

Apache CarbonData
Ver 1.0
Documentation

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1 Quick Start

Quick Start

This tutorial provides a quick introduction to using CarbonData.

1.1 Prerequisites

- Installation and building CarbonData.
- Create a sample.csv file using the following commands. The CSV file is required for loading data into CarbonData.

```
cd carbondata cat > sample.csv << EOF id,name,city,age 1,david,shenzhen,31
2,eason,shenzhen,27 3,jarry,wuhan,35 EOF
```

1.2 Interactive Analysis with Spark Shell Version 2.1

Apache Spark Shell provides a simple way to learn the API, as well as a powerful tool to analyze data interactively. Please visit [Apache Spark Documentation](#) for more details on Spark shell.

1.2.1.1 Basics

Start Spark shell by running the following command in the Spark directory:

```
./bin/spark-shell --jars <carbondata assembly jar path>
```

NOTE: Assembly jar will be available after building CarbonData and can be copied from `./assembly/target/scala-2.1x/carbondata_xxx.jar`

In this shell, SparkSession is readily available as `spark` and Spark context is readily available as `sc`.

In order to create a CarbonSession we will have to configure it explicitly in the following manner :

- Import the following :

```
import org.apache.spark.sql.Session
import org.apache.spark.sql.Session._
```

- Create a CarbonSession :

```
val carbon = Session.builder().config(sc.getConf)
    .getOrCreateCarbonSession("<hdfs store path>")
```

NOTE: By default metastore location is pointed to `./carbon.metastore`, user can provide own metastore location to CarbonSession like
`Session.builder().config(sc.getConf) .getOrCreateCarbonSession("<hdfs store path>", "<local metastore path>")`

1.2.1.2 Executing Queries

1. Creating a Table

```
scala>carbon.sql("CREATE TABLE
                  IF NOT EXISTS test_table(
                      id string,
                      name string,
                      city string,
                      age Int)
                  STORED BY 'carbondata'")
```

1. Loading Data to a Table

```
scala>carbon.sql("LOAD DATA INPATH '/path/to/sample.csv'
                  INTO TABLE test_table")
```

NOTE: Please provide the real file path of `sample.csv` for the above script. If you get “tablestatus.lock” issue, please refer to [troubleshooting](#)

1. Query Data from a Table

```
scala>carbon.sql("SELECT * FROM test_table").show()

scala>carbon.sql("SELECT city, avg(age), sum(age)
                  FROM test_table
                  GROUP BY city").show()
```

2 Data Management on CarbonData

Data Management on CarbonData

This tutorial is going to introduce all commands and data operations on CarbonData.

- CREATE TABLE
- TABLE MANAGEMENT
- LOAD DATA
- UPDATE AND DELETE
- COMPACTION
- PARTITION
- BUCKETING
- SEGMENT MANAGEMENT

2.1 CREATE TABLE

This command can be used to create a CarbonData table by specifying the list of fields along with the table properties.

```
CREATE TABLE [IF NOT EXISTS] [db_name.]table_name[(col_name
data_type , ...)] STORED BY 'carbondata' [TBLPROPERTIES
(property_name=property_value, ...)]
```

2.1.1 Usage Guidelines

Following are the guidelines for TBLPROPERTIES, CarbonData's additional table options can be set via carbon.properties.

- **Dictionary Encoding Configuration**

Dictionary encoding is turned off for all columns by default from 1.3 onwards, you can use this command for including columns to do dictionary encoding. Suggested use cases : do dictionary encoding for low cardinality columns, it might help to improve data compression ratio and performance.

```
TBLPROPERTIES ('DICTIONARY_INCLUDE'='column1, column2')
```

- **Inverted Index Configuration**

By default inverted index is enabled, it might help to improve compression ratio and query speed, especially for low cardinality columns which are in reward position. Suggested use cases : For high cardinality columns, you can disable the inverted index for improving the data loading performance.

```
TBLPROPERTIES ('NO_INVERTED_INDEX'='column1, column3')
```

- **Sort Columns Configuration**

This property is for users to specify which columns belong to the MDK(Multi-Dimensions-Key) index. * If users don't specify "SORT_COLUMN" property, by default MDK index be built by using all dimension columns except complex datatype column. * If this property is specified but with empty argument, then the table will be loaded without sort.. Suggested use cases : Only build MDK index for required columns, it might help to improve the data loading performance.

```
TBLPROPERTIES ('SORT_COLUMNS'='column1, column3') OR TBLPROPERTIES
('SORT_COLUMNS'='')
```

- **Sort Scope Configuration**

This property is for users to specify the scope of the sort during data load, following are the types of sort scope.

- **LOCAL_SORT**: It is the default sort scope.
- **NO_SORT**: It will load the data in unsorted manner, it will significantly increase load performance.
- **BATCH_SORT**: It increases the load performance but decreases the query performance if identified blocks > parallelism.
- **GLOBAL_SORT**: It increases the query performance, especially high concurrent point query. And if you care about loading resources isolation strictly, because the system uses the spark GroupBy to sort data, the resource can be controlled by spark.

- **Table Block Size Configuration**

This command is for setting block size of this table, the default value is 1024 MB and supports a range of 1 MB to 2048 MB.

TBLPROPERTIES ('TABLE_BLOCKSIZE'='512') NOTE: 512 or 512M both are accepted.

2.1.2 Example:

```

---
CREATE TABLE IF NOT EXISTS productSchema.productSalesTable (
    productNumber Int,
    productName String,
    storeCity String,
    storeProvince String,
    productCategory String,
    productBatch String,
    saleQuantity Int,
    revenue Int)
STORED BY 'carbodata'
TBLPROPERTIES ('DICTIONARY_INCLUDE'='productNumber',
    'NO_INVERTED_INDEX'='productBatch',
    'SORT_COLUMNS'='productName,storeCity',
    'SORT_SCOPE'='NO_SORT',
    'TABLE_BLOCKSIZE'='512')
---
```

2.2 TABLE MANAGEMENT

2.2.1 SHOW TABLE

This command can be used to list all the tables in current database or all the tables of a specific database. `SHOW TABLES [IN db_Name]`

Example: `SHOW TABLES` OR `SHOW TABLES IN defaultdb`

2.2.2 ALTER TABLE

The following section introduce the commands to modify the physical or logical state of the existing table(s).

- **RENAME TABLE**

This command is used to rename the existing table. `ALTER TABLE [db_name.]table_name RENAME TO new_table_name`

Examples: `ALTER TABLE carbon RENAME TO carbondata` OR `ALTER TABLE test_db.carbon RENAME TO test_db.carbondata`

- **ADD COLUMNS**

This command is used to add a new column to the existing table. `ALTER TABLE [db_name.]table_name ADD COLUMNS (col_name data_type,...) TBLPROPERTIES('DICTIONARY_INCLUDE'='col_name,...', 'DEFAULT.VALUE.COLUMN_NAME'='default_value')`

Examples: `ALTER TABLE carbon ADD COLUMNS (a1 INT, b1 STRING)`

`ALTER TABLE carbon ADD COLUMNS (a1 INT, b1 STRING) TBLPROPERTIES('DICTIONARY_INCLUDE'='a1')`

`ALTER TABLE carbon ADD COLUMNS (a1 INT, b1 STRING) TBLPROPERTIES('DEFAULT.VALUE.a1'='10')`

- **DROP COLUMNS**

This command is used to delete the existing column(s) in a table. `ALTER TABLE [db_name.]table_name DROP COLUMNS (col_name, ...)`

Examples: `` `ALTER TABLE carbon DROP COLUMNS (b1)` OR `ALTER TABLE test_db.carbon DROP COLUMNS (b1)`

`ALTER TABLE carbon DROP COLUMNS (c1,d1)` ``

- **CHANGE DATA TYPE**

This command is used to change the data type from INT to BIGINT or decimal precision from lower to higher. Change of decimal data type from lower precision to higher precision will only be supported for cases where there is no data loss. `ALTER TABLE [db_name.]table_name CHANGE col_name col_name changed_column_type`

Valid Scenarios - Invalid scenario - Change of decimal precision from (10,2) to (10,5) is invalid as in this case only scale is increased but total number of digits remains the same. - Valid scenario - Change of decimal precision from (10,2) to (12,3) is valid as the total number of digits are increased by 2 but scale is increased only by 1 which will not lead to any data loss. - NOTE: The allowed range is 38,38 (precision, scale) and is a valid upper case scenario which is not resulting in data loss.

