

February 2018

Welcome to the February 2018 edition of DataStax Developer's Notebook (DDN). This month we answer the following question(s);

My company was invited to participate in the DataStax Enterprise (DSE) 6.0 early release program. From discussions with DataStax, we learned there are a number of changes related to CQL native processing of DSE Search commands. Can you help us understand what this means ?

Excellent question ! On February 1, 2018, DataStax began accepting self nominations to the DSE release 6.0 Early Access Process (EAP) at the following Url,

<https://academy.datastax.com/eap?destination=eap>

When your nomination is accepted, you receive early access to the DSE version 6.0 software and documentation. In return, you are asked to formally test this release and participate in feedback relative to your experiences. The 6.0 release is huge, with many topics far larger than CQL native processing of DSE Search commands; this is a very cool, and strategic release.

In this document, we detail the DSE Core and DSE Search areas of functionality, their intent, how they work pre release 6.0, and are planned to work in the 6.0 release.

Software versions

The primary DataStax software component used in this edition of DDN is DataStax Enterprise (DSE), currently early release 6.0. 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 CentOS version 7.0, 64 bit.

14.1 Terms and core concepts

As stated above, we are detailing a very small piece of a future, large and strategic new release of DataStax Enterprise (DSE). You are going to enjoy this release greatly. As early access (pre-release) software, all comments below are subject to change.

Four functional areas of DSE

In section 10.1.8 of the October/2017 edition of this document (DataStax Developer's Notebook: DDN), we detailed the four major functional areas of DataStax Enterprise (DSE), namely:

- DSE Core (often denoted as, C*, powered by Apache Cassandra).
- Search (powered by Apache Lucene / Apache Solr).
- Analytics (powered by Apache Spark).
- Graph (powered by Apache TinkerPop, and Apache Gremlin).

Scalability, time constant lookups

Two of these functional areas are relevant to our current discussion of CQL native processing of DSE Search commands: DSE Core, and DSE Search. Regarding DSE Core, recall the following:

- DSE Core is that area of DSE that provides network partition fault tolerance, that is; always on, all nodes are capable of accepting writes, even if the ultimate/final destination of that data is not currently available. The write always succeeds and is preserved, even if only one of many nodes are operating.

Should the same (single data row) be written to on two separate nodes concurrently, DSE will automatically (merge) these separate writes into one best surviving version of this (single data row).

- And DSE Core also provides time constant lookups, that is; DSE Core is based on two seminal industry white papers, one from Google (Google BigTable), and one from Amazon (Amazon DynamoDB). The purpose of this over arching design is to serve data at Web scale in an always-on manner.

All database servers claim to scale horizontally without end. Almost none do.

At the heart of most database servers are sequential scans and/or B-Tree+ style indexes. We state as common knowledge that sequential scans do not scale linearly, as data volumes grow. Less commonly known is that B-Tree+ styles indexes also do not scale linearly.

Note: From the Wikipedia.com articles on B-Tree+ style indexes, and logarithmic time, available here,

<https://en.wikipedia.org/wiki/B-tree>

https://en.wikipedia.org/wiki/Time_complexity#Logarithmic_time

“In computer science, a B-tree is a self-balancing tree data structure that keeps data sorted and allows searches, sequential access, insertions, and deletions in *logarithmic time*.

“An algorithm is said to take logarithmic time if $T(n) = O(\log n)$ An $O(\log n)$ algorithm is considered highly efficient, as the ratio of the number of operations to the size of the input decreases, **and tends to zero when n increases**.

DSE Core, based on the seminal Google BigTable white paper, does not use B-Tree+ style indexes. This white paper is available here,

<https://static.googleusercontent.com/media/research.google.com/en//archive/bigtable-osdi06.pdf>

Note: The other seminal paper we refer to above (Amazon : Amazon DynamoDB), is available here,

<http://www.allthingsdistributed.com/files/amazon-dynamo-sosp2007.pdf>

Instead, DSE Core makes use of a hash based storage algorithm.

Note: From the Wikipedia.com article on hash tables available here,

https://en.wikipedia.org/wiki/Hash_table

“In a well-dimensioned hash table, **the average cost (number of instructions) for each lookup is independent of the number of elements stored in the table**. Many hash table designs also allow arbitrary insertions and deletions of key-value pairs, at (amortized[2]) **constant average cost per operation**.

So we're done right, make everything a hash ?

No, not unless you only need a key/value store. If you also need a general purpose database server, you need more.

As a stand alone technology, hash indexes can only effectively serve equalities on the whole of the (primary key) to the data row. Hash indexes suffer when serving key ranges, partial key searches, fuzzy searches, etcetera.

And this is why there are three other major functional areas to DataStax Enterprise (DSE). The DSE Search component to DSE provides:

- Additional indexes; Range queries and sorts, complex relational query predicates along the lines of SQL.
- Text analytics; text search, fuzzy search, highlighting, spell checking, synonyms, other.
- Spatial analytics; point, line, polygons, and more, nearness, intersects, other.
- Time series
- Faceting, clustering, grouping
- Other

Defining the term ‘DSE primary key’

Before we can go farther, we need to define the term *primary key* as it relates to DataStax Enterprise (DSE). Consider:

- A DSE primary key has a mandatory part called the *partitioning key*, and an optional part called the *clustering key*. Both the mandatory and optional parts may be composed of one or more columns. A concatenation of the partitioning key and clustering key together form the primary key. As a rule, there can not be two rows in the same table with the same primary key, and primary keys are immutable.

