SPARK ZERO TO HERO

100+ PAGES

All about Data Engineering! →

Spark Tutorial

What is Spark ?

Spark is an **Open Source Unified Computing Engine** with set of libraries for **parallel data processing** on Computer Cluster.

It supports widely used Programming languages such as:

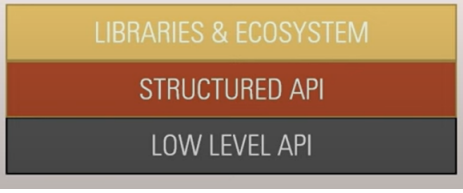
1. Scala
2. Python
3. Java
4. R

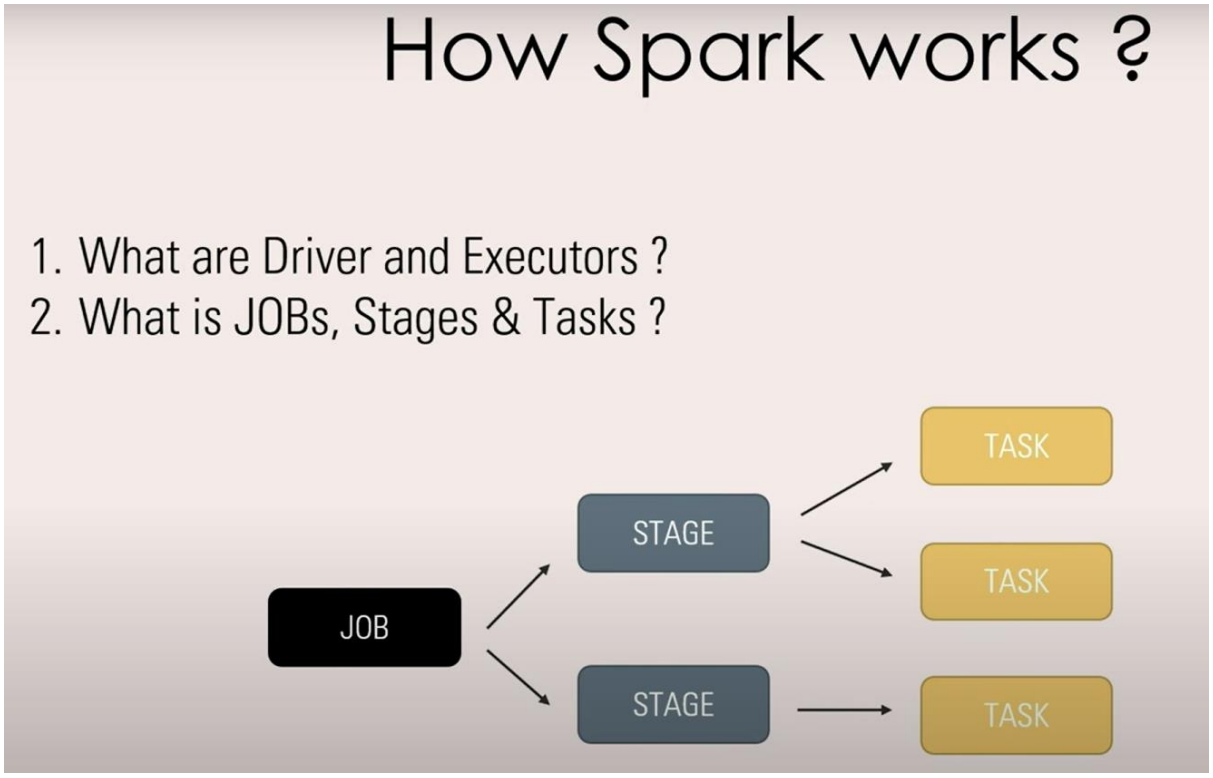
It processes data in memory(RAM) which makes it **100 times faster** than traditional Hadoop Map Reduce.

Spark Components

Following represents Spark Components on High level

1. Low Level API – RDD & Distributed Variables
2. Structured API – DataFrames, Datasets and SQL
3. Libraries and Ecosystem, Structured Streaming and Advanced Analytics





Driver:-

1. **Heart of the Spark Application**
2. **Manages the information and state of executors**
3. **Analyses, distributes and Schedules the work on executors**

Executor:-

1. **Execute the code**
2. **Report the status of execution to driver**

A User assigns a job to driver and driver in turn analyses distribution and breaks down the job into Stages and Tasks. And it assigns it to the executors. Here executors are basically a JVM process which runs in the cluster of machines and it consists of cores.

NOTE:-

1. **Each task can only work on 1 partition of data at a time.**
2. **Tasks can execute in parallel.**

3. **Executor are JVM processes running on cluster machines.**
4. **Executors hosts cores and each core can run 1 task at a time.**

What is Partition ?

To allow every executors to work in parallel, Spark breaks down the data into chunks called partitions.

So, from our last example – the bag of marble contained pouches of marble, which can be considered as Partition.

What is Transformation ?

The instruction or code to modify and transform data is known as Transformation.

Eg. select, where, groupBy etc.

Transformation help is building the logical plan.

Two types:

1. Narrow Transformation
2. Wide Transformation

Narrow Transformation:-

After applying transformation each partition contribute to at-most one partition.

Wide Transformation:-

After applying transformation if one partition contribute to more than one partition. This type of transformations lead to data shuffle.

What are Actions ?

To trigger the execution we need to call an Action.

This basically executes the plan created by Transformation

Actions are of three types:

1. View data in console
2. Collect data to native language
3. Write data to output data sources

Spark prefers Lazy Evaluation

Spark will wait till last moment to execute the graph of computation.

This allows Spark to optimize, plan and use the resources properly for execution.

What is Spark Session?

1. The Driver Process in known as Spark Session
2. It is the entry point for a Spark execution
3. The Spark Session instance executes the code in the cluster.
4. And the relation is one-to-one, i.e. For 1 Spark Application we will have 1 Spark Session instance.

Structured API - DataFrames

1. DataFrame is the most common Structured API, represented like a table
2. The table is represented in form on Rows and Columns
3. DataFrame has schema, which is the metadata for the columns
4. Data in DataFrames are in Partitions.
5. DataFrames are immutable

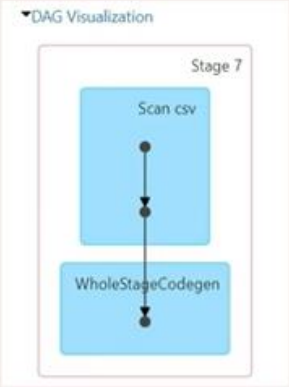
employee_id	department_id	name	age	gender	salary	hire_date
001	101	John Doe	30	Male	50000.0	2015-01-01
002	101	Jane Smith	25	Female	45000.0	2016-02-15
003	102	Bob Brown	35	Male	55000.0	2014-05-01
004	102	Alice Lee	28	Female	48000.0	2017-09-30
005	103	Jack Chan	40	Male	60000.0	2013-04-01
006	103	Jill Wong	32	Female	52000.0	2018-07-01
007	101	James Johnson	42	Male	70000.0	2012-03-15
008	102	Kate Kim	29	Female	51000.0	2019-10-01
009	103	Tom Tan	33	Male	58000.0	2016-06-01
010	104	Lisa Lee	27	Female	47000.0	2018-08-01

How Spark works on Data Partitions?

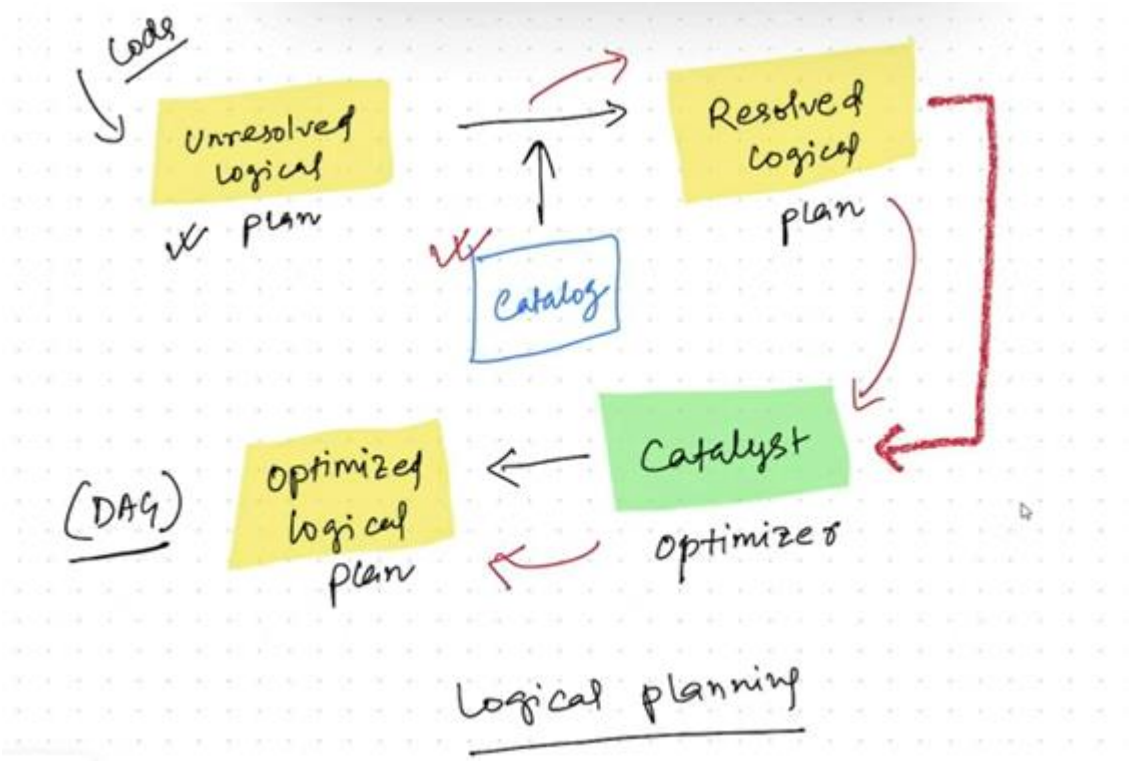
- **Spark distributes the data in form of partitions to the Cluster.**

Structured API Execution Plan

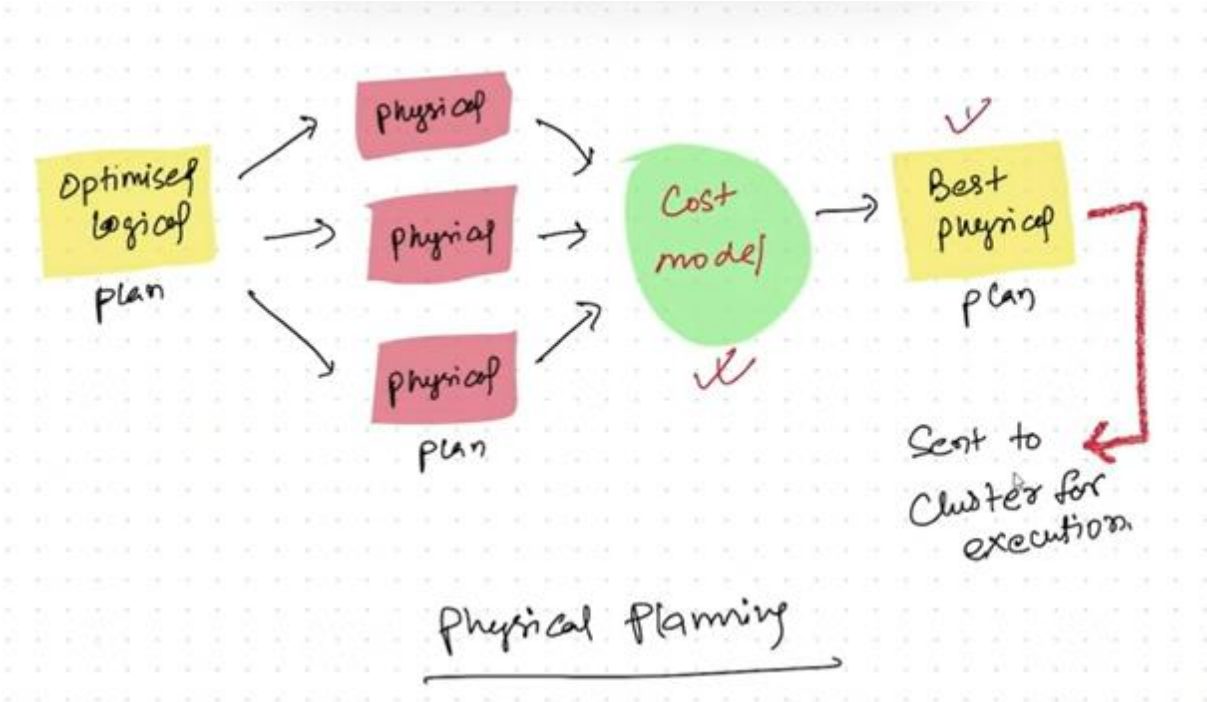
1. Logical Planning
2. Physical Planning

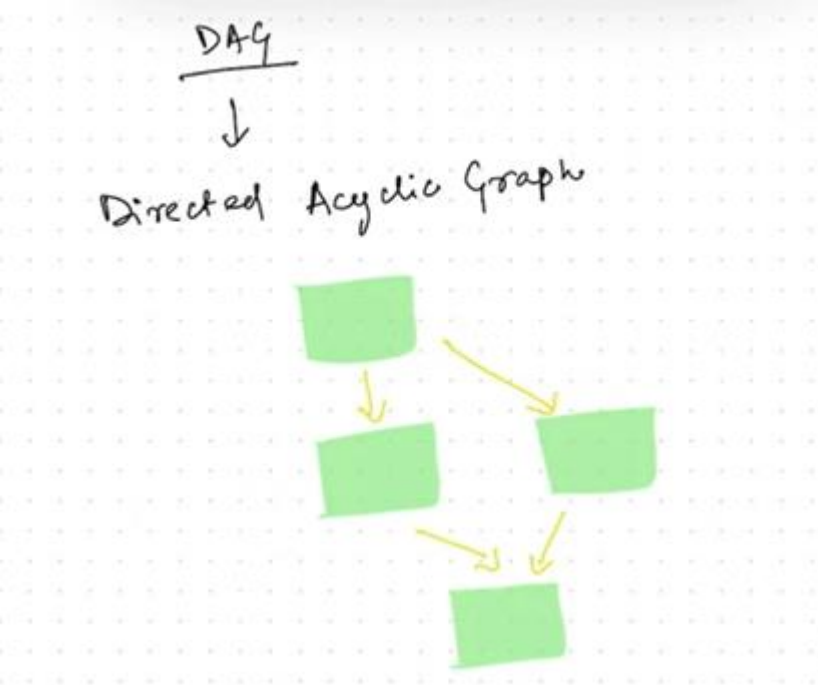


Logical Planning is the 1st Phase of Execution Planning



Physical Planning is the 2nd and Final Phase of Execution Planning





Directed Acyclic Graph(DAG)- A DAG represents the logical execution plan of a Spark Job.

Example- Generate the EMP dataframe and filter EMP salary>50000. Write the output in CSV format.

Spark Session Object is the entry point for our Spark Application

Spark Session object name -We are using generic name “spark” for better understanding.

Local([*]) is to run Spark locally with as many worker threads as logical cores on your machine.

In [1]:

```
# Spark Session
from pyspark.sql import SparkSession

spark = (
    SparkSession
    .builder
    .appName("Spark Introduction")
    .master("local[*]")
    .getOrCreate()
)
```

In [2]:

```
spark
```

Out[2]:

SparkSession - in-memory

SparkContext

Spark UI

Version	`v3.3.0`
Master	`local[*]`
AppName	`Spark Introduction`

In [3]:

```
# Emp Data & Schema

emp_data = [
    ["001","101","John Doe","30","Male","50000","2015-01-01"],
    ["002","101","Jane Smith","25","Female","45000","2016-02-15"],
    ["003","102","Bob Brown","35","Male","55000","2014-05-01"],
    ["004","102","Alice Lee","28","Female","48000","2017-09-30"],
    ["005","103","Jack Chan","40","Male","60000","2013-04-01"],
    ["006","103","Jill Wong","32","Female","52000","2018-07-01"],
    ["007","101","James Johnson","42","Male","70000","2012-03-15"],
    ["008","102","Kate Kim","29","Female","51000","2019-10-01"],
    ["009","103","Tom Tan","33","Male","58000","2016-06-01"],
    ["010","104","Lisa Lee","27","Female","47000","2018-08-01"],
    ["011","104","David Park","38","Male","65000","2015-11-01"],
    ["012","105","Susan Chen","31","Female","54000","2017-02-15"],
    ["013","106","Brian Kim","45","Male","75000","2011-07-01"],
    ["014","107","Emily Lee","26","Female","46000","2019-01-01"],
    ["015","106","Michael Lee","37","Male","63000","2014-09-30"],
    ["016","107","Kelly Zhang","30","Female","49000","2018-04-01"],
    ["017","105","George Wang","34","Male","57000","2016-03-15"],
    ["018","104","Nancy Liu","29","Female","50000","2017-06-01"],
    ["019","103","Steven Chen","36","Male","62000","2015-08-01"],
    ["020","102","Grace Kim","32","Female","53000","2018-11-01"]
]

emp_schema = "employee_id string, department_id string, name string, age string, gender string, salary string, hire_date stri
```

In [4]:
```
# Create emp DataFrame

emp = spark.createDataFrame(data=emp_data, schema=emp_schema)
```

In [5]:
```
# Check number of partitions

emp.rdd.getNumPartitions()
```

Out[5]: 8

In [6]:
```
# Show data (ACTION)

emp.show()
```

```
+-----------+-------------+-------------+---+------+------+----------+
|employee_id|department_id|         name|age|gender|salary| hire_date|
+-----------+-------------+-------------+---+------+------+----------+
|        001|          101|     John Doe| 30|  Male| 50000|2015-01-01|
|        002|          101|   Jane Smith| 25|Female| 45000|2016-02-15|
|        003|          102|    Bob Brown| 35|  Male| 55000|2014-05-01|
|        004|          102|    Alice Lee| 28|Female| 48000|2017-09-30|
|        005|          103|    Jack Chan| 40|  Male| 60000|2013-04-01|
|        006|          103|    Jill Wong| 32|Female| 52000|2018-07-01|
|        007|          101|James Johnson| 42|  Male| 70000|2012-03-15|
|        008|          102|     Kate Kim| 29|Female| 51000|2019-10-01|
|        009|          103|      Tom Tan| 33|  Male| 58000|2016-06-01|
|        010|          104|     Lisa Lee| 27|Female| 47000|2018-08-01|
|        011|          104|   David Park| 38|  Male| 65000|2015-11-01|
|        012|          105|   Susan Chen| 31|Female| 54000|2017-02-15|
|        013|          106|    Brian Kim| 45|  Male| 75000|2011-07-01|
|        014|          107|    Emily Lee| 26|Female| 46000|2019-01-01|
|        015|          106|  Michael Lee| 37|  Male| 63000|2014-09-30|
|        016|          107|  Kelly Zhang| 30|Female| 49000|2018-04-01|
|        017|          105|  George Wang| 34|  Male| 57000|2016-03-15|
|        018|          104|    Nancy Liu| 29|Female| 50000|2017-06-01|
|        019|          103|  Steven Chen| 36|  Male| 62000|2015-08-01|
|        020|          102|    Grace Kim| 32|Female| 53000|2018-11-01|
+-----------+-------------+-------------+---+------+------+----------+
```

In [7]:
```
# Write our first Transformation (EMP salary > 50000)

emp_final = emp.where("salary > 50000")
```

In [8]:
```
# Validate number of Partitions

emp_final.rdd.getNumPartitions()
```

Out[8]: 8

In [9]:
```
# Write data as CSV output (ACTION)

emp_final.write.format("csv").save("data/output/1/emp.csv")
```

If you want to change the spark session object name then this code you can use: (eg, new_object_name = spark.getActiveSession())

Spark Hands On

1. DataFrame Columns
2. DataFrame Rows
3. DataFrame Schema
4. Structured Transformations – select, expr, selectExpr, cast

Schema for DataFrame- Schema is the metadata that defines the name and the type of the column.

In [6]:
```
# Schema for emp

emp.schema
```

Out[6]:
```
StructType([StructField('employee_id', StringType(), True), StructField('department_id', StringType(), True), StructField('name', StringType(), True), StructField('age', StringType(), True), StructField('gender', StringType(), True), StructField('salary', StringType(), True), StructField('hire_date', StringType(), True)])
```

In [8]:
```
# Small Example for Schema
from pyspark.sql.types import StructType, StructField, StringType, IntegerType
schema_string = "name string, age int"

schema_spark =  StructType([
    StructField("name", StringType(), True),
    StructField("age", IntegerType(), True)
])
```

DataFrame is divided into two parts: Rows & Columns

You need DataFrame to manipulate the columns

In [18]:
```
# Columns and expression
from pyspark.sql.functions import col, expr

emp["salary"]
```

Out[18]:
```
Column<'salary'>
```

In [20]:
```
# SELECT columns
# select employee_id, name, age, salary from emp

emp_filtered = emp.select(col("employee_id"), expr("name"), emp.age, emp.salary)
```

In [21]:
```
# SHOW Dataframe (ACTION)

emp_filtered.show()
```

```
+-----------+-------------+---+------+
|employee_id|         name|age|salary|
+-----------+-------------+---+------+
|        001|     John Doe| 30| 50000|
|        002|   Jane Smith| 25| 45000|
|        003|    Bob Brown| 35| 55000|
|        004|    Alice Lee| 28| 48000|
|        005|    Jack Chan| 40| 60000|
|        006|    Jill Wong| 32| 52000|
|        007|James Johnson| 42| 70000|
|        008|     Kate Kim| 29| 51000|
|        009|      Tom Tan| 33| 58000|
|        010|     Lisa Lee| 27| 47000|
|        011|   David Park| 38| 65000|
|        012|   Susan Chen| 31| 54000|
|        013|    Brian Kim| 45| 75000|
|        014|    Emily Lee| 26| 46000|
|        015|  Michael Lee| 37| 63000|
|        016|  Kelly Zhang| 30| 49000|
|        017|  George Wang| 34| 57000|
|        018|    Nancy Liu| 29| 50000|
|        019|  Steven Chen| 36| 62000|
|        020|    Grace Kim| 32| 53000|
+-----------+-------------+---+------+
```

In [22]:
```
# Using expr for select
# select employee_id as emp_id, name, cast(age as int) as age, salary from emp_filtered

emp_casted = emp_filtered.select(expr("employee_id as emp_id"), emp.name, expr("cast(age as int) as age"), emp.salary)
```

In [23]:
```
# SHOW Dataframe (ACTION)

emp_casted.show()
```

```
+------+-------------+---+------+
|emp_id|         name|age|salary|
+------+-------------+---+------+
|   001|     John Doe| 30| 50000|
|   002|   Jane Smith| 25| 45000|
|   003|    Bob Brown| 35| 55000|
|   004|    Alice Lee| 28| 48000|
|   005|    Jack Chan| 40| 60000|
|   006|    Jill Wong| 32| 52000|
|   007|James Johnson| 42| 70000|
|   008|     Kate Kim| 29| 51000|
|   009|      Tom Tan| 33| 58000|
|   010|     Lisa Lee| 27| 47000|
|   011|   David Park| 38| 65000|
|   012|   Susan Chen| 31| 54000|
|   013|    Brian Kim| 45| 75000|
|   014|    Emily Lee| 26| 46000|
|   015|  Michael Lee| 37| 63000|
|   016|  Kelly Zhang| 30| 49000|
|   017|  George Wang| 34| 57000|
|   018|    Nancy Liu| 29| 50000|
|   019|  Steven Chen| 36| 62000|
|   020|    Grace Kim| 32| 53000|
+------+-------------+---+------+
```

In [25]:
```
emp_casted_1 = emp_filtered.selectExpr("employee_id as emp_id", "name", "cast(age as int) as age", "salary")
```

In [26]:
```
emp_casted_1.show()
```

```
+------+-------------+---+------+
|emp_id|         name|age|salary|
+------+-------------+---+------+
|   001|     John Doe| 30| 50000|
|   002|   Jane Smith| 25| 45000|
|   003|    Bob Brown| 35| 55000|
|   004|    Alice Lee| 28| 48000|
|   005|    Jack Chan| 40| 60000|
|   006|    Jill Wong| 32| 52000|
|   007|James Johnson| 42| 70000|
|   008|     Kate Kim| 29| 51000|
|   009|      Tom Tan| 33| 58000|
|   010|     Lisa Lee| 27| 47000|
|   011|   David Park| 38| 65000|
|   012|   Susan Chen| 31| 54000|
|   013|    Brian Kim| 45| 75000|
|   014|    Emily Lee| 26| 46000|
|   015|  Michael Lee| 37| 63000|
|   016|  Kelly Zhang| 30| 49000|
|   017|  George Wang| 34| 57000|
|   018|    Nancy Liu| 29| 50000|
|   019|  Steven Chen| 36| 62000|
|   020|    Grace Kim| 32| 53000|
+------+-------------+---+------+
```

In [24]:
```
emp_casted.printSchema()
```

```
root
 |-- emp_id: string (nullable = true)
 |-- name: string (nullable = true)
 |-- age: integer (nullable = true)
 |-- salary: string (nullable = true)
```

In [27]:
```
# Filter emp based on Age > 30
# select emp_id, name, age, salary from emp_casted where age > 30

emp_final = emp_casted.select("emp_id", "name", "age", "salary").where("age > 30")
```

In [27]:
```
# Filter emp based on Age > 30
# select emp_id, name, age, salary from emp_casted where age > 30

emp_final = emp_casted.select("emp_id", "name", "age", "salary").where("age > 30")
```

In [28]:
```
# SHOW Dataframe (ACTION)

emp_final.show()
```

```
+------+-------------+---+------+
|emp_id|         name|age|salary|
+------+-------------+---+------+
|   003|    Bob Brown| 35| 55000|
|   005|    Jack Chan| 40| 60000|
|   006|    Jill Wong| 32| 52000|
|   007|James Johnson| 42| 70000|
|   009|      Tom Tan| 33| 58000|
|   011|   David Park| 38| 65000|
|   012|   Susan Chen| 31| 54000|
|   013|    Brian Kim| 45| 75000|
|   015|  Michael Lee| 37| 63000|
|   017|  George Wang| 34| 57000|
|   019|  Steven Chen| 36| 62000|
|   020|    Grace Kim| 32| 53000|
+------+-------------+---+------+
```

In [29]:
```
# Write the data back as CSV (ACTION)

emp_final.write.format("csv").save("data/output/2/emp.csv")
```

In [30]:
```
# Bonus TIP

schema_str = "name string, age int"

from pyspark.sql.types import _parse_datatype_string

schema_spark = _parse_datatype_string(schema_str)

schema_spark
```

Out[30]:
```
StructType([StructField('name', StringType(), True), StructField('age', IntegerType(), True)])
```

The function _parse_datatype_string in PySpark is a private method used internally to parse a string representation of a data type into a PySpark DataType object. It is primarily utilized when working with schema definitions or manipulating data types programmatically.

Spark Hands On

1. Adding Columns
2. Using Literals/Static values
3. Renaming Columns
4. Removing Columns
5. Filtering and LIMIT for DataFrame
6. Structured Transformations – withColumn, withColumnRenamed, lit

In [1]:
```
# Spark Session
from pyspark.sql import SparkSession

spark = (
    SparkSession
    .builder
    .appName("Basic Transformation - II")
    .master("local[*]")
    .getOrCreate()
)

spark
```

Out[1]:

SparkSession - in-memory

SparkContext

Spark UI

Version	`v3.3.0`
Master	`local[*]`
AppName	`Basic Transformation - II`

In [2]:

```
# Emp Data & Schema

emp_data = [
    ["001","101","John Doe","30","Male","50000","2015-01-01"],
    ["002","101","Jane Smith","25","Female","45000","2016-02-15"],
    ["003","102","Bob Brown","35","Male","55000","2014-05-01"],
    ["004","102","Alice Lee","28","Female","48000","2017-09-30"],
    ["005","103","Jack Chan","40","Male","60000","2013-04-01"],
    ["006","103","Jill Wong","32","Female","52000","2018-07-01"],
    ["007","101","James Johnson","42","Male","70000","2012-03-15"],
    ["008","102","Kate Kim","29","Female","51000","2019-10-01"],
    ["009","103","Tom Tan","33","Male","58000","2016-06-01"],
    ["010","104","Lisa Lee","27","Female","47000","2018-08-01"],
    ["011","104","David Park","38","Male","65000","2015-11-01"],
    ["012","105","Susan Chen","31","Female","54000","2017-02-15"],
    ["013","106","Brian Kim","45","Male","75000","2011-07-01"],
    ["014","107","Emily Lee","26","Female","46000","2019-01-01"],
    ["015","106","Michael Lee","37","Male","63000","2014-09-30"],
    ["016","107","Kelly Zhang","30","Female","49000","2018-04-01"],
    ["017","105","George Wang","34","Male","57000","2016-03-15"],
    ["018","104","Nancy Liu","29","Female","50000","2017-06-01"],
    ["019","103","Steven Chen","36","Male","62000","2015-08-01"],
    ["020","102","Grace Kim","32","Female","53000","2018-11-01"]
]

emp_schema = "employee_id string, department_id string, name string, age string, gender string, salary string, hire_date str
```

In [3]:

```
# Create emp DataFrame

emp = spark.createDataFrame(data=emp_data, schema=emp_schema)
```

In [4]:

```
# Show emp dataframe (ACTION)

emp.show()
```

```
+-----------+-------------+-------------+---+------+------+----------+
|employee_id|department_id|         name|age|gender|salary| hire_date|
+-----------+-------------+-------------+---+------+------+----------+
|        001|          101|     John Doe| 30|  Male| 50000|2015-01-01|
|        002|          101|   Jane Smith| 25|Female| 45000|2016-02-15|
|        003|          102|    Bob Brown| 35|  Male| 55000|2014-05-01|
|        004|          102|    Alice Lee| 28|Female| 48000|2017-09-30|
|        005|          103|    Jack Chan| 40|  Male| 60000|2013-04-01|
|        006|          103|    Jill Wong| 32|Female| 52000|2018-07-01|
|        007|          101|James Johnson| 42|  Male| 70000|2012-03-15|
|        008|          102|     Kate Kim| 29|Female| 51000|2019-10-01|
|        009|          103|      Tom Tan| 33|  Male| 58000|2016-06-01|
|        010|          104|     Lisa Lee| 27|Female| 47000|2018-08-01|
|        011|          104|   David Park| 38|  Male| 65000|2015-11-01|
|        012|          105|   Susan Chen| 31|Female| 54000|2017-02-15|
|        013|          106|    Brian Kim| 45|  Male| 75000|2011-07-01|
|        014|          107|    Emily Lee| 26|Female| 46000|2019-01-01|
|        015|          106|  Michael Lee| 37|  Male| 63000|2014-09-30|
|        016|          107|  Kelly Zhang| 30|Female| 49000|2018-04-01|
|        017|          105|  George Wang| 34|  Male| 57000|2016-03-15|
|        018|          104|    Nancy Liu| 29|Female| 50000|2017-06-01|
|        019|          103|  Steven Chen| 36|  Male| 62000|2015-08-01|
|        020|          102|    Grace Kim| 32|Female| 53000|2018-11-01|
+-----------+-------------+-------------+---+------+------+----------+
```

In [5]:
```
# Print Schema

emp.printSchema()
```

```
root
 |-- employee_id: string (nullable = true)
 |-- department_id: string (nullable = true)
 |-- name: string (nullable = true)
 |-- age: string (nullable = true)
 |-- gender: string (nullable = true)
 |-- salary: string (nullable = true)
 |-- hire_date: string (nullable = true)
```

In [8]:
```
# Casting Column
# select employee_id, name, age, cast(salary as double) as salary from emp
from pyspark.sql.functions import col, cast

emp_casted = emp.select("employee_id", "name", "age", col("salary").cast("double"))
```

In [9]:
```
emp_casted.printSchema()
```

```
root
 |-- employee_id: string (nullable = true)
 |-- name: string (nullable = true)
 |-- age: string (nullable = true)
 |-- salary: double (nullable = true)
```

In [10]:
```
# Adding Columns
# select employee_id, name, age, salary, (salary * 0.2) as tax from emp_casted

emp_taxed = emp_casted.withColumn("tax", col("salary") * 0.2)
```

In [11]:
```
emp_taxed.show()
```

```
+-----------+-------------+---+-------+-------+
|employee_id|         name|age| salary|    tax|
+-----------+-------------+---+-------+-------+
|        001|     John Doe| 30|50000.0|10000.0|
|        002|   Jane Smith| 25|45000.0| 9000.0|
|        003|    Bob Brown| 35|55000.0|11000.0|
|        004|    Alice Lee| 28|48000.0| 9600.0|
|        005|    Jack Chan| 40|60000.0|12000.0|
|        006|    Jill Wong| 32|52000.0|10400.0|
|        007|James Johnson| 42|70000.0|14000.0|
|        008|     Kate Kim| 29|51000.0|10200.0|
|        009|      Tom Tan| 33|58000.0|11600.0|
|        010|     Lisa Lee| 27|47000.0| 9400.0|
|        011|   David Park| 38|65000.0|13000.0|
|        012|   Susan Chen| 31|54000.0|10800.0|
|        013|    Brian Kim| 45|75000.0|15000.0|
|        014|    Emily Lee| 26|46000.0| 9200.0|
|        015|  Michael Lee| 37|63000.0|12600.0|
|        016|  Kelly Zhang| 30|49000.0| 9800.0|
|        017|  George Wang| 34|57000.0|11400.0|
|        018|    Nancy Liu| 29|50000.0|10000.0|
|        019|  Steven Chen| 36|62000.0|12400.0|
|        020|    Grace Kim| 32|53000.0|10600.0|
+-----------+-------------+---+-------+-------+
```

In [12]:
```
# Literals
# select employee_id, name, age, salary, tax, 1 as columnOne, 'two' as columnTwo from emp_taxed
from pyspark.sql.functions import lit

emp_new_cols = emp_taxed.withColumn("columnOne", lit(1)).withColumn("columnTwo", lit('two'))
```

In [13]:
```
emp_new_cols.show()
```

```
+-----------+-------------+---+-------+-------+---------+---------+
|employee_id|         name|age| salary|    tax|columnOne|columnTwo|
+-----------+-------------+---+-------+-------+---------+---------+
|        001|     John Doe| 30|50000.0|10000.0|        1|      two|
|        002|   Jane Smith| 25|45000.0| 9000.0|        1|      two|
|        003|    Bob Brown| 35|55000.0|11000.0|        1|      two|
|        004|    Alice Lee| 28|48000.0| 9600.0|        1|      two|
|        005|    Jack Chan| 40|60000.0|12000.0|        1|      two|
|        006|    Jill Wong| 32|52000.0|10400.0|        1|      two|
|        007|James Johnson| 42|70000.0|14000.0|        1|      two|
|        008|     Kate Kim| 29|51000.0|10200.0|        1|      two|
|        009|      Tom Tan| 33|58000.0|11600.0|        1|      two|
|        010|     Lisa Lee| 27|47000.0| 9400.0|        1|      two|
|        011|   David Park| 38|65000.0|13000.0|        1|      two|
|        012|   Susan Chen| 31|54000.0|10800.0|        1|      two|
|        013|    Brian Kim| 45|75000.0|15000.0|        1|      two|
|        014|    Emily Lee| 26|46000.0| 9200.0|        1|      two|
|        015|  Michael Lee| 37|63000.0|12600.0|        1|      two|
|        016|  Kelly Zhang| 30|49000.0| 9800.0|        1|      two|
|        017|  George Wang| 34|57000.0|11400.0|        1|      two|
|        018|    Nancy Liu| 29|50000.0|10000.0|        1|      two|
|        019|  Steven Chen| 36|62000.0|12400.0|        1|      two|
|        020|    Grace Kim| 32|53000.0|10600.0|        1|      two|
+-----------+-------------+---+-------+-------+---------+---------+
```

In [14]:
```
# Renaming Columns
# select employee_id as emp_id, name, age, salary, tax, columnOne, columnTwo from emp_new_cols

emp_1 = emp_new_cols.withColumnRenamed("employee_id", "emp_id")
```

