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Apache Spark

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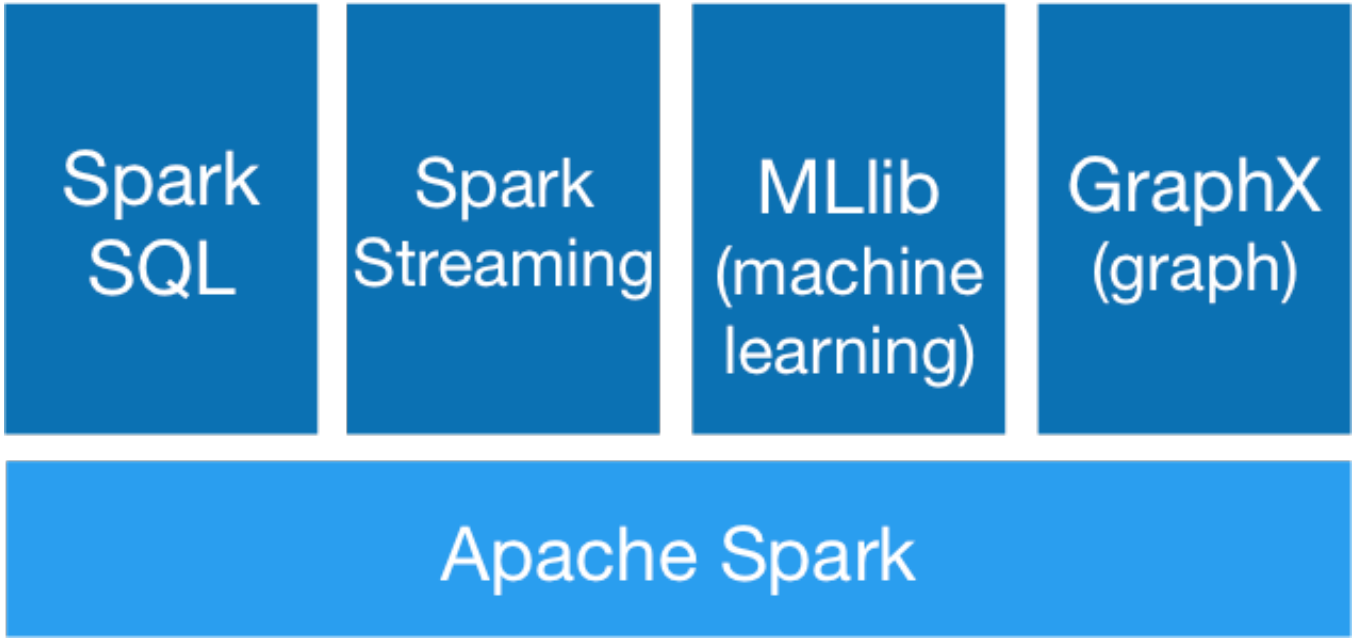
Spark SQL

SQL, Datasets, and DataFrames

Spark SQL


Spark SQL
Spark Streaming
MLlib (machine learning)
GraphX (graph)
Apache Spark

Spark SQL

- Spark SQL is a Spark module for structured data processing
  - Datasets have a known schema that determines the number, type (and names) of the fields in each data element
  - The API relies on the schema of the datasets under analysis

- The presence of a schema brings twofold advantages
  - Higher-level, declarative API, derived from established database languages
  - Pre-defined operators offer more opportunities for the engine to optimize the computation

Spark SQL

- Spark SQL offers different API/languages
  - SQL
  - DataFrame API
  - Dataset API

- The same Spark SQL engine is used, independently from the API/language adopted
  - It is possible to switch between different APIs depending on the specific needs of the application

SQL API

- The SQL API enables developers to execute standard SQL queries
  - From a programming language
  - From command-line
  - Over JDBC/ODBC
  - …

Dataset and DataFrames

- Dataset is an interface that provides the level of abstraction of RDDs …
  - Transformations and actions over large collections
- … with some additional benefits from Spark SQL optimized execution engine
  - Datasets use a specialized encoder to serialize the objects, processing them, and transmitting over the network
  - By knowing the format, Spark can perform many operations without deserializing the object
    - Filtering, sorting, hashing, …

Dataset and DataFrames

- DataFrames are a special type of DataSets
  - Implemented as DataSet<Row>
  - Represent relational tables, where elements are rows with fixed and known schema
  - Offer the same abstraction as SQL

