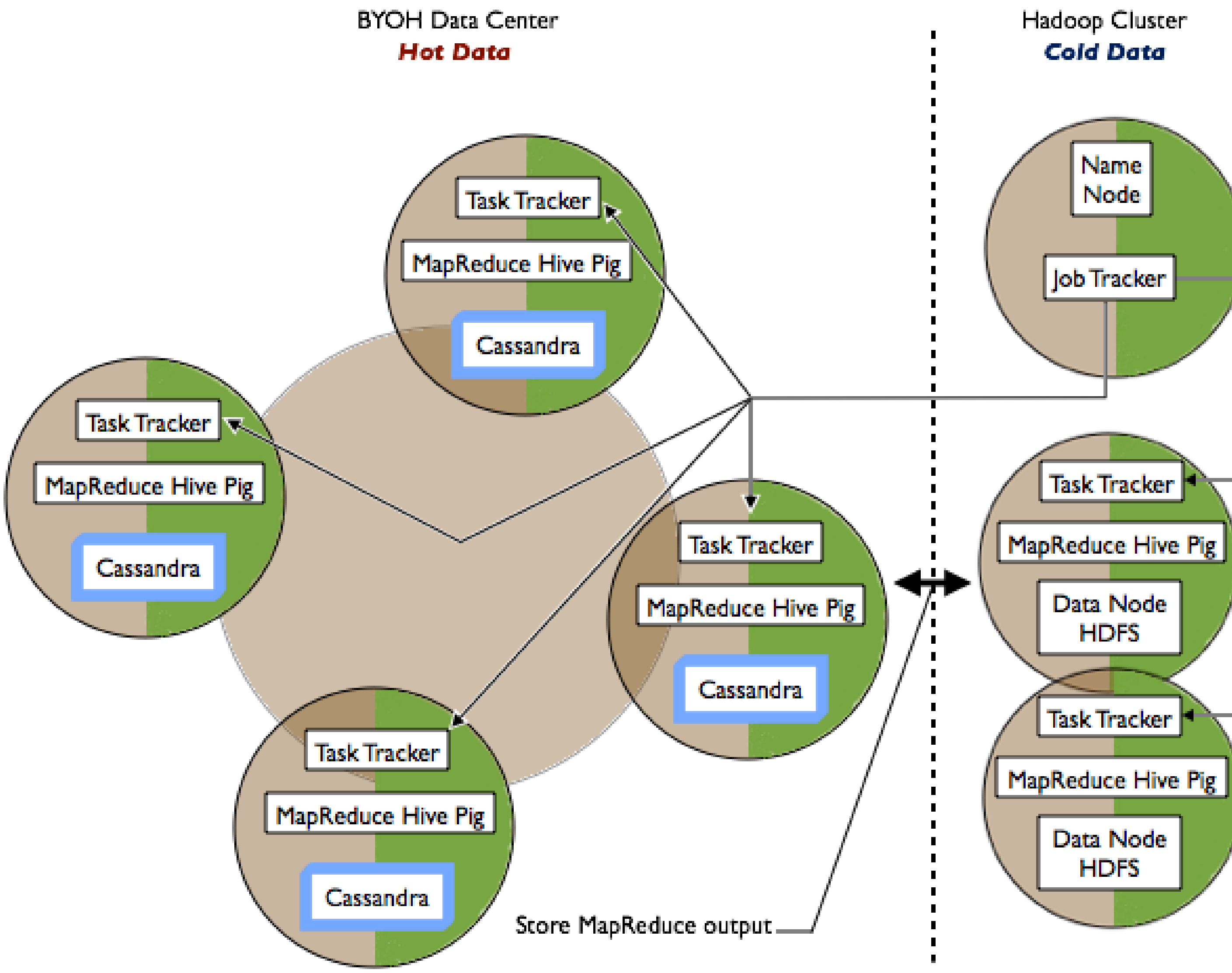
DataStax Enterprise runs only on BYOH nodes, and uses Hadoop components to integrate BYOH and Hadoop. You never start up the DataStax Enterprise installations on the Hadoop cluster.

MapReduce process

In a typical Hadoop cluster, Task Tracker and Data Node services run on each node. A Job Tracker service running on one of the master nodes coordinates MapReduce jobs between the Task Trackers, which pull data locally from data node. For the latest versions of Hadoop using YARN, Node Manager services replace Task Trackers and the Resource Manager service replaces the Job Tracker.

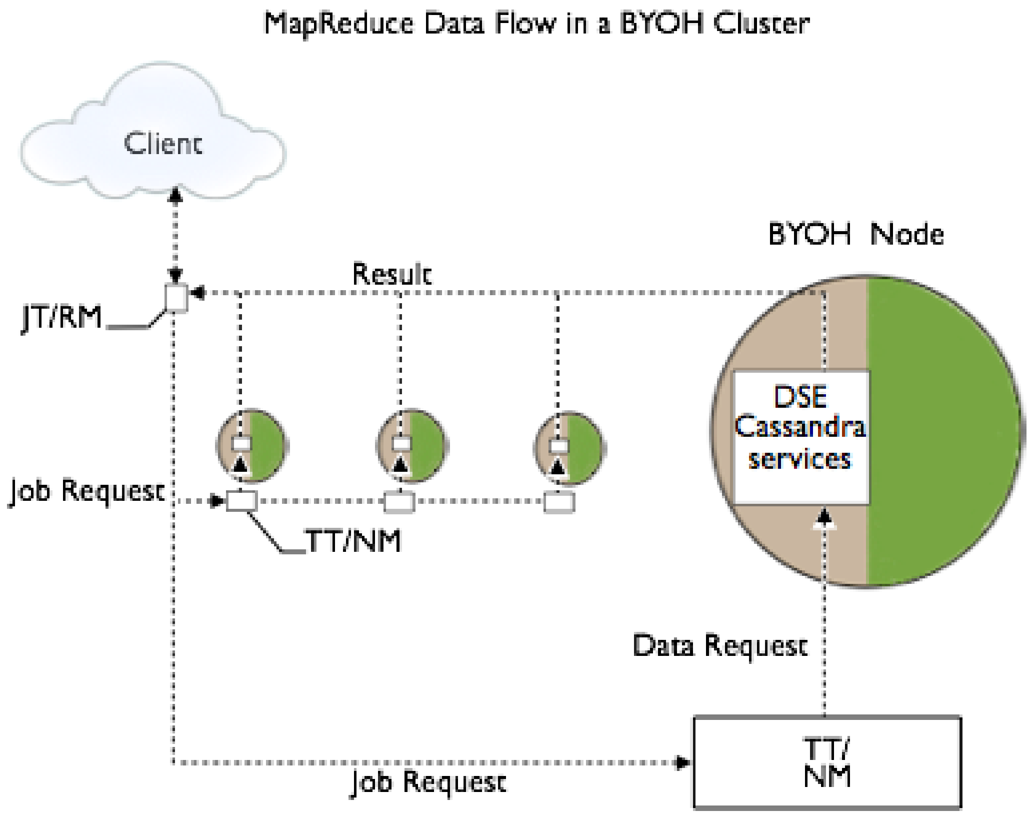
In contrast with the typical Hadoop cluster, in the BYOH model DSE Cassandra services can take the place of the Data Node service in MapReduce jobs, providing data directly to the Task Trackers/Node Managers, as shown in the following diagram. For simplicity purposes, the diagram uses the following nomenclature:

- Task Tracker--Means Task Tracker or Node Manager.
- Job Tracker--Means Job Tracker or Resource Manager.



A MapReduce service runs on each BYOH node along with optional MapReduce, Hive, and Pig clients. To take advantage of the performance benefits offered by Cassandra, BYOH handles frequently accessed hot data. The Hadoop cluster handles less-frequently and rarely accessed cold data. You design the MapReduce application to store output in Cassandra or Hadoop.

The following diagram shows the data flow of a job in a BYOH data center. The Job Tracker/Resource Manager (JT/RM) receives MapReduce input from the client application. The JT/RM sends a MapReduce job request to the Task Trackers/Node Managers (TT/NM) and optional clients, MapReduce, Hive, and Pig. The data is written to Cassandra and results sent back to the client.



BYOH workflow

BYOH clients submit Hive jobs to the Hadoop Job Tracker or ResourceManager in the case of YARN. If Cassandra is the source of the data, the Job Tracker evaluates the job, and the ColumnFamilyInputFormat creates input splits and assigns tasks to the various Task Trackers in the Cassandra node setup (giving the jobs local data access). The Hadoop job runs until the output phase.

During the output phase if Cassandra is the target of the output, the HiveCqlOutputFormat writes the data back into Cassandra from the various reducers. During the reduce step, if data is written back to Cassandra, locality is not a concern and data gets written normally into the cluster. For Hadoop in general, this pattern is the same. When spilled to disk, results are written to separate files, partial results for each reducer. When written to HDFS, the data is written back from each of the reducers.

Intermediate MapReduce files are stored on the local disk or in temporary HDFS tables, depending on configuration, but never in CFS. Using the BYOH model, Hadoop MapReduce jobs can access Cassandra as a data source and write results back to Cassandra or Hadoop.

BYOH Prerequisites and installation

Configure BYOH data centers to isolate workloads.

You must install DataStax Enterprise on all the nodes, nodes in the Hadoop cluster, and additional nodes outside the Hadoop cluster. Configure the additional nodes in one or more BYOH data centers to isolate workloads. Run sequential data loads, not random OLTP loads or Solr data loads in a BYOH data center.

Prerequisites

The prerequisites for installing and using the BYOH model are:

- Installation of a functioning CDH or HDP Hadoop cluster.
- Installation and configuration of these master services on the Hadoop cluster:
    - Job Tracker or Resource Manager (required)

    - HDFS Name Node (required)
    - Secondary Name Node or High Availability Name Nodes (required)
- At least one set of HDFS Data Nodes (required externally)

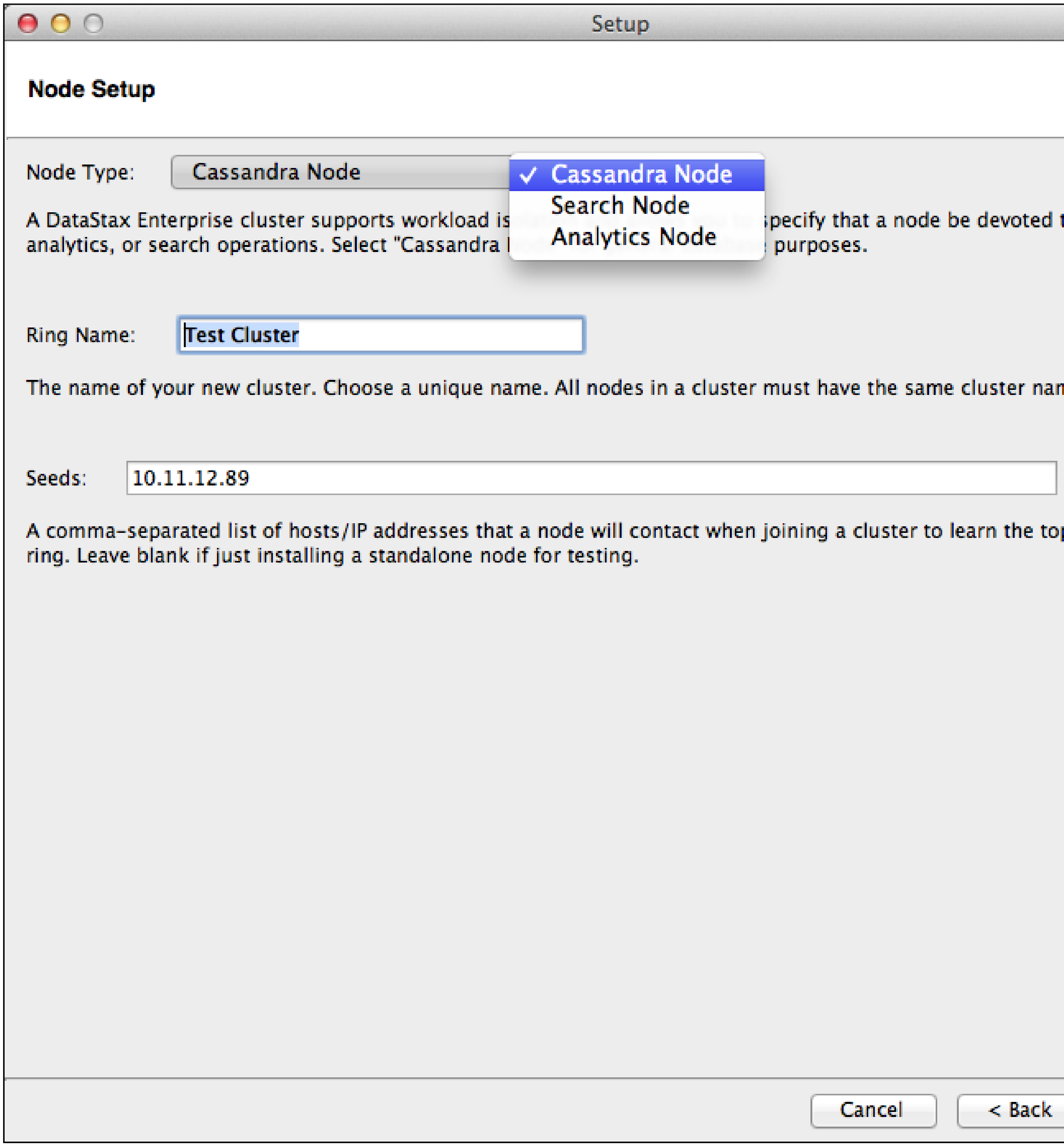
  The BYOH nodes must to be able to communicate with the HDFS Data Node that is located outside the BYOH data center.

  During the installation procedure, you install only the required Hadoop components in the BYOH data center: Task Trackers/Node Managers and optional clients, MapReduce, Hive, and Pig. Install Hadoop on the same paths on all nodes. CLASSPATH variables that are used by BYOH need to work on all nodes.

Installation procedure

To install DataStax Enterprise:

1. Ensure that you meet the prerequisites.
2. On each node in the BYOH and Hadoop cluster, install but do not start up DataStax Enterprise. Install DataStax Enterprise as a plain Cassandra node, not to run CFS, Solr, or integrated Hadoop. If you are using the GUI installer, on Node Setup, select Cassandra Node for Node Type.



Node Setup

Node Type: Cassandra Node

A DataStax Enterprise cluster supports workload is specify that a node be devoted t
analytics, or search operations. Select "Cassandra purposes.

Ring Name: Test Cluster

The name of your new cluster. Choose a unique name. All nodes in a cluster must have the same cluster nam

Seeds: 10.11.12.89

A comma-separated list of hosts/IP addresses that a node will contact when joining a cluster to learn the top
ring. Leave blank if just installing a standalone node for testing.

3. On packaged installations on the Hadoop cluster only, remove the `init.d` startup files for DataStax Enterprise and DataStax Enterprise Agent. For example, as root, stop DSE processes if they started up automatically, and then remove the files:

```
$ sudo /etc/init.d/dse stop
$ sudo /etc/init.d/datastax-agent stop
$ sudo rm -rf /etc/init.dse
$ sudo rm /etc/init.d/datastax-agent
```

Removing the startup files prevents accidental start up of DataStax Enterprise on the Hadoop cluster.

4. Deploy only the BYOH nodes in a virtual data center.
5. After configuring the cassandra.yaml and dse.yaml files as described in instructions for deploying the data center, copy both files to the nodes in the Hadoop cluster, overwriting the original files.
6. Observe workload isolation best practices. Do not enable vnodes.
7. Install the following Hadoop components and services on the BYOH nodes.

    - Task Tracker or Node Manager (required)
    - MapReduce (required).
    - Clients you want to use: Hive or Pig, for example (optional)

    Including the HDFS Data Node in the BYOH data center is optional, but not recommended.

Separating workloads

Use separate data centers to deploy mixed workloads. Within the same data center, do not mix nodes that run DSE Hadoop integrated Job Tracker and Task Trackers with external Hadoop services. In the BYOH mode, run external Hadoop services on the same nodes as Cassandra. Although you can enable CFS on these Cassandra nodes as a startup option, CFS as a primary data store is not recommended.

The location of the dse.yaml file depends on the type of installation:

Installer-Services	`/etc/dse/dse.yaml`
Package installations	`/etc/dse/dse.yaml`
Installer-No Services	*install_location*`/resources/dse/conf/dse.yaml`
Tarball installations	*install_location*`/resources/dse/conf/dse.yaml`

The location of the cassandra.yaml file depends on the type of installation:

Package installations	`/etc/cassandra/cassandra.yaml`
Tarball installations	*install_location*`/resources/cassandra/conf/cassandra.yaml`

Configuring an external Hadoop system

Perform configuration tasks after you install DataStax Enterprise.

You perform a few configuration tasks after installation of DataStax Enterprise.

- Configure Kerberos on the Hadoop cluster.
- Configure Java on the Hadoop cluster.
- Install Hive 0.12 on the Hadoop cluster.
- Configure BYOH environment variables on nodes in the BYOH data center.

Configuring Kerberos (optional)

To use Kerberos to protect your data, configure Hadoop security under Kerberos on your Hadoop cluster. For information about configuring Hadoop security, see "Using Cloudera Manager to Configure Hadoop Security" or the Hortonworks documentation.

Configuring Java

BYOH requires that the external Hadoop system use the same Java version as DataStax Enterprise. Ensure that the Cloudera and Hortonworks clusters are configured to use it.

Configuring Hive

Configure nodes to use Hive or Pig, generally the one that is provided with Cloudera or Hortonworks. Additional configuration is not required for BYOH with Apache and Cloudera versions of Hive versions 0.11 to 0.14.

1. If your Hadoop distribution is a version of Hive other than 0.11 to 0.14, follow these steps to install one of the supported versions.
2. For example, download Hive 0.12 http://apache.mirrors.pair.com/hive/hive-0.12.0/hive-0.12.0.tar.gz.
3. Unpack the archive to install Hive 0.12.

   ```
   $ tar -xzvf hive-0.12.0.tar.gz
   ```
4. If you move the Hive installation, avoid writing over the earlier version that was installed by Cloudera Manager or Ambari. For example, rename the Hive fork if necessary.
5. Move the Hive you installed to the following location:

   ```
   $ sudo mv hive-0.12.0 /usr/lib/hive12
   ```

After making the changes, restart the external Hadoop system. For example, restart the CDH cluster from the Cloudera Manager-Cloudera Management Service drop-down. Finally, configure BYOH environment variables before using DataStax Enterprise.

Configuring BYOH environment variables

The DataStax Enterprise installation includes the `byoh-env.sh` configuration file that sets up the DataStax Enterprise environment. Make these changes on all nodes in the BYOH data center. BYOH automatically extracts the Hive version from $HIVE_HOME/lib/hive-exec*.jar file name.

1. Open the byoh-env.sh file.

   The default location of the `byoh-env.sh` file depends on the type of installation:

Installer-Services and Package installations	`/etc/dse/byoh-env.sh`
Installer-No Services and Tarball installations	*`install_location`*`/bin/byoh-env.sh`

2. Set the DSE_HOME environment variable to the DataStax Enterprise installation directory.
   - Package installations: :

     ```
     export DSE_HOME="/etc/dse"
     ```
   - Installer-Services installations:

     ```
     export DSE_HOME="/usr/share/dse"
     ```
   - Installer-No Services and Tarball installations:

     ```
     export DSE_HOME="install_location"
     ```
3. Edit the `byoh-env.sh` file to point the BYOH configuration to the Hive version and the Pig version.

   ```
   HIVE_HOME="/usr/lib/hive"
   PIG_HOME="/usr/lib/pig"
   ```

   Note: You can manually change the Hive version in the HIVE_VERSION environment variable in `hive-env.sh`.
4. Check that other configurable variables match the location of components in your environment.

5. Configure the byoh-env.sh for using Pig by editing the IP addresses to reflect your environment. On a single node, cluster for example:

   ```
   export PIG_INITIAL_ADDRESS=127.0.0.1
   export PIG_OUTPUT_INITIAL_ADDRESS=127.0.0.1
   export PIG_INPUT_INITIAL_ADDRESS=127.0.0.1
   ```

6. If a Hadoop data node is not running on the local machine, configure the DATA_NODE_LIST and NAME_NODE variables as follows:

   - DATA_NODE_LIST

     Provide a comma-separated list of Hadoop data node IP addresses this machine can access. The list is set to mapreduce.job.hdfs-servers in the client configuration.
   - NAME_NODE

     Provide the name or IP address of the name node. For example:

     ```
     export DATA_NODE_LIST="192.168.1.1, 192.168.1.2, 192.168.1.3"
     export NAME_NODE="localhost"
     ```

   If a Hadoop data node is running on the local machine, leave these variables blank. For example:

   ```
   export DATA_NODE_LIST=
   export NAME_NODE=
   ```

Starting up the BYOH data center

Start the seed nodes first, and then start the rest of the nodes.

After you install and configure DataStax Enterprise on all nodes, start the seed nodes first, and then start the rest of the nodes, as described in Multiple data center deployment.

Installer-Services and Package installations:

1. Check the `/etc/default/dse` file to ensure that DSE Hadoop and DSE Search are disabled:

   - HADOOP_ENABLED=0 - Disables the DSE Hadoop integrated Job Tracker and Task Tracker services.
   - SOLR_ENABLED=0 - Disables the capability to run DSE Search workloads.

   DataStax does not support using the SOLR_ENABLED and HADOOP_ENABLED options in BYOH deployments.
2. Start each BYOH node using the following command.

   ```
   $ sudo service dse start
   ```

3. Check that the BYOH cluster is up and running.

   ```
   $ dsetool status
   ```

Installer-No Services and Tarball installations:

Start DataStax Enterprise in Cassandra mode, not Analytics mode.

1. From the installation directory, start up each BYOH node in Cassandra mode.

   ```
   $ bin/dse cassandra
   ```

   Do not use the -t option to start a BYOH node.
2. Check that the BYOH cluster up and running.

   ```
   $ cd install_location
   ```

```
$ bin/dsetool status
```

Using BYOH

Usage patterns for BYOH are the same as typical MapReduce usage patterns. Hadoop jobs run through Pig, Hive, or other MapReduce jobs.

Usage patterns for BYOH are the same as typical MapReduce usage patterns. Hadoop jobs run through Pig, Hive, or other MapReduce jobs. To access Cassandra data when working with the external Hadoop system, use the `byoh` command. For example, on Linux in the `bin` directory, prepend `byoh` to a Pig or Hive command. You can access the following data:

- Cassandra data in CQL or Thrift format using an application or utility, such as cqlsh.
- Data stored in HDFS through Pig or Hive.

Using CFS

DataStax does not recommend using the CFS as a primary data store. However, if you need to use CFS as a data source, or as the output destination for a BYOH job, you can run the `dse command` with the -c option when you start nodes. This option enables CFS, but not the integrated DSE Job Trackers and task trackers.

To migrate data from the CFS to HDFS, use distcp, or an alternative tool. Copy data from one HDFS to another either before or after the transition to BYOH.

Running the DSE Analytics Demos

You can run the portfolio demo against your installation of BYOH to test it.

Using Hive with BYOH

Apache Hive is a data warehouse system for Hadoop that projects a relational structure onto data that is stored in Hadoop-compatible file systems.

Apache Hive is a data warehouse system for Hadoop that projects a relational structure onto data stored in Hadoop-compatible file systems. Documentation about DataStax Enterprise DSE Hadoop provides a general introduction to Hive for new users.

BYOH capabilities connect DataStax Enterprise to a Hive MapReduce client in the external Hadoop system for querying the data using a SQL-like language called HiveQL.

Start Hive on a Cassandra BYOH node, and then run MapReduce queries directly on data outside or inside Cassandra. Use a Hive managed table to query data outside of Cassandra. Hive manages storing and deleting the data in a Hive managed table. Use a Hive external table to query data in Cassandra. Cassandra manages storing and deleting the data in a Hive external table.

Starting Hive

To start Hive use this byoh command:

```
$ bin/byoh hive
```

The output should look something like this:

```
/usr/lib/dse/resources/cassandra/conf

Logging initialized using configuration in jar:file:/usr/lib/hive12/lib/
hive-common-0.12.0.jar!/hive-logback.properties
SLF4J: Class path contains multiple SLF4J bindings.
SLF4J: Found binding in [jar:file:/usr/lib/hadoop/lib/slf4j-
logback12-1.6.1.jar!/org/slf4j/impl/StaticLoggerBinder.class]
```

```
SLF4J: Found binding in [jar:file:/usr/lib/hive12/lib/slf4j-
logback12-1.6.1.jar!/org/slf4j/impl/StaticLoggerBinder.class]
SLF4J: Found binding in [jar:file:/usr/lib/dse/resources/dse/lib/slf4j-
logback12-1.7.2.jar!/org/slf4j/impl/StaticLoggerBinder.class]
SLF4J: See http://www.slf4j.org/codes.html#multiple_bindings for an
 explanation.
SLF4J: Actual binding is of type [org.slf4j.impl.LogbackLoggerFactory]
hive>
```

Accessing data outside Cassandra

At the Hive prompt, you can create and query the Hive managed table. For example, you can query a flat file that you put on the HDFS (using a hadoop -fs command) or the file can be elsewhere, such as on an operating system file system.

Accessing data in Cassandra

Use the DataStax Enterprise custom metastore in the BYOH model to map Cassandra tables to Hive tables automatically. The keyspace and table must pre-exist in Cassandra. You create a schema representing your table using the `dse hive-schema` command. The command dumps your entire schema, or part of it, to standard output. Next, in the Hive client, you pass the table containing the map to Hive using the `byoh hive -f` command. DataStax Enterprise creates the Hive external table. Finally, create or alter CQL data from Hive.

The syntax of the hive-schema command is:

```
bin/dse hive-schema -keyspace testks -table testa testb -exclude testc testd
```

The `hive-schema` command options are:

-all

Include all keyspaces and tables

-decimal

Decimal parameters in form precision, scale for Hive 0.13 and later

-exclude

Exclude these tables

-help

Provide hive-schema command usage

-keyspace

Include these keyspaces

-table

Include these tables

To dump all Cassandra keyspaces and tables to a file called byoh_automap, for example, use this command:

```
$ dse hive-schema -all > byoh_automap
```

To start Hive and pass the hive-schema:

```
$ byoh hive -f byoh_automap
```

Running the Hive demo

The Hive demo creates a keyspace and table in Cassandra using cqlsh, creates a Hive external table, and then queries the table from Hive.

Note: DataStax Demos do not work with either LDAP or internal authorization (username/password) enabled.

1. Create a Cassandra keyspace and table using cqlsh.

   ```
   cqlsh> CREATE KEYSPACE cassandra_keyspace WITH replication =
            {'class': 'NetworkTopologyStrategy', 'Cassandra': 1};
   cqlsh> use cassandra_keyspace;
   cqlsh:cassandra_keyspace> CREATE TABLE exampletable ( key int PRIMARY
    KEY , data text );
   cqlsh:cassandra_keyspace> INSERT INTO exampletable (key, data ) VALUES
    ( 1, 'This data can be read automatically in hive');
   ```

2. On the command line, use the dse hive-schema command to create an automap file:

   ```
   $ bin/dse hive-schema -keyspace cassandra_keyspace -table exampletable
   ```

   The output is:

   ```
   CREATE DATABASE IF NOT EXISTS cassandra_keyspace;

   USE cassandra_keyspace;

   CREATE EXTERNAL TABLE IF NOT EXISTS exampletable (
     key int  COMMENT 'Auto-created based on
    org.apache.cassandra.db.marshal.Int32Type from Column Family meta data',
     data string  COMMENT 'Auto-created based on
    org.apache.cassandra.db.marshal.UTF8Type from Column Family meta data')
   ROW FORMAT SERDE
     'org.apache.hadoop.hive.cassandra.cql3.serde.CqlColumnSerDe'
   STORED BY
     'org.apache.hadoop.hive.cassandra.cql3.CqlStorageHandler'
   WITH SERDEPROPERTIES (
     'serialization.format'='1',
     'cassandra.columns.mapping'='key,data')
   TBLPROPERTIES (
     'auto_created' = 'true',
     'cassandra.partitioner' = 'org.apache.cassandra.dht.Murmur3Partitioner',
     'cql3.partition.key' = 'key',
     'cassandra.ks.name' = 'cassandra_keyspace',
     'cassandra.cf.name' = 'exampletable');
   ```

3. To start Hive and pass the hive-schema:

   ```
   $ byoh hive -f byoh_automap
   SLF4J: Found binding in [jar:file:/home/automaton/dse-4.6.0/resources/dse/
   lib/slf4j-logback12-1.7.2.jar!/org/slf4j/impl/StaticLoggerBinder.class]
   SLF4J: See http://www.slf4j.org/codes.html#multiple_bindings for an
    explanation.
   SLF4J: Actual binding is of type [org.slf4j.impl.LogbackLoggerFactory]
   OK
   Time taken: 5.15 seconds
   OK
   Time taken: 0.008 seconds
   OK
   Time taken: 3.085 seconds
   ```

4. Start Hive using the byoh hive command to access the Cassandra table.

   ```
   $ bin/byoh hive
   ```

5. In Hive, use the Cassandra keyspace and query the Cassandra table.

```
hive> use cassandra_keyspace;
OK
Time taken: 5.264 seconds

hive> select * from exampletable;
OK
1 This data can be read automatically in hive
Time taken: 3.815 seconds, Fetched: 1 row(s)
```

Using Pig

The external Hadoop system includes an Apache Pig Client that you enable through BYOH.

The external Hadoop system includes an Apache Pig Client that you enable through BYOH. Pig is a high-level programming environment for MapReduce coding. Using Pig under BYOH is straight-forward. You start the Pig client through BYOH. On the grunt command line, access Pig using the same data access commands, CQL pushdown filter, and URL-encoded prepared statements as used by DataStax Enterprise integrated Hadoop. Store Pig relations to Cassandra in the same manner also.

Generally, Pig examples work as shown in the documentation of DataStax Enterprise integrated Hadoop. For example, to run the Pig library demo, the only change to the steps is how you start Pig. To start Pig, use the byoh preface. On Linux, for example:

```
$ bin/byoh pig
grunt>
```

Using Mahout with external Hadoop

You can use Apache Mahout with external Hadoop systems and DataStax Enterprise.

Apache Mahout is a Hadoop component that offers machine learning libraries. You can use Apache Mahout with external Hadoop systems and DataStax Enterprise.

If Mahout is installed to its default location of `/usr/lib/mahout`, the `byoh-env.sh` file is already configured correctly. If Mahout is installed in a different location, open `byoh-env.sh` in a text editor and set `MAHOUT_HOME` to the correct location of Mahout.

```
export MAHOUT_HOME="/usr/local/lib/mahout"
```

Running the demo with external Mahout

Describes the steps to run the Mahout demo included with DSE on an external installation of Mahout.

About this task

The DataStax Enterprise installation includes a Mahout demo. The demo determines with some percentage of certainty which entries in the input data remained statistically in control and which have not. The input data is time series historical data. Using the Mahout algorithms, the demo classifies the data into categories based on whether it exhibited relatively stable behavior over a period of time. The demo produces a file of classified results. This procedure describes how to run the Mahout demo.

Procedure

Note: DataStax Demos do not work with either LDAP or internal authorization (username/password) enabled.

1. Go to the Hadoop home directory and make the test data directory.

```
$ cd <Hadoop home>
$ bin/hadoop fs -mkdir testdata
```

2. Add the data from the demo directory to Mahout.

```
$ bin/hadoop fs -put <DSE home>/demos/mahout/synthetic_control.data testdata
```

3. Go to the DSE home directory and run the demo's analysis job using `byoh`.

   ```
   $ bin/byoh mahout org.apache.mahout.clustering.syntheticcontrol.canopy.Job
   ```

   The job will take some time to complete. You can monitor the process of the job in OpsCenter if you have it installed.
4. When the job completes, output the classified data into a file in a temporary location.

   ```
   $ bin/byoh mahout clusterdump --input output/clusters-0-final --pointsDir
    output/clusteredPoints --output /tmp/clusteranalyze.txt
   ```
5. Open the `/tmp/clusteranalyze.txt` output data file and look at the results.

DSE Search

DataStax Enterprise Search (DSE Search) simplifies using search applications for data that is stored in a Cassandra database. DSE Search is an enterprise grade search solution that is scalable to work across multiple data centers and the cloud.

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About DSE Search

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DataStax Enterprise Search (DSE Search) simplifies using search applications for data that is stored in a Cassandra database. DSE Search is an enterprise grade search solution that is scalable to work across multiple data centers and the cloud.

The benefits of running enterprise search functions through DataStax Enterprise and DSE Search include:

- A fully fault-tolerant, no-single-point-of-failure search architecture across multiple data centers.
- Add search capacity just like you add capacity in Cassandra.
- Ability to isolate transactional, analytic, and search workloads to prevent competition for resources.
- Live indexing increases indexing throughput, reduces Lucene reader latency, and enables queries to be made against recently indexed data.
- Near real-time query capabilities.
- Commands for creating, reloading, and managing Solr core resources.
- Read/write to any DSE Search node and automatically index stored data.
- Selective updates of one or more fields and restricted query routing.
- Examine and aggregate real-time data in multiple ways using CQL or the Solr compatible HTTP API.
- Fault-tolerant queries, efficient deep paging, and advanced search node resiliency.
- Support of virtual nodes (vnodes).
- Manage where the Solr data files are saved on the server.

Indexing

DSE Search allows Cassandra columns to be automatically indexed by Solr through its secondary index API. Each insert or update of a Cassandra row triggers a new indexing on DSE Search, inserting or updating the document that corresponds to that Cassandra row. Using CQL, DSE Search supports partial document updates that enable you to modify existing information while maintaining a lower transaction cost.

Indexing DSE Search documents requires the `schema.xml` and `solrconfig.xml` resources. DSE can automatically generate these resources, or you can use custom resources.

Solr resources

DSE Search supports all Solr tools and APIs. See the following resources for more information on using Open Source Solr.

- Apache Solr documentation
- Solr Tutorial on Apache Lucene site
- Solr data import handler

- Comma-Separated-Values (CSV) file importer
- JSON importer
- Solr cell project, including a tool for importing data from PDFs

Starting and stopping DSE Search

The way you start a DSE Search node depends on the type of installation.

About this task

To install a DSE Search node, use the same installation procedure as you use to install any other type of node. To use real-time (Cassandra), analytics (Hadoop/Spark), or DSE Search nodes in the same cluster, segregate the different nodes into separate data centers. Using the default DSESimpleSnitch automatically puts all the DSE Search nodes in the same data center, so you need to change the snitch from the default to another type for multiple data center deployment.

Starting and stopping a DSE Search node

The way you start a DSE Search node depends on the type of installation:

- **Installer-No Services and Tarball installations:**

  From the install directory, use this command to start the DSE Search node:

  ```
  $ bin/dse cassandra -s
  ```

  The node starts up.

  From the install directory, use this command to stop the node:

  ```
  $ bin/dse cassandra-stop
  ```

- **Installer-Services and Package installations:**

  1. Enable DSE Search mode by setting this option in the `/etc/default/dse` file:

     ```
     SOLR_ENABLED=1
     ```

  2. Start the dse service using this command:

     ```
     $ sudo service dse start
     ```

     The DSE Search node starts.

  You stop a node using this command:

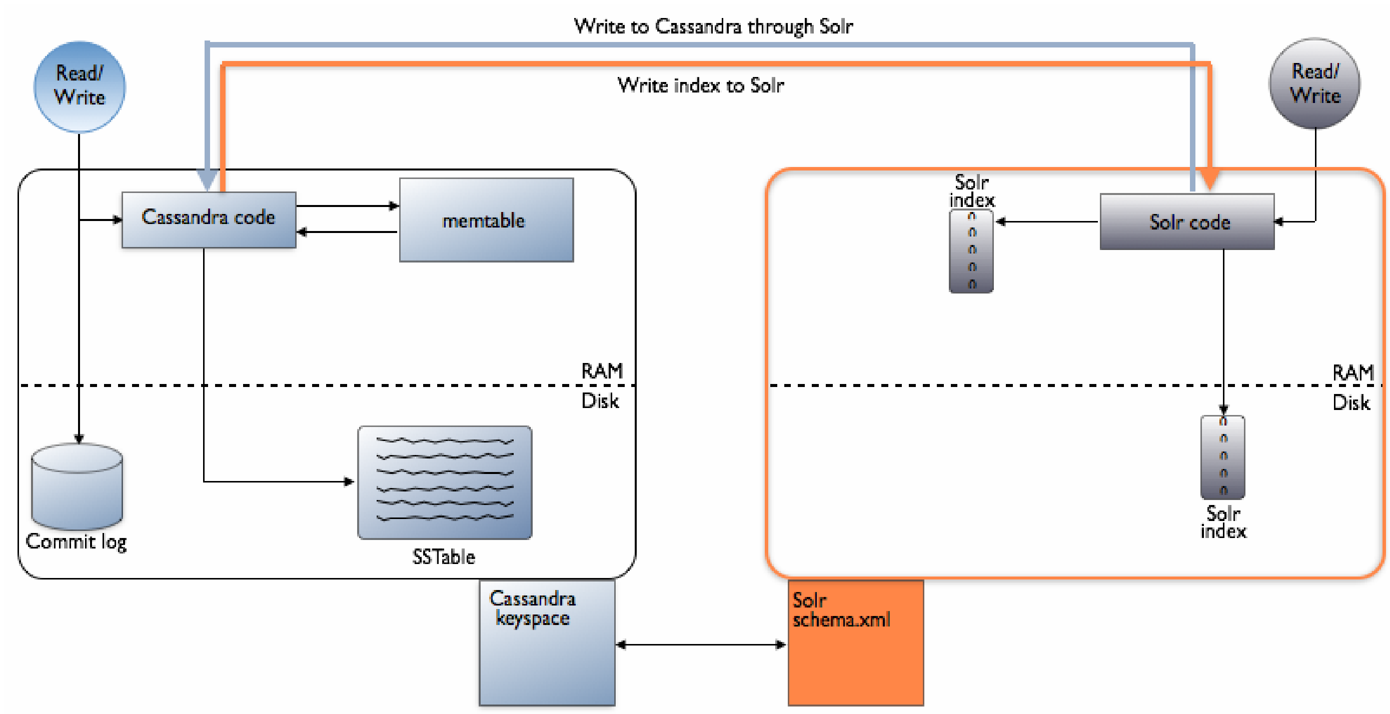
  ```
  $ sudo service dse stop
  ```

DSE Search architecture

An overview of DataStax Enterprise Search architecture.

In a distributed environment, such as DataStax Enterprise and Cassandra, the data is spread over multiple nodes. In a mixed-workload cluster, DSE Search nodes are in a separate data center. Deploy DSE Search nodes in a single data center to run DSE Search on all nodes.

A Solr API client writes data to Cassandra first, and then Cassandra updates indexes.



When you update a table using CQL, the Solr document is updated. Re-indexing occurs automatically after an update. Writes are durable. All writes to a replica node are recorded in memory and in a commit log before they are acknowledged as a success. If a crash or server failure occurs before the memory tables are flushed to disk, the commit log is replayed on restart to recover any lost writes.

Note: DSE Search does not support JBOD mode.

DSE Search terms

In DSE Search, there are several names for an index of documents and configuration on a single node:

- A Solr core
- A collection
- One shard of a collection

Each document in a Solr core/collection is considered unique and contains a set of fields that adhere to a user-defined schema. The schema lists the field types and how they should be indexed. DSE Search maps Solr cores/collections to Cassandra tables. Each table has a separate Solr core/collection on a particular node. Solr documents are mapped to Cassandra rows, and document fields to columns. The shard is analogous to a partition of the table. The Cassandra keyspace is a prefix for the name of the Solr core/collection and has no counterpart in Solr.

This table shows the relationship between Cassandra and Solr concepts:

Cassandra	Solr single node environment
Table	Solr core or collection
Row	Document
Partition key	Unique key
Column	Field
Node	N/A

Cassandra	Solr single node environment
Partition	N/A
Keyspace	N/A

With Cassandra replication, a Cassandra node or Solr core contains more than one partition (shard) of table (collection) data. Unless the replication factor equals the number of cluster nodes, the Cassandra node or Solr core contains only a portion of the data of the table or collection.

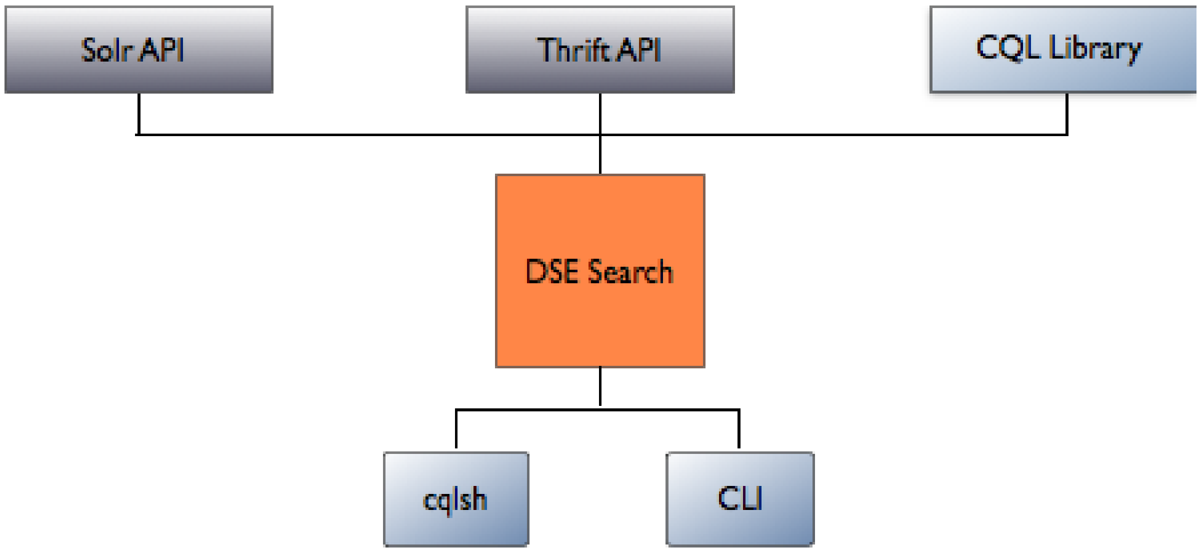
Note: Do not mix Solr indexes with Cassandra secondary indexes. Attempting to use both indexes on the same table is not supported.

Queries

DSE Search hooks into the Cassandra Command Line Interface (CLI), Cassandra Query Language (CQL) library, the cqlsh tool, existing Solr APIs, and Thrift APIs.

About this task

DSE Search hooks into the Cassandra Command Line Interface (CLI), Cassandra Query Language (CQL) library, the cqlsh tool, existing Solr APIs, and Thrift



APIs.

Avoid querying nodes that are indexing. For responding to queries, DSE Search ranks the nodes that are not performing Solr indexing higher than indexing ones. If only indexing nodes can satisfy the query, the query will not fail but instead will return potentially partial results.

Using CQL Solr queries in DSE Search

DataStax Enterprise supports production-grade implementation of CQL Solr queries in DSE Search. You can develop CQL-centric applications supporting full-text search without having to work with Solr-specific APIs.

DataStax Enterprise supports production-grade implementation of CQL Solr queries in DSE Search. You can develop CQL-centric applications supporting full-text search without having to work with Solr-specific APIs. Only full text search queries are supported in this release. Using CQL, DSE Search supports partial document updates that enable you to modify existing information while maintaining a lower transaction cost. Before using CQL Solr queries in DSE Search, configure solrconfig.xml to handle CQL queries.

Required configuration for CQL Solr queries in DSE Search

Using CQL solr_query syntax is supported only on nodes where search is enabled.

When you automatically generate resources, the `solrconfig.xml` file already contains the request handler for running CQL Solr queries in DSE Search. If you do not automatically generate resources and want to run CQL Solr queries using custom resources, add the following handler to the `solrconfig.xml` file:

```
<requestHandler
 class="com.datastax.bdp.search.solr.handler.component.CqlSearchHandler"
 name="solr_query" />
```

You can add default configurations: default number of rows, default search field, default sorting, and so on. For example:

```
<requestHandler
 class="com.datastax.bdp.search.solr.handler.component.CqlSearchHandler"
 name="solr_query">
     <lst name="defaults">
       <int name="rows">10</int>
     </lst>
   </requestHandler>
```

CQL Solr considerations

- CQL Solr queries are defaulted to an equivalent LIMIT 10.
- The row retrieval phase of CQL Solr queries uses the LOCAL_ONE consistency level for reads and can actuate read repair. In contrast, HTTP Solr queries use local/internal reads and do not actuate read repair.
- When using cqlsh, pagination is on by default. Solr pagination is transparently set. Solr restrictions apply to pagination.
- To turn pagination off, use the CQL PAGING command:

```
PAGING OFF
```

CQL Solr query syntax

You can run CQL Solr queries using the SELECT statement that includes the search expression.

Synopsis

```
SELECT select expression
 FROM table
 [WHERE solr_query = 'search expression'] [LIMIT n]
```

There are two types of search expressions:

- Search queries with CQL
- Search queries with JSON

Search queries with CQL

The Solr query expression uses the syntax supported by the Solr q parameter. For example:

```
SELECT * FROM keyspace.table WHERE solr_query='name: cat name: dog -
name:fish'
```

When you name specific columns, DSE Search retrieves only the specified columns and returns the columns as part of the resulting rows. DSE Search supports projections (SELECT a, b, c...) only, not functions, for the select expression. The following example retrieves only the name column:

```
SELECT name FROM keyspace.table WHERE solr_query='name:cat name:dog -
name:fish'
```

Use the LIMIT clause to specify how many rows to return. The following example retrieves only 1 row:

```
SELECT * FROM keyspace.table WHERE solr_query='name:cat name:dog -name:fish'
 LIMIT 1
```

You cannot use CQL Solr queries to set the consistency level, ordering, or specify WHERE clauses other than the solr_query one. The consistency level for CQL Solr queries is ONE by default and should not be changed; otherwise, the query will return an error.

Using partition key restrictions

Solr CQL queries support restriction to a single partition key.

Example:

```
SELECT id, date, value FROM keyspace.table WHERE id = 'series1' AND
 solr_query='value:bar*'"
```

Using the Solr token function

Solr CQL queries support limited use of the CQL token function. The token function enables targeted search that restricts the nodes queried to reduce latency.

Note: Using the Solr token function is for advanced users only and is supported only in specific use cases.

Example:

```
SELECT id, value FROM keyspace.table WHERE token(id) >= -3074457345618258601
 AND token(id) <= 3074457345618258603 AND solr_query='id:*'
```

Example with an open range:

```
SELECT id, value FROM keyspace.table WHERE token(id) >= 3074457345618258604
 AND solr_query='id:*'
```

Constraints apply to using the token function with Solr CQL queries:

- token() cannot be used with route.range or route.partition
- Wrapping token() ranges are not supported
- A specified token() range must be owned by a single node; ranges cannot span multiple nodes
- Because DSE uses the Solr single-pass queries, only the fields that are declared in the Solr schema are returned in the query results. If you have columns that do not need to be indexed, but still need to be returned by using a token-restricted query, you can declare the columns as stored non-indexed fields in your `schema.xml` file.

Search queries with JSON

DataStax Enterprise supports JSON-based query expressions queries.

DataStax Enterprise supports JSON queries.

JSON query syntax

The JSON query expression syntax is a JSON string. The JSON-based query expression supports local parameters in addition to the following parameters:

```
{
  "q": <query expression>,
  "fq": <filter query expression>,
  "sort": <sort expression>,
  "query.name": <name>
}
```

For example:

```
SELECT id FROM nhanes_ks.nhanes WHERE solr_query=' {"q":"ethnicity:Asian"}';
```

```
SELECT * FROM mykeyspace.mysolr WHERE solr_query='{"q" : "{!
edismax}quotes:yearning or kills"}';
```

```
SELECT id FROM nhanes_ks.nhanes WHERE solr_query='{"q":"ethnicity:Mexi*",
 "sort":"id asc"}' LIMIT 3;
```

Field, query, and range faceting with a JSON query

Specify the facet parameters inside a facet JSON object to perform field, query, and range faceting inside Solr queries. Distributed pivot faceting is supported. The query syntax is less verbose to specify facets by:

- Specifying each facet parameter without the facet prefix that is required by HTTP APIs.
- Expressing multiple facet fields and queries inside a JSON array.

A faceted search example:

```
SELECT * FROM solr WHERE solr_query='{"q":"id:*","facet":{"field":"type"}}';
```

A query facet example:

```
SELECT * FROM solr WHERE solr_query='{"q":"id:*","facet":
{"query":"type:0"}}';
```

Multiple queries example:

```
SELECT * FROM solr WHERE solr_query='{"q":"id:*","facet":{"query":
["type:0","type:1"]}}';
```

Distributed pivot faceting example:

```
SELECT id FROM <table> WHERE solr_query='{"q":"id:*","facet":
{"pivot":"type,value","limit":"-1"}}'
```

Range facet example:

```
SELECT * FROM solr WHERE solr_query='{"q":"id:*","facet":{range":"type",
 "f.type.range.start":-10, "f.type.range.end":10, "range.gap":1}}}';
```

The returned result is formatted as a single row with each column corresponding to the output of a facet (either field, query, or range). The value is represented as a JSON blob because facet results can be complex and nested. For example:

```
facet_fields             | facet_queries
```

```
-------------------------+-------------------------
 {"type":{"0":2,"1":1}} | {"type:0":2,"type:1":1}
```

Warning: Solr range facets before, after, and between might return incorrect and inconsistent results on multinode clusters. See SOLR-6187 and SOLR-6375.

JSON single-pass distributed query

Single-pass distributed queries are supported in CQL Solr queries.

To use a single pass distributed query instead of the standard two-pass query, specify the distrib.singlePass Boolean parameter in the JSON query expression:

```
SELECT * FROM ks.cf WHERE solr_query = '{"q" : "*:*", "distrib.singlePass" :
 true}'
```

Using a single-pass distributed query has an operational cost that includes potentially more disk and network overhead. With single-pass queries, each node reads all rows that satisfy the query and returns them to the coordinator node. An advanced feature, a single-pass distributed query saves one network round trip transfer during the retrieval of queried rows. A regular distributed query performs two network round trips, the first one to retrieve IDs from Solr that satisfy the query and another trip to retrieve only the rows that satisfy the query from Cassandra, based on IDs from the first step. Single-pass distributed queries are most efficient when most of the documents found are returned in the search results, and they are not efficient when most of the documents found will not be returned to the coordinator node.

For example, a distributed query that only fans out to a single node from the coordinator node will likely be most efficient as a single-pass query.

Single pass distributed queries for CQL are supported when the additional distrib.singlePass boolean parameter is included in the JSON query.

With single-pass queries, there is a limitation that only document fields that are defined in the Solr schema are returned as query results. This limitation also applies to map entries that do not conform to the dynamic field mapping.

JSON query name option

Using the following syntax to name your queries to support metrics and monitoring for performance objects. Naming queries can be useful for tagging and JMX operations, for example.

```
SELECT id FROM nhanes_ks.nhanes WHERE solr_query=' {"query.name":"Asian
 subjects", "q":"ethnicity:Asia*"}' LIMIT 50;
```

JSON query commit option

If you are executing custom queries after bulk document loading, and the normal auto soft commit is disabled or extremely infrequent, and you want the latest data to be visible to your query, use the JSON query commit option to ensure that all pending updates are soft-committed before the query runs. By default, the commit option is set to false.

For example:

```
SELECT id FROM nhanes_ks.nhanes WHERE solr_query='{"q":"ethnicity:Asia*",
 "commit":true}' LIMIT 50;
```

Warning: Do not use the JSON commit option for live operations against a production cluster. DataStax recommends using the JSON commit option only when you would otherwise be forced to issue a commit though the Solr HTTP interface. The commit option is not a replacement for the normal auto soft commit process.

Using the Solr HTTP API

Use the Solr HTTP API to query data that is indexed in DSE Search.

You can use the Solr HTTP API to query data that is indexed in DSE Search just as you would search for data indexed in Solr.

HTTP Solr queries use local/internal reads and do not actuate read repair. In contrast, the row retrieval phase of CQL Solr queries uses the LOCAL_ONE consistency level for reads and can actuate read repair.

Solr HTTP API example

Assuming you performed the example of using a collection set, to find the titles in the mykeyspace.mysolr table that begin with the letters Succ in XML, use this URL:

```
http://localhost:8983/solr/mykeyspace.mysolr/select?q=%20title
%3ASucc*&fl=title
```

The response is:

```
<response>
 <lst name="responseHeader">
   <int name="status">0</int>
   <int name="QTime">2</int>
   <lst name="params">
     <str name="fl">title</str>
     <str name="q">title:Succ*</str>
   </lst>
 </lst>
 <result name="response" numFound="2" start="0">
   <doc>
     <str name="title">Success</str>
   </doc>
   <doc>
     <str name="title">Success</str>
   </doc>
 </result>
</response>
```

Using Solr pagination (cursors)

Pagination, also called cursors, support using a cursor to scan results. Solr pagination restrictions apply.

DataStax Enterprise integrates native driver paging with Solr cursor-based paging. Pagination, also called cursors, supports using a cursor to scan results. Solr pagination restrictions apply. You can use CQL Solr queries and the Solr HTTP API.

Note: When using CQL Solr queries with Cassandra pagination enabled, you might experience a performance slowdown because Solr is not able to use its query result cache when pagination is configured. If you do not want to paginate through large result sets, disable pagination when running CQL Solr queries. See the driver documentation.

Using cursors with CQL Solr queries

When using a driver with a CQL Solr query, cursors are transparently activated when the driver is using pagination. To turn off cursors with CQL Solr queries, deactivate driver pagination. See the driver documentation for details. It is not mandatory to use a sort clause. However, if a sort clause is not provided, sorting is undefined.

DataStax Enterprise 4.7.0 only

Note: The Solr rows parameter and the CQL LIMIT keyword are interpreted as the Solr rows parameter. If you run a query on cqlsh with the Solr rows parameter and/or the CQL LIMIT keyword, the cursor is consumed and all rows are returned. To prevent this behavior, turn off pagination with the CQL PAGING command: `PAGING OFF`. To set a preferred FetchSize, consult the driver documentation because LIMIT does not apply.

LIMIT is respected in 4.7.1 and later.

Examples

```
SELECT * from ks.cf where solr_query='{"q":"*:*", "sort":"id asc, id2
 asc"}'
```

```
SELECT * from ks.cf where solr_query='{"q":"*:*"}'
```

Using cursors with the HTTP API

To use cursors with the Solr HTTP API, it is not mandatory to provide a sort clause. However, if a sort clause is not provided, sorting is undefined. Do not make assumptions on sorting. Follow the steps in Using CQL Solr queries.

Inserting/updating data using the Solr HTTP API

Steps for updating a CQL-based core using the Solr HTTP API.

About this task

Updates to a CQL-based Solr core replace the entire row. You cannot replace only a field in a CQL table. The deprecated replacefields parameter for inserting into, modifying, or deleting data from CQL Solr cores is not supported. The replacefields parameter is supported for updating indexed data in a non-CQL table and in Solr. Use the parameter in this way:

```
$ curl http://host:port/solr/keyspace.table/update?
  replacefields=false  -H 'Content-type: application/json' -d
  'json string'
```

To update a CQL-based core, use the following procedure:

Procedure

Building on the collections example, insert data into the mykeyspace.mytable data and Solr index. Use this `curl` command:

```
$ curl http://localhost:8983/solr/mykeyspace.mysolr/update -H 'Content-
type: application/json' -d '[{"id":"130", "quotes":"Life is a beach.",
 "name":"unknown", "title":"Life"}]'
```

The Solr convention is to use `curl` for issuing `update` commands instead of using a browser. You do not have to post a `commit` command in the `update` command as you do in Solr, and doing so is ineffective.

When you use CQL or CLI to update a field, DSE Search implicitly sets replacefields to false and updates individual fields in the Solr document. The re-indexing of data occurs automatically.

Caution: Do not include the optimize command in URLs to update Solr data. This warning appears in the system log when you use the optimize:

```
WARN [http-8983-2] 2013-03-26 14:33:04,450
 CassandraDirectUpdateHandler2.java (line 697)
Calling commit with optimize is not recommended.
```

The Lucene merge policy is very efficient. Using the optimize command is no longer necessary and using the optimize command in a URL can cause nodes to fail.

Querying a CQL collection set

In this example, you create a table containing a CQL collection set of famous quotations. Then, you insert data into the table by copying/pasting INSERT commands from a file that you download.

About this task

DataStax Enterprise supports CQL collections. In this example, you create a table containing a CQL collection set of famous quotations. You insert data into the table by copying/pasting INSERT commands from a file that you download.

Next, you insert a collection into Cassandra, index the data in DSE Search, and finally, query the search index.

Procedure

1. Start DataStax Enterprise in DSE Search mode.
2. Start cqlsh.
3. Create a keyspace and a table consisting of a set collection column and other columns, and then, insert some data for DSE Search to index.

```
CREATE KEYSPACE mykeyspace
  WITH REPLICATION = {'class':'NetworkTopologyStrategy', 'Solr':1};

USE mykeyspace;

CREATE TABLE mysolr (
  id text PRIMARY KEY,
  name text,
  title text,
  quotes set <text>
);
```

4. Download the INSERT commands in the `quotations.zip` file. Unzip the `quotations.zip` file that you downloaded, copy the insert commands, and paste the commands on the cqlsh command line.
5. Run the following command, which is located in the bin directory of tarball installations. For example, from a tarball installation:

```
$ install_location/bin/dsetool create_core mykeyspace.mysolr
 generateResources=true reindex=true
```

   If you are recreating the mykeyspace.mysolr core, use the `reload_core` instead of the `create_core` command.

   There is no output from this command. You can search Solr data after indexing finishes.
6. In cqlsh, search Solr-indexed data to find titles like Succ*.

```
SELECT * FROM mykeyspace.mysolr WHERE solr_query='title:Succ*';
```

   Because you created the core using automatically generated resources, the solrconfig defines the request handler for using CQL for Solr queries.
7. Using a browser, search Solr-indexed data using the Solr HTTP API to find titles like Succ*.

```
http://localhost:8983/solr/mykeyspace.mysolr/
```

```
    select?q=title%3ASucc*&wt=json&indent=on&omitHeader=on

  {
    "response":{"numFound":2,"start":0,"docs":[
        {
          "id":"126",
          "title":"Success",
          "quotes":["If A is success in life, then A equals x plus y
            plus z. Work is x; y is play; and z is keeping your mouth
            shut."],
          "name":"Albert Einstein"},
          {
          "id":"125",
          "title":"Success",
          "quotes":["Always bear in mind that your own resolution to
            succeed is more important than any one thing.",
            "Better to remain silent and be thought a fool than to speak
            out and remove all doubt."],
          "name":"Abraham Lincoln"}]
  }}
```

Deleting by id

Delete by id deletes the document with a specified id and is more efficient than delete by query.

Delete by id deletes the document with a specified id and is more efficient than delete by query. The id is the value of the uniqueKey field declared in the schema. The id can be a synthetic id that represents a Cassandra compound primary key, such as the one used in the Basic tutorial. To delete by id, the following example builds on the example in running a simple search. After clicking Execute Query, a list of results appears. Each result includes a _uniqueKey in JSON format. The uniqueKey is the first line of each result and looks like this:

```
<str name="_uniqueKey">["47336","29"]</str>
```

In this example, ["47336", "29"] are the values of the id, age compound primary key. The following delete by id query shows the HTTP API command you use to remove that particular record from the Solr index:

```
$ curl http://localhost:8983/solr/nhanes_ks.nhanes/update --data
  '<delete><id>["47336","29"]</id></delete>' -H 'Content-type:text/xml;
  charset=utf-8'
```

After deleting the record, run a simple search on the Solr tutorial data again. The Solr Admin shows that the number of documents has been reduced by one. Query the Cassandra table using cqlsh:

```
cqlsh:nhanes_ks> SELECT * FROM nhanes WHERE id=47336;
```

The cqlsh output also confirms that the data was removed. Null values appear instead of the data.

Deleting by query

Command for issuing a delete by query.

After you issue a delete by query, documents start getting deleted immediately and deletions continue until all documents are removed. For example you can delete the data that you inserted using this command on the operating system command line:

```
$ curl http://localhost:8983/solr/mykeyspace.mysolr/update --data
  '<delete><query>*:*</query></delete>' -H
   'Content-type:text/xml; charset=utf-8'
```

Using &allowPartialDeletes parameter set to false (default) prevents deletes if a node is down. Using &allowPartialDeletes set to true causes the delete to fail if a node is down and the delete does not meet a consistency level of quorum. Delete by queries using *:* are an exception to these rules. These queries issue a truncate, which requires all nodes to be up in order to succeed.

Joining cores

Requirements for joining Solr documents.

DataStax Enterprise supports the OS Solr query time join through a custom implementation. You can join Solr documents, including those having different Solr cores under these conditions:

- Solr cores need to have the same keyspace and same Cassandra partition key.
- Both Cassandra tables that support the Solr cores to be joined have to be either Thrift- or CQL-compatible. You cannot have one that is Thift-compatible and one that is CQL-compatible.
- The type of the unique key (Cassandra key validator of the partition key) are the same.
- The order of table partition keys and schema unique keys are the same.

DataStax Enterprise 4.5.0 and later provides faster DocValues-based joins than earlier versions of DataStax Enterprise, such as 4.0.2. In the earlier version, using the simplified syntax shown in the next section for a join query requires re-indexing the CQL Solr core, but not the Thrift Solr core. In DataStax Enterprise, using the simplified syntax automatically takes advantage of faster joins in the case of a CQL Solr core. In the case of a Thrift Solr core, to use the simplified syntax, re-index, and in the from field of the query, use docValues=true.

Simplified syntax

This simplified syntax is recommended for joining Solr cores:

```
q={!join fromIndex=test.from}field:value
```

The custom implementation eliminates the need to use to/from parameters required by OS Solr. Based on the key structure, DataStax Enterprise can determine what the parameters are. For backward compatibility with applications, the verbose, legacy syntax is also supported.

Example of using a query time join

This example creates two tables, songs and lyrics. The tables use the same partition key. The songs table uses a simple primary key, the UUID of a song. The primary key of the songs table is its partition key. The lyrics table uses a compound primary: id and song, both of type UUID. After joining cores, you construct a single query to retrieve information about songs having lyrics that include "love".

You can copy CQL commands, Solr HTTP requests, and the query from the downloaded commands.txt file.

1. Download and unzip the file containing the Solr schemas, Solr configuration files, and commands for this example.

   This action creates `/songs` and `/lyrics` directories, schemas, and Solr configuration files for indexing data in the songs and lyrics tables.
2. Start cqlsh, and then create and use a keyspace named internet.

   You can copy/paste from the downloaded `commands.txt` file.
3. Create two tables, song and lyrics, that share the internet keyspace and use the same partition key.

   ```
   cqlsh> CREATE TABLE songs (song uuid PRIMARY KEY, title text, artist
    text);
   cqlsh> CREATE TABLE lyrics (song uuid, id uuid, words text, PRIMARY KEY
    (song, id));
   ```

Both tables share the song partition key, a uuid. The second table also contains the id clustering column.

4. Insert the data from the downloaded file into the songs table.
5. Insert data into the lyrics table.

   The lyrics of songs by Big Data and John Cedrick mention love.
6. Navigate to the songs directory that you created in step 1, and take a look at the Solr schema.xml. Navigate to the lyrics directory and take a look at the schema. Notice that the order of the unique key in the schema and the partition key of the lyrics table are the same: (song, id). Using (id, song) does not work.

```
<schema name="songs_schema" version="1.5">
  <types>
     <fieldType name="uuid" class="solr.UUIDField" />
     <fieldType name="text" class="solr.TextField">
     <analyzer>
       <tokenizer class="solr.StandardTokenizerFactory"/>
     </analyzer>
     </fieldType>
  </types>
  <fields>
    <field name="song" type="uuid" indexed="true" stored="true"/>
    <field name="title" type="text" indexed="true" stored="true"/>
    <field name="artist" type="text" indexed="true" stored="true"/>
  </fields>
  <defaultSearchField>artist</defaultSearchField>
  <uniqueKey>song</uniqueKey>
</schema>

<schema name="lyrics_schema" version="1.5">
  <types>
    <fieldType name="uuid" class="solr.UUIDField" />
    <fieldType name="text" class="solr.TextField" >
    <analyzer>
      <tokenizer class="solr.StandardTokenizerFactory"/>
    </analyzer>
   </fieldType>
  </types>
    <fields>
      <field name="song" type="uuid" indexed="true" stored="true"/>
      <field name="id" type="uuid" indexed="true" stored="true"/>
      <field name="words" type="text" indexed="true" stored="true"/>
    </fields>
  <defaultSearchField>words</defaultSearchField>
  <uniqueKey>(song, id)</uniqueKey>
</schema>
```

7. In the songs directory, post `solrconfig.xml` and `schema.xml` for the internet.songs core, and create the Solr core for internet.songs.
8. In the lyrics directory, post the `solrconfig.xml` and `schema.xml` for the internet.lyrics core, and create the Solr core for internet.lyrics.
9. Search for songs that have lyrics about love.

```
http://localhost:8983/solr/internet.songs/select/?q={!join
+fromIndex=internet.lyrics}words:love&indent=true&wt=json
```

   The output includes two songs having the word "love" in the lyrics, one by Big Data and the other by John Cedrick:

```
"response":{"numFound":2,"start":0,"docs":[
          {
            "song":"a3e64f8f-bd44-4f28-b8d9-6938726e34d4",
            "title":"Dangerous",
            "artist":"Big Data"},
          {
            "song":"8a172618-b121-4136-bb10-f665cfc469eb",
            "title":"Internet Love Song",
            "artist":"John Cedrick"}]
     }}
```

Recursive join support

You can nest a join query to use the result of one join as an input for another join, and another, recursively. All joined data must reside on the same partition. To embed one query in the Solr query string of another, use the magic field name _query_.

Use the following syntax to construct a query that recursively joins cores.

```
F1:V1 AND _query_:"{!join fromIndex=keyspace.table}(F2:V2 AND _query_:\"{!
join fromIndex=keyspace.table}(F3:V3)\")"
```

Where the top level from query includes a nested join query. The nested join in this example is:

```
_query_:\"{!join fromIndex=keyspace.table}(F3:V3)\"
```

Like an SQL SELECT IN ... (SELECT IN ...) query, Solr executes the nested join queries first, enabling multiple nested join queries if required.

A Solr join query is not a relational join where the values from the nested join queries are returned in the results.

Example of a recursive join query

This example builds on the solr query time join example. Embed in the query to join songs and lyrics having words:"love" a second query to join award-winning videos using AND _query_:"award:true".

You can copy CQL commands, Solr HTTP requests, and the query from the downloaded commands.txt file.

1. In cqlsh, create a videos table that shares the internet keyspace and uses the same partition key as the songs and lyrics tables.

   ```
   cqlsh> CREATE TABLE videos (song uuid, award boolean, title text, PRIMARY
    KEY (song));
   ```

   All three tables use the song partition key, a uuid.
2. Insert the data from the downloaded file into the videos table. The video data sets the award field to true for the videos featuring songs by Big Data and Brad Paisley.
3. Navigate to the videos directory that was created when you unzipped the downloaded file.
4. In the videos directory, post `solrconfig.xml` and `schema.xml`, and create the Solr core for internet.videos.
5. Use a nested join query to recursively join the songs and lyrics documents with the videos document, and to select the song that mentions love and also won a video award.

   ```
   http://localhost:8983/solr/internet.songs/select/?q=
            {!join+fromIndex=internet.lyrics}words:love AND _query_:
            {!join+fromIndex=internet.videos}award:true&indent=true&wt=json
   ```

Output is:

```
"response":{"numFound":1,"start":0,"docs":[
    {
      "song":"a3e64f8f-bd44-4f28-b8d9-6938726e34d4",
      "title":"Dangerous",
      "artist":"Big Data"}]
}}
```

Support for the legacy join query

DataStax Enterprise supports using the legacy syntax that includes to/from fields in the query. The requirements for using the legacy syntax are:

- Tables do not use composite partition keys.
- The query includes the force=true local parser parameter, as shown in this example that joins mytable1 and mytable2 in mykeyspace.

Legacy syntax example

```
curl 'http://localhost:8983/solr/mykeyspace.mytable1/select/?q=\{!join
+from=id+to=id+fromIndex=mykeyspace.mytable2+force=true\}'
```

Querying multiple tables

Query multiple tables by using the shards parameter.

To map multiple Cassandra tables to a single Solr core, use the Solr HTTP API. Specify multiple tables using the shards parameter. For example:

```
http://host:port/solr/keyspace1.cf1/select?q=*:*&shards=
  host:port/solr/keyspace1.cf1,host:port/solr/keyspace2.cf2
```

Using the Solr API, you can query multiple tables simultaneously if they have same schema.

Using HTTP API SolrJ and other Solr clients

Solr clients work with DataStax Enterprise. DataStax has extended SolrJ to protect internal Solr communication and HTTP access using SSL. You can also use any Thrift API, such as Pycassa or Hector, to access DSE Search.

Solr clients work with DataStax Enterprise. If you have an existing Solr application, using it with DataStax Enterprise is straight-forward. Create a schema, then import your data and query using your existing Solr tools. The Wikipedia demo is built and queried using Solrj. The query is done using pure Ajax. No Cassandra API is used for the demo.

You can also use any Thrift API, such as Pycassa or Hector, to access DSE Search. Pycassa supports Cassandra indexes. You can use indexes in Pycassa just as you use the solr_query expression in DSE Search.

DataStax has extended SolrJ to protect internal Solr communication and HTTP access using SSL. You can also use SolrJ to change the consistency level of a DSE Search node.

Creating a schema and data modeling

A Solr schema defines the relationship between data in a table and a Solr core. The schema identifies the columns to index in Solr and maps column names to Solr types.

This document describes the Solr schema at a high level. For details about all the options and Solr schema settings, see the Solr wiki. A Solr schema defines the relationship between data in a table and a Solr core. The schema identifies the columns to index in Solr and maps column names to Solr types.

DataStax Enterprise supports CQL tables using simple, compound primary keys, as shown in the Solr query join example, and composite partition keys.

Compound primary and composite partition keys

The Basic tutorial presents a schema for a Cassandra table that uses a CQL compound primary key. A CQL table must be created in Cassandra before creating the Solr core. The schema for such a table requires a different syntax than the simple primary key.

- List each compound primary key column that appears in the CQL table in the Solr schema as a field, just like any other column.
- Declare the unique key using the key columns enclosed in parentheses.
- Order the keys in the uniqueKey element as the keys are ordered in the CQL table.
- When using composite partition keys, do not include the extra set of parentheses in the Solr uniqueKey.

  Use a single set of parentheses and list the fields in the same order as you define the fields in CQL:

Cassandra Partition Key	CQL Syntax	Solr uniqueKey Syntax
Simple CQL primary key	CREATE TABLE (. . . <a> <type> PRIMARY KEY, . . .);	<uniqueKey>(a)</uniqueKey>
Compound primary key	CREATE TABLE (. . . PRIMARY KEY (a, b, c));	<uniqueKey>(a, b, c)</uniqueKey>
Composite partition key	CREATE TABLE (. . . PRIMARY KEY ((a, b), c);	<uniqueKey>(a, b, c)</uniqueKey>

DSE Search maps schema fields and the unique key specification to the Cassandra key components, and generates a synthetic unique key for Solr. The schema used by the tutorial is a synthetic unique key that corresponds to the compound primary key in the Cassandra table definition, as shown in these excerpts from the tutorial table and `schema.xml`:

Table definition

```
CREATE TABLE nhanes (
  "id" INT,
  "num_smokers" INT,
  "age" INT,
  . . .
  PRIMARY KEY ("id", "age")
);
```

Schema definition

```
<schema name="solr_quickstart" version="1.1">
 <types>
 . . .
 <fields>
   <field name="id" type="int" indexed="true"  stored="true"/>
   <field name="num_smokers" type="int" indexed="true"  stored="true"/>
```

```
    <field name="age" type="int" indexed="true"  stored="true"/>
  . . .
  <uniqueKey>(id,age)</uniqueKey>
  . . .
```

Defining field attributes

All fields with `indexed="true"` are indexed and searched by Lucene. The indexed fields are stored in Cassandra, not in Lucene, regardless of the value of the stored attribute value, with the exception of copy fields.

- To store a field with `indexed="false"` in Cassandra and enable the field to be returned on search queries, set `stored="true"`.
- To ignore the field, set both `indexed="false"` and `stored="false"`.

Note: If `docValues="true"`, DataStax recommends setting `stored="true"`.

Defining the unique key

The schema must have a unique key and must not duplicate rows. The unique key is like a primary key in SQL. The unique key maps to the Cassandra partition key, which DataStax Enterprise uses to route documents to cluster nodes.

The last element in the following sample schema names the unique key id. Tokenized fields cannot be used as primary keys.

If you use legacy type mappings, the Solr schema needs to define the unique key as a string.

Sample schema

The following sample schema from the example of using a CQL collection set uses a simple primary key. The schema specifies a StrCollectionField for quotes, a collection set column in the CQL table. A tokenizer determines the parsing of the example text. The set of fields specifies the data that Solr indexes and stores. DSE Search indexes the id, quotes, name, and title fields.

```
<schema name="my_search_demo" version="1.5">
  <types>
    <fieldType class="solr.StrField" multiValued="true"
 name="StrCollectionField"/>
    <fieldType name="string" class="solr.StrField"/>
    <fieldType name="text" class="solr.TextField"/>
    <fieldType class="solr.TextField" name="textcollection"
 multiValued="true">
      <analyzer>
        <tokenizer class="solr.StandardTokenizerFactory"/>
      </analyzer>
    </fieldType>
  </types>
  <fields>
    <field name="id"  type="string" indexed="true"  stored="true"/>
    <field name="quotes"  type="textcollection" indexed="true"
 stored="true"/>
    <field name="name"  type="text" indexed="true"  stored="true"/>
    <field name="title"  type="text" indexed="true"  stored="true"/>
  </fields>
  <defaultSearchField>quotes</defaultSearchField>
  <uniqueKey>id</uniqueKey>
</schema>
```

Internal structure of the _uniqueKey field

In the Solr schema, you enclose the unique keys in parentheses if the field is a compound primary key or composite partition key column in Cassandra. During indexing, DataStax Enterprise recognizes and indexes the parenthetical as a _uniqueKey field. The structure of the _uniqueKey field is a string. The value is structured as a JSON array of string elements. Types, such as booleans, are enclosed in quotation marks. The actual type of the field is unimportant. Only the uniqueness of the value is important.

The structure of the _uniqueKey field is flat. The Cassandra-Solr-_uniqueKey mapping is:

Key	Cassandra	Solr	uniqueKey
Compound primary key	`(a, b)`	`(a, b)`	`["a", "b"]`
Composite partition key	`((a, b), c)`	`(a, b, c)`	`["a", "b", "c"]`

The final mapping to the uniqueKey flattens the Cassandra composite partition key ((a, b), c) on the Solr side.