In [15]:
```
emp_1.show()
```

```
+------+-------------+---+-------+-------+---------+---------+
|emp_id|         name|age| salary|    tax|columnOne|columnTwo|
+------+-------------+---+-------+-------+---------+---------+
|   001|     John Doe| 30|50000.0|10000.0|        1|      two|
|   002|   Jane Smith| 25|45000.0| 9000.0|        1|      two|
|   003|    Bob Brown| 35|55000.0|11000.0|        1|      two|
|   004|    Alice Lee| 28|48000.0| 9600.0|        1|      two|
|   005|    Jack Chan| 40|60000.0|12000.0|        1|      two|
|   006|    Jill Wong| 32|52000.0|10400.0|        1|      two|
|   007|James Johnson| 42|70000.0|14000.0|        1|      two|
|   008|     Kate Kim| 29|51000.0|10200.0|        1|      two|
|   009|      Tom Tan| 33|58000.0|11600.0|        1|      two|
|   010|     Lisa Lee| 27|47000.0| 9400.0|        1|      two|
|   011|   David Park| 38|65000.0|13000.0|        1|      two|
|   012|   Susan Chen| 31|54000.0|10800.0|        1|      two|
|   013|    Brian Kim| 45|75000.0|15000.0|        1|      two|
|   014|    Emily Lee| 26|46000.0| 9200.0|        1|      two|
|   015|  Michael Lee| 37|63000.0|12600.0|        1|      two|
|   016|  Kelly Zhang| 30|49000.0| 9800.0|        1|      two|
|   017|  George Wang| 34|57000.0|11400.0|        1|      two|
|   018|    Nancy Liu| 29|50000.0|10000.0|        1|      two|
|   019|  Steven Chen| 36|62000.0|12400.0|        1|      two|
|   020|    Grace Kim| 32|53000.0|10600.0|        1|      two|
+------+-------------+---+-------+-------+---------+---------+
```

In [18]:
```
# Column names with Spaces
# select employee_id as emp_id, name, age, salary, tax, columnOne, columnTwo as `Column Two` from emp_new_cols

emp_2 = emp_new_cols.withColumnRenamed("columnTwo", "Column Two")
```

In [19]:
```
emp_2.show()
```

```
+-----------+-------------+---+-------+-------+---------+----------+
|employee_id|         name|age| salary|    tax|columnOne|Column Two|
+-----------+-------------+---+-------+-------+---------+----------+
|        001|     John Doe| 30|50000.0|10000.0|        1|       two|
|        002|   Jane Smith| 25|45000.0| 9000.0|        1|       two|
|        003|    Bob Brown| 35|55000.0|11000.0|        1|       two|
|        004|    Alice Lee| 28|48000.0| 9600.0|        1|       two|
|        005|    Jack Chan| 40|60000.0|12000.0|        1|       two|
|        006|    Jill Wong| 32|52000.0|10400.0|        1|       two|
|        007|James Johnson| 42|70000.0|14000.0|        1|       two|
|        008|     Kate Kim| 29|51000.0|10200.0|        1|       two|
|        009|      Tom Tan| 33|58000.0|11600.0|        1|       two|
|        010|     Lisa Lee| 27|47000.0| 9400.0|        1|       two|
|        011|   David Park| 38|65000.0|13000.0|        1|       two|
|        012|   Susan Chen| 31|54000.0|10800.0|        1|       two|
|        013|    Brian Kim| 45|75000.0|15000.0|        1|       two|
|        014|    Emily Lee| 26|46000.0| 9200.0|        1|       two|
|        015|  Michael Lee| 37|63000.0|12600.0|        1|       two|
|        016|  Kelly Zhang| 30|49000.0| 9800.0|        1|       two|
|        017|  George Wang| 34|57000.0|11400.0|        1|       two|
|        018|    Nancy Liu| 29|50000.0|10000.0|        1|       two|
|        019|  Steven Chen| 36|62000.0|12400.0|        1|       two|
|        020|    Grace Kim| 32|53000.0|10600.0|        1|       two|
+-----------+-------------+---+-------+-------+---------+----------+
```

In [22]:
```
# Remove Column

emp_dropped = emp_new_cols.drop("columnTwo", "columnOne")
```

In [23]:
```
emp_dropped.show()
```

```
+-----------+-------------+---+-------+-------+
|employee_id|         name|age| salary|    tax|
+-----------+-------------+---+-------+-------+
|        001|     John Doe| 30|50000.0|10000.0|
|        002|   Jane Smith| 25|45000.0| 9000.0|
|        003|    Bob Brown| 35|55000.0|11000.0|
|        004|    Alice Lee| 28|48000.0| 9600.0|
|        005|    Jack Chan| 40|60000.0|12000.0|
|        006|    Jill Wong| 32|52000.0|10400.0|
|        007|James Johnson| 42|70000.0|14000.0|
|        008|     Kate Kim| 29|51000.0|10200.0|
|        009|      Tom Tan| 33|58000.0|11600.0|
|        010|     Lisa Lee| 27|47000.0| 9400.0|
|        011|   David Park| 38|65000.0|13000.0|
|        012|   Susan Chen| 31|54000.0|10800.0|
|        013|    Brian Kim| 45|75000.0|15000.0|
|        014|    Emily Lee| 26|46000.0| 9200.0|
|        015|  Michael Lee| 37|63000.0|12600.0|
|        016|  Kelly Zhang| 30|49000.0| 9800.0|
|        017|  George Wang| 34|57000.0|11400.0|
|        018|    Nancy Liu| 29|50000.0|10000.0|
|        019|  Steven Chen| 36|62000.0|12400.0|
|        020|    Grace Kim| 32|53000.0|10600.0|
+-----------+-------------+---+-------+-------+
```

In [24]:
```
# Filter data
# select employee_id as emp_id, name, age, salary, tax, columnOne from emp_col_dropped where tax > 1000

emp_filtered = emp_dropped.where("tax > 10000")
```

In [25]:
```
emp_filtered.show()
```

```
+-----------+-------------+---+-------+-------+
|employee_id|         name|age| salary|    tax|
+-----------+-------------+---+-------+-------+
|        003|    Bob Brown| 35|55000.0|11000.0|
|        005|    Jack Chan| 40|60000.0|12000.0|
|        006|    Jill Wong| 32|52000.0|10400.0|
|        007|James Johnson| 42|70000.0|14000.0|
|        008|     Kate Kim| 29|51000.0|10200.0|
|        009|      Tom Tan| 33|58000.0|11600.0|
|        011|   David Park| 38|65000.0|13000.0|
|        012|   Susan Chen| 31|54000.0|10800.0|
|        013|    Brian Kim| 45|75000.0|15000.0|
|        015|  Michael Lee| 37|63000.0|12600.0|
|        017|  George Wang| 34|57000.0|11400.0|
|        019|  Steven Chen| 36|62000.0|12400.0|
|        020|    Grace Kim| 32|53000.0|10600.0|
+-----------+-------------+---+-------+-------+
```

In [26]:
```
# LIMIT data
# select employee_id as emp_id, name, age, salary, tax, columnOne from emp_filtered limit 5

emp_limit = emp_filtered.limit(5)
```

In [28]:
```
# Show data

emp_limit.show(2)
```

```
+-----------+---------+---+-------+-------+
|employee_id|     name|age| salary|    tax|
+-----------+---------+---+-------+-------+
|        003|Bob Brown| 35|55000.0|11000.0|
|        005|Jack Chan| 40|60000.0|12000.0|
+-----------+---------+---+-------+-------+
only showing top 2 rows
```

In [ ]:
```
# Bonus TIP
# Add multiple columns

columns = {
    "tax" : col("salary") * 0.2 ,
    "oneNumber" : lit(1),
    "columnTwo" : lit("two")
}

emp_final = emp.withColumns(columns)
```

In [ ]:
```
emp_final.show()
```

```
+-----------+-------------+-------------+---+------+------+----------+-------+---------+---------+
|employee_id|department_id|         name|age|gender|salary| hire_date|    tax|oneNumber|columnTwo|
+-----------+-------------+-------------+---+------+------+----------+-------+---------+---------+
|        001|          101|     John Doe| 30|  Male| 50000|2015-01-01|10000.0|        1|      two|
|        002|          101|   Jane Smith| 25|Female| 45000|2016-02-15| 9000.0|        1|      two|
|        003|          102|    Bob Brown| 35|  Male| 55000|2014-05-01|11000.0|        1|      two|
|        004|          102|    Alice Lee| 28|Female| 48000|2017-09-30| 9600.0|        1|      two|
|        005|          103|    Jack Chan| 40|  Male| 60000|2013-04-01|12000.0|        1|      two|
|        006|          103|    Jill Wong| 32|Female| 52000|2018-07-01|10400.0|        1|      two|
|        007|          101|James Johnson| 42|  Male| 70000|2012-03-15|14000.0|        1|      two|
|        008|          102|     Kate Kim| 29|Female| 51000|2019-10-01|10200.0|        1|      two|
|        009|          103|      Tom Tan| 33|  Male| 58000|2016-06-01|11600.0|        1|      two|
|        010|          104|     Lisa Lee| 27|Female| 47000|2018-08-01| 9400.0|        1|      two|
|        011|          104|   David Park| 38|  Male| 65000|2015-11-01|13000.0|        1|      two|
|        012|          105|   Susan Chen| 31|Female| 54000|2017-02-15|10800.0|        1|      two|
|        013|          106|    Brian Kim| 45|  Male| 75000|2011-07-01|15000.0|        1|      two|
|        014|          107|    Emily Lee| 26|Female| 46000|2019-01-01| 9200.0|        1|      two|
|        015|          106|  Michael Lee| 37|  Male| 63000|2014-09-30|12600.0|        1|      two|
|        016|          107|  Kelly Zhang| 30|Female| 49000|2018-04-01| 9800.0|        1|      two|
|        017|          105|  George Wang| 34|  Male| 57000|2016-03-15|11400.0|        1|      two|
|        018|          104|    Nancy Liu| 29|Female| 50000|2017-06-01|10000.0|        1|      two|
|        019|          103|  Steven Chen| 36|  Male| 62000|2015-08-01|12400.0|        1|      two|
|        020|          102|    Grace Kim| 32|Female| 53000|2018-11-01|10600.0|        1|      two|
+-----------+-------------+-------------+---+------+------+----------+-------+---------+---------+
```

Adding or Overriding columns :- Spark provides withColumn() to create new column or override existing column.

Adding static values columns :- Spark provides lit() to create a distributed static column.

Renaming existing columns :- Spark provides withColumnRenamed() to the same.

Multiple ways for Rename :- We can use expr() or selectExpr() as well for renaming columns (eg, selectExpr(employee_id as emp_id)

Downstream system :- Any system which is dependent on your output.

Note- It is never recommended to use spaces in the column names.

Remove columns from DataFrame :- use drop().

Limit : In case we need to get only few records and not full dataset.

In [1]:
```
# Spark Session
from pyspark.sql import SparkSession

spark = (
    SparkSession
    .builder
    .appName("Working with Strings & Dates")
    .master("local[*]")
    .getOrCreate()
)

spark
```

Out[1]:

SparkSession - in-memory

SparkContext

Spark UI

Version	`v3.3.0`
Master	`local[*]`
AppName	`Working with Strings & Dates`

In [2]:
```
# Emp Data & Schema

emp_data = [
    ["001","101","John Doe","30","Male","50000","2015-01-01"],
    ["002","101","Jane Smith","25","Female","45000","2016-02-15"],
    ["003","102","Bob Brown","35","Male","55000","2014-05-01"],
    ["004","102","Alice Lee","28","Female","48000","2017-09-30"],
    ["005","103","Jack Chan","40","Male","60000","2013-04-01"],
    ["006","103","Jill Wong","32","Female","52000","2018-07-01"],
    ["007","101","James Johnson","42","Male","70000","2012-03-15"],
    ["008","102","Kate Kim","29","Female","51000","2019-10-01"],
    ["009","103","Tom Tan","33","Male","58000","2016-06-01"],
    ["010","104","Lisa Lee","27","Female","47000","2018-08-01"],
    ["011","104","David Park","38","Male","65000","2015-11-01"],
    ["012","105","Susan Chen","31","Female","54000","2017-02-15"],
    ["013","106","Brian Kim","45","Male","75000","2011-07-01"],
    ["014","107","Emily Lee","26","Female","46000","2019-01-01"],
    ["015","106","Michael Lee","37","Male","63000","2014-09-30"],
    ["016","107","Kelly Zhang","30","Female","49000","2018-04-01"],
    ["017","105","George Wang","34","Male","57000","2016-03-15"],
    ["018","104","Nancy Liu","29","","50000","2017-06-01"],
    ["019","103","Steven Chen","36","Male","62000","2015-08-01"],
    ["020","102","Grace Kim","32","Female","53000","2018-11-01"]
]

emp_schema = "employee_id string, department_id string, name string, age string, gender string, salary string, hire_date str
```

In [3]:
```
# Create emp DataFrame

emp = spark.createDataFrame(data=emp_data, schema=emp_schema)
```

In [4]:

```
# Show emp dataframe (ACTION)

emp.show()
```

```
+-----------+-------------+-------------+---+------+------+----------+
|employee_id|department_id|         name|age|gender|salary| hire_date|
+-----------+-------------+-------------+---+------+------+----------+
|        001|          101|     John Doe| 30|  Male| 50000|2015-01-01|
|        002|          101|   Jane Smith| 25|Female| 45000|2016-02-15|
|        003|          102|    Bob Brown| 35|  Male| 55000|2014-05-01|
|        004|          102|    Alice Lee| 28|Female| 48000|2017-09-30|
|        005|          103|    Jack Chan| 40|  Male| 60000|2013-04-01|
|        006|          103|    Jill Wong| 32|Female| 52000|2018-07-01|
|        007|          101|James Johnson| 42|  Male| 70000|2012-03-15|
|        008|          102|     Kate Kim| 29|Female| 51000|2019-10-01|
|        009|          103|      Tom Tan| 33|  Male| 58000|2016-06-01|
|        010|          104|     Lisa Lee| 27|Female| 47000|2018-08-01|
|        011|          104|   David Park| 38|  Male| 65000|2015-11-01|
|        012|          105|   Susan Chen| 31|Female| 54000|2017-02-15|
|        013|          106|    Brian Kim| 45|  Male| 75000|2011-07-01|
|        014|          107|    Emily Lee| 26|Female| 46000|2019-01-01|
|        015|          106|  Michael Lee| 37|  Male| 63000|2014-09-30|
|        016|          107|  Kelly Zhang| 30|Female| 49000|2018-04-01|
|        017|          105|  George Wang| 34|  Male| 57000|2016-03-15|
|        018|          104|    Nancy Liu| 29|      | 50000|2017-06-01|
|        019|          103|  Steven Chen| 36|  Male| 62000|2015-08-01|
|        020|          102|    Grace Kim| 32|Female| 53000|2018-11-01|
+-----------+-------------+-------------+---+------+------+----------+
```

In [5]:

```
# Print Schema

emp.printSchema()
```

```
root
 |-- employee_id: string (nullable = true)
 |-- department_id: string (nullable = true)
 |-- name: string (nullable = true)
 |-- age: string (nullable = true)
 |-- gender: string (nullable = true)
 |-- salary: string (nullable = true)
 |-- hire_date: string (nullable = true)
```

In [50]:

```
# Case When
# select employee_id, name, age, salary, gender,
# case when gender = 'Male' then 'M' when gender = 'Female' then 'F' else null end as new_gender, hire_date from emp
from pyspark.sql.functions import when, col, expr

emp_gender_fixed = emp.withColumn("new_gender", when(col("gender") == 'Male', 'M')
                                  .when(col("gender") == 'Female', 'F')
                                  .otherwise(None)
                                  )

emp_gender_fixed_1 = emp.withColumn("new_gender", expr("case when gender = 'Male' then 'M' when gender = 'Female' then 'F' e
```

```
ed_1 = emp.withColumn("new_gender", expr("case when gender = 'Male' then 'M' when gender = 'Female' then 'F' else null end"))
```

In [51]:
```
emp_gender_fixed_1.show()
```

```
+-----------+-------------+-------------+---+------+------+----------+----------+
|employee_id|department_id|         name|age|gender|salary| hire_date|new_gender|
+-----------+-------------+-------------+---+------+------+----------+----------+
|        001|          101|     John Doe| 30|  Male| 50000|2015-01-01|         M|
|        002|          101|   Jane Smith| 25|Female| 45000|2016-02-15|         F|
|        003|          102|    Bob Brown| 35|  Male| 55000|2014-05-01|         M|
|        004|          102|    Alice Lee| 28|Female| 48000|2017-09-30|         F|
|        005|          103|    Jack Chan| 40|  Male| 60000|2013-04-01|         M|
|        006|          103|    Jill Wong| 32|Female| 52000|2018-07-01|         F|
|        007|          101|James Johnson| 42|  Male| 70000|2012-03-15|         M|
|        008|          102|     Kate Kim| 29|Female| 51000|2019-10-01|         F|
|        009|          103|      Tom Tan| 33|  Male| 58000|2016-06-01|         M|
|        010|          104|     Lisa Lee| 27|Female| 47000|2018-08-01|         F|
|        011|          104|   David Park| 38|  Male| 65000|2015-11-01|         M|
|        012|          105|   Susan Chen| 31|Female| 54000|2017-02-15|         F|
|        013|          106|    Brian Kim| 45|  Male| 75000|2011-07-01|         M|
|        014|          107|    Emily Lee| 26|Female| 46000|2019-01-01|         F|
|        015|          106|  Michael Lee| 37|  Male| 63000|2014-09-30|         M|
|        016|          107|  Kelly Zhang| 30|Female| 49000|2018-04-01|         F|
|        017|          105|  George Wang| 34|  Male| 57000|2016-03-15|         M|
|        018|          104|    Nancy Liu| 29|      | 50000|2017-06-01|      null|
|        019|          103|  Steven Chen| 36|  Male| 62000|2015-08-01|         M|
|        020|          102|    Grace Kim| 32|Female| 53000|2018-11-01|         F|
+-----------+-------------+-------------+---+------+------+----------+----------+
```

In [12]:
```
# Replace in Strings
# select employee_id, name, replace(name, 'J', 'Z') as new_name, age, salary, gender, new_gender, hire_date from emp_gender_j
from pyspark.sql.functions import regexp_replace

emp_name_fixed = emp_gender_fixed.withColumn("new_name", regexp_replace(col("name"), "J", "Z"))
```

In [13]:
```
emp_name_fixed.show()
```

```
+-----------+-------------+-------------+---+------+------+----------+----------+-------------+
|employee_id|department_id|         name|age|gender|salary| hire_date|new_gender|     new_name|
+-----------+-------------+-------------+---+------+------+----------+----------+-------------+
|        001|          101|     John Doe| 30|  Male| 50000|2015-01-01|         M|     Zohn Doe|
|        002|          101|   Jane Smith| 25|Female| 45000|2016-02-15|         F|   Zane Smith|
|        003|          102|    Bob Brown| 35|  Male| 55000|2014-05-01|         M|    Bob Brown|
|        004|          102|    Alice Lee| 28|Female| 48000|2017-09-30|         F|    Alice Lee|
|        005|          103|    Jack Chan| 40|  Male| 60000|2013-04-01|         M|    Zack Chan|
|        006|          103|    Jill Wong| 32|Female| 52000|2018-07-01|         F|    Zill Wong|
|        007|          101|James Johnson| 42|  Male| 70000|2012-03-15|         M|Zames Zohnson|
|        008|          102|     Kate Kim| 29|Female| 51000|2019-10-01|         F|     Kate Kim|
|        009|          103|      Tom Tan| 33|  Male| 58000|2016-06-01|         M|      Tom Tan|
|        010|          104|     Lisa Lee| 27|Female| 47000|2018-08-01|         F|     Lisa Lee|
|        011|          104|   David Park| 38|  Male| 65000|2015-11-01|         M|   David Park|
|        012|          105|   Susan Chen| 31|Female| 54000|2017-02-15|         F|   Susan Chen|
|        013|          106|    Brian Kim| 45|  Male| 75000|2011-07-01|         M|    Brian Kim|
|        014|          107|    Emily Lee| 26|Female| 46000|2019-01-01|         F|    Emily Lee|
|        015|          106|  Michael Lee| 37|  Male| 63000|2014-09-30|         M|  Michael Lee|
|        016|          107|  Kelly Zhang| 30|Female| 49000|2018-04-01|         F|  Kelly Zhang|
|        017|          105|  George Wang| 34|  Male| 57000|2016-03-15|         M|  George Wang|
|        018|          104|    Nancy Liu| 29|      | 50000|2017-06-01|      null|    Nancy Liu|
|        019|          103|  Steven Chen| 36|  Male| 62000|2015-08-01|         M|  Steven Chen|
|        020|          102|    Grace Kim| 32|Female| 53000|2018-11-01|         F|    Grace Kim|
+-----------+-------------+-------------+---+------+------+----------+----------+-------------+
```

In [14]:
```
# Convert Date
# select *,  to_date(hire_date, 'YYYY-MM-DD') as hire_date from emp_name_fixed
from pyspark.sql.functions import to_date

emp_date_fix = emp_name_fixed.withColumn("hire_date", to_date(col("hire_date"), 'yyyy-MM-dd'))
```

In [16]:
```
emp_date_fix.printSchema()
```

```
root
 |-- employee_id: string (nullable = true)
 |-- department_id: string (nullable = true)
 |-- name: string (nullable = true)
 |-- age: string (nullable = true)
 |-- gender: string (nullable = true)
 |-- salary: string (nullable = true)
 |-- hire_date: date (nullable = true)
 |-- new_gender: string (nullable = true)
 |-- new_name: string (nullable = true)
```

In [17]:
```
# Add Date Columns
# Add current_date, current_timestamp, extract year from hire_date
from pyspark.sql.functions import current_date, current_timestamp

emp_dated = emp_date_fix.withColumn("date_now", current_date()).withColumn("timestamp_now", current_timestamp())
```

In [19]:
```
emp_dated.show(truncate=False)
```

```
+-----------+-------------+-------------+---+------+------+----------+----------+-------------+----------+-------------------
------+
|employee_id|department_id|name         |age|gender|salary|hire_date |new_gender|new_name     |date_now  |timestamp_now
|
+-----------+-------------+-------------+---+------+------+----------+----------+-------------+----------+-------------------
------+
|001        |101          |John Doe     |30 |Male  |50000 |2015-01-01|M         |Zohn Doe     |2023-04-12|2023-04-12 07:57:3
0.22104|
|002        |101          |Jane Smith   |25 |Female|45000 |2016-02-15|F         |Zane Smith   |2023-04-12|2023-04-12 07:57:3
0.22104|
|003        |102          |Bob Brown    |35 |Male  |55000 |2014-05-01|M         |Bob Brown    |2023-04-12|2023-04-12 07:57:3
0.22104|
|004        |102          |Alice Lee    |28 |Female|48000 |2017-09-30|F         |Alice Lee    |2023-04-12|2023-04-12 07:57:3
0.22104|
|005        |103          |Jack Chan    |40 |Male  |60000 |2013-04-01|M         |Zack Chan    |2023-04-12|2023-04-12 07:57:3
0.22104|
|006        |103          |Jill Wong    |32 |Female|52000 |2018-07-01|F         |Zill Wong    |2023-04-12|2023-04-12 07:57:3
0.22104|
|007        |101          |James Johnson|42 |Male  |70000 |2012-03-15|M         |Zames Zohnson|2023-04-12|2023-04-12 07:57:3
0.22104|
|008        |102          |Kate Kim     |29 |Female|51000 |2019-10-01|F         |Kate Kim     |2023-04-12|2023-04-12 07:57:3
0.22104|
|009        |103          |Tom Tan      |33 |Male  |58000 |2016-06-01|M         |Tom Tan      |2023-04-12|2023-04-12 07:57:3
0.22104|
|010        |104          |Lisa Lee     |27 |Female|47000 |2018-08-01|F         |Lisa Lee     |2023-04-12|2023-04-12 07:57:3
0.22104|
|011        |104          |David Park   |38 |Male  |65000 |2015-11-01|M         |David Park   |2023-04-12|2023-04-12 07:57:3
0.22104|
|012        |105          |Susan Chen   |31 |Female|54000 |2017-02-15|F         |Susan Chen   |2023-04-12|2023-04-12 07:57:3
0.22104|
|013        |106          |Brian Kim    |45 |Male  |75000 |2011-07-01|M         |Brian Kim    |2023-04-12|2023-04-12 07:57:3
0.22104|
|014        |107          |Emily Lee    |26 |Female|46000 |2019-01-01|F         |Emily Lee    |2023-04-12|2023-04-12 07:57:3
0.22104|
|015        |106          |Michael Lee  |37 |Male  |63000 |2014-09-30|M         |Michael Lee  |2023-04-12|2023-04-12 07:57:3
0.22104|
.           .             .             .   .      .      .          .          .             .          .
|016        |107          |Kelly Zhang  |30 |Female|49000 |2018-04-01|F         |Kelly Zhang  |2023-04-12|2023-04-12 07:57:3
0.22104|
|017        |105          |George Wang  |34 |Male  |57000 |2016-03-15|M         |George Wang  |2023-04-12|2023-04-12 07:57:3
0.22104|
|018        |104          |Nancy Liu    |29 |      |50000 |2017-06-01|null      |Nancy Liu    |2023-04-12|2023-04-12 07:57:3
0.22104|
|019        |103          |Steven Chen  |36 |Male  |62000 |2015-08-01|M         |Steven Chen  |2023-04-12|2023-04-12 07:57:3
0.22104|
|020        |102          |Grace Kim    |32 |Female|53000 |2018-11-01|F         |Grace Kim    |2023-04-12|2023-04-12 07:57:3
0.22104|
+-----------+-------------+-------------+---+------+------+----------+----------+-------------+----------+-------------------
------+
```

In [27]:
```
# Drop Null gender records
emp_1 = emp_dated.na.drop()
```

In [23]:
```
emp_1.show()
```

```
+-----------+-------------+-------------+---+------+------+----------+----------+-------------+----------+-------------------
-+
|employee_id|department_id|         name|age|gender|salary| hire_date|new_gender|     new_name|  date_now|       timestamp_no
w|
+-----------+-------------+-------------+---+------+------+----------+----------+-------------+----------+-------------------
-+
|        001|          101|     John Doe| 30|  Male| 50000|2015-01-01|         M|     Zohn Doe|2023-04-12|2023-04-12 08:0
0:...|
|        002|          101|   Jane Smith| 25|Female| 45000|2016-02-15|         F|   Zane Smith|2023-04-12|2023-04-12 08:0
0:...|
|        003|          102|    Bob Brown| 35|  Male| 55000|2014-05-01|         M|    Bob Brown|2023-04-12|2023-04-12 08:0
0:...|
|        004|          102|    Alice Lee| 28|Female| 48000|2017-09-30|         F|    Alice Lee|2023-04-12|2023-04-12 08:0
0:...|
|        005|          103|    Jack Chan| 40|  Male| 60000|2013-04-01|         M|    Zack Chan|2023-04-12|2023-04-12 08:0
0:...|
|        006|          103|    Jill Wong| 32|Female| 52000|2018-07-01|         F|    Zill Wong|2023-04-12|2023-04-12 08:0
0:...|
|        007|          101|James Johnson| 42|  Male| 70000|2012-03-15|         M|Zames Zohnson|2023-04-12|2023-04-12 08:0
0:...|
|        008|          102|     Kate Kim| 29|Female| 51000|2019-10-01|         F|     Kate Kim|2023-04-12|2023-04-12 08:0
0:...|
|        009|          103|      Tom Tan| 33|  Male| 58000|2016-06-01|         M|      Tom Tan|2023-04-12|2023-04-12 08:0
0:...|
|        010|          104|     Lisa Lee| 27|Female| 47000|2018-08-01|         F|     Lisa Lee|2023-04-12|2023-04-12 08:0
0:...|
|        011|          104|   David Park| 38|  Male| 65000|2015-11-01|         M|   David Park|2023-04-12|2023-04-12 08:0
0:...|
|        012|          105|   Susan Chen| 31|Female| 54000|2017-02-15|         F|   Susan Chen|2023-04-12|2023-04-12 08:0
0:...|
|        013|          106|    Brian Kim| 45|  Male| 75000|2011-07-01|         M|    Brian Kim|2023-04-12|2023-04-12 08:0
0:...|
|        014|          107|    Emily Lee| 26|Female| 46000|2019-01-01|         F|    Emily Lee|2023-04-12|2023-04-12 08:0
0:...|

|        015|          106|  Michael Lee| 37|  Male| 63000|2014-09-30|         M|  Michael Lee|2023-04-12|2023-04-12 08:0
0:...|
|        016|          107|  Kelly Zhang| 30|Female| 49000|2018-04-01|         F|  Kelly Zhang|2023-04-12|2023-04-12 08:0
0:...|
|        017|          105|  George Wang| 34|  Male| 57000|2016-03-15|         M|  George Wang|2023-04-12|2023-04-12 08:0
0:...|
|        019|          103|  Steven Chen| 36|  Male| 62000|2015-08-01|         M|  Steven Chen|2023-04-12|2023-04-12 08:0
0:...|
|        020|          102|    Grace Kim| 32|Female| 53000|2018-11-01|         F|    Grace Kim|2023-04-12|2023-04-12 08:0
0:...|
+-----------+-------------+-------------+---+------+------+----------+----------+-------------+----------+-------------------
-+
```

In [33]:
```
# Fix Null values
# select *, nvl('new_gender', 'O') as new_gender from emp_dated
from pyspark.sql.functions import coalesce, lit

emp_null_df = emp_dated.withColumn("new_gender", coalesce(col("new_gender"), lit("O")))
```

In [34]:
```
emp_null_df.show()
```

```
+-----------+-------------+-------------+---+------+------+----------+----------+-------------+----------+-------------------
-+
|employee_id|department_id|         name|age|gender|salary| hire_date|new_gender|     new_name|  date_now|       timestamp_no
w|
+-----------+-------------+-------------+---+------+------+----------+----------+-------------+----------+-------------------
-+
|        001|          101|     John Doe| 30|  Male| 50000|2015-01-01|         M|     Zohn Doe|2023-04-12|2023-04-12 08:0
6:...|
|        002|          101|   Jane Smith| 25|Female| 45000|2016-02-15|         F|   Zane Smith|2023-04-12|2023-04-12 08:0
6:...|
|        003|          102|    Bob Brown| 35|  Male| 55000|2014-05-01|         M|    Bob Brown|2023-04-12|2023-04-12 08:0
6:...|
|        004|          102|    Alice Lee| 28|Female| 48000|2017-09-30|         F|    Alice Lee|2023-04-12|2023-04-12 08:0
6:...|
|        005|          103|    Jack Chan| 40|  Male| 60000|2013-04-01|         M|    Zack Chan|2023-04-12|2023-04-12 08:0
6:...|
|        006|          103|    Jill Wong| 32|Female| 52000|2018-07-01|         F|    Zill Wong|2023-04-12|2023-04-12 08:0
6:...|
|        007|          101|James Johnson| 42|  Male| 70000|2012-03-15|         M|Zames Zohnson|2023-04-12|2023-04-12 08:0
6:...|
|        008|          102|     Kate Kim| 29|Female| 51000|2019-10-01|         F|     Kate Kim|2023-04-12|2023-04-12 08:0
6:...|
|        009|          103|      Tom Tan| 33|  Male| 58000|2016-06-01|         M|      Tom Tan|2023-04-12|2023-04-12 08:0
6:...|
|        010|          104|     Lisa Lee| 27|Female| 47000|2018-08-01|         F|     Lisa Lee|2023-04-12|2023-04-12 08:0
6:...|
|        011|          104|   David Park| 38|  Male| 65000|2015-11-01|         M|   David Park|2023-04-12|2023-04-12 08:0
6:...|
|        012|          105|   Susan Chen| 31|Female| 54000|2017-02-15|         F|   Susan Chen|2023-04-12|2023-04-12 08:0
6:...|
|        013|          106|    Brian Kim| 45|  Male| 75000|2011-07-01|         M|    Brian Kim|2023-04-12|2023-04-12 08:0
6:...|
|        014|          107|    Emily Lee| 26|Female| 46000|2019-01-01|         F|    Emily Lee|2023-04-12|2023-04-12 08:0
6:...|
|        015|          106|  Michael Lee| 37|  Male| 63000|2014-09-30|         M|  Michael Lee|2023-04-12|2023-04-12 08:0

 |        016|          107|  Kelly Zhang| 30|Female| 49000|2018-04-01|         F|  Kelly Zhang|2023-04-12|2023-04-12 08:0
6:...|
|        017|          105|  George Wang| 34|  Male| 57000|2016-03-15|         M|  George Wang|2023-04-12|2023-04-12 08:0
6:...|
|        018|          104|    Nancy Liu| 29|      | 50000|2017-06-01|         O|    Nancy Liu|2023-04-12|2023-04-12 08:0
6:...|
|        019|          103|  Steven Chen| 36|  Male| 62000|2015-08-01|         M|  Steven Chen|2023-04-12|2023-04-12 08:0
6:...|
|        020|          102|    Grace Kim| 32|Female| 53000|2018-11-01|         F|    Grace Kim|2023-04-12|2023-04-12 08:0
6:...|
+-----------+-------------+-------------+---+------+------+----------+----------+-------------+----------+-------------------
-+
```

In [36]:
```
# Drop old columns and Fix new column names
emp_final = emp_null_df.drop("name", "gender").withColumnRenamed("new_name", "name").withColumnRenamed("new_gender", "gender"
```

In [37]:
```
emp_final.show()
```

```
+-----------+-------------+---+------+----------+------+-------------+----------+--------------------+
|employee_id|department_id|age|salary| hire_date|gender|         name|  date_now|       timestamp_now|
+-----------+-------------+---+------+----------+------+-------------+----------+--------------------+
|        001|          101| 30| 50000|2015-01-01|     M|     Zohn Doe|2023-04-12|2023-04-12 08:08:...|
|        002|          101| 25| 45000|2016-02-15|     F|   Zane Smith|2023-04-12|2023-04-12 08:08:...|
|        003|          102| 35| 55000|2014-05-01|     M|    Bob Brown|2023-04-12|2023-04-12 08:08:...|
|        004|          102| 28| 48000|2017-09-30|     F|    Alice Lee|2023-04-12|2023-04-12 08:08:...|
|        005|          103| 40| 60000|2013-04-01|     M|    Zack Chan|2023-04-12|2023-04-12 08:08:...|
|        006|          103| 32| 52000|2018-07-01|     F|    Zill Wong|2023-04-12|2023-04-12 08:08:...|
|        007|          101| 42| 70000|2012-03-15|     M|Zames Zohnson|2023-04-12|2023-04-12 08:08:...|
|        008|          102| 29| 51000|2019-10-01|     F|     Kate Kim|2023-04-12|2023-04-12 08:08:...|
|        009|          103| 33| 58000|2016-06-01|     M|      Tom Tan|2023-04-12|2023-04-12 08:08:...|
|        010|          104| 27| 47000|2018-08-01|     F|     Lisa Lee|2023-04-12|2023-04-12 08:08:...|
|        011|          104| 38| 65000|2015-11-01|     M|   David Park|2023-04-12|2023-04-12 08:08:...|
|        012|          105| 31| 54000|2017-02-15|     F|   Susan Chen|2023-04-12|2023-04-12 08:08:...|
|        013|          106| 45| 75000|2011-07-01|     M|    Brian Kim|2023-04-12|2023-04-12 08:08:...|
|        014|          107| 26| 46000|2019-01-01|     F|    Emily Lee|2023-04-12|2023-04-12 08:08:...|
|        015|          106| 37| 63000|2014-09-30|     M|  Michael Lee|2023-04-12|2023-04-12 08:08:...|
|        016|          107| 30| 49000|2018-04-01|     F|  Kelly Zhang|2023-04-12|2023-04-12 08:08:...|
|        017|          105| 34| 57000|2016-03-15|     M|  George Wang|2023-04-12|2023-04-12 08:08:...|
|        018|          104| 29| 50000|2017-06-01|     O|    Nancy Liu|2023-04-12|2023-04-12 08:08:...|
|        019|          103| 36| 62000|2015-08-01|     M|  Steven Chen|2023-04-12|2023-04-12 08:08:...|
|        020|          102| 32| 53000|2018-11-01|     F|    Grace Kim|2023-04-12|2023-04-12 08:08:...|
+-----------+-------------+---+------+----------+------+-------------+----------+--------------------+
```

In [38]:
```
# Write data as CSV
emp_final.write.format("csv").save("data/output/4/emp.csv")
```

In [47]:
```
# Bonus TIP
# Convert date into String and extract date information
from pyspark.sql.functions import date_format

emp_fixed = emp_final.withColumn("date_year", date_format(col("timestamp_now"), "z"))
```