Note: Generally we state:

- As an industry term, *primary key* commonly denotes the unique identifier of a given data row.
It is not industry standard for the primary key to also affect the (storage location) of the given data row.
 - With DataStax Enterprise (DSE), the primary key denotes data row uniqueness, and affects (storage location).
 - Only the partitioning key portion of the primary key determines which node a given data row is located on. The clustering key portion of the primary key determines sort order on a given node.
-
- The partitioning key value uniquely places a given data row on a given (single) node.

Note: This is the role and unique value of the partitioning key; by querying an equality of the whole of the partitioning key, you can limit execution of the query to just one node. This operation can scale linearly.

Why do we say 'can scale linearly', and not say 'will scale linearly' ? You could write a poor implementation of a (hash lookup) that does not scale linearly for other reasons; global write locks (MUTEXES), blocking operations in critical sections of the server (product) code, other.

If you lose the whole of the partitioning key of the primary key (use only a subset of columns from the partitioning key, or use a relational operator other than equality, like range, or wildcard text, other), then you can not be certain you can limit the execution of the query to just one node. This operation will likely not scale linearly; when you need to span nodes, you are not likely to scale linearly.

Why do we say 'likely not to scale linearly' ? It is not multiple nodes that prevent scaling linearly; multiple nodes can scale linearly. It is how rows are identified (uniquely) that scales, or does not scale.

When an operation fails to use the whole of the partitioning key, then you are likely performing a scatter/gather query, or a range or sequential scan; these do not scale linearly.

Difference between a DSE Core query and DSE Search (query)

Short version: it is/was the presence of a "solr_query = " predicate.

Limiting this discussion to DSE Core, and DSE Search, and to just CQL native processing of DSE Search commands, the following is offered:

- Like SQL, DSE queries rely on a SELECT statement with multiple optional clauses for query predicates (a WHERE clause), an ORDER BY, other.

While there are minor exceptions, a DSE Core query (a time constant lookup), is expected to be on the whole of the partitioning key using an equality.

What minor exceptions ?

Minimally, there is an optional 'ALLOW FILTERING' clause to a DSE Core SELECT, which can allow a scatter/gather query when using DSE Core.

We say 'can allow', because these style of queries could effectively call to sequentially scan the entirety of a multi-node, multi-terabyte table. With default DSE server settings, DSE Core queries of this type will likely be shut down (experience a time out) by the DSE server.

- How do DSE Core queries and DSE Search queries differ ?

DSE Core queries have a query predicate (WHERE clause) similar to,

```
// Partitioning key is on col1
SELECT * FROM t1
WHERE col1 = 10;

// Partitioning key is on two cols; col1 and col2
SELECT * FROM t1
WHERE col1 = 10 AND col2 = 20;

// Partitoning key is on col1 and col2, a clustering key is on col3
SELECT * FROM t1
WHERE col1 = 10 AND col2 = 20 and col3 > 30;

// Partitoning key is on col1 and col2, a clustering key is on col3
SELECT * FROM t1
WHERE col1 = 10 and col2 = 20
ORDER BY col3;
```

DSE Search queries will have a "solr_query = " predicate,

```
SELECT name FROM t1
WHERE solr_query =
    '{ "q" : "(name:D* OR name:DAVE~1^8)
    AND
    gender:M AND century:2000" }';
```

Only the "solr_query = " predicate makes the above a DSE Search query. The remainder of that text is a Solr *query expression*. In effect, that string calls to:

- In a column titled "name", return rows that start with the letter "D" ("D*"), OR equal the word "DAVE", with up to 1 character misspelled at any location in the "DAVE" string literal; "DOVE", "DAVES", other.

This second portion of the OR clause is given a greater weight when prioritizing which results to return, meaning; DAVES will be returned before choosing to return DON.

- The remaining columns are returned based on equalities.

Note: As a DSE Search (query), the gender and century predicates could be configured as exact match, or as (weighted near matches).

E.g., This search should return a “gender = M”, but could also return a “gender = F”, if the other predicates are a strong enough match.

This is the difference between query and search.

What changes in DSE version 6.0 ?

As stated, the DataStax Enterprise (DSE) 6.0 release is huge. In just the area of CQL native processing of DSE Search commands, we state:

- Some queries which were previously written with a “solr_query = ” predicate, can now be written without same.

Syntactic sugar if you will, but also very cool. Instead of having to write DSE Core queries using CQL/SELECT, and DSE Search queries using CQL/SELECT/”solr_query = “, you can now drop the “solr_query = “ clause for an initial, and expectedly growing number of queries.

- DataStax Enterprise (DSE) is a multi-model database; DSE Core offering a wide column store, DSE Graph offering graph (a directed acyclic graph store, networked and relationship data), DSE Analytics offering in-memory/streaming, other.

The direction is stated to be supporting these models, without forcing the user to write specific query and other syntax for each model type; it's just a better, more productive integration.

Examples of new syntax

Below we display a number of examples to the syntax new found in release 6.0 of DataStax Enterprise (DSE). All examples are written in Python using the open source Cassandra/DSE client side driver.

Example 14-1 begins these examples. A code review follows.

