Contents

Exercise 1: Setting up the Environment

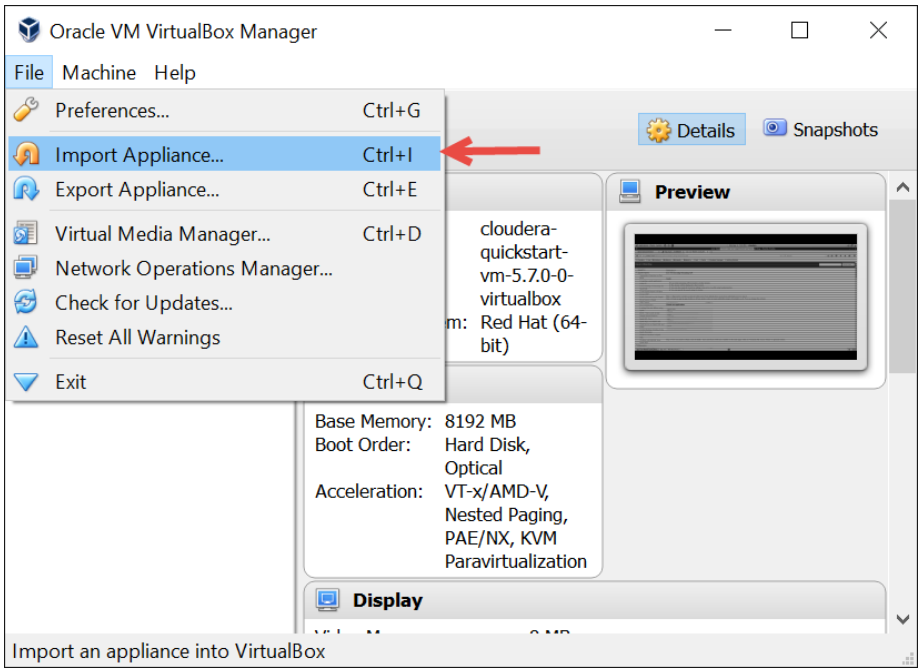
Step1: Installing Oracle VM virtual box from Training Bundle.

- Under 'Training Bundle' folder, navigate to "Software" folder.
- Find the executable file named 'VirtualBox-5.0.16-105871-Win' and complete the installation.

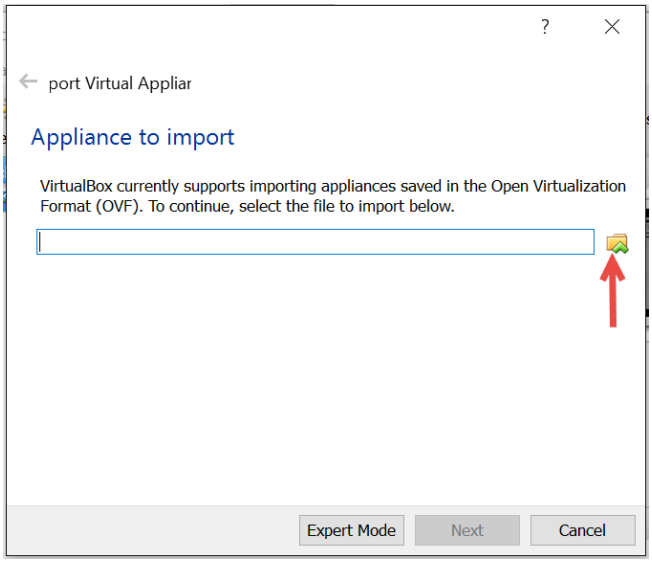
Step2: Extracting the Image

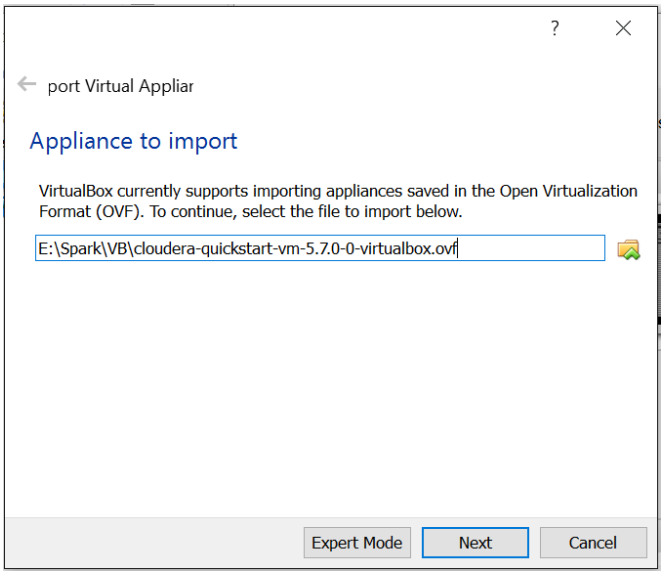
- From the same training bundle, locate the folder named VM image> 'cloudera-quickstart-vm-5.10.0-0-vmware'
- Load the image to get started with the machine.

Step3: Importing the file



➢ Browse to the location under "Training Bundle" and select the OVF file.





- This will prepare your machine.
- After import, change the number of processors to two before starting the machine.
- Verify all the running services with jps command

```
[cloudera@quickstart ~]$ sudo jps
6403 RESTServer
5709 SecondaryNameNode
5980 NodeManager
6878 RunJar
8543
10329 ZeppelinServer
9721 org.eclipse.equinox.launcher_1.3.0.v20140415-2008.jar
5841 Bootstrap
5366 DataNode
5454 JournalNode
8584
7516 HistoryServer
8518 Bootstrap
5573 NameNode
7484 Bootstrap
5303 QuorumPeerMain
6659 RunJar
5897 JobHistoryServer
18565 Jps
6184 ResourceManager
6521 ThriftServer
8191 Bootstrap
[cloudera@quickstart ~]$
```

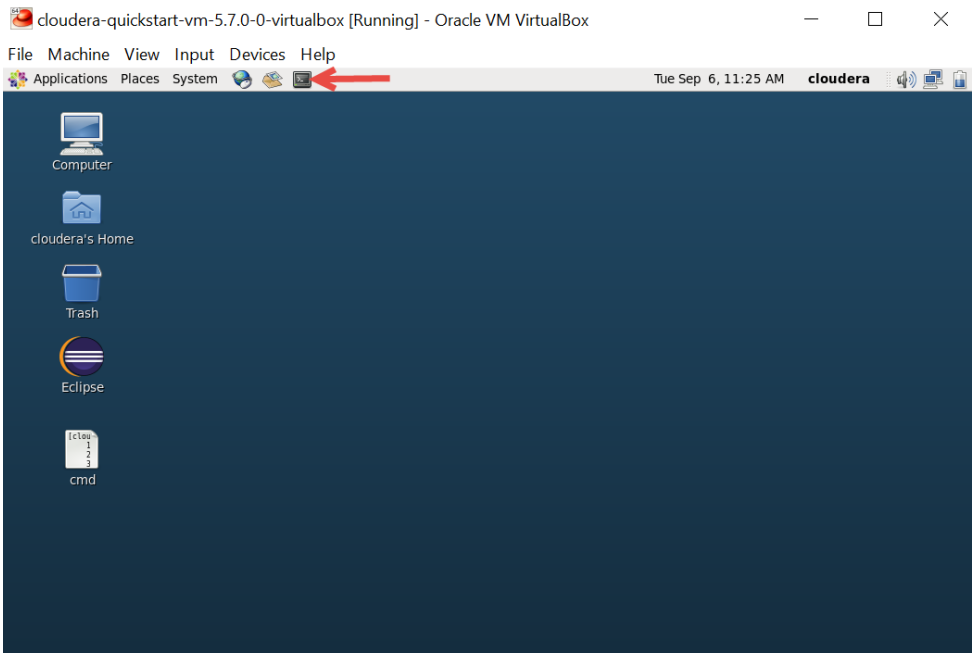
Exercise 2: Practicing HDFS Commands

Task 1: Using Hadoop Command Line Interface

Navigate to Application > System Tools > Terminal

OR

Use shortcut to open the terminal.



