UNIVERSITY of WASHINGTON

BIGDATA 210: Introduction to Data Engineering

Autumn 2017

Module 4: Data Processing Using Spark Part II

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Week 4 Agenda

- Outstanding VM/Docker Issues
- Assignment 2 Review
- Assignment 3 Discussion
- Programming in Spark Part II
  - Scaling Spark Applications
    - Understanding partitioning and shuffling
    - Persistence and shared variables
  - Programming in Spark
    - Spark SQL/DataFrames/Datasets

Docker/VM Issues

- Announcement made re: MS Azure Ubuntu kernel bug
  - https://canvas.uw.edu/courses/1166750/discussion_topics/4003691
- "Waiting for Ambari agent to connect……"
  - Did you change the Ambari "admin" user pw?
    - ambari-admin-password-reset
    - Change password on Web UI after logged in
  - Run "ambari-admin-password-reset" in Docker container (not VM) or through Web UI
    - Set password back to "4o12t0n"

Assignment 2 Review

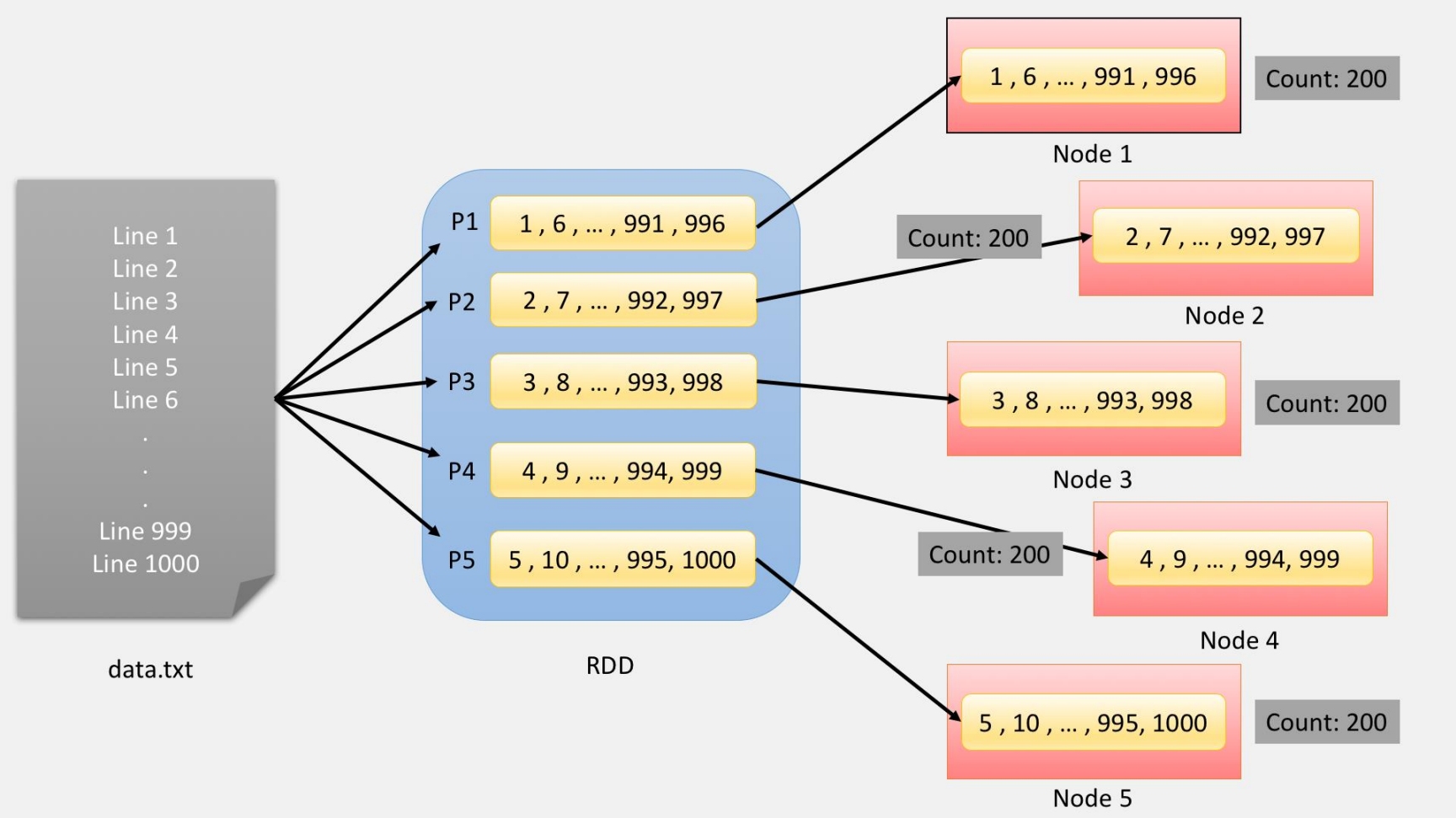
- Homework questions
- Killing YARN applications

Assignment 3 Discussion

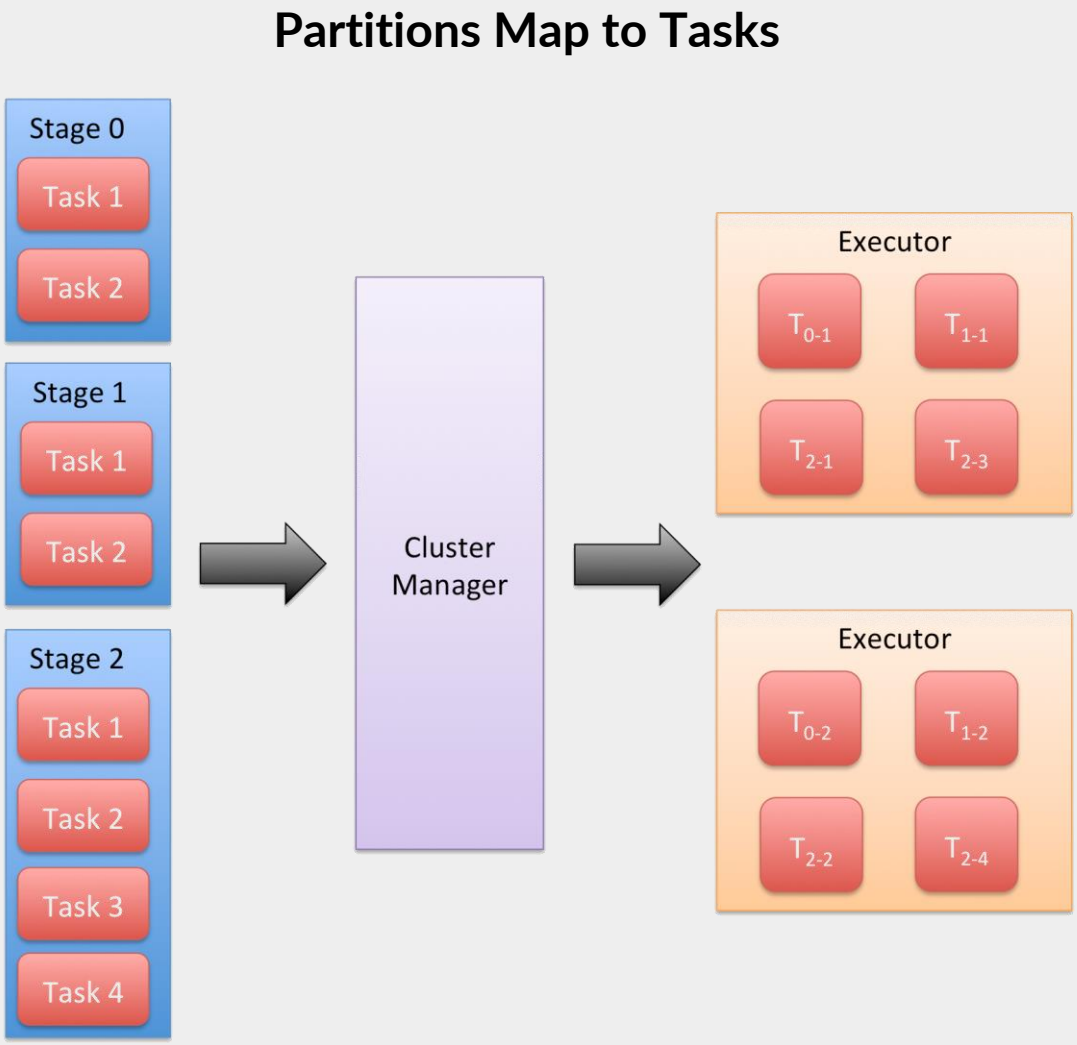
- Use RDD API !!!

