
APACHE
Spark
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Apache Spark

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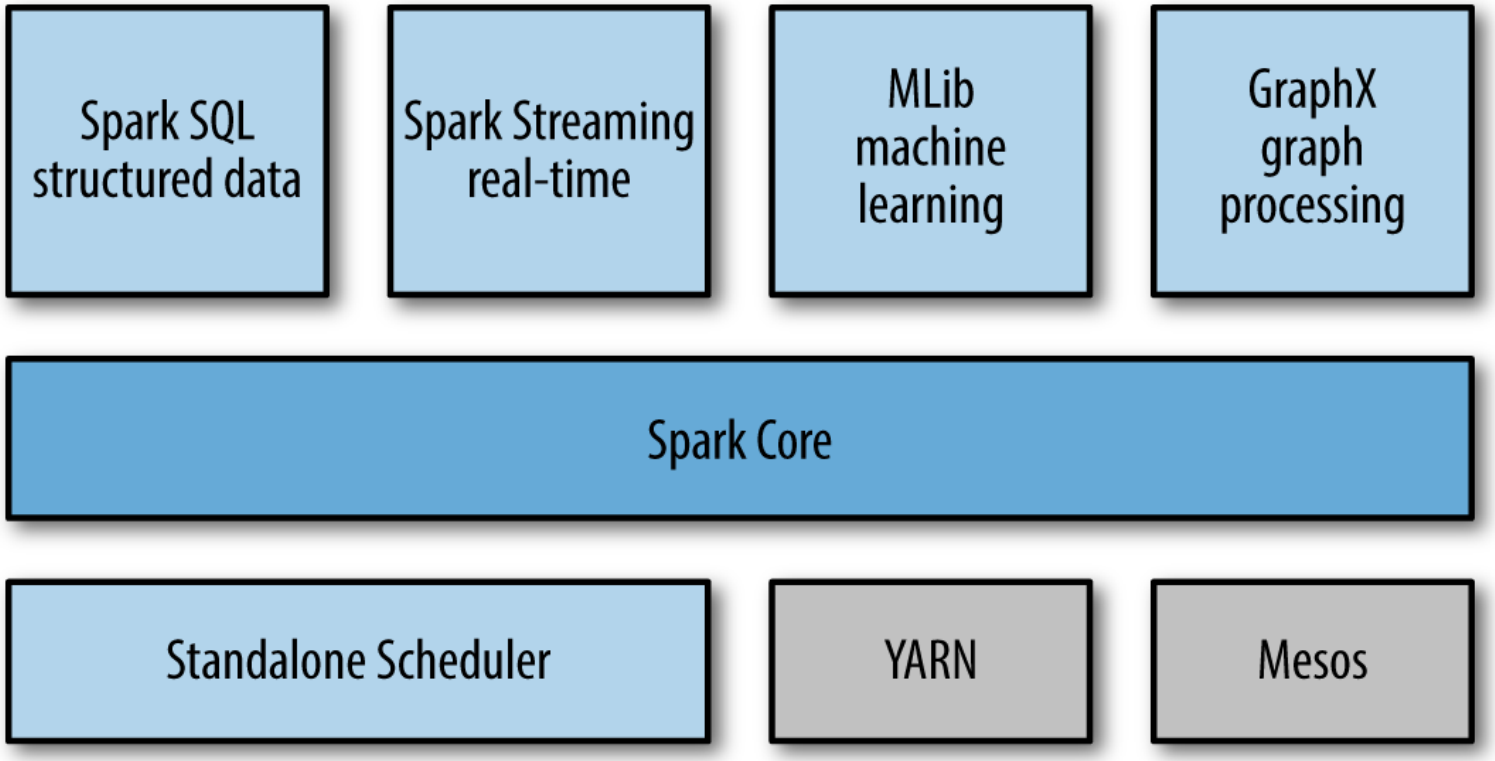
- Apache Spark is one of the hottest frameworks in data science
- It realizes the potential of bringing together both Big Data and machine learning
- Spark is fast (up to 100x faster than traditional Hadoop MapReduce) due to in-memory operation
- It offers robust, distributed, fault-tolerant data objects (called RDDs)
- It integrates beautifully with the world of machine learning and graph analytics through supplementary packages like MLlib and GraphX
- Spark is implemented on Hadoop/HDFS and written mostly in Scala, a functional programming language which runs on the JVM
- Spark provides a wonderful Python API called PySpark

The Spark Stack

- Apache Spark is an open-source cluster-computing framework



PySpark

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- PySpark is the Python API for Spark
- Public classes:
  - SparkContext: Main entry point for Spark functionality
  - RDD: A Resilient Distributed Dataset (RDD), the basic abstraction in Spark
  - Broadcast: A broadcast variable that gets reused across tasks
  - Accumulator: An “add-only” shared variable that tasks can only add values to
  - SparkConf: For configuring Spark
  - SparkFiles: Access files shipped with jobs
  - StorageLevel: Finer-grained cache persistence levels
- http://spark.apache.org/docs/2.1.0/api/python/pyspark.html