Spark SQL: SparkSession

- The Spark SQL module exposes its functionalities through the SparkSession class
  - Like SparkContext for the core Spark API
  - Obtained using a builder

```
SparkSession spark = SparkSession
    .builder()
    .appName("App name")
    .master("local")
    .config("option name", "option value")
    .getOrCreate();
```

Spark SQL: DataFrame creation

- SparkSession.read provides various sources
  - They create DataFrames

```
spark.read.json(“file”)
spark.read.csv(“file”)
spark.read.textFile(“file)
spark.read.jdbc(…)
```

Spark SQL: DataFrame creation

- DataFrames can also be created from RDDs
  - By programmatically defining the schema
  - By inferring the schema using reflection

how to define a scheme given a list of fields

```
List<StructField> fields = new ArrayList<>();

fields.add(DataTypes.createStructField
      ("name", DataTypes.StringType, false));

fields.add(DataTypes.createStructField
      ("age", DataTypes.IntegerType, true));

StructType schema = DataTypes
      .createStructType(fields);
```

Spark SQL: DataFrame

- It is possible to print the content of a DataFrame on the standard output

```
df.show();
```

- Textual representation of the table, …
- … very useful for testing and debugging
  - Display the results of transformation on a small dataset

Spark SQL: DataFrame operations

- DataFrames include additional information on their content (e.g., names of columns)
  - Enables more declarative processing
  - Simplified column access using the column name

```
df.filter(col("age").gt(18))
  .select("name", col("salary") + 10)
```

Spark SQL: DataFrame operations

on.y thing to do is to register a DataFrame with a

- Spark SQL also accepts SQL queries as strings

```
employeeDataFrame
    .createOrReplaceTempView("employee");

val resultDF = spark.sql
("    SELECT *
      FROM  employee
      WHERE salary < 100  ");
```

Spark SQL: DataFrame operations

- Spark SQL supports all operators coming from the relational algebra
  - selection, projection, filter, join, …
- It supports common aggregations
  - count(), countDistinct(), avg(), sum(), min(), max()
- It enables developers to write and use their own custom aggregations
  - Extending the UserDefinedAggregateFunction class

Spark SQL: engine

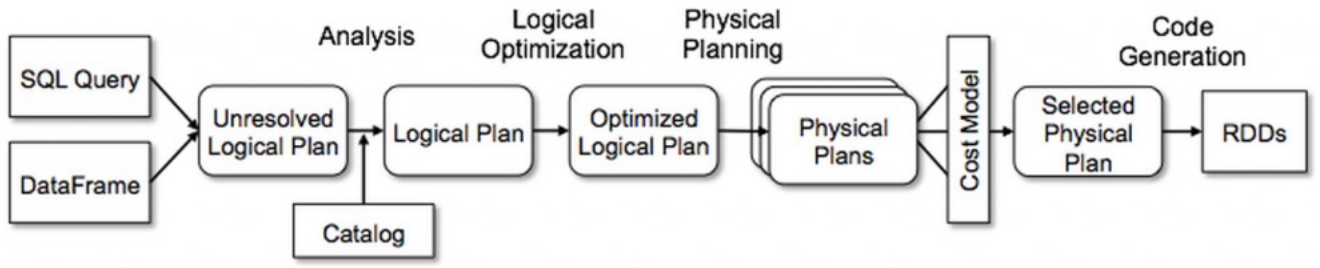
- Spark SQL can be seen as a scalable relational processing engine …
- … to execute expensive analytical queries in a distributed environment

- Developers express relational queries
  - Using SQL / DataFrame / DataSet API
- Queries are compiled to classic operations on RDDs
  - They undergo various optimization steps in the process

