CSCI 443: LECTURE 22 PYSPARK AND E-COMMERCE

Professor David Harrison

DATES OF INTEREST

April 22	HW5 handed out
May 2	HW5 due (Thursday)

worth 6% of your grade which is under the 10% limit for dead week.

May 6-10	Finals week (M-F)
May 7	Final (Tuesday, 4:00pm)

OFFICE HOURS

Tuesday	4:00-5:00 PM
Wednesday	12:30-2:30 PM

BLACKBOARD & GITHUB

Slides and a jupyter notebook for lectures 20 and 21 are on blackboard and in GitHub.

The project is at

https://github.com/dosirrah/CSCI443_AdvancedDataScience

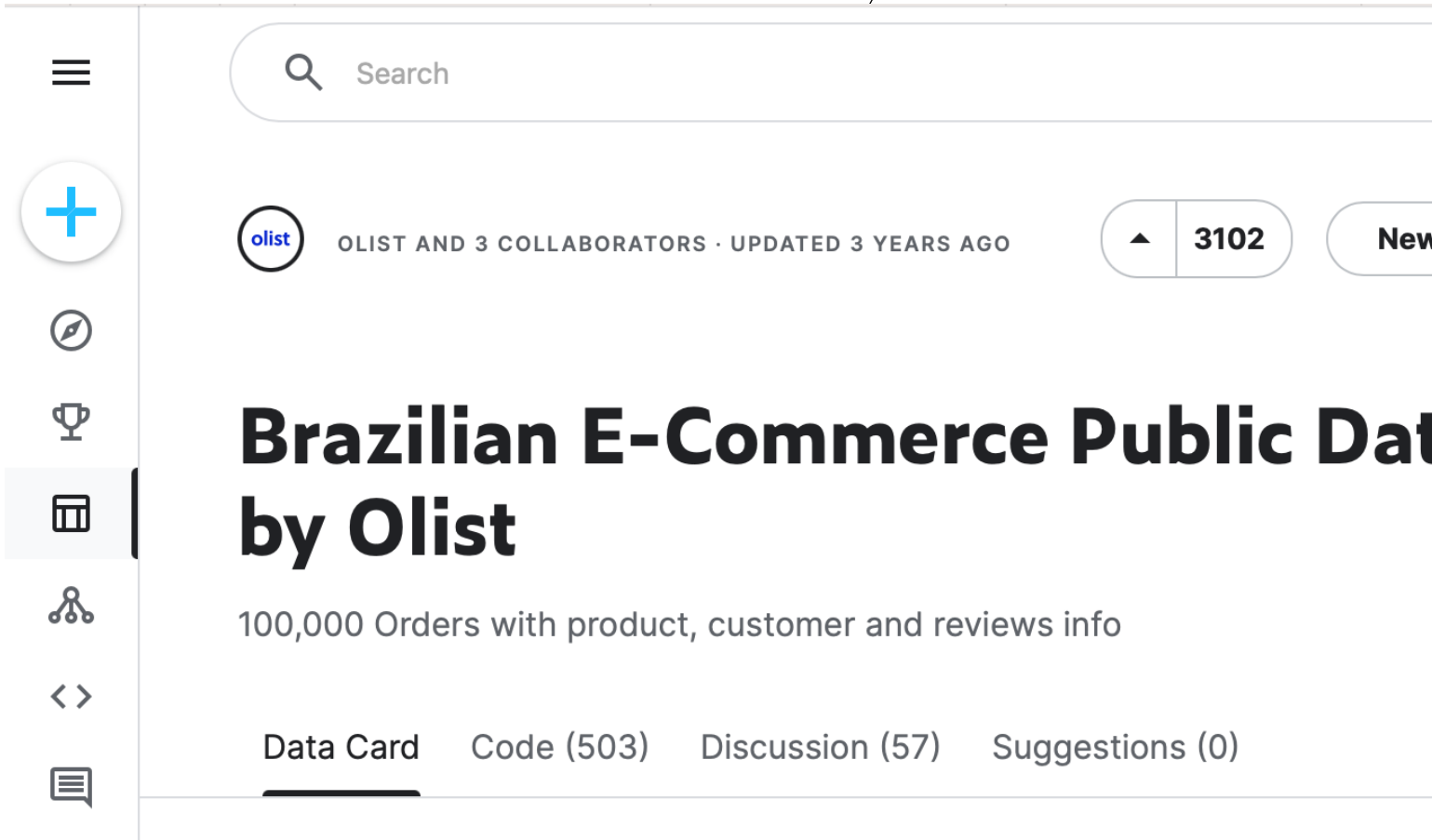
TODAY

- E-commerce Analytics with Olist Dataset
- Databricks
- Spark DataFrames
- RDD
- Catalyst Optimizer

OLIST: BRAZILIAN E-COMMERCE PLATFORM

OLIST

- Dataset for homework 5.
- We will create a data pipeline for creating periodic reports and for anomaly detection



OLIST

https://www.kaggle.com/datasets/olistbr/brazilian-ecommerce

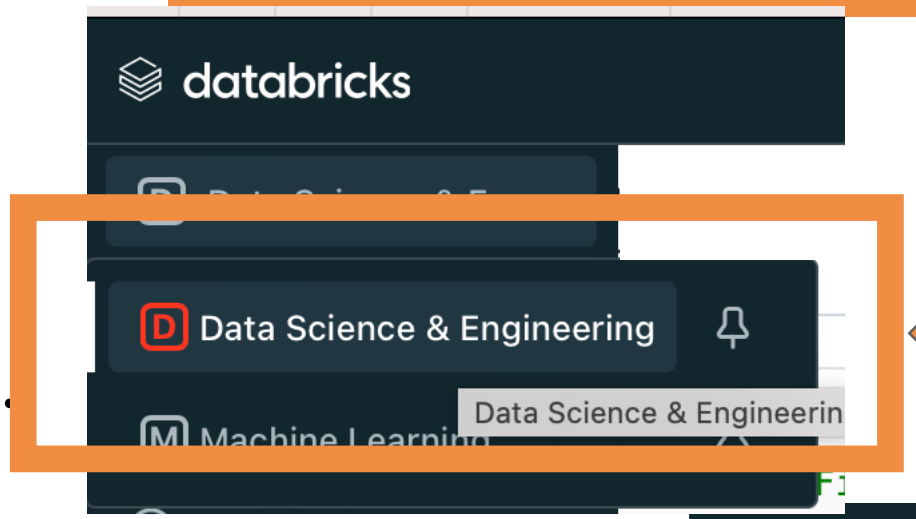
- The dataset is not too large, but large enough to exercise some of the capabilities of Spark.
- The dataset has been committed to github using git's large-file-storage (git-lfs).
- If you pull the class repository it will download a copy of the dataset to your local system. (see hw5/archive)

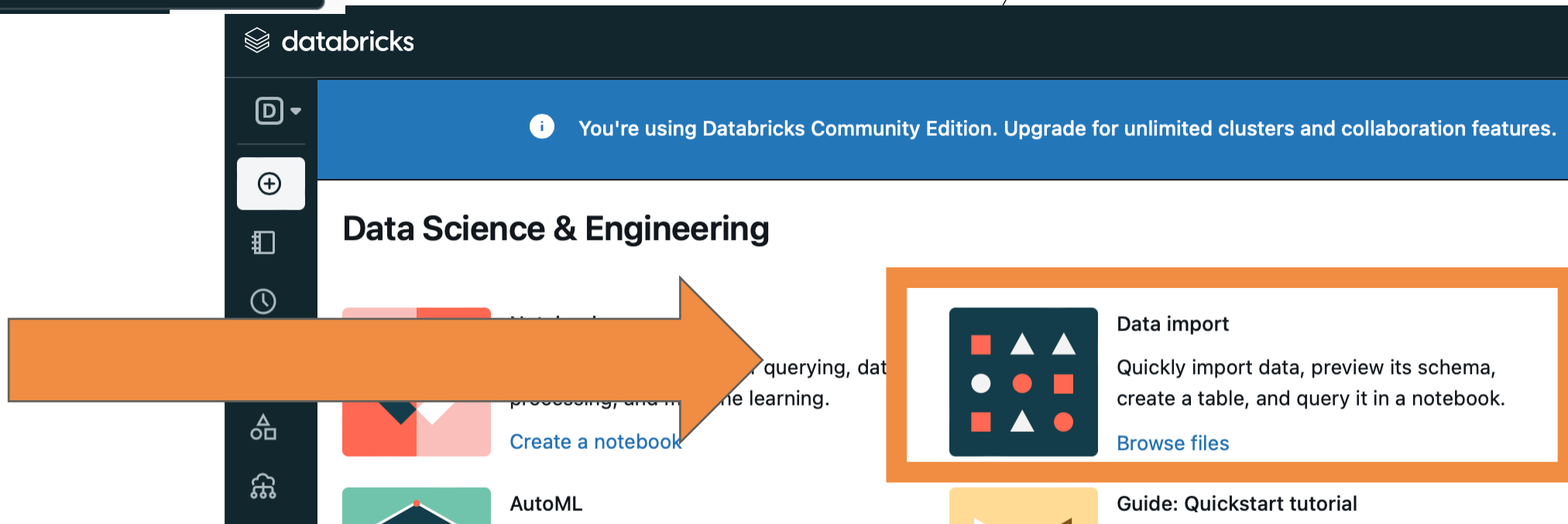
  OR

- Or you can download the dataset from Kaggle.

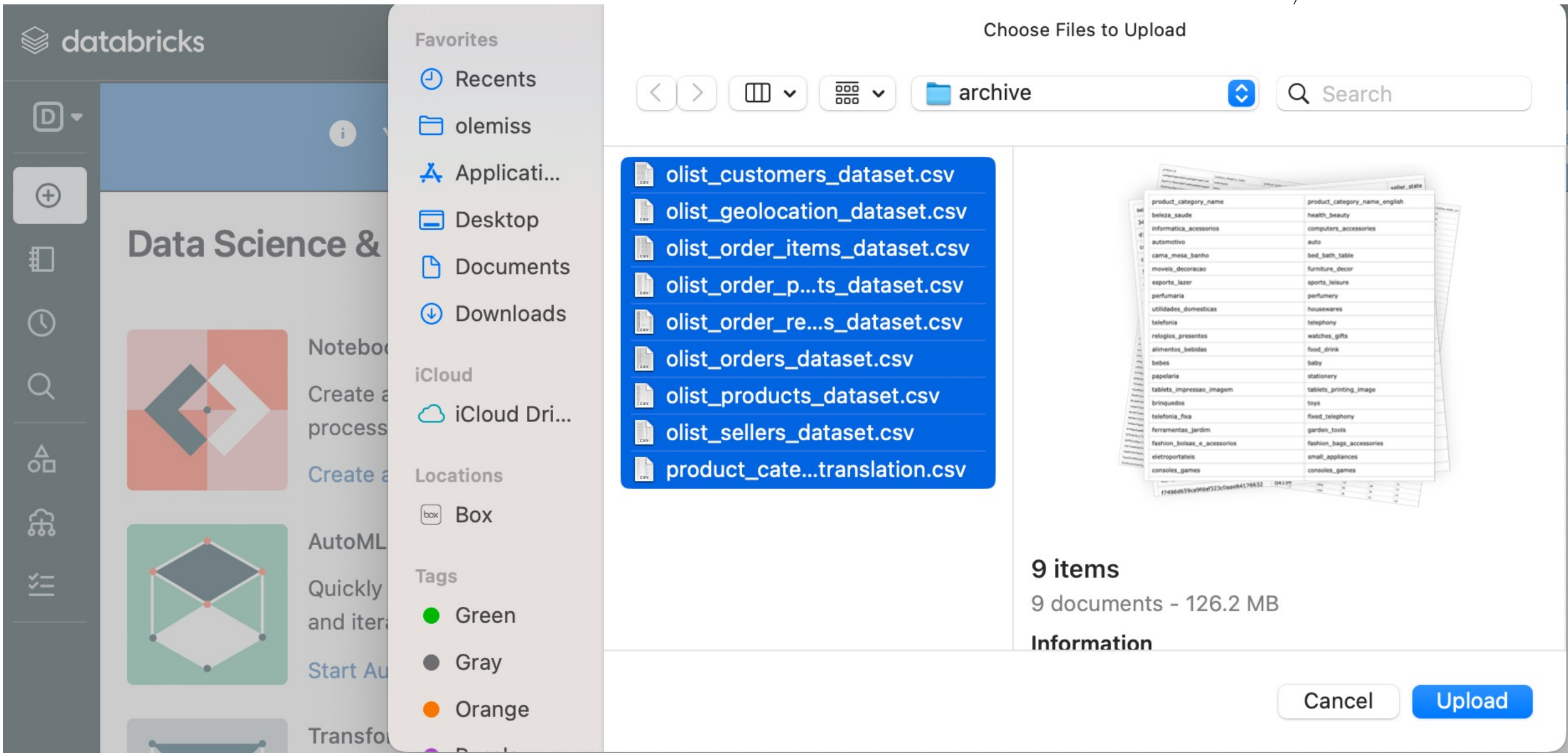
```
dave@FogelmauashsMBP archive % ls -1
olist_customers_dataset.csv
olist_geolocation_dataset.csv
olist_order_items_dataset.csv
olist_order_payments_dataset.csv
olist_order_reviews_dataset.csv
olist_orders_dataset.csv
olist_products_dataset.csv
olist_sellers_dataset.csv
product_category_name_translation.csv
dave@FogelmauashsMBP archive %
```