Download Apache Spark

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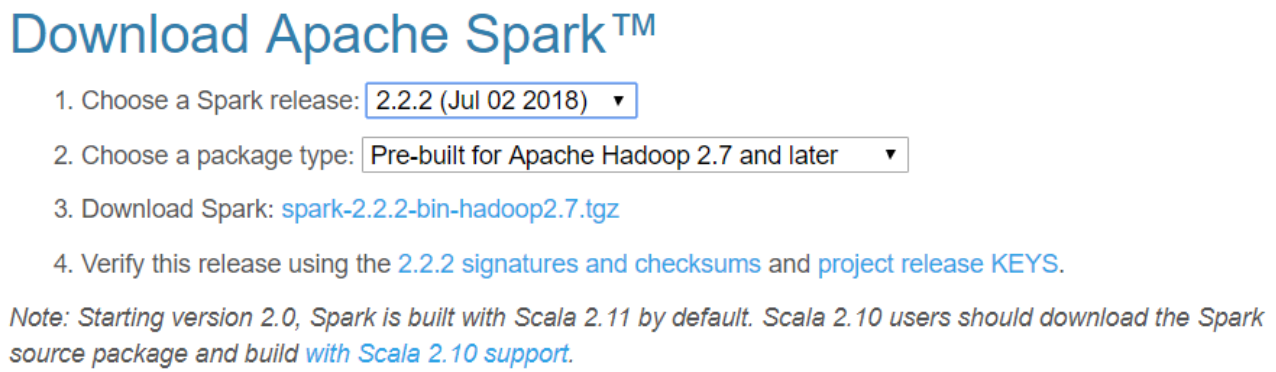
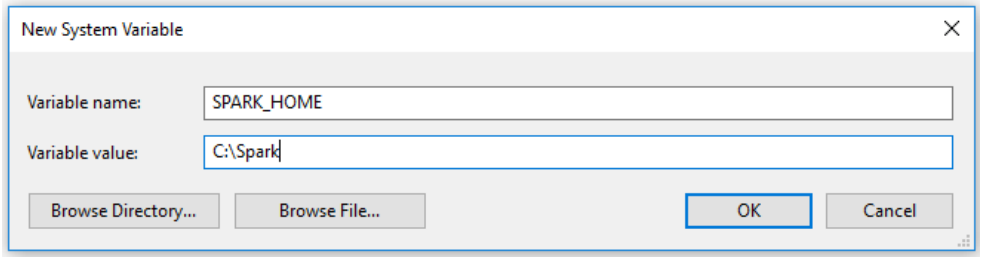
- Visit http://spark.apache.org/downloads.html



- Select Spark release 2.2.2 (Jul 02 2018)
  - Version 2.3.1 has some unresolved dependency conflict issues
- Select the package type of “Pre-built for Hadoop 2.7 and later,” and click the tar file
- This will download a compressed TAR file, called spark-2.2.2-bin-hadoop2.7.tgz
- Unzip this file into a new directory such as C:\Spark
  - The directory should be with no spaces

Install Apache Spark

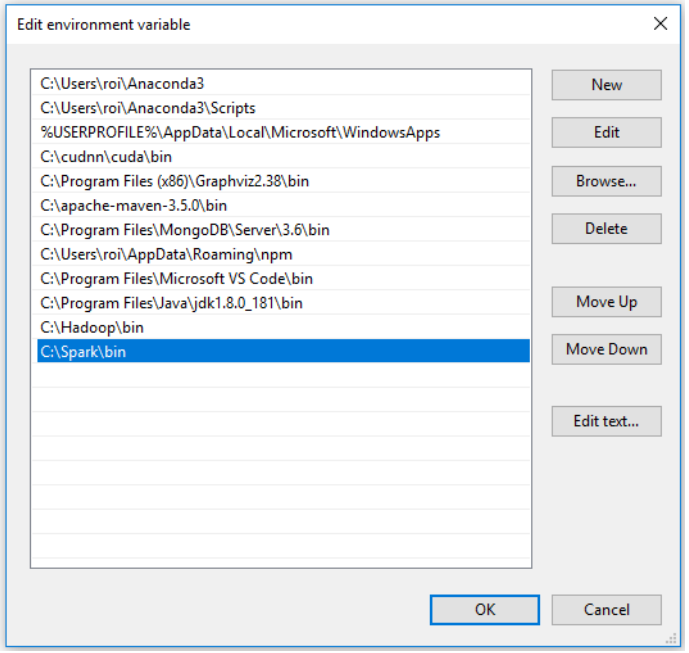
- Set the SPARK_HOME environment variables to C:\Spark



- Set the PYSPARK_PYTHON environment variable to the location of python.exe:

Install Apache Spark

- Add C:\Spark\bin to the path variable:

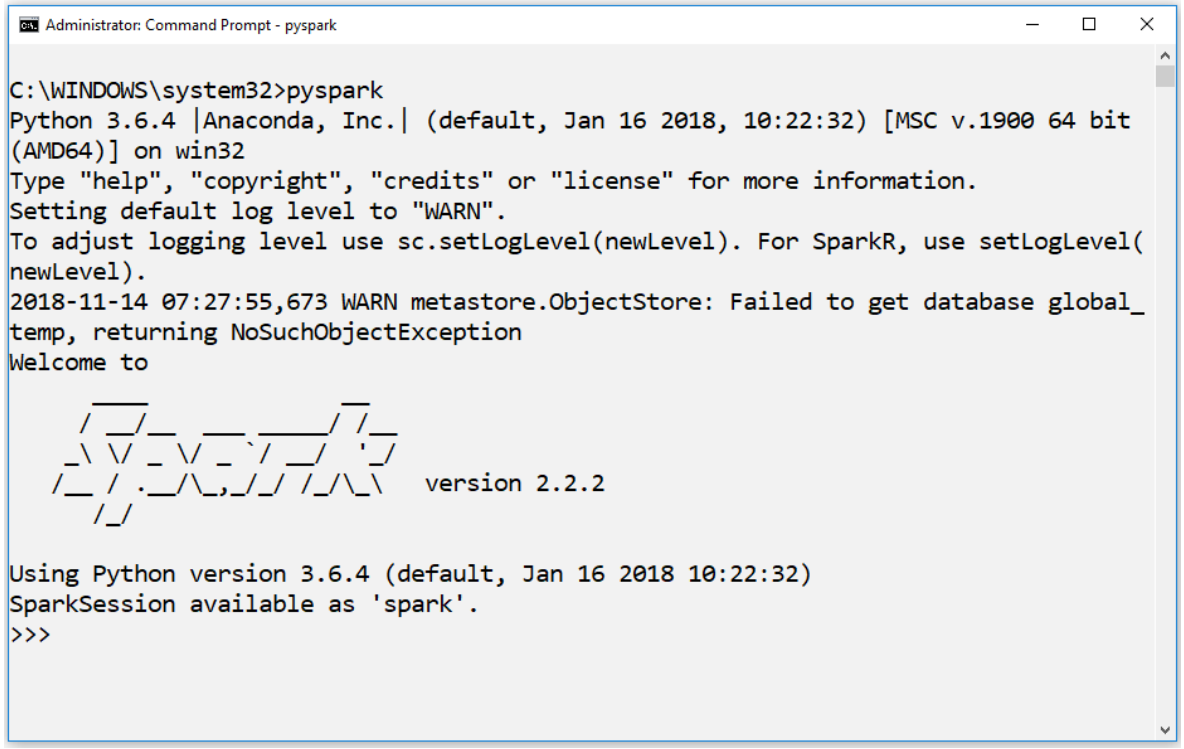


- In addition, you need to create the folder C:\tmp\hive
- You also need to set full permission on this folder using the command:

```
winutils chmod 777 C:\tmp\hive
```

PySpark Shell

- Now run command prompt as administrator
- Run pyspark
- You should see a welcome screen like this:



Testing

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- You can also try out typing a few lines from the official Quick Start Guide:

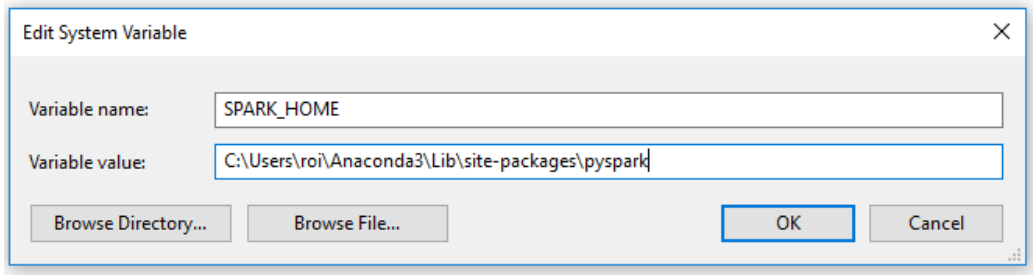
```
>>> textFile = sc.textFile("file:///C:/Spark/README.md")
>>> textFile.count()
103
```

- To exit Spark type quit()