In [48]:
```
emp_fixed.show()
```

```
+-----------+-------------+---+------+----------+------+-------------+----------+-------------------+---------+
|employee_id|department_id|age|salary| hire_date|gender|         name|  date_now|       timestamp_now|date_year|
+-----------+-------------+---+------+----------+------+-------------+----------+-------------------+---------+
|        001|          101| 30| 50000|2015-01-01|     M|     Zohn Doe|2023-04-12|2023-04-12 08:12:...|      UTC|
|        002|          101| 25| 45000|2016-02-15|     F|   Zane Smith|2023-04-12|2023-04-12 08:12:...|      UTC|
|        003|          102| 35| 55000|2014-05-01|     M|    Bob Brown|2023-04-12|2023-04-12 08:12:...|      UTC|
|        004|          102| 28| 48000|2017-09-30|     F|    Alice Lee|2023-04-12|2023-04-12 08:12:...|      UTC|
|        005|          103| 40| 60000|2013-04-01|     M|    Zack Chan|2023-04-12|2023-04-12 08:12:...|      UTC|
|        006|          103| 32| 52000|2018-07-01|     F|    Zill Wong|2023-04-12|2023-04-12 08:12:...|      UTC|
|        007|          101| 42| 70000|2012-03-15|     M|Zames Zohnson|2023-04-12|2023-04-12 08:12:...|      UTC|
|        008|          102| 29| 51000|2019-10-01|     F|     Kate Kim|2023-04-12|2023-04-12 08:12:...|      UTC|
|        009|          103| 33| 58000|2016-06-01|     M|      Tom Tan|2023-04-12|2023-04-12 08:12:...|      UTC|
|        010|          104| 27| 47000|2018-08-01|     F|     Lisa Lee|2023-04-12|2023-04-12 08:12:...|      UTC|
|        011|          104| 38| 65000|2015-11-01|     M|   David Park|2023-04-12|2023-04-12 08:12:...|      UTC|
|        012|          105| 31| 54000|2017-02-15|     F|   Susan Chen|2023-04-12|2023-04-12 08:12:...|      UTC|
|        013|          106| 45| 75000|2011-07-01|     M|    Brian Kim|2023-04-12|2023-04-12 08:12:...|      UTC|
|        014|          107| 26| 46000|2019-01-01|     F|    Emily Lee|2023-04-12|2023-04-12 08:12:...|      UTC|
|        015|          106| 37| 63000|2014-09-30|     M|  Michael Lee|2023-04-12|2023-04-12 08:12:...|      UTC|
|        016|          107| 30| 49000|2018-04-01|     F|  Kelly Zhang|2023-04-12|2023-04-12 08:12:...|      UTC|
|        017|          105| 34| 57000|2016-03-15|     M|  George Wang|2023-04-12|2023-04-12 08:12:...|      UTC|
|        018|          104| 29| 50000|2017-06-01|     O|    Nancy Liu|2023-04-12|2023-04-12 08:12:...|      UTC|
|        019|          103| 36| 62000|2015-08-01|     M|  Steven Chen|2023-04-12|2023-04-12 08:12:...|      UTC|
|        020|          102| 32| 53000|2018-11-01|     F|    Grace Kim|2023-04-12|2023-04-12 08:12:...|      UTC|
+-----------+-------------+---+------+----------+------+-------------+----------+-------------------+---------+
```

In [1]:
```
# Spark Session
from pyspark.sql import SparkSession

spark = (
    SparkSession
    .builder
    .appName("Sort Union & Aggregation")
    .master("local[*]")
    .getOrCreate()
)

spark
```

Out[1]:

SparkSession - in-memory

SparkContext

Spark UI

Version	`v3.3.0`
Master	`local[*]`
AppName	`Sort Union & Aggregation`

In [2]:
```
# Emp Data & Schema

emp_data_1 = [
    ["001","101","John Doe","30","Male","50000","2015-01-01"],
    ["002","101","Jane Smith","25","Female","45000","2016-02-15"],
    ["003","102","Bob Brown","35","Male","55000","2014-05-01"],
    ["004","102","Alice Lee","28","Female","48000","2017-09-30"],
    ["005","103","Jack Chan","40","Male","60000","2013-04-01"],
    ["006","103","Jill Wong","32","Female","52000","2018-07-01"],
    ["007","101","James Johnson","42","Male","70000","2012-03-15"],
    ["008","102","Kate Kim","29","Female","51000","2019-10-01"],
    ["009","103","Tom Tan","33","Male","58000","2016-06-01"],
    ["010","104","Lisa Lee","27","Female","47000","2018-08-01"]
]

emp_data_2 = [
    ["011","104","David Park","38","Male","65000","2015-11-01"],
    ["012","105","Susan Chen","31","Female","54000","2017-02-15"],
    ["013","106","Brian Kim","45","Male","75000","2011-07-01"],
    ["014","107","Emily Lee","26","Female","46000","2019-01-01"],
    ["015","106","Michael Lee","37","Male","63000","2014-09-30"],
    ["016","107","Kelly Zhang","30","Female","49000","2018-04-01"],
    ["017","105","George Wang","34","Male","57000","2016-03-15"],
    ["018","104","Nancy Liu","29","","50000","2017-06-01"],
    ["019","103","Steven Chen","36","Male","62000","2015-08-01"],
    ["020","102","Grace Kim","32","Female","53000","2018-11-01"]
]

emp_schema = "employee_id string, department_id string, name string, age string, gender string, salary string, hire_date stri
```

In [3]:
```
# Create emp DataFrame

emp_data_1 = spark.createDataFrame(data=emp_data_1, schema=emp_schema)
emp_data_2 = spark.createDataFrame(data=emp_data_2, schema=emp_schema)
```

In [4]:
```
# Show emp dataframe (ACTION)

emp_data_1.show()
emp_data_2.show()
```

```
+-----------+-------------+-------------+---+------+------+----------+
|employee_id|department_id|         name|age|gender|salary| hire_date|
+-----------+-------------+-------------+---+------+------+----------+
|        001|          101|     John Doe| 30|  Male| 50000|2015-01-01|
|        002|          101|   Jane Smith| 25|Female| 45000|2016-02-15|
|        003|          102|    Bob Brown| 35|  Male| 55000|2014-05-01|
|        004|          102|    Alice Lee| 28|Female| 48000|2017-09-30|
|        005|          103|    Jack Chan| 40|  Male| 60000|2013-04-01|
|        006|          103|    Jill Wong| 32|Female| 52000|2018-07-01|
|        007|          101|James Johnson| 42|  Male| 70000|2012-03-15|
|        008|          102|     Kate Kim| 29|Female| 51000|2019-10-01|
|        009|          103|      Tom Tan| 33|  Male| 58000|2016-06-01|
|        010|          104|     Lisa Lee| 27|Female| 47000|2018-08-01|
+-----------+-------------+-------------+---+------+------+----------+

+-----------+-------------+-----------+---+------+------+----------+
|employee_id|department_id|       name|age|gender|salary| hire_date|
+-----------+-------------+-----------+---+------+------+----------+
|        011|          104| David Park| 38|  Male| 65000|2015-11-01|
|        012|          105| Susan Chen| 31|Female| 54000|2017-02-15|
|        013|          106|  Brian Kim| 45|  Male| 75000|2011-07-01|
|        014|          107|  Emily Lee| 26|Female| 46000|2019-01-01|
|        015|          106|Michael Lee| 37|  Male| 63000|2014-09-30|
|        016|          107|Kelly Zhang| 30|Female| 49000|2018-04-01|
|        017|          105|George Wang| 34|  Male| 57000|2016-03-15|
|        018|          104|  Nancy Liu| 29|      | 50000|2017-06-01|
|        019|          103|Steven Chen| 36|  Male| 62000|2015-08-01|
|        020|          102|  Grace Kim| 32|Female| 53000|2018-11-01|
+-----------+-------------+-----------+---+------+------+----------+
```

In [5]:
```
# Print Schema

emp_data_1.printSchema()
emp_data_2.printSchema()
```

```
root
 |-- employee_id: string (nullable = true)
 |-- department_id: string (nullable = true)
 |-- name: string (nullable = true)
 |-- age: string (nullable = true)
 |-- gender: string (nullable = true)
 |-- salary: string (nullable = true)
 |-- hire_date: string (nullable = true)

root
 |-- employee_id: string (nullable = true)
 |-- department_id: string (nullable = true)
 |-- name: string (nullable = true)
 |-- age: string (nullable = true)
 |-- gender: string (nullable = true)
 |-- salary: string (nullable = true)
 |-- hire_date: string (nullable = true)
```

In [8]:
```
# UNION and UNION ALL
# select * from emp_data_1 UNION select * from emp_data_2
emp = emp_data_1.unionAll(emp_data_2)
```

In [9]:
```
emp.show()
```

```
+-----------+-------------+-------------+---+------+------+----------+
|employee_id|department_id|         name|age|gender|salary| hire_date|
+-----------+-------------+-------------+---+------+------+----------+
|        001|          101|     John Doe| 30|  Male| 50000|2015-01-01|
|        002|          101|   Jane Smith| 25|Female| 45000|2016-02-15|
|        003|          102|    Bob Brown| 35|  Male| 55000|2014-05-01|
|        004|          102|    Alice Lee| 28|Female| 48000|2017-09-30|
|        005|          103|    Jack Chan| 40|  Male| 60000|2013-04-01|
|        006|          103|    Jill Wong| 32|Female| 52000|2018-07-01|
|        007|          101|James Johnson| 42|  Male| 70000|2012-03-15|
|        008|          102|     Kate Kim| 29|Female| 51000|2019-10-01|
|        009|          103|      Tom Tan| 33|  Male| 58000|2016-06-01|
|        010|          104|     Lisa Lee| 27|Female| 47000|2018-08-01|
|        011|          104|   David Park| 38|  Male| 65000|2015-11-01|
|        012|          105|   Susan Chen| 31|Female| 54000|2017-02-15|
|        013|          106|    Brian Kim| 45|  Male| 75000|2011-07-01|
|        014|          107|    Emily Lee| 26|Female| 46000|2019-01-01|
|        015|          106|  Michael Lee| 37|  Male| 63000|2014-09-30|
|        016|          107|  Kelly Zhang| 30|Female| 49000|2018-04-01|
|        017|          105|  George Wang| 34|  Male| 57000|2016-03-15|
|        018|          104|    Nancy Liu| 29|      | 50000|2017-06-01|
|        019|          103|  Steven Chen| 36|  Male| 62000|2015-08-01|
|        020|          102|    Grace Kim| 32|Female| 53000|2018-11-01|
+-----------+-------------+-------------+---+------+------+----------+
```

In [17]:
```
# Sort the emp data based on desc Salary
# select * from emp order by salary desc
from pyspark.sql.functions import desc, asc, col

emp_sorted = emp.orderBy(col("salary").asc())
```

In [18]:
```
emp_sorted.show()
```

```
+-----------+-------------+-------------+---+------+------+----------+
|employee_id|department_id|         name|age|gender|salary| hire_date|
+-----------+-------------+-------------+---+------+------+----------+
|        002|          101|   Jane Smith| 25|Female| 45000|2016-02-15|
|        014|          107|    Emily Lee| 26|Female| 46000|2019-01-01|
|        010|          104|     Lisa Lee| 27|Female| 47000|2018-08-01|
|        004|          102|    Alice Lee| 28|Female| 48000|2017-09-30|
|        016|          107|  Kelly Zhang| 30|Female| 49000|2018-04-01|
|        001|          101|     John Doe| 30|  Male| 50000|2015-01-01|
|        018|          104|    Nancy Liu| 29|      | 50000|2017-06-01|
|        008|          102|     Kate Kim| 29|Female| 51000|2019-10-01|
|        006|          103|    Jill Wong| 32|Female| 52000|2018-07-01|
|        020|          102|    Grace Kim| 32|Female| 53000|2018-11-01|
|        012|          105|   Susan Chen| 31|Female| 54000|2017-02-15|
|        003|          102|    Bob Brown| 35|  Male| 55000|2014-05-01|
|        017|          105|  George Wang| 34|  Male| 57000|2016-03-15|
|        009|          103|      Tom Tan| 33|  Male| 58000|2016-06-01|
|        005|          103|    Jack Chan| 40|  Male| 60000|2013-04-01|
|        019|          103|  Steven Chen| 36|  Male| 62000|2015-08-01|
|        015|          106|  Michael Lee| 37|  Male| 63000|2014-09-30|
|        011|          104|   David Park| 38|  Male| 65000|2015-11-01|
|        007|          101|James Johnson| 42|  Male| 70000|2012-03-15|
|        013|          106|    Brian Kim| 45|  Male| 75000|2011-07-01|
+-----------+-------------+-------------+---+------+------+----------+
```

In [30]:
```
# Aggregation
# select dept_id, count(employee_id) as total_dept_count from emp_sorted group by dept_id
from pyspark.sql.functions import count

emp_count = emp_sorted.groupBy("department_id").agg(count("employee_id").alias("total_dept_count"))
```

In [31]:
```
emp_count.show()
```

```
+-------------+----------------+
|department_id|total_dept_count|
+-------------+----------------+
|          101|               3|
|          102|               4|
|          103|               4|
|          104|               3|
|          105|               2|
|          106|               2|
|          107|               2|
+-------------+----------------+
```

In [34]:
```
# Aggregation
# select dept_id, sum(salary) as total_dept_salary from emp_sorted group by dept_id
from pyspark.sql.functions import sum

emp_sum = emp_sorted.groupBy("department_id").agg(sum("salary").alias("total_dept_salary"))
```

In [35]:
```
emp_sum.show()
```

```
+-------------+-----------------+
|department_id|total_dept_salary|
+-------------+-----------------+
|          101|         165000.0|
|          107|          95000.0|
|          104|         162000.0|
|          102|         207000.0|
|          103|         232000.0|
|          106|         138000.0|
|          105|         111000.0|
+-------------+-----------------+
```

In [36]:
```
# Aggregation with having clause
# select dept_id, avg(salary) as avg_dept_salary from emp_sorted  group by dept_id having avg(salary) > 50000
from pyspark.sql.functions import avg

emp_avg = emp_sorted.groupBy("department_id").agg(avg("salary").alias("avg_dept_salary")).where("avg_dept_salary > 50000")
```

In [37]:
```
emp_avg.show()
```

```
+-------------+---------------+
|department_id|avg_dept_salary|
+-------------+---------------+
|          101|        55000.0|
|          104|        54000.0|
|          102|        51750.0|
|          103|        58000.0|
|          106|        69000.0|
|          105|        55500.0|
+-------------+---------------+
```

In [42]:
```
# Bonus TIP - unionByName
# In case the column sequence is different
emp_data_2_other = emp_data_2.select("employee_id", "salary", "department_id", "name", "hire_date", "gender", "age")

emp_data_1.printSchema()
emp_data_2_other.printSchema()
```

```
root
 |-- employee_id: string (nullable = true)
 |-- department_id: string (nullable = true)
 |-- name: string (nullable = true)
 |-- age: string (nullable = true)
 |-- gender: string (nullable = true)
 |-- salary: string (nullable = true)
 |-- hire_date: string (nullable = true)

root
 |-- employee_id: string (nullable = true)
 |-- salary: string (nullable = true)
 |-- department_id: string (nullable = true)
 |-- name: string (nullable = true)
 |-- hire_date: string (nullable = true)
 |-- gender: string (nullable = true)
 |-- age: string (nullable = true)
```

In [43]:
```
emp_fixed = emp_data_1.unionByName(emp_data_2_other)
```

In [ ]:
```
emp_fixed.show()
```

```
+-----------+-------------+-------------+---+------+------+----------+
|employee_id|department_id|         name|age|gender|salary| hire_date|
+-----------+-------------+-------------+---+------+------+----------+
|        001|          101|     John Doe| 30|  Male| 50000|2015-01-01|
|        002|          101|   Jane Smith| 25|Female| 45000|2016-02-15|
|        003|          102|    Bob Brown| 35|  Male| 55000|2014-05-01|
|        004|          102|    Alice Lee| 28|Female| 48000|2017-09-30|
|        005|          103|    Jack Chan| 40|  Male| 60000|2013-04-01|
|        006|          103|    Jill Wong| 32|Female| 52000|2018-07-01|
|        007|          101|James Johnson| 42|  Male| 70000|2012-03-15|
|        008|          102|     Kate Kim| 29|Female| 51000|2019-10-01|
|        009|          103|      Tom Tan| 33|  Male| 58000|2016-06-01|
|        010|          104|     Lisa Lee| 27|Female| 47000|2018-08-01|
|        011|          104|   David Park| 38|  Male| 65000|2015-11-01|
|        012|          105|   Susan Chen| 31|Female| 54000|2017-02-15|
|        013|          106|    Brian Kim| 45|  Male| 75000|2011-07-01|
|        014|          107|    Emily Lee| 26|Female| 46000|2019-01-01|
|        015|          106|  Michael Lee| 37|  Male| 63000|2014-09-30|
|        016|          107|  Kelly Zhang| 30|Female| 49000|2018-04-01|
|        017|          105|  George Wang| 34|  Male| 57000|2016-03-15|
|        018|          104|    Nancy Liu| 29|      | 50000|2017-06-01|
|        019|          103|  Steven Chen| 36|  Male| 62000|2015-08-01|
|        020|          102|    Grace Kim| 32|Female| 53000|2018-11-01|
+-----------+-------------+-------------+---+------+------+----------+
```

In [ ]:
```
emp.count()
```

Out[ ]: 20

Union vs UnionAll :- Union removed the duplicated from the combined dataset whereas UnionAll doesn't.

Using select or selectExpr- We can write the column aggregation expressions in select or selectExpr as well.

In [1]:
```python
# Spark Session
from pyspark.sql import SparkSession

spark = (
    SparkSession
    .builder
    .appName("Unique data & Window Functions")
    .master("local[*]")
    .getOrCreate()
)

spark
```

Out[1]:

SparkSession - in-memory

SparkContext

Spark UI

Version	`v3.3.0`
Master	`local[*]`
AppName	`Unique data & Window Functions`

In [2]:
```python
# Emp Data & Schema

emp_data = [
    ["001","101","John Doe","30","Male","50000","2015-01-01"],
    ["002","101","Jane Smith","25","Female","45000","2016-02-15"],
    ["003","102","Bob Brown","35","Male","55000","2014-05-01"],
    ["004","102","Alice Lee","28","Female","48000","2017-09-30"],
    ["005","103","Jack Chan","40","Male","60000","2013-04-01"],
    ["006","103","Jill Wong","32","Female","52000","2018-07-01"],
    ["007","101","James Johnson","42","Male","70000","2012-03-15"],
    ["008","102","Kate Kim","29","Female","51000","2019-10-01"],
    ["009","103","Tom Tan","33","Male","58000","2016-06-01"],
    ["010","104","Lisa Lee","27","Female","47000","2018-08-01"],
    ["011","104","David Park","38","Male","65000","2015-11-01"],
    ["012","105","Susan Chen","31","Female","54000","2017-02-15"],
    ["013","106","Brian Kim","45","Male","75000","2011-07-01"],
    ["014","107","Emily Lee","26","Female","46000","2019-01-01"],
    ["015","106","Michael Lee","37","Male","63000","2014-09-30"],
    ["016","107","Kelly Zhang","30","Female","49000","2018-04-01"],
    ["017","105","George Wang","34","Male","57000","2016-03-15"],
    ["018","104","Nancy Liu","29","","50000","2017-06-01"],
    ["019","103","Steven Chen","36","Male","62000","2015-08-01"],
    ["020","102","Grace Kim","32","Female","53000","2018-11-01"]
]

emp_schema = "employee_id string, department_id string, name string, age string, gender string, salary string, hire_date stri
```

In [3]:
```python
# Create emp DataFrame

emp = spark.createDataFrame(data=emp_data, schema=emp_schema)
```

In [4]:
```python
# Show emp dataframe (ACTION)

emp.show()
```

```
+-----------+-------------+-------------+---+------+------+----------+
|employee_id|department_id|         name|age|gender|salary| hire_date|
+-----------+-------------+-------------+---+------+------+----------+
|        001|          101|     John Doe| 30|  Male| 50000|2015-01-01|
|        002|          101|   Jane Smith| 25|Female| 45000|2016-02-15|
|        003|          102|    Bob Brown| 35|  Male| 55000|2014-05-01|
|        004|          102|    Alice Lee| 28|Female| 48000|2017-09-30|
|        005|          103|    Jack Chan| 40|  Male| 60000|2013-04-01|
|        006|          103|    Jill Wong| 32|Female| 52000|2018-07-01|
|        007|          101|James Johnson| 42|  Male| 70000|2012-03-15|
|        008|          102|     Kate Kim| 29|Female| 51000|2019-10-01|
|        009|          103|      Tom Tan| 33|  Male| 58000|2016-06-01|
|        010|          104|     Lisa Lee| 27|Female| 47000|2018-08-01|
|        011|          104|   David Park| 38|  Male| 65000|2015-11-01|
|        012|          105|   Susan Chen| 31|Female| 54000|2017-02-15|
|        013|          106|    Brian Kim| 45|  Male| 75000|2011-07-01|
|        014|          107|    Emily Lee| 26|Female| 46000|2019-01-01|
|        015|          106|  Michael Lee| 37|  Male| 63000|2014-09-30|
|        016|          107|  Kelly Zhang| 30|Female| 49000|2018-04-01|
|        017|          105|  George Wang| 34|  Male| 57000|2016-03-15|
|        018|          104|    Nancy Liu| 29|      | 50000|2017-06-01|
|        019|          103|  Steven Chen| 36|  Male| 62000|2015-08-01|
|        020|          102|    Grace Kim| 32|Female| 53000|2018-11-01|
+-----------+-------------+-------------+---+------+------+----------+
```

In [5]:
```
# Print Schema

emp.printSchema()
```

```
root
 |-- employee_id: string (nullable = true)
 |-- department_id: string (nullable = true)
 |-- name: string (nullable = true)
 |-- age: string (nullable = true)
 |-- gender: string (nullable = true)
 |-- salary: string (nullable = true)
 |-- hire_date: string (nullable = true)
```

In [6]:
```
# Get unique data
# select distinct emp.* from emp
emp_unique = emp.distinct()
```

In [7]:
```
emp_unique.show()
```

```
+-----------+-------------+-------------+---+------+------+----------+
|employee_id|department_id|         name|age|gender|salary| hire_date|
+-----------+-------------+-------------+---+------+------+----------+
|        001|          101|     John Doe| 30|  Male| 50000|2015-01-01|
|        002|          101|   Jane Smith| 25|Female| 45000|2016-02-15|
|        003|          102|    Bob Brown| 35|  Male| 55000|2014-05-01|
|        004|          102|    Alice Lee| 28|Female| 48000|2017-09-30|
|        005|          103|    Jack Chan| 40|  Male| 60000|2013-04-01|
|        006|          103|    Jill Wong| 32|Female| 52000|2018-07-01|
|        007|          101|James Johnson| 42|  Male| 70000|2012-03-15|
|        010|          104|     Lisa Lee| 27|Female| 47000|2018-08-01|
|        009|          103|      Tom Tan| 33|  Male| 58000|2016-06-01|
|        008|          102|     Kate Kim| 29|Female| 51000|2019-10-01|
|        012|          105|   Susan Chen| 31|Female| 54000|2017-02-15|
|        011|          104|   David Park| 38|  Male| 65000|2015-11-01|
|        014|          107|    Emily Lee| 26|Female| 46000|2019-01-01|
|        013|          106|    Brian Kim| 45|  Male| 75000|2011-07-01|
|        015|          106|  Michael Lee| 37|  Male| 63000|2014-09-30|
|        016|          107|  Kelly Zhang| 30|Female| 49000|2018-04-01|
|        019|          103|  Steven Chen| 36|  Male| 62000|2015-08-01|
|        017|          105|  George Wang| 34|  Male| 57000|2016-03-15|
|        018|          104|    Nancy Liu| 29|      | 50000|2017-06-01|
|        020|          102|    Grace Kim| 32|Female| 53000|2018-11-01|
+-----------+-------------+-------------+---+------+------+----------+
```

In [ ]:
```
# Unique of department_ids
# select distinct department_id from emp
emp_dept_id = emp.select("department_id").distinct()
```

In [ ]:
```
emp_dept_id.show()
```

```
+-------------+
|department_id|
+-------------+
|          101|
|          102|
|          103|
|          104|
|          105|
|          107|
|          106|
+-------------+
```

In [14]:
```
# Window Functions
# select *, max(salary) over(partition by department_id order by salary desc) as max_salary from emp_unique
from pyspark.sql.window import Window
from pyspark.sql.functions import max, col, desc

window_spec = Window.partitionBy(col("department_id")).orderBy(col("salary").desc())
max_func = max(col("salary")).over(window_spec)

emp_1 = emp.withColumn("max_salary", max_func)
```

In [18]:
```
emp_1.show()

# Window Functions - 2nd highest salary of each department
# select *, row_number() over(partition by department_id order by salary desc) as rn from emp_unique where rn = 2
from pyspark.sql.window import Window
from pyspark.sql.functions import row_number, desc, col

window_spec = Window.partitionBy(col("department_id")).orderBy(col("salary").desc())
rn = row_number().over(window_spec)

emp_2 = emp.withColumn("rn", rn).where("rn = 2")
```

```
+-----------+-------------+-------------+---+------+------+----------+----------+
|employee_id|department_id|         name|age|gender|salary| hire_date|max_salary|
+-----------+-------------+-------------+---+------+------+----------+----------+
|        007|          101|James Johnson| 42|  Male| 70000|2012-03-15|     70000|
|        001|          101|     John Doe| 30|  Male| 50000|2015-01-01|     70000|
|        002|          101|   Jane Smith| 25|Female| 45000|2016-02-15|     70000|
|        003|          102|    Bob Brown| 35|  Male| 55000|2014-05-01|     55000|
|        020|          102|    Grace Kim| 32|Female| 53000|2018-11-01|     55000|
|        008|          102|     Kate Kim| 29|Female| 51000|2019-10-01|     55000|
|        004|          102|    Alice Lee| 28|Female| 48000|2017-09-30|     55000|
|        019|          103|  Steven Chen| 36|  Male| 62000|2015-08-01|     62000|
|        005|          103|    Jack Chan| 40|  Male| 60000|2013-04-01|     62000|
|        009|          103|      Tom Tan| 33|  Male| 58000|2016-06-01|     62000|
|        006|          103|    Jill Wong| 32|Female| 52000|2018-07-01|     62000|
|        011|          104|   David Park| 38|  Male| 65000|2015-11-01|     65000|
|        018|          104|    Nancy Liu| 29|      | 50000|2017-06-01|     65000|
|        010|          104|     Lisa Lee| 27|Female| 47000|2018-08-01|     65000|
|        017|          105|  George Wang| 34|  Male| 57000|2016-03-15|     57000|
|        012|          105|   Susan Chen| 31|Female| 54000|2017-02-15|     57000|
|        013|          106|    Brian Kim| 45|  Male| 75000|2011-07-01|     75000|
|        015|          106|  Michael Lee| 37|  Male| 63000|2014-09-30|     75000|
|        016|          107|  Kelly Zhang| 30|Female| 49000|2018-04-01|     49000|
|        014|          107|    Emily Lee| 26|Female| 46000|2019-01-01|     49000|
+-----------+-------------+-------------+---+------+------+----------+----------+
```

In [19]:
```
emp_2.show()
```

```
+-----------+-------------+-----------+---+------+------+----------+---+
|employee_id|department_id|       name|age|gender|salary| hire_date| rn|
+-----------+-------------+-----------+---+------+------+----------+---+
|        001|          101|   John Doe| 30|  Male| 50000|2015-01-01|  2|
|        020|          102|  Grace Kim| 32|Female| 53000|2018-11-01|  2|
|        005|          103|  Jack Chan| 40|  Male| 60000|2013-04-01|  2|
|        018|          104|  Nancy Liu| 29|      | 50000|2017-06-01|  2|
|        012|          105| Susan Chen| 31|Female| 54000|2017-02-15|  2|
|        015|          106|Michael Lee| 37|  Male| 63000|2014-09-30|  2|
|        014|          107|  Emily Lee| 26|Female| 46000|2019-01-01|  2|
+-----------+-------------+-----------+---+------+------+----------+---+
```

In [22]:
```
# Window function using expr
# select *, row_number() over(partition by department_id order by salary desc) as rn from emp_unique where rn = 2
from pyspark.sql.functions import expr

emp_3 = emp.withColumn("rn", expr("row_number() over(partition by department_id order by salary desc)")).where("rn = 2")
```

In [22]:
```
# Window function using expr
# select *, row_number() over(partition by department_id order by salary desc) as rn from emp_unique where rn = 2
from pyspark.sql.functions import expr

emp_3 = emp.withColumn("rn", expr("row_number() over(partition by department_id order by salary desc)")).where("rn = 2")
```

In [23]:
```
emp_3.show()
```

```
+-----------+-------------+-----------+---+------+------+----------+---+
|employee_id|department_id|       name|age|gender|salary| hire_date| rn|
+-----------+-------------+-----------+---+------+------+----------+---+
|        001|          101|   John Doe| 30|  Male| 50000|2015-01-01|  2|
|        020|          102|  Grace Kim| 32|Female| 53000|2018-11-01|  2|
|        005|          103|  Jack Chan| 40|  Male| 60000|2013-04-01|  2|
|        018|          104|  Nancy Liu| 29|      | 50000|2017-06-01|  2|
|        012|          105| Susan Chen| 31|Female| 54000|2017-02-15|  2|
|        015|          106|Michael Lee| 37|  Male| 63000|2014-09-30|  2|
|        014|          107|  Emily Lee| 26|Female| 46000|2019-01-01|  2|
+-----------+-------------+-----------+---+------+------+----------+---+
```

In [ ]:
```
# Bonus TIP
# Databricks community cloud
```

Unique and Distinct data from selected column.

Window or Analytical Functions :- Applies aggregate and ranking functions over a particular window(set of rows).

Expr() function for the rescue:- In case anytime PySpark API looks difficult, we can use SQL in expr functions easily.

In [1]:
```
# Spark Session
from pyspark.sql import SparkSession

spark = (
    SparkSession
    .builder
    .appName("Joins and Data Partitions")
    .master("local[*]")
    .getOrCreate()
)

spark
```

Out[1]:

SparkSession - in-memory

SparkContext

Spark UI

Version	`v3.3.0`
Master	`local[*]`
AppName	`Joins and Data Partitions`

In [2]:

```
# Emp Data & Schema

emp_data = [
    ["001","101","John Doe","30","Male","50000","2015-01-01"],
    ["002","101","Jane Smith","25","Female","45000","2016-02-15"],
    ["003","102","Bob Brown","35","Male","55000","2014-05-01"],
    ["004","102","Alice Lee","28","Female","48000","2017-09-30"],
    ["005","103","Jack Chan","40","Male","60000","2013-04-01"],
    ["006","103","Jill Wong","32","Female","52000","2018-07-01"],
    ["007","101","James Johnson","42","Male","70000","2012-03-15"],
    ["008","102","Kate Kim","29","Female","51000","2019-10-01"],
    ["009","103","Tom Tan","33","Male","58000","2016-06-01"],
    ["010","104","Lisa Lee","27","Female","47000","2018-08-01"],
    ["011","104","David Park","38","Male","65000","2015-11-01"],
    ["012","105","Susan Chen","31","Female","54000","2017-02-15"],
    ["013","106","Brian Kim","45","Male","75000","2011-07-01"],
    ["014","107","Emily Lee","26","Female","46000","2019-01-01"],
    ["015","106","Michael Lee","37","Male","63000","2014-09-30"],
    ["016","107","Kelly Zhang","30","Female","49000","2018-04-01"],
    ["017","105","George Wang","34","Male","57000","2016-03-15"],
    ["018","104","Nancy Liu","29","","50000","2017-06-01"],
    ["019","103","Steven Chen","36","Male","62000","2015-08-01"],
    ["020","102","Grace Kim","32","Female","53000","2018-11-01"]
]

emp_schema = "employee_id string, department_id string, name string, age string, gender string, salary string, hire_date str

dept_data = [
    ["101", "Sales", "NYC", "US", "1000000"],
    ["102", "Marketing", "LA", "US", "900000"],
    ["103", "Finance", "London", "UK", "1200000"],
    ["104", "Engineering", "Beijing", "China", "1500000"],
    ["105", "Human Resources", "Tokyo", "Japan", "800000"],
    ["106", "Research and Development", "Perth", "Australia", "1100000"],
    ["107", "Customer Service", "Sydney", "Australia", "950000"]
]

dept_schema = "department_id string, department_name string, city string, country string, budget string"
```

In [3]:

```
# Create emp & dept DataFrame

emp = spark.createDataFrame(data=emp_data, schema=emp_schema)
dept = spark.createDataFrame(data=dept_data, schema=dept_schema)
```

In [4]:

```
# Show emp dataframe (ACTION)

emp.show()
dept.show()
```

```
+-----------+-------------+-------------+---+------+------+----------+
|employee_id|department_id|         name|age|gender|salary| hire_date|
+-----------+-------------+-------------+---+------+------+----------+
|        001|          101|     John Doe| 30|  Male| 50000|2015-01-01|
|        002|          101|   Jane Smith| 25|Female| 45000|2016-02-15|
|        003|          102|    Bob Brown| 35|  Male| 55000|2014-05-01|
|        004|          102|    Alice Lee| 28|Female| 48000|2017-09-30|
|        005|          103|    Jack Chan| 40|  Male| 60000|2013-04-01|
|        006|          103|    Jill Wong| 32|Female| 52000|2018-07-01|
|        007|          101|James Johnson| 42|  Male| 70000|2012-03-15|
|        008|          102|     Kate Kim| 29|Female| 51000|2019-10-01|
|        009|          103|      Tom Tan| 33|  Male| 58000|2016-06-01|
|        010|          104|     Lisa Lee| 27|Female| 47000|2018-08-01|
|        011|          104|   David Park| 38|  Male| 65000|2015-11-01|
|        012|          105|   Susan Chen| 31|Female| 54000|2017-02-15|
|        013|          106|    Brian Kim| 45|  Male| 75000|2011-07-01|
|        014|          107|    Emily Lee| 26|Female| 46000|2019-01-01|
|        015|          106|  Michael Lee| 37|  Male| 63000|2014-09-30|
|        016|          107|  Kelly Zhang| 30|Female| 49000|2018-04-01|
|        017|          105|  George Wang| 34|  Male| 57000|2016-03-15|
|        018|          104|    Nancy Liu| 29|      | 50000|2017-06-01|
|        019|          103|  Steven Chen| 36|  Male| 62000|2015-08-01|
|        020|          102|    Grace Kim| 32|Female| 53000|2018-11-01|
+-----------+-------------+-------------+---+------+------+----------+
```

```
dept.show()
```

```
+-----------+-------------+-------------+---+------+------+----------+
|employee_id|department_id|         name|age|gender|salary| hire_date|
+-----------+-------------+-------------+---+------+------+----------+
|        001|          101|     John Doe| 30|  Male| 50000|2015-01-01|
|        002|          101|   Jane Smith| 25|Female| 45000|2016-02-15|
|        003|          102|    Bob Brown| 35|  Male| 55000|2014-05-01|
|        004|          102|    Alice Lee| 28|Female| 48000|2017-09-30|
|        005|          103|    Jack Chan| 40|  Male| 60000|2013-04-01|
|        006|          103|    Jill Wong| 32|Female| 52000|2018-07-01|
|        007|          101|James Johnson| 42|  Male| 70000|2012-03-15|
|        008|          102|     Kate Kim| 29|Female| 51000|2019-10-01|
|        009|          103|      Tom Tan| 33|  Male| 58000|2016-06-01|
|        010|          104|     Lisa Lee| 27|Female| 47000|2018-08-01|
|        011|          104|   David Park| 38|  Male| 65000|2015-11-01|
|        012|          105|   Susan Chen| 31|Female| 54000|2017-02-15|
|        013|          106|    Brian Kim| 45|  Male| 75000|2011-07-01|
|        014|          107|    Emily Lee| 26|Female| 46000|2019-01-01|
|        015|          106|  Michael Lee| 37|  Male| 63000|2014-09-30|
|        016|          107|  Kelly Zhang| 30|Female| 49000|2018-04-01|
|        017|          105|  George Wang| 34|  Male| 57000|2016-03-15|
|        018|          104|    Nancy Liu| 29|      | 50000|2017-06-01|
|        019|          103|  Steven Chen| 36|  Male| 62000|2015-08-01|
|        020|          102|    Grace Kim| 32|Female| 53000|2018-11-01|
+-----------+-------------+-------------+---+------+------+----------+
```

```
+-------------+--------------------+-------+---------+-------+
|department_id|     department_name|   city|  country| budget|
+-------------+--------------------+-------+---------+-------+
|          101|               Sales|    NYC|       US|1000000|
|          102|           Marketing|     LA|       US| 900000|
|          103|             Finance| London|       UK|1200000|
|          104|         Engineering|Beijing|    China|1500000|
|          105|     Human Resources|  Tokyo|    Japan| 800000|
|          106|Research and Deve...|  Perth|Australia|1100000|
|          107|    Customer Service| Sydney|Australia| 950000|
+-------------+--------------------+-------+---------+-------+
```

In [5]:
```
# Print Schema

emp.printSchema()
dept.printSchema()
```

```
root
 |-- employee_id: string (nullable = true)
 |-- department_id: string (nullable = true)
 |-- name: string (nullable = true)
 |-- age: string (nullable = true)
 |-- gender: string (nullable = true)
 |-- salary: string (nullable = true)
 |-- hire_date: string (nullable = true)

root
 |-- department_id: string (nullable = true)
 |-- department_name: string (nullable = true)
 |-- city: string (nullable = true)
 |-- country: string (nullable = true)
 |-- budget: string (nullable = true)
```

In [6]:
```
# Get number of partitions for emp
emp.rdd.getNumPartitions()
```

Out[6]: 8

In [7]:
```
# Get number of partitions for dept
dept.rdd.getNumPartitions()
```

Out[7]: 8

In [22]:
```
# Repartition of data using repartition & coalesce
emp_partitioned = emp.repartition(4, "department_id")
```

