Delta lake format introduction

Disclaimer (I)

Most of the code is based on jupyter notebooks using the spylon kernel (scala), but there may be some .dbc files

Disclaimer (II)

You can enable delta on your local spark by download the jar and enabling the extensions.

```
bin/spark-shell --packages io.delta:delta-spark_2.12:3.0.0
--conf "spark.sql.extensions=io.delta.sql.DeltaSparkSessionExtension"
--conf "spark.sql.catalog.spark_catalog=org.apache.spark.sql.delta.catalog.DeltaCatalog"
```

Disclaimer (III)

https://docs.delta.io/latest/delta-standalone.html

Disclaimer (IV)

There is a docker-compose file in the project granting you access to a jupyter notebook with delta

What is Delta Lake?

It was a project launched by Databricks in 2017 for merging the data warehouse and the datalake and it become managed by the Linux Foundation in 2019.

Advantages?

- ACID transactions on file formats
- Efficient data layout
- Rename, reorder columns in a table
- Metadata scale
- Time travel to older versions of the table
- Enable change data feed aka change data capture

https://www.vldb.org/pvldb/vol13/p3411-armbrust.pdf

How does it work?

It is based on parquet files containing the actual data + json files describing a protocol.

Demo time

From Parquet to Delta

```
import io.delta.tables._

DeltaTable.convertToDelta(spark, "parquet.`sample_data/user_data`")
```

tree files delta

Delta from a dataframe

```scala
val sampleData = Seq(
    (1,"Pedro"),
    (2,"Sergi"),
    (3,"Aleix"),
    (4,"David")
)

import spark.implicits._
val df = sampleData.toDF()
df.coalesce(1).write.mode("overwrite").format("delta").saveAsTable("data_engineers")
```

Table directory

```
spark-warehouse/data_engineers/
|->delta_log/
|           |->00000000000000000000.json
|->part-00000-1642cfd8-1dfa-497a-8c3f-2e000c2b1d79-c000.snappy.parquet
```

Delta Log (I)

```
{
    "commitInfo": {
        "timestamp": 1698680849935,
        "operation": "CREATE OR REPLACE TABLE AS SELECT",..
    }
{
        "protocol": {
            "minReaderVersion": 1,
            "minWriterVersion": 2
        }
    }
{
        "metaData": {
            "id": "ab71b946-f933-4dff-a11f-e7c6ecf70264",
            "format": {
                "provider": "parquet",
                "options": {}
            },
            "partitionColumns": [],
            "configuration": {},
            "createdTime": 1698680849740
        }
    }
```

Delta Log (II)

```
{
    "add": {
        "path": "part-00000-1642cfd8-1dfa-497a-8c3f-2e000c2b1d79-c000.snappy.parquet",
        "partitionValues": {},
        "size": 714,
        "modificationTime": 1698680849845,
        "dataChange": true,
        "stats": "{\"numRecords\":4,\"minValues\":{\"_1\":1,\"_2\":\"Aleix\"},\"maxValues\":{\"_1\":4,\"_2\":\"Sergi\"},\"nullCount\":{\"_1\":0,\"_2\":0}}"
    }
}
```

Merging data (I)

```
import io.delta.tables._

val newDataDf = Seq(
    (4,"Adrian"),
    (5,"David"),
    (6,"Simon")
).toDF()

DeltaTable
.forName("data_engineers")
.as("oldData").merge(newDataDf.as("newData"),"oldData._1 = newData._1")
  .whenMatched(some condition)
  .updateAll
  .whenNotMatched
  .insertAll
  .execute()
```

How does it get atomicity for a merge?

1. Find files in the table that match join condition
2. Read those files and write them again with updates and / or inserted rows
3. Add a new entry in the protocol removing the touched files and adding the new ones

Merging data (II)

Merge data (III)

insertOnly -> leftAntiJoin (left join where right is null)
updateOnly -> rightJoin
insert, update and delete -> fullOuterJoin

Merging data (III)

```
spark-warehouse/data_engineers/
|->delta_log/
|           |->00000000000000000000.json
|           |->00000000000000000000.json.crc
|           |->00000000000000000001.json
|           |->00000000000000000001.json.crc
|->part-00000-1642cfd8-1dfa-497a-8c3f-2e000c2b1d79-c000.snappy.parquet
|->part-00000-1642cfd8-1dfa-497a-8c3f-2e000c2b1d79-c000.snappy.parquet.crc
|->part-00000-17fb70c7-4412-4a3e-8e03-d12d0e41b449-c000.snappy.parquet
|->part-00000-17fb70c7-4412-4a3e-8e03-d12d0e41b449-c000.snappy.parquet.crc
```