Spark SQL: declarative API

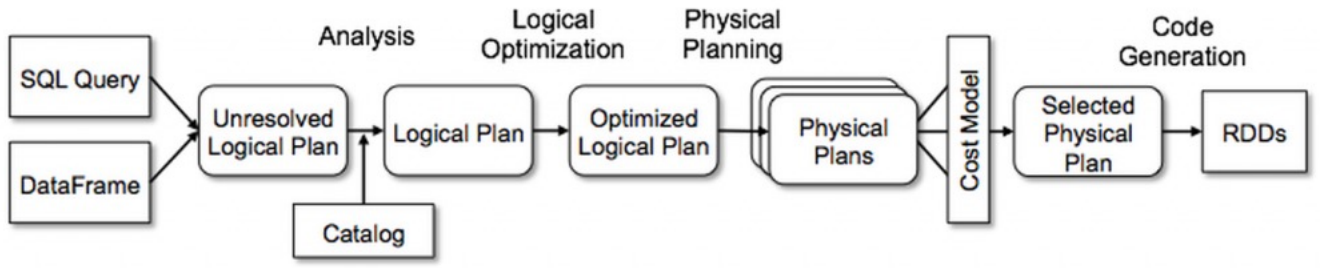
- SQL is totally declarative (queries are strings)
  - Pro: automated optimization
  - Cons: reduced flexibility, syntax errors detected at runtime
- DataFrames are equivalent to SQL, but defined programmatically
  - Pro: automated optimization, syntax errors detected at compile time
  - Cons: reduced flexibility
- Datasets are typed: not Rows, but structures
  - Pro: syntax errors detected at compile time, more flexibility with user-defined lambdas
  - Cons: possibilities for optimizations reduced by the presence of user-defined functions

Spark SQL: optimization



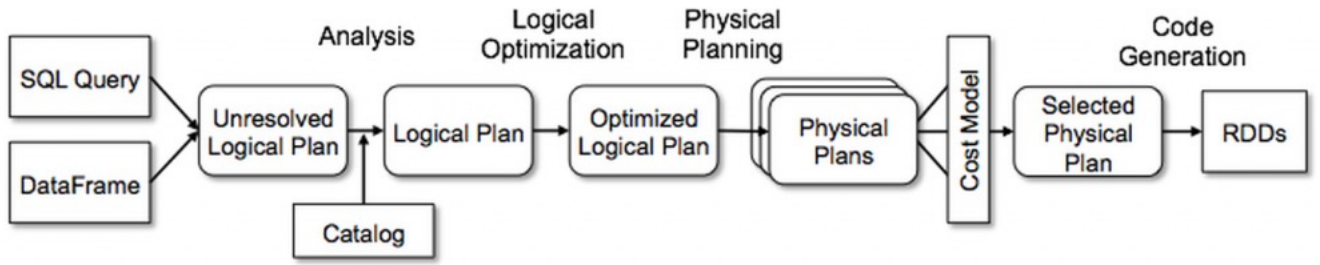
- Logical plan: the engine optimizes the query plans based on well known techniques and heuristics from DBMSs
  - Column pruning, join reordering, filter push down, …

Spark SQL: optimization



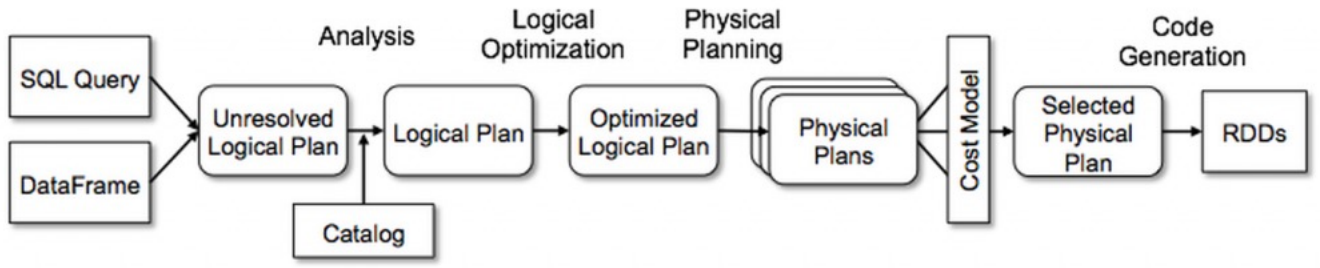
- Physical plans
  - From "what to do" to "how / where to do" it
  - E.g., a join can translate to a broadcast hash join or to a sort merge join

Spark SQL: optimization



- Out of many physical plans one is selected based on the minimization of a cost function
  - The expected cost of a plan is estimated based on the cardinality of the input tables, distribution of data, operators, filtering conditions, …

Spark SQL: optimization



- Code generation: translates the physical plan into optimized JVM / Spark code
  - Whole stage code generation converts an entire stage into simplified JVM code
  - Adopts binary data format efficient for computation and memory
    - E.g., if a table is persisted / cached, it is stored in columnar format, possibly compressed

Spark SQL: abstraction

- Due to code generation, understanding the execution can be difficult

- Spark offers a SQL visualization tool with the details of the physical plan that is translated to jobs and stages
  - Comparing the two can offer a better insight on the execution and help locating possible bottlenecks