- Operation on Files and directories

To check the content of root directory in HDFS

```
hdfs dfs -ls /
```

```
[cloudera@quickstart ~]$ hdfs dfs -ls /
Found 5 items
drwxrwxrwx   - hdfs  supergroup          0 2016-04-05 23:56 /benchmarks
drwxr-xr-x   - hbase supergroup          0 2016-09-04 10:14 /hbase
drwxrwxrwt   - hdfs  supergroup          0 2016-08-03 01:56 /tmp
drwxr-xr-x   - hdfs  supergroup          0 2016-08-02 08:08 /user
drwxr-xr-x   - hdfs  supergroup          0 2016-04-05 23:58 /var
[cloudera@quickstart ~]$
```

View the content of /user directory

```
hdfs dfs -ls /user
```

```
[cloudera@quickstart ~]$ hdfs dfs -ls /user
Found 9 items
drwxr-xr-x   - cloudera cloudera            0 2016-08-03 01:54 /user/cloudera
drwxr-xr-x   - hdfs     supergroup          0 2016-08-02 08:08 /user/hdfs
drwxr-xr-x   - mapred   hadoop              0 2016-04-05 23:56 /user/history
drwxrwxrwx   - hive     supergroup          0 2016-04-05 23:58 /user/hive
drwxrwxrwx   - hue      supergroup          0 2016-04-05 23:57 /user/hue
drwxrwxrwx   - jenkins  supergroup          0 2016-04-05 23:56 /user/jenkins
drwxrwxrwx   - oozie    supergroup          0 2016-04-05 23:57 /user/oozie
drwxrwxrwx   - root     supergroup          0 2016-04-05 23:57 /user/root
drwxr-xr-x   - hdfs     supergroup          0 2016-04-05 23:58 /user/spark
```

For an empty directory the prompt does not show any error while querying whereas if the directory doesn't exist it will throw an error.

Example: Query a non-existing directory say /music

```
hdfs dfs -ls /music
```

```
[cloudera@quickstart ~]$ hdfs dfs -ls /music
ls: `/music': No such file or directory
[cloudera@quickstart ~]$
```

The directory structure of Hadoop filesystem is different from local filesystem i.e. Linux filesystem. To know the difference, list the files on your local filesystem.

Create a new directory named "hadoop" in HDFS

```
hdfs dfs -mkdir hadoop
```

Create a sample.txt file on local and upload the file into newly created directory

```
hdfs dfs -put sample.txt hadoop/sample.txt
```

View the content of new file

```
hdfs dfs -cat hadoop/sample.txt
```

In HDFS, any non-absolute path is considered relative to your home directory i.e. /user/cloudera. Unlike Linux filesystem concept of "current" or "present working directory".

Download a file from HDFS to your local filesystem, specify HDFS path and local path to achieve the same.

```
hdfs dfs -get /user/cloudera/sample.text /home/cloudera
```

Remove the directory along with its content (perform this step after completing Task 2)

```
hdfs dfs -rm -r hadoop
```

List all the shell commands supported by Hadoop

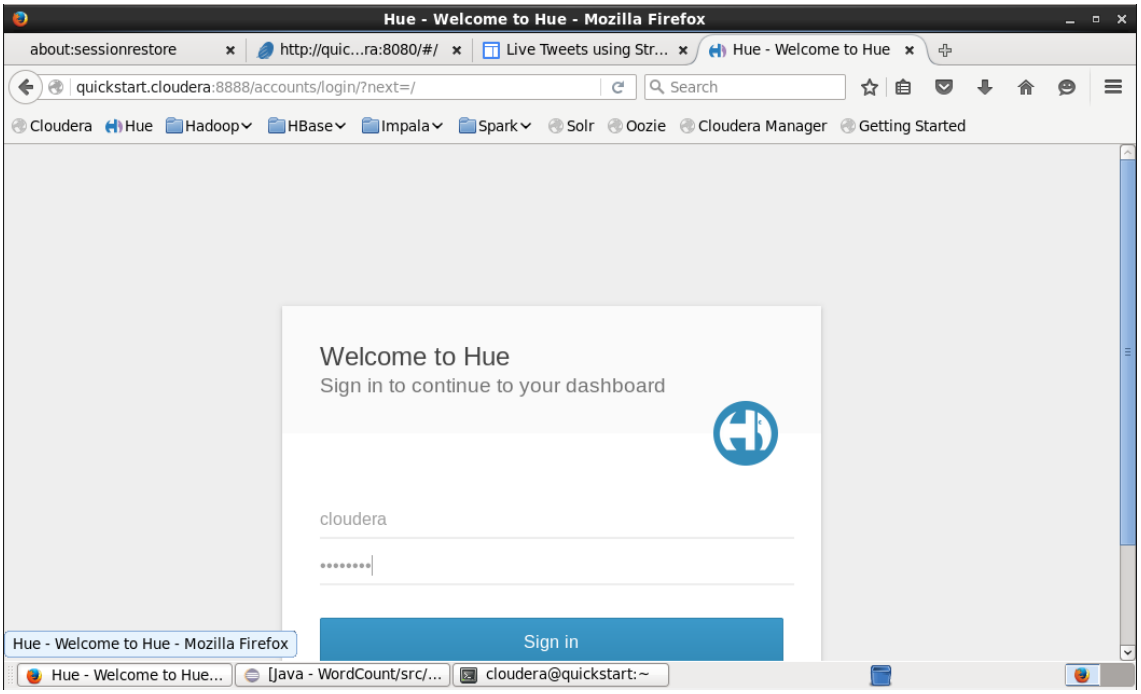
```
hdfs dfs
```

Task2: Using HUE File browser

1. Open a web browser on your VM, and navigate to bookmark tab and select HUE. This can be alternatively launched by specifying http://quickstart.cloudera:8888
2. Enter username as 'cloudera' and password 'cloudera'.
3. To access HDFS, click on Manage HDFS in the HUE menu bar
4. By default, the content of home directory i.e. /user/cloudera will be visible.
5. Point out to the directory named "hadoop" created above and view the file 'sample.txt'
6. Click on Upload button and select the appropriate format of the file to be uploaded i.e. plain file or zipped file

The zipped file will be automatically unzipped after upload.

7. Select Files> Select Files, and browser to location of data file on your local filesystem
8. Choose the file and click the Open button.
9. The selected file will be displayed in the directory /user/cloudera/
10. Click on the checkbox next to file's icon and then tab on Actions button to know the possible actions that can be performed on the file.
11. Once you have practised above steps, you can remove the files by clicking on "Move to Trash" button.