Example 14-1 Python program to create a table and insert data.

```
from dse.cluster import Cluster

import time

l_cluster = Cluster(
    contact_points=['127.0.0.1']
)
```

```

l_session = l_cluster.connect()

l_stmt =
    "DROP KEYSPACE IF EXISTS ks_14;
    #
l_resu = l_session.execute(l_stmt)

l_stmt =
    "CREATE KEYSPACE ks_14 WITH REPLICATION =
    '{class: 'SimpleStrategy',
    'replication_factor': 1};
    #
l_resu = l_session.execute(l_stmt)

l_stmt =
    "DROP TABLE IF EXISTS ks_14.my_table;
    #
l_resu = l_session.execute(l_stmt)

l_stmt =
    "CREATE TABLE ks_14.my_table
    (
    col1          TEXT,
    col2          TEXT,
    col3          TEXT,
    col4          TEXT,
    col8          SET<TEXT>,
    PRIMARY KEY (col1)
    );
    #
l_resu = l_session.execute(l_stmt)

l_stmt =
    "INSERT INTO ks_14.my_table
    (col1, col2, col3, col4, col8)
    VALUES ( %s, %s, %s, %s, %s);

s_col1      = "aaa"
s_col2      = "aaa"
s_col3      = "aaa"
s_col4      = "aaa"
#
s_col8      = { "aaa", "bbb"}
```



```
l_session.execute(l_stmt, ( s_col1, s_col2, s_col3, s_col4, s_col8))
```

Relative to Example 14-1, the following is offered:

- This Python client program connects to a local DSE server, creates a keyspace, table, and adds data.
- Every part of this program is supported by DSE Core functionality. Thus, DSE could have been booted without the optional DSE Search functional area. E.g.,

```
dse cassandra -f -R
```

Run DSE Core in the foreground (“-f”), and allow it to be run as root (“-R”).

- “col8” is one of the three DataStax Enterprise collection types (array types). Collection types are documented here,

```
https://docs.datastax.com/en/cql/3.1/cql/ddl/ddl\_collection\_columns\_c.html
```

Adding to the bottom of the code from Example 14-1, we see the following in Example 14-2. A code review follows.

Example 14-2 Adding more code to the bottom of the previous example.

```
l_stmt =                                     \
"SELECT * FROM ks_14.my_table              " + \
"WHERE col3 IS NOT NULL;                   "
#
try:
    l_rows = l_session.execute(l_stmt)
    #
    for l_row in l_rows:
        print l_row
    print "passed on 1."
    print "this is not normal."
except:
    print "failed on 1."
    print "this is normal."

print ""
```

Relative to Example 14-2, the following is offered:

- This example asks for an inequality on a column that is not part of the primary key, not part of the partitioning key, to this table.

With our current runtime configuration, that request will fail with a,

```
dse.InvalidRequest: Error from server: code=2200 [Invalid
query] message="Unsupported restriction: col3 IS NOT NULL
```

Our server is currently booted with just DSE Core running. If we add DSE Search to the operation of this server,

```
dse cassandra -f -R -s
```

Then the above operation will still fail, because we have not created a DSE Search index to support this query.

- We need to boot our server with support for DSE Search, and add the appropriate DSE Search index. Example as shown in Example 14-3, with a code review that follows.

Example 14-3 Creating the necessary DSE Search index.

```
l_stmt =
    "CREATE SEARCH INDEX ON ks_14.my_table      \" + \"\\
    \"WITH CONFIG                               \" + \"\\
    \"{ realtime:true } AND OPTIONS { reindex:true }; \"
    #
l_resu = l_session.execute(l_stmt)
#
time.sleep(5)
```

Relative to Example 14-3, the following is offered:

- If we try to create the index without DSE Search being turned on, we receive the error below,

```
dse.InvalidRequest: Error from server: code=2200 [Invalid
query] message="Search statements are not supported on this
node"
```

With DSE Search enabled, the above statement succeeds.

- The sleep command is entirely optional. As our program executes in batch, top to bottom, the index build would not be complete if we immediately were to fetch/query data. Our fetch statement would succeed, but not return the complete result set as expected.

Example 14-4 displays the continuation of our example. A code review follows.

Example 14-4 Index built, running the actual queries.

```

try:
    l_stmt =
        "SELECT * FROM ks_14.my_table
        "WHERE col3 IS NOT NULL;
        #
    l_rows = l_session.execute(l_stmt)
    #
    for l_row in l_rows:
        print l_row
    print "passed on 2."
    print "this is normal."
except:
    print "failed on 2."
    print "this is not normal."

print ""

try:
    l_stmt =
        "SELECT * FROM ks_14.my_table
        "WHERE col3 IS NULL;
        #
    l_rows = l_session.execute(l_stmt)
    #
    for l_row in l_rows:
        print l_row
    print "passed on 3."
    print "this is not normal."
except:
    print "failed on 3."
    print "this is normal."

```

Relative to Example 14-4, the following is offered:

- The first SELECT succeeds, and the second fails.
IS NOT NULL, is one of the new CQL native processing of DSE Search commands. IS NULL is not. (The expectation being that IS NULL will arrive at some near and future time.)
Either of these two queries could still be written using “solr_query = “.
- Does there always need to be a Search index on the column referred to in the query predicate (when the predicate is not on the primary key) ?

