Operational Database
Hands-on Lab Guide

2 Hours to Data Innovation with Cloudera Operational Database

December 01, 2023

Accessing Your COD Lab Environment

Because you'll be running a bunch of commands, let's gather some information about our COD environment and populate some variables in your session so you don't have to worry about entering details each time you need to connect. To accomplish this, proceed with the following steps:

- If not already completed, *open your COD UI by using the workshop URL*: https://bit.ly/HOL1130

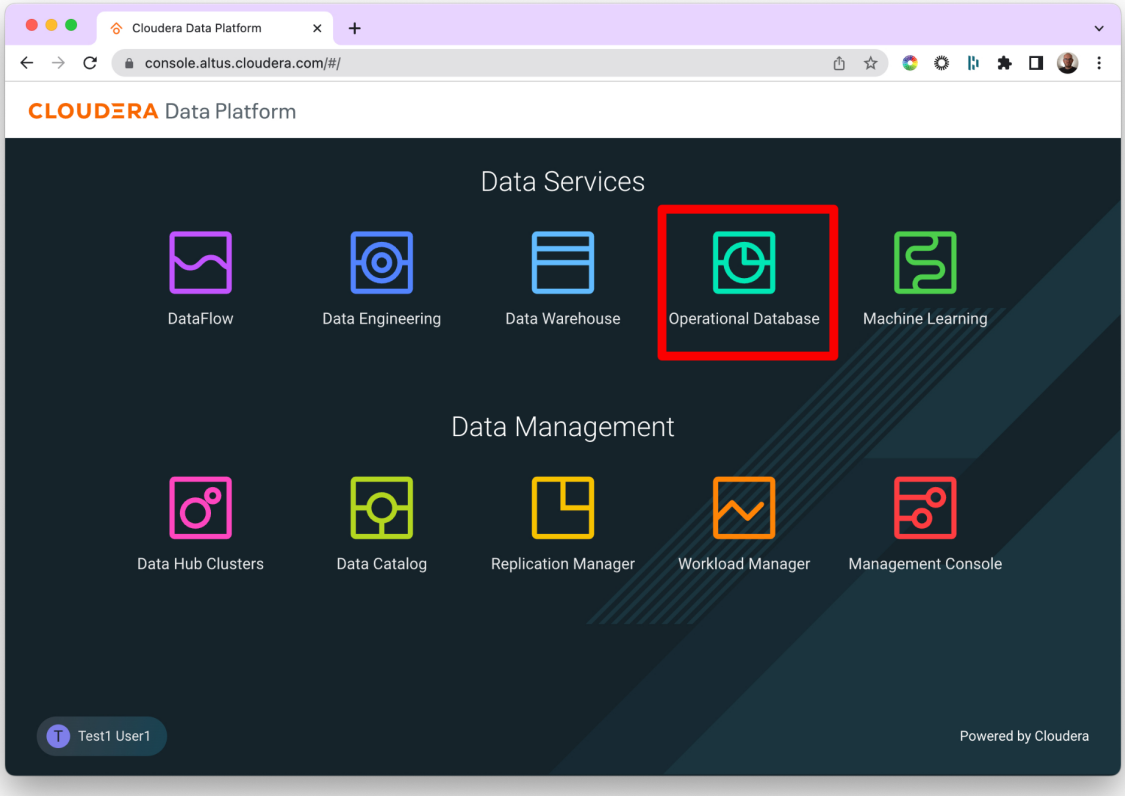
NOTE: You must NOT be on a VPN

- Enter your username and password:

first name	**last name**	**user**	**password**
Paul	Williamson	user046	G0yvxvdms5srhyKF
Santosh	Patel	user044	G0yvxvdms5srhyKF

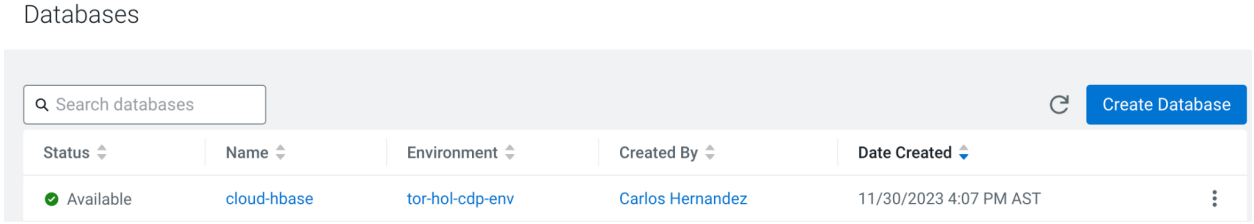
You should see the following screen:

Once connected, *click on the Operational Database tile*. This will get you into the COD management console.



COD Instance for Lab

- You'll see a single COD instance. The instance **cloud-hbase** will be the one we will use for the lab. *Click on cloud-hbase*.



Storage Location and Data Hub Name

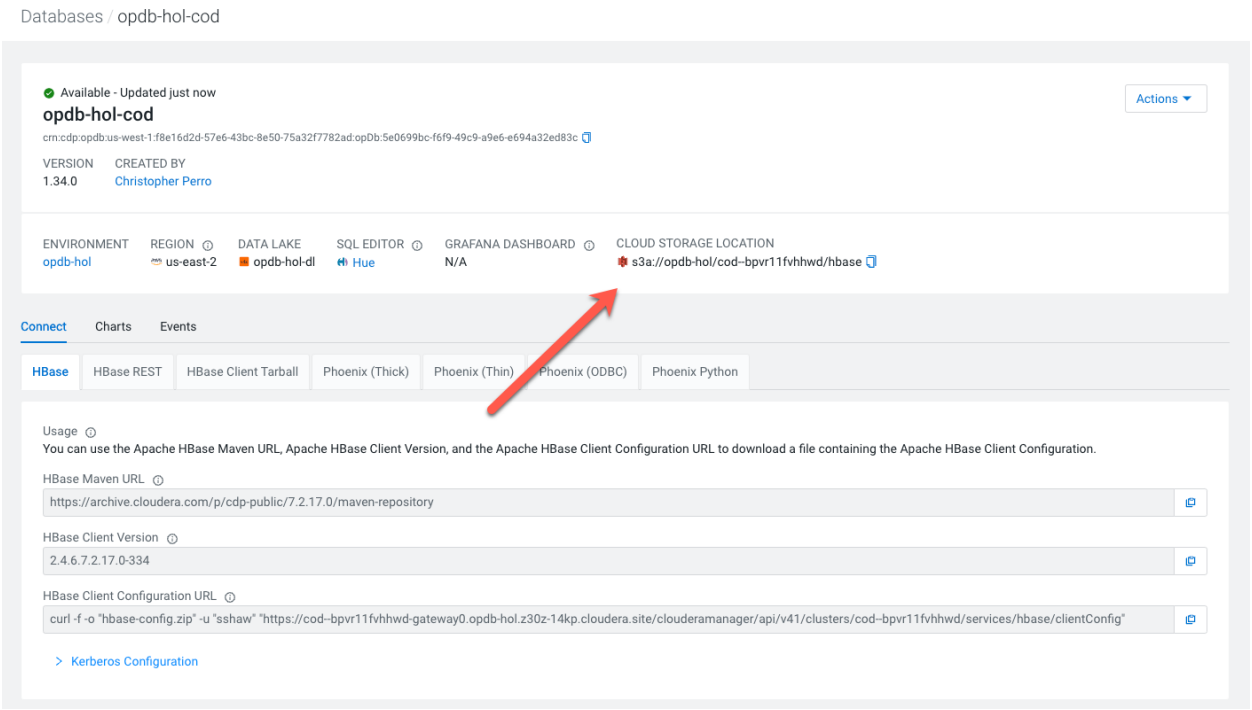
DEFINITION: A Data Hub is a collection of servers much like a traditional cluster.

Let's begin by gathering information on where our data resides and the nodes associated with our COD cluster. Keep in mind that COD is cloud enabled and leverages object storage in either AWS, Azure, or Google. This provides for significant cost savings without negatively impacting performance.

- First, copy your **cloud storage location** from your COD UI. Save this information for later.

  In our case, this is **s3a://tor-hol-buk-fdeea6f5/cod-1ihojougenp25/hbase**

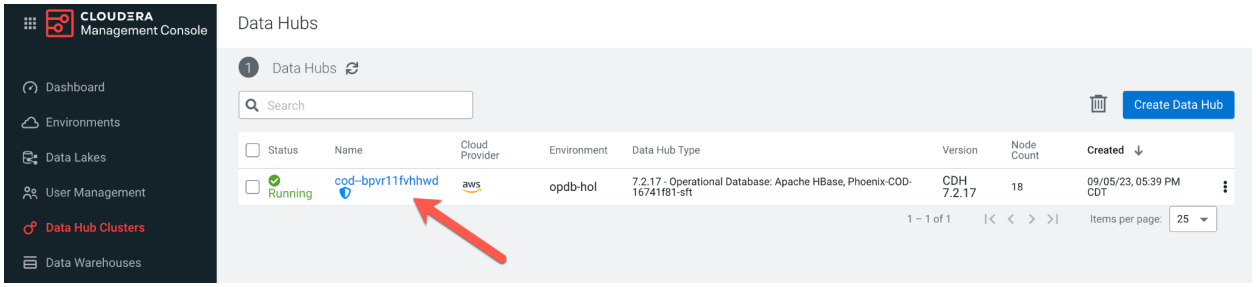
  Associated S3 bucket name : **tor-hol-buk-fdeea6f5**
  Associated Data Hub name : **cod-1ihojougenp25**



Accessing the Edge node

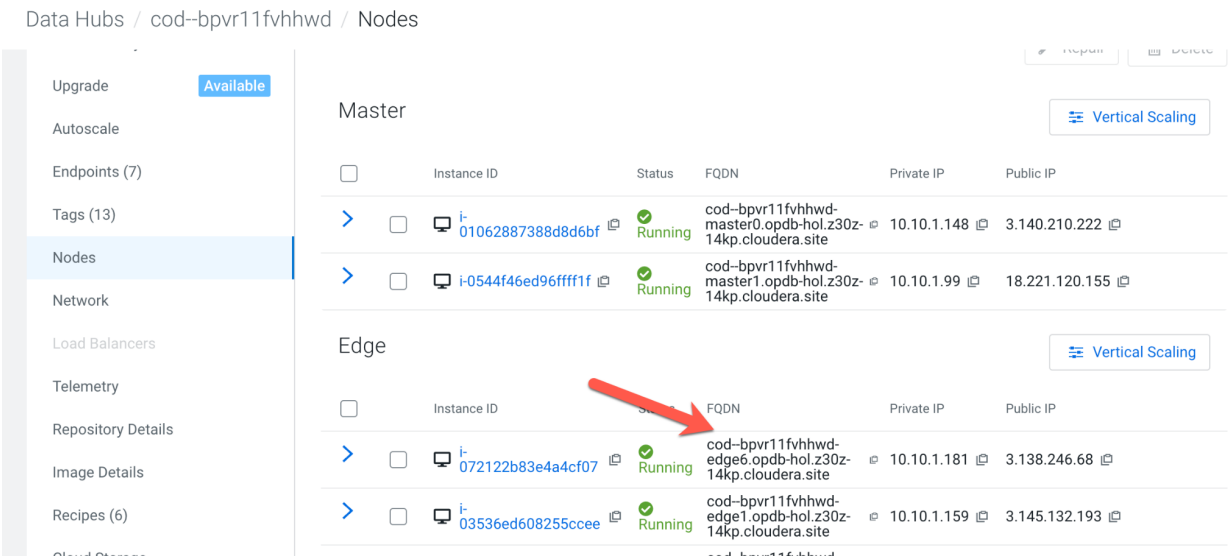
- To identify the FQDN of the edge node to leverage SSH, we'll need to locate the edge node in the COD Data Hub. To do this, click on the **Data Hub** tile in the main CDP Control Plane

- This will open the main Data Hub page. Click on the Data Hub associated with the COD instance.



- Edge nodes are listed under Nodes tab
- Copy your edge node FQDN using the icon next to the FQDN name:

user	**edge node fqn**
user046	cod-1ihojougenp25-edge0.tor-hol.z30z-14kp.cloudera.site
user044	cod-1ihojougenp25-edge1.tor-hol.z30z-14kp.cloudera.site



- Now, let's set up your edge node in your shell so it will be easier to connect. On your laptop, add an *EDGENODE* variable to your bash_profile, to have them populated automatically without having to enter them all throughout the workshop

Unset

```
:
#
#use user assigned in lab
#
# EdgeNode
echo "EDGENODE=cod-1ihojougenp25-edge2.tor-hol.z30z-14kp.cloudera.site" >>
~/.bash_profile

echo "COD_USER=<user01-099>" >> ~/.bash_profile
source ~/.bash_profile
```

- Now, SSH to your assigned edge node

Unset

```
ssh $COD_USER@$EDGENODE
```

- Finally, let's set environment variables to avoid needing to remember cryptic COD names. Value for BUCKET and COD variable is captured in section above Storage location and underline datahub name
- On the edge node, set the bucket name and COD edgenode name.

```
Unset
echo "export BUCKET=tor-hol-buk-fdeea6f5" >> ~/.bash_profile
echo "export COD=cod-1ihojougenp25" >> ~/.bash_profile
source ~/.bash_profile
```

- Now, open a second terminal (to be used later), SSH to your assigned edge node

```
Unset
      ssh $COD_USER@$EDGENODE
```

You should now have 2 open terminal sessions.

Workshop

This workshop will demonstrate features and capabilities of COD with a focus on using a JDBC interface provided through Apache Phoenix

You will be executing each exercise against a COD cluster instance. All commands are run on your assigned edge node.

Section One - COD Basics

- Run the cd command to the `cod-workshop` directory on your edge node.

```
Unset
cd cod-workshop/
```

A script has already been run to generate 1M CDR (call data records) in the **cdr** subdirectory.

- Now let's take a look at one line of the CDR data generated:

```
Unset
zcat cdr/cdr-20231201_00.csv.gz | head -1

0033733147213,c1dc8fec-076f-4289-883e-d4b882a0a81d,0033670188928,2023-02-06
00:16:00,2023-02-06
00:23:33,0,SMS,SUCCESS,1,GSM,21889,1.350476,49.690095,9,GSM,2516,5.901936,47.244771
```

This is a compressed CSV file. Here are the significant parameters:

Calling_msisdn : `0033648163427`
Session_id : `2eff6824-6315-4f09-b96c-add56d7d3015`
Called_msisdn : `0033648143665`
date_beginning of the call : `2023-02-06 00:25:00`
Date_end : `2023-02-06 00:38:25`
duration (seconds) : `805`

```
call_type (could be Voice/SMS): Voice
Call_result : SUCCESS
calling_net_type (Mobile Network Code) : 2
Radio_calling : GSM
cell_calling (ID of the cell) : 45343
Longitude of calling cell : 5.147953
Latitude of calling cell : 47.285376
Called_net_type : 2
Radio_called : GSM
Cell_called : 14168
Lon_called : -1.649971
Lat_called : 48.592906
```

Exercise 1: Accessing COD

There are a number of tools and options available to access the HBase cluster managed by COD and the same is applicable for HBase clusters provisioned in CDP Base or CDP Private Cloud clusters.

1. **Phoenix-sqlline CLI** - enables a client to run SQL on HBase. It runs from the command line of your Edge node.

2. **HBase Shell -** enables a client to deploy applications and manage HBase. It also runs from the command line of your Edge node.

3. **External SQL editor tools -** can also connect to databases in a COD cluster, their connection is managed via a gateway node. We will use HUE as SQL Editor, later in the Lab

Access the Database and Tables in COD

Apache Phoenix provides a JDBC interface to connect to a COD cluster. Apache Phoenix allows users and applications to interface with HBase through standard SQL and provides full ACID capabilities and the benefits of schema-on-read.

Apache Phoenix provides for either a **thick client** which resides on the edge node or a **thin client** that allows for connection pooling on a **Phoenix Query Server (PQS)**.

Phoenix-sqlline is typically useful to developers and engineers to prepare and test queries. The Phoenix-sqlline uses the Phoenix thick client.

For this lab, CLI tools are already deployed on the edge node with the correct default parameters; you don't need to specify the arguments (e.g. zookeeper quorum url etc).

NOTE: As mentioned before you should have two separate SSH terminal sessions connecting to Edge node to help facilitate lab work.

Let's first do a quick test on each utility to make sure they are working correctly for the lab.

Using Phoenix-sqlline

- Using one of your 2 SSH sessions, launch Phoenix-sqlline CLI

```
Unset
phoenix-sqlline
0: jdbc:phoenix:>
```

- list your tables with the `!tables` command:

```
Unset
!tables
```

```
+-----------+-------------+-------------+---------------+---------+-----------+---------------------------+-----------------+-------------+-----------------+--------------+------------
--+-------+
| TABLE_CAT | TABLE_SCHEM | TABLE_NAME |  TABLE_TYPE  | REMARKS | TYPE_NAME | SELF_REFERENCING_COL_NAME | REF_GENERATION | INDEX_STATE | IMMUTABLE_ROWS | SALT_BUCKETS |
MULTI_TENANT | VIEW_ |
+-----------+-------------+-------------+---------------+---------+-----------+---------------------------+-----------------+-------------+-----------------+--------------+------------
--+-------+
|           | SYSTEM      | CATALOG     | SYSTEM TABLE |         |           |                           |                 | false       | null            | false
|       |
|           | SYSTEM      | CHILD_LINK  | SYSTEM TABLE |         |           |                           |                 | false       | null            | false
|       |
|           | SYSTEM      | FUNCTION    | SYSTEM TABLE |         |           |                           |                 | false       | null            | false
|       |
|           | SYSTEM      | LOG         | SYSTEM TABLE |         |           |                           |                 | true        | 32              | false
|       |
|           | SYSTEM      | MUTEX       | SYSTEM TABLE |         |           |                           |                 | true        | null            | false
|       |
|           | SYSTEM      | SEQUENCE    | SYSTEM TABLE |         |           |                           |                 | false       | null            | false
|       |
|           | SYSTEM      | STATS       | SYSTEM TABLE |         |           |                           |                 | false       | null            | false
|       |
|           | SYSTEM      | TASK        | SYSTEM TABLE |         |           |                           |                 | false       | null            | false
|       |
+-----------+-------------+-------------+---------------+---------+-----------+---------------------------+-----------------+-------------+-----------------+--------------+------------
--+-------+
```

- Exit phoenix-sqlline

```
Unset
!exit
```

Using the HBase CLI

- Open another SSH session, on your edge node, launch the HBase CLI:

```
Unset
hbase shell
hbase:001:0>
```

- You can list HBase tables with the `list` command:

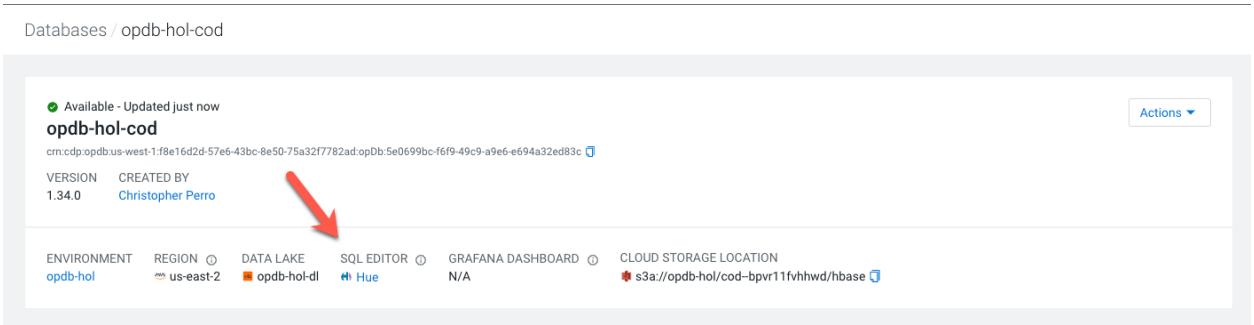
```
Unset
hbase:002:0> list

TABLE
SYSTEM:CATALOG
SYSTEM:CHILD_LINK
SYSTEM:FUNCTION
SYSTEM:LOG
SYSTEM:MUTEX
SYSTEM:SEQUENCE
SYSTEM:STATS
SYSTEM:TASK
OMID_COMMIT_TABLE
OMID_TIMESTAMP_TABLE
10 row(s)
Took 1.9995 seconds
=> ["SYSTEM:CATALOG", "SYSTEM:CHILD_LINK", "SYSTEM:FUNCTION", "SYSTEM:LOG",
"SYSTEM:MUTEX", "SYSTEM:SEQUENCE", "SYSTEM:STATS", "SYSTEM:TASK",
"OMID_COMMIT_TABLE", "OMID_TIMESTAMP_TABLE"]
hbase:003:0>
```

NOTE: You can use any SQL editors (DBeaver, SQLWorkbench, whatever) to connect to the COD cluster using JDBC URL. We will be using phoenix-sqlline for the labwork.

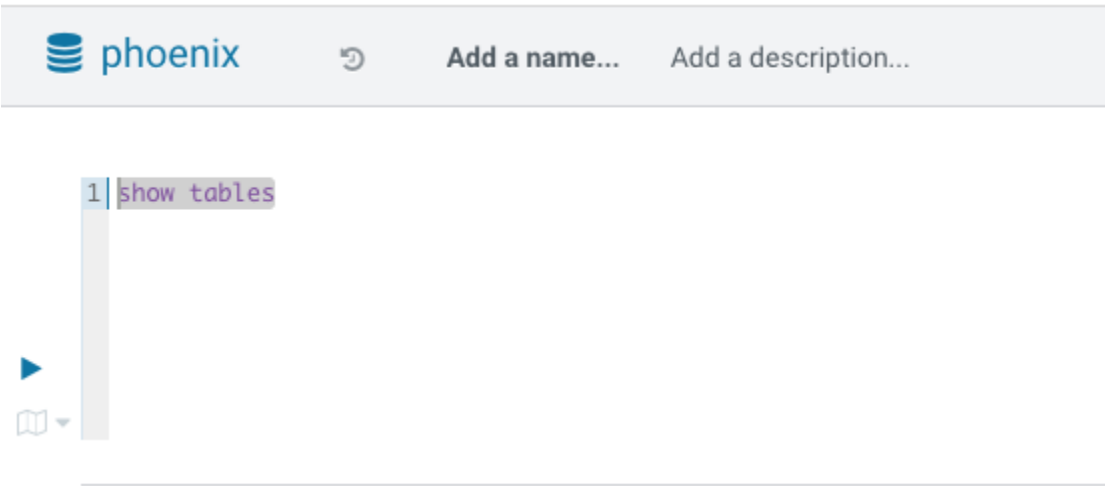
Using Hue

CDP provides a HUE web-based SQL editor UI, it is integrated with COD.

