Chapter 25.

March 2019

Welcome to the March 2019 edition of DataStax Developer's Notebook (DDN). This month we answer the following question(s);

> My company was using application server tiered security, and now needs to implement database tier level security. Can you help ?
>
> *Excellent question ! Obviously security is a broad topic; OS level security (the OS hosting DSE), database level security, data in flight, data at rest, and more.*
>
> *Minimally we'll overview DSE security, and detail how to implement password protection of same.*

Software versions

The primary DataStax software component used in this edition of DDN is DataStax Enterprise (DSE), currently release 6.7. All of the steps outlined below can be run on one laptop with 16 GB of RAM, or if you prefer, run these steps on Amazon Web Services (AWS), Microsoft Azure, or similar, to allow yourself a bit more resource.

For isolation and (simplicity), we develop and test all systems inside virtual machines using a hypervisor (Oracle Virtual Box, VMWare Fusion version 8.5, or similar). The guest operating system we use is Ubuntu Desktop version 18.04, 64 bit.

25.1 Terms and core concepts

As stated above, ultimately the end goal is to secure the database server. Topics include:

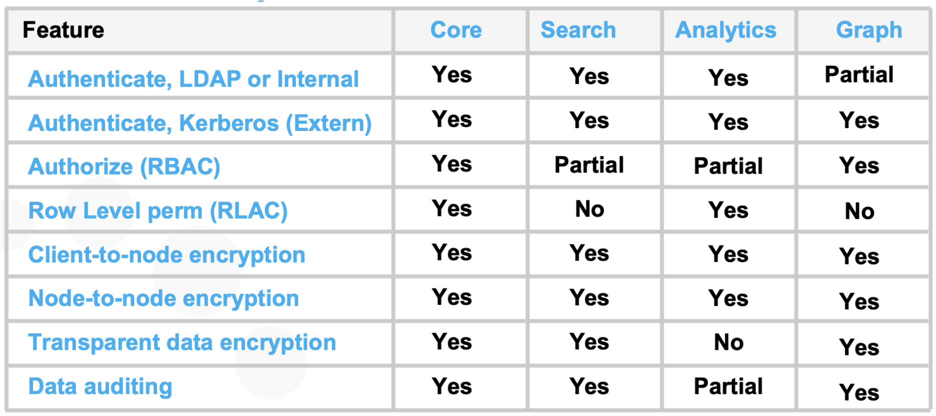
- Securing the operating system (pre DSE)
- Securing DSE-
  - Database connections, end user
  - Data in flight (encryption on the line)
  - Data at rest (encryption at the disk level)
  - Securing files; configuration and temporary files
  - Auditing (was I breached, when, how)
  - (Other)

Based on whatever source you reference, an average cost for a breach of 1,000 records generally cost between $52,000 and $87,000 US; source Verizon, year 2015.

Minimally, this document details how to implement DSE server level authentication and authorization:

- Authentication, Are you who you say you are
- Authorization, and now that I know who you are, what are you allowed to do

Figure 25-1overviews given security capabilities for given functional areas within DSE. A code review follows.



Feature	Core	Search	Analytics	Graph
Authenticate, LDAP or Internal	Yes	Yes	Yes	Partial
Authenticate, Kerberos (Extern)	Yes	Yes	Yes	Yes
Authorize (RBAC)	Yes	Partial	Partial	Yes
Row Level perm (RLAC)	Yes	No	Yes	No
Client-to-node encryption	Yes	Yes	Yes	Yes
Node-to-node encryption	Yes	Yes	Yes	Yes
Transparent data encryption	Yes	Yes	No	Yes
Data auditing	Yes	Yes	Partial	Yes

Figure 25-1 Overview of security in DSE 6.0, check for updates-

Relative to Figure 25-1, the following is offered:

- This chart was produced from the DSE version 6.0 documentation. Obviously there is now release 6.7 of DSE, and even point releases to 6.7. So, check the documentation for your specific release.
- To overcome any (security short comings) in version 6.0, you could of course, limit available data (a subset of data) to a given data center, other.