Document level boosting

To add document-level boosting on CQL tables, add a column named _docBoost of type float to the table. Fields belonging to that document will be boosted at indexing time.

Changing a schema

Changing the Solr schema makes reloading the Solr core necessary. Re-indexing can be disruptive. Users can be affected by performance hits caused by re-indexing. Changing the schema is recommended only when absolutely necessary. Also, changing the schema during scheduled down time is recommended.

Mapping of Solr types

Reference information of DataStax Enterprise mapping of Solr types to CQL types and Cassandra validators.

This table shows the DataStax Enterprise mapping of Solr types to CQL types and Cassandra validators.

Solr Type	CQL type	Cassandra Validator	Description
AsciiStrField	ascii	AsciiType	Indexed as a standard Solr StrField
BCDIntField	int	Int32Type	Binary-coded decimal (BCD) integer
BCDLongField	bigint	LongType	BCD long integer
BCDStrField	text, varchar	UTF8Type	BCD string
BinaryField	blob	BytesType	Binary data
BoolField	boolean	BooleanType	True (1, t, or T) or False (not 1, t, or T)
ByteField	int	Int32Type	Contains an 8-bit number value
DateField	timestamp	DateType	Point in time with millisecond precision
DecimalStrField	decimal	DecimalType	Indexed as a standard Solr StrField

Solr Type	CQL type	Cassandra Validator	Description
DoubleField	double	DoubleType	Double (64-bit IEEE floating point)
EnumType	int	Int32Type	A closed set having a pre-determined sort order
ExternalFileField	text, varchar	UTF8Type	Values from disk file
FloatField	float	FloatType	32-bit IEEE floating point
GeoHashField	text, varchar	UTF8Type	Geohash lat/lon pair represented as a string
InetField	inet	InetAddressType	InetField is currently implemented and indexed as a standard Solr StrField.
IntField	int	Int32Type	32-bit signed integer
LatLonType	text, varchar	UTF8Type	Latitude/Longitude 2-D point, latitude first
LongField	bigint	LongType	Long integer (64-bit signed integer)
PointType	text, varchar	UTF8Type	Arbitrary n-dimensional point for spatial search
RandomSortField	text, varchar	UTF8Type	Dynamic field in random order
ShortField	int	Int32Type	Short integer
SortableDoubleField	double	DoubleType	Numerically sorted doubles
SortableFloatField	float	FloatType	Numerically sorted floating point
SortableIntField	int	Int32Type	Numerically sorted integer
SortableLongField	bigint	LongType	Numerically sorted long integer
SpatialRecursivePrefixTreeFieldType	text, varchar	UTF8Type	Spatial field type for a geospatial context
StrField	text, varchar	UTF8Type	String (UTF-8 encoded string or Unicode)
TextField	text, varchar	UTF8Type	Text, usually multiple words or tokens
TrieDateField	timestamp	DateType	Date field for Lucene TrieRange processing
TrieDoubleField	double	DoubleType	Double field for Lucene TrieRange processing
TrieField	n/a	n/a	Same as any Trie field type
TrieFloatField	float	FloatType	Floating point field for Lucene TrieRange processing
TrieIntField	int	Int32Type	Int field for Lucene TrieRange processing
TrieLongField	bigint	LongType	Long field for Lucene TrieRange processing

Solr Type	CQL type	Cassandra Validator	Description
UUIDField	uuid, timeuuid	UUIDType	Universally Unique Identifier (UUID)
VarIntStrField	varint	IntegerType	Indexed as a standard Solr StrField
Other	text, varchar	UTF8Type	Indexed as a standard Solr StrField

For efficiency in operations such as range queries, using Trie types is recommended. Keep the following information in mind about these types:

- UUIDField

  DataStax Enterprise supports the Cassandra TimeUUID type. A value of this type is a Type 1 UUID that includes the time of its generation. Values are sorted, conflict-free timestamps. For example, use this type to identify a column, such as a blog entry, by its timestamp and allow multiple clients to write to the same partition key simultaneously. To find data mapped from a Cassandra TimeUUID to a Solr UUIDField, users need to search for the whole UUID value, not just its time component.
- BCD

  A relatively inefficient encoding that offers the benefits of quick decimal calculations and quick conversion to a string.
- SortableDoubleField/DoubleType

  If you use the plain types (DoubleField, IntField, and so on) sorting will be lexicographical instead of numeric.
- TrieField

  Used with a type attribute and value: integer, long, float, double, date.

Mapping of CQL collections

DSE Search maps collections as follows:

- Collection list and set: multi-valued field. See Managing the field cache memory and Example: copy fields and docValues
- Collection maps: dynamic field. See Using dynamic fields.

The name of the dynamic field minus the wildcard is the map name. For example, a map column name dyna* is mapped to dyna. Inner keys are mapped to the full field name.

Legacy mapping of Solr types

Legacy mapping of Solr types is requires if you created indexes in DataStax Enterprise 3.0.x or earlier. DataStax Enterprise 3.0.x and earlier use the legacy type mapping by default.

Configure legacy mapping of Solr types if you created indexes in DataStax Enterprise 3.0.x or earlier. DataStax Enterprise 3.0.x and earlier use the legacy type mapping by default.

Solr Type	Cassandra Validator
TextField	UTF8Type
StrField	UTF8Type
LongField	LongType
IntField	Int32Type
FloatField	FloatType
DoubleField	DoubleType

Solr Type	Cassandra Validator
DateField	UTF8Type
ByteField	BytesType
BinaryField	BytesType
BoolField	UTF8Type
UUIDField	UUIDType
TrieDateField	UTF8Type
TrieDoubleField	UTF8Type
TrieField	UTF8Type
TrieFloatField	UTF8Type
TrieIntField	UTF8Type
TrieLongField	UTF8Type
All Others	UTF8Type

If you use legacy type mappings, the solr schema needs to define the unique key as a string.

Changing Solr Types

Changing a Solr type is rarely if ever done and is not recommended; however, for particular circumstances, such as converting the Solr LongField to TrieLongField, configure the dseTypeMappingVersion using the force option.

Changing a Solr type is rarely if ever done and is not recommended; however, for particular circumstances, such as converting Solr types such as the Solr LongField to TrieLongField, you configure the dseTypeMappingVersion using the force option.

The Cassandra internal validation classes of the types you are converting to and from must be compatible. Also, the actual types you are converting to and from must be valid types. For example, converting a legacy Trie type to a new Trie type is invalid because corresponding Cassandra validators are incompatible. The output of the `CLI` command, `DESCRIBE` keyspace_name, shows the validation classes assigned to columns.

For example, the `org.apache.cassandra.db.marshal.LongType` column validation class is mapped to solr.LongType. You can force this column to be of the TrieLongField type by using force="true" in the `solrconfig.xml`, and then performing a Solr core reload with re-indexing.

```
<dseTypeMappingVersion force = "true">1</dseTypeMappingVersion>
```

Use this option only if you are an expert and have confirmed that the Cassandra internal validation classes of the types involved in the conversion are compatible.

To use DSE Search data from a 3.0 release or earlier, use the legacy type mapping.

Using dynamic fields

Use dynamic fields to index content in fields that are not explicitly defined by the schema and process multiple Solr fields. Use a generic prefix or suffix to reference the field. A common use case for dynamic fields is to identify fields that should not be indexed or to implement a schema-less index.

About this task

Using dynamic fields, you can index content in fields that are not explicitly defined by the schema. Using dynamic fields, you can also process multiple Solr fields the same way. Use a generic prefix or suffix to reference the field. A common use case for dynamic fields is to identify fields that should not be indexed or to implement a schema-less index.

In CQL-based Solr cores, the Solr schema fields that are dynamic and multivalued are not supported.

To use a dynamic field:

- Include a Solr dynamic field in `schema.xml`.

  Name the field using wildcard at the beginning or end of the field. For example, an asterisk prefix or suffix in the field name in the schema designates a dynamic field.

  - dyna_*
  - *_s
- In CQL, to define the map collection column, use the same base name (no asterisk) as you used for the field in the schema.xml.

  For example, use dyna_* in `schema.xml` and dyna_ for the name of the CQL map collection.
- Use type text for the map key. For example:

```
CREATE TABLE my_dynamic_table (
  . . .
  dyna_ map<text, int>,
  . . .
);
```

- Using CQL, insert data into the map using the base name as a prefix or suffix in the first component of each map pair. The format of the map using a prefix is:

  { prefix_literal : literal, *prefix_literal : literal, . . .* }

  For example, the CQL map looks like this:

```
'dyn_' : {dyn_1 : 1, dyn_2 : 2, dyn_3 : 3}
```

  DSE Search maps the Solr dynamic field to a Cassandra map collection column, as shown in the advanced tutorial.

Using copy fields

DSE Search supports the stored=false copy field directive in the `schema.xml` file. Ingested data is copied by the copy field mechanism to the destination field for search, but is not stored in Cassandra.

About this task

DSE Search supports the stored=false copy field directive in the `schema.xml` file. Ingested data is copied by the copy field mechanism to the destination field for search, but is not stored in Cassandra. When you add a new copyField directive to the `schema.xml`, pre-existing and newly ingested data is re-indexed when copied as a result of the new directive.

The Solr stored=true copyField directive is removed. DataStax recommends that you upgrade an existing core by changing the directive and reloading the core as follows:

1. Change the stored attribute value of a copyField directive from true to false in the `schema.xml` file.

2. Post the solrconfig.xml and the modified schema.xml.
3. Reload the Solr core, specifying an in-place re-index.

Old data and Cassandra columns remain intact, but stored copy fields are not applied to new data.

Using a copy field and multivalued field

When you use copy fields to copy multiple values into a field, CQL comes in handy because you do not need to format the data in JSON, for example, when you insert it. Using the Solr HTTP API `update` command, the data must be formatted.

Use the `CQL BATCH` command to insert column values in a single CQL statement to prevent overwriting. This process is consistent with Solr HTTP APIs, where all copied fields need to be present in the inserted document. You need to use BATCH to insert the column values whether or not the values are stored in Cassandra.

Using docValues and copy fields for faceting

Using docValues can improve performance of faceting, grouping, filtering, sorting, and other operations described on the Solr Wiki.

For faceting to use docValues, the schema needs to specify multiValued="true" even if the field is a single-value facet field. The field needs to include docValues="true". You also need to use a field type that supports being counted by Solr. The text type, which tokenizes values, cannot be used, but the string type works fine. DataStax Enterprise supports all aspects of copy fields except:

- The maxChars attribute is not supported.
- Copying from/to the same dynamic field is not supported.

Example: copy fields and docValues

This example uses copy fields to copy various aliases, such as a twitter name and email alias, to a multivalue field. You can then query the multivalue field using any alias as the term to get the other aliases in the same row or rows as the term.

About this task

This example uses copy fields to copy various aliases, such as a twitter name and email alias, to a multivalue field. You can then query the multivalue field using any alias as the term to get the other aliases in the same row or rows as the term.

Step 9 covers how to see information about the per-segment field cache and filter cache. DataStax Enterprise moves the DSE per-segment filter cache off-heap by using native memory, hence reducing on-heap memory consumption and garbage collection overhead. The off-heap filter cache is enabled by default, but can be disabled by passing the following JVM system property at startup time: -Dsolr.offheap.enable=false.

Procedure

1. If you did not already create a directory named `solr_tutorial46` that contains a `schema.xml` and `solrconfig.xml`, do so now. You can use the `schema.xml` and `solrconfig.xml` from the `demos/wikipedia` directory by copying these files to `solr_tutorial46`.
2. Using CQL, create a keyspace and a table to store user names, email addresses, and their skype, twitter, and irc names. The all field will exist in the Solr index only, so you do not need an all column in the table.

```
CREATE KEYSPACE user_info
  WITH REPLICATION = { 'class' : 'SimpleStrategy', 'replication_factor' :
 1 };

CREATE TABLE user_info.users (
  id text PRIMARY KEY,
  name text,
  email text,
  skype text,
  irc text,
  twitter text
) ;
```

3. Run a `CQL BATCH` command, as explained earlier, if the schema includes a multivalue field.

```
BEGIN BATCH
  INSERT INTO user_info.users (id, name, email, skype, irc, twitter)
 VALUES
  ('user1', 'john smith', 'jsmith@abc.com', 'johnsmith', 'smitty',
 '@johnsmith')

  INSERT INTO user_info.users (id, name, email, skype, irc, twitter)
 VALUES
  ('user2', 'elizabeth doe', 'lizzy@swbell.net', 'roadwarriorliz',
 'elizdoe',  '@edoe576')

  INSERT INTO user_info.users (id, name, email, skype, irc, twitter)
 VALUES
  ('user3', 'dan graham', 'etnaboy1@aol.com', 'danielgra', 'dgraham',
 '@dannyboy')

  INSERT INTO user_info.users (id, name, email, skype, irc, twitter)
 VALUES
  ('user4', 'john smith', 'jonsmit@fyc.com', 'johnsmith', 'jsmith345',
 '@johnrsmith')

 INSERT INTO user_info.users (id, name, email, skype, irc, twitter) VALUES
  ('user5', 'john smith', 'jds@adeck.net', 'jdsmith', 'jdansmith',
 '@smithjd999')

 INSERT INTO user_info.users (id, name, email, skype, irc, twitter) VALUES
  ('user6', 'dan graham', 'hacker@legalb.com', 'dangrah', 'dgraham',
 '@graham222')

APPLY BATCH;
```

4. Use a schema that contains the multivalued field--all, copy fields for each alias plus the user id, and a docValues option.

```
<schema name="my_search_demo" version="1.5">
  <types>
    <fieldType name="string" class="solr.StrField"/>
    <fieldType name="text" class="solr.TextField">
      <analyzer>
        <tokenizer class="solr.StandardTokenizerFactory"/>
      </analyzer>
    </fieldType>
  </types>
  <fields>
    <field name="id"  type="string" indexed="true"  stored="true"/>
    <field name="name"  type="string" indexed="true"  stored="true"/>
    <field name="email" type="string" indexed="true" stored="true"/>
    <field name="skype" type="string" indexed="true"  stored="true"/>
    <field name="irc"  type="string" indexed="true"  stored="true"/>
    <field name="twitter" type="string" indexed="true" stored="true"/>
    <field name="all" type="string" docValues="true" indexed="true"
 stored="false" multiValued="true"/>
  </fields>
  <defaultSearchField>name</defaultSearchField>
  <uniqueKey>id</uniqueKey>
```

```
    <copyField source="id" dest="all"/>
    <copyField source="email" dest="all"/>
    <copyField source="skype" dest="all"/>
    <copyField source="irc" dest="all"/>
    <copyField source="twitter" dest="all"/>
  </schema>
```

5. On the command line in the `solr_tutorial46` directory, upload the `schema.xml` and `solrconfig.xml` to Solr. Create the Solr core for the keyspace and table, user_info.users.

```
$ curl http://localhost:8983/solr/resource/user_info.users/solrconfig.xml
  --data-binary @solrconfig.xml -H 'Content-type:text/xml; charset=utf-8'

$ curl http://localhost:8983/solr/resource/user_info.users/schema.xml
  --data-binary @schema.xml -H 'Content-type:text/xml; charset=utf-8'

$ curl "http://localhost:8983/solr/admin/cores?
action=CREATE&name=user_info.users"
```

6. In a browser, search Solr to identify the user, alias, and id of users having an alias smitty.

```
http://localhost:8983/solr/user_info.users/select?q=all
%3Asmitty&wt=xml&indent=true
```

The output is:

```
<result name="response" numFound="1" start="0">
 <doc>
   <str name="id">user1</str>
   <str name="twitter">@johnsmith</str>
   <str name="email">jsmith@abc.com</str>
   <str name="irc">smitty</str>
   <str name="name">john smith</str>
   <str name="skype">johnsmith</str>
 </doc>
</result>
```

7. Run this query:

```
http://localhost:8983/solr/user_info.users/select/?
q=*:*&facet=true&facet.field=name&facet.mincount=1&indent=yes
```

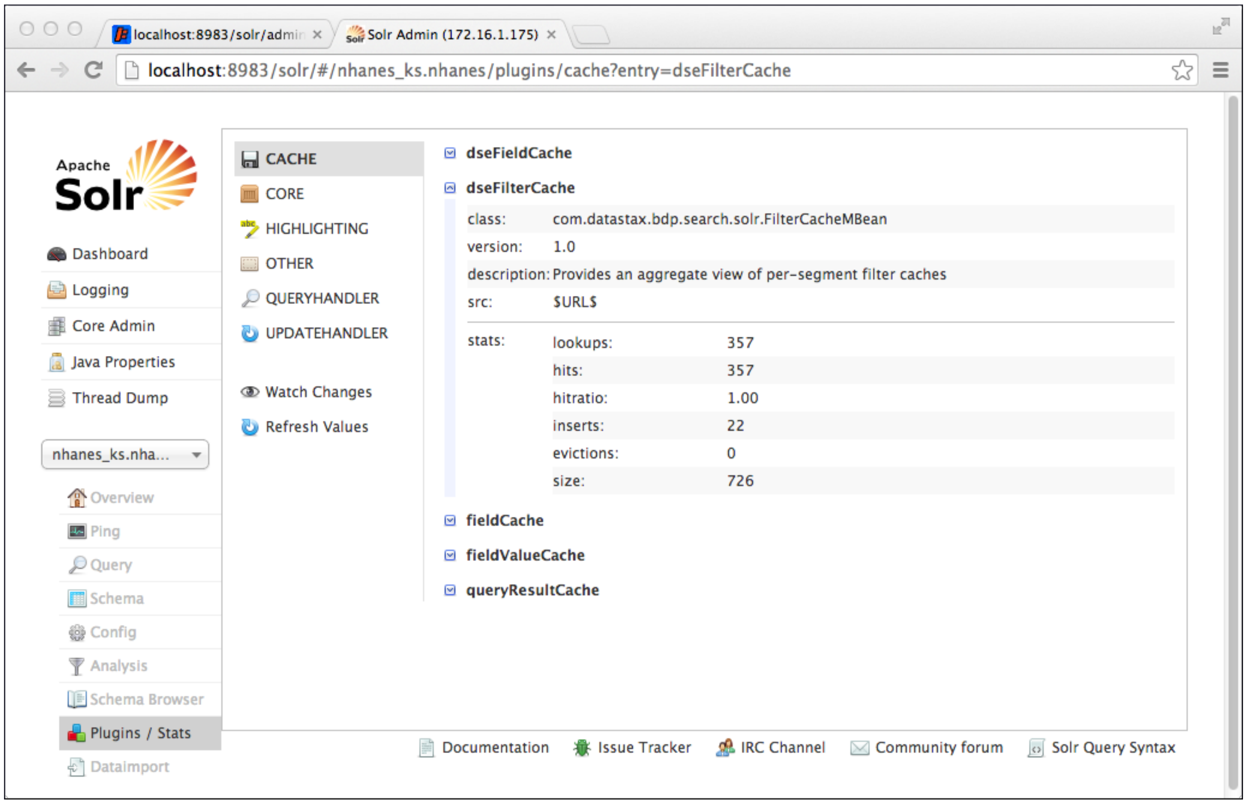
At the bottom of the output, the facet results appear. Three instances of john smith, two instances of dan graham, and one instance of elizabeth doe:

```
. . .
</result>
<lst name="facet_counts">
  <lst name="facet_queries"/>
  <lst name="facet_fields">
    <lst name="name">
      <int name="john smith">3</int>
      <int name="dan graham">2</int>
      <int name="elizabeth doe">1</int>
    </lst>
  </lst>
  . . .
```

8. Now you can view the status of the field cache memory to see the RAM usage of docValues per Solr field. Results look something like the example shown in Example 2.

9. In the Solr Admin, after selecting a Solr core from the drop-down menu, click **Plugins / Stats**. Expand **dseFieldCache** and **dseFilterCache** to see information about the per-segment field cache and filter cache.

   Choose **Watch Changes** or **Refresh Values** to get updated information.



```
class:       com.datastax.bdp.search.solr.FilterCacheMBean
version:     1.0
description: Provides an aggregate view of per-segment filter caches
src:         $URL$

stats:       lookups:     357
             hits:        357
             hitratio:    1.00
             inserts:     22
             evictions:   0
             size:        726
```

Configuring DSE Search

DSE Search configuration includes configurating nodes, search components, threading, global filter cache, indexing, and completing other configuration tasks.

DSE Search configuration includes configurating nodes, search components, threading, global filter cache, indexing, and completing other configuration tasks.

Note: By default, DataStax Enterprise turns off virtual nodes (vnodes). If you use vnodes on DSE Search nodes, DataStax recommends a range of 64 to 256 vnodes, which increases overhead by approximately 30%. If you use virtual nodes on DSE Search nodes, configure vnodes before starting to use DSE Search.

Segregating workloads in a cluster

Organize the nodes that run different workloads into virtual data centers.

About this task

A common question is how to use real-time (Cassandra), integrated Hadoop or Spark/Shark (DSE Analytics), an external Hadoop system, or DSE Search nodes in the same cluster. Within the same data center, attempting to run DSE Search on some nodes and real-time queries, analytics, or external Hadoop on other nodes does not work. The answer is to organize the nodes running different workloads into virtual data centers.

The answer is to organize the nodes running different workloads into virtual data centers.

Replicating data across data centers

You set up replication for DSE Search nodes exactly as you do for other nodes in a Cassandra cluster, by creating a keyspace. You can change the replication of a keyspace after creating it.

Configuring the Solr type mapping version

DSE Search uses Solr type mapping to define how Solr types are mapped to Cassandra Thrift or Cassandra types. DataStax Enterprise 4.7 uses type mapping version 2.

The Solr type mapping version defines how Solr types are mapped to Cassandra Thrift or Cassandra types.

DataStax Enterprise 3.2 and later releases use type mapping version 2. New tables, including those using compact storage, created using CQL 3 require type mapping version 2. CQL 3 is the default mode in Cassandra 2.x, which is based on CQL specification 3.1.0.

Tables that were migrated from previous DataStax Enterprise installations can keep the old mapping versions. Newly created non-CQL 3 tables require type mapping version 1.

During and after upgrades from 3.2.x to 4.x, tables that were created with DataStax Enterprise 3.0.x require type mapping version 0. DataStax Enterprise 3.0 used type mapping version 0, also known as legacy mapping. DataStax Enterprise 3.1 used type mapping version 1.

To change the type mapping, configure dseTypeMappingVersion in the `solrconfig.xml` file:

```
<dseTypeMappingVersion>2</dseTypeMappingVersion>
```

Switching between versions is not recommended after the Solr core has been created successfully: attempting to load a `solrconfig.xml` file with a different dseTypeMappingVersion configuration and reloading the Solr core will cause an error.

Configuring search components

Recommendations for the basic configuration for the Search Handler, and an example that shows adding a search component.

The wikipedia demo `solrconfig.xml` configures the Search Handler as follows:

```
<requestHandler name="search" class="solr.SearchHandler" default="true">
```

DataStax recommends using this basic configuration for the Search Handler.

Configuring additional search components

To configure the search handler for managing additional search components, you generally need to add the additional component to the array of last-components to preserve the default configured components. Distributed search does not work properly if you fail to preserve the default configured components. Unless otherwise specified in Solr documentation, declare the additional component as described in the following example.

How to add a search component

This example shows the configuration of an additional search component for spellchecking and how to add that component to the last-components array of the search handler. The additional component specifies the Java spelling checking package JaSpell:

Component configuration

```
<searchComponent class="solr.SpellCheckComponent" name="suggest_jaspell">
```

```
      <lst name="spellchecker">
        <str name="name">suggest</str>
        <str name="classname">org.apache.solr.spelling.suggest.Suggester</str>
        <str
 name="lookupImpl">org.apache.solr.spelling.suggest.jaspell.JaspellLookup</
str>
        <str name="field">suggest</str>
        <str name="storeDir">suggest</str>
        <str name="buildOnCommit">true</str>
        <float name="threshold">0.0</float>
      </lst>
    </searchComponent>
```

To add the spell check component to the last-components array:

Last-components declaration

```
<requestHandler class="org.apache.solr.handler.component.SearchHandler"
 name="/suggest">
    <lst name="defaults">
      <str name="spellcheck">true</str>
      <str name="spellcheck.dictionary">suggest</str>
      <str name="spellcheck.collate">true</str>
      <str name="spellcheck.extendedResults">true</str>
    </lst>
    <arr name="last-components">
      <str>suggest_jaspell</str>
    </arr>
  </requestHandler>
```

Configuring multithreaded DocValuesFacets

You can set the query executor threads parameter in solrconfig.xml to enable multithreading for filter queries, normal queries, and doc values facets.

You can set the query executor threads parameter in the `solrconfig.xml` file to enable multithreading for filter queries, normal queries, and doc values facets.

```
<queryExecutorThreads>4</queryExecutorThreads>
```

Configuring global filter cache for searching

The DSE Search configurable global filter cache, SolrFilterCache, can reliably bound the filter cache memory usage for a Solr core. This implementation contrasts with the default Solr implementation which defines bounds for filter cache usage per segment.

About this task

The DSE Search configurable global filter cache, SolrFilterCache, can reliably bound the filter cache memory usage for a Solr core. This implementation contrasts with the default Solr implementation which defines bounds for filter cache usage per segment. SolrFilterCache bounding works by evicting cache entries after the configured per core high water mark is reached, and stopping after the configured lower water mark is reached.

Change the filterCache element in the `solrconfig.xml` file to configure the global filter cache thresholds.

Procedure

1. In your `solrconfig.xml` file, set the class attribute of the filterCache element to `solr.search.SolrFilterCache`.

2. To define the low and high watermark for cache eviction, set the lowWaterMarkMB and highWaterMarkMB attributes.

lowWaterMarkMB

The minimum memory use in MB to stop cache eviction.

highWaterMarkMB

The maximum memory use in MB to trigger the cache eviction.

Use the following configuration to set the lower bound cache usage of 128 MB and the upper bound of cache usage of 256 MB:

```
<filterCache
       class="solr.search.SolrFilterCache"
       lowWaterMarkMB="128"
       highWaterMarkMB="256" />
```

Indexing resources

DSE Search allows Cassandra columns to be automatically indexed by Solr through its secondary index API. Indexing DSE Search documents requires resources. You can automatically generate or create custom resources.

DSE Search allows Cassandra columns to be automatically indexed by Solr through its secondary index API. Each insert or update of a Cassandra row triggers a new indexing on DSE Search, inserting or updating the document that corresponds to that Cassandra row. Using CQL, DSE Search supports partial document updates that enable you to modify existing information while maintaining a lower transaction cost.

Indexing DSE Search documents requires these resources:

Schema.xml

Describes the fields to index in Solr and types associated with them. These fields map to Cassandra columns. To route search requests to the appropriate nodes, the schema needs a unique key.

Solrconfig.xml

Holds configuration information for query handlers and Solr-specific caches.

DSE can automatically generate these resources, or you can use custom resources.

Note: When you post schema or configuration files simultaneously, schema disagreements might occur and cause Solr errors. Do not make schema changes on live production systems.

Using automatically generated resources

Use the automated procedure to create resources that are based on a CQL table.

Use the automated procedure for creating resources based on a CQL table. DataStax Enterprise generates `schema.xml` and `solrconfig.xml` resources for a CQL-based core, and then creates the core. You can customize automatic resource generation using a number of options, such as the directory factory used for generating the resource. Use dsetool commands to reload a core or output the resource.

Creating a core with automatic resource generation

An existing CQL table is required to create a core with automatic resource generation. Options are available to generate resources automatically.

The prerequisite for creating a core with automatic resource generation is an existing CQL table. DSE Search automatically generates default `solrconfig.xml` and `schema.xml` files that are based on the table metadata. You can generate resources automatically, using an HTTP POST request or a `dsetool` command and the generateResources option. The following list describes the options for generating resources automatically.

Table 13: Options for generating resources

Option	Settings	Default	Description of Default Setting
coreOptions	path to a YAML file	not applicable	Provides options for generating the solrconfig and schema.
deleteAll=	true or false	false	Setting reindex=true and deleteAll=true re-indexes data in place or re-indexes in full. Accepting the defaults reloads the core and no re-indexing occurs. Setting reindex=true and deleteAll=false re-indexes data and keeps the existing Lucene index. During the uploading process, user searches yield inaccurate results.
distributed=	true or false	true	Distributes an index to nodes in the cluster. False re-indexes the Solr data on one node. The false setting is used in certain recovery and upgrade procedures.
generateResources=	true or false	true	Generates the schema and solrconfig.
recovery=	true or false	false	Used in upgrade situations.
reindex=	true or false	false	Deletes any existing Lucene index and indexes the data for the first time, or re-indexes the data.
rt=	true or false	false	Enables live indexing.
schema=	<path>	n/a	Path of the schema file used for creating the core, not necessary when generateResources=true
solrconfig=	<path>	n/a	Path of the solrconfig file used for creating the core, not necessary when generateResources=true

dsetool syntax

The `dsetool` syntax for generating resources automatically and creating the Solr core is:

```
$ dsetool create_core <keyspace>.<table> [<option> ...]
```

Examples

The following examples show the HTTP POST method and the `dsetool` method (preferred) of automatically generating resources for the nhanes_ks keyspace and nhanes table:

```
$ curl "http://localhost:8983/solr/admin/cores?
action=CREATE&name=nhanes_ks.nhanes&generateResources=true"
```

or

```
$ dsetool create_core nhanes_ks.nhanes generateResources=true
```

By default, when you automatically generate resources, existing data is not re-indexed. DataStax recommends to check and customize the resources prior to indexing.

To override the default and -reindex existing data, use the reindex=true option:

```
$ curl "http://localhost:8983/solr/admin/cores?
action=CREATE&name=nhanes_ks.nhanes&generateResources=true&reindex=true"
```

or

```
$ dsetool create_core nhanes_ks.nhanes generateResources=true reindex=true
```

DataStax Enterprise uses the type mapping that is shown in “Mapping of Solr types” to generate the CQL-based core and resources. To generate resources automatically, the CQL table can consist of keys and columns of any CQL data type, however, decimal and varint are indexed as strings. Lucene does not support the precision required by these numeric types. Range and sorting queries do not work as expected if a table uses these types.

Note: If one or more nodes fail to create the core in distributed operations, an error message indicates a list of the failing node or nodes. Distributed operations fail if the core creation or core reload fails on one of the nodes. To solve the problem, follow the resolution steps in the error message. For example, if a core creation or core reload succeeds in all nodes except one, an error message suggests a core reload to solve the issue. The error message includes a list of the failing nodes.

Customizing automatic resource generation

You can customize solrconfig.xml and schema.xml generation by providing a yaml-formatted file of options.

You can customize `solrconfig.xml` and `schema.xml` generation by providing a yaml-formatted file of options:

auto_soft_commit_max_time

The maximum auto soft commit time in milliseconds.

default_query_field

The schema field to use when no field is specified in queries.

dsetype_mapping_version

The Solr/Cassandra type mapping version.

directory_factory_class

The class name of the directory factory.

enable_string_copy_fields

Specify to enable generation of non-stored string copy fields for non-key text fields. Text data can be tokenized or non tokenized. The enable_string_copy fields is false by default. True creates a non-stored, non-tokenized copy field, so that you can have text both ways.

generate_docvalues_for_fields

Define the fields to automatically configure doc values in the generated schema. Specify '*' to add all possible fields:

```
generate_docvalues_for_fields: '*' ## You can omit this parameter or not
 specify a value
```

or specify a comma-separated list of fields, for example:

```
generate_docvalues_for_fields: uuidfield, bigintfield
```

index_merge_factor

The index merge factor.

index_ram_buffer_size

The index ram buffer size in megabytes.

rt

Enable live indexing to increase indexing throughput.

```
rt=true
```

Example to customize the solrconfig and yaml

For example, create a yaml file that lists options to customize the solrconfig and yaml:

```
default_query_field: name
auto_soft_commit_max_time: 1000
generate_docvalues_for_fields: '*'
enable_string_copy_fields: false
```

Use the `dsetool` command to create the core and customize the solrconfig and schema generation. Use coreOptions to specify the yaml file.

```
$ dsetool create_core nhanes_ks.nhanes generateResources=true
 coreOptions=config.yaml
```

You can verify that DSE Search created the solrconfig and schema by reading core resources using `dsetool`.

Reloading a Solr core using dsetool

After you modify schema.xml or solrconfig.xml, reload a Solr core instead of creating a new one. Do not make schema changes on production systems.

Reload a Solr core instead of creating a new one after you modify the `schema.xml` or `solrconfig.xml`. Do not make schema changes on production systems.

To simplify Solr code reloading, use `dsetool reload_core`. The syntax of the command is:

```
$ dsetool reload_core <keyspace>.<table> [<option> ...]
```

where <option> is one or more of the following options:

Option	Settings	Default	Description of Default Setting
schema=	<path>	n/a	Path of the schema file used for reloading the core
solrconfig=	<path>	n/a	Path of the solrconfig file used for reloading the core
distributed=	true or false	true	Distributes an index to nodes in the cluster. False re-indexes the Solr data on one node. The false setting is used in certain recovery and upgrade procedures.
reindex=	true or false	false	Deletes any existing Lucene index and indexes the data for the first time, or re-indexes the data.
deleteAll=	true or false	false	Setting reindex=true and deleteAll=true re-indexes data in place or re-indexes in full. Accepting the defaults reloads the core and no re-indexing occurs. Setting reindex=true and deleteAll=false re-indexes data and keeps the existing Lucene index. During the uploading process, user searches yield inaccurate results.

None of these options is mandatory. If the solrconfig or schema, or both, are provided, DataStax Enterprise uploads the files before reloading the core. You use these options, described in "Creating a core with automatic resource generation", the same way with the dsetool command or with an HTTP RELOAD request.

When you make a change to the schema, the compatibility of the existing index and the new schema is questionable. If the change to the schema made changes to a field's type, the index and schema will certainly be incompatible. Changes to a field's type can actually occur in subtle ways, occasionally without a change to the `schema.xml` file itself. For example, a change to other configuration files, such as synonyms, can change the schema. If such an incompatibility exists, a full re-index, which includes deleting all the old data, of the Solr data is required. In these cases, anything less than a full re-index renders the schema changes ineffective. Typically, a change to the Solr schema requires a full re-indexing.

Note: If one or more nodes fail to reload the core in distributed operations, an error message indicates a list of the failing node or nodes. Issue the reload again.

Re-indexing in place

Setting `reindex=true` and `deleteAll=false` re-indexes data and keeps the existing lucene index. During the uploading process, user searches yield inaccurate results. To perform an in-place re-index, use this syntax:

```
$ dsetool reload_core keyspace.table reindex=true deleteAll=false
```

Re-indexing in full

Setting `reindex=true` and `deleteAll=true` deletes the Lucene index and re-indexes the dataset. User searches initially return no documents as the Solr cores reload and data is re-indexed.

```
$ dsetool reload_core keyspace.table reindex=true deleteAll=true
```

Verifying indexing status

Use the Solr Admin to check the indexing status.

Reading core resources using dsetool

To simplify accessing the solrconfig and schema, use the dsetool command.

To simplify accessing the solrconfig and schema, use the `dsetool` command. The syntax of these commands is:

```
dsetool get_core_schema <keyspace>.<table> [current=true|false]
dsetool get_core_config <keyspace>.<table> [current=true|false]
```

If the value of the current option is false (the default), DSE Search outputs the last solrconfig or schema file that was uploaded; otherwise, DataStax Enterprise outputs the solrconfig or schema currently in use by the core.

For example, to output the latest uploaded schema, use this command:

```
$ dsetool get_core_schema nhanes_ks.nhanes
```

The generated schema for the nhanes table in the nhanes_ks keyspace appears.

Using custom resources

When you use legacy applications instead of CQL tables, use the classic procedure for creating a Solr core.

Use the classic procedure for creating a Solr core when you use legacy applications instead of CQL tables, or when you modify or create custom resources. Using HTTP-post methods available in previous releases, you can create or reload a Solr core.

Uploading the schema and configuration

Create a Solr index by posting solrconfig.xml and schema.xml to a DSE Search node in the DataStax Enterprise cluster.

About this task

After writing a schema.xml, you HTTP-post `solrconfig.xml` and `schema.xml` to a DSE Search node in the DataStax Enterprise cluster to create a Solr index.

Procedure

1. Post the configuration file using the curl command line tool:

   ```
   curl http://localhost:8983/solr/resource/keyspace.table/solrconfig.xml
     --data-binary @solrconfig.xml -H 'Content-type:text/xml; charset=utf-8'
   ```

2. Post the schema file:

   ```
   curl http://localhost:8983/solr/resource/keyspace.table/schema.xml
     --data-binary @schema.xml -H 'Content-type:text/xml; charset=utf-8'
   ```

Creating a Solr core

Creating a Solr core on one node automatically creates the core on other DSE Search nodes, and DSE Search stores the files on all the Cassandra nodes. Use the `curl` command to create a Solr core.

About this task

You cannot create a Solr core unless you first upload the schema and configuration files. If you are creating a CQL-based Solr core, the table must exist in Cassandra before creating the core.

Use the `curl` command to create a Solr core.

```
$ curl "http://localhost:8983/solr/admin/cores?
action=CREATE&name=keyspace.table"
```

Creating a Solr core on one node automatically creates the core on other DSE Search nodes, and DSE Search stores the files on all the Cassandra nodes.

Note: If one or more nodes fail to create the core in distributed operations, an error message indicates a list of the failing node or nodes. If it failed to create the core immediately, issue the create again. If it failed to create on some nodes, issue a reload for those nodes to load the newly created core.

By default, the cassandra user has full permissions on all keyspaces. If you specify a non-default user to create a Solr core, the specified user must have the necessary Cassandra permissions. When specifying a user to create a Solr core, ensure that the user has either:

- CREATE permission on all keyspaces
- All permissions on all keyspaces (superuser)

Reloading a Solr core using dsetool

After you modify schema.xml or solrconfig.xml, reload a Solr core instead of creating a new one. Do not make schema changes on production systems.

Reload a Solr core instead of creating a new one after you modify the `schema.xml` or `solrconfig.xml`. Do not make schema changes on production systems.

To simplify Solr code reloading, use `dsetool reload_core`. The syntax of the command is:

```
$ dsetool reload_core <keyspace>.<table> [<option> ...]
```

where <option> is one or more of the following options:

Option	Settings	Default	Description of Default Setting
schema=	<path>	n/a	Path of the schema file used for reloading the core
solrconfig=	<path>	n/a	Path of the solrconfig file used for reloading the core
distributed=	true or false	true	Distributes an index to nodes in the cluster. False re-indexes the Solr data on one node. The false setting is used in certain recovery and upgrade procedures.
reindex=	true or false	false	Deletes any existing Lucene index and indexes the data for the first time, or re-indexes the data.
deleteAll=	true or false	false	Setting reindex=true and deleteAll=true re-indexes data in place or re-indexes in full. Accepting the defaults reloads the core and no re-indexing occurs. Setting reindex=true and deleteAll=false re-indexes data and keeps the existing Lucene index. During the uploading process, user searches yield inaccurate results.

None of these options is mandatory. If the solrconfig or schema, or both, are provided, DataStax Enterprise uploads the files before reloading the core. You use these options, described in "Creating a core with automatic resource generation", the same way with the dsetool command or with an HTTP RELOAD request.

When you make a change to the schema, the compatibility of the existing index and the new schema is questionable. If the change to the schema made changes to a field's type, the index and schema will certainly be incompatible. Changes to a field's type can actually occur in subtle ways, occasionally without a change to the `schema.xml` file itself. For example, a change to other configuration files, such as synonyms, can change the schema. If such an incompatibility exists, a full re-index, which includes deleting all the old data, of the Solr data is required. In these cases, anything less than a full re-index renders the schema changes ineffective. Typically, a change to the Solr schema requires a full re-indexing.

Note: If one or more nodes fail to reload the core in distributed operations, an error message indicates a list of the failing node or nodes. Issue the reload again.

Re-indexing in place

Setting `reindex=true` and `deleteAll=false` re-indexes data and keeps the existing lucene index. During the uploading process, user searches yield inaccurate results. To perform an in-place re-index, use this syntax:

```
$ dsetool reload_core keyspace.table reindex=true deleteAll=false
```

Re-indexing in full

Setting `reindex=true` and `deleteAll=true` deletes the Lucene index and re-indexes the dataset. User searches initially return no documents as the Solr cores reload and data is re-indexed.

```
$ dsetool reload_core keyspace.table reindex=true deleteAll=true
```

Verifying indexing status

Use the Solr Admin to check the indexing status.

Increasing indexing throughput

Live indexing enables queries to be made against recently indexed data. Live indexing improves index throughput and reduces Lucene reader latency while supporting all Solr functionality.

About this task

Live indexing enables queries to be made against recently indexed data. Live indexing improves index throughput and reduces Lucene reader latency while supporting all Solr functionality. Live indexing works for all DSE Search applications. Fields that are sorted on must be docvalues, otherwise the field cache is used and is inefficient with live indexing.

The location of the dse.yaml file depends on the type of installation:

Installer-Services	`/etc/dse/dse.yaml`
Package installations	`/etc/dse/dse.yaml`
Installer-No Services	*`install_location`*`/resources/dse/conf/dse.yaml`
Tarball installations	*`install_location`*`/resources/dse/conf/dse.yaml`

Procedure

1. To enable the live indexing property, increase the RAM buffer size, and ensure that the autoSoftCommit time is 1000ms, edit the `solrconfig.xml` file:

   ```
   <rt>true</rt>
   <ramBufferSizeMB>2000</ramBufferSizeMB>
   ...
   <autoSoftCommit>
       <maxTime>1000</maxTime>
   </autoSoftCommit>
   ```

   The larger RAM buffer enables faster indexing.
2. Increase the heap size. For live indexing, DataStax recommends a heap size of at least 20 GB.
3. Set the value of the max_solr_concurrency_per_core in the dse.yaml file. DataStax recommends using the actual number of available CPU cores.
4. Restart DSE to use live indexing with the increased heap size.
5. Optional: To filter a given range query:

   ```
   _query_:"{!rtrange}tint:[0 TO 5}" OR _query_:"{!rtrange}tint:[-10 TO -5}"
   ```

Configuring the Solr library path

Workaround for DSE Search failure to find files in directories that are defined by the <lib> property.

Contrary to the examples shown in the `solrconfig.xml` file that indicate support for relative paths, DataStax Enterprise does not support the relative path values that are set for the <lib> property. DSE Search fails to find files in directories that are defined by the <lib> property. The workaround is to place custom code or Solr contrib modules in the Solr library directories.

The default Solr library path location depends on the type of installation:

Installer-Services	`/usr/share/dse/resources/solr/lib`
Package installations	`/usr/share/dse/solr/lib`
Installer-No Services and Tarball installations	*`install_location`*`/resources/solr/lib`

Configuring the Data Import Handler

You can import data into DSE Search from data sources, such as XML and RDBMS. The configuration-driven method to import data differs from the method that is used by open source Solr.

About this task

You can import data into DSE Search from data sources, such as XML and RDBMS. The configuration-driven method to import data differs from the method that is used by open source Solr. Requirements for using the Data Import Handler in DSE Search are:

- A JDBC driver, the JDBC connection URL format, and driver class name for accessing the data source for the data to be imported
- Credentials for accessing the data to be imported

Procedure

1. Put the driver in the DSE Search location and add the path to the driver to your PATH environment variable.

   The default location of the Solr driver depends on the type of installation:

Installer-Services and Package installations	`/usr/share/dse/solr`
Installer-No Services and Tarball installations	*`install_location`*`/resources/dse/lib`

2. Create a file named `dataimport.properties` that contains the following settings, modified for your environment. Comment, uncomment, or edit the self-descriptive settings. The URL params section refers to a mandatory suffix for the Solr HTTP API `dataimport` command.

```
#  to sync or not to sync
#  1 - active; anything else - inactive
syncEnabled=1

#  which cores to schedule
#  in a multi-core environment you can decide which cores you want
 synchronized
#  leave empty or comment it out if using single-core deployment
#syncCores=coreHr,coreEn

#  solr server name or IP address
#  [defaults to localhost if empty]
server=localhost

#  solr server port
#  [defaults to 80 if empty]
port=8983

#  application name/context
#  [defaults to current ServletContextListener's context (app) name]
webapp=solrTest_WEB

#  URL params [mandatory]
#  remainder of URL
params=/select?qt=/dataimport&command=delta-import&clean=false
#  schedule interval
#  number of minutes between two runs
#  [defaults to 30 if empty]
interval=10
```

3. Save the `dataimport.properties` file.

   The file location depends on the type of installation:

Installer-No Services and Tarball installations	*`install_location`*`/resources/solr/conf`
Package installations	`/etc/dse/cassandra/`
Installer-Services	`/usr/share/dse/resources/solr/conf`

4. Create a Solr schema to represent the data in Solr. For example:

```
 <?xml version="1.0" encoding="UTF-8" ?>
<schema name="my_imported_data" version="1.0">
 <types>
    <fieldType name="text" class="solr.TextField">
      <analyzer>
      <tokenizer class="solr.StandardTokenizerFactory"/>
      </analyzer>
    </fieldType>
    <fieldType name="float" class="solr.FloatField" multiValued="false"/>
    <fieldType name="int" class="solr.IntField" multiValued="false"/>
 </types>
 <fields>
    <field name="mytable_key" type="int" indexed="true" stored="true"/>
    <field name="myfield" type="int" indexed="true" stored="true"/>
    . . .
  </fields>
  <uniqueKey>mytable_key</uniqueKey>
</schema>
```

5. Create a file named `data-config.xml` that maps the data to be imported to the Cassandra table that is created automatically. For example:

```
<dataConfig>
  <propertyWriter dateFormat="yyyy-MM-dd HH:mm:ss" type=
    "SimplePropertiesWriter" directory=
    "<install_location>/resources/solr/conf/" filename=
    "dataimport.properties"  />
<dataSource driver="org.mysql.jdbc.Driver" url=
  "jdbc:mysql://localhost/mydb" user=
  "changeme" password="changeme" />
  <document name="test">
    <entity name="cf" query="select * from mytable">
      <field column="mytable_key" name="mytable_key" />
      <field column="myfield" name="myfield" />
      . . .
    </entity>
  </document>
</dataConfig>
```

6. Create a directory in the DataStax Enterprise installation home directory. Save the `data-config.xml` in the directory that you created.
7. Copy the `solrconfig.xml` file from the `demos/wikipedia` directory.

   The default wikipedia demo location depends on the type of installation:

Installer-No Services and Tarball installations	`*install_location*/demos/wikipedia`
Installer-Services and Package installations	`/usr/share/dse/demos/wikipedia`

8. Paste the `solrconfig.xml` file to the directory that you created in step 6.
9. Add a requestHandler element to the `solrconfig.xml` file that contains the location of `data-config.xml` and data source connection information. For example:

```
<requestHandler name="/dataimport"
 class="org.apache.solr.handler.dataimport.DataImportHandler">
  <lst name="defaults">
     <str name="config">data-config.xml</str>
     <lst name="datasource">
        <str name="driver">com.mysql.jdbc.Driver</str>
        <str name="url">jdbc:mysql://localhost/mydb</str>
        <str name="user">changeme</str>
        <str name="password">changeme</str>
     </lst>
  </lst>
</requestHandler>
```

10. Upload the `solrconfig.xml`, `schema.xml`, and `data-config.xml`, and create the Solr core. For example:

```
$ curl http://localhost:8983/solr/resource/mydb.mytable/solrconfig.xml --
data-binary @solrconfig.xml -H 'Content-type:text/xml; charset=utf-8'

$ curl http://localhost:8983/solr/resource/mydb.mytable/schema.xml --data-
binary @schema.xml -H 'Content-type:text/xml; charset=utf-8'
```

```
$ curl http://localhost:8983/solr/resource/mydb.mytable/data-config.xml --
data-binary @data-config.xml -H 'Content-type:text/xml; charset=utf-8'

$ curl "http://localhost:8983/solr/admin/cores?
action=CREATE&name=mydb.mytable"
```

11. Import the data from the data source using HTTP API syntax. For example:

```
http://localhost:8983/solr/mydb.mytable/dataimport?command=full-import
```

where mydb is the Cassandra keyspace and mytable is the Cassandra table.

Limiting columns indexed and returned by a query

When using dynamic fields, the default column limit controls the maximum number of indexed columns overall, not just dynamic field columns, in legacy (Thrift) tables. The column limit for legacy tables also controls the maximum number of columns returned during queries.

When using dynamic fields, the default column limit controls the maximum number of indexed columns overall, not just dynamic field columns, in legacy (Thrift) tables. The column limit for legacy tables also controls the maximum number of columns returned during queries. This column limit prevents out of memory errors caused by using too many dynamic fields. If dynamic fields are not used, the column limit has no effect.

DataStax Enterprise 4.0 and later supports CQL tables. When using dynamic fields in these releases, the default column limit applies only if the table is created using the deprecated method of automatically creating a table on core creation or creating a compact storage table.

To change the default column limit, which is 1024, configure the dseColumnLimit element in the `solrconfig.xml` file. You can override the default configuration using the column.limit parameter in a query to specify a different value, for example 2048.

```
http://localhost:8983/solr/keyspace.table/select?q=
  title%3Amytitle*&fl=title&column.limit=2048
```

Configuring autocomplete/spellcheck

The default solrconfig.xml does not include configuration for the Solr suggestor. To specify the autocomplete/spellcheck behavior, issue a query using the shards.qt= parameter

By default, the `solrconfig.xml` does not include configuration for the Solr suggestor. After configuring the search component in the `solrconfig.xml` for /suggest, you can issue a query specifying the autocomplete/spellcheck behavior using the shards.qt= parameter. For example, to test the suggestor:

```
curl "http://localhost:8983/solr/mykeyspace.mysolr/select?shards.qt=/
suggest&qt=/suggest&q=testin"
```

Changing maxBooleanClauses

The maxBooleanClauses parameter defines the maximum number of clauses in a boolean query. If you change the maxBooleanClauses parameter in `solrconfig.xml`, restart the nodes to make the change effective.

About this task

The maxBooleanClauses parameter defines the maximum number of clauses in a boolean query. An exception is thrown if this value is exceeded. If you change the maxBooleanClauses parameter in `solrconfig.xml`, restart the nodes to make the change effective. Reloading the Solr cores does not make this change effective.

Operations

You can run DSE Search on one or more nodes. Typical operations including configuration of nodes, policies, query routing, balancing loads, and communications.

About this task

You can run Solr on one or more nodes. DataStax does not support running Solr and Hadoop on the same node, although it's possible to do so in a development environment. In production environments, separate workloads by running real-time (Cassandra), analytics (Hadoop), or DSE Search (Solr) nodes on separate nodes and in separate data centers.

Adding, decommissioning, repairing a DSE search node

Steps to add, decommission nodes, and repair DSE search nodes.

About this task

To add, decommission, or repair a DSE Search node, use the same methods as you would for a Cassandra node.

Procedure

- To increase the number of DSE Search nodes in a data center, add a search node to the cluster, and then use OpsCenter to rebalance the cluster.

  The default DSESimpleSnitch automatically puts the DSE Search nodes in the same data center.
- To repair a DSE Search node, see Repairing nodes in the Cassandra documentation.

  DataStax recommends using the subrange repair method.
- To decommission a DSE Search node, see Removing a node in the Cassandra documentation.

Enabling the disk failure policy

Configure DSE Search to respond to an I/O exception during any index update by enabling the indexing disk failure policy.

You can configure DSE Search to respond to an I/O exception during any index update by enabling the indexing disk failure policy. When enabled, DSE Search uses the configured Cassandra disk failure policy, which by default shuts down gossip and other processes, rendering the node dead. When disabled, DSE Search ignores the Cassandra disk failure policy. The node does not shut down.

1. Open the dse.yaml file for editing.
2. Locate the following section:

```
# Applies the configured Cassandra disk failure policy to index write
 failures.
# Default is disabled (false).
#
# enable_index_disk_failure_policy: false
```

3. Uncomment the last line and change false to true:

```
enable_index_disk_failure_policy: true
```

Restricted query routing

For expert users only, restricted query routing supports restricting common queries to a single partition.

DSE Search restricted query routing is designed for applications that have a data model that supports restricting common queries to a single partition. This feature is for use by experts and should be used with care. You can restrict queries based on a list of partition keys to a limited number of nodes. You can also restrict queries based on a single token range. Use token range routing only if you thoroughly understand cluster token placement.

Partition key routing

To specify routing by partition keys, use the route.partition query parameter and set its value to one or more partition keys. DSE Search queries only the nodes that own the given partition keys. The vertical line delimiter separates components of a composite key. The comma delimiter separates different partition keys.

For example:

```
route.partition=k1c1|k1c2,k2c1|k2c2 . . .
```

If the actual partition key value contains a delimiter character, use a backslash character to escape the delimiter.

Examples

You can route Solr HTTP API and Solr CQL queries. This example shows how to use the route queries on a table with a composite partition key, where "nike" and "2" are composite key parts.

```
http://localhost:8983/solr/test.route/select?
q=*:*&indent=true&shards.info=true&route.partition=nike|2,reebok|2
```

Or, in CQL:

```
SELECT * FROM test.route WHERE solr_query='{"q" : "*:*", "route.partition" :
 ["nike|2","reebok|2"]}'
```

Token range routing

For simplicity, routing queries by partition range is recommended over routing by token range. To specify routing by token range, use the route.range query parameter and set its value to the two token values that represent the range, separated by comma:

For example:

```
route.range=t1,t2
```

DSE Search queries only the nodes in the given token range.

Shuffling shards to balance the load

Several shard shuffle strategies are available to balance the load and minimize data that is transferred from non-local nodes.

DataStax Enterprise uses a shuffling technique to balance the load, and also attempts to minimize the number of shards that are queried as well as the amount of data that is transferred from non-local nodes.

To balance the load in a distributed environment, choose from several strategies for shuffling the shards. The shard shuffling strategy specifies how one node is selected over others for reading the Solr data. The value of the shard.shuffling.strategy parameter must be one of the following values:

- host

  Shards are selected based on the host that received the query.
- query

  Shards are selected based on the query string.
- host_query

  Shards are selected by host x query.

- random

  Different random set of shards are selected with each request (default).
- SEED

  Selects the same shard from one query to another.

Methods for selecting shard shuffling strategy

- Append `shard.shuffling.strategy = <strategy>` to the HTTP API query. For example:

  ```
  http://localhost:8983/solr/wiki.solr/select?
  q=title:natio*&shard.shuffling.strategy=host
  ```

  Issuing this query determines the shard shuffling strategy for this query only.
- Create a `dse-search.properties` file and POST it to Solr.

  For example:

  1. Create the `dse-search.properties` file with the following contents:

     ```
     shard.shuffling.strategy=query
     ```
  2. Post the command to DSE Search. For example:

     ```
     curl -v --data-binary @dse-search.properties
         http://localhost:8983/solr/resource/wiki.solr/dse-search.properties
     ```

     Posting the command determines the shard shuffling strategy for all queries to the given Solr core. The strategy is propagated to all nodes and saved in Solr core metadata.
- Set the following parameters to use the SEED strategy:

  1. Pass the `shard.shuffling.strategy=SEED` as a request parameter.
  2. Specify a request parameter, such as an IP address or any string, using the `shard.shuffling.seed` parameter. When you reuse the same seed value between queries on a stable cluster, the same shard strategy will be in effect.

     Every time you pass the same string, the same list of shards is queried, regardless of the target node you actually query; if you change the string, a different list of shards are queried.
  3. Verify that the strategy was maintained by passing the `shards.info=true request` parameter. For example:

     ```
     curl "http://localhost:8983/solr/demo.solr/select/?
     q=text:search&shards.info=true&shard.shuffling.strategy=SEED&shard.shuffling.seed=1
     ```

Shuffling does not always result in the node selection you might expect. For example, using a replication factor of 3 with six nodes, the best and only solution is a two-shard solution where half of the data is read from the originator node and half from another node. A three-shard solution would be inefficient.

Managing the location of Solr data

Manage where the Solr data files are saved on the server.

About this task

Data that is added to a DSE Search node is locally indexed in the Cassandra node. Data changes to one node also apply to the other node. Like Cassandra data files, DSE Search has its own indexing files. You can control where the Search indexing data files are saved on the server. By default, the Solr data is saved in *cassandra_data_dir*/`solr.data`, or as specified by the dse.solr.data.dir system property.

Procedure

1. Shut down the search node.
2. Move the `solr.data` directory to the new location.
3. Specify the location:

Option	Description

From the command line	`$ cd install_location`
	`$ bin/dse cassandra -s -Ddse.solr.data.dir=/solr_data_dir`

In dse.yaml	`solr_data_dir: solr_data_dir`

   The location of the dse.yaml file depends on the type of installation:

Installer-Services	`/etc/dse/dse.yaml`
Package installations	`/etc/dse/dse.yaml`
Installer-No Services	*`install_location`*`/resources/dse/conf/dse.yaml`
Tarball installations	*`install_location`*`/resources/dse/conf/dse.yaml`

4. Start the node.

Results

The location change is permanent when set in `dse.yaml`. The command-line argument must be used consistently or DSE reverts to the default data directory.

Changing the Solr connector port

The http.port setting in the catalina.properties file configures the Solr port.

To change the Solr port from the default, 8983, change the http.port setting in the `catalina.properties` file that is installed with DSE in *`install_location`*`/tomcat/conf`, usually `/usr/share/dse/tomcat/conf/catalina.properties`.

Deleting Solr data

To delete a Cassandra table and its data, including the data indexed in Solr, from a DSE Search node, drop the table using CQL.

About this task

To delete a Cassandra table and its data, including the data indexed in Solr, from a DSE Search node, drop the table using CQL. The following example assumes that you ran the example of using a collection set. List the Solr files on the file system, drop the table named mysolr that the demo created, and then verify that the files are deleted from the file system:

Wait until you finish working through all the examples before you delete the example data.

Procedure

1. List the Solr data files on the file system.

- Installer-Services and Package installations:

  ```
  ls /usr/local/var/lib/dse/data/solr.data/mykeyspace.mysolr/index/
  ```
- Installer-No Services and Tarball installations:

  ```
  ls /var/lib/cassandra/data/solr.data/mykeyspace.mysolr/index
  ```

The output looks something like this:

```
_33.fdt      _35_nrm.cfe   _38_Lucene40_0.tim
_33.fdx      _35_nrm.cfs   _38_Lucene40_0.tip
_33.fnm      _36.fdt     _38_nrm.cfe
. . .
```

2. Launch cqlsh and execute the CQL command to drop the table named solr.

   ```
   DROP TABLE mykeyspace.mysolr;
   ```
3. Exit cqlsh and verify that the files are deleted from the file system. For example:

   ```
   ls /var/lib/cassandra/data/solr.data/mykeyspace.mysolr/index
   ```

   The output is:

   ```
   ls: /var/lib/cassandra/data/solr.data/mykeyspace.mysolr/index: No such
    file or directory
   ```

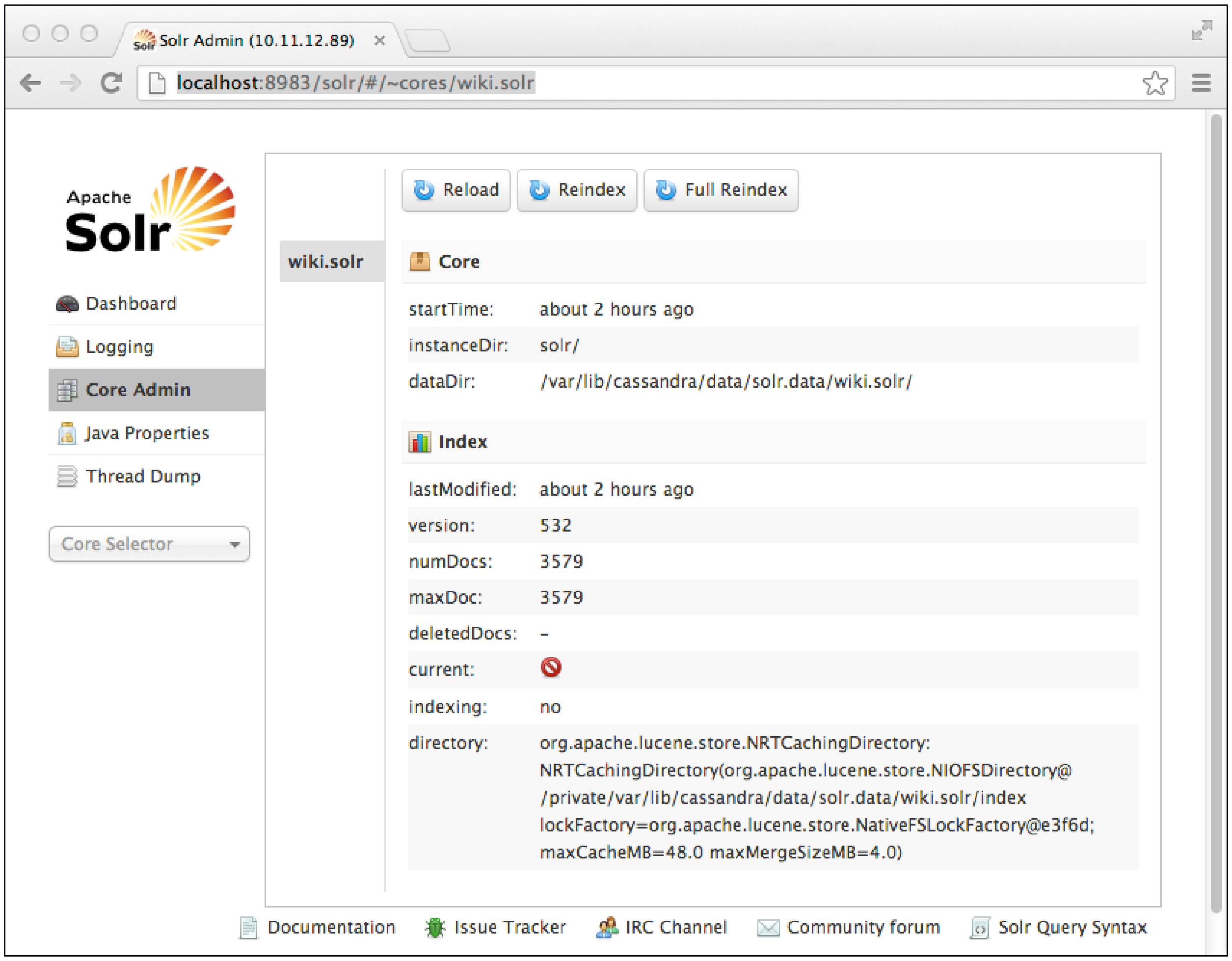
Viewing the Solr core status

Use the Solr API to view the status of the Solr core.

About this task

You can use the Solr API to view the status of the Solr core. For example, to view the status of the wiki.solr core after running the wikipedia demo, use this URL:

```
http://localhost:8983/solr/#/~cores/wiki.solr
```



```
startTime:      about 2 hours ago
instanceDir:    solr/
dataDir:        /var/lib/cassandra/data/solr.data/wiki.solr/

lastModified:   about 2 hours ago
version:        532
numDocs:        3579
maxDoc:         3579
deletedDocs:    -
current:        🚫
indexing:       no
directory:      org.apache.lucene.store.NRTCachingDirectory:
                NRTCachingDirectory(org.apache.lucene.store.NIOFSDirectory@
                /private/var/lib/cassandra/data/solr.data/wiki.solr/index
                lockFactory=org.apache.lucene.store.NativeFSLockFactory@e3f6d;
                maxCacheMB=48.0 maxMergeSizeMB=4.0)
```

Status of all Solr cores

To view the status of all Solr cores:

```
http://localhost:8983/solr/admin/cores?action=STATUS
```

For example, the status of the wiki.solr core looks like this:

```
{
    "defaultCoreName":"default.1371321667755813000",
    "initFailures":{},
    "status":{
      "wiki.solr":{
        "name":"wiki.solr",
        "isDefaultCore":false,
        "instanceDir":"solr/",
        "dataDir":"/var/lib/cassandra/data/solr.data/wiki.solr/",
        "config":"solrconfig.xml",
        "schema":"schema.xml",
        "startTime":"2013-06-16T21:05:54.894Z",
        "uptime":7212565,
        "index":{
          "numDocs":3579,
          "maxDoc":3579,
          "deletedDocs":0,
          "version":532,
          "segmentCount":15,
          "current":false,
          "hasDeletions":false,
          "directory":"org.apache.lucene.store.
            NRTCachingDirectory:NRTCachingDirectory
          (org.apache.lucene.store.NIOFSDirectory
          @/private/var/lib/cassandra/data/solr.data/wiki.solr/index
lockFactory=
          org.apache.lucene.store.NativeFSLockFactory@e3f6d;
            maxCacheMB=48.0 maxMergeSizeMB=4.0)",
          "userData":{"commitTimeMSec":"1371416801053"},
          "lastModified":"2013-06-16T21:06:41.053Z",
          "sizeInBytes":8429726,
          "size":"8.04 MB"},
        "indexing":false}}}
```

Solr log messages

DSE Search logs Solr errors, warnings, debug, trace, and info messages in the Cassandra system log.

DSE Search logs Solr errors, warnings, debug, trace, and info messages in the Cassandra system log:

```
/var/log/cassandra/system.log
```

Changing the Solr logging level

You can control the granularity of Solr log messages, and other log messages, in the Cassandra `system.log` file by configuring the logback.xml file.

The location of the `logback.xml` file depends on the type of installation:

Installer-Services and Package installations	`/etc/dse/cassandra/conf/logback.xml`
Installer-No Services and Tarball installations	`*install_location*/resources/cassandra/conf/logback.xml`

To set log levels, specify one of these values:

- All - turn on all logging
- OFF - no logging
- FATAL - severe errors causing premature termination
- ERROR - other runtime errors or unexpected conditions
- WARN - use of deprecated APIs, poor use of API, near errors, and other undesirable or unexpected runtime situations
- DEBUG - detailed information on the flow through the system
- TRACE - more detailed than DEBUG
- INFO - highlight the progress of the application at a coarse-grained level

Accessing the validation log

DSE Search stores validation errors that arise from non-indexable data that is sent from nodes other than DSE Search nodes:

```
/var/log/cassandra/solrvalidation.log
```

For example, if a Cassandra node that is not running DSE Search puts a string in a date field, an exception is logged for that column when the data is replicated to the Solr node.

Securing a DSE Search cluster

DSE Search data is completely or partially secured by using DataStax Enterprise security features.

DataStax Enterprise supports secure enterprise search using Apache Solr 4.6 and Lucene. The security table summarizes the security features of DSE Search and other integrated components. DSE Search data is completely or partially secured by using DataStax Enterprise security features:

- Object permission management

  Access to Solr documents, excluding cached data, can be limited to users who have been granted access permissions. Permission management also secures tables used to store Solr data.
- Transparent data encryption

  Data at rest in Cassandra tables, excluding cached and Solr-indexed data, can be encrypted. Encryption occurs on the Cassandra side and impacts performance slightly.
- Client-to-node encryption

  You can encrypt HTTP access to Solr data and internal, node-to-node Solr communication using SSL. Enable SSL node-to-node encryption on the DSE Search node by setting encryption options in the dse.yaml file as described in Client-to-node encryption.
- Kerberos authentication

  You can authenticate DSE Search users through Kerberos authentication using Simple and Protected GSSAPI Negotiation Mechanism (SPNEGO). To use the SolrJ API against DSE Search clusters with Kerberos authentication, client applications should use the SolrJ-Auth library and the DataStax Enterprise SolrJ component as described in the solrj-auth-README.md file.

You can also use HTTP Basic Authentication, but this is not recommended.

HTTP Basic Authentication

When you enable Cassandra's internal authentication by specifying `authenticator: org.apache.cassandra.auth.PasswordAuthenticator` in `cassandra.yaml`, clients must use HTTP Basic Authentication to provide credentials to Solr services. Due to the stateless nature of HTTP Basic Authentication, this can have a significant performance impact as the authentication process must be executed on each HTTP request. For this reason, DataStax does not recommend using internal authentication on DSE Search clusters in production. To secure DSE Search in production, enable DataStax Enterprise Kerberos authentication.

To configure DSE Search to use Cassandra's internal authentication, follow this configuration procedure:

The location of the cassandra.yaml file depends on the type of installation:

Package installations	`/etc/cassandra/cassandra.yaml`
Tarball installations	`*install_location*/resources/cassandra/conf/cassandra.yaml`

The location of the dse.yaml file depends on the type of installation:

Installer-Services	`/etc/dse/dse.yaml`
Package installations	`/etc/dse/dse.yaml`
Installer-No Services	`*install_location*/resources/dse/conf/dse.yaml`
Tarball installations	`*install_location*/resources/dse/conf/dse.yaml`

1. Comment AllowAllAuthenticator and uncomment the PasswordAuthenticator in cassandra.yaml to enable HTTP Basic authentication for Solr.

   ```
   #authenticator: org.apache.cassandra.auth.AllowAllAuthenticator
   authenticator: org.apache.cassandra.auth.PasswordAuthenticator
   #authenticator: com.datastax.bdp.cassandra.auth.PasswordAuthenticator
   #authenticator: com.datastax.bdp.cassandra.auth.KerberosAuthenticator
   ```
2. Configure the replication strategy for the system_auth keyspace.
3. Start the server.
4. Open a browser, and go to the service web page. For example, assuming you ran the Wikipedia demo, go to `http://localhost:8983/demos/wikipedia/`.

   The browser asks you for a Cassandra username and password.

Adding and viewing index resources

DSE Search includes a REST API for viewing and adding resources that are associated with an index.

DSE Search includes a REST API for viewing and adding resources that are associated with an index. You can look at the contents of the existing Solr resource by loading its URL in a web browser or using HTTP `get`. Retrieving and viewing resources returns the last uploaded resource, even if the resource is not the one currently in use.

Use this URL to post a file to Solr:

```
http://host:port/solr/resource/keyspace.table/filename.ext
```

If you upload a new schema, and then request the schema resource before reloading, Solr returns the new schema even though the Solr core continues to use the old schema.

Generally, you can post any resource that is required by Solr to this URL. For example, `stopwords.txt` and `elevate.xml` are optional, frequently-used Solr configuration files that you post using this URL.

Checking indexing status

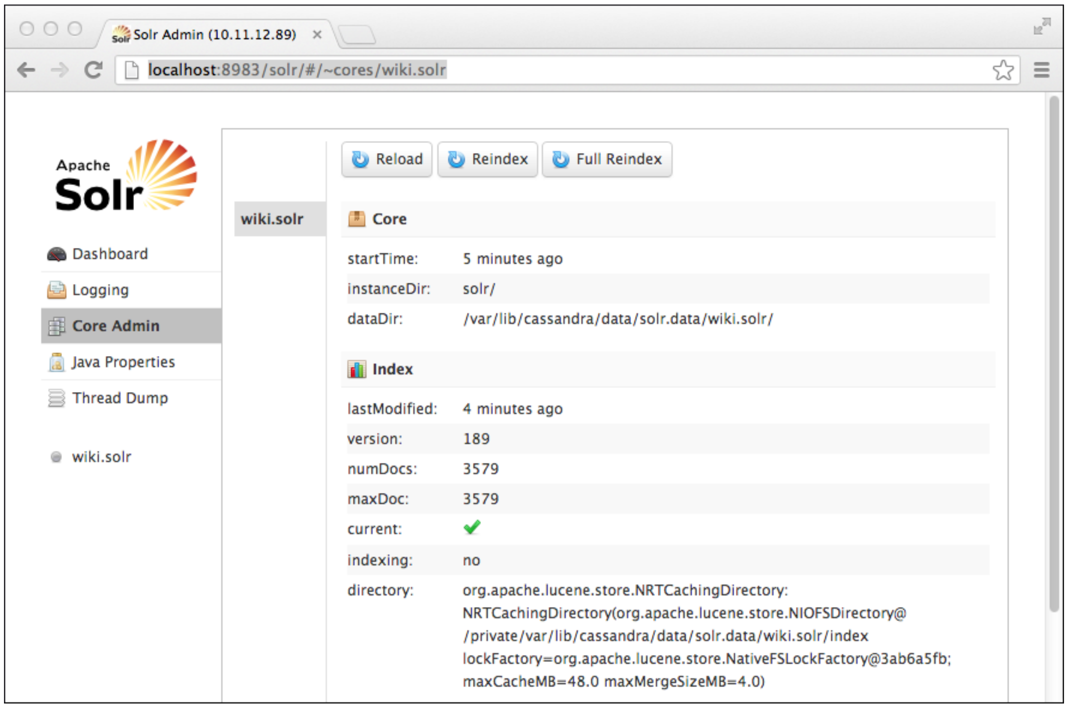
You can check the indexing status using either the Core Admin or the logs.

You can check the indexing status using either the Core Admin or the logs.

If you use HTTP to post the files to a pre-existing table, DSE Search starts indexing the data. If you use HTTP to post the files to a non-existent column keyspace or table, DSE Search creates the keyspace and table, and then starts indexing the data. For example, you can change the `stopwords.txt` file, repost the schema, and the index updates.

Checking the indexing status using the Core Admin

To check the indexing status, open the Solr Admin and click **Core Admin**.



Core

startTime:	5 minutes ago
instanceDir:	solr/
dataDir:	/var/lib/cassandra/data/solr.data/wiki.solr/

Index

lastModified:	4 minutes ago
version:	189
numDocs:	3579
maxDoc:	3579
current:	✓
indexing:	no
directory:	org.apache.lucene.store.NRTCachingDirectory: NRTCachingDirectory(org.apache.lucene.store.NIOFSDirectory@ /private/var/lib/cassandra/data/solr.data/wiki.solr/index lockFactory=org.apache.lucene.store.NativeFSLockFactory@3ab6a5fb; maxCacheMB=48.0 maxMergeSizeMB=4.0)

Checking the indexing status using the logs

You can also check the logs to get the indexing status. For example, you can check information about the plugin initializer:

```
INDEXING / REINDEXING -
INFO SolrSecondaryIndex plugin initializer. 2013-08-26 19:25:43,347
 SolrSecondaryIndex.java (line 403) Reindexing 439171 keys for core
 wiki.solr
```

Or you can check the SecondaryIndexManager.java information:

```
INFO Thread-38 2013-08-26 19:31:28,498 SecondaryIndexManager.java (line 136)
 Submitting index build of wiki.solr for data in SSTableReader(path='/mnt/
cassandra/data/wiki/solr/wiki-solr-ic-5-Data.db'), SSTableReader(path='/mnt/
cassandra/data/wiki/solr/wiki-solr-ic-6-Data.db')

FINISH INDEXING -
INFO Thread-38 2013-08-26 19:38:10,701 SecondaryIndexManager.java (line 156)
 Index build of wiki.solr complete
```

Fast repair

Repair subranges of data in a cluster instead of running a nodetool repair operation on entire ranges.