Example1: Changing data type of column a1 from INT to BIGINT. `ALTER TABLE test_db.carbon CHANGE a1 a1 BIGINT`

Example2: Changing decimal precision of column a1 from 10 to 18. `ALTER TABLE test_db.carbon CHANGE a1 a1 DECIMAL(18,2)`

2.2.3 DROP TABLE

This command is used to delete an existing table. `DROP TABLE [IF EXISTS] [db_name.]table_name`

Example: `DROP TABLE IF EXISTS productSchema.productSalesTable`

2.3 LOAD DATA

2.3.1 LOAD FILES TO CARBONDATA TABLE

This command is used to load csv files to carbondata, OPTIONS are not mandatory for data loading process. Inside OPTIONS user can provide either of any options like DELIMITER, QUOTECHAR, FILEHEADER, ESCAPECHAR, MULTILINE as per requirement.

```
LOAD DATA [LOCAL] INPATH 'folder_path' INTO TABLE [db_name.]table_name
OPTIONS(property_name=property_value, ...)
```

You can use the following options to load data:

- **DELIMITER:** Delimiters can be provided in the load command.

```
OPTIONS('DELIMITER'=',')
```

- **QUOTECHAR:** Quote Characters can be provided in the load command.

```
OPTIONS('QUOTECHAR'='"')
```

- **COMMENTCHAR:** Comment Characters can be provided in the load command if user want to comment lines.

```
OPTIONS('COMMENTCHAR'='#')
```

- **FILEHEADER:** Headers can be provided in the LOAD DATA command if headers are missing in the source files.

```
OPTIONS('FILEHEADER'='column1,column2')
```

- **MULTILINE:** CSV with new line character in quotes.

```
OPTIONS('MULTILINE'='true')
```

- **ESCAPECHAR:** Escape char can be provided if user want strict validation of escape character on CSV.

```
OPTIONS('ESCAPECHAR'='\')
```

- **COMPLEX_DELIMITER_LEVEL_1:** Split the complex type data column in a row (eg., a\$b \$c -> Array = {a,b,c}).

```
OPTIONS('COMPLEX_DELIMITER_LEVEL_1'='$')
```

- **COMPLEX_DELIMITER_LEVEL_2:** Split the complex type nested data column in a row. Applies level_1 delimiter & applies level_2 based on complex data type (eg., a:b\$c:d -> Array> = {{a,b},{c,d}}).

```
OPTIONS('COMPLEX_DELIMITER_LEVEL_2'=':')
```

- **ALL_DICTIONARY_PATH:** All dictionary files path.

```
OPTIONS('ALL_DICTIONARY_PATH'='/opt/alldictionary/data.dictionary')
```

- **COLUMNNECT:** Dictionary file path for specified column.

```
OPTIONS('COLUMNNECT'='column1:dictionaryFilePath1,column2:dictionaryFilePath2')
```

NOTE: ALL_DICTIONARY_PATH and COLUMNNECT can't be used together.

- **DATEFORMAT/TIMESTAMPFORMAT:** Date and Timestamp format for specified column.

OPTIONS('DATEFORMAT' = 'yyyy-MM-dd', 'TIMESTAMPFORMAT'='yyyy-MM-dd HH:mm:ss') NOTE: Date formats are specified by date pattern strings. The date pattern letters in CarbonData are same as in JAVA. Refer to SimpleDateFormat.

- **SINGLE_PASS:** Single Pass Loading enables single job to finish data loading with dictionary generation on the fly. It enhances performance in the scenarios where the subsequent data loading after initial load involves fewer incremental updates on the dictionary.

This option specifies whether to use single pass for loading data or not. By default this option is set to FALSE.

OPTIONS('SINGLE_PASS'='TRUE') NOTE: * If this option is set to TRUE then data loading will take less time. * If this option is set to some invalid value other than TRUE or FALSE then it uses the default value. * If this option is set to TRUE, then high.cardinality.identify.enable property will be disabled during data load. * For first Load SINGLE_PASS loading option is disabled.

Example: LOAD DATA local inpath '/opt/rawdata/data.csv' INTO table carbontable options('DELIMITER'=',', 'QUOTECHAR'='"', 'COMMENTCHAR'='#', 'FILEHEADER'='empno,empname,designation,doj,workgroupcategory,workgroupcategoryname,deptno,deptname,projectcode,projectjoindate,projectenddate,attendance,utilization,salary', 'MULTILINE'='true', 'ESCAPECHAR'='\', 'COMPLEX_DELIMITER_LEVEL_1'='\$', 'COMPLEX_DELIMITER_LEVEL_2'=':', 'ALL_DICTIONARY_PATH'='/opt/alldictionary/data.dictionary', 'SINGLE_PASS'='TRUE')

- **BAD RECORDS HANDLING:** Methods of handling bad records are as follows:

- Load all of the data before dealing with the errors.
- Clean or delete bad records before loading data or stop the loading when bad records are found.

```
OPTIONS('BAD_RECORDS_LOGGER_ENABLE'='true', 'BAD_RECORD_PATH'='hdfs://hacluster
```

NOTE: * BAD_RECORD_ACTION property can have four type of actions for bad records FORCE, REDIRECT, IGNORE and FAIL. * If the REDIRECT option is used, CarbonData will add all bad records in to a separate CSV file. However, this file must not be used for subsequent data loading because the content may not exactly match the source record. You are advised to cleanse the original source record for further data ingestion. This option is used to remind you which records are bad records. * If the FORCE option is used, then it auto-corrects the data by storing the bad records as NULL before Loading data. * If the IGNORE option is used, then bad records are neither loaded nor written to the separate CSV file. * IF the FAIL option is used, then data loading fails if any bad records are found. * In loaded data, if all records are bad records, the BAD_RECORDS_ACTION is invalid and the load operation fails. * The maximum number of characters per column is 100000. If there are more than 100000 characters in a column, data loading will fail.

Example: `LOAD DATA INPATH 'filepath.csv' INTO TABLE tablename
 OPTIONS('BAD_RECORDS_LOGGER_ENABLE'='true','BAD_RECORD_PATH'='hdfs://
 hacluster/tmp/carbon',
 'BAD_RECORDS_ACTION'='REDIRECT','IS_EMPTY_DATA_BAD_RECORD'='false')`

2.3.2 INSERT DATA INTO CARBONDATA TABLE

This command inserts data into a CarbonData table, it is defined as a combination of two queries Insert and Select query respectively. It inserts records from a source table into a target CarbonData table, the source table can be a Hive table, Parquet table or a CarbonData table itself. It comes with the functionality to aggregate the records of a table by performing Select query on source table and load its corresponding resultant records into a CarbonData table.

```
INSERT INTO TABLE <CARBONDATA TABLE> SELECT * FROM sourceTableName [ WHERE  
{ <filter_condition> } ]
```

You can also omit the table keyword and write your query as:

```
INSERT INTO <CARBONDATA TABLE> SELECT * FROM sourceTableName [ WHERE  
{ <filter_condition> } ]
```

Overwrite insert data: `INSERT OVERWRITE <CARBONDATA TABLE> SELECT * FROM
 sourceTableName [WHERE { <filter_condition> }]`

NOTE: * The source table and the CarbonData table must have the same table schema. * The data type of source and destination table columns should be same * INSERT INTO command does not support partial success if bad records are found, it will fail. * Data cannot be loaded or updated in source table while insert from source table to target table is in progress.

Examples `INSERT INTO table1 SELECT item1, sum(item2 + 1000) as result FROM
 table2 group by item1`

```
INSERT INTO table1 SELECT item1, item2, item3 FROM table2 where item2='xyz'
```

```
INSERT OVERWRITE table1 SELECT * FROM TABLE2
```

2.4 UPDATE AND DELETE

2.4.1 UPDATE

This command will allow to update the CarbonData table based on the column expression and optional filter conditions.

```
UPDATE <table_name> SET (column_name1, column_name2, ... column_name n) =  
(column1_expression , column2_expression, ... column n_expression ) [ WHERE  
{ <filter_condition> } ]
```

alternatively the following the command can also be used for updating the CarbonData Table :

```
UPDATE <table_name> SET (column_name1, column_name2) =(select  

  sourceColumn1, sourceColumn2 from sourceTable [ WHERE  
{ <filter_condition> } ] ) [ WHERE { <filter_condition> } ]
```

NOTE:The update command fails if multiple input rows in source table are matched with single row in destination table.

Examples: `UPDATE t3 SET (t3_salary) = (t3_salary + 9) WHERE t3_name = 'aaa1'`

```
UPDATE t3 SET (t3_date, t3_country) = ('2017-11-18', 'india') WHERE  

t3_salary < 15003
```

```
UPDATE t3 SET (t3_country, t3_name) = (SELECT t5_country, t5_name FROM t5
WHERE t5_id = 5) WHERE t3_id < 5

UPDATE t3 SET (t3_date, t3_serialname, t3_salary) = (SELECT '2099-09-09',
t5_serialname, '9999' FROM t5 WHERE t5_id = 5) WHERE t3_id < 5

UPDATE t3 SET (t3_country, t3_salary) = (SELECT t5_country, t5_salary FROM
t5 FULL JOIN t3 u WHERE u.t3_id = t5_id and t5_id=6) WHERE t3_id >6
```

2.4.2 DELETE

This command allows us to delete records from CarbonData table. `DELETE FROM table_name [WHERE expression]`

Examples:

```
DELETE FROM carbontable WHERE column1 = 'china'

DELETE FROM carbontable WHERE column1 IN ('china', 'USA')

DELETE FROM carbontable WHERE column1 IN (SELECT column1 FROM
sourceTable2)

DELETE FROM carbontable WHERE column1 IN (SELECT column1 FROM sourceTable2
WHERE column1 = 'USA')
```

2.5 COMPACTION

Compaction improves the query performance significantly. During the load data, several CarbonData files are generated, this is because data is sorted only within each load (per load segment and one B+ tree index).