  Or, you could implement, for example, data encryption at the operating system level for Apache Spark, other.

DSE Security: Authentication

DataStax Enterprise (DSE) inter-nodal communication (gossip, other) authentication is achieved using SSL certificates, which we will say is beyond scope for this document.

Database connections (client to node, tools and applications), is afforded via DSE "unified authentication", which means;

- Internal to DSE authentication, we detail delivering this below-
- Kerberos
  - PKI, public key infrastructure
  - KMIP, key management interoperability protocol

While this document details how to enable the DSE internal authentication, we list a number of Urls on the internal (and external) authentication subsystem configurations-

– DSE inter-nodal traffic is authenticated using SSL, and the communication can be encrypted.

  Reference Url, Securing internal transactional node connections

  `https://docs.datastax.com/en/dse/6.0/dse-admin/datastax_enterprise/security/secInternodeSsl.html`

– Setting up Kerberos

  Reference Url,

  `https://docs.datastax.com/en/dse/6.0/dse-admin/datastax_enterprise/security/secKerberosTOC.html`

– Setting up LDAP (LDAP v3 compatible servers)

  Reference Url,

  `https://docs.datastax.com/en/dse/6.0/dse-admin/datastax_enterprise/security/secLDAPScheme.html`

  Microsoft Active Directory: Windows 2008, Windows 2012, OpenLDAP 2.4.x, Oracle Directory Server Enterprise Edition 11.1.1.7.0

– JConsole, as a client, has special requirements

  Reference Url, Setting up SSL for jconsole (JMX)

  `https://docs.datastax.com/en/dse/6.0/dse-admin/datastax_enterprise/security/secureJconsoleSSL.html`

– Client to server communication can be encrypted.

  Reference Url, Securing client to cluster connections

  `https://docs.datastax.com/en/dse/6.0/dse-admin/datastax_enterprise/security/encryptClientNodeSSL.html`

– Specific to DSE Search

  DSE Search (Apache Solr) Solr Admin UI is pre-integrated with Kerberos.

  DataStax recommends using Kerberos authentication with the Solr Admin UI and when running commands with cURL using the SolrJ API.

  To authenticate DSE Search clients with Kerberos authentication, use Simple and Protected GSSAPI Negotiation Mechanism (SPNEGO).

  To use the SolrJ API against DSE Search clusters with Kerberos authentication, client applications must use the SolrJ-Auth library and the DataStax Enterprise SolrJ component as described in the solrj-auth-README.md file.

  Define Accessing search indexes from Solr Admin UI (deprecated). (Perform index management tasks with the CQL shell using Enabling DSE Unified Authentication.)

- Specific to DSE Analytics

  DataStax recommends the following security practices:

  - Enable client-to-node encryption using SSL.
  - Spark ports for internode communications should run within a secured network without exposure to outside traffic.
  - Distinct secrets for internode and per application, see Configuring Spark nodes.
  - Native authentication for users of each application executor (run as) and isolation of related data, see Configuring Spark nodes.
  - Spark UI internal or LDAP authentication, see Monitoring Spark with the web interface.
  - User authentication for Spark jobs. DataStax Enterprise supports internal, LDAP, and Kerberos authentication for Spark.

  Internal and LDAP: For DataStax Enterprise Spark applications and tools, use the Spark authentication commands to provide the authentication credentials, see Running spark-submit job with internal authentication.

  Kerberos: Defining a Kerberos scheme applies to connecting Spark to DSE database, not authenticating Spark components between each other. The Spark Web UI is not secured, so some parameters passed to the executor in the command line might be visible. However, the DSE username, password, and delegation token are hidden. By default, when Kerberos is the only authentication scheme, the Spark UI is inaccessible, so UI authorization must be disabled.

- Specific to DSE Graph

  DataStax Enterprise supports secure enterprise graph-database operations. DSE Graph data is completely or partially secured by using DataStax Enterprise security features:

  Allow only authenticated users to access DSE Graph data by enabling DSE Unified Authentication on the transactional database and configure credentials in the DSE Graph remote.yaml.