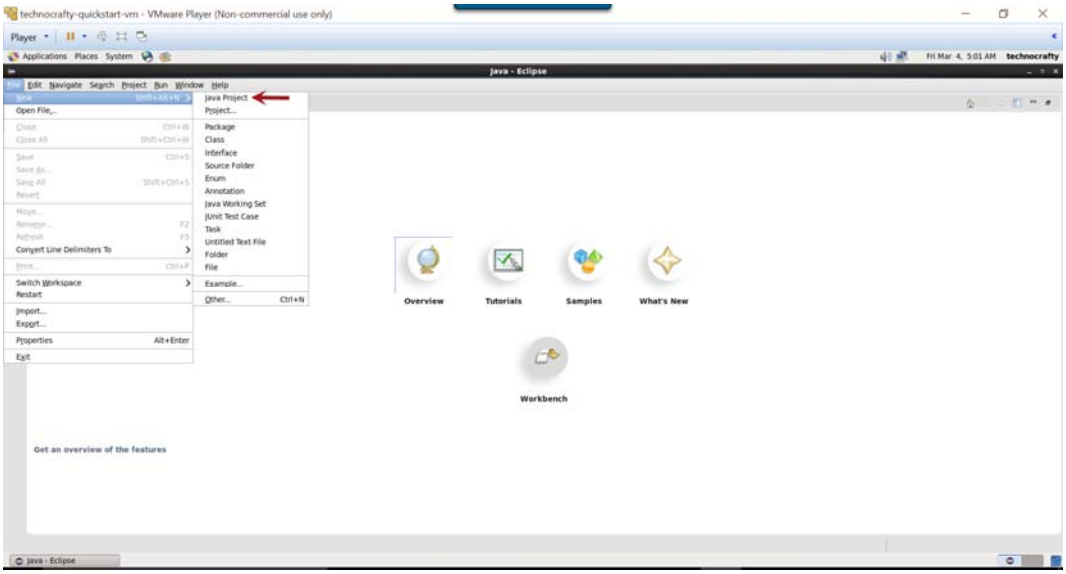


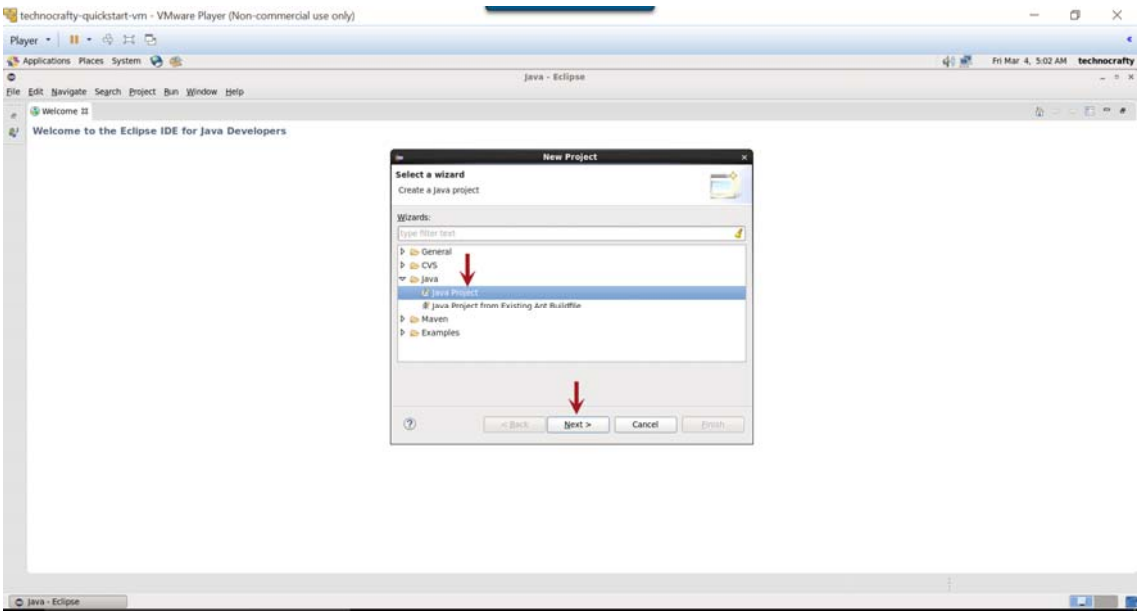
Exercise 3: Running MapReduce Job

Prerequisites: Create an Eclipse WordCount Project

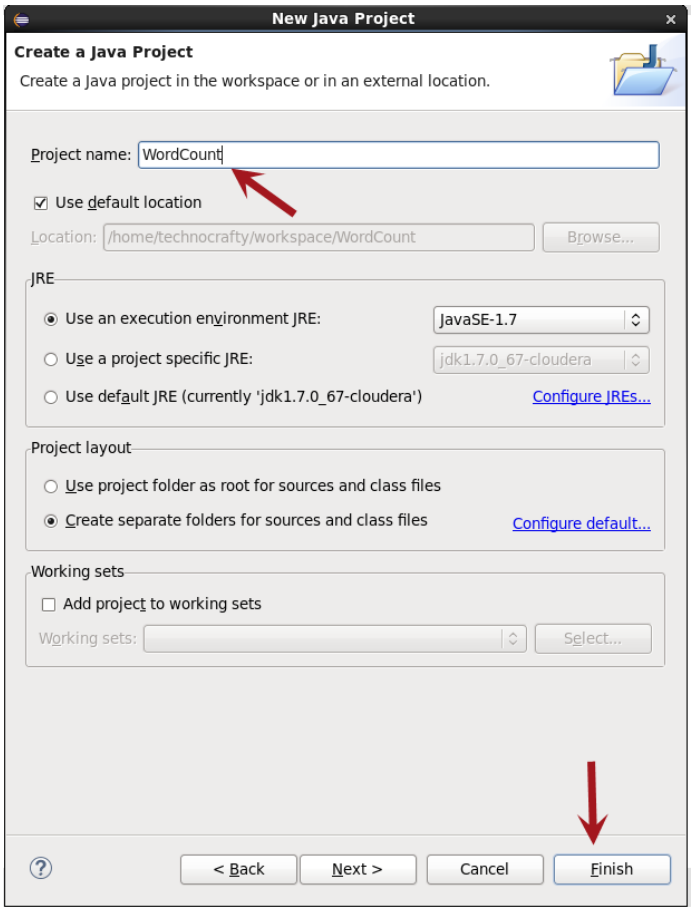
Step1: Launch Eclipse, Select the workspace location, and click on "OK".

Step2: Select File > New > Java Project > Next

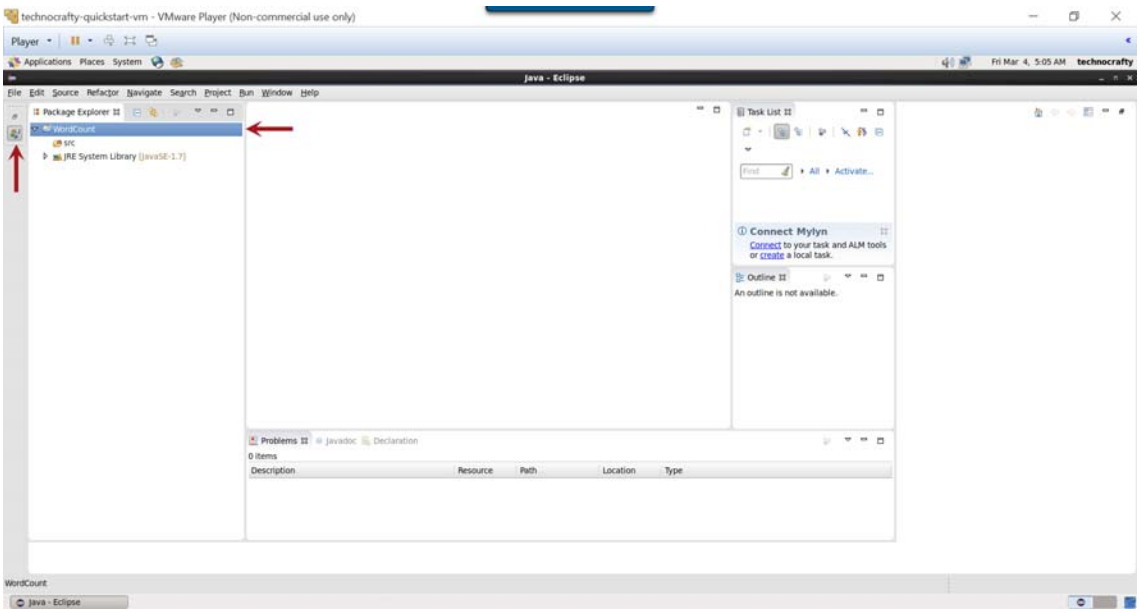




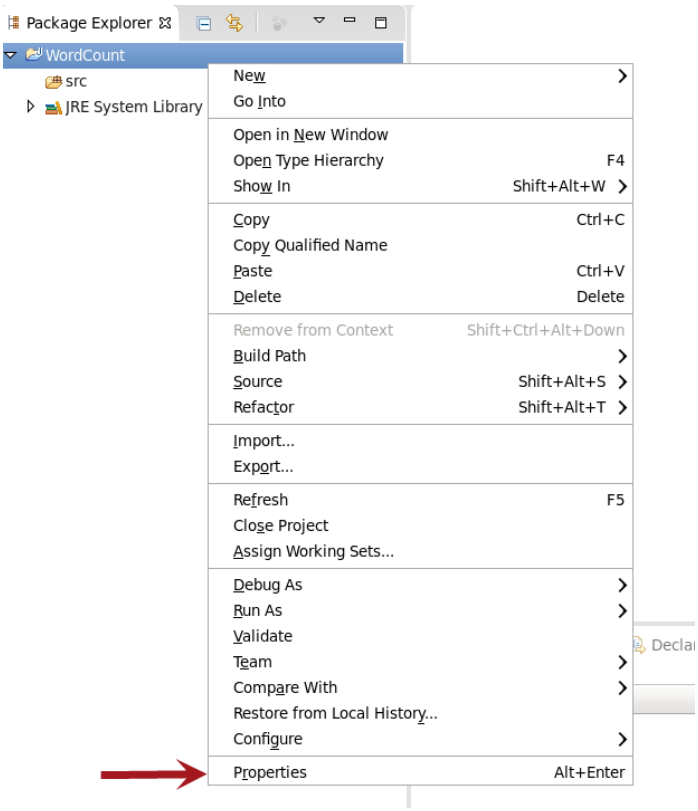
Step3: Name the project as "Wordcount" and click "Finish"