Repairing subranges of data in a cluster is faster than running a nodetool repair operation on entire ranges because all the data replicated during the nodetool repair operation has to be re-indexed. When you repair a subrange of the data, less data has to be re-indexed.

To repair a subrange

Perform these steps as a rolling repair of the cluster, one node at a time.

1. Run the dsetool list_subranges command, using the approximate number of rows per subrange, the beginning of the partition range (token), and the end of the partition range of the node.

   ```
   dsetool list_subranges my_keyspace my_table 10000
    113427455640312821154458202477256070485 0
   ```

   The output lists the subranges.

   ```
   Start Token                                        End Token
         Estimated Size
   ----------------------------------------------------------------------------------
   113427455640312821154458202477256070485
    132425442795624521227151664615147681247 11264
   132425442795624521227151664615147681247
    151409576048389227347257997936583470460 11136
   151409576048389227347257997936583470460 0
         11264
   ```

2. Use the output of the previous step as input to the nodetool repair command.

   ```
   nodetool repair my_keyspace my_table -st
    113427455640312821154458202477256070485
     -et 132425442795624521227151664615147681247
   nodetool repair my_keyspace my_table -st
    132425442795624521227151664615147681247
     -et 151409576048389227347257997936583470460
   nodetool repair my_keyspace my_table -st
    151409576048389227347257997936583470460
     -et 0
   ```

   The anti-entropy node repair runs from the start to the end of the partition range.

Excluding hosts from Solr-distributed queries

You can exclude hosts from Solr-distributed queries.

To exclude hosts from Solr-distributed queries, perform these steps on each node that you want to send queries to.

1. Navigate to the `solr/conf` directory.

   The default Solr conf location depends on the type of installation:

Installer-Services and Package installations	`/usr/share/dse/resources/solr/conf`
Installer-No Services and Tarball installations	*`dse_install_location`*`/resources/solr/conf`

2. Open the `exclude.hosts` file, and add the list of nodes to be excluded. Separate each name with a newline character.
3. Update the list of routing endpoints on each node by calling the JMX operation `refreshEndpoints()` on the `com.datastax.bdp:type=ShardRouter mbean`.

Shard transport options for DSE Search communications

A custom, TCP-based communications layer for Solr is the default type in DataStax Enterprise. To improve Solr inter-node communications and avoid distributed deadlock during queries, switch from the HTTP-based communications to the netty non-blocking communications layer.

A custom, TCP-based communications layer for Solr is the default type in DataStax Enterprise. The TCP-based type, netty, is an alternative to the HTTP-based, Tomcat-backed interface, which is reportedly slow and resource intensive. The communications layer improves Solr inter-node communications in several ways:

- Lowers latency
- Reduces resource consumption
- Increases throughput even while handling thousands of concurrent requests
- Provides nonblocking I/O processing

To avoid distributed deadlock during queries, switch from the HTTP-based communications to the netty non-blocking communications layer.

The TCP-based communications layer for Solr supports client-to-node and node-to-node encryption using SSL, but does not support Kerberos.

Configure the shard transport options in the dse.yaml file to select HTTP- or TCP-based communication.

The shard_transport_options in the dse.yaml file for managing inter-node communication between DSE Search nodes are:

- type: netty or http

  The default type, netty, configures TCP-based Solr communications. Choosing http configures Solr communication that uses the standard HTTP-based communications interface. Accept the netty default so that the following netty options are applicable.
- netty_server_port: 8984

  The TCP listen port, mandatory to use the netty type. To use the http type indefinitely, either comment netty_server_port or set it to -1.
- netty_server_acceptor_threads

  The number of server acceptor threads. The default is number of available processors.
- netty_server_worker_threads

  The number of server worker threads. The default is number of available processors times 8.
- netty_client_worker_threads

  The number of client worker threads. The default is number of available processors times 8.
- netty_client_max_connections

  The maximum number of client connections. The default is 100.
- netty_client_request_timeout

  The client request timeout in milliseconds. The default is 60000.

Upgrading to use the netty type

If you upgrade to DataStax Enterprise 4.0 or later, perform the upgrade procedure using the shard transport type of your old installation, and after the upgrade, change the shard transport type to netty. Start the cluster using a rolling restart.

The location of the dse.yaml file depends on the type of installation:

Installer-Services	`/etc/dse/dse.yaml`
Package installations	`/etc/dse/dse.yaml`
Installer-No Services	*`install_location`*`/resources/dse/conf/dse.yaml`
Tarball installations	*`install_location`*`/resources/dse/conf/dse.yaml`

Expiring a DSE Search column

You can update a DSE Search column to set a time when data expires.

You can update a DSE Search column to set a time when data expires in these ways:

- Configuring the high-performance update handler

  Configuring per-document TTL causes removal of the entire document. Configuring per-field TTL causes removal of the field only.
- Using the Solr HTTP API
- Using CQL to set TTL

If you configure TTL in the `solrconfig.xml` file, and then use the Solr HTTP API or CQL to configure a different TTL, the latter takes precedence.

Configuring expiration using the Solr HTTP API

Use the Solr HTTP API `update` command to set a time-to-live (TTL). You can construct a URL to update data that includes the TTL per-document or per-field parameter:

- Using the ttl parameter

  Specifies per-document TTL. For example:

  ```
  curl http://host:port/solr/mykeyspace.mytable/update?ttl=86400
  ```
- Using the ttl.*field name* parameter

  Specifies per-field TTL. For example:

  ```
  curl http://host:port/solr/mykeyspace.mytable/update?ttl.myfield=86400
  ```

Configuring expiration using CQL

Using a CQL INSERT or UPDATE operation, you can set the TTL property. For example, continuing with the example of using a collection set, insert a 5 minute (300 seconds) TTL property on the all columns of the Einstein data:

```
INSERT INTO mysolr (id, name, title, body)
  VALUES ('126', 'Albert Einstein', 'Success', 'If A is success
  in life, then A equals x plus y plus z. Work is x; y is play;
  and z is keeping your mouth shut.')
  USING TTL 300;
```

After a few seconds, check the remaining time-to-live on the data:

```
SELECT TTL (name) FROM mykeyspace.mysolr WHERE id = '126';
```

The output after 9 seconds expire is:

```
 ttl(name)
-----------
        291
```

After the remaining time has passed, the data expires, and querying the data returns no results. If you refresh the Solr Admin console, the number of documents is 3 instead of 4.

Configuring expiration scope

You can configure the `solrconfig.xml` to include the TTL per-document or per-field on data added to the Solr index or Cassandra database. You construct a Solr HTTP API query to search the Solr index using a ttl component. Depending on the configuration, TTL then applies to the entire document or just to a named field.

To configure per-document or per-field TTL in the update handler:

1. Configure the high-performance update handler section of the `solrconfig.xml`.

- For per-document TTL, add these lines to the high-performance updateHandler section:

  ```
  <!-- The default high-performance update handler -->
   <updateHandler class="solr.DirectUpdateHandler2">
  . . .

  <lst name="defaults">
   <int name="ttl">1</int>
  </lst>
  ```
- For per-field TTL, add these lines to the updateHandler section:

  ```
  <lst name = "defaults">
   <int  name = "ttl.<column/field name1>">1</int>
   <int  name = "ttl.<column/field name2>">1</int>
   <int  name = "ttl.<column/field name3>">1</int>
   <int  name = "ttl.<column/field name4>">1</int>
   . . .
  </lst>
  ```

2. Re-index the data by uploading the `schema.xml` and `solrconfig.xml` and reloading the Solr core.

Managing expired columns

After Cassandra expires a column using the time-to-live (TTL) mechanism, DSE Search can still find the expired column. The column data remains in the index until one of the following conditions is met:

- Re-indexing occurs due to a DSE Search ttl rebuild timeout.

  Set the ttl rebuild timeout properties in the dse.yaml file.
- All columns in a row expire due to the Cassandra time-to-live (TTL) mechanism, triggering removal of the entire row/Solr document from the index.

Setting the ttl rebuild timeout properties is the recommended method for managing expired columns.

Changing the HTTP interface to Apache JServe Protocol

How to enable the AJP connector for DSE search to use the AJP (Apache JServe Protocol). This capability is typically used where https serves a web application and DSE Search powers the backend.

In addition to the widely-used HTTP interface, you can configure DSE search to use the AJP (Apache JServe Protocol). AJP is an optimized, binary version of HTTP that facilitates Tomcat communication with an Apache web server using mod_jk. This capability is typically used where https serves a web application and DSE Search powers the backend.

By default the AJP connector is disabled. To enable the AJP connector, uncomment the connector configuration in the Tomcat server.xml file. For example, remove the comments as follows:

```
<!-- Define an AJP 1.3 Connector on port 8009 -->
Connector port="8009" protocol="AJP/1.3" redirectPort="8443"
```

The default location of the Tomcat `server.xml` file depends on the type of installation:

Installer-Services and Package installations	`/usr/share/dse/resources/tomcat/conf/server.xml`
Installer-No Services and Tarball installations	`*install_location*/resources/tomcat/conf/server.xml`

Performance tuning

Tuning DSE Search in the event of performance degradation, high memory consumption, or other problems.

About this task

In the event of a performance degradation, high memory consumption, or other problem with DataStax Enterprise Search nodes, try:

- Using Cassandra table compression
- Configuring the Search Handler
- Configuring the update handler and autoSoftCommit
- Changing the stack size and memtable space
- Managing the data consistency level
- Configuring the available indexing threads
- Adding replicas to increase read performance
- Changing the replication factor
- Configuring re-indexing and repair
- Performance impact when using deep paging with CQL Solr queries

Using metrics MBeans

To troubleshoot, tune performance, and resolve consistency issues, use commit, merge, query, and update metrics MBeans.

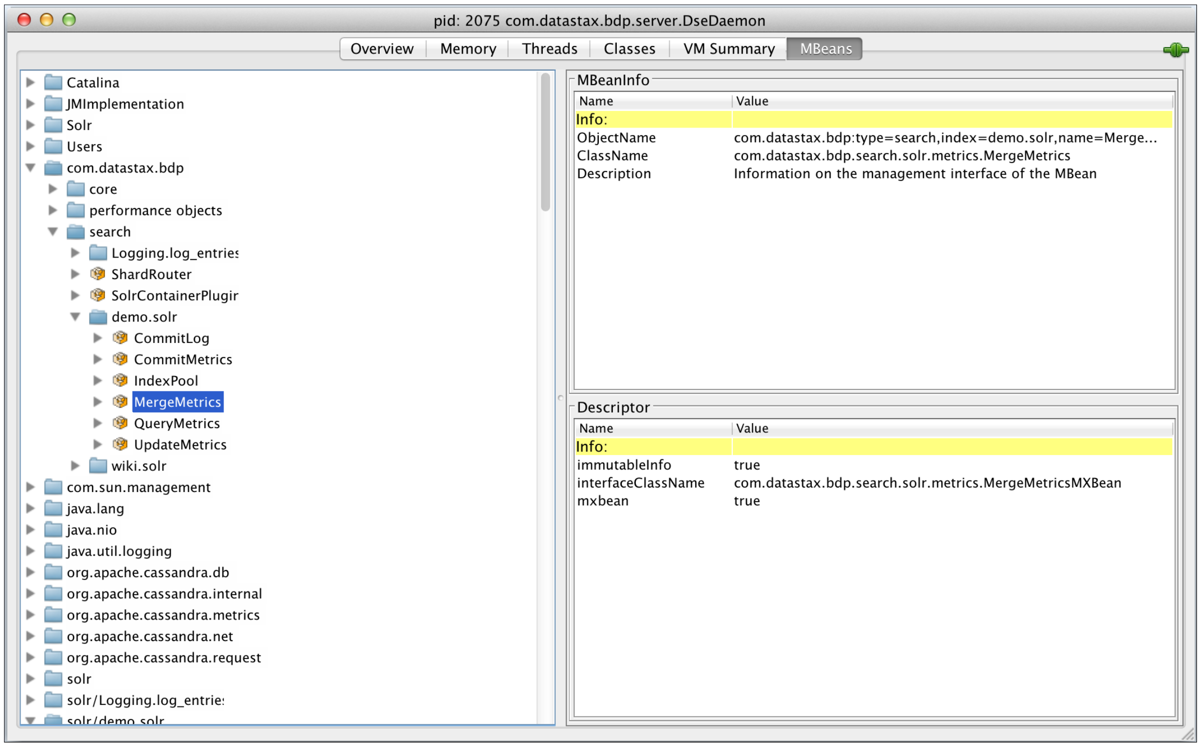
DataStax Enterprise provides commit, merge, query, and update metrics MBeans for troubleshooting and tuning performance and consistency issues.

The following paths identify the MBeans:

```
type=search,index=<core>,name=CommitMetrics
type=search,index=<core>,name=MergeMetrics
type=search,index=<core>,name=QueryMetrics
type=search,index=<core>,name=UpdateMetrics
```

<core> is the name of the Solr core referenced by the metric.

For example, the following figure shows the com.datastax.bdp merge metrics MBean in jconsole. The demo.solr core under search is expanded.


pid: 2075 com.datastax.bdp.server.DseDaemon

```
▶ Catalina
▶ JMImplementation
▶ Solr
▶ Users
▼ com.datastax.bdp
   ▶ core
   ▶ performance objects
   ▼ search
      ▶ Logging.log_entries
      ▶ ShardRouter
      ▶ SolrContainerPlugin
      ▼ demo.solr
         ▶ CommitLog
         ▶ CommitMetrics
         ▶ IndexPool
         ▶ MergeMetrics
         ▶ QueryMetrics
         ▶ UpdateMetrics
      ▶ wiki.solr
▶ com.sun.management
▶ java.lang
▶ java.nio
▶ java.util.logging
▶ org.apache.cassandra.db
▶ org.apache.cassandra.internal
▶ org.apache.cassandra.metrics
▶ org.apache.cassandra.net
▶ org.apache.cassandra.request
▶ solr
▶ solr/Logging.log_entrie:
▼ solr/demo.solr
```

MBeanInfo

Name	Value
Info:	
ObjectName	com.datastax.bdp:type=search,index=demo.solr,name=Merge...
ClassName	com.datastax.bdp.search.solr.metrics.MergeMetrics
Description	Information on the management interface of the MBean

Descriptor

Name	Value
Info:	
immutableInfo	true
interfaceClassName	com.datastax.bdp.search.solr.metrics.MergeMetricsMXBean
mxbean	true

Commit metrics MBean

The commit metrics MBean is useful for troubleshooting index performance and resolving data consistency issues that are caused by asynchronous commits between different index replicas.

The commit metrics MBean is useful for troubleshooting index performance as well as data consistency issues caused by asynchronous commits between different index replicas. Using this MBean is also useful for fine-tuning indexing back pressure. The commit metrics MBean records the amount of time that is spent to execute two main phases of a commit operation on the index.

Main operational phases

The main phases of a commit operation on the index are:

- FLUSH: comprising the time spent by flushing the async indexing queue.
- EXECUTE: comprising the time spent by actually executing the commit on the index.

Commit metrics MBean operations

The commit metrics MBean measures latency in microseconds. Operations are:

- setEnabled(boolean enabled)

  Enables/disables metrics recording. Enabled by default.
- isEnabled()

  Checks that metrics recording is enabled.
- getLatencyPercentile(String phase, double percentile)

  Gets a commit latency percentile by its phase.
- getRecordedLatencyCount(String phase)

  Gets the total count of recorded latency metrics by its commit phase.
- getUnrecordedLatencyCount()

  Gets the total count of unrecorded latency values due to exceeding the maximum tracked latency, which is 10 minutes.
- resetLatency(String phase)

  Resets latency metrics for the given commit phase.
- resetLatencies()

  Resets all latency metrics.

Commit metrics MBean operations use the FLUSH and EXECUTE commit phase names.

Merge metrics MBean

The merge metrics MBean is useful to tune merge operations.

The merge metrics MBean tracks the time Solr/Lucene spends on merging segments that accumulate on disk. Segments are files that store new documents and are a self-contained index. When data is deleted, Lucene does not remove it, but instead marks documents as deleted. For example, during the merging process, Lucene copies the data from 100 segment files into a single, new file. Documents that are marked deleted are not included in the new segment files. Next, Lucene removes the 100 old segment files, and the single, new file holds the index on disk.

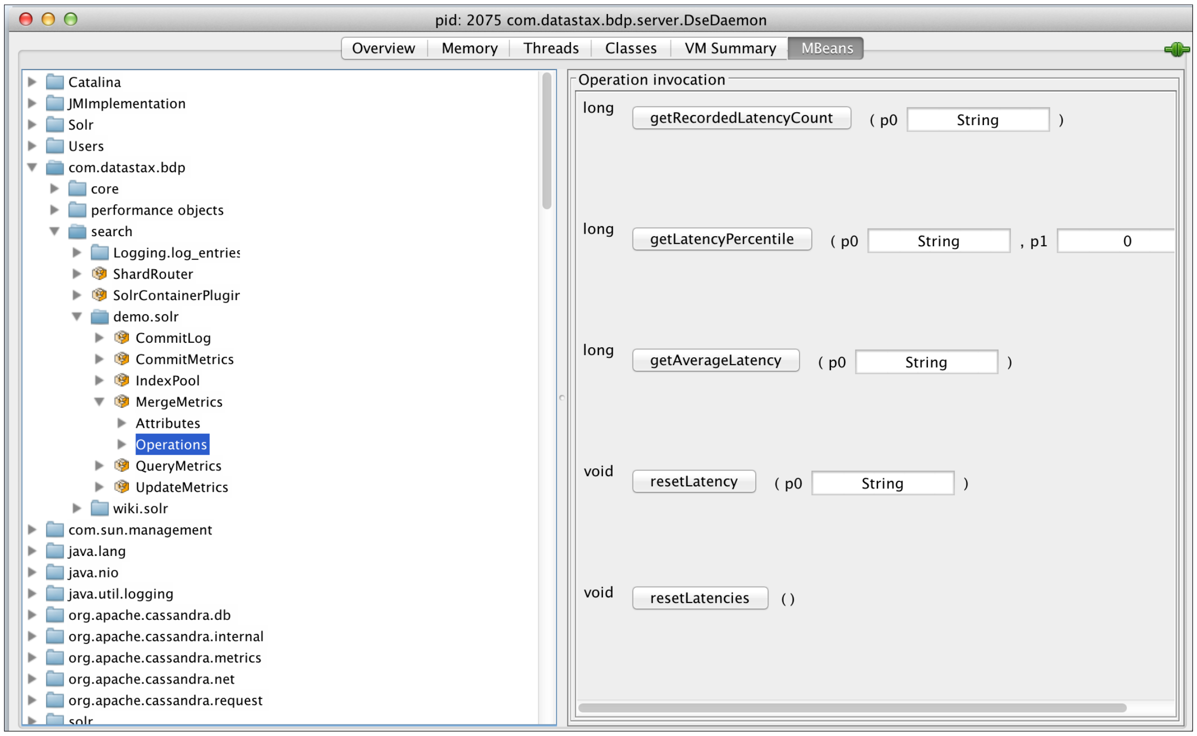
After segments are written to disk, they are immutable.

In a high throughput environment, a single segment file is rare. Typically, there are several files and Lucene runs the merge metric operation concurrently with inserts and updates of the data using a merge policy and merge schedule.

Merge operations are costly and can impact the performance of solr queries. A huge merge operation can cause a sudden increase in query execution time.

The merge metrics MBean operations, as shown in the following figure, are:

- getRecordedLatencyCount
- getLatencyPercentile
- getAverageLatency
- resetLatency
- resetLatencies



Merge metrics operations use these merge phase names:

- INIT

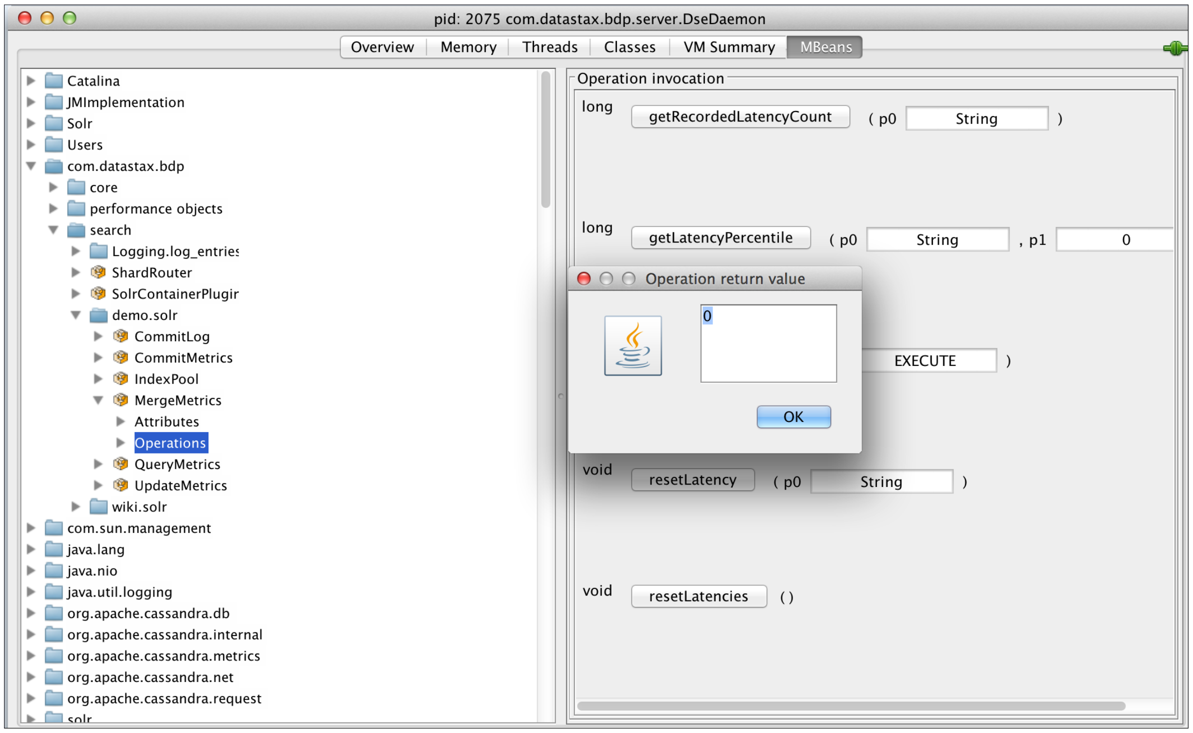
  How long it takes to initialize the merge process.
- EXECUTE

  How long it takes to execute the merge process.
- WARM

  How long it takes to warm up segments to speed up cold queries.

WARM time is part of EXECUTE time: EXECUTE time = WARM time + other operations. For example, if the EXECUTE phase is 340 ms, and the WARM phase is 120 ms, then other operations account for the remainder, 220 ms.

To get merge metrics, insert one of the phases of the merge operation and select a phase, for example EXECUTE, as shown in the following figure.



Query metrics MBean

The query metrics MBean is useful for troubleshooting query performance, tuning the Solr configuration, such as the schema and caches, and tuning server resources, such as the JVM heap.

About this task

The query metrics MBean is useful for troubleshooting query performance, tuning the Solr configuration, such as the schema and caches, and tuning server resources, such as the JVM heap. The query metrics MBean records the amount of time spent to execute several main phases of a distributed query on the index.

Main operational phases

The main phases of a distributed query operation are:

- COORDINATE

  Comprises the total amount of time spent by the coordinator node to distribute the query and gather/ process results from shards. This value is computed only on query coordinator nodes.
- EXECUTE

  Comprises the time spent by a single shard to execute the actual index query. This value is computed on the local node executing the shard query.
- RETRIEVE

  Comprises the time spent by a single shard to retrieve the actual data from Cassandra. This value will be computed on the local node hosting the requested data.

Query metrics MBean operations

The query metrics MBean measures latency in microseconds. Metrics can be grouped by query, by providing an additional query.name parameter. For example, assuming you are using a Solr core named demo.solr and have indexed a field named type, this URL provides the additional query.name parameter:

```
http://localhost:8983/solr/demo.solr/select/?q=type:1&query.name=myquery
```

All metrics collected under a given query name are recorded and retrieved separately, as shown in the following list of operations. If no query name is provided, all metrics are recorded together.

Operations are:

- setEnabled(boolean enabled)

  Enables/disables metrics recording. Enabled by default.
- isEnabled()

  Checks if metrics recording is enabled.
- getLatencyPercentile(String phase, String query, double percentile)

  Gets a query latency percentile by its query name, which is optional and can be null, and phase.
- getRecordedLatencyCount(String phase, String query)

  Gets the total count of recorded latency metrics by its query name, which is optional and can be null, and phase.
- getUnrecordedLatencyCount()

  Gets the total count of unrecorded latency values due to exceeding the maximum tracked latency, which is 10 minutes.
- resetLatency(String query)

  Resets latency metrics for the given query name, which is optional and can be null.
- resetLatencies()

  Resets all latency metrics.

Query metrics MBean operations use the phase names previously listed.

Using MBeans to evaluate performance

The following example shows how to use the MBeans on Linux to obtain information about performance while running the DataStax Solr stress test demo.

1. Start a single DSE Search node.
2. Start jconsole using the PID of the DSE Search node: For example:

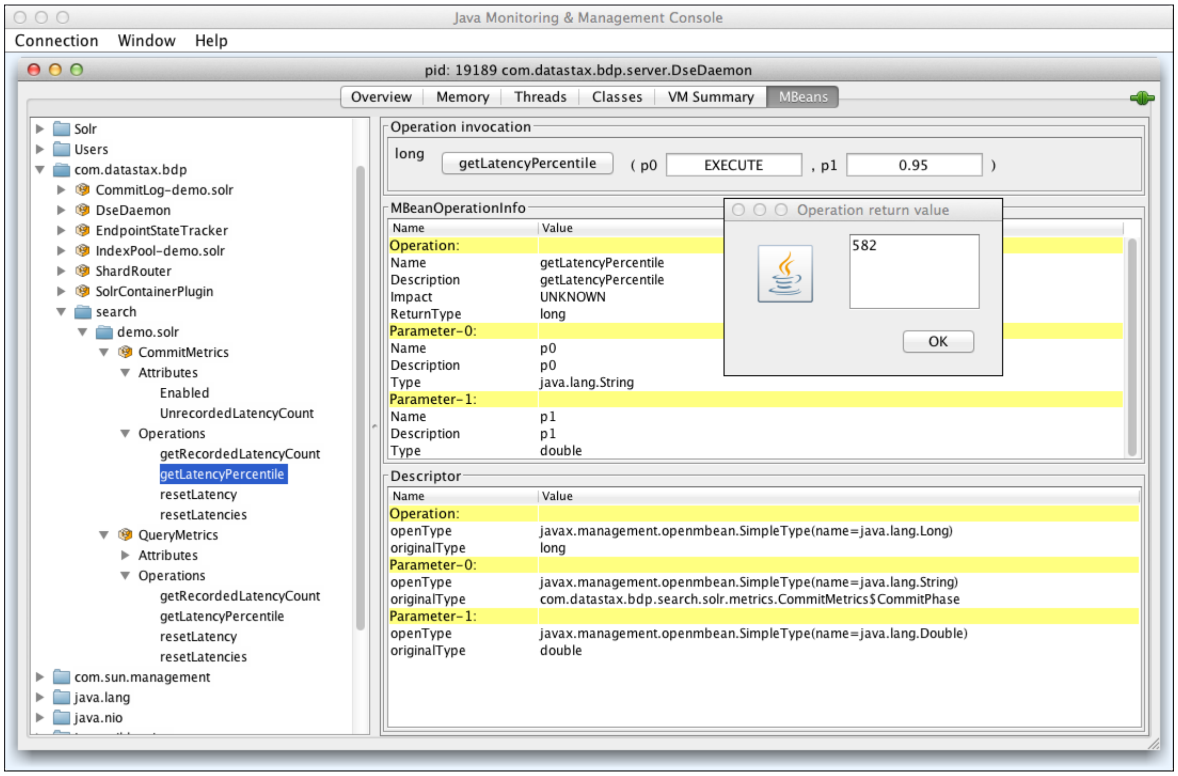
   ```
   sudo jconsole 1284
   ```
3. On Linux, for example, execute these scripts to run the Solr stress demo in `dse-4.0.0/demos/solr_stress`.

   ```
   ./1-add-schema.sh
   ./2-run-benchmark.sh --clients=10 --loops=10000 --type=both
   ```

   The demo creates a Solr core named demo.solr and indexes 50,000 documents.
4. In jconsole, expand **com.datastax.bdp** > **search** > **demo.solr**.

   The CommitMetrics and QueryMetrics MBean items appear.
5. In jconsole, in **Search** > **demo.solr** > **CommitMetrics** > **Operations** > **getLatencyPercentile**, type EXECUTE in the p0 text entry box and 0.95 in the p1 text entry box. Click the **getLatencyPercentile** button.

The Operation return value, 582 microseconds, appears:



long getLatencyPercentile (p0 EXECUTE , p1 0.95)

582

Name	Value
Operation:	
Name	getLatencyPercentile
Description	getLatencyPercentile
Impact	UNKNOWN
ReturnType	long
Parameter-0:	
Name	p0
Description	p0
Type	java.lang.String
Parameter-1:	
Name	p1
Description	p1
Type	double

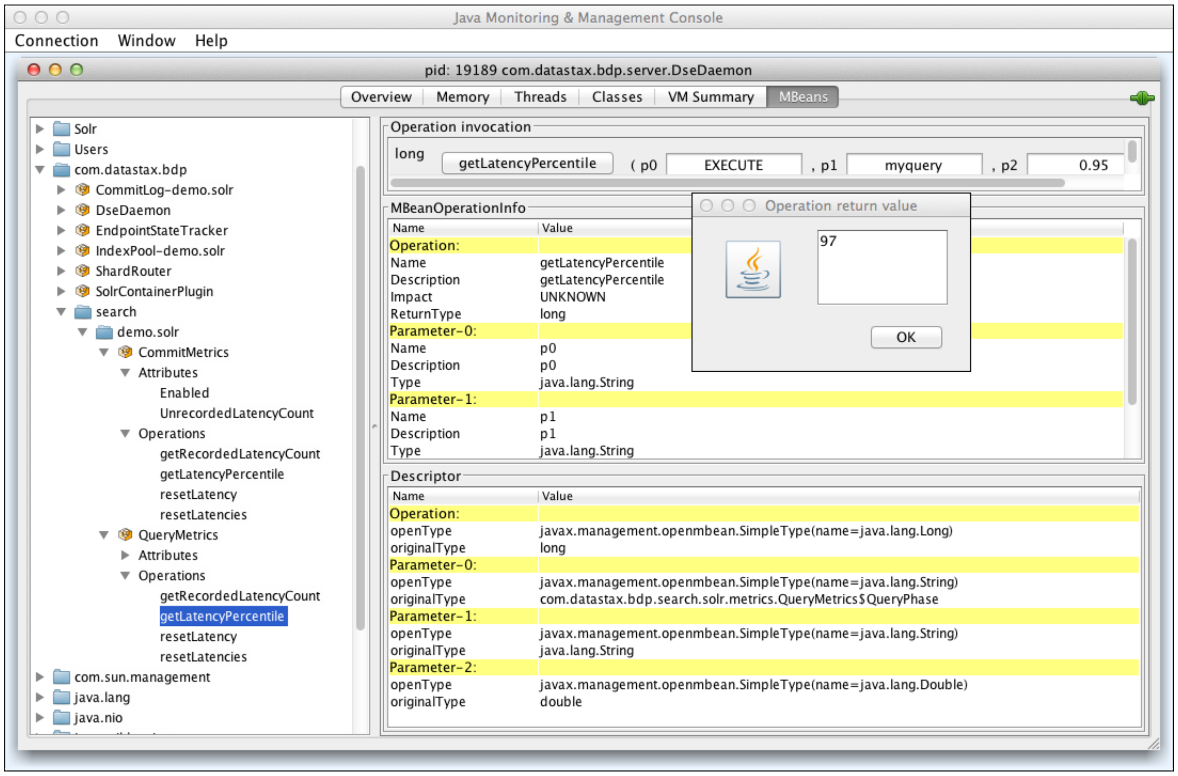
Name	Value
Operation:	
openType	javax.management.openmbean.SimpleType(name=java.lang.Long)
originalType	long
Parameter-0:	
openType	javax.management.openmbean.SimpleType(name=java.lang.String)
originalType	com.datastax.bdp.search.solr.metrics.CommitMetrics$CommitPhase
Parameter-1:	
openType	javax.management.openmbean.SimpleType(name=java.lang.Double)
originalType	double

6. Click **OK**.
7. Query Solr 20,000 times using the query.name parameter. For example:

```
curl "http://localhost:8983/solr/demo.solr/select/?
q=type:1&query.name=myquery"
curl "http://localhost:8983/solr/demo.solr/select/?
q=type:3&query.name=myquery"
```

8. In jconsole, in **Search** > **demo.solr** > **QueryMetrics Operations getLatencyPercentile**, type EXECUTE in the p0 text entry box, myquery in the p1 text entry box, and 95.0 in the P2 text entry box.

   The Operation return value, 97 microseconds, appears.



Java Monitoring & Management Console
Connection Window Help
pid: 19189 com.datastax.bdp.server.DseDaemon
Overview Memory Threads Classes VM Summary MBeans

```
Solr
Users
com.datastax.bdp
  CommitLog-demo.solr
  DseDaemon
  EndpointStateTracker
  IndexPool-demo.solr
  ShardRouter
  SolrContainerPlugin
  search
    demo.solr
      CommitMetrics
        Attributes
          Enabled
          UnrecordedLatencyCount
        Operations
          getRecordedLatencyCount
          getLatencyPercentile
          resetLatency
          resetLatencies
      QueryMetrics
        Attributes
        Operations
          getRecordedLatencyCount
          getLatencyPercentile
          resetLatency
          resetLatencies
com.sun.management
java.lang
java.nio
```

Operation invocation

```
long  getLatencyPercentile  ( p0 EXECUTE , p1 myquery , p2 0.95
```

Operation return value: 97 — OK

MBeanOperationInfo

Name	Value
Operation:	
Name	getLatencyPercentile
Description	getLatencyPercentile
Impact	UNKNOWN
ReturnType	long
Parameter-0:	
Name	p0
Description	p0
Type	java.lang.String
Parameter-1:	
Name	p1
Description	p1
Type	java.lang.String

Descriptor

Name	Value
Operation:	
openType	javax.management.openmbean.SimpleType(name=java.lang.Long)
originalType	long
Parameter-0:	
openType	javax.management.openmbean.SimpleType(name=java.lang.String)
originalType	com.datastax.bdp.search.solr.metrics.QueryMetrics$QueryPhase
Parameter-1:	
openType	javax.management.openmbean.SimpleType(name=java.lang.String)
originalType	java.lang.String
Parameter-2:	
openType	javax.management.openmbean.SimpleType(name=java.lang.Double)
originalType	double

Update metrics MBean

The update metrics MBean is useful for tuning indexing performance.

The update metrics MBean is identified by the following path: *type=search,index=core,name=UpdateMetrics*, where core is the Solr core name that the metrics reference.

This MBean records the amount of time spent to execute an index update, split by the following main phases:

- WRITE: comprising the time spent to convert the Solr document and write it into Cassandra (only available when indexing via the SOlrj HTTP APIs).
- QUEUE: comprising the time spent by the index update task into the index pool.
- PREPARE: comprising the time spent preparing the actual index update.
- EXECUTE: comprising the time spent to actually execute the index update on Lucene.

The following MBean operations are provided:

- setEnabled(boolean enabled)

  Enables/disables metrics recording (enabled by default).
- isEnabled()

  Checks if metrics recording is enabled.
- getLatencyPercentile(String phase, double percentile)

  Gets a commit latency percentile by its phase.
- getRecordedLatencyCount(String phase)

  Gets the total count of recorded latency metrics by its phase.
- getUnrecordedLatencyCount()

  Gets the total count of unrecorded latency values, because exceeding the max tracked latency.
- resetLatency(String phase)

Resets latency metrics for the given phase.
- resetLatencies()

  Resets all latency metrics.

The maximum tracked latency is 10 minutes. Latency values are in microseconds.

The update metrics MBean can be useful to guide tuning of all factors affecting indexing performance, such as back pressure, indexing threads, RAM buffer size and merge factor.

Using table compression

Configure data compression on a per-table basis to optimize performance of read-dominated tasks.

Search nodes typically engage in read-dominated tasks, so maximizing storage capacity of nodes, reducing the volume of data on disk, and limiting disk I/O can improve performance. In Cassandra 1.0 and later, you can configure data compression on a per-table basis to optimize performance of read-dominated tasks.

Configuration affects the compression algorithm for compressing SSTable files. For read-heavy workloads, such as those carried by Enterprise Search, LZ4 compression is recommended. Compression using the LZ4 compressor is enabled by default when you create a table. You can change compression options using CQL. Developers can also implement custom compression classes using the org.apache.cassandra.io.compress.ICompressor interface. You can configure the compression chunk size for read/write access patterns and the average size of rows in the table.

Configuring the update handler and autoSoftCommit

To configure the update handler, set the default high-performance update handler flag.

You need to configure the `solrconfig.xml` to use near real-time capabilities in Solr by setting the default high-performance update handler flag.

For example, the Solr configuration file for the Wikipedia demo sets this flag as follows and uncomments the autoSoftCommit element:

```
<!-- The default high-performance update handler -->
 <updateHandler class="solr.DirectUpdateHandler2">

  . . .

   <autoSoftCommit>
     <maxTime>1000</maxTime>
   </autoSoftCommit>
</updateHandler>
```

The autoCommit element is removed to prevent hard commits that hit the disk and flush the cache. The soft commit forces uncommitted documents into internal memory. When data is committed, is it immediately available after the commit.

The autoSoftCommit element uses the maxTime update handler attribute. The update handler attributes enable near real-time performance and trigger a soft commit of data automatically, so checking synchronization of data to disk is not necessary. This table describes both update handler options.

Attribute	Default	Description
maxDocs	No default	Maximum number of documents to add since the last soft commit before automatically triggering a new soft commit.
maxTime	1000	Maximum expired time in milliseconds between the addition of a document and a new, automatically triggered soft commit. With live indexing, use the default 1000.

See the Solr documentation for information about the update handler and modifying `solrconfig.xml`.

Configuring update performance

If updates take too long and the value of autoSoftCommit is higher than the default (1000ms), reset autoSoftCommit to the default value in the `solrconfig.xml` file.

Note: A higher value for autoSoftCommit, such as 10000, is suitable when live indexing is not enabled. DataStax recommends using the default value of 1000 when live indexing is enabled.

Parallelizing large Cassandra row reads

Configure DSE Search to parallelize the retrieval of a large number of rows to improve performance.

For performance, you can configure DSE Search to parallelize the retrieval of a large number of rows. First, configure the queryResponseWriter in the `solrconfig.xml` as follows:

```
<queryResponseWriter name="javabin" class="solr.BinaryResponseWriter">
  <str
 name="resolverFactory">com.datastax.bdp.search.solr.response.ParallelRowResolver
$Factory</str>
</queryResponseWriter>
```

By default, the parallel row resolver uses up to *x* threads to execute parallel reads, where *x* is the number of CPUs. Each thread sequentially reads a batch of rows equal to the total requested rows divided by the number of CPUs:

Rows read = Total requested rows / Number of CPUs

You can change the batch size per request, by specifying the cassandra.readBatchSize HTTP request parameter. Smaller batches use more parallelism, while larger batches use less.

Changing the stack size and memtable space

Increasing the stack size can improve performance under Tomcat.

Some Solr users have reported that increasing the stack size improves performance under Tomcat. To increase the stack size, uncomment and modify the default -Xss256k setting in the `cassandra-env.sh` file. Also, decreasing the memtable space to make room for Solr caches might improve performance. Modify the memtable space using the memtable_total_space_in_mb property in the cassandra.yaml file.

The location of the cassandra.yaml file depends on the type of installation:

Package installations	`/etc/cassandra/cassandra.yaml`
Tarball installations	*`install_location`*`/resources/cassandra/conf/cassandra.yaml`

Managing the consistency level

Configure how up-to-date and synchronized a row of data is on all of its replicas.

Consistency refers to how up-to-date and synchronized a row of data is on all of its replicas. Like Cassandra, DSE Search extends Solr by adding an HTTP parameter, cl, that you can send with Solr data to tune consistency. The format of the URL is:

```
curl "http://host:port/solr/keyspace.table/update?cl=ONE"
```

The cl parameter specifies the consistency level of the write in Cassandra on the client side. The default consistency level is QUORUM. To globally change the default on the server side, use Cassandra's drivers and client libraries.

Setting the consistency level using SolrJ

SolrJ does not allow setting the consistency level parameter using a Solr update request. To set the consistency level parameter:

```
HttpSolrServer httpSolrServer = new HttpSolrServer ( url );
httpSolrServer . getInvariantParams (). add ( "cl" , "ALL" );
```

See the Data Consistency in DSE Search blog.

Configuring the available indexing threads

Improve performance on machines that have multiple CPU cores.

DSE Search provides multi-threaded indexing to improve performance on machines that have multiple CPU cores. All index updates are internally dispatched to a per CPU core indexing thread pool and executed asynchronously. This implementation allows for greater concurrency and parallelism, but as a consequence, index requests return a response before the indexing operation is actually executed. The number of available indexing threads per Solr core is by default equal to the number of available CPU cores.

To configure the available threads, edit the max_solr_concurrency_per_core parameter in the dse.yaml configuration file. DataStax recommends using the actual number of available CPU cores. For example, for four CPU cores, set max_solr_concurrency_per_core to 4.

If set to 1, DSE Search uses the legacy synchronous indexing implementation.

DSE Search also provides advanced JMX-based, configurability and visibility through the IndexPool-ks.cf (where ks.cf is the name of a DSE Search core) MBean under the `com.datastax.bdp` namespace.

Configuring re-indexing

Change the size of the RAM buffer and increase the soft commit time in the `solrconfig.xml` file to tune the performance of re-indexing and index building.

About this task

When running the RELOAD command using the reindex or deleteAll options, a long delay might indicate that tuning is needed. Tune the performance of re-indexing and index rebuilding by making a few changes in the `solrconfig.xml` file.

Procedure

1. Increase the size of the RAM buffer, which is set to 100MB by default. For example, increase to 2000.

   ```
   <indexConfig>
     <useCompoundFile>false</useCompoundFile>
     <ramBufferSizeMB>2000</ramBufferSizeMB>
     <mergeFactor>10</mergeFactor>
   . . .
   ```

2. Increase the soft commit time, which is set to 1000 ms by default, to a larger value. For example, increase the time to 15-16 minutes:

   ```
   <autoSoftCommit>
     <maxTime>1000000</maxTime>
   </autoSoftCommit>
   ```

   A disadvantage of changing the autoSoftCommit attribute is that newly updated rows take longer than usual (1000 ms) to appear in search results.

   Note: A higher value for autoSoftCommit, such as 10000, is suitable when live indexing is not enabled. DataStax recommends using the default value of 1000 when live indexing is enabled.

Tuning index size and range query speed

Advanced users can change the precision step of special token field types to tune index size.

In DataStax Enterprise, you can trade off Solr index size for range query speed and vice versa. You make this tradeoff to suit a particular use case and on a core-by-core basis by setting up the precision step of two special token field types that are used by DataStax Enterprise.

Use extreme care when performing this tuning. This advanced tuning feature is recommended for use in rare cases. In most cases, using the default values is the best. To perform this tuning, you change the precision step of one or both DataStax Enterprise internal field types:

- token_long

  Used for filtering over token fields during query routing.
- ttl_long

  Used for searching for expiring documents.

Change the precision step as follows:

1. In the `fieldType` definition, set the class attribute of `token_long` and `ttl_long` to `solr.TrieLongField`.
2. Set the `precisionStep` attribute from the default 8 to another number. Choose this number based on an understanding of its impact. Usually, a smaller precision step increases the index size and range query speed, while a larger precision step reduces index size, but potentially reduces range query speed.

   The following snippet of the schema.xml shows an example of the required configuration of both field types:

```
<?xml version="1.0" encoding="UTF-8" ?>
<schema name="test" version="1.0">
    <types>
        . . .
       <fieldType name="token_long" class="solr.TrieLongField"
 precisionStep="16" />
 <fieldType name="ttl_long" class="solr.TrieLongField"
 precisionStep="16" />
  . . .
</types>
<fields>
. . .
</schema>
```

DataStax Enterprise ignores one or both of these field type definitions and uses the default precision step if you make any of these mistakes:

- The field type is defined using a name other than `token_long` or `ttl_long`.
- The class is something other than solr.TrieLongField.
- The precision step value is not a number. DataStax Enterprise logs a warning.

The definition of a fieldType alone sets up the special field. You do not need to use `token_long` or `ttl_long` types as fields in the <fields> tag.

Increasing read performance by adding replicas

Increase DSE Search read performance by configuring replicas.

About this task

You can increase DSE Search read performance by configuring replicas just as you do in Cassandra. You define a strategy class, the names of your data centers, and the number of replicas. For example, you can add replicas using the NetworkToplogyStrategy replica placement strategy. To configure this strategy, use CQL.

Procedure

For example, if you are using a PropertyFileSnitch, perform these steps:

1. Check the data center names of your nodes using the nodetool command.

   ```
   ./nodetool -h localhost ring
   ```

   The data center names, DC1 and DC2 in this example, must match the data center name configured for your snitch.
2. Start CQL on the DSE command line and create a keyspace that specifies the number of replicas you want.

   Set the number of replicas in data centers, one replica in data center 1 and three in data center 2. For more information about adding replicas, see Choosing Keyspace Replication Options.

Changing the replication factor for a Solr keyspace

Steps for changing the keyspace replication factor after the solrconfig.xml and schema.xml files are posted.

About this task

This example assumes the `solrconfig.xml` and `schema.xml` files have already been posted using mykeyspace.mysolr in the URL, which creates a keyspace named mykeyspace that has a default replication factor of 1. You want three replicas of the keyspace in the cluster, so you need to change the keyspace replication factor.

Procedure

To change the keyspace replication factor

1. Check the name of the data center of the Solr/Search nodes.

   ```
   ./nodetool -h localhost ring
   ```

   The output tells you that the name of the data center for your node is, for example, datacenter1.
2. Use CQL to change the replication factor of the keyspace from 1 to 3.

   ```
   ALTER KEYSPACE mykeyspace WITH REPLICATION =  { 'class' :
     'NetworkTopologyStrategy', 'datacenter1' : 3 };
   ```

   If you have data in a keyspace and then change the replication factor, run nodetool repair to avoid having missing data problems or data unavailable exceptions.

Managing caching

Modifying the solrconfig.xml to use the StandardDirectoryFactory.

About this task

The DSENRTCachingDirectoryFactory is deprecated. If you use DSENRTCachingDirectoryFactory or the NRTCachingDirectoryFactory, modify the `solrconfig.xml` to use the StandardDirectoryFactory. For example, change the directoryFactory element in the solrconfig as follows:

```
<directoryFactory class="solr.StandardDirectoryFactory"
 name="DirectoryFactory"/>
```

Capacity planning

Using DSE Search is memory-intensive. Use a discovery process to develop a plan to ensure sufficient memory resources.

About this task

Using DSE Search is memory-intensive. Solr rereads the entire row when updating indexes, and can impose a significant performance hit on spinning disks. Use solid-state drives (SSD) for applications that have very aggressive insert and update requirements.

This capacity planning discovery process helps you develop a plan for having sufficient memory resources to meet the operational requirements.

Overview

First, estimate how large your Solr index will grow by indexing a number of documents on a single node, executing typical user queries, and then examining the field cache memory usage for heap allocation. Repeat this process using a greater number of documents until you get a solid estimate of the size of the index for the maximum number of documents that a single node can handle. You can then determine how many servers to deploy for a cluster and the optimal heap size. Store the index on SSDs or in the system IO cache.

Capacity planning requires a significant effort by operations personnel to achieve these results:

- Optimal heap size per node.
- Estimate of the number of nodes that are required for your application.

  Increase the replication factor to support more queries per second.

Note: The Pre-flight tool can detect and fix many invalid or suboptimal configuration settings.

Before you begin

A node with:

- The amount of RAM that is determined during capacity planning
- SSD or spinning disk

Input data:

- *N* documents indexed on a single test node
- A complete set of sample queries to be executed
- The maximum number of documents the system will support

Procedure

1. Create the `schema.xml` and `solrconfig.xml` files.
2. Start a node.
3. Add *N* docs.
4. Run a range of queries that simulate a production environment.
5. View the status of the field cache memory to discover the memory usage.
6. View the size of the index (on disk) included in the status information about the Solr core.
7. Based on the server's system IO cache available, set a maximum index size per server.
8. Based on the memory usage, set a maximum heap size required per server.

   - For JVM memory to provide the required performance and memory capacity, DataStax recommends a heap size of 14 GB or larger.
   - For live indexing, DataStax recommends a heap size of at least 20 GB.

9. Calculate the maximum number of documents per node based on steps 6 and 7.

When the system is approaching the maximum docs per node, add more nodes.

Managing the field cache memory

The Solr field cache caches values for all indexed documents. To avoid out-of-memory errors, monitor the status of the field cache and set options for storing the cache on disk or on the heap.

The Solr field cache caches values for all indexed documents, which if left unchecked, can result in out-of-memory errors. For example, when performing faceted queries using multi-valued fields the multiValued fields are multi-segmented (as opposed to single segmented single-valued fields), resulting in an inefficient near real time (NRT) performance. You can use densely packed DocValue field types and per-segment docsets. Facet queries will be per-segment, which improves real-time search performance problems.

To ensure that the JVM heap can accommodate the cache, monitor the status of the field cache and take advantage of the Solr option for storing the cache on disk or on the heap. To view the status of the field cache memory usage, append `&memory=true` to the URL used to view the status of Solr cores. For example, to view the field cache memory usage of the DSE Search quick start example after running a few facet queries, use this URL:

```
http://localhost:8983/solr/admin/cores?action=STATUS&memory=true
```

Example 1

For example, the URL for viewing the field cache memory usage in JSON format and the output is:

```
http://localhost:8983/solr/admin/cores?
action=STATUS&wt=json&indent=on&omitHeader=on
  &memory=true

. . .

  "memory":{
    "unInvertedFields":{
      "totalSize":0,
      "totalReadableSize":"0 bytes"},
    "multiSegment":{
      "multiSegment":"StandardDirectoryReader(segments_3:532:nrt _6p(4.6):
      C3193 _71(4.6):C161 _6i(4.6):C15 _6n(4.6):C21 _6e(4.6):C16 _6k(4.6):
      C19 _6t(4.6):C17 _6g(4.6):C10 _77(4.6):C12 _6v(4.6):C9 _7c(4.6):
      C66 _72(4.6):C14 _6x(4.6):C7 _6y(4.6):C7 _6w(4.6):C12)",
      "fieldCache":{
        "entriesCount":0},
      "totalSize":0,
      "totalReadableSize":"0 bytes"},
    "segments":{
      "_6p":{
        "segment":"_6p",
        "docValues":{
        . . .

        "fieldCache":{
          "entriesCount":0},
        "totalSize":51600,
        "totalReadableSize":"50.4 KB"}},
    "totalSize":619200,
    "totalReadableSize":"604.7 KB"}},
"totalMemSize":619200,
"totalReadableMemSize":"604.7 KB"}}
```

Example 2

After running a few sort by query functions, the output looks something like this:

```
 . . .

       "fieldCache":{
         "entriesCount":1,
         "id":{
           "cacheType":"org.apache.lucene.index.SortedDocValues",
           "size":260984,
           "readableSize":"254.9 KB"}},
       "totalSize":260984,
       "totalReadableSize":"254.9 KB"},
     "segments":{

 . . .

         "fieldCache":{
           "entriesCount":2,
           "age":{
             "cacheType":"int",
             "size":3832,
             "readableSize":"3.7 KB"},
           "id":{
             "cacheType":"int",
             "size":3832,
             "readableSize":"3.7 KB"}},
         "totalSize":59232,
         "totalReadableSize":"57.8 KB"}},
     "totalSize":524648,
     "totalReadableSize":"512.4 KB"}},
 "totalMemSize":524648,
 "totalReadableMemSize":"512.4 KB"}}
```

Using the field cache

In Lucene-Solr 4.5 and later, docValues are mostly disk-based to avoid the requirement for large heap allocations in Solr. If you use the field cache in sort, stats, and other queries, make those fields docValues.

Update request processor and field transformer

Use the custom update request processor (URP) to extend the Solr URP. Use the field input/output transformer API as an option to the input/output transformer support in Solr.

DataStax Enterprise supports the classic Solr update request processor (URP), a custom URP chain for processing requests and transforming data, and a field input/output transformer API. The DataStax Enterprise custom URP implementation provides similar functionality to the Solr URP chain, but appears as a plugin to Solr. The classic URP is invoked when updating a document using HTTP, the custom URP when updating a table using Cassandra. If both classic and custom URPs are configured, the classic version is executed first.

A field input/output transformer, an alternative for handling update requests, is executed later than a URP at indexing time. For more information, see the DataStax Developer Blog post DSE field transformers.

Examples are provided for using the custom URP and the field input/output transformer API.

Custom URP example

Use the custom update request processor (URP) to extend the Solr URP.

About this task

DSE Search includes the released version of a plugin API for Solr updates and a plugin to the CassandraDocumentReader. The plugin API transforms data from the secondary indexing API before data is submitted to Solr. The plugin to the CassandraDocumentReader transforms the results data from Cassandra to Solr.

Using the API, applications can tweak a Solr Document before it is mapped and indexed according to the `schema.xml` file. The API is a counterpart to the input/output transformer support in Solr.

The field input transformer (FIT) requires a trailing Z for date field values.

Procedure

To use the API:

1. Configure the custom URP in the `solrconfig.xml`.

```
<dseUpdateRequestProcessorChain name="dse">
    <processor
 class="com.datastax.bdp.search.solr.functional.DSEUpdateRequestProcessorFactoryExamp
    </processor>
</dseUpdateRequestProcessorChain>
```

2. Write a class to use the custom URP that extends the Solr UpdateRequestProcessor. For example:

```
package com.datastax.bdp.search.solr.functional;

import
 com.datastax.bdp.search.solr.handler.update.CassandraAddUpdateCommand;
import
 com.datastax.bdp.search.solr.handler.update.CassandraCommitUpdateCommand;
import
 com.datastax.bdp.search.solr.handler.update.CassandraDeleteUpdateCommand;
import java.io.IOException;

import org.apache.solr.update.AddUpdateCommand;
import org.apache.solr.update.CommitUpdateCommand;
import org.apache.solr.update.DeleteUpdateCommand;
import org.apache.solr.update.MergeIndexesCommand;
import org.apache.solr.update.processor.UpdateRequestProcessor;

public class TestUpdateRequestProcessor extends UpdateRequestProcessor
{
    public boolean cprocessAdd = false;
    public boolean processAdd = false;

    public boolean cprocessDelete = false;
    public boolean processDelete = false;

    public boolean cprocessCommit = false;
    public boolean processCommit = false;

    public TestUpdateRequestProcessor(UpdateRequestProcessor next)
    {
        super(next);
    }

    public void processAdd(AddUpdateCommand cmd) throws IOException
    {
        if (cmd instanceof CassandraAddUpdateCommand)
        {
            cprocessAdd = true;
        }
        else
        {
            processAdd = true;
        }
        super.processAdd(cmd);
    }

    public void processDelete(DeleteUpdateCommand cmd) throws IOException
    {
        if (cmd instanceof CassandraDeleteUpdateCommand)
        {
            cprocessDelete = true;
        }
        else
        {
            processDelete = true;
        }
        super.processDelete(cmd);
    }

    public void processMergeIndexes(MergeIndexesCommand cmd) throws
 IOException
    {
        super.processMergeIndexes(cmd);
    }

    public void processCommit(CommitUpdateCommand cmd) throws IOException
    {
        if (cmd instanceof CassandraCommitUpdateCommand)
        {
            cprocessCommit = true;
        }
        else
        {
            processCommit = true;
        }
        super.processCommit(cmd);
    }
}
```

3. Export the class to a JAR, and place the JAR in this location:

   - Installer-No Services and Tarball installations: `install-location/resources/solr/lib`
   - Installer-Services and Package installations: `/usr/share/dse/solr/lib`

   The JAR is added to the CLASSPATH automatically.
4. Test your implementation. For example:

```
package com.datastax.bdp.search.solr.functional;

import
 com.datastax.bdp.search.solr.handler.update.DSEUpdateProcessorFactory;
import org.apache.solr.core.SolrCore;
import org.apache.solr.update.processor.UpdateRequestProcessor;

public class DSEUpdateRequestProcessorFactoryExample extends
 DSEUpdateProcessorFactory
{
    SolrCore core;
```

```
        public DSEUpdateRequestProcessorFactoryExample(SolrCore core) {
            this.core = core;
        }

        public UpdateRequestProcessor getInstance(
                UpdateRequestProcessor next)
        {
            return new TestUpdateRequestProcessor(next);
        }
    }
```

Field input/output transformer example

Use the field input/output transformer API as an option to the input/output transformer support in Solr.

About this task

Use the field input/output transformer API as an option to the input/output transformer support in Solr.

DSE Search includes the released version of a plugin API for Solr updates and a plugin to the CassandraDocumentReader. The plugin API transforms data from the secondary indexing API before data is submitted to Solr. The plugin to the CassandraDocumentReader transforms the results data from Cassandra to Solr.

Using the API, applications can tweak a Solr Document before it is mapped and indexed according to the `schema.xml`. The API is a counterpart to the input/output transformer support in Solr.

The field input transformer (FIT) requires a trailing Z for date field values.

Procedure

To use the API:

1. Define the plugin in the `solrconfig.xml` for a Cassandra table (Solr core).

```
<fieldInputTransformer name="dse" class="
  com.datastax.bdp.cassandra.index.solr.functional.
  BinaryFieldInputTransformer">
</fieldInputTransformer>

<fieldOutputTransformer name="dse" class="
  com.datastax.bdp.cassandra.index.solr.functional.
  BinaryFieldOutputTransformer">
</fieldOutputTransformer>
```

2. Write a transformer class something like this reference implementation to tweak the data in some way.
3. Export the class to a JAR, and place the JAR in this location:

   - Installer-No Services and Tarball installations: `*install-location*/resources/solr/lib`
   - Installer-Services and Package installations: `/usr/share/dse/solr/lib`

   The JAR is added to the CLASSPATH automatically.
4. Test your implementation using something like the reference implementation.

FIT reference implementation

Field input and output transformer (FIT) class examples.

About this task

The DataStax Developer Blog provides an introduction to DSE Field Transformers.

Here are examples of field input and output transformer (FIT) classes.

Input transformer example

```
package com.datastax.bdp.search.solr.functional;

import java.io.IOException;

import org.apache.commons.codec.binary.Hex;
import org.apache.commons.lang.StringUtils;
import org.apache.lucene.document.Document;
import org.apache.solr.core.SolrCore;
import org.apache.solr.schema.SchemaField;

import com.datastax.bdp.search.solr.FieldOutputTransformer;
import org.apache.solr.schema.IndexSchema;

public class BinaryFieldInputTransformer extends FieldInputTransformer
{
    @Override
    public boolean evaluate(String field)
    {
        return field.equals("binary");
    }

    @Override
    public void addFieldToDocument(SolrCore core,
            IndexSchema schema,
            String key,
            Document doc,
            SchemaField fieldInfo,
            String fieldValue,
            float boost,
            DocumentHelper helper)
            throws IOException
    {
        try
        {
            byte[] raw = Hex.decodeHex(fieldValue.toCharArray());
            byte[] decomp = DSP1493Test.decompress(raw);
            String str = new String(decomp, "UTF-8");
            String[] arr = StringUtils.split(str, ",");
            String binary_name = arr[0];
            String binary_type = arr[1];
            String binary_title = arr[2];

            SchemaField binaryNameField =
 core.getSchema().getFieldOrNull("binary_name");
            SchemaField binaryTypeField =
 core.getSchema().getFieldOrNull("binary_type");
            SchemaField binaryTitleField =
 core.getSchema().getFieldOrNull("binary_title");

            helper.addFieldToDocument(core, core.getSchema(), key, doc,
 binaryNameField, binary_name, boost);
            helper.addFieldToDocument(core, core.getSchema(), key, doc,
 binaryTypeField, binary_type, boost);
            helper.addFieldToDocument(core, core.getSchema(), key, doc,
 binaryTitleField, binary_title, boost);
        }
        catch (Exception ex)
        {
            throw new RuntimeException(ex);
        }
    }
}
```

Output transformer example

```
package com.datastax.bdp.search.solr.functional;

import java.io.IOException;
import org.apache.commons.lang.StringUtils;
import org.apache.lucene.index.FieldInfo;
import org.apache.lucene.index.StoredFieldVisitor;
import com.datastax.bdp.search.solr.FieldOutputTransformer;

public class BinaryFieldOutputTransformer extends FieldOutputTransformer
{
    @Override
    public void binaryField(FieldInfo fieldInfo, byte[] value,
            StoredFieldVisitor visitor, DocumentHelper helper) throws
 IOException
    {
        byte[] bytes = DSP1493Test.decompress(value);
        String str = new String(bytes, "UTF-8");
       String[] arr = StringUtils.split(str, ",");
        String binary_name = arr[0];
        String binary_type = arr[1];
        String binary_title = arr[2];

       FieldInfo binary_name_fi = helper.getFieldInfo("binary_name");
        FieldInfo binary_type_fi = helper.getFieldInfo("binary_type");
        FieldInfo binary_title_fi = helper.getFieldInfo("binary_title");

        visitor.stringField(binary_name_fi, binary_name);
        visitor.stringField(binary_type_fi, binary_type);
        visitor.stringField(binary_title_fi, binary_title);
    }
}
```

Interface for custom field types

The CustomFieldType interface marks Solr custom field types and provides their actual stored field type.

About this task

DataStax Enterprise implements a CustomFieldType interface that marks Solr custom field types and provides their actual stored field type. The custom field type stores an integer trie field as a string representing a comma separated list of integer values: when indexed, the string is split into its integer values, each one indexed as a trie integer field. This class effectively implements a multi-valued field based on its string representation.

To use the CustomFieldType interface:

1. Implement a custom field type class something like the following reference implementation.
2. Export the class to a JAR, and place the JAR in this location:

- Package installations: `usr/share/dse`
- Installer-No Services and Tarball installations: `*install_location*/resources/dse/lib`

The JAR is added to the CLASSPATH automatically.

Reference implementation

Here is an example of a custom field type class:

```
package com.datastax.bdp.search.solr.functional;
```

```
import com.datastax.bdp.search.solr.CustomFieldType;
import java.util.ArrayList;
import java.util.List;
import org.apache.lucene.index.IndexableField;
import org.apache.solr.schema.FieldType;
import org.apache.solr.schema.SchemaField;
import org.apache.solr.schema.StrField;
import org.apache.solr.schema.TrieField;

public class CustomTestField extends TrieField implements CustomFieldType
{
    public CustomTestField()
    {
        this.type = TrieField.TrieTypes.INTEGER;
    }

    @Override
    public FieldType getStoredFieldType()
    {
        return new StrField();
    }

    @Override
    public boolean multiValuedFieldCache()
    {
        return true;
    }

    @Override
    public List<IndexableField> createFields(SchemaField sf, Object value,
 float boost)
    {
        String[] values = ((String) value).split(" ");
        List<IndexableField> fields = new ArrayList<IndexableField>();
        for (String v : values)
        {
            fields.add(createField(sf, v, boost));
        }
        return fields;
    }

    @Override
    public String toInternal(String value)
    {
        return value;
    }

    @Override
    public String toExternal(IndexableField f)
    {
        return f.stringValue();
    }
}
```

Unsupported features

Unsupported Cassandra and DSE Search features.

Unsupported features include Cassandra and Solr features. CQL-based Solr cores require a new type mapping version 2. A CQL table must be created in Cassandra before creating the Solr core. The schema corresponding to a CQL table using a compound primary key requires a special syntax.

Unsupported Cassandra features

- Cassandra 2.0.6 static columns
- Cassandra compound primary keys for COMPACT STORAGE tables
- Cassandra counter columns
- Cassandra super columns
- Cassandra Thrift-compatible tables with column comparators other than UTF-8 or ASCII.

Unsupported Solr features

- Solr schema fields that are both dynamic and multivalued for CQL-based Solr cores (only)
- The deprecated replaceFields request parameters on document updates for CQL-based Solr cores. Use the suggested procedure for inserting/updating data.
- Block joins based on the Lucene BlockJoinQuery in Solr indexes and CQL tables
- Schemaless mode
- Partial schema updates through the REST API after Solr resources are uploaded. For example, to update individual fields of a schema using the REST API to add a new field to a schema, you must change the `schema.xml` file, upload it again to Solr, and reload the core (same for copy fields).
- org.apache.solr.spelling.IndexBasedSpellChecker and org.apache.solr.spelling.FileBasedSpellChecker (org.apache.solr.spelling.DirectSolrSpellChecker is supported for spell checking)
- The commitWithin parameter
- The SolrCloud CloudSolrServer feature of SolrJ for endpoint discovery and round-robin load balancing

Other unsupported features

- Dynamic fields of the Solr type LatLongTypeSolr are not supported.
- DSE Search does not support JBOD mode.
- The commit log replaces the Solr updatelog. The Solr updatelog is not supported in DSE Search. Consequently, features that require the updateLog are not supported. Instead of using atomic updates, partial document updates are available by running the update with CQL.

DSE Search versus Open Source Solr

Differences between DSE Search and Open Source Solr (OSS).

By virtue of its integration into DataStax Enterprise, differences exist between DSE Search and Open Source Solr (OSS).

Major differences

The major differences in capabilities are:

Capability	DSE Search	OS Solr	Description
Includes a database	yes	no	A user has to create an interface to add a database to OSS.
Indexes real-time data	yes	no	Cassandra ingests real-time data and Solr indexes the data.
Provides an intuitive way to update data	yes	no	DataStax provides a SQL-like language and command-line shell, CQL, for loading and updating data. Data added to Cassandra shows up in Solr
Indexes Hadoop output without ETL	yes	no	Cassandra ingests the data, Solr indexes the data, and you run MapReduce against that data in one cluster.

Capability	DSE Search	OS Solr	Description
Supports data distribution	yes	yes [1]	DataStax Enterprise distributes Cassandra real-time, Hadoop, and Solr data to multiple nodes in a cluster transparently.
Balances loads on nodes/shards	yes	no	Unlike Solr and Solr Cloud loads can be rebalanced efficiently.
Spans indexes over multiple data centers	yes	no	A cluster can have more than one data center for different types of nodes.
Automatically re-indexes Solr data	yes	no	The only way to re-index data in Solr is to have the client re-ingest everything.
Stores data added through Solr in Cassandra	yes	no	Data updated using the Solr API shows up in Cassandra.
Makes durable updates to data	yes	no	Updates are durable and written to the Cassandra commit log regardless of how the update is made.
Upgrades of Lucene preserve data	yes	no	DataStax integrates Lucene upgrades periodically and when you upgrade DSE, data is preserved. Solr users must re-ingest all their data after upgrading to Lucene.
Security	yes	no	DataStax has extended SolrJ to protect internal communication and HTTP access. Solr data can be encrypted and audited. For example, use Kerberos or SSL security for a DSE instance and then run secure queries of that DSE instance by using CQL or HTTP.

[1] Requires using Zookeeper.

DSE Search tutorials and demos

Use the tutorials and demos to learn how to use DSE Search.

Use the tutorials and demos to learn how to use DSE Search.

Tutorial: Basics

Setting up for the DSE Search tutorial includes creating a Cassandra node, importing data, and creating resources.

About this task

Setting up DSE Search for this tutorial involves the same basic tasks as setting up a typical application:

- Create a Cassandra table.
- Import data.
- Create resources automatically.

After finishing the setup tasks, you perform these tasks:

- Explore the Solr Admin.
- Search the data using the Solr Admin.
- Search the data using CQL.

In this tutorial, you use some sample data from a health-related census.

Start DSE Search and download files

This setup assumes you started DataStax Enterprise in DSE Search mode and downloaded the sample data and tutorial files. The tutorial files include a CQL table definition, which uses a compound primary key. The partitioning key is the id column and the clustering key is the age column.

Procedure

1. Download the sample data and tutorial files.
2. Unzip the files you downloaded in the DataStax Enterprise installation home directory.
   A `solr_tutorial46` directory is created that contains the following files.
   - `copy_nhanes.cql`

     The `COPY` command you use to import data
   - `create_nhanes.cql`

     The Cassandra CQL table definition
   - `nhanes52.csv`

     The CSV (comma separated value) data
   - `schema.xml` and `solrconfig.xml`

     The Solr schema and configuration file for the advanced tutorial
3. Take a look at these files using your favorite editor.

Create a Cassandra table

Create a Cassandra table as part of the basic tutorial.

Procedure

1. Ensure that your configuration is appropriate, and that you know the snitch for your cluster. See Configuring replication and verify the status of your node:

```
$ nodetool status
```

2. Start cqlsh, and create a keyspace. Use the keyspace.

```
cqlsh> CREATE KEYSPACE nhanes_ks WITH REPLICATION =
       {'class':'NetworkTopologyStrategy', 'Solr':1};

cqlsh> USE nhanes_ks;
```

3. Copy the CQL table definition from the downloaded `create_nhanes.cql` file, and paste it on the cqlsh command line.
   This action creates the nhanes table in the nhanes_ks keyspace.

Import data

After you create a Cassandra table, import data to set up DSE Search for the tutorial.

Procedure

1. Copy the cqlsh `COPY` command from the downloaded `copy_nhanes.cql` file.
2. Paste the `COPY` command on the cqlsh command line, but do not run the command yet.
3. Change the FROM clause to match the path to `/solr_tutorial46/nhanes52.csv` that you downloaded to your computer, and then run the command.

This action imports the data from the CSV file into the nhanes table in Cassandra. Output is:

```
20050 rows imported in 27.524 seconds.
```

Generate resources automatically

After you create a Cassandra table and import data, generate resources to complete the set up of DSE Search for the tutorial.

About this task

You can generate solrconfig and schema resources automatically when creating a core. You can use either a `dsetool` command or an HTTP-post command to automatically generate resources, or you can create the core from custom resources using the classic manual method shown in the advanced tutorial.

Follow these steps to create resources automatically using the `dsetool` command.

Procedure

1. Exit cqlsh.
2. Run the following command, which is located in the bin directory of tarball installations. On a tarball installation:

   ```
   $ bin/dsetool create_core nhanes_ks.nhanes generateResources=true
    reindex=true
   ```

   There is no output from this command. You can search Solr data after indexing finishes.

Explore the Solr Admin

After you create the Solr core, use the browser-based Solr Admin to verify that the Solr index is working.

About this task

After creating the Solr core, you can verify that the Solr index is working by using the browser-based Solr Admin:

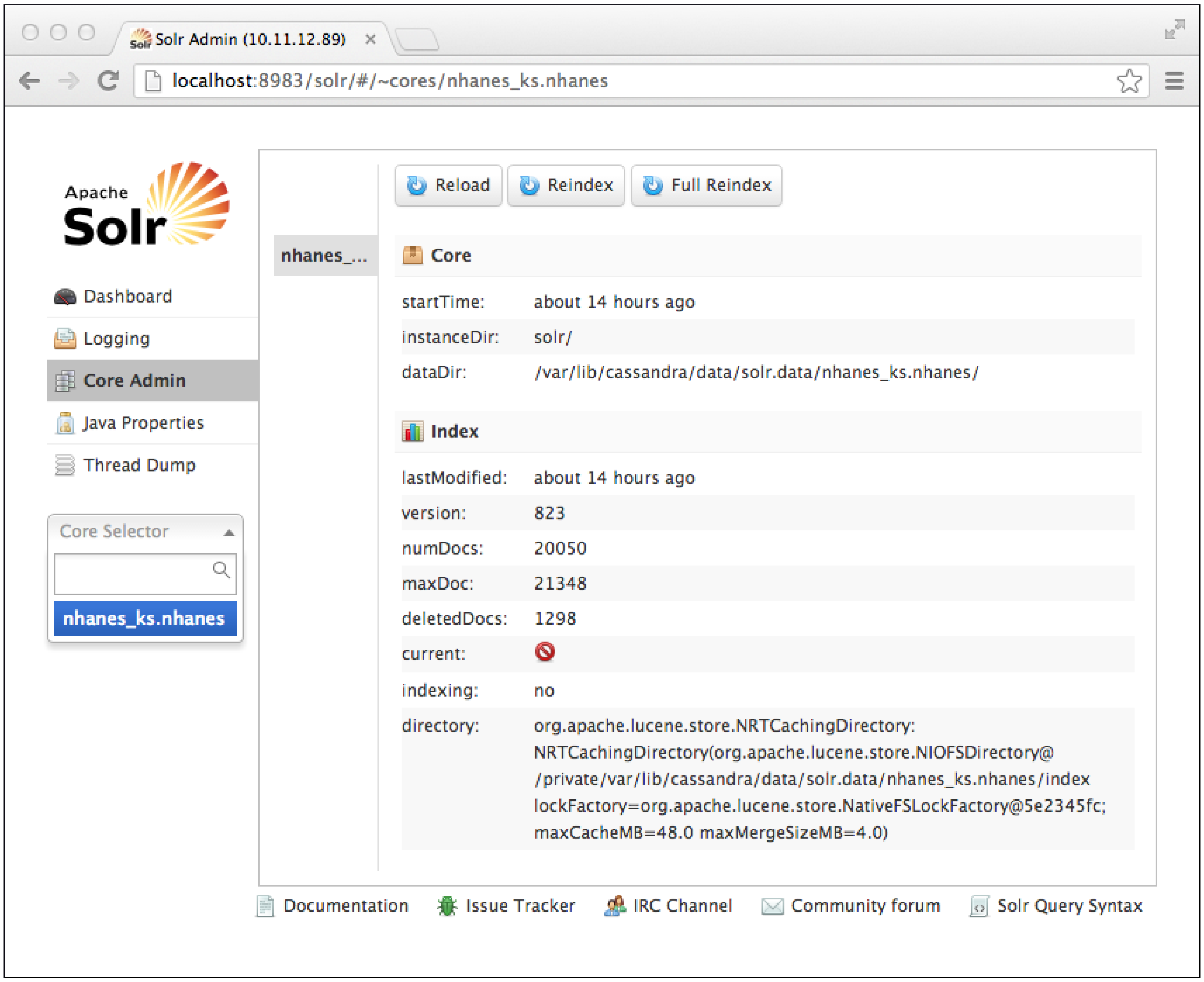
```
http://localhost:8983/solr/
```

Procedure

To explore the Solr Admin:

1. Click Core Admin. Unless you loaded other Solr cores, the path to the default Solr core, nhanes_ks.nhanes, appears.

   At the top of the Solr Admin console, the **Reload**, **Reindex**, and **Full Reindex** buttons perform functions that correspond to `RELOAD` command options. If you modify the `schema.xml` or `solrconfig.xml`, you can use these controls to re-index the data or you can use the classic POST approach used in the advanced tutorial.
2. Check that the numDocs value is 20,050. The number of Solr documents corresponds to the number of rows in the CSV data and nhanes table you created in Cassandra.
3. In **Core Selector**, select the name of the Solr core, nhanes_ks.nhanes.
   Selecting the name of the Solr core brings up additional items, such as **Query**, in the vertical navigation bar.