DSE Security: Authorization

Role based access control (RBAC) is available using DSe, when authentication is enabled.

Using the internal authentication, there is a 1 to 1 mapping of user name to roles. Using LDAP, there is a one to many mapping, user assigned roles that match groups in LDAP.

More on authorization:

– Specific to DSE Search

  Reference Urls, Managing search index permissions

  ```
  https://docs.datastax.com/en/dse/6.0/dse-admin/datastax_enterp
  rise/security/secSearchIndexPermissions.html
  ```

  Setting row-level permissions with row-level access control (RLAC) is not supported for use with DSE Search or DSE Graph.

– Specific to DSE Analytics

  Data pulled from the database for Spark jobs and access control for Spark application submissions is protected by role-based access control (RBAC). The user running the request must have permission to access the data through their role assignment.

  No authorization for the Spark UI master and workers is available.

– Specific to DSE Graph

  Reference Urls, Managing access to DSE Graph keyspaces

  ```
  https://docs.datastax.com/en/dse/6.0/dse-admin/datastax_enterp
  rise/security/secRbacGraph.html
  ```

  Limit access to graph data by defining roles for DSE Graph keyspaces and tables, see Managing access to DSE Graph keyspaces.

  RBAC does not apply to cached data. Setting row-level permissions with row-level access control (RLAC) is not supported for use with DSE Search or DSE Graph.

  Grant execute permissions for the DseGraphRpc object to the defined roles.

– Graph Sandbox-

  Enabled by default, the Graph sandbox can be configured to allow or disallow execution of Java packages, super-classes, and types, see,

  ```
  https://docs.datastax.com/en/dse/6.0/dse-admin/datastax_enterp
  rise/graph/config/configGraphSandbox.html
  ```

DSE: Encryption of data in flight

SSL encryption of data in flight is available for the following DSE functional areas:

– DSE transactional nodes

– DSE Search (Apache Solr)

– DSE Analytics (Apache Spark)

– DSE Graph

– DSE tools

- DSE drivers
- DSE OpsCenter

More:

- Reference Urls,

  `https://docs.datastax.com/en/dse/6.0/dse-admin/datastax_enterprise/security/secSslTOC.html`
- Using CQL shell (cqlsh) with SSL,

  `https://docs.datastax.com/en/dse/6.0/dse-admin/datastax_enterprise/security/usingCqlshSslAndKerberos.html`
- Setting up SSL for nodetool, dsetool, and dse advrep

  `https://docs.datastax.com/en/dse/6.0/dse-admin/datastax_enterprise/security/secureToolSSL.html`
- Setting up SSL for jconsole (JMX)

  `https://docs.datastax.com/en/dse/6.0/dse-admin/datastax_enterprise/security/secureJconsoleSSL.html`
- Connecting sstableloader to a secured cluster

  `https://docs.datastax.com/en/dse/6.0/dse-admin/datastax_enterprise/security/secSstableloaderSsl.html`
- Other loaders, other-

  See documentation specific to each

DSE: Encryption at rest

Relative to DataStax Enterprise (DSE) "transparent data encryption" (TDE), the following is offered:

You can encrypt,

- Entire tables (except for partition keys which are always stored in plain text).
- SSTables containing data, including system tables (such as system.batchlog and system.paxos)
- Search indexes
- File-based Hints (in DSE 5.0 and later)
- Commit logs
- Sensitive properties in dse.yaml and cassandra.yam

You may not encrypt using DSE,

- TDE only applies to data stored in the database. DSE does not support encrypting data that is used by Spark and stored in DSEFS or local temporary directories.
- Graph: Cached data is not encrypted. Encryption may slightly impact performance.