Partitioning and Shuffling

Distributing an RDD among nodes of a cluster



Partitioning and Shuffling



Partitioning and Shuffling

- Default Number of Partitions
  - Total number of cores in cluster
  - spark.default.parallelism config parameter
  - HDFS block size

Partitioning and Shuffling

- Controlling Partition Size
  - When loading data

```
val defaultFile = sc.textFile("file:///data/war_and_peace.txt")
defaultFile.partitions.size
// 2
```

```
val manualFile = sc.textFile(file:///data/war_and_peace.txt, 100)
manualFile.partitions.size
// 100
```

Partitioning and Shuffling

- Controlling Partition Size
  - Resizing after loading

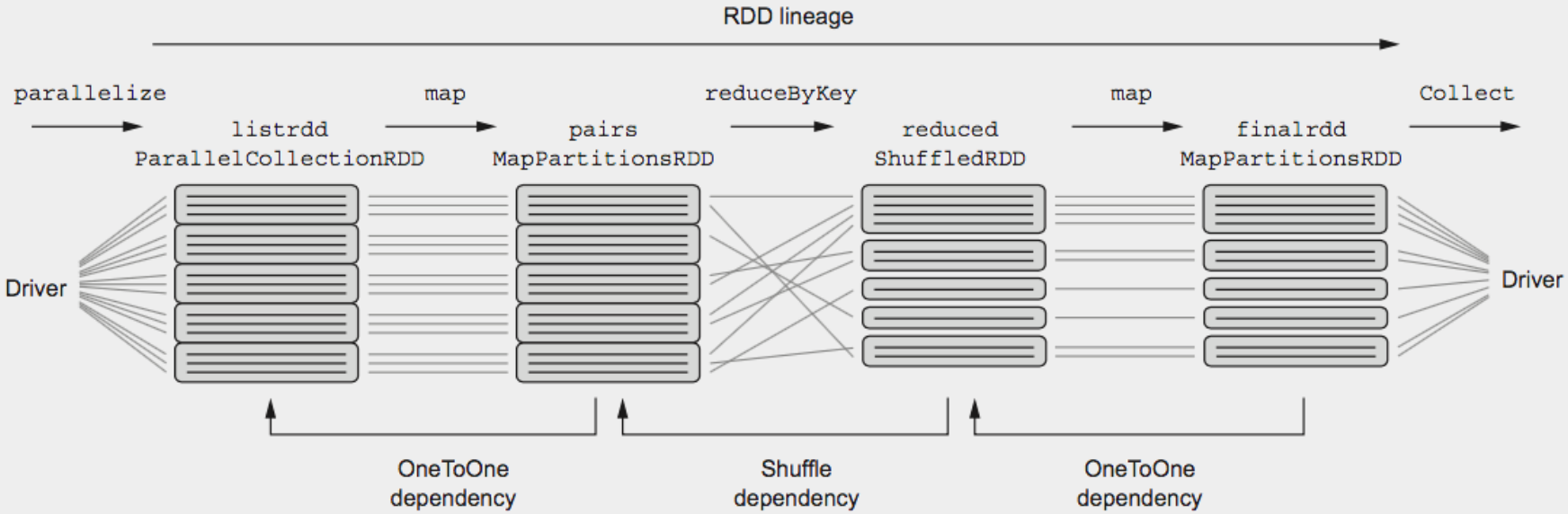
```
val file = sc.textFile("file:///data/war_and_peace.txt")
file.partitions.size
// 2
```

```
val resized = file.repartition(1000)
resized.partitions.size
// 1000
```

```
val coalesced = resized.coalesce(50)
coalesced.partitions.size
// 50
```