There are two types of compaction, Minor and Major compaction.

```
ALTER TABLE [db_name.]table_name COMPACT 'MINOR/MAJOR'
```

• Minor Compaction

In Minor compaction, user can specify the number of loads to be merged. Minor compaction triggers for every data load if the parameter `carbon.enable.auto.load.merge` is set to true. If any segments are available to be merged, then compaction will run parallel with data load, there are 2 levels in minor compaction: * Level 1: Merging of the segments which are not yet compacted. * Level 2: Merging of the compacted segments again to form a larger segment.

```
ALTER TABLE table_name COMPACT 'MINOR'
```

• Major Compaction

In Major compaction, multiple segments can be merged into one large segment. User will specify the compaction size until which segments can be merged, Major compaction is usually done during the off-peak time. This command merges the specified number of segments into one segment:

```
ALTER TABLE table_name COMPACT 'MAJOR'
```

2.6 PARTITION

Similar to other system's partition features, CarbonData's partition feature also can be used to improve query performance by filtering on the partition column.

2.6.1 Create Hash Partition Table

This command allows us to create hash partition.

```
CREATE TABLE [IF NOT EXISTS] [db_name.]table_name [(col_name
data_type , ...)] PARTITIONED BY (partition_col_name data_type)
STORED BY 'carbodata' [TBLPROPERTIES ('PARTITION_TYPE'='HASH',
'NUM_PARTITIONS'='N' ...)] NOTE: N is the number of hash partitions
```

Example: CREATE TABLE IF NOT EXISTS hash_partition_table(col_A String, col_B Int, col_C Long, col_D Decimal(10,2), col_F Timestamp) PARTITIONED BY (col_E Long) STORED BY 'carbodata' TBLPROPERTIES('PARTITION_TYPE'='HASH', 'NUM_PARTITIONS'='9')

2.6.2 Create Range Partition Table

This command allows us to create range partition. CREATE TABLE [IF NOT EXISTS] [db_name.]table_name [(col_name data_type , ...)] PARTITIONED BY (partition_col_name data_type) STORED BY 'carbodata' [TBLPROPERTIES ('PARTITION_TYPE'='RANGE', 'RANGE_INFO'='2014-01-01, 2015-01-01, 2016-01-01, ...')]

NOTE: * The 'RANGE_INFO' must be defined in ascending order in the table properties. * The default format for partition column of Date/Timestamp type is yyyy-MM-dd. Alternate formats for Date/Timestamp could be defined in CarbonProperties.

Example: CREATE TABLE IF NOT EXISTS range_partition_table(col_A String, col_B Int, col_C Long, col_D Decimal(10,2), col_E Long) partitioned by (col_F Timestamp) PARTITIONED BY 'carbodata' TBLPROPERTIES('PARTITION_TYPE'='RANGE', 'RANGE_INFO'='2015-01-01, 2016-01-01, 2017-01-01, 2017-02-01')

2.6.3 Create List Partition Table

This command allows us to create list partition. CREATE TABLE [IF NOT EXISTS] [db_name.]table_name [(col_name data_type , ...)] PARTITIONED BY (partition_col_name data_type) STORED BY 'carbodata' [TBLPROPERTIES ('PARTITION_TYPE'='LIST', 'LIST_INFO'='A, B, C, ...')] NOTE: List partition supports list info in one level group.

Example: CREATE TABLE IF NOT EXISTS list_partition_table(col_B Int, col_C Long, col_D Decimal(10,2), col_E Long, col_F Timestamp) PARTITIONED BY (col_A String) STORED BY 'carbodata' TBLPROPERTIES('PARTITION_TYPE'='LIST', 'LIST_INFO'='aaaa, bbbb, (cccc, dddd), eeee')

2.6.4 Show Partitions

The following command is executed to get the partition information of the table

```
SHOW PARTITIONS [db_name.]table_name
```

2.6.5 Add a new partition

```
ALTER TABLE [db_name].table_name ADD PARTITION('new_partition')
```

2.6.6 Split a partition

```
ALTER TABLE [db_name].table_name SPLIT PARTITION(partition_id)
INTO('new_partition1', 'new_partition2'...)
```

2.6.7 Drop a partition

Only drop partition definition, but keep data `ALTER TABLE [db_name].table_name DROP PARTITION(partition_id)`

Drop both partition definition and data `ALTER TABLE [db_name].table_name DROP PARTITION(partition_id) WITH DATA`

NOTE: * Hash partition table is not supported for ADD, SPLIT and DROP commands. * Partition Id: in CarbonData like the hive, folders are not used to divide partitions instead partition id is used to replace the task id. It could make use of the characteristic and meanwhile reduce some metadata.

```
SegmentDir/0_batchno0-0-1502703086921.carbonindex ^ SegmentDir/
part-0-0_batchno0-0-1502703086921.carbondata ^
```

Here are some useful tips to improve query performance of carbonData partition table: * The partitioned column can be excluded from SORT_COLUMNS, this will let other columns to do the efficient sorting. * When writing SQL on a partition table, try to use filters on the partition column.

2.7 BUCKETING

Bucketing feature can be used to distribute/organize the table/partition data into multiple files such that similar records are present in the same file. While creating a table, user needs to specify the columns to be used for bucketing and the number of buckets. For the selection of bucket the Hash value of columns is used.

```
CREATE TABLE [IF NOT EXISTS] [db_name.]table_name
[(col_name data_type, ...)] STORED BY 'carbondata'
TBLPROPERTIES('BUCKETNUMBER'='noOfBuckets', 'BUCKETCOLUMNS'='columnname')
```

NOTE: * Bucketing can not be performed for columns of Complex Data Types. * Columns in the BUCKETCOLUMN parameter must be only dimension. The BUCKETCOLUMN parameter can not be a measure or a combination of measures and dimensions.

```
Example: CREATE TABLE IF NOT EXISTS productSchema.productSalesTable
( productNumber Int, saleQuantity Int, productName String, storeCity
String, storeProvince String, productCategory String, productBatch String,
revenue Int) STORED BY 'carbondata' TBLPROPERTIES ('BUCKETNUMBER'='4',
'BUCKETCOLUMNS'='productName')
```

2.8 SEGMENT MANAGEMENT

2.8.1 SHOW SEGMENT

This command is used to get the segments of CarbonData table.

```
SHOW SEGMENTS FOR TABLE [db_name.]table_name LIMIT number_of_segments
```

Example: `SHOW SEGMENTS FOR TABLE CarbonDatabase.CarbonTable LIMIT 4`

2.8.2 DELETE SEGMENT BY ID

This command is used to delete segment by using the segment ID. Each segment has a unique segment ID associated with it. Using this segment ID, you can remove the segment.

The following command will get the segmentID.

```
SHOW SEGMENTS FOR TABLE [db_name.]table_name LIMIT number_of_segments
```

After you retrieve the segment ID of the segment that you want to delete, execute the following command to delete the selected segment.

```
DELETE FROM TABLE [db_name.]table_name WHERE SEGMENT.ID IN (segment_id1,  
segments_id2, ...)
```

Example:

```
DELETE FROM TABLE CarbonDatabase.CarbonTable WHERE SEGMENT.ID IN (0) DELETE  
FROM TABLE CarbonDatabase.CarbonTable WHERE SEGMENT.ID IN (0,5,8)
```

2.8.3 DELETE SEGMENT BY DATE

This command will allow to delete the CarbonData segment(s) from the store based on the date provided by the user in the DML command. The segment created before the particular date will be removed from the specific stores.

```
DELETE FROM TABLE [db_name.]table_name WHERE SEGMENT.STARTTIME BEFORE  
DATE_VALUE
```

Example: `DELETE FROM TABLE CarbonDatabase.CarbonTable WHERE
SEGMENT.STARTTIME BEFORE '2017-06-01 12:05:06'`

3 Data Types

Data Types

3.1.1.1 CarbonData supports the following data types:

- Numeric Types
 - SMALLINT
 - INT/INTEGER
 - BIGINT
 - DOUBLE
 - DECIMAL
- Date/Time Types
 - TIMESTAMP
 - DATE
- String Types
 - STRING
 - CHAR
 - VARCHAR
- Complex Types
 - arrays: `ARRAY <data_type>`
 - structs: `STRUCT <col_name : data_type COMMENT col_comment, ...>`
- Other Types
 - BOOLEAN

4 CarbonData File Structure

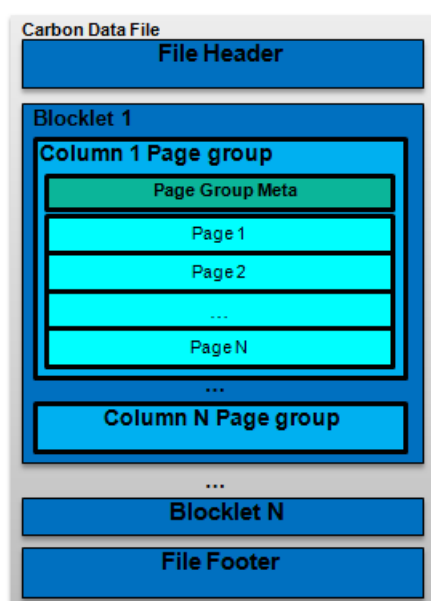
CarbonData File Structure

CarbonData files contain groups of data called blocklets, along with all required information like schema, offsets and indices etc, in a file header and footer, co-located in HDFS.

