Exercises Preparation I

Start Hadoop Cluster and Test Spark Shell
(Word Count Example)

Start Gcloud VM and Connect

1. Start Gcloud Instance:

```
gcloud compute instances start big-data
```

2. Connect to Gcloud instance via SSH (on Windows using Putty):

```
ssh hans.wurst@XXX.XXX.XXX.XXX
```

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Pull and Start Docker Container

1. Pull Docker Image:

```
docker pull marcelmittelstaedt/spark_base:latest
```

2. Start Docker Image:

```
docker network create --driver bridge bigdatanet
docker run -dit --name hadoop \
        -p 8088:8088 -p 9870:9870 -p 9864:9864 -p 10000:10000 \
        -p 8032:8032 -p 8030:8030 -p 8031:8031 -p 9000:9000 \
        -p 8888:8888 --net bigdatanet \
        marcelmittelstaedt/spark_base:latest
```

3. Wait till first Container Initialization finished:

```
docker logs hadoop

[…]
Stopping nodemanagers
Stopping resourcemanager
Container Startup finished.
```

Start Hadoop Cluster

1. Get into Docker container:

```
docker exec -it hadoop bash
```

2. Switch to hadoop user:

```
sudo su hadoop
```

```
cd
```

3. Start Hadoop Cluster:

```
start-all.sh
```

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Add Test text file to HDFS (Faust 1)

1. Download test Text File (Faust_1.txt):

```
wget https://raw.githubusercontent.com/marcelmittelstaedt/BigData/master/exer
cises/winter_semester_2022-2023/01_hadoop/sample_data/Faust_1.txt
```

2. Upload file to HDFS:

```
hadoop fs -put Faust_1.txt /user/hadoop/Faust_1.txt
```

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Start Spark (on Yarn)

1. Start Spark Shell:

```
spark-shell --master yarn
```

```
Spark context Web UI available at http://localhost:4040
Spark context available as 'sc' (master = yarn, app id = application_1572177196643_0001).
Spark session available as 'spark'.
Welcome to
      ____              __
     / __/__  ___ _____/ /__
    _\ \/ _ \/ _ `/ __/  '_/
   /___/ .__/\_,_/_/ /_/\_\   version 2.3.4
      /_/

Using Scala version 2.11.8 (OpenJDK 64-Bit Server VM, Java 1.8.0_222)
Type in expressions to have them evaluated.
Type :help for more information.

scala>
```

Start Spark – WordCount Example (Scala)

1. Execute Word Count Example in Scala:

```
scala> val text_file = sc.textFile("/user/hadoop/Faust_1.txt")
scala> val words = text_file.flatMap(line => line.split(" "))
scala> val counts = words.map(word => (word, 1))
scala> val reduced_counts = counts.reduceByKey((count1, count2) => count1 + count2)
scala> val sorted_counts = reduced_counts.sortBy(- _._2)
```

```
scala> sorted_counts.take(10)

res0: Array[(String, Int)] = Array(("",1603), (und,509), (die,463), (der,440), (ich,435), (Und,
400), (nicht,346), (zu,319), (ist,291), (ein,284))
```

2. Save results to HDFS:

```
scala> sorted_counts.saveAsTextFile("/user/hadoop/Faust_1_WordCounts_Scala.txt")
```

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Start Spark – WordCount Example (Scala)

3. Get results from HDFS to local filesystem:

```
hadoop fs -get /user/hadoop/Faust_1_WordCounts_Scala.txt/part-00000 Faust_1_WordCounts_Scala.txt
```

4. Check Result:

```
head -10 Faust_1_WordCounts_Scala.txt

(,1603)
(und,509)
(die,463)
(der,440)
(ich,435)
(Und,400)
(nicht,346)
(zu,319)
(ist,291)
(ein,284)
```

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Start Spark (on Yarn) – WordCount Example

5. See Spark Shell Container Running on Yarn http://xxx.xxx.xxx.xxx:8088/cluster :

Exercises Preparation II

Test PySpark Shell (Word Count Example)