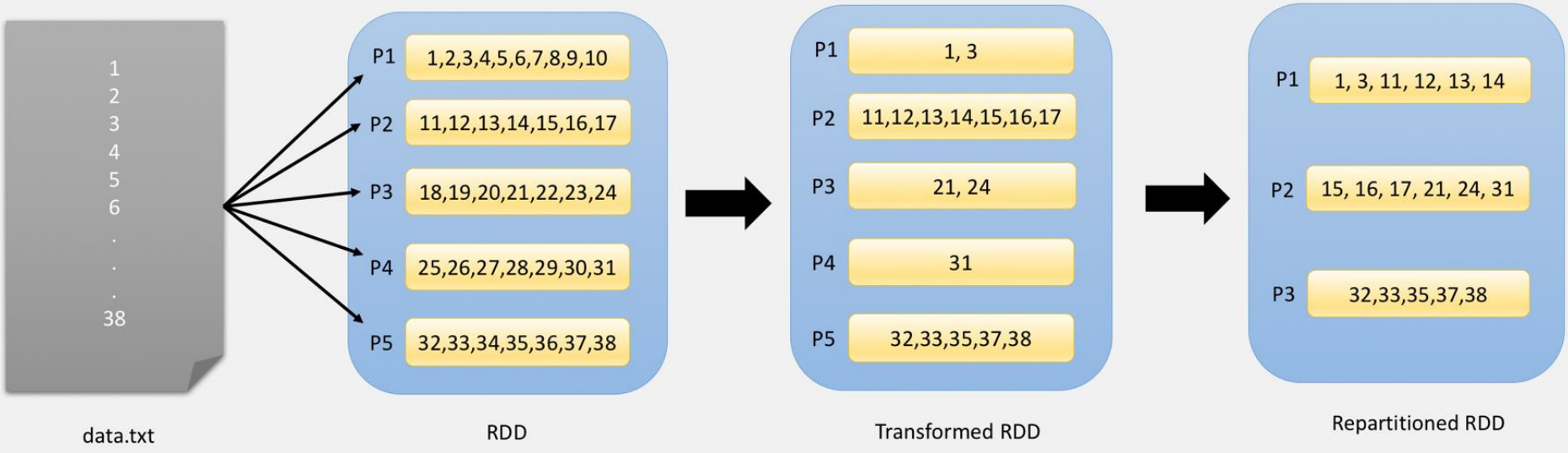
Partitioning and Shuffling

- Shuffling
  - Narrow vs. Wide Dependencies



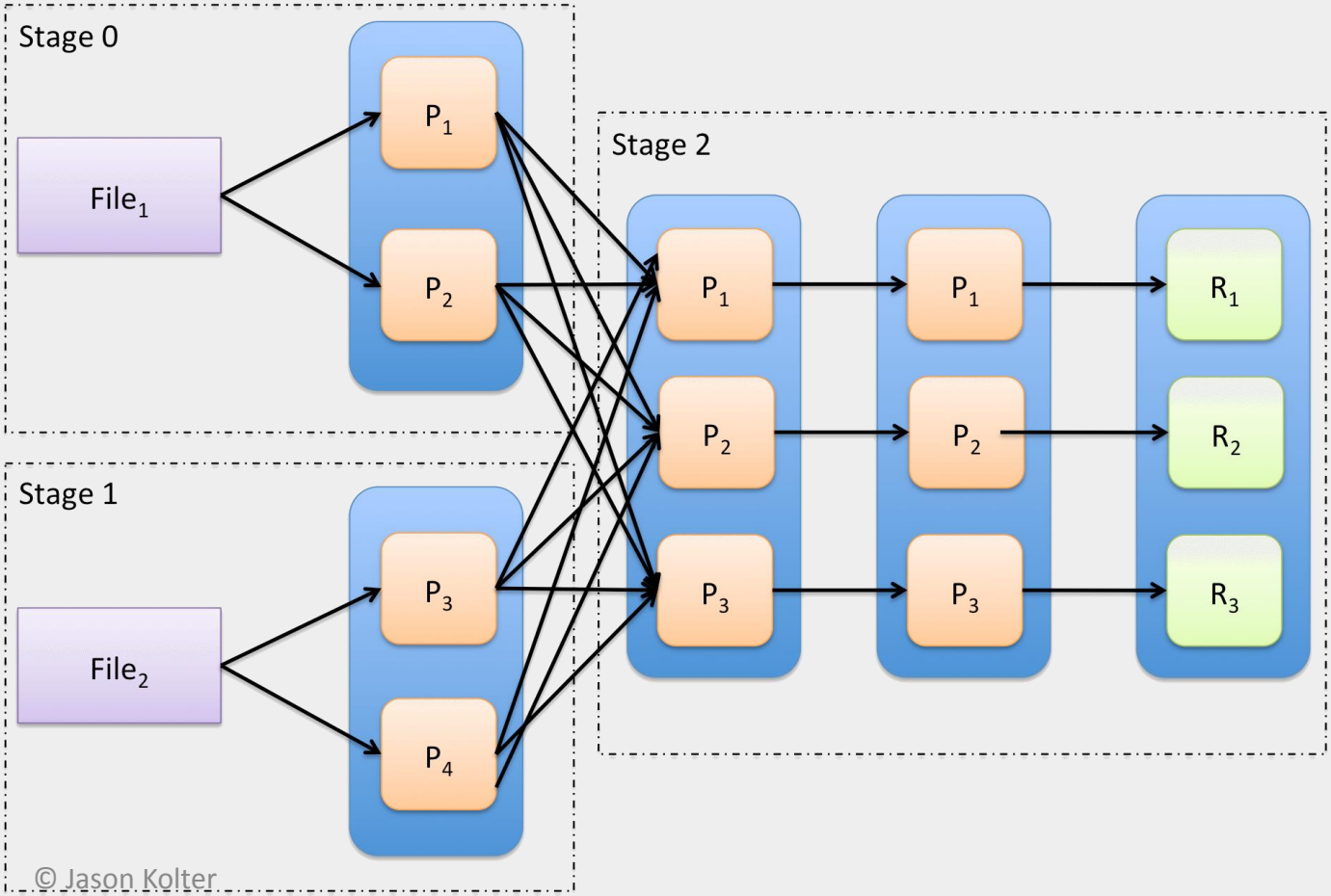
Partitioning and Shuffling

- Shuffling
  - Force Repartition



Partitioning and Shuffling

- Shuffling Determines Stage Boundaries



Partitioning and Shuffling

- Best Practices
  - Know your data

Partitioning and Shuffling

- Best Practices
  - mapPartitions vs. map

```
val airports = sc.textFile("file:///data/airport_codes.csv")

def expensiveMapFunction (airport:String) {
    val expensiveConnection = new ExpensiveConnection()
    expensiveConnection.enrichAirportData(airport)
}

val enrichedAirportData = airports.map(expensiveMapFunction)
```

```
def betterMapFunction (airportData:Iterator[String]) {
    val expensiveConnection = new ExpensiveConnection()
    airportData.map(expensiveConnection.enrichAirportData(_)).iterator
}

val enrichedAirportData = airports.mapPartitions(betterMapFunction)
```

Partitioning and Shuffling

- Best Practices
  - foreachPartition vs. foreach

```
val airports = sc.textFile("file:///data/airport_codes.csv")

def expensiveForeachFunction (airport : String) {
    val dbConnection = new DBConnection
    dbConnection.save(airport)
}

airports.foreach(expensiveForeachFunction)
```

```
def betterForeachFunction (airportData:Iterator[String]) {
    val dbConnection = new DBConnection
    airportData.foreach(dbConnection.save(_))
}

airports.foreachPartition(betterForeachFunction)
```

Partitioning and Shuffling

- Best Practices
  - Custom Partitioner

```
import org.apache.spark.Partitioner

class MyPartitioner(override val numPartitions : Int) extends
org.apache.spark.Partitioner {
    override def getPartition(key: Any): Int = {
        return key.asInstanceOf[Int];
    }

    override def equals(other: Any): Boolean = {
        return true;
    }
}
```

Persistence and Caching

```
val rdd = sc.textFile(“file://data/war_and_peace.txt")

val filtered = rdd.filter(x => x.toUpperCase().contains("WAR"))
filtered.saveAsTextFile("2.3-1")

val mapped = rdd.map(x => x.toUpperCase().replace("WAR", "PEACE"))
mapped.saveAsTextFile("2.3-2")
```

Persistence and Caching

```
val rdd = sc.textFile(“file://data/war_and_peace.txt")

rdd.persist

val filtered = rdd.filter(x => x.toUpperCase().contains("WAR"))
filtered.saveAsTextFile("2.3-3")

val mapped = rdd.map(x => x.toUpperCase().replace("WAR", "PEACE"))
mapped.saveAsTextFile("2.3-4")
```

Persistence and Caching

- Storage Levels
  - MEMORY_ONLY (DEFAULT)
    - Store RDD as deserialized Java objects in memory
    - If entire RDD doesn't fit
      - Some partitions will not be cached and will be recomputed
  - MEMORY_AND_DISK
    - Store RDD as deserialized Java objects in memory
    - If entire RDD doesn't fit
      - Store partitions that don't fit on disk read as (if) needed
  - DISK_ONLY
    - "cache" on disk

Persistence and Caching

- Storage Levels
  - MEMORY_ONLY_SER
    - Store RDD as serialized Java objects in memory
    - If entire RDD doesn't fit
      - Some partitions will not be cached and will be recomputed
  - MEMORY_AND_DISK_SER
    - Store RDD as serialized Java objects in memory
    - If entire RDD doesn't fit
      - Store partitions that don't fit on disk read as (if) needed