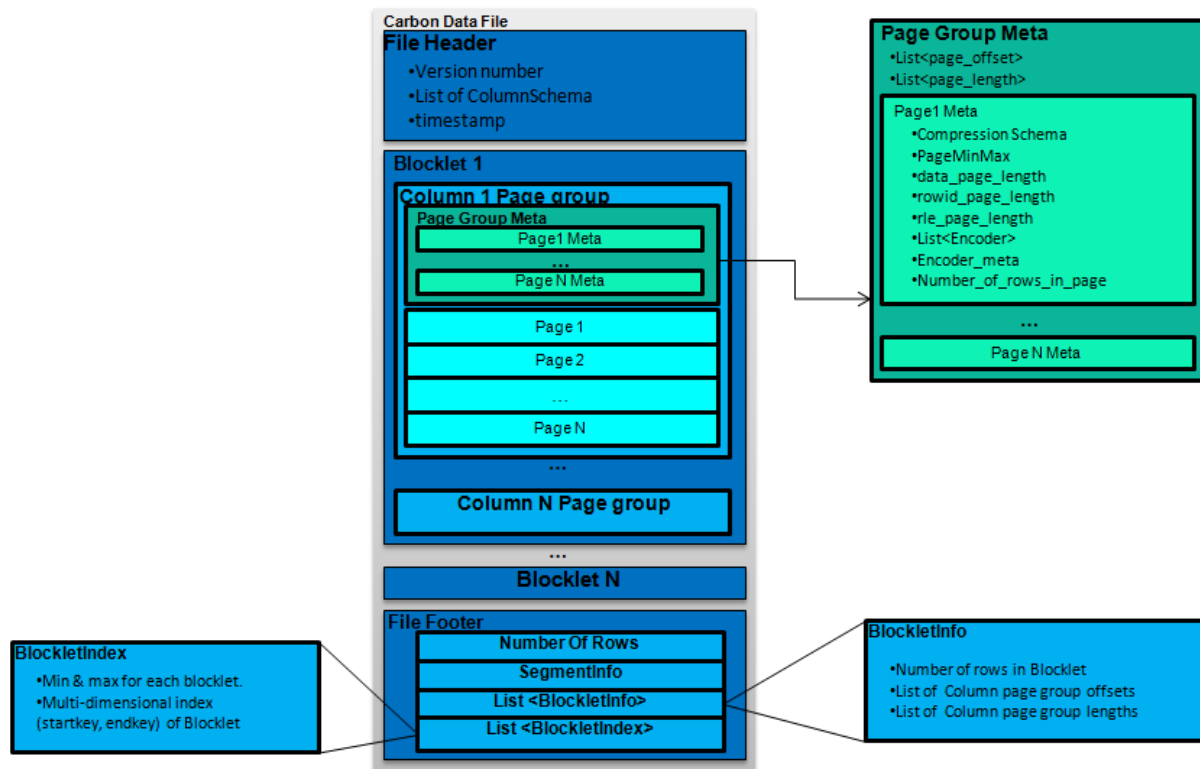
The file footer can be read once to build the indices in memory, which can be utilized for optimizing the scans and processing for all subsequent queries.

4.1.1 Understanding CarbonData File Structure

- **Block** : It would be as same as HDFS block, CarbonData creates one file for each data block, user can specify `TABLE_BLOCKSIZE` during creation table. Each file contains File Header, Blocklets and File Footer.



- **File Header** : It contains CarbonData file version number, list of column schema and schema updation timestamp.
- **File Footer** : it contains Number of rows, segmentinfo ,all blocklets' info and index, you can find the detail from the below diagram.
- **Blocklet** : Rows are grouped to form a blocklet, the size of the blocklet is configurable and default size is 64MB, Blocklet contains Column Page groups for each column.
- **Column Page Group** : Data of one column and it is further divided into pages, it is guaranteed to be contiguous in file.
- **Page** : It has the data of one column and the number of row is fixed to 32000 size.



4.1.2 Each page contains three types of data

- Data Page: Contains the encoded data of a column of columns.
- Row ID Page (optional): Contains the row ID mappings used when the data page is stored as an inverted index.
- RLE Page (optional): Contains additional metadata used when the data page is RLE coded.

5 Installation

Installation Guide

This tutorial guides you through the installation and configuration of CarbonData in the following two modes :

- Installing and Configuring CarbonData on Standalone Spark Cluster
- Installing and Configuring CarbonData on Spark on YARN Cluster

followed by :

- Query Execution using CarbonData Thrift Server

5.1 Installing and Configuring CarbonData on Standalone Spark Cluster

5.1.1 Prerequisites

- Hadoop HDFS and Yarn should be installed and running.
- Spark should be installed and running on all the cluster nodes.
- CarbonData user should have permission to access HDFS.

5.1.2 Procedure

1. Build the CarbonData project and get the assembly jar from `./assembly/target/scala-2.1x/carbondata_xxx.jar`.
 2. Copy `./assembly/target/scala-2.1x/carbondata_xxx.jar` to `$SPARK_HOME/carbonlib` folder.
- NOTE:** Create the carbonlib folder if it does not exist inside `$SPARK_HOME` path.
3. Add the carbonlib folder path in the Spark classpath. (Edit `$SPARK_HOME/conf/spark-env.sh` file and modify the value of `SPARK_CLASSPATH` by appending `$SPARK_HOME/carbonlib/*` to the existing value)
 4. Copy the `./conf/carbon.properties.template` file from CarbonData repository to `$SPARK_HOME/conf/` folder and rename the file to `carbon.properties`.
 5. Repeat Step 2 to Step 5 in all the nodes of the cluster.
 6. In Spark node[master], configure the properties mentioned in the following table in `$SPARK_HOME/conf/spark-defaults.conf` file.

Property	Value	Description
<code>spark.driver.extraJavaOptions</code>	<code>-Dcarbon.properties.filepath=\$SPARK_HOME/conf/carbon.properties</code>	A string of extra JVM options to pass to the driver. For instance, GC settings or other logging.
<code>spark.executor.extraJavaOptions</code>	<code>-Dcarbon.properties.filepath=\$SPARK_HOME/conf/carbon.properties</code>	A string of extra JVM options to pass to executors. For instance, GC settings or other logging. NOTE: You can enter multiple values separated by space.

1. Add the following properties in `$SPARK_HOME/conf/carbon.properties` file:

Property	Required	Description	Example	Remark
----------	----------	-------------	---------	--------

carbon.storelocation	NO	Location where data CarbonData will create the store and write the data in its own format.	hdfs:// HOSTNAME:PORT/ Opt/CarbonStore	Propose to set HDFS directory
----------------------	----	--	--	-------------------------------

1. Verify the installation. For example:

```
./spark-shell --master spark://HOSTNAME:PORT --total-executor-cores 2
--executor-memory 2G
```

NOTE: Make sure you have permissions for CarbonData JARs and files through which driver and executor will start.

To get started with CarbonData : Quick Start, DDL Operations on CarbonData

5.2 Installing and Configuring CarbonData on Spark on YARN Cluster

This section provides the procedure to install CarbonData on “Spark on YARN” cluster.

5.2.1 Prerequisites

- Hadoop HDFS and Yarn should be installed and running.
- Spark should be installed and running in all the clients.
- CarbonData user should have permission to access HDFS.

5.2.2 Procedure

The following steps are only for Driver Nodes. (Driver nodes are the one which starts the spark context.)

1. Build the CarbonData project and get the assembly jar from `./assembly/target/scala-2.1x/carbondata_xxx.jar` and copy to `$SPARK_HOME/carbonlib` folder.

NOTE: Create the carbonlib folder if it does not exists inside `$SPARK_HOME` path.