UPLOADING DATA





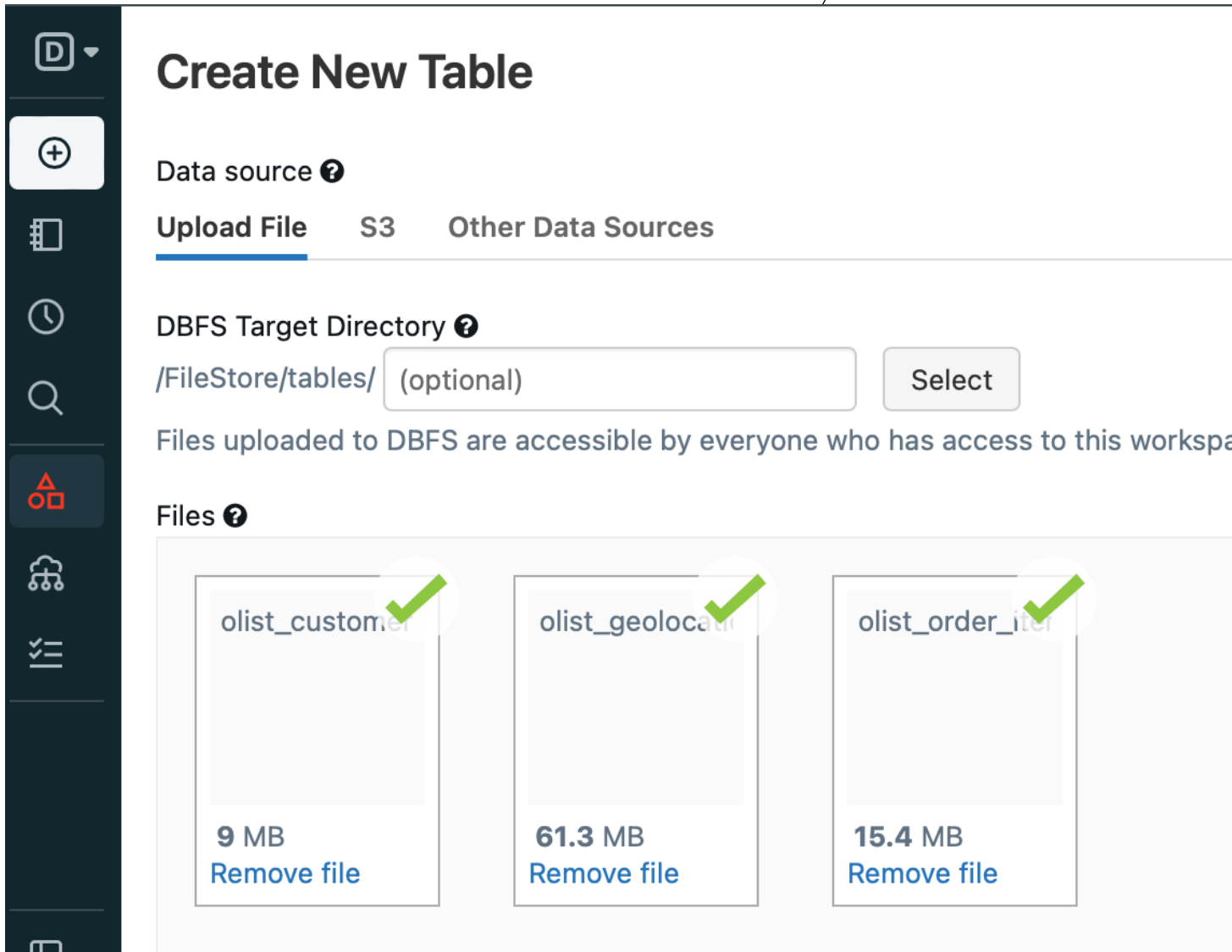
UPLOADING DATA



UPLOADING DATA

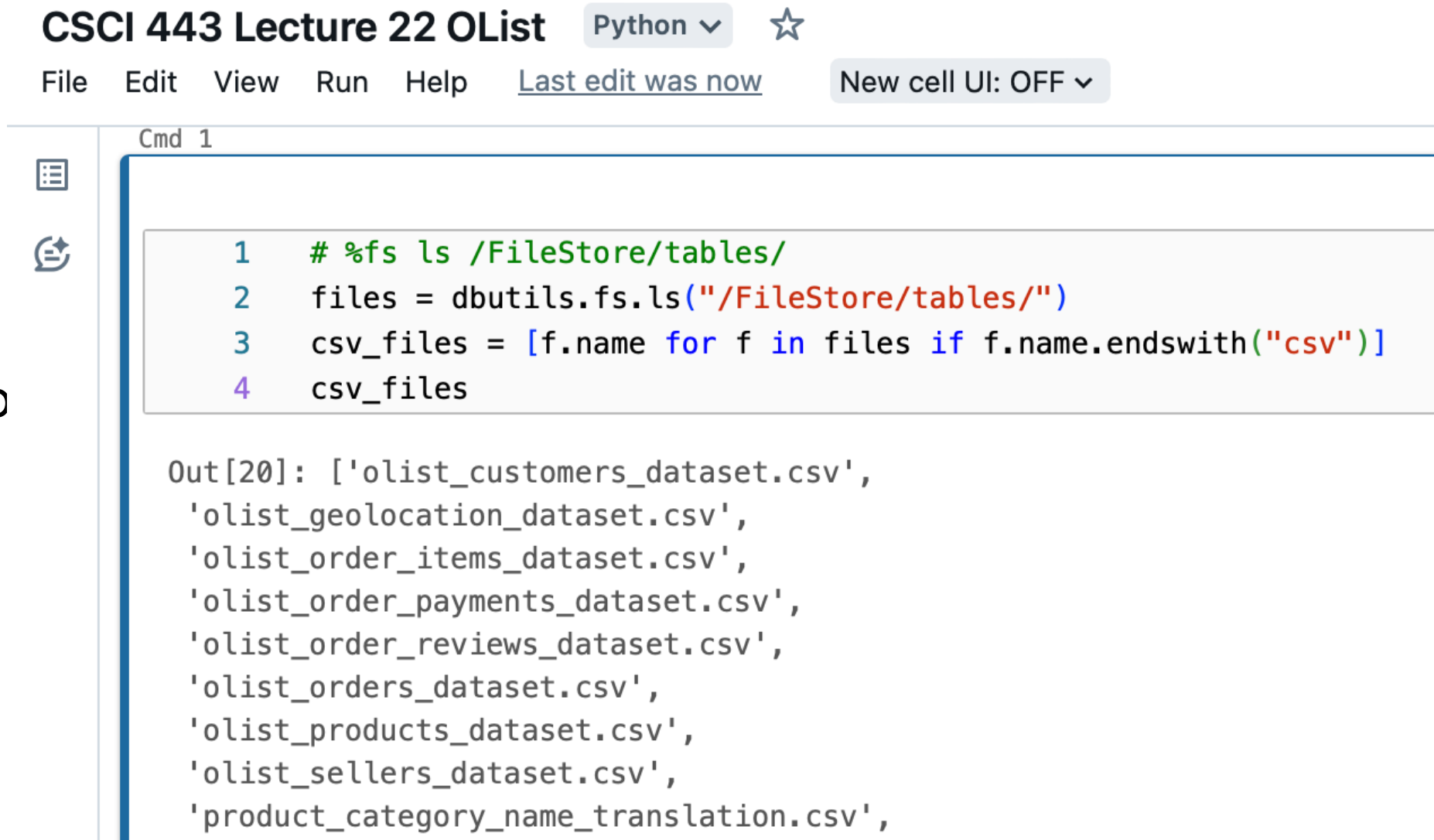
It assumes we are creating a table, but for now I only want to upload the files.

I put them in the default location: /FileStore/tables/



CONFIRMING DATA

- Create a new notebook.
- Use dbutils to list files.



USE A SPARK DATAFRAME

Pandas DataFrame

- Operates in-memory on a single machine.
- Fast for small datasets
- Struggles with large datasets
- Primarily uses Python
- DataFrames are mutable.
  - Can change after creation
  - No Fault Tolerance
  - Data is lost if notebook crashes or interrupted.
- Does not natively support concurrency

Spark DataFrame

- Operates on a distributed system.
  - Data partitioned across multiple machines.
- Handles large datasets
  - Processes data in partitions allowing parallelism across machines.
- Uses lazy evaluation
  - Plans tasks
  - Executes them when an action is triggered.
- Provides APIs in Python, Scala, Java, and R
- DataFrames are immutable
  - Provides fault tolerance

USE A KOALAS TO INTERFACE TO SPARK

- Koalas provides a Pandas-like interface to Spark
- Koalas uses Spark DataFrames under the hood.
- Koalas is as scalable as Spark DataFrames.

USE A KOALAS TO INTERFACE TO SPARK

- Koalas provides a Pandas interface to Spark DataFrames

```
1  import databricks.koalas as ks
```

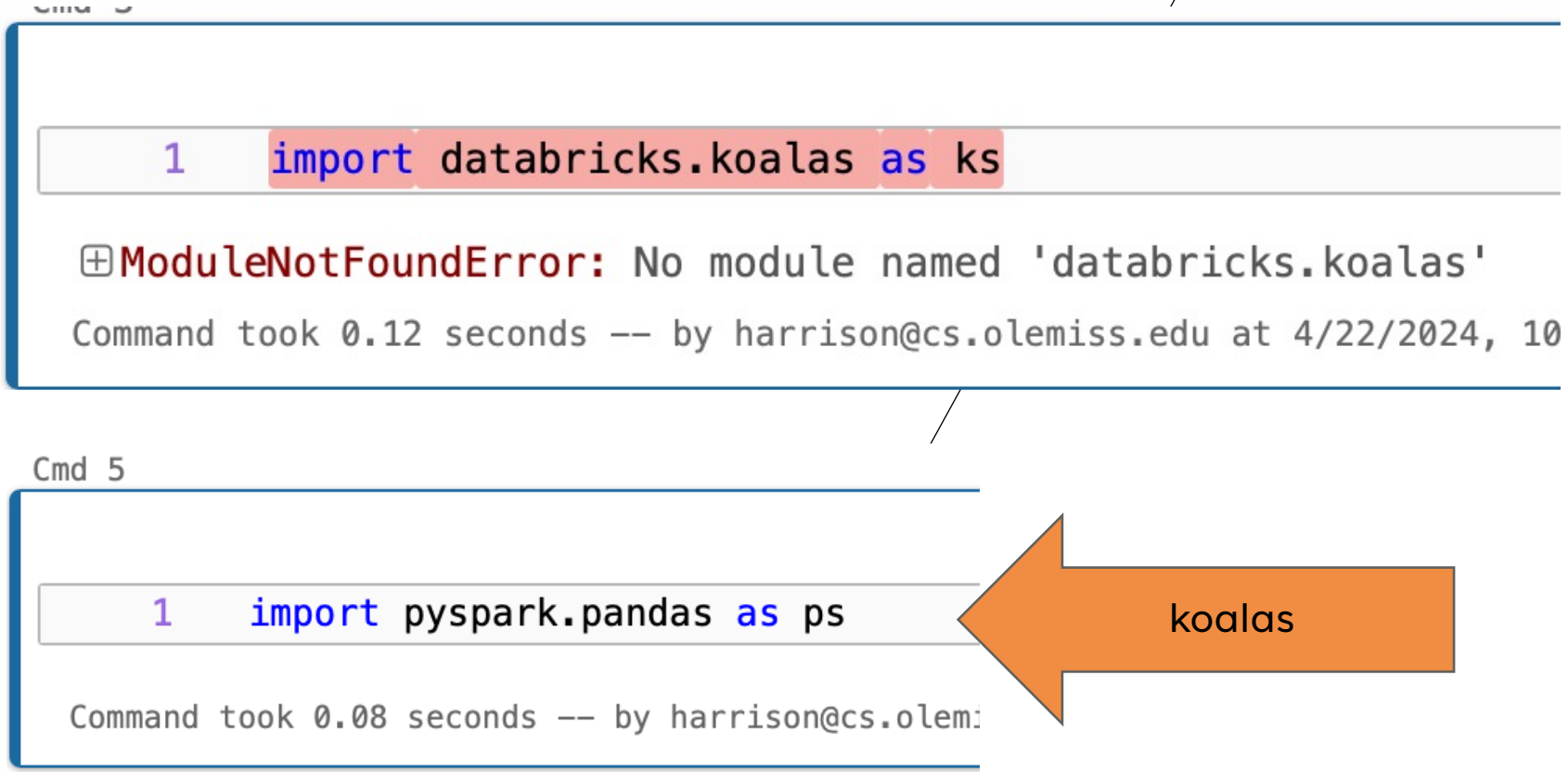
```
ModuleNotFoundError: No module named 'databricks.koalas'
Command took 0.12 seconds -- by harrison@cs.olemiss.edu at 4/22/2024, 10
```

```
1  %pip install koalas
2  import databricks.koalas as ks
```

```
Python interpreter will be restarted.
Requirement already satisfied: koalas in /local_disk0/.ephemeral_nfs/envs
b/python3.9/site-packages (1.8.2)
Requirement already satisfied: pandas>=0.23.2 in /databricks/python3/lib/
Requirement already satisfied: numpy>=1.14 in /databricks/python3/lib/pyt
Requirement already satisfied: pyarrow>=0.10 in /databricks/python3/lib/p
Requirement already satisfied: python-dateutil>=2.8.1 in /databricks/pyth
2->koalas) (2.8.2)
Requirement already satisfied: pytz>=2020.1 in /databricks/python3/lib/py
(2021.3)
Requirement already satisfied: six>=1.5 in /databricks/python3/lib/python
das>=0.23.2->koalas) (1.16.0)
Python interpreter will be restarted.
```