Reference Urls,

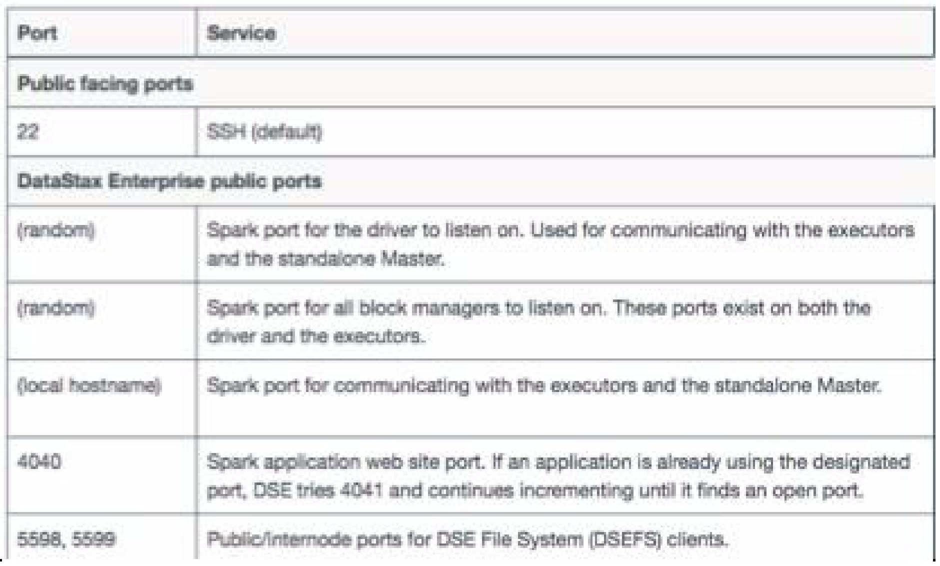
```
https://docs.datastax.com/en/dse/6.0/dse-admin/datastax_enterprise/s
ecurity/secEncryptTDE.html
```

Encrypting Search indexes,

```
https://docs.datastax.com/en/dse/6.0/dse-admin/datastax_enterprise/s
ecurity/secEncryptSearch.html
```

DSE: Securing ports, temporary directories (JNA)

Figure 25-2 displays the first of 30 or more ports in use by DSE. A code review follows.



Port	Service
Public facing ports	
22	SSH (default)
DataStax Enterprise public ports	
(random)	Spark port for the driver to listen on. Used for communicating with the executors and the standalone Master.
(random)	Spark port for all block managers to listen on. These ports exist on both the driver and the executors.
(local hostname)	Spark port for communicating with the executors and the standalone Master.
4040	Spark application web site port. If an application is already using the designated port, DSE tries 4041 and continues incrementing until it finds an open port.
5598, 5599	Public/internode ports for DSE File System (DSEFS) clients.

Figure 25-2 Ports needing security attention using DSE

Relative to Figure 25-2, the following is offered:

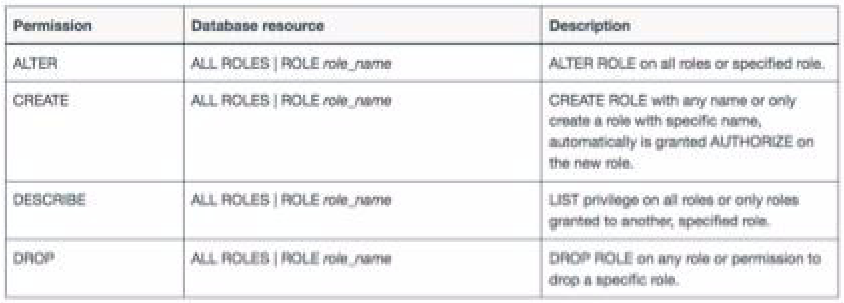
- The above is a screen capture of a documentation page available at, `https://docs.datastax.com/en/dse/6.0/dse-admin/datastax_enterprise/security/secFirewallPorts.html`

– Securing any temporary directories using JNA is documented at,

`https://docs.datastax.com/en/dse/6.0/dse-admin/datastax_enterprise/security/secTmp.html`

DSE: Role based access control (RBAC)

Role based access control (RBAC) using DSE is similar to the same feature in most RDBMS(s). Sample syntax as displayed in Figure 25-3. A code review follows.