Installing PySpark

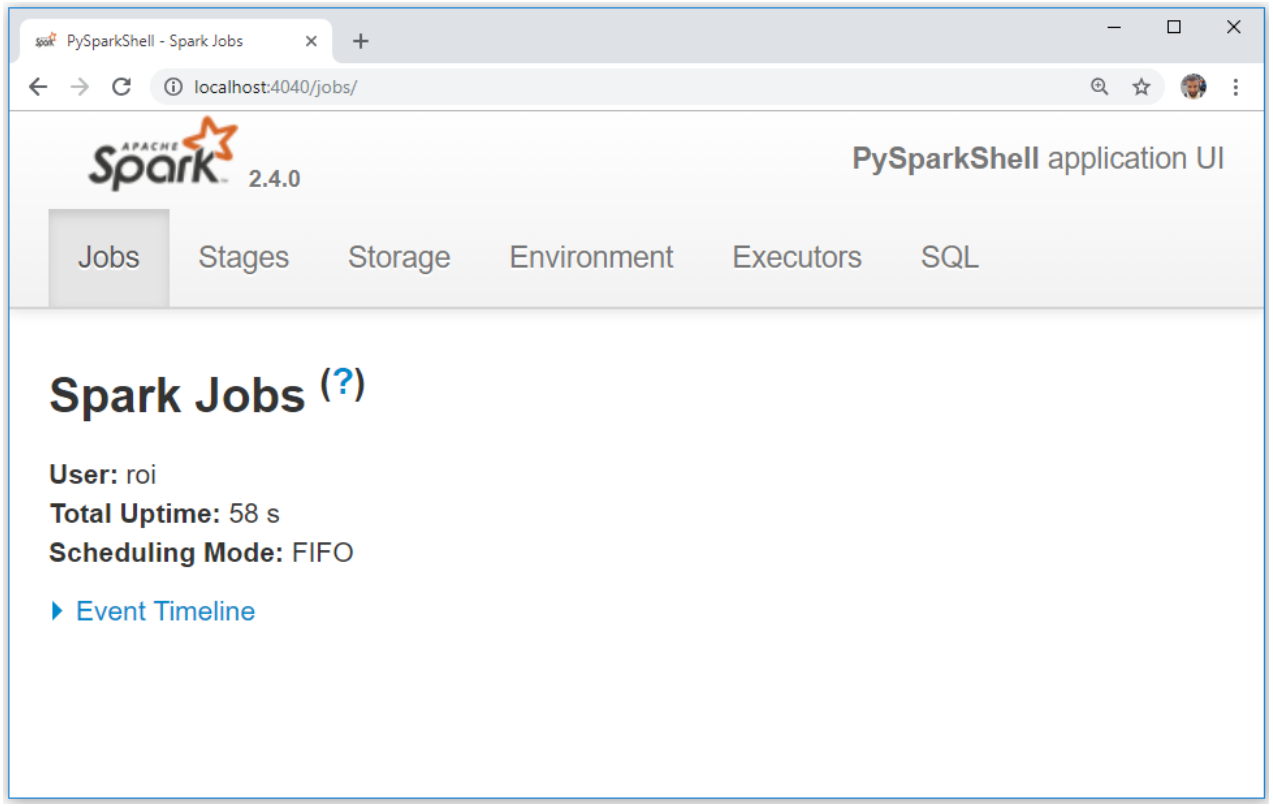
- pip install --user pyspark==2.3.2

```
C:\Users\roi>pip install pyspark
Collecting pyspark
  Downloading https://files.pythonhosted.org/packages/88/01/a37e827c2d80c6a754e40e99b9826d978b
55254cc6c6672b5b08f2e18a7f/pyspark-2.4.0.tar.gz (213.4MB)
    100% |████████████████████████████████| 213.4MB 97kB/s
Collecting py4j==0.10.7 (from pyspark)
  Downloading https://files.pythonhosted.org/packages/e3/53/c737818eb9a7dc32a7cd4f1396e787bd94
200c3997c72c1dbe028587bd76/py4j-0.10.7-py2.py3-none-any.whl (197kB)
    100% |████████████████████████████████| 204kB 1.3MB/s
Building wheels for collected packages: pyspark
  Running setup.py bdist_wheel for pyspark ... done
  Stored in directory: C:\Users\roi\AppData\Local\pip\Cache\wheels\cd\54\c2\abfcc942eddeaa7101
228ebd6127a30dbdf903c72db4235b23
Successfully built pyspark
Installing collected packages: py4j, pyspark
Successfully installed py4j-0.10.7 pyspark-2.4.0
```



Spark UI

- At this point you should also be able to access the Spark UI from your favorite browser at http://localhost:4040



SparkContext

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- This class is the main entry point for Spark functionality
- A SparkContext represents the connection to a Spark cluster, and can be used to create RDDs, accumulators and broadcast variables on that cluster
- Only one SparkContext may be active per JVM
- You must stop() the active SparkContext before creating a new one
- Create a new Jupyter notebook and type

```
import pyspark
```

```
# Create a Spark context
sc = pyspark.SparkContext(appName='MyFirstSparkApp')
```

Resilient Distributed DataSets (RDDs)

- Spark revolves around the concept of a *resilient distributed dataset* (RDD), which is a fault-tolerant collection of elements that can be operated on in parallel
- There are two ways to create RDDs: *parallelizing* an existing collection in your driver program, or referencing a dataset in an external storage system, such as a shared filesystem, HDFS, HBase, or any data source offering a Hadoop InputFormat

Parallelized Collections

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- Parallelized collections are created by calling SparkContext's parallelize() method on an existing iterable or collection in your program
- The elements of the collection are copied to form a distributed dataset that can be operated on in parallel
- For example, to create a parallelized collection holding the numbers 1 to 5:+

```
data = [1, 2, 3, 4, 5]
dist_data = sc.parallelize(data)
```