Yes. Without an index, the requested operation would require a sequential scan of potentially millions of rows, on hundreds of nodes; really not something you want to do.

DSE Indexes (and materialized views)

In effect, there are three (or four) DSE index topics.

Thus far we have detailed that DSE Core stores data in a specific physical manner, based on a hash of the primary key; the partitioning key part of the primary key determines the node/location of the data, and the clustering key part of the primary key determines sort order on a node (within a given partition). The physical ordering/placement of the primary key acts as an index of sorts. (It provides a file (table) access method, which is exactly what indexes do.)

And DSE Core supports *materialized views*, similar to Oracle or other relational database server materialized views. DSE Core materialized views were originally called (DSE Core) *global indexes*. DSE Core materialized views are detailed at the following Url,

http://docs.datastax.com/en/cql/3.3/cql/cql_reference/cqlCreateMaterializedView.html

Example 14-5 offers a materialized view. A code review follows.

Example 14-5 Example materialized view.

```
CREATE TABLE t1
(
  col1          TEXT,
  col2          TEXT,
  col3          TEXT,
  col4          TEXT,
  col5          TEXT,
  col6          TEXT,
  col7          TEXT,
  col8          TEXT,
  PRIMARY KEY ((col1, col2), col3, col4)
);

// This next statement will fail
CREATE MATERIALIZED VIEW mv1
AS
  SELECT col1, col2, col3, col4, col5, col6, col7, col8
  FROM t1
  WHERE col7 IS NOT NULL AND col8 IS NOT NULL
  PRIMARY KEY (col7, col8)
  WITH caching = { 'keys' : 'ALL',
```

```
'rows_per_partition' : '100' }
AND comment = 'yadda' ;

// This statement will succeed
CREATE MATERIALIZED VIEW mv1
AS
  SELECT col1, col2, col3, col4, col5, col6, col7, col8
  FROM t1
  WHERE col1 IS NOT NULL AND col2 IS NOT NULL AND
        col3 IS NOT NULL AND col4 IS NOT NULL AND
        col7 IS NOT NULL
  PRIMARY KEY (col1, col2, col3, col4, col7)
  WITH caching = { 'keys' : 'ALL',
    'rows_per_partition' : '100' }
  AND comment = 'yadda' ;
```

Relative to Example 14-5, the following is offered:

- After the create table statement, the first materialized view statement will fail with a,

```
InvalidRequest: Error from server: code=2200 [Invalid query]
message="Cannot create Materialized View mv1 without primary
key columns from base t1 (col1,col3,col2,col4)"
```

In effect, a materialized view can *extend* the primary key constraint from its base table, but it can not (replace) the primary key constraint.

Huh ? You can change the ordering of the rows within the existing partition (partitioning key), but not change the partitioning key itself.

This does have value; you could specify a base table with a primary key (partitioning key), then have a number of materialized views that offer differing ORDER BY support. And, these would be queries that support time constant look ups.

This seems restrictive; why is this a good thing ?

Well first off, sorting is blocking operation; you can not return any rows from a sort until all rows have been received. What if the first row that should have been returned was the last row processed- Further, no sort operation scales linearly. The best sort operations sort algorithmically.

The ORDER BY support we are discussing here has the rows *pre-sorted* on disk before any request for SQL processing. That is how this (sort) can scale linearly.

- By *materialized* in the phrase materialized view, we mean to say that this data is stored on disk, just like a regular table. As the base table is

updated/deleted/other, all dependent materialized views are automatically and asynchronously (updated).

- The second materialized view statement succeeds.

And before we get to DSE Search indexes, there is another/third index topic with DSE Core we should detail; SASI (Secondary Attached Storage Indexes), also known as secondary indexes. Example as shown in Example 14-6. A code review follows.

Example 14-6 Secondary index example.

```
create index i2 on t1 (col6);
select * from t1 where col6 = 'a';
```

col1	col2	col3	col4	col5	col6	col7	col8
a	a	a	a	a	a	a	a

(1 rows)

Relative to Example 14-6, the following is offered:

- DSE Core secondary indexes are most common to the same named secondary indexes in standard relational databases; standard, except that DSE is most commonly a multi-nodal database.

Where the DSE Core primary key value determines node location, the secondary index does not (can not). DSE Core secondary index data is stored inside DSE, adjacent to the (normal/standard) data to a table. But, the secondary index is not anchored by the partition key, and as such a query relying on a secondary index may observe a scatter/gather behavior.

Like a relational database, this index data is automatically updated as you would expect.

- A further syntax exists for multi-column secondary indexes, detailed here,

https://docs.datastax.com/en/dse/5.1/cql/cql/cql_reference/cql_commands/cqlCreateCustomIndex.html

When you successfully create a SASI Custom index, you will receive the following warning,

SASI index was enabled for 'ks_14.t1'. SASI is still in beta, take extra caution when using it in production.

- When DSE Core secondary indexes first arrived in version 0.7, they received much bad press. It is very likely this bad press was due to the scatter/gather behavior of a non-anchored retrieval, and nothing more.

Finally, Search indexes

When we made the DSE Search index above, we followed this operation with a sleep statement. This is not required. We included the sleep because of the batch nature of our sample/test program above; make an index, and immediately query a data row using this index.

The creation of a new DSE Search index, and even the (insert) of a new data record (into that index) is an asynchronous operation. With no sleep in our batch/test program, its likely our query would not return our single sample data record as expected.