Persistence and Caching

- Storage Levels
  - MEMORY_ONLY_2
  - MEMORY_ONLY_SER_2
  - MEMORY_AND_DISK_2
  - MEMORY_AND_DISK_SER_2

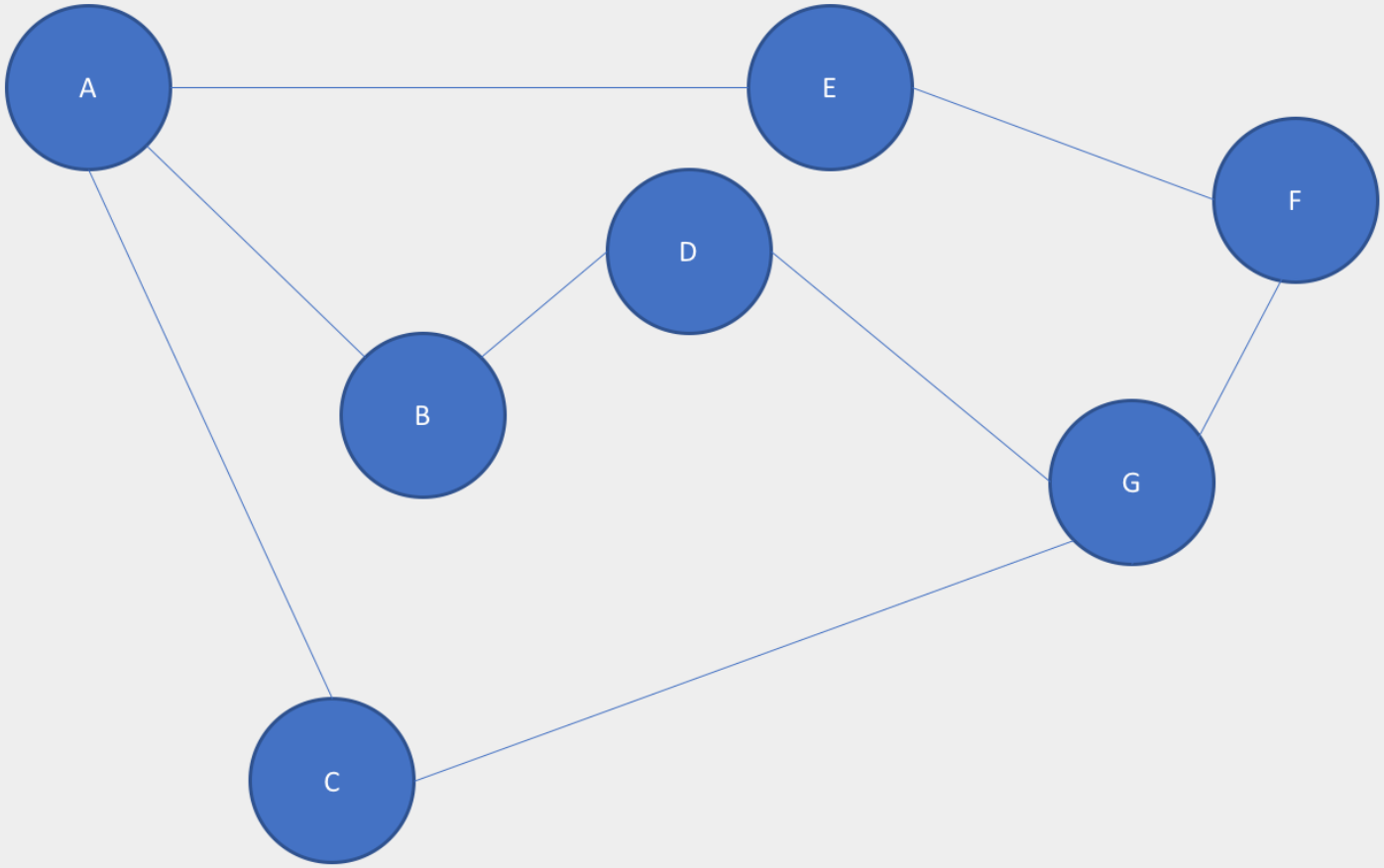
- **Same as previous but replicate 2X**

Persistence and Caching

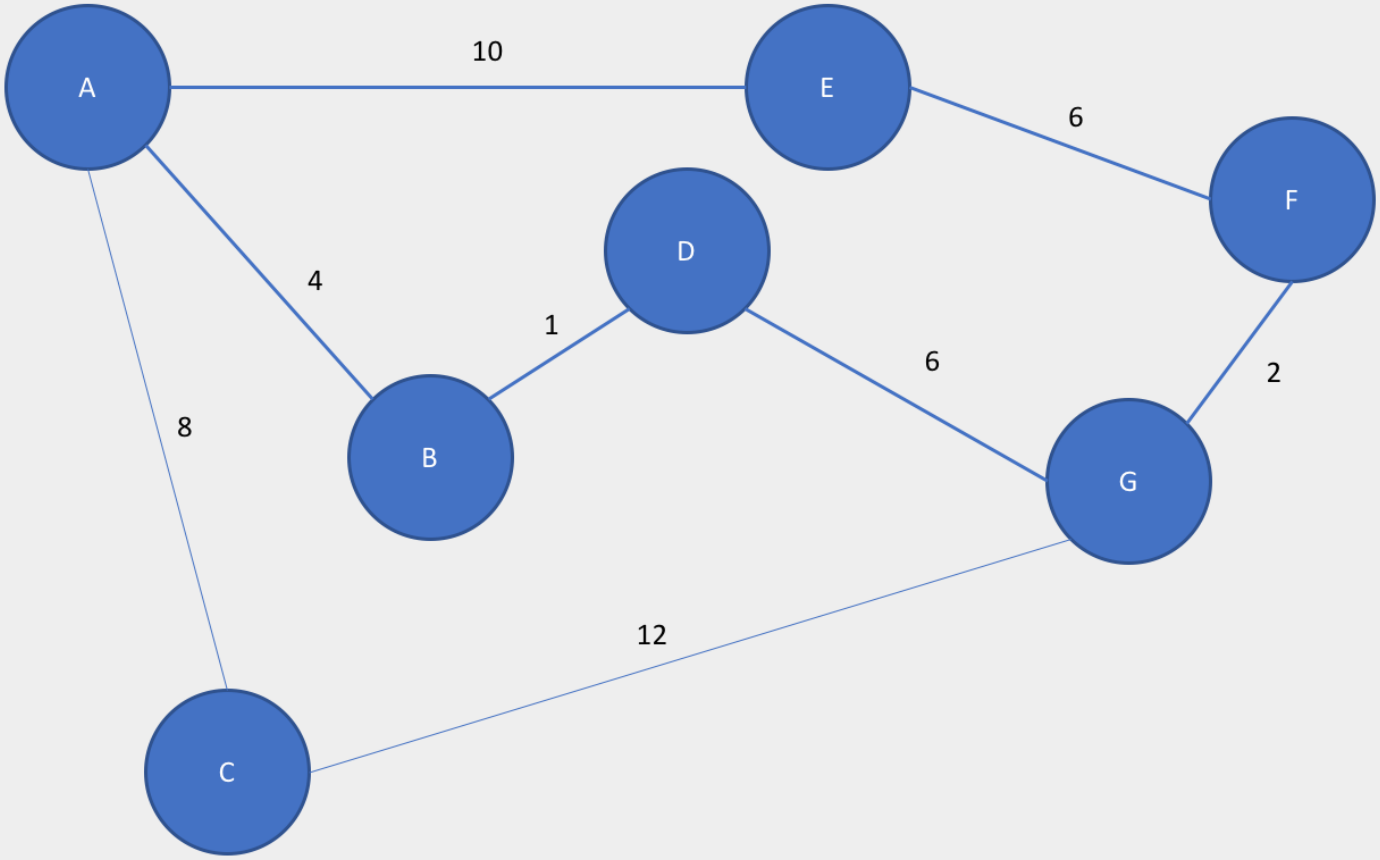
```
val lines = sc.textFile("data/war_and_peace.txt")
val complexResult = lines.filter(x => complexFilterFunction()).map(x =>
complexMapFunction)
complexResult.persist(StorageLevel.MEMORY_AND_DISK)
```

```
complexResult.unpersist
```