Start PySpark (on Yarn) – Test Install

1. As PySpark is already installed, start PySpark Shell and execute previous example as Python code:

```
pyspark --master yarn
```

```
Python 3.6.8 (default, Oct  7 2019, 12:59:55)
[GCC 8.3.0] on linux
Type "help", "copyright", "credits" or "license" for more information.
Setting default log level to "WARN".
To adjust logging level use sc.setLogLevel(newLevel). For SparkR, use setLogLevel(newLevel).
Welcome to
      ____              __
     / __/__  ___ _____/ /__
    _\ \/ _ \/ _ `/ __/  '_/
   /__ / .__/\_,_/_/ /_/\_\   version 2.3.4
      /_/

Using Python version 3.6.8 (default, Oct  7 2019 12:59:55)
SparkSession available as 'spark'.
>>>
```

PySpark – WordCount Example (Python)

1. Execute Word Count Example in Python:

```
>>> text_file = spark.read.text("/user/hadoop/Faust_1.txt").rdd.map(lambda r: r[0])
>>> words = text_file.flatMap(lambda line: line.split(" "))
>>> counts = words.map(lambda word: (word, 1)).reduceByKey(lambda a,b:a +b)
>>> output = counts.collect()
>>> sorted_output = sorted(output,key=lambda x:(-x[1],x[0]))
```

```
>>> sorted_output[:10]

[('', 1603), ('und', 509), ('die', 463), ('der', 440), ('ich', 435), ('Und', 400), ('nicht', 34
6), ('zu', 319), ('ist', 291), ('ein', 284)]
```

2. Save results to HDFS:

```
>>> counts.saveAsTextFile("/user/hadoop/Faust_1_WordCounts_Python.txt")
```

PySpark – WordCount Example (Python)

3. Get results from HDFS to local filesystem:

```
hadoop fs -get /user/hadoop/Faust_1_WordCounts_Python.txt/part-00000 Faust_1_WordCounts_Python.txt
```

4. Check Result:

```
head -10 Faust_1_WordCounts_Python.txt

('Johann', 1)
('Wolfgang', 1)
('von', 133)
('Goethe:', 1)
('Faust,', 8)
('Der', 130)
('Tragödie', 1)
('erster', 2)
('Teil', 6)
('', 1603)
```

PySpark (on Yarn) – WordCount Example

5. See PySpark Shell Container Running on Yarn http://xxx.xxx.xxx.xxx:8088/cluster :

TIME FOR A BREAK

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Exercises Preparation III

Start and work with Jupyter Notebooks
(on PySpark)

Start Jupyter

1. Start Jupyter Notebook

```
jupyter notebook

[I 14:02:39.790 NotebookApp] Writing notebook server cookie secret to /home/hadoop/.local/share/jupyter/runtime/notebook_cookie_secret
[I 14:02:40.957 NotebookApp] Serving notebooks from local directory: /home/hadoop
[I 14:02:40.957 NotebookApp] The Jupyter Notebook is running at:
[I 14:02:40.957 NotebookApp] http://e0f4472dcb12:8888/?token=76b68a3c700b415790b019e07a3dd46a0d068c153a732d27
[I 14:02:40.957 NotebookApp]  or http://127.0.0.1:8888/?token=76b68a3c700b415790b019e07a3dd46a0d068c153a732d27
[I 14:02:40.957 NotebookApp] Use Control-C to stop this server and shut down all kernels (twice to skip confirmation).
[W 14:02:40.979 NotebookApp] No web browser found: could not locate runnable browser.
[C 14:02:40.980 NotebookApp]

    To access the notebook, open this file in a browser:
        file:///home/hadoop/.local/share/jupyter/runtime/nbserver-8624-open.html
    Or copy and paste one of these URLs:
        http://e0f4472dcb12:8888/?token=76b68a3c700b415790b019e07a3dd46a0d068c153a732d27
     or http://127.0.0.1:8888/?token=76b68a3c700b415790b019e07a3dd46a0d068c153a732d27
```