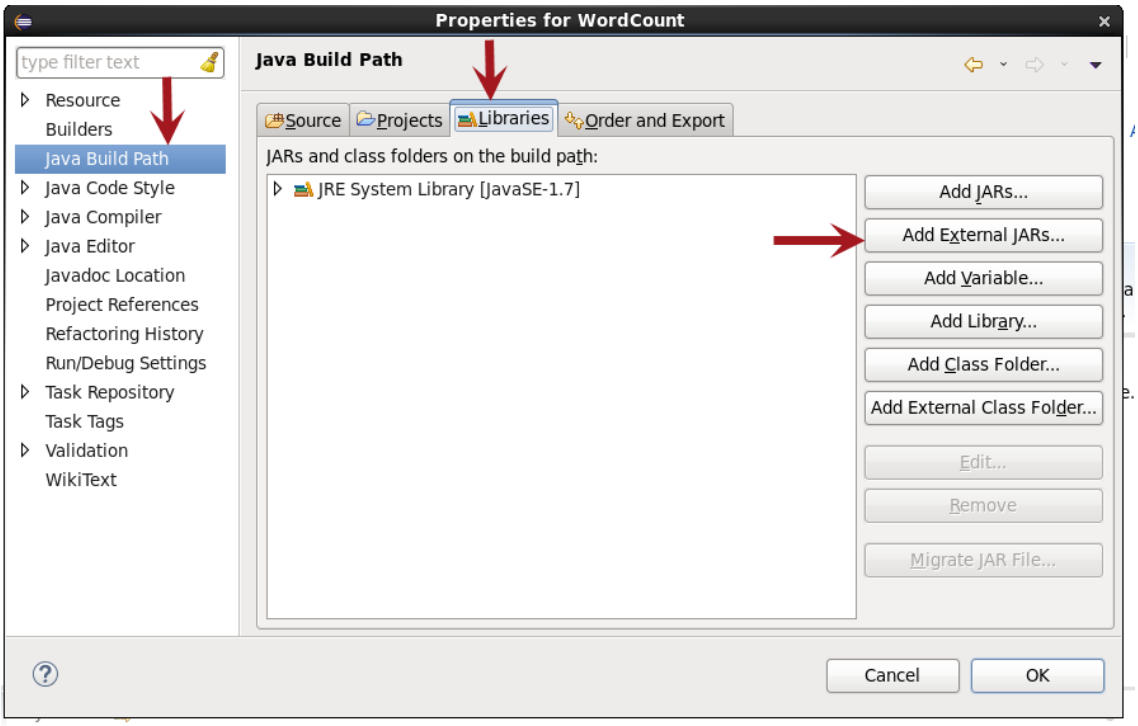
Step4: Expand the "Package Explorer" tab and locate your new project i.e. "WordCount".



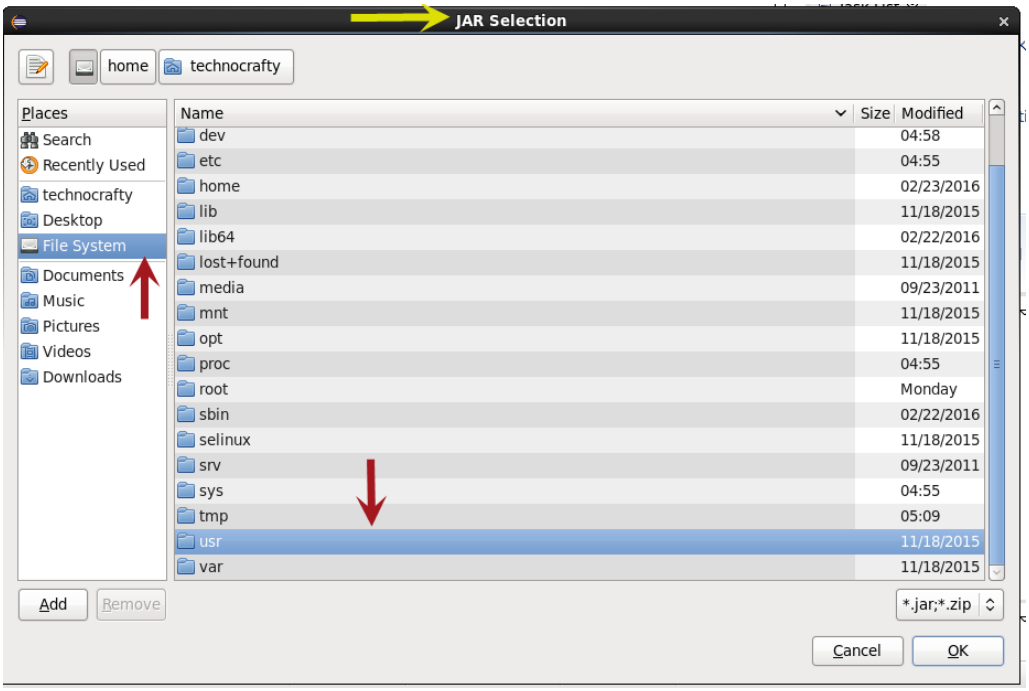
Step5: Export Hadoop Libraries by Right Click on Wordcount project and selecting Properties

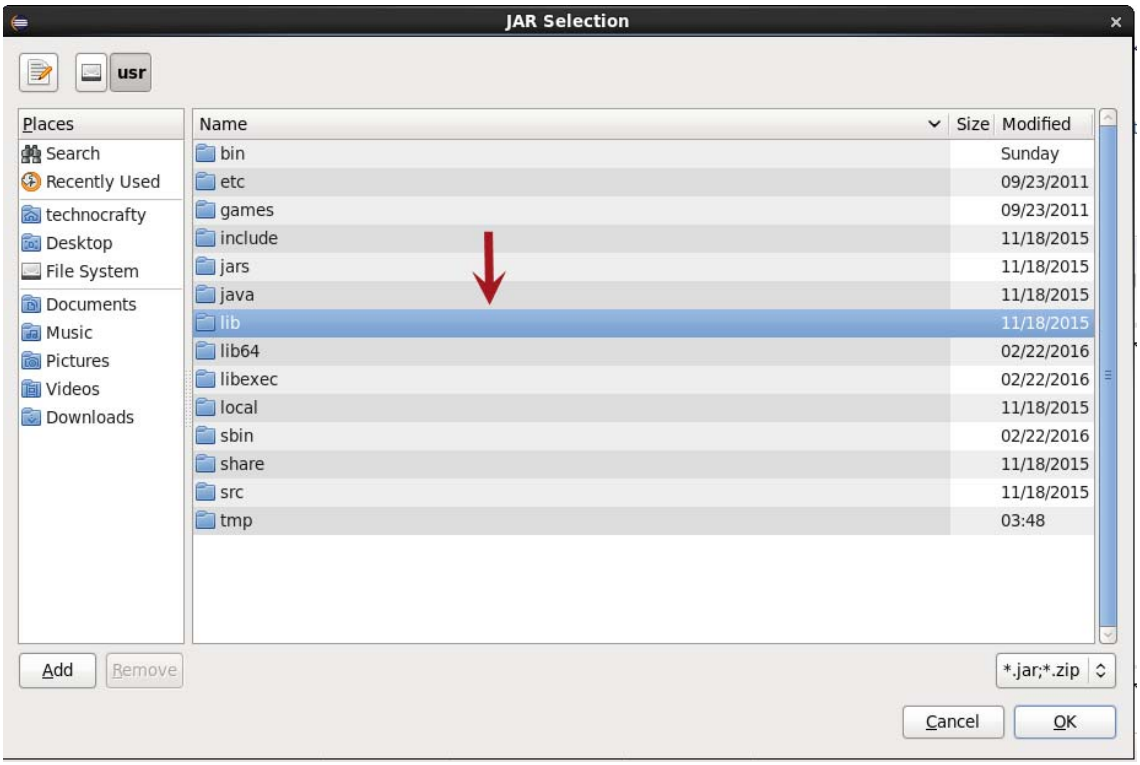


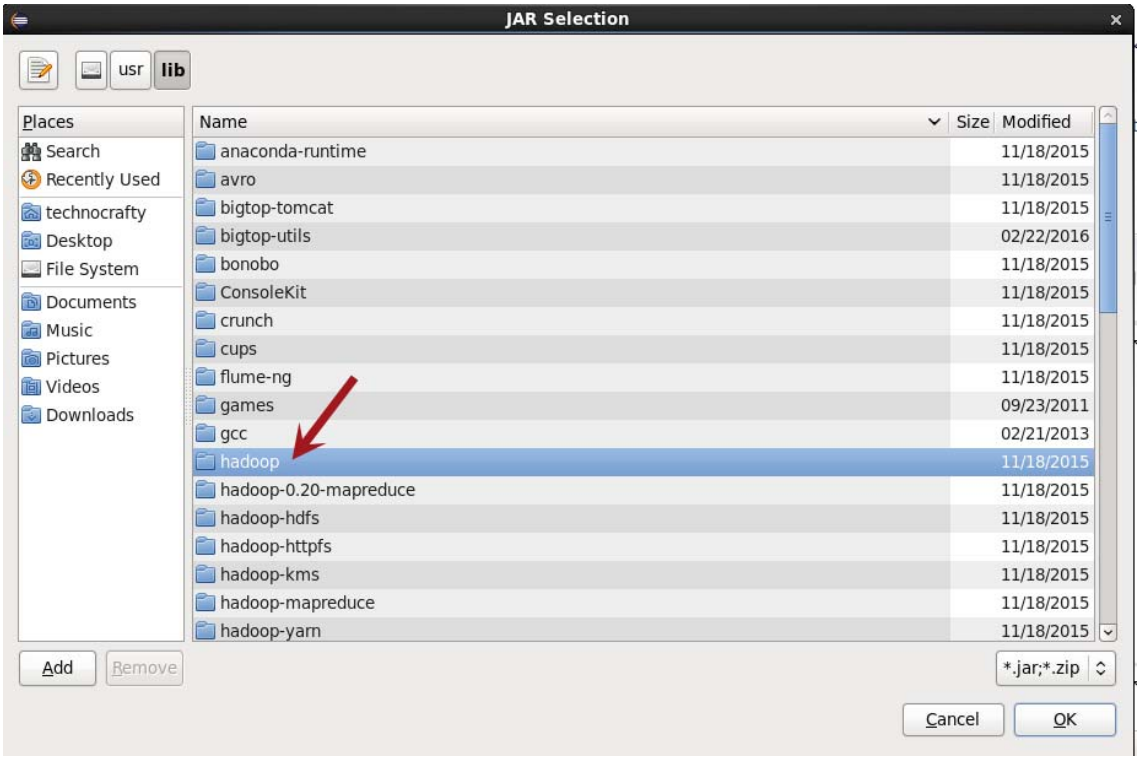
Step6: Click on Java Build Path from left panel and select “Libraries” tab from right panel view