- From the COD database instance page, click on the HUE link to start HUE editor in a new tab.



- Type "`Show tables`" to show the user's tables.



Exercise 2: Namespace and Table

This lab demonstrates how to create a namespace and table, and access table schemas.

Creating Namespace and table

Apache Phoenix provides a SQL layer over Apache Hbase, allowing users/ applications to connect to the Hbase cluster using JDBC connections and interact with the cluster leveraging the widely used SQL language. Apache Phoenix client compiles a user provided SQL query into very efficient HBase native calls thus shielding developers from the complexity of HBase native interface while helping improve developer productivity and reduce application code complexity.

Apache community performed a number of benchmarks, and identified that Apache Phoenix delivers equal or better performance than using Hbase native interface.

Create Table

Following is a list of key points concerning creating an HBase table through Phoenix.

1. A Phoenix table can be created using `CREATE TABLE…` SQL syntax.
2. When a table is created using Apache Phoenix it is mapped directly to the HBase table. So while the user/application is interacting with the Phoenix table, data is stored in the HBase table and HBase controls the management of the data.
3. Any table's primary key(s) defined are mapped to an HBase table's rowkey.

To load the test data created earlier, you'll create a table with a *PRIMARY KEY* set on [`calling_msisdn, session_id`]

WHY?: If the primary key would be set only on `calling_msisdn` then msisdn input records would be automatically deduplicated through the inserts.

- Use Phoenix-sqlline cli to create your first table and replace `${USER}` with your username.

Unset

```
CREATE TABLE IF NOT EXISTS test_${USER}
(calling_msisdn BIGINT NOT NULL,
session_id VARCHAR NOT NULL,
called_msisdn BIGINT,
date_beg VARCHAR,
date_end VARCHAR,
duration INTEGER,
call_type VARCHAR,
call_result CHAR(9),
calling_net_type TINYINT,
radio_calling VARCHAR,
cell_calling INTEGER,
lon_calling DECIMAL(10,8),
lat_calling DECIMAL(10,8),
called_net_type TINYINT,
radio_called VARCHAR,
cell_called INTEGER,
lon_called DECIMAL(10,8),
lat_called DECIMAL(10,8)
CONSTRAINT pk PRIMARY KEY (calling_msisdn,session_id));
```

Now list the tables and notice the table you just created shows in the list

Unset

```
0: jdbc:phoenix:> !tables

+-----------+-------------+--------------+--------------+---------+-----------+-------
--------------------+----------------+-------------+---------------+
| TABLE_CAT | TABLE_SCHEM |  TABLE_NAME  |  TABLE_TYPE  | REMARKS | TYPE_NAME |
SELF_REFERENCING_COL_NAME | REF_GENERATION | INDEX_STATE | IMMUTABLE_ROW |
+-----------+-------------+--------------+--------------+---------+-----------+-------
--------------------+----------------+-------------+---------------+
|           | SYSTEM      | CATALOG      | SYSTEM TABLE |         |           |
|                |             | false         |
|           | SYSTEM      | CHILD_LINK   | SYSTEM TABLE |         |           |
|                |             | false         |
```

```
|           | SYSTEM      | FUNCTION     | SYSTEM TABLE |         |           |
|               |             | false        |
|           | SYSTEM      | LOG          | SYSTEM TABLE |         |           |
|               |             | true         |
|           | SYSTEM      | MUTEX        | SYSTEM TABLE |         |           |
|               |             | true         |
|           | SYSTEM      | SEQUENCE     | SYSTEM TABLE |         |           |
|               |             | false        |
|           | SYSTEM      | STATS        | SYSTEM TABLE |         |           |
|               |             | false        |
|           | SYSTEM      | TASK         | SYSTEM TABLE |         |           |
|               |             | false        |
|           |             | TEST_NLADDHA | TABLE        |         |           |
|               |             | false        |
+-----------+-------------+--------------+--------------+---------+-----------+-------
--------------------+----------------+-------------+---------------+
0: jdbc:phoenix:>
```

This has created a simple phoenix table without any salting applied. So the underlying table is created with only one region. We will cover SALTING and SALT_BUCKETS later.

- **Using the HBase CLI,** let's check in Hbase using hbase-shell, `list` command provides a list of Hbase tables and `list_regions` command provides a list of regions associated with the specified table. Make sure you type the table name in **ALL CAPS**.

Unset

```
hbase:003:0> list

hbase:004:0> list_regions "TEST_${USER}"
                                                                                SERVER_NAME |
REGION_NAME |  START_KEY |    END_KEY |  SIZE |   REQ |   LOCALITY |
 ------------------------------------------------------------------------------- |
------------------------------------------------------------ | ---------- |
---------- | ----- | ----- | ---------- |
 cod-bhyfehf766wh-worker4.ps-sandb.a465-9q4k.cloudera.site,16020,1689078075786 |
TEST_NLADDHA,,1689333890021.a4f5c6a922bb88ff79d6cd20bec9d32e. |            |
|     0 |     1 |        0.0 |
 1 rows
```

```
Took 0.5524 seconds
hbase:005:0>
```

Notice also that the table is created under the default namespace (database schema).

Now look at the table, notice the table columns all appear in uppercase. Notice also the Primary Key appears in another color.

- **Use the Phoenix-sqlline cli** to perform a `SELECT *` from newly created table.

Unset

```
SELECT * FROM test_${USER};

+----------------+------------+---------------+----------+
| CALLING_MSISDN | SESSION_ID | CALLED_MSISDN | DATE_BEG |
+----------------+------------+---------------+----------+
+----------------+------------+---------------+----------+
No rows selected (0.033 seconds)
```

NOTE: phoenix-sqlline requires a semicolon at the end of all SQL queries

Identifying Table Structure and Primary Keys

Let's look at the table schema. This is useful when the table structure/schema is unknown. You can do with `!describe` command

- Use Phoenix-sqlline cli to execute the `!describe` command

Unset

```
0: jdbc:phoenix:> !describe TEST_${USER}
```

```
+-----------+-------------+--------------+------------------+-----------+-----------+-------------+-----------
----+---------------+--------------+
| TABLE_CAT | TABLE_SCHEM |  TABLE_NAME  |   COLUMN_NAME    | DATA_TYPE | TYPE_NAME | COLUMN_SIZE |
BUFFER_LENGTH | DECIMAL_DIGITS | NUM_PREC_RAD |
+-----------+-------------+--------------+------------------+-----------+-----------+-------------+-----------
----+---------------+--------------+
|           |             | TEST_NLADDHA | CALLING_MSISDN   | -5        | BIGINT    | null        | null
| null           | null         |
|           |             | TEST_NLADDHA | SESSION_ID       | 12        | VARCHAR   | null        | null
| null           | null         |
|           |             | TEST_NLADDHA | CALLED_MSISDN    | -5        | BIGINT    | null        | null
| null           | null         |
|           |             | TEST_NLADDHA | DATE_BEG         | 12        | VARCHAR   | null        | null
| null           | null         |
|           |             | TEST_NLADDHA | DATE_END         | 12        | VARCHAR   | null        | null
| null           | null         |
|           |             | TEST_NLADDHA | DURATION         | 4         | INTEGER   | null        | null
| null           | null         |
|           |             | TEST_NLADDHA | CALL_TYPE        | 12        | VARCHAR   | null        | null
| null           | null         |
|           |             | TEST_NLADDHA | CALL_RESULT      | 1         | CHAR      | 9           | null
| null           | null         |
|           |             | TEST_NLADDHA | CALLING_NET_TYPE | -6        | TINYINT   | null        | null
| null           | null         |
|           |             | TEST_NLADDHA | RADIO_CALLING    | 12        | VARCHAR   | null        | null
| null           | null         |
|           |             | TEST_NLADDHA | CELL_CALLING     | 4         | INTEGER   | null        | null
| null           | null         |
|           |             | TEST_NLADDHA | LON_CALLING      | 3         | DECIMAL   | 10          | null
| 8              | null         |
|           |             | TEST_NLADDHA | LAT_CALLING      | 3         | DECIMAL   | 10          | null
| 8              | null         |
|           |             | TEST_NLADDHA | CALLED_NET_TYPE  | -6        | TINYINT   | null        | null
| null           | null         |
|           |             | TEST_NLADDHA | RADIO_CALLED     | 12        | VARCHAR   | null        | null
| null           | null         |
|           |             | TEST_NLADDHA | CELL_CALLED      | 4         | INTEGER   | null        | null
| null           | null         |
|           |             | TEST_NLADDHA | LON_CALLED       | 3         | DECIMAL   | 10          | null
| 8              | null         |
|           |             | TEST_NLADDHA | LAT_CALLED       | 3         | DECIMAL   | 10          | null
| 8              | null         |
+-----------+-------------+--------------+------------------+-----------+-----------+-------------+-----------
----+---------------+--------------+
```

When you want to check table primary keys, it can be displayed using `!primarykeys` command

- Use Phoenix-sqlline cli to execute the `!primarykeys` command

```
Unset
0: jdbc:phoenix:> !primarykeys TEST_${USER}

+-----------+-------------+-------------+----------------+---------+---------+-----
--------+-----------+-----------+-------------+---------+-----+
| TABLE_CAT | TABLE_SCHEM |  TABLE_NAME  |  COLUMN_NAME   | KEY_SEQ | PK_NAME |
ASC_OR_DESC | DATA_TYPE | TYPE_NAME | COLUMN_SIZE | TYPE_ID | VIE |
+-----------+-------------+-------------+----------------+---------+---------+-----
--------+-----------+-----------+-------------+---------+-----+
|           |             | TEST_NLADDHA | CALLING_MSISDN | 1       | PK      | A
| -5        | BIGINT    | null        | -5      |     |
|           |             | TEST_NLADDHA | SESSION_ID     | 2       | PK      | A
| 12        | VARCHAR   | null        | 12      |     |
+-----------+-------------+-------------+----------------+---------+---------+-----
--------+-----------+-----------+-------------+---------+-----+
```

Note that KEY_SEQ column provides the order of primary keys, it is important information while defining a performant `SELECT` query to read record(s).

Create Table Namespace

A table namespace (database schema) allows you to group a table under a defined namespace.

- First create a WORKSHOP_<USERNAME> schema by using the `CREATE SCHEMA` syntax. We are adding the username value since multiple schemas with the same name cannot exist.

```
Unset
0: jdbc:phoenix:> CREATE SCHEMA WORKSHOP_${USER};

No rows affected (0.343 seconds)
```

- Create the same table as above but under the WORKSHOP_<USERNAME> schema. Note that the table name uses the format of `<namespace>.<tablename>`

```
Unset
0: jdbc:phoenix:> CREATE TABLE IF NOT EXISTS workshop_${USER}.test_${USER}
(calling_msisdn BIGINT NOT NULL,
session_id VARCHAR NOT NULL,
called_msisdn BIGINT,
date_beg VARCHAR,
date_end VARCHAR,
duration INTEGER,
call_type VARCHAR,
call_result CHAR(9),
calling_net_type TINYINT,
radio_calling VARCHAR,
cell_calling INTEGER,
lon_calling DECIMAL(10,8),
lat_calling DECIMAL(10,8),
called_net_type TINYINT,
radio_called VARCHAR,
cell_called INTEGER,
lon_called DECIMAL(10,8),
lat_called DECIMAL(10,8)
CONSTRAINT pk PRIMARY KEY (calling_msisdn,session_id));
```

- Now check the list of tables using the `!tables` command. Notice that the results now include both tables: one with schema name WORKSHOP and another without the schema name (created earlier). Note that both are two separate tables.

```
Unset
0: jdbc:phoenix:> !tables

+-----------+-------------+--------------+--------------+---------+-----------+---------------------------+---
-------------+-------------+--------+
| TABLE_CAT | TABLE_SCHEM |  TABLE_NAME  |  TABLE_TYPE  | REMARKS | TYPE_NAME | SELF_REFERENCING_COL_NAME |
REF_GENERATION | INDEX_STATE | IMMUTA |
+-----------+-------------+--------------+--------------+---------+-----------+---------------------------+---
-------------+-------------+--------+
|           | SYSTEM      | CATALOG      | SYSTEM TABLE |         |           |                           |
|             | false  |
|           | SYSTEM      | CHILD_LINK   | SYSTEM TABLE |         |           |                           |
|             | false  |
|           | SYSTEM      | FUNCTION     | SYSTEM TABLE |         |           |                           |
|             | false  |
|           | SYSTEM      | LOG          | SYSTEM TABLE |         |           |                           |
|             | true   |
```

```
|           | SYSTEM      | MUTEX        | SYSTEM TABLE |         |           |                           |
|             | true   |
|           | SYSTEM      | SEQUENCE     | SYSTEM TABLE |         |           |                           |
|             | false  |
|           | SYSTEM      | STATS        | SYSTEM TABLE |         |           |                           |
|             | false  |
|           | SYSTEM      | TASK         | SYSTEM TABLE |         |           |                           |
|             | false  |
|           |             | TEST_NLADDHA | TABLE        |         |           |                           |
|             | false  |
|           | WORKSHOP    | TEST_NLADDHA | TABLE        |         |           |                           |
|             | false  |
+-----------+-------------+--------------+--------------+---------+-----------+---------------------------+---
-------------+-------------+--------+
```

Lets now check the same tables in HBase using hbase-shell `list` command. This is a simple command to provide a list of all HBase tables.

- Using hbase-shell cli, type the `list` command

Unset

```
hbase:005:0> list

TABLE
SYSTEM:CATALOG
SYSTEM:CHILD_LINK
SYSTEM:FUNCTION
SYSTEM:LOG
SYSTEM:MUTEX
SYSTEM:SEQUENCE
SYSTEM:STATS
SYSTEM:TASK
WORKSHOP:TEST_${USER}
OMID_COMMIT_TABLE
OMID_TIMESTAMP_TABLE
TEST_${USER}
12 row(s)
Took 0.0138 seconds
=> ["SYSTEM:CATALOG", "SYSTEM:CHILD_LINK", "SYSTEM:FUNCTION", "SYSTEM:LOG",
"SYSTEM:MUTEX", "SYSTEM:SEQUENCE", "SYSTEM:STATS", "SYSTEM:TASK",
"WORKSHOP:TEST_NLADDHA", "OMID_COMMIT_TABLE", "OMID_TIMESTAMP_TABLE",
"TEST_NLADDHA"]
```

```
hbase:006:0>
```

NOTE: All phoenix table names and their columns names are CAPITALIZED by default in HBase, so remember to type phoenix table names in CAPITAL letters when using the hbase-shell CLI

TIP: In a Production deployment, it is best practice to create a database schema (aka table namespace), and then create tables under the appropriate schema. This allows you to group tables using namespaces.

Table Data Handling - UPSERT/READ/DELETE

Data in HBase is never static. CRUD (create, read, update, delete) is fundamental to any database operation, whether relational or a nosql database like HBase. Let's see how the phoenix-sqlline handles each scenario.

- **Using your phoenix-sqlline CLI**, let's do the following:

    1. `UPSERT` to ingest and/update record(s) to table
    2. `SELECT` to read record(s)
    3. `DELETE` to delete record(s)

Unset

```
UPSERT INTO test_${USER} (CALLING_MSISDN,SESSION_ID)
VALUES(123456789,'session');

1 row affected (0.064 seconds)
```

```
select CALLING_MSISDN,SESSION_ID,CALLED_MSISDN from test_${USER} where
CALLING_MSISDN=123456789;

+---------------+------------+---------------+
| CALLING_MSISDN | SESSION_ID | CALLED_MSISDN |
+---------------+------------+---------------+
| 123456789      | session    | null          |
+---------------+------------+---------------+
1 row selected (0.024 seconds)



DELETE FROM test_${USER} WHERE CALLING_MSISDN=123456789;

1 row affected (0.029 seconds)

!exit
```

Now let's insert some lines by importing a file. To exit from your Phoenix CLI, type `!exit` or you can open a new terminal window.

- On your edge node, create a file named data.csv with 10 lines of data:

```
Unset
echo
"0033733147213,c1dc8fec-076f-4289-883e-d4b882a0a81d,0033670188928,2023-02-06
00:16:00,2023-02-06
00:23:33,0,SMS,SUCCESS,1,GSM,21889,1.350476,49.690095,9,GSM,2516,5.901936,47.24
4771
0033648163427,2eff6824-6315-4f09-b96c-add56d7d3015,0033648143665,2023-02-06
00:25:00,2023-02-06
00:38:25,805,Voice,SUCCESS,2,GSM,45343,5.147953,47.285376,2,GSM,14168,-1.649971
,48.592906
0033690127891,c2d0fe02-4096-4cd1-aea0-7b46dc41aace,0033653204161,2023-02-06
00:20:00,2023-02-06
00:20:45,45,Voice,SUCCESS,9,GSM,11510,5.317312,47.944747,10,GSM,22656,4.871122,
45.031399
0033751119091,ce8bfe49-ab05-42ab-b808-94f6dda09c6c,0033795178310,2023-02-06
00:11:00,2023-02-06
00:27:02,962,Voice,SUCCESS,9,GSM,15438,5.894631,48.575936,2,GSM,7574,0.186621,4
6.057284
```

```
0033780183331,3aefe1a2-5be1-47bf-b9b3-ca941a3ba85a,0033635151591,2023-02-06
00:05:00,2023-02-06
00:16:35,695,Voice,SUCCESS,21,GSM,449,3.6701202392578,50.440292358398,10,GSM,45
201,5.064914,45.672283
0033678176048,79ae6532-a4b8-4695-98f4-a76cea2c2fad,0033616116529,2023-02-06
00:21:00,2023-02-06
00:31:06,606,Voice,SUCCESS,1,GSM,1857,4.853037,45.311832,15,GSM,29308,7.204447,
43.762039
0033693155656,10223aeb-d35f-453d-a378-c9e4b4b0fefa,003342753209969,2023-02-06
00:39:00,2023-02-06
00:43:00,240,Voice,SUCCESS,21,GSM,24614,0.519582,48.096866,1,GSM,14410,7.271668
,43.699879
0033772106353,56531bc3-e929-4c4a-ae65-4d80f0da9686,0033758186973,2023-02-06
00:39:00,2023-02-06
00:40:50,110,Voice,SUCCESS,2,GSM,12969,2.470707,49.099391,20,GSM,57388,4.771405
,44.154108
0033725195471,dfde6cc2-c75f-47ca-9a0d-7f573f56fca0,0033716114791,2023-02-06
00:13:00,2023-02-06
00:24:04,664,Voice,SUCCESS,15,GSM,29308,7.204447,43.762039,8,GSM,5724,6.706298,
49.127397
0033716123232,b73e3b81-a90a-4661-800c-3e6dd75d8a53,0033617105755,2023-02-06
00:38:00,2023-02-06
00:52:23,0,Voice,FAILURE,1,GSM,52377,5.975871,47.218095,8,GSM,10061,6.114757,49
.071954" > ./data.csv
```

Now let's import that data to the table we created above.

- From the edge node, execute the following command to import records from a file. This will use the *phoenix-psql* utility. You will perform the following steps:

    1. Run the `phoenix-psql` command. This will list all available command line options
    2. Run the `phoenix-psql -t` command. This will load the data into the table
    3. Run `phoenix-sql` and execute a `SELECT *` statement to retrieve the records. Be sure to replace `<USERNAME>` with your username IN ALL CAPS.

Unset

```
phoenix-psql
```

```
phoenix-psql -t TEST_${USER} data.csv

CSV Upsert complete. 10 rows upserted
Time: 0.063 sec(s)

phoenix-sqlline

0: jdbc:phoenix:> select * from test_${USER}; #(output has been cut)

+----------------+--------------------------------------+---------------+-----------------
----+
| CALLING_MSISDN |              SESSION_ID              | CALLED_MSISDN |      DATE_BEG
|
+----------------+--------------------------------------+---------------+-----------------
----+
| 33648163427    | 2eff6824-6315-4f09-b96c-add56d7d3015 | 33648143665   | 2023-02-06
00:25:00 |
| 33678176048    | 79ae6532-a4b8-4695-98f4-a76cea2c2fad | 33616116529   | 2023-02-06
00:21:00 |
| 33690127891    | c2d0fe02-4096-4cd1-aea0-7b46dc41aace | 33653204161   | 2023-02-06
00:20:00 |
| 33693155656    | 10223aeb-d35f-453d-a378-c9e4b4b0fefa | 3342753209969 | 2023-02-06
00:39:00 |
| 33716123232    | b73e3b81-a90a-4661-800c-3e6dd75d8a53 | 33617105755   | 2023-02-06
00:38:00 |
| 33725195471    | dfde6cc2-c75f-47ca-9a0d-7f573f56fca0 | 33716114791   | 2023-02-06
00:13:00 |
| 33733147213    | c1dc8fec-076f-4289-883e-d4b882a0a81d | 33670188928   | 2023-02-06
00:16:00 |
| 33751119091    | ce8bfe49-ab05-42ab-b808-94f6dda09c6c | 33795178310   | 2023-02-06
00:11:00 |
| 33772106353    | 56531bc3-e929-4c4a-ae65-4d80f0da9686 | 33758186973   | 2023-02-06
00:39:00 |
| 33780183331    | 3aefe1a2-5be1-47bf-b9b3-ca941a3ba85a | 33635151591   | 2023-02-06
00:05:00 |
+----------------+--------------------------------------+---------------+-----------------
----+
10 rows selected (0.052 seconds)
```

Exercise 3: Dynamic Columns and Table Views

Understanding Dynamic Columns

Phoenix supports dynamic schemas. At runtime, a column can be added without redefining the table. It is called a *dynamic column*.

To do so, we will perform an `upsert` statement and add the new column name along with its type. In this case, we will add a `boolean` flag field to the call record for demonstration purposes.