Core

startTime:	about 14 hours ago
instanceDir:	solr/
dataDir:	/var/lib/cassandra/data/solr.data/nhanes_ks.nhanes/

Index

lastModified:	about 14 hours ago
version:	823
numDocs:	20050
maxDoc:	21348
deletedDocs:	1298
current:	🚫
indexing:	no
directory:	org.apache.lucene.store.NRTCachingDirectory: NRTCachingDirectory(org.apache.lucene.store.NIOFSDirectory@ /private/var/lib/cassandra/data/solr.data/nhanes_ks.nhanes/index lockFactory=org.apache.lucene.store.NativeFSLockFactory@5e2345fc; maxCacheMB=48.0 maxMergeSizeMB=4.0)

Search using the Solr Admin

Using Solr Admin, you have several choices of how to search the database.

About this task

To search the database, you have several choices:

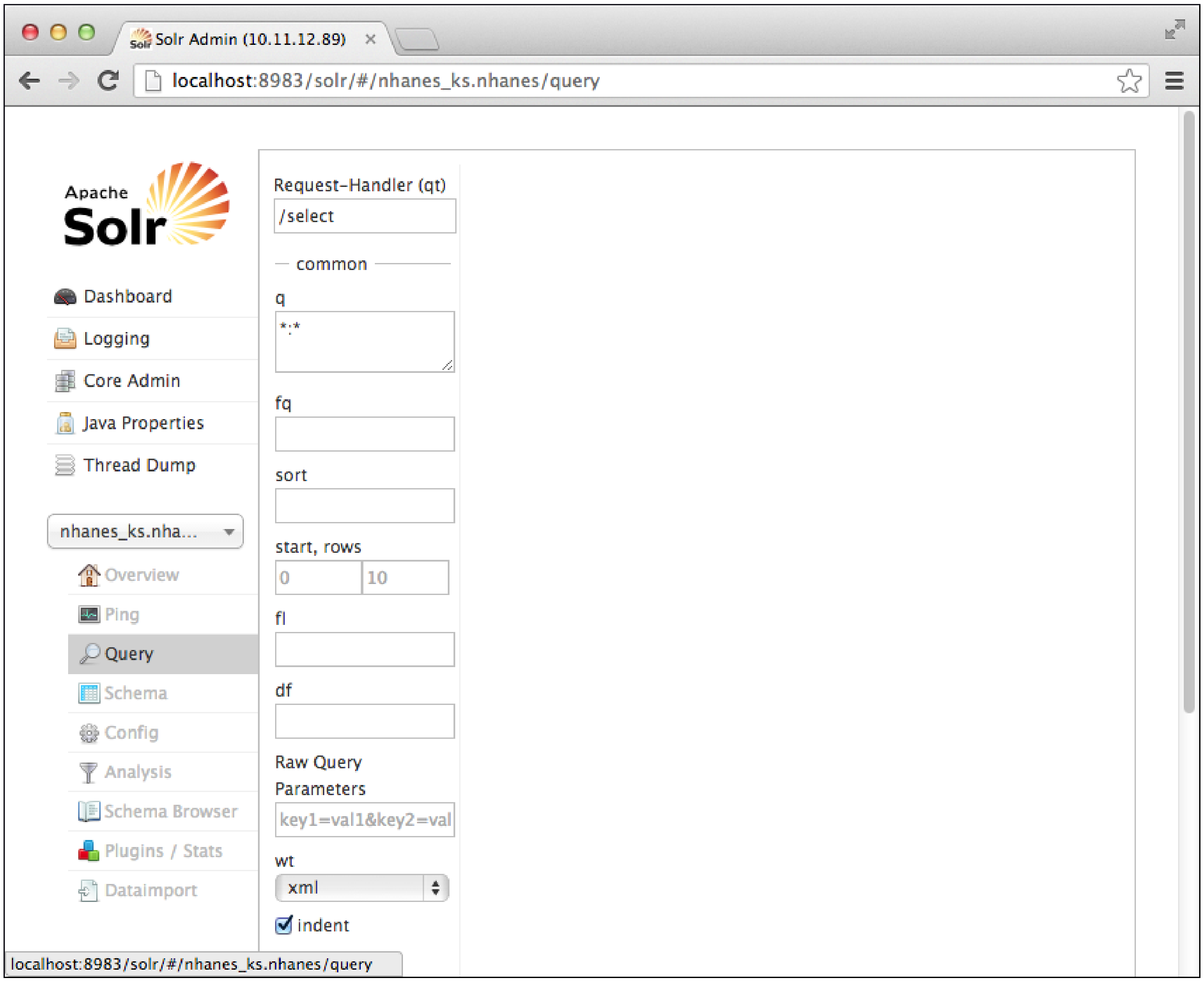
- Run CQL queries in cqlsh or an application.
- Run Solr HTTP API queries in an application, a browser, or on the command line using the curl utility.
- Use the Solr Admin query form.

If you are new to Solr, using the query form has some advantages. The form contains text entry boxes for constructing a query and can provide query debugging information.

Procedure

After generating resources, get started searching the nhanes database by following these steps:

1. In the Solr Admin, click **Query**.
   A query form appears.



Request-Handler (qt): /select

common

q: *:*

fq:

sort:

start, rows: 0 10

fl:

df:

Raw Query Parameters: key1=val1&key2=val

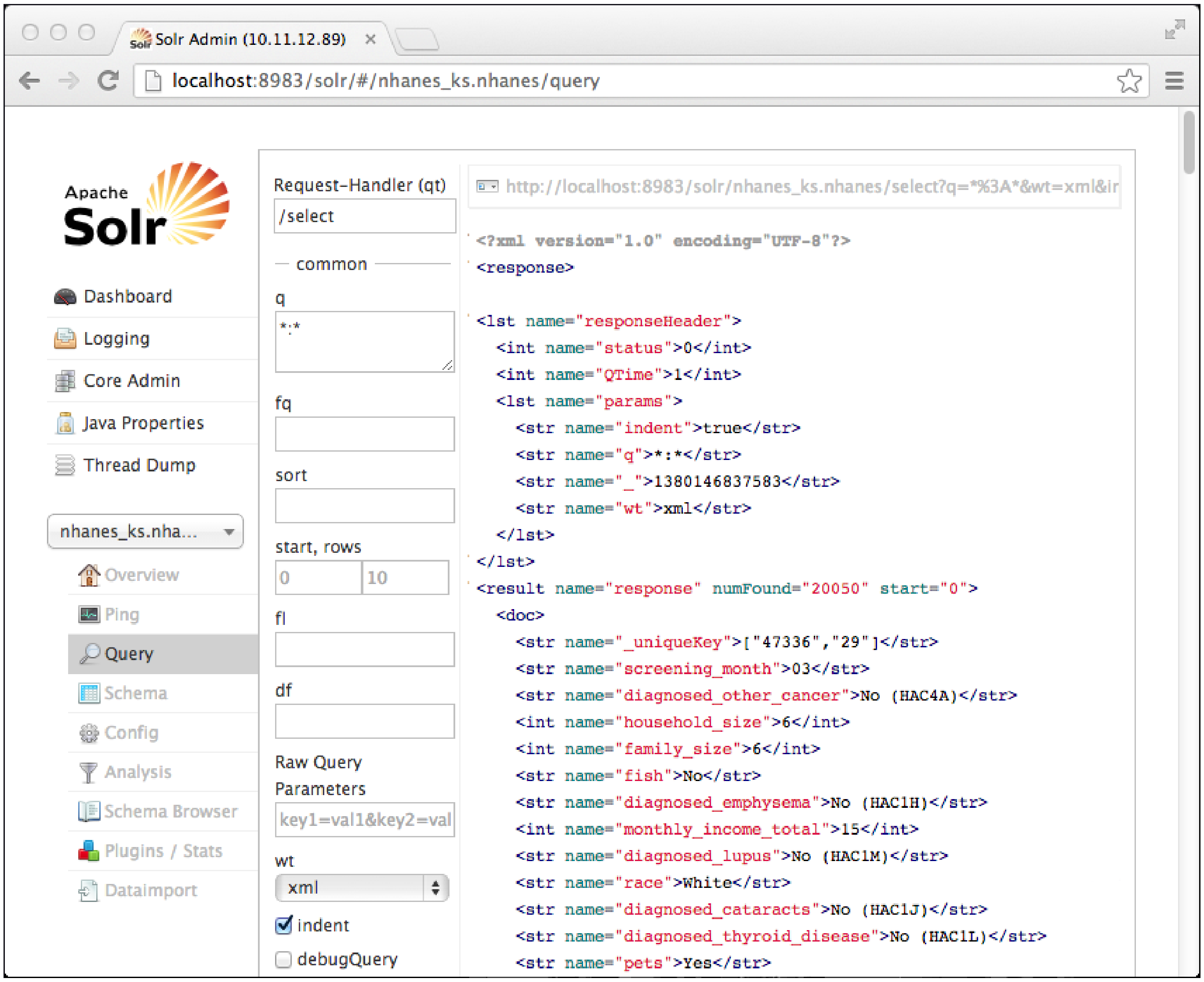
wt: xml

[✓ indent]

localhost:8983/solr/#/nhanes_ks.nhanes/query

Notice that the form has a number of query defaults set up, including the select URL in **Request-Handler (qt)** and *:* in the main query parameter entry box--**q**.

2. Select **xml** from the **wt** drop down.
   Output will appear in XML format.
3. Scroll down the form and click **Execute Query**.
   The defaults select all the fields in all the documents, starting with row 0 and ending at row 10. The output looks something like this:



Request-Handler (qt): /select

common

q: `*:*`

fq

sort

start, rows: 0 10

fl

df

Raw Query Parameters: key1=val1&key2=val

wt: xml

indent [✓]

debugQuery

http://localhost:8983/solr/nhanes_ks.nhanes/select?q=*%3A*&wt=xml&ir

```
<?xml version="1.0" encoding="UTF-8"?>
<response>

<lst name="responseHeader">
  <int name="status">0</int>
  <int name="QTime">1</int>
  <lst name="params">
    <str name="indent">true</str>
    <str name="q">*:*</str>
    <str name="_">1380146837583</str>
    <str name="wt">xml</str>
  </lst>
</lst>
<result name="response" numFound="20050" start="0">
  <doc>
    <str name="_uniqueKey">["47336","29"]</str>
    <str name="screening_month">03</str>
    <str name="diagnosed_other_cancer">No (HAC4A)</str>
    <int name="household_size">6</int>
    <int name="family_size">6</int>
    <str name="fish">No</str>
    <str name="diagnosed_emphysema">No (HAC1H)</str>
    <int name="monthly_income_total">15</int>
    <str name="diagnosed_lupus">No (HAC1M)</str>
    <str name="race">White</str>
    <str name="diagnosed_cataracts">No (HAC1J)</str>
    <str name="diagnosed_thyroid_disease">No (HAC1L)</str>
    <str name="pets">Yes</str>
```

Search using CQL

Tutorial steps to get started using CQL to search the database.

About this task

After generating resources, get started searching the nhanes database by following these steps:

Procedure

1. Start cqlsh.
2. Search the family_size field to find the ids of families of 6 or more.

```
SELECT id FROM nhanes_ks.nhanes WHERE solr_query='family_size:6' LIMIT 3;

 id
-------
 13322
 36213
  8856
```

```
(3 rows)
```

3. Perform a search for the ids of subjects in a Federal Information Processing Standards (fips) region that starts with the letters “Il” and whose ethnicity starts with the letters “Me”.

   ```
   SELECT id FROM nhanes_ks.nhanes WHERE solr_query='fips:Il* AND
    ethnicity:Mex*' LIMIT 5;
   ```

   ```
    id
   -------
    48654
    11298
    36653
    35025
    35344

   (5 rows)
   ```

4. Perform a fuzzy search for subjects are non-Hispanic.

   ```
   select id, ethnicity FROM nhanes_ks.nhanes WHERE
    solr_query='ethnicity:"~Hispanic"' LIMIT 10;
   ```

   ```
   id     | ethnicity
   -------+----------------
    38875 |   Not Hispanic
     7789 |   Not Hispanic
    50309 |   Not Hispanic
    38721 |   Not Hispanic
    48797 |   Not Hispanic
    46146 |   Not Hispanic
    49842 | Other Hispanic
    47675 |   Not Hispanic
    13861 |   Not Hispanic
    13014 |   Not Hispanic

   (10 rows)
   ```

5. Perform a range search for ids of subjects who are from 551 to 590 months old.

   ```
   SELECT id FROM nhanes_ks.nhanes WHERE solr_query='age_months:[551 TO 590}'
    LIMIT 3;
   ```

   ```
    id
   -------
   50309
   40371
   32907

   (3 rows)
   ```

6. Perform a JSON-based query that searches for the ids of subjects whose ethnicity is Mexican-American. Sort the results by id in descending order.

   ```
   SELECT id FROM nhanes_ks.nhanes WHERE solr_query='{"q":"ethnicity:Mexi*",
    "sort":"id asc"}' LIMIT 3;
   ```

   ```
    id
   -------
    53582
   ```

```
 53592
 53595

(3 rows)
```

Tutorial: Advanced

This DSE Search tutorial builds on the basic tutorial and requires prerequisites.

Before attempting to step through this tutorial, complete the following prerequisites:

- Install the curl utility on your computer.
- Perform the “Setup,” “Create a Cassandra table,” and “Import data” sections of the basic tutorial.

Use facets: Solr Admin

Tutorial steps for a faceted search to drill down into filter search results that are based on a category of data.

About this task

Distributed pivot faceting is supported. This tutorial performs a faceted search using the Solr Admin query form to drill down into filter search results that are based on a category of data.

Faceting is the arrangement of search results into categories based on indexed terms. Searchers are presented with the indexed terms, along with numerical counts of how many matching documents were found were each term. Faceting makes it easy to explore search results by narrowing the search results to what you are looking for.

Procedure

The following steps drill down into the health census database that you set up in the basic tutorial. Use the Solr Admin to query the database using the age facet parameter in a query.

1. Open the Solr Admin.

   ```
   http://localhost:8983/solr/
   ```

2. In **Core Selector**, select the name of the Solr core, nhanes_ks.nhanes.
3. Click Core Admin and then click Query.
4. In the Solr Admin query form, specify a family size of 9 in the main query parameter text entry box--**q**:

   ```
   family_size:9
   ```

5. In **sort**, specify sorting by age in ascending order, youngest to oldest:

   ```
   age asc
   ```

6. In **fl** (filter list), specify returning only age and family size in results:

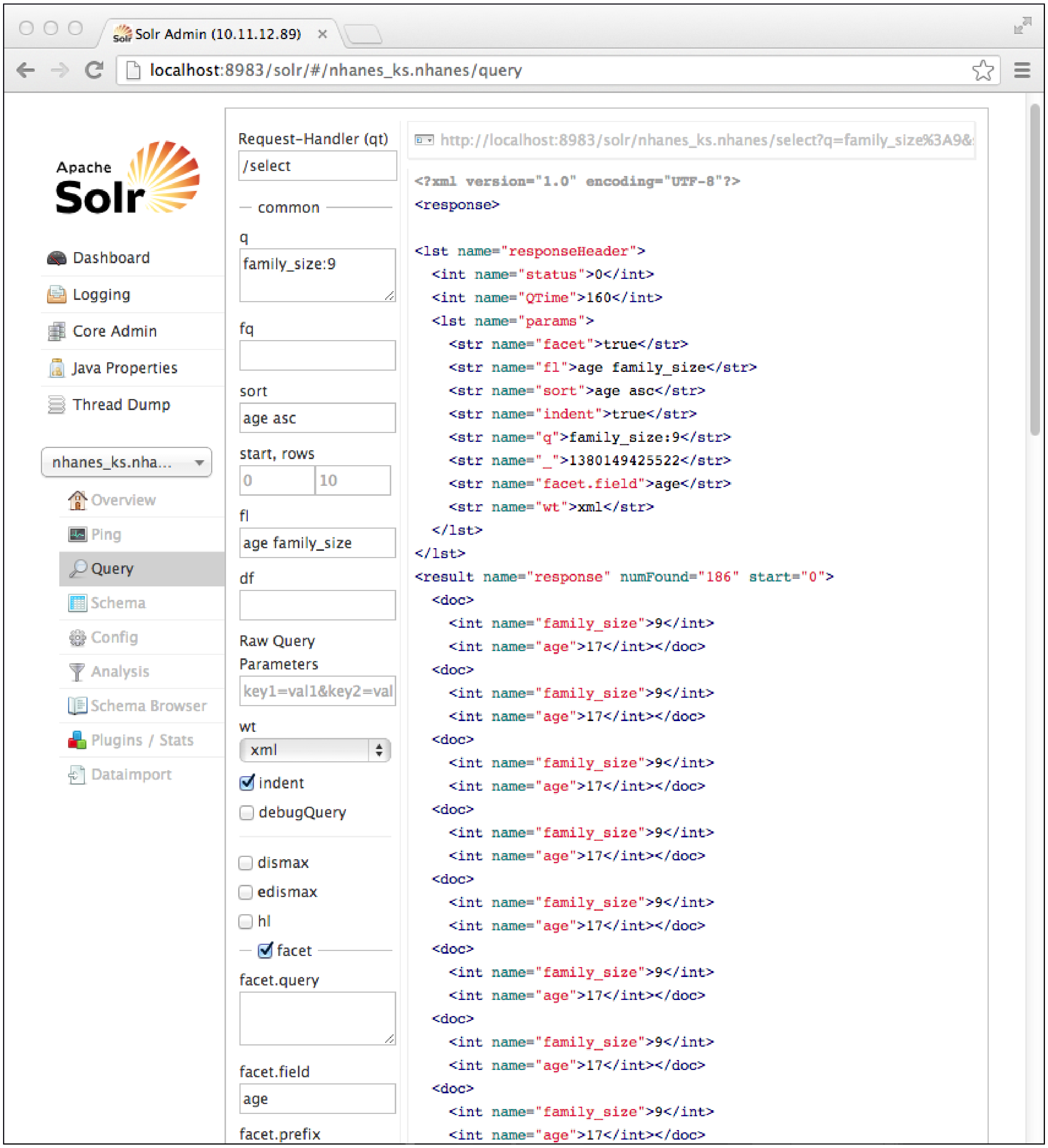
   ```
   age family_size
   ```

   Results from the main query will include only data about families of 9.
7. Select **xml** from the **wt** drop down.
   Output will appear in XML format.
8. Select the **facet** option.
   Text entry boxes for entering facet parameter values appear.
9. In **facet.field**, type this value:

   ```
   age
   ```

The number of people in each age group will appear toward the end of the query results.

10.Click **Execute Query**.
The numfound value shows that 186 families having nine members were found. The query results include only results from the fields in the filter list, age and family_size.



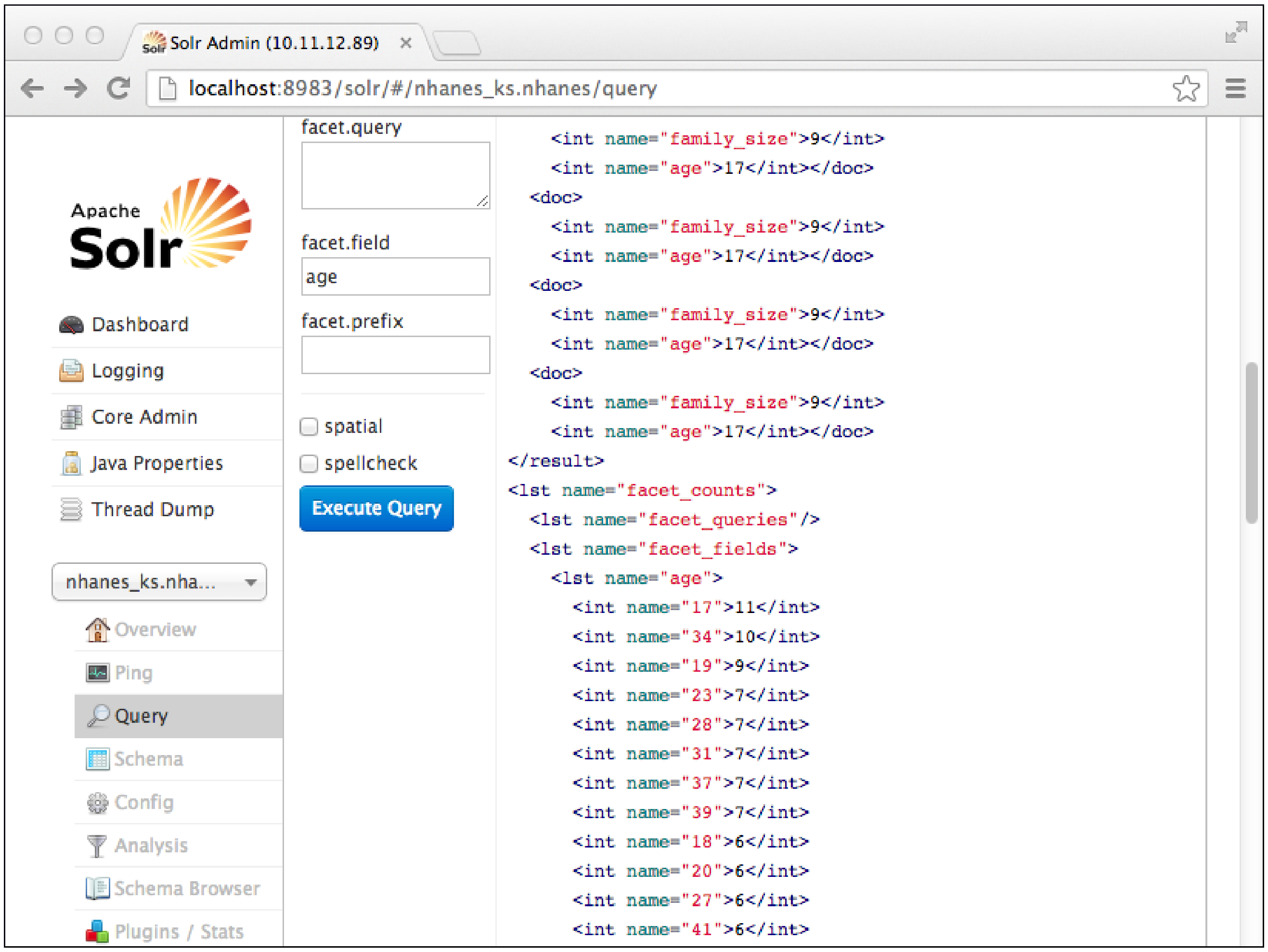
Request-Handler (qt): /select
common
q: family_size:9
fq:
sort: age asc
start, rows: 0 10
fl: age family_size
df:
Raw Query Parameters: key1=val1&key2=val
wt: xml
[✓] indent
[ ] debugQuery
[ ] dismax
[ ] edismax
[ ] hl
[✓] facet
facet.query:
facet.field: age
facet.prefix

http://localhost:8983/solr/nhanes_ks.nhanes/select?q=family_size%3A9&

```
<?xml version="1.0" encoding="UTF-8"?>
<response>

<lst name="responseHeader">
  <int name="status">0</int>
  <int name="QTime">160</int>
  <lst name="params">
    <str name="facet">true</str>
    <str name="fl">age family_size</str>
    <str name="sort">age asc</str>
    <str name="indent">true</str>
    <str name="q">family_size:9</str>
    <str name="_">1380149425522</str>
    <str name="facet.field">age</str>
    <str name="wt">xml</str>
  </lst>
</lst>
<result name="response" numFound="186" start="0">
  <doc>
    <int name="family_size">9</int>
    <int name="age">17</int></doc>
  <doc>
    <int name="family_size">9</int>
    <int name="age">17</int></doc>
  <doc>
    <int name="family_size">9</int>
    <int name="age">17</int></doc>
  <doc>
    <int name="family_size">9</int>
    <int name="age">17</int></doc>
  <doc>
    <int name="family_size">9</int>
    <int name="age">17</int></doc>
  <doc>
    <int name="family_size">9</int>
    <int name="age">17</int></doc>
  <doc>
    <int name="family_size">9</int>
    <int name="age">17</int></doc>
  <doc>
    <int name="family_size">9</int>
    <int name="age">17</int></doc>
```

11.Scroll to the end of the query form to see the facet results.
The facet results show 11 people of age 17, 10 of age 34, and so on.



```
    <int name="family_size">9</int>
    <int name="age">17</int></doc>
  <doc>
    <int name="family_size">9</int>
    <int name="age">17</int></doc>
  <doc>
    <int name="family_size">9</int>
    <int name="age">17</int></doc>
  <doc>
    <int name="family_size">9</int>
    <int name="age">17</int></doc>
</result>
<lst name="facet_counts">
  <lst name="facet_queries"/>
  <lst name="facet_fields">
    <lst name="age">
      <int name="17">11</int>
      <int name="34">10</int>
      <int name="19">9</int>
      <int name="23">7</int>
      <int name="28">7</int>
      <int name="31">7</int>
      <int name="37">7</int>
      <int name="39">7</int>
      <int name="18">6</int>
      <int name="20">6</int>
      <int name="27">6</int>
      <int name="41">6</int>
```

Distributed pivot faceting is supported. You can do field, query, and range faceting with a JSON query.

Search the data: Solr HTTP API

Use the Solr HTTP API to run search queries.

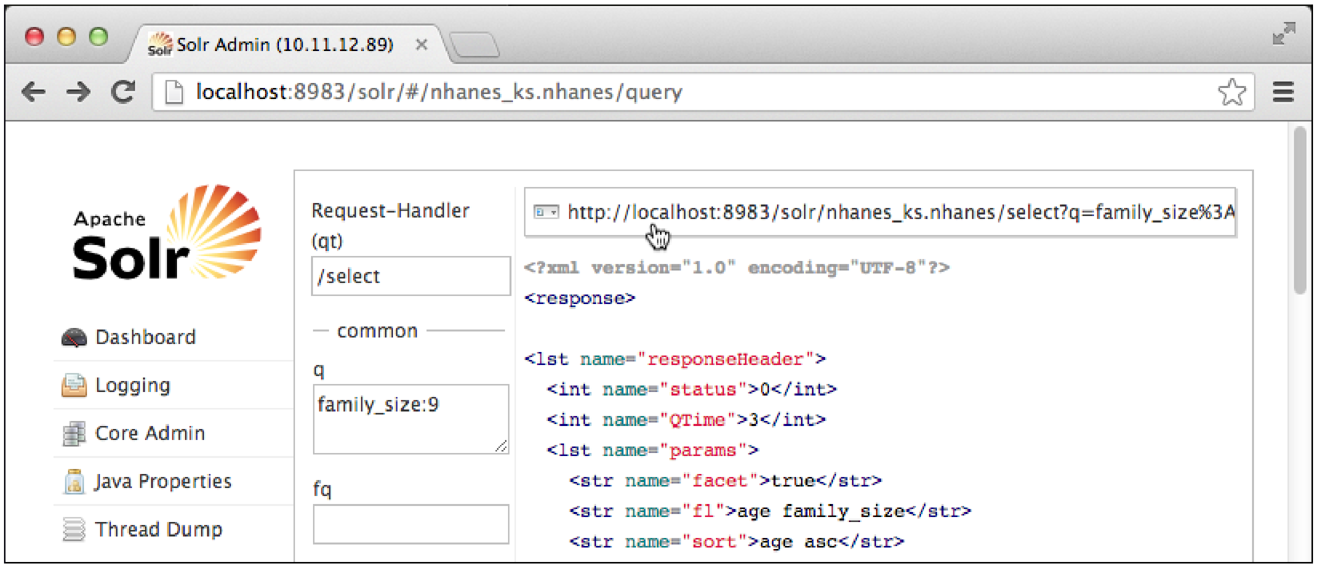
About this task

You can use the Solr HTTP API to run search queries. The Solr Admin query form is limited, but useful for learning about Solr, and can even help you get started using the Solr HTTP API. The queries in Solr HTTP format appear at the top of the form. After looking at a few URLs, you can try constructing queries in Solr HTTP format.

Procedure

To get started using the Solr HTTP API:

1. Scroll to the top of the form, and click the greyed out URL.



```
<?xml version="1.0" encoding="UTF-8"?>
<response>

<lst name="responseHeader">
  <int name="status">0</int>
  <int name="QTime">3</int>
  <lst name="params">
    <str name="facet">true</str>
    <str name="fl">age family_size</str>
    <str name="sort">age asc</str>
```

A page of output, independent of the query form, appears that you can use to examine and change the URL. The URL looks like this:

```
http://localhost:8983/solr/nhanes_ks.nhanes/select?
  q=family_size%3A9&sort=age+asc&fl=age+family_size
  &wt=xml&indent=true&facet=true&facet.field=age
```

2. In the URL in the address bar, make these changes:

   FROM:

   ```
   q=family_size%3A9
   &fl=age+family_size
   ```

   TO:

   ```
   q=age:[20+TO+40]
   &fl=age+family_size+num_smokers
   ```

   The modified URL looks like this:

   ```
   http://localhost:8983/solr/nhanes_ks.nhanes/select?
     q=age:[20+TO+40]&sort=age+asc&fl=age+family_size+num_smokers
     &wt=xml&indent=true&facet=true&facet.field=age
   ```

   In the Solr Admin query form, you can use spaces in the range [20 TO 40], but in the URL, you need to use URL encoding for spaces and special characters. For example, use + or %20 instead of a space, [20+TO+40].
3. Use the modified URL to execute the query. Move to the end of the URL, and press ENTER.

   The number of hits increases from 186 to 7759. Results show the number of smokers and family size of families whose members are 20-40 years old. Facets show how many people fell into the various age groups.

   ```
   . . .
     </doc>
   </result>
   <lst name="facet_counts">
   <lst name="facet_queries"/>
    <lst name="facet_fields">
   ```

```
      <lst name="age">
      <int name="23">423</int>
      <int name="24">407</int>
      <int name="31">403</int>
      <int name="30">388</int>
      <int name="40">382</int>
      <int name="28">381</int>
      <int name="27">378</int>
      <int name="21">377</int>
      <int name="33">377</int>
      <int name="22">369</int>
      <int name="29">367</int>
      <int name="20">365</int>
      <int name="32">363</int>
      <int name="34">361</int>
      <int name="36">361</int>
      <int name="25">358</int>
      <int name="26">358</int>
      <int name="35">358</int>
      <int name="38">353</int>
      <int name="37">339</int>
      <int name="39">291</int>
      <int name="17">0</int>
    . . .
```

Create a CQL collection

In these advanced DSE Search tutorial steps, you create a Cassandra table having a map collection column.

About this task

Using dynamic fields, you process multiple Solr fields the same way by using a generic prefix or suffix to reference the field. In this task, you create a Cassandra table having a map collection column. This column will correspond to a dynamic field that you set up in the Solr schema in the next task.

Procedure

1. Create a keyspace.

   ```
   CREATE KEYSPACE mykeyspace
     WITH REPLICATION = {'class':'NetworkTopologyStrategy', 'Solr':1};

   USE mykeyspace;
   ```

2. Create a table having a map collection column. Apply the dynamic field naming convention that you plan to use in the schema to the column name.

   ```
   CREATE TABLE hits (
     song uuid,
     lang_ map<text, text>,
     PRIMARY KEY (song)
   );
   ```

3. Insert the following data about Italian and Hawaiian songs into the hits table. Use the lang_ to prefix the first component of each map pair.

   ```
   INSERT INTO hits (song, lang_) VALUES
    ( 62c36092-82a1-3a00-93d1-46196ee77204, { 'lang_i-title'  : 'La Vita E La
    Felicita', 'lang_i-artist' : 'Michele Bravi' });
   ```

```
INSERT INTO hits (song, lang_) VALUES ( 8a172618-b121-4136-bb10-
f665cfc469eb, { 'lang_h-title'  : 'Blew it', 'lang_h-artist' : 'Maoli f/
 Fiji' });
INSERT INTO hits (song, lang_) VALUES ( a3e64f8f-bd44-4f28-
b8d9-6938726e34d4, { 'lang_i-title'  : 'Dimmi Che Non Passa Felicita',
 'lang_i-artist' : 'Violetta' });
```

Create a custom schema

In these advanced DSE Search tutorial steps, you replace the basic tutorial Solr schema with a custom schema.

About this task

The tutorial files that you downloaded in the "Setup" section of the basic tutorial include a Solr schema and a solrconfig file. You replace the schema with a custom schema that corresponds to the hits table and defines a dynamic field.

Procedure

1. Open the `schema.xml` in the solr_tutorial46 directory.
2. Compare the schema with the corresponding hits table that you created.

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<schema name="topHits" version="1.5">
  <types>
    <fieldType class="org.apache.solr.schema.TextField" name="TextField">
      <analyzer>
        <tokenizer class="solr.StandardTokenizerFactory"/>
        <filter class="solr.LowerCaseFilterFactory"/>
      </analyzer>
    </fieldType>
    <fieldType class="org.apache.solr.schema.UUIDField" name="UUIDField"/>
  </types>
<fields>
  <dynamicField indexed="true" multiValued="false" name="lang_*"
 stored="true" type="TextField"/>
  <field indexed="true" multiValued="false" name="song" stored="true"
 type="UUIDField"/>
</fields>
<uniqueKey>song</uniqueKey>
</schema>
```

The uniqueKey is the name of the CQL primary key. The dynamicField is the name of the CQL lang_ column plus the asterisk wildcard suffix. A tokenizer determines the parsing of the example text. The fields specify the data that Solr indexes and stores. You will be able to query on data using lang_*, as shown later in this tutorial.

Check the request handler

In these advanced DSE Search tutorial steps, verify that solrconfig.xml includes a solr_query request handler that is required to run CQL Solr queries.

About this task

To run CQL Solr queries, the `solrconfig.xml` must include a solr_query request handler. An automatically generated solrconfig includes this request handler. Verify that the `solrconfig.xml` file includes the request handler.

Procedure

1. In a text editor, open the `solrconfig.xml` file in the solr_tutorial46 directory that you downloaded.

2. In your editor, search the `solrconfig.xml` file for "SearchHandler".

   You see this location:

   ```
   <!-- SearchHandler

          http://wiki.apache.org/solr/SearchHandler

          For processing Search Queries, the primary Request Handler
          provided with Solr is "SearchHandler" It delegates to a sequent
          of SearchComponents (see below) and supports distributed
          queries across multiple shards
       -->
   ```

3. Check that the following request handler appears below the SearchHandler comment.

   ```
   <requestHandler
    class="com.datastax.bdp.search.solr.handler.component.CqlSearchHandler"
         name="solr_query">
   ```

   If the solr_query request handler is not in `solrconfig.xml`, add it.

Upload custom resources

In these advanced DSE Search tutorial steps, you create a search index using the cURL utility.

About this task

Create a search index using the curl command line tool. On the operating system command line in the solr_tutorial46 directory, post the configuration and schema, and create a Solr core.

Procedure

Post the configuration file.

```
dsetool create_core mykeyspace.mycolumnfamily solrconfig=/path/my/
solrconfig.xml schema=/path/my/schema.xml
```

The return code 0 indicates success.

Search the dynamic field

In these advanced DSE Search tutorial steps, search the dynamic field to find data.

About this task

To find data about hit songs in Italy, query on either of the prefixed map literals, lang_i-title or lang_i-artist.

Procedure

1. Open a browser.
2. Enter this Solr HTTP query in the address bar:

   ```
   http://localhost:8983/solr/mykeyspace.hits/select?q=lang_i-title
   %3A*&wt=xml&indent=true
   ```

   ```
   <result name="response" numFound="2" start="0">
     <doc>
       <str name="song">62c36092-82a1-3a00-93d1-46196ee77204</str>
       <str name="lang_i-artist">Michele Bravi</str>
       <str name="lang_i-title">La Vita E La Felicita</str.</doc>
     <doc>
   ```

```
        <str name="song">a3e64f8f-bd44-4f28-b8d9-6938726e34d4</str>
        <str name="lang_i-artist">Violetta</str>
        <str name="lang_i-title">Dimmi Che Non Passa Felicita</str></doc>
    </result>
```

Running Wikipedia demo using DSE Search

Run the Wikipedia demo using DSE Search on a single node to download Wikipedia articles, create a CQL table, store the articles, and index the articles in Solr.

About this task

The following instructions describe how to run the Wikipedia demo on a single node. You run scripts that download 3,000 Wikipedia articles, create a CQL table, store the articles, and index the articles in Solr. The demo includes a web interface for querying the articles. You can also use the Solr HTTP API or CQL to query the articles.

The scripts that you run in this demo are written to set up the localhost and fail if the default interface of the node is not 127.0.0.1.

Procedure

1. Start DataStax Enterprise as a Solr node if you haven't already done so.
2. Go to the wikipedia demo directory.
   - Installer-Services and Package installations: `$ cd /usr/share/dse/demos/wikipedia`
   - Installer-No Services and Tarball installations: `$ cd` *`install_location`*`/demos/wikipedia`
3. Upload the schema by running the add schema script. On Linux, for example:

   ```
   $ ./1-add-schema.sh
   ```

   The script posts `solrconfig.xml` and `schema.xml` to these locations:

   - `http://localhost:8983/solr/resource/wiki.solr/solrconfig.xml`
   - `http://localhost:8983/solr/resource/wiki.solr/schema.xml`

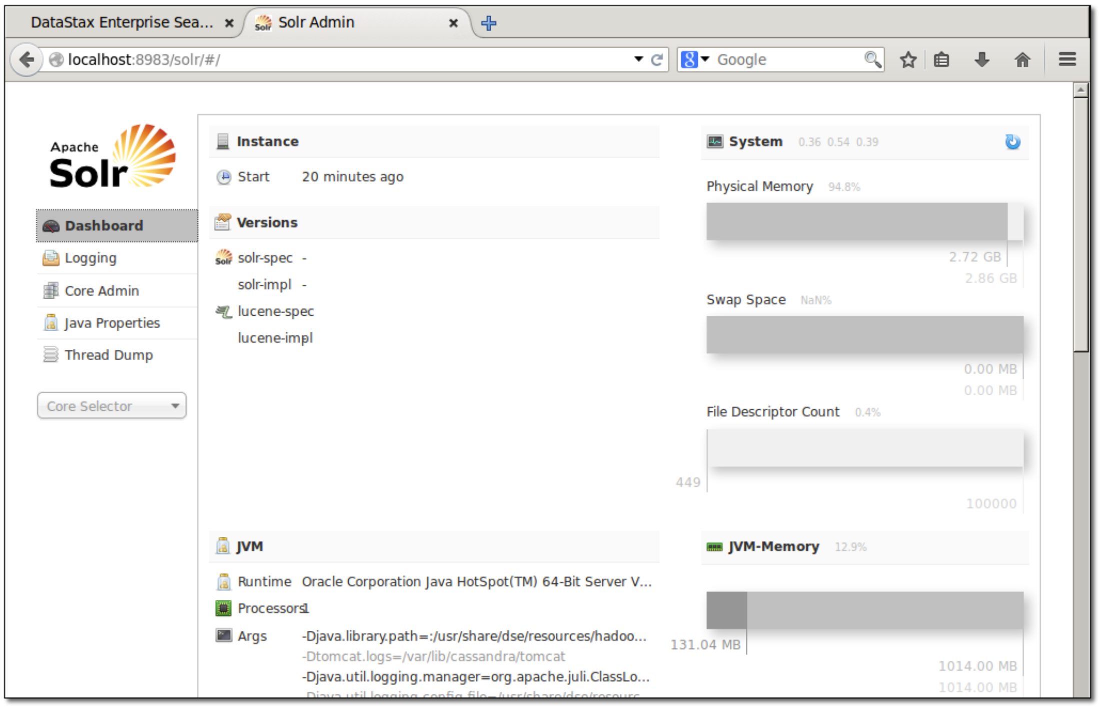
   The script also creates the Solr index and core. The wiki.solr part of the URL creates the keyspace (wiki) and the column family (solr) in Cassandra.
4. Index the articles contained in the `wikipedia-sample.bz2` file in the demo directory by running the index script.

   ```
   $ ./2-index.sh --wikifile wikipedia-sample.bz2
   ```

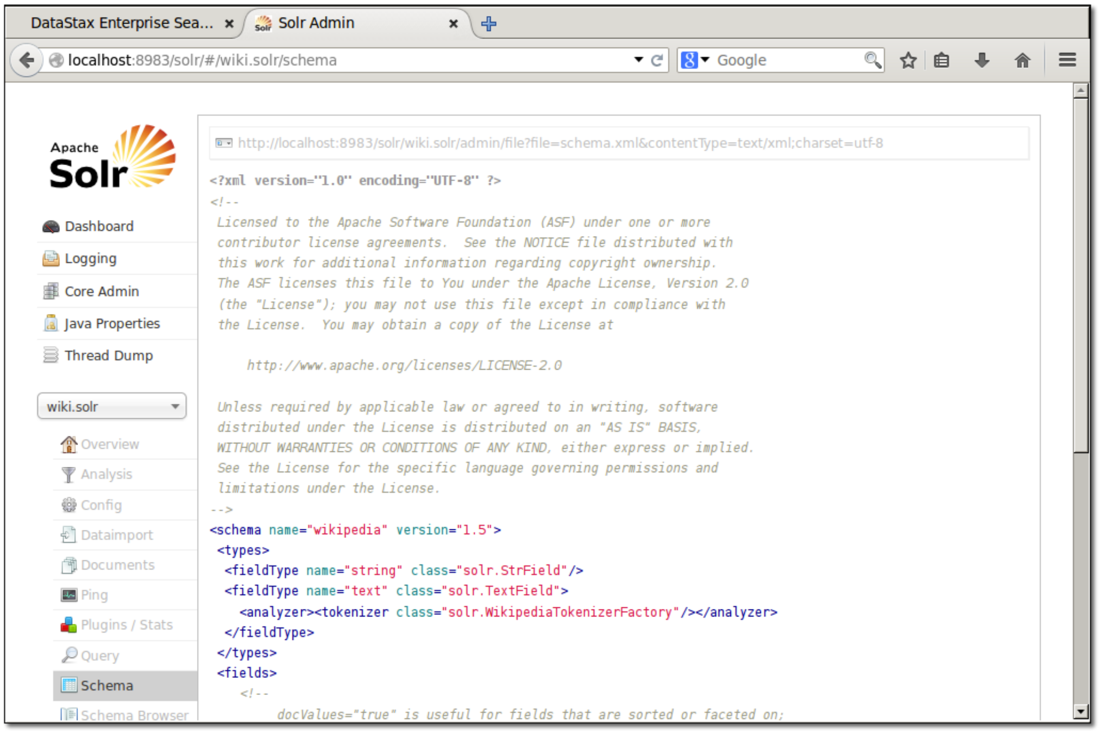
   Three thousand articles load.
5. Open the **Solr Admin** tool.

   Be sure to enter the trailing "/".

   ```
    http://localhost:8983/solr/
   ```



6. Inspect the schema. In the **Solr Admin**, select wiki.solr from the **Core Selector** drop-down. Click the **Schema** in the vertical navigation bar.



```
http://localhost:8983/solr/wiki.solr/admin/file?file=schema.xml&contentType=text/xml;charset=utf-8

<?xml version="1.0" encoding="UTF-8" ?>
<!--
 Licensed to the Apache Software Foundation (ASF) under one or more
 contributor license agreements.  See the NOTICE file distributed with
 this work for additional information regarding copyright ownership.
 The ASF licenses this file to You under the Apache License, Version 2.0
 (the "License"); you may not use this file except in compliance with
 the License.  You may obtain a copy of the License at

     http://www.apache.org/licenses/LICENSE-2.0

 Unless required by applicable law or agreed to in writing, software
 distributed under the License is distributed on an "AS IS" BASIS,
 WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or implied.
 See the License for the specific language governing permissions and
 limitations under the License.
-->
<schema name="wikipedia" version="1.5">
 <types>
  <fieldType name="string" class="solr.StrField"/>
  <fieldType name="text" class="solr.TextField">
    <analyzer><tokenizer class="solr.WikipediaTokenizerFactory"/></analyzer>
  </fieldType>
 </types>
 <fields>
    <!--
         docValues="true" is useful for fields that are sorted or faceted on;
```

You can use the Solr Admin to query the Wikipedia database in Cassandra. You can also use the Solr HTTP API or cqlsh to query the database.

7. Start cqlsh, and use the wiki keyspace. Execute a CQL select statement using the solr_query expression to find the titles in the table named solr that begin with the letters natio:

```
USE wiki;
```

```
SELECT title FROM solr WHERE solr_query='title:natio*';
```

The output, sorted in lexical order, appears:

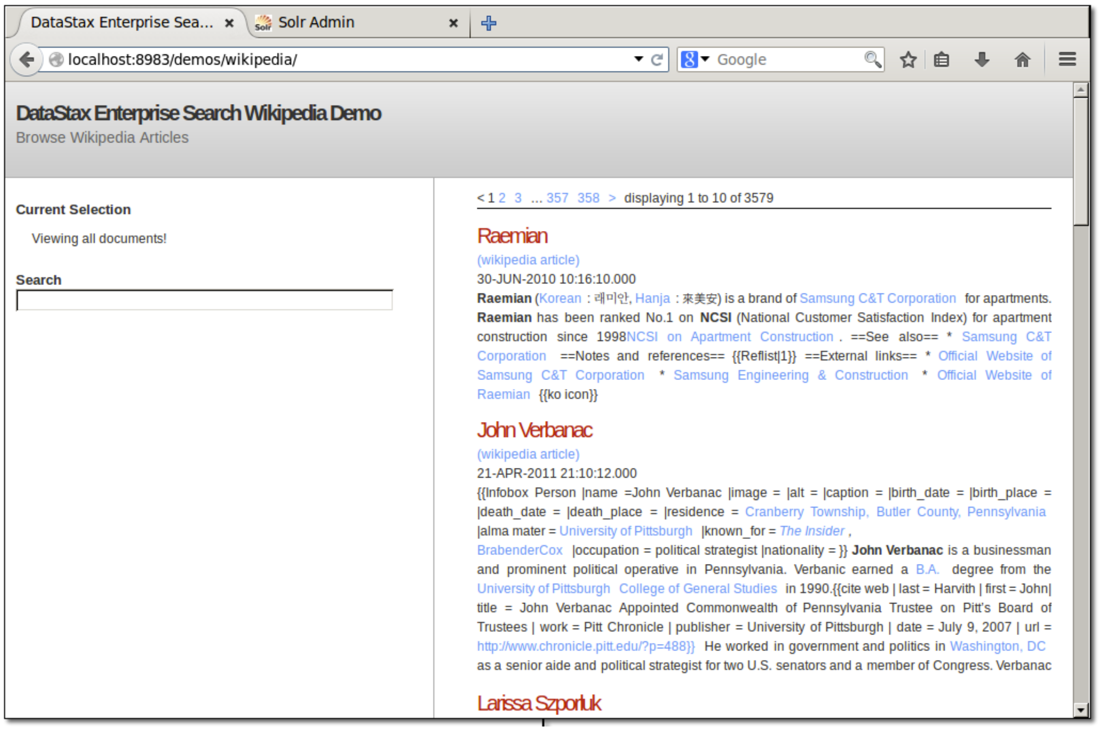
```
 title
--------------------------------------------------------------------------
                                     Kenya national under-20 football team
                                       Bolivia national football team 2002
                                  Israel men's national inline hockey team
  List of French born footballers who have played for other national teams
                                       Bolivia national football team 1999
                                       Bolivia national football team 2001
                                       Bolivia national football team 2000
```

Using CQL, you can enclose the Solr query string in single quotation marks. For example, after running the Solr Demo, you can use these Solr query strings:

Type of Query	Example	Description
Field search	'title:natio* AND Kenya'	You can use multiple fields defined in the schema: 'title:natio* AND body:CarlosAragonés'
Wildcard search	'Ken?a'	Use ? or * for single or multi-character searches.
Fuzzy search	'Kenya~'	Use with caution, many hits can occur.
Phrase search	'"American football player"'	Searches for the phrase enclosed in double quotation marks.
Proximity search	'"football Bolivia"~10'	Searches for football and Bolivia within 10 words of each other.
Range searches	'title:[football TO soccer}'	Supports both inclusive and exclusive bounds using square brackets and curly braces, respectively.
Term boosting	'"football"^4 "soccer"'	By default, the boost factor is 1. Must be a positive number.
Boolean operator	'+Macedonian football'	AND, +, OR, NOT and - can be used.
Grouping	'(football OR soccer) AND Carlos Aragonés'	Use parentheses to group clauses.
Field grouping	'title:(+football +"Bolivia")'	Use parentheses to group multiple clauses into one field.

8. To see the sample Wikipedia search UI, open your web browser and go to this URL:

```
http://localhost:8983/demos/wikipedia
```



DataStax Enterprise Search Wikipedia Demo

Browse Wikipedia Articles

Current Selection

Viewing all documents!

Search

< 1 2 3 ... 357 358 > displaying 1 to 10 of 3579

Raemian

(wikipedia article)

30-JUN-2010 10:16:10.000

Raemian (Korean : 래미안, Hanja : 來美安) is a brand of Samsung C&T Corporation for apartments. **Raemian** has been ranked No.1 on **NCSI** (National Customer Satisfaction Index) for apartment construction since 1998NCSI on Apartment Construction . ==See also== * Samsung C&T Corporation ==Notes and references== {{Reflist|1}} ==External links== * Official Website of Samsung C&T Corporation * Samsung Engineering & Construction * Official Website of Raemian {{ko icon}}

John Verbanac

(wikipedia article)

21-APR-2011 21:10:12.000

{{Infobox Person |name =John Verbanac |image = |alt = |caption = |birth_date = |birth_place = |death_date = |death_place = |residence = Cranberry Township, Butler County, Pennsylvania |alma mater = University of Pittsburgh |known_for = *The Insider* , BrabenderCox |occupation = political strategist |nationality = }} **John Verbanac** is a businessman and prominent political operative in Pennsylvania. Verbanic earned a B.A. degree from the University of Pittsburgh College of General Studies in 1990.{{cite web | last = Harvith | first = John| title = John Verbanac Appointed Commonwealth of Pennsylvania Trustee on Pitt's Board of Trustees | work = Pitt Chronicle | publisher = University of Pittsburgh | date = July 9, 2007 | url = http://www.chronicle.pitt.edu/?p=488}} He worked in government and politics in Washington, DC as a senior aide and political strategist for two U.S. senators and a member of Congress. Verbanac

Larissa Szporluk

9. To search in the bodies of the articles, enter a word in the Search field, and press Enter.

Running the Wikipedia search demo on a secure cluster

You can run the Wikipedia, stress, and log search demo directories on a secure cluster.

Kerberos Options

- -a enable Kerberos authentication
- -h *hostname* server hostname (not required if server hostname resolution is correctly set up)

HTTP Basic Authentication

Use with Cassandra's PasswordAuthenticator.

- -u username
- -p password

SSL Options

- -e *cert* enable HTTPS for client to node encryption, using *cert* certificate file
- -k disable strict hostname checking for SSL certificates

Troubleshooting

Take appropriate action to troubleshoot inconsistent query results, trace Solr HTTP requests, and use Mbeans.

Handling inconsistencies in query results

Consider session stickiness, subrange node repair, and follow best practices for soft commit points on different replica nodes.

DSE Search implements an efficient, highly available distributed search algorithm on top of Cassandra, which tries to select the minimum number of replica nodes required to cover all token ranges, and also avoid hot spots. Consequently, due to the eventually consistent nature of Cassandra, some replica nodes might not have received or might not have indexed the latest updates yet. This situation might cause DSE Search to return inconsistent results (different numFound counts) between queries due to different replica node selections. This behavior is intrinsic to how highly available distributed systems work, as described in the ACM article, "Eventually Consistent" by Werner Vogels. Most of the time, eventual consistency is not an issue, yet DSE Search implements *session stickiness* to guarantee that consecutive queries will hit the same set of nodes on a healthy, stable cluster, hence providing monotonic results. Session stickiness works by adding a *session seed* to request parameters as follows:

```
shard.shuffling.strategy=SEED
shard.shuffling.seed=<session id>
```

In the event of unstable clusters with missed updates due to failures or network partitions, consistent results can be achieved by repairing nodes using the subrange repair method.

Finally, another minor source of inconsistencies is caused by different soft commit points on different replica nodes: A given item might be indexed and committed on a given node, but not yet on its replica. This situation is primarily a function of the load on each node. Implement the following best practices:

- Evenly balance read/write load between nodes
- Properly tune soft commit time and async indexing concurrency
- Configure back pressure in the dse.yaml file

About back pressure

To maximize insert throughput, DSE/Solr buffers insert requests from Cassandra so that application insert requests can be acknowledged as quickly as possible. However, if too many requests accumulate in the buffer (a configurable setting), DSE/Solr pauses or blocks incoming requests until DSE/Solr catches up with the buffered requests. In extreme cases, that pause causes a timeout to the application. See "Multi-threaded indexing in DSE Search."

Tracing Solr HTTP requests

To troubleshoot queries, trace Solr HTTP requests.

For debugging and troubleshooting queries, you can trace Solr HTTP requests in one of the following ways:

- Enable probabilistic tracing.
- Pass an explicit cassandra.trace=true request parameter in the HTTP query.

After running the example of using a join query, you can trace the join query by adding the cassandra.trace parameter to the HTTP request:

```
http://localhost:8983/solr/internet.songs/select/?
q={!join+from=song+to=id+fromIndex=internet.lyrics
+force=true}words:love&indent=true&wt=json&cassandra.trace=true
```

The Solr response includes a cassandra.trace.session value, the unique session id of the tracing session for the request:

```
{
  "cassandra.trace.session":"3e503490-bdb9-11e3-860f-73ded3cb6170",
  "responseHeader":{
    "status":0,
    "QTime":1,
    "params":{
      "indent":"true",
      "q":"{!join from=song to=id fromIndex=internet.lyrics
 force=true}words:love",
      "wt":"json",
      "cassandra.trace":"true"}},
  "response":{"numFound":2,"start":0,"docs":[
      {
        "id":"8a172618-b121-4136-bb10-f665cfc469eb",
        "title":"Internet Love Song",
        "artist":"John Cedrick"},
      {
        "id":"a3e64f8f-bd44-4f28-b8d9-6938726e34d4",
        "title":"Dangerous",
        "artist":"Big Data"}]
}}
```

To see the information from the trace, query the system_traces.events, using the session id to filter the output.

```
cqlsh> select * from system_traces.events where session_id = 3e503490-
bdb9-11e3-860f-73ded3cb6170;

 session_id  | activity
             | source_elapsed
-------------
+-----------------------------------------------------------------------------
+----------------
 3e503490... |          Parsing SELECT * from "internet"."songs" WHERE "id"
 = 8a172618...|           2607
 3e503490... |
 Preparing statement |           3943
 3e503490... |                                Executing single-partition
 query on songs |           4246
 3e503490... |                                             Acquiring
 sstable references |           4261
 3e503490... |                                              Merging
 memtable tombstones |           4305
 3e503490... |                                              Key cache hit
 for sstable 1 |           4388
 3e503490... |                        Seeking to partition indexed section
 in data file |           4399
 3e503490... | Skipped 0/1 non-slice-intersecting sstables, included 0 due
 to tombstones |           4873
 3e503490... |                               Merging data from memtables
 and 1 sstables |           4954
 3e503490... |                                       Read 1 live and 0
 tombstoned cells |           5162
 3e503490... |        Parsing SELECT * from "internet"."songs" WHERE "id" =
 a3e64f8f...  |           6160
 3e503490... |
 Preparing statement |           7424
 . . .
```

For example purposes, the event_id, node IP address, and thread id have been deleted from this output to fit on the page.

In the case of distributed queries over several nodes, Cassandra uses the same tracing session id on all nodes, which makes it possible to correlate Cassandra operations on all the nodes taking part in the distributed query.

Using Solr MBeans

The solr/NativeAllocatorStats MBean exposes native memory allocation.

DataStax Enterprise provides enhanced visibility into native memory allocation through the solr/ NativeAllocatorStats MBean, exposing the following information:

- enabled: if native memory is enabled or not.
- debug: if debug mode is enabled or not.

- numAlloc: number of native objects allocations.
- numFree: number of freed native objects.
- activeAllocatedMemoryInBytes: allocated native memory currently in use.
- totalAllocatedMemoryInBytes: total allocated native memory over time.
- totalFreedMemoryInBytes: total freed native memory over time.

The solr/NativeTrackerStats MBean provides information about the tracked native objects and related threads that allocated them:

- registeredThreads: number of threads currently registered and actively tracking (allocating) native objects.
- trackedObjects: number of currently tracked (allocated and not freed) native objects.
- handedOffObjects: number of currently handed off (allocated and stored for later reuse) native objects.

Using the ShardRouter Mbean

Use the com.datastax.bdp:type=ShardRouter Mbean to retrieve information and update the list of endpoints.

The ShardRouter Mbean, not present in open source Solr, provides information about how DSE search routes queries. JMX Mbeans can be accessed by connecting to the (default) JMX port 7199 on any DataStax Enterprise node using a JMX application like JConsole. The following the attributes and operations are available in this Mbean:

- getShardSelectionStrategy(String core) retrieves the name of the shard selection strategy used for the given Solr core.
- getEndpoints(String core) retrieves the list of endpoints that can be queried for the given Solr core.
- getEndpointLoad(String core) retrieves the list of endpoints with related query load for the given Solr core. The load is computed as a 1-minute, 5-minutes and 15-minutes exponentially weighted moving average, based on the number of queries received by the given node.
- refreshEndpoints() manually refreshes the list of endpoints to be used for querying Solr cores.

DSE Advanced Security

DataStax Enterprise includes advanced data protection for enterprise-grade databases including LDAP authentication support, internal authentication, object permissions, encryption, Kerberos authentication, and data auditing.

About security management

An overview of DataStax Enterprise security.

About this task

DataStax Enterprise includes advanced data protection for enterprise-grade databases:

- LDAP authentication support for external LDAP services.
- Internal authentication using login accounts and passwords
- Managing object permissions using internal authorization based on the GRANT/REVOKE paradigm
- Client-to-node encryption using SSL for data going from the client to the Cassandra cluster and for Sqoop-imported and exported data
- Node to node encryption using SSL for data between nodes
- Kerberos authentication to allow nodes to communicate over a non-secure network by proving their identity to one another in a secure manner using tickets
- Configuring and using data auditing for creating detailed audit trails of cluster activity
- Transparent data encryption that transparently encodes data flushed from the memtable in system memory to the SSTables on disk (at rest data), making the at rest data unreadable by unauthorized users

The TCP-communications layer for Solr supports client-to-node and node-to-node encryption using SSL, but does not support Kerberos.

If you use the bring your own Hadoop (BYOH) model and use Kerberos to protect your data, configure external Hadoop security under Kerberos on your cluster. For information about configuring Hadoop security, see "Using Cloudera Manager to Configure Hadoop Security" or the Hortonworks documentation.

The DataStax Java Driver and DataStax C# Driver, available on the DataStax web site, enables Kerberos support and also SSL for client/server communication.

Limitations

Assuming you configure security features, this table describes which data is secured (or not) based on the workload type: transactional DSE Cassandra, DSE Analytics (Hadoop/Spark), and DSE Search.

Feature	DSE/ Cassandra	DSE Hadoop	Solr	Spark
Internal authentication	Yes	Yes [1]	No	Yes [2]
LDAP/Object permission management	Yes	Partial [3]	Partial [3]	Partial [3]
Client to node encryption	Yes [4]	Yes [5]	Yes [6]	Yes [7]
Kerberos authentication	Yes [8]	Yes	Yes	Yes [2]
Transparent data encryption	Yes [9]	Yes	Partial [10]	No

Feature	DSE/ Cassandra	DSE Hadoop	Solr	Spark
Data auditing	Yes	Partial [11]	Full	Partial [11]

[1] Password authentication pertains to connecting Hadoop to Cassandra, not authenticating Hadoop components between each other.

[2] Password authentication pertains to connecting Spark to Cassandra, not authenticating Spark components between each other, for internal authentication and Kerberos. The Spark Web UI is not secured and might show the Spark configuration, including username, password, or delegation token when Kerberos is used.

[3] Permissions to access objects stored in Cassandra are checked. The Solr cache and indexes and the DSE Hadoop cache are not under control of Cassandra, and therefore are not checked. You can, however, set up permission checks to occur on tables that store DSE Hadoop or Solr data.

[4] The inter-node gossip protocol is protected using SSL.

[5] The Thrift interface between DSE Hadoop and the Cassandra File System (CFS) is SSL-protected. Inter-tracker communication is Kerberos authenticated, but not SSL secured. Hadoop access to Cassandra is SSL- and Kerberos-protected.

[6] HTTP access to the DSE Search data is protected using SSL. Node-to-node encryption using SSL protects internal Solr communication.

[7] SSL client-to-node encryption is for Spark Executor to Cassandra connections only.

[8] The inter-node gossip protocol is not authenticated using Kerberos. Node-to-node encryption using SSL can be used.

[9] Cassandra commit log data is not encrypted, only at rest data is encrypted.

[10] Data in DSE Search tables is encrypted by Cassandra. Encryption has a slight performance impact, but ensures the encryption of original documents after Cassandra permanently stores the documents on disk. However, Solr cache data and Solr index data (metadata) is not encrypted.

[11] DSE Hadoop and Spark data auditing is done at the Cassandra access level, so requests to access Cassandra data is audited. Node-to-node encryption using SSL protects communication over inter-node gossip protocol.

Using Kerberos and SSL at the same time

Both the Kerberos and SSL libraries provide authentication, encryption, and integrity protection:

- Kerberos - If you enable Kerberos authentication, integrity protection is also enabled. However, you can enable integrity protection without encryption.
- SSL - When using SSL, authentication, integrity protection, and encryption are all enabled or disabled.
- Kerberos and SSL - You can enable both Kerberos authentication and SSL together. However, this causes some overlap because authentication is performed twice by two different schemes: Kerberos authentication and certificates through SSL. DataStax recommends choosing one and using it for both encryption and authentication. These settings are described in the dse.yaml configuration file.

Security options for sstableloader

The procedure for securing sstableloader has changed slightly from previous releases.

Authenticating a cluster with Kerberos

DataStax Enterprise authentication with Kerberos protocol uses tickets to prove identity for nodes that communicate over non-secure networks.

Kerberos guidelines

An overview of Kerberos in DataStax Enterprise and recommendations.

About this task

DataStax Enterprise cluster can use Kerberos for security.

Kerberos is a computer network authentication protocol that allows nodes communicating over a non-secure network to prove their identity to one another in a secure manner using tickets. For information on installing and setting up Kerberos, see the MIT Kerberos Consortium.

Caution: When using Kerberos security, be aware of the scope of Kerberos tickets. Using the su or sudo command leaves existing credentials behind and requires you to re-authenticate as that new user. If you encounter authentication issues, ensure that you have a proper Kerberos ticket.

Using Kerberos with DataStax Enterprise

- Using Kerberos and SSL at the same time
- Using dsetool with Kerberos.

To configure Kerberos in an external Hadoop system, see "Using Cloudera Manager to Configure Hadoop Security" or the Hortonworks documentation.

Kerberos guidelines

The following are general guidelines for setting up Kerberos:

- Before implementing Kerberos on your DataStax Enterprise nodes, set up your Kerberos servers.
- Set up several machines as authentication servers (Key Distribution Center [KDC]). One server will be the primary or administration KDC, the other servers are secondary.
- Do not install the KDC servers on DataStax Enterprise nodes.
- Set up firewalls on each KDC server.
- Physically protect the KDC machines.
- Secure the keytab files that are owned by the user running DataStax Enterprise. The files should be readable and writable only by the owner, without permissions for any other user (chmod 0600).
- If using Oracle Java 7, you must use at least 1.7.0_25. If using Oracle Java 8, you must use at least 1.8.0_40.

AES-256 support

How to remove AES-256 settings and steps for installing the JCE Unlimited Strength Jurisdiction Policy Files.

About this task

Because JCE-based products are restricted for export to certain countries by the U.S. Export Administration Regulations, DataStax Enterprise does not ship with the Java Cryptography Extension (JCE) Unlimited Strength Jurisdiction Policy. DataStax recommends installing the JCE Unlimited Strength Jurisdiction Policy Files:

If not using AES-256

If you do not use AES-256, you must remove the AES-256 settings as an allowed cypher for each principal and then regenerate the keys for the krbtgt principal. Remove AES-256 settings in one of the following ways:

- If you have **not** created the principals, use the -e flag to specify encryption:salt type pairs. For example: -e "arcfour-hmac:normal des3-hmac-sha1:normal". This method requires Kerberos 5-1.2 on the KDC.
- If you have already created the principals, modify the Kerberos principals using the -e flag as described above and then recreate the keytab file. This method requires Kerberos 5-1.2 on the KDC.

  Alternately, you can modify the `/etc/krb5kdc/kdc.conf` file by removing any entries containing aes256 from the *supported_enctypes* variable for the realm in which the DSE nodes are members. Then change the keys for the krbtgt principal.

Note: If the KDC is used by other applications, changing the krbtgt principal's keys invalidates any existing tickets. To prevent this, use the -keepold option when executing the `change_password` command. For example:

```
'cpw -randkey krbtgt/krbtgt/REALM@REALM'
```

Procedure

Installing the JCE Unlimited Strength Jurisdiction Policy Files.

1. Download the Cryptography Extension (JCE) Unlimited Strength Jurisdiction Policy Files from Oracle Java SE download page.
2. Unzip the downloaded file.
3. Copy `local_policy.jar` and `US_export_policy.jar` to the `$JAVA_HOME/jre/lib/security` directory overwriting the existing JARS.

Securing DataStax Enterprise nodes with Kerberos

Steps for securing DataStax Enterprise nodes with Kerberos.

About this task

Do not upgrade DataStax Enterprise and set up Kerberos at the same time; see Security Recommendations.

Procedure

Perform the following steps on every node:

1. Install the Kerberos client software.

   Note: If using Oracle Java 7, you must use at least 1.7.0_25. If using Oracle Java 8, you must use at least 1.8.0_40.
2. If you are not using the JCE Unlimited Strength Jurisdiction Policy, make sure that your ticket granting principal does not use AES-256.
3. Use Kerberos to generate one keytab file for each node:

   ```
   kadmin -p username/admin
   addprinc -randkey dse/FQDN
   addprinc -randkey HTTP/FQDN
   ktadd -k dse.keytab dse/FQDN
   ktadd -k dse.keytab HTTP/FQDN
   quit
   ```

   - -randkey creates a random password.

- ktadd -k creates a keytab for the dse and HTTP principals; -k specifies the keytab file name. In this example, the keytab entry is added to the `dse.keytab` file in the current directory.

4. In the cassandra.yaml file, set the authenticator as Kerberos:

```
authenticator: com.datastax.bdp.cassandra.auth.KerberosAuthenticator
```

The location of the cassandra.yaml file depends on the type of installation:

Package installations	`/etc/cassandra/cassandra.yaml`
Tarball installations	`*install_location*/resources/cassandra/conf/cassandra.yaml`

5. Change the replication strategy and default replication factor for the system_auth keyspace. See Configuring system_auth keyspace replication.

DataStax recommends configuring system_auth keyspaces for fault tolerance (in case of failure). In a multi-node cluster, if the node storing the user data goes down, the default replication factor of 1 for the system_auth keyspace precludes logging into any secured node.

The location of the dse.yaml file depends on the type of installation:

Installer-Services	`/etc/dse/dse.yaml`
Package installations	`/etc/dse/dse.yaml`
Installer-No Services	`*install_location*/resources/dse/conf/dse.yaml`
Tarball installations	`*install_location*/resources/dse/conf/dse.yaml`

6. Set the DataStax Enterprise service principals, keytab location, and qop (Quality of Protection) in the dse.yaml file:

```
kerberos_options:
   keytab: path_to_keytab/dse.keytab
   service_principal: dse_user/_HOST@REALM
   http_principal: HTTP/_HOST@REALM
   qop: auth
```

a) Set the service_principal that the Cassandra and Hadoop processes run under. It must use the form *dse_user*/_HOST@*REALM*, where *dse_user* is cassandra in package and GUI/Text Services installs (the name of the user running the service) and the name of the UNIX user that starts the service in tarball and GUI/Text No Services installs. It must be consistent everywhere: in the `dse.yaml`, present in the keytab, and in the `cqlshrc` file (where it is separated into the *service*/*hostname*).

b) Set *REALM* to the name of your Kerberos realm. In the Kerberos principal, *REALM* must be all uppercase.

c) Leave _`HOST` as is. DataStax Enterprise automatically substitutes the FQDN (Fully Qualified Domain Name) of the host where it runs. There must be credentials for this principal in the keytab file and readable by the user that Cassandra runs as, usually cassandra.

d) The `http_principal` is used by the application container, which is tomcat, and used to run Solr. The web server uses GSS-API mechanism (SPNEGO) to negotiate the GSSAPI security mechanism (Kerberos). To set up password authentication for a DSE Search node, see Running the Wikipedia search demo on a secure cluster.

e) The keytab file must contain the credentials for both of the fully resolved principal names, which replace _HOST with the FQDN of the host in the `service_principal` and `http_principal` settings. The UNIX user running DataStax Enterprise must also have read permissions on the keytab.

f) The `qop` is a comma delimited list of Quality of Protection values that clients and servers can use for each connection. The client can have multiple QOP values, while the server can have only a single QOP value. The available settings are:

- `auth` - authentication only [default]
- `auth-int` - authentication plus integrity protection for all transmitted data
- `auth-conf` - authentication plus integrity protection and encryption of all transmitted data

For example, if the realm name is foo.com and keytab file is in the `resources/dse/conf` directory:

```
kerberos_options:
   keytab: resources/dse/conf/dse.keytab
   service_principal: cassandra/_HOST@FOO.COM
   http_principal: HTTP/_HOST@FOO.COM
   qop: auth
```

Be sure that the realm name is uppercase.

Creating Kerberos users

You can use password authentication or the cassandra@REALM Kerberos principal to create Kerberos users.

About this task

The location of the cassandra.yaml file depends on the type of installation:

Package installations	`/etc/cassandra/cassandra.yaml`
Tarball installations	*`install_location`*`/resources/cassandra/conf/cassandra.yaml`

DataStax Enterprise automatically creates a `cassandra` superuser, which you can authenticate as and use `cqlsh` to create other users. Two methods are available:

- Password authentication:
  1. In the cassandra.yaml file, set the authenticator to `org.apache.cassandra.auth.PasswordAuthenticator`:

     ```
     authenticator: org.apache.cassandra.auth.PasswordAuthenticator
     ```
  2. Start `cqlsh` and login using the superuser name and password:

     ```
     $ ./cqlsh -u cassandra -p cassandra
     ```
  3. Create the other Kerberos users, such as `user@REALM`. Be sure to create at least one with superuser privileges.
  4. Remove the `cassandra` user. See DROP USER. This step is optional but highly recommended.
  5. Re-enable Kerberos authorization in the `cassandra.yaml` file:

     ```
     authenticator: com.datastax.bdp.cassandra.auth.KerberosAuthenticator
     ```
- `cassandra@REALM` Kerberos principal:
  1. As shown in step 6 in *Authenticating a DataStax Enterprise cluster with Kerberos*, create a `cassandra@REALM` Kerberos principal and turn on Kerberos authorization.
  2. Log in and create the other Kerberos users. Be sure to create at least one user with superuser privileges.
  3. Remove the cassandra user. See DROP USER. This step is optional but highly recommended.

Enabling and disabling Kerberos security

Turn Kerberos authorization on and off by changing the authenticator in cassandra.yaml.

After setting up Kerberos users, you can turn Kerberos authorization on and off by changing the authenticator in the cassandra.yaml file:

- On: `com.datastax.bdp.cassandra.auth.KerberosAuthenticator`
- Off: any other authenticator

The location of the cassandra.yaml file depends on the type of installation:

Package installations	`/etc/cassandra/cassandra.yaml`
Tarball installations	*`install_location`*`/resources/cassandra/conf/cassandra.yaml`

Using cqlsh with Kerberos security

Install required packages to use cqlsh with Kerberos.

About this task

To use cqlsh with a Kerberized cluster, you must install the PyKerberos and python-pure-sasl packages.

- The PyKerberos package is a high-level wrapper for Kerberos (GSSAPI) operations.
- The python-pure-sasl package is a pure Python client-side SASL (Simple Authentication and Security Layer) implementation.

Before you begin

- To set up Kerberos, follow the guidelines in Kerberos guidelines.
- The Kerberos client must be installed and configured in your Kerberos realm:

RHEL

```
$ yum install krb5-workstation krb5-libs krb5-auth-dialog
```

Ubuntu/Debian

```
$ sudo apt-get install krb5-user
```

Mac OS X

See the documentation MIT Kerberos Consortium.

Procedure

To use cqlsh with Kerberos:

1. Install pure-sasl:

```
$ sudo pip install pure-sasl
```

2. Install PyKerberos:

RHEL

```
$ sudo yum install python-kerberos
```

Ubuntu/Debian

```
$ sudo apt-get install python-kerberos
```

Other

```
$ sudo pip install kerberos
```

3. Create a cqlshrc file in `~/.cassandra` or client program `~/.cassandra` directory.

Using Kerberos authentication with Sqoop

Sqoop can use Kerberos user authentication when connecting to DSE nodes.

About this task

Sqoop can use Kerberos user authentication when connecting to DSE nodes.

Before you begin

Before you can enable Kerberos authentication with Sqoop, you must have:

- Created a Kerberos principal user for the realm.
- Added the principal's user to Cassandra on the node on which Sqoop will run.

Procedure

1. On the machine running Sqoop, create a ticket for the Kerberos principal.

   ```
   $ kinit <principal name>
   ```

   Enter the principal's password when prompted.
2. Create a JAAS configuration file to enable Kerberos for DataStax Enterprise.

   ```
   DseClient {
       com.sun.security.auth.module.Krb5LoginModule required
       useTicketCache=true
       renewTGT=true;
   };
   ```
3. Add the Kerberos configuration options customized for your environment to a Sqoop options file.

   ```
   --cassandra-host
   <fully qualified domain name of the Cassandra host>
   --cassandra-enable-kerberos
   --cassandra-kerberos-config-path
   <path to the JAAS configuration file>
   --cassandra-kerberos-service-principal
   <principal name>/<fully qualified host name>@<realm>
   ```
4. Run Sqoop with the options file.

   ```
   $ bin/dse sqoop --options-file <path to options file>
   ```

Authenticating a cluster with LDAP

DataStax Enterprise supports LDAP authentication support for external LDAP services.

The Lightweight Directory Access Protocol (LDAP) is a standard way of authenticating users across applications. DataStax Enterprise supports LDAP authentication for external LDAP services.

When you enable LDAP authentication in DataStax Enterprise, users that are managed by external LDAP servers can be authenticated by DataStax Enterprise. Authenticated users can then be authorized to access Cassandra objects, as described in Managing object permissions using internal authorization.

LDAP authentication is supported in the following DataStax Enterprise components:

- CQL

- Solr using the HTTP interface
- Analytics
    - Spark
    - Shark
    - Hadoop
    - Hive
    - Pig
- Sqoop

LDAP authentication is not supported in the following components:

- OpsCenter versions earlier than 5.2
- Mahout
- DevCenter

Enabling LDAP authentication

Configuring DataStax Enterprise to use an external LDAP server to enable LDAP authentication.

About this task

LDAP authentication is enabled by configuring DataStax Enterprise to use an external LDAP server.

Before you begin

You must have a properly configured LDAP v3 server running. The supported LDAP servers are:

- Microsoft Active Directory:
    - Windows 2008
    - Windows 2012
- OpenLDAP 2.4.x
- Oracle Directory Server Enterprise Edition 11.1.1.7.0

Procedure

1. Open the cassandra.yaml file in a text editor and set the `authenticator` to `com.datastax.bdp.cassandra.auth.LdapAuthenticator`.

    The location of the cassandra.yaml file depends on the type of installation:

Package installations	`/etc/cassandra/cassandra.yaml`
Tarball installations	*`install_location`*`/resources/cassandra/conf/cassandra.yaml`

    The location of the dse.yaml file depends on the type of installation:

Installer-Services	`/etc/dse/dse.yaml`
Package installations	`/etc/dse/dse.yaml`
Installer-No Services	*`install_location`*`/resources/dse/conf/dse.yaml`
Tarball installations	*`install_location`*`/resources/dse/conf/dse.yaml`

    ```
    authenticator: com.datastax.bdp.cassandra.auth.LdapAuthenticator
    ```

2. Open the dse.yaml file in a text editor and set the configuration for your LDAP server. The settings are only used if the authenticator is set to `com.datastax.bdp.cassandra.auth.LdapAuthenticator` in `cassandra.yaml`.

Option	Description
server_host	The host name of the LDAP server.
server_port	The port on which the LDAP server listens. The default value is 389. The default SSL port for LDAP is 636.
search_dn	The username of the user that is used to search for other users on the LDAP server.
search_password	The password of the `search_dn` user.
use_ssl	Set to `true` to enable SSL connections to the LDAP server. If set to `true`, you may need to change `server_port` to the SSL port of the LDAP server. The default value is `false`.
use_tls	Set to `true` to enable TLS connections to the LDAP server. If set to `true`, you may need to change the `server_port` to the TLS port of the LDAP server. The default value is `false`.
truststore_path	The path to the trust store for SSL certificates.
truststore_password	The password to access the trust store.
truststore_type	The type of trust store. The default value is `jks`.
user_search_base	The search base for your domain, used to look up users. Set the ou and dc elements for your LDAP domain. Typically this is set to `ou=users,dc=`*`domain`*`,dc=`*`top level domain`*. For example, `ou=users,dc=example,dc=com`. Active Directory uses a different search base, typically `CN=search,CN=Users,DC=`*`Active Directory domain name`*`,DC=internal`. For example, `CN=search,CN=Users,DC=example-sales,DC=internal`.
user_search_filter	The search filter for looking up usernames. The default setting is `(uid={0})`. When using Active Directory set the filter to `(sAMAccountName={0})`.
search_validity_in_seconds	The duration period in milliseconds for the search cache. To disable the cache, set it to 0. The cache is disabled by default. Enabling a search cache reduces the number of requests sent to the LDAP server, improving performance. Changes in user data on the LDAP server will not be reflected during the cache period, however.

Option	Description
credentials_validity_in_ms	The duration period in milliseconds for the credential cache. To disable the cache, set it to 0. The cache is disabled by default. With the cache enabled DataStax Enterprise will store the user credentials locally during the period set in `credentials_validity_in_ms`. Binding to a remote LDAP server takes time and resources, so enabling a credential cache will usually result in faster performance following the initial authentication phase. Changes in user credentials on the LDAP server, however, will not be reflected in DataStax Enterprise during the cache period.
connection_pool	The configuration settings for the connection pool for making LDAP requests.
max_active	The maximum number of active connections to the LDAP server. The default value is 8.
max_idle	The maximum number of idle connections in the pool awaiting requests. The default value is 8.