In [23]:
```
emp_partitioned.rdd.getNumPartitions()
```

Out[23]: 4

In [26]:
```
# Find the partition info for partitions and reparition
from pyspark.sql.functions import spark_partition_id

emp_1 = emp.repartition(4, "department_id").withColumn("partition_num", spark_partition_id())
```

In [27]:
```
emp_1.show()
```

```
+-----------+-------------+-------------+---+------+------+----------+-------------+
|employee_id|department_id|         name|age|gender|salary| hire_date|partition_num|
+-----------+-------------+-------------+---+------+------+----------+-------------+
|        003|          102|    Bob Brown| 35|  Male| 55000|2014-05-01|            0|
|        004|          102|    Alice Lee| 28|Female| 48000|2017-09-30|            0|
|        008|          102|     Kate Kim| 29|Female| 51000|2019-10-01|            0|
|        014|          107|    Emily Lee| 26|Female| 46000|2019-01-01|            0|
|        016|          107|  Kelly Zhang| 30|Female| 49000|2018-04-01|            0|
|        020|          102|    Grace Kim| 32|Female| 53000|2018-11-01|            0|
|        012|          105|   Susan Chen| 31|Female| 54000|2017-02-15|            1|
|        017|          105|  George Wang| 34|  Male| 57000|2016-03-15|            1|
|        010|          104|     Lisa Lee| 27|Female| 47000|2018-08-01|            2|
|        011|          104|   David Park| 38|  Male| 65000|2015-11-01|            2|
|        013|          106|    Brian Kim| 45|  Male| 75000|2011-07-01|            2|
|        015|          106|  Michael Lee| 37|  Male| 63000|2014-09-30|            2|
|        018|          104|    Nancy Liu| 29|      | 50000|2017-06-01|            2|
|        001|          101|     John Doe| 30|  Male| 50000|2015-01-01|            3|
|        002|          101|   Jane Smith| 25|Female| 45000|2016-02-15|            3|
|        005|          103|    Jack Chan| 40|  Male| 60000|2013-04-01|            3|
|        006|          103|    Jill Wong| 32|Female| 52000|2018-07-01|            3|
|        007|          101|James Johnson| 42|  Male| 70000|2012-03-15|            3|
|        009|          103|      Tom Tan| 33|  Male| 58000|2016-06-01|            3|
|        019|          103|  Steven Chen| 36|  Male| 62000|2015-08-01|            3|
+-----------+-------------+-------------+---+------+------+----------+-------------+
```

In [33]:
```
# INNER JOIN datasets
# select e.emp_name, d.department_name, d.department_id, e.salary
# from emp e inner join dept d on emp.department_id = dept.department_id

df_joined = emp.alias("e").join(dept.alias("d"), how="inner", on=emp.department_id==dept.department_id)
```

In [35]:
```
df_joined.select("e.name", "d.department_id", "d.department_name", "e.salary").show()
```

```
+-------------+-------------+--------------------+------+
|         name|department_id|     department_name|salary|
+-------------+-------------+--------------------+------+
|     John Doe|          101|               Sales| 50000|
|   Jane Smith|          101|               Sales| 45000|
|James Johnson|          101|               Sales| 70000|
|    Bob Brown|          102|           Marketing| 55000|
|    Alice Lee|          102|           Marketing| 48000|
|     Kate Kim|          102|           Marketing| 51000|
|    Grace Kim|          102|           Marketing| 53000|
|    Jack Chan|          103|             Finance| 60000|
|    Jill Wong|          103|             Finance| 52000|
|      Tom Tan|          103|             Finance| 58000|
|  Steven Chen|          103|             Finance| 62000|
|     Lisa Lee|          104|         Engineering| 47000|
|   David Park|          104|         Engineering| 65000|
|    Nancy Liu|          104|         Engineering| 50000|
|   Susan Chen|          105|     Human Resources| 54000|
|  George Wang|          105|     Human Resources| 57000|
|    Brian Kim|          106|Research and Deve...| 75000|
|  Michael Lee|          106|Research and Deve...| 63000|
|    Emily Lee|          107|    Customer Service| 46000|
|  Kelly Zhang|          107|    Customer Service| 49000|
+-------------+-------------+--------------------+------+
```

In [36]:
```
# LEFT OUTER JOIN datasets
# select e.emp_name, d.department_name, d.department_id, e.salary
# from emp e left outer join dept d on emp.department_id = dept.department_id

df_joined = emp.alias("e").join(dept.alias("d"), how="left_outer", on=emp.department_id==dept.department_id)
```

In [38]:
```
df_joined.select("e.name", "d.department_name", "d.department_id", "e.salary").show()
```

```
+-------------+--------------------+-------------+------+
|         name|     department_name|department_id|salary|
+-------------+--------------------+-------------+------+
|     John Doe|               Sales|          101| 50000|
|   Jane Smith|               Sales|          101| 45000|
|    Bob Brown|           Marketing|          102| 55000|
|    Alice Lee|           Marketing|          102| 48000|
|    Jack Chan|             Finance|          103| 60000|
|    Jill Wong|             Finance|          103| 52000|
|James Johnson|               Sales|          101| 70000|
|     Lisa Lee|         Engineering|          104| 47000|
|     Kate Kim|           Marketing|          102| 51000|
|      Tom Tan|             Finance|          103| 58000|
|   David Park|         Engineering|          104| 65000|
|   Susan Chen|     Human Resources|          105| 54000|
|    Emily Lee|    Customer Service|          107| 46000|
|    Brian Kim|Research and Deve...|          106| 75000|
|  Kelly Zhang|    Customer Service|          107| 49000|
|  Michael Lee|Research and Deve...|          106| 63000|
|    Nancy Liu|         Engineering|          104| 50000|
|    Grace Kim|           Marketing|          102| 53000|
|  Steven Chen|             Finance|          103| 62000|
|  George Wang|     Human Resources|          105| 57000|
+-------------+--------------------+-------------+------+
```

In [41]:
```
# Write the final dataset
df_joined.select("e.name", "d.department_name", "d.department_id","e.salary").write.format("csv").save("data/output/7/emp_jo
```

In [52]:
```
# Bonus TIP
# Joins with cascading conditions
# Join with Department_id and only for departments 101 or 102
# Join with not null/null conditions

df_final = emp.join(dept, how="left_outer",
                    on=(emp.department_id==dept.department_id) & ((emp.department_id == "101") | (emp.department_id == "102"
                     & (emp.salary.isNull())
                    )
```

In [53]:
```
df_final.show()
```

```
+-----------+-------------+-------------+---+------+------+----------+-------------+---------------+----+-------+------+
|employee_id|department_id|         name|age|gender|salary| hire_date|department_id|department_name|city|country|budget|
+-----------+-------------+-------------+---+------+------+----------+-------------+---------------+----+-------+------+
|        001|          101|     John Doe| 30|  Male| 50000|2015-01-01|         null|           null|null|   null|  null|
|        002|          101|   Jane Smith| 25|Female| 45000|2016-02-15|         null|           null|null|   null|  null|
|        003|          102|    Bob Brown| 35|  Male| 55000|2014-05-01|         null|           null|null|   null|  null|
|        004|          102|    Alice Lee| 28|Female| 48000|2017-09-30|         null|           null|null|   null|  null|
|        005|          103|    Jack Chan| 40|  Male| 60000|2013-04-01|         null|           null|null|   null|  null|
|        006|          103|    Jill Wong| 32|Female| 52000|2018-07-01|         null|           null|null|   null|  null|
|        007|          101|James Johnson| 42|  Male| 70000|2012-03-15|         null|           null|null|   null|  null|
|        010|          104|     Lisa Lee| 27|Female| 47000|2018-08-01|         null|           null|null|   null|  null|
|        008|          102|     Kate Kim| 29|Female| 51000|2019-10-01|         null|           null|null|   null|  null|
|        009|          103|      Tom Tan| 33|  Male| 58000|2016-06-01|         null|           null|null|   null|  null|
|        011|          104|   David Park| 38|  Male| 65000|2015-11-01|         null|           null|null|   null|  null|
|        012|          105|   Susan Chen| 31|Female| 54000|2017-02-15|         null|           null|null|   null|  null|
|        014|          107|    Emily Lee| 26|Female| 46000|2019-01-01|         null|           null|null|   null|  null|
|        013|          106|    Brian Kim| 45|  Male| 75000|2011-07-01|         null|           null|null|   null|  null|
|        016|          107|  Kelly Zhang| 30|Female| 49000|2018-04-01|         null|           null|null|   null|  null|
|        015|          106|  Michael Lee| 37|  Male| 63000|2014-09-30|         null|           null|null|   null|  null|
|        018|          104|    Nancy Liu| 29|      | 50000|2017-06-01|         null|           null|null|   null|  null|
|        020|          102|    Grace Kim| 32|Female| 53000|2018-11-01|         null|           null|null|   null|  null|
|        019|          103|  Steven Chen| 36|  Male| 62000|2015-08-01|         null|           null|null|   null|  null|
|        017|          105|  George Wang| 34|  Male| 57000|2016-03-15|         null|           null|null|   null|  null|
+-----------+-------------+-------------+---+------+------+----------+-------------+---------------+----+-------+------+
```

Coalesce vs Repartitions:-

Repartition involves data shuffling, whereas Coalesce doesn’t.

Repartition can increase or decrease partition numbers but Coalesce can only decrease not increase.

Repartition allows uniform data distribution, but Coalesce can't guarantee it.

In [10]:
```
# Spark Session
from pyspark.sql import SparkSession

spark = (
    SparkSession
    .builder
    .appName("Reading from CSV Files")
    .master("local[*]")
    .getOrCreate()
)

spark
```

Out[10]:

SparkSession - in-memory

SparkContext

Spark UI

Version	`v3.3.0`
Master	`local[*]`
AppName	`Reading from CSV Files`

In [13]:
```
# Read a csv file into dataframe

df = spark.read.format("csv").option("header", True).option("inferSchema", True).load("data/input/emp.csv")
```

In [14]:
```
df.printSchema()
```

```
root
 |-- employee_id: integer (nullable = true)
 |-- department_id: integer (nullable = true)
 |-- name: string (nullable = true)
 |-- age: integer (nullable = true)
 |-- gender: string (nullable = true)
 |-- salary: integer (nullable = true)
 |-- hire_date: timestamp (nullable = true)
```

In [15]:
```
df.show()
```

```
+-----------+-------------+-------------+---+------+------+-------------------+
|employee_id|department_id|         name|age|gender|salary|          hire_date|
+-----------+-------------+-------------+---+------+------+-------------------+
|          1|          101|     John Doe| 30|  Male| 50000|2015-01-01 00:00:00|
|          2|          101|   Jane Smith| 25|Female| 45000|2016-02-15 00:00:00|
|          3|          102|    Bob Brown| 35|  Male| 55000|2014-05-01 00:00:00|
|          4|          102|    Alice Lee| 28|Female| 48000|2017-09-30 00:00:00|
|          5|          103|    Jack Chan| 40|  Male| 60000|2013-04-01 00:00:00|
|          6|          103|    Jill Wong| 32|Female| 52000|2018-07-01 00:00:00|
|          7|          101|James Johnson| 42|  Male| 70000|2012-03-15 00:00:00|
|          8|          102|     Kate Kim| 29|Female| 51000|2019-10-01 00:00:00|
|          9|          103|      Tom Tan| 33|  Male| 58000|2016-06-01 00:00:00|
|         10|          104|     Lisa Lee| 27|Female| 47000|2018-08-01 00:00:00|
|         11|          104|   David Park| 38|  Male| 65000|2015-11-01 00:00:00|
|         12|          105|   Susan Chen| 31|Female| 54000|2017-02-15 00:00:00|
|         13|          106|    Brian Kim| 45|  Male| 75000|2011-07-01 00:00:00|
|         14|          107|    Emily Lee| 26|Female| 46000|2019-01-01 00:00:00|
|         15|          106|  Michael Lee| 37|  Male| 63000|2014-09-30 00:00:00|
|         16|          107|  Kelly Zhang| 30|Female| 49000|2018-04-01 00:00:00|
|         17|          105|  George Wang| 34|  Male| 57000|2016-03-15 00:00:00|
|         18|          104|    Nancy Liu| 29|Female| 50000|2017-06-01 00:00:00|
|         19|          103|  Steven Chen| 36|  Male| 62000|2015-08-01 00:00:00|
|         20|          102|    Grace Kim| 32|Female| 53000|2018-11-01 00:00:00|
+-----------+-------------+-------------+---+------+------+-------------------+
```

In [18]:
```
# Reading with Schema
_schema = "employee_id int, department_id int, name string, age int, gender string, salary double, hire_date date"

df_schema = spark.read.format("csv").option("header",True).schema(_schema).load("data/input/emp.csv")
```

In [19]:
```
df_schema.show()
```

```
+-----------+-------------+-------------+---+------+-------+----------+
|employee_id|department_id|         name|age|gender| salary| hire_date|
+-----------+-------------+-------------+---+------+-------+----------+
|          1|          101|     John Doe| 30|  Male|50000.0|2015-01-01|
|          2|          101|   Jane Smith| 25|Female|45000.0|2016-02-15|
|          3|          102|    Bob Brown| 35|  Male|55000.0|2014-05-01|
|          4|          102|    Alice Lee| 28|Female|48000.0|2017-09-30|
|          5|          103|    Jack Chan| 40|  Male|60000.0|2013-04-01|
|          6|          103|    Jill Wong| 32|Female|52000.0|2018-07-01|
|          7|          101|James Johnson| 42|  Male|70000.0|2012-03-15|
|          8|          102|     Kate Kim| 29|Female|51000.0|2019-10-01|
|          9|          103|      Tom Tan| 33|  Male|58000.0|2016-06-01|
|         10|          104|     Lisa Lee| 27|Female|47000.0|2018-08-01|
|         11|          104|   David Park| 38|  Male|65000.0|2015-11-01|
|         12|          105|   Susan Chen| 31|Female|54000.0|2017-02-15|
|         13|          106|    Brian Kim| 45|  Male|75000.0|2011-07-01|
|         14|          107|    Emily Lee| 26|Female|46000.0|2019-01-01|
|         15|          106|  Michael Lee| 37|  Male|63000.0|2014-09-30|
|         16|          107|  Kelly Zhang| 30|Female|49000.0|2018-04-01|
|         17|          105|  George Wang| 34|  Male|57000.0|2016-03-15|
|         18|          104|    Nancy Liu| 29|Female|50000.0|2017-06-01|
|         19|          103|  Steven Chen| 36|  Male|62000.0|2015-08-01|
|         20|          102|    Grace Kim| 32|Female|53000.0|2018-11-01|
+-----------+-------------+-------------+---+------+-------+----------+
```

In [36]:
```
# Handle BAD records - PERMISSIVE (Default mode)

_schema = "employee_id int, department_id int, name string, age int, gender string, salary double, hire_date date, bad_recor

df_p = spark.read.format("csv").schema(_schema).option("columnNameOfCorruptRecord", "bad_record").option("header", True).loa
```

In [37]:
```
df_p.printSchema()
```

```
root
 |-- employee_id: integer (nullable = true)
 |-- department_id: integer (nullable = true)
 |-- name: string (nullable = true)
 |-- age: integer (nullable = true)
 |-- gender: string (nullable = true)
 |-- salary: double (nullable = true)
 |-- hire_date: date (nullable = true)
 |-- bad_record: string (nullable = true)
```

In [38]:
```
df_p.show()
```

```
+-----------+-------------+-------------+---+------+-------+----------+--------------------+
|employee_id|department_id|         name|age|gender| salary| hire_date|          bad_record|
+-----------+-------------+-------------+---+------+-------+----------+--------------------+
|          1|          101|     John Doe| 30|  Male|50000.0|2015-01-01|                null|
|          2|          101|   Jane Smith| 25|Female|45000.0|2016-02-15|                null|
|          3|          102|    Bob Brown| 35|  Male|55000.0|2014-05-01|                null|
|          4|          102|    Alice Lee| 28|Female|48000.0|2017-09-30|                null|
|          5|          103|    Jack Chan| 40|  Male|60000.0|2013-04-01|                null|
|          6|          103|    Jill Wong| 32|Female|52000.0|2018-07-01|                null|
|          7|          101|James Johnson| 42|  Male|   null|2012-03-15|007,101,James Joh...|
|          8|          102|     Kate Kim| 29|Female|51000.0|2019-10-01|                null|
|          9|          103|      Tom Tan| 33|  Male|58000.0|2016-06-01|                null|
|         10|          104|     Lisa Lee| 27|Female|47000.0|2018-08-01|                null|
|         11|          104|   David Park| 38|  Male|65000.0|      null|011,104,David Par...|
|         12|          105|   Susan Chen| 31|Female|54000.0|2017-02-15|                null|
|         13|          106|    Brian Kim| 45|  Male|75000.0|2011-07-01|                null|
|         14|          107|    Emily Lee| 26|Female|46000.0|2019-01-01|                null|
|         15|          106|  Michael Lee| 37|  Male|63000.0|2014-09-30|                null|
|         16|          107|  Kelly Zhang| 30|Female|49000.0|2018-04-01|                null|
|         17|          105|  George Wang| 34|  Male|57000.0|2016-03-15|                null|
|         18|          104|    Nancy Liu| 29|Female|50000.0|2017-06-01|                null|
|         19|          103|  Steven Chen| 36|  Male|62000.0|2015-08-01|                null|
|         20|          102|    Grace Kim| 32|Female|53000.0|2018-11-01|                null|
+-----------+-------------+-------------+---+------+-------+----------+--------------------+
```

In [44]:
```
# Handle BAD records - DROPMALFORMED
_schema = "employee_id int, department_id int, name string, age int, gender string, salary double, hire_date date"

df_m = spark.read.format("csv").option("header", True).option("mode", "DROPMALFORMED").schema(_schema).load("data/input/emp_
```

In [45]:
```
df_m.printSchema()
```

```
root
 |-- employee_id: integer (nullable = true)
 |-- department_id: integer (nullable = true)
 |-- name: string (nullable = true)
 |-- age: integer (nullable = true)
 |-- gender: string (nullable = true)
 |-- salary: double (nullable = true)
 |-- hire_date: date (nullable = true)
```

In [46]:
```
df_m.show()
```

```
+-----------+-------------+-----------+---+------+-------+----------+
|employee_id|department_id|       name|age|gender| salary| hire_date|
+-----------+-------------+-----------+---+------+-------+----------+
|          1|          101|   John Doe| 30|  Male|50000.0|2015-01-01|
|          2|          101| Jane Smith| 25|Female|45000.0|2016-02-15|
|          3|          102|  Bob Brown| 35|  Male|55000.0|2014-05-01|
|          4|          102|  Alice Lee| 28|Female|48000.0|2017-09-30|
|          5|          103|  Jack Chan| 40|  Male|60000.0|2013-04-01|
|          6|          103|  Jill Wong| 32|Female|52000.0|2018-07-01|
|          8|          102|   Kate Kim| 29|Female|51000.0|2019-10-01|
|          9|          103|    Tom Tan| 33|  Male|58000.0|2016-06-01|
|         10|          104|   Lisa Lee| 27|Female|47000.0|2018-08-01|
|         12|          105| Susan Chen| 31|Female|54000.0|2017-02-15|
|         13|          106|  Brian Kim| 45|  Male|75000.0|2011-07-01|
|         14|          107|  Emily Lee| 26|Female|46000.0|2019-01-01|
|         15|          106|Michael Lee| 37|  Male|63000.0|2014-09-30|
|         16|          107|Kelly Zhang| 30|Female|49000.0|2018-04-01|
|         17|          105|George Wang| 34|  Male|57000.0|2016-03-15|
|         18|          104|  Nancy Liu| 29|Female|50000.0|2017-06-01|
|         19|          103|Steven Chen| 36|  Male|62000.0|2015-08-01|
|         20|          102|  Grace Kim| 32|Female|53000.0|2018-11-01|
+-----------+-------------+-----------+---+------+-------+----------+
```

In [47]:
```
# Handle BAD records - FAILFAST

_schema = "employee_id int, department_id int, name string, age int, gender string, salary double, hire_date date"

df_m = spark.read.format("csv").option("header", True).option("mode", "FAILFAST").schema(_schema).load("data/input/emp_new.
```

In [48]:
```
df_m.printSchema()
```

```
root
 |-- employee_id: integer (nullable = true)
 |-- department_id: integer (nullable = true)
 |-- name: string (nullable = true)
 |-- age: integer (nullable = true)
 |-- gender: string (nullable = true)
 |-- salary: double (nullable = true)
 |-- hire_date: date (nullable = true)
```

In [49]:
```
df_m.show()
```

```
---------------------------------------------------------------------------
Py4JJavaError                             Traceback (most recent call last)
Cell In[49], line 1
----> 1 df_m.show()

File /spark/python/pyspark/sql/dataframe.py:606, in DataFrame.show(self, n, truncate, vertical)
    603     raise TypeError("Parameter 'vertical' must be a bool")
    605 if isinstance(truncate, bool) and truncate:
--> 606     print(self._jdf.showString(n, 20, vertical))
    607 else:
    608     try:

File /spark/python/lib/py4j-0.10.9.5-src.zip/py4j/java_gateway.py:1321, in JavaMember.__call__(self, *args)
   1315 command = proto.CALL_COMMAND_NAME +\
   1316     self.command_header +\
   1317     args_command +\
   1318     proto.END_COMMAND_PART
```

In [50]:
```
# BONUS TIP
# Multiple options

_options = {
    "header" : "true",
    "inferSchema" : "true",
    "mode" : "PERMISSIVE"
}

df = (spark.read.format("csv").options(**_options).load("data/input/emp.csv"))
```

In [51]:
```
df.show()
```

```
+-----------+-------------+-------------+---+------+------+-------------------+
|employee_id|department_id|         name|age|gender|salary|          hire_date|
+-----------+-------------+-------------+---+------+------+-------------------+
|          1|          101|     John Doe| 30|  Male| 50000|2015-01-01 00:00:00|
|          2|          101|   Jane Smith| 25|Female| 45000|2016-02-15 00:00:00|
|          3|          102|    Bob Brown| 35|  Male| 55000|2014-05-01 00:00:00|
|          4|          102|    Alice Lee| 28|Female| 48000|2017-09-30 00:00:00|
|          5|          103|    Jack Chan| 40|  Male| 60000|2013-04-01 00:00:00|
|          6|          103|    Jill Wong| 32|Female| 52000|2018-07-01 00:00:00|
|          7|          101|James Johnson| 42|  Male| 70000|2012-03-15 00:00:00|
|          8|          102|     Kate Kim| 29|Female| 51000|2019-10-01 00:00:00|
|          9|          103|      Tom Tan| 33|  Male| 58000|2016-06-01 00:00:00|
|         10|          104|     Lisa Lee| 27|Female| 47000|2018-08-01 00:00:00|
|         11|          104|   David Park| 38|  Male| 65000|2015-11-01 00:00:00|
|         12|          105|   Susan Chen| 31|Female| 54000|2017-02-15 00:00:00|
|         13|          106|    Brian Kim| 45|  Male| 75000|2011-07-01 00:00:00|
|         14|          107|    Emily Lee| 26|Female| 46000|2019-01-01 00:00:00|
|         15|          106|  Michael Lee| 37|  Male| 63000|2014-09-30 00:00:00|
|         16|          107|  Kelly Zhang| 30|Female| 49000|2018-04-01 00:00:00|
|         17|          105|  George Wang| 34|  Male| 57000|2016-03-15 00:00:00|
|         18|          104|    Nancy Liu| 29|Female| 50000|2017-06-01 00:00:00|
|         19|          103|  Steven Chen| 36|  Male| 62000|2015-08-01 00:00:00|
|         20|          102|    Grace Kim| 32|Female| 53000|2018-11-01 00:00:00|
+-----------+-------------+-------------+---+------+------+-------------------+
```

In [9]:
```
spark.stop()
```

How many jobs created when we specify the schema during data read?

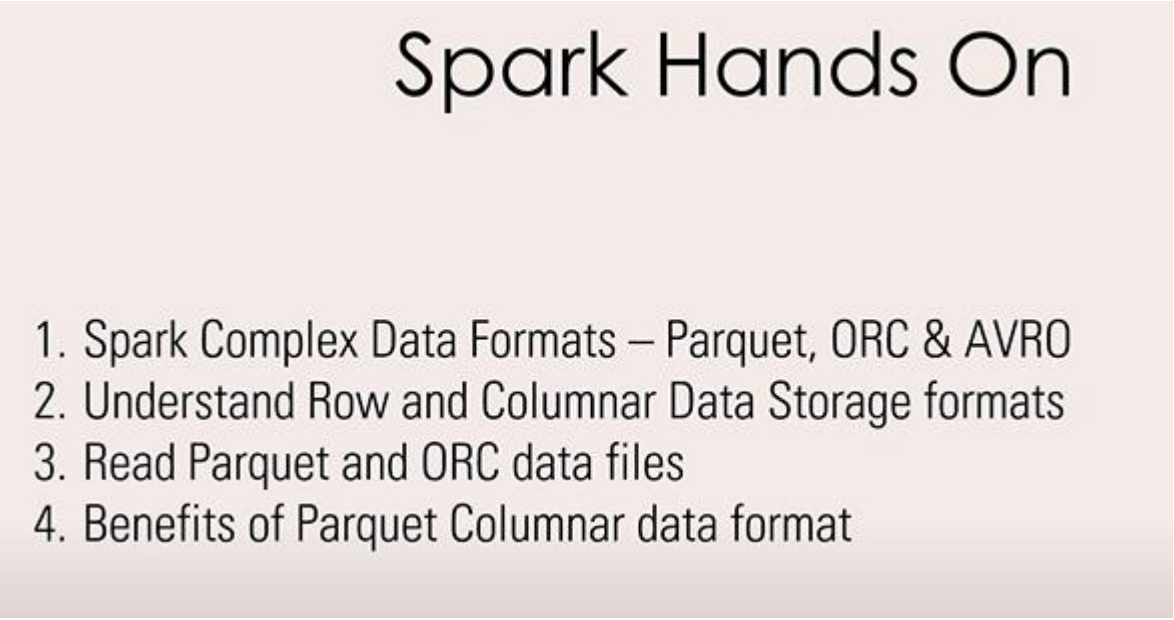
- **When you specify the schema during data reading in Apache Spark, no additional jobs are created for schema inference. This behavior can significantly improve performance because schema inference requires Spark to scan part of the data, which would otherwise trigger additional jobs.**

Read Mode for csv:- Useful to handle Bad Records, Schema is mandatory.

Permissive Mode:- Default Mode for data read. We don't need to specify mode explicitly in code.

Drop Malformed Mode:- Drops the Bad Records.

Fail Fast Mode:- Fails the Job as soon a Bad Record is identified.



In [1]:
```
# Spark Session
from pyspark.sql import SparkSession

spark = (
    SparkSession
    .builder
    .appName("Reading Complex Data Formats")
    .master("local[*]")
    .getOrCreate()
)

spark
```

Out[1]:

SparkSession - in-memory

SparkContext

Spark UI

Version	`v3.3.0`
Master	`local[*]`
AppName	`Reading Complex Data Formats`

In [8]:
```
# Read Parquet Sales data

df_parquet = spark.read.format("parquet").load("data/input/sales_total_parquet/*.parquet")
```

In [9]:
```
df_parquet.printSchema()
```

```
root
 |-- transacted_at: timestamp (nullable = true)
 |-- trx_id: integer (nullable = true)
 |-- retailer_id: integer (nullable = true)
 |-- description: string (nullable = true)
 |-- amount: double (nullable = true)
 |-- city_id: integer (nullable = true)
```

In [10]:
```
df_parquet.show()
```

```
+-------------------+----------+-----------+--------------------+-------+----------+
|      transacted_at|    trx_id|retailer_id|         description| amount|   city_id|
+-------------------+----------+-----------+--------------------+-------+----------+
|2017-12-27 19:00:00| 330765426|  887300947|Kroger   ccd id: ...|  33.56|2068475652|
|2017-11-26 21:00:00|1377679664| 1070485878|Amazon.com    ccd...|  24.43|1640819540|
|2017-12-12 23:00:00| 472018705| 2001148981|  unkn      Columbia|   1.24| 481821583|
|2017-05-19 19:00:00|1127671830|  847200066|            Wal-Mart|2155.48|2074005445|
|2017-11-17 21:00:00| 233137169|  847200066|            Wal-Mart|   4.13|2043825401|
|2017-12-15 12:00:00| 603124844|  887300947|Kroger   ccd id: ...|  31.92|1640819540|
|2017-11-08 12:00:00|1591888712|  143327090|  Menard       11-08|   42.3|2043825401|
|2017-12-23 12:00:00|1775468459|  887300947|Kroger  arc id: 1...|  284.8|2055198208|
|2017-09-01 13:00:00|1020833609| 2120842315|Burger King   ccd...|   20.2|1141716004|
|2017-11-30 12:00:00|1714628652| 1898522855|Target    ppd id:...| 488.42| 569532635|
|2017-11-26 23:00:00|1533320464|   62988535|Bed Bath & Beyond...|    6.1|1098014353|
|2017-11-28 21:00:00|2057742958|  562903918|McDonald's     pp...|2051.68|1487857621|
|2017-01-25 19:00:00| 123604891|  847200066|Wal-Mart    ccd i...|  23.53|  45522086|
|2017-05-21 21:00:00|1660120794|  865681996|Nordstrom     arc...| 708.81|  28424447|
|2017-12-18 22:00:00|1882911667|  997626433|Sears        Anka...| 160.29|1698762556|
|2017-11-24 20:00:00| 734317675|  511877722|Best Buy    arc i...| 1104.7|2001708947|
|2017-12-21 18:00:00| 513313448|  887300947|unkn    arc id: 9...|   32.7|2023698313|
|2017-12-13 19:00:00|1380128813|  582210968|unkn     ppd id: ...|  19.88|1359730291|
|2017-11-15 20:00:00| 941860469|  887300947|Kroger     arc id...|  55.69|  31398417|
|2017-12-06 23:00:00|1957163946|  400404203|unkn   arc id: 97...|   9.24|1284771958|
+-------------------+----------+-----------+--------------------+-------+----------+
only showing top 20 rows
```

In [11]:
```
# Read ORC Sales data

df_orc = spark.read.format("orc").load("data/input/sales_total_orc/*.orc")
```

In [12]:
```
df_orc.printSchema()
```

```
root
 |-- transacted_at: timestamp (nullable = true)
 |-- trx_id: integer (nullable = true)
 |-- retailer_id: integer (nullable = true)
 |-- description: string (nullable = true)
 |-- amount: double (nullable = true)
 |-- city_id: integer (nullable = true)
```

In [13]:
```
df_orc.show()
```

```
+-------------------+----------+-----------+--------------------+-------+----------+
|      transacted_at|    trx_id|retailer_id|         description| amount|   city_id|
+-------------------+----------+-----------+--------------------+-------+----------+
|2017-12-27 19:00:00| 330765426|  887300947|Kroger   ccd id: ...|  33.56|2068475652|
|2017-11-26 21:00:00|1377679664| 1070485878|Amazon.com    ccd...|  24.43|1640819540|
|2017-12-12 23:00:00| 472018705| 2001148981|  unkn      Columbia|   1.24| 481821583|
|2017-05-19 19:00:00|1127671830|  847200066|            Wal-Mart|2155.48|2074005445|
|2017-11-17 21:00:00| 233137169|  847200066|            Wal-Mart|   4.13|2043825401|
|2017-12-15 12:00:00| 603124844|  887300947|Kroger   ccd id: ...|  31.92|1640819540|
|2017-11-08 12:00:00|1591888712|  143327090|  Menard       11-08|   42.3|2043825401|
|2017-12-23 12:00:00|1775468459|  887300947|Kroger  arc id: 1...|  284.8|2055198208|
|2017-09-01 13:00:00|1020833609| 2120842315|Burger King   ccd...|   20.2|1141716004|
|2017-11-30 12:00:00|1714628652| 1898522855|Target    ppd id:...| 488.42| 569532635|
|2017-11-26 23:00:00|1533320464|   62988535|Bed Bath & Beyond...|    6.1|1098014353|
|2017-11-28 21:00:00|2057742958|  562903918|McDonald's     pp...|2051.68|1487857621|
|2017-01-25 19:00:00| 123604891|  847200066|Wal-Mart    ccd i...|  23.53|  45522086|
|2017-05-21 21:00:00|1660120794|  865681996|Nordstrom     arc...| 708.81|  28424447|
|2017-12-18 22:00:00|1882911667|  997626433|Sears        Anka...| 160.29|1698762556|
|2017-11-24 20:00:00| 734317675|  511877722|Best Buy    arc i...| 1104.7|2001708947|
|2017-12-21 18:00:00| 513313448|  887300947|unkn    arc id: 9...|   32.7|2023698313|
|2017-12-13 19:00:00|1380128813|  582210968|unkn     ppd id: ...|  19.88|1359730291|
|2017-11-15 20:00:00| 941860469|  887300947|Kroger     arc id...|  55.69|  31398417|
|2017-12-06 23:00:00|1957163946|  400404203|unkn   arc id: 97...|   9.24|1284771958|
+-------------------+----------+-----------+--------------------+-------+----------+
only showing top 20 rows
```

In [15]:
```
# Benefits of Columnar Storage

# Lets create a simple Python decorator - {get_time} to get the execution timings
# If you dont know about Python decorators - check out : https://www.geeksforgeeks.org/decorators-in-python/
import time

def get_time(func):
    def inner_get_time() -> str:
        start_time = time.time()
        func()
        end_time = time.time()
        return (f"Execution time: {(end_time - start_time)*1000} ms")
    print(inner_get_time())
```

In [16]:
```
@get_time
def x():
    df = spark.read.format("parquet").load("data/input/sales_data.parquet")
    df.count()
```

```
Execution time: 672.5492477416992 ms
```

In [17]:
```
@get_time
def x():
    df = spark.read.format("parquet").load("data/input/sales_data.parquet")
    df.select("trx_id").count()
```

```
Execution time: 348.848819732666 ms
```

In [ ]:
```
# BONUS TIP
# RECURSIVE READ

sales_recursive
|__ sales_1\1.parquet
|__ sales_1\sales_2\2.parquet
```

In [18]:
```
df_1 = spark.read.format("parquet").load("data/input/sales_recursive/sales_1/1.parquet")
df_1.show()
```

```
+-------------------+----------+-----------+--------------------+------+---------+
|      transacted_at|    trx_id|retailer_id|         description|amount|  city_id|
+-------------------+----------+-----------+--------------------+------+---------+
|2017-11-24 19:00:00|1734117021|  644879053|unkn    ppd id: 7...|  8.58|930259917|
+-------------------+----------+-----------+--------------------+------+---------+
```

In [19]:
```
df_1 = spark.read.format("parquet").load("data/input/sales_recursive/sales_1/sales_2/2.parquet")
df_1.show()
```

```
+-------------------+----------+-----------+--------------------+------+--------+
|      transacted_at|    trx_id|retailer_id|         description|amount| city_id|
+-------------------+----------+-----------+--------------------+------+--------+
|2017-11-24 19:00:00|1734117123| 1953761884|unkn   ppd id: 15...| 19.55|45522086|
+-------------------+----------+-----------+--------------------+------+--------+
```

In [22]:
```
df_1 = spark.read.format("parquet").option("recursiveFileLookup", True).load("data/input/sales_recursive/")
df_1.show()
```

```
+-------------------+----------+-----------+--------------------+------+---------+
|      transacted_at|    trx_id|retailer_id|         description|amount|  city_id|
+-------------------+----------+-----------+--------------------+------+---------+
|2017-11-24 19:00:00|1734117123| 1953761884|unkn   ppd id: 15...| 19.55| 45522086|
|2017-11-24 19:00:00|1734117021|  644879053|unkn    ppd id: 7...|  8.58|930259917|
+-------------------+----------+-----------+--------------------+------+---------+
```

Row vs Columnar Data Format

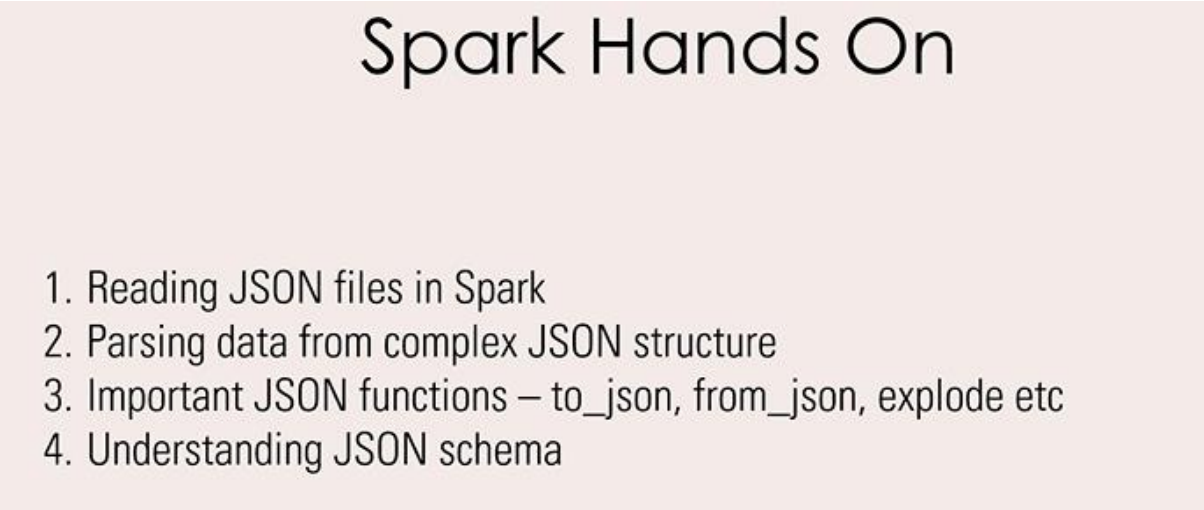
Benefit of Columnar Format:- The columnar format lets the reader read, decompress, and process only the columns that are required for the current query.

