Spark Execution Plans

@falekmiah

falekmiah.com

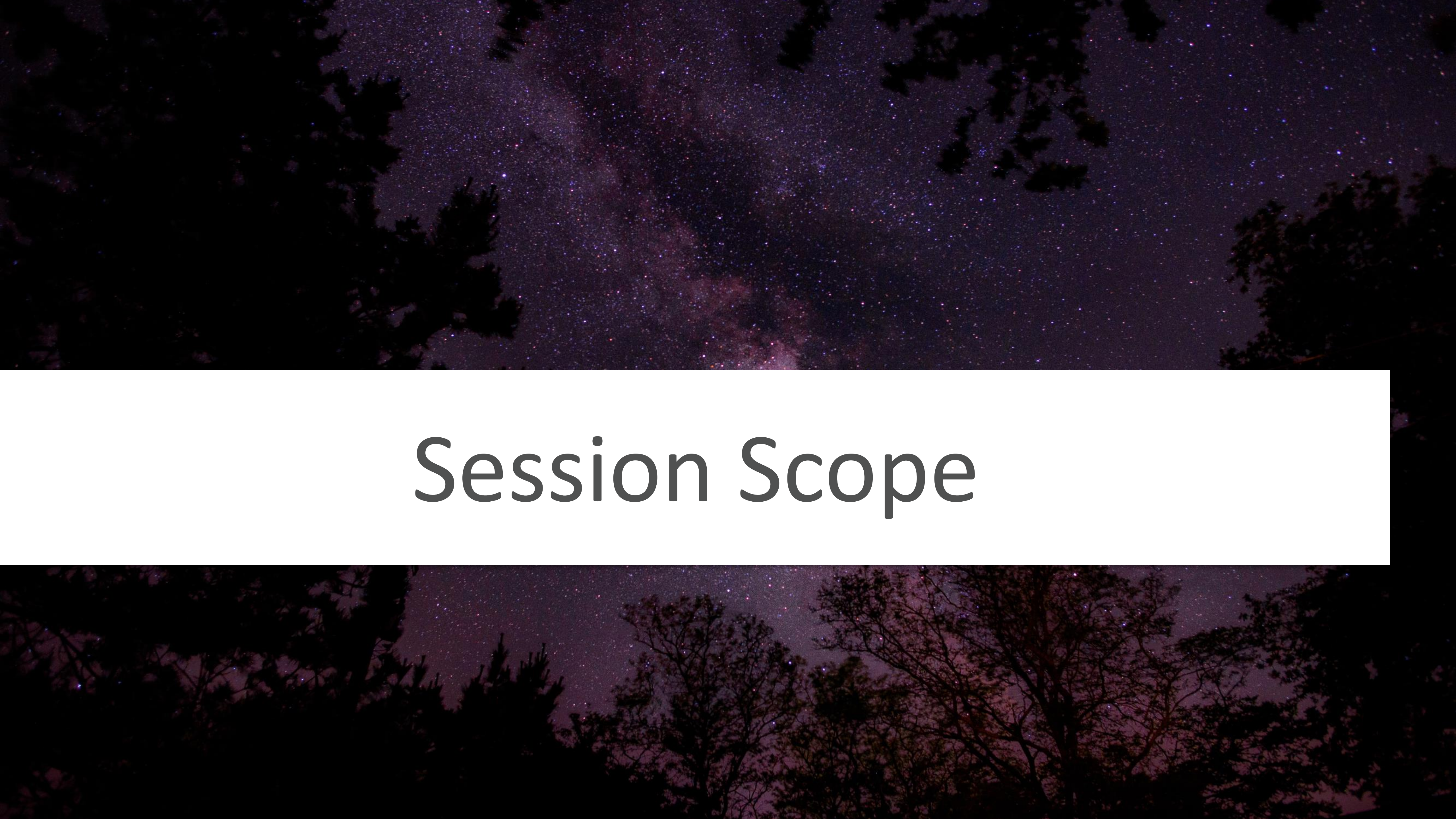
FalekMiah01

Falek Miah

Principal Consultant

- 15+ Years Microsoft Data Analytics
- Intensive Data Engineering Experience
- Data, Cloud & DevOps Enthusiast
- Databricks Champion and Microsoft Azure & Terraform (HashiCorp) certified engineer

@falekmiah
falekmiah.com
FalekMiah01

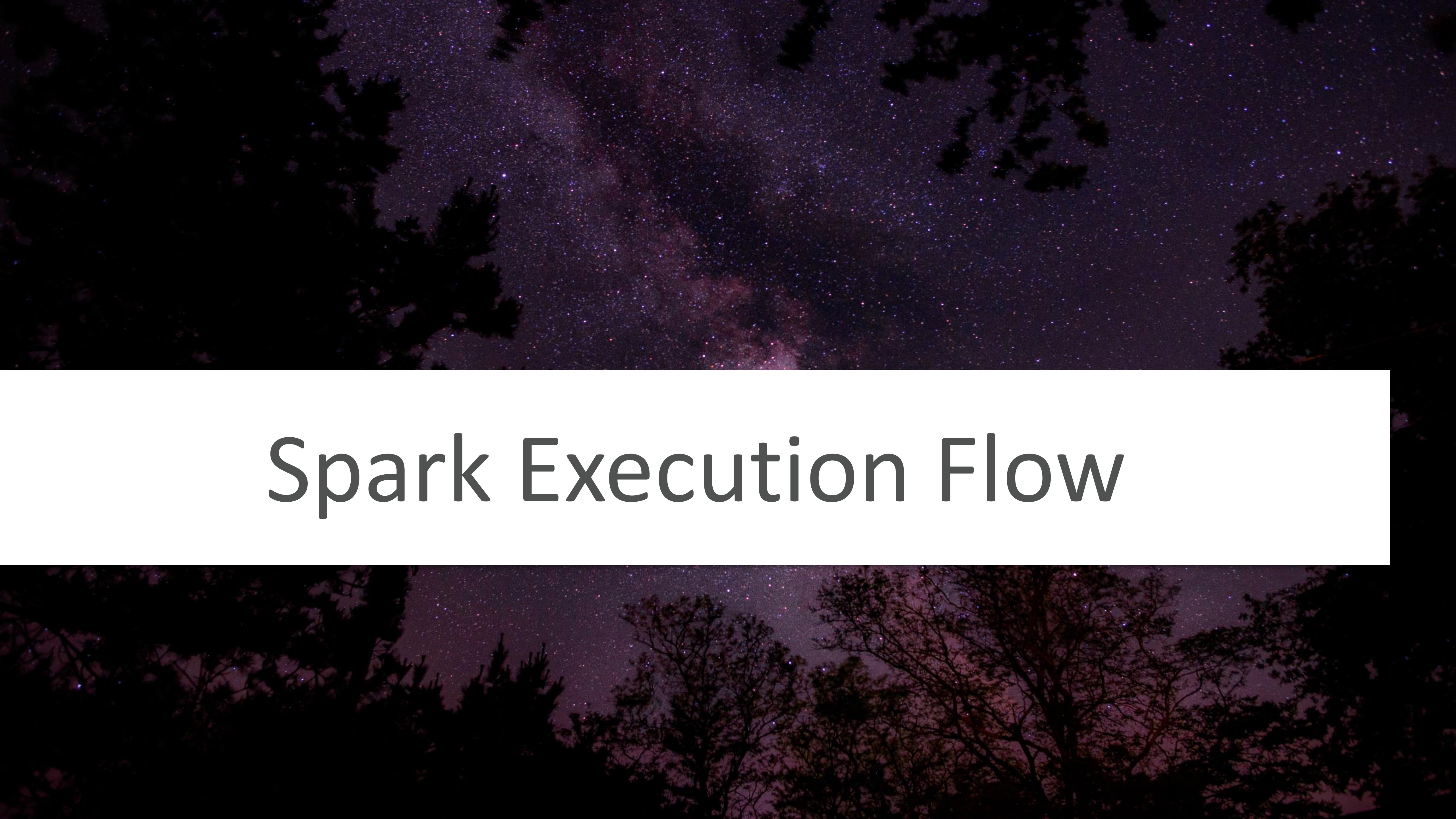


Session Scope

Session Scope

- Optimise Performance
    - Daunting
    - Where to start!