```
ldap_options:
    server_host: localhost
    server_port: 389
    search_dn: cn=Admin
    search_password: secret
    use_ssl: false
    use_tls: false
    truststore_path:
    truststore_password:
    truststore_type: jks
    user_search_base: ou=users,dc=example,dc=com
    user_search_filter: (uid={0})
    credentials_validity_in_ms: 0
    connection_pool:
        max_active: 8
        max_idle: 8
```

3. Repeat these steps on each node in the cluster.

Creating LDAP users

Create a superuser and other users in Cassandra.

About this task

DataStax Enterprise automatically creates a `cassandra` superuser but it is unlikely that this user will be available on the remote LDAP service. Use the following steps to create a superuser and other users in Cassandra.

Procedure

1. In the cassandra.yaml file, set the authenticator to `org.apache.cassandra.auth.PasswordAuthenticator`.

   The location of the cassandra.yaml file depends on the type of installation:

Package installations	`/etc/cassandra/cassandra.yaml`
Tarball installations	*install_location*`/resources/cassandra/conf/cassandra.yaml`

```
authenticator: org.apache.cassandra.auth.PasswordAuthenticator
```

2. Start `cqlsh` and login using the superuser name and password.

```
$ ./cqlsh -u cassandra -p cassandra
```

3. Create the other LDAP users but give them blank passwords. Be sure to create at least one with superuser privileges. These users need to match the available users in the remote LDAP service.
4. Re-enable LDAP authorization in the `cassandra.yaml` file.

```
authenticator: com.datastax.bdp.cassandra.auth.LdapAuthenticator
```

5. Login as the new superuser and delete the default `cassandra` user.

   Note: This step is highly recommended to improve the security DataStax Enterprise.
6. Enable LDAP authentication on each node in the cluster.

Encryption

DataStax Enterprise supports encryption for in-flight data and at-rest data.

DataStax Enterprise supports encryption for in-flight data and at-rest data.

Note: For Spark security, see Spark SSL encryption.

Client-to-node encryption

Client-to-node encryption protects data in flight from client machines to a database cluster using SSL. It establishes a secure channel between the client and the coordinator node.

About this task

Client-to-node encryption protects data in flight from client machines to a database cluster using SSL (Secure Sockets Layer). It establishes a secure channel between the client and the coordinator node. Unlike Kerberos, SSL is fully distributed and does not require setting up a shared authentication service. For information about generating SSL certificates, see Preparing server certificates.

Note: DSE Search

When you enable SSL, the authentication/authorization filters are automatically enabled in the Solr `web.xml` file and an SSL connector in Tomcat is configured. You do not have to change your `web.xml` or `server.xml` files.

Procedure

1. On each node, in the cassandra.yaml file, under `client_encryption_options`:

   - To enable encryption, set enabled to true.
   - Set the paths to your `.keystore` and `.truststore` files.
   - Provide the passwords that were used when generating the keystore and truststore.
   - To enable client certificate authentication, set require_client_auth to true.

```
client_encryption_options:
    enabled: true
```

```
   keystore: resources/dse/conf/.keystore  ## Path to your .keystore file
   keystore_password: keystore password  ## Password that you used to
generate the keystore
   store_type: JKS
   truststore: resources/dse/conf/.truststore  ## Path to
your .truststore
   truststore_password: truststore password  ## Password that you used to
generate the truststore
   protocol: ssl
   require_client_auth: true
   cipher_suites: [TLS_RSA_WITH_AES_128_CBC_SHA,
TLS_RSA_WITH_AES_256_CBC_SHA]
```

For information about using Kerberos with SSL, see Using Kerberos and SSL at the same time.

The location of the cassandra.yaml file depends on the type of installation:

Package installations	`/etc/cassandra/cassandra.yaml`
Tarball installations	`install_location/resources/cassandra/conf/cassandra.yaml`

The location of the dse.yaml file depends on the type of installation:

Installer-Services	`/etc/dse/dse.yaml`
Package installations	`/etc/dse/dse.yaml`
Installer-No Services	`install_location/resources/dse/conf/dse.yaml`
Tarball installations	`install_location/resources/dse/conf/dse.yaml`

2. If the `client_encryption_options` are set in dse.yaml file, remove them.
3. If you are not using the JCE Unlimited Strength Jurisdiction Policy, make sure that your ticket granting principal does not use AES-256.
   If your ticket granting principle uses AES-256, you might see a warning like this in the logs:

```
WARN [StreamConnectionEstablisher:18] 2015-06-22
 14:12:18,589 SSLFactory.java (line 162) Filtering out
 TLS_DHE_RSA_WITH_AES_256_CBC_SHA,TLS_RSA_WITH_AES_256_CBC_SHA,TLS_ECDHE_RSA_WITH_AES
 as it isnt supported by the socket
```

Node-to-node encryption

Node-to-node encryption protects data that is transferred between nodes in a cluster using SSL.

About this task

Node-to-node encryption protects data transferred between nodes in a cluster using SSL (Secure Sockets Layer). For information about generating SSL certificates, see Preparing server certificates.

SSL settings for node-to-node encryption

To enable node-to-node SSL, you must set the encryption options in the cassandra.yaml file.

The location of the cassandra.yaml file depends on the type of installation:

Package installations	`/etc/cassandra/cassandra.yaml`

Tarball installations	*install_location*/resources/cassandra/conf/cassandra.yaml

On each node, under encryption_options:

- Enable the internode_encryption options (described below).
- Set the appropriate paths to your `.keystore` and `.truststore` files.
- Provide the required passwords. The passwords must match the passwords used when generating the keystore and truststore.
- To enable peer certificate authentication, set require_client_auth to true.

The available inter-node options are:

- all
- none
- dc - Cassandra encrypts the traffic between the data centers.
- rack - Cassandra encrypts the traffic between the racks.

```
encryption_options:
   internode_encryption: internode_option
   keystore: resources/dse/conf/.keystore
   keystore_password: keystore password
   truststore: resources/dse/conf/.truststore
   truststore_password: truststore password
   require_client_auth: true or false
```

Spark SSL encryption

Communication between Spark clients and clusters as well as communication between Spark nodes can be encrypted using SSL.

About this task

Communication between Spark clients and clusters as well as communication between Spark nodes can be encrypted using SSL. You must configure encryption on each node in your cluster.

Configure Spark SSL encryption on the server-side by editing dse.yaml, and for Spark clients by editing `spark-defaults.conf` in the Spark configuration directory.

The default location of the Spark configuration files depends on the type of installation:

Installer-Services and Package installations	/etc/dse/spark/
Installer-No Services and Tarball installations	*install_location*/resources/spark/conf/

Spark SSL encryption is limited to Akka control messages and file sharing. It does not encrypt RDD data exchanges or the web user interface.

The location of the dse.yaml file depends on the type of installation:

Installer-Services	/etc/dse/dse.yaml
Package installations	/etc/dse/dse.yaml
Installer-No Services	*install_location*/resources/dse/conf/dse.yaml
Tarball installations	*install_location*/resources/dse/conf/dse.yaml

Procedure

1. Open dse.yaml in a text editor.
2. In the spark_encryption_options section set the options as described below.

Option	Description
enabled	Enables or disables server-side encryption. The default is false.
keystore	The path to the keystore file, relative to the Spark configuration directory. The default keystore is a file named `.keystore` located in the Spark configuration directory.
keystore_password	The password used to access the keystore. The default password is cassandra.
truststore	The path to the truststore file, relative to the Spark configuration directory. The default truststore is a file named `.truststore` located in the Spark configuration directory.
truststore_password	The password used to access the truststore. The default password is cassandra.
protocol	The SSL protocol used when encrypting communications. The default is TLS.
cipher_suites	The cipher suites used with the protocol, enclosed in square brackets ([]) and separated by commas. The default suites are [TLS_RSA_WITH_AES_128_CBC_SHA,TLS_RSA_WITH_AES

3. In each client, set the client encryption options in the `spark-default.conf` file in the Spark configuration directory.

Option	Description
spark.ssl.enabled	Enables or disables client-side encryption. The default is false.
spark.ssl.keyStore	The path to the keystore file, relative to the Spark configuration directory. The default keystore is a file named `.keystore` located in the Spark configuration directory.
spark.ssl.keyStorePassword	The password used to access the keystore. The default password is cassandra.
spark.ssl.keyPassword	The password for the private key. The default password is cassandra.
spark.ssl.trustStore	The path to the truststore file, relative to the Spark configuration directory. The default truststore is a file named `.truststore` located in the Spark configuration directory.
spark.ssl.trustStorePassword	The password used to access the truststore. The default password is cassandra.
spark.ssl.protocol	The SSL protocol used when encrypting communications. The default is TLS.

Option	Description
spark.ssl.enabledAlgorithms	The cipher suites used with the protocol, separated by commas. The default suites are TLS_RSA_WITH_AES_128_CBC_SHA,TLS_RSA_WITH_AES_
spark.ssl.useNodeLocalConf	Sets whether the Spark executors inherit the SSL configuration from the Spark Workers. The default is true.

Preparing server certificates

All nodes requires relevant SSL certificates. Generate SSL certificates for client-to-node encryptions or node-to-node encryption.

About this task

This topic provides information about generating SSL certificates for client-to-node encryption or node-to-node encryption. If you generate the certificates for one type of encryption, you do not need to generate them again for the other: the same certificates are used for both.

All nodes must have all the relevant SSL certificates on all nodes. A keystore contains private keys. The truststore contains SSL certificates for each node and doesn't require signing by a trusted and recognized public certification authority.

Procedure

To prepare server certificates:

1. Generate the private and public key pair for the nodes of the cluster leaving the key password the same as the keystore password:

   ```
   $ keytool -genkey -alias dse_node0 -keyalg RSA -keystore .keystore
   ```
2. Repeat the previous step on each node using a different alias for each one.
3. Export the public part of the certificate to a separate file and copy these certificates to all other nodes.

   ```
   $ keytool -export -alias dse_node0 -file dsenode0.cer -keystore .keystore
   ```
4. Add the certificate of each node to the truststore of each node, so nodes can verify the identity of other nodes.
   A prompt for setting a password for the newly created truststore appears.

   ```
   $ keytool -import -v -trustcacerts -alias dse_node0 -file dse_node0.cer -
   keystore .truststore
   $ keytool -import -v -trustcacerts -alias dse_node1 -file dse_node1.cer -
   keystore .truststore
   . . .
   $ keytool -import -v -trustcacerts -alias dse_nodeN -file dse_nodeN.cer -
   keystore .truststore
   ```
5. Make sure `.keystore` is readable only by the DSE daemon and not by any user of the system.

Spark security

DataStax Enterprise supports Password and LDAP authentication, Kerberos, client-to-node encryption through SSL security in Spark and Shark, and Spark SSL encryption.

DataStax Enterprise supports Password and LDAP authentication, Kerberos, client-to-node encryption through SSL security in Spark and Shark, and Spark SSL encryption.

Password and LDAP authentication

You can pass Cassandra credentials to Spark by setting the following properties in the Spark configuration object `SparkConf` before creating Spark Context:

- cassandra.username
- cassandra.password

For DataStax Enterprise Spark applications and tools, you can setup a set up a .dserc file or use the Spark and Shark authentication commands to provide the login credentials.

The following examples show how to include Cassandra credentials in your applications:

Example: Passing hard-wired Cassandra credentials

```
import com.datastax.bdp.spark.DseSparkConfHelper._
import org.apache.spark.{SparkConf, SparkContext}

object AuthenticationExample extends App {

 def createSparkContext() = {
   val myJar =
 getClass.getProtectionDomain.getCodeSource.getLocation.getPath

   val conf = new SparkConf()
     .setAppName("Authentication example")
     .setMaster("local")
     .setJars(Array(myJar))
     .set("cassandra.username", "cassandra")
     .set("cassandra.password", "cassandra")
     .forDse

   new SparkContext(conf)
 }

 val sc = createSparkContext()

 // ...

 sc.stop()
}
```

Example: Prompting for Cassandra credentials

```
import com.datastax.bdp.spark.DseSparkConfHelper._
import org.apache.spark.{SparkConf, SparkContext}

object AuthenticationExample extends App {

 def createSparkContext() = {
   /*
     -Dcassandra.username=... and -Dcassandra.password=... arguments will be
 copied to system properties and removed
     from the args list
    */

   val args = setSystemPropertiesFromArgs(this.args)
   val myJar =
 getClass.getProtectionDomain.getCodeSource.getLocation.getPath

   val conf = new SparkConf()
     .setAppName("Authentication example")
     .setMaster("local")
     .setJars(Array(myJar))
```

```
      .forDse

    new SparkContext(conf)
  }

  val sc = createSparkContext()

  // ...

  sc.stop()
 }
```

You can configure a number of parameters to run your own Spark applications with DataStax Enterprise.

Providing credentials for Cassandra in a Spark application

This procedure describes how to write a Spark application that uses password authentication. The `SparkContext` is not authenticated. The authentication pertains to connecting Spark to Cassandra, not authenticating Spark components between each other.

1. Include the instruction in your application to import the `DseSparkConfHelper` package.

   ```
   import com.datastax.bdp.spark.DseSparkConfHelper._
   ```

2. Set authentication properties.

   ```
   System.setProperty(“cassandra.username”, xxx)
   System.setProperty(“cassandra.password”, yyy)
   ```

3. Create a new `SparkContext`, passing `SparkConf.forDSE` as an argument. The `.forDSE` method extends the `SparkConf` object for DataStax Enterprise.

   ```
   new SparkContext(args(0), "PortfolioDemo",
   new SparkConf().setJars(Array(myJar)).forDse)
   ```

   If the `~/.dserc` file is not configured, use the `DseSparkConfHelper` method to find properties in the format Dprop=value and pass them to the System properties automatically. You call `setSystemPropertiesFromArgs(args)` where `args` are command line arguments passed to the main method.

Kerberos authentication

Kerberos authentication pertains to connecting Spark to Cassandra, not authenticating Spark components between each other. The Spark Web UI is not secured and might show the Spark configuration, including delegation token when using Kerberos.

Spark to Cassandra SSL encryption

Client-to-node encryption protects data in flight for the Spark Executor to Cassandra connections by establishing a secure channel between the client and the coordinator node. SSL is fully distributed and does not require setting up a shared authentication service. You need to prepare server certificates and enable client-to-node SSL.

Spark SSL encryption

Spark internode and client-to-cluster communication can also be encrypted using SSL by enabling it server-side in dse.yaml and client-side in the Spark configuration file `spark-defaults.conf`. See Spark SSL encryption for details.

The location of the dse.yaml file depends on the type of installation:

Installer-Services	`/etc/dse/dse.yaml`
Package installations	`/etc/dse/dse.yaml`
Installer-No Services	*`install_location`*`/resources/dse/conf/dse.yaml`
Tarball installations	*`install_location`*`/resources/dse/conf/dse.yaml`

Security limitations

DataStax Enterprise is limited in securing Spark data:

- Client-to-node encryption using SSL is supported for Spark Executor to Cassandra connections only.
- Spark executors run under the same user account as DataStax Enterprise.
- The Spark Web UI is not secured and might show the Spark configuration, including username, password, or delegation token when Kerberos is used.

DataStax recommends the following security practices:

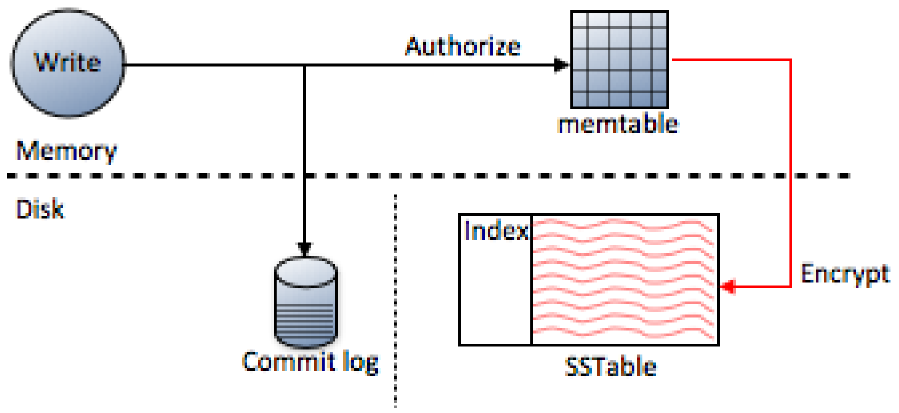
- Expose Spark components to trusted users only.
- Allow only trusted users to access the file system.

Because Spark executors run under the same user account as DataStax Enterprise, an unapproved user can execute a potentially malicious Spark program that can access the file system on the nodes. System files as well as Cassandra SSTables are vulnerable. Users who cannot access Cassandra files on the node, but who you entrust with your file system, can access temporary directories where RDD fragments are stored temporarily. Having sufficient privileges, a user can also execute malicious system commands. Using password authentication, LDAP, or Kerberos to secure Cassandra makes no sense unless you restrict direct access to the file system.

Transparent data encryption

Transparent data encryption (TDE) protects at rest data. TDE requires a secure local file system to be effective.

Transparent data encryption (TDE) protects at rest data. At rest data is data that has been flushed from the memtable in system memory to the SSTables on disk.



As shown in the diagram, data stored in the commit log is not encrypted. If you need commit log encryption, store the commit log on an OS-level encrypted file system using a security product such as Vormetric. Data can be encrypted using different algorithms, or not at all. SSTable data files are immutable after they have been flushed to disk and encrypted only once when they are written to disk.

The Cassandra File System (CFS) is accessed as part of the Hadoop File System (HDFS) using the configured authentication. If you encrypt the CFS keyspace's sblocks and inode tables, all CFS data is encrypted.

Requirements

TDE requires a secure local file system to be effective. Encryption certificates are stored off-server with KMIP encryption or locally with on-server encryption.

Limitations and recommendations

Data is not directly protected by TDE when you access the data using the following utilities.

Utility	Reason utility is not encrypted
json2sstable	Operates directly on the SSTables.
nodetool	Uses only JMX, so data is not accessed.
sstable2json	Operates directly on the SSTables.
sstablekeys	Operates directly on the SSTables.
sstableloader	Operates directly on the SSTables.
sstablescrub	Operates directly on the SSTables.

Compression and encryption introduce performance overhead.

Options

To get the full capabilities of TDE, download and install the Java Cryptography Extension (JCE), unzip the jar files and place them under `$JAVA_HOME/jre/lib/security`. JCE-based products are restricted for export to certain countries by the U.S. Export Administration Regulations.

Configuring encryption using local encryption keys

To encrypt data using encryption keys that are stored locally, use the dse command to create a system key for encryption.

About this task

To encrypt data using encryption keys that are stored locally, use the dse command to create a system key for encryption. Next, copy the system key to the other nodes in the cluster. The entire cluster uses the system key to decrypt SSTables for operations such as repair. You also use the system key during upgrading and restoring SSTables that might have been corrupted.

Procedure

1. Back up SSTables.
2. Set the system_key_directory.
   - On a packaged installation, accept the default system_key_directory `/etc/dse/conf`. Go to the next step to set permissions on the directory.
   - On a tarball installation, optionally change the directory on each node in the cluster from `/etc/dse/conf` to another directory, or skip this step and adjust permissions as described in the next step. You must configure the path to the system key to relocate the key to a directory that you have permission to access.
     - Navigate to *`install-directory`*`/resources/dse/conf`.
     - Open the dse.yaml file for editing.

- Change the path of the system_key_directory to the path of a directory that you have permission to access.

The location of the dse.yaml file depends on the type of installation:

Installer-Services	`/etc/dse/dse.yaml`
Package installations	`/etc/dse/dse.yaml`
Installer-No Services	*`install_location`*`/resources/dse/conf/dse.yaml`
Tarball installations	*`install_location`*`/resources/dse/conf/dse.yaml`

3. Set permissions on the system_key_directory to give rights to change the keytab file only to the user/group running DataStax Enterprise. JNA takes care of setting these permissions.
4. Ensure that the user who encrypts data has been granted ALTER permission on the table that contains the data to be encrypted. You can use LIST PERMISSIONS to view the permissions that are granted to a user.
5. Create a system key using the `dsetool createsystemkey` command.

   For example:

   ```
   $ dsetool createsystemkey 'AES/ECB/PKCS5Padding' 128 system_key
   ```
6. Restart the cluster.
7. Copy the created key to the system_key_directory on each node in the cluster.
8. Set encryption options as you create a table or alter an existing table.

   Tables are encrypted when Cassandra stores the tables on disk as SSTables.
9. Rewrite all SSTables using nodetool upgradesstables --include-all-sstables to immediately store the tables on disk.
10. After encrypted SSTables are flushed to disk, you can verify that the dse_system keyspace and encrypted_keys table exist:

    ```
    cqlsh:mykeyspace> DESCRIBE KEYSPACES;
    ```

    ```
    system  dse_system  mykeyspace  system_traces
    ```

    On all nodes, the system key appears when selected from the dse_system.encrypted_keys table:

    ```
    cqlsh:mykeyspace> SELECT * FROM dse_system.encrypted_keys;
    ```

    ```
    key_file   | cipher | strength | key_id         | key
    -----------+--------+----------+----------------+-----------
    system_key |    AES |      128 | 2e4ea4a0-... | uyBEGhX...
    ```

Configuring encryption using off-server encryption keys

Configure KMIP (Key Management Interoperability Protocol) encryption to use encryption keys that are stored on another server.

About this task

Configure KMIP (Key Management Interoperability Protocol) encryption to use encryption keys that are stored on another server. In addition to encrypting table data, you can optionally encrypt passwords in configuration files and sensitive information in system tables.

The location of the dse.yaml file depends on the type of installation:

Installer-Services	`/etc/dse/dse.yaml`
Package installations	`/etc/dse/dse.yaml`
Installer-No Services	*`install_location`*`/resources/dse/conf/dse.yaml`
Tarball installations	*`install_location`*`/resources/dse/conf/dse.yaml`

Use OpsCenter to configure an alert to monitor KMIP server status.

Procedure

1. Perform host configuration for one or more KMIP key server groups.
   a) Configure the KMIP key manager and authorize each DataStax Enterprise node to the KMIP key server group. Consult the KMIP key server documentation.
   b) On each DataStax Enterprise node, open the dse.yaml file in a text editor and configure the KMIP key server group or key server groups in the kmip_hosts section. Configure options for a *kmip_groupname* section for each KMIP key server or group of KMIP key servers. Using separate key server configuration settings allows use of different key servers to encrypt table data, and eliminates the need to enter key server configuration information in DDL statements and other configurations.

Option	Description
hosts	A comma-separated list of hosts[:port] for the KMIP key server. There is no load balancing. In failover scenarios, failover occurs in the same order that servers are listed. For example: `hosts: kmip1.yourdomain.com, kmip2.yourdomain.com`
keystore_path	The path to a java keystore that identifies the DSE node to the KMIP key server. For example: `/path/to/keystore.jks`
keystore_type	The type of key store. The default value is `jks`.
keystore_password	The password to access the key store.
truststore_path	The path to a java truststore that identifies the KMIP key server to the DSE node. For example: `/path/to/truststore.jks`
truststore_type	The type of trust store. The default value is `jks`.
truststore_password	The password to access the trust store.
key_cache_millis	Milliseconds to locally cache the encryption keys that are read from the KMIP hosts. The longer the encryption keys are cached, the fewer requests are made to the KMIP key server, but the longer it takes for changes, like revocation, to propagate to the DSE node. Default: 300000.
timeout	Socket timeout in milliseconds. Default: 1000.

   This example shows configuration settings for Vormetric and Thales key servers:

```
kmip_hosts:
  vormetricgroup:
    hosts: vormetric1.mydomain.com, vormetric2.mydomain.com,
 vormetric3.mydomain.com
    keystore_path: pathto/kmip/keystore.jks
    keystore_type: jks
    keystore_password: password
    truststore_path: pathto/kmip/truststore.jks
    truststore_type: jks
    truststore_password: password

  thalesgroup:
    hosts: thales1.mydomain.com, thales2.mydomain.com
    keystore_path: pathto/kmip/keystore.jks
    keystore_type: jks
    keystore_password: password
    truststore_path: pathto/kmip/truststore.jks
    truststore_type: jks
    truststore_password: password
```

2. On each DataStax Enterprise node, confirm communication with the KMIP key server and restart the node.

   a) Use the dsetool utility to confirm communication.

   ```
   $ dsetool managekmip kmip_groupname list
   ```

   b) After communication between the DataStax Enterprise node and the KMIP key server or servers is verified, restart the node. Repeat this step on each node.
   The DataStax Enterprise node will not start if it is unable to connect to the configured KMIP key server.

3. Set and use KMIP as the encryption key provider.

   a) Set KMIP encryption options when you create a table or alter an existing table.

   b) Optional: Configure password encryption to encrypt stored passwords in the configuration files. Use `dsetool` to generate the required URL:

   ```
   $ dsetool createsystemkey -kmip=kmip_groupname
   ```

   Edit the dse.yaml file in a text editor. For the config_encryption_key_name property, paste the URL that is returned from the `dsetool createsystemkey` utility.

   c) Optional: Configure system table encryption to encrypt system tables that contain sensitive information. Edit the dse.yaml file in a text editor. In the system_info_encryption section, comment out key_name, and uncomment or add key_provider and kmip_host:

   ```
    system_info_encryption:
      enabled: false
      cipher_algorithm: AES
      secret_key_strength: 128
      chunk_length_kb: 64
      #key_name: system_table_keytab
      key_provider: KmipKeyProviderFactory
      kmip_host: <kmip_groupname>
   ```

Encrypting table data with KMIP encryption keys

How to encrypt table data using keys that are provided by a KMIP key server.

Designate encryption on a per table basis. Using encryption, your application can read and write to SSTables that use different encryption algorithms or use no encryption at all. You must login as a superuser to encrypt data. For example:

```
$ cqlsh -u cassandra -p cassandra
```

The CREATE TABLE and ALTER TABLE syntax for setting encryption options is the same as the syntax for setting data compression options.

For example, to set compression options in the customers table:

```
 CREATE TABLE customers
   ...
   WITH compression =
```

```
  { 'sstable_compression' : 'DeflateCompressor',
  'chunk_length_kb' : 64 };
```

Designating data for encryption using ALTER TABLE does not encrypt existing SSTables, just new SSTables that are generated. When setting up data to be encrypted, but not compressed, set the chunk_length_kb option to the lowest possible value. Setting this option to a low value such as 1 improves read performance by limiting the data that needs to be decrypted for each read operation to 1 KB.

About this task

To encrypt table data using keys that are provided by a KMIP key server, without compression:

```
CREATE TABLE customers
  ...
  WITH COMPRESSION =
  { 'sstable_compression': 'Encryptor',
  'key_provider': 'KmipKeyProviderFactory',
  'kmip_host': 'kmip_group1',
  'cipher_algorithm': 'AES/ECB/PKCS5Padding',
  'secret_key_strength': 128 };
```

- `'key_provider': 'KmipKeyProviderFactory'` tells the encryptor to use a KMIP key server to manage its encryption keys. Include the `'key provider'` entry only to specify to use a KMIP key server, otherwise omit this entry.
- `'kmip_host': 'kmip_group1'` specifies the user-defined the KMIP key server group named kmip_group1 that is set in the kmip_hosts section in dse.yaml.

To encrypt table data using keys that are provided by a KMIP key server, and use compression, specify a compression algorithm such as the EncryptingDeflateCompressor compressor:

```
ALTER TABLE customers
  ...
  WITH COMPRESSION =
  { 'sstable_compression': 'EncryptingDeflateCompressor',
  'key_provider': 'KmipKeyProviderFactory',
  'kmip_host': 'kmip_group2',
  'cipher_algorithm': 'AES/ECB/PKCS5Padding',
  'secret_key_strength': 128 };
```

The location of the dse.yaml file depends on the type of installation:

Installer-Services	`/etc/dse/dse.yaml`
Package installations	`/etc/dse/dse.yaml`
Installer-No Services	*`install_location`*`/resources/dse/conf/dse.yaml`
Tarball installations	*`install_location`*`/resources/dse/conf/dse.yaml`

Configuring encryption per table

Configure encryption on a per table basis. You can configure encryption with or without compression.

Designate encryption on a per table basis. Using encryption, your application can read and write to SSTables that use different encryption algorithms or use no encryption at all. You must login as a superuser to encrypt data. For example:

```
$ cqlsh -u cassandra -p cassandra
```

The CREATE TABLE and ALTER TABLE syntax for setting encryption options is the same as the syntax for setting data compression options.

For example, to set compression options in the customers table:

```
CREATE TABLE customers
  ...
  WITH compression =
  { 'sstable_compression' : 'DeflateCompressor',
  'chunk_length_kb' : 64 };
```

Designating data for encryption using ALTER TABLE does not encrypt existing SSTables, just new SSTables that are generated. When setting up data to be encrypted, but not compressed, set the chunk_length_kb option to the lowest possible value. Setting this option to a low value such as 1 improves read performance by limiting the data that needs to be decrypted for each read operation to 1 KB.

Encrypting table data with encryption and compression

Encryption can be set with compression using a single statement. The single CQL statement is:

```
CREATE TABLE users
  ...
  WITH compression =
  { 'sstable_compression' : 'EncryptingSnappyCompressor',
  'cipher_algorithm' : 'AES/ECB/PKCS5Padding',
  'secret_key_strength' : 128,
,   'chunk_length_kb' : 128 };
```

Encryption/compression options and sub-options

Using encryption, your application can read and write to SSTables that use different encryption algorithms or no encryption at all. Using different encryption algorithms to encrypt SSTable data is similar to using different compression algorithms to compress data.

The high-level container option for encryption and/or compression used in the CREATE TABLE and ALTER TABLE statements are:

Encryptor	Encrypts table data
EncryptingDeflateCompressor	Encrypts table data and uses Deflate compression algorithm
EncryptingSnappyCompressor	Encrypts table data and uses Snappy compression algorithm
DeflateCompressor	Does not encrypt table data, uses Deflate compression algorithm
SnappyCompressor	Does not encrypt table data, uses Snappy compression algorithm
LZ4Compressor (default)	Does not encrypt table data, uses LZ4 compression algorithm

Note: If defining a table with the Encryptor encryptor, set the young generation heap (-Xmn) parameter to a larger space to improve garbage collection. For example if running cassandra-stress, set : -Xmn1600M.

cipher_algorithm sub-option

When Java Cryptography Extension (JCE) is installed, the cipher_algorithm options and acceptable secret_key_strength for the algorithms are:

cipher_algorithm	secret_key_strength
AES/CBC/PKCS5Padding	128, 192, or 256
AES/ECB/PKCS5Padding	128, 192, or 256
DES/CBC/PKCS5Padding	56
DESede/CBC/PKCS5Padding	112 or 168
Blowfish/CBC/PKCS5Padding	32-448
RC2/CBC/PKCS5Padding	40-128

When JCE is installed, the following encryption options are valid:

- sstable_compression = EncryptingDeflateCompressor
- cipher_algorithm = 'AES/CBC/PKCS5Padding'
- secret_key_strength = 256
- chunk_length_kb = 128
- key_provider = KmipKeyProviderFactory
- kmip_host = kmip_group2

You can install custom providers for your JVM. The AES-512 is not supported out-of the box.

key_provider

Specify KmipKeyProviderFactory to use the KMIP key server for encryption.

kmip_host

The name of the KMIP key server group set in the kmip_hosts section in dse.yaml.

The key location sub-option

Create global encryption keys using the createsystemkey command. The global encryption keys, called system keys, are created at the location that is specified by system_key_directory in the `dse.yaml` file.

To specify a global encryption key when you create or alter a table, use:

```
'system_key_file':'<name of file>'
```

The chunk_length_kb sub-option

On disk, SSTables are encrypted and compressed by block (to allow random reads). This subproperty of compression defines the size (in KB) of the block and is a power of 2. Values larger than the default value might improve the compression rate, but increases the minimum size of data to be read from disk when a read occurs. While the default value (64) is a good middle-ground for compressing tables, the maximum key size for Data Encryption Standard (DES) is 64 and the maximum key size for all other encryption algorithms is 128. For stronger encryption, install Java Cryptography Extension (JCE).

Using just encryption and no compression, the size of SSTables are larger than they would be if you combined compression. During creation of the table, DataStax Enterprise looks for the system key as specified in dse.yaml. You do not need to specify the location of keytab file that contains the system key.

The iv_length sub-option

Not all algorithms allow you to set this sub-option, and most complain if it is not set to 16 bytes. Either use 16 or accept the default.

The syntax for setting this sub-option is similar to setting a compression algorithm to compress data.

```
ALTER TABLE users
```

```
...
WITH compression =
{ 'sstable_compression' : 'EncryptingSnappyCompressor',
'cipher_algorithm' : 'AES/ECB/PKCS5Padding',
'secret_key_strength' : 128,
'iv_length' : 16 };
```

Using SolrJ Auth to implement encryption

To use the SolrJ-Auth libraries to implement encryption, follow instructions in the solrj-auth-README.md file.

The default location of the `solrj-auth-README.md` file depends on the type of installation:

Debian installations	`/usr/share/doc/dse-libsolr*`
RHEL-based installations	`/usr/share/doc/dse-libsolr`
Binary installations	`resources/solr`

These SolrJ-Auth libraries are included in the clients directory in DataStax Enterprise distribution. The SolrJ-Auth code is public.

The default location of the `clients` directory depends on the type of installation:

Debian installations	`/usr/share/dse/clients`
Binary installations	*`install_location`*`/clients`

Migrating encrypted tables

Encrypted tables require specific actions to migrate to later versions of DataStax Enterprise.

About this task

Steps to migrate encrypted tables from earlier versions to DataStax Enterprise.

Procedure

1. Back up the entire keyspace that has a dse_system.encrypted_keys table.
2. Back up all system keys.
3. Upgrade the cluster to DataStax Enterprise 4.7, following instructions in the "DataStax Upgrade Guide."
4. Restart the cluster as described in the Upgrade Guide.
5. Check that the dse_system.encrypted_keys table was created using the cqlsh DESCRIBE KEYSPACES command.

   If you need to restore the dse_system.encrypted_keys table, load the table. Do not truncate or delete anything.
6. If the dse_system.encrypted_keys table was created, go to the next step; otherwise, create the table manually:

```
CREATE KEYSPACE dse_system WITH replication = {'class':
 'EverywhereStrategy'};

USE dse_system;

CREATE TABLE encrypted_keys (
  key_file text,
  cipher text,
  strength int,
  key_id timeuuid,
  key text,
  PRIMARY KEY (key_file, cipher, strength, key_id)
);
```

7. Rewrite all SSTables.

```
$ nodetool upgradesstables --include-all-sstables
```

Running cqlsh with Kerberos/SSL

Sample files are provided for Kerberos, SSL, and Kerberos and SSL.

You cannot use cqlsh when client certificate authentication is enabled (require_client_auth=true). DataStax Enterprise provides sample files.

The default location of the sample files depends on the type of installation:

Package installations	`/etc/dse/cassandra`
Installer-Services installations	`/usr/share/dse/resources/cassandra/conf`
Installer-No Services and Tarball installations	`install_location/resources/cassandra/conf`

Kerberos example

```
[kerberos]
hostname = cassandra01.example.com
service = cassandra
principal = bill/cassandra-admin@example.com ;; Optional.
qops = auth-conf ;; Optional, see the paragraph below.
```

If qops is not specified the default (auth) is used. On the client side, the qops option is a comma-delimited list of the QOP values allowed by the client for the connection. The client (cqlsh) value list must contain at least one of the QOP values specified on the server. To clarify, the client can have multiple QOP values, while the server can only have a single QOP value, which is specified in the dse.yaml file.

The location of the dse.yaml file depends on the type of installation:

Installer-Services	`/etc/dse/dse.yaml`
Package installations	`/etc/dse/dse.yaml`
Installer-No Services	`install_location/resources/dse/conf/dse.yaml`
Tarball installations	`install_location/resources/dse/conf/dse.yaml`

The Kerberos hostname and service are mandatory settings and must be provided in the configuration file or as environment variables. The environment variables (KRB_HOST, KRB_SERVICE, and KRB_PRINCIPAL) override the options that are set in this file. For more information about these settings, see Securing DataStax Enterprise nodes. The hostname and service must match the values set in the `dse.yaml`.

SSL example

```
[authentication]
username = fred
```

```
password = !!bang!!$

[connection]
hostname = 127.0.0.1
port = 9160
factory = cqlshlib.ssl.ssl_transport_factory

[ssl]
certfile = ~/keys/cassandra.cert
validate = true ;; Optional, true by default. False means no server
 authentication.
userkey = ~/key.pem ;; Provide when require_client_auth=true
usercert = ~/cert.pem ;; Provide when require_client_auth=true

[certfiles] ;; Optional section, overrides the default certfile in the [ssl]
 section.
10.209.182.160 = /etc/dse/cassandra/conf/dsenode0.cer
10.68.65.199 = /etc/dse/cassandra/conf/dsenode1.cer
```

Note: When generating the certificate, be sure to set the CN to the hostname of the node.

To validate/authenticate the server, you must use `validate = true` and generate the pem certificate that is used in the `cqlshrc` file.

- When `validate = false` there is no server authentication, only data encryption.
- When `validate = true` cqlsh will validate the server's certificate against the certfile.

The client uses the pem certificate to validate the server. For example:

```
$ keytool -importkeystore -srckeystore .keystore -destkeystore user.p12 -
deststoretype PKCS12
openssl pkcs12 -in user.p12 -out user.pem -nodes
```

This pem key is required. The SSL certificate must be provided in the configuration file or as an environment variable. The environment variables (SSL_CERTFILE and SSL_VALIDATE) override options that are set in the configuration file.

Kerberos and SSL

For information about using Kerberos with SSL, see Using Kerberos and SSL at the same time.

The settings for using both Kerberos and SSL are a combination of the Kerberos and SSL sections in these examples.

The supported environmental variables are KRB_HOST, KRB_SERVICE, KRB_PRINCIPAL, SSL_CERTFILE, and SSL_VALIDATE variables.

Configuring and using data auditing

Enable logging for the audit logger on the node that is set up for logging. Logs provide detailed audit trails of cluster activity.

About this task

The audit logger logs information only on nodes set up for logging. For example, node 0 has audit turned on, node 1 does not. This means issuing updates and other commands on node 1 does not affect the node 0 audit log. For maximum information from data auditing, turn on data auditing on every node.

Audit logs can be written to filesystem log files using logback, or to a Cassandra table. When you turn on audit logging, the default is to write to logback filesystem log files.

For simple installations, logging to logback files is typically easier than logging audit data to a Cassandra tables. The log files can be read from a terminal for troubleshooting queries or managing security.

However, larger clusters can make logback audit logs cumbersome. Because the log files grow extremely large, it's difficult to analyze all the messages. Additionally, the format of the logback files are not flexible. Moreover, because the node's log files are local, it is difficult to find out what is happening across the cluster.

As your cluster scales up, logging audit data to a Cassandra table is more useful. The data can be queried like any other table, making analysis easier and custom audit reports possible.

Audit logging of queries and prepared statements submitted to the DataStax drivers, which use the CQL binary protocol, is supported.

Procedure

1. Open the dse.yaml file in a text editor.

   The location of the dse.yaml file depends on the type of installation:

Installer-Services	`/etc/dse/dse.yaml`
Package installations	`/etc/dse/dse.yaml`
Installer-No Services	*`install_location`*`/resources/dse/conf/dse.yaml`
Tarball installations	*`install_location`*`/resources/dse/conf/dse.yaml`

2. In the audit_logging_options section, set `enabled` to `true`.

```
# Audit logging options
audit_logging_options:
    enabled: true
```

3. Set the `logger` option to either:

   - `CassandraAuditWriter`

     Logs to a Cassandra table.
   - `SLF4JAuditWriter`

     Logs to the SLF4J logger.
4. Optional: To include or exclude event categories from being logged, add the event types `include_categories` or `exclude_categories` and specify the categories in a comma separated list. You can set either event type, but not both.

Setting	Logging
`ADMIN`	Logs describe schema versions, cluster name, version, ring, and other administration events.
`AUTH`	Logs login events.
`DML`	Logs insert, update, delete and other DML events.
`DDL`	Logs object and user create, alter, drop, and other DDL events.
`DCL`	Logs grant, revoke, create user, drop user, and list users events.
`QUERY`	Logs all queries.

5. Optional: To include or exclude Cassandra keyspaces from being logged, add a comma separated list of keyspaces to the `included_keyspaces` or `excluded_keyspaces` options. You can set either one, but not both.

6. If you are logging to a Cassandra table, set the retention time for logged events by setting the `retention_time` option to the number of hours the events should be retained. The default value is *0*, which retains all event data indefinitely.
7. Configure the audit logging writer.
   - SLF4JAuditWriter
   - Cassandra table

Example

The following example sets the audit logger to log to a Cassandra table.

```
# Audit logging options
audit_logging_options:
    enabled: true
    logger: CassandraAuditWriter
```

Configuring audit logging to a logback log file

Configuring audit logging in DataStax Enterprise.

About this task

If you've enabled audit logging and set the logger to output to the SLF4JAuditWriter as described in Configuring and using data auditing, you can configure the logger by setting options in `logback.xml`. DataStax Enterprise places the audit log in the directory defined in the logback.xml configuration file. After the log file reaches the configured size threshold, it rolls over, and the log file name is changed. The file names include a numerical suffix that is determined by the `maxBackupIndex` property.

The location of the `logback.xml` file depends on the type of installation:

Installer-Services and Package installations	`/etc/dse/cassandra/conf/logback.xml`
Installer-No Services and Tarball installations	*`install_location`*`/resources/cassandra/conf/logback.xml`

Because auditing is configured through a text file in the file system, the file is vulnerable to OS-level security breaches. You can address this issue by changing DataStax Enterprise's umask setting to change the permissions to 600 on the audit files by default. Be aware that if other tools look at the data, changing this setting can cause read problems. Alternately, you can store the audit file on an OS-level encrypted file system such as Vormetric.

Configuring data auditing

You can configure which categories of audit events to log, and whether to omit operations against specific keyspaces from audit logging.

Procedure

1. Open the logback.xml file in a text editor.
2. Accept the default settings or change the properties in the `logback.xml` file to configure data auditing:

```
<!--audit log-->
<appender name="SLF4JAuditWriterAppender"
 class="ch.qos.logback.core.rolling.RollingFileAppender">
    <file>${cassandra.logdir}/audit/audit.log</file> <!-- logfile location
 -->
    <encoder>
```

```
        <pattern>%-5level [%thread] %date{ISO8601} %F:%L - %msg%n</pattern>
   <!-- the layout pattern used to format log entries -->
        <immediateFlush>true</immediateFlush>
      </encoder>
      <rollingPolicy
   class="ch.qos.logback.core.rolling.FixedWindowRollingPolicy">
        <fileNamePattern>${cassandra.logdir}/audit/audit.log.%i.zip</
  fileNamePattern>
        <minIndex>1</minIndex>
        <maxIndex>5</maxIndex> <!-- max number of archived logs that are
   kept -->
      </rollingPolicy>
      <triggeringPolicy
   class="ch.qos.logback.core.rolling.SizeBasedTriggeringPolicy">
        <maxFileSize>200MB</maxFileSize> <!-- The size of the logfile that
   triggers a switch to a new logfile, and the current one archived -->
      </triggeringPolicy>
    </appender>
  <logger name="SLF4JAuditWriter" level="INFO" additivity="false">
      <appender-ref ref="SLF4JAuditWriterAppender"/>
    </logger>
```

The audit logger logs at INFO level, so the `DataAudit` logger must be configured at INFO (or lower) level in logback.xml. Setting the logger to a higher level, such as WARN, prevents any log events from being recorded, but it does not completely disable the data auditing. Some overhead occurs beyond overhead that is caused by regular processing.

3. Restart the node to see changes in the log.

Example

By default, the audit log section of the `logback.xml` file looks like this:

```
slf4j.logger.DataAudit=INFO, A
slf4j.additivity.DataAudit=false
slf4j.appender.A=org.apache.log4j.RollingFileAppender
slf4j.appender.A.File=/var/log/cassandra/audit.log
slf4j.appender.A.bufferedIO=true
slf4j.appender.A.maxFileSize=200MB
slf4j.appender.A.maxBackupIndex=5
slf4j.appender.A.layout=org.apache.log4j.PatternLayout
slf4j.appender.A.layout.ConversionPattern=%m%n
```

Formats of logs

The log format is a simple set of pipe-delimited name/value pairs. A name/value pair, or field, is only included in the log line if a value exists for that particular event.

The log format is a simple set of pipe-delimited name/value pairs. The pairs themselves are separated by the pipe symbol ("|"), and the name and value portions of each pair are separated by a colon. A name/value pair, or field, is only included in the log line when a value exists for that particular event. Some fields always have a value, and are always present. Others might not be relevant for a given operation. To make parsing with automated tools easier, the order in which fields appear (when present) in the log line is predictable. For example, the text of CQL statements is unquoted, but if present, is always the last field in the log line.

Field Label	Field Value	Optional
host	dse node address	no
source	client address	no

Field Label	Field Value	Optional
user	authenticated user	no
timestamp	system time of log event	no
category	DML/DDL/QUERY for example	no
type	API level operation	no
batch	batch id	yes
ks	keyspace	yes
cf	column family	yes
operation	textual description	yes

The textual description value for the operation field label is currently only present for CQL.

Auditing is completely separate from authorization, although the data points logged include the client address and authenticated user, which may be a generic user if the default authenticator is not overridden. Logging of requests can be activated for any or all of the list of categories described in Configuring and using data auditing.

CQL logging examples

Generally, SELECT queries are placed into the QUERY category. The INSERT, UPDATE, and DELETE statements are categorized as DML. CQL statements that affect schema, such as CREATE KEYSPACE and DROP KEYSPACE are categorized as DDL.

CQL USE

```
USE dsp904;

host:/192.168.56.1|source:/192.168.56.101|user:#User allow_all groups=[]
  |timestamp:1351003707937|category:DML|type:SET_KS|ks:dsp904|operation:use
 dsp904;
```

CLI USE

```
USE dsp904;

host:/192.168.56.1|source:/192.168.56.101|user:#User allow_all groups=[]
  |timestamp:1351004648848|category:DML|type:SET_KS|ks:dsp904
```

CQL query

```
SELECT * FROM t0;

host:/192.168.56.1|source:/192.168.56.101|user:#User allow_all groups=[]
  |timestamp:1351003741953|category:QUERY|type:CQL_SELECT|ks:dsp904|cf:t0|
operation:select * from t0;
```

CQL BATCH

```
BEGIN BATCH
  INSERT INTO t0(id, field0) VALUES (0, 'foo')
  INSERT INTO t0(id, field0) VALUES (1, 'bar')
  DELETE FROM t1 WHERE id = 2
APPLY BATCH;

host:192.168.56.1|source:/192.168.56.101|user:#User allow_all groups=[]
```

```
  |timestamp:1351005482412|category:DML|type:CQL_UPDATE
  |batch:fc386364-245a-44c0-a5ab-12f165374a89|ks:dsp904|cf:t0
  |operation:INSERT INTO t0 ( id , field0 ) VALUES ( 0 , 'foo' )

host:192.168.56.1|source:/192.168.56.101|user:#User allow_all groups=[]
  |timestamp:1351005482413|category:DML|type:CQL_UPDATE
  |batch:fc386364-245a-44c0-a5ab-12f165374a89|ks:dsp904|cf:t0
  |operation:INSERT INTO t0 ( id , field0 ) VALUES ( 1 , 'bar' )

host:192.168.56.1|source:/192.168.56.101|user:#User allow_all groups=[]
  |timestamp:1351005482413|category:DML|type:CQL_DELETE
  |batch:fc386364-245a-44c0-a5ab-12f165374a89|ks:dsp904|cf:t1
  |operation:DELETE FROM t1 WHERE id = 2
```

CQL DROP KEYSPACE

```
DROP KEYSPACE dsp904;

host:/192.168.56.1|source:/192.168.56.101|user:#User allow_all groups=[]
  |timestamp:1351004777354|category:DDL|type:DROP_KS
  |ks:dsp904|operation:drop keyspace dsp904;
```

CQL prepared statement

```
host:/10.112.75.154|source:/127.0.0.1|user:allow_all
  |timestamp:1356046999323|category:DML|type:CQL_UPDATE
  |ks:ks|cf:cf|operation:INSERT INTO cf (id, name) VALUES (?, ?)
 [id=1,name=vic]
```

Thrift batch_mutate

```
host:/192.168.56.1|source:/192.168.56.101|user:#User allow_all groups=[]
  |timestamp:1351005073561|category:DML|type:INSERT
  |batch:7d13a423-4c68-4238-af06-a779697088a9|ks:Keyspace1|cf:Standard1

host:/192.168.56.1|source:/192.168.56.101|user:#User allow_all groups=[]
  |timestamp:1351005073562|category:DML|type:INSERT
  |batch:7d13a423-4c68-4238-af06-a779697088a9|ks:Keyspace1|cf:Standard1

host:/192.168.56.1|source:/192.168.56.101|user:#User allow_all groups=[]
  |timestamp:1351005073562|category:DML|type:INSERT
  |batch:7d13a423-4c68-4238-af06-a779697088a9|ks:Keyspace1|cf:Standard1
```

DataStax Java Driver queries

```
host:ip-10-85-22-245.ec2.internal/10.85.22.245|source:/127.0.0.1|
user:anonymous
  |timestamp:1370537557052|category:DDL|type:ADD_KS
  |ks:test|operation:create keyspace test with replication =
 {'class':'NetworkTopologyStrategy', 'Analytics': 1};

host:ip-10-85-22-245.ec2.internal/10.85.22.245|source:/127.0.0.1|
user:anonymous
  |timestamp:1370537557208|category:DDL|type:ADD_CF
  |ks:test|cf:new_cf|operation:create COLUMNFAMILY test.new_cf ( id text
 PRIMARY KEY , col1 int, col2 ascii, col3 int);

host:ip-10-85-22-245.ec2.internal/10.85.22.245|source:/127.0.0.1|
user:anonymous
  |timestamp:1370537557236|category:DML|type:CQL_UPDATE
  |ks:test|cf:new_cf|operation:insert into test.new_cf (id, col1, col2,
 col3) values ('test1', 42, 'blah', 3);
```

```
host:ip-10-85-22-245.ec2.internal/10.85.22.245|source:/127.0.0.1|
user:anonymous
  |timestamp:1370537704885|category:QUERY|type:CQL_SELECT
  |ks:test|cf:new_cf|operation:select * from test.new_cf;
```

Batch updates

Batch updates, whether received via a Thrift batch_mutate call, or in `CQL BEGIN BATCH....APPLY BATCH` block, are logged in the following way: A UUID is generated for the batch, then each individual operation is reported separately, with an extra field containing the batch id.

Configuring audit logging to a Cassandra table

Set options in dse.yaml if audit logging is enabled and set to output to a Cassandra table.

About this task

If you've enabled audit logging and set the logger to output to a Cassandra table as described in Configuring and using data auditing, you can configure the logger by setting options in `dse.yaml`.

Audit events are written to the `dse_audit.audit_log` table. The logger can be run synchronously or asynchronously. By default, the logger runs synchronously. The permissions for accessing `dse_audit.audit_log` can be managed using the `GRANT` or `REVOKE` CQL commands.

When run synchronously, an event will not complete until the event has been written to the table. If there is a failure after the event has been written to the table but before the event completed, the log may contain events that were never completed. For example, a query may be logged in the table but it did not successfully complete.

When run asynchronously, audit events are queued for writing to the table, but may not be logged before the event is completed. For example, when logging a query, the query may execute before the audit event is written to the table. A pool of writer threads handles logging audit events from the queue, writing to the table in batch queries. The advantage of writing audit events asynchronously is better performance under load, however if there is a failure before an audit event is written to the table, the audit event may not be logged even though the event has completed.

Procedure

1. Open dse.yaml in a text editor.

   The location of the dse.yaml file depends on the type of installation:

Installer-Services	`/etc/dse/dse.yaml`
Package installations	`/etc/dse/dse.yaml`
Installer-No Services	`*install_location*/resources/dse/conf/dse.yaml`
Tarball installations	`*install_location*/resources/dse/conf/dse.yaml`

   The location of the cassandra.yaml file depends on the type of installation:

Package installations	`/etc/cassandra/cassandra.yaml`
Tarball installations	`*install_location*/resources/cassandra/conf/cassandra.yaml`

2. Set the options in the audit_logging_options section.

Option	Description
`cassandra_batch_size`	The maximum number of events the writer will dequeue before writing them to the audit table. The default value is 50. Set this option to less than 1 to log events synchronously. If you see warnings about the batches being too large, set this number to a lower number or increase the setting of `batch_size_warn_threshold_in_kb` in cassandra.yaml.
`cassandra_flush_time`	The maximum amount of time in milliseconds an event will be dequeued by a writer before being written out. The default value is 500. Set this option to less than 1 to log events synchronously. This option prevents events from waiting too long before being written to the table when there are few audit events occurring.
`cassandra_num_writers`	The number of worker threads asynchronously logging events to the table. The default value is 0. Set this value to less than 1 to log events synchronously. To log events asynchronously, setting this option to 10 is a good starting value.
`cassandra_queue_size`	The size of the queue feeding the asynchronous audit log writer threads. The default value is 10,000. When there are more audit events than the queue can handle, new events will be blocked until there is space in the queue. If this option is set to less than 1, the queue size will be unbounded, which can lead to resource exhaustion under heavy loads.
`cassandra_dropped_event_log`	When running asynchronously, failures may prevent the events in the queue from being written to the table. If this occurs, the events are logged to this file. The default setting is `/var/log/cassandra/dropped_audit_events.log`.
`cassandra_keyspace_replication`	This section is used to configure how the audit logging table is replicated, has to suboptions: `class` and `replication_factor`. By default, `class` is set to `SimpleStrategy`, and `replication_factor` is set to 3.
`cassandra_table_compression`	This section configures the audit logging table's compression, has one suboption: `sstable_compression`. By default, `sstable_compression` is set to `SnappyCompressor`.
`cassandra_table_compaction`	This section configures the audit logging table's compaction strategy, and has one suboption: `class`. By default `class` is set to `SizeTieredCompactionStrategy`.

3. Save the file and restart DataStax Enterprise.

CassandraAuditWriter table columns

When logging audit data to a Cassandra table using the `CassandraAuditWriter` logger, the audit data is stored in the `dse_audit.audit_log` table.

When logging audit data to a Cassandra table using the `CassandraAuditWriter` logger, the audit data is stored in the `dse_audit.audit_log` table. This table has the following columns.

Table 14: Audit log table columns

Column	Description
`date`	Date of the event.
`node`	DSE node address.
`day_partition`	
`event_time`	The system timestamp of the event.
`batch_id`	The UUID of the batch query the event was grouped with when written to Cassandra.
`category`	The event category.
`keyspace_name`	The keyspace of the event.
`operation`	The query or event description.
`source`	The IP address of the client.
`table_name`	The table affected by the event.
`type`	The type of the event.
`username`	The authenticated user triggering the event. If authentication isn't enabled, the user is anonymous.

Configuring auditing for a DSE Search cluster

The filter-mapping element in the Solr web.xml file enables auditing.

About this task

If auditing is enabled, DSE Search nodes do not require additional configuration. If the `filter-mapping` element in the Solr web.xml file is commented out, the auditor cannot log anything from Solr.

Procedure

If necessary, uncomment the filter-mapping element in the Solr web.xml file.

The default location of the `web.xml` file depends on the type of installation:

Installer-Services and Package installations	`/usr/share/dse/solr/web/solr/WEB-INF/web.xml`
Installer-No Services and Tarball installations	`*install_location*/resources/solr/web/solr/WEB-INF/web.xml`

```
<filter-mapping>
    <filter-name>DseAuditLoggingFilter</filter-name>
    <url-pattern>/*</url-pattern>
</filter-mapping>
```

Here is an example of the data audit log of a Solr query:

```
host:/10.245.214.159|source:127.0.0.1|user:jdoe|timestamp:1356045339910|
category:QUERY
  |type:SOLR_QUERY|ks:wiki|cf:solr|operation:/wiki.solr/select/?
q=body:trains
```

Configuring and using internal authentication

Internal authentication is based on Cassandra-controlled login accounts and passwords. You can authenticate uses of Hadoop tools, Spark-to-Cassandra connections, and Shark configuration changes.

Like object permission management (which uses internal authorization), internal authentication is based on Cassandra-controlled login accounts and passwords. Internal authentication is supported on the following clients when you provide a user name and password to start up the client:

- Astyanax
- cassandra-cli
- cqlsh
- Drivers
- Hector
- pycassa

Internal authentication stores user names and bcrypt-hashed passwords in the system_auth.credentials table. You can authenticate uses of Hadoop tools, Spark-to-Cassandra connections, and Shark configuration changes.

Limitations

DataStax Enterprise provides internal authentication support for some Hadoop tools and for connecting Spark to Cassandra, not authenticating Spark components between each other.

Using a file to provide credentials

You can provide the user name and password by creating a file named `~/.dserc` in your DataStax Enterprise home directory or enter the user name and password on the command line. The `~/.dserc` file contains the user name and password:

```
username=<username>
password=<password>
```

When the user launches a password-protected tool, DataStax Enterprise uses the user name and password in the `~/.dserc` file.

Authentication for Spark-to-Cassandra connection

After configuring authentication, create a `~/.dserc` file to authenticate the Spark-to-Cassandra connection. If a `~/.dserc` file does not exist, use these options on the command line with Spark commands to provide the login credentials.

Using passwords to launch Spark

If a `~/.dserc` file does not exist, use these options on the dse command line to provide the login credentials:

```
$ dse -u username -p password spark
```

Authenticating Shark configuration

Use the following command to provide the login credentials when configuring Shark.

```
$ dse shark -hiveconf cassandra.username=<username> -hiveconf
 cassandra.password=<password>
```

Authentication for Hadoop tools

After configuring authentication, starting Hadoop requires a user name and password. These login credentials can be provided using a ~/.dserc file or a command line option.

Using the command line

If a ~/.dserc file does not exist, use these options on the dse command line to provide the login credentials:

```
dse hadoop <command> -Dcassandra.username=<username> -
Dcassandra.password=<password> <other options>

dse hive <hive options> -hiveconf cassandra.username=<username> -hiveconf
 cassandra.password=<password>

dse pig -Dcassandra.username=<username> -Dcassandra.password=<password> <pig
 options>

dse sqoop <sqoop options> --cassandra-username=<username> --cassandra-
password=<password>
```

The dse command reference covers other options.

Hadoop tool authentication limitations

The following authentication limitations apply when using Hadoop tools:

- Internal authentication is not supported for Mahout.
- Using internal authentication to run the `hadoop jar` command is not supported.

  The `hadoop jar` command accepts only the jar file name as an option, and rejects other options such as username and password. The main class in the jar is responsible for making sure that the credentials are applied to the job configuration.
- In Pig scripts that use the custom storage handlers CqlNativeStorage and CassandraStorage, provide credentials in the URL of the URL-encoded prepared statement:

  ```
  cql://<username>:<password>@<keyspace>/<columnfamily>
  cassandra://<username>:<password>@<keyspace>/<columnfamily>
  ```

  Use this method of providing authentication for Pig commands regardless of the mechanism you use for passing credentials to Pig.
- To use Hadoop tools, such as Hive, a user who is not a superuser needs *all* privileges to HiveMetaStore and cfs keyspaces. To configure a user account named jdoe, for example, to use Hadoop tools, use these cqlsh commands:

  ```
  cqlsh> GRANT ALL PERMISSIONS ON KEYSPACE "HiveMetaStore" TO jdoe;
  cqlsh> GRANT ALL PERMISSIONS ON KEYSPACE cfs TO jdoe;
  ```

Configuring internal authentication and authorization

Set internal authentication and authorization at the same time, then set object permissions.

About this task

You must set internal authentication and authorization at the same time. After setting the `Authorizer` and the `Authenticator` in the cassandra.yaml file, set object permissions, as described in Managing object permissions using internal authorization.

Procedure

Perform the first three steps on every node.

1. Change the authenticator option in the cassandra.yaml to the native `Cassandra PasswordAuthenticator` by uncommenting only the `PasswordAuthenticator`:

   The location of the cassandra.yaml file depends on the type of installation:

Package installations	`/etc/cassandra/cassandra.yaml`
Tarball installations	*`install_location`*`/resources/cassandra/conf/cassandra.yaml`

   ```
   authenticator: org.apache.cassandra.auth.PasswordAuthenticator
   ```

   You can use any authenticator except AllowAll.
2. Change the authorizer option by commenting the `AllowAllAuthorizer` and adding the `CassandraAuthorizer`:

   ```
   #authorizer: org.apache.cassandra.auth.AllowAllAuthorizer
   authorizer: org.apache.cassandra.auth.CassandraAuthorizer
   ```

3. Restart the node.

   Note: You can enable internal authorization on existing clusters with no downtime.
4. On one node, configure the system_auth keyspace replication factor.

   Fetching permissions can be an expensive operation. If necessary, adjust the validity period for permissions caching by setting the permissions_validity_in_ms option in `cassandra.yaml`. You can also disable permission caching by setting this option to 0.
5. Run a full repair of the system_auth keyspace.
6. Start cqlsh using the same superuser name and password (cassandra) that you use to start the supported client. For example, to start cqlsh on Linux:

   ```
   ./cqlsh -u cassandra -p cassandra
   ```

7. Change the superuser's user name and password.

Changing the default superuser

You can change the default superuser from the default cassandra user.

About this task

By default, each installation of Cassandra includes a superuser account named cassandra whose password is also cassandra. A superuser grants initial permissions to access Cassandra data, and subsequently a user may or may not be given the permission to grant/revoke permissions.

Procedure

1. Configure internal authentication if you have not already done so.
2. Create another superuser, not named cassandra, using the CREATE USER command.
3. Log in as that new superuser.
4. Change the cassandra user password to something long and incomprehensible, and then forget about it. It won't be used again.
5. Take away the cassandra user's superuser status.
6. Now, that the superuser password is secure, set up user accounts and authorize users to access the database objects by using CQL to grant them permissions on those objects.

   CQL supports the following authentication statements:

   - alter-user
   - create-user
   - drop-user
   - list-users

Enable internal security without downtime

TransitionalAuthenticator and TransitionalAuthorizer allow internal authentication and authorization to be enabled without downtime or modification to client code or configuration.

About this task

The `TransitionalAuthenticator` and `TransitionalAuthorizer` allow internal authentication and authorization to be enabled without downtime or modification to client code or configuration.

Procedure

1. On each node, in the cassandra.yaml file:

   The location of the cassandra.yaml file depends on the type of installation:

Package installations	`/etc/cassandra/cassandra.yaml`
Tarball installations	`*install_location*/resources/cassandra/conf/cassandra.yaml`

   - Set the authenticator to `com.datastax.bdp.cassandra.auth.TransitionalAuthenticator`.
   - Set the authorizer to `com.datastax.bdp.cassandra.auth.TransitionalAuthorizer`.
2. Perform a rolling restart.
3. Run a full repair of the system_auth keyspace
4. After the restarts are complete, use cqlsh with the default superuser login to setup the users, credentials, and permissions.
5. After the setup is complete, edit the `cassandra.yaml` file again and perform another rolling restart:

   - Change the authenticator to org.apache.cassandra.auth.PasswordAuthenticator.
   - Change the authorizer to org.apache.cassandra.auth.CassandraAuthorizer.
6. After the restarts have completed, remove the default superuser and create at least one new superuser.

Logging in with cqlsh

Create cqlshrc in your ~/.cassandra directory to pass default login information.

About this task

To avoid having to pass credentials for every login using cqlsh, you can create a `cqlshrc` file in your `~/.cassandra` directory. When present, it passes default login information to cqlsh. For example:

Procedure

Create the `cqlshrc` file with the following in formation:

```
[authentication]
username = username
password = password
```

Be sure to set the correct permissions and secure this file so that no unauthorized users can gain access to database login information.

Note: Sample `cqlshrc` files are available.

The default location of the sample files depends on the type of installation:

Package installations	`/etc/dse/cassandra`
Installer-Services installations	`/usr/share/dse/resources/cassandra/conf`
Installer-No Services and Tarball installations	*`install_location`*`/resources/cassandra/conf`

Managing object permissions using internal authorization

Use GRANT/REVOKE to grant or revoke permissions to access Cassandra data.

About this task

You use the familiar relational database GRANT/REVOKE paradigm to grant or revoke permissions to access Cassandra data. A superuser grants initial permissions, and subsequently a user may or may not be given the permission to grant/revoke permissions. Object permission management is independent of authentication (works with Kerberos or Cassandra).

CQL supports the following authorization statements:

- GRANT
- LIST PERMISSIONS
- REVOKE

Accessing system resources

Read access to these system tables is implicitly given to every authenticated user because the tables are used by most Cassandra tools:

- system.schema_keyspace
- system.schema_columns
- system.schema_columnfamilies
- system.local
- system.peers

Configuration

`CassandraAuthorizer` is one of many possible `IAuthorizer` implementations, and the one that stores permissions in the system_auth.permissions table to support all authorization-related CQL statements. Configuration consists mainly of changing the authorizer option in cassandra.yaml as described in Configuring internal authentication and authorization.

The location of the cassandra.yaml file depends on the type of installation:

Package installations	`/etc/cassandra/cassandra.yaml`
Tarball installations	*`install_location`*`/resources/cassandra/conf/cassandra.yaml`

Note: You must set internal authentication and authorization at the same time.

Configuring system_auth and dse_security keyspace replication

The system_auth and dse_security keyspaces store security authentication and authorization information.

About this task

Cassandra uses the system_auth and dse_security keyspaces for storing security authentication and authorization information.

- DataStax Enterprise uses the system_auth keyspace when you enable any kind of authentication.
- DataStax Enterprise uses the dse_security keyspace when you enable Kerberos authentication.

Increase the replication factor of these keyspaces depending on your failure tolerance. Data is queried at a consistency level LOCAL_ONE or QUORUM. See About write consistency. The data can be queried frequently. In small clusters, such as those with fewer than 10 nodes, you can set the replication strategy to EverywhereStrategy. However, for larger clusters, choose Simple or Network replication strategy with the replication factor based on your specific requirements.

Attention: To prevent a potential problem logging into a secure cluster, set the replication factor of the system_auth and dse_security keyspaces to a value that is greater than 1. In a multi-node cluster, using the default of 1 prevents logging into any node when the node that stores the user data is down.

Use a keyspace command such as ALTER KEYSPACE to change the replication factor.

Setting the replication factor

About this task

Follow this procedure to increase the default replication factor of 1 of the system_auth and dse_security keyspaces.

Procedure

1. Set the replication factor based on one of the following examples depending on your environment:

   - **SimpleStrategy example:**

     ```
     ALTER KEYSPACE "system_auth"
        WITH REPLICATION = { 'class' : 'SimpleStrategy',
      'replication_factor' : 3 };

     ALTER KEYSPACE "dse_security"
     ```

```
     WITH REPLICATION = { 'class' : 'SimpleStrategy',
   'replication_factor' : 3 };
```

- **NetworkTopologyStrategy example:**

```
ALTER KEYSPACE "system_auth"
   WITH REPLICATION = {'class' : 'NetworkTopologyStrategy', 'dc1' : 3,
 'dc2' : 2};

ALTER KEYSPACE "dse_security"
   WITH REPLICATION = {'class' : 'NetworkTopologyStrategy', 'dc1' : 3,
 'dc2' : 2};
```

2. Run the `nodetool repair` command on the system_auth and dse_security keyspaces. (nodetool repair system_auth; nodetool repair dse_security)