Start Jupyter
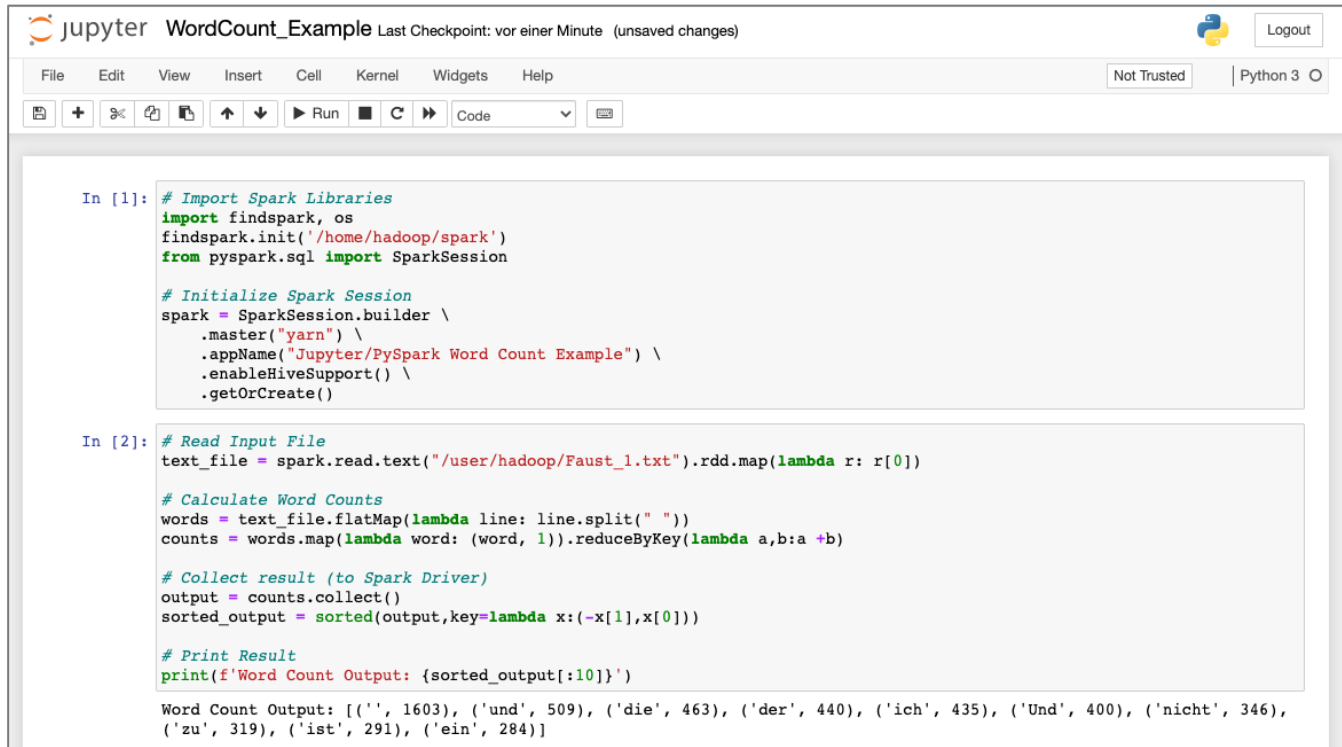
2. Open Notebook in Browser: http://XXX.XXX.XXX.XXX:8888/?token=[XYZXYZXYZ]

Use Jupyter (Word Count Example)

1. Execute previous Word Count example

Use Jupyter (Word Count Example)

2. See **Jupyter** PySpark Container Running on Yarn http://xxx.xxx.xxx.xxx:8088/cluster :

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Get some data…

1. Get some IMDb data:

```
wget https://datasets.imdbws.com/title.basics.tsv.gz && gunzip title.basics.tsv.gz
wget https://datasets.imdbws.com/title.ratings.tsv.gz && gunzip title.ratings.tsv.gz
```