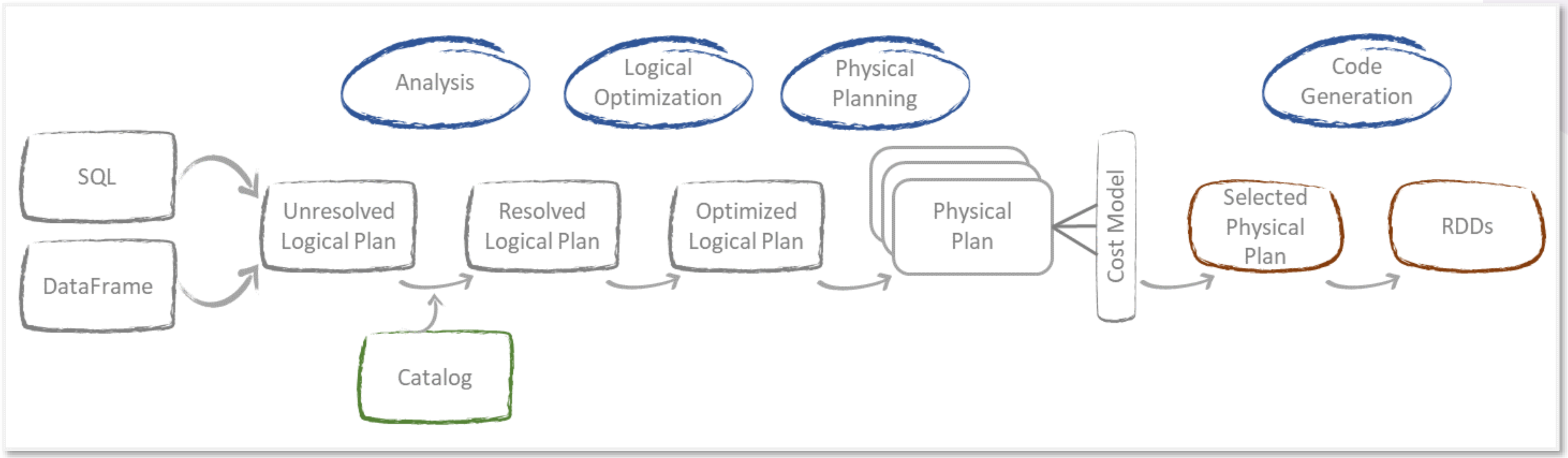
- Spark Execution Plans
    - Execution Plans
    - Execution Flow
    - Adaptive Query Execution (AQE)
    - Spark UI

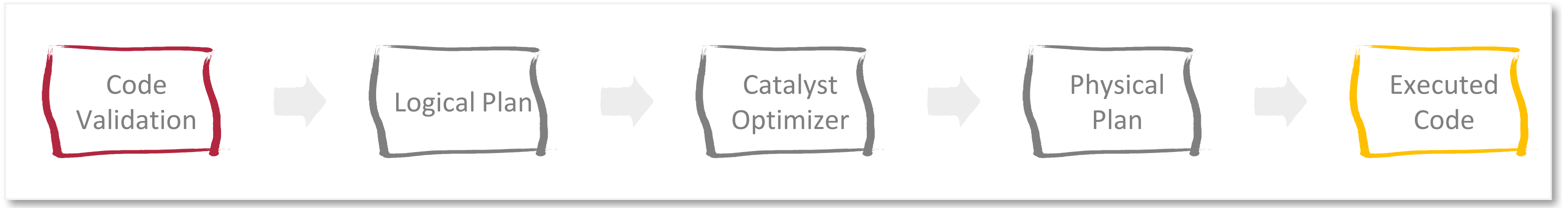


Spark Execution Flow

Spark Execution Flow

- All Spark Applications use Catalyst Optimizer





Spark Execution Plans

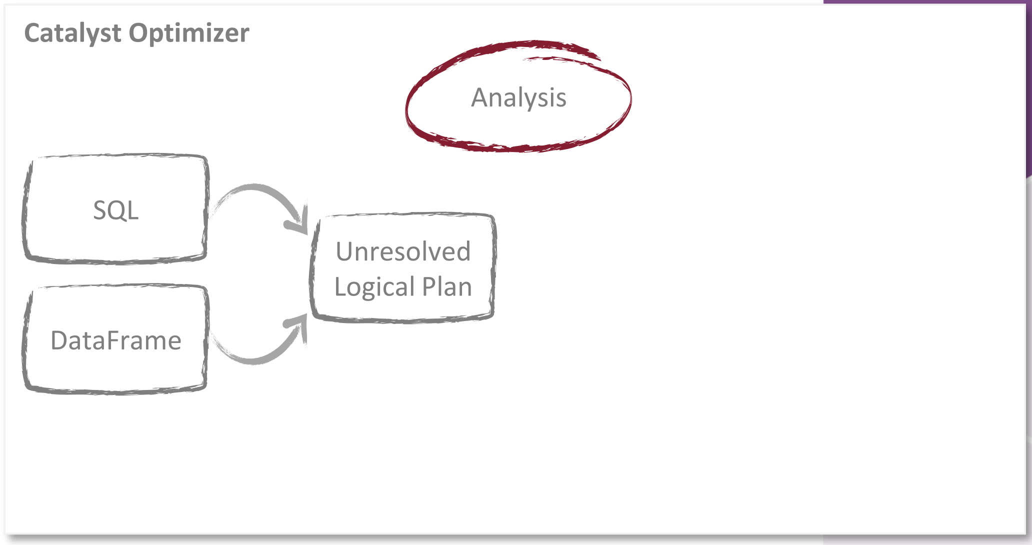
Spark Execution Plans

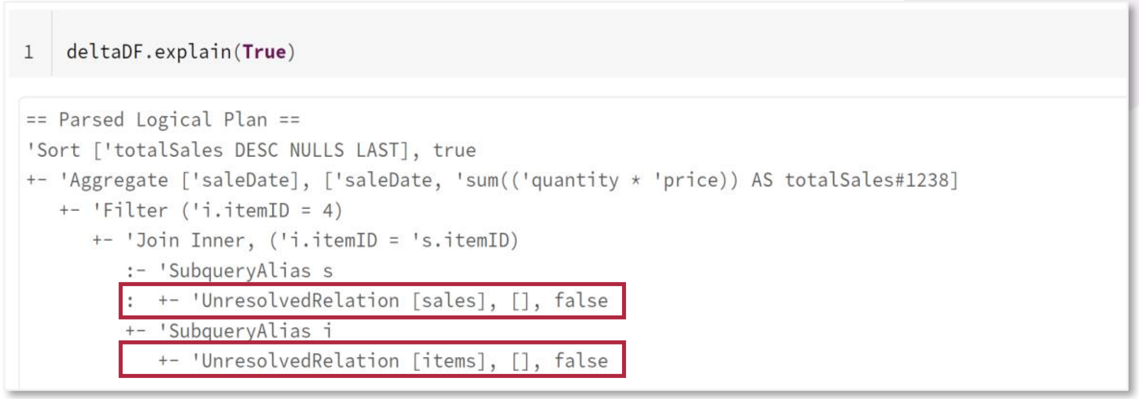
- Logical Plan
    - Unresolved Logical Plan
    - Resolved Logical Plan
    - Optimized Logical Plan

- Physical Plan

Logical Plan

- **Unresolved Logical Plan** (Parsed Logical Plan)
  - Identifies the `Unresolved` objects
  - Flags unvalidated objects as `Unresolved`