Parquet vs ORC vs AVRO

PROP/FILE FORMAT	PARQUET	ORC	AVRO
COMPRESSION	BETTER	BEST	GOOD
READ/WRITE	READ	HEAVY READ	WRITE
ROW/COLUMNAR	COLUMN	COLUMN	ROW
SCHEMA EVOLUTION	GOOD	BETTER	BEST
EXAMPLE USE	DELTA LAKE/SPARK	HIVE	KAFKA

Parquet stores the data along with the data.

Demo for Columnar Data Benefit:- Performance benefit while reading Columnar data.



In [1]:
```
# Spark Session
from pyspark.sql import SparkSession

spark = (
    SparkSession
    .builder
    .appName("Reading and Parsing JSON Files/Data")
    .master("local[*]")
    .getOrCreate()
)

spark
```

Out[1]:

SparkSession - in-memory

SparkContext

Spark UI

Version	`v3.3.0`
Master	`local[*]`
AppName	`Reading and Parsing JSON Files/Data`

In [2]:
```
# Read Single line JSON file

df_single = spark.read.format("json").load("data/input/order_singleline.json")
```

In [3]:
```
df_single.printSchema()
```

```
root
 |-- contact: array (nullable = true)
 |    |-- element: long (containsNull = true)
 |-- customer_id: string (nullable = true)
 |-- order_id: string (nullable = true)
 |-- order_line_items: array (nullable = true)
 |    |-- element: struct (containsNull = true)
 |    |    |-- amount: double (nullable = true)
 |    |    |-- item_id: string (nullable = true)
 |    |    |-- qty: long (nullable = true)
```

In [4]:
```
df_single.show()
```

```
+--------------------+-----------+--------+--------------------+
|             contact|customer_id|order_id|    order_line_items|
+--------------------+-----------+--------+--------------------+
|[9000010000, 9000...|       C001|    O101|[{102.45, I001, 6...|
+--------------------+-----------+--------+--------------------+
```

In [5]:
```
# Read Multiline JSON file

df_multi = spark.read.format("json").option("multiLine", True).load("data/input/order_multiline.json")
```

In [6]:
```
df_multi.printSchema()
```

```
root
 |-- contact: array (nullable = true)
 |    |-- element: long (containsNull = true)
 |-- customer_id: string (nullable = true)
 |-- order_id: string (nullable = true)
 |-- order_line_items: array (nullable = true)
 |    |-- element: struct (containsNull = true)
 |    |    |-- amount: double (nullable = true)
 |    |    |-- item_id: string (nullable = true)
 |    |    |-- qty: long (nullable = true)
```

In [7]:
```
df_multi.show()
```

```
+--------------------+-----------+--------+--------------------+
|             contact|customer_id|order_id|    order_line_items|
+--------------------+-----------+--------+--------------------+
|[9000010000, 9000...|       C001|    0101|[{102.45, I001, 6...|
+--------------------+-----------+--------+--------------------+
```

In [8]:
```
df = spark.read.format("text").load("data/input/order_singleline.json")
```

In [9]:
```
df.printSchema()
```

```
root
 |-- value: string (nullable = true)
```

In [11]:
```
df.show(truncate=False)
```

```
+-------------------------------------------------------------------------------------------------------------------------------
-------------------------------------------------------+
|value
|
+-------------------------------------------------------------------------------------------------------------------------------
-------------------------------------------------------+
|{"order_id":"0101","customer_id":"C001","order_line_items":[{"item_id":"I001","qty":6,"amount":102.45},{"item_id":"I003","qt
y":2,"amount":2.01}],"contact":[9000010000,9000010001]}|
+-------------------------------------------------------------------------------------------------------------------------------
-------------------------------------------------------+
```

In [17]:
```
# With Schema

_schema = "customer_id string, order_id string, contact array<long>"

df_schema = spark.read.format("json").schema(_schema).load("data/input/order_singleline.json")
```

In [18]:
```
df_schema.show()
```

```
+-----------+--------+--------------------+
|customer_id|order_id|             contact|
+-----------+--------+--------------------+
|       C001|    0101|[9000010000, 9000...|
+-----------+--------+--------------------+
```

In [11]:
```
df.show(truncate=False)
```

```
+-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------+
|value                                                                                                                                                                          |
+-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------+
|{"order_id":"O101","customer_id":"C001","order_line_items":[{"item_id":"I001","qty":6,"amount":102.45},{"item_id":"I003","qty":2,"amount":2.01}],"contact":[9000010000,9000010001]}|
+-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------+
```

In [17]:
```
# With Schema

_schema = "customer_id string, order_id string, contact array<long>"

df_schema = spark.read.format("json").schema(_schema).load("data/input/order_singleline.json")
```

In [18]:
```
df_schema.show()
```

```
+-----------+--------+--------------------+
|customer_id|order_id|             contact|
+-----------+--------+--------------------+
|       C001|    O101|[9000010000, 9000...|
+-----------+--------+--------------------+
```

In [23]:
```
df_schema_new.show()
```

```
+--------------------+-----------+--------+--------------------+
|             contact|customer_id|order_id|    order_line_items|
+--------------------+-----------+--------+--------------------+
|[9000010000, 9000...|       C001|    O101|[{102.45, I001, 6...|
+--------------------+-----------+--------+--------------------+
```

In [26]:
```
# Function from_json to read from a column

_schema = "contact array<string>, customer_id string, order_id string, order_line_items array<struct<amount double, item_id

from pyspark.sql.functions import from_json

df_expanded = df.withColumn("parsed", from_json(df.value, _schema))
```

In [27]:
```
df_expanded.printSchema()
```

```
root
 |-- value: string (nullable = true)
 |-- parsed: struct (nullable = true)
 |    |-- contact: array (nullable = true)
 |    |    |-- element: string (containsNull = true)
 |    |-- customer_id: string (nullable = true)
 |    |-- order_id: string (nullable = true)
 |    |-- order_line_items: array (nullable = true)
 |    |    |-- element: struct (containsNull = true)
 |    |    |    |-- amount: double (nullable = true)
 |    |    |    |-- item_id: string (nullable = true)
 |    |    |    |-- qty: long (nullable = true)
```

In [28]:

```
df_expanded.show()
```

```
+--------------------+--------------------+
|               value|              parsed|
+--------------------+--------------------+
|{"order_id":"0101...|{[9000010000, 900...|
+--------------------+--------------------+
```

In [29]:

```
# Function to_json to parse a JSON string
from pyspark.sql.functions import to_json

df_unparsed = df_expanded.withColumn("unparsed", to_json(df_expanded.parsed))
```

In [30]:

```
df_unparsed.printSchema()
```

```
root
 |-- value: string (nullable = true)
 |-- parsed: struct (nullable = true)
 |    |-- contact: array (nullable = true)
 |    |    |-- element: string (containsNull = true)
 |    |-- customer_id: string (nullable = true)
 |    |-- order_id: string (nullable = true)
 |    |-- order_line_items: array (nullable = true)
 |    |    |-- element: struct (containsNull = true)
 |    |    |    |-- amount: double (nullable = true)
 |    |    |    |-- item_id: string (nullable = true)
 |    |    |    |-- qty: long (nullable = true)
 |-- unparsed: string (nullable = true)
```

In [32]:

```
df_unparsed.select("unparsed").show(truncate=False)
```

```
+-----------------------------------------------------------------------------------------------------------------------------
-----------------------------------------------------------+
|unparsed
|
+-----------------------------------------------------------------------------------------------------------------------------
-----------------------------------------------------------+
|{"contact":["9000010000","9000010001"],"customer_id":"C001","order_id":"0101","order_line_items":[{"amount":102.45,"item_i
d":"I001","qty":6},{"amount":2.01,"item_id":"I003","qty":2}]}|
+-----------------------------------------------------------------------------------------------------------------------------
-----------------------------------------------------------+
```

In [36]:

```
# Get values from Parsed JSON

df_1 = df_expanded.select("parsed.*")
```

In [38]:

```
from pyspark.sql.functions import explode

df_2 = df_1.withColumn("expanded_line_items", explode("order_line_items"))
```

In [39]:

```
df_2.show()
```

```
+--------------------+-----------+--------+--------------------+-------------------+
|             contact|customer_id|order_id|    order_line_items|expanded_line_items|
+--------------------+-----------+--------+--------------------+-------------------+
|[9000010000, 9000...|       C001|    0101|[{102.45, I001, 6...|  {102.45, I001, 6}|
|[9000010000, 9000...|       C001|    0101|[{102.45, I001, 6...|    {2.01, I003, 2}|
+--------------------+-----------+--------+--------------------+-------------------+
```

In [48]:
```
df_3 = df_2.select("contact", "customer_id", "order_id", "expanded_line_items.*")
```

In [49]:
```
df_3.show()
```

```
+--------------------+-----------+--------+------+-------+---+
|             contact|customer_id|order_id|amount|item_id|qty|
+--------------------+-----------+--------+------+-------+---+
|[9000010000, 9000...|       C001|    O101|102.45|   I001|  6|
|[9000010000, 9000...|       C001|    O101|  2.01|   I003|  2|
+--------------------+-----------+--------+------+-------+---+
```

In [50]:
```
# Explode Array fields
df_final = df_3.withColumn("contact_expanded", explode("contact"))
```

In [51]:
```
df_final.printSchema()
```

```
root
 |-- contact: array (nullable = true)
 |    |-- element: string (containsNull = true)
 |-- customer_id: string (nullable = true)
 |-- order_id: string (nullable = true)
 |-- amount: double (nullable = true)
 |-- item_id: string (nullable = true)
 |-- qty: long (nullable = true)
 |-- contact_expanded: string (nullable = true)
```

In [53]:
```
df_final.drop("contact").show()
```

```
+-----------+--------+------+-------+---+----------------+
|customer_id|order_id|amount|item_id|qty|contact_expanded|
+-----------+--------+------+-------+---+----------------+
|       C001|    O101|102.45|   I001|  6|      9000010000|
|       C001|    O101|102.45|   I001|  6|      9000010001|
|       C001|    O101|  2.01|   I003|  2|      9000010000|
|       C001|    O101|  2.01|   I003|  2|      9000010001|
+-----------+--------+------+-------+---+----------------+
```

Python Datatype – List/Array or Struct/Dict are important.

Reading JSON Files – Default is single line JSON. In case of multiline we need to specify an option.

Read JSON data in Single Column – We will use format as TEXT.

Read with Schema – Reading JSON file with Schema.

Write JSON Schema – How to write complex JSON schema in string ddl format?

from_json function – Parse the JSON from String

to_json function – Converts Parsed JSON data to String JSON text.

Flatten JSON data – Expand and explode the JSON data to simple tabular structure.

Dot Notation – It can be used to extract\expand struct/dict data.

Spark Hands On

1. Write Data in Spark
2. Understand how Spark writes data with help of Spark UI
3. Important write modes available
4. How writing data with partition works

In [1]:
```
# Spark Session
from pyspark.sql import SparkSession

spark = (
    SparkSession
    .builder
    .appName("Writing data")
    .master("local[*]")
    .getOrCreate()
)

spark
```

Out[1]:

SparkSession - in-memory

SparkContext

Spark UI

Version	`v3.3.0`
Master	`local[*]`
AppName	`Writing data`

In [2]:
```
# Spark available cores with defaultParallism in Spark UI

spark.sparkContext.defaultParallelism
```

Out[2]: 8

In [3]:
```
# Emp Data & Schema

emp_data = [
    ["001","101","John Doe","30","Male","50000","2015-01-01"],
    ["002","101","Jane Smith","25","Female","45000","2016-02-15"],
    ["003","102","Bob Brown","35","Male","55000","2014-05-01"],
    ["004","102","Alice Lee","28","Female","48000","2017-09-30"],
    ["005","103","Jack Chan","40","Male","60000","2013-04-01"],
    ["006","103","Jill Wong","32","Female","52000","2018-07-01"],
    ["007","101","James Johnson","42","Male","70000","2012-03-15"],
    ["008","102","Kate Kim","29","Female","51000","2019-10-01"],
    ["009","103","Tom Tan","33","Male","58000","2016-06-01"],
    ["010","104","Lisa Lee","27","Female","47000","2018-08-01"],
    ["011","104","David Park","38","Male","65000","2015-11-01"],
    ["012","105","Susan Chen","31","Female","54000","2017-02-15"],
    ["013","106","Brian Kim","45","Male","75000","2011-07-01"],
    ["014","107","Emily Lee","26","Female","46000","2019-01-01"],
    ["015","106","Michael Lee","37","Male","63000","2014-09-30"],
    ["016","107","Kelly Zhang","30","Female","49000","2018-04-01"],
    ["017","105","George Wang","34","Male","57000","2016-03-15"],
    ["018","104","Nancy Liu","29","Female","50000","2017-06-01"],
    ["019","103","Steven Chen","36","Male","62000","2015-08-01"],
    ["020","102","Grace Kim","32","Female","53000","2018-11-01"]
]

emp_schema = "employee_id string, department_id string, name string, age string, gender string, salary string, hire_date str
```

In [4]:
```
# Create emp DataFrame

emp = spark.createDataFrame(data=emp_data, schema=emp_schema)
```

In [8]:
```
# Get number of partitions and show data

emp.rdd.getNumPartitions()
emp.show()
```

```
+-----------+-------------+-------------+---+------+------+----------+
|employee_id|department_id|         name|age|gender|salary| hire_date|
+-----------+-------------+-------------+---+------+------+----------+
|        001|          101|     John Doe| 30|  Male| 50000|2015-01-01|
|        002|          101|   Jane Smith| 25|Female| 45000|2016-02-15|
|        003|          102|    Bob Brown| 35|  Male| 55000|2014-05-01|
|        004|          102|    Alice Lee| 28|Female| 48000|2017-09-30|
|        005|          103|    Jack Chan| 40|  Male| 60000|2013-04-01|
|        006|          103|    Jill Wong| 32|Female| 52000|2018-07-01|
|        007|          101|James Johnson| 42|  Male| 70000|2012-03-15|
|        008|          102|     Kate Kim| 29|Female| 51000|2019-10-01|
|        009|          103|      Tom Tan| 33|  Male| 58000|2016-06-01|
|        010|          104|     Lisa Lee| 27|Female| 47000|2018-08-01|
|        011|          104|   David Park| 38|  Male| 65000|2015-11-01|
|        012|          105|   Susan Chen| 31|Female| 54000|2017-02-15|
|        013|          106|    Brian Kim| 45|  Male| 75000|2011-07-01|
|        014|          107|    Emily Lee| 26|Female| 46000|2019-01-01|
|        015|          106|  Michael Lee| 37|  Male| 63000|2014-09-30|
|        016|          107|  Kelly Zhang| 30|Female| 49000|2018-04-01|
|        017|          105|  George Wang| 34|  Male| 57000|2016-03-15|
|        018|          104|    Nancy Liu| 29|Female| 50000|2017-06-01|
|        019|          103|  Steven Chen| 36|  Male| 62000|2015-08-01|
|        020|          102|    Grace Kim| 32|Female| 53000|2018-11-01|
+-----------+-------------+-------------+---+------+------+----------+
```

In [9]:
```
# Write the data in parquet format

emp.write.format("parquet").save("data/output/11/2/emp.parquet")
```

In [10]:
```
# View data partition information
from pyspark.sql.functions import spark_partition_id

emp.withColumn("partition_id", spark_partition_id()).show()
```

```
+-----------+-------------+-------------+---+------+------+----------+------------+
|employee_id|department_id|         name|age|gender|salary| hire_date|partition_id|
+-----------+-------------+-------------+---+------+------+----------+------------+
|        001|          101|     John Doe| 30|  Male| 50000|2015-01-01|           0|
|        002|          101|   Jane Smith| 25|Female| 45000|2016-02-15|           0|
|        003|          102|    Bob Brown| 35|  Male| 55000|2014-05-01|           1|
|        004|          102|    Alice Lee| 28|Female| 48000|2017-09-30|           1|
|        005|          103|    Jack Chan| 40|  Male| 60000|2013-04-01|           2|
|        006|          103|    Jill Wong| 32|Female| 52000|2018-07-01|           2|
|        007|          101|James Johnson| 42|  Male| 70000|2012-03-15|           3|
|        008|          102|     Kate Kim| 29|Female| 51000|2019-10-01|           3|
|        009|          103|      Tom Tan| 33|  Male| 58000|2016-06-01|           3|
|        010|          104|     Lisa Lee| 27|Female| 47000|2018-08-01|           3|
|        011|          104|   David Park| 38|  Male| 65000|2015-11-01|           4|
|        012|          105|   Susan Chen| 31|Female| 54000|2017-02-15|           4|
|        013|          106|    Brian Kim| 45|  Male| 75000|2011-07-01|           5|
|        014|          107|    Emily Lee| 26|Female| 46000|2019-01-01|           5|
|        015|          106|  Michael Lee| 37|  Male| 63000|2014-09-30|           6|
|        016|          107|  Kelly Zhang| 30|Female| 49000|2018-04-01|           6|
|        017|          105|  George Wang| 34|  Male| 57000|2016-03-15|           7|
|        018|          104|    Nancy Liu| 29|Female| 50000|2017-06-01|           7|
|        019|          103|  Steven Chen| 36|  Male| 62000|2015-08-01|           7|
|        020|          102|    Grace Kim| 32|Female| 53000|2018-11-01|           7|
+-----------+-------------+-------------+---+------+------+----------+------------+
```

In [11]:
```
emp.write.format("csv").option("header", True).save("data/output/11/3/emp.csv")
```

In [12]:
```
# Write the data with Partition to output location

emp.write.format("csv").partitionBy("department_id").option("header", True).save("data/output/11/4/emp.csv")
```

In [16]:
```
# Write Modes - append, overwrite, ignore and error

emp.write.format("csv").mode("error").option("header", True).save("data/output/11/3/emp.csv")
```

```
---------------------------------------------------------------------------
AnalysisException                         Traceback (most recent call last)
/tmp/ipykernel_1108/3271497296.py in <module>
      1 # Write Modes - append, overwrite, ignore and error
      2
----> 3 emp.write.format("csv").mode("error").option("header", True).save("data/output/11/3/emp.csv")

/spark/python/pyspark/sql/readwriter.py in save(self, path, format, mode, partitionBy, **options)
    966             self._jwrite.save()
    967         else:
--> 968             self._jwrite.save(path)
    969
    970     @since(1.4)

/spark/python/lib/py4j-0.10.9.5-src.zip/py4j/java_gateway.py in __call__(self, *args)
   1320         answer = self.gateway_client.send_command(command)
   1321         return_value = get_return_value(
-> 1322             answer, self.gateway_client, self.target_id, self.name)
   1323
   1324         for temp_arg in temp_args:

/spark/python/pyspark/sql/utils.py in deco(*a, **kw)
    194                 # Hide where the exception came from that shows a non-Pythonic
    195                 # JVM exception message.

/spark/python/pyspark/sql/utils.py in deco(*a, **kw)
    194                 # Hide where the exception came from that shows a non-Pythonic
    195                 # JVM exception message.
--> 196                 raise converted from None
    197             else:
    198                 raise

AnalysisException: path file:/home/jupyter/pyspark-zero-to-hero/data/output/11/3/emp.csv already exists.
```

In [17]:
```
# Bonus TIP
# What if we need to write only 1 output file to share with DownStream?

emp.repartition(1).write.format("csv").option("header", True).save("data/output/11/5/emp.csv")
```

How Spark writes data?

- **Cluster with 1 node, 2 Executors and each Executor with 2 cores.**
- **Total cores/Parallelism : 4**

Number of Files – The processed data from each partition will be written to individual files.

Default Parallelism – Total number of Cores available for processing data in parallel.

Spark creates the folder.

Spark Partition folders – It allows Spark to skip un-necessary data read in case you need data based on specific partition.

Note – Spark doesn't write department_id column in files as it is the partition column (info from folder name). You can see it is missing in the files.

In [7]:
```
# Spark Session
from pyspark.sql import SparkSession

spark = (
    SparkSession
    .builder
    .appName("Cluster Execution")
    .master("spark://17e348267994:7077")
    .config("spark.executor.instances", 4)
    .config("spark.executor.cores", 4)
    .config("spark.executor.memory", "512M")
    .getOrCreate()
)

spark
```

Out[7]:

SparkSession - in-memory

SparkContext

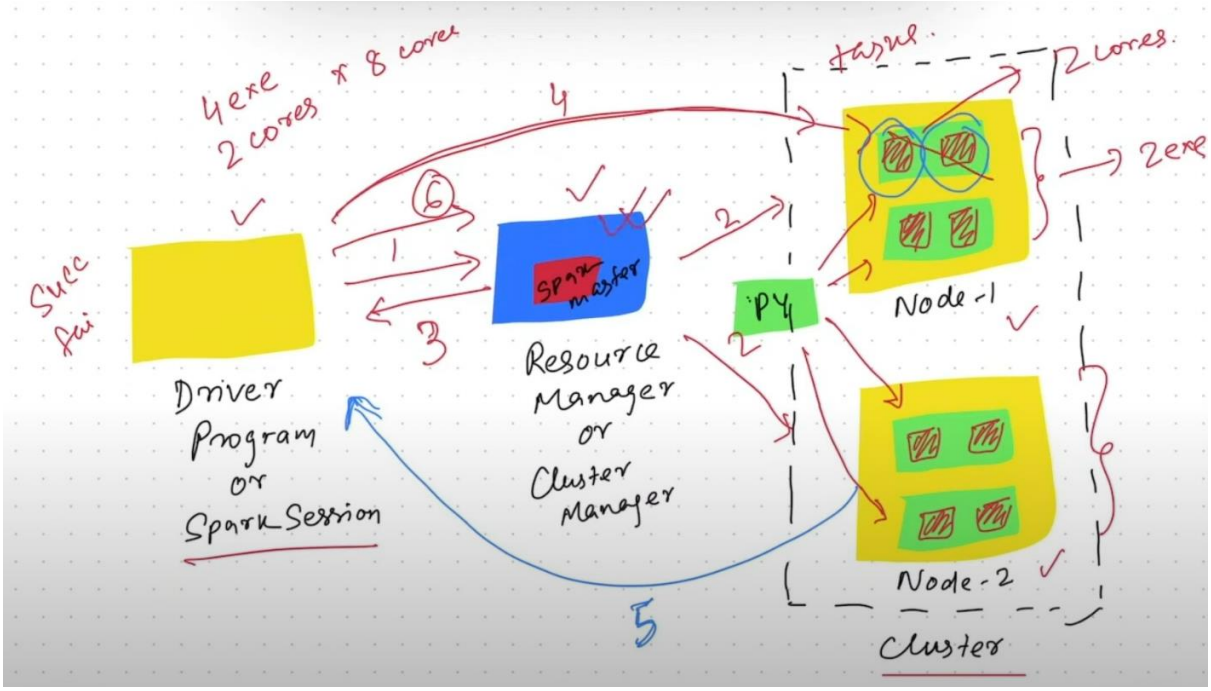
Spark UI

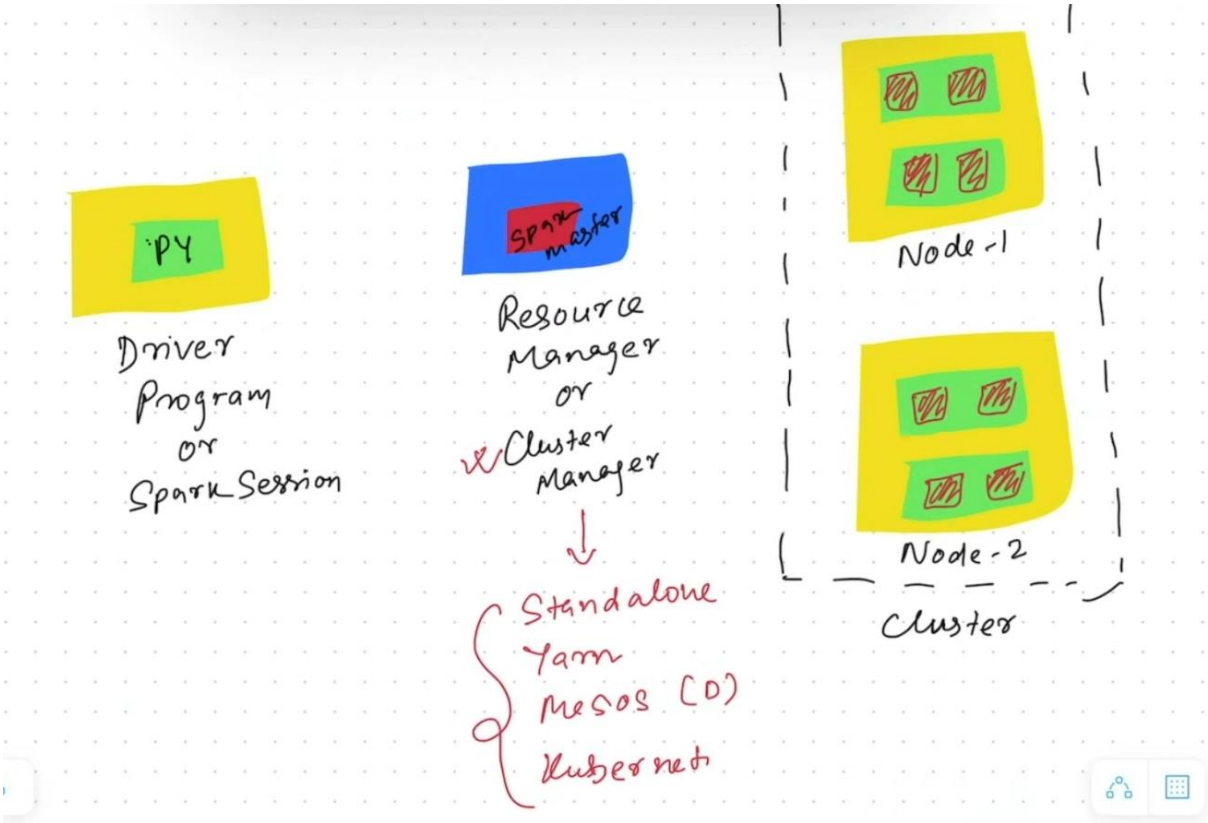
Version	`v3.3.0`
Master	`spark://17e348267994:7077`
AppName	`Cluster Execution`

In [8]:
```
# Create a sample data frame

df = spark.range(10)
```

In [9]:
```
# Write the data of the data frame

df.write.format("csv").option("header", True).save("/data/output/15/3/range.csv")
```

In [10]:
```
# Stop Spark Settion

spark.stop()
```





Spark Submit – Command is used to execute Spark application on Cluster.

Note – Spark Submit command can be supplied from the installed Spark folder, check your setting before executing the code.

Note: For Standalone clusters:

the –num-executors parameter may not work always.

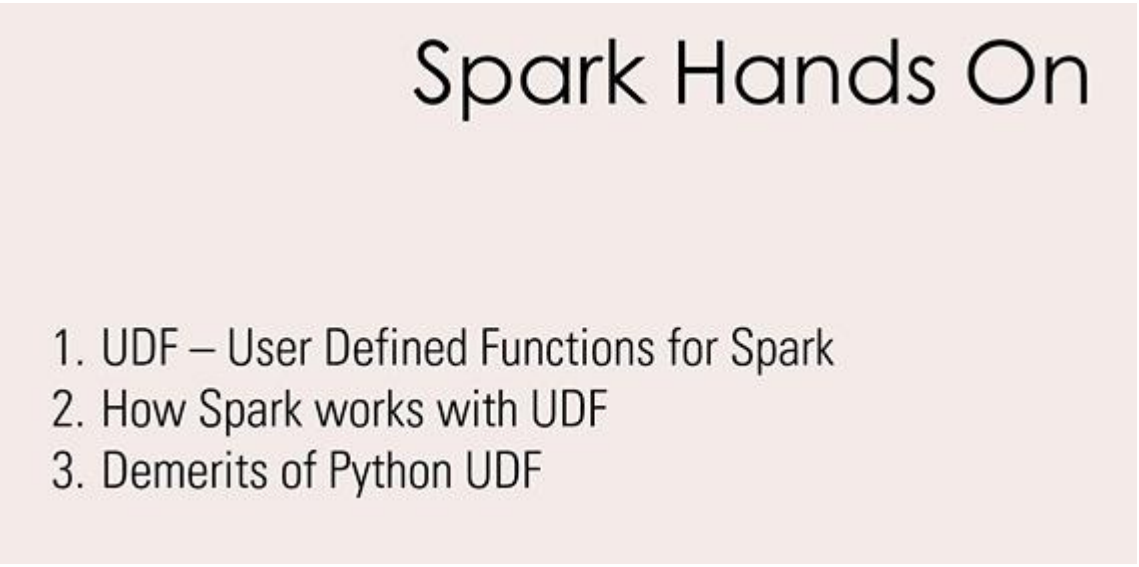
So, to control the number of executors:

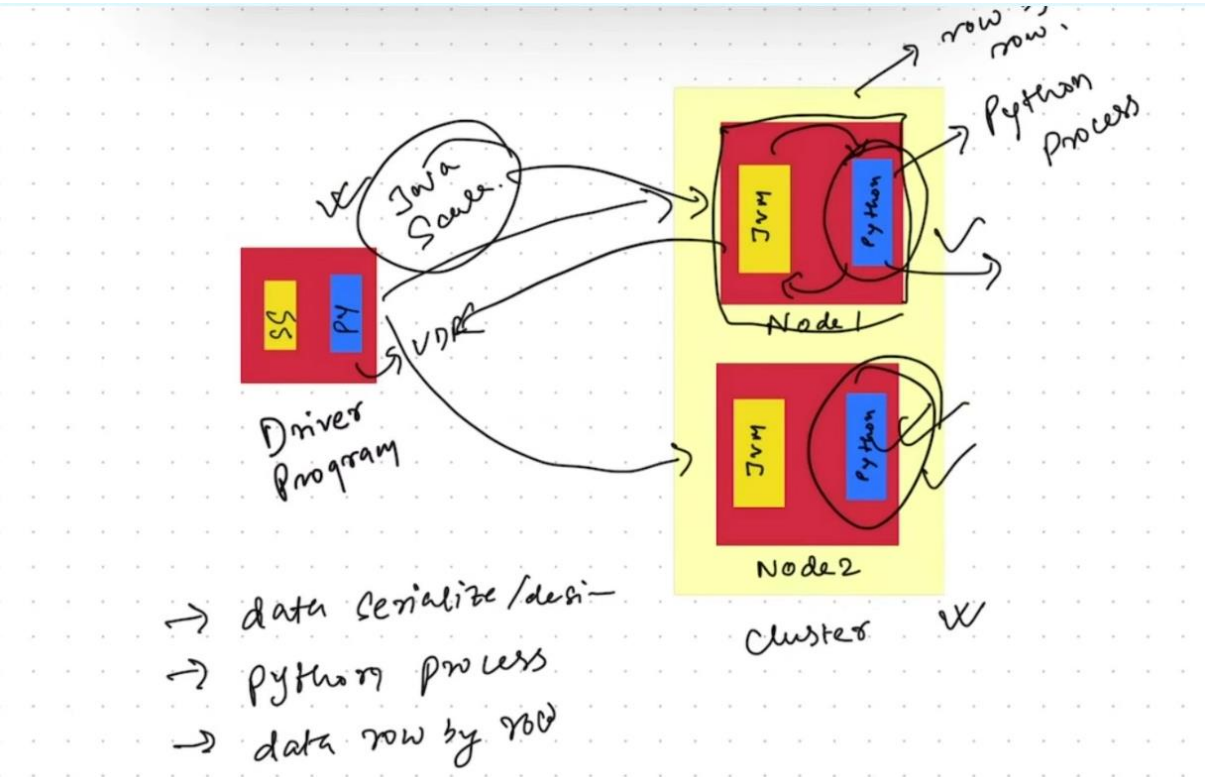
1. **Define number of cores per executors with –executor-cores parameter(spark.executor.cores)**
2. **Control max number of cores for execution with –total-executor-cores parameter(spark.cores.max)**

If you need 3 executors with 2 cores(you don't need to use –num-executors) --executor-cores 2 –total-executor-cores 6

--num-executors parameter can be used to control number of executor for YARN resource manager.

Note: Spark Submit commands are often scheduled or triggered to execute jobs on Clusters in Production setting.





What are JVM here?

-JVM are the executors requested by the Spark Application.

In [13]:
```
# Spark Session
from pyspark.sql import SparkSession

spark = (
    SparkSession
    .builder
    .appName("User Defined Functions")
    .master("spark://17e348267994:7077")
    .config("spark.executor.cores", 2)
    .config("spark.cores.max", 6)
    .config("spark.executor.memory", "512M")
    .getOrCreate()
)

spark
```

Out[13]:

SparkSession - in-memory

SparkContext

Spark UI

Version	`v3.3.0`
Master	`spark://17e348267994:7077`
AppName	`User Defined Functions`

In [15]:
```
# Read employee data

emp_schema = "employee_id string, department_id string, name string, age string, gender string, salary string, hire_date str

emp = spark.read.format("csv").option("header", True).schema(emp_schema).load("/data/output/3/emp.csv")

emp.rdd.getNumPartitions()
```

Out[15]: 2

In [19]:
```
# Create a function to generate 10% of Salary as Bonus

def bonus(salary):
    return int(salary) * 0.1
```

In [20]:
```
# Register as UDF
from pyspark.sql.functions import udf

bonus_udf = udf(bonus)

spark.udf.register("bonus_sql_udf", bonus, "double")
```

Out[20]: <function __main__.bonus(salary)>

In [24]:
```
# Create new column as bonus using UDF
from pyspark.sql.functions import expr

emp.withColumn("bonus", expr("bonus_sql_udf(salary)")).show()
```

```
+-----------+-------------+-------------+---+------+------+----------+------+
|employee_id|department_id|         name|age|gender|salary| hire_date| bonus|
+-----------+-------------+-------------+---+------+------+----------+------+
|        017|          105|  George Wang| 34|  Male| 57000|2016-03-15|5700.0|
|        018|          104|    Nancy Liu| 29|Female| 50000|2017-06-01|5000.0|
|        019|          103|  Steven Chen| 36|  Male| 62000|2015-08-01|6200.0|
|        020|          102|    Grace Kim| 32|Female| 53000|2018-11-01|5300.0|
|        007|          101|James Johnson| 42|  Male| 70000|2012-03-15|7000.0|
|        008|          102|     Kate Kim| 29|Female| 51000|2019-10-01|5100.0|
|        009|          103|      Tom Tan| 33|  Male| 58000|2016-06-01|5800.0|
|        010|          104|     Lisa Lee| 27|Female| 47000|2018-08-01|4700.0|
|        015|          106|  Michael Lee| 37|  Male| 63000|2014-09-30|6300.0|
|        016|          107|  Kelly Zhang| 30|Female| 49000|2018-04-01|4900.0|
|        011|          104|   David Park| 38|  Male| 65000|2015-11-01|6500.0|
|        012|          105|   Susan Chen| 31|Female| 54000|2017-02-15|5400.0|
|        013|          106|    Brian Kim| 45|  Male| 75000|2011-07-01|7500.0|
|        014|          107|    Emily Lee| 26|Female| 46000|2019-01-01|4600.0|
|        001|          101|     John Doe| 30|  Male| 50000|2015-01-01|5000.0|
|        002|          101|   Jane Smith| 25|Female| 45000|2016-02-15|4500.0|
|        003|          102|    Bob Brown| 35|  Male| 55000|2014-05-01|5500.0|
|        004|          102|    Alice Lee| 28|Female| 48000|2017-09-30|4800.0|
|        005|          103|    Jack Chan| 40|  Male| 60000|2013-04-01|6000.0|
|        006|          103|    Jill Wong| 32|Female| 52000|2018-07-01|5200.0|
+-----------+-------------+-------------+---+------+------+----------+------+
```

In [25]:
```
# Create new column as bonus without UDF

emp.withColumn("bonus", expr("salary * 0.1")).show()
```

```
+-----------+-------------+-------------+---+------+------+----------+------+
|employee_id|department_id|         name|age|gender|salary| hire_date| bonus|
+-----------+-------------+-------------+---+------+------+----------+------+
|        017|          105|  George Wang| 34|  Male| 57000|2016-03-15|5700.0|
|        018|          104|    Nancy Liu| 29|Female| 50000|2017-06-01|5000.0|
|        019|          103|  Steven Chen| 36|  Male| 62000|2015-08-01|6200.0|
|        020|          102|    Grace Kim| 32|Female| 53000|2018-11-01|5300.0|
|        007|          101|James Johnson| 42|  Male| 70000|2012-03-15|7000.0|
|        008|          102|     Kate Kim| 29|Female| 51000|2019-10-01|5100.0|
|        009|          103|      Tom Tan| 33|  Male| 58000|2016-06-01|5800.0|
|        010|          104|     Lisa Lee| 27|Female| 47000|2018-08-01|4700.0|
|        015|          106|  Michael Lee| 37|  Male| 63000|2014-09-30|6300.0|
|        016|          107|  Kelly Zhang| 30|Female| 49000|2018-04-01|4900.0|
|        011|          104|   David Park| 38|  Male| 65000|2015-11-01|6500.0|
|        012|          105|   Susan Chen| 31|Female| 54000|2017-02-15|5400.0|
|        013|          106|    Brian Kim| 45|  Male| 75000|2011-07-01|7500.0|
|        014|          107|    Emily Lee| 26|Female| 46000|2019-01-01|4600.0|
|        001|          101|     John Doe| 30|  Male| 50000|2015-01-01|5000.0|
|        002|          101|   Jane Smith| 25|Female| 45000|2016-02-15|4500.0|
|        003|          102|    Bob Brown| 35|  Male| 55000|2014-05-01|5500.0|
|        004|          102|    Alice Lee| 28|Female| 48000|2017-09-30|4800.0|
|        005|          103|    Jack Chan| 40|  Male| 60000|2013-04-01|6000.0|
|        006|          103|    Jill Wong| 32|Female| 52000|2018-07-01|5200.0|
+-----------+-------------+-------------+---+------+------+----------+------+
```

In [26]:
```
# Stop Spark Session

spark.stop()
```

Spark Hands On

1. Understand Spark Explain Plan
2. Understand DAG
3. Understand Shuffle and Impact on Stages/Tasks?
4. What are Data Frames made of ?