Merging data (IV)

```
{
    "commitInfo":
        "timestamp": 1698682774893,
        "operation": "MERGE",
    "remove": {
        "path": "part-00000-17fb70c7-4412-4a3e-8e03-d12d0e41b449-c000.snappy.parquet",
        "deletionTimestamp": 1698682774892,
        "size": 726
    "add": {
        "path": "part-00000-c906bcfb-2fe9-49bc-b07b-c65cc9b5fdcc-c000.snappy.parquet",
        "modificationTime": 1698682774892,
        "dataChange": true,
        "stats": "{\"numRecords\":5,\"minValues\":{\"_1\":1,\"_2\":\"Adrian\"},\"maxValues\":{\"_1\":5,\"_2\":\"Simon\"},\"nullCount\":{\"_1\":0,\"_2\":0}}"
}
```

Delta Log (III)

Checkpoints and last_checkpoint

```
5.to(14).foreach(i => {
    val newIntern = Seq((i, s"Intern ${i}")).toDF("id","engineer")
    newIntern.write.mode("append").format("delta").saveAsTable("data_engineers_checkpoint")
})
```

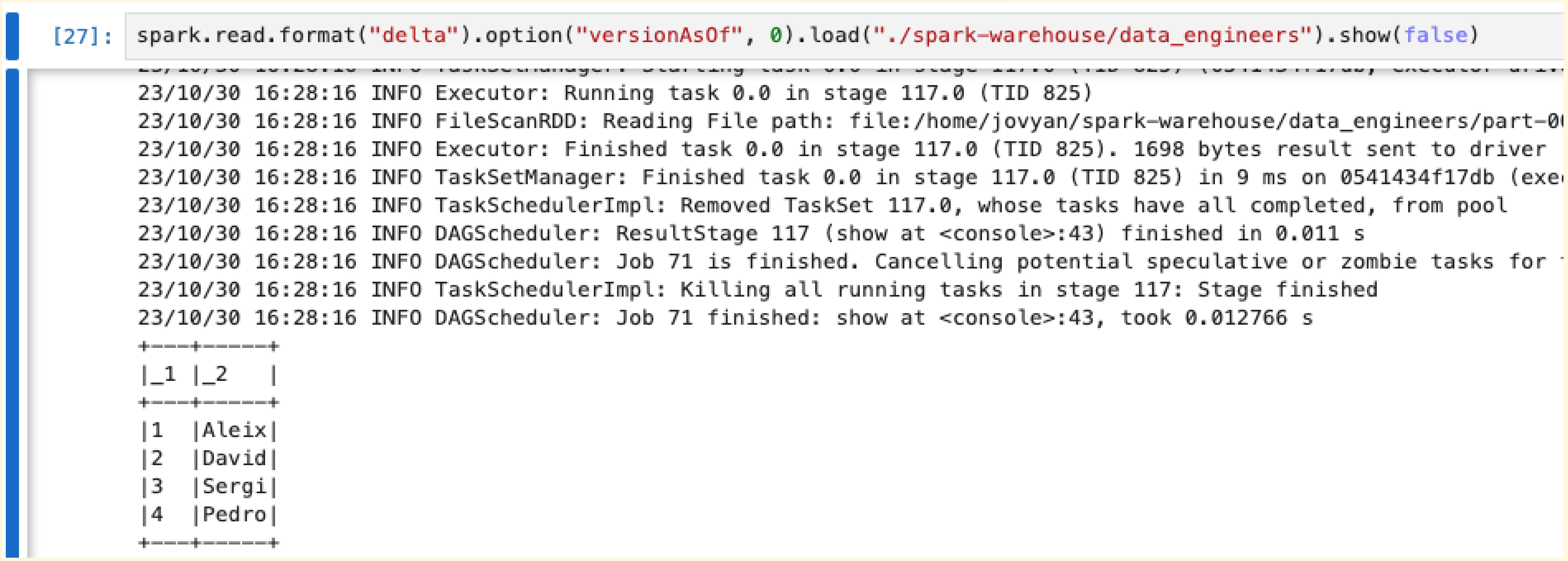
```
spark-warehouse/data_engineers_cdc/
|->_delta_log/
|           |->_last_checkpoint
|           |->00000000000000000000.json
|           |->...
|           |->00000000000000000010.checkpoint.parquet
```