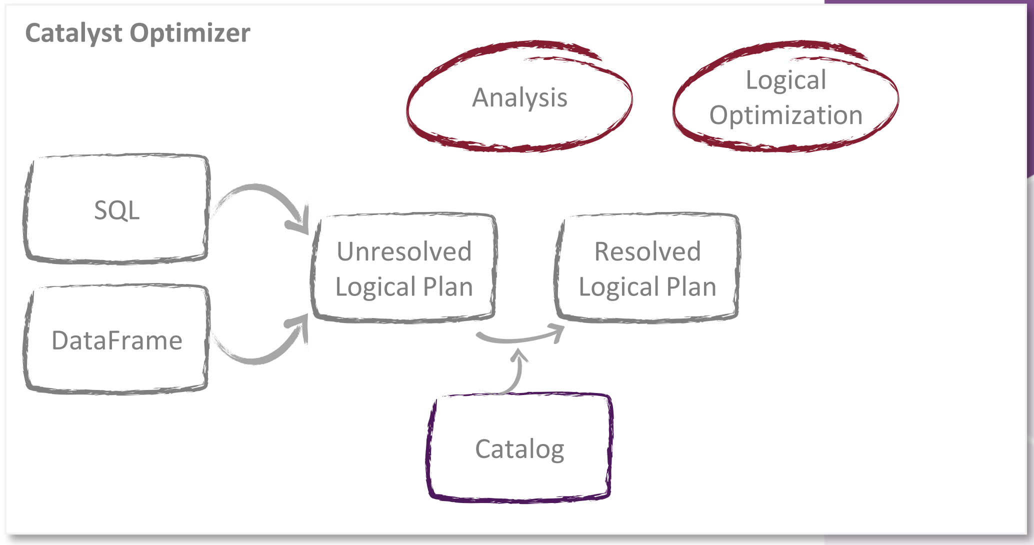
```
deltaDF.explain(True)
```

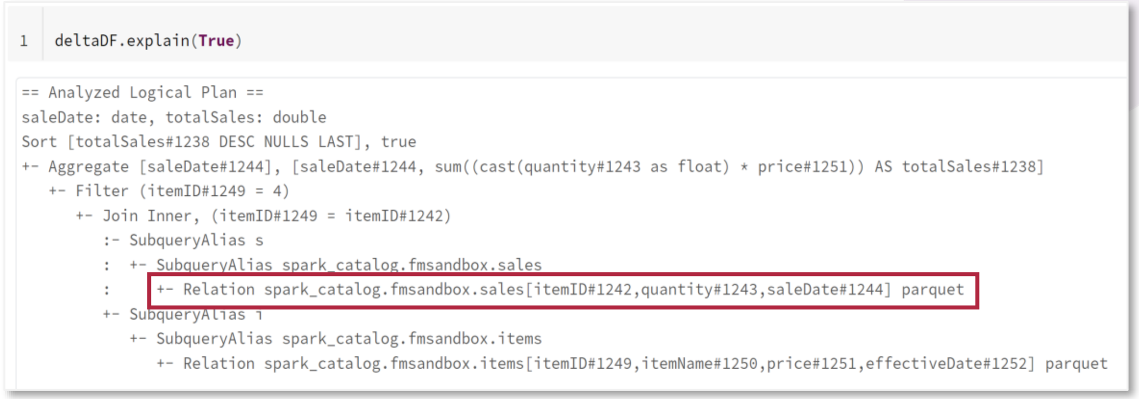
```
== Parsed Logical Plan ==
'Sort ['totalSales DESC NULLS LAST], true
+- 'Aggregate ['saleDate], ['saleDate, 'sum(('quantity * 'price)) AS totalSales#1238]
   +- 'Filter ('i.itemID = 4)
      +- 'Join Inner, ('i.itemID = 's.itemID)
         :- 'SubqueryAlias s
         :  +- 'UnresolvedRelation [sales], [], false
         +- 'SubqueryAlias i
            +- 'UnresolvedRelation [items], [], false
```

Logical Plan

- **Unresolved Logical Plan** (Parsed Logical Plan)
  - Flags unvalidated objects as `Unresolved`

- **Resolved Logical Plan** (Analyzed Logical Plan)
  - Validates the `Unresolved` objects
  - Uses `Catalog` metadata repository



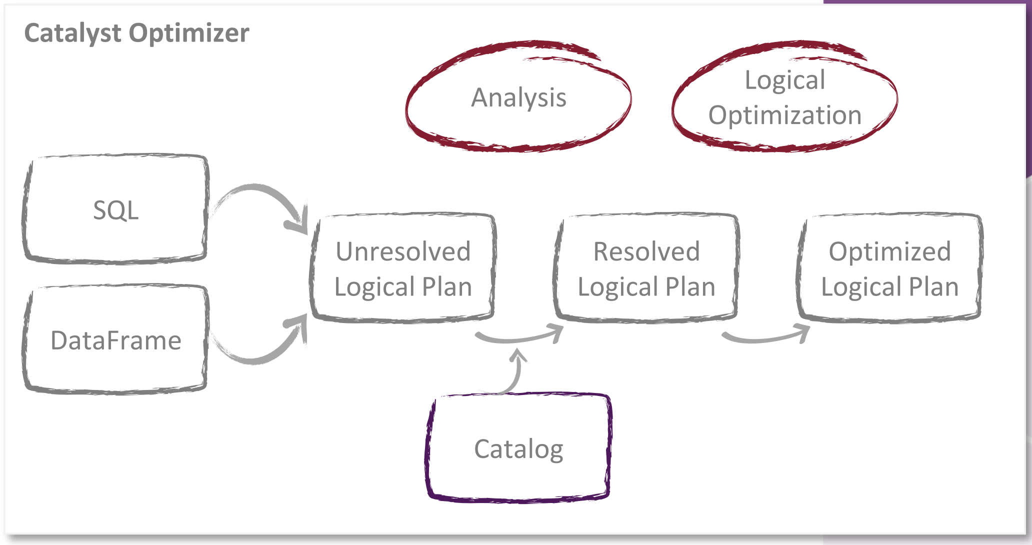


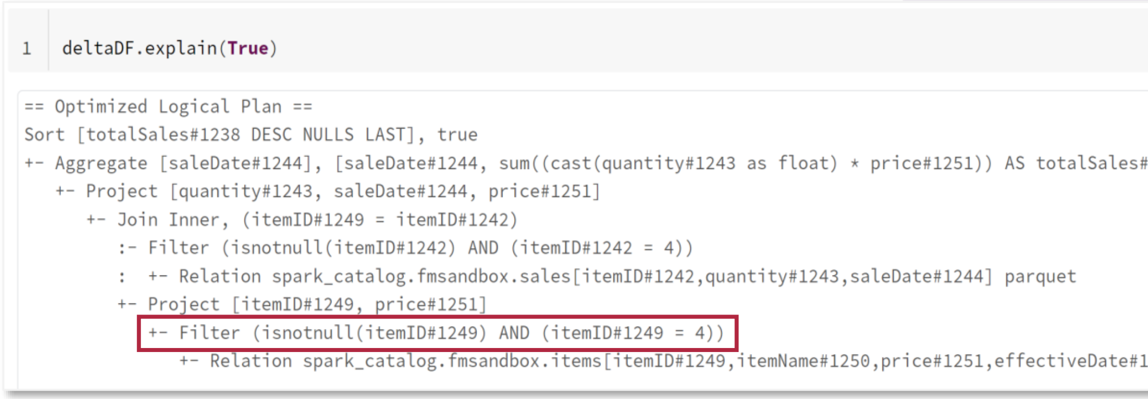
```
deltaDF.explain(True)
```

```
== Analyzed Logical Plan ==
saleDate: date, totalSales: double
Sort [totalSales#1238 DESC NULLS LAST], true
+- Aggregate [saleDate#1244], [saleDate#1244, sum((cast(quantity#1243 as float) * price#1251)) AS totalSales#1238]
   +- Filter (itemID#1249 = 4)
      +- Join Inner, (itemID#1249 = itemID#1242)
         :- SubqueryAlias s
         :  +- SubqueryAlias spark_catalog.fmsandbox.sales
         :     +- Relation spark_catalog.fmsandbox.sales[itemID#1242,quantity#1243,saleDate#1244] parquet
         +- SubqueryAlias i
            +- SubqueryAlias spark_catalog.fmsandbox.items
               +- Relation spark_catalog.fmsandbox.items[itemID#1249,itemName#1250,price#1251,effectiveDate#1252] parquet
```