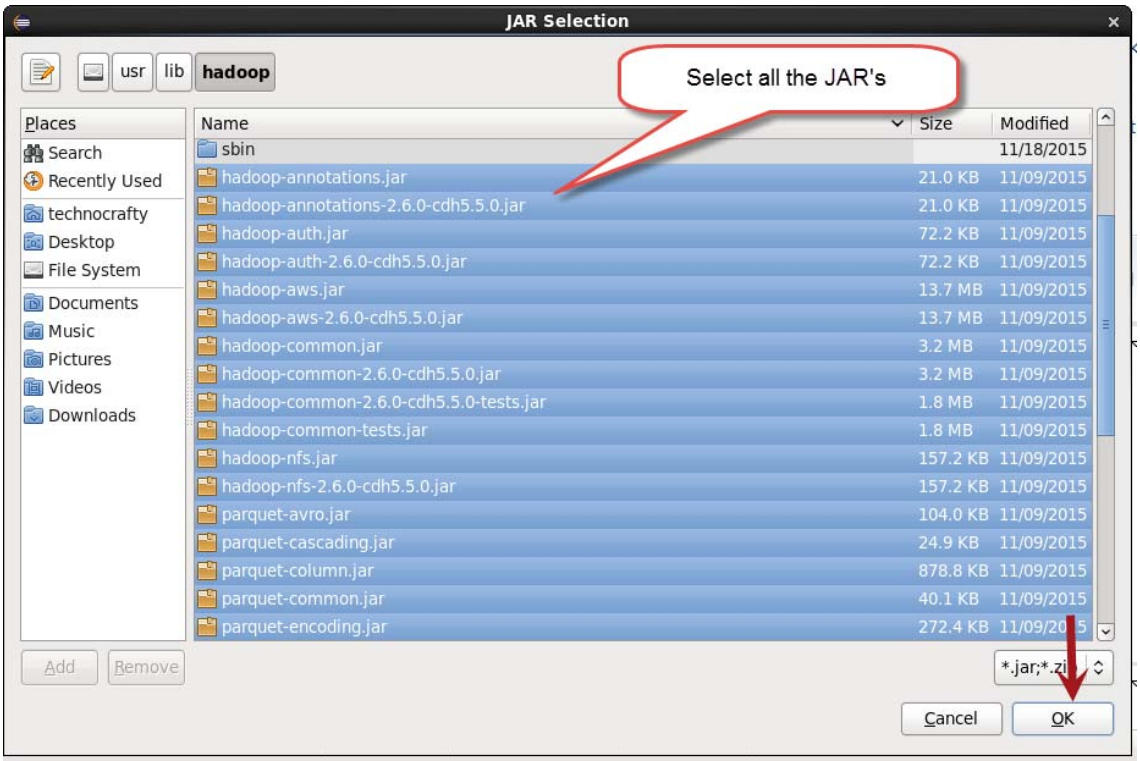
Step7: Select "Add External JAR…", then navigate to File System > usr > lib > Hadoop



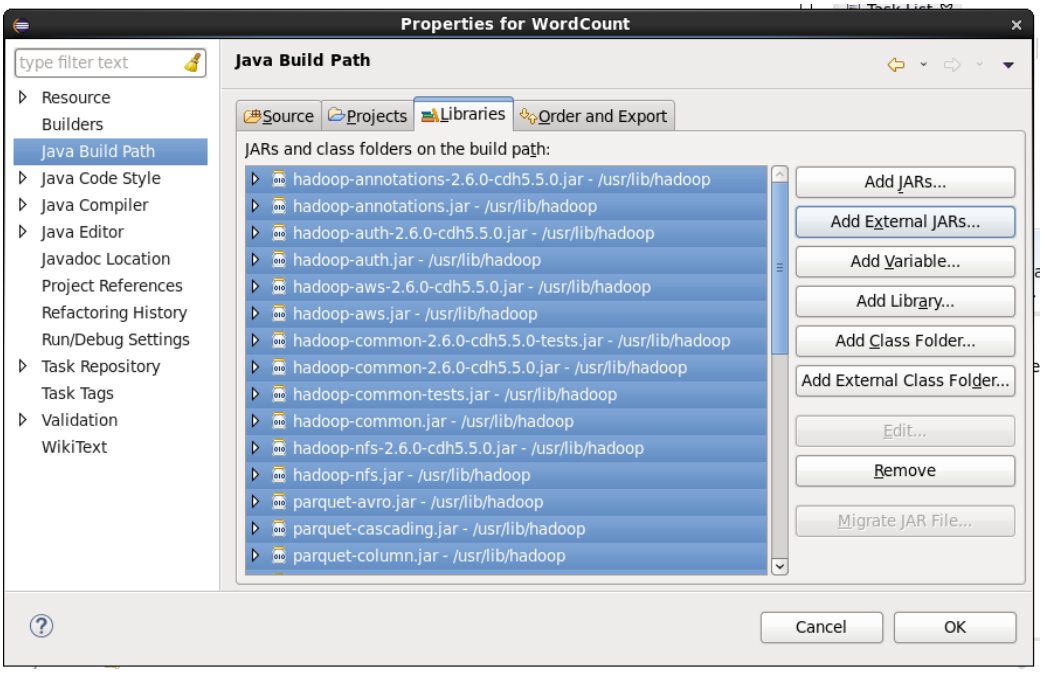




Step8: Select all the JAR available under this folder

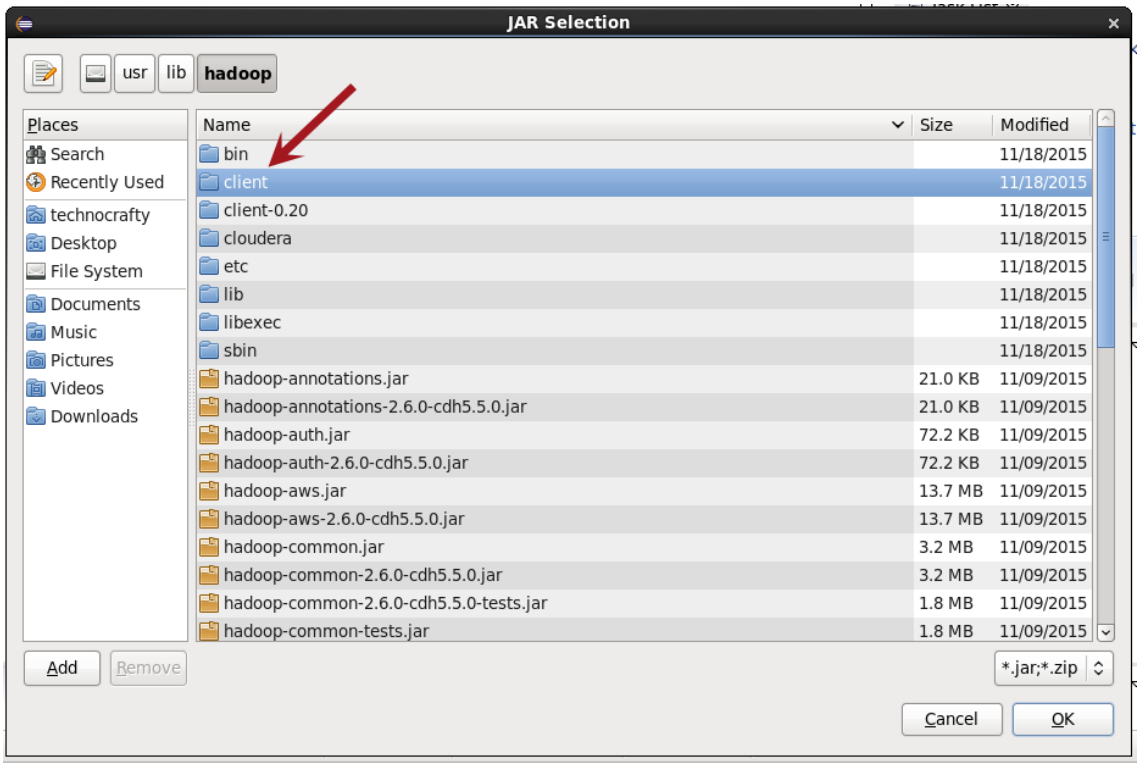


Click on "OK"