Permission	Database resource	Description
ALTER	ALL ROLES | ROLE *role_name*	ALTER ROLE on all roles or specified role.
CREATE	ALL ROLES | ROLE *role_name*	CREATE ROLE with any name or only create a role with specific name, automatically is granted AUTHORIZE on the new role.
DESCRIBE	ALL ROLES | ROLE *role_name*	LIST privilege on all roles or only roles granted to another, specified role.
DROP	ALL ROLES | ROLE *role_name*	DROP ROLE on any role or permission to drop a specific role.

Figure 25-3 RBAC using DSE

Relative to Figure 25-3, the following is offered:

– The diagram above is captured from,

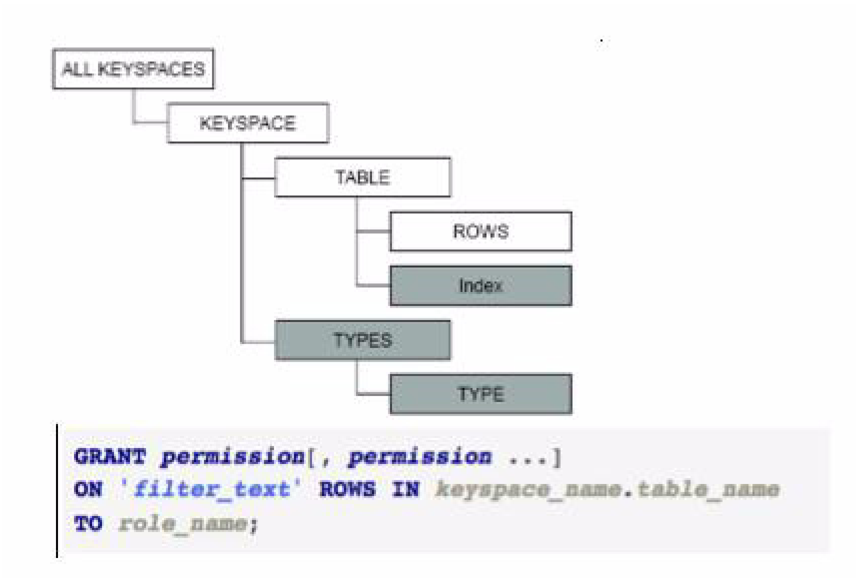
`https://docs.datastax.com/en/dse/6.0/dse-admin/datastax_enterprise/security/secRBAC.html`

– Additionally, to better serve multi-tenancy, DSE can suppress display of keyspace names-

- In the cassandra.yaml file, set system_keyspaces_filtering to true
- To view a keyspace, the user/role needs DESCRIBE permission on a keyspace.

DSE object hierarchy for permissions, RLAC

Figure 25-4 displays the object hierarchy for row level access control (RLAC). A code review follows.



```
GRANT permission[, permission ...]
ON 'filter_text' ROWS IN keyspace_name.table_name
TO role_name;
```

Figure 25-4 DSE object hierarchy

Relative to Figure 25-4, the following is offered:

– The diagram above was produced from information posted at,

  `https://docs.datastax.com/en/dse/6.0/dse-admin/datastax_enterprise/security/secDataResourcesAbout.html`

– RLAC is disabled by default. To enable, set allow_row_level_security to true in the dse.yaml file.

DSE audit secure subsystem

DataStax Enterprise (DSE) supports capturing database activity to a log file or table. the audit logger also captures queries and prepared statements submitted by DataStax drivers which use the CQL binary protocol.

Use cases include:

– Security logging, separation of duties

– Tuning, capacity planning

Reference Urls,

– `https://docs.datastax.com/en/dse/6.0/dse-admin/datastax_enterprise/security/secAuditTOC.html`

– Log formats

`https://docs.datastax.com/en/dse/6.0/dse-admin/datastax_enterprise/security/secAuditLogFormat.html`

– Viewing events

`https://docs.datastax.com/en/dse/6.0/dse-admin/datastax_enterprise/security/secAuditTableColumns.html`

25.2 Complete the following

In this section of this document, we enable and test DSE authentication and authorization using the internal DSE (password mechanism).