Note: Many tunables and many diagnostics are available here. We'll cover some of the diagnostics now, and plan to cover the tunables in a future edition of this document.

Covering tunables involves detailing many more DSE Search index pre-requisite topics than we plan to cover here; a full DSE search index topic treatment is a large discussion. Stay tuned.

As a CQL command, 'describe table' tells us what indexes are in place on a table and more. Example as shown in Example 14-7. A code review follows.

Example 14-7 CQL command describe table.

```
describe table t1;

CREATE TABLE ks_14.t1 (
  col1 text,
  col2 text,
  col3 text,
  col4 text,
  col5 text,
  col6 text,
  col7 text,
  col8 text,
  PRIMARY KEY ((col1, col2), col3, col4)
) WITH CLUSTERING ORDER BY (col3 ASC, col4 ASC)
   AND bloom_filter_fp_chance = 0.01
   AND caching = {'keys': 'ALL', 'rows_per_partition': 'NONE'}
   AND comment = ''
```

```
    AND compaction = {'class':
'org.apache.cassandra.db.compaction.SizeTieredCompactionStrategy',
'max_threshold': '32', 'min_threshold': '4'}
    AND compression = {'chunk_length_in_kb': '64', 'class':
'org.apache.cassandra.io.compress.LZ4Compressor'}
    AND crc_check_chance = 1.0
    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 = '99PERCENTILE';
CREATE CUSTOM INDEX i4 ON ks_14.t1 (col7) USING
'org.apache.cassandra.index.sasi.SASIndex';
```

Relative to Example 14-7, the following is offered:

- At the bottom of the display, we see the SASI index we created on this table. All indexes would be displayed here.
- And we see all (including the default) settings in place when creating this table.
- A DSE Search index would display as,

```
CREATE CUSTOM INDEX ks_14_my_table_solr_query_index ON
ks_14.my_table (solr_query) USING
'com.datastax.bdp.search.solr.Cql3SolrSecondaryIndex';
```

As stated above, index build occurs asynchronously in the background. To determine whether the index build is complete, we can run a `dsetool` command. Example as shown as Example 14-8. A code review follows.

Example 14-8 Sample dsetool checking index build.

```
// CQL command
CREATE SEARCH INDEX ON ks_14.my_table WITH CONFIG
{ realtime:true } AND OPTIONS { reindex:true };
```

Warnings :

Please remember this operation is DC specific and should be repeated on each desired DC.

```
// Command line utility
#dsetool core_indexing_status ks_14.my_table
```



```
[ks_14.my_table]: INDEXING, 84% complete, ETA 18081 milliseconds (18 seconds)
# dsetool core_indexing_status ks_14.my_table
[ks_14.my_table]: INDEXING, 98% complete, ETA 2118 milliseconds (2 seconds)
# dsetool core_indexing_status ks_14.my_table
[ks_14.my_table]: FINISHED
```

Relative to Example 14-8, the following is offered:

- The index created above was on a 14MB dataset with 200,000 rows. As stated in the introduction to this document, this work was done on a laptop virtual machine with 8GB of RAM.

And we were indexing everything; all columns in all rows.

This is the default behavior, per the CREATE SEARCH INDEX statement we detailed above in Example 14-3. You can, of course, deviate from the defaults (index fewer columns, and with less search capable behavior).

- While the index is being built, there is no blocking; all end user queries return. If the index build is not completed, the query results may not be complete.

Another set of diagnostics is available via the Solr Administration Web screen, available at,

`http://IP-address:8983/solr`

Where 'IP-address' is the address of the node hosting any DSE Search function. Example as displayed in Figure 14-1.

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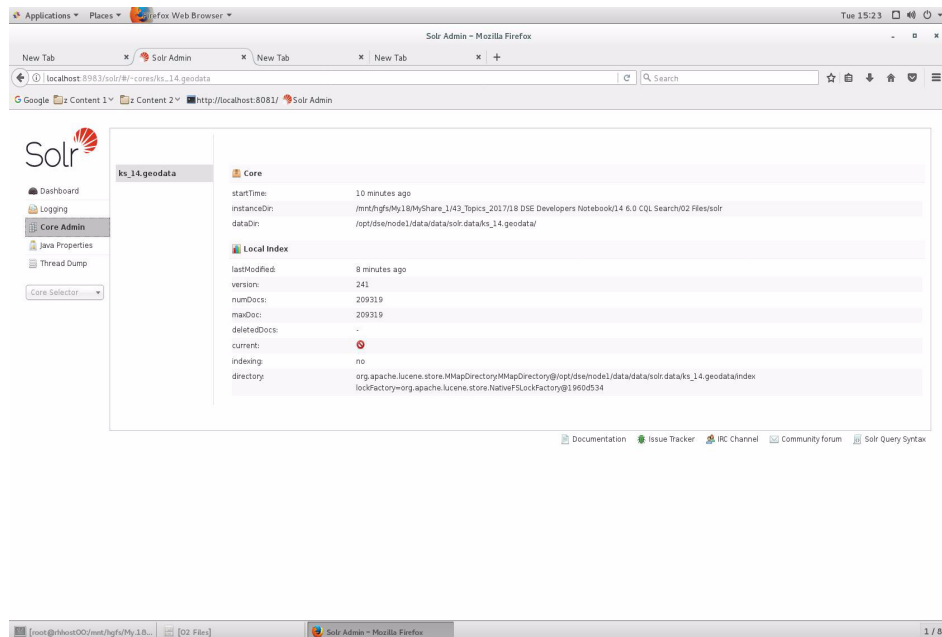


Figure 14-1 Solr Admin screen, IP-address:8983/solr

And lastly tracing; tracing is an ability through the CQL command shell. Example as displayed in Example 14-9. A code review follows.