Logical Plan

- **Unresolved Logical Plan** (Parsed Logical Plan)
  - Flags unvalidated objects as `Unresolved`
- **Resolved Logical Plan** (Analyzed Logical Plan)
  - Validates the `Unresolved` objects
  - Uses `Catalog` metadata repository
- **Optimized Logical Plan**
  - Applies predicates or rules to further optimize the plan



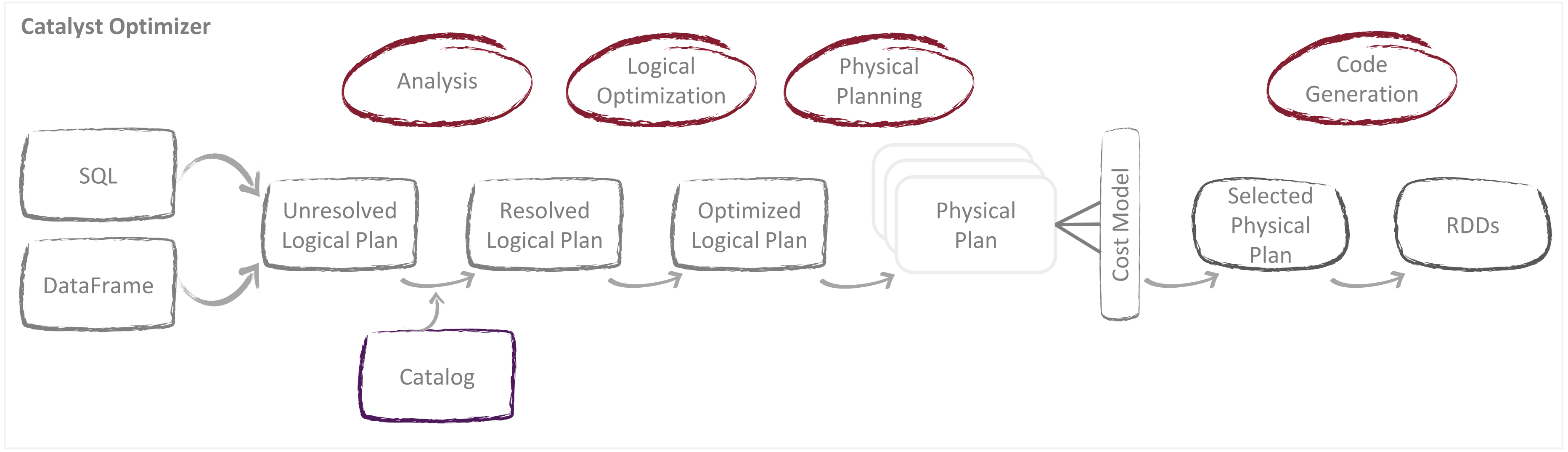


```
deltaDF.explain(True)
```

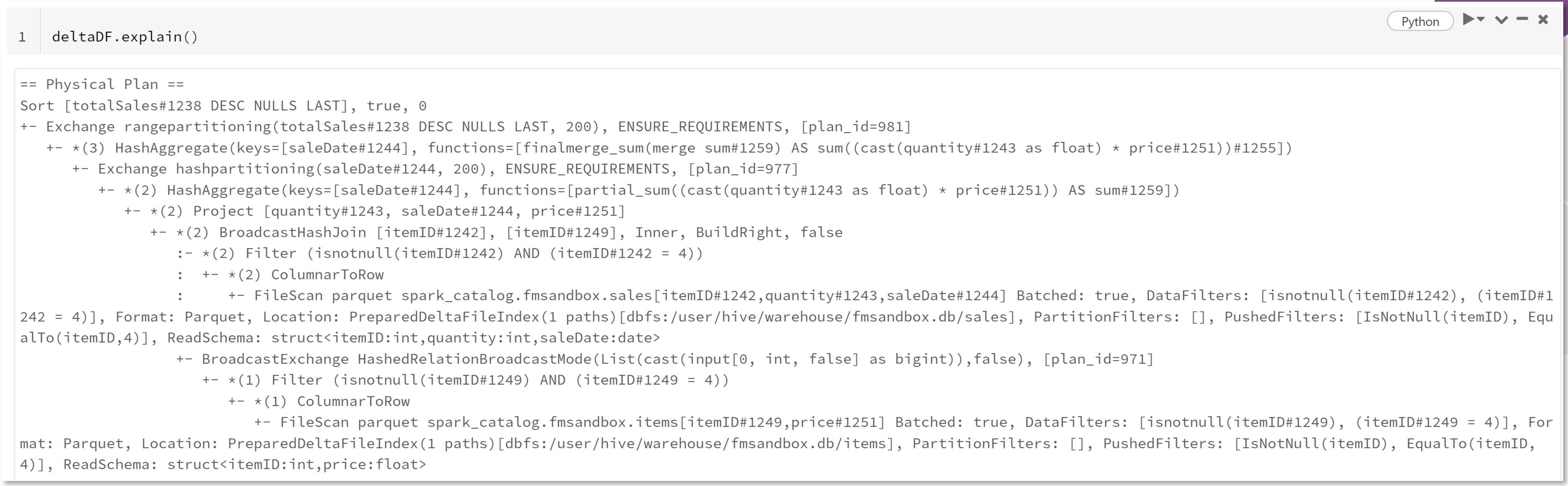
```
== Optimized Logical Plan ==
Sort [totalSales#1238 DESC NULLS LAST], true
+- Aggregate [saleDate#1244], [saleDate#1244, sum((cast(quantity#1243 as float) * price#1251)) AS totalSales#
   +- Project [quantity#1243, saleDate#1244, price#1251]
      +- Join Inner, (itemID#1249 = itemID#1242)
         :- Filter (isnotnull(itemID#1242) AND (itemID#1242 = 4))
         :  +- Relation spark_catalog.fmsandbox.sales[itemID#1242,quantity#1243,saleDate#1244] parquet
         +- Project [itemID#1249, price#1251]
            +- Filter (isnotnull(itemID#1249) AND (itemID#1249 = 4))
               +- Relation spark_catalog.fmsandbox.items[itemID#1249,itemName#1250,price#1251,effectiveDate#1
```

Physical Plan

- Is how the Logical Plan will be **executed** on the cluster
- Generates different execution **strategies**
- Compares them through a **Cost Model**
- Selects the **best optimal plan/strategy** as the “Best Physical Plan”



Physical Plan



```python
deltaDF.explain()
```

```
== Physical Plan ==
Sort [totalSales#1238 DESC NULLS LAST], true, 0
+- Exchange rangepartitioning(totalSales#1238 DESC NULLS LAST, 200), ENSURE_REQUIREMENTS, [plan_id=981]
   +- *(3) HashAggregate(keys=[saleDate#1244], functions=[finalmerge_sum(merge sum#1259) AS sum((cast(quantity#1243 as float) * price#1251))#1255])
      +- Exchange hashpartitioning(saleDate#1244, 200), ENSURE_REQUIREMENTS, [plan_id=977]
         +- *(2) HashAggregate(keys=[saleDate#1244], functions=[partial_sum((cast(quantity#1243 as float) * price#1251)) AS sum#1259])
            +- *(2) Project [quantity#1243, saleDate#1244, price#1251]
               +- *(2) BroadcastHashJoin [itemID#1242], [itemID#1249], Inner, BuildRight, false
                  :- *(2) Filter (isnotnull(itemID#1242) AND (itemID#1242 = 4))
                  :  +- *(2) ColumnarToRow
                  :     +- FileScan parquet spark_catalog.fmsandbox.sales[itemID#1242,quantity#1243,saleDate#1244] Batched: true, DataFilters: [isnotnull(itemID#1242), (itemID#1
242 = 4)], Format: Parquet, Location: PreparedDeltaFileIndex(1 paths)[dbfs:/user/hive/warehouse/fmsandbox.db/sales], PartitionFilters: [], PushedFilters: [IsNotNull(itemID), Equ
alTo(itemID,4)], ReadSchema: struct<itemID:int,quantity:int,saleDate:date>
                  +- BroadcastExchange HashedRelationBroadcastMode(List(cast(input[0, int, false] as bigint)),false), [plan_id=971]
                     +- *(1) Filter (isnotnull(itemID#1249) AND (itemID#1249 = 4))
                        +- *(1) ColumnarToRow
                           +- FileScan parquet spark_catalog.fmsandbox.items[itemID#1249,price#1251] Batched: true, DataFilters: [isnotnull(itemID#1249), (itemID#1249 = 4)], For
mat: Parquet, Location: PreparedDeltaFileIndex(1 paths)[dbfs:/user/hive/warehouse/fmsandbox.db/items], PartitionFilters: [], PushedFilters: [IsNotNull(itemID), EqualTo(itemID,
4)], ReadSchema: struct<itemID:int,price:float>
```