2. Put them into HDFS:

```
hadoop fs -mkdir /user/hadoop/imdb
```

```
hadoop fs -mkdir /user/hadoop/imdb/title_basics
hadoop fs -mkdir /user/hadoop/imdb/title_ratings
```
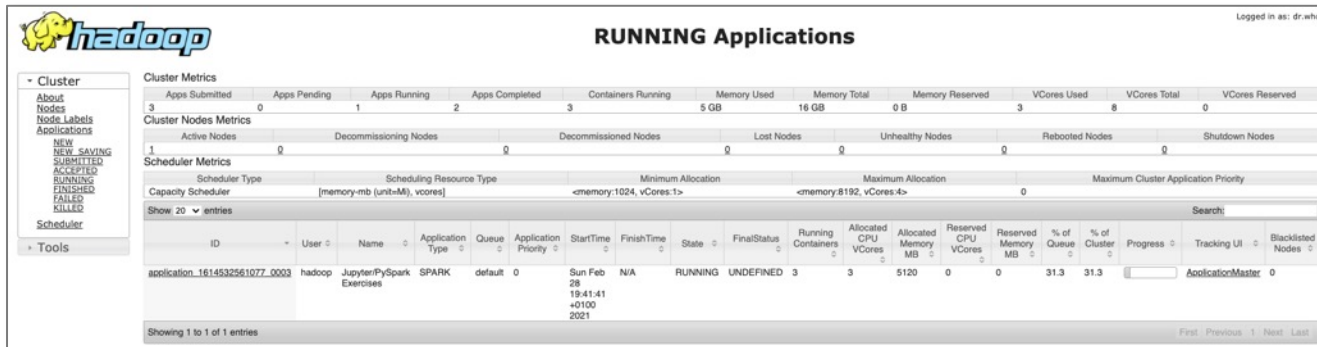
```
hadoop fs -put title.basics.tsv /user/hadoop/imdb/title_basics/title.basics.tsv
hadoop fs -put title.ratings.tsv /user/hadoop/imdb/title_ratings/title.ratings.tsv
```

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PySpark Operations

1. Initialize Spark Session:

```python
In [1]:  # Import Spark Libraries
         import findspark, os
         findspark.init('/home/hadoop/spark')
         from pyspark.sql import SparkSession

         # Initialize Spark Session
         spark = SparkSession.builder \
             .master("yarn") \
             .appName("Jupyter/PySpark Exercises") \
             .enableHiveSupport() \
             .getOrCreate()
```


https://github.com/marcelmittelstaedt/BigData/tree/master/exercises/winter_semester_2023-2024/04_spark_pyspark_jupyter/Exercises.html

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PySpark Operations

2. Basic PySpark operations: Read Files from HDFS into DataFrames:

```
In [2]:  # Read IMDb title basics CSV file from HDFS
         df_title_basics = spark.read \
             .format('csv') \
             .options(header='true', delimiter='\t', nullValue='null', inferSchema='true') \
             .load('/user/hadoop/imdb/title_basics/title.basics.tsv')
```

```
In [3]:  # Print Schema of DataFrame
         df_title_basics.printSchema()

root
 |-- tconst: string (nullable = true)
 |-- titleType: string (nullable = true)
 |-- primaryTitle: string (nullable = true)
 |-- originalTitle: string (nullable = true)
 |-- isAdult: string (nullable = true)
 |-- startYear: string (nullable = true)
 |-- endYear: string (nullable = true)
 |-- runtimeMinutes: string (nullable = true)
 |-- genres: string (nullable = true)
```

```
In [4]:  # Print First 3 Rows of DataFrame Data
         df_title_basics.show(3)

+---------+---------+--------------------+--------------------+-------+---------+-------+--------------+--------------+
|   tconst|titleType|        primaryTitle|       originalTitle|isAdult|startYear|endYear|runtimeMinutes|        genres|
+---------+---------+--------------------+--------------------+-------+---------+-------+--------------+--------------+
|tt0000001|    short|          Carmencita|          Carmencita|      0|     1894|     \N|             1|   Documentary,Short|
|tt0000002|    short|Le clown et ses c...|Le clown et ses c...|      0|     1892|     \N|             5|     Animation,Short|
|tt0000003|    short|       Pauvre Pierrot|       Pauvre Pierrot|      0|     1892|     \N|             4|Animation,Comedy,...|
+---------+---------+--------------------+--------------------+-------+---------+-------+--------------+--------------+
only showing top 3 rows
```