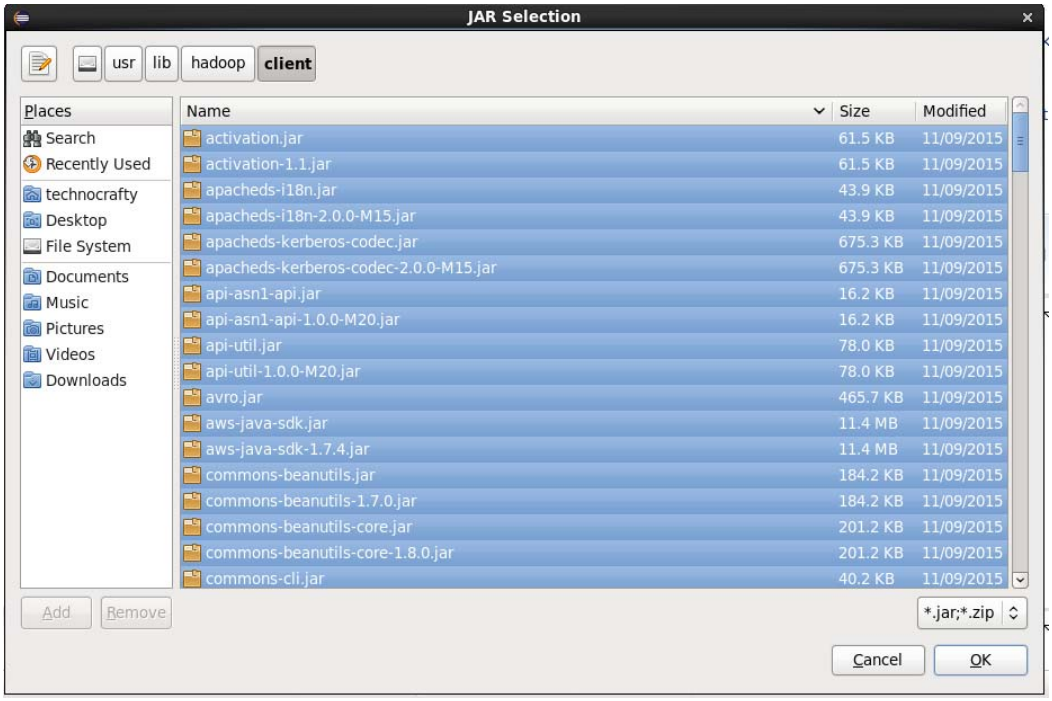


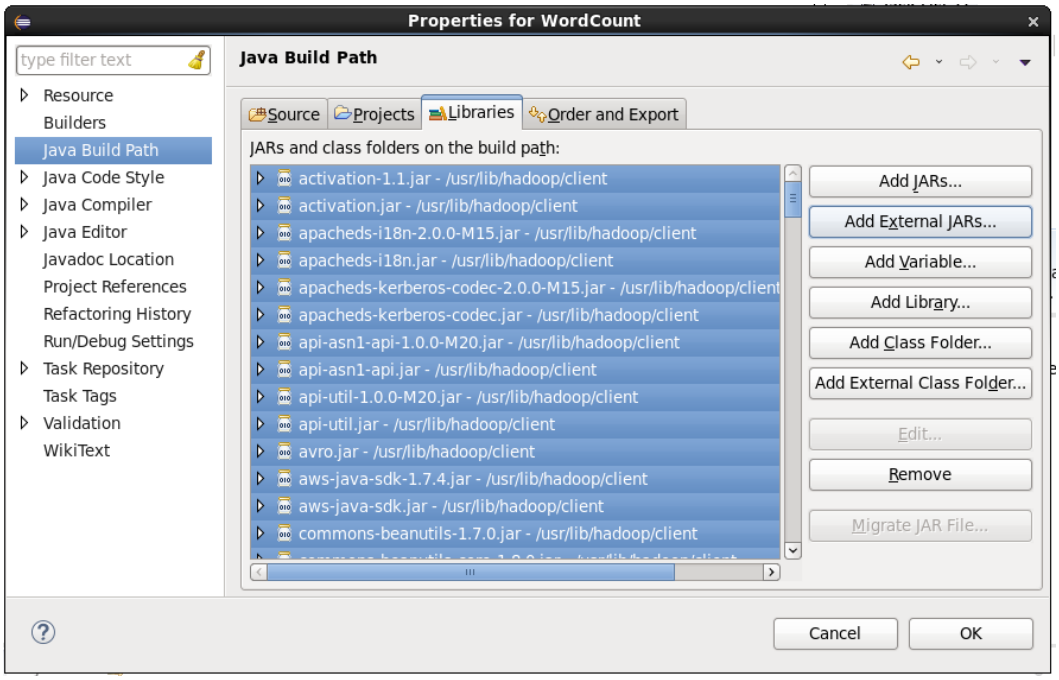
Step 9: Perform same steps for /usr/lib/hadoop-mapreduce and /usr/lib/Hadoop-yarn

Step10: Now grab all the library JAR files under "Client", by following the same method.