Generate Execution Plans

Generate Execution Plans

PySpark

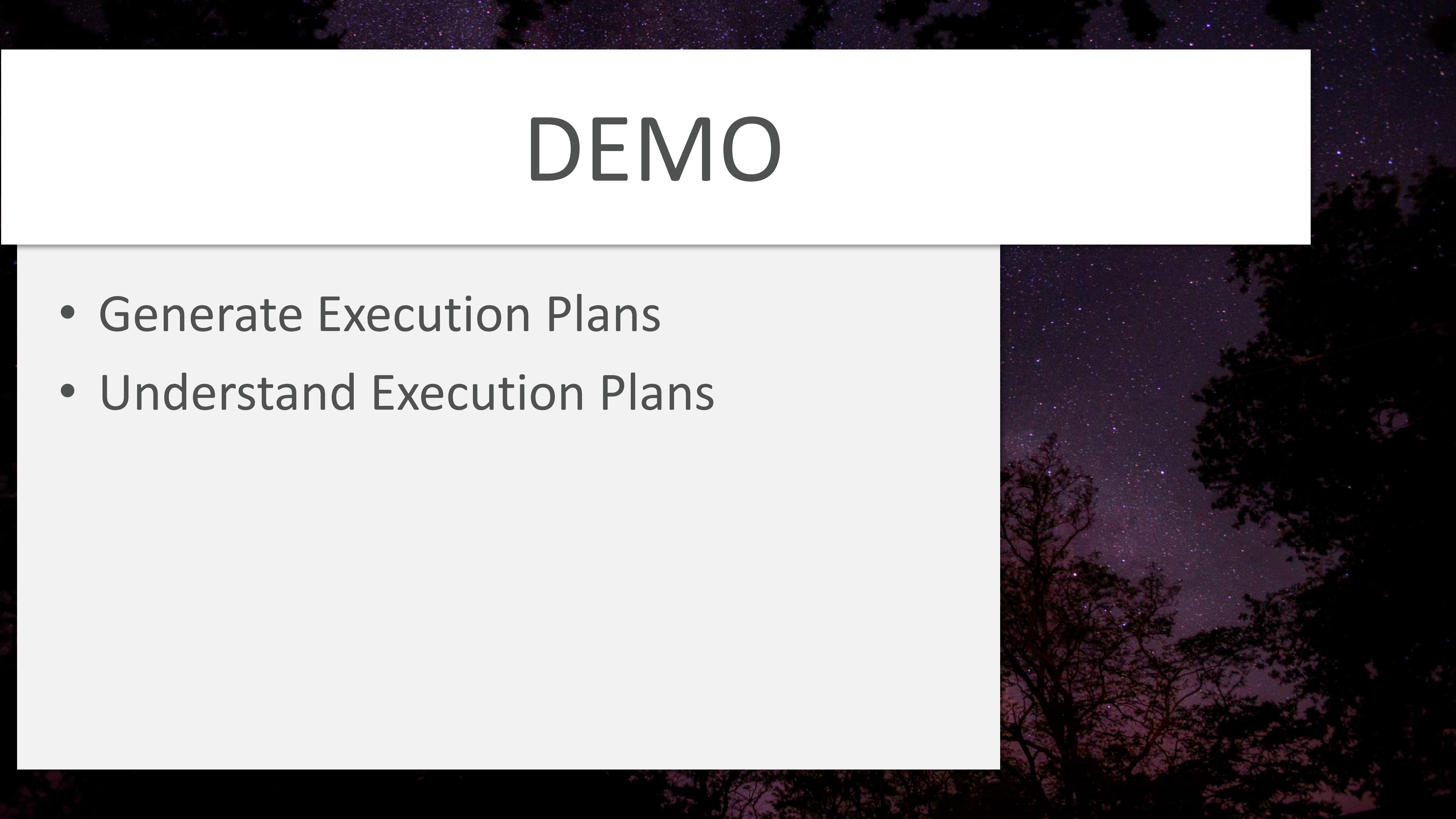
```
.explain()
```

```
.explain(True) or .explain(mode="extended")

.explain(mode="codegen")

.explain(mode="cost")

.explain(mode="formatted")
```

Spark SQL

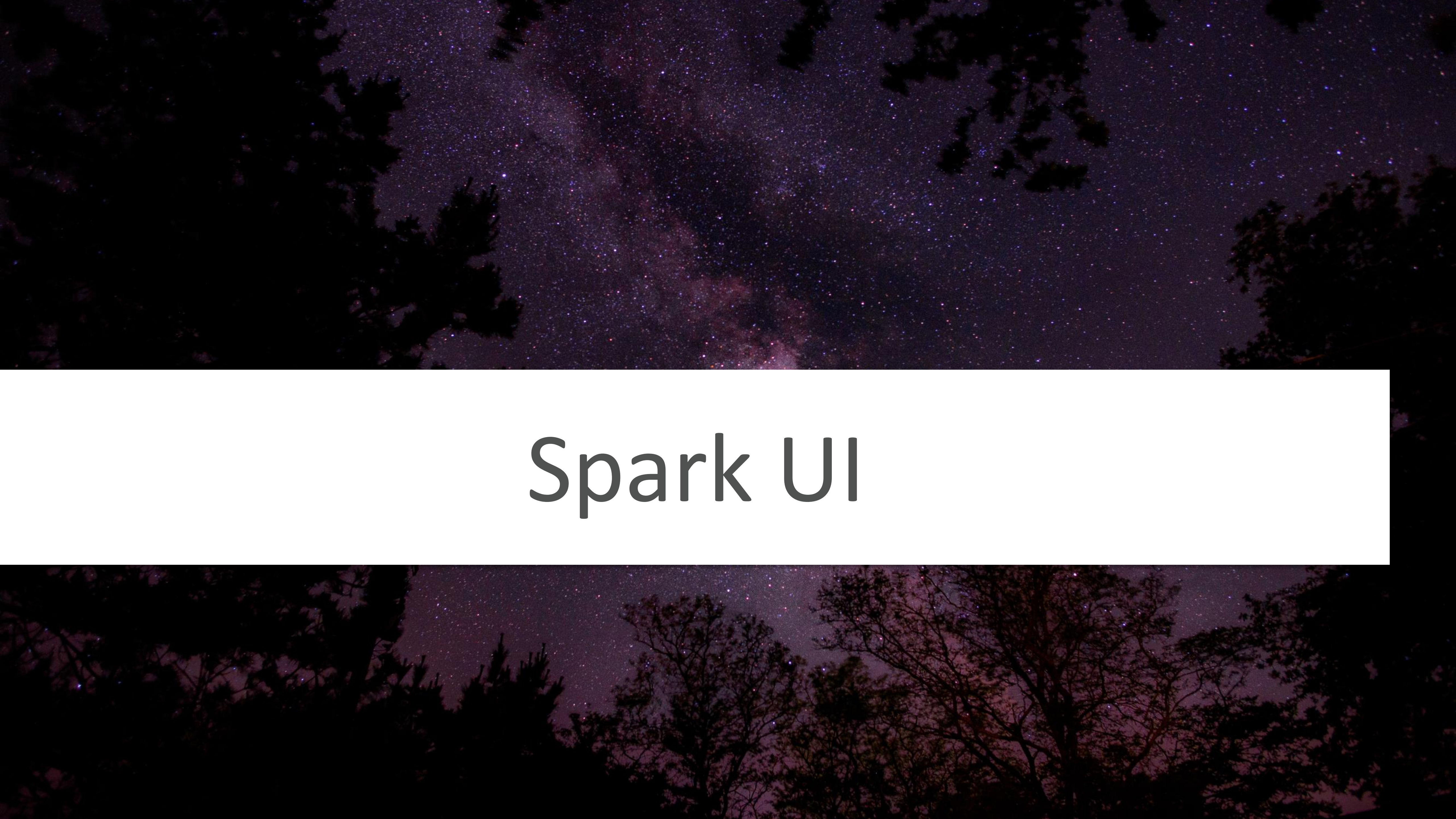
```
EXPLAIN
```

```
EXPLAIN [ EXTENDED | CODEGEN | COST | FORMATTED ]
```