Delta Log (IV)

```
{
    "version": 10,
    "size": 13,
    "sizeInBytes": 15001,
    "numOfAddFiles": 11,
    "checkpointSchema": ...
}
```

txn	add	remove	metaData	protocol
null	{part-00000-d08223e8-87b6-487c-bcc5-837c64e24d2e-c000.snappy.parquet, {}, 733, 1701035863803, ... }	null	null	null

Time travel



```
[27]: spark.read.format("delta").option("versionAsOf", 0).load("./spark-warehouse/data_engineers").show(false)
```

```
23/10/30 16:28:16 INFO Executor: Running task 0.0 in stage 117.0 (TID 825)
23/10/30 16:28:16 INFO FileScanRDD: Reading File path: file:/home/jovyan/spark-warehouse/data_engineers/part-0
23/10/30 16:28:16 INFO Executor: Finished task 0.0 in stage 117.0 (TID 825). 1698 bytes result sent to driver
23/10/30 16:28:16 INFO TaskSetManager: Finished task 0.0 in stage 117.0 (TID 825) in 9 ms on 0541434f17db (exe
23/10/30 16:28:16 INFO TaskSchedulerImpl: Removed TaskSet 117.0, whose tasks have all completed, from pool
23/10/30 16:28:16 INFO DAGScheduler: ResultStage 117 (show at <console>:43) finished in 0.011 s
23/10/30 16:28:16 INFO DAGScheduler: Job 71 is finished. Cancelling potential speculative or zombie tasks for
23/10/30 16:28:16 INFO TaskSchedulerImpl: Killing all running tasks in stage 117: Stage finished
23/10/30 16:28:16 INFO DAGScheduler: Job 71 finished: show at <console>:43, took 0.012766 s
+---+-----+
|_1 |_2   |
+---+-----+
|1  |Aleix|
|2  |David|
|3  |Sergi|
|4  |Pedro|
+---+-----+
```

Delta Restore (I)

```
val deltaTable = DeltaTable
.forName("data_engineers_restore")

deltaTable.restoreToVersion(0)
```

Delta Restore (II)

```
{
    "commitInfo": {
        "timestamp": 1701005204513,
        "operation": "RESTORE",
    }
    "add": {
        "path": "part-00000-4a1eabf4-8001-4114-a8a1-3658ef390cbe-c000.snappy.parquet",
        "stats": "{...}"
    }
    "remove": {
        "path": "part-00000-89eda872-b3ea-4583-8cfa-80070de0f091-c000.snappy.parquet",
        "deletionTimestamp": 1701005204557,
        "size": 740
    }
}
```

Limits

`delta.logRetentionDuration` = "Each time a a checkpoint is written, <Databricks> automatically cleans up log entries older than the retention interval. Default 30 days.

`delta.deletedFileRetentionDuration` = "controls how long ago a file must have been deleted before being a candidate for VACUUM. The default is interval 7 days.

Manual Maintenance

Two main operations:

- Compaction: Reorder files for improving reading speeds
- Vacuum : Get rid of unused versions

Compaction (I)

```
OPTIMIZE my_table
```

```
spark.read.parquet.load("small_files").coalesce(1).write
```

Compaction (II) Z-order

```
OPTIMIZE my_table zorder by id
```

https://github.com/delta-io/delta/blob/13f7fbce7b89cec387df9fbaba0389fe892322b8/spark/src/main/scala/org/apache/spark/sql/delta/expressions/InterleaveBits.scala#L81

Conflicts

	INSERT (1)	UPDATE, DELETE, MERGE INTO	OPTIMIZE
INSERT	Cannot conflict		
UPDATE, DELETE, MERGE INTO	Cannot conflict in WriteSerializable. Can conflict in Serializable; see avoid conflicts with partitions.	Can conflict in Serializable and WriteSerializable; see avoid conflicts with partitions.	
OPTIMIZE	Cannot conflict	Can conflict	Can conflict