NOTE: The `UPSERT` command is documented here: https://phoenix.apache.org/atomic_upsert.html

We will use the HUE editor in this lab. To access HUE see section Using Hue. Alternatively you can do the following using phoenix-sqlline

Adding a Dynamic Column

- Let's add a new dynamic column called "`FLAG`" of `Boolean` type to your previously created table. Be sure to specify the dynamic column name and its data type in the `UPSERT` query. Replace `${USER}` with your user

```
Unset
UPSERT INTO TEST_${USER}
(CALLING_MSISDN,
SESSION_ID,
CALLED_MSISDN,
DATE_BEG,DATE_END,
DURATION,CALL_TYPE,
CALL_RESULT,
CALLING_NET_TYPE,
RADIO_CALLING,CELL_CALLING,
LON_CALLING,
LAT_CALLING,
CALLED_NET_TYPE,
RADIO_CALLED,
CELL_CALLED,
```

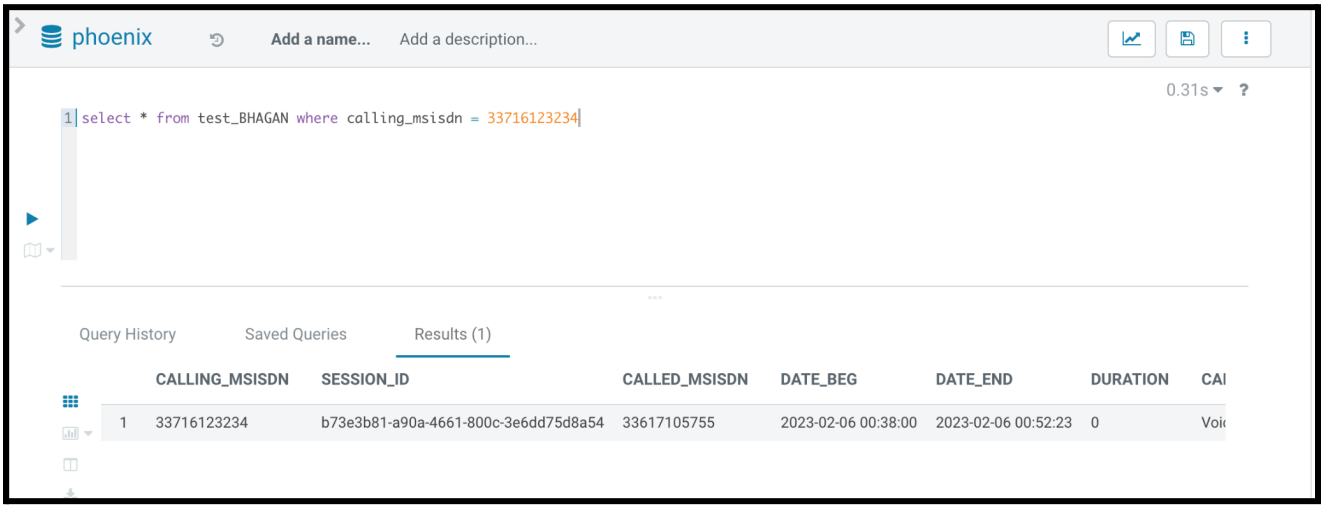
```
LON_CALLED,
LAT_CALLED,
FLAG BOOLEAN)
VALUES
(0033716123234,'b73e3b81-a90a-4661-800c-3e6dd75d8a54',0033617105755,'2023-02-06
00:38:00','2023-02-06
00:52:23',0,'Voice','FAILURE',1,'GSM',52377,5.975871,47.218095,8,'GSM',10061,6.
114757,49.071954,TRUE);

SELECT * FROM TEST_${USER};
```

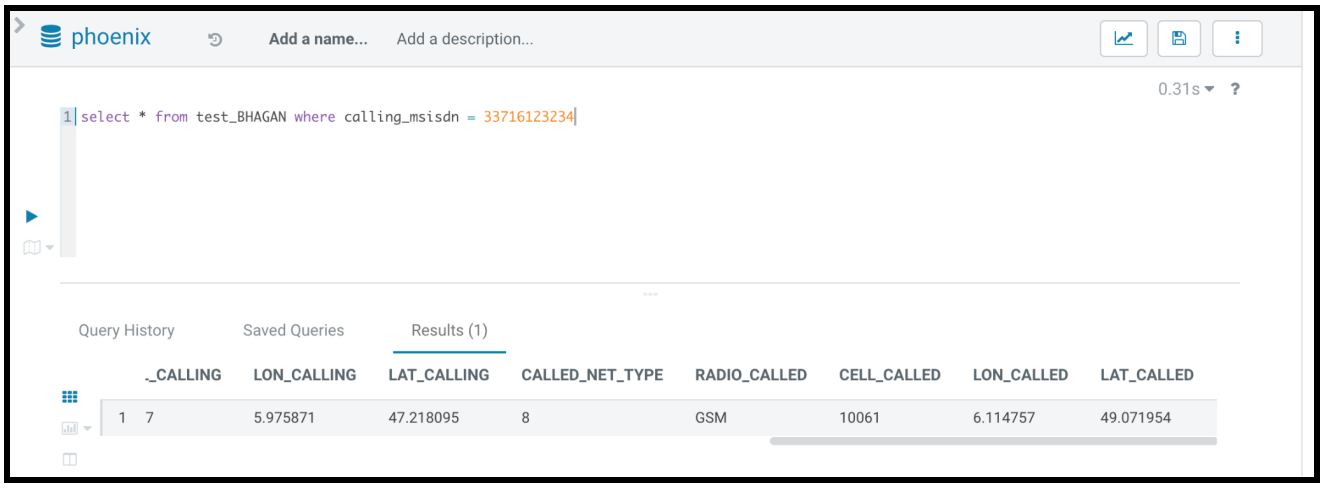
Reading Dynamic Columns from a Table

- Without referencing the dynamic column in your `SELECT` query you may notice that the new field and value is not returned.

Unset

```
SELECT * FROM test_${USER} WHERE calling_msisdn = 33716123234;
```





- We need to specify the dynamic field and its data type in our SELECT statement to let it know that we want to read data from the dynamic column as well.

```
Unset
SELECT * FROM test_${USER} (FLAG BOOLEAN) WHERE calling_msisdn = 33716123234;
```

If you execute the same query from phoenix-sqlline, you'll notice that only the columns that fit in the terminal are displayed

```
0: jdbc:phoenix:> SELECT * FROM TEST_USER001 WHERE CALLING_MSISDN=1000;
+---------------+-----------+--------------+-----------+-----------+----------+-----------+-------------+-----------------+--------------+--------------+--+
| CALLING_MSISDN | SESSION_ID | CALLED_MSISDN |  DATE_BEG  |  DATE_END  | DURATION | CALL_TYPE | CALL_RESULT | CALLING_NET_TYPE | RADIO_CALLING | CELL_CALLING | |
+---------------+-----------+--------------+-----------+-----------+----------+-----------+-------------+-----------------+--------------+--------------+--+
| 1000          | 1000a     | 2000         | 2023-01-01 | 2023-01-01 | 10       | LOCAL     | GOOD        | 5               | N            | 1            | |
+---------------+-----------+--------------+-----------+-----------+----------+-----------+-------------+-----------------+--------------+--------------+--+
1 row selected (0.027 seconds)
```

One workaround is to only select the columns you want to see

Unset

```
SELECT CALLING_MSISDN,SESSION_ID,FLAG FROM TEST_${USER} (FLAG BOOLEAN) WHERE
CALLING_MSISDN=33716123234;

+----------------+--------------------------------------+------+
| CALLING_MSISDN |              SESSION_ID              | FLAG |
+----------------+--------------------------------------+------+
| 33716123234    | b73e3b81-a90a-4661-800c-3e6dd75d8a54 | true |
+----------------+--------------------------------------+------+
```

Another option is to leverage the `!outputformat vertical` option.

- Try running the full `SELECT *` query again, but this time include the `!outputformat vertical` option

Unset

```
!outputformat vertical
SELECT * FROM TEST_${USER} (FLAG BOOLEAN) WHERE CALLING_MSISDN=33716123234;

CALLING_MSISDN    33716123234
SESSION_ID        b73e3b81-a90a-4661-800c-3e6dd75d8a54
CALLED_MSISDN     0033617105755
DATE_BEG          2023-02-06 00:38:00
DATE_END          2023-02-06 00:52:23
DURATION          0
CALL_TYPE         Voice
CALL_RESULT       Failure
CALLING_NET_TYPE  1
RADIO_CALLING     GSM
CELL_CALLING      52377
LON_CALLING       5.975871
LAT_CALLING       47.218095
```

```
CALLED_NET_TYPE   8
RADIO_CALLED      GSM
CELL_CALLED       10061
LON_CALLED        6.114757
LAT_CALLED        49.071954
FLAG              true

1 row selected (0.012 seconds)
```

NOTE: There are a number of other formats you can use. Feel free to experiment with others. In order to return to the default, execute the `!outputformat table` option.

NOTE: Dynamic columns are not defined in table schema and hence are not displayed through `!describe` command

USE CASE: Our customers are extensively using dynamic column features to simplify their solution design.

For example, an Insurance client, selling various insurance products (e.g. home insurance, car insurance) are managed by various systems. For downstream data processing purposes they require all insurance policy records from various systems to be accessible in a centralized location.

While there are few common attributes (fields) across product families, each one also has a set of product specific fields which are not common across other products.
The customer defined a policy table using Apache Phoenix in HBase where common fields across product families are defined as static fields (i.e. part of table definition) and product specific fields are recorded as dynamic fields.

Through the dynamic column (schema evolution) feature, Apache Phoenix (HBase) provided them a capability where they can bring all policy records to a single location..
This solution also supported the need for a downstream data processing pipeline where it processed and updated each record to add new computed fields (as dynamic columns) for each record (based on applicable business rule).

Section 2 - COD Operations

Exercise 4: Monitoring COD

In this exercise we will look at various tools to monitor your COD cluster. These tools include HBase native tools, as well as a built-in Grafana dashboard. First off, we will look at how to monitor for the common issue of region hotspotting.

Region hotspotting can be a familiar performance issue on an HBase cluster. In the majority cases, region hotspotting is due to a poorly designed HBase table. HBase clusters can scale to petabytes of data by providing horizontal scalability. Tables are divided into regions and regions are spread over the nodes in the cluster. The regions are hosted and managed by region servers. If data is being loaded into and accessed from only one or a few number of regions and not utilizing the rest of the cluster, this is termed as region hotspotting. It is always important to avoid region hotspotting.

To have more understanding about what's going on in HBase and how we can detect region hotspotting, we're going to use two things: `hbtop` and `pe`.

hbtop

HBase `hbtop` is a real-time monitoring tool for HBase, inspired by the 'top' command you might know from Unix. `hbtop` provides two key functionalities:

1. A convenient way to see and understand what's happening in a COD cluster instance, like whether a region is over-solicited compared to the others, data locality, etc.

2. Stats can be displayed at different levels (namespace, table, region, regionserver) and you can drill down on a metric. For example if you spot a hot region in a namespace, you can then go down to the table then the regions.

- Firstly, on your edge node, launch `hbtop`

```
Unset
hbase hbtop
```

- Now we will examine the various parameters. Execute each one and notice the results.

1. Enter **`m`** to change mode from region to table and then to namespace
2. Enter **`d and then "1"`** to change computing delay to 1s
3. Type **`ESC`** to exit

pe

`pe` is a versatile tool for testing HBase performance. It is capable of testing three key access patterns:

1. Random reads
2. Random writes
3. Sequential scan

In this section, we will quickly run through how to set up pe and how to use it to best understand how our HBase cluster will perform under various access conditions.

Though `pe` provides a lot of option, in this section we will only do the following:

1. Launch a performance evaluation
2. Presplit on 10 regions
3. Load data using random writes with 3 threads
4. Random Writes
5. Sequential Writes

- Type `CTRL+z` to exit

Region Hotspotting

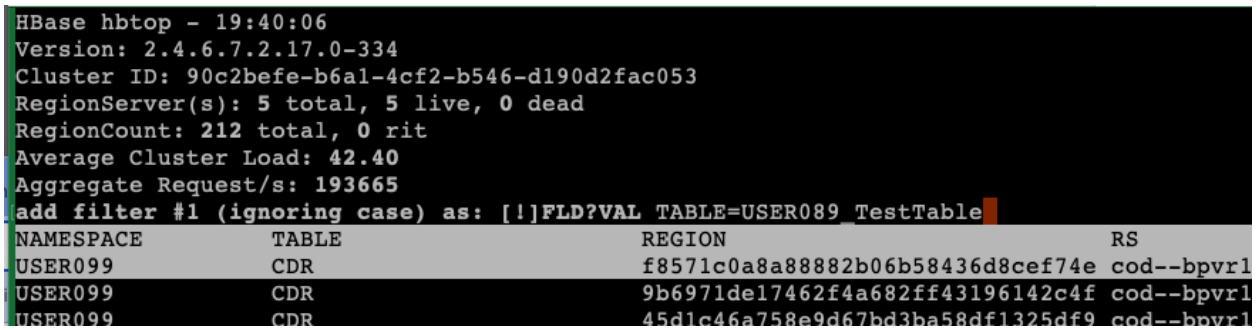
Now using two separate SSH sessions to the edge node, we will start the `pe` tool in one window to generate data load and use the other window to monitor the table regions where data is being loaded.

- In one of your terminal windows, ssh to your edge node. On your edge node, launch `hbtop`.

```
Unset
hbase hbtop
```

- Increase refresh rate from 3 sec to 1 sec, then: go on to the region level and filter on table `<USERNAME>_TestTable`, which is the name of the table that will be created using the `pe` tool. You'll also sort by RegionName

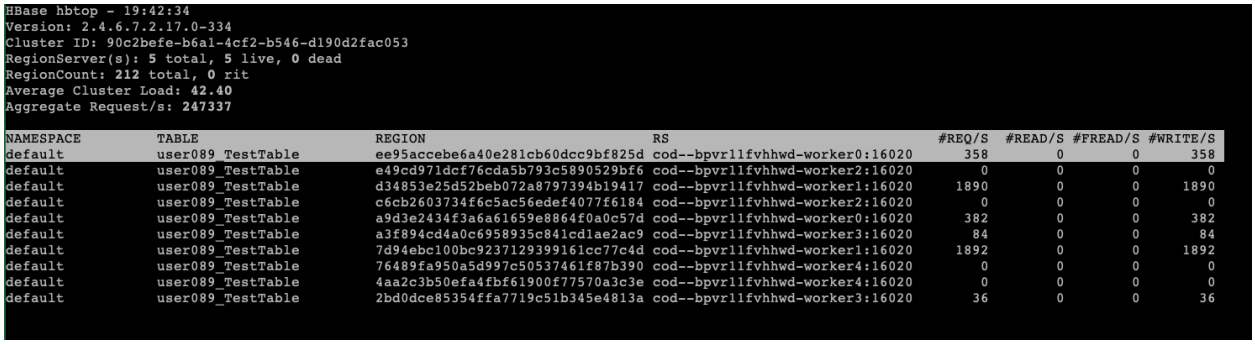
```
Unset
d 1
m [region]
o TABLE=${USER}_TestTable
f [REGION] s q
```



- Using second terminal window, on your edge node, launch `pe`, load data to table with presplitting on 10 regions, and load data using random writes with 3 threads

```
Unset
hbase pe --nomapred --table=${USER}_TestTable --presplit=10 randomWrite 3
```

Take a look at your HBase `hbtop` now, you can see requests well distributed, 150k requests/s total, each thread writing a default number of 1 million lines.



- Now launch the `pe` command again but with a sequential writing process, like writing rowkey 0, 1… to 1M

Unset

```
hbase pe --nomapred --table=${USER}_TestTable --presplit=10 sequentialWrite 3
```

Take a look at the `hbtop` terminal, what are you observing?

It's writing on 3 regions (because 3 threads here), sometimes 4 because of region splitting, but what you're observing here is **REGION HOTSPOTTING**

This is what you want to avoid at all costs! It is very important to have optimal row key design, as well as using table salting for Phoenix tables.

NOTE: If you want to read the standard on HBase row design, here is an excellent article to get you started.

https://ajaygupta-spark.medium.com/design-principles-for-hbase-key-and-rowkey-3016a77fc52d

```
HBase hbtop - 19:47:13
Version: 2.4.6.7.2.17.0-334
Cluster ID: 90c2befe-b6a1-4cf2-b546-d190d2fac053
RegionServer(s): 5 total, 5 live, 0 dead
RegionCount: 212 total, 0 rit
Average Cluster Load: 42.40
Aggregate Request/s: 190074
```

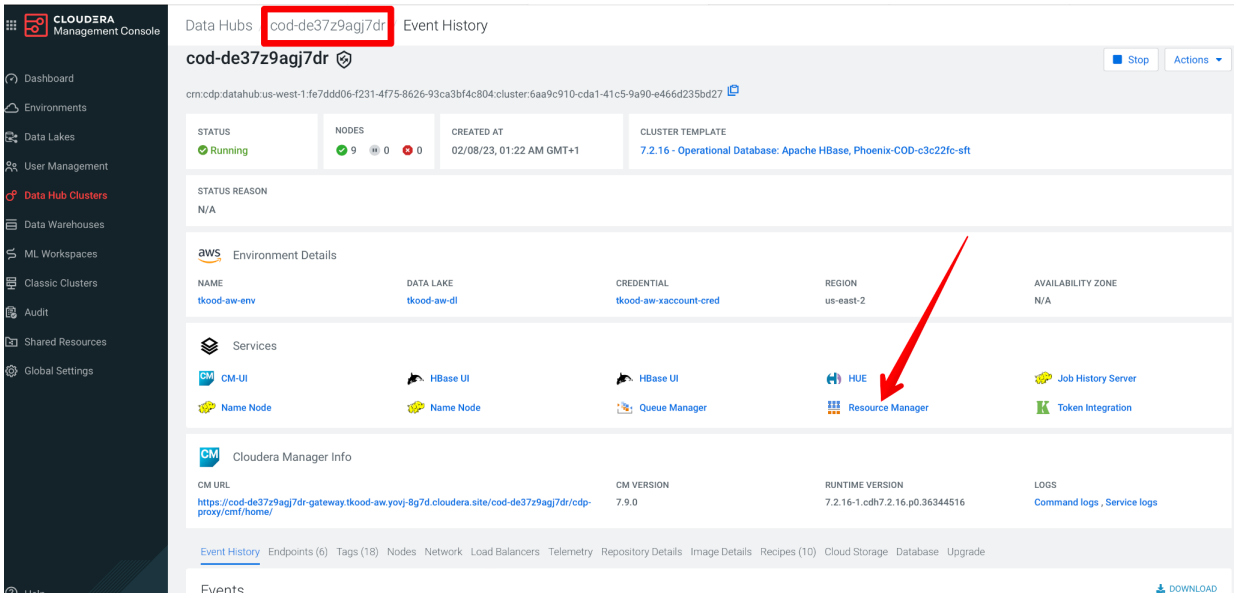
~ — hbtop — ssh user089@cod--bpvr11fvhhwd-edge5.opdb-hol.z30z-14kp.cloudera.site

NAMESPACE	TABLE	REGION	RS	#REQ/S	#READ/S	#FREAD/S	#WRITE/S
default	user089_TestTable	e35e707e70c8ae2816bc2c2408308edc	cod--bpvr11fvhhwd-worker4:16020	22234	0	0	22234
default	user089_TestTable	bccc00b71fc4fa8cb5e5ddaf9c6f4363	cod--bpvr11fvhhwd-worker2:16020	0	0	0	0
default	user089_TestTable	aa6ed8a6a0dea83275f82b0ea981c616	cod--bpvr11fvhhwd-worker0:16020	0	0	0	0
default	user089_TestTable	8f261e82efeced972776df9f5427c008	cod--bpvr11fvhhwd-worker3:16020	0	0	0	0
default	user089_TestTable	887f14a5bca7427862009dd56f667e4e	cod--bpvr11fvhhwd-worker4:16020	16758	0	0	16758
default	user089_TestTable	84b7114a3ceadff0d3a681accf486045	cod--bpvr11fvhhwd-worker1:16020	0	0	0	0
default	user089_TestTable	818766cd5336070364a9a0b0198b0e5b	cod--bpvr11fvhhwd-worker3:16020	0	0	0	0
default	user089_TestTable	5a10fbf9cdc33388fe97c8420b6ebe42	cod--bpvr11fvhhwd-worker2:16020	24256	0	0	24256
default	user089_TestTable	2274c40e169dadf16e740a5ca844a0d9	cod--bpvr11fvhhwd-worker1:16020	0	0	0	0
default	user089_TestTable	0c174f204ca6a7d442fc988d31eb7bf6	cod--bpvr11fvhhwd-worker0:16020	0	0	0	0

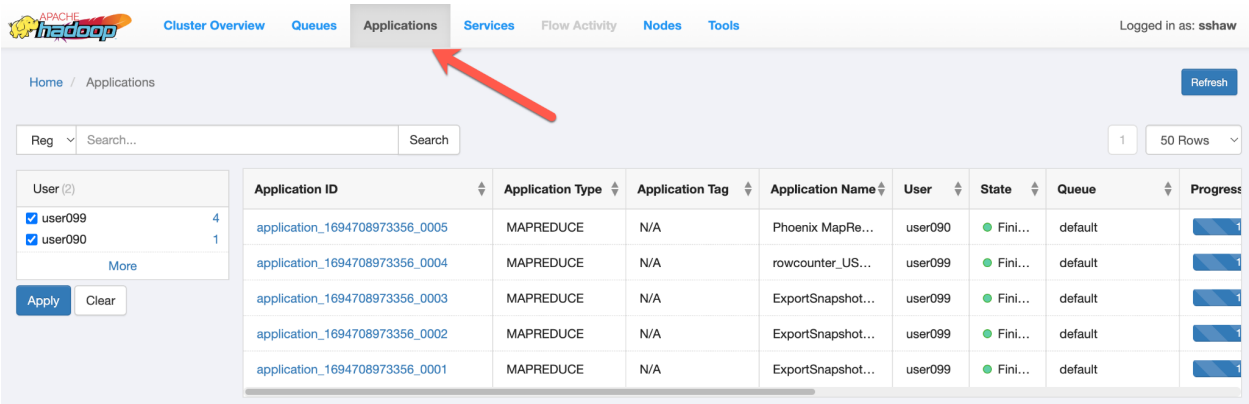
Resource Manager

COD and the underlying HBase environment is still a fully part of the CDP ecosystem. You still have access to many of the open source tools you may be using today on your existing cluster. One of these tools is the YARN Resource Manager. We'll use Resource Manager in more detail later in the lab. For now, let's go to the Resource Manager page

- For that, open ResourceManager from your COD underlying Datahub page:



- Click on the Applications tab. You won't see any jobs here yet for your userid.