NEWER KOALAS INTERFACE

- Koalas provides a Pandas interface to Spark DataFrames



1. LOAD THE DATA

- Use pandas read_csv to load csv files from Databricks FileStore

Cmd 5

Python

```
1  import pyspark.pandas as ps
2
3  # Reading a CSV file into a Koalas DataFrame
4  df = ps.read_csv('/FileStore/tables/olist_customers_dataset.csv')
5
6  # Now you can use Pandas-like operations
7  print(df.head())
```

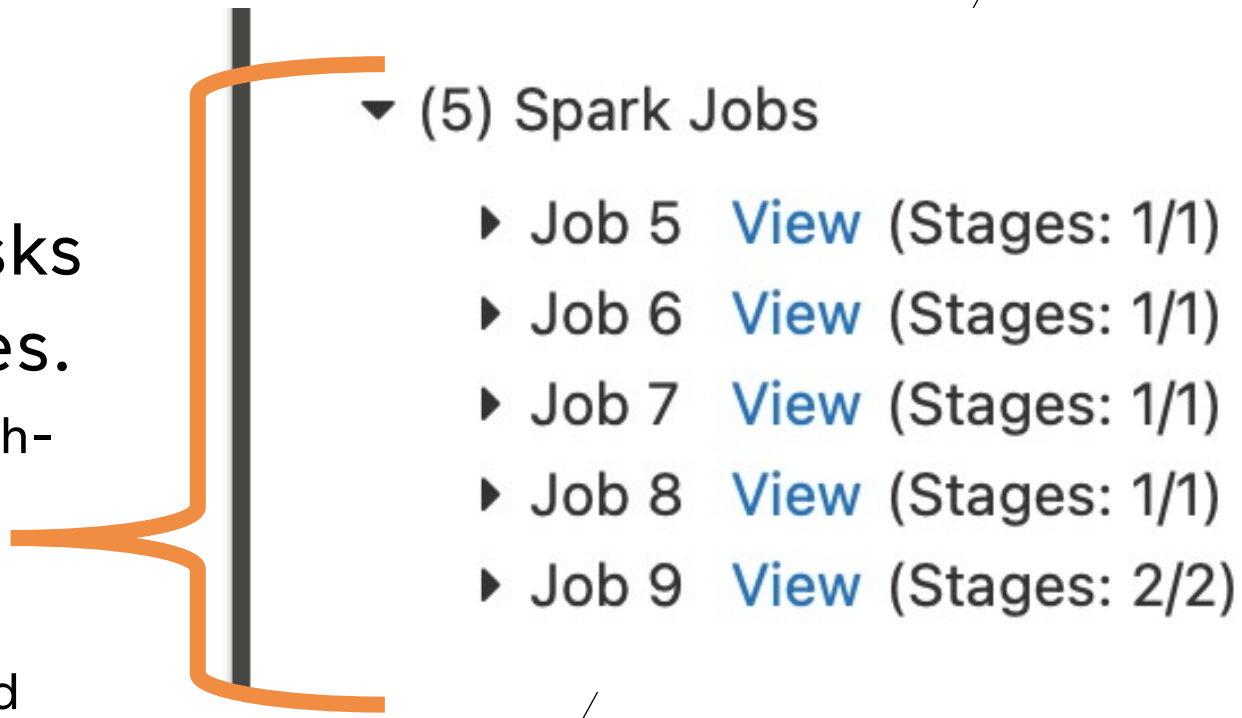
(5) Spark Jobs

- Job 5 View (Stages: 1/1)
- Job 6 View (Stages: 1/1)
- Job 7 View (Stages: 1/1)
- Job 8 View (Stages: 1/1)
- Job 9 View (Stages: 2/2)

```
                        customer_id                customer_unique_id  customer_zip_cod
e_prefix          customer_city customer_state
0  06b8999e2fba1a1fbc88172c00ba8bc7  861eff4711a542e4b93843c6dd7febb0
14409                  franca             SP
1  18955e83d337fd6b2def6b18a428ac77  290c77bc529b7ac935b93aa66c333dc3
```

1. LOAD THE DATA (CONT.)

- Shows Spark running jobs that distribute tasks across the cluster nodes.
  - Each job corresponds to a high-level action (like reading, collecting, outputing)
  - Each stage involves shuffling data (repartitioning as caused by SQL joins, groupBy, ...)



2. DATA EXPLORATION

Python

```
1  customers_df.columns
```

```
Out[9]: Index(['customer_id', 'customer_unique_id', 'customer_zip_code_prefix',
       'customer_city', 'customer_state'],
      dtype='object')
```

Command took 0.05 seconds -- by harrison@cs.olemiss.edu at 4/23/2024, 12:13:29 AM on Olist Cluster

Is there missing data?

```
1  customers_df.isnull().sum()
2
```

▸ (3) Spark Jobs

```
Out[10]: customer_id                0
customer_unique_id         0
customer_zip_code_prefix   0
customer_city              0
customer_state             0
dtype: int64
```

```
1  customers_df.describe()
2
```

▸ (2) Spark Jobs

	customer_zip_code_prefix
count	99441.000000
mean	35137.474583
std	29797.938996
min	1003.000000
25%	11346.000000
50%	24415.000000
75%	58884.000000
max	99990.000000

3. DATA CLEANING

Is there missing data?

- If yes, we need to either using imputing to fill-in missing data

OR

- We remove the records missing data.

NO missing data in this case.

```
1   customers_df.isnull().sum()
2
```

▸ (3) Spark Jobs

```
Out[10]: customer_id                 0
customer_unique_id          0
customer_zip_code_prefix    0
customer_city               0
customer_state              0
dtype: int64
```

4. ANALYZE THE DATA

Let’s perform some

- Simple transformations
- Basic filtering
- Aggregation

Python

```
1  customers_df.columns
```

```
Out[9]: Index(['customer_id', 'customer_unique_id', 'customer_zip_code_prefix',
       'customer_city', 'customer_state'],
      dtype='object')
```

Command took 0.05 seconds -- by harrison@cs.olemiss.edu at 4/23/2024, 12:13:29 AM on Olist Cluster

TRANSFORMATION

Create a new column that categorizes customers by what part of the country they come from based on state.

1. There are 26 states and a federal district.
2. South Region: Paraná, Santa Catarina, and Rio Grande do Sul
3. Southeast Region: Espírito Santo, Minas Gerais, Rio de Janeiro, and São Paulo
4. North Region: Acre, Amapá, Amazonas, Pará, Rondônia, Roraima, and Tocantins
5. Northeast Region: Alagoas, Bahia, Ceará, Maranhão, Paraíba, Pernambuco, Piauí, Rio Grande do Norte, and Sergipe
6. Central-West Region: Goiás, Mato Grosso, Mato Grosso do Sul, and the Federal District

1. **Acre (AC)**
2. **Alagoas (AL)**
3. **Amapá (AP)**
4. **Amazonas (AM)**
5. **Bahia (BA)**
6. **Ceará (CE)**
7. **Distrito Federal (DF)**
8. **Espírito Santo (ES)**
9. **Goiás (GO)**
10. **Maranhão (MA)**
11. **Mato Grosso (MT)**
12. **Mato Grosso do Sul (MS)**
13. **Minas Gerais (MG)**
14. **Pará (PA)**
15. **Paraíba (PB)**
16. **Paraná (PR)**
17. **Pernambuco (PE)**
18. **Piauí (PI)**
19. **Rio de Janeiro (RJ)**
20. **Rio Grande do Norte (RN)**
21. **Rio Grande do Sul (RS)**
22. **Rondônia (RO)**
23. **Roraima (RR)**
24. **Santa Catarina (SC)**
25. **São Paulo (SP)**
26. **Sergipe (SE)**
27. **Tocantins (TO)**

ASIDE: EXAMPLE DIFFERENCE BETWEEN PANDAS AND KOALAS

Pandas DataFrame

- Obtains list of ALL customer states
- Slices first 10,
  - i.e., truncates to the first 10.
- Resonably fast only because Pandas works entirely in memory.
- Although would still be slow for large in-memory data frames.

Pandas on Spark DataFrame (Koalas)

- Lazy evaluates.
  - The slice [:10] doesn't trigger evaluation, buts adds to an exrecution plan.
    collect()
- Doesn't actually execute any queries at this point.

ASIDE: EXAMPLE DIFFERENCE BETWEEN PANDAS AND KOALAS

Pandas on Spark DataFrame

- Steps added to execution plan.
- Note the absence of any “Spark jobs”
- 0.21 second execution time.

ASIDE: EXAMPLE DIFFERENCE BETWEEN PANDAS AND KOALAS

Pandas on Spark DataFrame

- Steps added to execution plan.
- Note the absence of any “Spark jobs”
- 0.21 second execution time.

Spark jobs!!!!

- print() forces execution of the execution plan.
- 2.32 second execution time.

```
states = customers_df["customer_state"][:10]
```

```
Command took 0.21 seconds -- by harrison@cs.olemiss.edu at
```

```
Cmd 12
```

```
print(states)
```

```
▸ (3) Spark Jobs

0    SP
1    SP
2    SP
3    SP
4    SP
5    SC
6    SP
7    MG
8    PR
9    MG
Name: customer_state, dtype: object

Command took 2.32 seconds -- by harrison@cs.olemiss.edu at
```

ASIDE: MORE CONVENTIONAL WAY OF OBTAINING FIRST 10

Pandas on Spark DataFrame

- head(10) added to execution plan.
- Note the absence of any “Spark jobs”
- 0.23 second execution time.

Spark jobs!!!!

- print() forces execution of the execution plan.
- 1.59 second execution time.

```
states = customers_df["customer_state"].head(10)

Command took 0.23 seconds -- by harrison@cs.olemiss.edu at 4/23/20

Cmd 16

print(states)

▸ (3) Spark Jobs

0    SP
1    SP
2    SP
3    SP
4    SP
5    SC
6    SP
7    MG
8    PR
9    MG
Name: customer_state, dtype: object

Command took 1.59 seconds -- by harrison@cs.olemiss.edu at 4/23/20
```

TRANSFORMATION

Create a new column that categorizes customers by what part of the country they come from based on state.

1. The code checks the two letter state code and returns a region name.
2. apply() calls categorize_state for each row in the column “customer_state” resulting in a “transformation” of the data into a new set of data.

```python
def categorize_state(state):
    # Southeast Region: Espírito Santo, Minas Gerais, Rio de Janeiro, and São Paulo
    if state in ['SP', 'RJ', 'ES', 'MG']:
        return 'Southeast'
    # South Region: Paraná, Santa Catarina, and Rio Grande do Sul
    elif state in ['RS', 'SC', 'PR']:
        return 'South'
    # North Region: Acre, Amapá, Amazonas, Pará, Rondônia, Roraima, and Tocantins
    elif state in ['AC', 'AP', 'AM', 'PA', 'RO', 'RR', 'TO']:
        return 'North':
    # Northeast Region: Alagoas, Bahia, Ceará, Maranhão, Paraíba, Pernambuco,
    # Piauí, Rio Grande do Norte, and Sergipe
    elif state in ['AL', 'BA', 'CE', 'MA', 'PB', 'PE', 'PI', 'RN', 'SE']
        return 'Northeast':
    #Central-West Region: Goiás, Mato Grosso, Mato Grosso do Sul, and the Federal District
    else:
        return "Central-West"

customers_df['region'] = customers_df['customer_state'].apply(categorize_state)
```

- Any call that creates new data is called a *transformation*.
- Transformations create new data but cannot modify the underlying Spark DataFrames.
- In Spark, DataFrames are immutable.
- Pandas-on-Spark wraps a Spark DataFrame and maintains a “lineage” of transformations to that Spark DataFrame.