Comments:

– Instructions are provided for a single node DSE cluster, and all work as demonstrated as the root user. Generally though, the procedures are similar to multi-node, other.

– With a multi-node system, no downtime is required to make this change.

Note: Implementing authorization/authentication can be done without downtime.

Client programs are rolled out using the TRANSITIONAL client side driver switch. See,

`https://docs.datastax.com/en/dse/5.1/dse-admin/datastax_enterprise/security/Auth/secProductionEnvironment.html`

Server side, not server outage is achieved using a rolling restart.

– And instructions are provided for testing at the command prompt using CQLSH.

Note: In the real world, you should change the replication strategy and replication factor on a number of system keyspaces (specifically those that store password information).

See,

`https://docs.datastax.com/en/dse/5.1/dse-admin/datastax_enterprise/security/secSystemKeyspace.html`

Specifically we want to change; `system_auth` and `dse_security`

Note: Follow changes to replication strategy and replication factor with a “nodetool repair” similar to,

```
nodetool repair --full system_auth

nodetool repair --full dse_security
```

Create a keyspace for later use

Example 25-1 creates a keyspace, table and data for continued use in this section.

Example 25-1 Creating a keyspace

```
DROP KEYSPACE IF EXISTS ks_6221;

CREATE KEYSPACE ks_6221
   WITH REPLICATION =
   {'class': 'SimpleStrategy',
   'replication_factor': 1};

USE ks_6221;

DROP TABLE IF EXISTS cust_orders;

CREATE TABLE cust_orders
   (
   region            TEXT,
   cust_name         TEXT,
   ord_num           INT,
   other             TEXT,
   PRIMARY KEY ((region, cust_name),
      ord_num)
   );

INSERT INTO cust_orders
   (region, cust_name, ord_num, other)
VALUES ('EMEA', 'IKEA'  , 101, 'Shoes'        );
   ...
VALUES ('NA'  , 'SEARS' , 101, 'Shoes, Washer');
VALUES ('NA'  , 'SEARS' , 102, 'Oranges'      );
VALUES ('NA'  , 'MACYS' , 101, 'Dress, Tie'   );


DROP TABLE IF EXISTS cust_payments;

CREATE TABLE cust_payments
   (
   cust_name         TEXT,
   payment_num       INT,
   other             TEXT,
   PRIMARY KEY ((cust_name, payment_num))
   );
INSERT INTO cust_payments (cust_name,
   payment_num, other)
VALUES ('SEARS' , 101, '$100');
   ...
VALUES ('MACYS' , 101, '$200');
```

Affect these changes in cassandra.yaml, dse.yaml

In the cassandra.yaml file, confirm, set or eventually tune the following:

– Confirm the default settings are in place,

```
authenticator:
com.datastax.bdp.cassandra.auth.DseAuthenticator

role_manager: com.datastax.bdp.cassandra.auth.DseRoleManager
```

– If doing RLAC (we are), eventually consider tuning the following,

```
# Uncomment any that are commented

# permissions_cache_max_entries  not present in 6.0

permissions_validity_in_ms: 2000

permissions_uddate_interval_in_ms: 2000

permissions_cache_max_entries: 1000
```

– Documentation to the above,

```
https://docs.datastax.com/en/dse/5.1/dse-admin/datastax_enterp
rise/security/secRlac.html

https://docs.datastax.com/en/dse/5.1/dse-admin/datastax_enterp
rise/security/secAuthCacheSettings.html#secAuthCacheSettings__
cache
```

In the dse.yaml file, confirm, or set the following,

```
#  Uncomment all

#  Set,      enabled: true

#  Ensure,   default_scheme: internal

authentication_options:

   enabled: true
```

```
    default_scheme: internal
    other_schemes:
    scheme_permissions: false
    allow_digest_with_kerberos: true
    plain_text_without_ssl: warn
    transitional_mode: disabled
#   Uncomment
role_management_options:
    mode: internal
#   Uncomment
#   Set,      enabled: true
authorization_options:
    enabled: true
    transitional_mode: disabled
    allow_row_level_security: true
```

DSE Security: reboot DSE

Rebooting is not required for production systems, but is easier and does involve fewer steps. And, in production you could do a rolling restart of multiple nodes to prevent any outage.