2. Copy the `./conf/carbon.properties.template` file from CarbonData repository to `$SPARK_HOME/conf/` folder and rename the file to `carbon.properties`.
3. Create `tar.gz` file of carbonlib folder and move it inside the carbonlib folder.

```
cd $SPARK_HOME
tar -zcvf carbondata.tar.gz carbonlib/
mv carbondata.tar.gz carbonlib/
```

1. Configure the properties mentioned in the following table in `$SPARK_HOME/conf/spark-defaults.conf` file.

Property	Description	Value
spark.master	Set this value to run the Spark in yarn cluster mode.	Set yarn-client to run the Spark in yarn cluster mode.
spark.yarn.dist.files	Comma-separated list of files to be placed in the working directory of each executor.	<code>\$SPARK_HOME/conf/carbon.properties</code>

spark.yarn.dist.archives	Comma-separated list of archives to be extracted into the working directory of each executor.	\$SPARK_HOME/carbonlib/ carbodata.tar.gz
spark.executor.extraJavaOptions	A string of extra JVM options to pass to executors. For instance NOTE: You can enter multiple values separated by space.	- Dcarbon.properties.filepath = carbon.properties
spark.executor.extraClassPath	Extra classpath entries to prepend to the classpath of executors. NOTE: If SPARK_CLASSPATH is defined in spark-env.sh, then comment it and append the values in below parameter spark.driver.extraClassPath	carbodata.tar.gz/ carbonlib/*
spark.driver.extraClassPath	Extra classpath entries to prepend to the classpath of the driver. NOTE: If SPARK_CLASSPATH is defined in spark-env.sh, then comment it and append the value in below parameter spark.driver.extraClassPath.	\$SPARK_HOME/carbonlib/*
spark.driver.extraJavaOptions	A string of extra JVM options to pass to the driver. For instance, GC settings or other logging.	- Dcarbon.properties.filepath = \$SPARK_HOME/conf/ carbon.properties

1. Add the following properties in \$SPARK_HOME/conf/carbon.properties:

Property	Required	Description	Example	Default Value
carbon.storelocation	NO	Location where CarbonData will create the store and write the data in its own format.	hdfs:// HOSTNAME:PORT/ Opt/CarbonStore	Propose to set HDFS directory

1. Verify the installation.

```
./bin/spark-shell --master yarn-client --driver-memory 1g
--executor-cores 2 --executor-memory 2G
```

NOTE: Make sure you have permissions for CarbonData JARs and files through which driver and executor will start.

Getting started with CarbonData : Quick Start, DDL Operations on CarbonData

5.3 Query Execution Using CarbonData Thrift Server

5.3.1 Starting CarbonData Thrift Server.

a. cd \$SPARK_HOME

b. Run the following command to start the CarbonData thrift server.

```
./bin/spark-submit
--conf spark.sql.hive.thriftServer.singleSession=true
--class org.apache.carbondata.spark.thriftserver.CarbonThriftServer
$SPARK_HOME/carbonlib/$CARBON_ASSEMBLY_JAR <carbon_store_path>
```

Parameter	Description	Example
CARBON_ASSEMBLY_JAR	CarbonData assembly jar name present in the \$SPARK_HOME/carbonlib/ folder.	carbodata_2.xx-x.x.x-SNAPSHOT-shade-hadoop2.7.2.jar
carbon_store_path	This is a parameter to the CarbonThriftServer class. This a HDFS path where CarbonData files will be kept. Strongly Recommended to put same as carbon.storelocation parameter of carbon.properties.	hdfs://<host_name>:port/user/hive/warehouse/carbon.store

Examples

- Start with default memory and executors.

```
./bin/spark-submit
--conf spark.sql.hive.thriftServer.singleSession=true
--class org.apache.carbondata.spark.thriftserver.CarbonThriftServer
$SPARK_HOME/carbonlib
/carbodata_2.xx-x.x.x-SNAPSHOT-shade-hadoop2.7.2.jar
hdfs://<host_name>:port/user/hive/warehouse/carbon.store
```

- Start with Fixed executors and resources.

```
./bin/spark-submit --conf spark.sql.hive.thriftServer.singleSession=true
--class org.apache.carbondata.spark.thriftserver.CarbonThriftServer
--num-executors 3 --driver-memory 20g --executor-memory 250g
--executor-cores 32
/srv/OSCON/BigData/HACluster/install/spark/sparkJdbc/lib
/carbodata_2.xx-x.x.x-SNAPSHOT-shade-hadoop2.7.2.jar
hdfs://<host_name>:port/user/hive/warehouse/carbon.store
```

5.3.2 Connecting to CarbonData Thrift Server Using Beeline.

```
cd $SPARK_HOME
./sbin/start-thriftserver.sh
./bin/beeline -u jdbc:hive2://<thriftserver_host>:port
```

Example

```
./bin/beeline -u jdbc:hive2://10.10.10.10:10000
```

6 Configuring CarbonData

Configuring CarbonData

This tutorial guides you through the advanced configurations of CarbonData :

- System Configuration
- Performance Configuration
- Miscellaneous Configuration
- Spark Configuration
- Dynamic Configuration In CarbonData Using SET-RESET

6.1 System Configuration

This section provides the details of all the configurations required for the CarbonData System.

System Configuration in carbon.properties

Property	Default Value	Description
carbon.storelocation	/user/hive/warehouse/carbon.store	Location where CarbonData will create the store, and write the data in its own format. NOTE: Store location should be in HDFS.
carbon.ddl.base.hdfs.url	hdfs://hacluster/opt/data	This property is used to configure the HDFS relative path, the path configured in carbon.ddl.base.hdfs.url will be appended to the HDFS path configured in fs.defaultFS. If this path is configured, then user need not pass the complete path while dataload. For example: If absolute path of the csv file is hdfs://10.18.101.155:54310/data/cnbc/2016/xyz.csv, the path “hdfs://10.18.101.155:54310” will come from property fs.defaultFS and user can configure the /data/cnbc/ as carbon.ddl.base.hdfs.url. Now while dataload user can specify the csv path as /2016/xyz.csv.
carbon.badRecords.location	/opt/Carbon/Spark/badrecords	Path where the bad records are stored.
carbon.data.file.version	2	If this parameter value is set to 1, then CarbonData will support the data load which is in old format(0.x version). If the value is set to 2(1.x onwards version), then CarbonData will support the data load of new format only.

6.2 Performance Configuration

This section provides the details of all the configurations required for CarbonData Performance Optimization.

Performance Configuration in carbon.properties

- **Data Loading Configuration**

Parameter	Default Value	Description	Range
carbon.number.of.cores.whi	6	Number of cores to be used while loading data.	
carbon.sort.size	500000	Record count to sort and write intermediate files to temp.	
carbon.max.driver.lru.cache	-1	Max LRU cache size upto which data will be loaded at the driver side. This value is expressed in MB. Default value of -1 means there is no memory limit for caching. Only integer values greater than 0 are accepted.	
carbon.max.executor.lru.ca	-1	Max LRU cache size upto which data will be loaded at the executor side. This value is expressed in MB. Default value of -1 means there is no memory limit for caching. Only integer values greater than 0 are accepted. If this parameter is not configured, then the carbon.max.driver.lru.cache value will be considered.	
carbon.merge.sort.prefetch	true	Enable prefetch of data during merge sort while reading data from sort temp files in data loading.	
carbon.update.persist.enabl	true	Enabling this parameter considers persistent data. Enabling this will reduce the execution time of UPDATE operation.	
carbon.load.global.sort.parti	0	The Number of partitions to use when shuffling data for sort. If user don't configurate or configurate it less than 1, it uses the number of map tasks as reduce tasks. In general, we recommend 2-3 tasks per CPU core in your cluster.	

<code>carbon.options.bad.records</code>	<code>false</code>	Whether to create logs with details about bad records.
<code>carbon.bad.records.action</code>	<code>FORCE</code>	This property can have four types of actions for bad records <code>FORCE</code> , <code>REDIRECT</code> , <code>IGNORE</code> and <code>FAIL</code> . If set to <code>FORCE</code> then it auto-corrects the data by storing the bad records as <code>NULL</code> . If set to <code>REDIRECT</code> then bad records are written to the raw CSV instead of being loaded. If set to <code>IGNORE</code> then bad records are neither loaded nor written to the raw CSV. If set to <code>FAIL</code> then data loading fails if any bad records are found.
<code>carbon.options.is.empty.dat</code>	<code>false</code>	If false, then empty ("" or " or ,,) data will not be considered as bad record and vice versa.
<code>carbon.options.bad.record.p</code>		Specifies the HDFS path where bad records are stored. By default the value is Null. This path must to be configured by the user if bad record logger is enabled or bad record action redirect.
<code>carbon.enable.vector.reade</code>	<code>true</code>	This parameter increases the performance of select queries as it fetch columnar batch of size 4*1024 rows instead of fetching data row by row.

• Compaction Configuration

Parameter	Default Value	Description	Range
<code>carbon.number.of.cores.whi</code>	<code>2</code>	Number of cores which are used to write data during compaction.	

<code>carbon.compaction.level.thr 4, 3</code>	<p>This property is for minor compaction which decides how many segments to be merged. Example: If it is set as 2, 3 then minor compaction will be triggered for every 2 segments. 3 is the number of level 1 compacted segment which is further compacted to new segment.</p>	Valid values are from 0-100.
<code>carbon.major.compaction.si 1024</code>	<p>Major compaction size can be configured using this parameter. Sum of the segments which is below this threshold will be merged. This value is expressed in MB.</p>	
<code>carbon.horizontal.compactic true</code>	<p>This property is used to turn ON/OFF horizontal compaction. After every DELETE and UPDATE statement, horizontal compaction may occur in case the delta (DELETE/UPDATE) files becomes more than specified threshold.</p>	
<code>carbon.horizontal.UPDATE. 1</code>	<p>This property specifies the threshold limit on number of UPDATE delta files within a segment. In case the number of delta files goes beyond the threshold, the UPDATE delta files within the segment becomes eligible for horizontal compaction and compacted into single UPDATE delta file.</p>	Values between 1 to 10000.
<code>carbon.horizontal.DELETE. 1</code>	<p>This property specifies the threshold limit on number of DELETE delta files within a block of a segment. In case the number of delta files goes beyond the threshold, the DELETE delta files for the particular block of the segment becomes eligible for horizontal compaction and compacted into single DELETE delta file.</p>	Values between 1 to 10000.

carbon.update.segment.par 1	This property specifies the parallelism for each segment during update. If there are segments that contain too many records to update and the spark job encounter data-spill related errors, it is better to increase this property value. It is recommended to set this value to a multiple of the number of executors for balance.	Values between 1 to 1000.
-----------------------------	--	---------------------------

- **Query Configuration**

Parameter	Default Value	Description	Range
carbon.number.of.cores	4	Number of cores to be used while querying.	
carbon.enable.quick.filter	false	Improves the performance of filter query.	