- Once created, the distributed dataset (dist_data) can be operated on in parallel
- For example, we can call dist_data.reduce(lambda a, b: a + b) to add up the elements of the list

```
dist_data.reduce(lambda a, b: a + b)
```

```
15
```

Partitions

- Spark manages data using partitions that helps parallelize distributed data processing with minimal network traffic for sending data between executors
- You can check the number of partitions using the method getNumPartitions() of RDD

```
dist_data.getNumPartitions()
```

```
8
```

- Spark can only run 1 concurrent task for every partition of an RDD, up to the number of cores in your cluster
- So if you have a cluster with 50 cores, you want your RDDs to at least have 50 partitions (and probably x2-3 times that)

RDD Operations

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- RDDs support two types of operations:
  - *Transformations*, which create a new dataset from an existing one
    - For example, map is a transformation that passes each dataset element through a function and returns a new RDD representing the results
  - *Actions*, which return a value to the driver program after running a computation on the dataset
- For example, reduce is an action that aggregates all the elements of the RDD using some function and returns the final result to the driver program
- The transformations are only computed when an action requires a result to be returned to the driver program

RDD Operations

- For example, the following script computes π by generating random points in the unit square ((0,0) to (1,1)) and checking how many fall in the unit circle.

```
# pi.py
import pyspark
import random

sc = pyspark.SparkContext(appName='pi')
num_samples = 10000000

def inside(p):
    x, y = random.random(), random.random()
    return x ** 2 + y ** 2 < 1

count = sc.parallelize(range(0, num_samples)).filter(inside).count()

pi = 4 * count / num_samples
print(pi)
```

```
3.1418336
```

Launching PySpark on YARN

- There are two deploy modes that can be used to launch Spark applications on YARN:
  - In cluster mode, the Spark driver runs inside an application master process which is managed by YARN on the cluster, and the client can go away after initiating the application.
  - In client mode, the driver runs in the client process, and the application master is only used for requesting resources from YARN.
- To launch a Spark script in cluster mode:

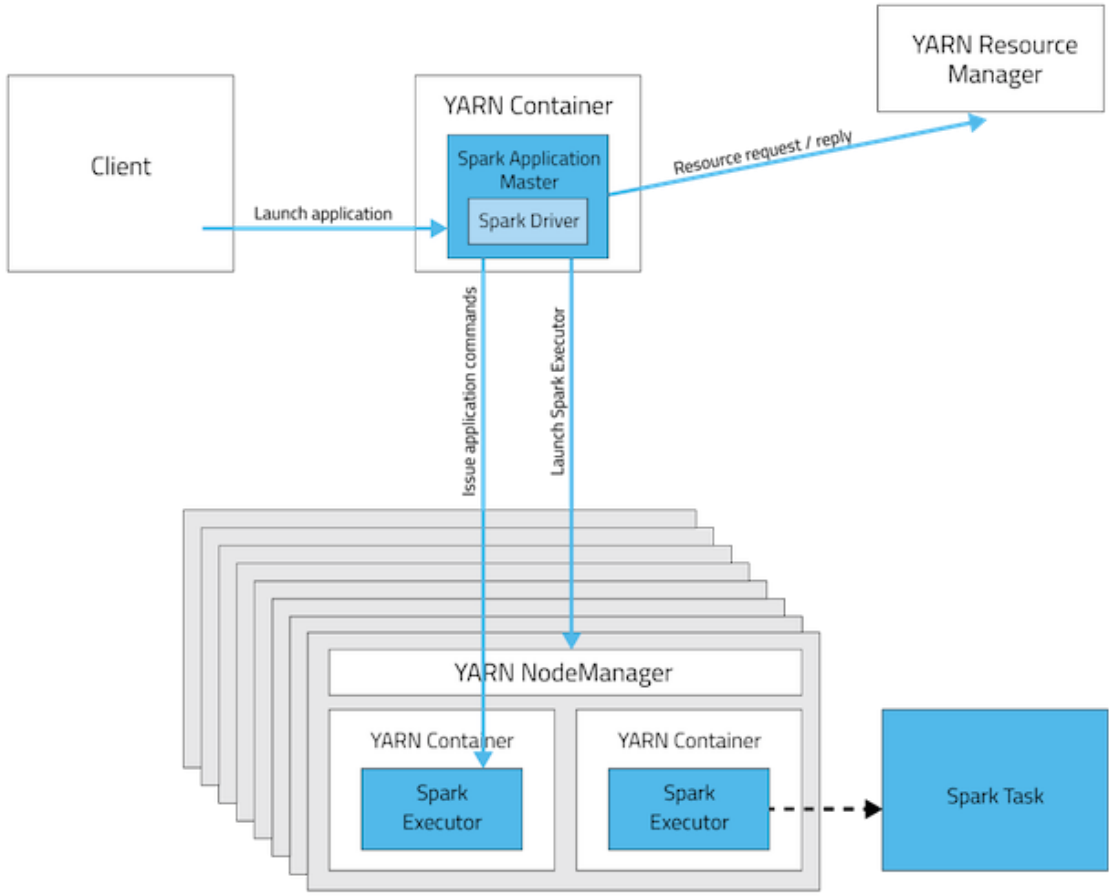
```
spark-submit --master yarn --deploy-mode cluster [path to python script]
```