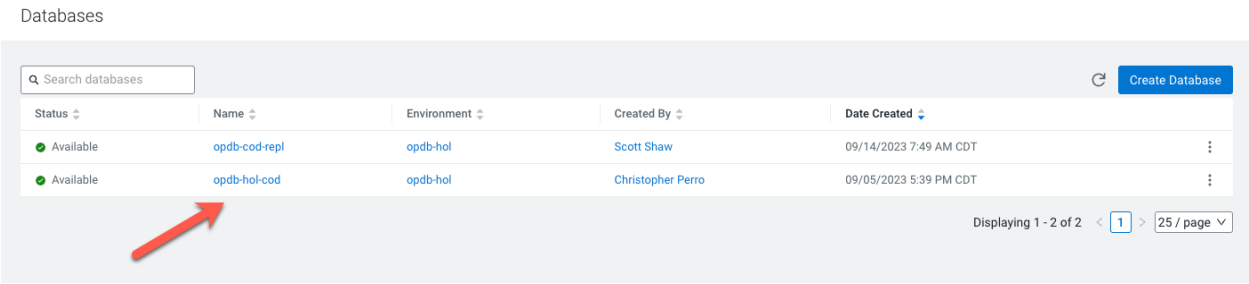


- Leave the tab open and we can see them later.

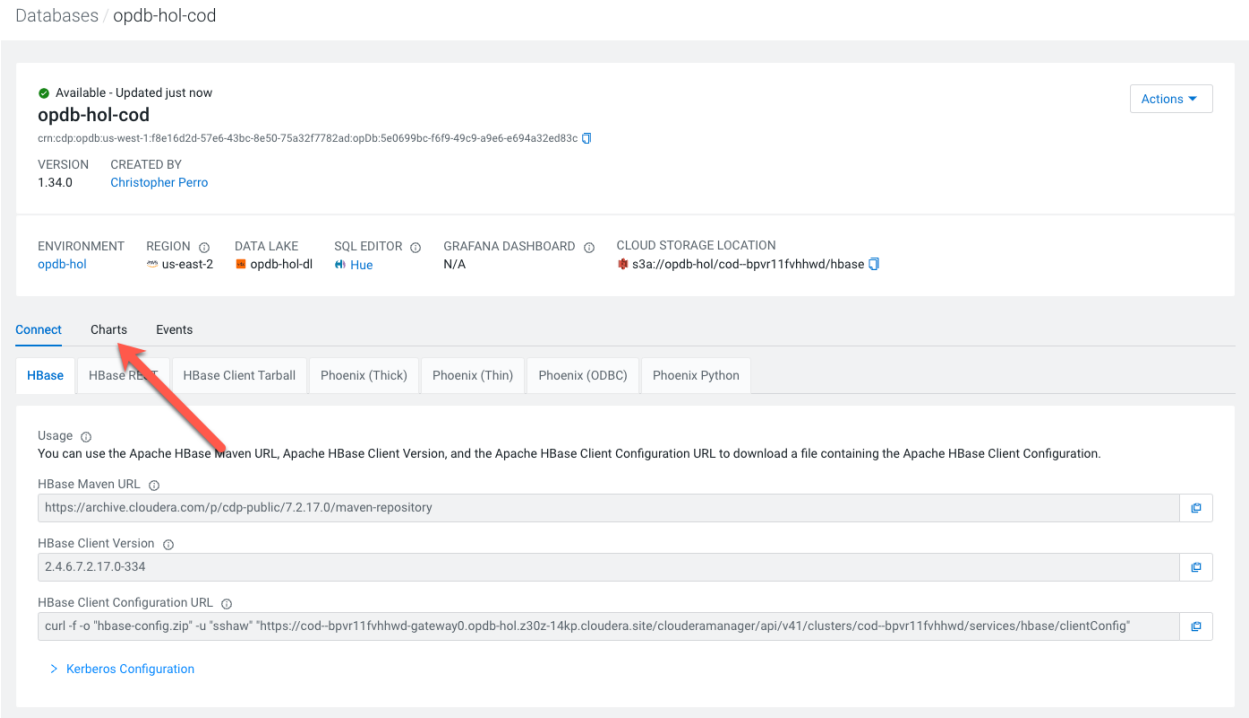
Grafana Charts

Another useful monitoring feature of COD is the use of Grafana Charts. These charts are built into your COD cluster by default. Let's take a quick look at the details they provide.

- Navigate to the COD database page and click on the `opdb-hol-cod` database.

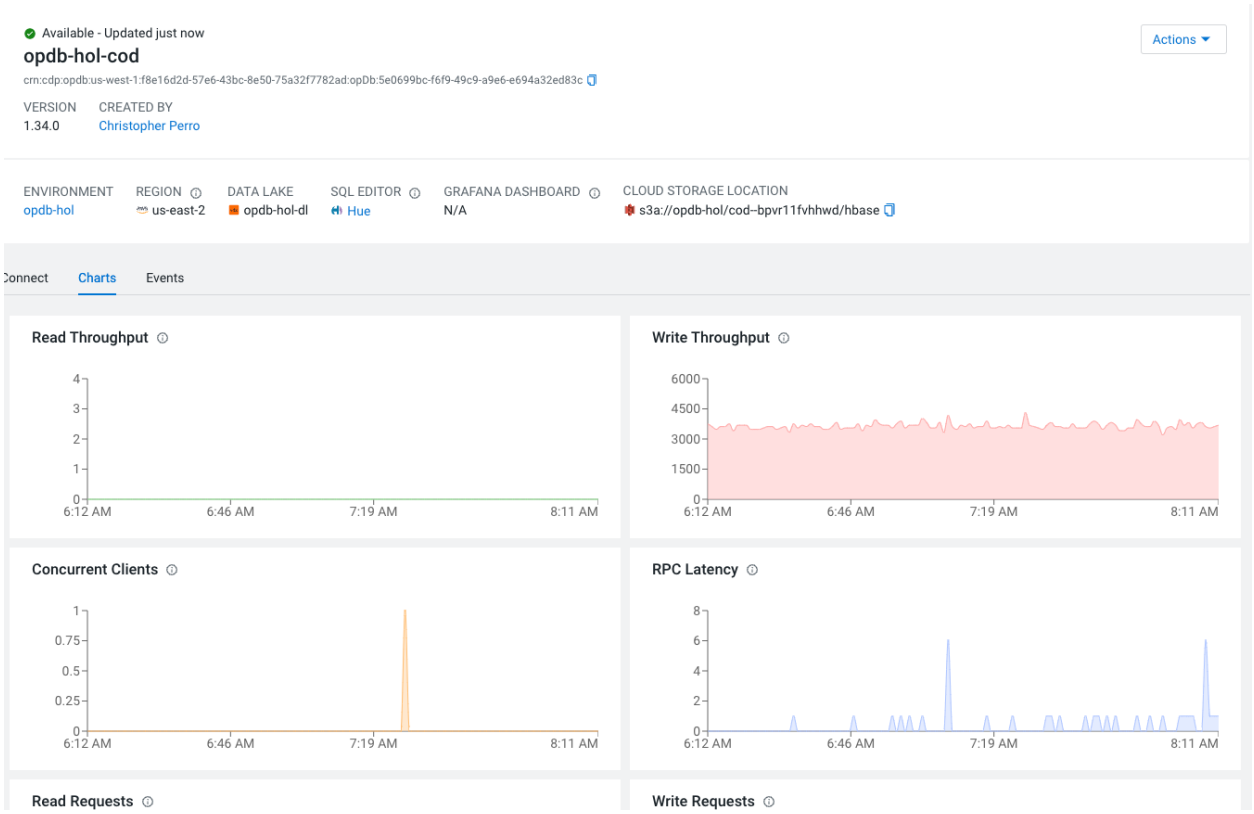


- On the next screen, select the Charts tab to view the graphs.



From this page you are ablt to quickly view a number of key metrics for you COD cluster. These metrics include:

1. Read Throughput
2. Write Throughput
3. Concurrent Clients
4. RPC Latency
5. Read Requests
6. Write Requests
7. P99 Get Latency
8. Block Cache Hit Ratio
9. Compaction Queue Size



These metrics can help an administrator to quickly identify potential issues that may be negatively impacting cluster performance. From here an administrator can identify a potential problem and then dig further and address the problem through other methods.

Exercise 5 : Bulkload Data

There are multiple use cases requiring the loading of a large volume of records from a CSV or JSON file to a Phoenix (Hbase) table. For example, a source system providing daily/ weekly/monthly data extracts.

Bulk loading utilities are provided to load data to Phoenix tables and/or Hbase tables. Here for the lab we will focus on bulk load utility to load data to a Phoenix table

In this exercise, we will use the test data CSV that you generated in section Prepare test data,

We have two ways of doing this:

1. PSQL client utility
2. CSV Bulkload

PSQL Client Utility

The `phoenix-psql` command line utility is accessible on the edge node. It is a single-threaded client loading tool, provided out of the box.

- On your edge node, you will first copy the file as a .gz using `cp` You will then unzip the file using `gunzip`. Finally, you will load the data using `phoenix-psql` with a `time` parameter. Feel free to move on with the lab while it loads. Normally it takes 4-8 minutes.
- Make sure the <USER> is UPPER CASE

```
Unset
cp cdr/cdr-20231201_00.csv.gz ./cdr.csv.gz
gunzip cdr.csv.gz

time phoenix-psql -t TEST_<USER> cdr.csv

CSV Upsert complete. 1000000 rows upserted
```

```
Time: 495.803 sec(s)

real    8m20.352s
user    0m50.751s
sys     0m3.292s
```

As you will notice, the imports are taking a long time. The `phoenix-psql` utility is useful to load small amounts of data. It does not require initiating a MR reduce job as well as there is no need to move data to HDFS or a S3 bucket (as explain in next section)

CSVBulkloadTool

In the case you have a large volume of data available as CSV files, it is more efficient to use a MapReduce job in order to take advantage of parallelism for bulk loading operations. Following are some of the key advantages of the bulkload tool.

1. The `CsvBulkLoadTool` Map-Reduce job utility provided out of the box
2. The utility natively supports compression, source systems can compress files before copying to HDFS or S3 buckets.
3. The job can be initiated from edge-node.

- Firstly, let's verify that you have an available S3 bucket. If you do not, then run `hdfs dfs -mkdir` to create the directory.

Unset

```
// Create a home directory for your username
hdfs dfs -mkdir s3a://$BUCKET/user/${USER}
```

- Once you have verified the directory, you will put the file on S3 and verify it is there

```
Unset
# put your CSV in HDFS
hdfs dfs -put ./cdr/cdr*.csv.gz s3a://$BUCKET/user/${USER}/

# check the file is here
hdfs dfs -ls -C s3a://$BUCKET/user/${USER}/ 2>/dev/null
```

- Finally, run the `CsvBulkLoadTool` to load the data

```
Unset
# Import with MapReduce
time hbase org.apache.phoenix.mapreduce.CsvBulkLoadTool --table test_${USER}
--input s3a://$BUCKET/users/${USER}/*

23/01/12 18:35:05 INFO mapreduce.Job: The url to track the job:
https://...cloudera.site:8090/proxy/application_1673261990934_0009/
23/01/12 18:35:05 INFO mapreduce.Job: Running job: job_1673261990934_0009
23/01/12 18:35:17 INFO mapreduce.Job:  map 0% reduce 0%
23/01/12 18:35:40 INFO mapreduce.Job:  map 13% reduce 0%
23/01/12 18:35:46 INFO mapreduce.Job:  map 33% reduce 0%
23/01/12 18:35:52 INFO mapreduce.Job:  map 68% reduce 0%
23/01/12 18:35:58 INFO mapreduce.Job:  map 74% reduce 0%
23/01/12 18:36:08 INFO mapreduce.Job:  map 100% reduce 0%
23/01/12 18:36:25 INFO mapreduce.Job:  map 100% reduce 40%
23/01/12 18:36:37 INFO mapreduce.Job:  map 100% reduce 100%
23/01/12 18:36:37 INFO mapreduce.Job: Job job_1673261990934_0009 completed successfully
[...]
       Phoenix MapReduce Import
              Upserts Done=1000000
[...]

real   1m47.828s
user   0m19.076s
sys    0m1.065s
```

- Much faster! Now let's scale it out and generate a whole day of data, being 10 files of 1M records each (it should only take a couple of minutes).

```
Unset
for i in {0..9}; do python3 cdr-fr.py 20230206 1000000 $i & done; wait;
echo "finished"
```

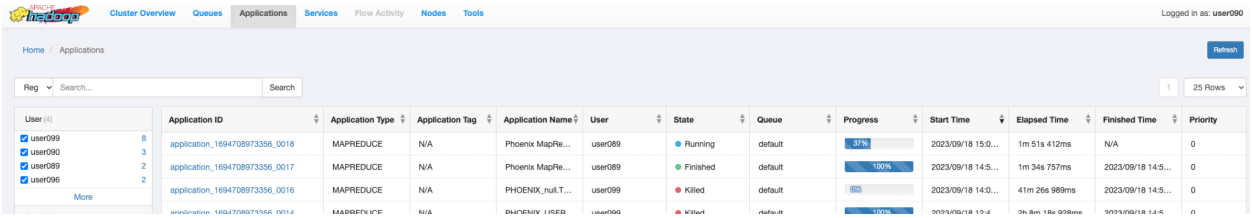
- Copy the data to your S3 bucket

```
Unset
hdfs dfs -put ./cdr/* s3a://${BUCKET}/user/${USER}/
```

- Now import them all as done previously. A new parameter is introduced to skip system-table-checks. This helps to further improve bulk data load operations. Note the total time required for ingesting the data

```
Unset
time hbase org.apache.phoenix.mapreduce.CsvBulkLoadTool
-Dphoenix.skip.system.tables.existence.check=true --table test_${USER} --input
"s3a://${BUCKET}/user/${USER}/cdr*"
```

- While the job is running, you can observe progress in the Resource Manager



Exercise 6: COD Administration

In this exercise we will focus on the process of replicating data using HBase snapshots. This is the process native to HBase and is the core method of HBase migration in CDP Replication Manager. This also allows you to take hot backups without incurring costly writes.

Snapshots

- Let's start from a snapshot on another bucket: First look at all existing snapshots located on S3

```
Unset
hdfs dfs -ls -C s3a://${BUCKET}/snapshots/.hbase-snapshot 2>/dev/null

s3a://opdb-hol/snapshots/.hbase-snapshot/.tmp
s3a://opdb-hol/snapshots/.hbase-snapshot/CDR_Index_snapshot
s3a://opdb-hol/snapshots/.hbase-snapshot/CDR_snapshot
s3a://opdb-hol/snapshots/.hbase-snapshot/snapshot_10M
```

  You should see a snapshot named snapshot_10M snapshot. This particular snapshot contains 10M records

- Copy the snapshot to your instance and rename it by appending your username

```
Unset
time hbase snapshot export --snapshot snapshot_10M \
--copy-from s3a://${BUCKET}/snapshots \
--copy-to s3a://opdb-hol/cod--bpvr11fvhhwd/hbase \
--target snapshot_10M_${USER}
```

This launches a MapReduce job called `ExportSnapshot-snapshot_10M`, belonging to your user id.

- Check for the snapshot by executing the list_snapshots from within the HBase shell

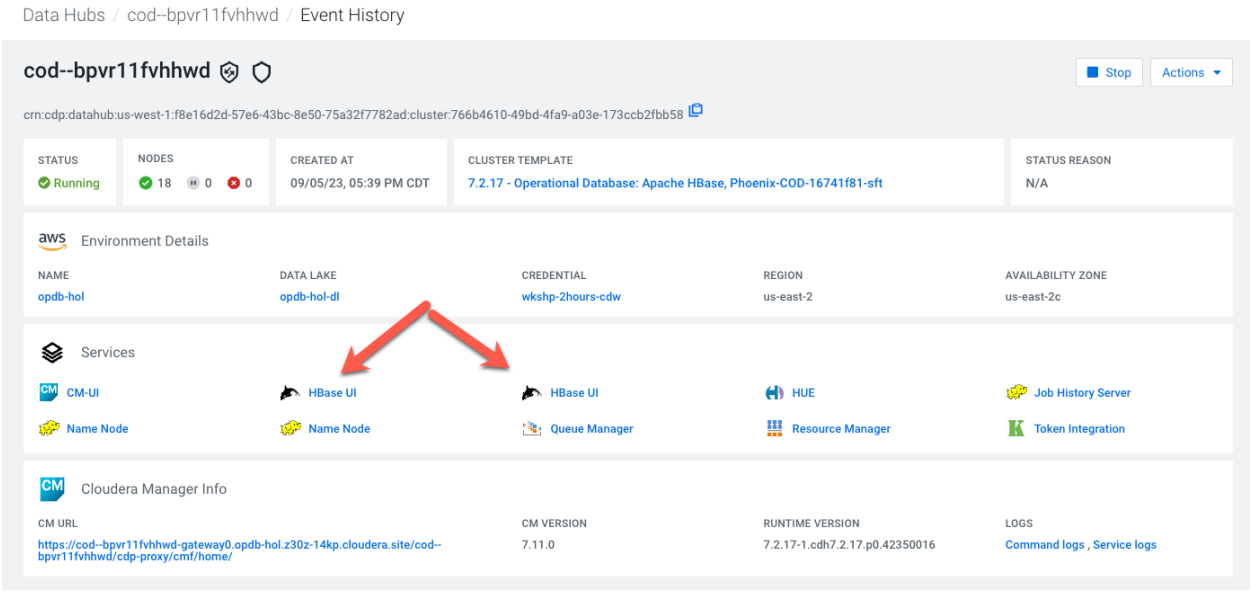
```
Unset
hbase shell

hbase:001:0> list_snapshots

SNAPSHOT                                                    TABLE + CREATION TIME
 snapshot_10M_ledel                                         TEST (2023-02-08 12:59:06 UTC)
6 row(s)
Took 0.8244 seconds
=> ["snapshot_10M_ledel"]
```

Now we'll work to get the snapshot restored back to a Phoenix table.

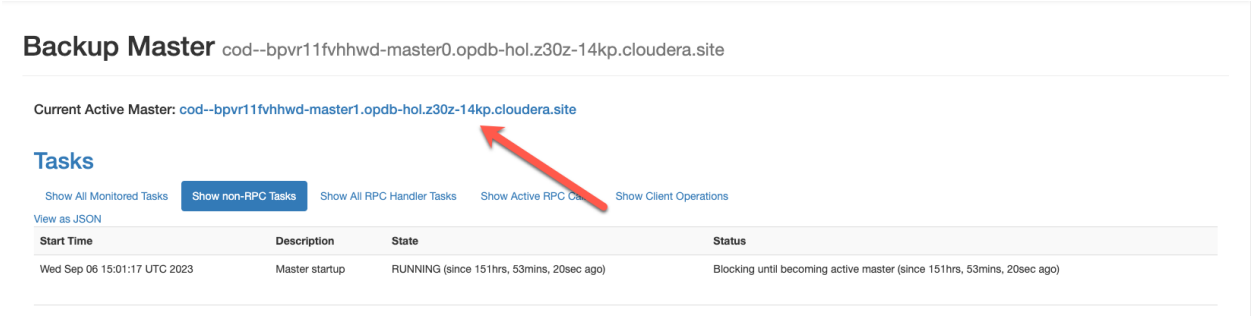
- Using the Phoenix CLI, let's create a new table in Phoenix. Replace `${USER}` with your username.

```
Unset
CREATE TABLE IF NOT EXISTS test3_${USER} (
calling_msisdn BIGINT NOT NULL,
session_id VARCHAR NOT NULL,
called_msisdn BIGINT,
date_beg VARCHAR,
date_end VARCHAR,
duration INTEGER,
call_type VARCHAR,
call_result CHAR(9),
calling_net_type TINYINT,
radio_calling VARCHAR,
cell_calling INTEGER,
lon_calling DECIMAL(10,8),
lat_calling DECIMAL(10,8),
called_net_type TINYINT,
radio_called VARCHAR,
cell_called INTEGER,
lon_called DECIMAL(10,8),
lat_called DECIMAL(10,8)
CONSTRAINT pk PRIMARY KEY (calling_msisdn,session_id));
```

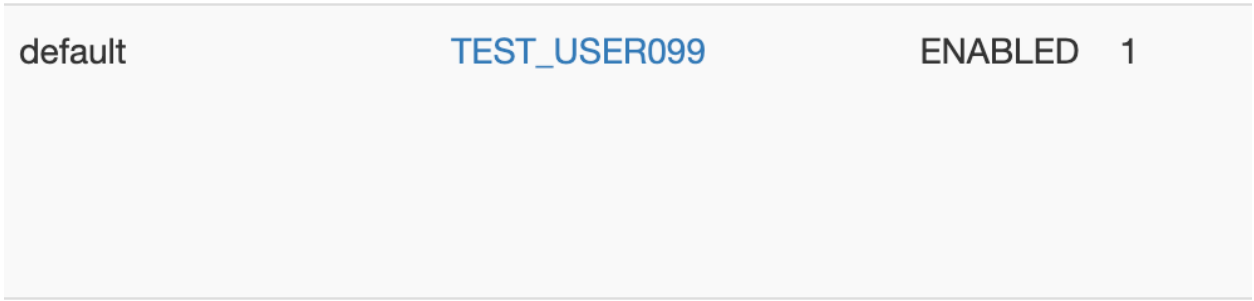
- Open the HBase Master UI by going to the Data Hub page and clicking on HBase UI



- If it is the backup/standby master, go to the active one clicking on the link



Find your table in the HBase tables list, there's only one region, as expected.



When you create a table in Phoenix, all the underlying table properties are created in HBase. So, you should be able to view the table in HBase as well as in Phoenix. Because of this, we first have to delete it from HBase but keep the schema defined in Phoenix.