6.3 Miscellaneous Configuration

Extra Configuration in carbon.properties

- **Time format for CarbonData**

Parameter	Default Format	Description
carbon.timestamp.format	yyyy-MM-dd HH:mm:ss	Timestamp format of input data used for timestamp data type.

- **Dataload Configuration**

Parameter	Default Value	Description
carbon.sort.file.write.buffer.size	10485760	File write buffer size used during sorting.

carbon.lock.type	LOCALLOCK	This configuration specifies the type of lock to be acquired during concurrent operations on table. There are following types of lock implementation: - LOCALLOCK: Lock is created on local file system as file. This lock is useful when only one spark driver (thrift server) runs on a machine and no other CarbonData spark application is launched concurrently. - HDFSLOCK: Lock is created on HDFS file system as file. This lock is useful when multiple CarbonData spark applications are launched and no ZooKeeper is running on cluster and HDFS supports file based locking.
carbon.sort.intermediate.files.limit	20	Minimum number of intermediate files after which merged sort can be started.
carbon.block.meta.size.reserved.perc	10	Space reserved in percentage for writing block meta data in CarbonData file.
carbon.csv.read.buffer.size.byte	1048576	csv reading buffer size.
high.cardinality.value	100000	To identify and apply compression for non-high cardinality columns.
carbon.merge.sort.reader.thread	3	Maximum no of threads used for reading intermediate files for final merging.
carbon.load.metadata.lock.retries	3	Maximum number of retries to get the metadata lock for loading data to table.
carbon.load.metadata.lock.retry.time	5	Interval between the retries to get the lock.
carbon.tempstore.location	/opt/Carbon/TempStoreLoc	Temporary store location. By default it takes System.getProperty("java.io.tmpdir").
carbon.load.log.counter	500000	Data loading records count logger.

• Compaction Configuration

Parameter	Default Value	Description
carbon.numberof.preserve.segments	0	If the user wants to preserve some number of segments from being compacted then he can set this property. Example: carbon.numberof.preserve.segments = 2 then 2 latest segments will always be excluded from the compaction. No segments will be preserved by default.

carbon.allowed.compaction.days	0	Compaction will merge the segments which are loaded with in the specific number of days configured. Example: If the configuration is 2, then the segments which are loaded in the time frame of 2 days only will get merged. Segments which are loaded 2 days apart will not be merged. This is disabled by default.
carbon.enable.auto.load.merge	false	To enable compaction while data loading.

- **Query Configuration**

Parameter	Default Value	Description
max.query.execution.time	60	Maximum time allowed for one query to be executed. The value is in minutes.
carbon.enableMinMax	true	Min max is feature added to enhance query performance. To disable this feature, set it false.

- **Global Dictionary Configurations**

Parameter	Default Value	Description
high.cardinality.identify.enable	true	If the parameter is true, the high cardinality columns of the dictionary code are automatically recognized and these columns will not be used as global dictionary encoding. If the parameter is false, all dictionary encoding columns are used as dictionary encoding. The high cardinality column must meet the following requirements: value of cardinality > configured value of high.cardinality. Note: If SINGLE_PASS is used during data load, then this property will be disabled.
high.cardinality.threshold	1000000	It is a threshold to identify high cardinality of the columns.If the value of columns' cardinality > the configured value, then the columns are excluded from dictionary encoding.

carbon.cutOffTimestamp	1970-01-01 05:30:00	Sets the start date for calculating the timestamp. Java counts the number of milliseconds from start of "1970-01-01 00:00:00". This property is used to customize the start of position. For example "2000-01-01 00:00:00". The date must be in the form "carbon.timestamp.format".
carbon.timegranularity	SECOND	The property used to set the data granularity level DAY, HOUR, MINUTE, or SECOND.

6.4 Spark Configuration

Spark Configuration Reference in spark-defaults.conf

Parameter	Default Value	Description
spark.driver.memory	1g	Amount of memory to be used by the driver process.
spark.executor.memory	1g	Amount of memory to be used per executor process.

6.5 Dynamic Configuration In CarbonData Using SET-RESET

SET/RESET commands are used to add, update, display, or reset the carbondata properties dynamically without restarting the driver.

Syntax

- **Add or Update :** This command adds or updates the value of parameter_name.

```
SET parameter_name=parameter_value
```

- **Display Property Value:** This command displays the value of the specified parameter_name.

```
SET parameter_name
```

- **Display Session Parameters:** This command displays all the supported session parameters.

```
SET
```

- **Display Session Parameters along with usage details:** This command displays all the supported session parameters along with their usage details.

```
SET -v
```

- **Reset:** This command clears all the session parameters.

RESET

Parameter Description:

Parameter	Description
parameter_name	Name of the property whose value needs to be dynamically added, updated, or displayed.
parameter_value	New value of the parameter_name to be set.

Dynamically Configurable Properties of CarbonData

Properties	Description
carbon.options.bad.records.logger.enable	To enable or disable bad record logger.
carbon.options.bad.records.action	This property can have four types of actions for bad records FORCE, REDIRECT, IGNORE and FAIL. If set to FORCE then it auto-corrects the data by storing the bad records as NULL. If set to REDIRECT then bad records are written to the raw CSV instead of being loaded. If set to IGNORE then bad records are neither loaded nor written to the raw CSV. If set to FAIL then data loading fails if any bad records are found.
carbon.options.is.empty.data.bad.record	If false, then empty ("" or " " or ",") data will not be considered as bad record and vice versa.
carbon.options.sort.scope	This property can have four possible values BATCH_SORT, LOCAL_SORT, GLOBAL_SORT and NO_SORT. If set to BATCH_SORT, the sorting scope is smaller and more index tree will be created, thus loading is faster but query maybe slower. If set to LOCAL_SORT, the sorting scope is bigger and one index tree per data node will be created, thus loading is slower but query is faster. If set to GLOBAL_SORT, the sorting scope is bigger and one index tree per task will be created, thus loading is slower but query is faster. If set to NO_SORT data will be loaded in unsorted manner.
carbon.options.batch.sort.size.inmb	Size of batch data to keep in memory, as a thumb rule it supposed to be less than 45% of sort.inmemory.size.inmb otherwise it may spill intermediate data to disk.
carbon.options.single.pass	Single Pass Loading enables single job to finish data loading with dictionary generation on the fly. It enhances performance in the scenarios where the subsequent data loading after initial load involves fewer incremental updates on the dictionary. This option specifies whether to use single pass for loading data or not. By default this option is set to FALSE.
carbon.options.bad.record.path	Specifies the HDFS path where bad records needs to be stored.

<code>carbon.options.global.sort.partitions</code>	The Number of partitions to use when shuffling data for sort. If user don't configurate or configurate it less than 1, it uses the number of map tasks as reduce tasks. In general, we recommend 2-3 tasks per CPU core in your cluster.
<code>carbon.custom.block.distribution</code>	Specifies whether to use the Spark or Carbon block distribution feature.
<code>enable.unsafe.sort</code>	Specifies whether to use unsafe sort during data loading. Unsafe sort reduces the garbage collection during data load operation, resulting in better performance.

Examples:

- Add or Update:

```
SET enable.unsafe.sort =true
```

- Display Property Value:

```
SET enable.unsafe.sort
```

- Reset:

```
RESET
```

System Response:

- Success will be recorded in the driver log.
- Failure will be displayed in the UI.

7 FAQs

FAQs

- What are Bad Records?
- Where are Bad Records Stored in CarbonData?
- How to enable Bad Record Logging?
- How to ignore the Bad Records?
- How to specify store location while creating carbon session?
- What is Carbon Lock Type?
- How to resolve Abstract Method Error?
- How Carbon will behave when execute insert operation in abnormal scenarios?

7.1 What are Bad Records?

Records that fail to get loaded into the CarbonData due to data type incompatibility or are empty or have incompatible format are classified as Bad Records.

7.2 Where are Bad Records Stored in CarbonData?

The bad records are stored at the location set in `carbon.badRecords.location` in `carbon.properties` file. By default **`carbon.badRecords.location`** specifies the following location `/opt/Carbon/Spark/badrecords`.

7.3 How to enable Bad Record Logging?

While loading data we can specify the approach to handle Bad Records. In order to analyse the cause of the Bad Records the parameter `BAD_RECORDS_LOGGER_ENABLE` must be set to value `TRUE`. There are multiple approaches to handle Bad Records which can be specified by the parameter `BAD_RECORDS_ACTION`.