- To launch a Spark script in client mode:

```
spark-submit --master yarn --deploy-mode client [path to python script]
```

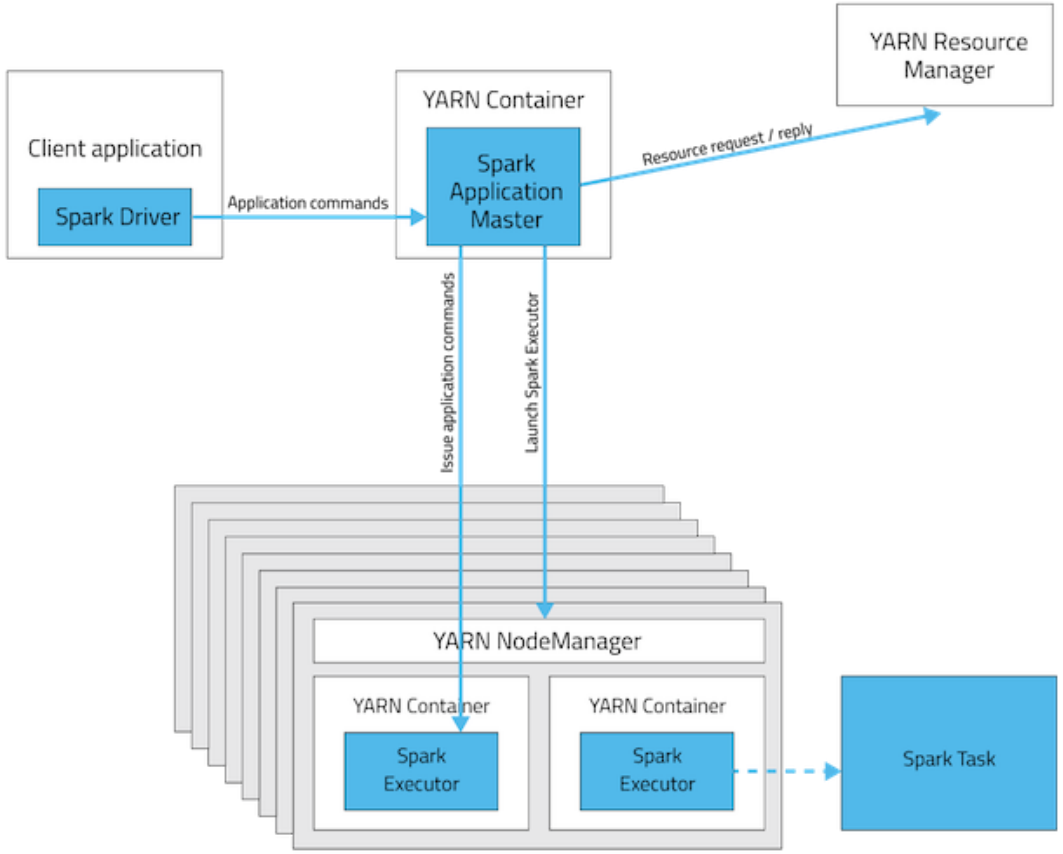
Cluster Deployment Mode

- In client mode, the Spark driver runs on the host where the job is submitted



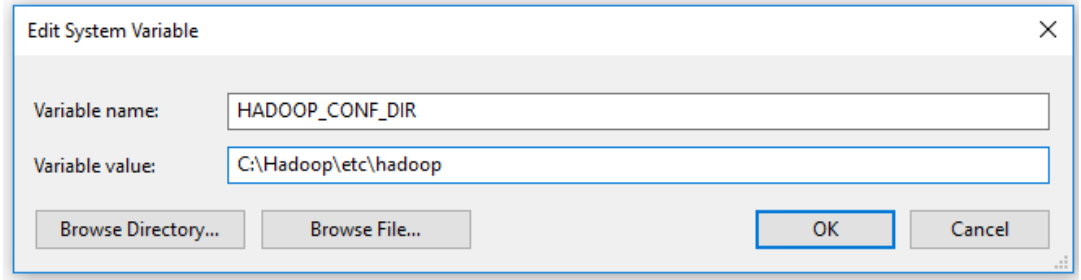
Client Deployment Mode

- In client mode, the Spark driver runs on the host where the job is submitted



Launching Spark on YARN

- First make sure that the HDFS and YARN daemons are running
- Set the environment variable HADOOP_CONF_DIR to the directory which contains the configuration files for the Hadoop cluster (C:\Hadoop\etc\hadoop)