TRANSFORMATION

Lazy operation again?

apply() adds transformations to the execution plan.

It isn't always clear when an operation triggers an evaluation.

```python
def categorize_state(state):
    # Southeast Region: Espírito Santo, Minas Gerais, Rio de Janeiro, and São Paulo
    if state in ['SP', 'RJ', 'ES', 'MG']:
        return 'Southeast'
    # South Region: Paraná, Santa Catarina, and Rio Grande do Sul
    elif state in ['RS', 'SC', 'PR']:
        return 'South'
    # North Region: Acre, Amapá, Amazonas, Pará, Rondônia, Roraima, and Tocantins
    elif state in ['AC', 'AP', 'AM', 'PA', 'RO', 'RR', 'TO']:
        return 'North':
    # Northeast Region: Alagoas, Bahia, Ceará, Maranhão, Paraíba, Pernambuco,
    # Piauí, Rio Grande do Norte, and Sergipe
    elif state in ['AL', 'BA', 'CE', 'MA', 'PB', 'PE', 'PI', 'RN', 'SE']
        return 'Northeast':
    #Central-West Region: Goiás, Mato Grosso, Mato Grosso do Sul, and the Federal District
    else:
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    elif state in ['RS', 'SC', 'PR']:
        return 'South'
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        return 'Northeast'
    #Central-West Region: Goiás, Mato Grosso, Mato Grosso do Sul, and the Federal District
    else:
        return "Central-West"

customers_df['region'] = customers_df['customer_state'].apply(categorize_state)
```

Spark jobs!!!!

▸ (3) Spark Jobs

Command took 2.24 seconds -- by harrison@cs.olemiss.edu at 4/23/2024, 12:35:39 PM on Olist Cluster C

FILTERING

Filter to obtain only customers in the Souteast region.

Cmd 23

```
southeast_customers = customers_df[customers_df['region'] == 'Southeast']
```

Command took 0.27 seconds -- by harrison@cs.olemiss.edu at 4/23/2024, 12:51:01 PM on Olist Cluster C

Cmd 24

```
southeast_customers.head()
```

▸ (3) Spark Jobs

Spark jobs!!!!

	customer_id	customer_unique_id	customer_zip_code_prefix	customer_city	customer_state	region
0	06b8999e2fba1a1fbc88172c00ba8bc7	861eff4711a542e4b93843c6dd7febb0	14409	franca	SP	Southeast
1	18955e83d337fd6b2def6b18a428ac77	290c77bc529b7ac935b93aa66c333dc3	9790	sao bernardo do campo	SP	Southeast
2	4e7b3e00288586ebd08712fdd0374a03	060e732b5b29e8181a18229c7b0b2b5e	1151	sao paulo	SP	Southeast
3	b2b6027bc5c5109e529d4dc6358b12c3	259dac757896d24d7702b9acbbff3f3c	8775	mogi das cruzes	SP	Southeast
4	4f2d8ab171c80ec8364f7c12e35b23ad	345ecd01c38d18a9036ed96c73b8d066	13056	campinas	SP	Southeast

Command took 6.12 seconds -- by harrison@cs.olemiss.edu at 4/23/2024, 12:51:04 PM on Olist Cluster C

AGGREGATION

groupby adds transformation to execution plan.

print(sizes) triggers groupby to shuffle data between partitions.

Spark jobs!!!!

Cmd 20

```
sizes = customers_df.groupby('region').size()
```

Command took 0.16 seconds -- by harrison@cs.olemiss.edu a

Cmd 21

```
print(sizes)
```

▸ (4) Spark Jobs

```
region
South            14148
Southeast        68266
Central-West      5782
North             1851
Northeast         9394
dtype: int64
```

Command took 4.29 seconds -- by harrison@cs.olemiss.edu a

VISUALIZATION

Matplotplib doesn't always play well with Pandas-on-spark.

```
plt.figure(figsize=(8, 5))
plt.bar(region_counts.index, region_counts.values)
plt.show()
```

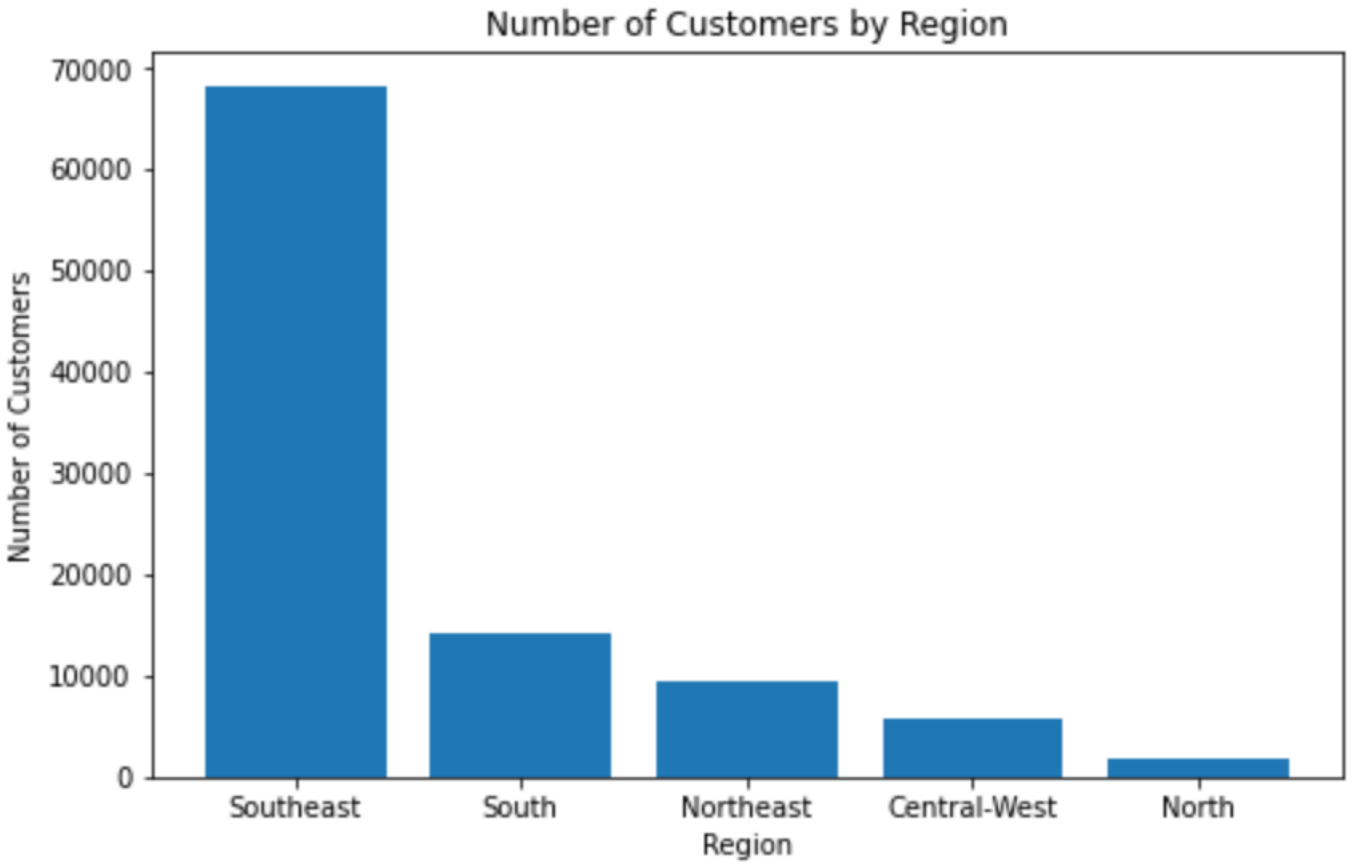
```
...
  File "/databricks/python/lib/python3.9/site-packages/executing/executing.py"
    raise NotOneValueFound('Expected one value, found 0')
executing.executing.NotOneValueFound: Expected one value, found 0
```

VISUALIZATION

Matplotplib doesn't always play well with Pandas-on-spark.

Converting Series index to numpy array, solved the problem.

```
labels = region_counts.index.to_numpy()
plt.figure(figsize=(8, 5))
plt.bar(labels, region_counts.values)
plt.title('Number of Customers by Region')
plt.xlabel('Region')
plt.ylabel('Number of Customers')
plt.show()
```



RESILIENT DISTRIBUTED DATASETS (RDD)

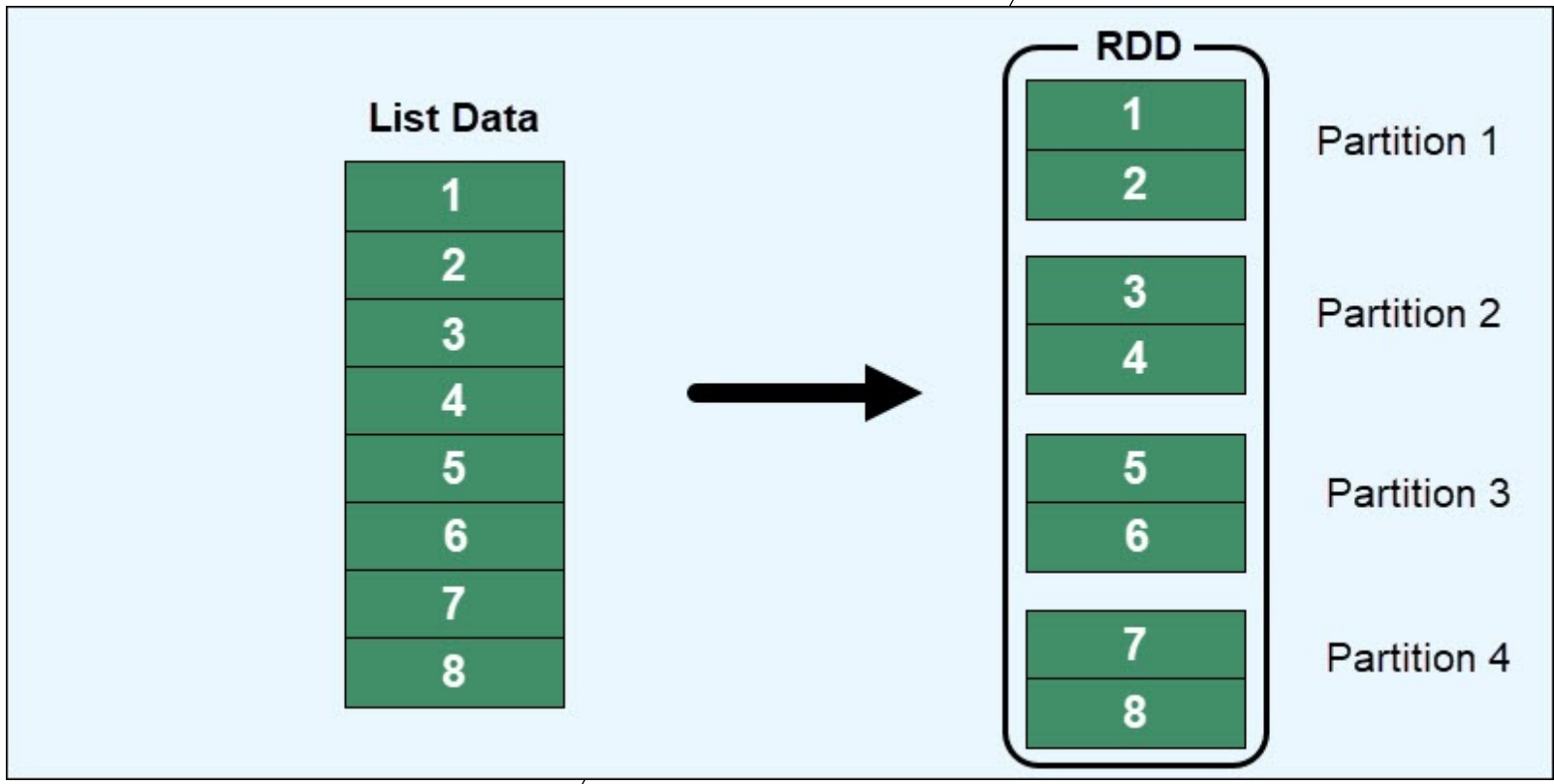
Each DataFrame has an underlying RDD.

Each Row in the RDD holds data for a record.