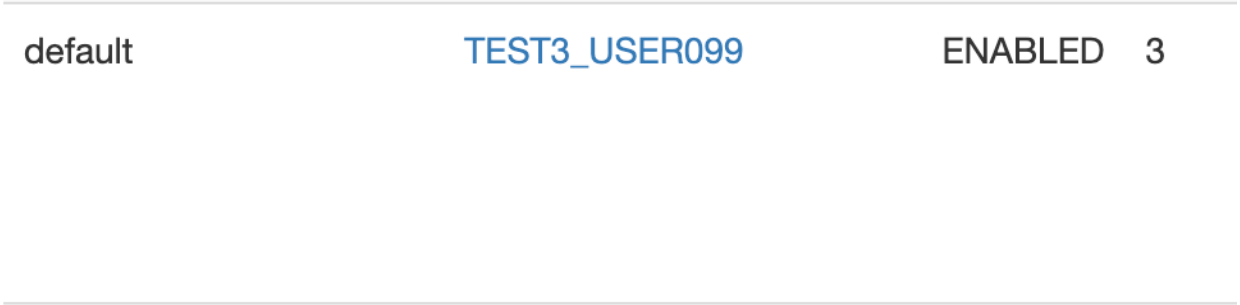
- While in the HBase shell, drop the underlying HBase table by using the `disable` and `drop` commands. Remember to use all caps for the table name.

```
Unset
hbase:001:0> disable 'TEST3_${USER}'

Took 1.8049 seconds

hbase:002:0> drop 'TEST3_${USER}'

Took 1.2282 seconds
```

- Now we will use the `clone_snapshot` command to restore the snapshot to the newly created table. Be sure to use uppercase for the table name. Replace `<USERNAME>` with your username.

```
Unset
hbase:003:0> clone_snapshot 'snapshot_10M_${USER}', 'TEST3_${USER}'

Took 8.2659 seconds
```

- Validate in the HBase UI that your table took the number of regions that belong to the snapshot



- Finally, check the results in Phoenix by executing a `SELECT *`

```
Unset
0: jdbc:phoenix:> select count(*) from TEST3_${USER};

+----------+
| COUNT(1) |
+----------+
| 10000000 |
+----------+
1 row selected (57.166 seconds)
```

NOTE: If you do that on your existing (populated) table, you'll have exceptions due to outdated cache boundaries which are stored in the Phoenix meta table.

```
Unset
Caused by: org.apache.hadoop.hbase.ipc.RemoteWithExtrasException:
org.apache.hadoop.hbase.DoNotRetryIOException: ERROR 1108 (XCL08): Cache of region
boundaries are out of date. tableName=TEST2_LJE
       at
o.a.p.c.BaseScannerRegionObserver.throwIfScanOutOfRegion(BaseScannerRegionObserver.j
ava:211)
       at
o.a.p.c.BaseScannerRegionObserver.preScannerOpen(BaseScannerRegionObserver.java:239)
       at
o.a.p.c.UngroupedAggregateRegionObserver.preScannerOpen(UngroupedAggregateRegionObse
rver.java:334)
       [...]
```

For that, delete the region boundaries in Phoenix:

```
Unset
0: jdbc:phoenix:> DELETE FROM SYSTEM.STATS WHERE PHYSICAL_NAME='TEST3_${USER}';
```

Understanding Your Data

Let's do a bit of analytics to understand the data. In the Phoenix shell, execute the following queries (replace ${USER} with your username):

1. `SELECT COUNT(DISTINCT(calling_msisdn)) FROM test3_${USER};`

2. `SELECT calling_msisdn,COUNT(*) AS nb FROM test3_${USER} GROUP BY calling_msisdn ORDER BY nb DESC LIMIT 5;`

3. `SELECT AVG(compteur) FROM (SELECT calling_msisdn, COUNT(*) AS compteur FROM test3_${USER} GROUP BY calling_msisdn);`

Unset

```
# how many different phone numbers has an activity
0: jdbc:phoenix:> select count(distinct(calling_msisdn)) from test3_${USER};

+---------------------------------+
| DISTINCT_COUNT(CALLING_MSISDN) |
+---------------------------------+
| 7555696                         |
+---------------------------------+
1 row selected (93.106 seconds)

# nb of records by phone number
0: jdbc:phoenix:> select calling_msisdn,count(*) as nb from test3_${USER}
group by calling_msisdn order by nb desc LIMIT 5;

+----------------+----+
| CALLING_MSISDN | NB |
+----------------+----+
| 33718139793    | 8  |
| 33760153496    | 8  |
| 33725158497    | 8  |
| 33632141625    | 7  |
| 33797117678    | 7  |
+----------------+----+
```

```
10 rows selected (350.031 seconds)

# how many calls by phone number in average
0: jdbc:phoenix:> SELECT AVG(compteur) FROM (select calling_msisdn, count(*) as
compteur from test3_${USER} group by calling_msisdn);

+---------------+
| AVG(COMPTEUR) |
+---------------+
| 1.3235        |
+---------------+
1 row selected (166.842 seconds)
```

You might realize by now that Phoenix is not designed for analytics. Phoenix is designed for OLTP (Online Transactional Processing). The primary focus of Phoenix is to support very high speed and high volume data records handling, i.e. insert/update/read/delete records etc. with ability to support billions of records with a horizontal scaling architecture. Phoenix also supports a high number of concurrent connections and queries serving multiple clients.

When you combine Phoenix with COD, you get a full OLTP solution that is easy to deploy, easy to administer, and easy to access.

Our customers are using it to successfully

1. deliver high traffic web/ mobile applications
2. deliver CDC pipeline,where transactional records from operational systems are streamed to Phoenix/ HBase
3. implementing real-time streaming use-cases, where data from multiple sources are ingested/updated to Phoenix.
4. Implementing streaming transformation use-cases that enrich billions of records and updates to Phoenix.
5. Utilized in streaming uses cases to enrich data using fast lookup on phoenix table
6. Batch jobs are loading data to phoenix/hbase using bulk load utility to phoenix/hbase and it is accessed by web application. Thus allows customers to meet requirements to provide access to billions of transactions.

There are several reasons why Phoenix and COD make a good fit for these use cases:

1. HBase cells contain binary data, it doesn't have any meaning per se

2. Simple count(*) is doing a full scan of the table, going row by row to increment a counter…

From an architecture perspective, you might understand the following:

1. The **row key design** in HBase (or Primary Key in Phoenix) is the most important thing.

2. The row key can't be changed once defined. You can add columns but you cannot update the row keys so it is important to give special attention to them when you build your table.

3. Any query in HBase/Phoenix has to take the row key as the performance factor:

    a. row key being MSISDN only is the best choice

    b. row key being MSISDN and DATE would limit drastically the number of rows being scanned, if you're doing queries over period of times and not the whole history

- Let's do some counting now. In the Phoenix shell execute a `SELECT COUNT(*)`.

```
Unset
0: jdbc:phoenix:> select count(*) from test3_${USER};

+----------+
| COUNT(1) |
+----------+
| 10000000 |
+----------+
1 row selected (47.053 seconds)
```

It's taking a lot of time since it's a full table scan. Counting a table with billions of rows would probably take hours!

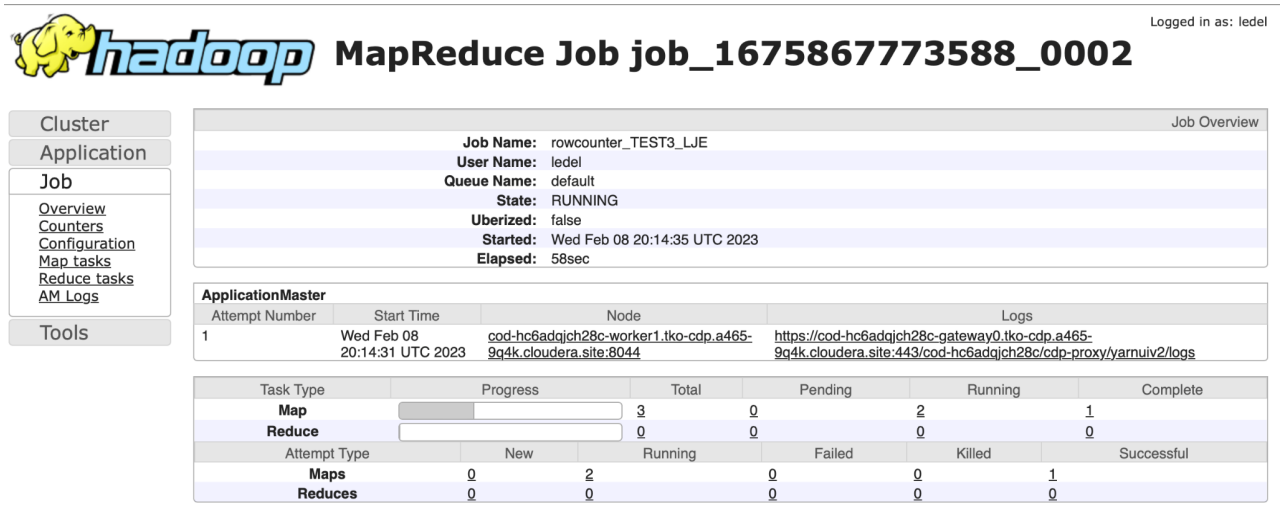
There are several MapReduce utilities in HBase to help you do basic stuff, and counting rows is one of them.

NOTE: The HBase table row number is the same as the Phoenix table!

- Let's test the HBase utility. Execute the `hbase rowcount` command from the HBase CLI.

```
Unset
hbase rowcounter TEST3_${USER}
```

- (Optional) You can check the MapReduce job in the YARN UI



Notice that the job is taking as many mappers as my table has regions, in this case 3.

At the very end, you have your result, 10 million rows

```
        Map-Reduce Framework
                Map input records=10000000
                Map output records=0
                Input split bytes=638
                Spilled Records=0
                Failed Shuffles=0
                Merged Map outputs=0
                GC time elapsed (ms)=516
                CPU time spent (ms)=65980
                Physical memory (bytes) snapshot=2510913536
                Virtual memory (bytes) snapshot=19547738112
                Total committed heap usage (bytes)=4019191808
                Peak Map Physical memory (bytes)=965447680
                Peak Map Virtual memory (bytes)=6763069440
        HBaseCounters
                BYTES_IN_REMOTE_RESULTS=191518734
                BYTES_IN_RESULTS=740000000
                MILLIS_BETWEEN_NEXTS=175727
                NOT_SERVING_REGION_EXCEPTION=0
                REGIONS_SCANNED=3
                REMOTE_RPC_CALLS=25881
                REMOTE_RPC_RETRIES=0
                ROWS_FILTERED=1000001
                ROWS_SCANNED=11000001
                RPC_CALLS=100002
                RPC_RETRIES=0
        org.apache.hadoop.hbase.mapreduce.RowCounter$RowCounterMapper$Counters
                ROWS=10000000
        File Input Format Counters
                Bytes Read=0
        File Output Format Counters
                Bytes Written=0
23/02/08 20:16:06 INFO impl.MetricsSystemImpl: Stopping s3a-file-system metrics system...
```

The bigger the table, the more regions you have, the more mappers you have, the more you're saving time over a SELECT COUNT(*) result in Phoenix or HBase.

NOTE: Use the following query to identify the approximate number of rows (which is usually less than the actual number) from the Phoenix table rather than the exact number of rows to get an understanding of table size.

```
SELECT PHYSICAL_NAME, COLUMN_FAMILY, SUM(GUIDE_POSTS_ROW_COUNT)
FROM SYSTEM.STATS WHERE PHYSICAL_NAME='<table-name>' GROUP BY
PHYSICAL_NAME, COLUMN_FAMILY;
```

Indexing

Selecting data on a DATE (or any field that is not part of the primary key) will result in a full scan, thus very long query time. Remember that Phoenix is built on HBase, which is a Key->Value store! In this exercise we will build indexes on our test table.

- Execute the following command in the Phoenix shell `CREATE INDEX index_date_${USER} ON test (date_beg) ASYNC;`

```
Unset
[edge0 ~]$ phoenix-sqlline

0: jdbc:phoenix:> CREATE INDEX index_date_${USER} ON TEST3_${USER}(date_beg)
ASYNC;

No rows affected (4.387 seconds)

0: jdbc:phoenix:> !tables

+-------------+----------------+-------------+-------------+-------------+---
---------+
| TABLE_SCHEM |   TABLE_NAME   |  TABLE_TYPE  | INDEX_STATE | SALT_BUCKETS |
INDEX_TYPE |
+-------------+----------------+-------------+-------------+-------------+---
---------+
| CDR         | INDEX_DATE_xxx | INDEX        | BUILDING    | null         |
GLOBAL     |
| SYSTEM      | CATALOG        | SYSTEM TABLE |             | null         |
|
| SYSTEM      | CHILD_LINK     | SYSTEM TABLE |             | null         |
|
| SYSTEM      | FUNCTION       | SYSTEM TABLE |             | null         |
|
| SYSTEM      | LOG            | SYSTEM TABLE |             | 32           |
|
| SYSTEM      | MUTEX          | SYSTEM TABLE |             | null         |
|
| SYSTEM      | SEQUENCE       | SYSTEM TABLE |             | null         |
|
| SYSTEM      | STATS          | SYSTEM TABLE |             | null         |
|
| SYSTEM      | TASK           | SYSTEM TABLE |             | null         |
|
```

```
|             | test           | TABLE        |             | null         |
|
+-------------+----------------+--------------+-------------+--------------+---
---------+
```

As our index builds, note that we built it as asynchronous (not dependent on the writes), so we now need to trigger the initial build.

- On your edge node, create the directory where the index files will be located

Unset

```
hdfs dfs -mkdir s3a://opdb-hol/cod--bpvr11fvhhwd/hbase/index_cdr_${USER}
```

- Now launch the job using the IndexTool

Unset

```
hbase org.apache.phoenix.mapreduce.index.IndexTool \
--data-table TEST3_${USER} --index-table INDEX_DATE_${USER} \
--output-path s3a://opdb-hol/cod--bpvr11fvhhwd/hbase/index_cdr_${USER}
```

While mappers are finishing (this could take a minute), understand what the index is

Unset

```
[edge0 ~]$ phoenix-sqlline

0: jdbc:phoenix:> select * from INDEX_DATE_${USER} limit 5;

+---------------------+-----------------+--------------------------------------
+
|     0:DATE_BEG      | :CALLING_MSISDN |             :SESSION_ID
|
```

```
+--------------------+-----------------+--------------------------------------
+
| 2023-01-01 00:01:00 | 003325566187884 | 42debf97-a312-466d-b724-12b68287315c
|
| 2023-01-01 00:01:00 | 003332841174595 | 3b4c703e-3ce4-4f1e-a032-841032e160d2
|
| 2023-01-01 00:01:00 | 003337013187940 | 028a0fef-38b4-401f-9605-fad5ccdb39e9
|
| 2023-01-01 00:01:00 | 0033610121797   | 2bc2d5d5-e1ca-4041-9d0b-3398f7d87449
|
| 2023-01-01 00:01:00 | 0033610127836   | 0a7eb95b-a773-411f-8894-8328ad0c90fe
|
+--------------------+-----------------+--------------------------------------
+
```

Our INDEX is a table with indexed fields as primary key, and primary key of our source table as value.

Check how many rows do we have in the tables

Unset

```
[edge0 ~]$ phoenix-sqlline

0: jdbc:phoenix:> select count(*) from TEST3_${USER};

+----------+
| COUNT(1) |
+----------+
| 1000000  |
+----------+
1 row selected (7.86 seconds)

0: jdbc:phoenix:> select count(*) from index_date_${USER};

+----------+
| COUNT(1) |
+----------+
| 1000000  |
+----------+
```

```
1 row selected (6.933 seconds)
```

The indexing process can take time: it should be around 5 minutes, but for a 1.4B rows table, it took 6 hours on a 5 workers COD instance.

Resiliency

So, what happens when a RegionServer goes down?

- In the Phoenix CLI, let's create a thin table with only 2 records

```
Unset
CREATE TABLE TEST_${USER} ( id BIGINT not null primary key, name VARCHAR);

UPSERT INTO TEST_${USER} VALUES(1,'bar');

UPSERT INTO TEST_${USER} VALUES(2,'foo');

SELECT * FROM TEST_${USER};

+----+------+
| ID | NAME |
+----+------+
| 1  | bar  |
| 2  | foo  |
+----+------+
2 rows selected (0.014 seconds)
```

Since the table is very thin, it only has a single region. Let see where this region is located and kill the RegionServer hosting that region to see the resiliency.

- You can check the region in HBase UI, or you can use HBase shell:

```
Unset
list_regions 'TEST_${USER}'
```

```
                                                                                SERVER_NAME |
REGION_NAME |  START_KEY |    END_KEY |  SIZE |   REQ |   LOCALITY |
 ------------------------------------------------------------------------------------------ |
----------- | ---------- | ---------- | ----- | ----- | ---------- |
 cod--bpvr11fvhhwd-worker1.opdb-hol.z30z-14kp.cloudera.site,16020,1694853593864 |
563163ab7d. |            |            |     0 |     3 |        0.0 |
 1 rows
Took 0.5798 seconds
```

Here, the SERVER_NAME hosting the region is `cod--bpvr11fvhhwd-worker1.opdb-hol.z30z-14kp.cloudera.site,16020,1694853593864`

The ENCODED_REGIONNAME is `TEST_099,,1694875378606.6b6554f7c85e9f90626bb7563163ab7d.`

Save this ENCODED_REGIONNAME for future reference. You can also notice start and end keys if that makes sense (ie when you got several regions for the table) and the number of requests for example.

For everybody to be on the same RegionServer (you don't want to kill all the RegionServers!), let's force assign that region to RegionServer on worker0.

During the life of the cluster, HBase master is making decisions on how to place regions, and allow for every RegionServer to serve globally the same number of regions. We do not want all regions of the same table being located on the same RegionServer, this would cause *hotspotting*.

- Now let's identify our RegionServers

```
Unset
hbase:004:0> list_liveservers
```

```
SERVERNAME
cod--bpvr11fvhhwd-worker0.opdb-hol.z30z-14kp.cloudera.site,16020,1694853596218
cod--bpvr11fvhhwd-worker1.opdb-hol.z30z-14kp.cloudera.site,16020,1694853593864
cod--bpvr11fvhhwd-worker2.opdb-hol.z30z-14kp.cloudera.site,16020,1694853594878
cod--bpvr11fvhhwd-worker3.opdb-hol.z30z-14kp.cloudera.site,16020,1694853594721
cod--bpvr11fvhhwd-worker4.opdb-hol.z30z-14kp.cloudera.site,16020,1694853594488
5 row(s)
Took 0.0216 seconds
```

- Copy worker0 line (`<EDGENODE FQDN>`), it is our destination `SERVER_NAME`
- Use the "move" command, the syntax being `move 'ENCODED_REGIONNAME', 'SERVER_NAME'`. Replace the parameters accordingly and launch, still in HBase shell:

```
Unset
move '6b6554f7c85e9f90626bb7563163ab7d',
'bpvr11fvhhwd-worker0.opdb-hol.z30z-14kp.cloudera.site,16020,1675853620633'

Took 3.5633 seconds
```

- Let's check if the move worked, the SERVER_NAME must be worker0

```
Unset
list_regions 'TEST_&{USER}'
```

Now ask for RegionServer to be killed by the presenter when everyone's ready!

- Do a `SELECT` again in Phoenix

```
Unset
0: jdbc:phoenix:> SELECT * FROM TEST_${USER};

+----+------+
| ID | NAME |
+----+------+
| 1  | bar  |
| 2  | foo  |
+----+------+
2 rows selected (6.078 seconds)
```

It took 6s because of reassigning the region on another server! The region is now hosted by another worker. All regions that were hosted on worker0 have been reassigned to other RegionServers until worker() joins again and a new regions repartition can be triggered by the Master.

Create a Large Table

Now that you understand the data and some commands, let's go with sample production data that represents a much larger dataset. That means here we'll load 1.4 billion lines in a single table!

- First, let's take a look at HDFS.

```
Unset
[edge0 ~]$ hdfs dfs -ls /

Found 4 items
drwxr-xr-x   - hbase hbase               0 2023-01-10 17:29 /hbase-wals
drwxrwxrwt   - hdfs  supergroup          0 2023-01-10 17:32 /tmp
drwxr-xr-x   - hdfs  supergroup          0 2023-01-11 16:07 /user
drwxr-xr-x   - hdfs  supergroup          0 2023-01-10 17:29 /yarn
```

Why do we have only those directories? No `/hbase`? The reason, HDFS is only for WALs (write-ahead logs). The data files are on S3!

As you might recall, your COD instance data is located in `opdb-hol`, with `cod--bpvr11fvhhwd` instance, in directory `hbase`. The COD instance name is the same as the underlying data hub being used, that you can find in your environment (storage).

Unset

```
hdfs dfs -ls -C s3a://opdb-hol/cod--bpvr11fvhhwd/hbase 2>/dev/null

s3a://opdb-hol/cod--bpvr11fvhhwd/hbase/.hbase-snapshot
s3a://opdb-hol/cod--bpvr11fvhhwd/hbase/.hbck
s3a://opdb-hol/cod--bpvr11fvhhwd/hbase/.tmp
s3a://opdb-hol/cod--bpvr11fvhhwd/hbase/MasterData
s3a://opdb-hol/cod--bpvr11fvhhwd/hbase/archive
s3a://opdb-hol/cod--bpvr11fvhhwd/hbase/data
s3a://opdb-hol/cod--bpvr11fvhhwd/hbase/hbase.id
s3a://opdb-hol/cod--bpvr11fvhhwd/hbase/hbase.version
s3a://opdb-hol/cod--bpvr11fvhhwd/hbase/index_cdr
s3a://opdb-hol/cod--bpvr11fvhhwd/hbase/mobdir
s3a://opdb-hol/cod--bpvr11fvhhwd/hbase/staging
```

We have a cold backup of our production table that has been stored in `s3a://opdb-hol/snapshots`

Let's bring that snapshot to our instance

NOTE: This could take some time, around 20mn because of the amount of data. You can start over with an existing snapshot.

- Using your terminal session, execute the ExportSnapshot command to restore the snapshot. Replace `${USER}` with your username.

```
Unset
hbase org.apache.hadoop.hbase.snapshot.ExportSnapshot \
--snapshot CDR_snapshot \
--target CDR_snapshot_${USER} \
--copy-from s3a://opdb-hol/snapshots \
--copy-to s3a://${EDGENODE FQDN}
```

This is again launching a MapReduce job, you can follow it in the console and/or check that in Resource Manager. Click Enter every 10 minutes or so if you don't want to be disconnected from your session!