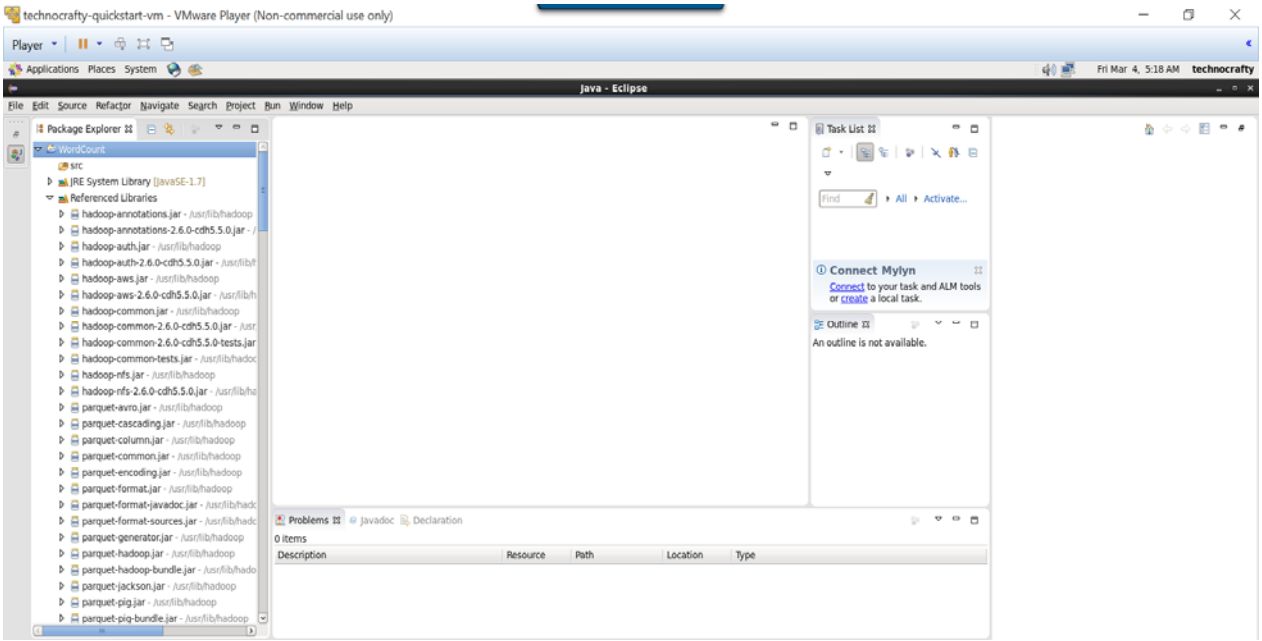


Select the files and click OK

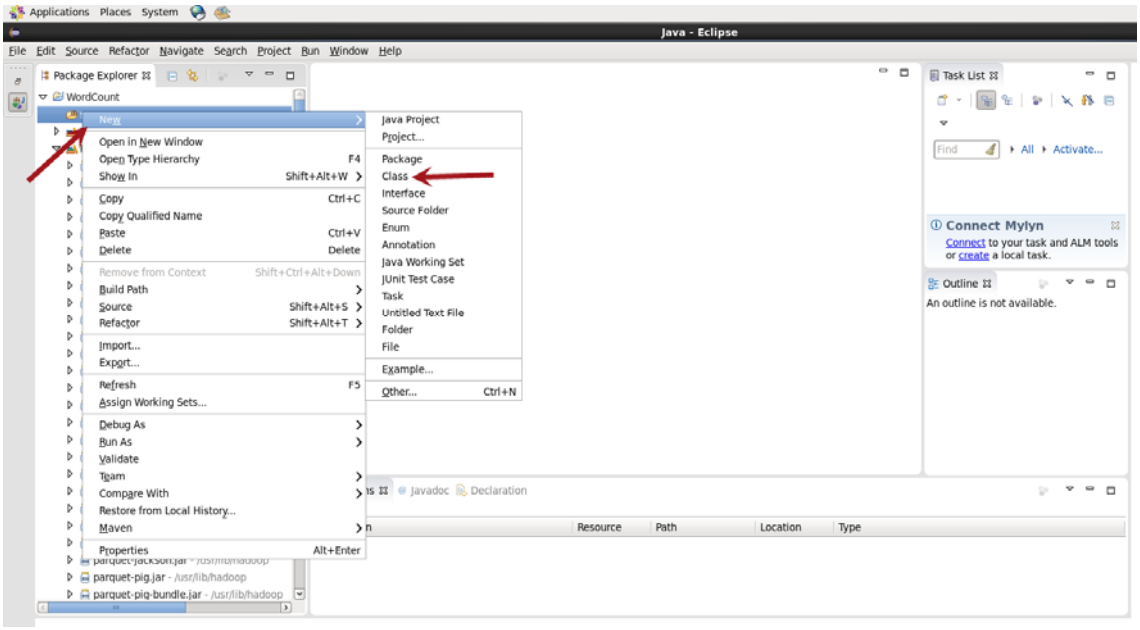




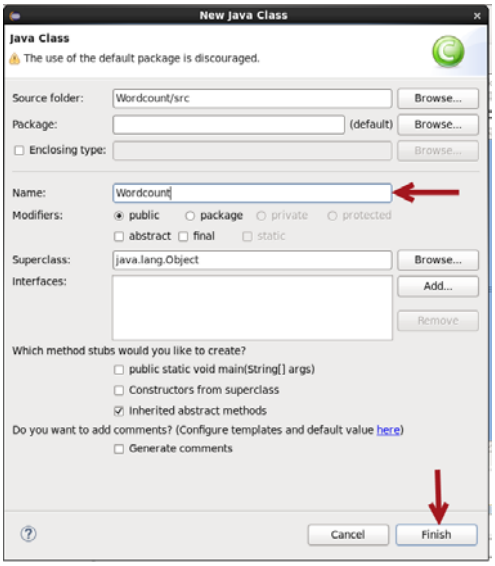
Step11: Finally, you will find all the JAR files under "Referenced Libraries"



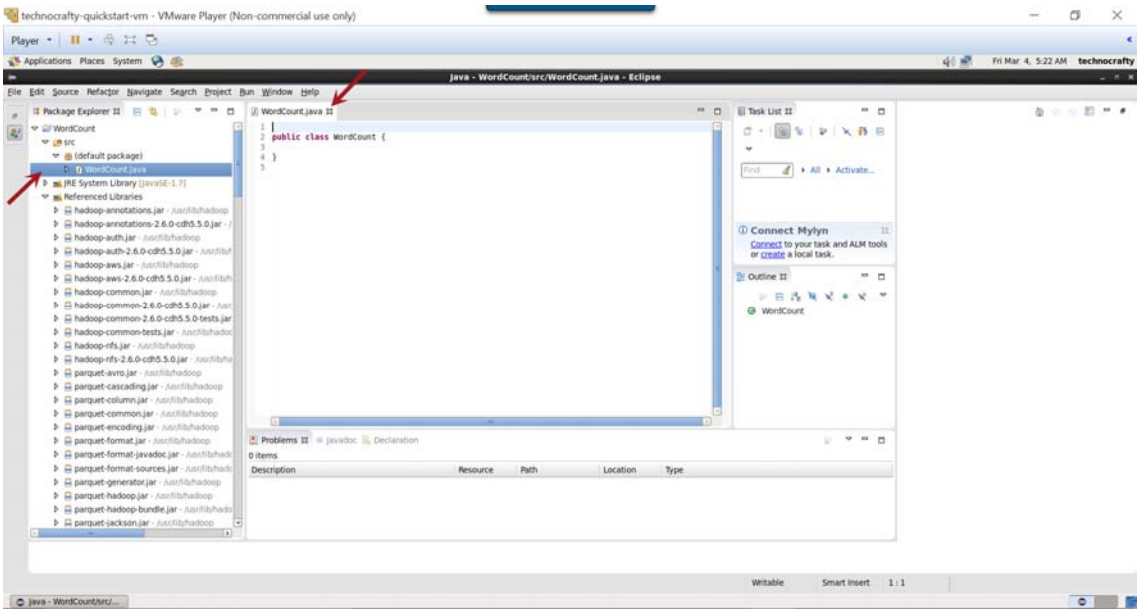
Step12: Creating the class files, Right click on src under WordCount and select New > Class



Step13: Enter the name of Java Class as "Wordcount" and click on Finish.



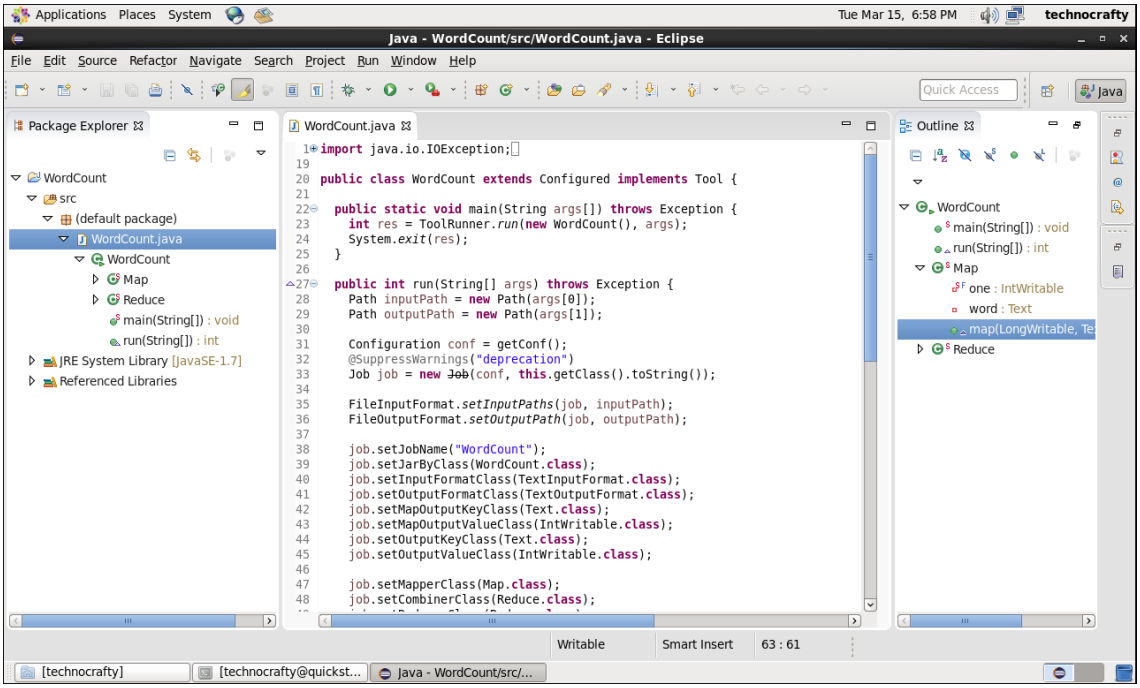
Step14: Now it's ready to take your input Mapreduce program