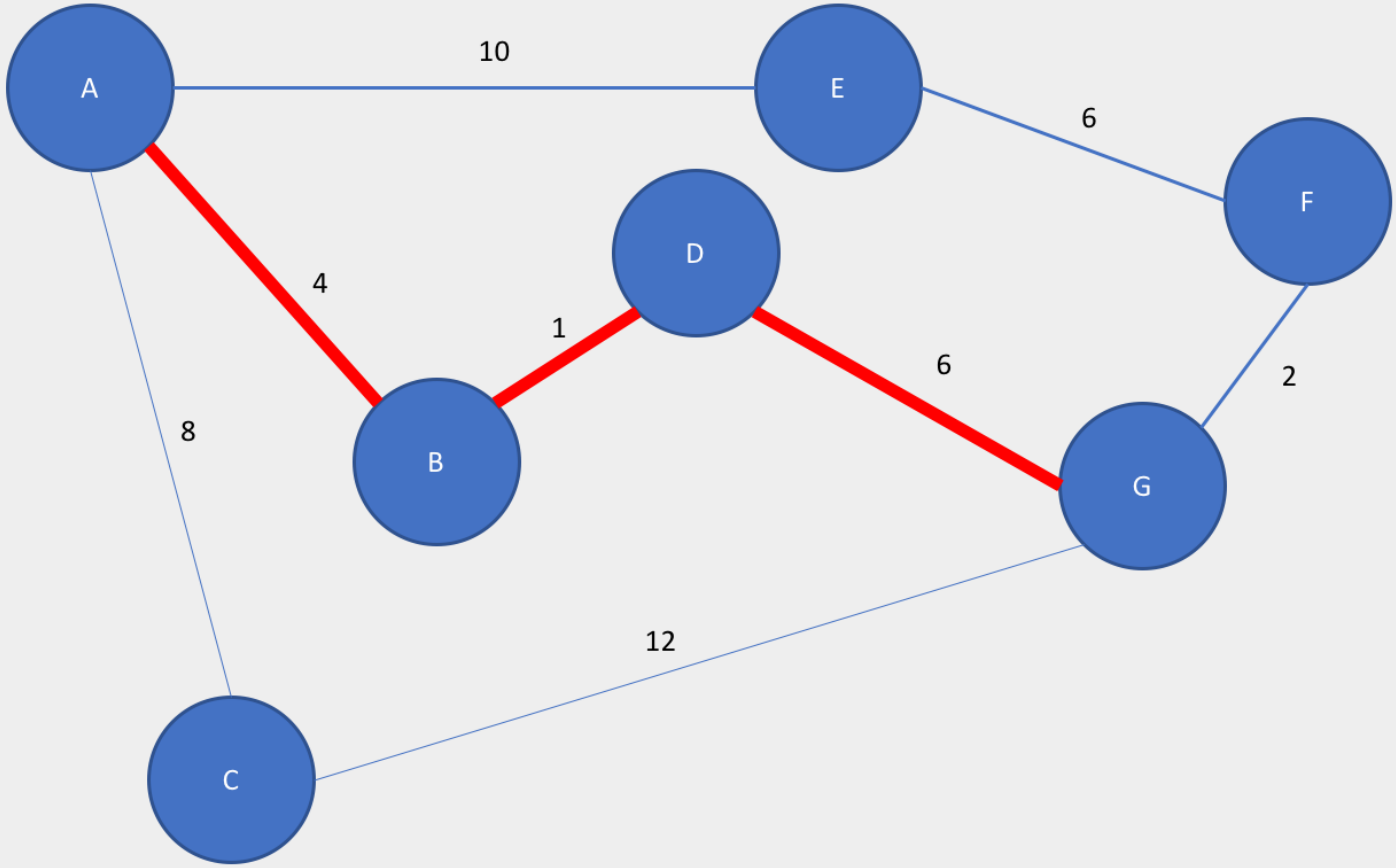
Spark SQL



Spark SQL

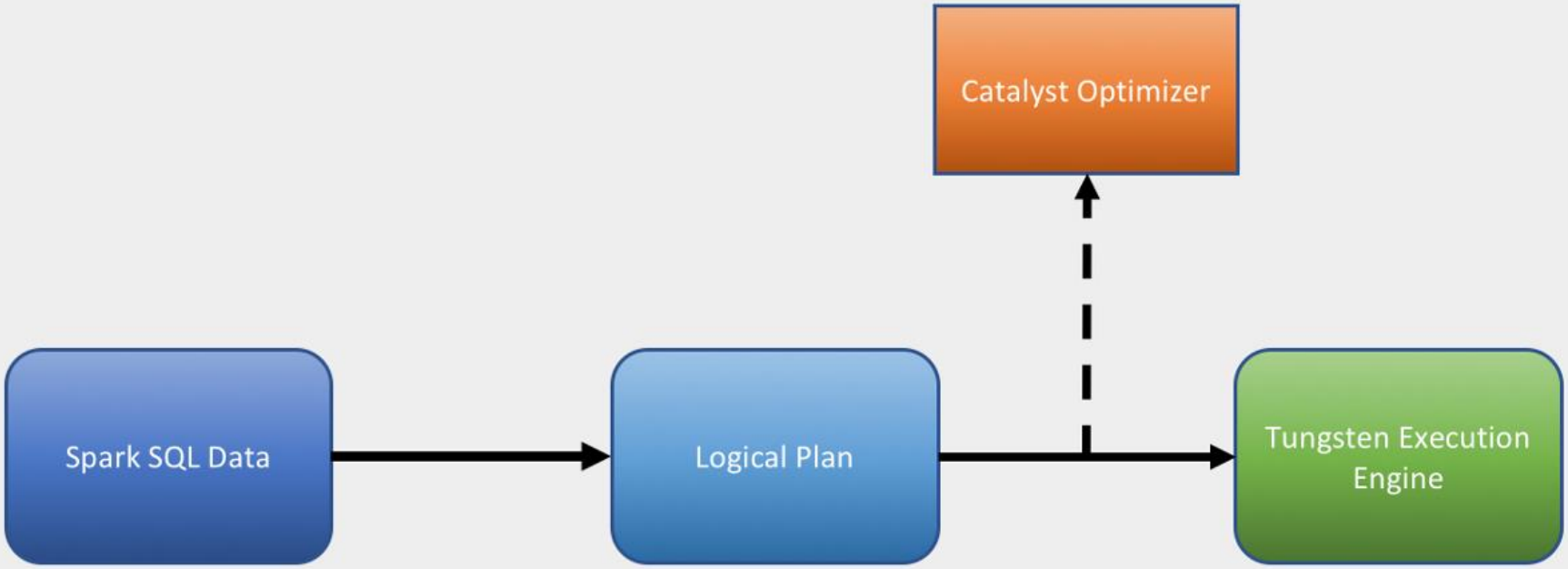


Spark SQL



Spark SQL

- Spark SQL Components



Spark SQL

- DataFrame vs. Dataset

Year	Make	Model
Int	String	String
Int	String	String
Int	String	String

Object (Car)
Object (Car)
Object (Car)