In [1]:
```
# Spark Session
from pyspark.sql import SparkSession

spark = (
    SparkSession
    .builder
    .appName("Understand Plans and DAG")
    .master("local[*]")
    .getOrCreate()
)

spark
```

Out[1]:

SparkSession - in-memory

SparkContext

Spark UI

Version	`v3.3.0`
Master	`local[*]`
AppName	`Understand Plans and DAG`

In [2]:
```
# Disable AQE and Broadcast join

spark.conf.set("spark.sql.adaptive.enabled", False)
spark.conf.set("spark.sql.adaptive.coalescePartitions.enabled", False)
spark.conf.set("spark.sql.autoBroadcastJoinThreshold", -1)
```

In [3]:
```
# Check default Parallism

spark.sparkContext.defaultParallelism
```

Out[3]: 8

In [4]:
```
# Create dataframes

df_1 = spark.range(4, 200, 2)
df_2 = spark.range(2, 200, 4)
```

In [6]:
```
df_2.rdd.getNumPartitions()
```

Out[6]: 8

In [7]:
```
# Re-partition data

df_3 = df_1.repartition(5)
df_4 = df_2.repartition(7)
```

In [9]:
```
df_4.rdd.getNumPartitions()
```

Out[9]: 7

In [10]:
```
# Join the dataframes

df_joined = df_3.join(df_4, on="id")
```

In [11]:
```
# Get the sum of ids

df_sum = df_joined.selectExpr("sum(id) as total_sum")
```

In [12]:
```
# View data
df_sum.show()
```

```
+---------+
|total_sum|
+---------+
|     4998|
+---------+
```

In [13]:
```
# Explain plan

df_sum.explain()
```

```
== Physical Plan ==
*(6) HashAggregate(keys=[], functions=[sum(id#0L)])
+- Exchange SinglePartition, ENSURE_REQUIREMENTS, [id=#182]
   +- *(5) HashAggregate(keys=[], functions=[partial_sum(id#0L)])
      +- *(5) Project [id#0L]
         +- *(5) SortMergeJoin [id#0L], [id#2L], Inner
            :- *(2) Sort [id#0L ASC NULLS FIRST], false, 0
            :  +- Exchange hashpartitioning(id#0L, 200), ENSURE_REQUIREMENTS, [id=#166]
            :     +- Exchange RoundRobinPartitioning(5), REPARTITION_BY_NUM, [id=#165]
            :        +- *(1) Range (4, 200, step=2, splits=8)
            +- *(4) Sort [id#2L ASC NULLS FIRST], false, 0
               +- Exchange hashpartitioning(id#2L, 200), ENSURE_REQUIREMENTS, [id=#173]
                  +- Exchange RoundRobinPartitioning(7), REPARTITION_BY_NUM, [id=#172]
                     +- *(3) Range (2, 200, step=4, splits=8)
```

In [14]:
```
# Union the data again to see the skipped stages

df_union = df_sum.union(df_4)
```

In [15]:
```
df_union.show()
```

```
+---------+
|total_sum|
+---------+
|     4998|
|       14|
|       38|
|       50|
|       74|
|      110|
|      130|
|      154|
|      186|
|       10|
|       30|
|       54|
|       98|
|      118|
|      138|
|      158|
|      178|
|        6|
|       42|
|       70|
+---------+
only showing top 20 rows
```

In [16]:
```
# Explain plan

df_union.explain()
```

```
== Physical Plan ==
Union
:- *(6) HashAggregate(keys=[], functions=[sum(id#0L)])
:  +- Exchange SinglePartition, ENSURE_REQUIREMENTS, [id=#420]
:     +- *(5) HashAggregate(keys=[], functions=[partial_sum(id#0L)])
:        +- *(5) Project [id#0L]
:           +- *(5) SortMergeJoin [id#0L], [id#2L], Inner
:              :- *(2) Sort [id#0L ASC NULLS FIRST], false, 0
:              :  +- Exchange hashpartitioning(id#0L, 200), ENSURE_REQUIREMENTS, [id=#404]
:              :     +- Exchange RoundRobinPartitioning(5), REPARTITION_BY_NUM, [id=#403]
:              :        +- *(1) Range (4, 200, step=2, splits=8)
:              +- *(4) Sort [id#2L ASC NULLS FIRST], false, 0
:                 +- Exchange hashpartitioning(id#2L, 200), ENSURE_REQUIREMENTS, [id=#411]
:                    +- Exchange RoundRobinPartitioning(7), REPARTITION_BY_NUM, [id=#410]
:                       +- *(3) Range (2, 200, step=4, splits=8)
+- ReusedExchange [id#20L], Exchange RoundRobinPartitioning(7), REPARTITION_BY_NUM, [id=#410]
```

In [17]:
```
# DataFrame to RDD

df_1.rdd
```

Out[17]:
```
MapPartitionsRDD[5] at javaToPython at NativeMethodAccessorImpl.java:0
```

Shuffle or Exchange – Shuffle divides the JOB into Stages.

Default Shuffle Partition – By default the shuffle partition value is 200. This can be controlled from Spark config.

In [1]:
```
# Spark Session
from pyspark.sql import SparkSession

spark = (
    SparkSession
    .builder
    .appName("Optimizing Shuffles")
    .master("spark://17e348267994:7077")
    .config("spark.cores.max", 16)
    .config("spark.executor.cores", 4)
    .config("spark.executor.memory", "512M")
    .getOrCreate()
)

spark
```

Out[1]:

SparkSession - in-memory

SparkContext

Spark UI

Version	`v3.3.0`
Master	`spark://17e348267994:7077`
AppName	`Optimizing Shuffles`

In [2]:
```
# Check Spark defaultParallelism

spark.sparkContext.defaultParallelism
```

Out[2]: 16

In [3]:
```
# Disable AQE and Broadcast join

spark.conf.set("spark.sql.adaptive.enabled", False)
spark.conf.set("spark.sql.adaptive.coalescePartitions.enabled", False)
spark.conf.set("spark.sql.autoBroadcastJoinThreshold", -1)
```

In [4]:
```
# Read EMP CSV file with 10M records

_schema = "first_name string, last_name string, job_title string, dob string, email string, phone string, salary double, dep

emp = spark.read.format("csv").schema(_schema).option("header", True).load("/data/input/datasets/employee_records.csv")
```

In [6]:
```
# Find out avg salary as per dept
from pyspark.sql.functions import avg

emp_avg = emp.groupBy("department_id").agg(avg("salary").alias("avg_sal"))
```

In [15]:
```
# Write data for performance Benchmarking

emp_avg.write.format("noop").mode("overwrite").save()
```

In [14]:
```
# Check Spark Shuffle Partition setting

spark.conf.get("spark.sql.shuffle.partitions")
```

Out[14]: '16'

In [13]:
```
spark.conf.set("spark.sql.shuffle.partitions", 16)
```

In [9]:
```
from pyspark.sql.functions import spark_partition_id

emp.withColumn("partition_id", spark_partition_id()).where("partition_id = 0").show()
```

```
+----------+----------+--------------------+----------+--------------------+--------------------+--------+-------------+-----
-------+
|first_name| last_name|           job_title|       dob|               email|               phone|  salary|department_id|parti
tion_id|
+----------+----------+--------------------+----------+--------------------+--------------------+--------+-------------+-----
-------+
|   Richard|  Morrison|Public relations ...|1973-05-05|melissagarcia@exa...|       (699)525-4827|512653.0|            8|
0|
|     Bobby|  Mccarthy|   Barrister's clerk|1974-04-25|   llara@example.net|  (750)846-1602x7458|999836.0|            7|
0|
|    Dennis|    Norman|Land/geomatics su...|1990-06-24| jturner@example.net|    873.820.0518x825|131900.0|           10|
0|
|      John|    Monroe|        Retail buyer|1968-06-16|  erik33@example.net|    820-813-0557x624|485506.0|            1|
0|
|  Michelle|   Elliott|      Air cabin crew|1975-03-31|tiffanyjohnston@e...|       (705)900-5337|604738.0|            8|
0|
|    Ashley|   Montoya|        Cartographer|1976-01-16|patrickalexandra@...|        211.440.5466|483339.0|            6|
0|
| Nathaniel|     Smith|     Quality manager|1985-06-28|  lori44@example.net|        936-403-3179|419644.0|            7|
0|
|     Faith|  Cummings|Industrial/produc...|1978-07-01| ygordon@example.org|       (889)246-5588|205939.0|            7|
0|
```

```
0|
|  Margaret|    Sutton|Administrator, ed...|1975-08-16| diana44@example.net|001-647-530-5036x...|671167.0|           8|
0|
|      Mary|    Sutton|   Freight forwarder|1979-12-28|  ryan36@example.com|   422.562.7254x3159|993829.0|           7|
0|
|      Jake|      King|       Lexicographer|1994-07-11|monica93@example.org|+1-535-652-9715x6...|702101.0|           4|
0|
|   Heather|     Haley|         Music tutor|1981-06-01|stephanie65@examp...|   (652)815-7973x298|570960.0|           6|
0|
|    Thomas|    Thomas|Chartered managem...|2001-07-17|pwilliams@example...|001-245-848-0028x...|339441.0|           6|
0|
|   Leonard|   Carlson|       Art therapist|1990-10-18|gabrielmurray@exa...|          9247590563|469728.0|           8|
0|
|      Mark|      Wood|   Market researcher|1963-10-13|nicholas76@exampl...|   311.439.1606x3342|582291.0|           4|
0|
|    Tracey|Washington|Travel agency man...|1986-05-07|  mark07@example.com|    001-912-206-6456|146456.0|           4|
0|
|   Rachael| Rodriguez|         Media buyer|1966-12-02|griffinmary@examp...| +1-791-344-7586x548|544732.0|           1|
0|
|      Tara|       Liu|   Financial adviser|1998-10-12|alexandraobrien@e...|        216.696.6061|399503.0|           3|
0|
|       Ana|    Joseph|      Retail manager|1995-01-10|  rmorse@example.org|  (726)363-7526x9965|761988.0|          10|
0|
|   Richard|      Hall|Engineer, civil (...|1967-03-02|brandoncardenas@e...| (964)451-9007x22496|660659.0|           4|
0|
+----------+----------+--------------------+----------+--------------------+--------------------+--------+------------+-----
-------+
only showing top 20 rows
```

In [16]:
```
# Read the partitioned data

emp_part = spark.read.format("csv").schema(_schema).option("header", True).load("/data/input/emp_partitioned.csv/")
```

In [17]:
```
emp_avg = emp_part.groupBy("department_id").agg(avg("salary").alias("avg_sal"))
```

In [18]:
```
emp_avg.write.format("noop").mode("overwrite").save()
```

Shuffle Files:

Are serialized in Tungsten Binary Format(Unsafe Row). These files can directly be read in memory thus improving read performance.

Adaptive Query Engine (AQE):

By default provides some performance benefits on Shuffle.

In [2]:
```
# Spark Session
from pyspark.sql import SparkSession

spark = (
    SparkSession
    .builder
    .appName("Understand Caching")
    .master("local[*]")
    .config("spark.executor.memory", "512M")
    .getOrCreate()
)

spark
```

Out[2]:

SparkSession - in-memory

SparkContext

Spark UI

Version	`v3.3.0`
Master	`local[*]`
AppName	`Understand Caching`

In [3]:
```
# Read Sales CSV Data - 752MB Size ~ 7.2M Records

_schema = "transacted_at string, trx_id string, retailer_id string, description string, amount double, city_id string"

df = spark.read.format("csv").schema(_schema).option("header", True).load("data/input/new_sales.csv")
```

In [4]:
```
df.where("amount > 300").show()
```

```
+--------------------+----------+-----------+--------------------+-------+----------+
|       transacted_at|    trx_id|retailer_id|         description| amount|   city_id|
+--------------------+----------+-----------+--------------------+-------+----------+
|2017-11-24T19:00:...|1734117022|  847200066|Wal-Mart  ppd id:...|1737.26|1646415505|
|2017-11-24T19:00:...|1734117030| 1953761884|Home Depot     pp...|  384.5| 287177635|
|2017-11-24T19:00:...|1734117153|  847200066|unkn        Kings...|2907.57|1483931123|
|2017-11-24T19:00:...|1734117241|  486576507|              iTunes|2912.67|1663872965|
|2017-11-24T19:00:...|2076947146|  511877722|unkn     ccd id: ...|1915.35|1698762556|
|2017-11-24T19:00:...|2076947113| 1996661856|AutoZone  arc id:...| 1523.6|1759612211|
|2017-11-24T19:00:...|2076946994| 1898522855|Target    ppd id:...|2589.93|2074005445|
|2017-11-24T19:00:...|2076946121|  562903918|unkn    ccd id: 5...| 315.86|1773943669|
|2017-11-24T19:00:...|2076946063| 1070485878|Amazon.com   arc ...| 785.27|1126623009|
|2017-11-24T19:00:...|2076944979| 1654681099|Delhaize America ...|  303.1|1243655802|
|2017-11-24T19:00:...|2076944941| 1157343460|unkn    ppd id: 1...|2853.33|1141716004|
|2017-11-24T19:00:...|2076944228| 1522061472|         YUM! Brands|1737.45| 592064091|
|2017-11-24T19:00:...|2076944195| 1070485878|unkn   ppd id: 11...|2440.55|1525790470|
|2017-11-24T19:00:...|2076944142|  847200066|Wal-Mart  ppd id:...| 331.63|1345953582|
|2017-11-24T19:00:...|2076944073| 2077350195|Walgreen     arc ...|  396.9|2001708947|
|2017-11-24T19:00:...|2076943052|  103953879|Rite Aid  arc id:...| 1910.8|1998549640|
|2017-11-24T19:00:...|2076942340|  643354906|               BJ's|  372.7| 115209716|
|2017-11-24T19:00:...|2076942282| 1445595477|Meijer    ccd id:...|  366.9|1717498102|
|2017-11-24T19:00:...|2076942274| 2001148981|unkn    ppd id: 2...| 333.41| 559832710|
|2017-11-24T19:00:...|2076942246|    9225731|AT&T Wireless  pp...|  396.9| 407629665|
+--------------------+----------+-----------+--------------------+-------+----------+
only showing top 20 rows
```

In [12]:
```
# Cache DataFrame (cache or persist)

df_cache = df.where("amount > 100").cache()
```

In [13]:
```
df_cache.count()
```

Out[13]:
```
2549058
```

In [14]:
```
df.where("amount > 50").show()
```

```
+--------------------+----------+-----------+--------------------+-------+----------+
|       transacted_at|    trx_id|retailer_id|         description| amount|   city_id|
+--------------------+----------+-----------+--------------------+-------+----------+
|2017-11-24T19:00:...|1995601912| 2077350195|Walgreen       11-25| 197.23| 216510442|
|2017-11-24T19:00:...|1734117022|  847200066|Wal-Mart  ppd id:...|1737.26|1646415505|
|2017-11-24T19:00:...|1734117030| 1953761884|Home Depot     pp...|  384.5| 287177635|
|2017-11-24T19:00:...|1734117089| 1898522855| Target        11-25|  66.33|1855530529|
|2017-11-24T19:00:...|1734117117|  997626433|Sears  ppd id: 85...| 298.87| 957346984|
|2017-11-24T19:00:...|1734117153|  847200066|unkn        Kings...|2907.57|1483931123|
|2017-11-24T19:00:...|1734117212| 1996661856|unkn    ppd id: 4...| 140.38| 336763936|
|2017-11-24T19:00:...|1734117241|  486576507|             iTunes|2912.67|1663872965|
|2017-11-24T19:00:...|2076947148|  847200066|Wal-Mart         ...|  62.83|1556600840|
|2017-11-24T19:00:...|2076947146|  511877722|unkn     ccd id: ...|1915.35|1698762556|
|2017-11-24T19:00:...|2076947113| 1996661856|AutoZone  arc id:...| 1523.6|1759612211|
|2017-11-24T19:00:...|2076946994| 1898522855|Target    ppd id:...|2589.93|2074005445|
|2017-11-24T19:00:...|2076946899|  644879053|unkn     ccd id: ...|  91.91|2068475652|
|2017-11-24T19:00:...|2076946121|  562903918|unkn    ccd id: 5...| 315.86|1773943669|
|2017-11-24T19:00:...|2076946063| 1070485878|Amazon.com   arc ...| 785.27|1126623009|
|2017-11-24T19:00:...|2076945932|   87529419|Albertsons  arc i...| 284.16|1813967666|
|2017-11-24T19:00:...|2076945195|  562903918|unkn       Harris...| 165.75| 216135201|
|2017-11-24T19:00:...|2076945156|  562903918|McDonald's  ccd i...|  119.4| 576697624|
|2017-11-24T19:00:...|2076945132|   83040202|GameStop    arc i...| 242.75| 870108334|
|2017-11-24T19:00:...|2076945098| 2139149619|Trader Joe's     ...| 114.17|   7441192|
+--------------------+----------+-----------+--------------------+-------+----------+
only showing top 20 rows
```

In [20]:
```
# MEMORY_ONLY, MEMORY_AND_DISK, MEMORY_ONLY_SER, MEMORY_AND_DISK_SER, DISK_ONLY, MEMORY_ONLY_2, MEMORY_AND_DISK_2
import pyspark

df_persist = df.persist(pyspark.StorageLevel.MEMORY_ONLY_2)
```

In [21]:
```
df_persist.write.format("noop").mode("overwrite").save()
```

In [22]:
```
# Remove Cache

spark.catalog.clearCache()
```

Note:

For cache we need and action and count and write are always preferred as they will scan the whole dataset resulting in proper caching.

Storage Level:

Default storage level for cache in MEMORY_AND_DISK for dataframes and datasets.

Spark Hands On

1. Distributed Shared Variables
2. Broadcast Variable
3. Accumulators

In [1]:
```
# Spark Session
from pyspark.sql import SparkSession

spark = (
    SparkSession
    .builder
    .appName("Distributed Shared Variables")
    .master("spark://17e348267994:7077")
    .config("spark.cores.max", 16)
    .config("spark.executor.cores", 4)
    .config("spark.executor.memory", "512M")
    .getOrCreate()
)

spark
```

Out[1]:

SparkSession - in-memory

SparkContext

Spark UI

Version	`v3.3.0`
Master	`spark://17e348267994:7077`
AppName	`Distributed Shared Variables`

In [2]:
```
# Read EMP CSV data

_schema = "first_name string, last_name string, job_title string, dob string, email string, phone string, salary double, dep

emp = spark.read.format("csv").schema(_schema).option("header", True).load("/data/input/datasets/employee_records.csv")
```

In [3]:
```
# Variable (Lookup)
dept_names = {1 : 'Department 1',
              2 : 'Department 2',
              3 : 'Department 3',
              4 : 'Department 4',
              5 : 'Department 5',
              6 : 'Department 6',
              7 : 'Department 7',
              8 : 'Department 8',
              9 : 'Department 9',
              10 : 'Department 10'}
```

In [4]:
```
# Broadcast the variable

broadcast_dept_names = spark.sparkContext.broadcast(dept_names)
```

In [6]:
```
# Check the value of the variable
broadcast_dept_names.value
```

Out[6]:
```
{1: 'Department 1',
 2: 'Department 2',
 3: 'Department 3',
 4: 'Department 4',
 5: 'Department 5',
 6: 'Department 6',
 7: 'Department 7',
 8: 'Department 8',
 9: 'Department 9',
 10: 'Department 10'}
```

In [11]:
```
# Create UDF to return Department name

from pyspark.sql.functions import udf, col

@udf
def get_dept_names(dept_id):
    return broadcast_dept_names.value.get(dept_id)
```

In [12]:
```
emp_final = emp.withColumn("dept_name", get_dept_names(col("department_id")))
```

In [13]:
```
emp_final.show()
```

```
+----------+----------+--------------------+----------+--------------------+--------------------+--------+-------------+-----
--------+
|first_name| last_name|           job_title|       dob|               email|               phone|  salary|department_id|    d
ept_name|
+----------+----------+--------------------+----------+--------------------+--------------------+--------+-------------+-----
--------+
|   Richard|  Morrison|Public relations ...|1973-05-05|melissagarcia@exa...|       (699)525-4827|512653.0|            8| Depa
rtment 8|
|     Bobby|  Mccarthy|   Barrister's clerk|1974-04-25|   llara@example.net|(750)846-1602x7458|999836.0|            7| Depa
rtment 7|
|    Dennis|    Norman|Land/geomatics su...|1990-06-24| jturner@example.net|    873.820.0518x825|131900.0|           10|Depar
tment 10|
|      John|    Monroe|        Retail buyer|1968-06-16|  erik33@example.net|    820-813-0557x624|485506.0|            1| Depa
rtment 1|
|  Michelle|   Elliott|      Air cabin crew|1975-03-31|tiffanyjohnston@e...|       (705)900-5337|604738.0|            8| Depa
rtment 8|
|    Ashley|   Montoya|        Cartographer|1976-01-16|patrickalexandra@...|        211.440.5466|483339.0|            6| Depa
rtment 6|
| Nathaniel|     Smith|     Quality manager|1985-06-28|  lori44@example.net|        936-403-3179|419644.0|            7| Depa
rtment 7|
|     Faith|  Cummings|Industrial/produc...|1978-07-01| ygordon@example.org|       (889)246-5588|205939.0|            7| Depa
rtment 7|
|  Margaret|    Sutton|Administrator, ed...|1975-08-16| diana44@example.net|001-647-530-5036x...|671167.0|            8| Depa
rtment 8|
|      Mary|    Sutton|   Freight forwarder|1979-12-28|  ryan36@example.com|   422.562.7254x3159|993829.0|            7| Depa
rtment 7|
|      Jake|      King|       Lexicographer|1994-07-11|monica93@example.org|+1-535-652-9715x6...|702101.0|            4| Depa
rtment 4|
|   Heather|     Haley|         Music tutor|1981-06-01|stephanie65@examp...|   (652)815-7973x298|570960.0|            6| Depa
rtment 6|
|    Thomas|    Thomas|Chartered managem...|2001-07-17|pwilliams@example...|001-245-848-0028x...|339441.0|            6| Depa
rtment 6|
|   Leonard|   Carlson|       Art therapist|1990-10-18|gabrielmurray@exa...|          9247590563|469728.0|            8| Depa
rtment 8|
|      Mark|      Wood|   Market researcher|1963-10-13|nicholas76@exampl...|   311.439.1606x3342|582291.0|            4| Depa
rtment 4|
```

```
|      Mark|      Wood|   Market researcher|1963-10-13|nicholas76@exampl...|   311.439.1606x3342|582291.0|            4| Depa
rtment 4|
|    Tracey|Washington|Travel agency man...|1986-05-07|  mark07@example.com|    001-912-206-6456|146456.0|            4| Depa
rtment 4|
|   Rachael| Rodriguez|        Media buyer|1966-12-02|griffinmary@examp...| +1-791-344-7586x548|544732.0|            1| Depa
rtment 1|
|      Tara|       Liu|   Financial adviser|1998-10-12|alexandraobrien@e...|        216.696.6061|399503.0|            3| Depa
rtment 3|
|       Ana|    Joseph|      Retail manager|1995-01-10|  rmorse@example.org|  (726)363-7526x9965|761988.0|           10|Depar
tment 10|
|   Richard|      Hall|Engineer, civil (...|1967-03-02|brandoncardenas@e...| (964)451-9007x22496|660659.0|            4| Depa
rtment 4|
+----------+----------+--------------------+----------+--------------------+--------------------+--------+-------------+-----
--------+
only showing top 20 rows
```

In [15]:
```
# Calculate total salary of Department 6

from pyspark.sql.functions import sum

emp.where("department_id = 6").groupBy("department_id").agg(sum("salary").cast("long")).show()
```

```
+-------------+--------------------------+
|department_id|CAST(sum(salary) AS BIGINT)|
+-------------+--------------------------+
|            6|               50294510721|
+-------------+--------------------------+
```

In [22]:
```
# Accumulators

dept_sal = spark.sparkContext.accumulator(0)
```

In [23]:
```
# Use foreach

def calculate_salary(department_id, salary):
    if department_id == 6:
        dept_sal.add(salary)

emp.foreach(lambda row : calculate_salary(row.department_id, row.salary))
```

In [24]:
```
# View total value

dept_sal.value
```

Out[24]: 50294510721.0

In [25]:
```
# Stop Spark Session

spark.stop()
```

Note:

Data partitions will be read by all executors in parallel thus is will be in different executors.

Joins can lead to shuffle if not optimized correctly.

Spark Hands On

1. How to Optimize Joins – Big vs Small and Big vs Big table
2. ShuffleHash, SortMerge and BroadCast Joins
3. Bucketing Strategy to load data faster
4. Spark UI to understand tasks/partitions with join data

In [2]:
```
# Spark Session
from pyspark.sql import SparkSession

spark = (
    SparkSession
    .builder
    .appName("Optimizing Joins")
    .master("spark://17e348267994:7077")
    .config("spark.cores.max", 16)
    .config("spark.executor.cores", 4)
    .config("spark.executor.memory", "512M")
    .getOrCreate()
)

spark
```

Out[2]:

SparkSession - in-memory

SparkContext

Spark UI

Version	`v3.3.0`
Master	`spark://17e348267994:7077`
AppName	`Optimizing Joins`

In [3]:
```
# Disable AQE and Broadcast join

spark.conf.set("spark.sql.adaptive.enabled", False)
spark.conf.set("spark.sql.adaptive.coalescePartitions.enabled", False)
spark.conf.set("spark.sql.autoBroadcastJoinThreshold", -1)
```

Join Big and Small table - SortMerge vs BroadCast Join

In [3]:
```
# Read EMP CSV data

_schema = "first_name string, last_name string, job_title string, dob string, email string, phone string, salary double, dep

emp = spark.read.format("csv").schema(_schema).option("header", True).load("/data/input/datasets/employee_records.csv")
```

In [4]:
```
# Read DEPT CSV data

_dept_schema = "department_id int, department_name string, description string, city string, state string, country string"

dept = spark.read.format("csv").schema(_dept_schema).option("header", True).load("/data/input/datasets/department_data.csv")
```

In [8]:
```
# Join Datasets
from pyspark.sql.functions import broadcast

df_joined = emp.join(broadcast(dept), on=emp.department_id==dept.department_id, how="left_outer")
```

In [9]:
```
df_joined.write.format("noop").mode("overwrite").save()
```

In [10]:
```
df_joined.explain()
```

```
== Physical Plan ==
*(2) BroadcastHashJoin [department_id#7], [department_id#16], LeftOuter, BuildRight, false
:- FileScan csv [first_name#0,last_name#1,job_title#2,dob#3,email#4,phone#5,salary#6,department_id#7] Batched: false, DataFil
ters: [], Format: CSV, Location: InMemoryFileIndex(1 paths)[file:/data/input/datasets/employee_records.csv], PartitionFilter
s: [], PushedFilters: [], ReadSchema: struct<first_name:string,last_name:string,job_title:string,dob:string,email:string,phon
e:string,s...
+- BroadcastExchange HashedRelationBroadcastMode(List(cast(input[0, int, false] as bigint)),false), [id=#160]
   +- *(1) Filter isnotnull(department_id#16)
      +- FileScan csv [department_id#16,department_name#17,description#18,city#19,state#20,country#21] Batched: false, DataFi
lters: [isnotnull(department_id#16)], Format: CSV, Location: InMemoryFileIndex(1 paths)[file:/data/input/datasets/department_
data.csv], PartitionFilters: [], PushedFilters: [IsNotNull(department_id)], ReadSchema: struct<department_id:int,department_n
ame:string,description:string,city:string,state:string,count...
```

Join Big and Big table - SortMerge without Buckets

In [9]:
```
# Read Sales data

sales_schema = "transacted_at string, trx_id string, retailer_id string, description string, amount double, city_id string"

sales = spark.read.format("csv").schema(sales_schema).option("header", True).load("/data/input/datasets/new_sales.csv")
```

In [10]:
```
# Read City data

city_schema = "city_id string, city string, state string, state_abv string, country string"

city = spark.read.format("csv").schema(city_schema).option("header", True).load("/data/input/datasets/cities.csv")
```

In [7]:
```
# Join Data

df_sales_joined = sales.join(city, on=sales.city_id==city.city_id, how="left_outer")
```

In [8]:
```
df_sales_joined.write.format("noop").mode("overwrite").save()
```

In [ ]:
```
# Explain Plan
```

Write Sales and City data in Buckets

In [13]:
```
# Write Sales data in Buckets

sales.write.format("csv").mode("overwrite").bucketBy(4, "city_id").option("header", True).option("path", "/data/input/datase
```

In [14]:
```
# Write City data in Buckets

city.write.format("csv").mode("overwrite").bucketBy(4, "city_id").option("header", True).option("path", "/data/input/dataset
```

In [15]:
```
# Check tables

spark.sql("show tables in default").show()
```

```
+---------+------------+-----------+
|namespace|   tableName|isTemporary|
+---------+------------+-----------+
|  default| city_bucket|      false|
|  default|sales_bucket|      false|
+---------+------------+-----------+
```

Join Sales and City data - SortMerge with Bucket

In [16]:
```
# Read Sales table

sales_bucket = spark.read.table("sales_bucket")
```

In [17]:
```
# Read City table

city_bucket = spark.read.table("city_bucket")
```

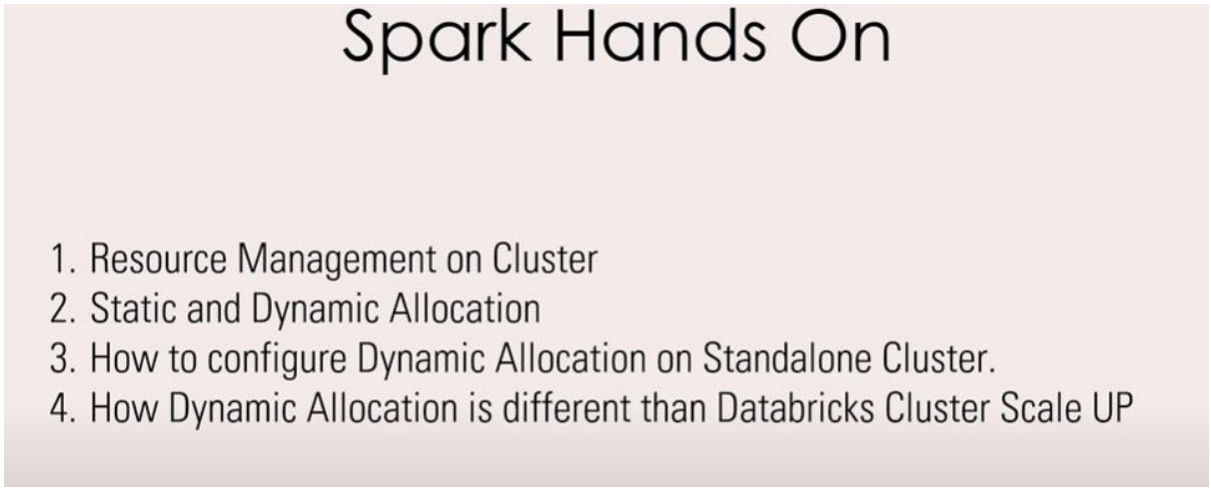
In [19]:
```
# Join datasets

df_joined_bucket = sales_bucket.join(city_bucket, on=sales_bucket.city_id==city_bucket.city_id, how="left_outer")
```

In [20]:
```
# Write dataset

df_joined_bucket.write.format("noop").mode("overwrite").save()
```

In [21]:
```
df_joined_bucket.explain()
```

```
== Physical Plan ==
*(3) SortMergeJoin [city_id#176], [city_id#183], LeftOuter
:- *(1) Sort [city_id#176 ASC NULLS FIRST], false, 0
:  +- FileScan csv default.sales_bucket[transacted_at#171,trx_id#172,retailer_id#173,description#174,amount#175,city_id#176]
Batched: false, Bucketed: true, DataFilters: [], Format: CSV, Location: InMemoryFileIndex(1 paths)[file:/data/input/datasets/
sales_bucket.csv], PartitionFilters: [], PushedFilters: [], ReadSchema: struct<transacted_at:string,trx_id:string,retailer_i
d:string,description:string,amount:double,cit..., SelectedBucketsCount: 4 out of 4
+- *(2) Sort [city_id#183 ASC NULLS FIRST], false, 0
   +- *(2) Filter isnotnull(city_id#183)
      +- FileScan csv default.city_bucket[city_id#183,city#184,state#185,state_abv#186,country#187] Batched: false, Bucketed:
true, DataFilters: [isnotnull(city_id#183)], Format: CSV, Location: InMemoryFileIndex(1 paths)[file:/data/input/datasets/city
_bucket.csv], PartitionFilters: [], PushedFilters: [IsNotNull(city_id)], ReadSchema: struct<city_id:string,city:string,state:
string,state_abv:string,country:string>, SelectedBucketsCount: 4 out of 4
```

In [ ]:
```
# View how tasks are reading Bucket data
```



In [1]:
```
# Spark Session
from pyspark.sql import SparkSession

spark = (
    SparkSession
    .builder
    .appName("Dynamic Allocation")
    .master("spark://197e20b418a6:7077")
    .config("spark.executor.cores", 2)
    .config("spark.executor.memory", "512M")
    .config("spark.dynamicAllocation.enabled", True)
    .config("spark.dynamicAllocation.minExecutors", 0)
    .config("spark.dynamicAllocation.maxExecutors", 5)
    .config("spark.dynamicAllocation.initialExecutors", 1)
    .config("spark.dynamicAllocation.shuffleTracking.enabled", True)
    .config("spark.dynamicAllocation.executorIdleTimeout", "60s")
    .config("spark.dynamicAllocation.cachedExecutorIdleTimeout", "60s")
    .getOrCreate()
)

spark
```

Out[1]:

SparkSession - in-memory

SparkContext

Spark UI

Version	`v3.3.0`
Master	`spark://197e20b418a6:7077`
AppName	`Dynamic Allocation`

In [2]:
```
# Read Sales data

sales_schema = "transacted_at string, trx_id string, retailer_id string, description string, amount double, city_id string"

sales = spark.read.format("csv").schema(sales_schema).option("header", True).load("/data/input/new_sales.csv")
```

In [3]:
```
# Read City data

city_schema = "city_id string, city string, state string, state_abv string, country string"

city = spark.read.format("csv").schema(city_schema).option("header", True).load("/data/input/cities.csv")
```

In [4]:
```
# Join Data

df_sales_joined = sales.join(city, on=sales.city_id==city.city_id, how="left_outer")
```

In [5]:
```
df_sales_joined.write.format("noop").mode("overwrite").save()
```

In [ ]:
```
# Difference between Scale UP in Databricks and Dynamic Allocation
```

In [1]:
```
# Spark Session
from pyspark.sql import SparkSession

spark = (
    SparkSession
    .builder
    .appName("Optimizing Skewness and Spillage")
    .master("spark://197e20b418a6:7077")
    .config("spark.cores.max", 8)
    .config("spark.executor.cores", 4)
    .config("spark.executor.memory", "512M")
    .getOrCreate()
)

spark
```