PySpark Operations

3. Basic PySpark: Operations on DataFrames (aggregations…):

```
In [5]:  # Get Number of Rows of a DataFrame
         df_title_basics.count()

Out[5]:  7656314

In [6]:  # Groups and Counts: Get column titleTypes values with counts and ordered descending
         from pyspark.sql.functions import desc
         df_title_basics \
             .groupBy("titleType") \
             .count() \
             .orderBy(desc("count")) \
             .show()

         +-----------+-------+
         |  titleType|  count|
         +-----------+-------+
         |    tvEpisode|5556805|
         |        short| 796470|
         |        movie| 569437|
         |        video| 296405|
         |     tvSeries| 202321|
         |      tvMovie| 130185|
         |  tvMiniSeries|  36080|
         |    tvSpecial|  31590|
         |    videoGame|  27416|
         |      tvShort|   9602|
         |     audiobook|      1|
         |      episode|      1|
         |  radioSeries|      1|
         +-----------+-------+

In [7]:  # Calculate average Movie length in minutes
         from pyspark.sql.functions import avg, col
         df_title_basics \
             .where(col('titleType') == 'movie') \
             .agg(avg('runtimeMinutes')) \
             .show()

         +-------------------+
         |avg(runtimeMinutes)|
         +-------------------+
         |  89.62651045204976|
         +-------------------+
```

PySpark Operations

4. Basic PySpark: Save PySpark DataFrame back to HDFS (as partitioned parquet files):

```python
In [8]:   # Save Dataframe back to HDFS (partitioned) as Parquet files
          df_title_basics.repartition('startYear').write \
              .format("parquet") \
              .mode("overwrite") \
              .partitionBy('startYear') \
              .save('/user/hadoop/imdb/title_basics_partitioned_files')
```

		/user/hadoop/imdb/title_basics_partitioned_files				Go!			

Show [25] entries   Search: [   ]

		Permission	Owner	Group	Size	Last Modified	Replication	Block Size	Name	
☐		drwxr-xr-x	hadoop	supergroup	0 B	Feb 28 19:53	0	0 B	startYear=2005	🗑
☐		drwxr-xr-x	hadoop	supergroup	0 B	Feb 28 19:53	0	0 B	startYear=2006	🗑
☐		drwxr-xr-x	hadoop	supergroup	0 B	Feb 28 19:53	0	0 B	startYear=2007	🗑
☐		drwxr-xr-x	hadoop	supergroup	0 B	Feb 28 19:53	0	0 B	startYear=2008	🗑
☐		drwxr-xr-x	hadoop	supergroup	0 B	Feb 28 19:53	0	0 B	startYear=2009	🗑
☐		drwxr-xr-x	hadoop	supergroup	0 B	Feb 28 19:53	0	0 B	startYear=2010	🗑
☐		drwxr-xr-x	hadoop	supergroup	0 B	Feb 28 19:53	0	0 B	startYear=2011	🗑

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5. Basic PySpark: Save PySpark DataFrame back to HDFS (as table and partitioned parquet files):

```
In [9]:   # Save Dataframe back to HDFS (partitioned) as EXTERNAL TABLE and Parquet files
          df_title_basics.repartition('startYear').write \
              .format("parquet") \
              .mode("overwrite") \
              .option('path', '/user/hadoop/imdb/title_basics_partitioned_table') \
              .partitionBy('startYear') \
              .saveAsTable('default.title_basics_partitioned')
```