DEMO

- Generate Execution Plans
- Understand Execution Plans

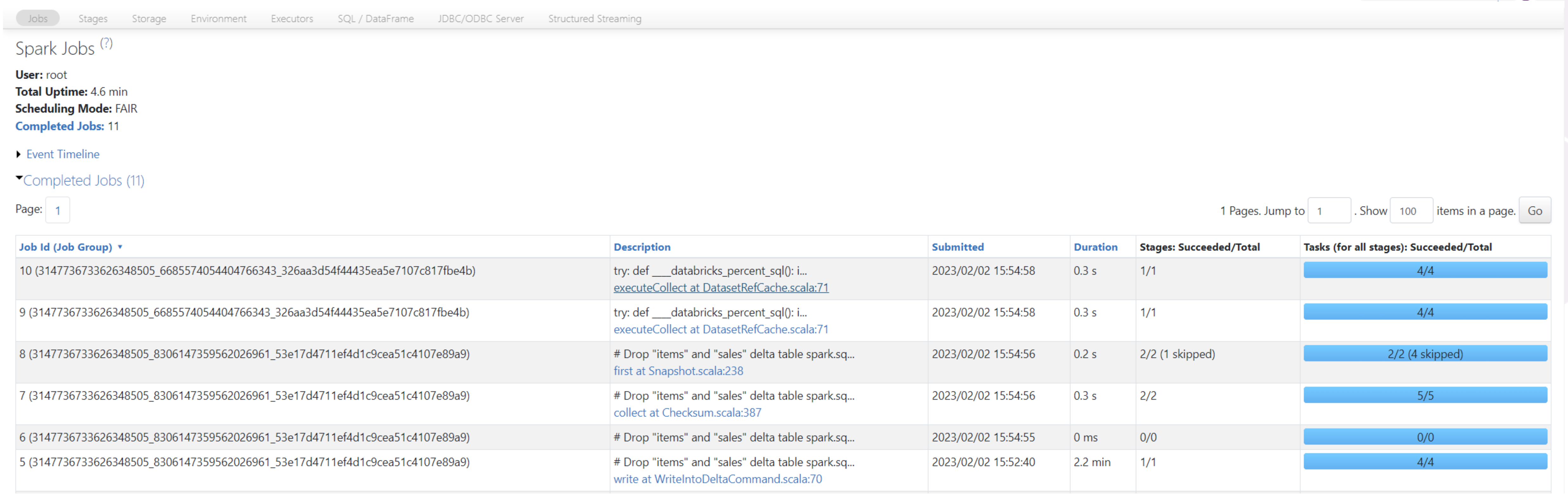


Spark UI

Spark UI

- Monitor Spark Application
- Insight Into Executions and Workload
- Debugging
- Displays queries, jobs, DAG, and query plans

Spark UI - Jobs



Spark Jobs (?)

User: root
Total Uptime: 4.6 min
Scheduling Mode: FAIR
Completed Jobs: 11

▸ Event Timeline

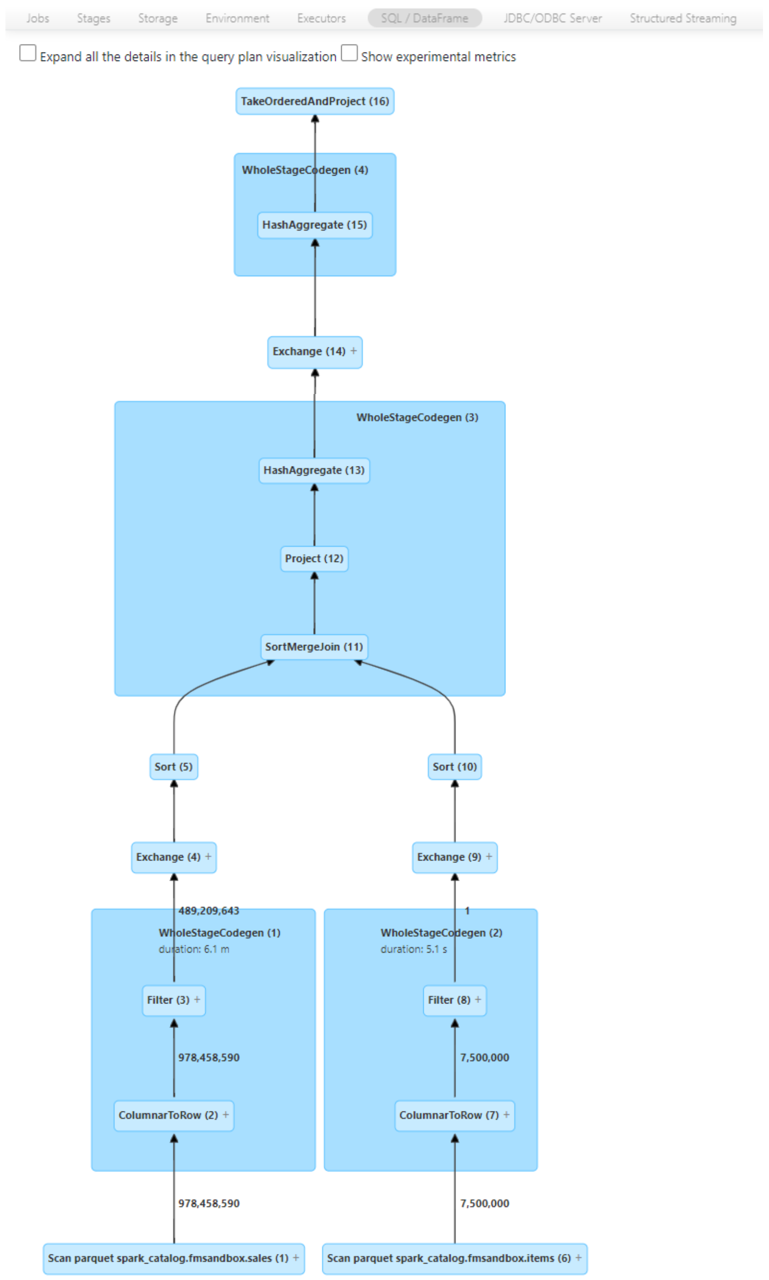
▾Completed Jobs (11)