Example 14-9 Using tracing in the CQL command shell.

```
# select * from my_table;
#
#  col1 | col2 | col3 | col4 | solr_query
#  -----+-----+-----+-----+-----
#   aaa |  aaa |   aaa |   aaa |         null
#
# (1 rows)
#
# Tracing session: 48af6660-052a-11e8-be54-4b5b3cf8ae6e
#
# activity
# | timestamp                | source      | source_elapsed | client
#
# -----+-----+-----+-----+-----
# -----+-----+-----+-----+-----
# -----+-----
```

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```
#
Execute CQL3 query | 2018-01-29 12:26:20.105000 | 127.0.0.1 | 0 |
127.0.0.1
#
Parsing
select * from my_table; [CoreThread-2] | 2018-01-29 12:26:20.108000 | 127.0.0.1
| 3772 | 127.0.0.1
#
Preparing statement [CoreThread-2] | 2018-01-29 12:26:20.108000 | 127.0.0.1 |
4241 | 127.0.0.1
#
Computing ranges to query [CoreThread-2] | 2018-01-29 12:26:20.109000 |
127.0.0.1 | 4744 | 127.0.0.1
# Submitting range requests on 2 ranges with a concurrency of 2 (0.675 rows
per range expected) [CoreThread-2] | 2018-01-29 12:26:20.109000 | 127.0.0.1 |
5118 | 127.0.0.1
# Submitted 1
concurrent range requests [CoreThread-2] | 2018-01-29 12:26:20.110000 |
127.0.0.1 | 6224 | 127.0.0.1
# Executing seq scan across 1 sstables for (min(-9223372036854775808),
min(-9223372036854775808)) [CoreThread-1] | 2018-01-29 12:26:20.110000 |
127.0.0.1 | 6466 | 127.0.0.1
# Read 1 live
and 0 tombstone cells [CoreThread-1] | 2018-01-29 12:26:20.111000 | 127.0.0.1 |
6945 | 127.0.0.1
#
Request complete | 2018-01-29 12:26:20.114322 | 127.0.0.1 | 9322 |
127.0.0.1

# select * from my_table where col3 is not null;
#
# col1 | col2 | col3 | col4 | solr_query
# -----+-----+-----+-----+-----
# aaa | aaa | aaa | aaa | null
#
# (1 rows)
#
# Tracing session: 7bd08ab0-052a-11e8-be54-4b5b3cf8ae6e
#
#
# activity
# | timestamp | source | source_elapsed | client
# -----+-----+-----+-----+-----
# -----+-----+-----+-----+-----
# -----+-----+-----+-----+-----
#
#
Execute CQL3 query | 2018-01-29 12:27:45.883000 | 127.0.0.1 | 0 |
127.0.0.1
```

```
#
Parsing select * from my_table where col3 is not null; [CoreThread-2] |
2018-01-29 12:27:45.884000 | 127.0.0.1 | 324 | 127.0.0.1
#
Preparing statement [CoreThread-2] | 2018-01-29 12:27:45.884000 | 127.0.0.1 |
715 | 127.0.0.1
# Processed response from shard 127.0.0.1:8609/solr/ks_14.my_table: numFound:
1, maxScore: 1.0, elapsed time: 4 ms, token ranges:
[(-9223372036854775808,-9223372036854775808)] [Solr CQL query thread-0] |
2018-01-29 12:27:45.890000 | 127.0.0.1 | 7147 | 127.0.0.1
#
Executing single-partition query on my_table [CoreThread-1] | 2018-01-29
12:27:45.896000 | 127.0.0.1 | 325 | 127.0.0.1
#
Acquiring sstable references [CoreThread-1] | 2018-01-29 12:27:45.896000 |
127.0.0.1 | 434 | 127.0.0.1
#
Merging data from sstable 1 [CoreThread-1] | 2018-01-29 12:27:45.896000 |
127.0.0.1 | 539 | 127.0.0.1
#
Merged data from memtables and 1 sstables [CoreThread-1] | 2018-01-29
12:27:45.896000 | 127.0.0.1 | 819 | 127.0.0.1
#
Read 1 live and 0 tombstone cells [CoreThread-1] | 2018-01-29 12:27:45.896000 |
127.0.0.1 | 891 | 127.0.0.1
#
Request complete | 2018-01-29 12:27:45.896887 | 127.0.0.1 | 13887 |
127.0.0.1
#

#####

#
# tracing off
#
```

Relative to Example 14-9, the following is offered:

- DSE Search queries will have a tracing line similar to,
Processed response from shard
127.0.0.1:8609/solr/ks_14.my_table: numFound: 1, maxScore:
11.846154, elapsed time: 1621 ms, token ranges:
[(-9223372036854775808,-9223372036854775808)] [Solr CQL query