/user/hadoop/imdb/title_basics_partitioned_table

Show 25 entries

	Permission	Owner	Group	Size	Last Modified	Replication	Block Size	Na
☐	drwxr-xr-x	hadoop	supergroup	0 B	Feb 28 19:54	0	0 B	startYear=2
☐	drwxr-xr-x	hadoop	supergroup	0 B	Feb 28 19:54	0	0 B	startYear=2006
☐	drwxr-xr-x	hadoop	supergroup	0 B	Feb 28 19:54	0	0 B	startYear=2007
☐	drwxr-xr-x	hadoop	supergroup	0 B	Feb 28 19:54	0	0 B	startYear=2008
☐	drwxr-xr-x	hadoop	supergroup	0 B	Feb 28 19:54	0	0 B	startYear=2009
☐	drwxr-xr-x	hadoop	supergroup	0 B	Feb 28 19:54	0	0 B	startYear=2010
☐	drwxr-xr-x	hadoop	supergroup	0 B	Feb 28 19:54	0	0 B	startYear=2011

Spark
Table

```
In [10]:  spark.sql('SHOW TABLES').show(10, False)

          +--------+------------------------+-----------+
          |database|tableName               |isTemporary|
          +--------+------------------------+-----------+
          |default |title_basics_partitioned|false      |
          +--------+------------------------+-----------+
```

PySpark Operations

6. Basic PySpark: Interact with Spark Tables (using plain Spark SQL):

```
In [12]: # Read External Spark table using plain Spark SQL
         df = spark.sql('SELECT tconst, primaryTitle, startYear FROM default.title_basics_partitioned WHERE startYear = 2020')
         # Print Result
         df.show(3)

         +---------+--------------------+---------+
         |   tconst|        primaryTitle|startYear|
         +---------+--------------------+---------+
         |tt0060366|A Embalagem de Vidro|     2020|
         |tt0062336|El Tango del Viud...|     2020|
         |tt0065392|  Bucharest Memories|     2020|
         +---------+--------------------+---------+
         only showing top 3 rows
```

7. Basic PySpark: Interact with Spark Tables (using Spark programmatically):

```
In [11]: # Read External Spark table in programmatical way
         df = spark.table('default.title_basics_partitioned') \
             .where(col('startYear') == '2020') \
             .select('tconst', 'primaryTitle', 'startYear')
         # Print Result
         df.show(3)

         +---------+--------------------+---------+
         |   tconst|        primaryTitle|startYear|
         +---------+--------------------+---------+
         |tt0060366|A Embalagem de Vidro|     2020|
         |tt0062336|El Tango del Viud...|     2020|
         |tt0065392|  Bucharest Memories|     2020|
         +---------+--------------------+---------+
         only showing top 3 rows
```

Same Result!