Page: 1

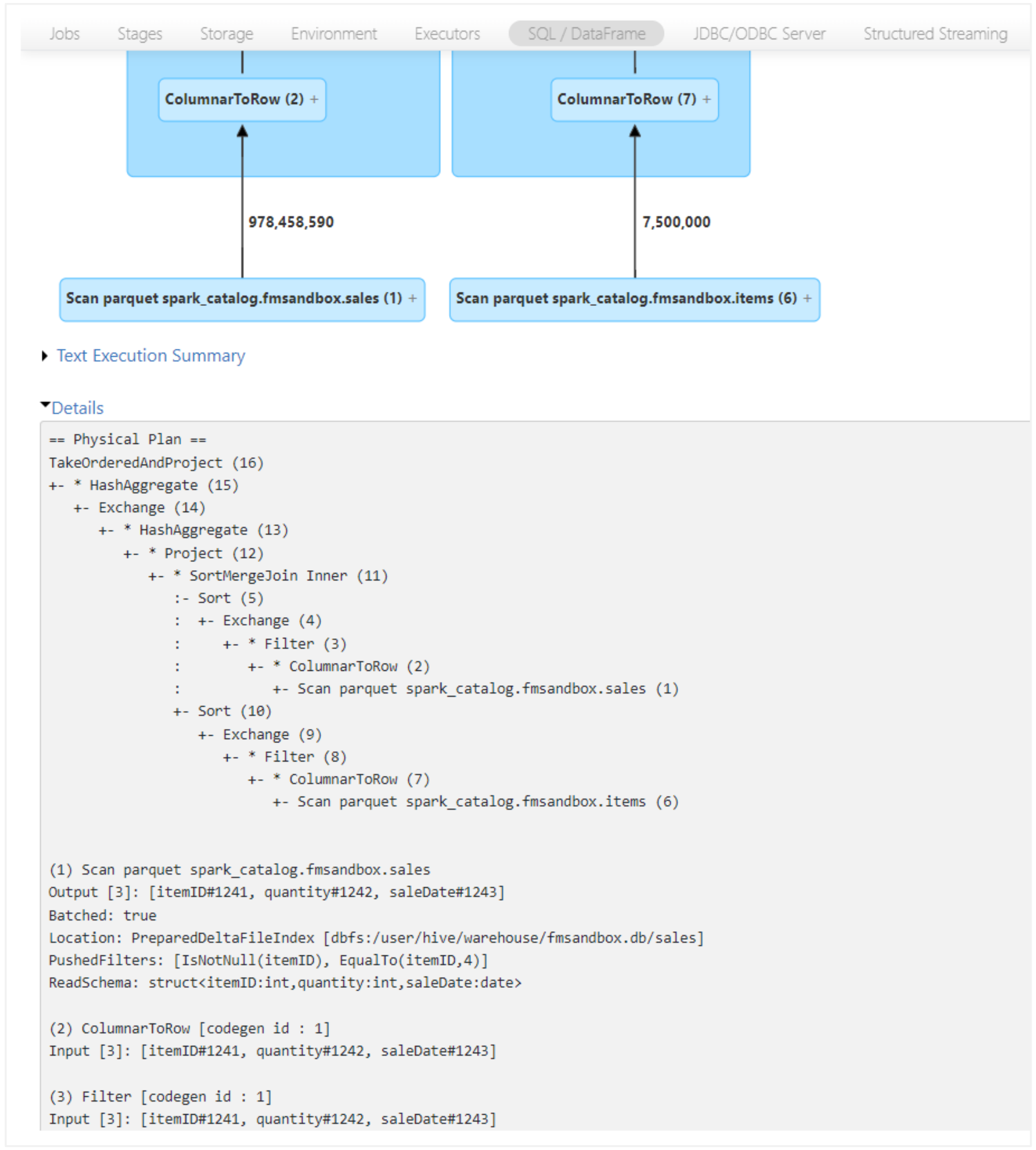
1 Pages. Jump to 1 . Show 100 items in a page. Go

Job Id (Job Group) ▾	Description	Submitted	Duration	Stages: Succeeded/Total	Tasks (for all stages): Succeeded/Total
10 (3147736733626348505_6685574054404766343_326aa3d54f44435ea5e7107c817fbe4b)	try: def ___databricks_percent_sql(): i... executeCollect at DatasetRefCache.scala:71	2023/02/02 15:54:58	0.3 s	1/1	4/4
9 (3147736733626348505_6685574054404766343_326aa3d54f44435ea5e7107c817fbe4b)	try: def ___databricks_percent_sql(): i... executeCollect at DatasetRefCache.scala:71	2023/02/02 15:54:58	0.3 s	1/1	4/4
8 (3147736733626348505_8306147359562026961_53e17d4711ef4d1c9cea51c4107e89a9)	# Drop "items" and "sales" delta table spark.sq... first at Snapshot.scala:238	2023/02/02 15:54:56	0.2 s	2/2 (1 skipped)	2/2 (4 skipped)
7 (3147736733626348505_8306147359562026961_53e17d4711ef4d1c9cea51c4107e89a9)	# Drop "items" and "sales" delta table spark.sq... collect at Checksum.scala:387	2023/02/02 15:54:56	0.3 s	2/2	5/5
6 (3147736733626348505_8306147359562026961_53e17d4711ef4d1c9cea51c4107e89a9)	# Drop "items" and "sales" delta table spark.sq...	2023/02/02 15:54:55	0 ms	0/0	0/0
5 (3147736733626348505_8306147359562026961_53e17d4711ef4d1c9cea51c4107e89a9)	# Drop "items" and "sales" delta table spark.sq... write at WriteIntoDeltaCommand.scala:70	2023/02/02 15:52:40	2.2 min	1/1	4/4

Spark UI - DAG


Jobs
Stages
Storage
Environment
Executors
SQL / DataFrame
JDBC/ODBC Server
Structured Streaming
Expand all the details in the query plan visualization
Show experimental metrics
TakeOrderedAndProject (16)
WholeStageCodegen (4)
HashAggregate (15)
Exchange (14) +
WholeStageCodegen (3)
HashAggregate (13)
Project (12)
SortMergeJoin (11)
Sort (5)
Sort (10)
Exchange (4) +
Exchange (9) +
489,209,643
1
WholeStageCodegen (1)
duration: 6.1 m
WholeStageCodegen (2)
duration: 5.1 s
Filter (3) +
Filter (8) +
978,458,590
7,500,000
ColumnarToRow (2) +
ColumnarToRow (7) +
978,458,590
7,500,000
Scan parquet spark_catalog.fmsandbox.sales (1) +
Scan parquet spark_catalog.fmsandbox.items (6) +

Spark UI - Query Plan



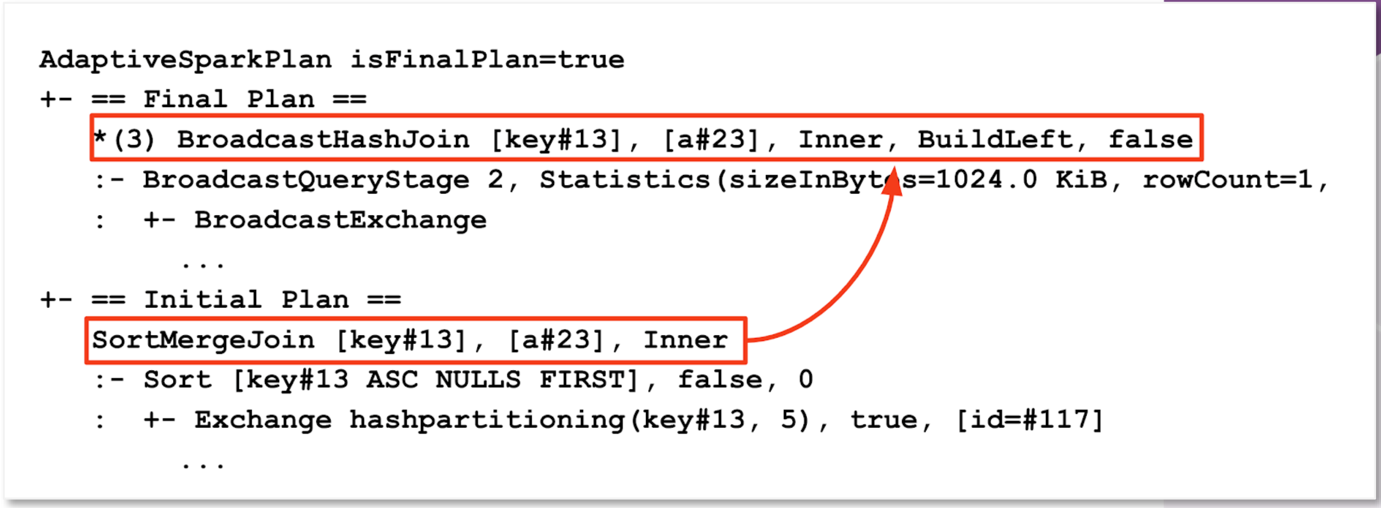
```
== Physical Plan ==
TakeOrderedAndProject (16)
+- * HashAggregate (15)
   +- Exchange (14)
      +- * HashAggregate (13)
         +- * Project (12)
            +- * SortMergeJoin Inner (11)
               :- Sort (5)
               :  +- Exchange (4)
               :     +- * Filter (3)
               :        +- * ColumnarToRow (2)
               :           +- Scan parquet spark_catalog.fmsandbox.sales (1)
               +- Sort (10)
                  +- Exchange (9)
                     +- * Filter (8)
                        +- * ColumnarToRow (7)
                           +- Scan parquet spark_catalog.fmsandbox.items (6)


(1) Scan parquet spark_catalog.fmsandbox.sales
Output [3]: [itemID#1241, quantity#1242, saleDate#1243]
Batched: true
Location: PreparedDeltaFileIndex [dbfs:/user/hive/warehouse/fmsandbox.db/sales]
PushedFilters: [IsNotNull(itemID), EqualTo(itemID,4)]
ReadSchema: struct<itemID:int,quantity:int,saleDate:date>

(2) ColumnarToRow [codegen id : 1]
Input [3]: [itemID#1241, quantity#1242, saleDate#1243]

(3) Filter [codegen id : 1]
Input [3]: [itemID#1241, quantity#1242, saleDate#1243]
```