Vacuum

```
VACUUM my_table DRY RUN    -- do dry run to get the list of files to be deleted
VACUUM my_table
```

> **Warning**
> VACUUM WILL REMOVE ALL FILES THAT ARE NOT LISTED IN THE DELTA TABLE UNLESS THEY START BY _, if you have a checkpoint in the same path call it _checkpoint

Parallel deletes

spark.databricks.delta.vacuum.parallelDelete.enabled -> true

Column Mapping (I)

```
spark.sql("""
 ALTER TABLE data_engineers_mapping SET TBLPROPERTIES (
    'delta.minReaderVersion' = '2',
    'delta.minWriterVersion' = '5',
    'delta.columnMapping.mode' = 'name'
  )
""")
```

Column Mapping (II)

```
spark.sql("ALTER TABLE data_engineers_mapping RENAME COLUMN engineer TO employee")
```

```
"commitInfo": {
    "timestamp": 1701011573250,
    "operation": "RENAME COLUMN",
    "schemaString": {
    "type": "struct",
    "fields": [
        {
            "name": "id",
            "type": "integer",
            "nullable": true,
            "metadata": {
                "delta.columnMapping.id": 1,
                "delta.columnMapping.physicalName": "id"
            }
        },
        {
            "name": "employee",
            "type": "string",
            "nullable": true,
            "metadata": {
                "delta.columnMapping.id": 2,
                "delta.columnMapping.physicalName": "engineer"
            }
        }
    ]
}
```

Column Mapping (III)

```
spark.sql("ALTER TABLE data_engineers_mapping DROP COLUMN employee")
```

```
{
    "type": "struct",
    "fields": [
        {
            "name": "id",
            "type": "integer",
            "nullable": true,
            "metadata": {
                "delta.columnMapping.id": 1,
                "delta.columnMapping.physicalName": "id"
            }
        }
    ]
}
```

Change data feed (I)

```
ALTER TABLE myDeltaTable SET TBLPROPERTIES (delta.enableChangeDataFeed = true)
```

> WARNING: only for future changes after enabled!

```
org.apache.spark.sql.delta.DeltaAnalysisException:
Error getting change data for range [0 , 2] as change data was not
recorded for version [0].
If you've enabled change data feed on this table,
use `DESCRIBE HISTORY` to see when it was first enabled.
```

Change data feed (II)

```
spark.read.format("delta")
  .option("readChangeFeed", "true")
  .option("startingVersion", 0)
  .table("data_engineers_cdc").show(false)
```

_1	_2	_change_type	_commit_version
4	David	update_preimage	1
4	Adrian	update_postimage	1
5	David	insert	1

Change data feed (III)

```
spark-warehouse/data_engineers_cdc/
|->_change_data/
|              |->cdc-00000-540b06a2-4586-48e4-af82-7e48ffdd89c4.c000.snappy.parquet
|->_delta_log/
|           |->00000000000000000000.json
|           |->00000000000000000001.json
|->part-00000-96291cc4-788d-46aa-8aa1-272cbf1e04dd.c000.snappy.parquet
|->part-00000-b6e25d04-253f-49af-bd09-ab65916c8675-c000.snappy.parquet
```

The future

- Deletion Vectors: mark in metadata rows as remove and rewrite the files during an optimize
- Row - level concurrency: allow incompatible operations to run together such as merge and optimizes

Going back to parquet

If you want to go back from Delta to Parquet you need to:

1. Get rid of old versions of the data.
2. Clean the delta_log folder.

Going back to parquet (II)

```
VACUUM <table> RETAIN 0 HOURS
```

```
spark.databricks.delta.retentionDurationCheck.enabled false
```

Extra resources

https://www.databricks.com/blog/2019/08/21/diving-into-delta-lake-unpacking-the-transaction-log.html
https://www.databricks.com/blog/2020/09/29/diving-into-delta-lake-dml-internals-update-delete-merge.html
https://docs.delta.io/0.7.0/delta-batch.html#-data-retention
https://canadiandataguy.medium.com/delta-vs-parquet-a-deep-dive-into-big-data-storage-solutions-34ffab2fea52
https://github.com/delta-io/delta/blob/13f7fbce7b89cec387df9fbaba0389fe892322b8/spark/src/main/scala/org/apache/spark/sql/delta/commands/VacuumCommand.scala#L323