Spark SQL - Datasets

```
import org.apache.spark.sql.SparkSession

val ss = SparkSession.
            builder().
            master("local").
            appName("Spark in Motion Example").
            config("spark.config.option", "some-value").
            getOrCreate()
```

```
//In notebook or shell
print(spark)
```

```
import ss.implicits._
val ds = spark.createDataset(1 to 500)
ds.show(10)
```

```
+-----+
|value|
+-----+
| 1   |
| 2   |
| 3   |
| 4   |
| 5   |
| 6   |
| 7   |
| 8   |
| 9   |
| 10  |
+-----+
```

Spark SQL - Datasets

- Creating

```
val textRDD = sc.textFile("file:///data/war_and_peace.txt")
```

```
import spark.implicits._
val textDS = spark.read.textFile("file:///data/war_and_peace.txt")
```

```
val lowerText = textDS.map(line => line.toLowerCase)
val words = lowerText.flatMap(line => line.split("\\s+"))
val groupedWords = words.groupByKey(x => x)
groupedWords.count.show(10)
```

```
+---------+--------+
|    value|count(1)|
+---------+--------+
|       07|       2|
|    still|     611|
|     some|     825|
|    cold,|      32|
|    those|     635|
|     "oh,|     174|
|connected|      20|
|     hope|      65|
|    seat.|      10|
|   spared|       2|
+---------+--------+
only showing top 10 rows
```

Spark SQL - Datasets

- Using

```
ident,category,name,latitude_deg,longitude_deg,elevation_ft,continent,iso_country,iso_region,municipality,gps_code,iata_code,local_code
00A,heliport,Total Rf Heliport,40.07080078,-74.93360138,11,NA,US,US-PA,Bensalem,00A,,00A
00AK,small_airport,Lowell Field,59.94919968,-151.6959991,450,NA,US,US-AK,Anchor Point,00AK,,00AK
00AL,small_airport,Epps Airpark,34.8647995,-86.77030182,820,NA,US,US-AL,Harvest,00AL,,00AL
00AR,heliport,Newport Hospital & Clinic Heliport,35.6086998,-91.25489807,237,NA,US,US-AR,Newport,00AR,,00AR
```

```
case class Airport (ident:String, category:String, name:String, latitude_deg:Double, longitude_deg:Double,
                    elevation_ft:Integer, continent:String, iso_country:String, iso_region:String, municipality:String,
                    gps_code:String, iata_code:String, local_code:String)

val airports = spark.read.option("inferSchema", "true").option("header","true").csv("data/airport_codes.csv").as[Airport]
airports.show(5)
```

```
+-----+-------------+--------------------+------------+-------------+------------+---------+-----------+----------+------------+--------+---------+----------+
|ident|     category|                name|latitude_deg|longitude_deg|elevation_ft|continent|iso_country|iso_region|municipality|gps_code|iata_code|local_code|
+-----+-------------+--------------------+------------+-------------+------------+---------+-----------+----------+------------+--------+---------+----------+
|  00A|     heliport|   Total Rf Heliport| 40.07080078| -74.93360138|          11|       NA|         US|     US-PA|    Bensalem|     00A|     null|       00A|
| 00AK|small_airport|        Lowell Field| 59.94919968| -151.6959991|         450|       NA|         US|     US-AK|Anchor Point|    00AK|     null|      00AK|
| 00AL|small_airport|        Epps Airpark|  34.8647995| -86.77030182|         820|       NA|         US|     US-AL|     Harvest|    00AL|     null|      00AL|
| 00AR|     heliport|Newport Hospital ...|  35.6086998| -91.25489807|         237|       NA|         US|     US-AR|     Newport|    00AR|     null|      00AR|
| 00AZ|small_airport|      Cordes Airport| 34.30559921| -112.1650009|        3810|       NA|         US|     US-AZ|      Cordes|    00AZ|     null|      00AZ|
+-----+-------------+--------------------+------------+-------------+------------+---------+-----------+----------+------------+--------+---------+----------+
only showing top 5 rows
```

Spark SQL - Datasets

```
val airportsCA = airports.filter(_.iso_region == "US-CA")
airportsCA.show(5)
```

```
+-----+------------+--------------------+-----------+------------+-----------+---------+-----------+----------+---------------+--------+---------+----------+
|ident|    category|                name|latitude_deg|longitude_deg|elevation_ft|continent|iso_country|iso_region|   municipality|gps_code|iata_code|local_code|
+-----+------------+--------------------+-----------+------------+-----------+---------+-----------+----------+---------------+--------+---------+----------+
| 00CA|small_airport|Goldstone /Gts/ A...|  35.3504982| -116.8880005|       3038|       NA|         US|     US-CA|        Barstow|    00CA|     null|      00CA|
| 01CA|     heliport|Lugo Substation H...| 34.36824059| -117.3700587|       3733|       NA|         US|     US-CA|       Hesperia|    01CA|     null|      01CA|
| 01CL|small_airport|Swansboro Country...| 38.79990005| -120.7340012|       2594|       NA|         US|     US-CA|    Placerville|    01CL|     null|      01CL|
| 01CN|     heliport|Los Angeles Count...| 34.03779984| -118.1539993|        300|       NA|         US|     US-CA|    Los Angeles|    01CN|     null|      01CN|
| 02CA|     heliport|Swepi Beta Platfo...| 33.58250046| -118.1289978|        122|       NA|         US|     US-CA|Huntington Beach|    02CA|     null|      02CA|
+-----+------------+--------------------+-----------+------------+-----------+---------+-----------+----------+---------------+--------+---------+----------+
only showing top 5 rows
```

```
val heliportsCA = airports.filter(_.iso_region == "US-CA").filter(_.category == "heliport").filter(_.elevation_ft > 1000)
heliportsCA.show(5)
```

```
+-----+--------+--------------------+-----------+------------+-----------+---------+-----------+----------+---------------+--------+---------+----------+
|ident|category|                name|latitude_deg|longitude_deg|elevation_ft|continent|iso_country|iso_region|   municipality|gps_code|iata_code|local_code|
+-----+--------+--------------------+-----------+------------+-----------+---------+-----------+----------+---------------+--------+---------+----------+
| 01CA|heliport|Lugo Substation H...| 34.36824059| -117.3700587|       3733|       NA|         US|     US-CA|       Hesperia|    01CA|     null|      01CA|
| 06CA|heliport|Sce Solar I Heliport| 34.87080002| -116.8339996|       1942|       NA|         US|     US-CA|          Yermo|    06CA|     null|      06CA|
| 08CA|heliport|Pg & E Co. Placer...| 38.69490051| -120.8270035|       1810|       NA|         US|     US-CA|Diamond Springs|    08CA|     null|      08CA|
| 0CL9|heliport|Sce San Jacinto V...| 33.74110031|  -117.151001|       1482|       NA|         US|     US-CA|       Romoland|    0CL9|     null|      0CL9|
| 10CA|heliport|William E Poole H...|   34.602252|  -117.172451|       3120|       NA|         US|     US-CA|   Apple Valley|    10CA|     null|      10CA|
+-----+--------+--------------------+-----------+------------+-----------+---------+-----------+----------+---------------+--------+---------+----------+
only showing top 5 rows
```

```
airports.CA.persist
```