Adaptive Query Execution (AQE)

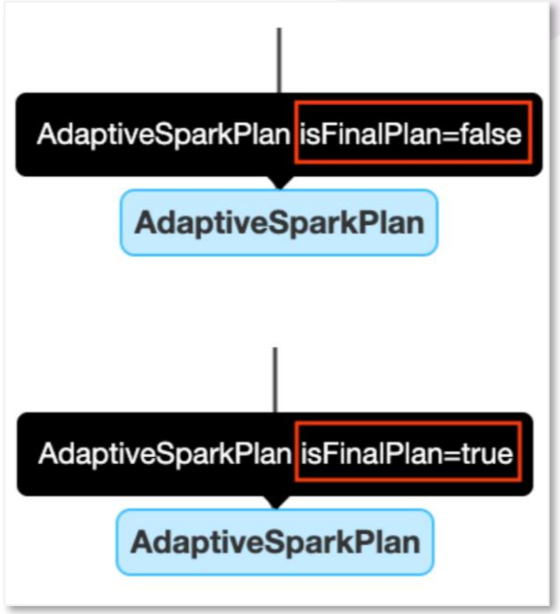
Adaptive Query Execution (AQE)

- Optimizes further
- Changes Query Plan
  - Uses Runtime Statistics
  - Increases Query Performance
- Visible in Spark UI
- Enable using Spark Configuration settings

```
spark.conf.set("spark.sql.adaptive.enabled", "true")
```



```
AdaptiveSparkPlan isFinalPlan=true
+- == Final Plan ==
   *(3) BroadcastHashJoin [key#13], [a#23], Inner, BuildLeft, false
   :- BroadcastQueryStage 2, Statistics(sizeInBytes=1024.0 KiB, rowCount=1,
   :  +- BroadcastExchange
        ...
+- == Initial Plan ==
   SortMergeJoin [key#13], [a#23], Inner
   :- Sort [key#13 ASC NULLS FIRST], false, 0
   :  +- Exchange hashpartitioning(key#13, 5), true, [id=#117]
        ...
```


AdaptiveSparkPlan isFinalPlan=false
AdaptiveSparkPlan
AdaptiveSparkPlan isFinalPlan=true
AdaptiveSparkPlan

Query Hints

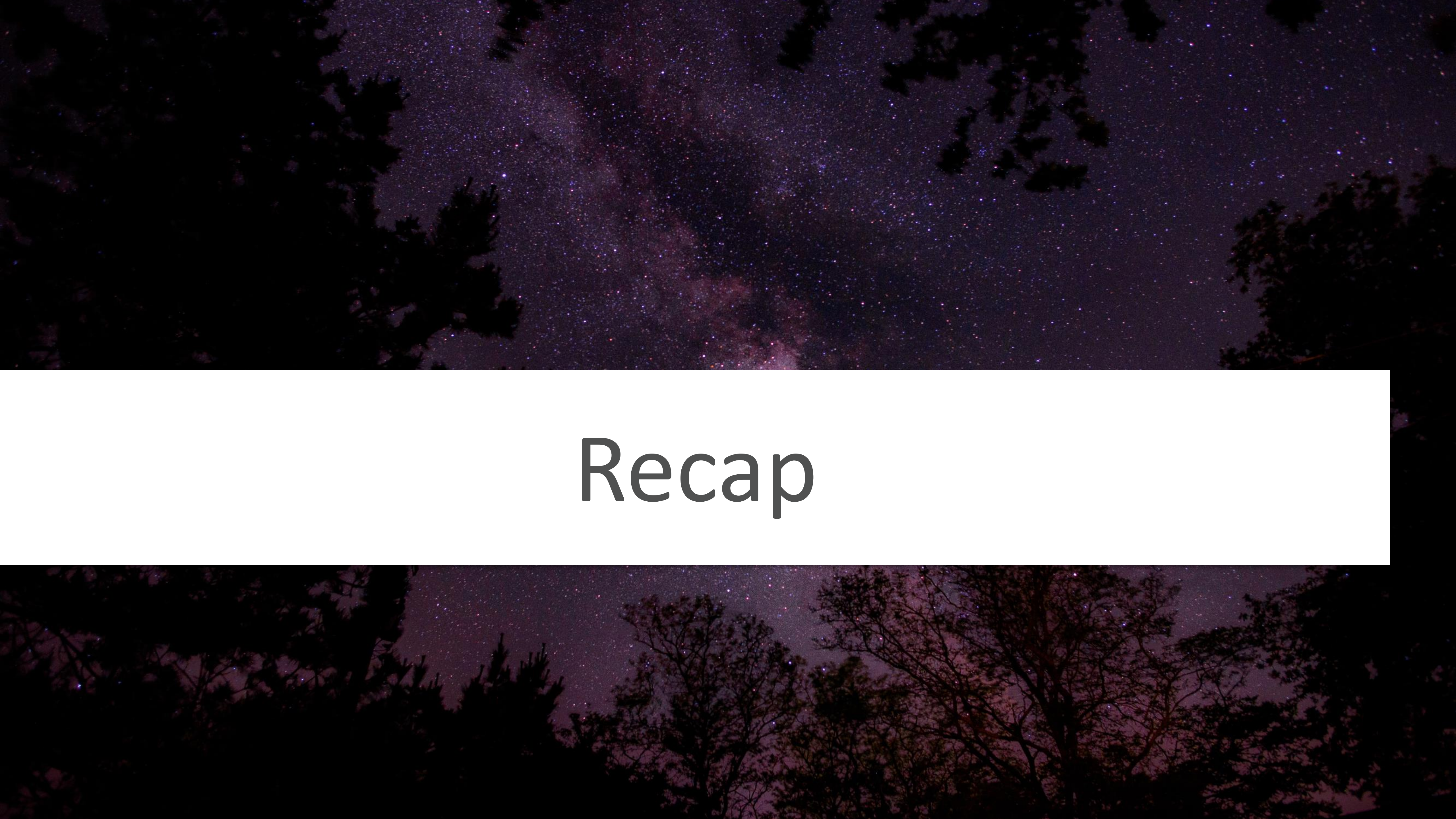
Query Hints

- Specify the approach
- Partitioning Hints
  - COALESCE, REPARTITION, REPARTITION_BY_RANGE, REBALANCE

```
SELECT /*+ [COALESCE | REPARTITION | REPARTITION_BY_RANGE | REBALANCE](n) */
    <columnName>
FROM <t1>
```

- Join Hints
  - BROADCAST, MERGE, SHUFFLE_HASH, SHUFFLE_REPLICATE_NL

```
SELECT /*+ [BROADCAST | MERGE | SHUFFLE_HASH | SHUFFLE_HASH](t1) */
    <columnName>
FROM <t1>
INNER JOIN <t2> ON t1.key = t2.key;
```



Recap

Recap

- Execution Plans
- Logical Plan and Physical Plan
- Additional parameters
- Spark UI
- Adaptive Query Execution (AQE)

TRY IT OUT

```
.explain() or EXPLAIN
```

Check out our YouTube channel and Blogs

Thank You

falek@advancinganalytics.co.uk

@falekmiah

falekmiah.com

FalekMiah01