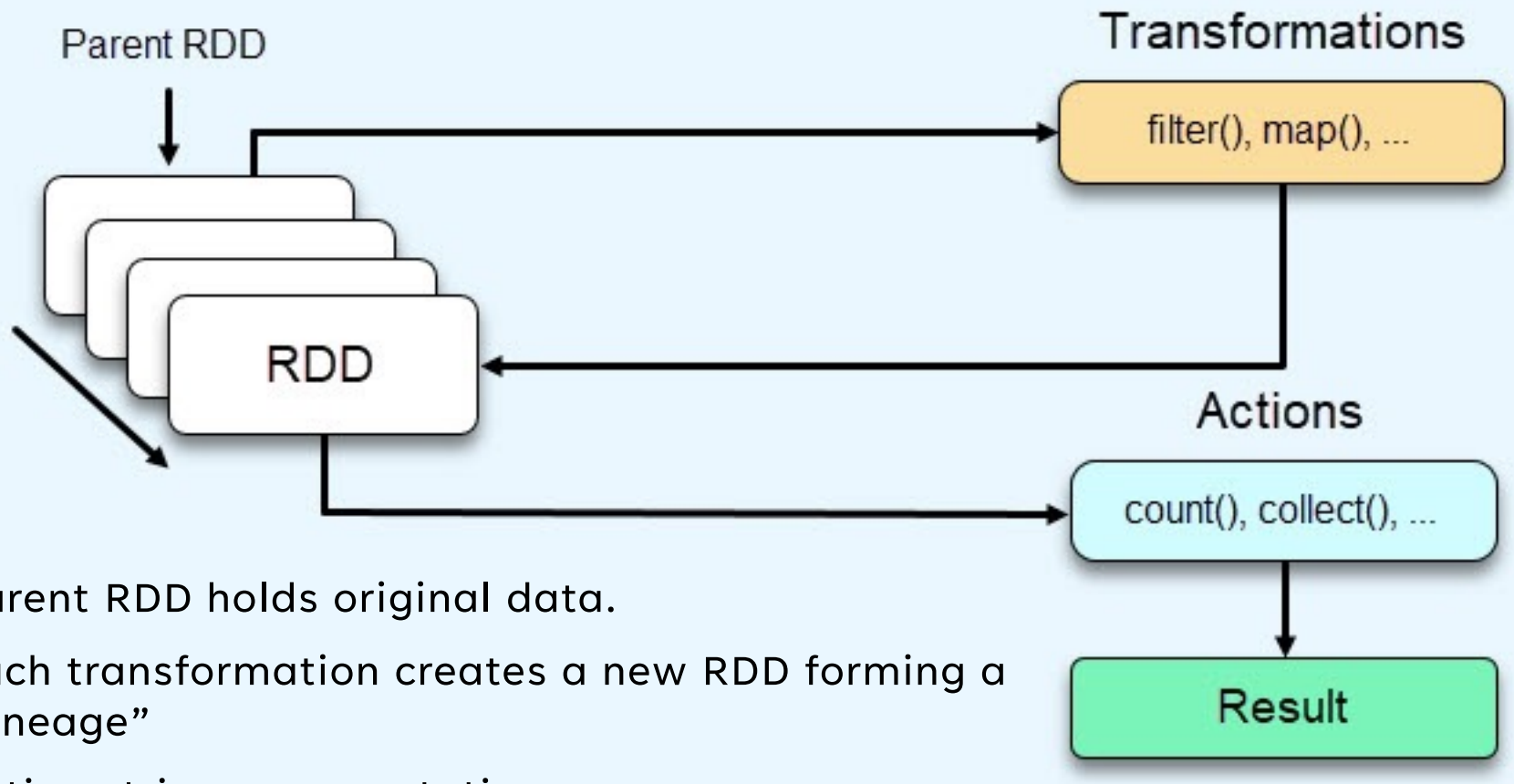
A Row is like an array where each field corresponds to a column in the DataFrame.

RDD partitioned across the cluster.

- Set of rows in each partition.



SEQUENCE OF TRANSFORMATIONS

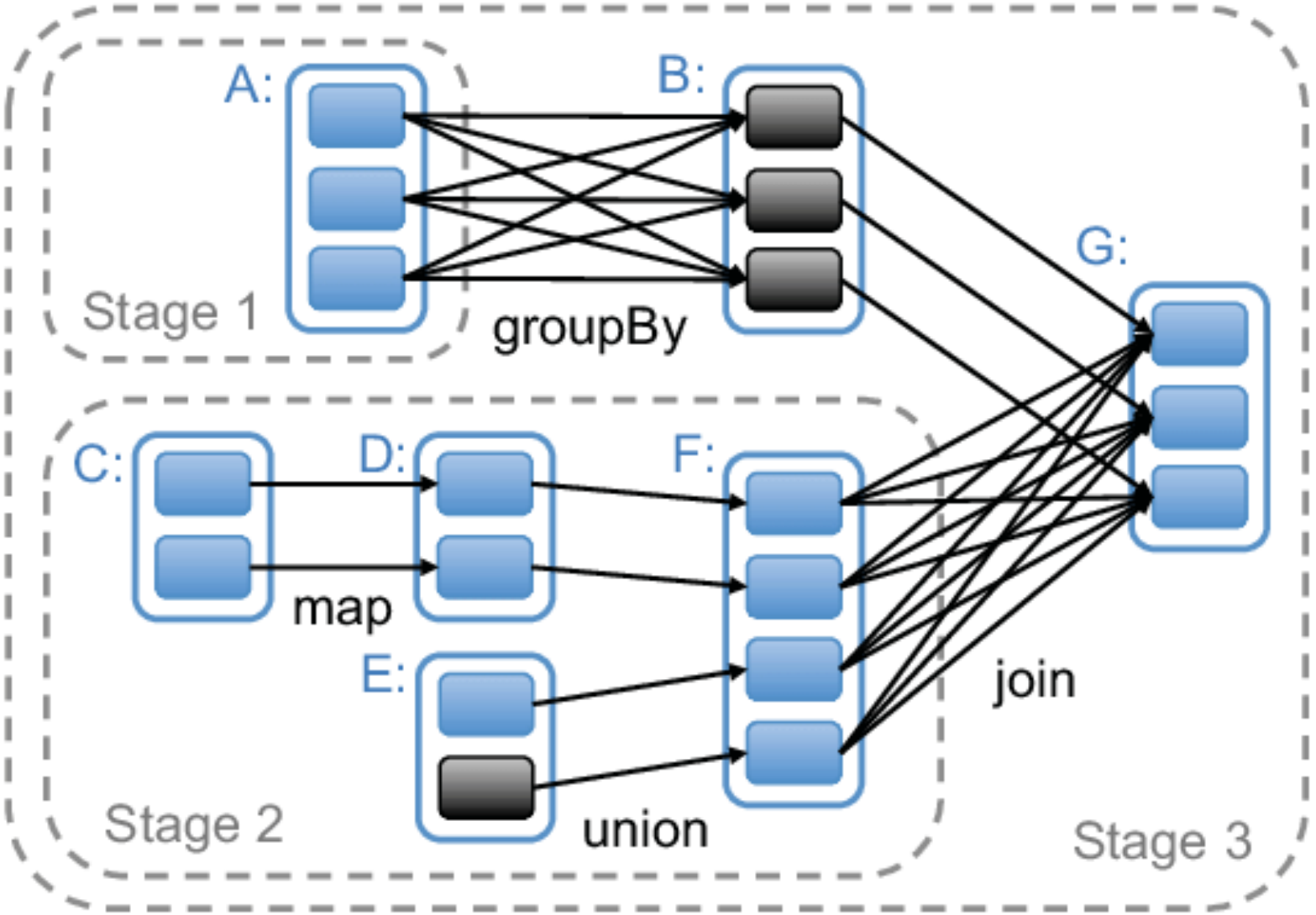


Parent RDD holds original data.

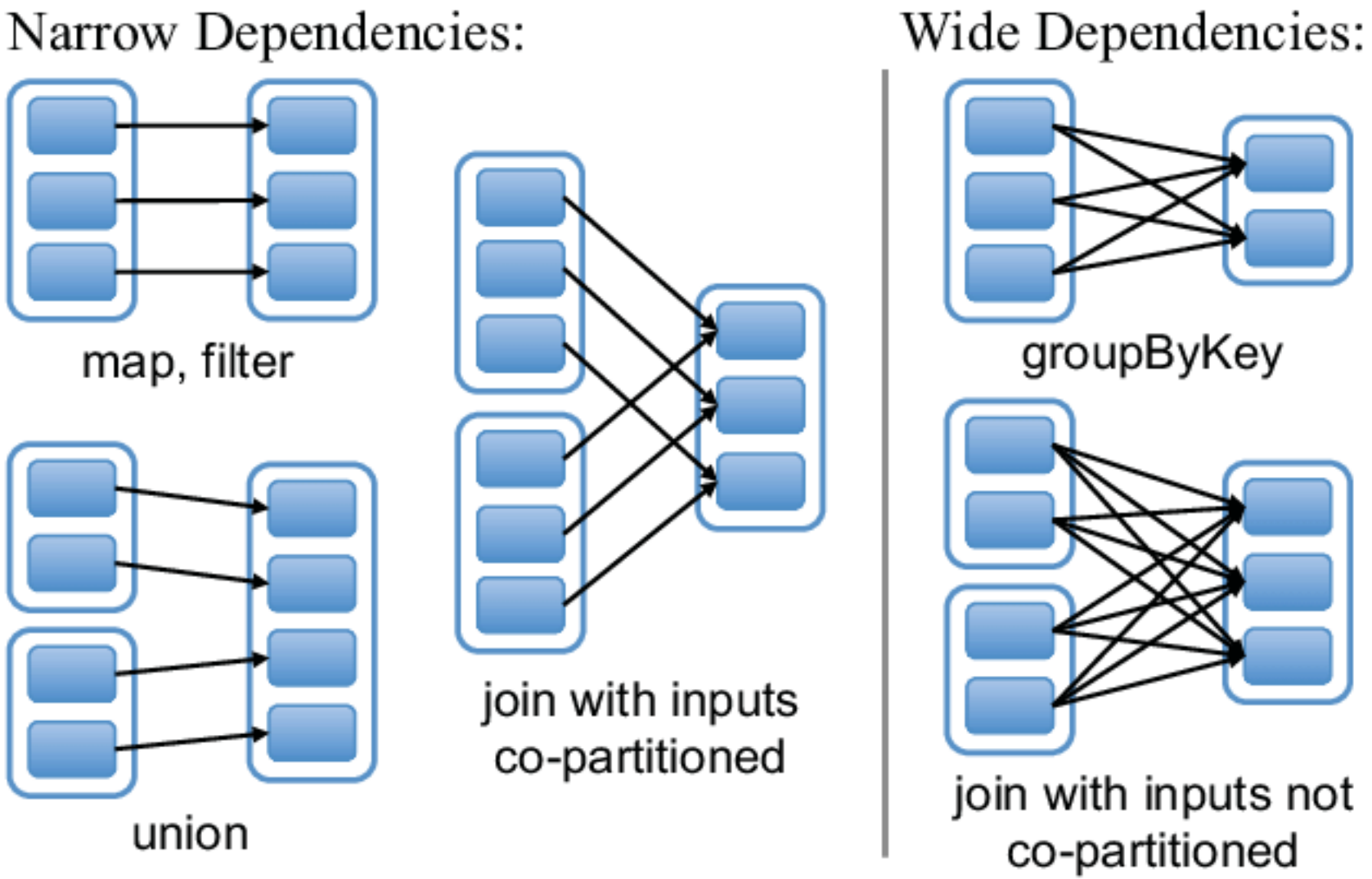
Each transformation creates a new RDD forming a "lineage"

Actions trigger computation.