Spark SQL - DataFrames

Year	Make	Model
Int	String	String
Int	String	String
Int	String	String

Year | Make | Model
Year | Make | Model
Year | Make | Model

Spark SQL - DataFrames

```
case class Airport (ident:String, category:String, name:String, latitude_deg:Double, longitude_deg:Double, elevation_ft:Integer, continent:String,
                    iso_country:String, iso_region:String, municipality:String, gps_code:String, iata_code:String, local_code:String)
```

```
val airportsDF = spark.read.option("inferSchema", "true").option("header","true").csv("data/airport_codes.csv").as[Airport].toDF
airportsDF.show(5)
```

```
+-----+-------------+--------------------+------------+-------------+------------+---------+-----------+----------+------------+--------+---------+----------+
|ident|     category|                name|latitude_deg|longitude_deg|elevation_ft|continent|iso_country|iso_region|municipality|gps_code|iata_code|local_code|
+-----+-------------+--------------------+------------+-------------+------------+---------+-----------+----------+------------+--------+---------+----------+
|  00A|     heliport|   Total Rf Heliport| 40.07080078| -74.93360138|          11|       NA|         US|     US-PA|    Bensalem|     00A|     null|       00A|
| 00AK|small_airport|        Lowell Field| 59.94919968| -151.6959991|         450|       NA|         US|     US-AK|Anchor Point|    00AK|     null|      00AK|
| 00AL|small_airport|        Epps Airpark|  34.8647995| -86.77030182|         820|       NA|         US|     US-AL|     Harvest|    00AL|     null|      00AL|
| 00AR|     heliport|Newport Hospital ...|  35.6086998| -91.25489807|         237|       NA|         US|     US-AR|     Newport|    00AR|     null|      00AR|
| 00AZ|small_airport|      Cordes Airport| 34.30559921| -112.1650009|        3810|       NA|         US|     US-AZ|      Cordes|    00AZ|     null|      00AZ|
+-----+-------------+--------------------+------------+-------------+------------+---------+-----------+----------+------------+--------+---------+----------+
only showing top 5 rows
```

```
val airportsDF = spark.read.option("inferSchema", "true").option("header","true").csv("data/airport_codes.csv")
airportsDF.show(5)
```

```
+-----+-------------+--------------------+------------+-------------+------------+---------+-----------+----------+------------+--------+---------+----------+
|ident|     category|                name|latitude_deg|longitude_deg|elevation_ft|continent|iso_country|iso_region|municipality|gps_code|iata_code|local_code|
+-----+-------------+--------------------+------------+-------------+------------+---------+-----------+----------+------------+--------+---------+----------+
|  00A|     heliport|   Total Rf Heliport| 40.07080078| -74.93360138|          11|       NA|         US|     US-PA|    Bensalem|     00A|     null|       00A|
| 00AK|small_airport|        Lowell Field| 59.94919968| -151.6959991|         450|       NA|         US|     US-AK|Anchor Point|    00AK|     null|      00AK|
| 00AL|small_airport|        Epps Airpark|  34.8647995| -86.77030182|         820|       NA|         US|     US-AL|     Harvest|    00AL|     null|      00AL|
| 00AR|     heliport|Newport Hospital ...|  35.6086998| -91.25489807|         237|       NA|         US|     US-AR|     Newport|    00AR|     null|      00AR|
| 00AZ|small_airport|      Cordes Airport| 34.30559921| -112.1650009|        3810|       NA|         US|     US-AZ|      Cordes|    00AZ|     null|      00AZ|
+-----+-------------+--------------------+------------+-------------+------------+---------+-----------+----------+------------+--------+---------+----------+
only showing top 5 rows
```

Spark SQL - DataFrames

```
val airportsCA = airportsDF.filter($"iso_region" === "US-CA")
airportsCA.show(5)
```

```
+-----+-------------+--------------------+-----------+------------+-----------+---------+-----------+----------+---------------+--------+--------+----------+
|ident|     category|                name|latitude_deg|longitude_deg|elevation_ft|continent|iso_country|iso_region|   municipality|gps_code|iata_code|local_code|
+-----+-------------+--------------------+-----------+------------+-----------+---------+-----------+----------+---------------+--------+--------+----------+
| 00CA|small_airport|Goldstone /Gts/ A...|  35.3504982| -116.8880005|       3038|       NA|         US|     US-CA|        Barstow|    00CA|    null|      00CA|
| 01CA|     heliport|Lugo Substation H...| 34.36824059| -117.3700587|       3733|       NA|         US|     US-CA|       Hesperia|    01CA|    null|      01CA|
| 01CL|small_airport|Swansboro Country...| 38.79990005| -120.7340012|       2594|       NA|         US|     US-CA|    Placerville|    01CL|    null|      01CL|
| 01CN|     heliport|Los Angeles Count...| 34.03779984| -118.1539993|        300|       NA|         US|     US-CA|    Los Angeles|    01CN|    null|      01CN|
| 02CA|     heliport|Swepi Beta Platfo...| 33.58250046| -118.1289978|        122|       NA|         US|     US-CA|Huntington Beach|    02CA|    null|      02CA|
+-----+-------------+--------------------+-----------+------------+-----------+---------+-----------+----------+---------------+--------+--------+----------+
only showing top 5 rows
```

```
val heliportsCA = airports.filter($"iso_region" === "US-CA").filter($"category" === "heliport").filter($"elevation_ft" > 1000)
heliportsCA.show(5)
```

```
+-----+--------+--------------------+-----------+------------+-----------+---------+-----------+----------+---------------+--------+--------+----------+
|ident|category|                name|latitude_deg|longitude_deg|elevation_ft|continent|iso_country|iso_region|   municipality|gps_code|iata_code|local_code|
+-----+--------+--------------------+-----------+------------+-----------+---------+-----------+----------+---------------+--------+--------+----------+
| 01CA|heliport|Lugo Substation H...| 34.36824059| -117.3700587|       3733|       NA|         US|     US-CA|       Hesperia|    01CA|    null|      01CA|
| 06CA|heliport|Sce Solar I Heliport| 34.87080002| -116.8339996|       1942|       NA|         US|     US-CA|          Yermo|    06CA|    null|      06CA|
| 08CA|heliport|Pg & E Co. Placer...| 38.69490051| -120.8270035|       1810|       NA|         US|     US-CA|Diamond Springs|    08CA|    null|      08CA|
| 0CL9|heliport|Sce San Jacinto V...| 33.74110031|  -117.151001|       1482|       NA|         US|     US-CA|       Romoland|    0CL9|    null|      0CL9|
| 10CA|heliport|William E Poole H...|   34.602252|  -117.172451|       3120|       NA|         US|     US-CA|   Apple Valley|    10CA|    null|      10CA|
+-----+--------+--------------------+-----------+------------+-----------+---------+-----------+----------+---------------+--------+--------+----------+
only showing top 5 rows
```