You can recall cloning snapshots in on HBase level, so the process will be:

1. Create a table through Phoenix
2. Disable it (so we can't read/write to it anymore)
3. Drop the table
4. Restore the snapshot on the table

- In the HBase shell, check to see if the snapshot is there

```
Unset
hbase:014:0> list_snapshots

SNAPSHOT                                           TABLE + CREATION TIME
 CDR_snapshot                                      CDR:CDR (2023-02-07 11:59:05 UTC)
 CDR_snapshot_ledel                                CDR:CDR (2023-02-07 11:59:05 UTC)
 snapshot_10M_ledel                                TEST (2023-02-08 12:59:06 UTC)
 test_snapshot_01                                  TEST (2023-02-07 12:52:50 UTC)
7 row(s)
Took 0.5299 seconds
=> ["CDR_snapshot", "CDR_snapshot_ledel", "snapshot_10M_ledel", "test_snapshot_01"]
```

NOTE: The "production" way is to use snapshots "as is" but here we're cloning tables from a snapshot. You can also *restore* a snapshot.

When you do a simple `restore_snapshot <SNAPSHOT>`, it just restores the table as is. Here you're restoring to a new table, thus you have to drop the table in HBase. The usual process is simpler as you're already having your existing table in Phoenix. Here are the commands you would execute in the HBase shell

```
Unset
disable <TABLE>
restore_snapshot <SNAPSHOT>
enable <TABLE>
```

As we're all working on the same instance, we can't just `clone_snapshot` because it would result in the same CDR:CDR table.

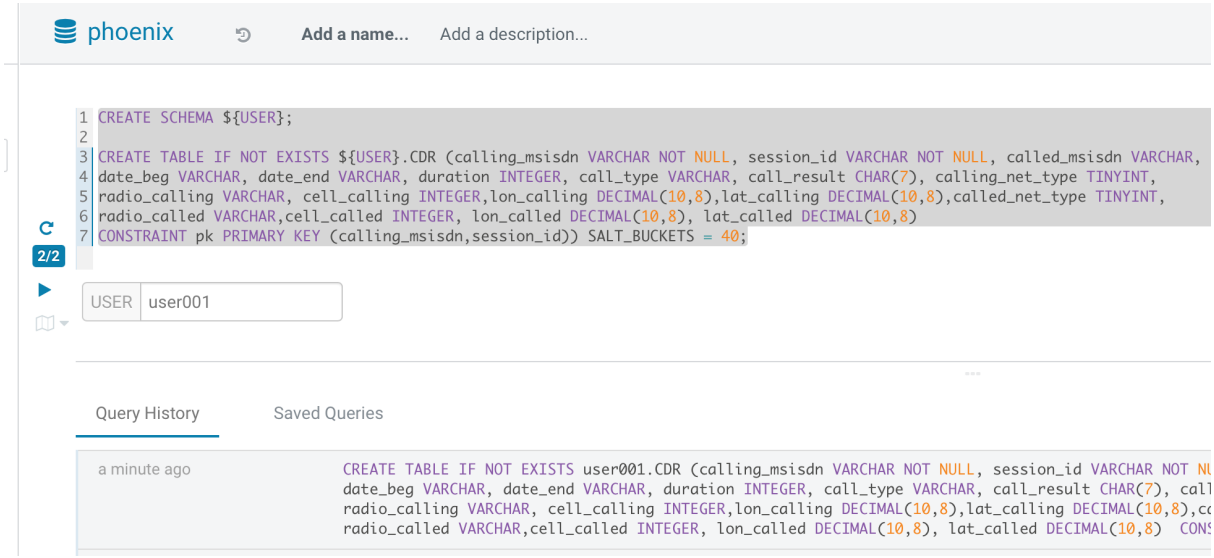
We need to define our Phoenix schema first. Storing data like we're doing also has some constraints. We're using HBase, so the row key (or the primary key in Phoenix) design is having a lot of impact.

We can see a problem here: the distribution of the MSISDN is obviously not homogeneous! the quantity of calling MSISDNs between 336000000 and 336100000 is (way probably) not the same as in the range 337500000 and 337600000 for example. The latest attributed MSISDNs are starting with 337, 336 are "old" numbers.

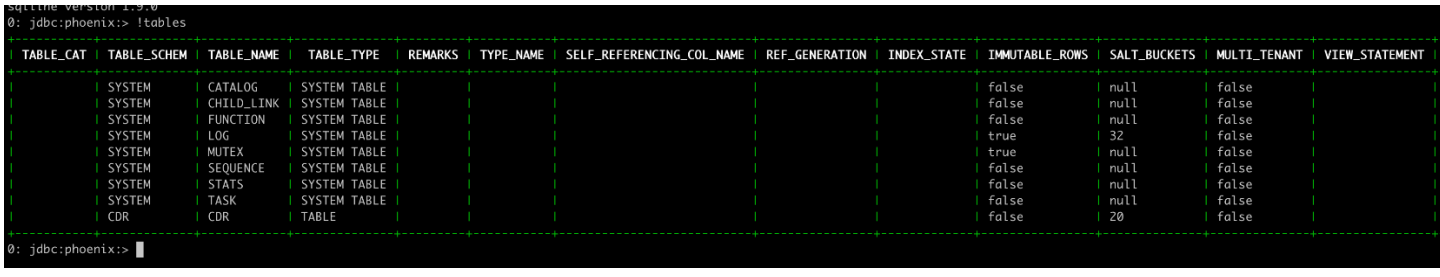
- Let’s first create the table in Phoenix. You can run this from the Phoenix CLI or from HUE

```
Unset
CREATE SCHEMA ${USER};

CREATE TABLE IF NOT EXISTS ${USER}.CDR (
calling_msisdn VARCHAR NOT NULL,
session_id VARCHAR NOT NULL,
called_msisdn VARCHAR,
date_beg VARCHAR,
date_end VARCHAR,
duration INTEGER,
call_type VARCHAR,
call_result CHAR(7),
calling_net_type TINYINT,
```

```
radio_calling VARCHAR,
cell_calling INTEGER,
lon_calling DECIMAL(10,8),
lat_calling DECIMAL(10,8),
called_net_type TINYINT,
radio_called VARCHAR,
cell_called INTEGER,
lon_called DECIMAL(10,8),
lat_called DECIMAL(10,8)
CONSTRAINT pk PRIMARY KEY (calling_msisdn,session_id))
SALT_BUCKETS = 40;
```



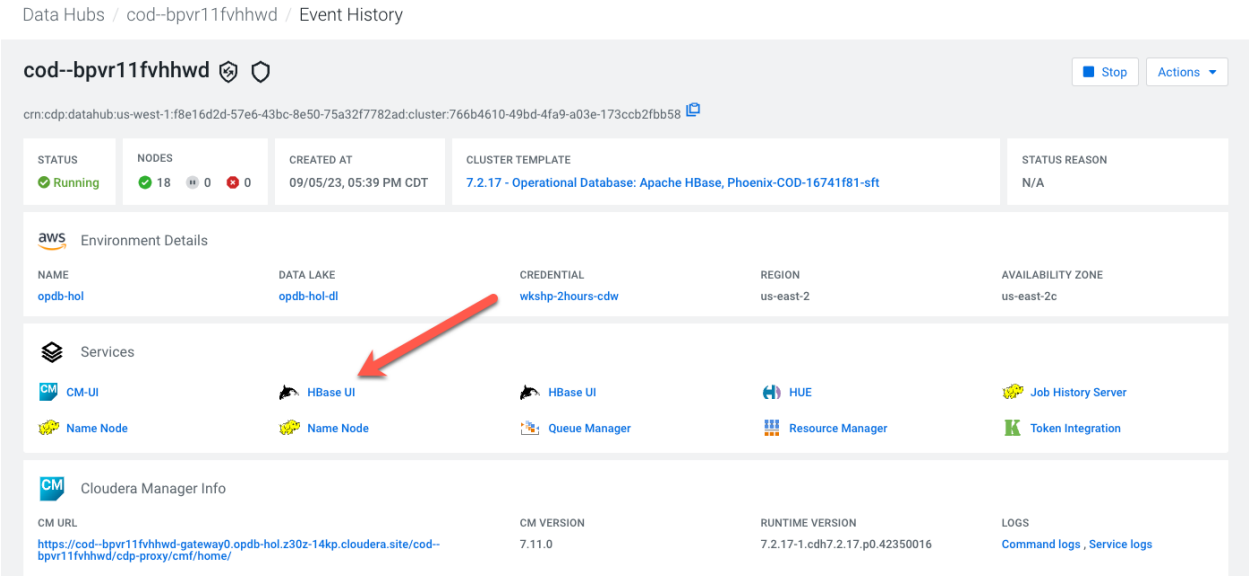
- Notice the SALT_BUCKETS column has been populated

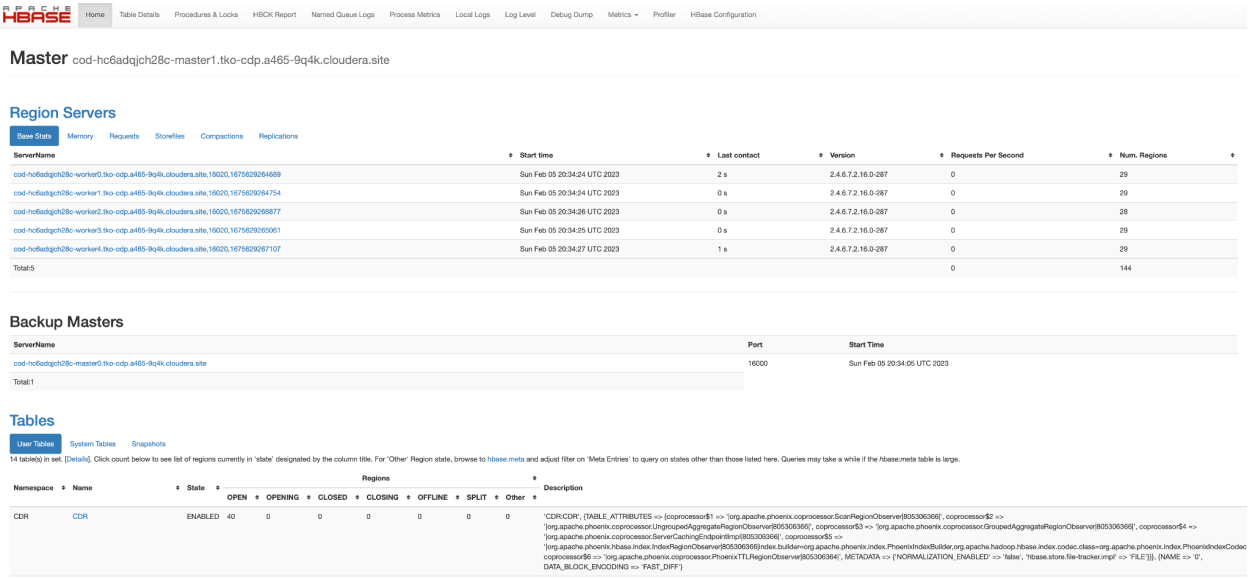


NOTE: You can't do that in Hue, but you can see the statistics like SALT_BUCKETS:

```
Unset
select * from SYSTEM.CATALOG where TABLE_SCHEMA=UPPER('${USER}');
```

- Now go see what the table looks like from an HBase point of view. Again, go into your Data Hub instance and open the HBase Master UI.





Notice the ${USER}.CDR table with 40 regions is here. Also notice the default parameters that has been set by Phoenix: the coprocessors, etc

- On Table details, look at the regions in your **CDR** table

Table Regions

Base Stats | Localities | Compactions

Name(40)	Region Server	ReadRequests (40)	WriteRequests (0)	StorefileSize (0 MB)	Num.Storefiles (0)	MemSize (0 MB)	Start Key	End Key	Region State
USER001:CDR,,1675894371686.431f07ca89f6ae632b95c9112ac7497a.	cod-hc6adqjch28c-worker11.tko-cdp.a465-9q4k.cloudera.site:16030	1	0	0 MB	0	0 MB		\x01\x00\x00	OPEN
USER001:CDR,\x01\x00\x00,1675894371686.48943d5ba40f75fbe67ad214ee51d24b.	cod-hc6adqjch28c-worker2.tko-cdp.a465-9q4k.cloudera.site:16030	1	0	0 MB	0	0 MB	\x01\x00\x00	\x02\x00\x00	OPEN
USER001:CDR,\x02\x00\x00,1675894371686.e9f7d1e8306117097134452f1ab3e5c9.	cod-hc6adqjch28c-worker0.tko-cdp.a465-9q4k.cloudera.site:16030	1	0	0 MB	0	0 MB	\x02\x00\x00	\x03\x00\x00	OPEN
USER001:CDR,\x03\x00\x00,1675894371686.8f4a74a8f8236a25dd7e6b8fac8c92ed.	cod-hc6adqjch28c-worker1.tko-cdp.a465-9q4k.cloudera.site:16030	1	0	0 MB	0	0 MB	\x03\x00\x00	\x04\x00\x00	OPEN
USER001:CDR,\x04\x00\x00,1675894371686.6e55913062ec7637d1b801a8c20f8ed6.	cod-hc6adqjch28c-worker11.tko-cdp.a465-9q4k.cloudera.site:16030	1	0	0 MB	0	0 MB	\x04\x00\x00	\x05\x00\x00	OPEN
USER001:CDR,\x05\x00\x00,1675894371686.9a7c2e7c03f48f61b174727ad2918b17.	cod-hc6adqjch28c-worker10.tko-cdp.a465-9q4k.cloudera.site:16030	1	0	0 MB	0	0 MB	\x05\x00\x00	\x06\x00\x00	OPEN
USER001:CDR,\x06\x00\x00,1675894371686.d5b85c222f0c012a23bf08a4fd23a47f.	cod-hc6adqjch28c-worker10.tko-cdp.a465-9q4k.cloudera.site:16030	1	0	0 MB	0	0 MB	\x06\x00\x00	\x07\x00\x00	OPEN

- Now proceed with the restore of the snapshot. In HBase shell, execute the following commands

Unset

```
disable '${USER}:CDR'

drop '${USER}:CDR'
```

```
clone_snapshot 'CDR_snapshot_${USER}', '${USER}:CDR'

Took 18.6040 seconds
```

There it is! 18 seconds for 1.4 billion lines…

- Refresh your HBase UI, see the data is here

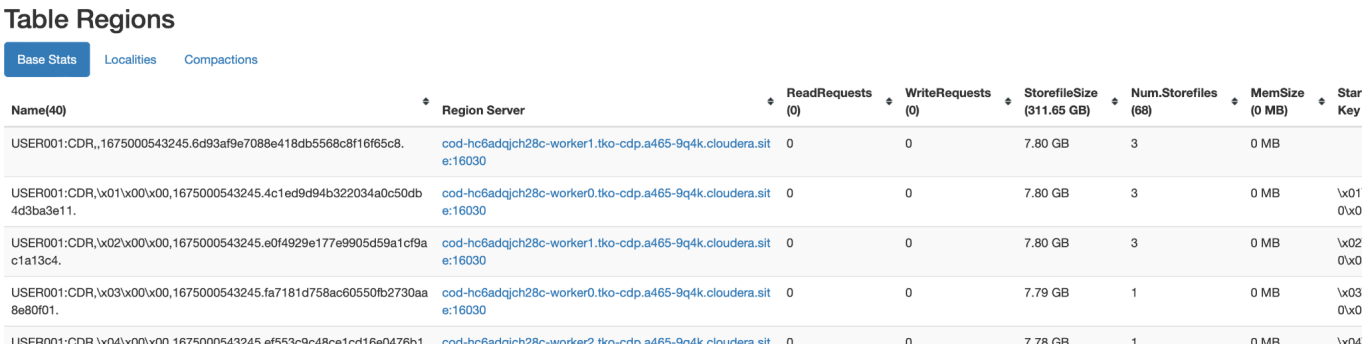


Table Regions

Base Stats | Localities | Compactions

Name(40)	Region Server	ReadRequests (0)	WriteRequests (0)	StorefileSize (311.65 GB)	Num.Storefiles (68)	MemSize (0 MB)	Star Key
USER001:CDR,,1675000543245.6d93af9e7088e418db5568c8f16f65c8.	cod-hc6adqjch28c-worker1.tko-cdp.a465-9q4k.cloudera.site:16030	0	0	7.80 GB	3	0 MB	
USER001:CDR,\x01\x00\x00,1675000543245.4c1ed9d94b322034a0c50db4d3ba3e11.	cod-hc6adqjch28c-worker0.tko-cdp.a465-9q4k.cloudera.site:16030	0	0	7.80 GB	3	0 MB	\x01 0\x0
USER001:CDR,\x02\x00\x00,1675000543245.e0f4929e177e9905d59a1cf9ac1a13c4.	cod-hc6adqjch28c-worker1.tko-cdp.a465-9q4k.cloudera.site:16030	0	0	7.80 GB	3	0 MB	\x02 0\x0
USER001:CDR,\x03\x00\x00,1675000543245.fa7181d758ac60550fb2730aa8e80f01.	cod-hc6adqjch28c-worker0.tko-cdp.a465-9q4k.cloudera.site:16030	0	0	7.79 GB	1	0 MB	\x03 0\x0
USER001:CDR,\x04\x00\x00,1675000543245.ef553c9c48ce1cd16e0476b1	cod-hc6adqjch28c-worker2.tko-cdp.a465-9q4k.cloudera.site	0	0	7.78 GB	1	0 MB	\x04

- Let's count rows! In your terminal window, execute the `hbase rowcounter` command

```
Unset
hbase rowcounter ${USER}:CDR
```

If you look at the application, it again makes sense. Since our table has 40 salt buckets, then we're having 40 regions, and 40 mappers!

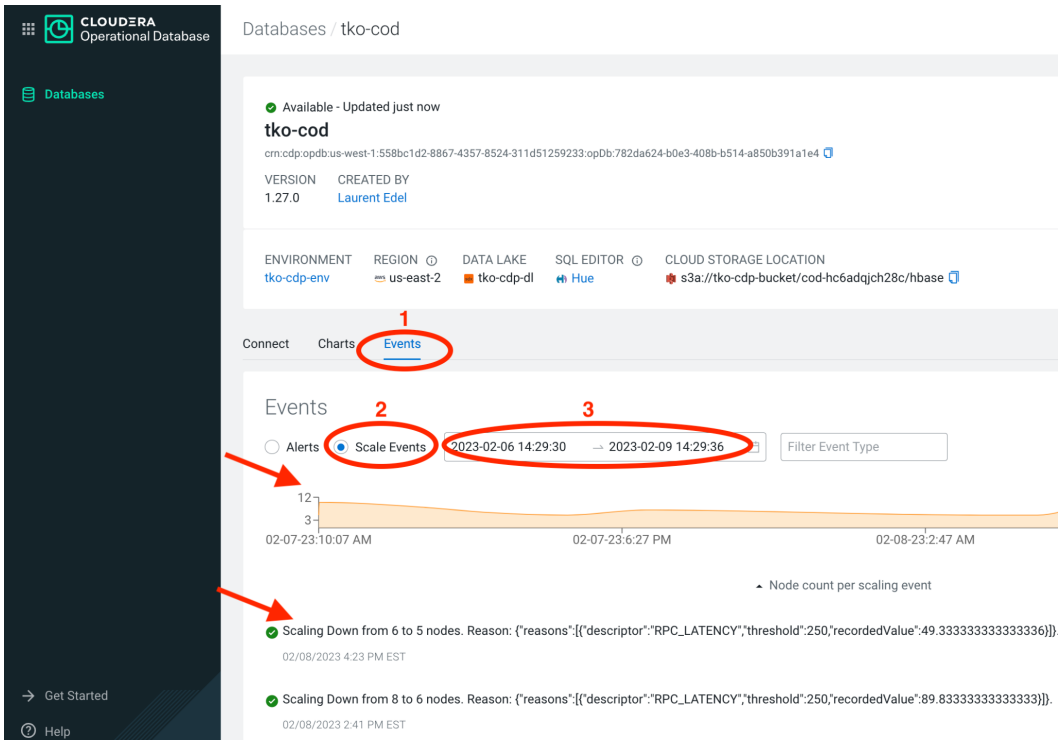
Exercise 7: Auto-Scaling

How Does COD Auto-scale?

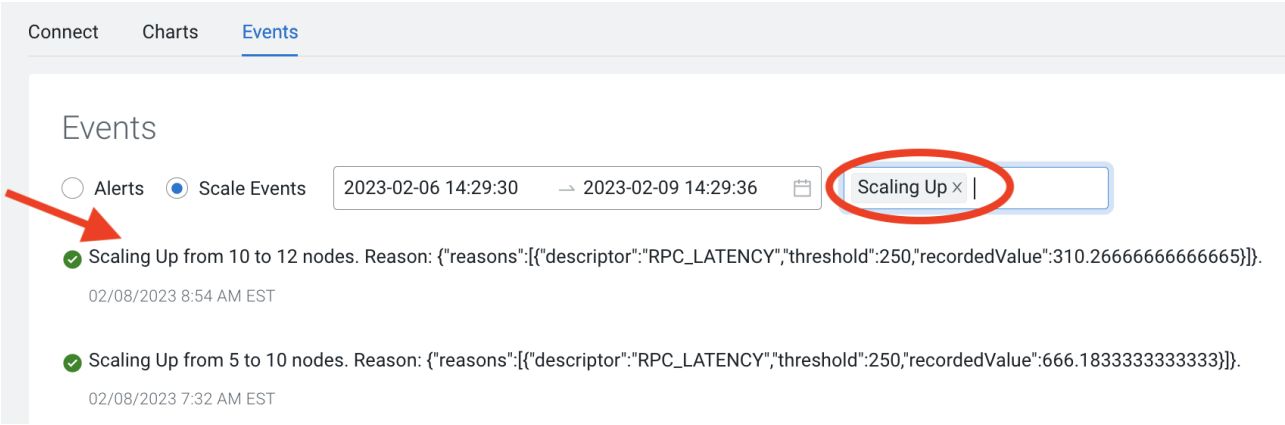
You can monitor the events related to scaling in COD. We first need to create an event by doing the following in the Events window in our COD database.