TRANSFORMATIONS FORM A DAG

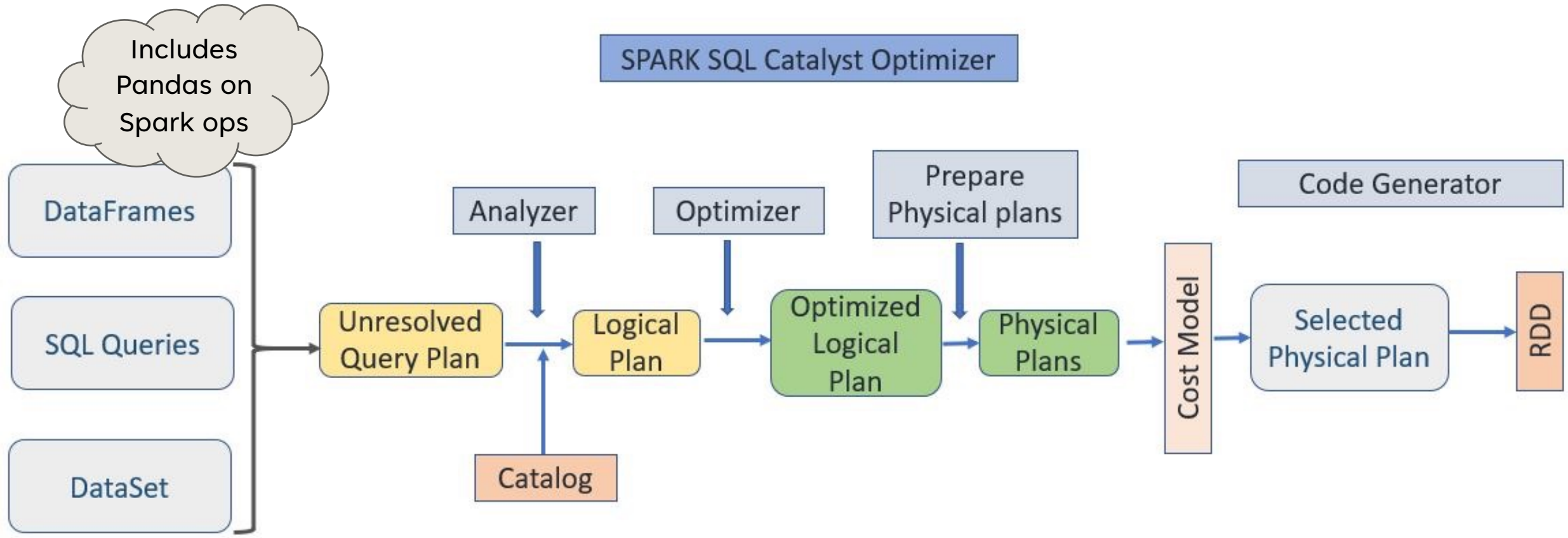


DIFFERENT TRANSFORMATIONS, DIFFERENT DEPENDENCIES

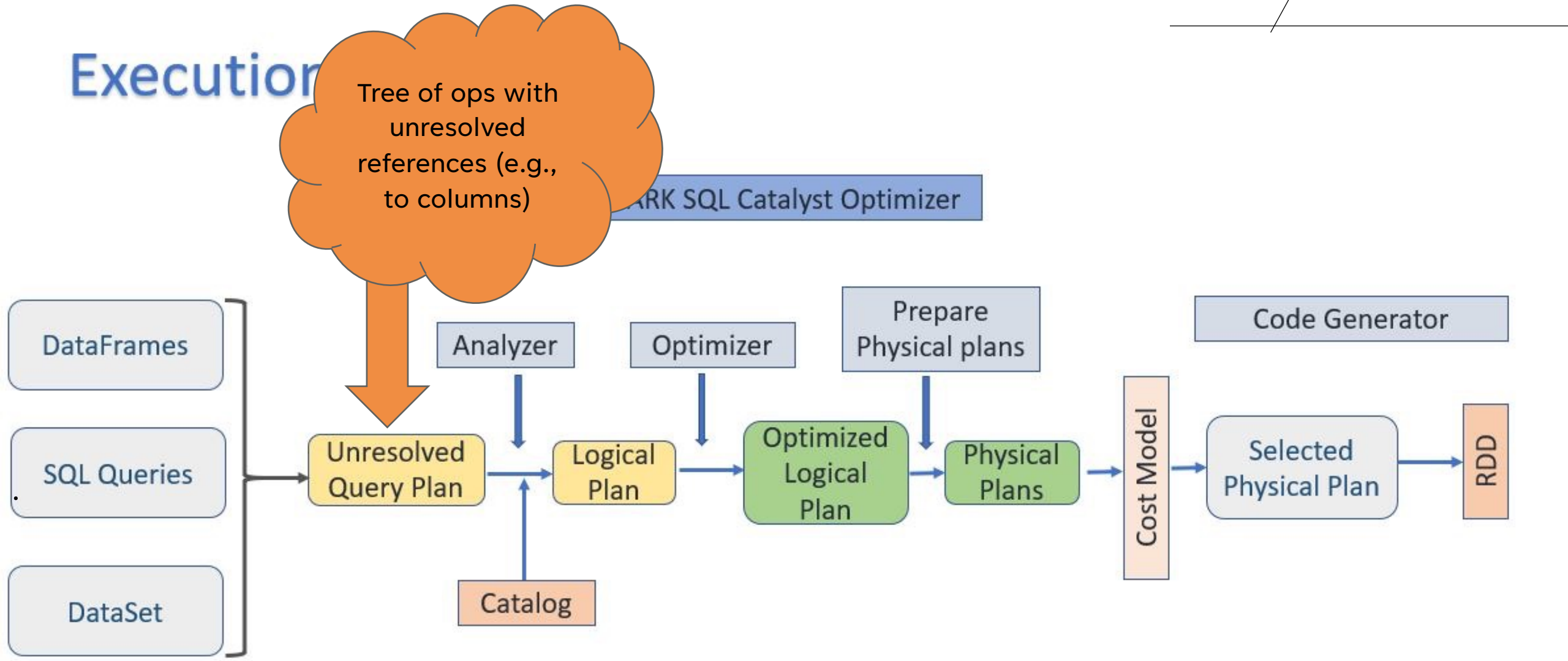


CATALYST OPTIMIZER

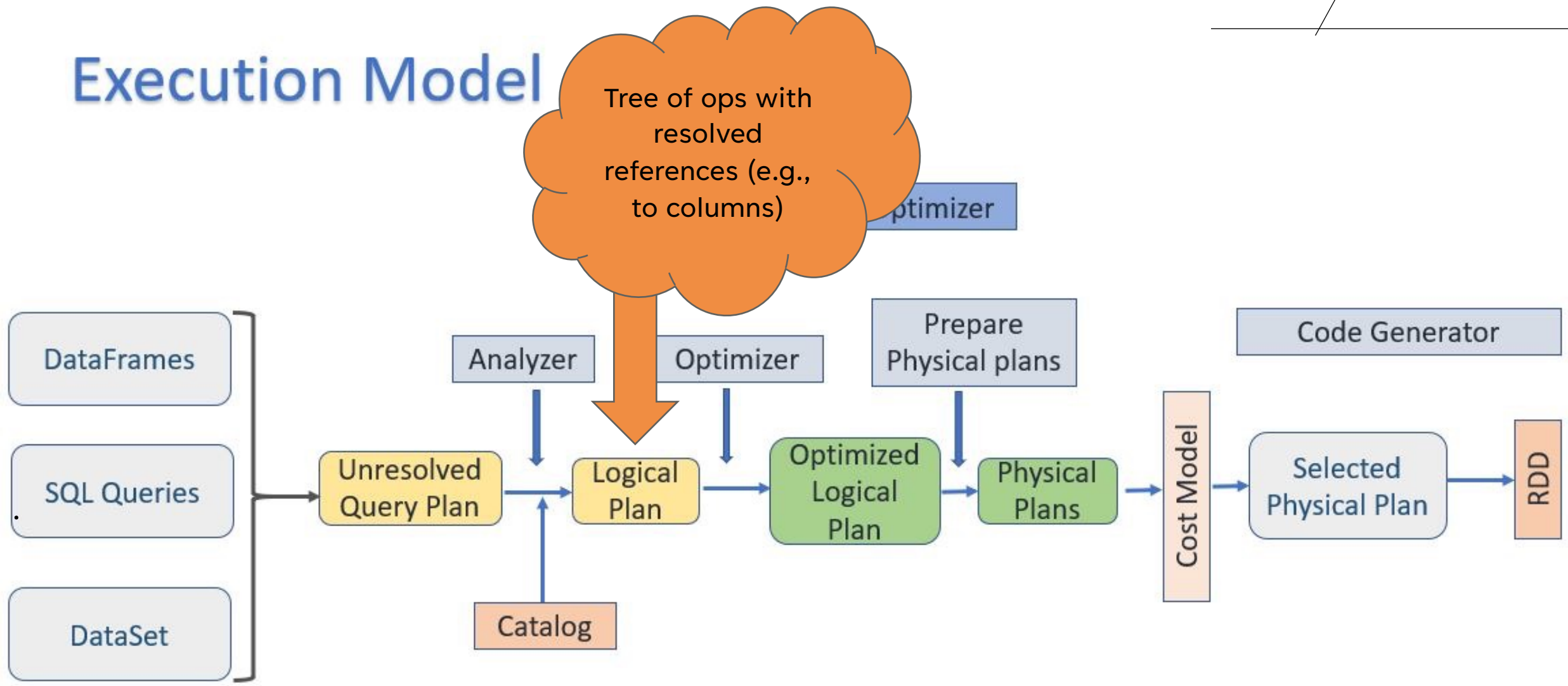
Execution Model



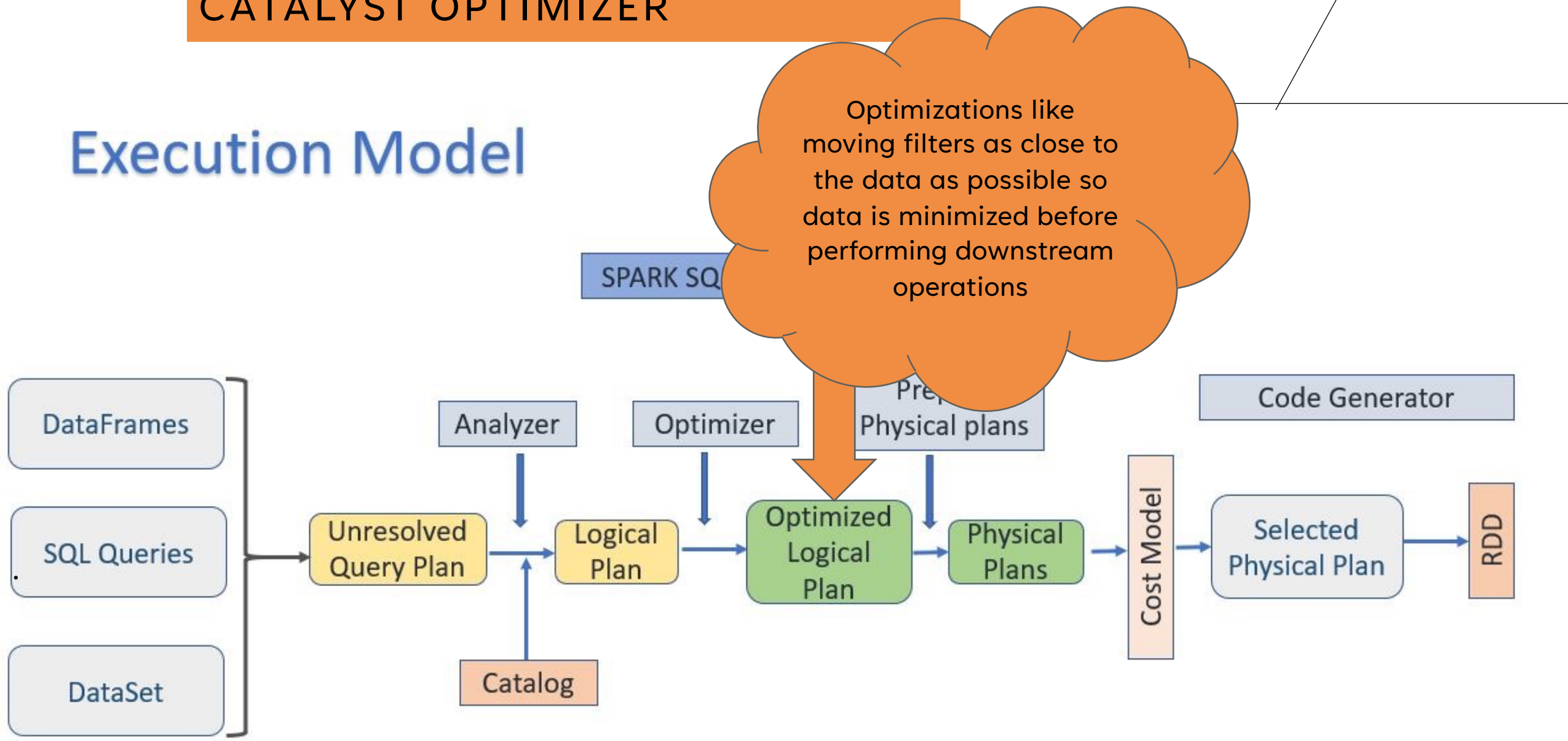
CATALYST OPTIMIZER