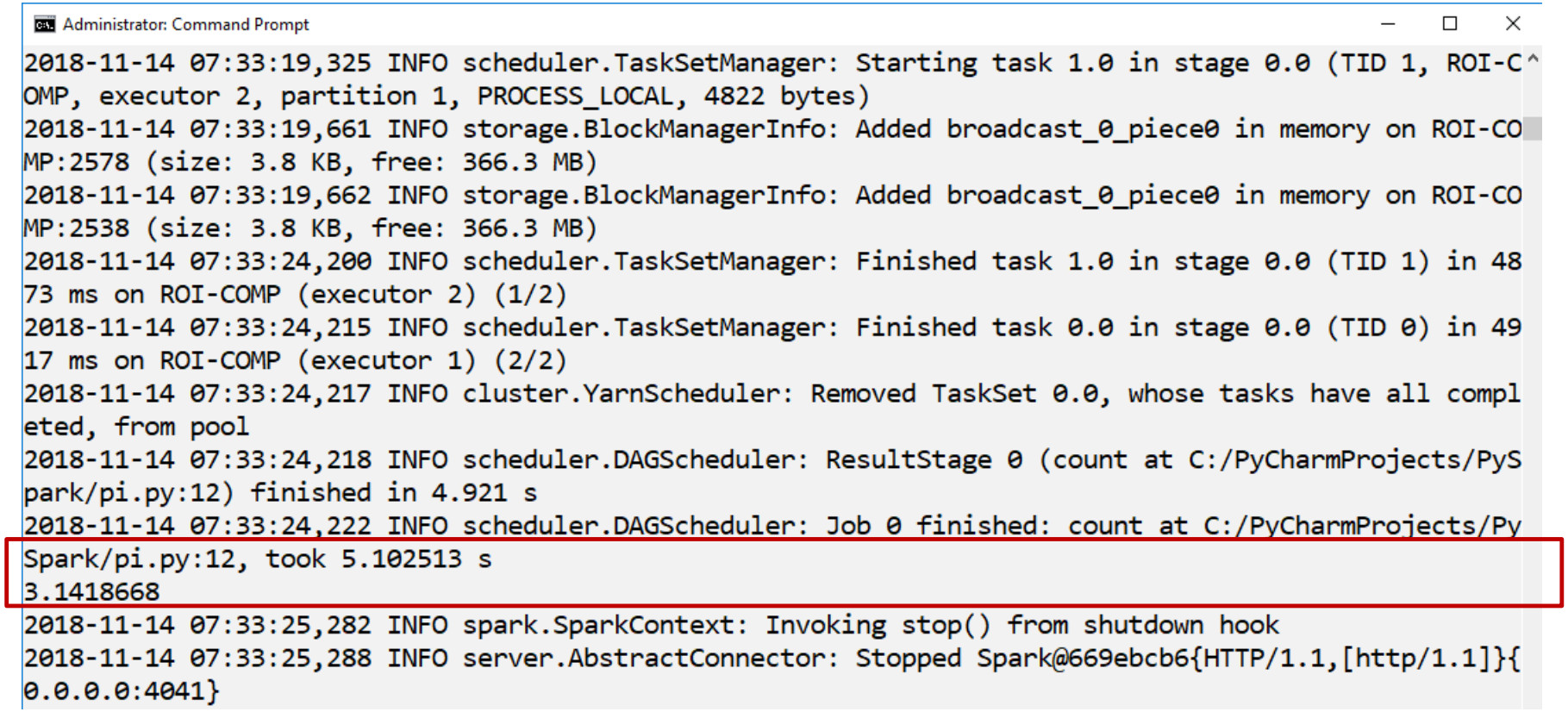
Launching Spark on YARN

- To run the pi.py script in yarn:
- Start command prompt (under administrator)
- Type the following command

```
spark-submit --master yarn --deploy-mode client C:\PyCharmProjects\PySpark\pi.py
```

Launching Spark on YARN

- You should see the result in the console:



Spark UI

- In the Spark UI you can see the status of the submitted job:

Details for Job 0

Status: SUCCEEDED
Completed Stages: 1

- Event Timeline
- DAG Visualization

Completed Stages (1)

Stage Id ▾	Description	Submitted	Duration	Tasks: Succeeded/Total	Input	Output	Shuffle Read	Shuffle Write
0	count at <stdin>:1 +details	2018/11/14 07:29:59	1 s	2/2	5.6 KB			

Exercise

- Write a script that reads a text file and prints all the unique words in the file in alphabetical order

SparkML

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- MLlib is Spark's machine learning (ML) library. Its goal is to make practical machine learning scalable and easy.
- At a high level, it provides tools such as:
  - ML Algorithms: common learning algorithms such as classification, regression, clustering, and collaborative filtering
  - Featurization: feature extraction, transformation, dimensionality reduction, and selection
  - Pipelines: tools for constructing, evaluating, and tuning ML Pipelines
  - Persistence: saving and load algorithms, models, and Pipelines
  - Utilities: linear algebra, statistics, data handling, etc.