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PySpark Operations

8. PySpark SQL: Join Spark DataFrames:

```
In [13]:  # Read title.ratings.tsv into Spark dataframe
          df_title_ratings = spark.read \
              .format('csv') \
              .options(header='true', delimiter='\t', nullValue='null', inferSchema='true') \
              .load('/user/hadoop/imdb/title_ratings/title.ratings.tsv')

In [14]:  # Print Schema of title_ratings dataframe
          df_title_ratings.printSchema()

          root
           |-- tconst: string (nullable = true)
           |-- averageRating: double (nullable = true)
           |-- numVotes: integer (nullable = true)

In [15]:  # Show first 3 rows of title_ratings dataframe
          df_title_ratings.show(3)

          +---------+-------------+--------+
          |   tconst|averageRating|numVotes|
          +---------+-------------+--------+
          |tt0000001|          5.7|    1685|
          |tt0000002|          6.0|     208|
          |tt0000003|          6.5|    1425|
          +---------+-------------+--------+
          only showing top 3 rows
```

```
In [16]:  # JOIN Data Frames
          joined_df = df_title_basics.join(df_title_ratings, df_title_basics.tconst == df_title_ratings.tconst)

In [17]:  # Print Schema of joined DataFrame
          joined_df.printSchema()

          root
           |-- tconst: string (nullable = true)
           |-- titleType: string (nullable = true)
           |-- primaryTitle: string (nullable = true)
           |-- originalTitle: string (nullable = true)
           |-- isAdult: string (nullable = true)
           |-- startYear: string (nullable = true)
           |-- endYear: string (nullable = true)
           |-- runtimeMinutes: string (nullable = true)
           |-- genres: string (nullable = true)
           |-- tconst: string (nullable = true)
           |-- averageRating: double (nullable = true)
           |-- numVotes: integer (nullable = true)

In [18]:  # Show Frist 3 Rows of Joined DataFrame
          joined_df.show(3)

          +---------+---------+-------------------+-------------------+-------+---------+-------+--------------+-------------
          --+---------+-------------+--------+
          |   tconst|titleType|       primaryTitle|      originalTitle|isAdult|startYear|endYear|runtimeMinutes|         genr
          es|   tconst|averageRating|numVotes|
          +---------+---------+-------------------+-------------------+-------+---------+-------+--------------+-------------
          --+---------+-------------+--------+
          |tt0000658|    short|The Puppet's Nigh...|Le cauchemar de F...|      0|     1908|     \N|             2|Animation,Sho
          rt|tt0000658|          6.4|     184|
          |tt0001732|    short|The Lighthouse Ke...|The Lighthouse Ke...|      0|     1911|     \N|            \N|    Drama,Sho
          rt|tt0001732|          7.1|       8|
          |tt0002253|    short|         Home Folks|         Home Folks|      0|     1912|     \N|            17|    Drama,Sho
          rt|tt0002253|          3.7|       6|
          +---------+---------+-------------------+-------------------+-------+---------+-------+--------------+-------------
          --+---------+-------------+--------+
          only showing top 3 rows
```

PySpark Operations

9. Basic PySpark: Filtering, Ordering and Selecting: Get Top 5 TV Series

```
In [19]:  top_tvseries = joined_df \
              .where(col('titleType') == 'tvSeries') \
              .where(col('numVotes') > 200000) \
              .orderBy(desc('averageRating')) \
              .select('originalTitle', 'startYear', 'endYear', 'averageRating', 'numVotes')

          # Print Top 5 TV Series
          top_tvseries.show(5)

          +--------------------+---------+-------+-------------+--------+
          |       originalTitle|startYear|endYear|averageRating|numVotes|
          +--------------------+---------+-------+-------------+--------+
          |        Breaking Bad|     2008|   2013|          9.5| 1470997|
          |            The Wire|     2002|   2008|          9.3|  286432|
          |     Game of Thrones|     2011|   2019|          9.3| 1775327|
          |      Rick and Morty|     2013|     \N|          9.2|  377428|
          |Avatar: The Last ...|     2005|   2008|          9.2|  249236|
          +--------------------+---------+-------+-------------+--------+
          only showing top 5 rows
```

PySpark Operations

10. Basic PySpark: Add/Calculate Columns:

```
In [20]: from pyspark.sql.functions import when, lit

         # Add a calculated column: classify movies as being either 'good' or 'worse' based on average rating
         df_with_classification = joined_df \
             .withColumn('classification',
                         when(col('averageRating') > 8, lit('good')) \
                         .otherwise(lit('worse'))) \
             .select('primaryTitle', 'startYear', 'averageRating', 'classification')

         # Print Result
         df_with_classification.show(3, False)

         +----------------------+---------+-------------+--------------+
         |primaryTitle          |startYear|averageRating|classification|
         +----------------------+---------+-------------+--------------+
         |The Puppet's Nightmare|1908     |6.4          |worse         |
         |The Lighthouse Keeper  |1911     |7.1          |worse         |
         |Home Folks            |1912     |3.7          |worse         |
         +----------------------+---------+-------------+--------------+
         only showing top 3 rows
```