```
$ nodetool repair system_auth
$ nodetool repair dse_security
```

Configuring firewall port access

If a firewall runs on the nodes in the Cassandra or DataStax Enterprise cluster, open up ports to allow communication between the nodes.

About this task

If you have a firewall running on the nodes in your Cassandra or DataStax Enterprise cluster, you must open up the following ports to allow communication between the nodes, including certain Cassandra ports. If this isn't done, when you start Cassandra (or Hadoop in DataStax Enterprise) on a node, the node will act as a standalone database server rather than joining the database cluster.

Procedure

Open the following ports:

The location of the cassandra.yaml file depends on the type of installation:

Package installations	`/etc/cassandra/cassandra.yaml`
Tarball installations	`*install_location*/resources/cassandra/conf/cassandra.yaml`

Port	Description	Configurable in
Public Facing Ports		
22	SSH (default)	See your OS documentation on sshd.
DataStax Enterprise public ports		
4040	Spark application web site port.	
7080	Spark Master web site port.	`spark-env.sh`
7081	Spark Worker web site port.	`spark-env.sh`

Port	Description	Configurable in
8012	Hadoop Job Tracker client port. The Job Tracker listens on this port for job submissions and communications from Task Trackers; allows traffic from each analytics node in a cluster.	cassandra.yaml See Setting the Job Tracker node.
8983	Solr port and Demo applications web site port (Portfolio, Search, Search log, Weather Sensors)	
50030	Hadoop Job Tracker web site port. The Job Tracker listens on this port for HTTP requests. If initiated from the OpsCenter, these requests are proxied through the opscenterd daemon; otherwise, they come directly from the browser. [1]	`mapred-site.xml` using the mapred.job.tracker.http.address property.
50060	Hadoop Task Tracker web site port. Each Task Tracker listens on this port for HTTP requests coming directly from the browser and not proxied by the opscenterd daemon. [1]	`mapred-site.xml` using the mapred.task.tracker.http.address property.
OpsCenter public ports		
8888	OpsCenter web site port. The opscenterd daemon listens on this port for HTTP requests coming directly from the browser. [1]	`opscenterd.conf`
Inter-node Ports		
Cassandra inter-node ports		
1024 - 65355	JMX reconnection/loopback ports. Please read the description for port 7199.	
7000	Cassandra inter-node cluster communication port.	`cassandra.yaml` See storage_port.
7001	Cassandra SSL inter-node cluster communication port.	`cassandra.yaml` See ssl_storage_port.
7199	Cassandra JMX monitoring port.	`cassandra-env.sh` See JMX options in Tuning Java resources.
9160	Cassandra client port (Thrift) port. OpsCenter agents makes Thrift requests to their local node on this port. Additionally, the port can be used by the opscenterd daemon to make Thrift requests to each node in the cluster.	`cassandra.yaml` See rpc_port.
DataStax Enterprise inter-node ports		
7077	Spark Master inter-node communication port.	`dse.yaml`
8984	Solr inter-node communication port.	`dse.yaml` See Shard transport options for DSE Search communications.
9042	CQL native clients port.	`cassandra.yaml`

Port	Description	Configurable in
		See native_transport_port.
9290	Hadoop Job Tracker Thrift port. The Job Tracker listens on this port for Thrift requests coming from the opscenterd daemon.	
10000	Hive server port. **Note:** Use a different port if you run the Hive server and Shark server at the same time.	Set with the -p option in the `dse hive --service hiveserver -p` *`port`* command or configure in hive-site.xml.
10000	Shark server port.	Set with the -p option in the `dse shark --service sharkserver -p` *`port`* command.
OpsCenter specific inter-node		
50031	OpsCenter HTTP proxy for Job Tracker port. The opscenterd daemon listens on this port for incoming HTTP requests from the browser when viewing the Hadoop Job Tracker page directly. [1]	
61620	OpsCenter monitoring port. The opscenterd daemon listens on this port for TCP traffic coming from the agent. [1]	
61621	OpsCenter agent port. The agents listen on this port for SSL traffic initiated by OpsCenter. [1]	

The default location of the `hive-site.xml` file depends on the type of installation:

Installer-Services and Package installations	`/etc/dse/hive/hive-site.xml`
Installer-No Services and Tarball installations	*`install_location`*`/resources/hive/conf/hive-site.xml`

[1] See OpsCenter and DataStax agent ports.

DSE Management Services

DSE Management Services automatically handle administration and maintenance tasks and assist with overall database cluster management.

DSE Management Services are a set of services in DataStax Enterprise and OpsCenter that are designed to automatically handle various administration and maintenance tasks and assist with overall database cluster management.

Performance Service

The DataStax Enterprise Performance Service automatically collects and organizes performance diagnostic information into a set of data dictionary tables that can be queried with CQL.

The DataStax Enterprise Performance Service automatically collects and organizes performance diagnostic information into a set of data dictionary tables that can be queried with CQL.

About the Performance Service

The DSE Performance Service automatically collects and organizes performance diagnostic information into a set of data dictionary tables that can be queried with CQL.

The DataStax Enterprise Performance Service automatically collects and organizes performance diagnostic information from Cassandra, DSE Search, and DSE Analytics into a set of data dictionary tables. These tables are stored in the `dse_perf` keyspace and can be queried with CQL using any CQL-based utility, such as cqlsh, DataStax DevCenter, or any application using a Cassandra CQL driver.

Use this service to obtain database metrics and optimize Cassandra performance and fine-tune DSE Search. Examples include:

- Identify slow queries on a cluster to easily find and tune poorly performing queries.
- View latency metrics for tables on all user (non-system) keyspaces.
- Collect per node and cluster wide lifetime metrics by table and keyspace.
- Obtain recent and lifetime statistics about tables, such as the number of SSTables, read/write latency, and partition (row) size.
- Track read/write activity on a per-client, per-node level for both recent and long-lived activity to identify problematic user and table interactions.
- Detect bottlenecks in DSE Search.
- Monitor the resources used in a DSE Analytics cluster.
- Monitor particular DSE Analytics applications.

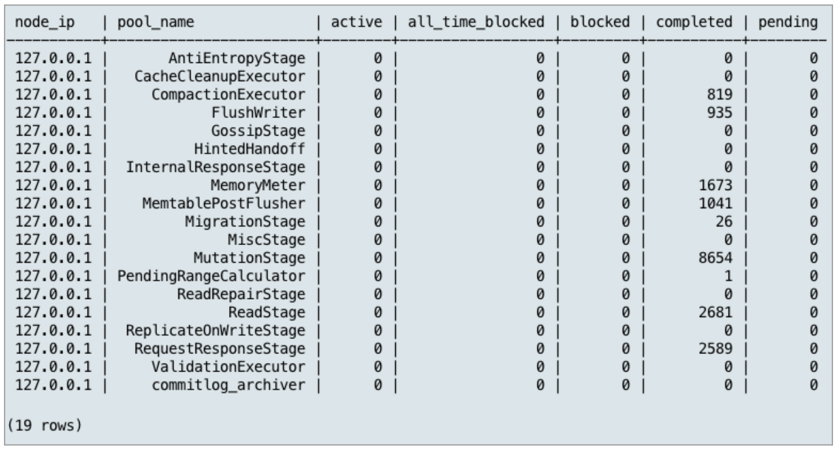
See the following for a complete listing of the available diagnostic tables:

- Cassandra diagnostic table reference
- Solr diagnostic table reference

The following is sample output from querying thread pool statistics:

```
cqlsh:dse_perf> select * from thread_pool;
```

Result:



```
 node_ip   | pool_name              | active | all_time_blocked | blocked | completed | pending
-----------+------------------------+--------+------------------+---------+-----------+---------
 127.0.0.1 |       AntiEntropyStage |      0 |                0 |       0 |         0 |       0
 127.0.0.1 |   CacheCleanupExecutor |      0 |                0 |       0 |         0 |       0
 127.0.0.1 |     CompactionExecutor |      0 |                0 |       0 |       819 |       0
 127.0.0.1 |            FlushWriter |      0 |                0 |       0 |       935 |       0
 127.0.0.1 |            GossipStage |      0 |                0 |       0 |         0 |       0
 127.0.0.1 |          HintedHandoff |      0 |                0 |       0 |         0 |       0
 127.0.0.1 |  InternalResponseStage |      0 |                0 |       0 |         0 |       0
 127.0.0.1 |            MemoryMeter |      0 |                0 |       0 |      1673 |       0
 127.0.0.1 |     MemtablePostFlusher |      0 |                0 |       0 |      1041 |       0
 127.0.0.1 |         MigrationStage |      0 |                0 |       0 |        26 |       0
 127.0.0.1 |              MiscStage |      0 |                0 |       0 |         0 |       0
 127.0.0.1 |          MutationStage |      0 |                0 |       0 |      8654 |       0
 127.0.0.1 | PendingRangeCalculator |      0 |                0 |       0 |         1 |       0
 127.0.0.1 |        ReadRepairStage |      0 |                0 |       0 |         0 |       0
 127.0.0.1 |              ReadStage |      0 |                0 |       0 |      2681 |       0
 127.0.0.1 |  ReplicateOnWriteStage |      0 |                0 |       0 |         0 |       0
 127.0.0.1 |   RequestResponseStage |      0 |                0 |       0 |      2589 |       0
 127.0.0.1 |     ValidationExecutor |      0 |                0 |       0 |         0 |       0
 127.0.0.1 |     commitlog_archiver |      0 |                0 |       0 |         0 |       0

(19 rows)
```

Configuring Performance Service replication strategy

To configure the Performance Service replication strategy, adjust the dse_perf keyspace that stores performance metrics data.

About this task

To configure the Performance Service replication strategy, adjust the dse_perf keyspace that stores performance metrics data. Depending on the specific requirements, adjust the replication factor with a keyspace command, such as ALTER KEYSPACE, to prevent potential unavailability of metrics data when nodes are down.

Enabling security

Tables in the dse_perf keyspace that stores performance metrics data do not require special handling for user reads and writes. Because DataStax Enterprise uses internal system APIs to write data to these tables, you do not have to create a system user to perform the writes when security is enabled.

1. To enforce restrictions, enable internal authentication and authorization and specify appropriate permissions on the tables.
2. To prevent users from viewing sensitive information like keyspace, table, and user names that are recorded in the performance tables, restrict users from reading the tables.

Setting the replication factor

By default DataStax Enterprise writes performance metrics data with consistency level ONE and writes are performed asynchronously. If you need to increase the replication factor of performance metrics data, use ALTER KEYSPACE. See Configuring data consistency.

Procedure

Set the replication factor based depending on your environment:

- **SimpleStrategy example:**

  ```
  ALTER KEYSPACE "dse_perf"
    WITH REPLICATION = { 'class' : 'SimpleStrategy',
   'replication_factor' : 3 };
  ```

- **NetworkTopologyStrategy example:**

  ```
  ALTER KEYSPACE "dse_perf"
    WITH REPLICATION = {'class' : 'NetworkTopologyStrategy', 'dc1' : 3,
   'dc2' : 2};
  ```

Enabling the collection of Cassandra data

Edit dse.yaml to enable and configure collection of Cassandra data.

Collecting slow queries

The node_slow_log retains query information of long-running CQL statements to help you identify slow queries on a cluster to easily find and tune poorly performing queries.

About this task

The node_slow_log table collects information about slow queries on a node and retains query information of long-running CQL statements to help you identify slow queries on a cluster to find and tune poorly performing queries.

The location of the dse.yaml file depends on the type of installation:

Installer-Services	`/etc/dse/dse.yaml`
Package installations	`/etc/dse/dse.yaml`
Installer-No Services	*install_location*`/resources/dse/conf/dse.yaml`
Tarball installations	*install_location*`/resources/dse/conf/dse.yaml`

Procedure

1. You can collect statements that are issued when the query exceeds a specified time threshold.

    - To permanently enable collecting information on slow queries, edit the dse.yaml file uncomment the cql_slow_log_threshold_ms parameter and define values for the CQL slow log settings:

      ```
      # CQL slow log settings
      enabled: true
      threshold_ms: 100
      ttl_seconds: 86400
      async_writers: 1
      ```

    - To temporarily enable collecting information on slow queries that exceeded the threshold of 200 milliseconds:

      ```
      $ dsetool perf cqlslowlog enable
      $ dsetool perf cqlslowlog 200
      ```

      After you collect information for some time using this temporarily set threshold, you can run a script to view queries that took longer with this threshold than the previously set threshold. For example:

      ```
      $ cqlsh
      cqlsh> use dse_perf;
      cqlsh:dse_perf> select * from node_slow_log;
      ...
      ```

2. You can export slow queries using the CQL copy command:

```
cqlsh:dse_perf> COPY node_slow_log ( date, commands, duration ) TO
 'slow_queries.csv' WITH HEADER = true;
```

Collecting system level diagnostics

Collect system-wide performance information about a cluster. Enable and set the cql_system_info_options parameter in `dse.yaml`.

About this task

The following system level diagnostic tables collect system-wide performance information about a cluster:

- key_cache

  Per node key cache metrics. Equivalent to nodetool info.
- net_stats

  Per node network information. Equivalent to nodetool netstats.
- thread_pool

  Per node thread pool active/blocked/pending/completed statistics by pool. Equivalent to nodetool tpstats.
- thread_pool_messages

  Per node counts of dropped messages by message type. Equivalent to nodetool tpstats.

Procedure

To collect system level data:

1. Edit the dse.yaml file.

   The location of the dse.yaml file depends on the type of installation:

Installer-Services	`/etc/dse/dse.yaml`
Package installations	`/etc/dse/dse.yaml`
Installer-No Services	`*install_location*/resources/dse/conf/dse.yaml`
Tarball installations	`*install_location*/resources/dse/conf/dse.yaml`

2. In the `dse.yaml` file, set the enabled option for cql_system_info_options to true.

   ```
   # CQL system info tables settings
   cql_system_info_options:
       enabled: true
       refresh_rate_ms: 10000
   ```

3. (Optional) To control how often the statistics are refreshed, increase or decrease the refresh_rate_ms parameter.

   The refresh_rate_ms specifies the length of the sampling period, that is, the frequency with which this data is updated.

Collecting object I/O level diagnostics

Collect data on object I/O statistics. Enable and set the resource_level_latency_tracking_options parameter in `dse.yaml`.

About this task

The following object I/O level diagnostic tables collect data on object I/O statistics:

- object_io

  Per node recent latency metrics by keyspace and table.

- object_read_io_snapshot

  Per node recent latency metrics, broken down by keyspace and table and orders data by mean read latency.
- object_write_io_snapshot

  Per node recent latency metrics, broken down by keyspace and table and orders data mean write latency.

Procedure

To enable the collection of this data:

1. Edit the dse.yaml file.

   The location of the dse.yaml file depends on the type of installation:

Installer-Services	`/etc/dse/dse.yaml`
Package installations	`/etc/dse/dse.yaml`
Installer-No Services	*install_location*`/resources/dse/conf/dse.yaml`
Tarball installations	*install_location*`/resources/dse/conf/dse.yaml`
2. In the `dse.yaml` file, set the enabled option for resource_level_latency_tracking_options to true.

   ```
   # Data Resource latency tracking settings
   resource_level_latency_tracking_options:
       enabled: true
       refresh_rate_ms: 10000
   ```
3. (Optional) To control how often the statistics are refreshed, increase or decrease the refresh_rate_ms parameter.

   The refresh_rate_ms specifies the length of the sampling period, that is, the frequency with which this data is updated.

Statistics gathered for objects

The Performance Service maintains two latency-ordered tables, which record the mean read/write latencies and total read/write operations on a per-node, per-table basis.

To identify which objects (keyspace, table, or client) are currently experiencing the highest average latencies, the Performance Service maintains two latency-ordered tables, which record the mean read/write latencies and total read/write operations on a per-node, per-table basis:

- object_read_io_snapshot
- object_write_io_snapshot

The two tables are essentially views of the same data, but are ordered differently. Using these tables, you can identify which data objects on the node currently cause the most write and read latency to users. Because this is time-sensitive data, if a data object sees no activity for a period, no data will be recorded for them in these tables.

In addition to these two tables, the Performance Service also keeps per-object latency information with a longer retention policy in the object_io table. Again, this table holds mean latency and total count values for both read and write operations, but it can be queried for statistics on specific data objects (either at the keyspace or table level). Using this table enables you to pull back statistics for all tables on a particular node, with the option of restricting results to a given keyspace or specific table.

Table activity broken down by user is retained in the object_user_read_io_snapshot, object_user_write_io_snapshot and object_user_io tables. The first two tables are ordered according to their mean latency values, making it easy for you to quickly identify which clients are currently experiencing the highest latency on specific data objects. Having identified the hot tables on a node, you can drill down and see a breakdown of the users accessing those objects. These tables are refreshed periodically to provide the most up to date view of activity, whereas the user_object_io table retains data for a longer period, enabling it to be queried by node and user with the option of restricting further by keyspace or even table.

Collecting database summary diagnostics

Enable the db_summary_stats_options parameter in `dse.yaml`.

About this task

The following database summary diagnostic tables collect statistics at a database level:

- node_table_snapshot

  Per node lifetime table metrics broken down by keyspace and table.
- table_snapshot

  Cluster wide lifetime table metrics broken down by keyspace and table (aggregates node_table_snapshot from each node in the cluster).
- keyspace_snapshot

  Cluster wide lifetime table metrics, aggregated at the keyspace level (rolls up the data in table_snapshot).

Procedure

To enable the collection of database-level statistics data:

1. Edit the dse.yaml file.

   The location of the dse.yaml file depends on the type of installation:

Installer-Services	`/etc/dse/dse.yaml`
Package installations	`/etc/dse/dse.yaml`
Installer-No Services	`*install_location*/resources/dse/conf/dse.yaml`
Tarball installations	`*install_location*/resources/dse/conf/dse.yaml`

2. In the `dse.yaml` file, set the enabled option for db_summary_stats_options to true.

```
# Database summary stats options
db_summary_stats_options:
    enabled: true
    refresh_rate_ms: 10000
```

3. (Optional) To control how often the statistics are refreshed, increase or decrease the refresh_rate_ms parameter.

   The refresh_rate_ms specifies the length of the sampling period, that is, the frequency with which this data is updated.

Collecting cluster summary diagnostics

Enable the cluster_summary_stats_options parameter in `dse.yaml`.

About this task

The following cluster summary diagnostic tables collect statistics at a cluster-wide level:

- cluster_snapshot

  Per node system metrics.
- dc_snapshot

  Aggregates node_snapshot data at the data center level.
- node_snapshot

  Aggregates node_snapshot data for the whole cluster.

Procedure

1. Edit the dse.yaml file.

   The location of the dse.yaml file depends on the type of installation:

Installer-Services	`/etc/dse/dse.yaml`
Package installations	`/etc/dse/dse.yaml`
Installer-No Services	*`install_location`*`/resources/dse/conf/dse.yaml`
Tarball installations	*`install_location`*`/resources/dse/conf/dse.yaml`

2. In the `dse.yaml` file, set the enabled option for cluster_summary_stats_options to true.

   ```
   # Cluster summary stats options
   cluster_summary_stats_options:
       enabled: true
       refresh_rate_ms: 10000
   ```

3. (Optional) To control how often the statistics are refreshed, increase or decrease the refresh_rate_ms parameter.

   The refresh_rate_ms specifies the length of the sampling period, that is, the frequency with which this data is updated.

Collecting table histogram diagnostics

Enable the histogram_data_options parameter in `dse.yaml`.

About this task

The following histogram diagnostics tables collect histogram data at a table level:

- cell_count_histograms

  Cell count per partition.
- partition_size_histograms

  Partition size.
- read_latency_histograms

  Read latency.
- sstables_per_read_histograms

  SSTables per read.
- write_latency_histograms

  Write latency.

Note: These tables somewhat duplicate the information obtained by the nodetool cfhistograms utility. The major difference is that cfhistograms output is recent data, whereas the diagnostic tables contain lifetime data. Additionally, each time nodetool cfhistograms is run for a column family, the histogram values are reset; whereas the data in the diagnostic histogram tables are not.

Procedure

To enable the collection of table histogram data:

1. Edit the dse.yaml file.

   The location of the dse.yaml file depends on the type of installation:

Installer-Services	`/etc/dse/dse.yaml`
Package installations	`/etc/dse/dse.yaml`
Installer-No Services	*install_location*`/resources/dse/conf/dse.yaml`
Tarball installations	*install_location*`/resources/dse/conf/dse.yaml`

2. In the `dse.yaml` file, set the enabled option for histogram_data_options to true.

   ```
   # Column Family Histogram data tables options
   histogram_data_options:
     enabled: true
     refresh_rate_ms: 10000
     retention_count: 3
   ```

3. (Optional) To control how often the statistics are refreshed, increase or decrease the refresh_rate_ms parameter.

   The refresh_rate_ms specifies the length of the sampling period, that is, the frequency with which this data is updated.
4. (Optional) To control the number of complete histograms kept in the tables at any one time, change the retention_count parameter.

Collecting user activity diagnostics

Enable the user_level_latency_tracking_options parameter in dse.yaml to collect user activity in diagnostics tables.

About this task

The following diagnostics tables collect user activity:

- object_user_io

  Per node, long-lived read/write metrics broken down by keyspace, table, and client connection. Each row contains mean read/write latencies and operation counts for a interactions with a specific table by a specific client connection during the last sampling period in which it was active. This data has a 10 minute TTL.

  Note: A client connection is uniquely identified by a host and port.
- object_user_read_io_snapshot

  Per node recent read/write metrics by client, keyspace, and table. This table contains only data relating to clients that were active during the most recent sampling period. Ordered by mean read latency.
- object_user_write_io_snapshot

  Per node recent read/write metrics by client, keyspace, and table. This table contains only data relating to clients that were active during the most recent sampling period. Ordered by mean write latency.
- user_io

Per node, long-lived read/write metrics broken down by client connection and aggregated for all keyspaces and tables. Each row contains mean read/write latencies and operation counts for a specific connection during the last sampling period in which it was active. This data has a 10 minute TTL.

- user_object_io

  Per node, long-lived read/write metrics broken down by client connection, keyspace, and table. Each row contains mean read/write latencies and operation counts for interactions with a specific table by a specific client connection during the last sampling period in which it was active. This data has a 10 minute TTL.

  Note: object_user_io and user_object_io represent two different views of the same underlying data. The former is structured to enable querying by user, the latter for querying by table.
- user_object_read_io_snapshot

  Per node recent read/write metrics by keyspace, table, and client. This table contains only data relating to clients that were active during the most recent sampling period. Ordered by mean read latency.
- user_object_write_io_snapshot

  Per node recent read/write metrics by keyspace, table, and client. This table contains only data relating to clients that were active during the most recent sampling period. Ordered by mean read latency.
- user_read_io_snapshot

  Per node recent read/write metrics by client. This table contains only data relating to clients that were active during the most recent sampling period. Ordered by mean read latency.
- user_write_io_snapshot

  Per node recent read/write metrics by client. This table contains only data relating to clients that were active during the most recent sampling period. Ordered by mean write latency.

Procedure

1. Edit the dse.yaml file.

   The location of the dse.yaml file depends on the type of installation:

Installer-Services	`/etc/dse/dse.yaml`
Package installations	`/etc/dse/dse.yaml`
Installer-No Services	*install_location*`/resources/dse/conf/dse.yaml`
Tarball installations	*install_location*`/resources/dse/conf/dse.yaml`

2. In the `dse.yaml` file, set the enabled option for user_level_latency_tracking_options to true.

```
# User/Resource latency tracking settings
user_level_latency_tracking_options:
   enabled: true
   refresh_rate_ms: 10000
   top_stats_limit: 100
```

3. (Optional) To control how often the statistics are refreshed, increase or decrease the refresh_rate_ms parameter.

   The refresh_rate_ms specifies the length of the sampling period, that is, the frequency with which this data is updated.
4. (Optional) To limit the number of individual metrics, change the top_stats_limit parameter.

   Keeping this limit fairly low reduces the level of system resources required to process the metrics.

Statistics gathered for user activity

User activity data is stored in latency-order to quickly identify latency in the system and by user to retrieve statistics for a particular client connection.

User activity data is stored in two main ways: Latency-ordered for quickly identifying the hot spots in the system and by user to retrieve statistics for a particular client connection.

To identify which users are currently experiencing highest average latencies on a given node, you can query these tables:

- user_read_io_snapshot
- user_write_io_snapshot

These tables record mean the read/write latencies and total read/write counts per-user on each node. They are ordered by their mean latency values, so you can quickly see which users are the experiencing the highest average latencies on a given node. Having identified the users experiencing the highest latency on a node, you can then can drill down to find the hot spots for those clients.

To do this, query the user_object_read_io_snapshot and user_object_write_io_snapshot tables. These tables store mean read/write latency and total read/write count by table for the specified user. They are ordered according to the mean latency values, and therefore able to quickly show for a given user which tables are contributing most to the experienced latencies.

The data in these tables is refreshed periodically (by default every 10 seconds), so querying them always provides an up-to-date view of the data objects with the highest mean latencies on a given node. Because this is time-sensitive data, if a user performs no activity for a period, no data is recorded for them in these tables.

The user_object_io table also reports per-node user activity broken down by keyspace/table and retains it over a longer period (4 hours by default). This allows the Performance Service to query by node and user to see latency metrics from all tables or restricted to a single keyspace or table. The data in this table is updated periodically (again every 10 seconds by default).

The user_io table reports aggregate latency metrics for users on a single node. Using this table, you can query by node and user to see high-level latency statistics across all keyspaces.

Enabling the collection of Solr data

Edit dse.yaml to enable and configure collection of Solr data.

Collecting slow Solr queries

Enable the solr_slow_sub_query_log_options parameter in dse.yaml.

About this task

The solr_slow_sub_query_log_options performance object reports distributed sub-queries (query executions on individual shards) that take longer than a specified period of time.

All objects are disabled by default.

Procedure

1. Edit the dse.yaml file.

   The location of the dse.yaml file depends on the type of installation:

Installer-Services	`/etc/dse/dse.yaml`
Package installations	`/etc/dse/dse.yaml`
Installer-No Services	*`install_location`*`/resources/dse/conf/dse.yaml`

Tarball installations	*install_location*/resources/dse/conf/dse.yaml

2. In the `dse.yaml` file, under the solr_slow_sub_query_log_options parameter, change enabled to *true* and set the other options as required.

```
# Solr slow query log options
solr_slow_sub_query_log_options:
    enabled: true
    ttl_seconds: 604800
    async_writers: 1
    threshold_ms: 100
```

   The default parameter values minimize resource usage.

Table 15: Options

Name	Type	Affects
enabled	boolean	Whether or not the object is enabled at start up.
ttl_seconds	int	How long (in seconds) a record survives before expiring from the performance object.
async_writers	int	For event-driven objects, such as the slow log, determines the number of possible concurrent slow query recordings. Objects like solr_result_cache_stats are updated in the background.
threshold_ms	int	For the slow log, the level (in milliseconds) at which a sub-query slow enough to be reported.

Collecting indexing errors

Enable the solr_indexing_error_log_options parameter in dse.yaml.

About this task

The solr_indexing_error_log_options object records errors that occur during document indexing.

All objects are disabled by default.

Procedure

1. Edit the dse.yaml file.

   The location of the dse.yaml file depends on the type of installation:

Installer-Services	/etc/dse/dse.yaml
Package installations	/etc/dse/dse.yaml
Installer-No Services	*install_location*/resources/dse/conf/dse.yaml
Tarball installations	*install_location*/resources/dse/conf/dse.yaml

2. In the `dse.yaml` file, under the solr_indexing_error_log_options parameter, change enabled to *true* and set the other options as required.

```
# Solr indexing error log options
solr_indexing_error_log_options:
```

```
enabled: true
ttl_seconds: 604800
async_writers: 1
```

All objects are disabled by default.

Table 16: Options

Name	Type	Affects
enabled	boolean	Whether or not the object is enabled at start up.
ttl_seconds	int	How long (in seconds) a record survives before expiring from the performance object.
async_writers	int	For event-driven objects, such as the slow log, determines the number of possible concurrent slow query recordings. Objects like solr_result_cache_stats are updated in the background.

Collecting Solr performance statistics

Enable the solr_latency_snapshot_options parameter in dse.yaml and set the other options as required.

About this task

When solr_latency_snapshot_options is enabled, the performance service creates the required tables and schedules the job to periodically update the relevant snapshot from the specified data source.

The following snapshots collect performance statistics:

- Query latency snapshot

  Record phase-level cumulative percentile latency statistics for queries over time.
- Update latency snapshot

  Record phase-level cumulative percentile latency statistics for updates over time.
- Commit latency snapshot

  Record phase-level cumulative percentile latency statistics for commits over time.
- Merge latency snapshot

  Record phase-level cumulative percentile latency statistics for index merges over time.

All objects are disabled by default.

Procedure

1. Edit the dse.yaml file.

   The location of the dse.yaml file depends on the type of installation:

Installer-Services	`/etc/dse/dse.yaml`
Package installations	`/etc/dse/dse.yaml`
Installer-No Services	*install_location*`/resources/dse/conf/dse.yaml`
Tarball installations	*install_location*`/resources/dse/conf/dse.yaml`

2. In the `dse.yaml` file, under the solr_latency_snapshot_options parameter, change enabled to *true* and set the other options as required.

   ```
   # Solr latency snapshot options
   solr_latency_snapshot_options:
       enabled: true
       ttl_seconds: 604800
       refresh_rate_ms: 60000
   ```

   All objects are disabled by default.

   Table 17: Options

Name	Type	Affects
enabled	boolean	Whether or not the object is enabled at start up.
ttl_seconds	int	How long (in seconds) a record survives before expiring from the performance object.
refresh_rate_ms	int	Period (in milliseconds) between sample recordings for periodically updating statistics like the solr_result_cache_stats.

Collecting cache statistics

Enable the solr_cache_stats_options parameter in dse.yaml and set the other options as required.

About this task

The solr_cache_stats_options object records current and cumulative cache statistics.

The following diagnostic tables collect cache statistics:

- Filter cache statistics

  Record core-specific query result cache statistics over time.
- Query result cache statistics

  Record core-specific query result cache statistics over time.

All objects are disabled by default.

Procedure

1. Edit the dse.yaml file.

   The location of the dse.yaml file depends on the type of installation:

Installer-Services	`/etc/dse/dse.yaml`
Package installations	`/etc/dse/dse.yaml`
Installer-No Services	`*install_location*/resources/dse/conf/dse.yaml`
Tarball installations	`*install_location*/resources/dse/conf/dse.yaml`

2. In the `dse.yaml` file, under the solr_cache_stats_optionsparameter, change enabled to *true* and set the other options as required.

   ```
   # Solr cache statistics options
   solr_cache_stats_options:
       enabled: true
   ```

```
    ttl_seconds: 604800
    refresh_rate_ms: 60000
```

All objects are disabled by default.

Table 18: Options

Name	Type	Affects
enabled	boolean	Whether or not the object is enabled at start up.
ttl_seconds	int	How long (in seconds) a record survives before expiring from the performance object.
refresh_rate_ms	int	Period (in milliseconds) between sample recordings for periodically updating statistics like the solr_result_cache_stats.

Collecting index statistics

Enable the solr_index_stats_options parameter in dse.yaml and set the other options as required.

About this task

The solr_index_stats_options object records core-specific index overview statistics over time.

All objects are disabled by default.

Procedure

1. Edit the dse.yaml file.

   The location of the dse.yaml file depends on the type of installation:

Installer-Services	`/etc/dse/dse.yaml`
Package installations	`/etc/dse/dse.yaml`
Installer-No Services	*install_location*`/resources/dse/conf/dse.yaml`
Tarball installations	*install_location*`/resources/dse/conf/dse.yaml`

2. In the `dse.yaml` file, for the solr_index_stats_options parameter, change enabled to *true* and set the other options as required.

```
# Solr index statistics options
solr_index_stats_options:
    enabled: false
    ttl_seconds: 604800
    refresh_rate_ms: 60000
```

   All objects are disabled by default.

Table 19: Options

Name	Type	Affects
enabled	boolean	Whether or not the object is enabled at start up.
ttl_seconds	int	How long (in seconds) a record survives before expiring from the performance object.

Name	Type	Affects
refresh_rate_ms	int	Period (in milliseconds) between sample recordings for periodically updating statistics like the solr_result_cache_stats.

Collecting handler statistics

Enable the solr_update_handler_metrics_options parameter in dse.yaml and set the other options as required.

About this task

The Update handler statistics records core-specific direct update handler statistics over time.

All objects are disabled by default.

Procedure

1. Edit the dse.yaml file.

   The location of the dse.yaml file depends on the type of installation:

Installer-Services	`/etc/dse/dse.yaml`
Package installations	`/etc/dse/dse.yaml`
Installer-No Services	*`install_location`*`/resources/dse/conf/dse.yaml`
Tarball installations	*`install_location`*`/resources/dse/conf/dse.yaml`

2. In the `dse.yaml` file, uncomment the solr_update_handler_metrics_options parameter and set the options as required.

```
# Solr UpdateHandler metrics options
solr_update_handler_metrics_options:
    enabled: true
    ttl_seconds: 604800
    refresh_rate_ms: 60000
```

   All objects are disabled by default.

Table 20: Options

Name	Type	Affects
enabled	boolean	Whether or not the object is enabled at start up.
ttl_seconds	int	How long (in seconds) a record survives before expiring from the performance object.
refresh_rate_ms	int	Period (in milliseconds) between sample recordings for periodically updating statistics like the solr_result_cache_stats.

Collecting request handler metrics

Enable the solr_request_handler_metrics_options parameter in dse.yaml and set the other options as required.

About this task

The solr_request_handler_metrics_options object records core-specific direct and request update handler statistics over time.

The following diagnostic tables collect handler metrics:

- Update handler statistics

  Record core-specific direct update handler statistics over time.
- Update request handler statistics

  Record core-specific update request handler statistics over time.

All objects are disabled by default.

Procedure

1. Edit the dse.yaml file.

   The location of the dse.yaml file depends on the type of installation:

Installer-Services	`/etc/dse/dse.yaml`
Package installations	`/etc/dse/dse.yaml`
Installer-No Services	*`install_location`*`/resources/dse/conf/dse.yaml`
Tarball installations	*`install_location`*`/resources/dse/conf/dse.yaml`

2. In the `dse.yaml` file, under the solr_request_handler_metrics_options parameter, change enabled to *true* and set the other options as required.

```
# Solr request handler metrics options
solr_request_handler_metrics_options:
    enabled: true
    ttl_seconds: 604800
    refresh_rate_ms: 60000
```

   All objects are disabled by default.

Table 21: Options

Name	Type	Affects
enabled	boolean	Whether or not the object is enabled at start up.
ttl_seconds	int	How long (in seconds) a record survives before expiring from the performance object.
refresh_rate_ms	int	Period (in milliseconds) between sample recordings for periodically updating statistics like the solr_result_cache_stats.

Monitoring Spark with Spark Performance Objects

Performance data is stored in a table to allow you to monitor and tune Spark analytics jobs.

The Performance Service can collect data associated with Spark cluster and Spark applications and save it to a table in Cassandra. This allows monitoring the metrics for DSE Analytics applications for performance tuning and bottlenecks.

If authorization is enabled in your cluster, you must grant the user who is running the Spark application `SELECT` permissions to the `dse_system.spark_metrics_config` table, and `MODIFY` permissions to the `dse_perf.spark_apps_snapshot`.

Monitoring Spark cluster information

The Performance Service stores information about DSE Analytics clusters in the `dse_perf.spark_cluster_snapshot` table. The cluster performance objects store the available and used resources in the cluster, including cores, memory, and workers, as well as overall information about all registered Spark applications, drivers and executors, including the number of applications, the state of each application, and the host on which the application is running.

To enable collecting Spark cluster information, configure the options in the spark_cluster_info_options section of dse.yaml.

Table 22: Spark cluster info options

Option	Default value	Description
enabled	false	Enables or disables Spark cluster information collection.
refresh_rate_ms	10,000	The time in milliseconds in which the data will be collected and stored.

The `dse_perf.spark_cluster_snapshot` table has the following columns:

name

The cluster name.

active_apps

The number of applications active in the cluster.

active_drivers

The number of active drivers in the cluster.

completed_apps

The number of completed applications in the cluster.

completed_drivers

The number of completed drivers in the cluster.

executors

The number of Spark executors in the cluster.

master_address

The host name and port number of the Spark Master node.

master_recovery_state

The state of the master node.

nodes

The number of nodes in the cluster.

total_cores

The total number of cores available on all the nodes in the cluster.

total_memory_mb

The total amount of memory in MB available to the cluster.

used_cores

The total number of cores currently used by the cluster.

used_memory_mb

The total amount of memory in MB used by the cluster.

workers

The total number of Spark Workers in the cluster.

Monitoring Spark application information

Spark application performance information is stored per application and updated whenever a task is finished. It is stored in the `dse_perf.spark_apps_snapshot` table.

To enable collecting Spark application information, configure the options in the spark_application_info_options section of dse.yaml.

Table 23: Spark application information options

Option	Default	Description
enabled	false	Enables or disables collecting Spark application information.
refresh_rate_ms	10,000	The time in milliseconds in which the data will be collected and stored.

The driver subsection of spark_application_info_options controls the metrics collected by the Spark Driver.

Table 24: Spark Driver information options

Option	Default	Description
sink	false	Enables or disables collecting metrics from the Spark Driver.
connectorSource	false	Enables or disables collecting Spark Cassandra Connector metrics.
jvmSource	false	Enables or disables collecting JVM heap and garbage collection metrics from the Spark Driver.
stateSource	false	Enables or disables collecting application state metrics.

The executor subsection of spark_application_info_options controls the metrics collected by the Spark executors.

Table 25: Spark executor information options

Option	Default	Description
sink	false	Enables or disables collecting Spark executor metrics.

Option	Default	Description
connectorSource	false	Enables or disables collecting Spark Cassandra Connector metrics from the Spark executors.
jvmSource	false	Enables or disables collecting JVM heap or garbage collection metrics from the Spark executors.

The `dse_perf.spark_apps_snapshot` table has the following columns:

application_id

component_id

metric_id

count

metric_type

rate_15_min

rate_1_min

rate_5_min

rate_mean

snapshot_75th_percentile

snapshot_95th_percentile

snapshot_98th_percentile

snapshot_999th_percentile

snapshot_99th_percentile

snapshot_max

snapshot_mean

snapshot_median

snapshot_min

snapshot_stddev

value

The location of the dse.yaml file depends on the type of installation:

Installer-Services	`/etc/dse/dse.yaml`
Package installations	`/etc/dse/dse.yaml`
Installer-No Services	*`install_location`*`/resources/dse/conf/dse.yaml`
Tarball installations	*`install_location`*`/resources/dse/conf/dse.yaml`

Cassandra Performance Service diagnostic table reference

A complete listing and brief description of Cassandra performance service diagnostic tables.

The following types of tables are available:

- CQL slow log table
- CQL system info tables
- Data Resource latency tracking tables
- Database summary statistics tables
- Cluster summary statistics tables
- Histogram tables
- User and resource latency tracking tables

Note: Table names that contain _snapshot are not related to Cassandra nodetool snapshots; they are snapshots of the data in the last few seconds of activity in the system.

CQL slow log table

Table 26: `node_slow_log` table

Queries on a node exceeding the cql_slow_log_threshold_ms parameter.

Column Name	Data type	Description
node_ip	inet	Node address.
date	timestamp	Date of entry (MM/DD/YYYY granularity).
start_time	timeuuid	Start timestamp of query execution.
commands	list<text>	CQL statements being executed.
duration	bigint	Execution time in milliseconds.
parameters	map<text	Not used at this time.
source_ip	inet	Client address.
table_names	set<text>	CQL tables touched.
username	text	User executing query, if authentication is enabled.

CQL system info tables

Table 27: `key_cache` table

Key cache performance statistics.

Column Name	Data type	Description
node_ip	inet	Node address.
cache_capacity	bigint	Key cache capacity in bytes.
cache_hits	bigint	Total number of cache hits since startup.
cache_requests	bigint	Total number of cache requests since startup.
cache_size	bigint	Current key cache size in bytes.
hit_rate	double	Ratio of hits to requests since startup.

Table 28: `net_stats` table

Data flow operations repair tasks and more.

Column Name	Data type	Description
node_ip	inet	Node address.
commands_completed	bigint	Total read repair commands completed since startup.
commands_pending	int	Current number of read repair commands pending.
read_repair_attempted	bigint	Read repairs attempted since startup.
read_repaired_background	bigint	Number of read repairs performed asyncronously since startup.
read_repaired_blocking	bigint	Number of read repairs performed syncronously since startup.
responses_completed	bigint	Current read repairs completed count.
responses_pending	int	Current read repair responses pending count.

Table 29: `thread_pool` table

Information on thread pool activity.

Column Name	Data type	Description
node_ip	inet	Node address.
pool_name	text	Thread pool name.
active	bigint	Currently active tasks.
all_time_blocked	bigint	Total blocked tasks since startup.
blocked	bigint	Currently blocked tasks.
completed	bigint	Total completed tasks since startup.
pending	bigint	Currently pending tasks.

Table 30: `thread_pool_messages` table

Information about thread pool messages.

Column Name	Data type	Description
node_ip	inet	Node address.
message_type	text	Inter-node message type.
dropped_count	int	Total count of dropped messages since startup.

Data Resource latency tracking tables

Table 31: `object_io` table

Per node recent latency metrics by keyspace and table.

Column Name	Data type	Description
node_ip	inet	Node address.
keyspace_name	text	Keyspace name.
table_name	text	Table name.

Column Name	Data type	Description
last_activity	timestamp	End of sampling period in which this object was last active.
memory_only	boolean	DSE memory only table.
read_latency	double	Mean value in microseconds for all reads during the last active sampling period for this object.
total_reads	bigint	Count during the last active sampling period for this object.
total_writes	bigint	Count during the last active sampling period for this object.
write_latency	double	Mean value in microseconds for all writes during the last active sampling period for this object.

Table 32: `object_read_io_snapshot` table

Per node recent latency metrics by keyspace and table. Ordered by mean read latency.

Column Name	Data type	Description
node_ip	inet	Node address.
latency_index	int	Ranking by mean read latency during the last sampling period.
keyspace_name	text	Keyspace name.
memory_only	boolean	DSE memory only table.
read_latency	double	In microseconds during the last sampling period.
table_name	text	Table name.
total_reads	bigint	Count during the last sampling period.
total_writes	bigint	Count during the last sampling period.
write_latency	double	In microseconds during the last sampling period.

Table 33: `object_write_io_snapshot` table

Per node recent latency metrics by keyspace and table. Ordered by mean write latency. Scale of 0 to 99 (0 is worst).

Column Name	Data type	Description
node_ip	inet	Node address.
latency_index	int	Ranking by mean write latency during the last sampling period.
keyspace_name	text	Keyspace name.
memory_only	boolean	DSE memory only table.
read_latency	double	Mean value in microseconds during the active sampling period.
table_name	text	Table name.
total_reads	bigint	Count during the last sampling period.
total_writes	bigint	Count during the last sampling period.

Column Name	Data type	Description
write_latency	double	Mean value in microseconds during the last sampling period.

Database summary statistics tables

Table 34: `node_table_snapshot` table

Per node table metrics by keyspace and table.

Column Name	Data type	Description
node_ip	inet	Node address.
keyspace_name	text	Keyspace name.
table_name	text	Table name.
bf_false_positive_ratio	double	Bloom filter false positive ratio since startup.
bf_false_positives	bigint	Bloom filter false positive count since startup.
compression_ratio	double	Current compression ratio of SSTables.
droppable_tombstone_ratio	double	Ratio of tombstones older than gc_grace_seconds against total column count in all SSTables.
key_cache_hit_rate	double	Current key cache hit rate.
live_sstable_count	bigint	Current SSTable count.
max_row_size	bigint	Maximum partition size in bytes.
mean_read_latency	double	In microseconds for this table since startup.
mean_row_size	bigint	Average partition size in bytes.
mean_write_latency	double	In microseconds for this table since startup.
memtable_columns_count	bigint	Approximate number of cells for this table currently resident in memtables.
memtable_size	bigint	Total size in bytes of memtable data.
memtable_switch_count	bigint	Number of times memtables have been flushed since startup.
min_row_size	bigint	Minimum partition size in bytes.
total_data_size	bigint	Data size on disk in bytes.
total_reads	bigint	Number of reads since startup.
total_writes	bigint	Number of writes since startup.
unleveled_sstables	bigint	Current count of SSTables in level 0 (if using leveled compaction).

Table 35: `table_snapshot` table

Cluster wide lifetime table metrics by keyspace and table. This table aggregates node_table_snapshot from each node in the cluster.

Column Name	Data type	Description
keyspace_name	text	Keyspace name.
table_name	text	Table name.
bf_false_positive_ratio	double	Bloom filter false positive ratio since startup.
bf_false_positives	bigint	Bloom filter false positive count since startup.
compression_ratio	double	Current compression ratio of SSTables.
droppable_tombstone_ratio	double	Ratio of tombstones older than gc_grace_seconds against total column count in all SSTables.
key_cache_hit_rate	double	Current key cache hit rate.
live_sstable_count	bigint	Current SStable count.
max_row_size	bigint	Maximum partition size in bytes.
mean_read_latency	double	In microseconds for this table since startup.
mean_row_size	bigint	Average partition size in bytes.
mean_write_latency	double	In microseconds for this table since startup.
memtable_columns_count	bigint	Approximate number of cells for this table currently resident in memtables.
memtable_size	bigint	Total size in bytes of memtable data.
memtable_switch_count	bigint	Number of times memtables have been flushed since startup.
min_row_size	bigint	Minimum partition size in bytes.
total_data_size	bigint	Data size on disk in bytes.
total_reads	bigint	Number of reads since startup.
total_writes	bigint	Number of writes since startup.
unleveled_sstables	bigint	Current count of SStables in level 0 (if using leveled compaction).

Table 36: `keyspace_snapshot` table

Cluster wide lifetime table metrics, aggregated at the keyspace level (aggregates the data in table_snapshot).

Column Name	Data type	Description
keyspace_name	text	Keyspace name.
index_count	int	Number of secondary indexes.
mean_read_latency	double	For all tables in the keyspace and all nodes in the cluster since startup.
mean_write_latency	double	For all tables in the keyspace and all nodes in the cluster since startup.
table_count	int	Number of tables in the keyspace.
total_data_size	bigint	Total size in bytes of SSTables for all tables and indexes across all nodes in the cluster.

Column Name	Data type	Description
total_reads	bigint	For all tables, across all nodes.
total_writes	bigint	For all tables, across all nodes.

Cluster summary statistics tables

Table 37: `node_snapshot` table

Per node system metrics.

Column Name	Data type	Description
node_ip	inet	Node address.
cms_collection_count	bigint	CMS garbage collections since startup.
cms_collection_time	bigint	Total time spent in CMS garbage collection since startup.
commitlog_pending_tasks	bigint	Current commit log tasks pending.
commitlog_size	bigint	Total commit log size in bytes.
compactions_completed	bigint	Number of compactions completed since startup.
compactions_pending	int	Number of pending compactions.
completed_mutations	bigint	Total number of mutations performed since startup.
data_owned	float	Percentage of total data owned by this node.
datacenter	text	Data center name.
dropped_mutation_ratio	double	Ratio of dropped to completed mutations since startup.
dropped_mutations	bigint	Total number of dropped mutations since startup.
flush_sorter_tasks_pending	bigint	Current number of memtable flush sort tasks pending.
free_space	bigint	Total free disk space in bytes.
gossip_tasks_pending	bigint	Current number of gossip tasks pending.
heap_total	bigint	Total available heap memory in bytes.
heap_used	bigint	Current heap usage in bytes.
hinted_handoff_pending	bigint	Current number of hinted handoff tasks pending.
index_data_size	bigint	Total size in bytes of index column families.
internal_responses_pending	bigint	Current number of internal response tasks pending.
key_cache_capacity	bigint	Key cache capacity in bytes.
key_cache_entries	bigint	Current number of key cache entries.
key_cache_size	bigint	Current key cache size in bytes.
manual_repair_tasks_pending	bigint	Current number of manual repair tasks pending.
mean_range_slice_latency	double	Mean latency in microseconds for range slice operations since startup.
mean_read_latency	double	Mean latency in microseconds for reads since startup.
mean_write_latency	double	Mean latency in microseconds for writes since startup.

Column Name	Data type	Description
memtable_post_flushers_pending	bigint	Current number of memtable post flush tasks pending.
migrations_pending	bigint	Current number of migration tasks pending.
misc_tasks_pending	bigint	Current number of misc tasks pending.
parnew_collection_count	bigint	ParNew garbage collections since startup.
parnew_collection_time	bigint	Total time spent in ParNew garbage collection since startup.
process_cpu_load	double	Current CPU load for the DSE process (Linux only).
rack	text	Rack identifier.
range_slice_timeouts	bigint	Number of timed out range slice requests since startup.
read_repair_tasks_pending	bigint	Current number of read repair tasks pending.
read_requests_pending	bigint	Current read requests pending.
read_timeouts	bigint	Number of timed out range slice requests since startup.
replicate_on_write_tasks_pending	bigint	Current.
request_responses_pending	bigint	Current.
row_cache_capacity	bigint	Row cache capacity in byte.s
row_cache_entries	bigint	Current number of row cache entries.
row_cache_size	bigint	Current row cache size in bytes.
state	text	Node State (JOINING/LEAVING/MOVING/NORMAL).
storage_capacity	bigint	Total disk space in bytes.
streams_pending	int	Current number of pending streams.
table_data_size	bigint	Total size in bytes of non-index column families.
tokens	set<text>	Tokens owned by the this node.
total_batches_replayed	bigint	Total number of batchlog entries replayed since startup
total_node_memory	bigint	Total available RAM (Linux only).
total_range_slices	bigint	Total number of range slice operations performed since startup.
total_reads	bigint	Total number of reads performed since startup.
total_writes	bigint	Total number of writes performed since startup.
uptime	bigint	Node uptime in seconds.
write_requests_pending	bigint	Total number of write tasks pending.
write_timeouts	bigint	Number of timed out range slice requests since startup.

Table 38: `dc_snapshot` table

Aggregates node_snapshot data at the data center level.

Column Name	Data type	Description
name	text	Data center name
compactions_completed	bigint	Total number of compactions completed since startup by all nodes in the data center.
compactions_pending	int	Total number of pending compactions on all nodes in the data center.
completed_mutations	bigint	Total number of mutations performed since startup by all nodes in the data center.
dropped_mutation_ratio	double	Ratio of dropped to completed mutations since startup across all nodes in the data center.
dropped_mutations	bigint	Total number of dropped mutations since startup by all nodes in the data center.
flush_sorter_tasks_pending	bigint	Total number of memtable flush sort tasks pending across all nodes in the data center.
free_space	bigint	Total free disk space in bytes across all nodes in the data center.
gossip_tasks_pending	bigint	Total number of gossip tasks pending across all nodes in the data center.
hinted_handoff_pending	bigint	Total number of hinted handoff tasks pending across all nodes in the data center.
index_data_size	bigint	Total size in bytes of index column families across all nodes in the data center.
internal_responses_pending	bigint	number of internal response tasks pending across all nodes in the data center.
key_cache_capacity	bigint	Total capacity in bytes of key caches across all nodes in the data center.
key_cache_entries	bigint	Total number of entries in key caches across all nodes in the data center.
key_cache_size	bigint	Total consumed size in bytes of key caches across all nodes in the data center.
manual_repair_tasks_pending	bigint	Total number of manual repair tasks pending across all nodes in the data center.
mean_range_slice_latency	double	Mean latency in microseconds for range slice operations, averaged across all nodes in the data center.
mean_read_latency	double	Mean latency in microseconds for read operations, averaged across all nodes in the data center.
mean_write_latency	double	Mean latency in microseconds for write operations, averaged across all nodes in the data center.
memtable_post_flushers_pending	bigint	Total number of memtable post flush tasks pending across all nodes in the data center.
migrations_pending	bigint	Total number of migration tasks pending across all nodes in the data center.

Column Name	Data type	Description
misc_tasks_pending	bigint	Total number of misc tasks pending across all nodes in the data center.
node_count	int	Total number of live nodes in the data center.
read_repair_tasks_pending	bigint	Total number of read repair tasks pending across all nodes in the data center.
read_requests_pending	bigint	Total read requests pending across all nodes in the data center.
replicate_on_write_tasks_pending	bigint	Total number of counter replicate on write tasks pending across all nodes in the data center.
request_responses_pending	bigint	Total number of request response tasks pending across all nodes in the data center.
row_cache_capacity	bigint	Total capacity in bytes of partition caches across all nodes in the data center.
row_cache_entries	bigint	Total number of row cache entries all nodes in the data center.
row_cache_size	bigint	Total consumed size in bytes of row caches across all nodes in the data center.
storage_capacity	bigint	Total disk space in bytes across all nodes in the data center.
streams_pending	int	number of pending streams across all nodes in the data center.
table_data_size	bigint	Total size in bytes of non-index column families across all nodes in the data center.
total_batches_replayed	bigint	Total number of batchlog entries replayed since startup by all nodes in the data center.
total_range_slices	bigint	Total number of range slice operations performed since startup by all nodes in the data center.
total_reads	bigint	Total number of read operations performed since startup by all nodes in the data center.
total_writes	bigint	Total number of write operations performed since startup by all nodes in the data center.
write_requests_pending	bigint	Total number of write tasks pending across all nodes in the data center.

Table 39: `cluster_snapshot` table

Aggregates node_shapshot data for the whole cluster.

Column Name	Data type	Description
name	text	Cluster name.
compactions_completed	bigint	Total number of compactions completed since startup by all nodes in the cluster.

Column Name	Data type	Description
completed_mutations	bigint	Total number of mutations performed since startup by all nodes in the cluster.
compactions_pending	int	Total number of pending compactions on all nodes in the cluster.
datacenters	set<text>	Data center names.
dropped_mutation_ratio	double	Ratio of dropped to completed mutations since startup across all nodes in the cluster.
dropped_mutations	bigint	Total number of dropped mutations since startup by all nodes in the cluster.
flush_sorter_tasks_pending	bigint	Total number of memtable flush sort tasks pending across all nodes in the cluster.
free_space	bigint	Total free disk space in bytes across all nodes in the cluster.
gossip_tasks_pending	bigint	Total number of gossip tasks pending across all nodes in the cluster.
hinted_handoff_pending	bigint	Total number of hinted handoff tasks pending across all nodes in the cluster.
index_data_size	bigint	Total size in bytes of index column families across all nodes in the cluster.
internal_responses_pending	bigint	Number of internal response tasks pending across all nodes in the cluster.
key_cache_capacity	bigint	Total capacity in bytes of key caches across all nodes in the cluster.
key_cache_entries	bigint	Total number of entries in key caches across all nodes in the cluster.
key_cache_size	bigint	Total consumed size in bytes of key caches across all nodes in the cluster.
keyspace_count	int	Total number of keyspaces defined in schema.
manual_repair_tasks_pending	bigint	Total number of manual repair tasks pending across all nodes in the cluster.
mean_range_slice_latency	double	Mean latency in microseconds for range slice operations, averaged across all nodes in the cluster.
mean_read_latency	double	Mean latency in microseconds for read operations, averaged across all nodes in the cluster.
mean_write_latency	double	Mean latency in microseconds for write operations, averaged across all nodes in the cluster.
memtable_post_flushers_pending	bigint	Total number of memtable post flush tasks pending across all nodes in the cluster.
migrations_pending	bigint	Total number of migration tasks pending across all nodes in the cluster.
misc_tasks_pending	bigint	Total number of misc tasks pending across all nodes in the cluster.

Column Name	Data type	Description
node_count	int	Total number of live nodes in the cluster.
read_repair_tasks_pending	bigint	Total number of read repair tasks pending across all nodes in the cluster.
read_requests_pending	bigint	Total read requests pending across all nodes in the cluster.
replicate_on_write_tasks_pending	bigint	Total number of counter replicate on write tasks pending across all nodes in the cluster.
request_responses_pending	bigint	Total number of request response tasks pending across all nodes in the cluster
row_cache_capacity	bigint	Total capacity in bytes of partition caches across all nodes in the cluster.
row_cache_entries	bigint	Total number of row cache entries all nodes in the cluster.
row_cache_size	bigint	Total consumed size in bytes of row caches across all nodes in the cluster
storage_capacity	bigint	Total disk space in bytes across all nodes in the cluster.
streams_pending	int	Number of pending streams across all nodes in the cluster.
table_count	int	Total number of tables defined in schema.
table_data_size	bigint	Total size in bytes of non-index column families across all nodes in the cluster.
total_batches_replayed	bigint	Total number of batchlog entries replayed since startup by all nodes in the cluster.
total_range_slices	bigint	Total number of read operations performed since startup by all nodes in the cluster.
total_reads	bigint	Total number of write operations performed since startup by all nodes in the cluster.
total_writes	bigint	Total number of write tasks pending across all nodes in the cluster.
write_requests_pending	bigint	Total number of write tasks pending across all nodes in the cluster.

Histogram tables

Table 40: `read_latency_histograms` table

Read latency histogram data.

Column Name	Data type	Description
node_ip	inet	Node address
keyspace_name	text	Keyspace name
table_name	text	Table name
histogram_id	timestamp	Groups rows by the specific histogram they belong to. Rows for the same node, keyspace & table are ordered by this field, to enable date-based filtering

Column Name	Data type	Description
bucket_offset	bigint	Read latency in microseconds
bucket_count	bigint	Count of reads where the latency falls in the corresponding bucket

Table 41: `write_latency_histograms` table

Write latency histogram data.

Column Name	Data type	Description
node_ip	inet	Node address
keyspace_name	text	Keyspace name
table_name	text	Table name
histogram_id	timestamp	Groups rows by the specific histogram they belong to. Rows for the same node, keyspace & table are ordered by this field, to enable date-based filtering
bucket_offset	bigint	Write latency in microseconds
bucket_count	bigint	Count of writes where the latency falls in the corresponding bucket

Table 42: `sstables_per_read_histograms` table

SStables per read histogram data.

Column Name	Data type	Description
node_ip	inet	Node address
keyspace_name	text	Keyspace name
table_name	text	Table name
histogram_id	timestamp	Groups rows by the specific histogram they belong to. Rows for the same node, keyspace & table are ordered by this field, to enable date-based filtering
bucket_offset	bigint	Number of SSTables required to satisfy a read request
bucket_count	bigint	Count of reads where the number of SSTables read falls in the corresponding bucket

Table 43: `partition_size_histograms` table

Partition size histogram data.

Column Name	Data type	Description
node_ip	inet	Node address.
keyspace_name	text	Keyspace name.
table_name	text	Table name.
histogram_id	timestamp	Groups rows by the specific histogram they belong to. Rows for the same node, keyspace & table are ordered by this field, to enable date-based filtering.

Column Name	Data type	Description
bucket_offset	bigint	Partition size in bytes.
bucket_count	bigint	Number of partitions where the size falls in the corresponding bucket.

Table 44: `cell_count_histograms` table

Cell count per partition histogram data.

Column Name	Data type	Description
node_ip	inet	Node address.
keyspace_name	text	Keyspace name.
table_name	text	Table name.
histogram_id	timestamp	Groups rows by the specific histogram they belong to. Rows for the same node, keyspace, and table are ordered by this field, to enable date-based filtering.
bucket_offset	bigint	Number of cells in a partition.
bucket_count	bigint	Number of partitions where the cell count falls in the corresponding bucket.

User and resource latency tracking tables

Table 45: `user_io` table

Per node, long-lived read/write metrics by client connection and aggregated for all keyspaces and tables.

Column Name	Data type	Description
node_ip	inet	Node address.
conn_id	text	Unique client connection ID.
last_activity	timestamp	End of sampling period in which this client was last active.
read_latency	double	In microseconds for the last active sampling period.
total_reads	bigint	Count during the last active sampling period for this client.
total_writes	bigint	Count during the last active sampling period for this client.
user_ip	inet	Client origin address.
username	text	Present if authentication is enabled.
write_latency	double	In microseconds for the last active sampling period.

Table 46: `user_read_io_snapshot` table

Per node recent read/write metrics by keyspace, table, and client during the most recent sampling period.

Column Name	Data type	Description
node_ip	inet	Node address.

Column Name	Data type	Description
latency_index	int	Ranking by mean read latency during the last sampling period.
conn_id	text	Unique client connection ID.
read_latency	double	Mean value in microseconds during the last sampling period.
total_reads	bigint	During the last sampling period.
total_writes	bigint	During the last sampling period.
user_ip	inet	Client origin address.
username	text	Present if authentication is enabled.
write_latency	double	Mean value in microseconds during the last sampling period.

Table 47: `user_write_io_snapshot` table

Per node recent read/write metrics by keyspace, table, and client during the most recent sampling period.

Column Name	Data type	Description
node_ip	inet	Node address.
latency_index	int	Ranking by mean write latency during the last sampling period.
conn_id	text	Unique client connection ID.
read_latency	double	Mean value in microseconds during the last sampling period.
total_reads	bigint	During the last sampling period.
total_writes	bigint	During the last sampling period.
user_ip	inet	Client origin address.
username	text	Present if authentication is enabled.
write_latency	double	Mean value in microseconds during the last sampling period.

Table 48: `user_object_io` table

Per node, long-lived read/write metrics by client connection, keyspace and table.

Column Name	Data type	Description
node_ip	inet	Node address.
conn_id	text	Unique client connection ID.
keyspace_name	text	Keyspace name.
table_name	text	Table name.
last_activity	timestamp	End of sampling period in which this client was last active against this object.

Column Name	Data type	Description
read_latency	double	Mean value in microseconds during the last active sampling period for this object/client.
total_reads	bigint	During the last active sampling period for this object/client.
total_writes	bigint	During the last active sampling period for this object/client.
user_ip	inet	Client origin address.
username	text	Present if authentication is enabled.
write_latency	double	Mean value in microseconds during the last active sampling period for this object/client.

Table 49: `user_object_write_io_snapshot` table

Per node recent read/write metrics by client, keyspace, and table during the most recent sampling period.

Column Name	Data type	Description
node_ip	inet	Node address.
latency_index	int	Ranking by mean write latency during the last sampling period.
conn_id	text	Unique client connection ID.
keyspace_name	text	Keyspace name.
read_latency	double	Mean value in microseconds during the last sampling period.
table_name	text	Table name.
total_reads	bigint	During the last sampling period.
total_writes	bigint	During the last sampling period.
user_ip	inet	Client origin address.
username	text	Present if authentication is enabled.
write_latency	double	Mean value in microseconds during the last sampling period.

Table 50: `user_object_read_io_snapshot` table

Per node read/write metrics by client, keyspace, and table during the most recent sampling period.

Tracks best-worst latency on a scale of 0 to 99 (0 is worst).

Column Name	Data type	Description
node_ip	inet	Node address.
latency_index	int	Ranking by mean read latency during the last sampling period.
conn_id	text	Unique client connection ID.
keyspace_name	text	Keyspace name.

Column Name	Data type	Description
read_latency	double	Mean value in microseconds during the last sampling period.
table_name	text	Table name.
total_reads	bigint	During the last sampling period.
total_writes	bigint	During the last sampling period.
user_ip	inet	Client origin address.
username	text	Present if authentication is enabled.
write_latency	double	Mean value in microseconds during the last sampling period.

Table 51: `object_user_io` table

Overview of the I/O activity by user for each table.

Column Name	Data type	Description
node_ip	inet	Node address.
keyspace_name	text	Keyspace name.
table_name	text	Table name.
conn_id	text	Unique client connection ID.
last_activity	timestamp	End of sampling period in which this client connection was last active against this object.
read_latency	double	Mean value in microseconds during the last active sampling period for this object/client.
total_reads	bigint	Count during the last active sampling period for this object/ client.
total_writes	bigint	Count during the last active sampling period for this object/ client.
user_ip	inet	Client origin address.
username	text	Present if authentication is enabled.
write_latency	double	Mean value in microseconds during the last active sampling period for this object/client.

Table 52: `object_user_read_io_snapshot`table

Per node recent read/write metrics by client, keyspace, and table during the most recent sampling period. Tracks best-worst latency on a scale of 0 to 99 (0 is worst).

Column Name	Data type	Description
node_ip	inet	Node address.
latency_index	int	Ranking by mean read latency during the last sampling period.
conn_id	text	Unique client connection ID.

Column Name	Data type	Description
keyspace_name	text	Keyspace name.
read_latency	double	Mean value in microseconds during the last active sampling period for this object/client.
table_name	text	Table name.
total_reads	bigint	Count during the last active sampling period for this object/ client.
total_writes	bigint	Count during the last active sampling period for this object/ client.
user_ip	inet	Client origin address.
username	text	Present if authentication is enabled.
write_latency	double	Mean value in microseconds during the last active sampling period for this object/client.

Table 53: `object_user_write_io_snapshot` table

Per node recent read/write metrics by client, keyspace, and table during the most recent sampling period. Tracks best-worst latency on a scale of 0 to 99 (0 is worst).

Column Name	Data type	Description
node_ip	inet	Node address.
latency_index	int	Ranking by mean write latency during the last sampling period.
conn_id	text	Unique client connection ID.
keyspace_name	text	Keyspace name.
read_latency	double	Mean value in microseconds during the last active sampling period for this object/client.
table_name	text	Table name.
total_reads	bigint	Count during the last active sampling period for this object/ client.
total_writes	bigint	Count during the last active sampling period for this object/ client.
user_ip	inet	Client origin address.
username	text	Present if authentication is enabled.
write_latency	double	Mean value in microseconds during the last active sampling period for this object/client.

DSE Search Performance Service diagnostic table reference

FAQs about using, and log information, snapshot, statistics in the DSE Search Performance Service diagnostic tables.

Frequently asked questions about the Solr Performance Service

FAQs include object enablement and performance impact.

Question: Is it a good idea to leave the Solr performance objects enabled 24/7?

Answer: It depends on your use cases. If you're attempting to collect data pertaining to a problem that occurs sporadically, and you've chosen configuration values that don't introduce a painful amount of performance overhead, there's no reason you can't keep the objects enabled on an ongoing basis.

Question: What kind of performance impact will enabling the Solr performance objects have?

Answer: Performance overhead, in terms of CPU and memory usage, should be negligible when using the DataStax Enterprise's default configuration values. However, the overhead introduced by enabling the objects varies as the configuration is modified (described in the following sections). For instance, setting longer TTLs and shorter refresh intervals leads to higher memory and disk consumption.

Question: Should I enable the Solr performance objects on every node in my cluster?

Answer: The Solr performance objects should only be enabled on search nodes, that is, nodes where indexes reside that can observe search operations. While it is perfectly acceptable to enable the objects across an entire cluster, enabling them on a single node for observation first is a good way to mitigate risk.

Question: Can I use existing Cassandra CF with secondary indexes on some columns, and create Solr indexes on other columns in the same CF?

Answer: Do not mix Solr indexes with Cassandra secondary indexes. Attempting to use both indexes on the same table is not supported.

Slow sub-query log

Report distributed sub-queries (query executions on individual shards) that take longer than a specified period of time.

Report distributed sub-queries (query executions on individual shards) that take longer than a specified period of time.

JMX analog

None.

Schema

```
CREATE TABLE IF NOT EXISTS dse_perf.solr_slow_sub_query_log (
  core text,
  date timestamp,
  coordinator_ip inet,
  query_id timeuuid,
  node_ip inet,
  start_time timeuuid,
  parameters map<text, text>,
  elapsed_millis bigint,
  component_prepare_millis map<text, bigint>,
  component_process_millis map<text, bigint>,
  num_docs_found bigint,
  PRIMARY KEY ((core, date), coordinator_ip, query_id, node_ip)
)
```

Field	Type	Purpose
core	text	Name of the Solr core (keyspace.table) where the slow sub-query was executed.
date	timestamp	Midnight on the mm/dd/yyyy the slow sub-query started.
coordinator_ip	inet	Distributed query coordinator IP address.

Field	Type	Purpose
query_id	timeuuid	ID of distributed query to which the slow sub-query belongs.
node_ip	inet	Node IP address.
start_time	timestamp	Timestamp at the start of the slow sub-query.
parameters	map<text,text>	Solr query parameters.
elapsed_millis	bigint	How long the slow sub-query took.
component_prepare_millis	map<text,bigint>	Map of (component name -> time spent in prepare phase).
component_process_millis	map<text,bigint>	Map of (component name -> time spent in process phase).
num_docs_found	bigint	Number of documents found by the slow sub-query.

Slow sub-queries recorded on 10/17/2014 for core keyspace.table for coordinator at 127.0.0.1:

```
SELECT *
FROM solr_slow_sub_query_log
WHERE core = 'keyspace.table' AND date = '2014-10-17' AND coordinator_ip =
 '127.0.0.1';
```

Slow sub-queries recorded on 10/17/2014 for core keyspace.table for coordinator at 127.0.0.1 for a particular distributed query with an ID of 33e56d33-4e63-11e4-9ce5-335a04d08bd4 :

```
SELECT *
FROM solr_slow_sub_query_log
WHERE core = 'keyspace.table'
    AND date = '2014-10-17'
    AND coordinator_ip = '127.0.0.1'
    AND query_id = 33e56d33-4e63-11e4-9ce5-335a04d08bd4;
```

Indexing error log

Records errors that occur during document validation.

Record errors that occur during document indexing.

Specifically, this log records errors that occur during document validation. A common scenario is where a non-stored copy field is copied into a field with an incompatible type.

JMX Analog

None.

Schema

```
CREATE TABLE IF NOT EXISTS dse_perf.solr_indexing_errors (
  node_ip inet,
  core text,
  date timestamp,
  time timeuuid,
    document text,
    field_name text,
    field_type text,
    message text,
    PRIMARY KEY ((node_ip, core, date), time)
  )
  WITH CLUSTERING ORDER BY (time DESC)
```

Field	Type	Purpose
node_ip	inet	Node address.
core	text	Solr Core name, such as keyspace.table.
date	timestamp	Midnight on the mm/dd/yyyy the error occurred.
time	timeuuid	Timestamp for the time the error occurred.
document	text	The primary key for the Cassandra row corresponding to the document. For example: [foo, bar, baz] for a complex PK, or foo for a single element PK.
field_name	text	Name of the field that caused the validation error.
field_type	text	Name of the field that caused the validation error, such as solr.StrField.
message	text	Error message.

Indexing validation errors recorded on 10/17/2014 for core keyspace.table for at node 127.0.0.1:

```
SELECT *
FROM solr_indexing_errors
WHERE core = 'keyspace.table' AND date = '2014-10-17' AND node_ip =
 '127.0.0.1';
```

Most recent 5 indexing validation errors recorded on 10/17/2014 for core keyspace.table for at node 127.0.0.1:

```
SELECT *
FROM solr_indexing_errors
WHERE core = 'keyspace.table'
    AND date = '2014-10-17'
    AND node_ip = '127.0.0.1'
ORDER BY time DESC
LIMIT 5;
```

Query latency snapshot

Records phase-level cumulative percentile latency statistics for queries over time.

Record phase-level cumulative percentile latency statistics for queries over time.

Note: All statistics reset upon node restart.

This table is configured with gc_grace_seconds 0) to avoid issues with persistent tombstones as rows expire; tombstones are removed during compaction no matter how recently they were created.

JMX Analog

```
com.datastax.bdp/search/<core>/QueryMetrics
```

See Query metrics MBean.

Schema

```
CREATE TABLE dse_perf.solr_query_latency_snapshot (
  node_ip inet,
  core text,
  date timestamp,
  time timestamp,
  phase text,
  count bigint,
  latency_percentiles_micros map<text, bigint>
  PRIMARY KEY ((node_ip, core), phase, time)
)
WITH CLUSTERING ORDER BY (phase ASC, time DESC)
AND gc_grace_seconds=0
```

Field	Type	Purpose
node_ip	inet	Node IP address.
core	text	Solr Core name, such as keyspace.table.
date	timestamp	Midnight on the mm/dd/yyyy the snapshot was recorded.
time	timestamp	Time the snapshot was recorded.
phase	text	EXECUTE, COORDINATE, RETRIEVE
count	bigint	Cumulative number of queries recorded.
latency_percentiles_micros	map<text,bigint>	Cumulative latency percentiles of query: 25%, 50%, 75%, 95%, 99% and 99.9%

Snapshots recorded on 10/17/2014 for core keyspace.table on the node 127.0.0.1:

```
SELECT *
FROM solr_query_latency_snapshot
WHERE node_ip = '127.0.0.1' AND core = 'keyspace.table' AND date =
 '2014-10-17';
```

Most recent 5 snapshots for the EXECUTE phase recorded on 10/17/2014 for core keyspace.table on the node 127.0.0.1:

```
SELECT *
FROM solr_query_latency_snapshot
WHERE node_ip = '127.0.0.1'
```

```
    AND core = 'keyspace.table'
    AND date = '2014-10-17'
    AND phase = 'EXECUTE'
LIMIT 5;
```

Update latency snapshot

Records phase-level cumulative percentile latency statistics for updates over time.

Record phase-level cumulative percentile latency statistics for updates over time.

Note: All statistics reset upon node restart.

This table is configured with gc_grace_seconds 0) to avoid issues with persistent tombstones as rows expire; tombstones are removed during compaction no matter how recently they were created.

JMX analog

```
com.datastax.bdp/search/<core>/UpdateMetrics
```

See Query metrics MBean.

Schema

```
CREATE TABLE dse_perf.solr_update_latency_snapshot (
  node_ip inet,
  core text,
  date timestamp,
  time timestamp,
  phase text,
  count bigint,
  latency_percentiles_micros map<text, bigint>
  PRIMARY KEY ((node_ip, core), phase, time)
)
WITH CLUSTERING ORDER BY (phase ASC, time DESC)
AND gc_grace_seconds=0
```

Field	Type	Purpose
node_ip	inet	Node IP address.
core	text	Solr Core name, such as keyspace.table.
date	timestamp	Midnight on the mm/dd/yyyy the snapshot was recorded.
time	timestamp	Time the snapshot was recorded.
phase	text	WRITE, QUEUE, PREPARE, EXECUTE
count	bigint	Cumulative number of queries recorded.
latency_percentiles_micros	map<text,bigint>	Cumulative latency percentiles of query: 25%, 50%, 75%, 95%, 99% and 99.9%.

Snapshots recorded on 10/17/2014 for core keyspace.table on the node 127.0.0.1:

```
SELECT *
FROM solr_update_latency_snapshot
WHERE node_ip = '127.0.0.1' AND core = 'keyspace.table' AND date =
 '2014-10-17';
```

Most recent 5 snapshots for the EXECUTE phase recorded on 10/17/2014 for core keyspace.table on the node 127.0.0.1:

```
SELECT *
FROM solr_update_latency_snapshot
WHERE node_ip = '127.0.0.1'
    AND core = 'keyspace.table'
    AND date = '2014-10-17'
    AND phase = 'EXECUTE'
LIMIT 5;
```

Commit latency snapshot

Records phase-level cumulative percentile latency statistics for commits over time.

Record phase-level cumulative percentile latency statistics for commits over time.

Note: All statistics reset upon node restart.

This table is configured with gc_grace_seconds 0) to avoid issues with persistent tombstones as rows expire; tombstones are removed during compaction no matter how recently they were created.

JMX Analog

```
com.datastax.bdp/search/<core>/CommitMetrics
```

See Commit metrics MBean.

Schema

```
CREATE TABLE dse_perf.solr_commit_latency_snapshot (
  node_ip inet,
  core text,
  date timestamp,
  time timestamp,
  phase text,
  count bigint,
  latency_percentiles_micros map<text, bigint>
  PRIMARY KEY ((node_ip, core, date), phase, time)
)
WITH CLUSTERING ORDER BY (phase ASC, time DESC)
AND gc_grace_seconds=0
```

Field	Type	Purpose
node_ip	inet	Node IP address.
core	text	Solr Core name, such as keyspace.table.
date	timestamp	Midnight on the mm/dd/yyyy the snapshot was recorded.

Field	Type	Purpose
time	timestamp	Time the snapshot was recorded.
phase	text	FLUSH, EXECUTE
count	bigint	Cumulative number of queries recorded.
latency_percentiles_micros	map<text,bigint>	Cumulative latency percentiles of query: 25%, 50%, 75%, 95%, 99% and 99.9%.

Snapshots recorded on 10/17/2014 for core keyspace.table on the node 127.0.0.1:

```
SELECT *
FROM solr_commit_latency_snapshot
WHERE node_ip = '127.0.0.1' AND core = 'keyspace.table' AND date =
 '2014-10-17';
```

Most recent 5 snapshots for the EXECUTE phase recorded on 10/17/2014 for core keyspace.table on the node 127.0.0.1:

```
SELECT *
FROM solr_commit_latency_snapshot
WHERE node_ip = '127.0.0.1'
    AND core = 'keyspace.table'
    AND date = '2014-10-17'
    AND phase = 'EXECUTE'
LIMIT 5;
```

Merge latency snapshot

Records phase-level cumulative percentile latency statistics for index merges over time.

Record phase-level cumulative percentile latency statistics for index merges over time.

Note: All statistics reset upon node restart.

This table is configured with gc_grace_seconds 0) to avoid issues with persistent tombstones as rows expire; tombstones are removed during compaction no matter how recently they were created.

JMX analog

```
com.datastax.bdp/search/<core>/MergeMetrics
```

See Merge metrics MBean.

Schema

```
CREATE TABLE dse_perf.solr_merge_latency_snapshot (
  node_ip inet,
  core text,
  date timestamp,
  time timestamp,
  phase text,
  count bigint,
  latency_percentiles_micros map<text, bigint>
  PRIMARY KEY ((node_ip, core, date), phase, time)
)
```

```
WITH CLUSTERING ORDER BY (phase ASC, time DESC)
AND gc_grace_seconds=0
```

Field	Type	Purpose
node_ip	inet	Node IP address.
core	text	Solr Core name, such as keyspace.table.
date	timestamp	Midnight on the mm/dd/yyyy the snapshot was recorded.
time	timestamp	Time the snapshot was recorded.
phase	text	INIT, WARM, EXECUTE
count	bigint	Cumulative number of queries recorded.
latency_percentiles_micros	map<text,bigint>	Cumulative latency percentiles of query: 25%, 50%, 75%, 95%, 99% and 99.9%.

Snapshots recorded on 10/17/2014 for core keyspace.table on the node 127.0.0.1:

```
SELECT *
FROM solr_merge_latency_snapshot
WHERE node_ip = '127.0.0.1' AND core = 'keyspace.table' AND date =
 '2014-10-17';
```

Most recent 5 snapshots for the EXECUTE phase recorded on 10/17/2014 for core keyspace.table" on the node 127.0.0.1:

```
SELECT *
FROM solr_merge_latency_snapshot
WHERE node_ip = '127.0.0.1'
    AND core = 'keyspace.table'
    AND date = '2014-10-17'
    AND phase = 'EXECUTE'
LIMIT 5;
```

Filter cache statistics

Records core-specific filter cache statistics over time.

Record core-specific filter cache statistics over time.

Note: All statistics reset upon node restart.

This table is configured with gc_grace_seconds 0) to avoid issues with persistent tombstones as rows expire; tombstones are removed during compaction no matter how recently they were created.

Solr exposes a core's filter cache statistics through its registered index searcher, but the core may have many index searchers over its lifetime. To reflect this, it provides statistics for the currently registered searcher as well as cumulative/lifetime statistics.

JMX analog

```
solr/<core>/dseFilterCache/com.datastax.bdp.search.solr.FilterCacheMBean
```

Schema

```
CREATE TABLE dse_perf.solr_filter_cache_stats (
  node_ip inet,
  core text,
  date timestamp,
  time timestamp,
  hits bigint,
  inserts bigint,
  evictions bigint,
  hit_ratio float,
  lookups bigint,
  num_entries bigint,
  cumulative_lookups bigint,
  cumulative_hits bigint,
  cumulative_hitratio float,
  cumulative_inserts bigint,
  cumulative_evictions bigint,
  warmup_time bigint,
  PRIMARY KEY ((node_ip, core, date), time)
)
WITH gc_grace_seconds=0
```

Field	Type	Purpose
node_ip	inet	Node IP address.
core	text	Solr Core name, such as keyspace.table.
date	timestamp	Midnight on the mm/dd/yyyy the statistics were recorded.
time	timestamp	The exact time the statistics were recorded.
hits	bigint	Cache hits for the registered index searcher.
inserts	bigint	Cache insertions for the registered index searcher.
evictions	bigint	Cache evictions for the registered index searcher.
hit_ratio	float	The ratio of cache hits/lookups for the registered index searcher.
lookups	bigint	Cache lookups for the registered index searcher.
num_entries	bigint	Number of cache entries for the registered index searcher.
cumulative_lookups	bigint	Cumulative cache lookups for the core.
cumulative_hits	bigint	Cumulative cache hits for the core.
cumulative_hitratio	float	Cumulative ratio of cache hits/ lookups for the core.

Field	Type	Purpose
cumulative_inserts	bigint	Cumulative cache inserts for the core.
cumulative_evictions	bigint	Cumulative cache evictions for the core.
warmup_time	bigint	Warm-up time for the registered index searcher.

Snapshots for cumulative statistics recorded on 10/17/2014 for core “keyspace.table” on the node 127.0.0.1:

```
SELECT cumulative_lookups, cumulative_hits, cumulative_hitratio,
 cumulative_inserts
FROM solr_filter_cache_stats
WHERE node_ip = '127.0.0.1' AND core = 'keyspace.table' AND date =
 '2014-10-17';
```

Most recent 5 snapshots recorded on 10/17/2014 for core keyspace.table on the node 127.0.0.1:

```
SELECT *
FROM solr_filter_cache_stats
WHERE node_ip = '127.0.0.1'
    AND core = 'keyspace.table'
    AND date = '2014-10-17'
ORDER BY time DESC
LIMIT 5;
```

Query result cache statistics

Records core-specific query result cache statistics over time.

Record core-specific query result cache statistics over time.

Solr exposes a core’s result cache statistics through its registered index searcher, but the core may have many index searchers over its lifetime. To reflect this, it provides statistics for the currently registered searcher as well as cumulative/lifetime statistics.

JMX analog

```
solr/<core>/queryResultCache/*
```

Schema

```
CREATE TABLE dse_perf.solr_result_cache_stats (
  node_ip inet,
  core text,
  date timestamp,
  time timestamp,
  hits bigint,
  inserts bigint,
  evictions bigint,
  hit_ratio float,
  lookups bigint,
  num_entries bigint,
  cumulative_lookups bigint,
  cumulative_hits bigint,
    cumulative_hitratio float,
    cumulative_inserts bigint,
    cumulative_evictions bigint,
    warmup_time bigint,
    PRIMARY KEY ((node_ip, core, date), time)
  )
  WITH gc_grace_seconds=0
```

Field	Type	Purpose
node_ip	inet	Node IP address.
core	text	Solr Core name, such as keyspace.table.
date	timestamp	Midnight on the mm/dd/yyyy the statistics were recorded.
time	timestamp	The exact time the statistics were recorded.
hits	bigint	Cache hits for the registered index searcher.
inserts	bigint	Cache insertions for the registered index searcher.
evictions	bigint	Cache evictions for the registered index searcher.
hit_ratio	float	The ratio of cache hits / lookups for the registered index searcher.
lookups	bigint	Cache lookups for the registered index searcher.
num_entries	bigint	Number of cache entries for the registered index searcher.
cumulative_lookups	bigint	Cumulative cache lookups for the core.
cumulative_hits	bigint	Cumulative cache hits for the core.
cumulative_hitratio	float	Cumulative ratio of cache hits/ lookups for the core.
cumulative_inserts	bigint	Cumulative cache inserts for the core.
cumulative_evictions	bigint	Cumulative cache evictions for the core.
warmup_time	bigint	Warm-up time for the registered index searcher.

Snapshots for cumulative statistics recorded on 10/17/2014 for core keyspace.table on the node 127.0.0.1:

```
SELECT cumulative_lookups, cumulative_hits, cumulative_hitratio,
 cumulative_inserts
FROM solr_result_cache_stats
```

```
WHERE node_ip = '127.0.0.1' AND core = 'keyspace.table' AND date =
 '2014-10-17';
```

Most recent 5 snapshots recorded on 10/17/2014 for core keyspace.table on the node 127.0.0.1:

```
SELECT *
FROM solr_result_cache_stats
WHERE node_ip = '127.0.0.1'
    AND core = 'keyspace.table'
    AND date = '2014-10-17'
ORDER BY time DESC
LIMIT 5;
```

Index statistics

Records core-specific index overview statistics over time.

Record core-specific index overview statistics over time.

JMX analog

```
solr/<core name>/core/<core name> & solr/<core name>/Searcher*
```

Schema

```
CREATE TABLE dse_perf.solr_index_stats (
  node_ip inet,
  core text,
  date timestamp,
  time timestamp,
  size_in_bytes bigint,
  num_docs int,
  max_doc int,
  docs_pending_deletion int,
  PRIMARY KEY ((node_ip, core, date), time)
)
WITH gc_grace_seconds=0
```

Field	Type	Purpose
node_ip	inet	Node IP address.
core	text	Solr Core name, such as keyspace.table.
date	text	Midnight on the mm/dd/yyyy the statistics were recorded.
time	bigint	The exact time the statistics were recorded.
size_in_bytes	bigint	Index size on file system.
num_docs	int	The number of documents inserted into index.
max_docs	int	The number of documents inserted into index, plus those marked as removed, but not yet physically removed.

Field	Type	Purpose
docs_pending_deletion	int	max_docs - num_docs

Snapshots recorded on 10/17/2014 for core keyspace.table on the node 127.0.0.1:

```
SELECT *
FROM solr_index_stats
WHERE node_ip = '127.0.0.1' AND core = 'keyspace.table' AND date =
 '2014-10-17';
```

Most recent 5 snapshots recorded on 10/17/2014 for core keyspace.table on the node 127.0.0.1:

```
SELECT *
FROM solr_index_stats
WHERE node_ip = '127.0.0.1'
    AND core = 'keyspace.table'
    AND date = '2014-10-17'
ORDER BY time DESC
LIMIT 5;
```

Update handler statistics

Records core-specific direct update handler statistics over time.

Record core-specific direct update handler statistics over time.

Note: Do not to confuse this with Update request handler statistics.

A few fields in this table have both cumulative and non-cumulative versions. The non-cumulative statistics are zeroed out following rollback or commit, while the cumulative versions persist through those events. The exception is errors, which is actually cumulative and takes into account a few failure cases that cumulative_errors does not.

JMX analog

```
solr/<core>/updateHandler
```

Schema

```
CREATE TABLE dse_perf.solr_update_handler_metrics (
  node_ip inet,
  core text,
  date timestamp,
  time timestamp,
  adds bigint,
  cumulative_adds bigint,
  commits bigint,
  autocommits int,
  autocommit_max_time text,
  autocommit_max_docs int,
  soft_autocommits int,
  soft_autocommit_max_docs int,
  soft_autocommit_max_time text,
  deletes_by_id bigint,
  deletes_by_query bigint,
  cumulative_deletes_by_id bigint,
  cumulative_deletes_by_query bigint,
  expunge_deletes bigint,
    errors bigint,
    cumulative_errors bigint,
    docs_pending bigint,
    optimizes bigint,
    rollbacks bigint,
    PRIMARY KEY ((node_ip, core, date), time)
  )
  WITH gc_grace_seconds=0
```

Field	Type	Purpose
node_ip	inet	Node IP address.
core	text	Solr Core name, such as keyspace.table.
date	timestamp	Midnight on the mm/dd/yyyy the statistics were recorded.
time	timestamp	Exact time the statistics were recorded.
adds	bigint	Document add commands since last commit/rollback.
cumulative_adds	bigint	Cumulative document additions.
commits	long	Number of explicit commit commands issued.
autocommits	int	Number of auto-commits executed.
autocommit_max_time	text	Maximum time between auto-commits.
autocommit_max_docs	int	Maximum document adds between auto-commits.
soft_autocommits	int	Number of soft auto-commits executed.
soft_autocommit_max_docs	int	Maximum time between soft auto-commits.
soft_autocommit_max_time	int	Maximum document adds between soft auto-commits.
deletes_by_id	long	Currently uncommitted deletions by ID.
deletes_by_query	bigint	Currently uncommitted deletions by query.
cumulative_deletes_by_id	bigint	Cumulative document deletions by ID.
cumulative_deletes_by_query	bigint	Cumulative document deletions by ID.
expunge_deletes	bigint	Number of commit commands issued with expunge deletes.

Field	Type	Purpose
errors	bigint	Cumulative errors for add/delete/ commit/rollback commands.
cumulative_errors	bigint	Cumulative errors for add/delete commands.
docs_pending	bigint	Number of documents pending commit.
optimizes	bigint	Number of explicit optimize commands issued.
rollbacks	bigint	Number of rollbacks executed.

Snapshots recorded on 10/17/2014 for core keyspace.table on the node 127.0.0.1:

```
SELECT *
FROM solr_update_handler_metrics
WHERE node_ip = '127.0.0.1' AND core = 'keyspace.table' AND date =
 '2014-10-17';
```

Most recent 5 snapshots recorded on 10/17/2014 for core keyspace.table on the node 127.0.0.1:

```
SELECT *
FROM solr_update_handler_metrics
WHERE node_ip = '127.0.0.1'
    AND core = 'keyspace.table'
    AND date = '2014-10-17'
ORDER BY time DESC
LIMIT 5;
```

Update request handler statistics

Records core-specific update request handler statistics over time.

Record core-specific update request handler statistics over time.

Note: Do not to confuse this with Update handler statistics.

JMX analog

```
solr/<core>/update[/ | /<csv | /json]
```

Schema

```
CREATE TABLE dse_perf.solr_update_request_handler_metrics (
  node_ip inet,
  core text,
  date timestamp,
  handler_name text,
  time timestamp,
  requests bigint,
  errors bigint,
  timeouts bigint,
  total_time_seconds double,
  avg_requests_per_second double,
  five_min_rate_reqs_per_second double,
  fifteen_min_rate_reqs_per_second double,
  PRIMARY KEY ((node_ip, core, date), handler_name, time)
)
WITH CLUSTERING ORDER BY (handler_name ASC, time DESC)
AND gc_grace_seconds=0
```

Field	Type	Purpose
node_ip	inet	Node IP address.
core	text	Solr Core name, such as keyspace.table.
date	timestamp	Midnight on the mm/dd/yyyy the statistics were recorded.
handler_name	text	A handler name specified in the `solrconfig.xml` file.
time	timestamp	Exact time the statistics were recorded.
requests	bigint	Number of requests processed by the handler.
errors	bigint	Number of errors encountered by the handler.
timeouts	bigint	Number of responses received with partial results.
total_time	double	The sum of all request processing times.
avg_requests_per_second	double	Average number of requests per second.
five_min_rate_reqs_per_second	double	Requests per second over that past 5 minutes.
fifteen_min_rate_reqs_per_second	double	Requests per second over that past 15 minutes.

Snapshots recorded on 10/17/2014 for core keyspace.table on the node 127.0.0.1:

```
SELECT *
FROM solr_update_request_handler_metrics
WHERE node_ip = '127.0.0.1' AND core = 'keyspace.table' AND date =
 '2014-10-17';
```

Most recent 5 snapshots for handler “search” recorded on 10/17/2014 for core keyspace.table on the node 127.0.0.1:

```
SELECT *
FROM solr_search_request_handler_metrics
WHERE node_ip = '127.0.0.1'
    AND core = 'keyspace.table'
    AND date = '2014-10-17'
    AND handler_name = 'search'
LIMIT 5;
```

Search request handler statistics

Records core-specific search request handler statistics over time.

Record core-specific search request handler statistics over time.

JMX analog

```
solr/<core>/search
```

Schema

```
CREATE TABLE dse_perf.solr_search_request_handler_metrics (
  node_ip inet,
  core text,
  date timestamp,
  handler_name text,
  time timestamp,
  requests bigint,
  errors bigint,
  timeouts bigint,
  total_time_seconds double,
  avg_requests_per_second double,
  five_min_rate_reqs_per_second double,
  fifteen_min_rate_reqs_per_second double,
  PRIMARY KEY ((node_ip, core, date), handler_name, time)
)
WITH CLUSTERING ORDER BY (handler_name ASC, time DESC)
AND gc_grace_seconds=0
```

Field	Type	Purpose
node_ip	inet	Node IP address.
core	text	Solr Core name, such as keyspace.table.
date	timestamp	Midnight on the mm/dd/yyyy the statistics were recorded.
handler_name	text	A handler name specified in the `solrconfig.xml` file.
time	timestamp	Exact time the statistics were recorded.
requests	bigint	Number of requests processed by the handler.
errors	bigint	Number of errors encountered by the handler.
timeouts	bigint	Number of responses received with partial results.
total_time_seconds	double	The sum of all request processing times.
avg_requests_per_second	double	Average number of requests per second.

Field	Type	Purpose
five_min_rate_reqs_per_second	double	Requests per second over that past 5 minutes.
fifteen_min_rate_reqs_per_second	double	Requests per second over that past 15 minutes.

Snapshots recorded for all update handlers on 10/17/2014 for core keyspace.table on the node 127.0.0.1:

```
SELECT *
FROM solr_search_request_handler_metrics
WHERE node_ip = '127.0.0.1' AND core = 'keyspace.table' AND date =
 '2014-10-17';
```

Most recent 5 snapshots for handler “/update/json” recorded on 10/17/2014 for core keyspace.table on the node 127.0.0.1:

```
SELECT *
FROM solr_search_request_handler_metrics
WHERE node_ip = '127.0.0.1' AND
    core = 'keyspace.table'
    AND date = '2014-10-17'
    AND handler_name = '/update/json'
LIMIT 5;
```

Capacity Service

Automatically collects data about a cluster's operations, including Cassandra specific and platform specific (for example, disk metrics, network metrics), at both the node and column-family level (where applicable). Use OpsCenter to manage and perform trend analysis.

The Capacity Service automatically collects data about a cluster’s operations and provides for the ability to do historical trend analysis and forecasting of future trends.

For more details, see Capacity Service in the *OpsCenter User Guide*.

Repair Service

The Repair Service is designed to automatically keep data synchronized across a cluster. You can manage the Repair Service with OpsCenter or by using the command line.

The Repair Service is designed to automatically keep data synchronized across a cluster and can be managed either visually through OpsCenter Repair Service or by using the command line.

DSE In-Memory

DataStax Enterprise includes DSE In-Memory for storing data to and accessing data exclusively from memory.

DSE In-Memory delivers in-memory computing capabilities to Cassandra. DSE In-Memory allows developers, architects, and administrators to easily choose what parts (some or all) of a database reside fully in RAM. DSE In-Memory is designed for use cases that lend themselves to in-memory computing, while allowing disk-based workloads to be serviced by Cassandra's traditional storage model. This design allows applications with in-memory and disk-based requirements to be supported by one database platform.

DSE In-Memory delivers lightning-fast read performance for use cases that include primarily read-only workloads with slowly changing data and/or semi-static datasets. For example, a product catalog that is refreshed nightly, but read constantly during the day.

DSE In-Memory is not suitable for workloads with heavily changing data or monotonically growing datasets that can exceed the RAM capacity on the nodes/cluster.

DataStax recommends using OpsCenter to check performance metrics before and after configuring DSE In-Memory.

Creating or altering tables to use DSE In-Memory

Use CQL directives to create and alter tables to use DSE In-Memory.

Use CQL directives to create and alter tables to use DSE In-Memory and `dse.yaml` to limit the size of tables.

Creating a table to use DSE In-Memory

To create a table that uses DSE In-Memory, add a CQL directive to the CREATE TABLE statement. Use the compaction directive in the statement to specify the MemoryOnlyStrategy class, disable compression, and disable the key and row caches.

```
CREATE TABLE customers (
  uid text,
  fname text,
  lname text,
  PRIMARY KEY (uid)
) WITH compaction= { 'class': 'MemoryOnlyStrategy' }
      AND compression = {'sstable_compression' : ''}
      AND caching = {'keys':'NONE', 'rows_per_partition':'NONE'};
```

Altering an existing table to use DSE In-Memory

Use the ALTER TABLE statement to change a traditional table to use in-memory, or to change an in-memory table to a traditional table. For example, use the `DESCRIBE` command for a table named employee. Verify that employee is a traditional table because the output of the `DESCRIBE` command does not include a line that looks something like:

```
compaction={'class': 'MemoryOnlyStrategy'} >
```

Alter the employee table to use DSE In-Memory and, as a best practice, disable caching:

```
ALTER TABLE employee WITH compaction= { 'class': 'MemoryOnlyStrategy' }
  AND compression = {'sstable_compression' : ''}
  AND caching = {'keys':'NONE', 'rows_per_partition':'NONE'};
```

Limiting the size of tables

Use the max_memory_to_lock_fraction or max_memory_to_lock_mb configuration option in the dse.yaml file to specify how much system memory to use for all in-memory tables.

max_memory_to_lock_fraction	Specify a fraction of the system memory. The default value of 0.20 specifies to use up to 20% of system memory.
max_memory_to_lock_mb	Specify a maximum amount of memory in MB.

The location of the dse.yaml file depends on the type of installation:

Installer-Services	`/etc/dse/dse.yaml`
Package installations	`/etc/dse/dse.yaml`
Installer-No Services	*install_location*`/resources/dse/conf/dse.yaml`
Tarball installations	*install_location*`/resources/dse/conf/dse.yaml`

Disabling caching on tables

DataStax recommends disabling caching on tables that use the DSE In-Memory option. If caching is not disabled, a warning is logged. Set the table caching property to disable both types of caching:

```
ALTER TABLE customers WITH caching = {'keys':'NONE',
  'rows_per_partition':'NONE'};
```

Verifying table properties

In cqlsh, use the DESCRIBE command to view table properties.

In cqlsh, use the `DESCRIBE` command to view table properties:

```
cqlsh> DESCRIBE TABLE employee;
```

This output shows that the table uses DSE In-Memory:

```
CREATE TABLE employee (
  uid text PRIMARY KEY,
  fname text,
  lname text
) WITH bloom_filter_fp_chance = 0.01
  AND caching = '{"keys":"NONE", "rows_per_partition":"NONE"}'
  AND comment = ''
  AND compaction = {'min_threshold': '4', 'class':
 'org.apache.cassandra.db.compaction.MemoryOnlyStrategy',
'max_threshold': '32'}
  AND compression = {}
  AND dclocal_read_repair_chance = 0.1
  AND default_time_to_live = 0
  AND gc_grace_seconds = 864000
  AND max_index_interval = 2048
  AND memtable_flush_period_in_ms = 0
  AND min_index_interval = 128
  AND read_repair_chance = 0.0
  AND speculative_retry = '99.0PERCENTILE';
```

Managing memory

You must monitor and carefully manage available memory when using DSE In-Memory.

Because DataStax Enterprise runs in a distributed environment, you can inadvertently add excessive data that exceeds the available memory. When using DSE In-Memory, you must monitor and carefully manage available memory. DSE In-Memory retains the durability guarantees of Cassandra.

Recommended limits

To prevent exceeding the RAM capacity, DataStax recommends that in-memory objects consume no more than 45% of a node’s free memory.

Managing available memory

If the maximum memory capacity is exceeded, locking some of the data into memory is stopped, and read performance will degrade and a warning message is displayed.

The warning message looks something like this:

```
WARN  [main] 2015-03-27 09:34:00,050  MemoryOnlyStrategy.java:252 - File
MmappedSegmentedFile(path='/data/ks/test-f590c150b95911e4b66d85e0b6fd73a5/
ks-test-ka-94-Data.db',
length=43629650) buffer address: 140394485092352 length: 43629650 could not
 be locked.
Sizelimit (1048576) reached. After locking size would be: 43630592
```

Checking available memory

Use the `dsetool inmemorystatus` command to check the amount of data that is currently in memory. When the data size exceeds the specified **Max Memory to Lock** value, or some other problem exists, the **Couldn't Lock** column displays its value. The `system.log` file provides useful information for problem resolution.

```
$ dsetool inmemorystatus


Max Memory to Lock:                                1MB
Current Total Memory Locked:                       0MB
Current Total Memory Not Able To Lock:            46MB
Keyspace                ColumnFamily                     Size     Couldn't Lock
  Usage
mos_ks                  testmemory                        0MB              46MB
     0%
mos_ks                  testmemory2                       0MB               0MB
     0%
mos_ks                  testmemory4                       0MB               0MB
     0%
mos_ks                  testmemory3                       0MB               0MB
     0%
```

Backing up and restoring data

The procedures for backing up and restoring data is the same procedure for DSE In-Memory data and on-disk data.

The procedures for backing up and restoring data are the same for DSE In-Memory data and on-disk data.

Use the OpsCenter Backup Service or use the Cassandra snapshot process to manage backups and restores.

Deploying

Production deployment of DataStax Enterprise includes planning, configuration, and choosing how the data is divided across the nodes in the cluster.

Production deployment planning

Resources for deployment planning and recommendations for deployment.

For guidance in planning a DataStax Enterprise cluster, see Planning a cluster deployment in the Cassandra documentation. The Cassandra documentation includes information about:

- Spinning disks versus SSDs
- Memory and CPU recommendations
- Disk space
- Data size
- Network requirements
- RAID
- Data size
- Anti-patterns

The following resources and guidelines are also recommended:

- The DataStax Enterprise Reference Architecture white paper.
- For EC2 deployments, see:
    - User guide in the *Amazon Elastic Compute Cloud Documentation*
    - EC2 clusters spanning multiple regions and availability zones
    - What is the story with AWS storage
    - Get in the Ring with Cassandra and EC2
- DataStax Enterprise requires a solid network layer. Although not required, jumbo frames are recommended to improve streaming performance during processes such as bootstrapping and repair.
- Hadoop and DSE Search nodes require their own nodes/disks and have specific hardware requirements. See Capacity Planning in the *DataStax Enterprise Reference Architecture* and the Hadoop and Solr documentation.
- DataStax does not support or recommend using Network Attached Storage (NAS) because of performances issues, such as network saturation, I/O overload, pending-task swamp, excessive memory usage, and disk contention.
- If using a firewall, make sure that nodes within a cluster can reach each other. See Configuring firewall port access.

Configuring replication

How to set up DataStax Enterprise to store multiple copies of data on multiple nodes for reliability and fault tolerance.

About this task

Cassandra can store multiple copies of data on multiple nodes for reliability and fault tolerance. To configure replication, you must:

- Configure gossip.

Nodes communicate with each other about replication and other things using the gossip protocol.
- Choose whether to use vnodes.

  Vnodes provide many tokens per node and simply many tasks in Cassandra.

  Attention: DataStax Enterprise turns off virtual nodes (vnodes) by default. DataStax does not recommend turning on vnodes for DSE Hadoop or BYOH nodes. Before turning vnodes on for Hadoop, understand the implications of doing so DataStax Enterprise does support turning on vnodes for Spark nodes.
- Choose a data partitioner.

  Data partitioning determines how data is placed across the nodes in the cluster.
- Choose a snitch.

  A snitch determines which data centers and racks are written to and read from.
- Choose replica placement strategy.

  A replication strategy determines the nodes where replicas are placed.

For information about how these components work, see Data distribution and replication.

Partitioner settings

You can use either Murmur3Partitioner or RandomPartitioner with virtual nodes.

The Murmur3Partitioner (`org.apache.cassandra.dht.Murmur3Partitioner`) is the default partitioning strategy for Cassandra clusters. The Murmur3Partitioner is the right choice for new clusters in almost all cases. You can use Murmur3Partitioner for new clusters; you cannot change the partitioner in existing clusters.

The RandomPartitioner (`org.apache.cassandra.dht.RandomPartitioner`) was the default partitioner in Cassandra 1.2 and earlier. You can continue to use this partitioner when migrating to virtual nodes.

Snitch settings

A snitch determines which data centers and racks are written to and read from. It informs Cassandra about the network topology so that requests are routed efficiently and allows Cassandra to distribute replicas by grouping machines into data centers and racks. All nodes must have exactly the same snitch configuration. You set the snitch in the endpoint_snitch property in the cassandra.yaml file.

The following sections describe commonly used snitches. All available snitches are described in the Cassandra documentation.

DseSimpleSnitch

Use DseSimpleSnitch only for development in DataStax Enterprise deployments. This snitch logically configures each type of node in separate data centers to segregate the analytics, real-time, and search workloads.

When defining your keyspace, use Analytics, Cassandra, or Search for your data center names.

Note: Do not use SimpleSnitch with DataStax Enterprise nodes.

GossipingPropertyFile Snitch

The GossipingPropertyFileSnitch defines a local node's data center and rack; it uses gossip for propagating this information to other nodes. The cassandra-rackdc.properties file defines the default data center and rack that are used by this snitch:

```
dc=DC1
```

```
rack=RAC1
```

The default location of the `cassandra-rackdc.properties` file depends on the type of installation:

Installer-Services and Package installations	`/etc/dse/cassandra/cassandra-rackdc.properties`
Installer-No Services and Tarball installations	`*install_location*/resources/cassandra/conf/cassandra-rackdc.properties`

PropertyFileSnitch

The PropertyFileSnitch property allows you to define your data center and rack names to be whatever you want. Using this snitch requires that you define network details for each node in the cluster in the cassandra-topology.properties configuration file.

The default location of the `cassandra-topology.properties` file depends on the type of installation:

Installer-Services and Package installations	`/etc/dse/cassandra/cassandra-topology.properties`
Installer-No Services and Tarball installations	`*install_location*/resources/cassandra/conf/cassandra-topology.properties`

Every node in the cluster should be described in this file, and specified exactly the same on every node in the cluster.

For example, suppose you had non-uniform IPs and two physical data centers with two racks in each, and a third logical data center for replicating analytics data, you would specify them as follows:

```
# Data Center One

175.56.12.105=DC1:RAC1
175.50.13.200=DC1:RAC1
175.54.35.197=DC1:RAC1

120.53.24.101=DC1:RAC2
120.55.16.200=DC1:RAC2
120.57.102.103=DC1:RAC2

# Data Center Two

110.56.12.120=DC2:RAC1
110.50.13.201=DC2:RAC1
110.54.35.184=DC2:RAC1

50.33.23.120=DC2:RAC2
50.45.14.220=DC2:RAC2
50.17.10.203=DC2:RAC2

# Analytics Replication Group

172.106.12.120=DC3:RAC1
172.106.12.121=DC3:RAC1
172.106.12.122=DC3:RAC1

# default for unknown nodes
default=DC3:RAC1
```

Make sure the data center names defined in the `cassandra-topology.properties` file correlates to the data centers names in your keyspace definition.

Choosing keyspace replication options

When you create a keyspace, you must define the replica placement strategy class and the number of replicas. DataStax recommends choosing NetworkTopologyStrategy for single and multiple data center clusters. This strategy is as easy to use as the SimpleStrategy and allows for expansion to multiple data centers in the future. It is easier to configure the most flexible replication strategy when you create a keyspace, than to reconfigure replication after data is loaded into your cluster.

NetworkTopologyStrategy takes as options the number of replicas you want per data center. Even for single data center clusters, you can use this replica placement strategy and just define the number of replicas for one data center. For example:

```
CREATE KEYSPACE test
    WITH  REPLICATION= { 'class' :  'NetworkTopologyStrategy',  'us-east' :
 6 };
```

For a single node cluster, use the default data center name, Cassandra, Solr, or Analytics.

```
CREATE KEYSPACE test
    WITH  REPLICATION= { 'class' :  'NetworkTopologyStrategy',
 'Analytics' : 1 };
```

To define the number of replicas for a multiple data center cluster:

```
CREATE KEYSPACE test2
    WITH REPLICATION= { 'class' :  'NetworkTopologyStrategy',  'dc1' : 3,
 'dc2' : 3 };
```

When creating the keyspace, what you name your data centers depends on the snitch you have chosen for your cluster. The data center names must correlate to the snitch you are using in order for replicas to be placed in the correct location.

As a general rule, the number of replicas should not exceed the number of nodes in a replication group. However, it is possible to increase the number of replicas, and then add the desired number of nodes afterwards. When the replication factor exceeds the number of nodes, writes will be rejected, but reads will still be served as long as the desired consistency level can be met. The default consistency level is QUORUM.

To avoid DSE Hadoop operational problems, change the replication factor of these system keyspaces:

- cfs
- cfs_archive
- HiveMetaStore

The location of the cassandra.yaml file depends on the type of installation:

Package installations	`/etc/cassandra/cassandra.yaml`
Tarball installations	*`install_location`*`/resources/cassandra/conf/cassandra.yaml`

Mixing workloads in a cluster

Organize nodes that run different workloads into virtual data centers. Put analytic nodes in one data center, search nodes in another, and Cassandra real-time transactional nodes in another data center.

About this task

A common question is how to use the following types of nodes in the same cluster:

- Real-time Cassandra,
- DSE Hadoop, which is integrated Hadoop
- External Hadoop in the bring your own Hadoop (BYOH) model
- Spark
- DSE Search nodes

The answer is to organize the nodes running different workloads into virtual data centers: analytics workloads (either DSE Hadoop, Spark, or BYOH) nodes in one data center, search nodes in another, and Cassandra real-time nodes in another data center.

DataStax supports a data center that contains one or more nodes running in dual Spark/DSE Hadoop mode. Dual Spark/DSE Hadoop mode means you started the node using the -k and -t options on tarball or Installer-No Services installations, or set the startup options HADOOP_ENABLED=1 and SPARK_ENABLED=1 on package or Installer-Services installations.

Spark workloads

Spark does not absolutely require a separate data center or work load isolation from real-time and analytics workloads, but if you expect Spark jobs to be very resource intensive, use a dedicated data center for Spark. Spark jobs consume resources that can affect the latency and throughput of Cassandra jobs or Hadoop jobs. When you run a node in Spark mode, Cassandra runs an Analytics workload. An integrated DSE SearchAnalytics cluster allows analytics jobs to be performed using search queries.

BYOH workloads

BYOH nodes need to be isolated from Cloudera or Hortonworks masters.

DSE Search workloads

The batch needs of Hadoop and the interactive needs of DSE Search are incompatible from a performance perspective, so these workloads need to be segregated.

Cassandra workloads

Cassandra real-time applications and DSE Search applications are also incompatible, but for a different reason--dramatically distinct access patterns:

- A Cassandra real-time application needs very rapid access to Cassandra data.

  The real-time application accesses data directly by key, large sequential blocks, or sequential slices.
- A DSE Search application needs a broadcast or scatter model to perform full-index searching.

  Virtually every search needs to hit a large percentage of the nodes in the virtual data center (depending on the RF setting) to access data in the entire Cassandra table. The data from a small number of rows are returned at a time.

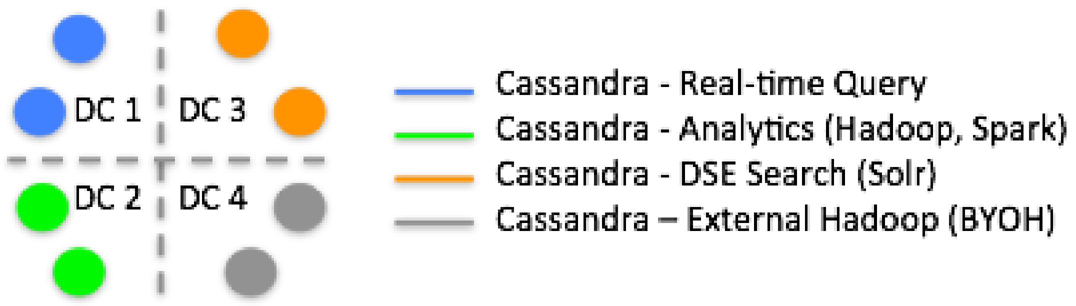
Creating a virtual data center

When you create a keyspace using CQL, Cassandra creates a virtual data center for a cluster, even a one-node cluster, automatically. You assign nodes that run the same type of workload to the same data center. The separate, virtual data centers for different types of nodes segregate workloads running Solr from those running other workload types. Segregating workloads ensures that only one type of workload is active per data center.

Workload segregation

Separating nodes running a sequential data load, from nodes running any other type of workload is a best practice. In the following diagram, nodes in separate data centers run a mix of:

- Real-time queries (Cassandra and no other services)
- Analytics (either DSE Hadoop, Spark, or dual mode DSE Hadoop/Spark)
- Solr
- External Hadoop system (BYOH)


DC 1
DC 3
DC 2
DC 4
Cassandra - Real-time Query
Cassandra - Analytics (Hadoop, Spark)
Cassandra - DSE Search (Solr)
Cassandra – External Hadoop (BYOH)

In a cluster having BYOH and DSE Hadoop nodes, the DSE Hadoop nodes would have priority with regard to start up. Start up seed nodes in the BYOH data center after starting up DSE Hadoop data centers.

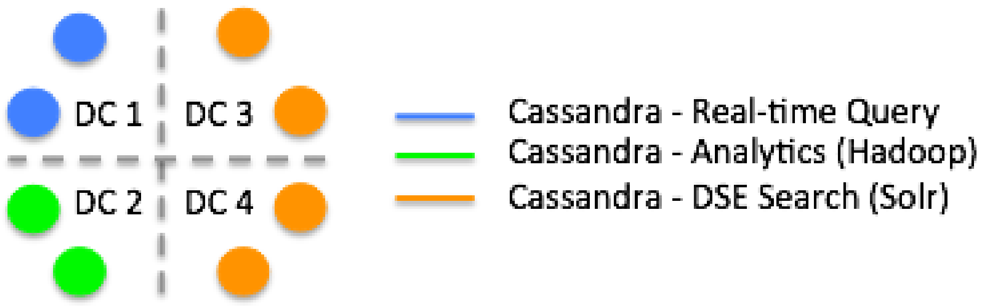
Occasionally, there is a use case for keeping DSE Hadoop and Cassandra nodes in the same data center. You do not have to have one or more additional replication factors when these nodes are in the same data center.

To deploy a mixed workload cluster, see "Multiple data center deployment."

In this diagram, nodes in data centers 1 and 2 (DC 1 and DC 2) run a mix of:

- Real-time queries (Cassandra and no other services)
- Analytics (Cassandra and integrated Hadoop)

Data centers 3 and 4 (DC 3 and DC 4) are dedicated to search.


DC 1
DC 3
DC 2
DC 4
Cassandra - Real-time Query
Cassandra - Analytics (Hadoop)
Cassandra - DSE Search (Solr)

This diagram shows DSE Hadoop analytics, Cassandra, and DSE Search nodes in separate data centers. In separate data centers, some DSE nodes handle search while others handle MapReduce, or just act as real-time Cassandra nodes. Cassandra ingests the data, Solr indexes the data, and you run MapReduce against that data in one cluster without performing manual extract, transform, and load (ETL) operations. Cassandra handles the replication and isolation of resources. The DSE Search nodes run HTTP and hold the indexes for the Cassandra table data. If a DSE Search node goes down, the commit log replays the Cassandra inserts, which correspond to Solr inserts, and the node is restored automatically.

Restrictions

- Do not create the keyspace using SimpleStrategy for production use or for use with mixed workloads.
- From DSE Hadoop and Cassandra real-time clusters in multiple data centers, do not attempt to insert data to be indexed by Solr using CQL or Thrift.
- Within the same data center, do not run Solr workloads on some nodes and other types of workloads on other nodes.

- Do not run DSE Search and DSE Hadoop on the same node in either production or development environments.
- Do not run some nodes in DSE Hadoop mode and some in Spark mode in the same data center.

  You can run all the nodes in Spark mode, all the nodes in Hadoop mode or all the nodes in Spark/DSE Hadoop mode.

Recommendations

Run the CQL or Thrift inserts on a DSE Search node in its own data center.

NetworkTopologyStrategy is highly recommended for most deployments because it is much easier to expand to multiple data centers when required by future expansion.

Getting cluster workload information

You can query the Cassandra system.peers table to get the types of workloads running on cluster nodes except the coordinator. The different workloads are:

- Analytics
- Cassandra
- Search

An Analytics workload is either DSE Hadoop, Spark, or dual mode DSE Hadoop/Spark. A Cassandra workload is Cassandra and no other services. A Search workload is DSE Search.

You can also query the system.local table to get the type of workload running on any local node. This tables has a column of workload data that Cassandra does not include in the output when you select all the data. You need to explicitly query the workload column.

```
SELECT workload FROM system.local;
```

The output looks something like this:

```
 workload
----------
 Analytics
```

Using the DESCRIBE FULL schema command reveals the definitions of all the columns. For example:

```
DESCRIBE FULL schema
```

The output shows the system and other table schemas. For example, the peers table schema is:

```
CREATE TABLE peers (
  peer inet,
  data_center text,
  host_id uuid,
  preferred_ip inet,
  rack text,
  release_version text,
  rpc_address inet,
  schema_version uuid,
  tokens set<text>,
  workload text,
  PRIMARY KEY ((peer))
) WITH
  . . .;
```

Replicating data across data centers

You set up replication by creating a keyspace. You can change the replication of a keyspace after creating it.

Single data center deployment per workload type

Steps for configuring nodes in a deployment scenario in a mixed workload cluster that has only one data center for each type of workload.

About this task

In this scenario, a mixed workload cluster has only one data center for each type of workload. For example, if the cluster has 3 analytics nodes, 3 Cassandra nodes, and 2 DSE Search nodes, the cluster has 3 data centers, one for each type of workload. In contrast, a multiple data-center cluster has more than one data center for each type of workload.

In Cassandra, a data center can be a physical data center or virtual data center. Different workloads must always use separate data centers, either physical or virtual. In a single data center deployment, data is replicated within its data center. For more information about replication:

- Choosing keyspace replication options
- Configuring replication
- Single-token architecture deployment
- Data replication (Applies only to the single-token-per-node architecture.)

Before you begin

- A good understanding of how Cassandra works. Be sure to read at least Understanding the architecture, Data Replication, and Cassandra's rack feature.
- Ensure DataStax Enterprise is installed on each node.
- Choose a name for the cluster.
- For a mixed-workload cluster, determine the purpose of each node.
- Determine the snitch and replication strategy. The GossipingPropertyFileSnitch and NetworkTopologyStrategy are recommended for production environments.
- Get the IP address of each node.
- Determine which nodes are seed nodes. **Do not make all nodes seed nodes.** Read Internode communications (gossip).
- Use the yaml_diff tool to review and make appropriate changes to the cassandra.yaml configuration file.

  The location of the cassandra.yaml file depends on the type of installation:

Package installations	`/etc/cassandra/cassandra.yaml`
Tarball installations	*`install_location`*`/resources/cassandra/conf/cassandra.yaml`

- Review and make appropriate changes to other property files, such as `cassandra-rackdc.properties`.
- Set virtual nodes correctly for the type of data center. DataStax does not recommend using virtual nodes on data centers running BYOH or DSE Hadoop. See Virtual nodes.

Procedure

This configuration example describes installing an 8 node cluster spanning 2 racks in a single data center. The default consistency level is QUORUM.

1. Suppose the nodes have the following IPs and one node per rack will serve as a seed:

- node0 110.82.155.0 (Cassandra seed)
- node1 110.82.155.1 (Cassandra)
- node2 110.82.155.2 (Cassandra)
- node3 110.82.155.3 (Analytics seed)
- node4 110.82.155.4 (Analytics)
- node5 110.82.155.5 (Analytics)
- node6 110.82.155.6 (Search - seed nodes are not required for Solr.)
- node7 110.82.155.7 (Search)

2. If the nodes are behind a firewall, open the required ports for internal/external communication. See Configuring firewall port access.
3. If DataStax Enterprise is running, stop the nodes and clear the data:
   - Installer-Services and Package installations:

     ```
     $ sudo service dse stop
     $ sudo rm -rf /var/lib/cassandra/*  # Clears the data from the  default
      directories
     ```
   - Installer-No Services and Tarball installations:

     From the install directory:

     ```
     $ sudo bin/dse cassandra-stop
     $ sudo rm -rf /var/lib/cassandra/*  # Clears the data from the  default
      directories
     ```

     Note: If you are clearing data from an AMI installation for restart, you need to preserve the log files.
4. Set the properties in the cassandra.yaml file for each node, located in:

   Important: After making any changes in `cassandra.yaml`, you must restart the node for the changes to take effect.

   If the nodes in the cluster are identical in terms of disk layout, shared libraries, and so on, you can use the same copy of the `cassandra.yaml` file on all of the nodes.

   Properties to set:

   - num_tokens: *256* for Cassandra nodes
   - num_tokens: *1* for Hadoop and DSE Search nodes
   - num_tokens: 64 to 256 for DSE Search nodes when using vnodes; otherwise num_tokens: 1
   - -seeds: *internal_IP_address* of each seed node
   - listen_address: *empty*

     If not set, Cassandra asks the system for the local address, the one associated with its host name. In some cases Cassandra doesn't produce the correct address and you must specify the listen_address.
   - endpoint_snitch: *snitch* See endpoint_snitch. If you are changing snitches, see Switching snitches.
   - auto_bootstrap: *false*

     Add the bootstrap setting only when initializing a fresh cluster with no data.
   - endpoint_snitch: *snitch*

     For more information, see endpoint_snitch and About Snitches.
   - If you are using a `cassandra.yaml` file from a previous version, remove the following options, as they are no longer supported by DataStax Enterprise:

     ```
      ## Replication strategy to use for the auth keyspace.
      auth_replication_strategy: org.apache.cassandra.locator.SimpleStrategy
     ```

```
    auth_replication_options:
        replication_factor: 1
```

Example:

```
cluster_name: 'MyDemoCluster'
num_tokens: 256
seed_provider:
  - class_name: org.apache.cassandra.locator.SimpleSeedProvider
    parameters:
         - seeds: "110.82.155.0,110.82.155.3"
listen_address:
endpoint_snitch: GossipingPropertyFileSnitch
```

5. In the cassandra-rackdc.properties (GossipingPropertyFileSnitch) or cassandra-topology.properties (PropertyFileSnitch) file, use your naming convention to assign data center and rack names to the IP addresses of each node, and assign a default data center name and rack name for unknown nodes.

   The default location of the `cassandra-topology.properties` file depends on the type of installation:

Installer-Services and Package installations	`/etc/dse/cassandra/cassandra-topology.properties`
Installer-No Services and Tarball installations	*`install_location`*`/resources/cassandra/conf/cassandra-topology.properties`

   The default location of the `cassandra-rackdc.properties` file depends on the type of installation:

Installer-Services and Package installations	`/etc/dse/cassandra/cassandra-rackdc.properties`
Installer-No Services and Tarball installations	*`install_location`*`/resources/cassandra/conf/cassandra-rackdc.properties`

   Example:

```
# Cassandra Node IP=Data Center:Rack
110.82.155.0=DC_Cassandra:RAC1
110.82.155.1=DC_Cassandra:RAC1
110.82.155.2=DC_Cassandra:RAC1
110.82.155.3=DC_Analytics:RAC1
110.82.155.4=DC_Analytics:RAC1
110.82.155.5=DC_Analytics:RAC1
110.82.155.6=DC_Solr:RAC1
110.82.155.7=DC_Solr:RAC1

# default for unknown nodes
default=DC1:RAC1
```

6. After you have installed and configured DataStax Enterprise on all nodes, start the seed nodes one at a time, and then start the rest of the nodes:

   - Packages/Services: See Starting DataStax Enterprise as a service.
   - Tarball/No Services: See Starting DataStax Enterprise as a stand-alone process.

   Note: If the node has restarted because of automatic restart, you must stop the node and clear the data directories, as described above.
7. Check that your cluster is up and running:

   - Installer-Services and Package installations: `$ nodetool status`

- Installer-No Services and Tarball installations: `$ install_location/bin/nodetool status`

Results

```
Datacenter: Cassandra
=======================
Status=Up/Down
|/ State=Normal/Leaving/Joining/Moving
-- Address          Load        Tokens    Owns    Host ID             Rack
UN 110.82.155.0     21.33 KB    256       33.3%   a9fa31c7-f3c0-...   RAC1
UN 110.82.155.1     21.33 KB    256       33.3%   f5bb416c-db51-...   RAC1
UN 110.82.155.2     21.33 KB    256       16.7%   b836748f-c94f-...   RAC1
Datacenter: Analytics
=======================
Status=Up/Down
|/ State=Normal/Leaving/Joining/Moving
-- Address          Load        Owns      Host ID                 Tokens
  Rack
UN 110.82.155.3     28.44 KB    13.0.%    e2451cdf-f070- ...      -922337....
  RAC1
UN 110.82.155.4     44.47 KB    16.7%     f9fa427c-a2c5- ...      30745512...
  RAC1
UN 110.82.155.5     54.33 KB    23.6%     b9fc31c7-3bc0- ..-      45674488...
  RAC1
Datacenter: Solr
=======================
Status=Up/Down
|/ State=Normal/Leaving/Joining/Moving
-- Address          Load        Owns      Host ID                 Tokens
  Rack
UN 110.82.155.6     15.44 KB    50.2.%    e2451cdf-f070- ...      9243578....
  RAC1
UN 110.82.155.7     18.78 KB    49.8.%    e2451cdf-f070- ...      10000
  RAC1
```

Multiple data center deployment per workload type

Steps for configuring nodes in a deployment scenario in a mixed workload cluster that has more than one data center for each type of node.

About this task

In this scenario, a mixed workload cluster has more than one data center for each type of node. For example, if the cluster has 4 analytics nodes, 4 Cassandra nodes, and 2 DSE Search nodes, the cluster could have 5 data centers: 2 data centers for analytics nodes, 2 data centers for Cassandra nodes, and 1 data center for the DSE Search node. A single data-center cluster has only one data center for each type of node.

In Cassandra, a data center can be a physical data center or virtual data center. Different workloads must always use separate data centers, either physical or virtual.

Uses for multiple data center deployments include:

- Isolating replicas from external infrastructure failures, such as networking between data centers and power outages.
- Distributed data replication across multiple, geographically dispersed nodes.
- Between different physical racks in a physical data center.
- Between public cloud providers and on-premise managed data centers.

- To prevent the slow down of a real-time analytics cluster by a development cluster running analytics jobs on live data.
- To ensure your reads from a specific data center is local to the requests, especially when using a consistency level greater than ONE, use virtual data centers in the physical data center. This strategy ensures lower latency because it avoids reads from one node in New York and another read from a node in Los Angeles.

For more information about replication:

- Choosing keyspace replication options
- Configuring replication
- Single-token architecture deployment
- Data replication (Applies only to the single-token-per-node architecture.)

Before you begin

To configure a multi-node cluster with multiple data centers:

- A good understanding of how Cassandra works. Be sure to read at least Understanding the architecture, Data Replication, and Cassandra's rack feature.
- Ensure DataStax Enterprise is installed on each node.
- Choose a name for the cluster.
- For a mixed-workload cluster, determine the purpose of each node.
- Determine the snitch and replication strategy. The GossipingPropertyFileSnitch and NetworkTopologyStrategy are recommended for production environments.
- Get the IP address of each node.
- Determine which nodes are seed nodes. **Do not make all nodes seed nodes.** Read Internode communications (gossip).
- Develop a naming convention for each data center and rack, for example: DC1, DC2 or 100, 200 and RAC1, RAC2 or R101, R102.
- Use the yaml_diff tool to review and make appropriate changes to the cassandra.yaml configuration file.

  The location of the cassandra.yaml file depends on the type of installation:

Package installations	`/etc/cassandra/cassandra.yaml`
Tarball installations	`*install_location*/resources/cassandra/conf/cassandra.yaml`

- Set virtual nodes correctly for the type of data center. DataStax does not recommend using virtual nodes on data centers running BYOH or DSE Hadoop. See Virtual nodes.

Procedure

This configuration example describes installing a 6 node cluster spanning 2 data centers. The default consistency level is QUORUM.

1. Suppose you install DataStax Enterprise on these nodes:
   - node0 10.168.66.41 (seed1)
   - node1 10.176.43.66
   - node2 10.168.247.41
   - node3 10.176.170.59 (seed2)
   - node4 10.169.61.170
   - node5 10.169.30.138
2. If the nodes are behind a firewall, open the required ports for internal/external communication. See Configuring firewall port access.
3. If DataStax Enterprise is running, stop the nodes and clear the data:

- Installer-Services and Package installations:

  ```
  $ sudo service dse stop
  $ sudo rm -rf /var/lib/cassandra/*  # Clears the data from the  default
   directories
  ```
- Installer-No Services and Tarball installations:

  From the install directory:

  ```
  $ sudo bin/dse cassandra-stop
  $ sudo rm -rf /var/lib/cassandra/*  # Clears the data from the  default
   directories
  ```

  Note: If you are clearing data from an AMI installation for restart, you need to preserve the log files.

4. Set the properties in the cassandra.yaml file for each node:

   The location of the cassandra.yaml file depends on the type of installation:

Package installations	`/etc/cassandra/cassandra.yaml`
Tarball installations	*`install_location`*`/resources/cassandra/conf/cassandra.yaml`

   Important: After making any changes in `cassandra.yaml`, you must restart the node for the changes to take effect.

   Properties to set:

   Note: If the nodes in the cluster are identical in terms of disk layout, shared libraries, and so on, you can use the same copy of the `cassandra.yaml` file on all of them.

   - num_tokens: *256* for Cassandra nodes
   - num_tokens: *1* for Hadoop and DSE Search nodes
   - num_tokens: 64 to 256 for DSE Search nodes when using vnodes; otherwise num_tokens: 1
   - -seeds: *internal_IP_address* of each seed node
   - listen_address: *empty*

     If not set, Cassandra asks the system for the local address, the one associated with its host name. In some cases Cassandra doesn't produce the correct address and you must specify the listen_address.
   - endpoint_snitch: *snitch* See endpoint_snitch. If you are changing snitches, see Switching snitches.
   - auto_bootstrap: *false*

     Add the bootstrap setting only when initializing a fresh cluster with no data.
   - endpoint_snitch: *snitch*

     For more information, see endpoint_snitch and About Snitches.
   - If you are using a `cassandra.yaml` file from a previous version, remove the following options, as they are no longer supported by DataStax Enterprise:

     ```
      ## Replication strategy to use for the auth keyspace.
      auth_replication_strategy: org.apache.cassandra.locator.SimpleStrategy

      auth_replication_options:
          replication_factor: 1
     ```

   Example:

You must include at least one seed node from each data center. It is a best practice to have more than one seed node per data center.

```
cluster_name: 'MyDemoCluster'
num_tokens: 256
seed_provider:
  - class_name: org.apache.cassandra.locator.SimpleSeedProvider
    parameters:
         - seeds: "10.168.66.41,10.176.170.59"
listen_address:
endpoint_snitch: GossipingPropertyFileSnitch
```

5. In the cassandra-rackdc.properties (GossipingPropertyFileSnitch) or cassandra-topology.properties (PropertyFileSnitch) file, use your naming convention to assign data center and rack names to the IP addresses of each node, and assign a default data center name and rack name for unknown nodes.

   The default location of the `cassandra-topology.properties` file depends on the type of installation:

Installer-Services and Package installations	`/etc/dse/cassandra/cassandra-topology.properties`
Installer-No Services and Tarball installations	*`install_location`*`/resources/cassandra/conf/cassandra-topology.properties`

   The default location of the `cassandra-rackdc.properties` file depends on the type of installation:

Installer-Services and Package installations	`/etc/dse/cassandra/cassandra-rackdc.properties`
Installer-No Services and Tarball installations	*`install_location`*`/resources/cassandra/conf/cassandra-rackdc.properties`

   Example:

```
# Cassandra Node IP=Data Center:Rack
10.168.66.41=DC1:RAC1
10.176.43.66=DC2:RAC1
10.168.247.41=DC1:RAC1
10.176.170.59=DC2:RAC1
10.169.61.170=DC1:RAC1
10.169.30.138=DC2:RAC1

# default for unknown nodes
default=DC1:RAC1
```

6. After you have installed and configured DataStax Enterprise on all nodes, start the seed nodes one at a time, and then start the rest of the nodes:

   - Packages/Services: See Starting DataStax Enterprise as a service.
   - Tarball/No Services: See Starting DataStax Enterprise as a stand-alone process.

   Note: If the node has restarted because of automatic restart, you must stop the node and clear the data directories, as described above.

7. Check that your cluster is up and running:

   - Installer-Services and Package installations: `$ nodetool status`
   - Installer-No Services and Tarball installations: `$` *`install_location`*`/bin/nodetool status`

Results

```
Datacenter: DC1
=======================
Status=Up/Down
|/ State=Normal/Leaving/Joining/Moving
-- Address          Load        Tokens    Owns    Host ID             Rack
UN 10.168.66.41     45.96 KB    256       27.4%   c885aac7-f2c0-...   RAC1
UN 10.168.247.41    66.34 KB    256       36.6%   fa31416c-db22-...   RAC1
UN 10.169.61.170    55.72 KB    256       33.0%   f488367f-c14f-...   RAC1
Datacenter: DC2
=======================
Status=Up/Down
|/ State=Normal/Leaving/Joining/Moving
-- Address          Load        Tokens    Owns    Host ID             Rack
UN 10.176.43.66     45.96 KB    256       27.4%   f9fa31c7-f3c0-...   RAC1
UN 10.176.170.59    66.34 KB    256       36.6%   a5bb526c-db51-...   RAC1
UN 10.169.30.138    55.72 KB    256       33.0%   b836478f-c49f-...   RAC1
```

What to do next

- Configuring replication
- Configuring system_auth and dse_security keyspace replication
- Configuring replication

Single-token architecture deployment

Steps for deploying when you are not using virtual nodes (vnodes).

About this task

Follow these steps only when not using virtual nodes (vnodes).

Before you begin

- Have a basic understanding of tokens and Database internals.
- Ensure DataStax Enterprise is installed on each node.
- Choose a name for the cluster.
- Take note of the total number of nodes in the cluster.
- For a mixed-workload cluster, determine the purpose of each node.
- Determine which nodes are seed nodes. **Do not make all nodes seed nodes.** Read Internode communications (gossip).
- If using multiple data centers, develop a naming convention for each data center and rack, for example: DC1, DC2 or 100, 200 and RAC1, RAC2 or R101, R102.
- Use the yaml_diff tool to review and make appropriate changes to the cassandra.yaml configuration file.

  The location of the cassandra.yaml file depends on the type of installation:

Package installations	`/etc/cassandra/cassandra.yaml`
Tarball installations	*`install_location`*`/resources/cassandra/conf/cassandra.yaml`

Procedure

1. Suppose you install DataStax Enterprise on these nodes:

   - node0 10.168.66.41 (seed1)

- node1 10.176.43.66
- node2 10.168.247.41
- node3 10.176.170.59 (seed2)
- node4 10.169.61.170
- node5 10.169.30.138

2. Calculate the token assignments using the information on Calculating tokens.

Table 54: Single Data Center

Node	Token
node0	0
node1	21267647932558653966460912964485513216
node2	42535295865117307932921825928971026432
node3	63802943797675961899382738893456539648
node4	85070591730234615865843651857942052864
node5	106338239662793269832304564822427566080

Table 55: Multiple Data Centers

Node	Token	Offset	Data Center
node0	0	NA	DC1
node1	56713727820156410577229101238628035242	NA	DC1
node2	113427455640312821154458202477256070485	NA	DC1
node3	100	100	DC2
node4	56713727820156410577229101238628035342	100	DC2
node5	113427455640312821154458202477256070585	100	DC2

3. If the nodes are behind a firewall, open the required ports for internal/external communication. See Configuring firewall port access.

4. If DataStax Enterprise is running, stop the nodes and clear the data:

- Installer-Services and Package installations:

```
$ sudo service dse stop
$ sudo rm -rf /var/lib/cassandra/*  # Clears the data from the  default
 directories
```

- Installer-No Services and Tarball installations:

  From the install directory:

```
$ sudo bin/dse cassandra-stop
$ sudo rm -rf /var/lib/cassandra/*  # Clears the data from the  default
 directories
```

Note: If you are clearing data from an AMI installation for restart, you need to preserve the log files.

5. Set the properties in the cassandra.yaml file for each node.

The location of the cassandra.yaml file depends on the type of installation:

Package installations	`/etc/cassandra/cassandra.yaml`

Tarball installations	`install_location/resources/cassandra/conf/cassandra.yaml`

Important: After making any changes in `cassandra.yaml`, you must restart the node for the changes to take effect.

Properties to set:

- initial_token: *token*
- num_tokens: *1*
- -seeds: *internal_IP_address* of each seed node
- listen_address: *empty*

  If not set, Cassandra asks the system for the local address, the one associated with its hostname. In some cases Cassandra doesn't produce the correct address and you must specify the list_address.
- endpoint_snitch: *snitch*

  For more information, see About Snitches.
- auto_bootstrap: *false*

  Add the bootstrap setting only when initializing a fresh cluster with no data.
- If you are using a `cassandra.yaml` from a previous version, remove the following options, as they are no longer supported by DataStax Enterprise:

```
## Replication strategy to use for the auth keyspace.
auth_replication_strategy: org.apache.cassandra.locator.SimpleStrategy

auth_replication_options:
    replication_factor: 1
```

Example:

If using more than one data center, include at least one seed node from each data center. It is a best practice to have more than one seed node per data center.

```
cluster_name: 'MyDemoCluster'
num_tokens: 256
seed_provider:
  - class_name: org.apache.cassandra.locator.SimpleSeedProvider
    parameters:
        - seeds: "10.168.66.41,10.176.170.59"
listen_address:
```

6. In the cassandra-topology.properties file, use your naming convention to assign data center and rack names to the IP addresses of each node, and assign a default data center name and rack name for unknown nodes.

   The default location of the `cassandra-topology.properties` file depends on the type of installation:

Installer-Services and Package installations	`/etc/dse/cassandra/cassandra-topology.properties`
Installer-No Services and Tarball installations	`install_location/resources/cassandra/conf/cassandra-topology.properties`

Example:

```
# Cassandra Node IP=Data Center:Rack
10.168.66.41=DC1:RAC1
10.176.43.66=DC2:RAC1
```

```
10.168.247.41=DC1:RAC1
10.176.170.59=DC2:RAC1
10.169.61.170=DC1:RAC1
10.169.30.138=DC2:RAC1

# default for unknown nodes
default=DC1:RAC1
```

7. After you have installed and configured DataStax Enterprise on all nodes, start the seed nodes one at a time, and then start the rest of the nodes:
   - Packages/Services: See Starting DataStax Enterprise as a service.
   - Tarball/No Services: See Starting DataStax Enterprise as a stand-alone process.

   Note: If the node has restarted because of automatic restart, you must stop the node and clear the data directories, as described above.
8. Check that your cluster is up and running:
   - Installer-Services and Package installations: `$ nodetool status`
   - Installer-No Services and Tarball installations: `$ install_location/bin/nodetool status`

Calculating tokens

How to calculate tokens when using single-token architecture. This is not required when using virtual nodes (vnodes).

This topic contains information when using single-token architecture. You do not need calculate tokens when using virtual nodes (vnode).

When you start a DataStax Enterprise cluster, you must choose how the data is divided across the nodes in the cluster. A partitioner determines what each node stores by row. A token is a partitioner-dependent element of the cluster. Each node in a cluster is assigned a token and that token determines the node's position in the ring and what data the node is responsible for in the cluster. The tokens assigned to your nodes need to be distributed throughout the entire possible range of tokens. Each node is responsible for the region of the ring between itself (inclusive) and its predecessor (exclusive). As a simple example, if the range of possible tokens is 0 to 100 and there are 4 nodes, the tokens for the nodes would be: 0, 25, 50, 75. This approach ensures that each node is responsible for an equal range of data.

Note:

When using multiple data centers, each data center should be partitioned as if it were its own distinct ring.

Before the node is started for the first time, each node in the cluster must be assigned a token. Set the token with the initial_token property in the cassandra.yaml configuration file. Also, be sure to comment out the num_token property.

For more detailed information, see Database internals.

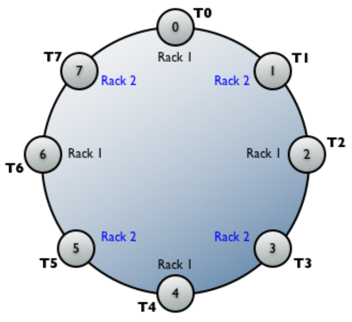
Calculating tokens for a single data center

For example, for 6 nodes in a single data center, the results for calculating tokens using the Murmur3Partitioner are:

```
[ '-9223372036854775808', '-6148914691236517206', '-3074457345618258604',
 '-2', '3074457345618258600', '6148914691236517202' ]
```

Calculating tokens for multiple racks in a single data center

If you have multiple racks in single data center, calculate the tokens for the number of nodes and then assign the tokens to nodes on alternating racks. For example: rack1, rack2, rack1, rack2, and so on. The image shows the rack assignments:



As a best practice, each rack should have the same number of nodes so you can alternate the rack assignments.

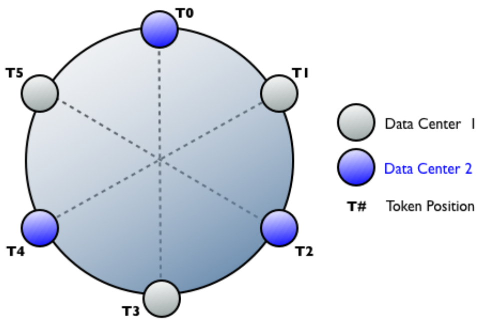
Calculating tokens for a multiple data center cluster

In multiple data center deployments using the NetworkTopologyStrategy, calculate the replica placement for your custom keyspaces per data center. The NetworkTopologyStrategy determines replica placement independently within each data center. The first replica is placed according to the partitioner. Additional replicas in the same data center are determined by walking the ring clockwise until a node in a different rack from the previous replica is found. If no such node exists, additional replicas are placed in the same rack.

Do not use SimpleStrategy for this type of cluster. There are different methods you can use when calculating multiple data center clusters. The important point is that the nodes within each data center manage an equal amount of data; the distribution of the nodes within the cluster is not as important. DataStax recommends using DataStax Enterprise OpsCenter to re-balance a cluster.

Alternating token assignments

Calculate the tokens for each data center and then alternate the token assignments so that the nodes for each data center are evenly dispersed around the ring. The following image shows the token position and data center assignments:



Avoiding token collisions

To avoid token collisions, offset the values for each token. Although you can increment in values of 1, it is better to use a larger offset value, such as 100, to allow room to replace a dead node.

The following shows the tokens for a cluster with two 3 node data centers and one 2 node data center.

Tokens for 3 nodes:

```
['-9223372036854775808',
'-3074457345618258603',
'3074457345618258602']
```

Tokens for 2 nodes:

```
['-9223372036854775808',
'0']
```

Using an offset value of 100:

- Data Center 1

  ```
  ['-9223372036854775808',
  '-3074457345618258603',
  '3074457345618258602']
  ```

- Data Center 2

  ```
  ['-9223372036854775708',
  '-3074457345618258503',
  '3074457345618258702']
  ```

- Data Center 3

  ```
  ['-9223372036854775608',
  '200']
  ```

The location of the cassandra.yaml file depends on the type of installation:

Package installations	`/etc/cassandra/cassandra.yaml`
Tarball installations	*`install_location`*`/resources/cassandra/conf/cassandra.yaml`

Expanding a DataStax AMI cluster

To expand your EC2 implementations, use OpsCenter.

The best way to expand your EC2 implementations is to use OpsCenter:

- Provisioning a new cluster
- Adding an existing cluster
- Adding nodes to a cluster

DataStax Enterprise data migration

Migrate data using Sqoop or other methods.

Migrating data using Sqoop

For DSE Hadoop, use Sqoop to transfer data between an RDBMS data source and Hadoop or between other data sources, such as NoSQL.

About Sqoop

DSE Hadoop supports Sqoop for migrating data and supports password authentication for Sqoop operations.

DSE Hadoop supports Sqoop, an Apache Software Foundation tool for transferring data between an RDBMS data source and Hadoop or between other data sources, such as NoSQL. DataStax Enterprise supports the following operations:

- Import and export data to and from CQL tables and any JDBC-compliant data source.
- Import SQL files into a CQL collection set, list, and map.
- Import data into CQL using a re-useable, file-based import command.
- Import legacy data using the `thrift-import` tool that supports backward compatibility with previous DataStax Enterprise versions.
- Use conventional Sqoop commands to import data into the Cassandra File System (CFS), the counterpart to HDFS, instead of a CQL table.

You can import and export MySQL, PostgreSQL, and Oracle data types that are listed in the Sqoop reference. An analytics node runs the MapReduce job that imports and exports data from a data source using Sqoop. You need a JDBC driver for the RDBMS or other type of data source.

Importing data

You can import data from any JDBC-compliant data source. For example:

- DB2
- MySQL
- Oracle
- SQL Server
- Sybase

Securing Sqoop

DataStax Enterprise supports password authentication for Sqoop operations. Configure password authentication using Cassandra-specific properties. Kerberos is also supported. Client-to-node encryption (SSL) is supported for Sqoop-imported and exported data.

Running the Sqoop demo

In this demo, you run SQL commands to put the data from a CSV file into a MySQL table in a MySQL database. Then import the SQL data from MySQL to a CQL table in Cassandra.

About this task

The Sqoop demo uses the MySQL database and data from the North American Numbering Plan. This data consists of the area-code (NPA) and telephone number (Nxx) for the USA and Canada. The demo runs SQL commands to put the data from a CSV file into a MySQL table in a MySQL database. You then import the SQL data from MySQL to a CQL table in Cassandra. The following steps show running the SQL commands from the mysql command line. Alternatively, you can run the commands on the operating system command line described below. The demo exports the data from MySQL, and then uses a subset of Sqoop commands to import the data into a CQL table.

Before you begin

To run the demo, you need:

- Latest version of Oracle Java SE Development Kit (JDK) 7. The JRE alone does not work.
- An installation of MySQL
- Sufficient MySQL database privileges to create database objects
- A JDBC driver for MySQL in the directory specified by the following demo procedure
- The connection string that is appropriate for the JDBC driver
- A DataStax Enterprise Analytics node
- A PATH environment variable that includes the `bin` directory of the DSE installation

To import data to CQL, the keyspace and CQL table must exist prior to the importation. If the CQL table contains data prior to the importation, cql-import updates the data.

Procedure

1. Install MySQL and download the JDBC driver for MySQL from the MySQL site.
2. Copy the JDBC driver for MySQL to the Sqoop library.

   The default location of the Sqoop library depends on the type of installation:

Installer-Services	`/usr/share/dse/resources/sqoop/lib`
Package installations	`/usr/share/dse/sqoop/lib`
Installer-No Services and Tarball installations	*`install_location`*`/resources/sqoop/lib`

3. Start DataStax Enterprise as an analytics node. For example:
   - **Installer-Services and Package installations:**
     1. Set HADOOP_ENABLED=1 in `/etc/default/dse`.
     2. Start an analytics node:

        ```
        $ sudo service dse start
        ```
   - **Installer-No Services and Tarball installations:**

     ```
     $ install_location/bin/dse cassandra -t
     ```

4. Start MySQL and create the demo database:

   ```
   mysql> CREATE DATABASE npa_nxx_demo ;
   ```

5. Connect to the database and create the table:

   ```
   mysql> CONNECT npa_nxx_demo;

   mysql> CREATE TABLE npa_nxx (
            npa_nxx_key int(11) NOT NULL,
            npa           int(11)  DEFAULT NULL,
            nxx           int(11)  DEFAULT NULL,
            lat           float  DEFAULT NULL,
            lon           float  DEFAULT NULL,
            linetype      char(1)  DEFAULT NULL,
   ```

```
          state       varchar(2)  DEFAULT NULL,
          city        varchar(36) DEFAULT NULL,
          PRIMARY KEY (npa_nxx_key)
        ) ENGINE=InnoDB DEFAULT CHARSET=latin1;
```

6. Locate the `npa_nxx_csv` file of the DataStax Enterprise installation.

   The default location of the Sqoop demo depends on the type of installation:

Installer-Services and Package installations	`/usr/share/dse/demos/sqoop`
Installer-No Services and Tarball installations	*`install_location`*`/demos/sqoop`

7. Populate the table by loading the CSV file:

```
 mysql> LOAD DATA LOCAL INFILE 'npa_nxx.csv'
          INTO TABLE npa_nxx_demo.npa_nxx
          FIELDS TERMINATED BY ','
          ENCLOSED BY '"'
          LINES TERMINATED BY '\n';
```

   Output is:

```
Query OK, 105291 rows affected (1.01 sec)
Records: 105291 Deleted: 0 Skipped: 0 Warnings: 0
```

8. On the analytics node you started in step 3, create a CQL keyspace and table that maps to the SQL table. Use compatible data types. For example, start cqlsh and run these commands:

```
 cqlsh> CREATE KEYSPACE npa_nxx WITH REPLICATION =
          {'class':'NetworkTopologyStrategy', 'Analytics':1};

 cqlsh> CREATE TABLE npa_nxx.npa_nxx_data (npa int, nxx int,
          latitude float, longitude float, state text, city text,
          PRIMARY KEY(npa, nxx));
```

   Alternatively, you can run the commands on the operating system command line from a cql script in the `demos/sqoop` directory.

   The default location of the Sqoop demo depends on the type of installation:

Installer-Services and Package installations	`/usr/share/dse/demos/sqoop`
Installer-No Services and Tarball installations	*`install_location`*`/demos/sqoop`

9. In a text editor, open the `import.options` file in the `demos/sqoop` directory.

   The default location of the Sqoop demo depends on the type of installation:

Installer-Services and Package installations	`/usr/share/dse/demos/sqoop`
Installer-No Services and Tarball installations	*`install_location`*`/demos/sqoop`

   The `import.options` file contains these options:

Table 56: import.options file

Contents	Description
cql-import	Perform an import operation.
--table	A SQL table name follows this option.
npa_nxx	SQL table name for the demo.

Contents	Description
--cassandra-keyspace	A keyspace name follows this option.
npa_nxx	The keyspace name for the demo.
--cassandra-table	A Cassandra table name follows this option.
npa_nxx_data	The Cassandra table name for the demo.
--cassandra-column-mapping	A CQL:SQL column mapping follows this option.
npa:npa,nxx:nxx,latitude:lat,longitude:lon,state:state,city:city	The Cassandra column names:corresponding MySQL column names, cql1:sql1,cql2:sql2, . . .
--connect	The JDBC connection string follows this option.
jdbc:mysql://<mysql_host>/npa_nxx_demo	The JDBC connection string.
--username	A MySQL user name follows this option.
<mysql_user>	The user name you configured as the MySQL admin.
--password	A MySQL password follows this option.
<mysql_password>	The MySQL administrative password you configured.
--cassandra-host	The IP address of the MySQL host node follows this option.
<cassandra_host>	The IP address of the host node. For example, 127.0.0.1. A fully-qualified domain name if using Kerberos.

Alternatively, you can enter these commands as options to the `dse sqoop command` to import the data from the SQL to the CQL table as shown in the example of exporting data.

10. Modify the `import.options` file for your environment. For example, assuming you plan to run the demo on a single-node cluster, modify the options as follows:

- --connect

  FROM: jdbc:mysql://<mysql_host>/npa_nxx_demo

  TO: jdbc:mysql://127.0.0.1/npa_nxx_demo
- --username

  FROM: <mysql_user>

  TO: your MySQL user name
- --password

  FROM: <mysql_password>

  TO: your MySQL password
- --cassandra-host

  FROM: <cassandra_host>

  TO: 127.0.0.1

As described in the Sqoop reference, you can list multiple IP addresses.

11. Import the SQL data into Cassandra using the file you edited. Use the `dse import` command to import the data from the MySQL table to the table in Cassandra. On Linux, for example:

    ```
    $ bin/dse sqoop --options-file fully-qualified path/demos/sqoop/
    import.options
    ```

    The MapReduce job runs and the end of the output looks like this:

    ```
    . . .
    14/05/23 14:41:17 INFO mapreduce.ImportJobBase: Transferred 0 bytes in
     50.5956 seconds (0 bytes/sec)
    14/05/23 14:41:17 INFO mapreduce.ImportJobBase: Retrieved 105291 records.
    ```

12. In cqlsh, verify that the data import succeeded.

    ```
    cqlsh> SELECT * FROM npa_nxx.npa_nxx_data LIMIT 5;



     npa | nxx | city        | latitude | longitude | state
    -----+-----+-------------+----------+-----------+-------
     660 | 200 |     Braymer |    39.59 |      93.8 |    MO
     660 | 202 |     Sedalia |     38.7 |     93.22 |    MO
     660 | 213 |    La Belle |    40.11 |     91.91 |    MO
     660 | 214 | Chillicothe |    39.79 |     93.55 |    MO
     660 | 215 |   Maryville |    40.34 |     94.87 |    MO
    ```

Importing SQL to a CQL table or CFS

Steps for importing SQL data into a CQL table or the Cassandra File System.

About this task

To import data to CQL, the keyspace and CQL table must exist prior to the importation. If the CQL table contains data prior to the importation, cql-import updates the data. The Sqoop demo shows how to import SQL data into a CQL table.

In addition to importing data to a CQL table, you can also import data to the Cassandra File System (CFS). The CFS is the Cassandra counterpart to the Hadoop Distributed File System (HDFS). The example in this section shows how to import SQL data to CFS. Using Hive and other utilities, you can access the CFS data.

Procedure

1. Follow the steps in the Sqoop demo to create the SQL database and table and the CQL keyspace and table.
2. Use the **dse sqoop import** command to migrate the data from the MySQL table to text files in the directory npa_nxx in the CFS. Use the database username and password. If the database account is not password-protected, just omit the password option. On Linux, for example:

    ```
    $ bin/dse sqoop import --connect
        jdbc:mysql://127.0.0.1/npa_nxx_demo
        --username mysql
        --password <password>
        --table npa_nxx
        --target-dir /npa_nxx
    ```

DataStax Enterprise returns this message:

```
INFO mapreduce.ImportJobBase: Retrieved 105291 records.
```

3. Use the command to view the results in the CFS. On Linux, for example:

   ```
   $ bin/dse hadoop fs -ls /npa_nxx
   ```

   Depending on the number of DataStax Enterprise analytics nodes and task tracker configuration, the output shows a number of files in the directory, part-m-0000n, where *n* ranges from 0 to the number of tasks that were executed as part of the Hadoop job.

   To view the contents of these files, use this hadoop fs command:

   ```
   $ bin/dse hadoop fs -cat /npa_nxx/part-m-00000
   ```

   By varying the number of tasks (the 00000), the output looks something like this:

   ```
   361991,361,991,27.73,097.40,L,TX,Corpus Christi
   361992,361,992,27.73,097.40,L,TX,Corpus Christi
   361993,361,993,27.73,097.40,L,TX,Corpus Christi
   361994,361,994,27.73,097.40,L,TX,Corpus Christi
   361998,361,998,27.79,097.90,L,TX,Agua Dulce
   361999,361,999,27.80,097.40,W,TX,Padre Island National Seashore
   ```

   As shown in the output, the CSV file format that Sqoop requires does not include optional spaces in the delimiter.

Importing data into a CQL list or set

Use the cql-import tool to map SQL columns to items in a collection set, list, or map.

DataStax Enterprise supports importing data into a CQL collection using the cql-import tool. You can use the cql-import tool to map SQL columns to items in a collection set, list, or map.

The cql-import tool supports two distinct mechanisms for importing data into list and set data types. Both mechanisms use the --cql-column-mapping parameter.

Mapping multiple SQL columns in a single row to a CQL list or set

The cql-import command supports the following cql-column-mapping parameter for mapping multiple SQL columns in a single row to a CQL list or set.