1. Select Events
2. Select Scaled Events
3. Enter Start and End dates

Below that you'll see the Scaling Up or or Scaling down events and a graph. Typical scaling events you'll see with COD auto-scaling are `RPC_LATENCY` and `HDFS_USAGE`.



You can also filter on the event types by selecting a type of events - either Scaling Up, Scaling Down, or both.



Auto-scaling in Action

Apache JMeter is a free open-source java-based application which is used for designing and running comprehensive performance tests of web applications, databases, SOAP and REST Web Services, FTP, LDAP and mail servers, TCP and SMTP protocols. JMeter can emulate a heavy workload on the server and help analyze performance under different test scenarios. JMeter comes with a GUI which is used for designing and running tests while measuring a variety of performance metrics such as average, min and max response time, standard deviation, throughput, and etc. Adding test plan elements (thread groups, listeners, samplers etc.) to the test plan can be easily done by right-clicking on an element in the tree and choosing a new element from the "**add**" list.

One of the more useful features provided by JMeter is the ability to easily change the number of concurrent threads running a particular workload.

Once a test scenario has been designed in JMeter, it can be saved into the file with the **.jmx** extension. For load testing and getting optimal results, it is recommended to run an already created test scenario in a Non-GUI CLI mode by supplying a **.jmx** file to the JMeter executable.

> **NOTE:** You can learn a lot more about JMeter capabilities by downloading it from https://jmeter.apache.org/ and reading tutorials/documentation

We're going to deploy JMeter on the Edge node and run a stress test scenario on COD.

- Log on to the edge node that you deployed earlier.

```
Unset
ssh $USER@$EDGENODE
```

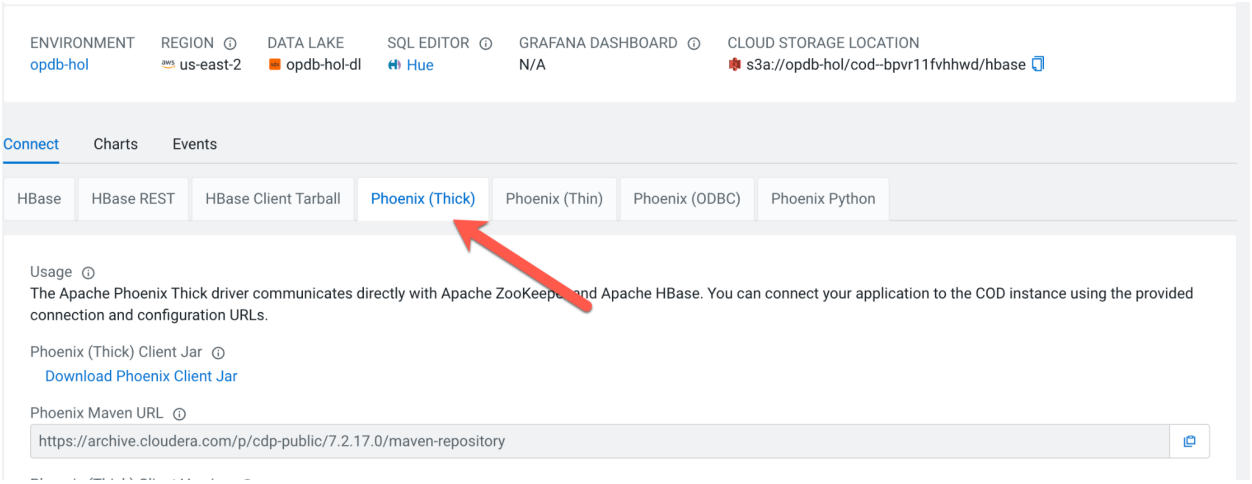
- Download JMeter binaries

```
Unset
wget https://dlcdn.apache.org//jmeter/binaries/apache-jmeter-5.5.tgz
tar xvf apache-jmeter-5.5.tgz
```

- Now you should have a Jmeter installed at your home directory.

```
Unset
ls -lrt

drwxr-x--- 8 pnovokshonov pnovokshonov      138 Jan  2  1970 apache-jmeter-5.5
-rw-r----- 1 pnovokshonov pnovokshonov 85476161 Jun 14  2022
apache-jmeter-5.5.tgz
```

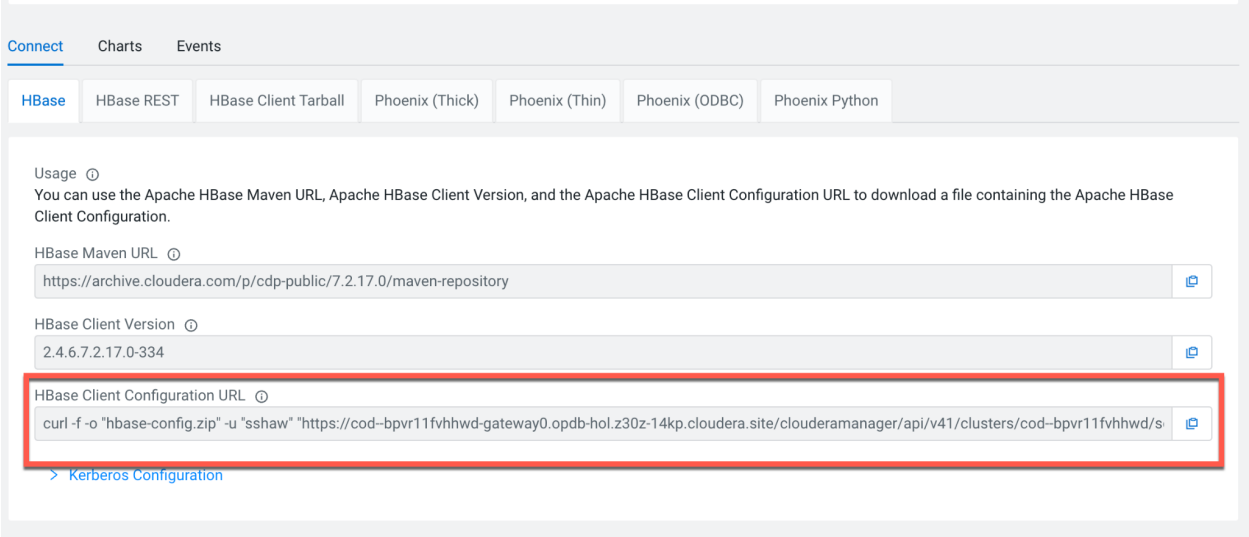
- We need to let JMeter know which driver to use to connect to COD. You'll use Phoenix JDBC Thick driver. You can check versions, get all the required drivers and JDBC URLs by going to the COD Connect Tab and choosing Phoenix (Thick) option.



- To get Phoenix Thick Driver switch to the Jmeter lib/ext directory and download the jar file.

```
Unset
cd ./apache-jmeter-5.5/lib/ext

wget
https://repository.cloudera.com/artifactory/cloudera-repos/org/apache/phoenix/phoenix-client-hbase-2.4/5.1.1.7.2.16.0-287/phoenix-client-hbase-2.4-5.1.1.7.2.16.0-287.jar
```

- Now you need to add 2 COD config files: **hbase-site.xml** and **core-site.xml** to the Thick Driver jar file. You can get those config files by going to the Hbase configuration tab in the COD Connect page and downloading the corresponding hbase-confi.zip file. It contains a set of HBase configuration files.




```
Unset
curl -f -o "hbase-config.zip" -u ${USER}
"https://cod--bpvr11fvhhwd-gateway0.opdb-hol.z30z-14kp.cloudera.site/clouderama
nager/api/v41/clusters/cod--bpvr11fvhhwd/services/hbase/clientConfig"

unzip hbase-config.zip

cp ./hbase-conf/hbase-site.xml .
cp ./hbase-conf/core-site.xml .
```

```
Unset
cp hbase-site.xml /home/${USER}/apache-jmeter-5.5/lib/ext

cp core-site.xml /home/${USER}/apache-jmeter-5.5/lib/ext
```

- Let’s add 2 config files to the Phoenix Thick Driver jar file

```
Unset
jar uf phoenix-client-hbase-2.4-5.1.1.7.2.16.0-287.jar hbase-site.xml
jar uf phoenix-client-hbase-2.4-5.1.1.7.2.16.0-287.jar core-site.xml
```

- Let’s check that those 2 config files were successfully added to the jar file. You should see those at the end.

```
Unset
jar -tf phoenix-client-hbase-2.4-5.1.1.7.2.16.0-287.jar

…

META-INF/services/org.apache.hadoop.hbase.master.MetricsAssignmentManagerSource
hbase-site.xml
core-site.xml
```

Let’s get the JMeter test scenario (.jmx) file and a parameter file, then upload those files to the Edge node. The **CDRLoadTest.jmx** file contains the test scenario and the **msisdn.csv** file contains a list of 10,000 MSISDN ids to be used in the test query WHERE clause.

- You can get these files from the following location and download them to your local host. Then just copy the files to your Edge node as shown below.

  https://drive.google.com/drive/u/1/folders/1qUc5MWBy8gyT0hFvrYaA1_WnOBmX_a20

```
Unset
scp CDRLoadTest.jmx ${USER}@${EDGENODE}:/home/${USER}/apache-jmeter-5.5/bin

scp msisdn.csv ${USER}@${EDGENODE}:/home/${USER}/apache-jmeter-5.5/bin
```

- Logon back to the Edge node and switch to the JMeter bin directory. You should find the files there.

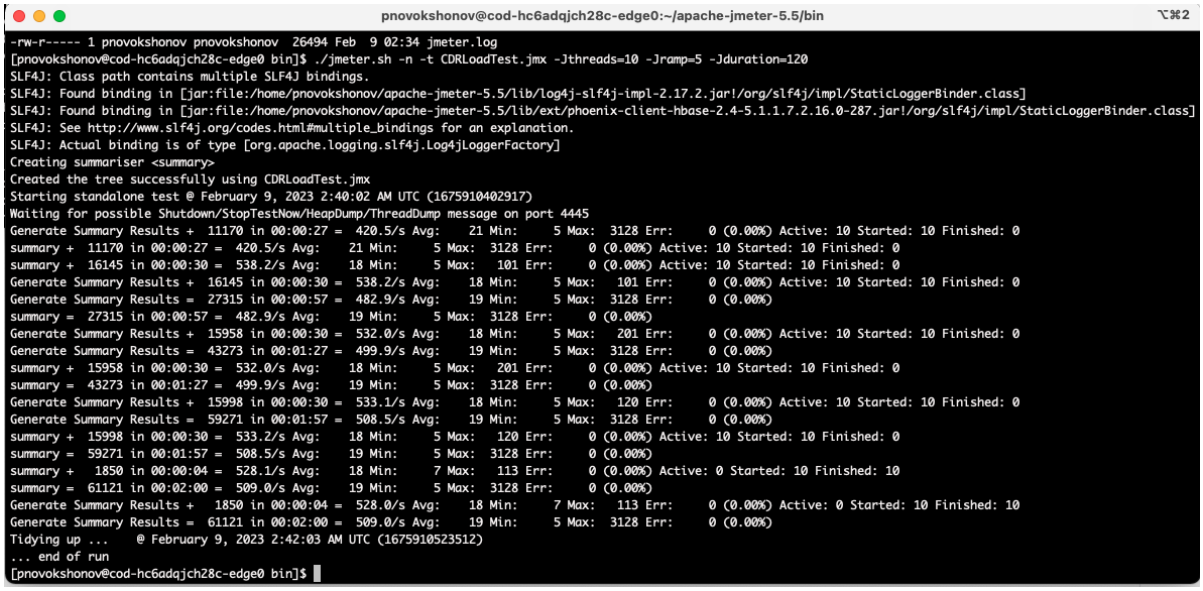
```
Unset

cd $HOME/apache-jmeter-5.5/bin

ls -lrt
…
-rw-r----- 1 pnovokshonov pnovokshonov 160000 Feb  9 01:52 msisdn.csv
-rw-r----- 1 pnovokshonov pnovokshonov  17088 Feb  9 01:53
CDRLoadTest.jmx
```

Let’s run the JMeter test and put some load on the COD.

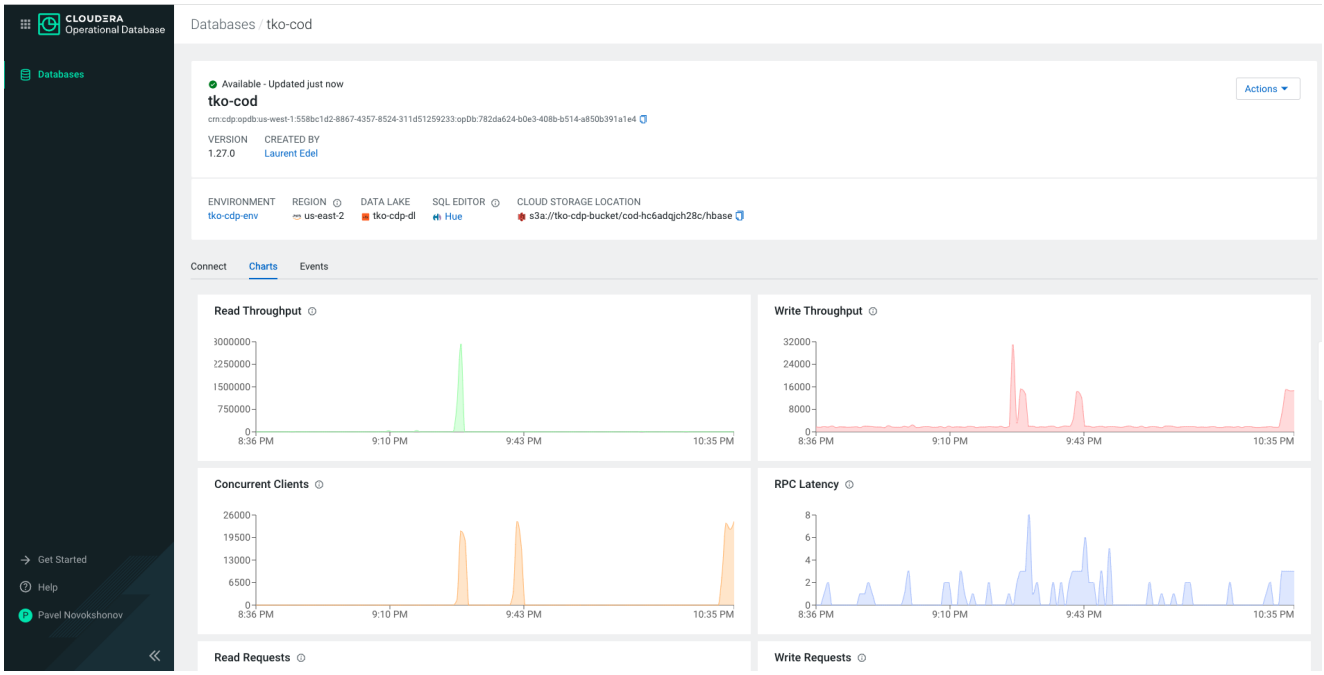
Here is an example of running a test with 10 concurrent threads, a ramp time for those threads to become active in 5 seconds and a test duration of 120 seconds.

```
Unset
./jmeter.sh -n -t CDRLoadTest.jmx -Jthreads=10 -Jramp=5 -Jduration=120
```

The output should look like this. In 120 seconds it ran 61,121 queries with max latency of 3128 msec and average latency of 19 msec. Feel free to run the test with more concurrent threads or change test duration. Err: 0 means that there were no errors during the run.



You can monitor COD performance metrics by going to the Charts tab

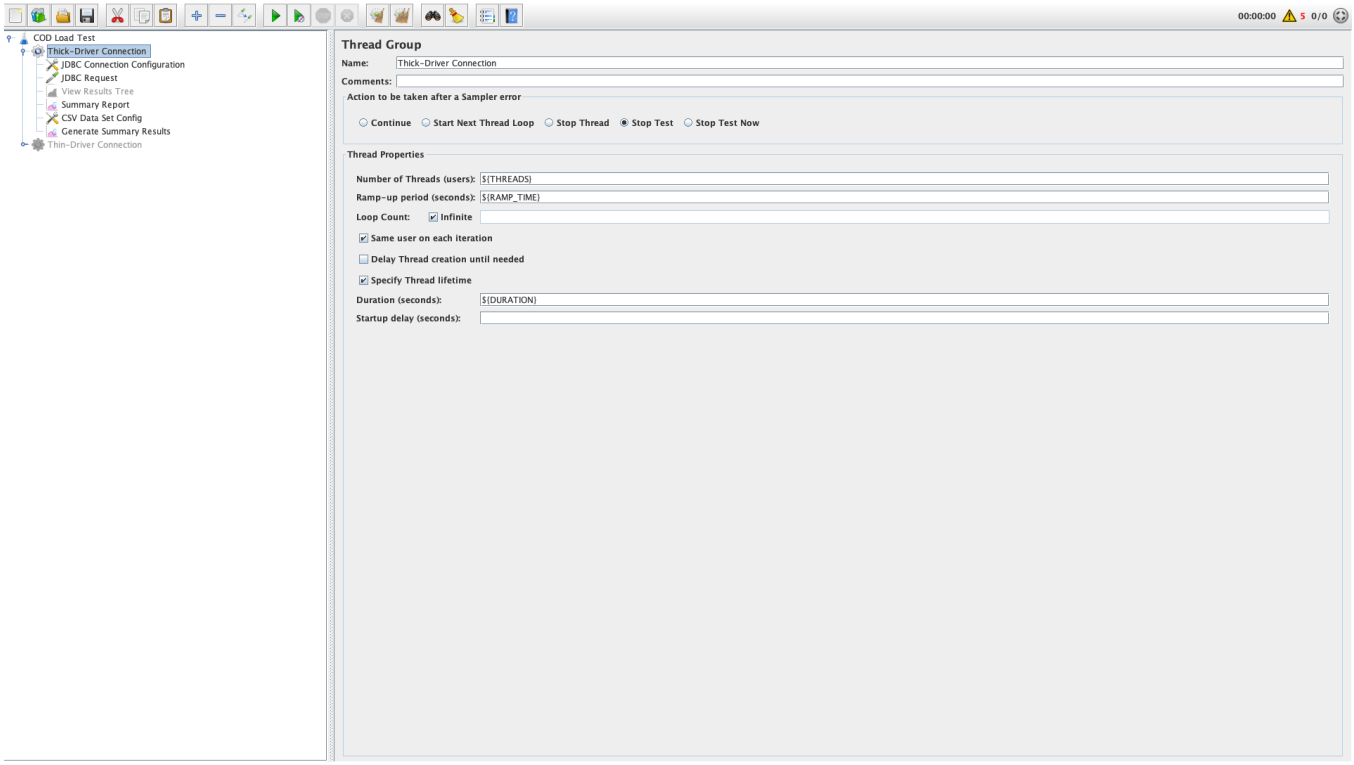


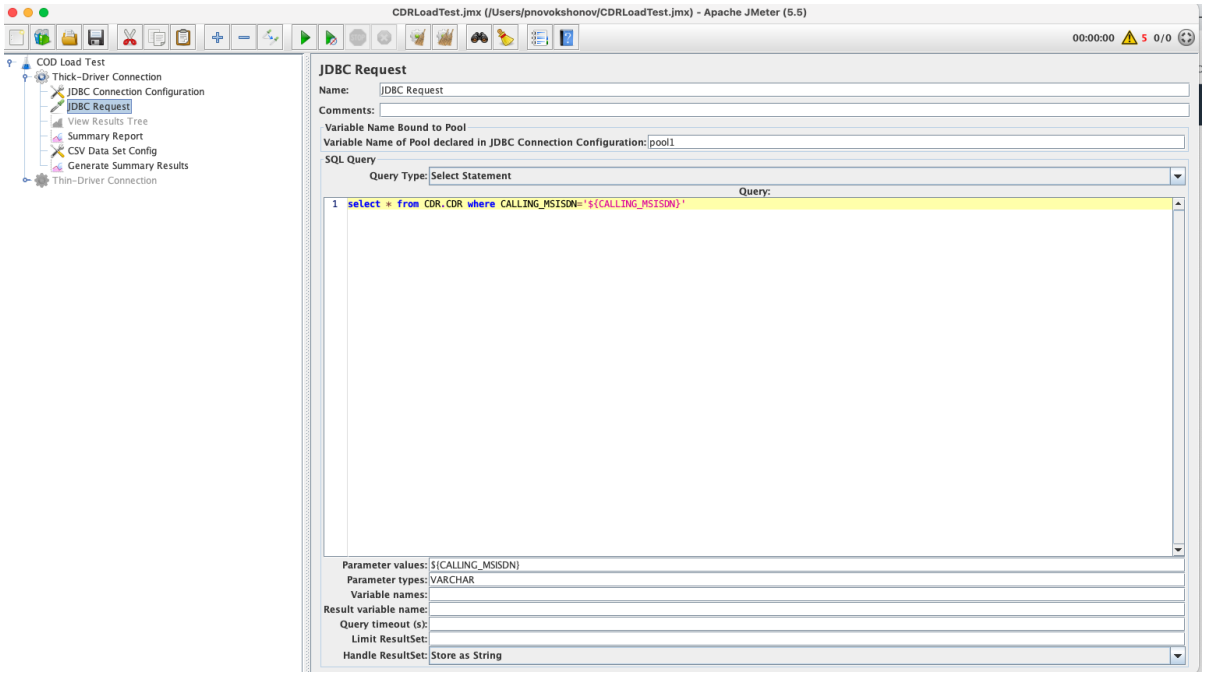
What is it we're running? You can open the **CDRLoadTest.jmx** and find the following select statement. This query is using part of the row key to pull records from Phoenix/HBase. Getting data by row key is a point lookup and a very fast operation.