Check the boot screen/log for error messages.

Actually implementing ROLES, other

Example 25-2 creates the roles, other. A code review follows.

Example 25-2 Creating the roles, other

```
DROP ROLE IF EXISTS bob             ;
DROP ROLE IF EXISTS nancy           ;
DROP ROLE IF EXISTS dirk            ;

DROP ROLE IF EXISTS senior_operator;
DROP ROLE IF EXISTS operator        ;
DROP ROLE IF EXISTS operator_na     ;

CREATE ROLE bob   WITH LOGIN = true AND PASSWORD = 'password';
GRANT EXECUTE on INTERNAL SCHEME to bob  ;
```

```
CREATE ROLE nancy WITH LOGIN = true AND PASSWORD = 'password';
GRANT EXECUTE on INTERNAL SCHEME to nancy;
CREATE ROLE dirk  WITH LOGIN = true AND PASSWORD = 'password';
GRANT EXECUTE on INTERNAL SCHEME to dirk ;


CREATE ROLE senior_operator;

// INSERT, UPDATE, DELETE and TRUNCATE rows in
// any table in the specified keyspace.
// ADD SELECT
GRANT MODIFY, SELECT ON KEYSPACE ks_6221 TO senior_operator;
GRANT senior_operator to nancy;

CREATE ROLE operator;

GRANT MODIFY,SELECT ON TABLE ks_6221.cust_orders   TO operator;
GRANT SELECT        ON TABLE ks_6221.cust_payments TO operator;

GRANT operator to bob;


CREATE ROLE operator_na;

// RESTRICT ROWS ON ks_6221.cust_orders USING other;
// InvalidRequest: Error from server: code=2200 [Invalid query]
// message="Restrict Rows Statement must be for a Primary Key
// or a Partition Key column"

RESTRICT ROWS ON ks_6221.cust_orders USING region;
RESTRICT ROWS ON ks_6221.cust_orders USING cust_name;
//  DESCRIBE TABLE shows cust_name only

RESTRICT ROWS ON ks_6221.cust_orders USING region;

GRANT SELECT ON 'NA' ROWS IN ks_6221.cust_orders TO operator_na;
GRANT operator_na to dirk;
```

Relative to Example 25-2, the following is offered:

– The first CREATE ROLE / GRANT pair details how to add a user titled, "bob", with password valued as "password". This block repeats for two additional users.

  Using internal DSE authentication, this is how users are created.

- Then we create a ROLE which will be used by a group of users titled, "senior_operator".

  This role is given; MODIFY and SELECT.

  And we give this role to "nancy".
- And we create the ROLE titled, "operator".
- The ROLE titled, "operator_na", is associated with a RESTRICT modifier, so that it can (view) a given subset of records in the table as a whole.
- And this ROLE is given to "dirk".

Note: The error messages displayed (and commented out), detail that the RESTRICT is partition in scope.

Test using CQLSH

Logon to DSE using CQLSH for each of the three users as shown,

```
cqlsh -u nancy -p password
cqlsh -u bob   -p password
cqlsh -u dirk  -p password


   use ks_6221;


   select * from cust_orders;
   select * from cust_payments;
```

Dirk should only be able to see a subset of records.

25.3 In this document, we reviewed or created:

This month and in this document we detailed the following:

- An overview of security related to DSE.
- We detailed the specific steps to implement row level access control.

Persons who help this month.

Kiyu Gabriel, and Jim Hatcher.

Additional resources:

Free DataStax Enterprise training courses,

```
https://academy.datastax.com/courses/
```

Take any class, any time, for free. If you complete every class on DataStax Academy, you will actually have achieved a pretty good mastery of DataStax Enterprise, Apache Spark, Apache Solr, Apache TinkerPop, and even some programming.

This document is located here,

```
https://github.com/farrell0/DataStax-Developers-Notebook
https://tinyurl.com/ddn3000
```