Spark SQL - DataFrames

```
val highAirportsCA = airports.filter($"iso_region" === "US-CA").groupBy($"iso_region").avg("elevation_ft")
highAirportsCA.show
```

```
+----------+------------------+
|iso_region| avg(elevation_ft)|
+----------+------------------+
|     US-CA|1047.5383858267717|
+----------+------------------+
```

```
val heliportsCAProjection = airports.select($"ident", $"name").filter($"iso_region" === "US-CA").
                                     filter($"category" === "heliport").filter($"elevation_ft" > 1000)
heliportsCAProjection.show(5)
```

```
+-----+--------------------+
|ident|                name|
+-----+--------------------+
| 01CA|Lugo Substation H...|
| 06CA|Sce Solar I Heliport|
| 08CA|Pg & E Co. Placer...|
| 0CL9|Sce San Jacinto V...|
| 10CA|William E Poole H...|
+-----+--------------------+
only showing top 5 rows
```

Spark SQL - DataFrames

```
val otherAirportData = spark.read.json("data/airports.jsonl")
otherAirportData.printSchema
```

```
root
 |-- carriers: string (nullable = true)
 |-- city: string (nullable = true)
 |-- code: string (nullable = true)
 |-- country: string (nullable = true)
 |-- direct_flights: string (nullable = true)
 |-- elev: string (nullable = true)
 |-- email: string (nullable = true)
 |-- icao: string (nullable = true)
 |-- lat: string (nullable = true)
 |-- lon: string (nullable = true)
 |-- name: string (nullable = true)
 |-- phone: string (nullable = true)
 |-- runway_length: string (nullable = true)
 |-- state: string (nullable = true)
 |-- types: string (nullable = true)
 |-- tz: string (nullable = true)
 |-- url: string (nullable = true)
 |-- woeid: string (nullable = true)
```

```
val joinedAirportData = airports.join(otherAirportData, airports("name") === otherAirportData("name")).select($"ident",airports("name"),$"tz")
joinedAirportData.show(5)
```

```
+-----+--------------------+----------------+
|ident|                name|              tz|
+-----+--------------------+----------------+
| 07SN|   Churchill Airport|America/Winnipeg|
| 0NE5|      Newman Airport| Australia/Perth|
|  0R2|Lincoln Municipal...| America/Chicago|
| 12NK|    Westport Airport|Pacific/Auckland|
|  14S|    Westport Airport|Pacific/Auckland|
+-----+--------------------+----------------+
only showing top 5 rows
```

Spark SQL - DataFrames

```
airportsDF.createOrReplaceTempView("airports")
otherAirportData.createOrReplaceTempView("other_airports")
```

```
spark.sql("SELECT * FROM airports WHERE iso_region = 'US-CA'").show(3)
```

```
+-----+-------------+--------------------+------------+-------------+------------+---------+-----------+----------+------------+--------+---------+----------+
|ident|     category|                name|latitude_deg|longitude_deg|elevation_ft|continent|iso_country|iso_region|municipality|gps_code|iata_code|local_code|
+-----+-------------+--------------------+------------+-------------+------------+---------+-----------+----------+------------+--------+---------+----------+
| 00CA|small_airport|Goldstone /Gts/ A...|  35.3504982| -116.8880005|        3038|       NA|         US|     US-CA|     Barstow|    00CA|     null|      00CA|
| 01CA|     heliport|Lugo Substation H...| 34.36824059| -117.3700587|        3733|       NA|         US|     US-CA|    Hesperia|    01CA|     null|      01CA|
| 01CL|small_airport|Swansboro Country...| 38.79990005| -120.7340012|        2594|       NA|         US|     US-CA| Placerville|    01CL|     null|      01CL|
+-----+-------------+--------------------+------------+-------------+------------+---------+-----------+----------+------------+--------+---------+----------+
only showing top 3 rows
```

```
spark.sql("SELECT a.ident, a.name, o.tz FROM airports a, other_airports o WHERE a.name = o.name").show(5)
```

```
+-----+--------------------+---------------+
|ident|                name|             tz|
+-----+--------------------+---------------+
| 07SN|   Churchill Airport|America/Winnipeg|
| 0NE5|      Newman Airport| Australia/Perth|
|  0R2|Lincoln Municipal...| America/Chicago|
| 12NK|    Westport Airport|Pacific/Auckland|
|  14S|    Westport Airport|Pacific/Auckland|
+-----+--------------------+---------------+
only showing top 5 rows
```

```
spark.sql("SELECT AVG(elevation_ft) FROM airports WHERE iso_region = 'US-CA'").show
```

```
+------------------+
| avg(elevation_ft)|
+------------------+
|1047.5383858267717|
+------------------+
```

Spark SQL - Data Sources

- CSV
  - Can use CSV parser with any delimiter
  - Set option “sep” to delimiter char

```
val suppliersDF = spark.read.option("sep", "|").csv("/data/supplier/suppliers.csv")
```

Spark SQL - Data Sources

- JSON
  - Default wants to read JSONL format
    - http://jsonlines.org
  - As of latest Spark can read multi-line
    - Set option “multiline” to “true”

```
val rows = spark.read.option("multiLine", true).json(“/data/rows.json")
```

Spark SQL - Data Sources

- Parquet
  - Spark SQL HIGHLY optimized for Parquet

Spark SQL - Data Sources

- JDBC
  - Can read/write directly to DB
  - Meant for small transactional updates not bulk queries
  - Need to include driver on the classpath

```
bin/spark-shell --driver-class-path postgresql-9.4.1207.jar --jars postgresql-9.4.1207.jar
```

```
import java.util.Properties
val connectionProperties = new Properties()
connectionProperties.put("user", "username")
connectionProperties.put("password", "password")
val jdbcDF = spark.read.jdbc("jdbc:postgresql:dbserver", "schema.tablename", connectionProperties)
```

Spark SQL - Data Sources

- Hive
  - Can access tables/file in Hive metastore
  - Already configured in HDP
  - Tables registered like using raw SQL

```
spark.sql("select id, date, price from home_data limit 10").show
+----------+---------------+-------+
|        id|           date|  price|
+----------+---------------+-------+
|7129300520|20141013T000000| 221900|
|6414100192|20141209T000000| 538000|
|5631500400|20150225T000000| 180000|
|2487200875|20141209T000000| 604000|
|1954400510|20150218T000000| 510000|
|7237550310|20140512T000000|1225000|
|1321400060|20140627T000000| 257500|
|2008000270|20150115T000000| 291850|
|2414600126|20150415T000000| 229500|
|3793500160|20150312T000000| 323000|
+----------+---------------+-------+
val hiveDF = spark.sql("select * from home_data")
```