```
thread-0] | 2018-01-30 15:52:25.103000 | 127.0.0.1 |  
2445916 | 127.0.0.1
```

In other words, you will see a score. Recall that search queries may return *near matches*, and thus have an associated score. (DSE Core) queries return only *exact matches*. and thus do not need a score.

- Both the tracing on and tracing off commands are shown.
- Why was this a single partition query ? We were running this on our laptop with only one node.

What if you add columns to the table after creating the index

DSE Search and DSE Search indexes are a huge, huge topic, and we plan a future edition of this document to cover same.

The (default) CREATE SEARCH INDEX statement we executed above called to index all columns; very likely this is not what you need, and instead you wish to index only a smaller number of columns. Further, text strings are indexed by token (delineated by white space). So, if you index a single text column with the value, "I like DSE Search.", four index entries are created; one for each word. This is done to serve the query for just the word "DSE", just the word "like", and all combinations therein. If you do not need to serve that (advanced) query, you can call to create the index in a different (less resource consumptive) manner. Again, much of this is beyond scope for this document.

But, what if you create another column in the table after creating the default (all columns at the time) index ? You will have to add this new column to the index, else queries against this new column will fail.

Example as shown in Example 14-10. A code review follows.

Example 14-10 Adding a column to a table, DSE Search index

```
alter table my_table add col6 text;
```

```
select * from my_table where col6 > 'ddd';
```

```
InvalidRequest: Error from server: code=2200 [Invalid query] message="Cannot  
execute this query as it might involve data filtering and thus may have  
unpredictable performance. If you want to execute this query despite the  
performance unpredictability, use ALLOW FILTERING"
```

```
ALTER SEARCH INDEX SCHEMA ON my_table ADD FIELD col6;
```

```
select * from my_table where col6 = 'g';
```

InvalidRequest: Error from server: code=2200 [Invalid query] message="Cannot execute this query as it might involve data filtering and thus may have unpredictable performance. If you want to execute this query despite the performance unpredictability, use ALLOW FILTERING"

```
RELOAD SEARCH INDEX ON my_table;
```

Warnings :

Please remember this operation is DC specific and should be repeated on each desired DC.

```
select * from my_table where col6 = 'g';
```

col1	col2	col3	col4	col6	col8	solr_query
-----+-----+-----+-----+-----+-----+-----						

(0 rows)

```
alter table my_table drop col4;
```

#

InvalidRequest: Error from server: code=2200 [Invalid query] message="Cannot drop column col4 because it has dependent secondary indexes (ks_14_my_table_solr_query_index)"

#

```
ALTER SEARCH INDEX SCHEMA ON my_table DROP field col4;
```

```
select * from my_table where col4 = 'g';
```

col1	col2	col3	col4	col6	col8	solr_query
-----+-----+-----+-----+-----+-----+-----						
g	g	g	g	g	null	null

(1 rows)

```
RELOAD SEARCH INDEX ON my_table;
```

Warnings :

Please remember this operation is DC specific and should be repeated on each desired DC.

```
select * from my_table where col4 = 'aaa';
```

InvalidRequest: Error from server: code=2200 [Invalid query] message="Cannot execute this query as it might involve data filtering and thus may have unpredictable performance. If you want to execute this query despite the performance unpredictability, use ALLOW FILTERING"

Relative to Example 14-10, the following is offered:

- First we add a new column to the table titled, col6.

The ALTER TABLE command is detailed here,

https://docs.datastax.com/en/cql/3.1/cql/cql_reference/alter_table_r.html

- The next statement attempts to query with a predicate on this new column. This operation fails, as there is no available index ready to serve this query.
- The ALTER SEARCH INDEX statement succeeds; this new column is now known to the index *from a schema perspective* (a data definition perspective).

The ALTER SEARCH INDEX command is detailed here,

https://docs.datastax.com/en/dse/6.0/cql/cql/cql_reference/cql_commands/cqlAlterSearchIndexSchema.html

- The next select referencing this new column in the predicate still fails. It is fine that the index knows about this column, but no index data has yet been loaded. This operation is performed with the RELOAD SEARCH INDEX command, detailed here,

https://docs.datastax.com/en/dse/5.1/dse-dev/datastax_enterprise/search/reloadSearchCore.html

Actually, there is a RELOAD (index) command and a REBUILD (index) command; each differ, and each are important. For now, we only need the RELOAD command.

Notice that these commands are reported as being local to one data center; data center is a DSE node grouping concept not discussed further here.

- And finally the SELECT statement succeeds.
- If we attempt to drop a column that is part of a usable index, this operation fails. We must first drop the column from the index, then drop it from the table. Example as shown.

The index data is still present on the dropped column until we call to RELOAD the index.

More new syntax (continued from above)

Thus far in this document we detailed the new IS NOT NULL operator. Other operators include:

- All of the algebraic operators: < > >= <= = !=
- IN

- CONTAINS
- LIKE

Examples for most follow in Example 14-10. A code review follows.

Example 14-11 More examples of the new query operators

```
select * from my_table;
```

col1	col2	col3	col4	solr_query
aaa	aaa	aaa	aaa	null

(1 rows)

```
select * from my_table where col3 <= 'ccc';
```

col1	col2	col3	col4	solr_query
aaa	aaa	aaa	aaa	null

(1 rows)

```
select * from my_table where col3 > 'ccc';
```

col1	col2	col3	col4	solr_query
------	------	------	------	------------

(0 rows)