Out[1]:

SparkSession - in-memory

SparkContext

Spark UI

Version	`v3.3.0`
Master	`spark://197e20b418a6:7077`
AppName	`Optimizing Skewness and Spillage`

In [2]:
```
# Disable AQE and Broadcast join

spark.conf.set("spark.sql.adaptive.enabled", False)
spark.conf.set("spark.sql.adaptive.coalescePartitions.enabled", False)
spark.conf.set("spark.sql.autoBroadcastJoinThreshold", -1)
```

In [3]:
```
# Read Employee data
_schema = "first_name string, last_name string, job_title string, dob string, email string, phone string, salary double, dep

emp = spark.read.format("csv").schema(_schema).option("header", True).load("/data/input/employee_records_skewed.csv")
```

In [4]:
```
# Read DEPT CSV data
_dept_schema = "department_id int, department_name string, description string, city string, state string, country string"

dept = spark.read.format("csv").schema(_dept_schema).option("header", True).load("/data/input/department_data.csv")
```

In [5]:
```
# Join Datasets

df_joined = emp.join(dept, on=emp.department_id==dept.department_id, how="left_outer")
```

In [6]:
```
df_joined.write.format("noop").mode("overwrite").save()
```

In [ ]:
```
#Explain Plan

df_joined.explain()
```

In [7]:
```
# Check the partition details to understand distribution
from pyspark.sql.functions import spark_partition_id, count, lit

part_df = df_joined.withColumn("partition_num", spark_partition_id()).groupBy("partition_num").agg(count(lit(1)).alias("cour

part_df.show()
```

```
+-------------+------+
|partition_num| count|
+-------------+------+
|          103| 19860|
|          122|420474|
|           43| 19899|
|          107| 19928|
|           49| 20006|
|           51| 19829|
|          102| 20099|
|           66| 20172|
|          174| 20229|
|           89|419504|
+-------------+------+
```

In [8]:
```
# Verify Employee data based on department_id
from pyspark.sql.functions import count, lit, desc, col

emp.groupBy("department_id").agg(count(lit(1))).show()
```

```
+-------------+--------+
|department_id|count(1)|
+-------------+--------+
|            1|   19899|
|            6|   20006|
|            3|   19829|
|            5|   20172|
|            9|  419504|
|            4|   20099|
|            8|   19860|
|            7|   19928|
|           10|  420474|
|            2|   20229|
+-------------+--------+
```

In [27]:
```
# Set shuffle partitions to a lesser number - 16

spark.conf.set("spark.sql.shuffle.partitions", 32)
```

In [28]:
```
# Let prepare the salt
import random
from pyspark.sql.functions import udf

# UDF to return a random number every time and add to Employee as salt
@udf
def salt_udf():
    return random.randint(0, 32)

# Salt Data Frame to add to department
salt_df = spark.range(0, 32)
salt_df.show()
```

```
+---+
| id|
+---+
|  0|
|  1|
|  2|
|  3|
|  4|
|  5|
|  6|
|  7|
|  8|
|  9|
| 10|
| 11|
| 12|
| 13|
| 14|
| 15|
| 16|
| 17|
| 18|
| 19|
+---+
```

In [29]:
```
# Salted Employee
from pyspark.sql.functions import lit, concat

salted_emp = emp.withColumn("salted_dept_id", concat("department_id", lit("_"), salt_udf()))

salted_emp.show()
```

```
+----------+---------+--------------------+----------+--------------------+--------------------+--------+-------------+-----
--------+
|first_name|last_name|           job_title|       dob|               email|               phone|  salary|department_id|salted
_dept_id|
+----------+---------+--------------------+----------+--------------------+--------------------+--------+-------------+-----
--------+
|  Samantha|    Brown|Diagnostic radiog...|1966-06-11| jwatson@example.com|       (428)806-5154|439679.0|            3|
3_5|
|    Justin|Castaneda|Human resources o...|1996-11-11|  sdavis@example.org|    001-581-642-9621| 97388.0|            4|
4_23|
|      Carl| Peterson|         Proofreader|1984-11-23|andrew20@example.net|   241-871-9102x3835|287728.0|            1|
1_5|
| Catherine|     Lane|    Location manager|1966-06-21|elizabethalexande...|   470.866.4415x0739|174151.0|            3|
3_25|
|     Aaron|  Delgado|Teacher, secondar...|1972-10-11|uwilliams@example...|   384.336.5759x4831|209013.0|            8|
8_17|
|  Michelle|     Hill|Customer service ...|1984-01-15|antoniojoseph@exa...|    368.485.0685x793|764126.0|            8|
8_15|
|  Kristina|   Martin|       IT consultant|1964-02-23|autumn05@example.com|       (625)327-0615|563768.0|            1|
1_9|
|     Carol|  Nichols|      Phytotherapist|1969-02-14|crawfordsarah@exa...|  422-490-1069x38089|156689.0|           10|
10_19|
|     Peter|     Hill|      Cytogeneticist|1964-09-23|   xholt@example.org|        935.573.8160|957436.0|            5|
5_23|
|  Benjamin|    Lopez|Agricultural engi...|1966-01-20|  ryan46@example.org| +1-256-376-8069x339|891725.0|            1|
1_5|
|     Susan|   Savage|Optician, dispensing|1996-07-27|taylorjoshua@exam...| +1-393-821-5515x816|198396.0|            6|
6_5|
|    Robert|      Cox|Occupational ther...|1993-06-27|anthony00@example...|          8008487748|907659.0|            3|
3_32|
|      Evan|    Terry|Local government ...|1982-01-03|srodriguez@exampl...|        220-913-4625|693419.0|            5|
```

In [30]:
```
# Salted Department

salted_dept = dept.join(salt_df, how="cross").withColumn("salted_dept_id", concat("department_id", lit("_"), "id"))

salted_dept.where("department_id = 9").show()
```

```
+-------------+--------------------+--------------------+-----------+-----+-------+---+--------------+
|department_id|     department_name|         description|       city|state|country| id|salted_dept_id|
+-------------+--------------------+--------------------+-----------+-----+-------+---+--------------+
|            9|Mcmahon, Terrell ...|De-engineered hig...|Marychester|   MN|  Italy|  0|           9_0|
|            9|Mcmahon, Terrell ...|De-engineered hig...|Marychester|   MN|  Italy|  1|           9_1|
|            9|Mcmahon, Terrell ...|De-engineered hig...|Marychester|   MN|  Italy|  2|           9_2|
|            9|Mcmahon, Terrell ...|De-engineered hig...|Marychester|   MN|  Italy|  3|           9_3|
|            9|Mcmahon, Terrell ...|De-engineered hig...|Marychester|   MN|  Italy|  4|           9_4|
|            9|Mcmahon, Terrell ...|De-engineered hig...|Marychester|   MN|  Italy|  5|           9_5|
|            9|Mcmahon, Terrell ...|De-engineered hig...|Marychester|   MN|  Italy|  6|           9_6|
|            9|Mcmahon, Terrell ...|De-engineered hig...|Marychester|   MN|  Italy|  7|           9_7|
|            9|Mcmahon, Terrell ...|De-engineered hig...|Marychester|   MN|  Italy|  8|           9_8|
|            9|Mcmahon, Terrell ...|De-engineered hig...|Marychester|   MN|  Italy|  9|           9_9|
|            9|Mcmahon, Terrell ...|De-engineered hig...|Marychester|   MN|  Italy| 10|          9_10|
|            9|Mcmahon, Terrell ...|De-engineered hig...|Marychester|   MN|  Italy| 11|          9_11|
|            9|Mcmahon, Terrell ...|De-engineered hig...|Marychester|   MN|  Italy| 12|          9_12|
|            9|Mcmahon, Terrell ...|De-engineered hig...|Marychester|   MN|  Italy| 13|          9_13|
|            9|Mcmahon, Terrell ...|De-engineered hig...|Marychester|   MN|  Italy| 14|          9_14|
|            9|Mcmahon, Terrell ...|De-engineered hig...|Marychester|   MN|  Italy| 15|          9_15|
|            9|Mcmahon, Terrell ...|De-engineered hig...|Marychester|   MN|  Italy| 16|          9_16|
|            9|Mcmahon, Terrell ...|De-engineered hig...|Marychester|   MN|  Italy| 17|          9_17|
|            9|Mcmahon, Terrell ...|De-engineered hig...|Marychester|   MN|  Italy| 18|          9_18|
|            9|Mcmahon, Terrell ...|De-engineered hig...|Marychester|   MN|  Italy| 19|          9_19|
+-------------+--------------------+--------------------+-----------+-----+-------+---+--------------+
only showing top 20 rows
```

In [31]:
```
# Lets make the salted join now
salted_joined_df = salted_emp.join(salted_dept, on=salted_emp.salted_dept_id==salted_dept.salted_dept_id, how="left_outer")
```

In [ ]:
```
```

In [33]:
```
salted_joined_df.write.format("noop").mode("overwrite").save()
```

In [32]:

```
# Check the partition details to understand distribution
from pyspark.sql.functions import spark_partition_id, count

part_df = salted_joined_df.withColumn("partition_num", spark_partition_id()).groupBy("partition_num").agg(count(lit(1)).alia

part_df.show()
```

```
+-------------+-----+
|partition_num|count|
+-------------+-----+
|           18|30975|
|           12|28636|
|           10|17942|
|           27|58641|
|            1|28039|
|            3|31642|
|           20|29552|
|           29| 4860|
|           13|20105|
|           14|18831|
|           23|81155|
|            6|18818|
|            9|55094|
|           11|44418|
|           26| 3006|
|            7|30275|
|           30| 4220|
|           28|16504|
|            0|30887|
|            8|30997|
+-------------+-----+
only showing top 20 rows
```

What is skewness?

-Basically unbalanced data not distributed properly.

2 types of spillage -Spillage memory & Spillage disk.

How to identify Skewness?

-We can find the partition count for the shuffled data.

Salted keys: Creation of new salted keys for joining at both tables.

Note: Salting Technique doesn’t need to be used everytime, make sure to use only when you have issues of memory due to spillage(mostly out of memory errors).

This was just a demo to show you how to fix spillage.

Spark Hands On

1. What is AQE (Adaptive Query Execution) ?
2. Benefits of AQE
3. Impact of AQE in Skew Joins, Sort Merge Joins & Broadcast Joins
4. Coalescing post-shuffle partitions with AQE

In [1]:
```
# Spark Session
from pyspark.sql import SparkSession

spark = (
    SparkSession
    .builder
    .appName("AQE in Spark")
    .master("spark://197e20b418a6:7077")
    .config("spark.cores.max", 8)
    .config("spark.executor.cores", 4)
    .config("spark.executor.memory", "512M")
    .getOrCreate()
)

spark
```

Out[1]:

SparkSession - in-memory

SparkContext

Spark UI

Version	v3.3.0
Master	spark://197e20b418a6:7077
AppName	AQE in Spark

In [2]:
```
# Disable AQE and Broadcast join

spark.conf.set("spark.sql.adaptive.enabled", False)
spark.conf.set("spark.sql.adaptive.coalescePartitions.enabled", False)
spark.conf.set("spark.sql.autoBroadcastJoinThreshold", -1)
```

In [3]:
```
# Read Employee data
_schema = "first_name string, last_name string, job_title string, dob string, email string, phone string, salary double, dep

emp = spark.read.format("csv").schema(_schema).option("header", True).load("/data/input/employee_records_skewed.csv")
```

In [4]:
```
# Read DEPT CSV data
_dept_schema = "department_id int, department_name string, description string, city string, state string, country string"

dept = spark.read.format("csv").schema(_dept_schema).option("header", True).load("/data/input/department_data.csv")
```

In [14]:
```
# Join Datasets

df_joined = emp.join(dept, on=emp.department_id==dept.department_id, how="left_outer")
```

In [15]:
```
df_joined.write.format("noop").mode("overwrite").save()
```

In [6]:
```
#Explain Plan

df_joined.explain()
```

```
== Physical Plan ==
*(4) SortMergeJoin [department_id#7], [department_id#16], LeftOuter
:- *(1) Sort [department_id#7 ASC NULLS FIRST], false, 0
:  +- Exchange hashpartitioning(department_id#7, 200), ENSURE_REQUIREMENTS, [id=#17]
:     +- FileScan csv [first_name#0,last_name#1,job_title#2,dob#3,email#4,phone#5,salary#6,department_id#7] Batched: false, D
ataFilters: [], Format: CSV, Location: InMemoryFileIndex(1 paths)[file:/data/input/employee_records_skewed.csv], PartitionFil
ters: [], PushedFilters: [], ReadSchema: struct<first_name:string,last_name:string,job_title:string,dob:string,email:string,p
hone:string,s...
+- *(3) Sort [department_id#16 ASC NULLS FIRST], false, 0
   +- Exchange hashpartitioning(department_id#16, 200), ENSURE_REQUIREMENTS, [id=#29]
      +- *(2) Filter isnotnull(department_id#16)
         +- FileScan csv [department_id#16,department_name#17,description#18,city#19,state#20,country#21] Batched: false, Dat
aFilters: [isnotnull(department_id#16)], Format: CSV, Location: InMemoryFileIndex(1 paths)[file:/data/input/department_data.c
sv], PartitionFilters: [], PushedFilters: [IsNotNull(department_id)], ReadSchema: struct<department_id:int,department_name:st
ring,description:string,city:string,state:string,count...
```

In [12]:
```
# Coalescing post-shuffle partitions - remove un-necessary shuffle partitions
# Skewed join optimization (balance partitions size) - join smaller partitions and split bigger partition

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

In [13]:
```
# Fix partition sizes to avoid Skew

spark.conf.set("spark.sql.adaptive.advisoryPartitionSizeInBytes", "8MB") #Default value: 64MB
spark.conf.set("spark.sql.adaptive.skewJoin.skewedPartitionThresholdInBytes", "10MB") #Default value: 256MB
```

In [16]:
```
# Converting sort-merge join to broadcast join

spark.conf.set("spark.sql.autoBroadcastJoinThreshold", "10MB")
```

In [17]:
```
# Join Datasets - without specifying specific broadcast table

df_joined = emp.join(dept, on=emp.department_id==dept.department_id, how="left_outer")
```

In [18]:
```
df_joined.write.format("noop").mode("overwrite").save()
```

Skewed Partitions Optimization:

Spark AQE will take care of the partition sizing to balance the data and avoid spillage.

Spark.sql.adaptive.advisoryPartitionSizeInBytes:

The size in bytes of the shuffle partition during adaptive optimization. This can control the size of shuffle partitions post-shuffle.

Now that out task partition memory is small we will make the partitions smaller in size to 8MB.

Spark.sql.adaptive.skewJoin.skewedPartitionThresholdInBytes:

A partition is considered as skewed if its size in bytes is larger than this threshold.

In [1]:
```
# Spark Session
from pyspark.sql import SparkSession

spark = (
    SparkSession
    .builder
    .appName("Spark SQL")
    .master("local[*]")
    .enableHiveSupport()
    .config("spark.sql.warehouse.dir", "/data/output/spark-warehouse")
    .getOrCreate()
)

spark
```

Out[1]:

SparkSession - hive

SparkContext

Spark UI

Version	`v3.3.0`
Master	`local[*]`
AppName	`Spark SQL`

In [9]:
```
# Read Employee data
_schema = "first_name string, last_name string, job_title string, dob string, email string, phone string, salary double, dep

emp = spark.read.format("csv").schema(_schema).option("header", True).load("/data/input/employee_records_skewed.csv")
```

In [10]:
```
# Read DEPT CSV data
_dept_schema = "department_id int, department_name string, description string, city string, state string, country string"

dept = spark.read.format("csv").schema(_dept_schema).option("header", True).load("/data/input/department_data.csv")
```

In [2]:
```
# Spark Catalog (Metadata) - in-memory/hive

spark.conf.get("spark.sql.catalogImplementation")
```

Out[2]:
```
'hive'
```

In [3]:
```
# Show databases
db = spark.sql("show databases")
db.show()
```

```
+---------+
|namespace|
+---------+
|  default|
+---------+
```

In [4]:
```
spark.sql("show tables in default").show()
```

```
+---------+---------+-----------+
|namespace|tableName|isTemporary|
+---------+---------+-----------+
|  default|emp_final|      false|
+---------+---------+-----------+
```

In [12]:
```
# Register dataframes are temp views

emp.createOrReplaceTempView("emp_view")

dept.createOrReplaceTempView("dept_view")
```

In [ ]:
```
# Show tables/view in catalog
```

In [16]:
```
# View data from table

emp_filtered = spark.sql("""
    select * from emp_view
    where department_id = 1
""")
```

In [17]:
```
emp_filtered.show()
```

```
+----------+---------+--------------------+----------+--------------------+--------------------+--------+-------------+
|first_name|last_name|           job_title|       dob|               email|               phone|  salary|department_id|
+----------+---------+--------------------+----------+--------------------+--------------------+--------+-------------+
|      Carl| Peterson|         Proofreader|1984-11-23|andrew20@example.net|  241-871-9102x3835|287728.0|            1|
|   Kristina|   Martin|       IT consultant|1964-02-23|autumn05@example.com|      (625)327-0615|563768.0|            1|
|   Benjamin|    Lopez|Agricultural engi...|1966-01-20| ryan46@example.org|+1-256-376-8069x339|891725.0|            1|
|    Leslie|Rodriguez|Horticulturist, c...|1973-06-16|thomassutton@exam...|001-630-539-4136x...|875940.0|            1|
|    Angela|   Martin|   Company secretary|1979-07-07| qholmes@example.org|001-267-831-8987x...|485302.0|            1|
|     Julia|    Gomez|       Advice worker|1963-03-02|xjackson@example.net|        495-667-0287| 59589.0|            1|
|    Jeremy|     Hunt|Radiation protect...|1987-12-06|moraeric@example.net|          6276248675|199026.0|            1|
|     Alice|     Rice|Advertising art d...|1964-04-03|   amy82@example.net|          2208895255|967862.0|            1|
|   Clinton|Cunningham|Designer, exhibit...|1984-07-22|margaret29@exampl...|  (526)879-8418x297|660617.0|            1|
|     Susan|     Ford|Geographical info...|1985-05-06|sherrirobinson@ex...|       (734)226-1079|991902.0|            1|
|   Gregory|  Stevens|Engineer, buildin...|1997-11-17|  sgreen@example.org|        676-481-8023|986664.0|            1|
|   Shannon|    Bowen|Industrial/produc...|1973-05-07| gharris@example.com|  (891)559-1318x860|201522.0|            1|
|     Dylan| Sullivan|Television camera...|1999-06-23|michaelallison@ex...|001-757-795-1822x...|715727.0|            1|
|Christopher|   Lozano|Database administ...|1979-03-15|thernandez@exampl...| (465)990-3733x09035|441011.0|            1|
|    William|     Pope|           Best boy|1983-05-07|jillianmorrison@e...|        303.475.9516|632646.0|            1|
|     Kevin|    Brown|    Engineer, mining|1965-09-26|williamroy@exampl...|+1-771-254-4086x1...| 61066.0|            1|
|   Michaela| Mckinney|Teacher, English ...|1997-10-04| brian65@example.net|001-384-754-4223x...|750122.0|            1|
|    Pamela|      Lee|                Land|1974-04-28|bartonangela@exam...|001-226-781-4414x...|157355.0|            1|
|    Robert|    Davis|Museum education ...|1965-12-31|savagesamantha@ex...|    001-487-554-6158|833494.0|            1|
|    Jeremy|  Alvarez|       Tour manager|1998-11-04|kelleybrittany@ex...|+1-960-957-6641x9...| 84979.0|            1|
+----------+---------+--------------------+----------+--------------------+--------------------+--------+-------------+
only showing top 20 rows
```

In [21]:
```
# Create a new column dob_year and register as temp view

emp_temp = spark.sql("""
    select e.*, date_format(dob, 'yyyy') as dob_year from emp_view e
""")
```

In [22]:
```
emp_temp.createOrReplaceTempView("emp_temp_view")
```

In [24]:
```
spark.sql("select * from emp_temp_view").show()
```

```
+----------+---------+--------------------+----------+--------------------+--------------------+--------+-------------+-------
--+
|first_name|last_name|           job_title|       dob|               email|               phone|  salary|department_id|dob_ye
ar|
+----------+---------+--------------------+----------+--------------------+--------------------+--------+-------------+-------
--+
|  Samantha|    Brown|Diagnostic radiog...|1966-06-11| jwatson@example.com|       (428)806-5154|439679.0|            3|    19
66|
|    Justin|Castaneda|Human resources o...|1996-11-11|  sdavis@example.org|    001-581-642-9621| 97388.0|            4|    19
96|
|      Carl| Peterson|         Proofreader|1984-11-23|andrew20@example.net|  241-871-9102x3835|287728.0|            1|    19
84|
| Catherine|     Lane|    Location manager|1966-06-21|elizabethalexande...|  470.866.4415x0739|174151.0|            3|    19
66|
|     Aaron|  Delgado|Teacher, secondar...|1972-10-11|uwilliams@example...|  384.336.5759x4831|209013.0|            8|    19
72|
|  Michelle|     Hill|Customer service ...|1984-01-15|antoniojoseph@exa...|   368.485.0685x793|764126.0|            8|    19
84|
|  Kristina|   Martin|       IT consultant|1964-02-23|autumn05@example.com|      (625)327-0615|563768.0|            1|    19
64|
|     Carol|  Nichols|      Phytotherapist|1969-02-14|crawfordsarah@exa...|  422-490-1069x38089|156689.0|           10|    19
69|
|     Peter|     Hill|      Cytogeneticist|1964-09-23|   xholt@example.org|       935.573.8160|957436.0|            5|    19
64|
|  Benjamin|    Lopez|Agricultural engi...|1966-01-20| ryan46@example.org|+1-256-376-8069x339|891725.0|            1|    19
66|
|     Susan|   Savage|Optician, dispensing|1996-07-27|taylorjoshua@exam...|+1-393-821-5515x816|198396.0|            6|    19
96|
|    Robert|      Cox|Occupational ther...|1993-06-27|anthony00@example...|          8008487748|907659.0|            3|    19
93|
|      Evan|    Terry|Local government ...|1982-01-03|srodriguez@exampl...|       220-913-4625|693419.0|            5|    19
```

```
82|
|    Justin| Santiago|               Make|1965-03-20| birdjoe@example.org|        801-317-7926|815251.0|            7|    19
65|
|      Rose|  Gregory|          Barrister|1974-10-31|samuel27@example.net|        923-304-9438|673811.0|            2|    19
74|
|  Nicholas|    Short|  Charity fundraiser|1998-10-03| brian12@example.com|        855.973.7301|538901.0|            4|    19
98|
|      John|   Hanson|Lecturer, higher ...|2001-04-12|  zweiss@example.org|       (453)740-2558|247223.0|            7|    20
01|
|     Bryan|   Turner|Public relations ...|1984-01-30|  ssmith@example.com|  426.547.0413x20201|286799.0|            6|    19
84|
|     Tonya|  Schultz|Contracting civil...|1982-05-07|douglas54@example...|        578-916-7661|664105.0|            4|    19
82|
|  Patricia| Anderson|       Set designer|1974-09-22|joshua92@example.net|001-765-729-3973x...|439446.0|            2|    19
74|
+----------+---------+--------------------+----------+--------------------+--------------------+--------+-------------+------
--+
only showing top 20 rows
```

In [13]:

```
# Join emp and dept - HINTs

emp_final = spark.sql("""
    select /*+ BROADCAST(d) */
    e.* , d.department_name
    from emp_view e left outer join dept_view d
    on e.department_id = d.department_id
""")
```

In [9]:

```
# Show emp data

emp_final.show()
```

```
+----------+---------+--------------------+----------+--------------------+--------------------+--------+-------------+------
--------------+
|first_name|last_name|           job_title|       dob|               email|               phone|  salary|department_id|     d
epartment_name|
+----------+---------+--------------------+----------+--------------------+--------------------+--------+-------------+------
--------------+
|  Samantha|    Brown|Diagnostic radiog...|1966-06-11| jwatson@example.com|       (428)806-5154|439679.0|            3|Pittma
n, Hess and...|
|    Justin|Castaneda|Human resources o...|1996-11-11|  sdavis@example.org|    001-581-642-9621| 97388.0|            4|Smith,
Snyder and...|
|      Carl| Peterson|         Proofreader|1984-11-23|andrew20@example.net|   241-871-9102x3835|287728.0|            1|
Bryan-James|
| Catherine|     Lane|    Location manager|1966-06-21|elizabethalexande...|   470.866.4415x0739|174151.0|            3|Pittma
n, Hess and...|
|     Aaron|  Delgado|Teacher, secondar...|1972-10-11|uwilliams@example...|   384.336.5759x4831|209013.0|            8|
Parker PLC|
|  Michelle|     Hill|Customer service ...|1984-01-15|antoniojoseph@exa...|    368.485.0685x793|764126.0|            8|
Parker PLC|
|  Kristina|   Martin|       IT consultant|1964-02-23|autumn05@example.com|       (625)327-0615|563768.0|            1|
Bryan-James|
|     Carol|  Nichols|      Phytotherapist|1969-02-14|crawfordsarah@exa...|  422-490-1069x38089|156689.0|           10|
Delgado-Keller|
|     Peter|     Hill|      Cytogeneticist|1964-09-23|   xholt@example.org|        935.573.8160|957436.0|            5|
Hardin Inc|
|  Benjamin|    Lopez|Agricultural engi...|1966-01-20|  ryan46@example.org| +1-256-376-8069x339|891725.0|            1|
Bryan-James|
|     Susan|   Savage|Optician, dispensing|1996-07-27|taylorjoshua@exam...| +1-393-821-5515x816|198396.0|            6|
Sanders LLC|
|    Robert|      Cox|Occupational ther...|1993-06-27|anthony00@example...|          8008487748|907659.0|            3|Pittma
n, Hess and...|
|      Evan|    Terry|Local government ...|1982-01-03|srodriguez@exampl...|        220-913-4625|693419.0|            5|
Hardin Inc|
|    Justin| Santiago|               Make|1965-03-20| birdjoe@example.org|        801-317-7926|815251.0|            7|
```

```
Hardin Inc|
|    Justin| Santiago|               Make|1965-03-20| birdjoe@example.org|        801-317-7926|815251.0|            7|
Ward-Gordon|
|      Rose|  Gregory|           Barrister|1974-10-31|samuel27@example.net|        923-304-9438|673811.0|            2|Smith,
Craig and ...|
|  Nicholas|    Short|  Charity fundraiser|1998-10-03| brian12@example.com|        855.973.7301|538901.0|            4|Smith,
Snyder and...|
|      John|   Hanson|Lecturer, higher ...|2001-04-12|  zweiss@example.org|       (453)740-2558|247223.0|            7|
Ward-Gordon|
|     Bryan|   Turner|Public relations ...|1984-01-30|  ssmith@example.com|  426.547.0413x20201|286799.0|            6|
Sanders LLC|
|     Tonya|  Schultz|Contracting civil...|1982-05-07|douglas54@example...|        578-916-7661|664105.0|            4|Smith,
Snyder and...|
|  Patricia| Anderson|        Set designer|1974-09-22|joshua92@example.net|001-765-729-3973x...|439446.0|            2|Smith,
Craig and ...|
+----------+---------+--------------------+----------+--------------------+--------------------+--------+-------------+------
--------------+
only showing top 20 rows
```

In [14]:
```
# Write the data as Table

emp_final.write.format("parquet").saveAsTable("emp_final")
```

In [5]:
```
# Read the data from Table

emp_new = spark.sql("select * from emp_final")
```

In [6]:
```
emp_new.show()
```

```
+----------+---------+--------------------+----------+--------------------+--------------------+--------+-------------+------
--------------+
|first_name|last_name|           job_title|       dob|               email|               phone|  salary|department_id|     d
epartment_name|
+----------+---------+--------------------+----------+--------------------+--------------------+--------+-------------+------
--------------+
|  Samantha|    Brown|Diagnostic radiog...|1966-06-11| jwatson@example.com|       (428)806-5154|439679.0|            3|Pittma
n, Hess and...|
|    Justin|Castaneda|Human resources o...|1996-11-11|  sdavis@example.org|    001-581-642-9621| 97388.0|            4|Smith,
Snyder and...|
|      Carl| Peterson|         Proofreader|1984-11-23|andrew20@example.net|   241-871-9102x3835|287728.0|            1|
Bryan-James|
| Catherine|     Lane|    Location manager|1966-06-21|elizabethalexande...|   470.866.4415x0739|174151.0|            3|Pittma
n, Hess and...|
|     Aaron|  Delgado|Teacher, secondar...|1972-10-11|uwilliams@example...|   384.336.5759x4831|209013.0|            8|
Parker PLC|
|  Michelle|     Hill|Customer service ...|1984-01-15|antoniojoseph@exa...|    368.485.0685x793|764126.0|            8|
Parker PLC|
|  Kristina|   Martin|       IT consultant|1964-02-23|autumn05@example.com|       (625)327-0615|563768.0|            1|
Bryan-James|
|     Carol|  Nichols|      Phytotherapist|1969-02-14|crawfordsarah@exa...|  422-490-1069x38089|156689.0|           10|
Delgado-Keller|
|     Peter|     Hill|      Cytogeneticist|1964-09-23|   xholt@example.org|        935.573.8160|957436.0|            5|
Hardin Inc|
|  Benjamin|    Lopez|Agricultural engi...|1966-01-20|  ryan46@example.org| +1-256-376-8069x339|891725.0|            1|
Bryan-James|
|     Susan|   Savage|Optician, dispensing|1996-07-27|taylorjoshua@exam...| +1-393-821-5515x816|198396.0|            6|
Sanders LLC|
|    Robert|      Cox|Occupational ther...|1993-06-27|anthony00@example...|          8008487748|907659.0|            3|Pittma
n, Hess and...|
|      Evan|    Terry|Local government ...|1982-01-03|srodriguez@exampl...|        220-913-4625|693419.0|            5|
Hardin Inc|
|    Justin| Santiago|               Make|1965-03-20| birdjoe@example.org|        801-317-7926|815251.0|            7|
Ward-Gordon|
|      Rose|  Gregory|           Barrister|1974-10-31|samuel27@example.net|        923-304-9438|673811.0|            2|Smith,
Craig and ...|
|  Nicholas|    Short|  Charity fundraiser|1998-10-03| brian12@example.com|        855.973.7301|538901.0|            4|Smith,
```

In [ ]:
```
# Persist metadata
```

In [8]:
```
# Show details of metadata

spark.sql("describe extended emp_final").show()
```

```
+--------------------+--------------------+-------+
|            col_name|           data_type|comment|
+--------------------+--------------------+-------+
|          first_name|              string|   null|
|           last_name|              string|   null|
|           job_title|              string|   null|
|                 dob|              string|   null|
|               email|              string|   null|
|               phone|              string|   null|
|              salary|              double|   null|
|       department_id|                 int|   null|
|     department_name|              string|   null|
|                    |                    |       |
|# Detailed Table ...|                    |       |
|            Database|             default|       |
|               Table|           emp_final|       |
|               Owner|                root|       |
|        Created Time|Sat Jan 06 10:03:...|       |
|         Last Access|             UNKNOWN|       |
|          Created By|         Spark 3.3.0|       |
|                Type|             MANAGED|       |
|            Provider|             parquet|       |
|          Statistics|      37700526 bytes|       |
+--------------------+--------------------+-------+
only showing top 20 rows
```

What is Catalog?

-Catalog stores the metadata of SQL Objects.

Temp Views:

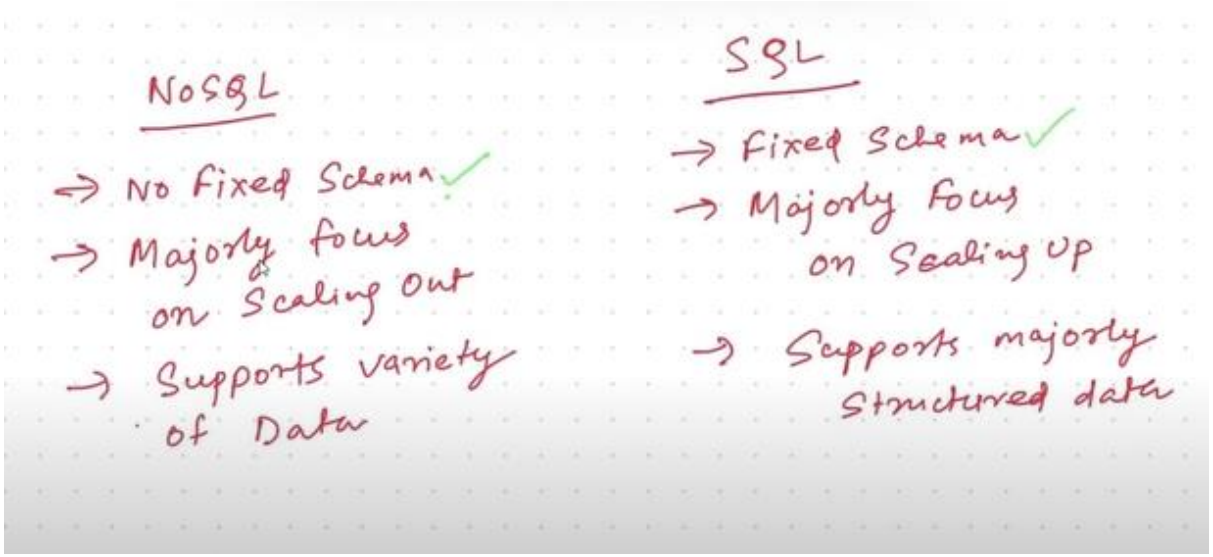
Temp views are only available until the session is active.

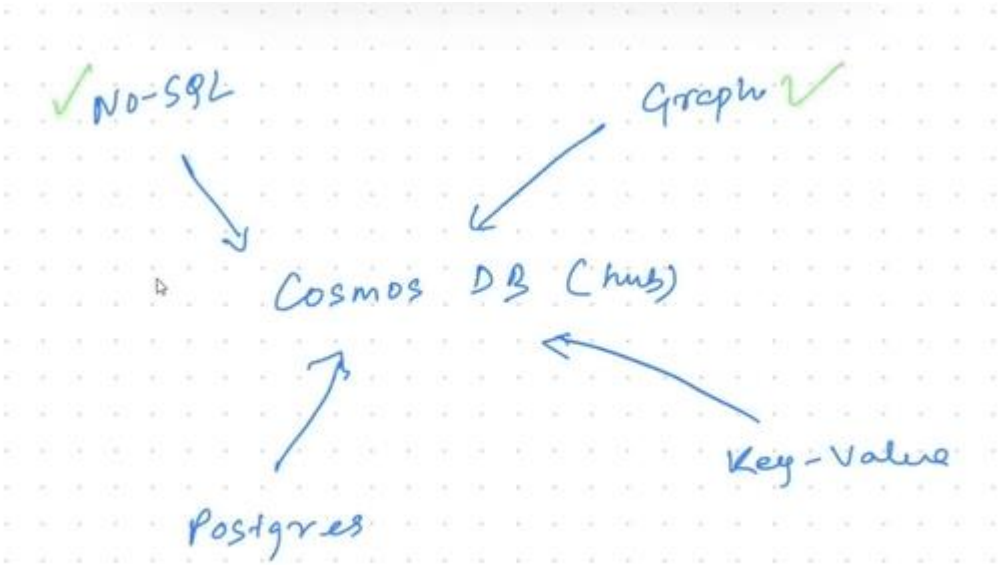
Spark SQL Functions:

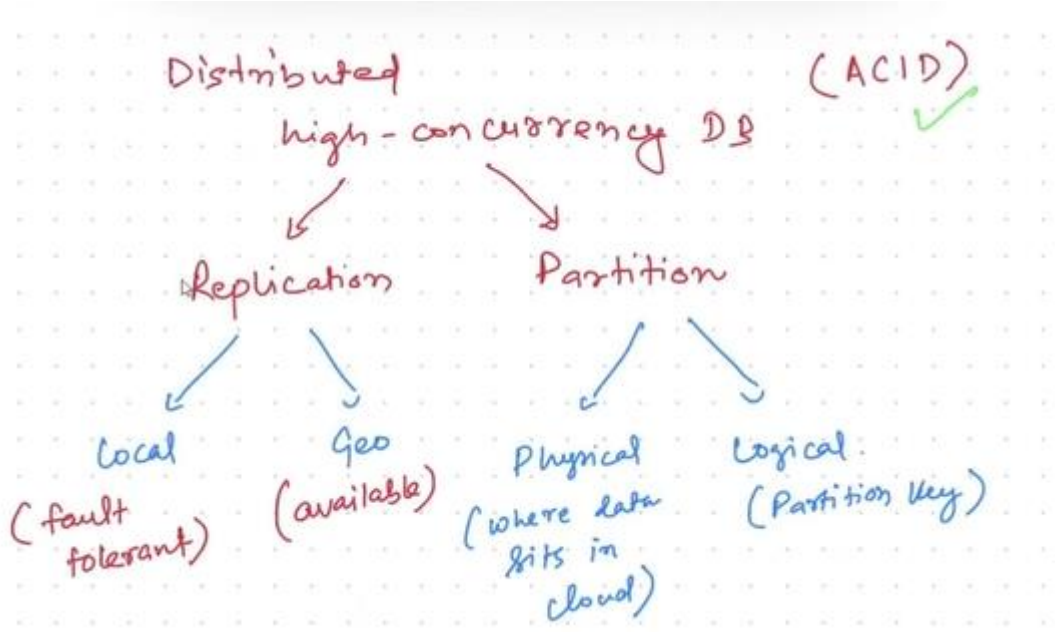
PySpark DataFrames API functions are available for Spark SQL by default. No need for any import.

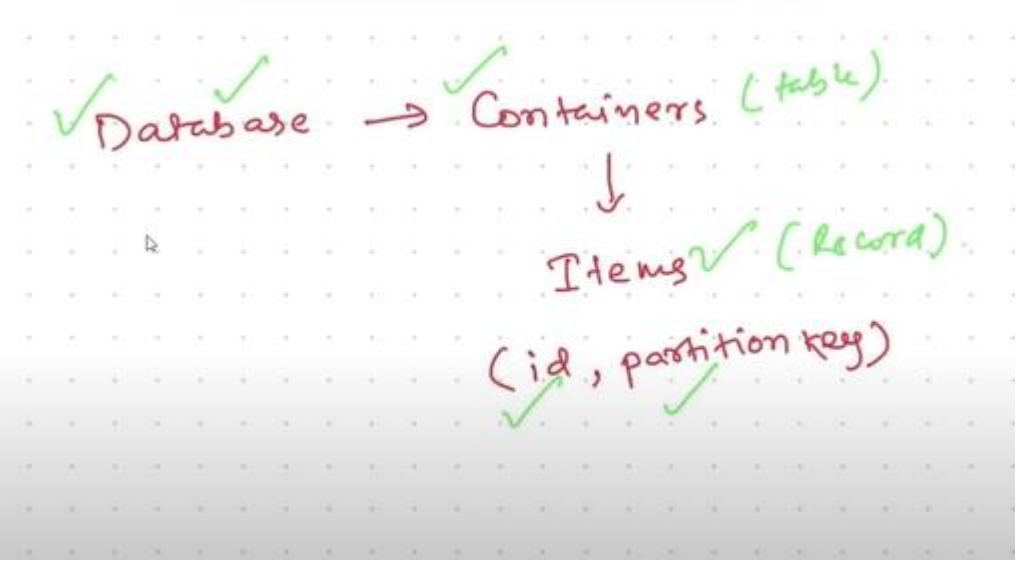
AZURE COSMOS DB

- WHAT IS NO-SQL DB?
- WHY IS COSMOS DB SO POPULAR?
- HOW TO SETUP COSMOS DB?
- HOW TO READ AND WRITE FROM COSMOS DB USING APACHE SPARK?



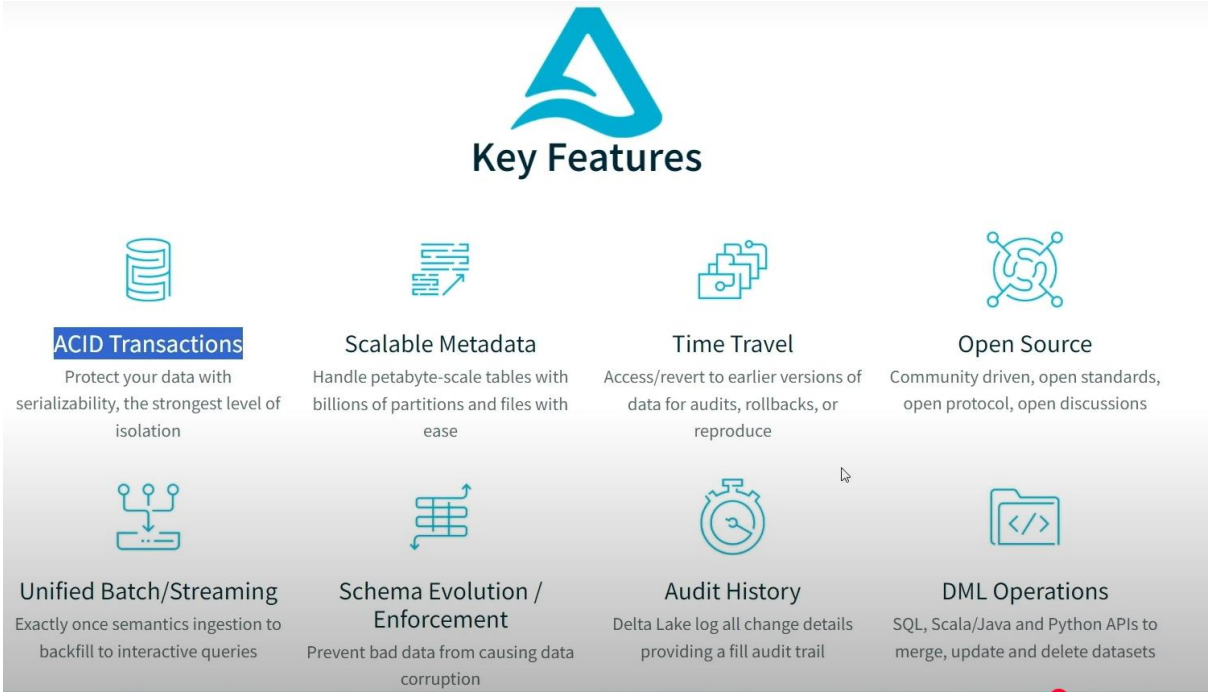

NO-SQL
Graph
Cosmos DB (hub)
Key-Value
Postgres


Distributed
high-concurrency DB
(ACID)
Replication
Partition
Local
(fault tolerant)
Geo
(available)
Physical
(where data sits in cloud)
Logical
(Partition key)



Using Secrets Securely:

This strategy works for on-premise or standard clusters. If you are working with Databricks, make sure to save secrets in Azure Key Vault and import them while reading or writing data.



In [0]:
```
# Spark Session
spark
```

SparkSession - hive

SparkContext

Spark UI

Version	`v3.3.2`
Master	`local[8]`
AppName	`Databricks Shell`

In [0]:
```
# Default Catalog for Databricks
spark.conf.get("spark.sql.catalogImplementation")
```