- To pad the incorrect values of the csv rows with NULL value and load the data in CarbonData, set the following in the query : `'BAD_RECORDS_ACTION' = 'FORCE'`
- To write the Bad Records without padding incorrect values with NULL in the raw csv (set in the parameter **`carbon.badRecords.location`**), set the following in the query : `'BAD_RECORDS_ACTION' = 'REDIRECT'`

7.4 How to ignore the Bad Records?

To ignore the Bad Records from getting stored in the raw csv, we need to set the following in the query : `'BAD_RECORDS_ACTION' = 'IGNORE'`

7.5 How to specify store location while creating carbon session?

The store location specified while creating carbon session is used by the CarbonData to store the meta data like the schema, dictionary files, dictionary meta data and sort indexes.

Try creating `carbonsession` with `storepath` specified in the following manner :

```
val carbon = SparkSession.builder().config(sc.getConf)
    .getOrCreateCarbonSession(<store_path>)
```

Example:

```
val carbon = SparkSession.builder().config(sc.getConf)
    .getOrCreateCarbonSession("hdfs://localhost:9000/carbon/store")
```

7.6 What is Carbon Lock Type?

The Apache CarbonData acquires lock on the files to prevent concurrent operation from modifying the same files. The lock can be of the following types depending on the storage location, for HDFS we specify it to be of type HDFSLOCK. By default it is set to type LOCALLOCK. The property carbon.lock.type configuration specifies the type of lock to be acquired during concurrent operations on table. This property can be set with the following values : - **LOCALLOCK** : This Lock is created on local file system as file. This lock is useful when only one spark driver (thrift server) runs on a machine and no other CarbonData spark application is launched concurrently. - **HDFSLOCK** : This Lock is created on HDFS file system as file. This lock is useful when multiple CarbonData spark applications are launched and no ZooKeeper is running on cluster and the HDFS supports, file based locking.

7.7 How to resolve Abstract Method Error?

In order to build CarbonData project it is necessary to specify the spark profile. The spark profile sets the Spark Version. You need to specify the spark version while using Maven to build project.

7.8 How Carbon will behave when execute insert operation in abnormal scenarios?

Carbon support insert operation, you can refer to the syntax mentioned in DML Operations on CarbonData. First, create a source table in spark-sql and load data into this created table.

```
CREATE TABLE source_table(
id String,
name String,
city String)
ROW FORMAT DELIMITED FIELDS TERMINATED BY ",";
```

```
SELECT * FROM source_table;
id  name    city
1   jack    beijing
2   erlu    hangzhou
3   davi    shenzhen
```

Scenario 1 :

Suppose, the column order in carbon table is different from source table, use script “SELECT * FROM carbon table” to query, will get the column order similar as source table, rather than in carbon table’s column order as expected.

```
CREATE TABLE IF NOT EXISTS carbon_table(  
id String,  
city String,  
name String)  
STORED BY 'carbodata';
```

```
INSERT INTO TABLE carbon_table SELECT * FROM source_table;
```

```
SELECT * FROM carbon_table;  
id  city    name  
1   jack    beijing  
2   erlu    hangzhou  
3   davi    shenzhen
```

As result shows, the second column is city in carbon table, but what inside is name, such as jack. This phenomenon is same with insert data into hive table.

If you want to insert data into corresponding column in carbon table, you have to specify the column order same in insert statment.

```
INSERT INTO TABLE carbon_table SELECT id, city, name FROM source_table;
```

Scenario 2 :

Insert operation will be failed when the number of column in carbon table is different from the column specified in select statement. The following insert operation will be failed.

```
INSERT INTO TABLE carbon_table SELECT id, city FROM source_table;
```

Scenario 3 :

When the column type in carbon table is different from the column specified in select statement. The insert operation will still success, but you may get NULL in result, because NULL will be substitute value when conversion type failed.

8 Troubleshooting

Troubleshooting

This tutorial is designed to provide troubleshooting for end users and developers who are building, deploying, and using CarbonData.

8.1 When loading data, gets tablestatus.lock issues:

Symptom 17/11/11 16:48:13 ERROR LocalFileLock: main hdfs:/localhost:9000/carbon/store/default/hdfstable/tablestatus.lock (No such file or directory) java.io.FileNotFoundException: hdfs:/localhost:9000/carbon/store/default/hdfstable/tablestatus.lock (No such file or directory) at java.io.FileOutputStream.open0(Native Method) at java.io.FileOutputStream.open(FileOutputStream.java:270) at java.io.FileOutputStream.<init>(FileOutputStream.java:213) at java.io.FileOutputStream.<init>(FileOutputStream.java:101)

Possible Cause If you use <hdfs path> as store path when creating carbonsession, may get the errors, because the default is LOCALLOCK.

Procedure Before creating carbonsession, sets as below:

```
import
org.apache.carbondata.core.util.CarbonProperties import
org.apache.carbondata.core.constants.CarbonCommonConstants
CarbonProperties.getInstance().addProperty(CarbonCommonConstants.LOCK_TYPE,
"HDFSLOCK")
```

8.2 Failed to load thrift libraries

Symptom

Thrift throws following exception :

```
thrift: error while loading shared libraries: libthriftc.so.0: cannot open
shared object file: No such file or directory
```

Possible Cause

The complete path to the directory containing the libraries is not configured correctly.

Procedure

Follow the Apache thrift docs at <https://thrift.apache.org/docs/install> to install thrift correctly.

8.3 Failed to launch the Spark Shell

Symptom

The shell prompts the following error :

```
org.apache.spark.sql.CarbonContext$$anon$$apache$spark$sql$catalyst
$analysis $OverrideCatalog$setter_$org$apache$spark$sql$catalyst$analysis
$OverrideCatalog$$overrides_$e
```

Possible Cause

The Spark Version and the selected Spark Profile do not match.

Procedure

1. Ensure your spark version and selected profile for spark are correct.

2. Use the following command :

```
"mvn -Pspark-2.1 -Dspark.version {yourSparkVersion} clean package"
```

Note : Refrain from using “mvn clean package” without specifying the profile.

8.4 Failed to execute load query on cluster.

Symptom

Load query failed with the following exception:

```
Dictionary file is locked for updation.
```

Possible Cause

The carbon.properties file is not identical in all the nodes of the cluster.

Procedure

Follow the steps to ensure the carbon.properties file is consistent across all the nodes:

1. Copy the carbon.properties file from the master node to all the other nodes in the cluster. For example, you can use ssh to copy this file to all the nodes.
2. For the changes to take effect, restart the Spark cluster.

8.5 Failed to execute insert query on cluster.

Symptom

Load query failed with the following exception:

```
Dictionary file is locked for updation.
```

Possible Cause

The carbon.properties file is not identical in all the nodes of the cluster.

Procedure

Follow the steps to ensure the carbon.properties file is consistent across all the nodes:

1. Copy the carbon.properties file from the master node to all the other nodes in the cluster. For example, you can use scp to copy this file to all the nodes.
2. For the changes to take effect, restart the Spark cluster.

8.6 Failed to connect to hiveuser with thrift

Symptom

We get the following exception :

```
Cannot connect to hiveuser.
```

Possible Cause

The external process does not have permission to access.

Procedure

Ensure that the Hiveuser in mysql must allow its access to the external processes.

8.7 Failed to read the metastore db during table creation.

Symptom

We get the following exception on trying to connect :

```
Cannot read the metastore db
```

Possible Cause

The metastore db is dysfunctional.

Procedure

Remove the metastore db from the carbon.metastore in the Spark Directory.

8.8 Failed to load data on the cluster

Symptom

Data loading fails with the following exception :

```
Data Load failure exeception
```

Possible Cause

The following issue can cause the failure :

1. The core-site.xml, hive-site.xml, yarn-site and carbon.properties are not consistent across all nodes of the cluster.
2. Path to hdfs ddl is not configured correctly in the carbon.properties.

Procedure

Follow the steps to ensure the following configuration files are consistent across all the nodes:

1. Copy the core-site.xml, hive-site.xml, yarn-site, carbon.properties files from the master node to all the other nodes in the cluster. For example, you can use scp to copy this file to all the nodes.
Note : Set the path to hdfs ddl in carbon.properties in the master node.
2. For the changes to take effect, restart the Spark cluster.

8.9 Failed to insert data on the cluster

Symptom

Insertion fails with the following exception :

```
Data Load failure exeception
```

Possible Cause

The following issue can cause the failure :

1. The core-site.xml, hive-site.xml, yarn-site and carbon.properties are not consistent across all nodes of the cluster.
2. Path to hdfs ddl is not configured correctly in the carbon.properties.

Procedure

Follow the steps to ensure the following configuration files are consistent across all the nodes:

1. Copy the core-site.xml, hive-site.xml, yarn-site, carbon.properties files from the master node to all the other nodes in the cluster. For example, you can use scp to copy this file to all the nodes.
Note : Set the path to hdfs ddl in carbon.properties in the master node.

2. For the changes to take effect, restart the Spark cluster.

8.10 Failed to execute Concurrent Operations(Load,Insert,Update) on table by multiple workers.

Symptom

Execution fails with the following exception :

Table is locked for updation.

Possible Cause

Concurrency not supported.

Procedure

Worker must wait for the query execution to complete and the table to release the lock for another query execution to succeed.