```
select * from my_table where col3 in ('bbb', 'ccc');
```

col1	col2	col3	col4	solr_query
------	------	------	------	------------

(0 rows)

```
select * from my_table where col3 in ('bbb', 'ccc', 'aaa');
```

col1	col2	col3	col4	solr_query
aaa	aaa	aaa	aaa	null

(1 rows)

```
select * from my_table where col3 contains ( 'eee', 'bbb');
```

InvalidRequest: Error from server: code=2200 [Invalid query] message="Cannot use CONTAINS on non-collection column col3"

```
select * from my_table where col8 contains ( 'eee', 'bbb');
```

InvalidRequest: Error from server: code=2200 [Invalid query] message="Invalid tuple type literal for value(col8) of type text"

```
select * from my_table where col8 contains 'eee';
```

col1	col2	col3	col4	col8	solr_query
-----	-----	-----	-----	-----	-----

(0 rows)

```
select * from my_table where col8 contains 'bbb';
```

col1	col2	col3	col4	col8	solr_query
-----	-----	-----	-----	-----	-----
aaa	aaa	aaa	aaa	{'aaa', 'bbb'}	null

(1 rows)

```
SELECT * FROM my_table where col3 != 'ddd';
```

col1	col2	col3	col4	col8	solr_query
-----	-----	-----	-----	-----	-----
aaa	aaa	aaa	aaa	{'aaa', 'bbb'}	null

(1 rows)

```
SELECT * FROM my_table where col3 = 'ddd';
```

col1	col2	col3	col4	col8	solr_query
-----	-----	-----	-----	-----	-----

(0 rows)

```
SELECT * FROM my_table where col3 LIKE 'aa%';
```

col1	col2	col3	col4	col8	solr_query
aaa	aaa	aaa	aaa	{'aaa', 'bbb'}	null

(1 rows)

```
SELECT json * FROM my_table where col3 LIKE 'aa%';
```

```
[json]
```

```
-----
{"col1": "aaa", "col2": "aaa", "col3": "aaa", "col4": "aaa", "col8": ["aaa",
"bbb"], "solr_query": null}
```

(1 rows)

Relative to Example 14-10, the following is offered:

- The first SELECT (ALL) will succeed on small sized data sets, and may fail on larger sized data sets. As a scatter/gather query (query all nodes), this DSE Core query may time out.

A common work around is to execute the above query as a DSE Search query. Example as shown,

```
SELECT count(*) FROM my_table WHERE solr_query = '{"q": "*:*"}';
```

If DSE Search is enabled, the above query will always succeed.

- The second and third queries with the “<=” and “>” operators against col3 will succeed.

As stated above and throughout this document, there exists a requirement that col3 carry a DSE Search index.

- The query with the IN operator compares a list of literals to a given (non array) DSE column type.

Contrast this with the later query with the CONTAINS operator, which compares a single/scalar literal to a DSE array column type. Array column types (officially named *collection* column types), include: set, list, map.

Set, list and map are detailed here,

https://docs.datastax.com/en/cql/3.1/cql/ddl/ddl_collection_columns_c.html

Recall how col8 was defined in the CREATE TABLE statement in Example 14-1,

```
col8          SET<TEXT>
```

It is this collection type that supports the CONTAINS operator.

- The NOT EQUALS (“ != “)operator is supported, as is EQUALS (“ = “).
- And finally, the last two SELECTs display support of the LIKE operator.
- The json modifier, as displayed, is not directly related to CQL native processing of DSE Search commands, however; the json modifier doesn’t get enough love, and we take the opportunity to highlight it here.

The json modifier calls to JSON format query results; super handy when developing Web and mobile applications.

Note: With a sharp eye, you will notice there was no mention of a DSE Core CQL (OR) modifier.

There is full support for OR using DSE Search “solr_search = “ query expression.

14.2 Complete the following

At this point in this document we have completed a general overview of the changes to release 6.0 of DataStax Enterprise (DSE), specifically as they relate to the new CQL native processing of DSE Search commands.

While we provided details regarding DSE Search commands, we did not give much detail about tuning, nor detail any specific configuration of the indexes created. A large topic, this will have to wait for another day.

At the point you are enabled to apply to the DataStax Enterprise (DSE) early access program (EAP), get the software, install it, and test the new commands detailed above. We tend to use a number of custom scripts to automate install and configuration of single and multi-node DSE installs. All of our scripts worked with version 6.0 without change. Yes, some settings in cassandra.yaml and similar were removed, some added, but generally release 6.0 is very backwards compatible. Cool.

Get the software, read the documentation, and test it using the commands above.

14.3 In this document, we reviewed or created:

This month and in this document we detailed the following:

- The four functional areas of DSE, including DSE Core with its network partition fault tolerance and time constant lookups.
- We detailed B-Tree+ and hash lookups, and which scale and why.
- We defined the DSE primary key, including its partitioning key and clustering key parts.
- We detailed what makes a query a DSE Core query versus a DSE Search query.
- We highlighted the new CQL native processing of DSE Search commands.
- We over viewed DSE materialized views, and secondary indexes.
- We detailed how to add and drop table columns, and inform DSE Search indexes of same.
- And we over viewed how to observe asynchronous/background index builds.

Persons who help this month.

Kiyu Gabriel, Matt Atwater, 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>