```
Out[2]: 'hive'
```

In [0]:
```
%sql
show databases
```

databaseName
default

In [0]:
```
# Read Sales parquet data
df_sales = spark.read.parquet("/data/input/sales_data.parquet")
```

In [0]:
```
# View data
display(df_sales)
```

transacted_at	trx_id	retailer_id	description	amount	city_id
2017-11-24T19:00:00.000+0000	1995601912	2077350195	Walgreen 11-25	197.23	216510442
2017-11-24T19:00:00.000+0000	1734117021	644879053	unkn ppd id: 768641 11-26	8.58	930259917
2017-11-24T19:00:00.000+0000	1734117022	847200066	Wal-Mart ppd id: 555914 Algiers 11-26	1737.26	1646415505
2017-11-24T19:00:00.000+0000	1734117030	1953761884	Home Depot ppd id: 265293 11-25	384.5	287177635
2017-11-24T19:00:00.000+0000	1734117089	1898522855	Target 11-25	66.33	1855530529

In [0]:
```
# Read a particular version - pyspark api
df_sales_delta = spark.read.table("sales_delta@v1")

display(df_sales_delta.where("trx_id = '1734117021'"))
```

transacted_at	trx_id	retailer_id	description	amount	city_id
2017-11-24T19:00:00.000+0000	1734117021	644879053	unkn ppd id: 768641 11-26	0.0	930259917

In [0]:
```
%sql

select * from sales_delta@v0 where trx_id = '1734117021'
```

transacted_at	trx_id	retailer_id	description	amount	city_id
2017-11-24T19:00:00.000+0000	1734117021	644879053	unkn ppd id: 768641 11-26	8.58	930259917

In [0]:
```
df_new = spark.sql("select *, current_timestamp() as time_now from sales_delta@v0 where trx_id = '1734117021'")

display(df_new)
```

transacted_at	trx_id	retailer_id	description	amount	city_id	time_now
2017-11-24T19:00:00.000+0000	1734117021	644879053	unkn ppd id: 768641 11-26	8.58	930259917	2024-05-26T07:30:03.636+0000

In [0]:
```
# Append data to existing delta table
df_new.write.format("delta").mode("append").option("mergeSchema", True).option("path", "/data/output/sales_delta_1/").saveAs
```

In [0]:

In [0]:
```
# View data
```

In [0]:
```
# Reading Delta Table using Delta libraries
from delta import DeltaTable

dt = DeltaTable.forName(spark, "sales_delta")

display(dt.history())
```

version	timestamp	userId	userName	operation	operationParameters	job	notebook	cl
2	2024-05-26T07:31:26.000+0000	5635101767402432	easewithdata@gmail.com	WRITE	Map(mode -> Append, partitionBy -> [])	null	List(954438656804733)	0 p7f
1	2024-05-26T07:16:09.000+0000	5635101767402432	easewithdata@gmail.com	UPDATE	Map(predicate -> ["(trx_id#2208 = 1734117021)"])	null	List(954438656804733)	0 p7f

In [0]:
```
# Converting a Parquet to Delta - Check and Convert

DeltaTable.isDeltaTable(spark, "/data/output/sales_delta_1")

DeltaTable.convertToDelta(spark, "parquet.`/data/output/sales_parquet_1`")
```

Out[67]: <delta.tables.DeltaTable at 0x7fe25dd57820>

In [0]:
```
# Validate
display(dbutils.fs.ls("/data/output/sales_parquet_1"))
```

path	name	size	modificationTime
dbfs:/data/output/sales_parquet_1/_SUCCESS	_SUCCESS	0	1716706626000
dbfs:/data/output/sales_parquet_1/_committed_6541294181759099722	_committed_6541294181759099722	122	1716706626000
dbfs:/data/output/sales_parquet_1/_delta_log/	_delta_log/	0	0
dbfs:/data/output/sales_parquet_1/_started_6541294181759099722	_started_6541294181759099722	0	1716706616000
dbfs:/data/output/sales_parquet_1/part-00000-tid-6541294181759099722-63ab469e-b892-46da-81bc-6924b0bb28c4-3-1-c000.snappy.parquet	part-00000-tid-6541294181759099722-63ab469e-b892-46da-81bc-6924b0bb28c4-3-1-c000.snappy.parquet	27539240	1716706625000

In [0]:
```
%sql

describe extended sales_parquet
```

col_name	data_type	comment
transacted_at	timestamp	null
trx_id	int	null
retailer_id	int	null
description	string	null
amount	double	null
city_id	int	null
# Detailed Table Information		
Catalog	spark_catalog	
Database	default	
Table	sales_parquet	
Created Time	Sun May 26 06:57:07 UTC 2024	
Last Access	UNKNOWN	
Created By	Spark 3.3.2	
Type	EXTERNAL	
Location	dbfs:/data/output/sales_parquet_1	
Provider	delta	
Owner	root	

In [0]:
```
%sql

CONVERT TO DELTA sales_parquet
```

In [0]:
```
%sql
RESTORE TABLE sales_delta TO VERSION AS OF 1
```

table_size_after_restore	num_of_files_after_restore	num_removed_files	num_restored_files	removed_files_size	restored_files_size
27539244	1	1	0	2362	0

In [0]:
```
%sql

select * from sales_delta where trx_id = '1734117021'
```

transacted_at	trx_id	retailer_id	description	amount	city_id
2017-11-24T19:00:00.000+0000	1734117021	644879053	unkn ppd id: 768641 11-26	0.0	930259917

In [0]:
```
spark.conf.set("spark.databricks.delta.retentionDurationCheck.enabled","false")

dt = DeltaTable.forName(spark, "sales_delta")

dt.vacuum(0)
```

Out[81]: DataFrame[]

In [0]:
```
display(dbutils.fs.ls("/data/output/sales_delta_1"))
```

In [0]:
```
display(dbutils.fs.ls("/data/output/sales_delta_1"))
```

path	name	size	modificationTime
dbfs:/data/output/sales_delta_1/_delta_log/	_delta_log/	0	0
dbfs:/data/output/sales_delta_1/part-00000-a5c1cf7a-0fab-4b45-a914-8d5c3dfb1ea5-c000.snappy.parquet	part-00000-a5c1cf7a-0fab-4b45-a914-8d5c3dfb1ea5-c000.snappy.parquet	27539244	1716707768000

In [0]:
```
%sql

select * from sales_delta@v0 where trx_id = '1734117021'
```

org.apache.spark.SparkException: Job aborted due to stage failure: Task 0 in stage 262.0 failed 1 times, most recent failure: Lost task 0.0 in stage 262.0 (TID 1616) (ip-10-172-218-81.us-west-2.compute.internal executor driver): com.databricks.sql.io.FileReadException: Error while reading file dbfs:/data/output/sales_delta_1/part-00000-52d6e56f-5f92-4280-b5f1-db1153aba3b8-c000.snappy.parquet. at org.apache.spark.sql.execution.datasources.FileScanRDD

In [0]:
```
# Demo dataset from Databricks
display(dbutils.fs.ls("/databricks-datasets/nyctaxi/tables/nyctaxi_yellow/"))
```

In [0]:
```
display(dbutils.fs.ls("/data/input/nyctaxi/parquet/"))
```

path	name	size	modificationTime
dbfs:/data/input/nyctaxi/parquet/part-00000-7dcc09ea-2fc1-491d-a234-3b0ce1db9336-c002.snappy.parquet	part-00000-7dcc09ea-2fc1-491d-a234-3b0ce1db9336-c002.snappy.parquet	374549044	1720944538000
dbfs:/data/input/nyctaxi/parquet/part-00001-158e21e1-9d7b-44e9-ad15-3ba7e1797de8-c002.snappy.parquet	part-00001-158e21e1-9d7b-44e9-ad15-3ba7e1797de8-c002.snappy.parquet	364876497	1720944572000

In [0]:
```
# Check the count and verify data scanning
# data copied at location - "/data/input/nyctaxi/parquet/"
df_parquet = spark.read.parquet("/data/input/nyctaxi/parquet/")
display(df_parquet)
```

In [0]:
```
# Check the count and verify data scanning
# data copied at location - "/data/input/nyctaxi/parquet/"
df_parquet = spark.read.parquet("/data/input/nyctaxi/parquet/")
display(df_parquet)
```

vendor_id	pickup_datetime	dropoff_datetime	passenger_count	trip_distance	pickup_longitude	pickup_latitude	rate_code_id	sto
CMT	2010-02-12T08:13:37.000+0000	2010-02-12T08:23:22.000+0000	1	1.0	-73.993828	40.732739	1	
CMT	2010-02-12T20:48:01.000+0000	2010-02-12T21:01:40.000+0000	1	2.3	-74.007883	40.716298	1	
CMT	2010-02-12T16:25:23.000+0000	2010-02-12T16:47:31.000+0000	2	4.2	-74.001943	40.706967	1	
CMT	2010-02-13T02:02:16.000+0000	2010-02-13T02:06:49.000+0000	1	0.7	-74.003708	40.729451	1	
CMT	2010-02-12T20:49:29.000+0000	2010-02-12T21:04:18.000+0000	1	5.8	-73.993709	40.681982	1	
CMT	2010-02-13T07:51:56.000+0000	2010-02-13T07:56:42.000+0000	1	1.8	-74.000636	40.727351	1	
CMT	2010-02-12T11:12:37.000+0000	2010-02-12T11:22:08.000+0000	1	1.8	-74.004539	40.707313	1	
CMT	2010-02-13T06:59:54.000+0000	2010-02-13T07:03:14.000+0000	1	1.1	-74.012405	40.709634	1	
CMT	2010-02-12T04:20:26.000+0000	2010-02-12T04:24:21.000+0000	1	1.2	-74.005623	40.726305	1	

In [0]:
```
# Check filter data
# select count(1) from nyctaxi where vendor_id = 'VTS' and trip_distance > 1.8

df_parquet.where("vendor_id = 'VTS' and trip_distance > 1.8").count()
```

Out[8]: 5466328

In [0]:
```
# Write the data in partitioned format
df_parquet.write.format("parquet").mode("overwrite").partitionBy("vendor_id").option("path", "/data/input/nyctaxi/partitione
```

In [0]:
```
display(dbutils.fs.ls("/data/input/nyctaxi/partitioned/"))
```

path	name	size	modificationTime
dbfs:/data/input/nyctaxi/partitioned/_SUCCESS	_SUCCESS	0	1720952782000
dbfs:/data/input/nyctaxi/partitioned/_started_1872870739494801713	_started_1872870739494801713	0	1720952067000
dbfs:/data/input/nyctaxi/partitioned/vendor_id=CMT/	vendor_id=CMT/	0	0
dbfs:/data/input/nyctaxi/partitioned/vendor_id=DDS/	vendor_id=DDS/	0	0
dbfs:/data/input/nyctaxi/partitioned/vendor_id=VTS/	vendor_id=VTS/	0	0

In [0]:
```
df_partitioned = spark.read.parquet("/data/input/nyctaxi/partitioned/")

df_partitioned.where("vendor_id = 'VTS' and trip_distance > 1.8").count()
```

Out[14]: 5466328

In [0]:
```
%sql

select count(1) from nyctaxi_partitioned where vendor_id = 'VTS' and trip_distance > 1.8
```

count(1)
5466328

Partitioning breaks data in folders:

Folder names are in format:<partitioning><column>=<key>e.g.country=IN

Note: Partitioning column should be part of query in-order to improve performance

Impact of High Cardinality Column:

Always avoid partitioning on High Cardinality or Unique value columns to avoid creating too many partitions.

In [0]:
```
# Dataset
display(dbutils.fs.ls("/databricks-datasets/definitive-guide/data/retail-data/all/"))
```

In [0]:
```
%fs head dbfs:/data/input/sales/sales.csv
```

[Truncated to first 65536 bytes] InvoiceNo,StockCode,Description,Quantity,InvoiceDate,UnitPrice,CustomerID,Country 536365,85123A,WHITE HANGING HEART T-LIGHT HOLDER,6,12/1/2010 8:26,2.55,17850,United Kingdom 536365,71053,WHITE METAL LANTERN,6,12/1/2010 8:26,3.39,17850,United Kingdom 536365,84406B,CREAM CUPID HEARTS COAT HANGER,8,12/1/2010 8:26,2.75,17850,United Kingdom 536365,84029G,KNITTED UNION FLAG HOT WATER BOTTLE,6,12/1/2010 8:26,3.39,17850,United Kingdom 536365,84029E,RED WOOLLY HOTTIE WHITE HEART.,6,12/1/2010 8:26,3.39,17850,United Kingdom 536365,22752,SET 7 BABUSHKA NESTING BOXES,2,12/1/2010 8:26,7.65,17850,United Kingdom 536365,21730,GLASS STAR FROSTED T-LIGHT HOLDER,6,12/1/2010 8:26,4.25,17850,United Kingdom 536366,22633,HAND WARMER UNION JACK,6,12/1/2010 8:28,1.85,17850,United Kingdom 536366,22632,HAND WARMER RED POLKA DOT,6,12/1/2010 8:28,1.85,17850,United Kingdom 536367,84879,ASSORTED COLOUR BIRD ORNAMENT,32,12/1/2010 8:34,1.69,13047,United Kingdom 536367,22745,POPPY'S PLAYHOUSE BEDROOM ,6,12/1/2010 8:34,2.1,13047,United Kingdom 536367,22748,POPPY'S PLAYHOUSE KITCHEN,6,12/1/2010 8:34,2.1,13047,United Kingdom 536367,22749,FELTCRAFT PRINCESS CHARLOTTE DOLL,8,12/1/2010 8:34,3.75,13047,United Kingdom 536367,22310,IVORY KNITTED MUG COSY ,6,12/1/2010 8:34,1.65,13047,United Kingdom 536367,84969,BOX OF 6 ASSORTED COLOUR TEASPOONS,6,12/1/2010 8:34,4.25,13047,United Kingdom 536367,22623,BOX OF VINTAGE JIGSAW BLOCKS ,3,12/1/2010 8:34,4.95,13047,United Kingdom 536367,22622,BOX OF VINTAGE ALPHABET BLOCKS,2,12/1/2010 8:34,9.95,13047,United Kingdom 536367,21754,HOME BUILDING BLOCK WORD,3,12/1/2010 8:34,5.95,13047,United Kingdom 536367,21755,LOVE BUILDING BLOCK WORD,3,12/1/2010 8:34,5.95,13047,United Kingdom 536367,21777,RECIPE BOX WITH METAL HEART,4,12/1/2010 8:34,7.95,13047,United Kingdom 536367,48187,DOORMAT NEW ENGLAND,4,12/1/2010 8:34,7.95,13047,United Kingdom 536368,22960,JAM MAKING SET WITH

In [0]:
```
# Write the data in form of delta table
df = spark.read.csv(path="/data/input/sales/sales.csv", inferSchema=True, header=True)
df.repartition(16).write.format("delta").mode("overwrite").partitionBy("country").option("path", "/data/output/sales_delta_
```

In [0]:
```
%sql
select * from sales_delta
```

```
org.apache.spark.sql.catalyst.ExtendedAnalysisException: [TABLE_OR_VIEW_NOT_FOUND] The table or view `sales_delta_partitioned
` cannot be found. Verify the spelling and correctness of the schema and catalog.
If you did not qualify the name with a schema, verify the current_schema() output, or qualify the name with the correct schem
a and catalog.
To tolerate the error on drop use DROP VIEW IF EXISTS or DROP TABLE IF EXISTS. SQLSTATE: 42P01; line 1 pos 14;
'Project [*]
+- 'UnresolvedRelation [sales_delta_partitioned], [], false

        at org.apache.spark.sql.catalyst.analysis.package$AnalysisErrorAt.tableNotFound(package.scala:90)
        at org.apache.spark.sql.catalyst.analysis.CheckAnalysis.$anonfun$checkAnalysis0$2(CheckAnalysis.scala:259)
        at org.apache.spark.sql.catalyst.analysis.CheckAnalysis.$anonfun$checkAnalysis0$2$adapted(CheckAnalysis.scala:232)
```

In [0]:
```
# Data at delta location
display(dbutils.fs.ls("/data/output/sales_delta/"))
```

path	name	size	modificationTime
dbfs:/data/output/sales_delta/_delta_log/	_delta_log/	0	0
dbfs:/data/output/sales_delta/part-00000-4c2446ef-409c-4392-8ad4-75a228f0627b-c000.snappy.parquet	part-00000-4c2446ef-409c-4392-8ad4-75a228f0627b-c000.snappy.parquet	556272	1721394879000
dbfs:/data/output/sales_delta/part-00001-1c209617-a48d-4c08-824c-4b6dbfc77c00-c000.snappy.parquet	part-00001-1c209617-a48d-4c08-824c-4b6dbfc77c00-c000.snappy.parquet	555198	1721394879000
dbfs:/data/output/sales_delta/part-00002-d49dc9e9-e26a-4e05-9b6c-42547c7a6016-c000.snappy.parquet	part-00002-d49dc9e9-e26a-4e05-9b6c-42547c7a6016-c000.snappy.parquet	555484	1721394880000
dbfs:/data/output/sales_delta/part-00003-255380dc-2bfd-452c-a507-3ed2021ce192-c000.snappy.parquet	part-00003-255380dc-2bfd-452c-a507-3ed2021ce192-c000.snappy.parquet	555210	1721394880000
dbfs:/data/output/sales_delta/part-00004-36d34035-61c9-4f4d-a1ec-035daf0f1651-c000.snappy.parquet	part-00004-36d34035-61c9-4f4d-a1ec-035daf0f1651-c000.snappy.parquet	555365	1721394880000
dbfs:/data/output/sales_delta/part-00005-5305094e-320b-4e4b-a4f7-b8c319f5e9c9-c000.snappy.parquet	part-00005-5305094e-320b-4e4b-a4f7-b8c319f5e9c9-c000.snappy.parquet	556829	1721394880000
dbfs:/data/output/sales_delta/part-00006-4fc7d66f-98fb-42c2-8a6e-cff0a9253ca2-c000.snappy.parquet	part-00006-4fc7d66f-98fb-42c2-8a6e-cff0a9253ca2-c000.snappy.parquet	554588	1721394880000
dbfs:/data/output/sales_delta/part-00007-384ded64-d5ff-42d8-89d3-ba5eabc87150-c000.snappy.parquet	part-00007-384ded64-d5ff-42d8-89d3-ba5eabc87150-c000.snappy.parquet	554633	1721394880000
dbfs:/data/output/sales_delta/part-00008-eff136d6-6a2d-4bc7-ac27-1753481853c0-c000.snappy.parquet	part-00008-eff136d6-6a2d-4bc7-ac27-1753481853c0-c000.snappy.parquet	554983	1721394882000

In [0]:
```
display(dbutils.fs.ls("/data/output/sales_delta_partitioned/Country=Australia/"))
```

path	name	size	modificationTime
dbfs:/data/output/sales_delta_partitioned/Country=Australia/part-00000-52f07f0c-dfc4-43a5-895d-6031814ef8c9.c000.snappy.parquet	part-00000-52f07f0c-dfc4-43a5-895d-6031814ef8c9.c000.snappy.parquet	25140	1721398404000
dbfs:/data/output/sales_delta_partitioned/Country=Australia/part-00000-c60956fa-a5d7-4d67-9f4b-acebcf042b2f.c000.snappy.parquet	part-00000-c60956fa-a5d7-4d67-9f4b-acebcf042b2f.c000.snappy.parquet	5322	1721398182000
dbfs:/data/output/sales_delta_partitioned/Country=Australia/part-00001-6656eab6-f5a1-4da4-be51-ccd4f6c5aeb6.c000.snappy.parquet	part-00001-6656eab6-f5a1-4da4-be51-ccd4f6c5aeb6.c000.snappy.parquet	5483	1721398182000
dbfs:/data/output/sales_delta_partitioned/Country=Australia/part-00002-8b0cf503-8be7-4c5a-be56-381391834518.c000.snappy.parquet	part-00002-8b0cf503-8be7-4c5a-be56-381391834518.c000.snappy.parquet	5498	1721398182000

In [0]:
```
%sql
select * from sales_delta_partitioned where InvoiceNo = '576394' and country = 'Australia'
```

InvoiceNo	StockCode	Description	Quantity	InvoiceDate	UnitPrice	CustomerID	Country
576394	22326	ROUND SNACK BOXES SET OF4 WOODLAND	96	11/15/2011 10:32	2.55	12415	Australia
576394	22384	LUNCH BAG PINK POLKADOT	100	11/15/2011 10:32	1.45	12415	Australia
576394	22131	FOOD CONTAINER SET 3 LOVE HEART	72	11/15/2011 10:32	1.65	12415	Australia
576394	22466	FAIRY TALE COTTAGE NIGHT LIGHT	96	11/15/2011 10:32	1.65	12415	Australia
576394	22631	CIRCUS PARADE LUNCH BOX	64	11/15/2011 10:32	1.65	12415	Australia
576394	23084	RABBIT NIGHT LIGHT	960	11/15/2011 10:32	1.79	12415	Australia
576394	20725	LUNCH BAG RED RETROSPOT	100	11/15/2011 10:32	1.45	12415	Australia
576394	23497	CLASSIC CHROME BICYCLE BELL	48	11/15/2011 10:32	1.25	12415	Australia
576394	21770	OPEN CLOSED METAL SIGN	36	11/15/2011 10:32	4.25	12415	Australia

In [0]:
```
%sql

select min(invoiceno), max(invoiceno), _metadata.file_name from sales_delta
group by _metadata.file_name
order by min(invoiceno)
```

min(invoiceno)	max(invoiceno)	file_name
536365	539259	part-00000-410bc7f1-2563-4a5c-ae69-a78e3e07de41-c000.snappy.parquet
539259	541784	part-00001-54d9343c-6d45-4472-850b-7cfdc712106d-c000.snappy.parquet
541784	544839	part-00002-ccf52c99-ecb0-464a-8722-969c8fbd773c-c000.snappy.parquet
544839	547940	part-00003-7d645b59-d0af-437f-a568-5fb3e030eb6d-c000.snappy.parquet
547940	550921	part-00004-f91da6ea-945d-40b5-aff7-4938bfea50a0-c000.snappy.parquet
550921	554083	part-00005-b66f1513-bac3-46b2-b263-1156cf64ae5b-c000.snappy.parquet
554083	557636	part-00006-ddb91e45-fa35-4862-a7ca-a8efebd4257c-c000.snappy.parquet
557636	560688	part-00007-a8bcbae2-51bf-4977-afe4-dd865e8050f7-c000.snappy.parquet
560688	563744	part-00008-3f5d5eaa-61f2-4bbf-9bf4-394c7a61026b-c000.snappy.parquet

In [0]:
```
spark.conf.set("spark.databricks.delta.optimize.maxFileSize", 64*1024*8)
```

In [0]:
```
%sql
OPTIMIZE sales_delta_partitioned where country = 'Australia' ZORDER BY (InvoiceNo)
```

path	metrics
dbfs:/data/output/sales_delta_partitioned	List(1, 16, List(25140, 25140, 25140.0, 1, 25140), List(5322, 6174, 5606.8125, 16, 89709), 1, List(minCubeSize(107374182400), List(0, 0), List(16, 89709), 0, List(16, 89709), 1, null), 1, 16, 0, false, 0, 0, 1721398399355, 1721398405941, 8, 1, null, List(0, 0), 8, 8, 327, 0, null)

In [0]:
```
%sql

select min(invoiceno), max(invoiceno), _metadata.file_name from sales_delta
group by _metadata.file_name
order by min(invoiceno)
```

min(invoiceno)	max(invoiceno)	file_name
536365	539259	part-00000-410bc7f1-2563-4a5c-ae69-a78e3e07de41-c000.snappy.parquet
539259	541784	part-00001-54d9343c-6d45-4472-850b-7cfdc712106d-c000.snappy.parquet
541784	544839	part-00002-ccf52c99-ecb0-464a-8722-969c8fbd773c-c000.snappy.parquet
544839	547940	part-00003-7d645b59-d0af-437f-a568-5fb3e030eb6d-c000.snappy.parquet

In [0]:
```
%sql

select country, min(invoiceno), max(invoiceno), _metadata.file_name from sales_delta
group by country, _metadata.file_name
order by country, min(invoiceno)
```

country	min(invoiceno)	max(invoiceno)	file_name
Australia	536389	539419	part-00000-c1f0b791-02a7-46c8-8d78-629ddd1e6a19-c000.snappy.parquet
Australia	540267	543376	part-00001-a32bfba6-703e-4211-845d-07d7b99350b5-c000.snappy.parquet
Australia	543989	547659	part-00002-049fc3a8-40ad-4a69-a364-c32ea6e5e1f3-c000.snappy.parquet
Australia	548661	553546	part-00003-b980260c-2329-4040-b79e-85f01e7fe504-c000.snappy.parquet
Australia	554037	558537	part-00004-56e69511-f3be-486e-bb64-d77d63d7bec4-c000.snappy.parquet
Australia	559919	563179	part-00005-bea09919-82e2-4bfe-b514-d2620783b724-c000.snappy.parquet
Australia	563614	567085	part-00006-77e59bd3-cd5e-4d80-a29f-3879f96a586b-c000.snappy.parquet
Australia	568145	569723	part-00007-61c9bac0-9944-4094-837c-f9b221704e7b-c000.snappy.parquet
Australia	574014	574469	part-00008-52278b78-d510-4da1-b7df-b354e1bf00b7-c000.snappy.parquet
Australia	576394	578459	part-00009-e8ad7bb7-3f5d-4c73-aac1-e7ac0a085224-c000.snappy.parquet
Australia	C538723	C574344	part-00010-9f07be7f-058d-487d-91b0-749ed32e61aa-c000.snappy.parquet
Austria	539330	539330	part-00000-c1f0b791-02a7-46c8-8d78-629ddd1e6a19-c000.snappy.parquet

High Cardinality Column:

Columns with more unique values (less repetition)

z-order can be done in more than one column.

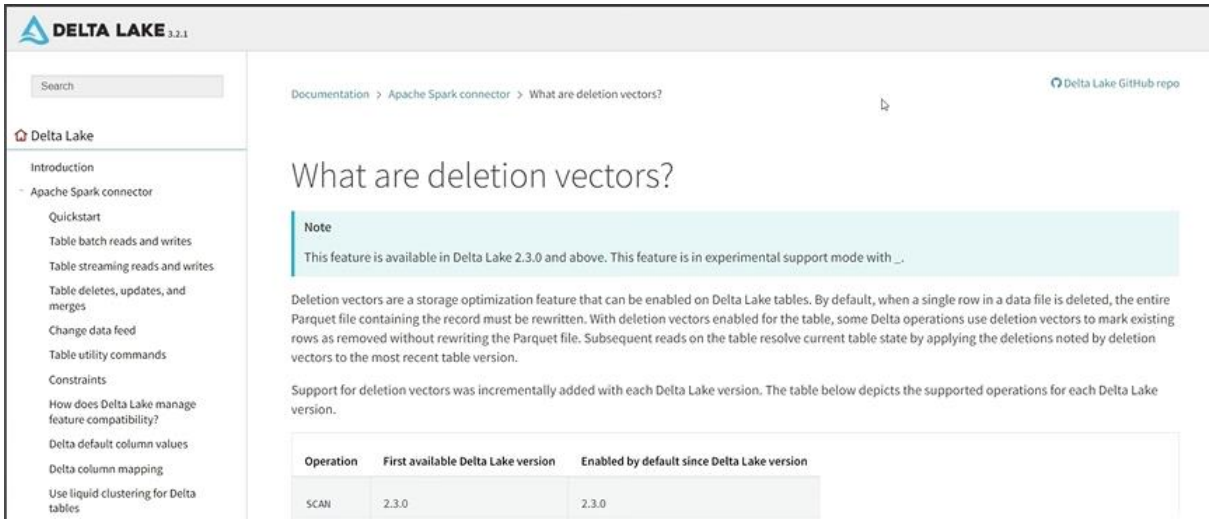
_metadata is a hidden column that can be used to get the source metadata.

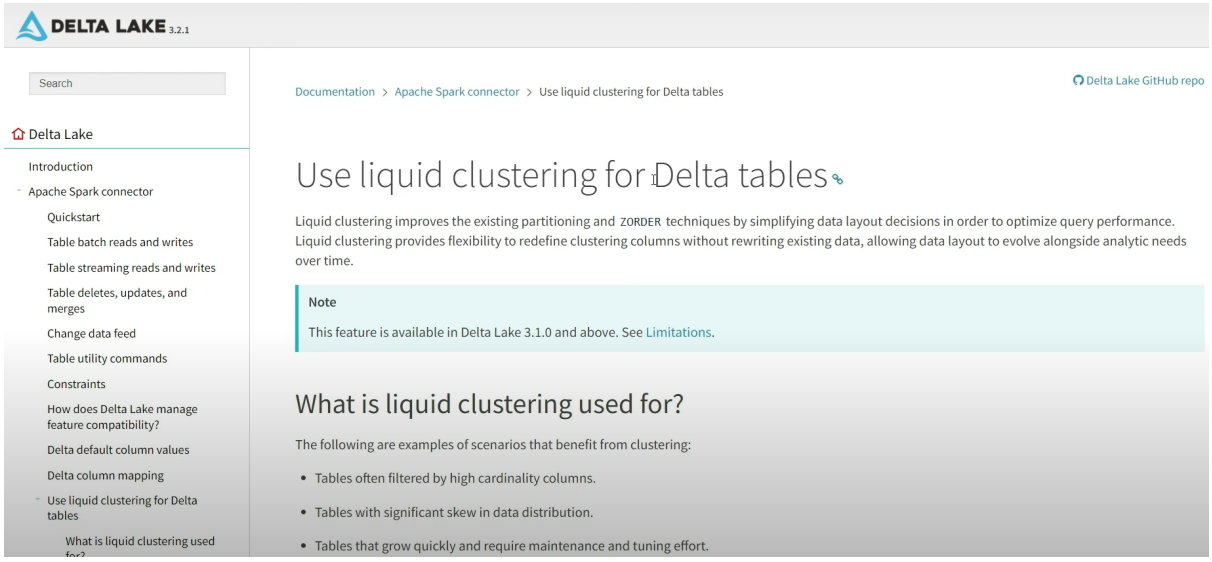
Configuration:

This configuration is used to control the file compaction max size using OPTIMIZE command.

Selective Z-Ordering with Partition filters:

Only Optimizes and Z-orders the data for the specific partition.





What is liquid clustering used for?

The following are examples of scenarios that benefit from clustering:

- Tables often filtered by high cardinality columns.
- Tables with significant skew in data distribution.
- Tables that grow quickly and require maintenance and tuning effort.
- Tables with access patterns that change over time.
- Tables where a typical partition column could leave the table with too many or too few partitions.

Enable liquid clustering

You must enable liquid clustering when creating a table. Clustering is not compatible with partitioning or `ZORDER`. Once enabled, run `OPTIMIZE` jobs as normal to incrementally cluster data. See How to trigger clustering.