8.11 Failed to create a table with a single numeric column.

Symptom

Execution fails with the following exception :

Table creation fails.

Possible Cause

Behaviour not supported.

Procedure

A single column that can be considered as dimension is mandatory for table creation.

9 Useful Tips

Useful Tips

This tutorial guides you to create CarbonData Tables and optimize performance. The following sections will elaborate on the above topics :

- Suggestions to create CarbonData Table
- Configuration for Optimizing Data Loading performance for Massive Data
- Optimizing Mass Data Loading

9.1 Suggestions to Create CarbonData Table

For example, the results of the analysis for table creation with dimensions ranging from 10 thousand to 10 billion rows and 100 to 300 columns have been summarized below. The following table describes some of the columns from the table used.

- **Table Column Description**

Column Name	Data Type	Cardinality	Attribution
msisdn	String	30 million	Dimension
BEGIN_TIME	BigInt	10 Thousand	Dimension
HOST	String	1 million	Dimension
Dime_1	String	1 Thousand	Dimension
counter_1	Decimal	NA	Measure
counter_2	Numeric(20,0)	NA	Measure
...	NA
counter_100	Decimal	NA	Measure

- **Put the frequently-used column filter in the beginning**

For example, MSISDN filter is used in most of the query then we must put the MSISDN in the first column. The create table command can be modified as suggested below :

```
``` create table carbondata_table( msisdn String, BEGIN_TIME bigint, HOST String, Dime_1 String,
counter_1, Decimal ...
```

```
)STORED BY 'carbondata'
TBLPROPERTIES ('SORT_COLUMNS'='msisdn, Dime_1')
```

```
```
```

Now the query with MSISDN in the filter will be more efficient.

- **Put the frequently-used columns in the order of low to high cardinality**

If the table in the specified query has multiple columns which are frequently used to filter the results, it is suggested to put the columns in the order of cardinality low to high. This ordering of frequently used columns improves the compression ratio and enhances the performance of queries with filter on these columns.

For example, if MSISDN, HOST and Dime_1 are frequently-used columns, then the column order of table is suggested as Dime_1>HOST>MSISDN, because Dime_1 has the lowest cardinality. The create table command can be modified as suggested below :

```
``` create table carbondata_table( msisdn String, BEGIN_TIME bigint, HOST String, Dime_1 String,
counter_1, Decimal ...
```

```
)STORED BY 'carbondata'
TBLPROPERTIES ('SORT_COLUMNS'='Dime_1, HOST, MSISDN')
```

```
```
```

- **For measure type columns with non high accuracy, replace Numeric(20,0) data type with Double data type**

For columns of measure type, not requiring high accuracy, it is suggested to replace Numeric data type with Double to enhance query performance. The create table command can be modified as below :

```
create table carbondata_table(
  Dime_1 String,
  BEGIN_TIME bigint,
  END_TIME bigint,
  HOST String,
  MSISDN String,
  counter_1 decimal,
  counter_2 double,
  ...
)STORED BY 'carbondata'
TBLPROPERTIES ('SORT_COLUMNS'='Dime_1, HOST, MSISDN')
```

The result of performance analysis of test-case shows reduction in query execution time from 15 to 3 seconds, thereby improving performance by nearly 5 times.

- **Columns of incremental character should be re-arranged at the end of dimensions**

Consider the following scenario where data is loaded each day and the begin_time is incremental for each load, it is suggested to put begin_time at the end of dimensions. Incremental values are efficient in using min/max index. The create table command can be modified as below :

```
create table carbondata_table( Dime_1 String, HOST String, MSISDN
String, counter_1 double, counter_2 double, BEGIN_TIME bigint, END_TIME
bigint, ... counter_100 double )STORED BY 'carbondata' TBLPROPERTIES
('SORT_COLUMNS'='Dime_1, HOST, MSISDN')
```

9.2 Configuration for Optimizing Data Loading performance for Massive Data

CarbonData supports large data load, in this process sorting data while loading consumes a lot of memory and disk IO and this can result sometimes in “Out Of Memory” exception. If you do not have much memory to use, then you may prefer to slow the speed of data loading instead of data load failure. You can configure CarbonData by tuning following properties in carbon.properties file to get a better performance.

| Parameter | Default Value | Description/Tuning |
|--------------------------------------|-----------------|---|
| carbon.number.of.cores.while.loading | Default: 2 | This value should be >= 2 Specifies the number of cores used for data processing during data loading in CarbonData. |
| carbon.sort.size | Default: 100000 | The value should be >= 100. Threshold to write local file in sort step when loading data |
| carbon.sort.file.write.buffer.size | Default: 50000 | DataOutputStream buffer. |
| carbon.number.of.cores.block.sort | Default: 7 | If you have huge memory and cpus, increase it as you will |
| carbon.merge.sort.reader.thread | Default: 3 | Specifies the number of cores used for temp file merging during data loading in CarbonData. |
| carbon.merge.sort.prefetch | Default: true | You may want set this value to false if you have not enough memory |

For example, if there are 10 million records, and i have only 16 cores, 64GB memory, will be loaded to CarbonData table. Using the default configuration always fail in sort step. Modify carbon.properties as suggested below:

```
carbon.number.of.cores.block.sort=1 carbon.merge.sort.reader.thread=1
carbon.sort.size=5000 carbon.sort.file.write.buffer.size=5000
carbon.merge.sort.prefetch=false
```

9.3 Configurations for Optimizing CarbonData Performance

Recently we did some performance POC on CarbonData for Finance and telecommunication Field. It involved detailed queries and aggregation scenarios. After the completion of POC, some of the configurations impacting the performance have been identified and tabulated below :

| Parameter | Location | Used For | Description | Tuning |
|-----------|----------|----------|-------------|--------|
|-----------|----------|----------|-------------|--------|

| | | | | |
|---|-----------------------------------|---------------------------|--|--|
| carbon.sort.intermediate.files.limit | spark/carbonlib/carbon.properties | Data loading | During the loading of data, local temp is used to sort the data. This number specifies the minimum number of intermediate files after which the merge sort has to be initiated. Increasing the parameter to a higher value will improve the load performance. For example, when we increase the value from 20 to 100, it increases the data load performance from 35MB/S to more than 50MB/S. Higher values of this parameter consumes more memory during the load. | |
| carbon.number.of.cores.while.loading | spark/carbonlib/carbon.properties | Data loading | Specifies the number of cores used for data processing during data loading in CarbonData. If you have more number of CPUs, then you can increase the number of CPUs, which will increase the performance. For example if we increase the value from 2 to 4 then the CSV reading performance can increase about 1 times | |
| carbon.compaction.level.threshold | spark/carbonlib/carbon.properties | Data loading and Querying | For minor compaction, specifies the number of segments to be merged in stage 1 and number of compacted segments to be merged in stage 2. Each CarbonData load will create one segment, if every load is small in size it will generate many small file over a period of time impacting the query performance. Configuring this parameter will merge the small segment to one big segment which will sort the data and improve the performance. For Example in one telecommunication scenario, the performance improves about 2 times after minor compaction. | |
| spark.sql.shuffle.partitions | spark/conf/spark-defaults.conf | Querying | The number of task started when spark shuffle. The value can be 1 to 2 times as much as the executor cores. In an aggregation scenario, reducing the number from 200 to 32 reduced the query time from 17 to 9 seconds. | |
| spark.executor.instances/spark.executor.cores/spark.executor.memory | spark/conf/spark-defaults.conf | Querying | The number of executors, CPU cores, and memory used for CarbonData query. In the bank scenario, we provide the 4 CPUs cores and 15 GB for each executor which can get good performance. This 2 value does not mean more the better. It needs to be configured properly in case of limited resources. For example, In the bank scenario, it has enough CPU 32 cores each node but less memory 64 GB each node. So we cannot give more CPU but less memory. For example, when 4 cores and 12GB for each executor. It sometimes happens GC during the query which impact the query performance very much from the 3 second to more than 15 seconds. In this scenario need to increase the memory or decrease the CPU cores. | |
| carbon.detail.batch.size | spark/carbonlib/carbon.properties | Data loading | The buffer size to store records, returned from the block scan. In limit scenario this parameter is very important. For example your query limit is 1000. But if we set this value to 3000 that means we get 3000 records from scan but spark will only take 1000 rows. So the 2000 remaining are useless. In one Finance test case after we set it to 100, in the limit 1000 scenario the performance increase about 2 times in comparison to if we set this value to 12000. | |
| carbon.use.local.dir | spark/carbonlib/carbon.properties | Data loading | Whether use YARN local directories for multi-table load disk load balance If this is set it to true CarbonData will use YARN local directories for multi-table load disk load balance, that will improve the data load performance. | |
| carbon.use.multiple.temp.dir | spark/carbonlib/carbon.properties | Data loading | Whether to use multiple YARN local directories during table data loading for disk load balance After enabling 'carbon.use.local.dir', if this is set to true, CarbonData will use all YARN local directories | |

during data load for disk load balance, that will improve the data load performance. Please enable this property when you encounter disk hotspot problem during data loading. |

Note: If your CarbonData instance is provided only for query, you may specify the property 'spark.speculation=true' which is in conf directory of spark.