CATALYST OPTIMIZER

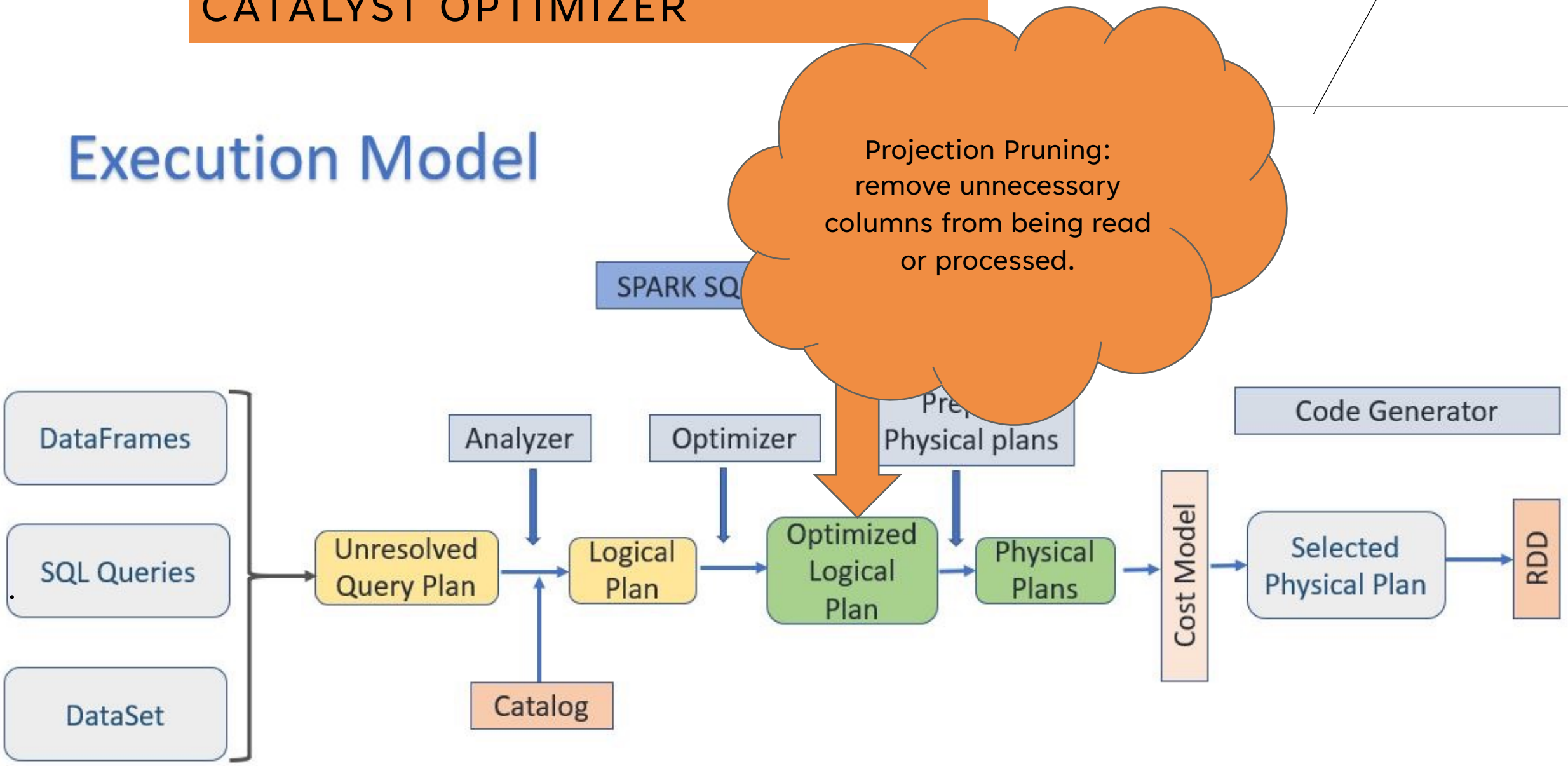


CATALYST OPTIMIZER



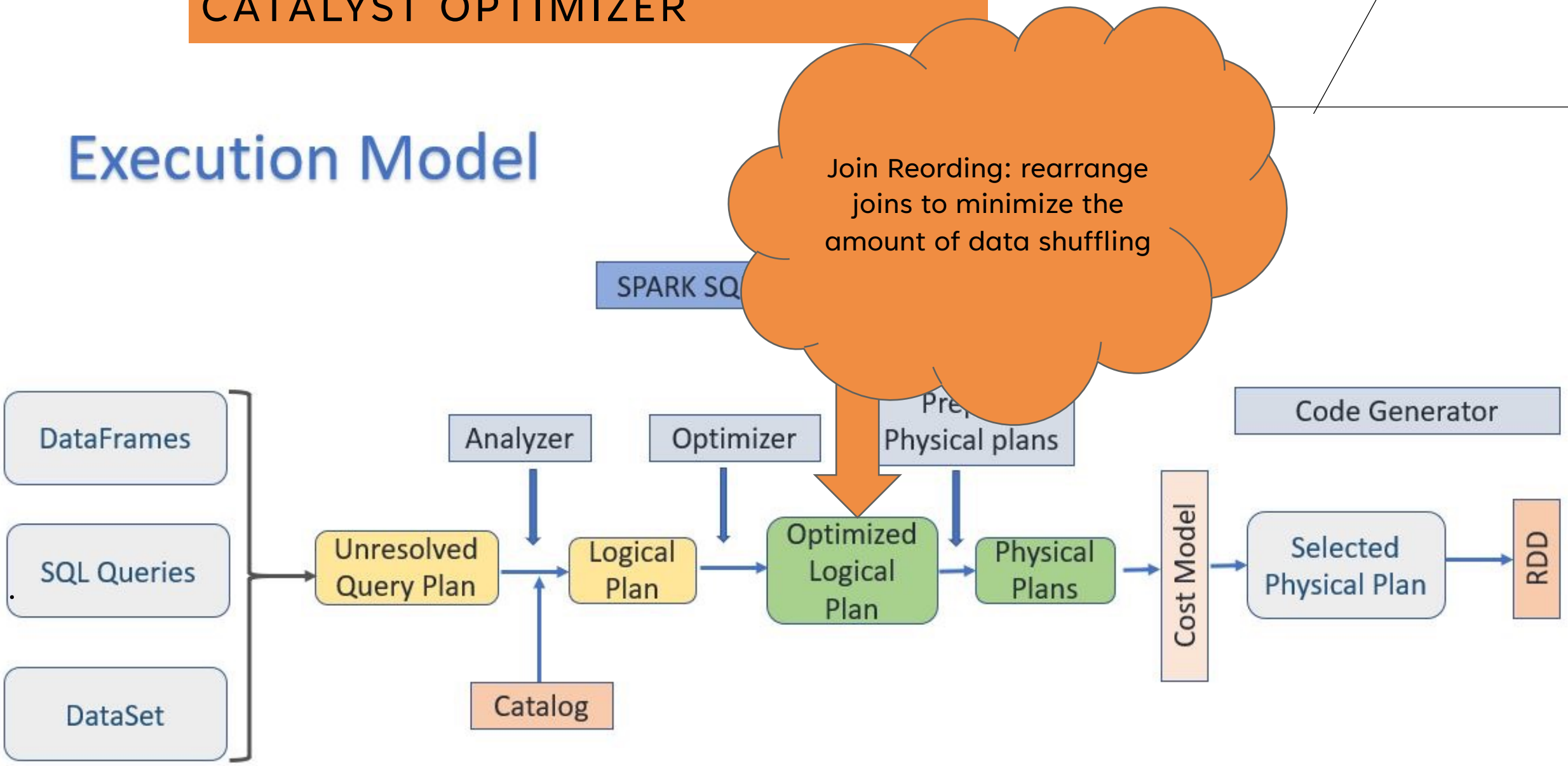
CATALYST OPTIMIZER

Execution Model



CATALYST OPTIMIZER

Execution Model



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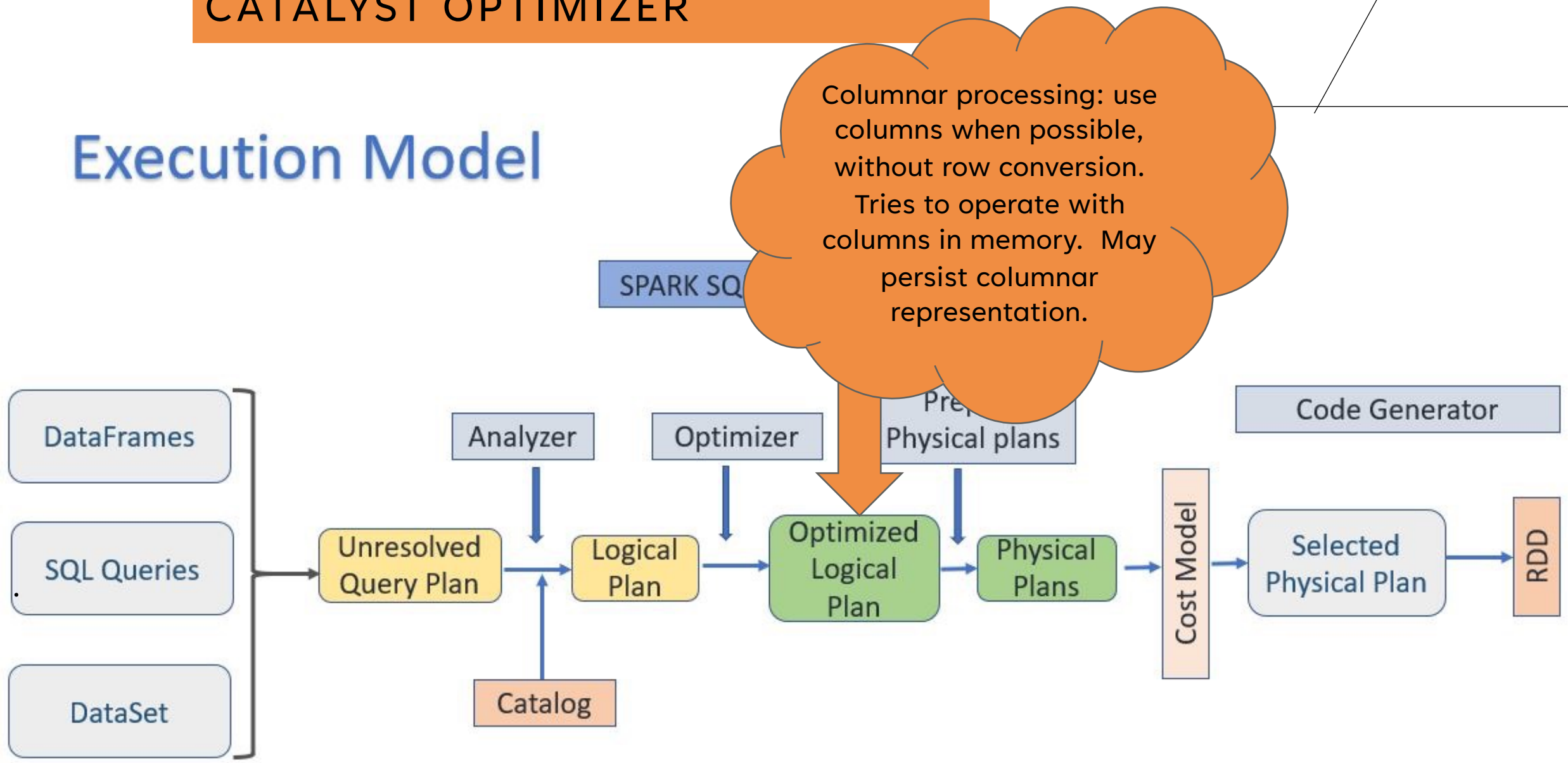