```
CQLCOL:[SQLCOL1,SQLCOL2,SQLCOL3]
```

This form of mapping adds the SQL columns SQLCOL1,SQLCOL2, and SQLCOL3 to the list or set CQLCOL.

The following example shows how to map a MySQL table having multiple SQL columns in a single row to a CQL list.

Suppose you have created and populated a MySQL table using the following commands:

```
mysql> CREATE TABLE sql_table (sqlid INTEGER PRIMARY KEY,  a VARCHAR(25), b
 VARCHAR(25), c VARCHAR(25));
mysql> INSERT INTO sql_table (sqlid, a, b, c) values (1, 'valuea', 'valueb',
 'valuec');
mysql> INSERT INTO sql_table (sqlid, a, b, c) values (2, 'valued', 'valuee',
 'valuef');
```

Using cqlsh, suppose you create the following table in Cassandra that corresponds to the MySQL table:

```
cqlsh> CREATE TABLE cql_table (cqlid int PRIMARY KEY, mylist list<text>);
```

The following map along with other options imports the data into CQL:

```
--cql-column-mapping=cqlid:sqlid,mylist:[a,b,c]
```

Querying Cassandra to select the table produces the following output:

```
 id  | mylist
-----+---------------------------
 1   | {'valuea','valueb','valuec'}
 2   | {'valued','valuee','valuef'}
```

Mapping a single SQL column from multiple SQL rows to a CQL list or set

The cql-import command also supports the following cql-column-mapping parameter to map a single SQL column from multiple SQL rows to a CQL list or set.

```
CQLCOL:SQLCOL
```

This form of mapping appends SQL column values from multiple SQL rows that share a common key to a CQL list or set.

The following example shows how to map a MySQL table having a single SQL column from multiple SQL rows to a CQL list.

Suppose you have created and populated a MySQL table using the following commands:

```
mysql> CREATE TABLE sql_table (sqlid INTEGER PRIMARY KEY,  id INTEGER, a
 VARCHAR(25));
mysql> INSERT INTO sql_table (sqlid, id, a) values (1, 1, 'valuea');
mysql> INSERT INTO sql_table (sqlid, id, a) values (2, 1, 'valueb');
mysql> INSERT INTO sql_table (sqlid, id, a) values (3, 1, 'valuec');
mysql> INSERT INTO sql_table (sqlid, id, a) values (4, 2, 'valued');
mysql> INSERT INTO sql_table (sqlid, id, a) values (5, 2, 'valuee');
```

Using cqlsh, suppose you create the following table in Cassandra that corresponds to the MySQL table:

```
cqlsh> CREATE TABLE cql_table (cqlid int PRIMARY KEY, mylist list<text>);
```

The following map along with other options imports the data into CQL:

```
--cql-column-mapping=cqlid:id,mylist:a
```

Querying Cassandra to select the table produces the following output:

```
 id  | mylist
-----+---------------------------
 1   | {'valuea','valueb','valuec'}
 2   | {'valued','valuee'}
```

Importing data into a CQL map

Use the cql-import tool to map SQL columns to items in a map, similar to importing data into list and set.

You can use the cql-import tool to map SQL columns to items in a map, similar to importing data into list and set. You use the following cql-column-mapping parameter to import data into a map.

```
CQLCOL:[KEY1:SQLCOL1,KEY2:SQLCOL2,KEY3:SQLCOL3]
```

This form of mapping maps SQL column data to map entries using the key name specified in the mapping. The SQL column names can be used as the key names by omitting the key from the mapping.

The mapping mechanism supports a mixed key name mapping.

```
CQLCOL:[KEY1:SQLCOL1,SQLCOL2,KEY3:SQLCOL3]
```

The following example shows how to import a MySQL table into a CQL map collection.

Suppose you have created and populated a MySQL table using the following commands:

```
mysql> CREATE TABLE sql_table (sqlid INTEGER PRIMARY KEY,  a VARCHAR(25), b
 VARCHAR(25), c VARCHAR(25));
mysql> INSERT INTO sql_table (sqlid, a, b, c) values (1, 'valuea', 'valueb',
 'valuec');
mysql> INSERT INTO sql_table (sqlid, a, b, c) values (2, 'valued', 'valuee',
 'valuef');
```

Using cqlsh, create the following table in Cassandra that corresponds to the MySQL table:

```
cqlsh> CREATE TABLE cql_table (cqlid int PRIMARY KEY, mymap map<text,text>);
```

The following map along with other options imports the data into CQL:

```
--cql-column-mapping=cqlid:sqlid,mymap:[key1:a,b,key3:c]
```

Querying Cassandra to select the table produces the following output:

```
 cqlid  | mymap
--------+---------------------------------------------
 1      | {'key1':'valuea', 'b':'valueb', 'key3':'valuec'}
 2      | {'key1':'valued', 'b':'valuee', 'key3':'valuef'}
```

Importing joined tables

A common use case example imports multiple tables, which are joined in SQL, to Cassandra.

About this task

A common use case is to import multiple tables, which are joined in SQL, to Cassandra. This example shows how to import two tables from MySQL. In MySQL, you use query joins to get famous quotations from one table and the author of the quotation from another. For example:

```
mysql> SELECT * FROM person INNER JOIN mysql_quotations ON
 person.id=mysql_quotations.speaker;



+-----+--------------------+---------+----+---------
+-------------------------------------------------------------+
| id  | name                 | title   | id | speaker | quote
                                          |
+-----+-------------------+---------+----+---------
+-----------------------------------------------------------+
| 123 | Christopher Morley | Life    |  1 |     123 | Life is a foreign
 language; all men mispronounce it.          |
| 123 | Christopher Morley | Life    |  2 |     123 | There are three
 ingredients in the good life: learning . . . |
| 124 | Daniel Akst        | Life    |  3 |     124 | In matters of self-
control as we shall see again and . . .    |
| 124 | Daniel Akst        | Life    |  4 |     124 | We Have Met the Enemy:
 Self-Control in an Age of Exc. . .     |
| 125 | Abraham Lincoln    | Success |  5 |     125 | Always bear in mind
 that your own resolution to . . .         |
| 125 | Abraham Lincoln    | Success |  6 |     125 | Better to remain
 silent and be thought a fool than . . .      |
| 126 | Albert Einstein    | Success |  7 |     126 | If A is success in
 life, then A equals x plus y plus . . .   |
+-----+-------------------+---------+----+---------
+-----------------------------------------------------------+
7 rows in set (0.00 sec)
```

This example assumes you have started an analytics node. To import SQL tables into CQL using a collection set for the quotations, follow these steps.

Procedure

1. Download the import_quotations.zip file.
2. Create the mysql_quotations and person tables in MySQL. You can copy/paste commands from the downloaded file to produce these tables.
3. Create the famous_words keyspace and quotations table in cqlsh. You can copy/paste the commands from the downloaded file.

```
cqlsh> CREATE KEYSPACE famous_words WITH REPLICATION =
         {'class':'NetworkTopologyStrategy', 'Analytics':1};
cqlsh> USE famous_words;
cqlsh:famous_words> CREATE TABLE quotations (
                      id text PRIMARY KEY,
                      name text,
                      title text,
                      quotes set <text>
                    );
```

4. Insert the data from the downloaded file into the person and mysql_quotations tables.
5. Create an import options file named import_persons.options having the following contents.

```
cql-import
--table
person
--cassandra-keyspace
famous_words
--cassandra-table
quotations
--cassandra-column-mapping
id:id,name:name,title:title
--connect
jdbc:mysql://127.0.0.1/famous_words
--username
root
--password
root
--cassandra-host
127.0.0.1
```

6. Import the person table into the CQL table. On Linux, for example:

   ```
   $ sudo bin/dse sqoop --options-file path/import_person.options
   ```

   The MapReduce job runs and at then end, looks something like this:

   ```
   . . .
   14/06/16 20:26:43 INFO mapreduce.ImportJobBase: Transferred 0 bytes in
    35.1743 seconds (0 bytes/sec)
   14/06/16 20:26:43 INFO mapreduce.ImportJobBase: Retrieved 4 records.
   ```
7. Check that the CQL quotations table now contains the data from the MySQL person table.

   ```
   cqlsh:famous_words> SELECT * FROM quotations;

    id  | name               | quotes | title
   -----+--------------------+--------+---------
    123 | Christopher Morley |   null |    Life
    125 |    Abraham Lincoln |   null | Success
    126 |    Albert Einstein |   null | Success
    124 |        Daniel Akst |   null |    Life

   (4 rows)
   ```
8. Create another import options file to import the mysql_quotations table. Use a free form query to import the quotations into the CQL table. The literal string $CONDITIONS needs to appear in the WHERE clause of the query. Sqoop replaces the string with its refined constraints. For example:

   ```
   cql-import
   --query
   select person.id, person.name, person.title, mysql_quotations.quote from
    person INNER JOIN mysql_quotations ON person.id=mysql_quotations.speaker
    WHERE $CONDITIONS
   --target-dir
   /sqoop
   --split-by
   person.id
   --cassandra-keyspace
   famous_words
   --cassandra-table
   quotations
   --cassandra-column-mapping
   id:id,name:name,title:title,quotes:quote
   --connect
   jdbc:mysql://127.0.0.1/famous_words
   --username
   root
   --password
   root
   --cassandra-host
   127.0.0.1
   ```

   >
9. Import the resultset of quotations into the CQL table. On Linux, assuming you named the options file import_quotes.options:

   ```
   $ sudo bin/dse sqoop --options-file path/import_quotes.options
   ```

10. Check that the CQL quotations table now contains a collection set of quotations as well as the name of the speaker and other information in the MySQL table.

    ```
    cqlsh:famous_words> SELECT * FROM quotations;
    ```

Exporting CQL data to SQL

Using Sqoop, you can export data of different data types from CQL to MySQL.

About this task

Using Sqoop, you can export data of different data types from CQL to MySQL. You can import SQL into CQL collections, and exporting CQL collections to multiple rows in SQL. This example creates a CQL table of columns of different data types, inserts values into the table, and exports the data to SQL.

Procedure

1. Create a keyspace using the default data center name Analytics, and use the keyspace.

   ```
   cqlsh> CREATE KEYSPACE tosql WITH REPLICATION =
            {'class':'NetworkTopologyStrategy', 'Analytics':1};
   cqlsh> USE tosql;
   ```

2. Create a table in CQL, and then, insert some data.

   ```
   cqlsh:tosql> CREATE TABLE cql_table (
                  id int PRIMARY KEY,
                  a timestamp,
                  b float,
                  c boolean,
                  d blob,
                  e inet,
                  f uuid);
   cqlsh:tosql> INSERT INTO cql_table ( id, a, b, c, d, e, f ) VALUES ( 123,
    '1974-07-17 22:18:32', 3.14159265, true, 0x1afb, '127.0.0.1', 69d5c4fd-
   a7b7-4269-9cb5-c6f7d5fc076e );
   cqlsh:tosql> INSERT INTO cql_table ( id, b ) VALUES ( 789, 11.001001000) ;
   ```

   Observe the range limitation of MySQL timestamps.

3. Create a database and table in MySQL that corresponds to the CQL table. Use compatible data types, which are listed in Table 62: Data type map for exporting CQL to SQL.

   ```
   mysql> CREATE DATABASE fromcql;
   mysql> USE fromcql;
   mysql> CREATE TABLE sql_table (
            id INTEGER PRIMARY KEY,
            a TIMESTAMP,
            b VARCHAR(25),
            c BOOLEAN,
            d BLOB,
            e VARCHAR(15),
            f VARCHAR(40)
          ) ENGINE=InnoDB DEFAULT CHARSET=latin1;
   ```

4. Export the CQL data to MySQL. This example shows the export command entered on the command line instead of using an options file.

   ```
   $ dse sqoop cql-export --connect jdbc:mysql://127.0.0.1/fromcql --username
    root --password root --table sql_table --cassandra-host 127.0.0.1 --
   cassandra-keyspace tosql --cassandra-table cql_table
   ```

Alternatively, you can adapt the export.options file to your environment in the manner shown earlier for modifying the import.options file, and then use this command:

```
$ bin/dse sqoop --options-file <path to export.options>
```

The MapReduce job runs and the end of the output looks like this:

```
 . . .
14/05/29 08:08:33 INFO mapreduce.ExportJobBase: Transferred 0 bytes in
 52.2312 seconds (0 bytes/sec)
14/05/29 08:08:33 INFO mapreduce.ExportJobBase: Exported 2 records.
```

5. Check that the data was exported into the MySQL table.

```
mysql> SELECT * FROM sql_table;

+---+------------+----------+----+----+----------+------------+
|id |a           | b        | c  |d   | e        |f           |
+---+------------+----------+----+----+----------+------------+
|123|1974-07-17...| 3.1415927|   1|?   |/127.0.0.1|69d5c4fd... |
|789|2014-05-29...| 11.001001|NULL|NULL|NULL      |NULL        |
+---+------------+----------+----+----+----------+------------+
3 rows in set (0.00 sec)
```

Exporting selected CQL data to SQL

Use export options to select columns for export and limit the page size of the export. You can conditionally filter the data to select for export.

About this task

You can use export options to select certain columns for export and limit the page size of the export. You can also conditionally filter the data to select for export using the --cassandra-where-clause option <clause>. You enclose the CQL WHERE clause in double quotation marks.

This example creates a CQL table of columns of different data types, inserts values into the table, and exports the data to SQL.

Procedure

1. Use the keyspace created in the previous example.

```
cqlsh> USE tosql;
```

2. Create a table in CQL, and then, insert some data.

```
cqlsh:tosql> CREATE TABLE ruling_stewards (
         steward_name text,
         king text,
         reign_start int,
         event text,
         PRIMARY KEY (steward_name, king, reign_start)
       );

cqlsh:tosql> INSERT INTO ruling_stewards (steward_name, king, reign_start,
 event) VALUES ('Hador', 'none', 2278, 'Last long-lived Duedian');

cqlsh:tosql> INSERT INTO ruling_stewards (steward_name, king, reign_start,
 event) VALUES ('Denethor', 'Brego', 2435, 'Watchful Peace broken');
```

```
cqlsh:tosql> INSERT INTO ruling_stewards (steward_name, king, reign_start,
 event) VALUES ('Boromir', 'Brego', 2477, 'Attacks continue');

cqlsh:tosql> INSERT INTO ruling_stewards (steward_name, king, reign_start,
 event) VALUES ('Cirion', 'Brego', 2489, 'Defeat of Balchoth');
```

3. Test a WHERE clause to use to filter data for export. Select only the data from King Brego's reign from 2450 up to, but not including, 2500.

```
cqlsh:tosql> SELECT * FROM ruling_stewards WHERE king = 'Brego' AND
 reign_start >= 2450 AND reign_start < 2500 ALLOW FILTERING;

 steward_name | king  | reign_start | event
--------------+-------+-------------+--------------------
      Boromir | Brego |        2477 |   Attacks continue
       Cirion | Brego |        2489 | Defeat of Balchoth

(2 rows)
```

4. Use the fromcql database from the previous example and create a MySQL table to accommodate the CQL ruling_stewards data.

```
mysql> USE fromcql;
mysql> create table sql_rulers (
         steward_name varchar(15) PRIMARY KEY,
         king varchar(15),
         reign_start INTEGER,
         event varchar (40)
       ) ENGINE=InnoDB DEFAULT CHARSET=latin1;
```

5. Export the only the CQL data from King Brego's reign from 2450 up to, but not including, 2500. This example shows the export command entered on the command line.

```
$ dse sqoop cql-export
    --connect jdbc:mysql://127.0.0.1/fromcql
    --username root --password root
    --table sql_rulers
    --cassandra-host 127.0.0.1
    --cassandra-keyspace tosql
    --cassandra-table ruling_stewards
    --cassandra-select-columns steward_name,king,reign_start
    --cassandra-where-clause "king='Brego' AND reign_start >=2450 AND
 reign_start < 2500"
```

The MapReduce job runs and the end of the output indicates success exporting two records:

```
 . . .
14/09/17 20:25:37 INFO mapreduce.ExportJobBase: Exported 2 records.
```

6. Verify that the data was exported into the MySQL table.

```
mysql> select * from sql_rulers;
+--------------+-------+-------------+-------+
| steward_name | king  | reign_start | event |
+--------------+-------+-------------+-------+
| Boromir      | Brego |        2477 | NULL  |
| Cirion       | Brego |        2489 | NULL  |
+--------------+-------+-------------+-------+
2 rows in set (0.02 sec)
```

Exporting data from CQL collections

The cql-export tool supports the export of data from list, set, and map collection types.

The cql-export tool supports the export of data from list, set, and map collection types.

Exporting a set or list

You can export a CQL list and set to multiple SQL rows. You map each element in the list to an SQL row, and then use the `cql-export` command to export the data. In the SQL database, multiple rows store the collection.

The cql-export tool supports exporting list and set data as multiple SQL rows using the following mapping:

```
CQLCOL:SQLCOL
```

The following example shows how to map a list of multiple SQL rows.

Suppose you have created and populated a CQL table using the following commands:

```
cqlsh> CREATE TABLE cql_table (cqlid int PRIMARY KEY, mylist list<text>);
cqlsh> INSERT INTO cql_table (cqlid, mylist) VALUES (1,
 ['value1','value2','value3']);
```

Using MySQL, you create the following table that corresponds to the CQL table:

```
mysql> CREATE TABLE sql_table(sqlid INTEGER GENERATED BY DEFAULT AS IDENTITY
 PRIMARY KEY, id INTEGER, value VARCHAR(20));
```

The following map along with other options exports the data into MySQL:

```
--cql-column-mapping=cqlid:id,mylist:value
```

Querying MySQL to select the table produces the following output:

```
+-------+----+--------+
| sqlid | id | value  |
+-------+----+--------+
| 1     | 1  | value1 |
| 2     | 1  | value2 |
| 3     | 1  | value3 |
+-------+----+--------+
```

Sqoop does not export sqlid from CQL. MySQL auto-generates the sqlid to give the table a unique id.

Exporting a map

You can export a CQL map collection to a single SQL row. You map each map key to SQL column names. You can only map one collection per Sqoop statement.

You use the following cql-column-mapping parameter to export CQL map entries to SQL columns where the key maps to a SQL column name. Where the map key is the same as the SQL column name, you can omit the key from the mapping:

```
CQLCOL:[SQLCOL1,SQLCOL2,SQLCOL3]
```

Like the importing mechanism, the mapping mechanism for exporting supports a mix of key name mapping.

```
CQLCOL:[KEY1:SQLCOL1,SQLCOL2,KEY3:SQLCOL3]
```

The following example shows how to map a CQL map to an SQL table.

Create and populate a CQL table using the following commands:

```
cqlsh> CREATE TABLE cql_table (cqlid int PRIMARY KEY, mymap
 map<text,text>);
cqlsh> INSERT INTO cql_table (cql, mymap) values (1,
 {'key1':'value1','col2':'value2','key3':'value3'});
```

Using MySQL, create the following table that corresponds to the CQL table:

```
mysql> CREATE TABLE sql_table(sqlid INTEGER PRIMARY KEY, col1 VARCHAR(20),
 col2 VARCHAR(20), col3 VARCHAR(20));
```

The following map along with other options exports the data to MySQL:

```
--cql-column-mapping=cqlid:sqlid,mymap:[key1:col1,col2,key3:col3]
```

Querying MySQL to select the table produces the following output:

```
+-------+--------+--------+--------+
| sqlid | col1   | col2   | col3   |
+-------+--------+--------+--------+
| 1     | value1 | value2 | value3 |
+-------+--------+--------+--------+
```

Automating a Sqoop operation

Use the Sqoop metastore to save configuration information for an import or export as a job.

DataStax Enterprise supports a native Cassandra implementation of the Sqoop metastore. You use the Sqoop metastore to store jobs, which are operations that you can run directly from Sqoop, such as an import or export. The native implementation saves the jobs in the sqoop_meta_store table in the dse_system keyspace.

You can save configuration information for an import or export as a job and run the job from the metastore repeatedly. You typically run the job from the metastore to incrementally import data. Sqoop imports only the newest rows.

Configuring the metastore

You use the sqoop-site.xml installed with DataStax Enterprise to configure the metastore. The default configuration sets up the native Cassandra metastore for use in a development environment. You need to make configuration changes to the following properties to use the metastore correctly in a working cluster:

Table 57: Cassandra metastore properties

Property	Description	Default
sqoop.cassandra.host	A comma-separated list of nodes that the metastore can use to connect to Cassandra	127.0.0.1
sqoop.cassandra.port	The native protocol port number that the metastore uses to connect to Cassandra	9042
sqoop.job.storage.write.consistency.level	The consistency level for metastore writes	LOCAL_ONE

Property	Description	Default
sqoop.job.storage.read.consistency.level	The consistency level for metastore reads	LOCAL_ONE
sqoop.metastore.client.record.password	Save passwords with the job	true

Job command syntax

To create and manage a job, use the job tool. The syntax of the job command is:

```
$ dse sqoop job <option> [jobId] -- <sqoop command>
```

The following list describes Sqoop job options:

- dse sqoop job --create <jobId> -- <sqoop commands>

  Creates a new job using the commands given after the '--'.
- dse sqoop job --list

  Lists available jobs.
- dse sqoop job --show <jobId>

  Displays information about a job.
- dse sqoop job --delete <jobId>

  Deletes an existing job.
- dse sqoop job --exec <jobId>

  Executes a saved job.

Creating a job

This example creates a job named myjob that imports the Sqoop demo data from the MySQL npa_nxx_demo database into a CQL table named npa_nxx in Cassandra:

```
$ dse sqoop job --create myjob -- cql-import --table npa_nxx --cassandra-
keyspace npa_nxx --cassandra-table npa_nxx_data --cassandra-column-mapping
 npa:npa,nxx:nxx,latitude:lat,longitude:lon,state:state,city:city --connect
jdbc:mysql://127.0.0.1/npa_nxx_demo
```

The following output indicates success. A job named myjob is saved in the DseMetaStore for execution later.

```
14/09/10 16:58:22 INFO policies.DCAwareRoundRobinPolicy: Using data-center
 name 'Analytics' for DCAwareRoundRobinPolicy (if this is incorrect,
 please provide the correct data center name with DCAwareRoundRobinPolicy
 constructor)
14/09/10 16:58:22 INFO core.Cluster: New Cassandra host /127.0.0.1:9042
 added
```

Listing a job

This example shows how to list the jobs saved in the DseMetaStore:

```
$ dse sqoop job --list

Available jobs:
myjob
```

Viewing the job configuration

This example shows how to view the configuration of a job:

```
$ dse sqoop job --show myjob

Job: myjob
Tool: cql-import
Options:
----------------------------
verbose = false
db.connect.string = jdbc:mysql://127.0.0.1/npa_nxx_demo
codegen.output.delimiters.escape = 0
codegen.output.delimiters.enclose.required = false
codegen.input.delimiters.field = 0
hbase.create.table = false
db.require.password = false
hdfs.append.dir = false
db.table = npa_nxx
import.fetch.size = null
codegen.input.delimiters.escape = 0
codegen.input.delimiters.enclose.required = false
codegen.output.delimiters.record = 10
import.max.inline.lob.size = 16777216
hcatalog.create.table = false
db.clear.staging.table = false
codegen.input.delimiters.record = 0
enable.compression = false
hive.overwrite.table = false
hive.import = false
codegen.input.delimiters.enclose = 0
hive.drop.delims = false
codegen.output.delimiters.enclose = 0
hdfs.delete-target.dir = false
codegen.output.dir = .
codegen.auto.compile.dir = true
mapreduce.num.mappers = 4
import.direct.split.size = 0
export.new.update = UpdateOnly
codegen.output.delimiters.field = 44
incremental.mode = None
hdfs.file.format = TextFile
codegen.compile.dir = /tmp/sqoop-root/
compile/498dc667d886a4c710b70c00624935de
direct.import = false
hive.fail.table.exists = false
db.batch = false
mapred.used.genericoptionsparser = true
sqoop.cassandra.keyspace = npa_nxx
sqoop.cassandra.column.family = npa_nxx_data
sqoop.cassandra.column.mapping =
 npa:npa,nxx:nxx,latitude:lat,longitude:lon,state:state,city:city
sqoop.cassandra.tool = cql-import
```

Running a job

This example assumes that you have truncated the npa_nxx.npa_nxx_data table using cqlsh. The following command runs the saved job.

```
$ dse sqoop job --exec myjob -- --username someuser -P
Enter password: ...
```

MapReduce runs the saved job.

Saved jobs and passwords

DataStax recommends using the --username and -P options on the command line as shown in the example of running a job. Because multiple users can access the DseMetaStore, it does not store passwords. You can set the sqoop.metastore.client.record.password option to true in the sqoop-site.xml to make the password prompt appear each time you create a job that requires a password. No prompting occurs when you run show or exec.

For security reasons, configuring these parameters in the sqoop-site.xml is not recommended:

- sqoop.metastore.client.autoconnect.username
- sqoop.metastore.client.autoconnect.password

Importing data incrementally

To import data in increments, you use the --incremental argument with the import command. Sqoop compares the values in a check column against a reference value for the most recent import. These arguments import all rows having an id greater than 100.

- --incremental
- --check-column id
- --last-value 100

If you run an incremental import from the command line, Sqoop prints the *last value* in a subsequent incremental import. If you run an incremental import from a saved job, Sqoop retains the last value in the saved job. To import only newer rows than those previously imported, use the --exec <row id> option. Sqoop imports only rows having an id greater than the specified row id.

Sqoop reference

Use the `dse sqoop` command to import SQL data into CQL, export SQL data to SQL, and import Thrift/CLI data to CQL.

DataStax Enterprise supports three forms of the `dse sqoop` command for use with Sqoop:

```
$ dse sqoop <action> --connect <jdbc url> --cassandra-keyspace <ks> --
cassandra-table <cf> --cassandra-host <host> --table <sql table>
```

where <action>, is one of the following keywords:

- Import SQL data into CQL:

  ```
  cql-import
  ```
- Export SQL data to CQL.

  ```
  cql-export
  ```
- Import Thrift/CLI data to CQL.

  ```
  thrift-import
  ```

The following tables list cql-import and -export command options. You can use most options to either import or export data. Exceptions are noted in the option description.

Table 58: cql-import and cql-export Cluster Options

Command	Description
--cassandra-consistency-level <consistencylevel>	The Cassandra consistency level, which is LOCAL_ONE by default
--cassandra-host <host>	A comma separated list of Cassandra hosts
--cassandra-partitioner <partitioner>	The Cassandra partitioner, which is Murmur3Partitioner by default
--cassandra-port <port>	The Cassandra port

Table 59: cql-import and cql-export Data Options

Command	Description
--query <sql query>	Supports importing SQL joins.
--cassandra-column-mapping *map*	Supports mapping ambiguous columns for import/export.
... where map = cql1:sql1,cql2:sql2	Maps cql and sql columns (not collections) for import/export.
... CQLLISTSET:[SQLCOL,SQLCOL,SQLCOL]	Maps a list or set type for import/export.
... CQLMAP:[SQLCOL:VALCOL,SQLCOL:VALCOL]	Handles importing/exporting of a map type.
--cassandra-page-size	cql-export only. Limits the page size of columns selected for export.
--cassandra-select-columns	cql-export only. Select the named columns to export.
--cassandra-where-clause	cql-export only. Filter the data selected for export based on the where condition.

Table 60: cql-import and cql-export Security Options

Command	Description
--cassandra-enable-kerberos	Enables kerberos authentication
--cassandra-kerberos-config-path <jaas.config path>	Path to the users `jaas.config` file
--cassandra-enable-ssl	Enables SSL transport
--cassandra-ssl-protocol <protocol>	Configures the SSL protocol
--cassandra-truststore-algo <algo>	Configures the SSL trust store algorithm
--cassandra-truststore-ciphers <ciphers>	Configures the SSL trust store ciphers
--cassandra-truststore-location <location>	Path to the SSL trust store
--cassandra-truststore-password <passwd>	Configures the SSL trust store password
--cassandra-truststore-type <type>	Configures the SSL trust store type
--cassandra-username <username>	Used for password authentication, which works only with the local Job Tracker
--cassandra-password <password>	Used for password authentication

Command	Description
--cassandra-kerberos-service-principal <service principal>	The Kerberos principal for which you have created a ticket using `kinit`

Table 61: Allowable data type conversions for importing SQL to CQL

SQL Type	CQL Type
VARCHAR	text, ascii, varchar
BIT	boolean, text, ascii, varchar
BIT(1)	boolean, text, ascii, varchar
BIT(>1)	blob
TINYINT	int, bigint, varint, float, double, decimal, text, ascii, varchar
SMALLINT	int, bigint, varint, float, double, decimal, text, ascii, varchar
INTEGER	int, bigint, varint, float, double, decimal, text, ascii, varchar
BIGINT	bigint, varint, float, double, decimal, text, ascii, varchar
FLOAT	float, double, decimal, text, ascii, varchar
DOUBLE	double, decimal, text, ascii, varchar
DECIMAL	decimal, text, ascii, varchar
NUMERIC	decimal, text, ascii, varchar
BLOB	blob
CLOB	blob, text, ascii, varchar
BINARY(n)	blob, text, ascii, varchar
VARBINARY(n)	blob, text, ascii, varchar
DATE	timestamp, text, ascii, varchar
TIME	timestamp, text, ascii, varchar
TIMESTAMP	timestamp, text, ascii, varchar

Table 62: Data type map for exporting CQL to SQL

CQL Type	SQL Type
int	TINYINT, SMALLINT, INTEGER, BIGINT, FLOAT, DOUBLE, DECIMAL, NUMERIC, VARCHAR
bigint	BIGINT, FLOAT, DOUBLE, DECIMAL, NUMERIC, VARCHAR
varint	DECIMAL, NUMERIC, VARCHAR
float	FLOAT, DOUBLE, DECIMAL, NUMERIC, VARCHAR

CQL Type	SQL Type
double	DOUBLE, DECIMAL, NUMERIC, VARCHAR
decimal	DECIMAL, NUMERIC, VARCHAR
ascii	VARCHAR, CLOB, BLOB, VARBINARY
text	VARCHAR, CLOB, BLOB, VARBINARY
varchar	VARCHAR, CLOB, BLOB, VARBINARY
timestamp	DATE, TIME, TIMESTAMP, VARCHAR
boolean	BOOLEAN, BIT, BIT(1), VARCHAR
blob	BLOB, VARBINARY
inet	VARCHAR
uuid	VARCHAR
timeuuid	VARCHAR

About the generated Sqoop JAR file

After running the `dse sqoop import` command, a Java class named `npa_nxx.java` appears in the DSE installation `bin` directory.

After running the `dse sqoop import` command, a Java class named `npa_nxx.java` appears in the DSE installation `bin` directory. This file can encapsulate one row of the imported data. You can specify the name of this JAR file, the output directory, and the class package using Sqoop command line options. See Sqoop documentation.

Getting information about the sqoop command

Use the help option of the sqoop import command to get online help on Sqoop command line options.

About this task

Use the help option of the sqoop import command to get online help on Sqoop command line options. For example, on the Mac:

```
$ cd install_location/bin
```

```
$ ./dse sqoop import --help
```

Migrating data using other methods

Migrating data to DataStax Enterprise solutions include the COPY command, the DSE Search/Solr Data Import Handler, and the Cassandra bulk loader.

About this task

Apache Sqoop transfers data between an RDBMS and Hadoop. DataStax Enterprise modified Sqoop so you can move data directly into Cassandra as well as transfer data from an RDBMS to the Cassandra File System (CFS). DataStax offers several solutions in addition to Sqoop for migrating from other databases:

- The COPY command, which mirrors what the PostgreSQL RDBMS uses for file/export import
- The DSE Search Data Import Handler, which is a configuration-driven method for importing data to be indexed for searching
- The Cassandra bulk loader that provides the ability to bulk load external data into a cluster

About the COPY command

You can use COPY in Cassandra’s CQL shell to load flat file data into Cassandra as well as write data out to OS files. Typically, an RDBMS has unload utilities for writing table data to OS files.

ETL Tools

If you need more sophistication applied to a data movement situation than just extract-load, you can use any number of extract-transform-load (ETL) solutions that now support Cassandra. These tools provide excellent transformation routines for manipulating source data to suit your needs and then loading the data into a Cassandra target. The tools offer many other features such as visual, point-and-click interfaces, scheduling engines, and more.

Many ETL vendors who support Cassandra supply community editions of their products that are free and able to solve many different use cases. Enterprise editions are also available that have useful features for serious enterprise data users.

You can freely download and try ETL tools from Jaspersoft, Pentaho, and Talend that work with DataStax Enterprise and Cassandra.

DataStax Enterprise tools

Tools include dse commands, dsetool, dfs-stress tool, pre-flight check and yaml_diff tools, and the Cassandra bulk loader.

dse commands

The dse commands provide additional controls for starting and using DataStax Enterprise.

The dse commands provide additional controls for starting and using DataStax Enterprise.

dse commands

Synopsis

```
$ dse [-u <username> -p <password>] <subcommand> [command-arguments]
```

Synopsis when using secure JMX

```
$ dse [-u <username>] [-a <jmx_username>] <subcommand> [command-arguments]
```

For commands that require authentication credentials or JMX credentials, issue the command and subcommands with only the Cassandra user name and/or secure JMX user name. When a .dserc file does not exist, you are prompted to enter the passwords on the next line. For example:

```
$ dse -u cassandra hadoop fs -ls /
```

Prompts you to enter the password to authenticate against the configured Cassandra authentication schema.

This table describes the authentication command arguments that can be used with all subcommands.

Command arguments	Description
-u	User name to authenticate against the configured Cassandra authentication schema.
-p	Password to authenticate against the configured Cassandra authentication schema.
-a	User name to authenticate with secure JMX.
-b	Password to authenticate with secure JMX.

This table describes the dse version command that can be used without authentication:

Command argument	Description
-v	Send the DSE version number to standard output.

dse subcommands

This table describes the dse subcommands that use authentication.

Subcommand	Command arguments	Description
beeline		Start the Beeline shell.
cassandra		Start up a real-time Cassandra node in the background. See Starting DataStax Enterprise.
cassandra	-c	Enable the Cassandra File System (CFS) but not the integrated DSE Job Trackers and Task Trackers. Use to start nodes for running an external Hadoop system.
cassandra	-f	Start up a real-time Cassandra node in the foreground. Can be used with -k, -t, or -s options.
cassandra	-k	Start up an analytics node in Spark mode in the background. See Starting Spark.
cassandra	-k -t	Start up an analytics node in Spark and DSE Hadoop mode. See Starting Spark.
cassandra	-s	Start up a DSE Search node in the background. See Starting DataStax Enterprise.
cassandra	-t	Start up an analytics node in DSE Hadoop mode in the background. See Starting DataStax Enterprise.
cassandra	-t -j	Start up an analytics node as the Job Tracker. See starting the Job Tracker node.
cassandra-stop	-p *pid*	Stop the DataStax Enterprise process number pid. See Stopping a node.
cassandra	-s -Ddse.solr.data.dir=*path*	Use *path* to store DSE Search data. See Moving `solr.data`
cassandra	-Dcassandra.replace_address	After replacing a node, replace the IP address in the table. See Replacing a dead node. All -D options in Cassandra start up commands are supported.
esri-import	ESRI import tool options	The DataStax Enterprise custom ESRI import tool supports the Enclosed JSON format. See Spatial analytics support.
hadoop	version	Sends the version of the Hadoop component to standard output.
hadoop	fs *options*	Invoke the Hadoop FileSystem shell. See the Hadoop tutorial.
hadoop	fs -help	Send Apache Hadoop fs command descriptions to standard output. See the Hadoop tutorial.
hive		Start a Hive client.
hive	--service *name*	Start a Hive server by connecting through the JDBC driver.
hive-schema		Create a hive schema representing the Cassandra table when Using Hive with BYOH.
hive-metastore-migrate	Hive-metastore-migrate tool options	Map custom external tables to the new release format after upgrading. See dse hive-metastore-migrate -to <to>.
mahout		Describe Mahout commands.

Subcommand	Command arguments	Description
mahout	*mahout command options*	Run Mahout commands.
mahout hadoop	*hadoop command options*	Add Mahout classes to classpath and execute the hadoop command. See Mahout commands.
pig		Start Pig.
pyspark		Start PySpark.
shark		Start the Shark shell.
spark		Accessing Cassandra from the Spark shell.
spark-submit	options	Launch applications on a cluster and use Spark cluster managers. See dse spark-submit.
sqoop	-help	Send Apache Sqoop command line help to standard output. See the Sqoop demo.

Note: The directory in which you run the `dse` Spark commands must be writable by the current user.

Hadoop, hive, mahout, and pig commands must be issued from an analytics node. The hadoop fs options, which DSE Hadoop supports with one exception (-moveToLocal), are described in the *HDFS File System Shell Guide* on the Apache Hadoop web site. DSE Hadoop does not support the -moveToLocal option; use the -copyToLocal option instead.

The default location of the `dse` tool depends on the type of installation:

Package installations	`/usr/bin/dse`
Installer-Services installations	`/usr/bin/dse`
Installer-No Services and Tarball installations	`*install_location*/bin/dse`

dsetool utility

Use the dsetool utility for Cassandra File System (CFS) and Hadoop-related tasks, such as managing the Job Tracker, checking the CFS, and listing node subranges of data in a keyspace.

You can use the dsetool utility for Cassandra File System (CFS) and Hadoop-related tasks, such as managing the Job Tracker, checking the CFS, and listing node subranges of data in a keyspace. Only JMX (java management extensions) provides dsetool password authentication. If JMX passwords are enabled, use the JMX passwords to use the dsetool utility.

Usage: `dsetool [-a <jmx_username> -b <jmx_password>] [-h|--host=<hostname>] [-p|--port=<#>] [-j|--jmxport=<#>] <command> <args>`

This table describes the dsetool arguments:

Short form	Long form	Description
`-a`	--jmx-username <arg>	User name for authenticating with secure JMX.
`-b`	--jmx-password <arg>	Password for authenticating with secure JMX.
`-h`	--host <arg>	Node hostname or IP address.
`-j`	--jmxport <arg>	Remote JMX agent port number.

Short form	Long form	Description
-p	--port	Node connection port number.
-u	--use_hadoop_config	Get Cassandra host from Hadoop configuration files.

The `dsetool` commands are:

autojt

Elects Job Trackers for a specified data center, or for all data centers when none is specified. Automatically manage Job Tracker selection and remove manual selections. If the current manually selected tracker is up, the manually selected Job Tracker continues to be used.

checkcfs

Checks a single CFS file or the whole CFS. See checking the CFS using dsetool.

create_core <keyspace.cf>

Creates the Solr core and optionally generates resources automatically. The Solr core is created with the specified keyspace and table name and following options:

- schema=<path> - path of the schema file used for creating the core, not necessary when generateResources=true
- solrconfig=<path> - path of the solrconfig file used for creating the core, not necessary when generateResources=true
- distributed=<true|false> - default: true
- recovery=<true|false> - default: false
- deleteAll=<true|false> - default: false
- reindex=<true|false> - only observed on auto-core creation (generateResources=true); otherwise, always reindexes on core creation. Default: false
- generateResources=<true|false> - default: false
- coreOptions - path to the options file when generateResources=true

createsystemkey <algorithm[/mode/padding]> <Key Strength> [<file>] [-kmip=<kmip_groupname>]

Creates a global encryption key, called a system key, for SSTable encryption. You can create multiple encryption keys with unique file names. Key strength is not required for HMAC algorithms.

encryptconfigvalue

Encrypts sensitive configuration information. This command takes no arguments and prompts for the value to encrypt.

get_core_schema <keyspace>.<table> [current=true|false]

Provides the Solr schema as the output of this command. If current is set to true, returns the current live schema.

get_core_config <keyspace>.<table> [current=true|false]

Provides the solrconfig as the output of this command. If current is set to true, returns the current live solrconfig.

infer_solr_schema <keyspace>.<table>

Automatically generates a schema based on the specified keyspace and table. Solr cores are not modified, the schema is inferred and proposed.

inmemorystatus [<keyspace> <table>]

Provides the memory size, capacity, and percentage for this node and the amount of memory each table is using. To get information about a single table, specify keyspace and table. The unit of measurement is MB. Bytes are truncated.

jobtracker

Returns the Job Tracker hostname and port. Returns the Job Tracker that is local to the data center from which you are running the command. See managing the Job Tracker using dsetool commands for examples of using dsetool commands for managing the Job Tracker.

listjt

Lists all Job Tracker nodes grouped by the data center that is local to them.

list_subranges <keyspace> <cf-name> <keys_per_range> <start_token>, <end_token>

Divides a token range for a given keyspace/table into a number of smaller subranges of approximately keys_per_range. To be useful, the specified range should be contained by the target node's primary range.

managekmip <kmip_groupname> list

Verifies communication with the specified KMIP key server and lists the KMIP encryption keys on that key server.

movejt

Moves the Job Tracker and notifies the Task Tracker nodes. This option has been deprecated. Use setjt and setrjt.

partitioner

Returns the fully qualified classname of the IPartitioner that is in use by the cluster.

perf <subcommand>

Modifies performance object settings as described in the subcommand section.

reload_core <keyspace>.<table> [<<option>> ...]

Reloads a core with the given keyspace and table name and following options:

- schema=<path> - path of the schema file used for reloading the core
- solrconfig=<path> - path of the solrconfig file used for reloading the core
- distributed=<true|false> - default: true
- deleteAll=<true|false> - default: false
- reindex=<true|false> - default: false

repaircfs

Repairs the CFS from orphan blocks.

rebuild_indexes <keyspace> <table-name> [<idx1,idx2,...>]

Rebuilds specified secondary indexes for given keyspace/table. Use only keyspace/table-name to re-build all indexes.

ring

Lists the nodes in the ring, including their node type.

setjt *IP address of JobTracker node*

Moves the JobTracker to the specified node and notifies the TaskTracker nodes of the change.

setrjt *IP address of reserve JobTracker node*

Moves the reserve JobTracker node to the specified IP address and notifies the TaskTracker nodes of the change.

sparkmaster [<subcommand>]

Unless a subcommand is provided, this command returns the address of Spark Master running in a data center. Otherwise, this command executes a subcommand related to Spark Master.

- cleanup - Drops and recreates the Spark Master recovery table.
- cleanup <data-center-name> - Removes recovery data for the specified data center.

sparkworker restart

Manually restarts the Spark Worker on the selected node, without restarting the node.

status

Same as the ring command.

Checking the CFS using dsetool

Use the `dsetool checkcfs` command to scan the Cassandra File System (CFS) for corrupted files. For example:

```
dsetool checkcfs cfs:///
```

Use the dsetool to get details about a particular file that has been corrupted. For example:

```
dsetool checkcfs /tmp/myhadoop/mapred/system/jobtracker.info
```

Listing sub-ranges using dsetool

The `dsetool` command syntax for listing subranges of data in a keyspace is:

```
dsetool [-h ] [hostname ] list_subranges <keyspace> <table> <rows per
 subrange> <start token> <end token>
```

- *rows per subrange* is the approximate number of rows per subrange.
- *start partition range* is the start range of the node.
- *end partition range* is the end range of the node.

Note: Run `nodetool repair` on a single node using the output of list_subranges. The output must be partition ranges that are used on that node.

Example

```
dsetool list_subranges Keyspace1 Standard1 10000
 113427455640312821154458202477256070485 0
```

Output

The output lists the subranges to use as input to the `nodetool repair` command. For example:

```
Start Token                             End Token
    Estimated Size
-------------------------------------------------------------------------------------------
113427455640312821154458202477256070485
 132425442795624521227151664615147681247 11264
132425442795624521227151664615147681247
 151409576048389227347257997936583470460 11136
151409576048389227347257997936583470460 0
    11264
```

Nodetool repair command options

You must use the nodetool utility to work with sub-ranges. The start partition range (-st) and end partition range (-et) options specify the portion of the node that needs repair. You get values for the start and end tokens from the output of `dsetool list_subranges` command. The `nodetool repair` syntax for using these options is:

```
nodetool repair <keyspace> <table> -st <start token>  -et <end token>
```

Example

```
nodetool repair Keyspace1 Standard1 -st
 113427455640312821154458202477256070485 -et
 132425442795624521227151664615147681247
nodetool repair Keyspace1 Standard1 -st
 132425442795624521227151664615147681247 -et
 151409576048389227347257997936583470460
nodetool repair Keyspace1 Standard1 -st
 151409576048389227347257997936583470460 -et 0
```

These commands begins an anti-entropy node repair from the start partition range to the end partition range.

Performance object subcommands

The self-explanatory `dsetool perf` command subcommands are:

Note: Enabling or disabling with the performance object subcommands does not persist between reboots and is useful only for short-term diagnostics. To make these settings permanent, see CQL Performance Service options.

Table 63: Performance object subcommands

Subcommand name	Possible values	Description
clustersummary	- enable|disable	Toggle cluster summary statistics. See Collecting database summary diagnostics.
cqlslowlog	- <threshold>	Set the CQL slow log threshold. See Collecting slow queries.
cqlslowlog	- enable|disable	Toggle the CQL slow log.
cqlsysteminfo	- enable|disable	Toggle CQL system information statistics. See Collecting system level diagnostics.
dbsummary	- enable|disable	Toggle database summary statistics. See Collecting database summary diagnostics.
histograms	- enable|disable	Toggle table histograms. See Collecting table histogram diagnostics.
resourcelatencytracking	- enable|disable	Toggle resource latency tracking. See Collecting system level diagnostics.
userlatencytracking	- enable|disable	Toggle user latency tracking. See Collecting user activity diagnostics.

Using dsetool with Kerberos

To use dsetool with Kerberos, use one of these methods:

- **Using the `~/.dserc` file**

  Create or edit the `~/.dserc` file in your DataStax Enterprise home directory and add the following entries:

  ```
  sasl_protocol=service_name
  login_config=path_to_login_config
  ```

- **Command line options**

Specify the service name and JAAS configuration file on the command line:

```
-Ddse.sasl.protocol=service_name
-Djava.security.auth.login.config=path_to_login_config
```

where:

- *service_name* is the service name component of the service_principal that is defined in the `dse.yaml` file
- *path_to_login_config* is the JAAS configuration file with the following options declared in it:

```
DseClient {
                com.sun.security.auth.module.Krb5LoginModule required
                useTicketCache=true
                renewTGT=true;
        };
```

The cfs-stress tool

The cfs-stress tool performs stress testing of the Cassandra File System (CFS) layer.

About this task

Usage:

```
$ cfs-stress [options] cfs_directory
```

where *cfs_directory* sets where to store test files.

Note: The tool uses the listen_address property in the cassandra.yaml file. If not using localhost, add the correct IP as an additional argument:

```
$ stress-cfs [options] cfs_directory listen_address
```

The location of the cassandra.yaml file depends on the type of installation:

Package installations	`/etc/cassandra/cassandra.yaml`
Tarball installations	`install_location/resources/cassandra/conf/cassandra.yaml`

Table 64: Options

Short form	Long form	Description
`-d`	`--data-generator` *`class`*	Data generator to create files. Available generators: RandomDataGenerator, TextDataGenerator, ZeroDataGenerator. The RandomDataGenerator is a fast pseudo-random data generator that delivers about 1.5 GB of data per second on a single core of Core i7 @ 2.4 GHz.
`-h`	`-help`	Display help.
`-n`	`--count` *`number`*	Total number of files read/written. Default: 100.
`-o`	`--operation R|W|WR|WRD`	Operation: *R* read, *W* write, *WR* write and read, *WRD* write and read and delete. Default: *W*

Short form	Long form	Description
`--r`	`--streams` *`number`*	Maximum number of streams kept open per thread. Default 2.
`-s`	`--size` *`number`*	Size of each file in KB. Default 1024.
	`--shared-cfs`	Causes all threads to share the same CFS object.
`-t`	`--threads` *`number`*	Number of threads. Default 8.

The cfs-stress tool is located in the `tools` directory.

The default location of the `tools` directory depends on the type of installation:

Installer-Services and Package installations	`/usr/share/dse/tools`
Installer-No Services and Tarball installations	*`install_location`*`/dse/tools`

Example

From the `tools` directory:

```
$ ./cfs-stress cfs_directory
```

The output looks like:

```
 Writing 104 MB to cfs://localhost:9160/user/pt/cfs_directory in 100 files.
 progress       bytes     curr rate       avg rate    max latency
    0.0%       0.0 MB      0.0 MB/s       0.0 MB/s         ------
    0.0%       0.0 MB      0.0 MB/s       0.0 MB/s         ------
    0.0%       0.0 MB      0.0 MB/s       0.0 MB/s         ------
    0.0%       0.0 MB      0.0 MB/s       0.0 MB/s         ------
    0.0%       0.0 MB      0.0 MB/s       0.0 MB/s         ------
   32.0%      33.6 MB      2.6 MB/s       5.5 MB/s     129.554 ms
   80.0%      83.9 MB     31.4 MB/s      11.7 MB/s      10.303 ms
   82.0%      86.0 MB     48.5 MB/s      10.5 MB/s         ------
  100.0%     104.9 MB     14.5 MB/s      12.4 MB/s       0.012 ms
```

Data	Description
progress	Total progress of the stress operation.
bytes	Total bytes written/read.
curr rate	Current rate of bytes being written/read per second.
avg rate	Average rate of bytes being written/read per second.
max latency	Maximum latency in milliseconds during the current reporting window.

Pre-flight check and yaml_diff tools

The pre-flight check tool is available for packaged installations. This collection of tests can be run on a node to detect and fix a configuration. The yaml_diff tool filters differences between cassandra.yaml files.

About this task

The pre-flight check tool, located in `/usr/share/dse/tools` of packaged installations, is a collection of tests that can be run on a node to detect and fix a configuration. The tool can detect and fix many invalid or suboptimal configuration settings. The tool is not available in tarball installations.

The yaml_diff tool in the tools directory filters differences between two cassandra.yaml files, which is useful during upgrades.

The location of the cassandra.yaml file depends on the type of installation:

Package installations	`/etc/cassandra/cassandra.yaml`
Tarball installations	`*install_location*/resources/cassandra/conf/cassandra.yaml`

Using the Cassandra bulk loader in a secure environment

The Cassandra bulk loader is the sstableloader tool.

About this task

The Cassandra bulk loader is the sstableloader tool. The command-line options for configuring secure sstableloader operations using Kerberos have changed slightly. If you run sstableloader from a DataStax Enterprise node that has been configured for Kerberos or client-to-node/node-to-node encryption using SSL, no additional configuration is needed for securing sstableloader operations. The sstableloader tool will pick up all required options from the configured node automatically, so no further configuration is needed. On an unconfigured developer machine, however, configure Kerberos or SSL as follows:

Kerberos

If you have not configured Kerberos on a DataStax Enterprise node, but you want to run sstableloader in a secure Kerberos environment, set the options on the command line as follows:

- To use credentials from default ticket cache, no extra options are necessary. sstableloader will do the right thing.
- To set the keytab location through system properties, use this example as a guide to setting the options:

```
JVM_OPTS="-Dkerberos.use.keytab=true \
    -Dkerberos.keytab=/home/dse/cassandra.keytab \
    -Dkerberos.client.principal=cassandra@LOCAL.DEV" \
    resources/cassandra/bin/sstableloader -d 192.168.56.102 /var/lib/
cassandra/data/Keyspace1/Standard1
```

- To set Kerberos options using the JAAS config, use this example as a guide to setting the options:

```
JVM_OPTS="-Dkerberos.use.config.file=true \
    -Djava.security.auth.login.config=/home/dse/keytab-basic-jaas.conf" \
    resources/cassandra/bin/sstableloader -d 192.168.56.102 /var/lib/
cassandra/data/Keyspace1/Standard1
```

- In the JAAS config, `/home/dse/keytab-basic-jaas.conf`, set these options:

  ```
  Client {
    com.sun.security.auth.module.Krb5LoginModule required
      useKeyTab=true
      keyTab="/home/dse/cassandra.keytab"
      principal="cassandra@LOCAL.DEV";
  };
  ```

Client- and node-to-node encryption using SSL

If you have not configured SSL on a DataStax Enterprise node, but you want to run sstableloader in a secure SSL environment, you can use the sstableloader script from Apache Cassandra to load SSTables into a cluster with client-to-node/node-to-node SSL encryption enabled. Use the following basic options:

```
resources/cassandra/bin/sstableloader -d 192.168.56.102 /var/lib/cassandra/
data/Keyspace1/Standard1 \
  -tf org.apache.cassandra.thrift.SSLTransportFactory \
  -ts /path/to/truststore \
  -tspw truststore_password
```

If you want to configure require_client_auth=true on the target, set these additional options:

```
resources/cassandra/bin/sstableloader -d 192.168.56.102 /var/lib/cassandra/
data/Keyspace1/Standard1 \
  -tf org.apache.cassandra.thrift.SSLTransportFactory \
  -ts /path/to/truststore \
  -tspw truststore_password \
  -ks /path/to/keystore \
  -kspw keystore_password
```

Troubleshooting

Use these troubleshooting examples to discover and resolve problems with DSE.

The following common problems, solutions, or workarounds have been reported about using DataStax Enterprise. Be sure to also check the Cassandra troubleshooting documentation.

Mahout Jobs that Use Lucene Not Supported

DataStax does not currently support Mahout jobs, such as built-in support for creating vectors from Lucene indexes, that use Lucene features. Attempting to run Mahout jobs that use Lucene features results in this type of error message:

```
Error: class org.apache.mahout.vectorizer.
DefaultAnalyzer overrides final method
tokenStream.
```

MX4J warning message during installation

When Cassandra loads, you may notice a message that MX4J will not load and that mx4j-tools.jar is not in the classpath.

You can ignore this message. MX4j provides an HTML and HTTP interface to JMX and is not necessary to run Cassandra. DataStax recommends using OpsCenter. It has more monitoring capabilities than MX4J.

DSE Search cannot find custom files

Solr supports relative paths that are set by the <lib> property in the `solrconfig.xml`, but DSE Search does not. Configuring the Solr library path describes a workaround for this issue.

Subprocesses not killed when DataStax Enterprise is shut down improperly

Attention: To prevent this problem, avoid using `kill 9` and shut down DataStax Enterprise as described in Stopping a node.

If DataStax Enterprise is shut down with `kill -9`, you must reboot the node or manually kill any remaining sub-processes:

- **Installer-Services and Package installations:**

  For example, if DataStax Enterprise was started using `sudo services dse start` or `sudo /etc/init.d/dse start` and the main process was killed using `$ kill -9 `cat /var/run/dse/dse.pid``:

  1. To view the subprocesses left behind (all DSE processes run under user "cassandra"):

     ```
     $ pgrep -c -ucassandra >/dev/null && ps -o pid,ppid,user,args `pgrep -
     ucassandra`
     ```
  2. To shut down the subprocesses:

     ```
     $ sudo pkill -ucassandra
     ```
- **Installer-No Services and Tarball installations:**

  For example, if DataStax Enterprise 4.7 was started using `sudo dse cassandra -k -t` and the main process was killed using `$ sudo kill -9 `cat /var/run/dse/dse.pid`` or `$ sudo pkill -9 -f jmxremote.port=7199`:

  1. To view the subprocesses left behind:

```
$ pgrep -c -f dse-4.7 >/dev/null && ps -o pid,ppid,user,args `pgrep -
f dse-4.7
```

All DSE processes run under user `cassandra`.

2. To shut down the subprocesses:

```
$ sudo pkill -f dse-4.7
```

Note: The `kill` command (SIGTERM) shuts down the subprocesses.

DataStax Enterprise 4.7 release notes

DataStax Enterprise release notes cover components, changes and enhancements, resolved issues, and issues for DataStax Enterprise 4.7.x releases.

Included in this document are release notes for:

- DataStax Enterprise 4.7.1
- DataStax Enterprise 4.7

4.7.1 Release notes for DataStax Enterprise

9 July 2015

4.7.1 Components

- Apache Cassandra 2.1.8.621
- Apache Solr 4.10.3.0.8
- Apache Spark 1.2.2.1
- Apache Tomcat 6.0.44
- Hive Cassandra Connector 0.1.17.1
- Spark Cassandra Connector 1.2.3
- Shark 1.2.1

4.7.1 Changes and enhancements

DataStax Enterprise 4.7.1 introduces the following changes:

- For all releases and all docs: awesome doc search with relevant, release-specific results. For example, using the Google site search in DataStax Enterprise 4.7 online documents provides search results that include only DSE 4.7, Cassandra 2.1, & CQL for Cassandra 2.x.
- Realtime Lucene search version 2 provides improved performance for live indexing. (DSP-4302)
    - Applying deletes is parallelized to improve reader open times.
    - The default autoSoftCommit maxTime is 1000ms when live indexing is enabled.
    - Improved performance for live indexing range queries.
- Python supports loading cassandraTables from a Spark streaming context and saving a DStream to Cassandra. (DSP-4685)
- Do not store spatial types in Lucene index by default. (DSP-4694)
- Add Kafka Spark Streaming demo in `./dse/demos`. (DSP-4804)
- Extend request handling and processing to support custom searchers. (DSP-5075)
- Support CQL partition key restrictions together with Solr queries. (DSP-5123)
- Change the default max_solr_concurrency_per_core to the number of available CPU cores. (DSP-5239)
- Securely pass nodetool, dsetool, and other passwords when -u is passed. (DSP-5308)
- New dsetool command to automatically generate schema at stdout. (DSP-5373)
- Support dynamic fields/maps with FieldInputTransformer. (DSP-5428)
- Support CQL LIMIT when Solr deep paging is active. (DSP-5657)
- CompositeKeyField, unique key, is now a text field DocValue. (DSP-5756)
- Include cassandra-stress example .yaml files in package installs. (DSP-5770)
- DSE Search node bootstrapping is more efficient. (DSP-5948)

4.7.1 Resolved issues

- Improvements of vnodes in Solr. (DSP-3759)
- Compaction of files stored on the cfs-archive layer is not disabled, and files are compacted automatically. (DSP-4081)
- Disable SSLv3 in the TomcatSolrRunner. (DSP-5070)
- CQL Solr queries do not error out when additional WHERE clauses are present. (DSP-5109)
- Hive queries fail with Thrift size error. (DSP-5247)
- Leader manager notifies its listeners even when no change happened. (DSP-5422)
- CSV copy command doesn't work inside cqlsh command file. (DSP-5469)
- Incorrect Shark/Hive warning messages about RF when using NetworkTopologyStrategy. (DSP-5498)
- dsetool get_core_schema: requires appropriate host to be set. (DSP-5516)
- Logback logging broken in some places. (DSP-5577)
- Change consistency level from QUORUM to LOCAL_QUORUM for CassandraStorageEngine. (DSP-5606)
- DSE hangs on restart with empty XML config files after unclean shutdown. (DSP-5645)
- Enabling userlatencytracking from dsetool causes NPE. (DSP-5654)
- Autogenerated cores allow invalid map types. Validation refactoring. (DSP-5655)
- byoh-env.sh problem locating dsetool. (DSP-5664)
- Spark Worker's web_ui port is not consistent with documentation. (DSP-5665)
- JDBC issue with Spark SQL thriftserver. (DSP-5686)
- Demos: Test for dse in path not correct. (DSP-5671)
- Bootstrapping TDE nodes try to read from themselves. (DSP-5701)
- ODBC issue with Spark SQL thriftserver. (DSP-5730)
- Query from SparkSQL fails when using user defined frozen type in Cassandra. (DSP-5800)
- Running sstable2json if Solr enabled results in NPE. (DSP-5893)
- Solr CQL index may handle RangeTombstones incorrectly. (DSP-5940)
- Spark jobs hang during compaction. (DSP-5984)
- HIVE - INNER JOIN, replacing nulls with other rows data. (DSP-5994)
- Netty client starvation with more nodes than the configured max connections. (DSP-6061)

Release notes for DataStax Enterprise 4.7

18 May 2015

4.7 Components

- Apache Cassandra 2.1.5.469 with production-certified Cassandra fixes
- Apache Hadoop 1.0.4.15
- Apache Hive 0.12.0.7
- Apache Mahout 0.8
- Apache Pig 0.10.1
- Apache Shark 1.1.1
- Apache Solr 4.10.3.0.6
- Apache Spark 1.2.1.2
- Apache Sqoop 1.4.5.15.1
- Apache Thrift 0.9.1
- Apache Tomcat 6.0.39
- Faster XML 2.1.2
- Guava 16.0.1
- HdrHistogram 1.2.1.1
- Java Driver for Apache Cassandra 2.1.5

- JBCrypt 0.3m
- Netty 4.0.13.Final
- Py4J 0.8.1
- SLF4J 1.7.2
- Spark Cassandra Connector 1.2.1
- Snappy 1.0.5.2

4.7 Changes and enhancements

DataStax Enterprise 4.7 introduces the following changes in addition to the new major features.

- For all releases and all docs: awesome doc search with relevant, release-specific results. For example, using the Google site search in DataStax Enterprise 4.7 online documents provides search results that include only DSE 4.7, Cassandra 2.1, & CQL for Cassandra 2.x.
-
- Support for Oracle Java SE Runtime Environment (JRE) 8 and OpenJDK 7. (DSP-3338 and DSP-2619)
- Support off-server encryption key management. (DSP-1758)
- Generalize leader (JobTracker, Spark Master) management and automatic high availability for Spark analytics. (DSP-2760)
- Save any RDD to Cassandra with automatic table creation. (DSP-3310)
- DSE In-Memory improvements expand the amount of data that can be maintained in memory and allow faster read operations on larger volumes of transactional data. (DSP-3341)
- Support for bulk loading data from Spark RDD to Cassandra. (DSP-3378)
- Support for live indexing increases indexing throughput and reduces Lucene index reader latency. (DSP-3740)
- Additions of Spark to CQL performance objects. (DSP-3751)
- Support for the token() syntax for Solr CQL queries. (DSP-3809)
- Switch from log4j to logback. (DSP-3858)
- Manage the location of Solr data. (DSP-3930)
- Implement global, configurable filter cache size. (DSP-3931)
- Improve shard routing by taking into account node health factors. (DSP-3958)
- Encrypt saved cache files when TDE is enabled. (DSP-4017)
- Implement fault-tolerant distributed queries. (DSP-4072)
- Internal queries are logged as system, not unknown. (DSP-4079)
- Integrate Spark SQL with Thrift JDBC server. (DSP-4203)
- Java Native Access (JNA) is upgraded to 4.0. (DSP-4600)
- Support for Solr stored copy fields has been removed. Data for existing stored copy fields in the database will still be returned. (DSP-4091)
- Improved error handling for core create and core reload failures. (DSP-4110)
- Added SSL security to Spark. (DSP-4170)
- Support for Spark MLlib. (DSP-4238)
- Production certification of Spark 1.2. (DSP-4311)
- Merge lucene-solr 4.10.2. (DSP-4473)
- Support for single-pass distributed queries in CQL Solr queries. (DSP-4475)
- Support for Solr cursors (pagination). (DSP-4476)

  Note: DataStax Enterprise 4.7 integrates native driver paging with Solr cursor-based paging. To retain the same behavior for your queries in 4.7 as in 4.6, ensure that your driver has protocol-level paging disabled for CQL-based Solr queries.
- Implement distributed pivot faceting with HTTP and CQL Solr queries. (DSP-4477)
- Implement sparse offheap filter. (DSP-4518)
- Allow for more than one worker per node. (DSP-4558)
- Production certification of Solr 4.10.

- Upgrade to lucene-solr 4.10.3. (DSP-4582)
- Hive connector supports schema generation for decimal types. (DSP-4664)
- Implement MemoryOnlyStrategy using mmap and mlock. (DSP-4650)
- Support for conditional log coloring. (DSP-4677)
- Allow custom filter cache implementations. (DSP-4686)
- Spark plus Search integration with workload on a single SearchAnalytics node. Limitations apply. (DSP-4703)
- Core resource options file for resource generation are read by dsetool on the client side. (DSP-4766)
- In Cassandra 2.1, the cqlsh utility uses the native protocol. With the DataStax python driver, the default cqlsh listen port is 9042. (DSP-4886)
- Add kmip management functions to dsetool. (DSP-4959)
- Add dsetool autojt command to enable switching to automatic leaders. (DSP-4965)
- Make updates replayed by the Solr commit log on startup immediately searchable. (DSP-5095)
- Allow passing JMX username and password to dsetool and dse commands. (DSP-5217)

4.7 Resolved issues

Resolved issues from DataStax Enterprise 4.6.7 and earlier are included.

- JMX defaults to binding only localhost to mitigate "CVE-2015-0225: Apache Cassandra remote execution of arbitrary code."

  After you upgrade to DataStax Enterprise 4.7, get the latest default values from `cassandra-env.sh` and ensure that your local `cassandra-env.sh` file has the latest default values. If you require remote access of JMX, you can safely enable remote JMX access by turning on JMX security. The latest default values from `cassandra-env.sh` are:

  ```
  LOCAL_JMX=yes
  if [ "$LOCAL_JMX" = "yes" ]; then
      JVM_OPTS="$JVM_OPTS -Dcassandra.jmx.local.port=$JMX_PORT -XX:
  +DisableExplicitGC"
  else
      JVM_OPTS="$JVM_OPTS -Dcom.sun.management.jmxremote.port=$JMX_PORT"
      JVM_OPTS="$JVM_OPTS -Dcom.sun.management.jmxremote.rmi.port=$JMX_PORT"

      JVM_OPTS="$JVM_OPTS -Dcom.sun.management.jmxremote.ssl=false"
      JVM_OPTS="$JVM_OPTS -Dcom.sun.management.jmxremote.authenticate=true"

      JVM_OPTS="$JVM_OPTS -Dcom.sun.management.jmxremote.password.file=/etc/
  cassandra/jmxremote.password"
  fi
  JVM_OPTS="$JVM_OPTS$JVM_EXTRA_OPTS"
  ```
- Analytics jobs use the broadcast address to connect to nodes even when ec2snitch or another snitch that supports public vs private is used. (DSP-3694)
- Improve error handling in case of core creation failures. (DSP-4110)
- Speed up dsetool. (DSP-4396)
- Integrate Spark SQL command line. (DSP-4399)
- Transitional authenticators do not work with the native protocol. (DSP-4620)
- Upgrade PySpark support to Spark 1.2 (DSP-4660)
- The Cassandra context is removed. Use the Spark context instead. (DSP-4672)
- Delete by query failing on mixed workload clusters. (DSP-4675)
- LDAP authenticator allows empty password to be authenticated. (DSP-4687)
- Race condition while loading secondary indexes upon upgrade. (DSP-4689)
- CompoundFileDirectory exceptions. (DSP-4848)
- DseDaemon throw NPE in safeStop if failure occurs in startup. (DSP-4865)

- Fix Solr document expiration when row has already been physically deleted from Cassandra. (DSP-4869)
- NPE when using Solr data import handler. (DSP-4888)
- Upgrade to Java driver 2.1.5. (DSP-4947)
- Plugin/stats not showing in the Solr Admin UI. (DSP-5007)
- Installed JNA is no longer used. (DSP-5033)
- Creating solr_query column before using dsetool causes solr queries in CQL to fail. (DSP-5105)
- Can't run describe keyspace in cqlsh on Solr core. (DSP-5117)
- Block incremental repair operations on remote anti-compaction. (DSP-5331)
- Removed CQLStorage handler, migrate the tables to CqlNativeStorage format that uses Cql Record Reader. (DSP-5538)

4.7 Issues

- Dynamic fields of the Solr type LatLongTypeSolr are not supported. (DSP-5002)
- Creating indexes with DEFERRED REBUILD is not supported in Spark SQL; a new column defaults to empty instead of none. (DSP-4713)
- Solr_query fails in mixed upgrade state because of Solr pagination. (DSP-5334)

  On a cluster with mixed versions of DSE, for example 4.6 and 4.7, where only the 4.7 version supports pagination, issuing queries from the 4.7 nodes returns only FetchSize results because 'FetchSize' is the driver iused when executing the query. To workaround this limitation, disable driver pagination so that Solr pagination is also disabled for the queries on 4.7 nodes.
- When starting DSE in Hadoop mode, an exception might occur that is related to the Task Tracker initially being unable to connect to the JobTracker. Automatic and immediate retry successfully connects and and does not impact Hadoop performance. (DSP-5621)

4.7 Cassandra fixes

Production-certified Cassandra fixes are included in DataStax Enterprise 4.7.

Cassandra changes

DataStax Enterprise 4.7 includes production-certified Cassandra changes.

- Cassandra changes in DataStax Enterprise 4.7

DataStax Enterprise 4.7

DataStax Enterprise 4.7 includes these production-certified Cassandra changes.

- Warn on misuse of unlogged batches (CASSANDRA-9282)
- Failure detector detects and ignores local pauses (CASSANDRA-9183)
- Add utility class to support for rate limiting a given log statement (CASSANDRA-9029)
- Add missing consistency levels to cassandra-stess (CASSANDRA-9361)
- Fix commitlog getCompletedTasks to not increment (CASSANDRA-9339)
- Fix for harmless exceptions logged as ERROR (CASSANDRA-8564)
- Delete processed sstables in sstablesplit/sstableupgrade (CASSANDRA-8606)
- Improve sstable exclusion from partition tombstones (CASSANDRA-9298)
- Validate the indexed column rather than the cell's contents for 2i (CASSANDRA-9057)
- Add support for top-k custom 2i queries (CASSANDRA-8717)
- Fix error when dropping table during compaction (CASSANDRA-9251)
- cassandra-stress supports validation operations over user profiles (CASSANDRA-8773)
- Add support for rate limiting log messages (CASSANDRA-9029)

- Log the partition key with tombstone warnings (CASSANDRA-8561)
- Reduce runWithCompactionsDisabled poll interval to 1ms (CASSANDRA-9271)
- Fix PITR commitlog replay (CASSANDRA-9195)
- GCInspector logs very different times (CASSANDRA-9124)
- Fix deleting from an empty list (CASSANDRA-9198)
- Update tuple and collection types that use a user-defined type when that UDT is modified (CASSANDRA-9148, CASSANDRA-9192)
- Use higher timeout for prepair and snapshot in repair (CASSANDRA-9261)
- Fix anticompaction blocking ANTI_ENTROPY stage (CASSANDRA-9151)
- Repair waits for anticompaction to finish (CASSANDRA-9097)
- Fix streaming not holding ref when stream error (CASSANDRA-9295)
- Fix canonical view returning early opened SSTables (CASSANDRA-9396)
- (cqlsh) Add LOGIN command to switch users (CASSANDRA-7212)
- Clone SliceQueryFilter in AbstractReadCommand implementations (CASSANDRA-8940)
- Push correct protocol notification for DROP INDEX (CASSANDRA-9310)
- token-generator - generated tokens too long (CASSANDRA-9300)
- Fix counting of tombstones for TombstoneOverwhelmingException (CASSANDRA-9299)
- Fix ReconnectableSnitch reconnecting to peers during upgrade (CASSANDRA-6702)
- Include keyspace and table name in error log for collections over the size limit (CASSANDRA-9286)
- Avoid potential overlap in LCS with single-partition sstables (CASSANDRA-9322)
- Log warning message when a table is queried before the schema has fully propagated (CASSANDRA-9136)
- Overload SecondaryIndex#indexes to accept the column definition (CASSANDRA-9314)
- (cqlsh) Add SERIAL and LOCAL_SERIAL consistency levels (CASSANDRA-8051)
- Fix index selection during rebuild with certain table layouts (CASSANDRA-9281)
- Fix partition-level-delete-only workload accounting (CASSANDRA-9194)
- Allow scrub to handle corrupted compressed chunks (CASSANDRA-9140)
- Fix assertion error when resetlocalschema is run during repair (CASSANDRA-9249)
- Disable single sstable tombstone compactions for DTCS by default (CASSANDRA-9234)
- IncomingTcpConnection thread is not named (CASSANDRA-9262)
- Close incoming connections when MessagingService is stopped (CASSANDRA-9238)
- Fix streaming hang when retrying (CASSANDRA-9132)

Tips for using DataStax documentation

DataStax documentation navigation tips.

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|↔|	Hide or display the left navigation.
«»	Go back or forward through the topics as listed in the table of contents.
✎	Toggle highlighting of search terms.
🖨	Print page.
🐦	See doc tweets and provide feedback.
⋮	Grab to adjust the size of the navigation pane.
¶	Appears on headings for bookmarking. Right-click the ¶ to get the link.
⊕	Toggles the legend for CQL statements and nodetool options.

Other resources

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- Documentation home page
- Datasheets
- Webinars
- Whitepapers
- Developer blogs
- Support