SparkML

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- Example for a script in SparkML (C:\Spark\examples\src\main\python\ml\kmeans_example.py)

```
from pyspark.ml.clustering import KMeans
spark = SparkSession.builder.appName("KMeansExample“).getOrCreate()

# Loads data.
dataset = spark.read.format("libsvm").load("data/mllib/sample_kmeans_data.txt")

# Trains a k-means model.
kmeans = KMeans().setK(2).setSeed(1)
model = kmeans.fit(dataset)

# Evaluate clustering by computing Within Set Sum of Squared Errors.
wssse = model.computeCost(dataset)
print("Within Set Sum of Squared Errors = " + str(wssse))

# Shows the result.
centers = model.clusterCenters()
print("Cluster Centers: ")
for center in centers:
    print(center)

spark.stop()
```

SparkML

- When you perform a yarn execution, Spark is looking for the data files on HDFS
- Thus, first you need to upload the data file to HDFS
- First create a directory /user/%USERNAME%/data/mllib on HDFS:

```
hdfs dfs –mkdir -p /user/%USERNAME%/data/mllib
```

```
C:\Users\roi>hdfs dfs -mkdir -p /user/%USERNAME%/data/mllib

C:\Users\roi>hdfs dfs -ls /user/roi/data
Found 1 items
drwxr-xr-x   - roi supergroup          0 2018-07-30 01:06 /user/roi/data/mllib
```

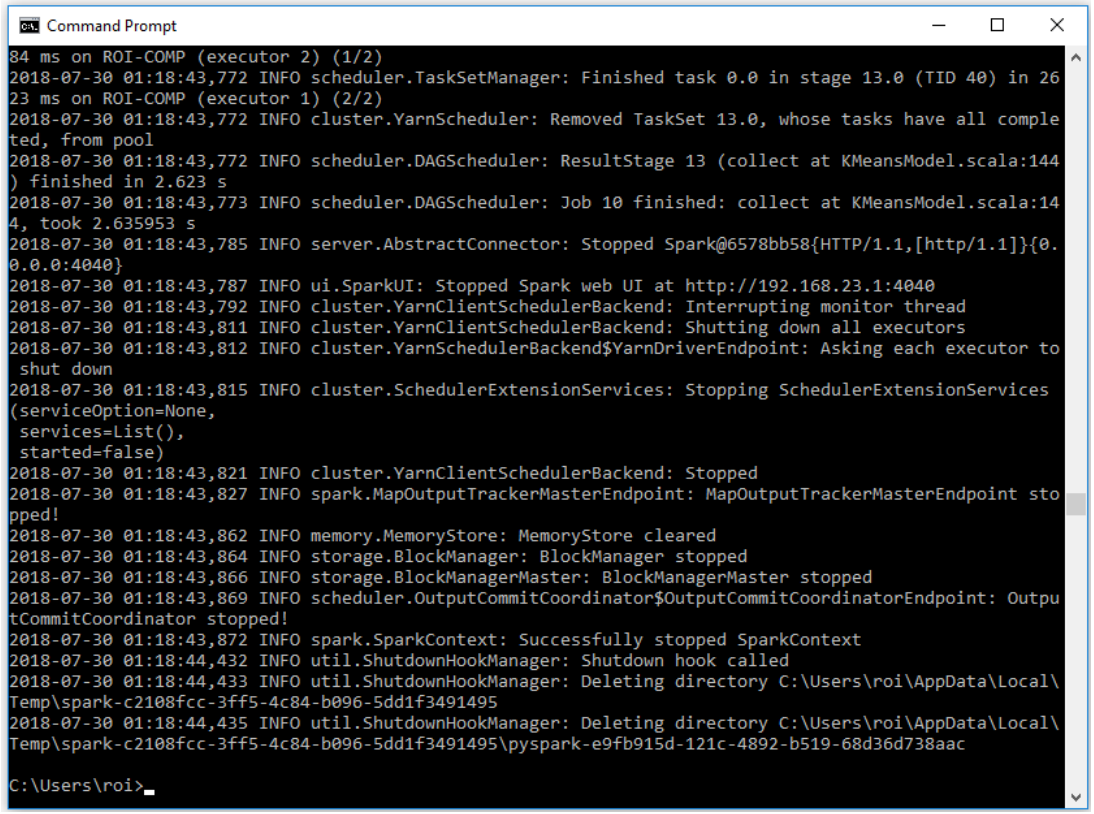
- Then copy the data file from C:\Spark\data\mllib to /user/%USERNAME%/data/mllib

```
hdfs dfs -put file:///C:/Spark/data/mllib/kmeans_data.txt /user/%USERNAME%/data/mllib
```

SparkML

- Type the following command:

```
spark-submit --master yarn --deploy-mode client
C:\Spark\examples\src\main\python\mllib\k_means_example.py
```



SparkML

- Type the following command:

```
2018-07-30 01:18:35,380 INFO scheduler.DAGScheduler: Job 5 finished: reduce at
C:/Spark/examples/src/main/python/mllib/k_means_example.py:46, took 0.555797 s
Within Set Sum of Squared Error = 0.6928203230275529
2018-07-30 01:18:36,529 INFO output.FileOutputCommitter: File Output Committer Algorithm
version is 1
2018-07-30 01:18:36,557 INFO spark.SparkContext: Starting job: saveAsTextFile at
KMeansModel.scala:128
```