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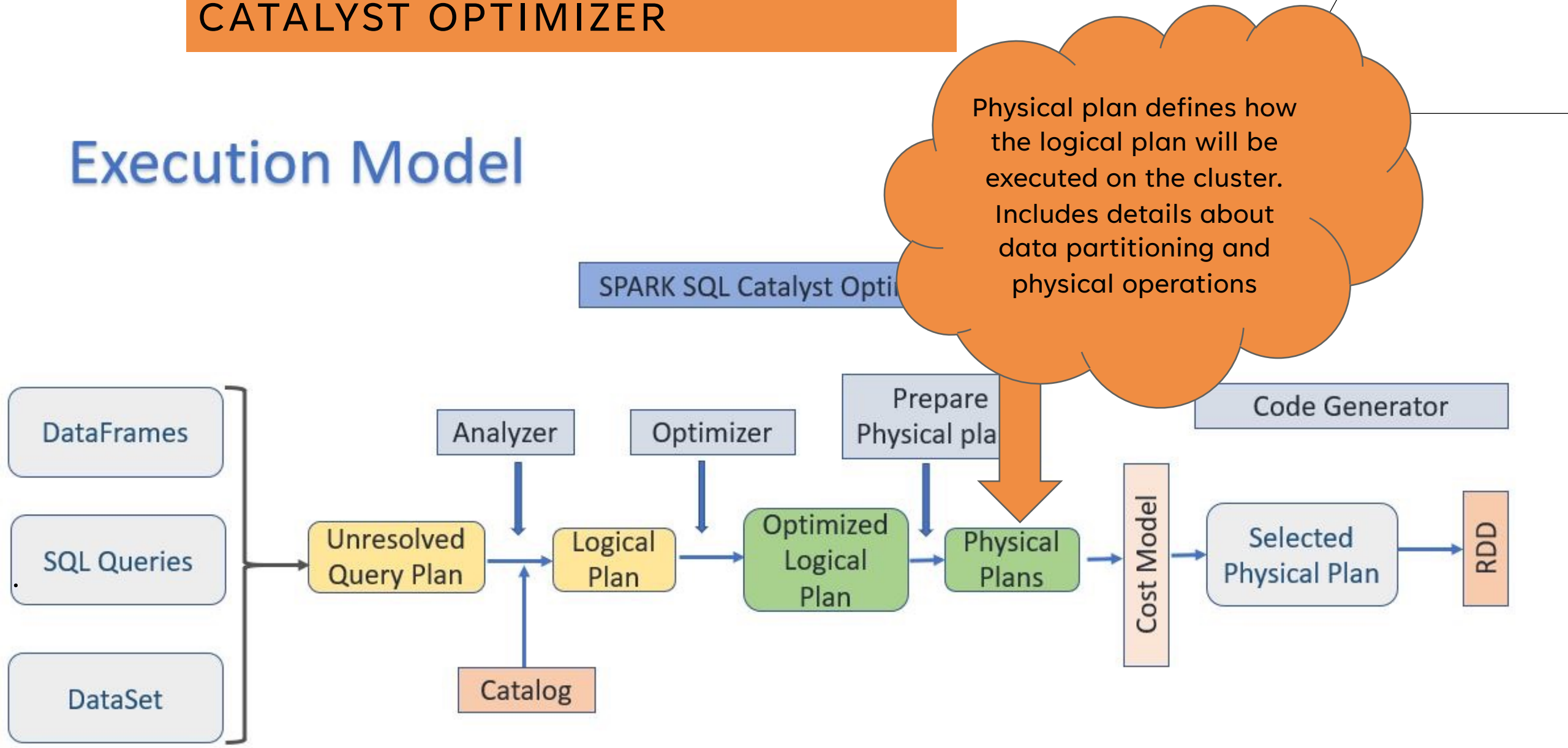

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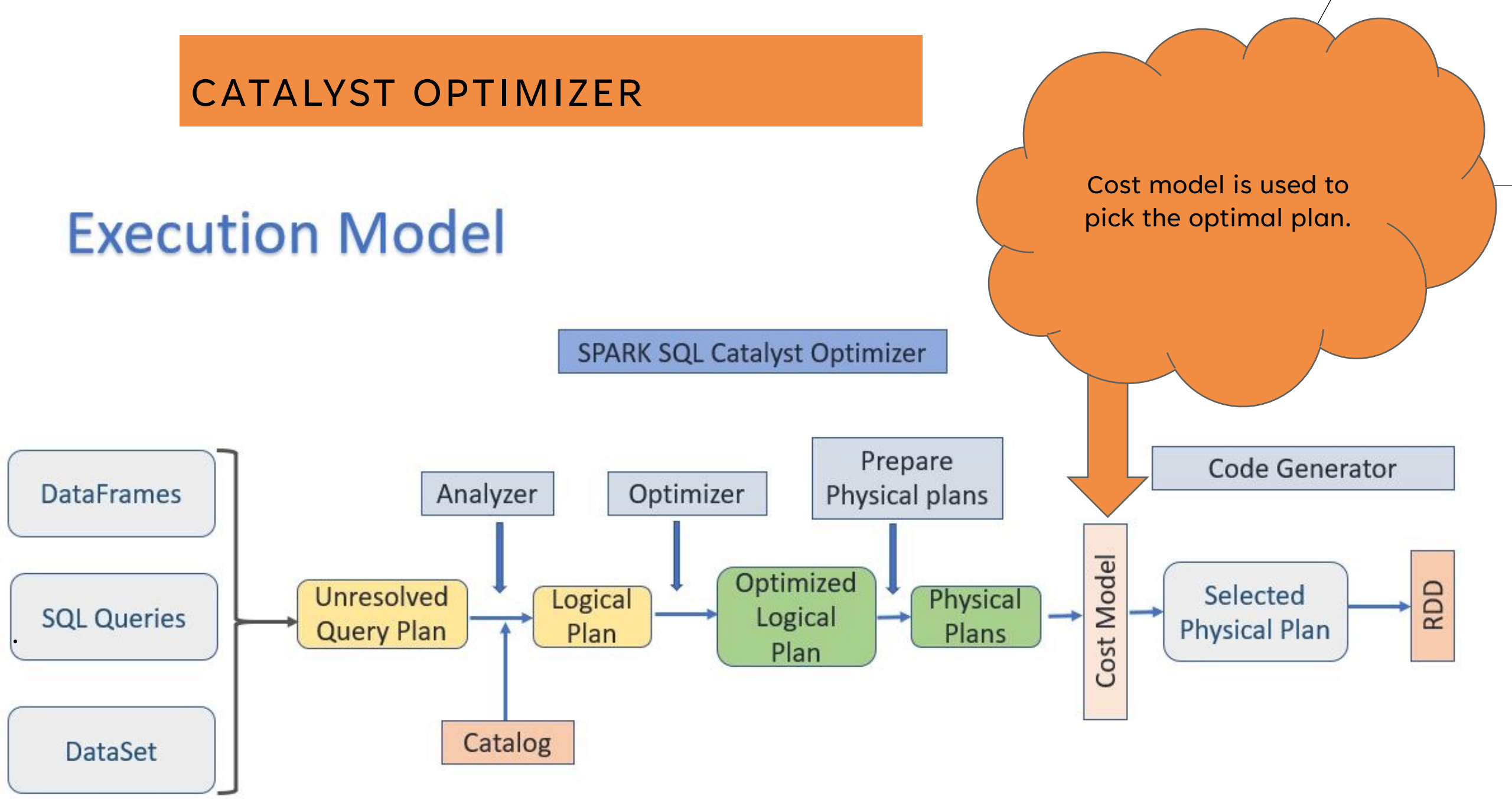

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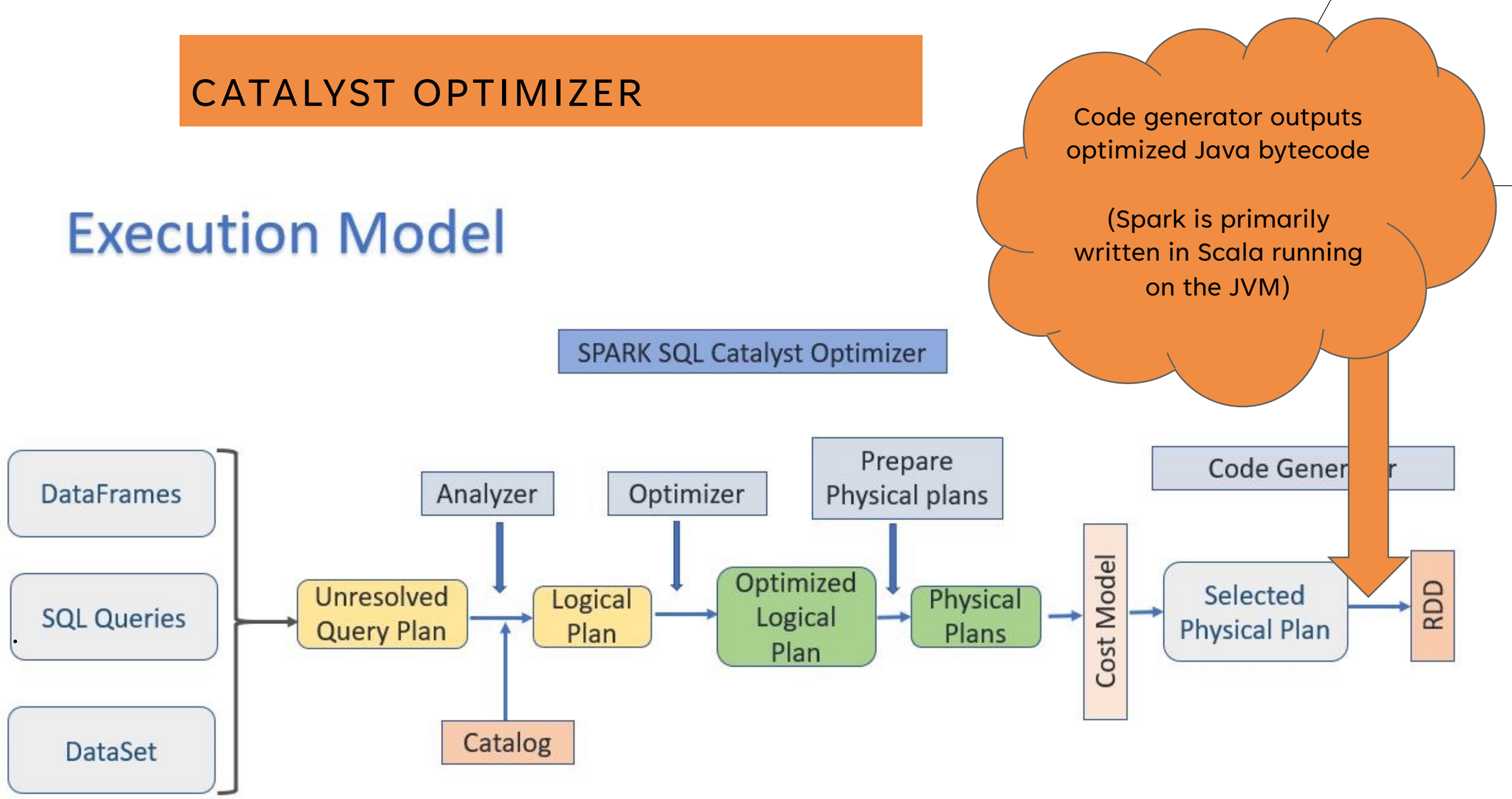

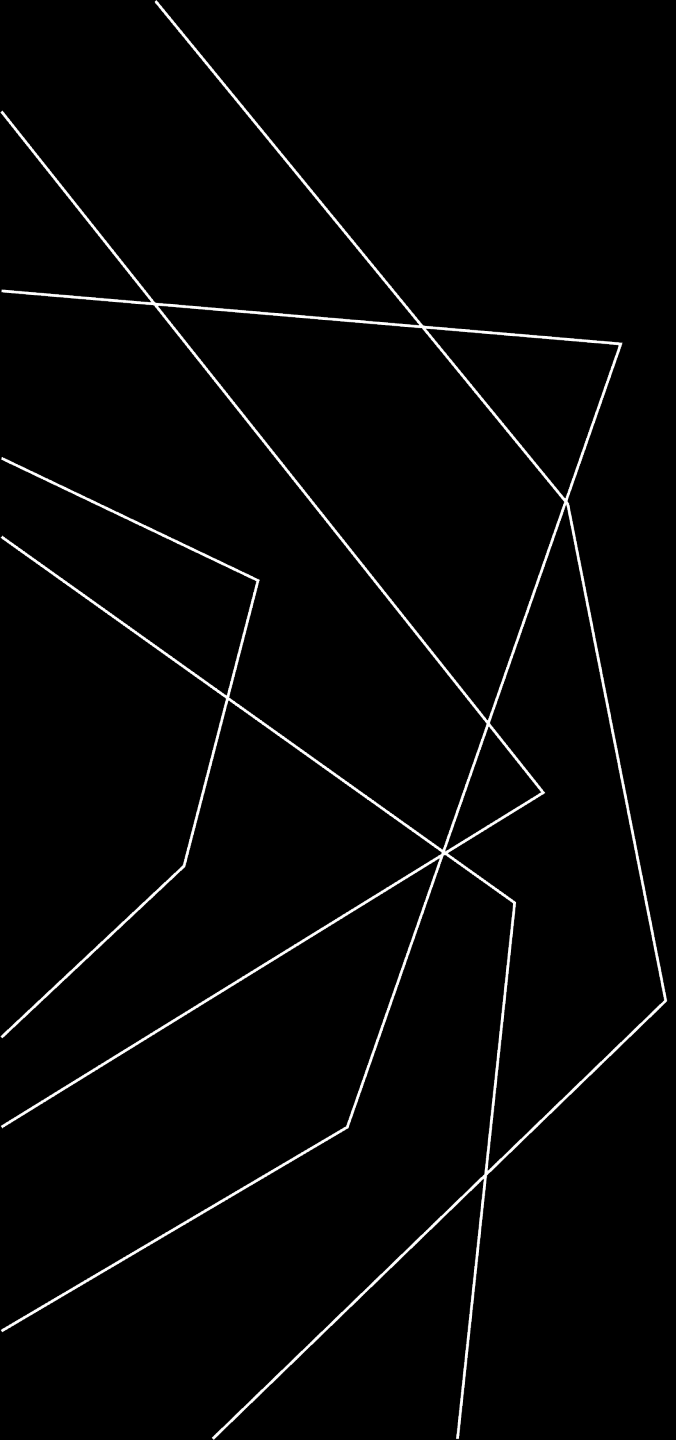

THANK YOU

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