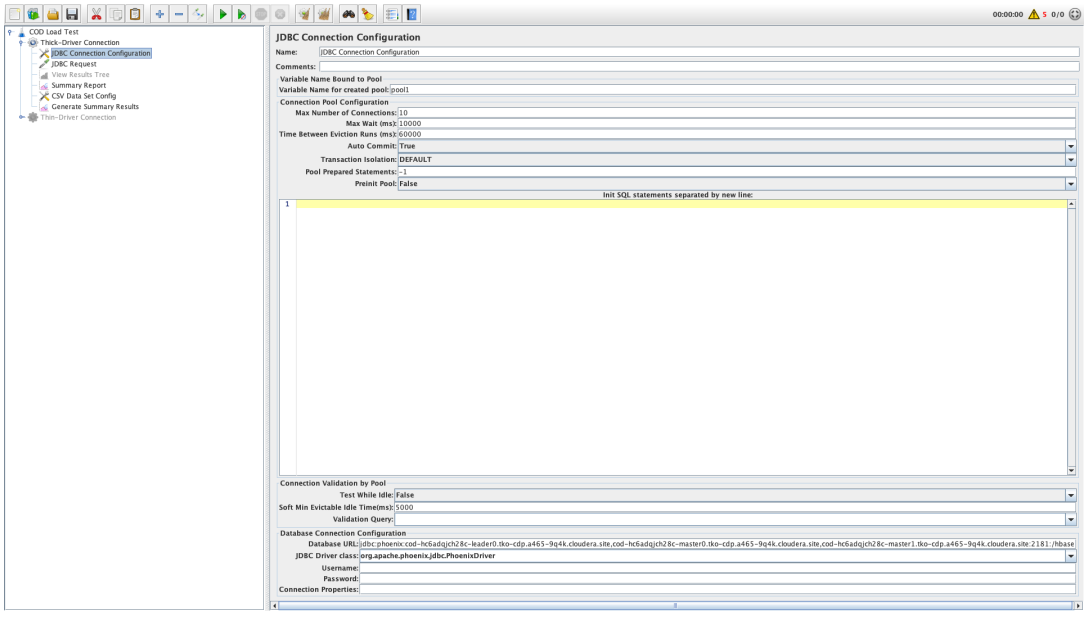
Unset

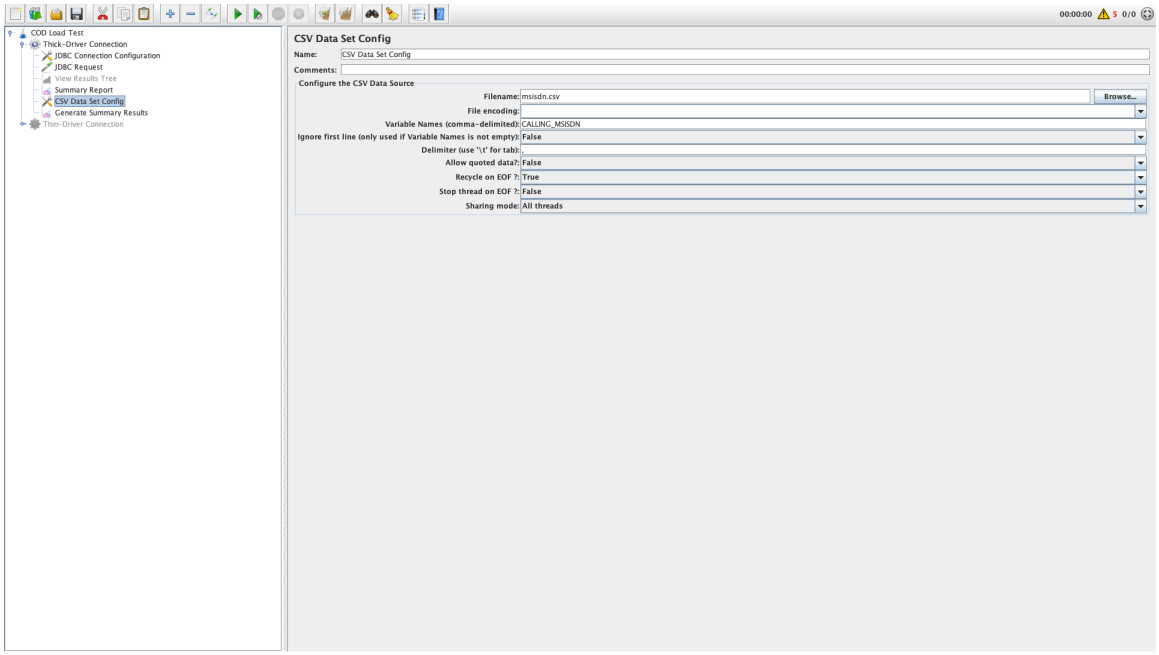
```
select * from CDR.CDR where CALLING_MSISDN=${CALLING_MSISDN};
```

What if you want to look at or change the test contents, add more queries, modify database parameters, create a new test, etc? You have to run JMeter in a GUI mode and open a .jmx file which is **CDRLoadTest.jmx** in our case**.** One option would be to install JMeter locally on your laptop, copy and open a .jmx file. Below are some screenshots depicting our test scenario.




CDRLoadTest.jmx (/Users/pnovokshonov/CDRLoadTest.jmx) - Apache JMeter (5.5)
00:00:00 5 0/0
COD Load Test
Thick-Driver Connection
JDBC Connection Configuration
JDBC Request
View Results Tree
Summary Report
CSV Data Set Config
Generate Summary Results
Thin-Driver Connection
JDBC Request
Name: JDBC Request
Comments:
Variable Name Bound to Pool
Variable Name of Pool declared in JDBC Connection Configuration: pool1
SQL Query
Query Type: Select Statement
Query:
1 select * from CDR.CDR where CALLING_MSISDN='${CALLING_MSISDN}'
Parameter values: ${CALLING_MSISDN}
Parameter types: VARCHAR
Variable names:
Result variable name:
Query timeout (s):
Limit ResultSet:
Handle ResultSet: Store as String


00:00:00 5 0/0
COD Load Test
Thick-Driver Connection
JDBC Connection Configuration
JDBC Request
View Results Tree
Summary Report
CSV Data Set Config
Generate Summary Results
Thin-Driver Connection
JDBC Connection Configuration
Name: JDBC Connection Configuration
Comments:
Variable Name Bound to Pool
Variable Name for created pool: pool1
Connection Pool Configuration
Max Number of Connections: 10
Max Wait (ms): 10000
Time Between Eviction Runs (ms): 60000
Auto Commit: True
Transaction Isolation: DEFAULT
Pool Prepared Statements: -1
Preinit Pool: False
Init SQL statements separated by new line:
1
Connection Validation by Pool
Test While Idle: False
Soft Min Evictable Idle Time(ms): 5000
Validation Query:
Database Connection Configuration
Database URL: jdbc:phoenix:cod-hc6adqjch28c-leader0.tko-cdp.a465-9q4k.cloudera.site,cod-hc6adqjch28c-master0.tko-cdp.a465-9q4k.cloudera.site,cod-hc6adqjch28c-master1.tko-cdp.a465-9q4k.cloudera.site:2181:/hbase
JDBC Driver class: org.apache.phoenix.jdbc.PhoenixDriver
Username:
Password:
Connection Properties:



NOTE: JMeter can run in GUI mode on the Linux server (Edge node) as well, but you would have to install and configure **X11** - **a remote-display protocol used by Linux/Unix machines.**
https://www.businessnewsdaily.com/11035-how-to-use-x11-forwarding.html

Appendix

Table Views

In Apache Phoenix, Table views can be created to read the data from table(s) as well as to write (update) tables provided conditions are met, (discussed below)

Lets create a Phoenix view using `CREATE VIEW`….

- Using phoenix-sqlline cli, execute the `CREATE VIEW` statement and replace `${USER}` with your username

```
Unset
CREATE VIEW simple_call_${USER}_vw AS SELECT * FROM test_${USER}
```

SELECT query powering the view can have complex WHERE clause e.g. joining two tables.

NOTE: Views in Phoenix are READ_ONLY

- Execute a `SELECT *` to read records using the view

```
Unset
SELECT * from simple_call_${USER}_vw
```

NOTE: When creating a Phoenix view over an existing Phoenix table, there is no need to explicitly define static columns that are already defined in the underlying table. The list of columns defined in the select query would be automatically included with the table view columns

You can also use a view to add new dynamic columns to an existing table. Phoenix allows you to write data (i.e execute DML) using a view as long as the view is defined on a single table and uses a simple equality expression in the `WHERE` clause.

Here we will add another table view on an existing table with an additional column named `"FLAG2,`. Any new columns added from the view would be added as dynamic columns to the underlying table.

- Run a `CREATE VIEW` statement and add the FLAG2 dynamic column. Replace `<USERNAME>` with your username

```
Unset
CREATE VIEW callView_${USER} (FLAG2 BOOLEAN) AS select * FROM test_${USER}
```

NOTE: The dynamic column “FLAG2” added in this view is different from the dynamic column FLAG that was added to the table in the earlier example.

Due to the COLUMN ENCODING feature added in Phoenix 4.10, data from any dynamic column added directly to the table would not be rendered from the view.

Any records (including existing records) that were present without the “specified” column will return a null value.

Similarly, when you add columns to a table with a view, you need to upsert data into the view. **You don’t have to add the new column’s type when using `UPSERT` into a view**

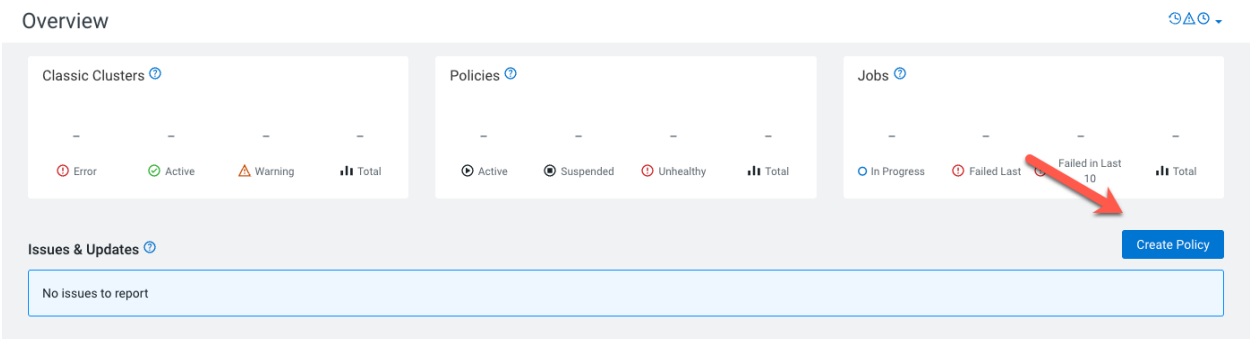
Replication Manager

Another useful tool for migration HBase data is Replication Manager. RM is an easy method to move all your tables or a single table from one HBase instance to another. For example, if you need to move your on-prem Hbase cluster (either HDP or CDH) to COD on CDP Public Cloud on object storage, you can use replication to move the data and then port your application to the new COD cluster with little to no code changes. Although we won’t create an active replication policy, here we will do a quick walk-through of the key features of Replication Manager.

- First, let’s open up the CDP Control Plane. Select the Replication Manager tile

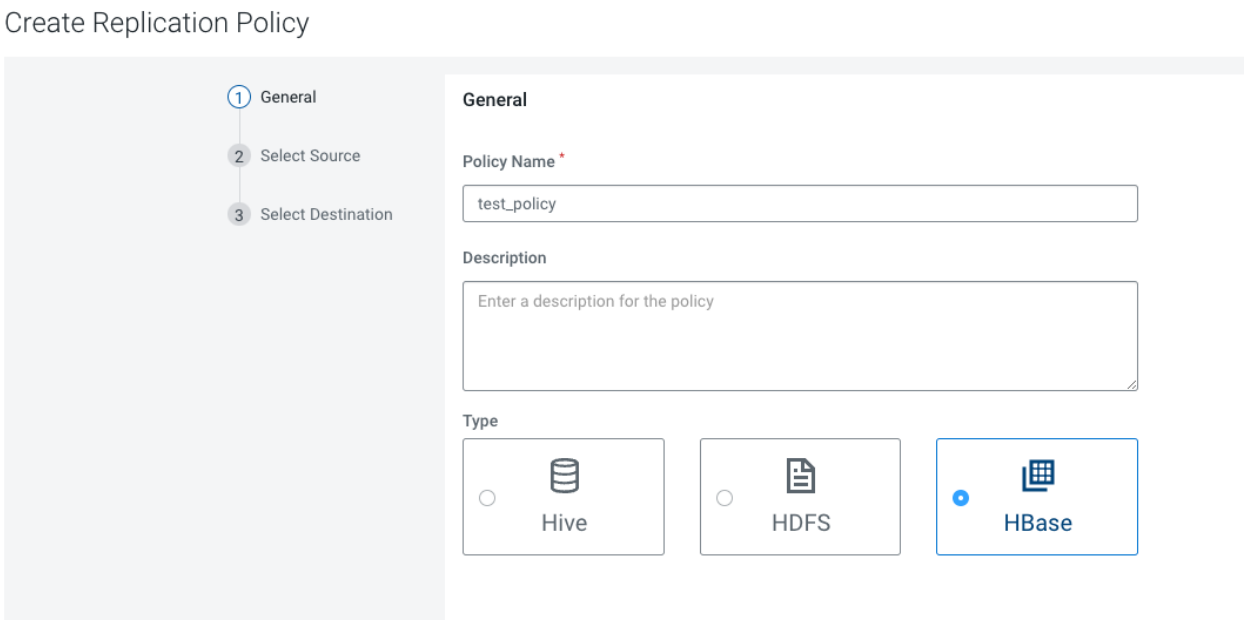
This will get you into the Replication Manager administration page. Since this is a new cluster, you won't see any replication policies. It's on this page you have the ability to create replication policies for HBase, Hive, and HDFS.

- Click on Create Policy to begin walking through the policy features.



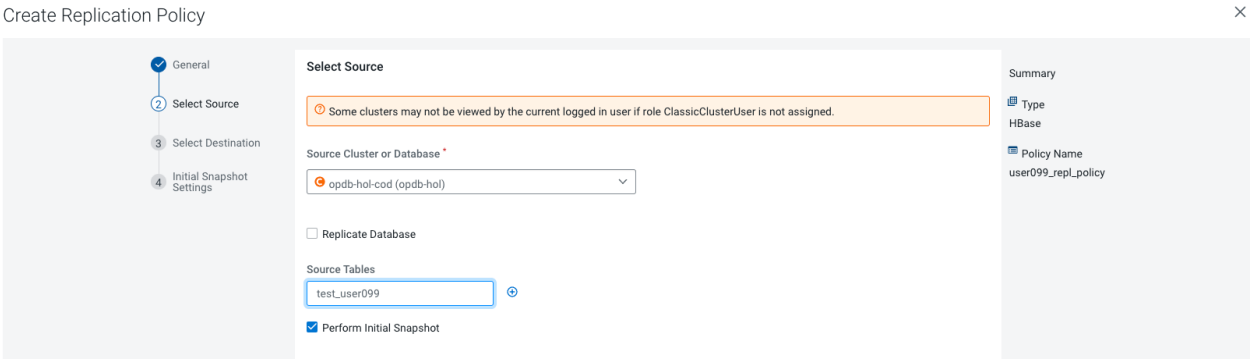
On the policy page you will see a simple step-by-step process for creating a policy. The first page is the general page where you will provide a policy name, (optional) description, and what service you want to replicate.

- On the General policy page, type a policy name and select HBase as the service you want to replicate. Click Next.



The process for replicating HBase is simple. You only need to select a source and a destination. Keep in mind that both source and destination need to exist.

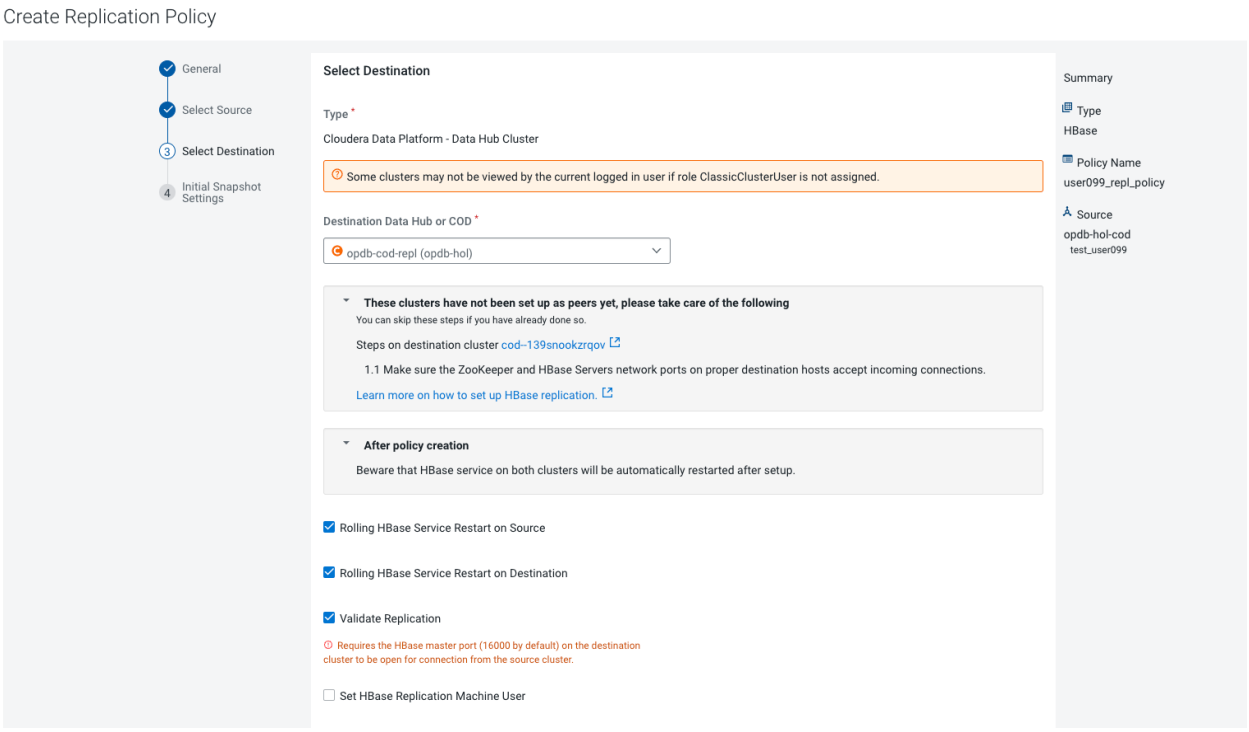
- In this example, we will select our COD cluster as the source. Click on Source Cluster or Database and select the `opdb-hol-cod` cluster from the drop down. Type in your test_<USERNAME> as the source table



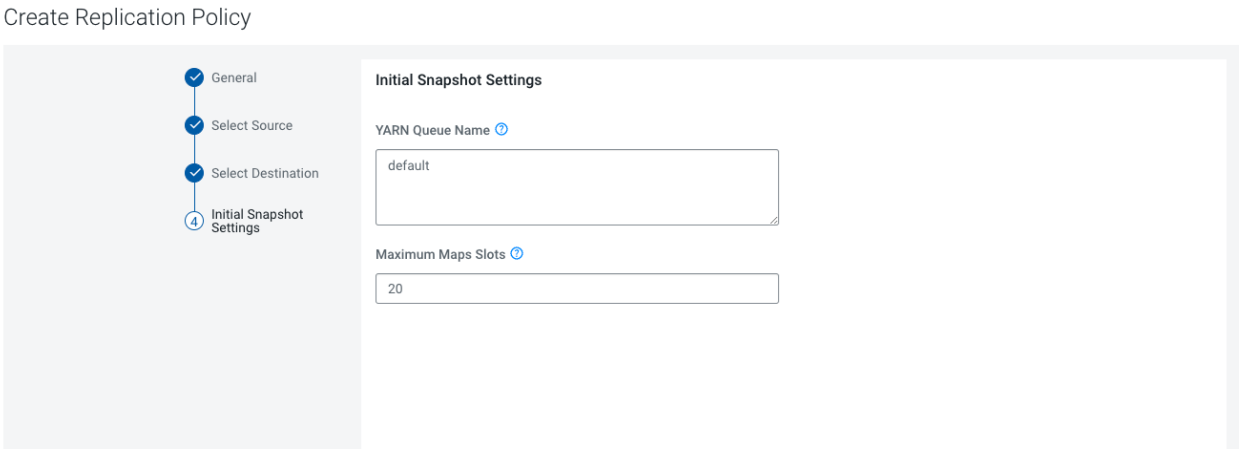
- In the Select Destination page, choose the database `opdb-cod-repl` as the destination database. You'll notice some warnings indicating that both the source and destination will go through rolling restarts and there will be a validation that the replication was successful.

- You will also need to Set the Workload user. For this enter the following

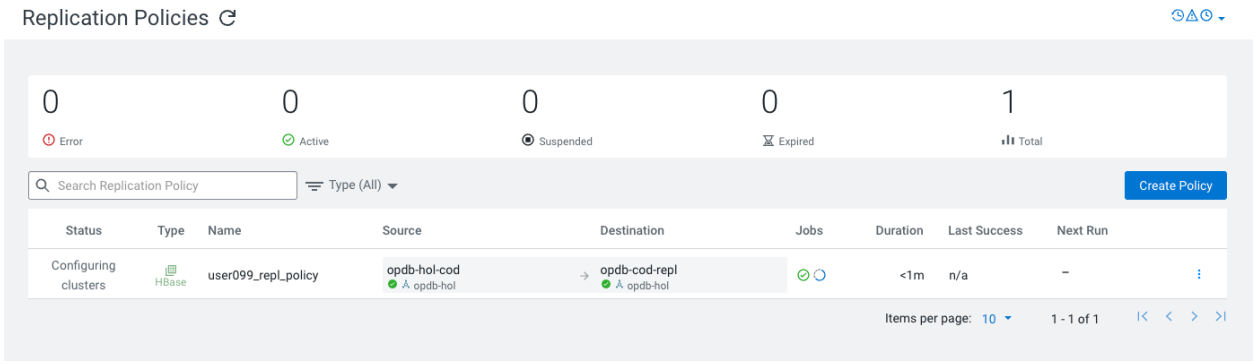
  Username: `cod_repl`
  Password: `Cloudera1234`



- On the Initial Snapshot screen, keep the defaults and click Create.



After a brief pause, you should be taken back to the policy screen where you monitor the replication process.


Replication Policies
0
Error
0
Active
0
Suspended
0
Expired
1
Total
Search Replication Policy
Type (All)
Create Policy
Status
Type
Name
Source
Destination
Jobs
Duration
Last Success
Next Run
Configuring clusters
HBase
user099_repl_policy
opdb-hol-cod
opdb-hol
opdb-cod-repl
opdb-hol
<1m
n/a
–
Items per page: 10
1 - 1 of 1