PySpark Operations

11. Basic PySpark/Python: Plot Data:

```
In [21]: # Plot data: good movies per year
         import matplotlib.pyplot as plt
         import pandas

         # Create DataFrame to be plotted
         good_movies = df_with_classification \
             .select('startYear', 'classification') \
             .where(col('classification') == 'good') \
             .where(col('startYear') > 2000) \
             .groupBy('startYear') \
             .count() \
             .sort(col('startYear').asc())

         # Convert Spark DataFrame to Pandas DataFrame
         pandas_df = good_movies.toPandas()

         # Plot DataFrame
         pandas_df.plot.bar(x='startYear', y='count')

Out[21]: <AxesSubplot:xlabel='startYear'>
```

TIME FOR A BREAK

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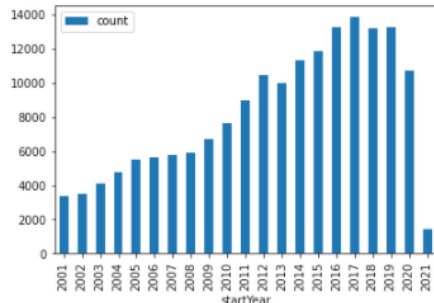
Exercises

Use PySpark Shell or Jupyter Notebooks on PySpark to solve exercises

PySpark Exercises - **IMDB**

1. Execute Tasks of previous HandsOn Slides

2. Create External Spark Table `title_ratings` on HDFS containing data of IMDb file *title.ratings.tsv*

3. Create External Spark Table `name_basics` on HDFS containing data of IMDb file *name.basics.tsv*

4. Use PySpark to answer following questions:

      a) How many **movies** and how many **TV series** are within the IMDB dataset?

      b) Who is the **youngest** actor/writer/… within the dataset?

PySpark Exercises - **IMDB**

4. Use PySpark to answer following questions:

    c) Create a list (`tconst, original_title, start_year, average_rating, num_votes`) of movies which are:
- equal or newer than year 2010
- have an average rating equal or better than 8,1
- have been voted more than 100.000 times

    d) Save result of c) as external Spark Table to HDFS.?

5. Create a Spark Table **`name_basics_partitioned`**, which:
    - contains all columns of table `name_basics`
    - is partitioned by column `partition_is_alive`, containing:
        - „*alive*" in case actor is still alive
        - „*dead*" in case actor is already dead

PySpark Exercises - **IMDB**

6. Create a partitioned Spark table `imdb_movies_and_ratings_partitioned`, which:
> - contains all columns of the two tables `title_basics_partitioned`
> and `title_ratings` and
> - is partitioned by start year of movie (create and add column `partition_year`).

7. Create following plot, which visualizes:
> - the amount of movies (type!)
> - per year
> - since 2000
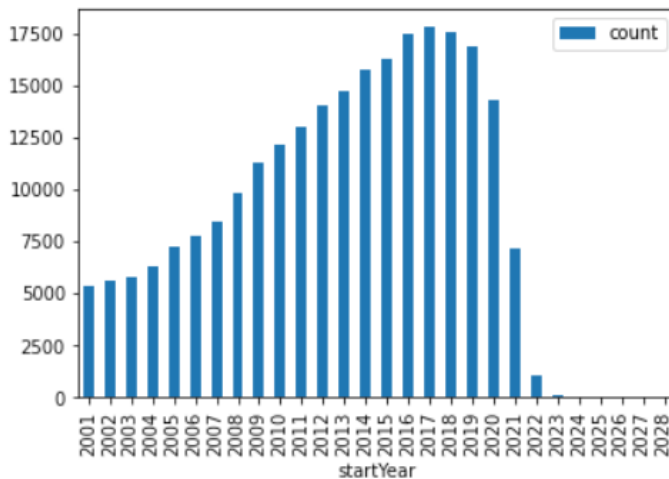
DON'T FORGET TO STOP YOUR VM INSTANCE!

```
gcloud compute instances stop big-data
```

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