Step15: MapReduce Wordcount Program

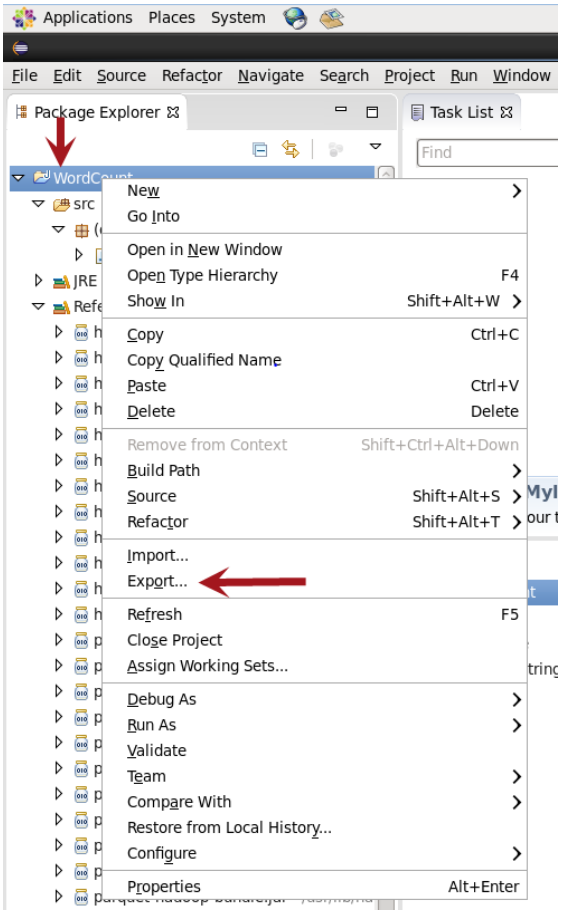
wordcount.txt

Step 16: Save the program

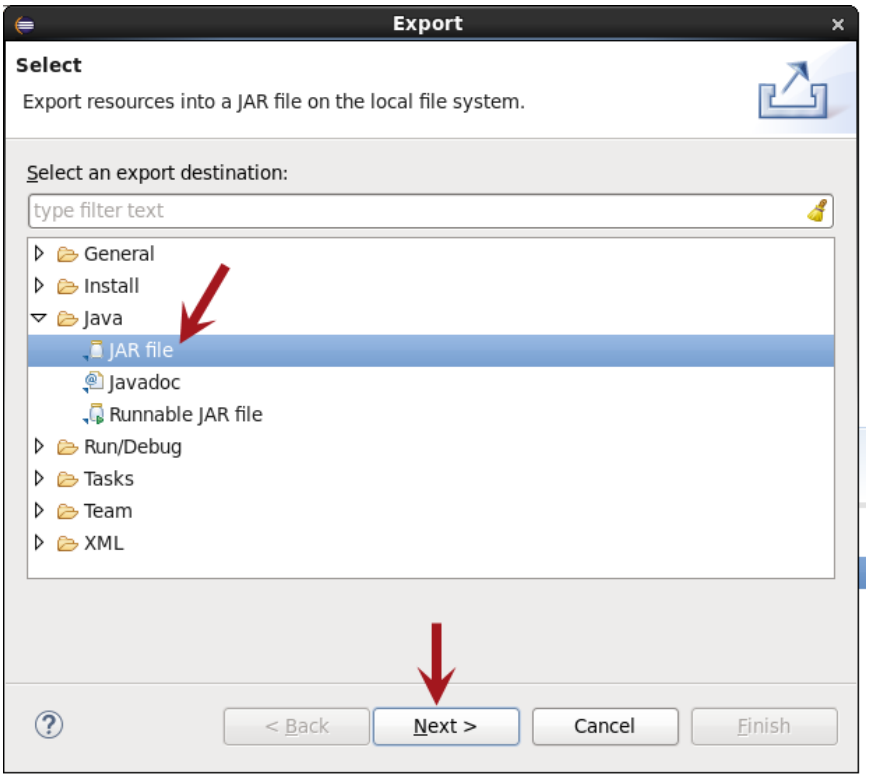


Ensure that there is no compilation error, before exporting the JAR file.

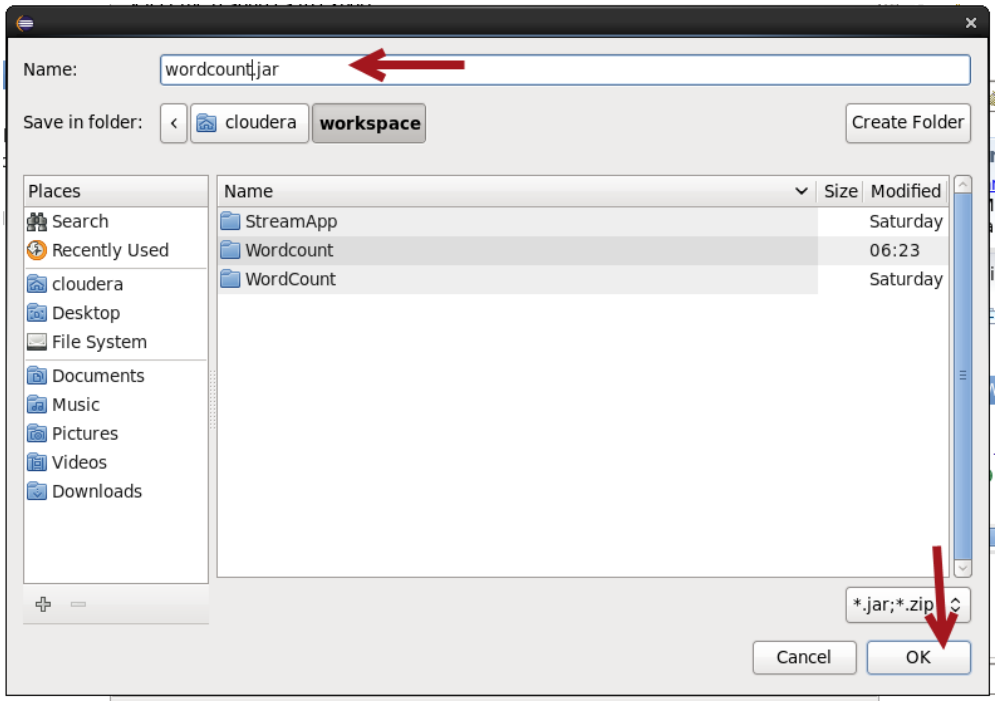
Step17: Exporting the JAR file, for that Right Click on WordCount project and select "Export"



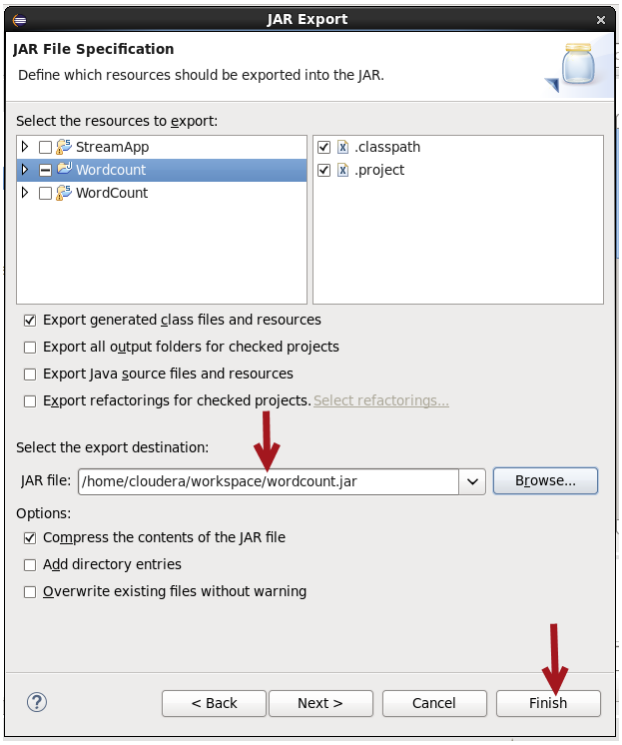
Step 18: In the next panel, expand Java and select JAR file



Step19: Name the JAR as "WordCount.jar" and select OK.



Step20: Browse to the location where you want to save the JAR and select FINISH.



Step21: Verify the file at the target location from the terminal.

```
[cloudera@quickstart workspace]$ ls -ltr
total 20
drwxrwxr-x 7 cloudera cloudera 4096 Sep 10 01:43 StreamApp
drwxrwxr-x 8 cloudera cloudera 4096 Sep 10 01:43 WordCount
drwxrwxr-x 5 cloudera cloudera 4096 Sep 13 06:23 Wordcount
-rw-rw-r-- 1 cloudera cloudera 6055 Sep 13 06:40 wordcount.jar
[cloudera@quickstart workspace]$
```

- **Let's run a simple MapReduce WordCount program.**

Step1: Import the data from local filesystem to HDFS

Under home directory of local filesystem, locate a folder named "datasets" followed by a file named story.txt

```
[cloudera@quickstart ~]$ cd datasets/
[cloudera@quickstart datasets]$ ls -ltr story.txt
-rw-rw-r-- 1 cloudera cloudera 2249 Sep  6 19:28 story.txt
[cloudera@quickstart datasets]$ pwd
/home/cloudera/datasets
[cloudera@quickstart datasets]$
```

Step2: Create a directory named "data" in the HDFS and import "story.txt" file.

```
hdfs dfs -mkdir data

hdfs dfs -put story.txt data
```

```
[cloudera@quickstart ~]$ hdfs dfs -ls data/story.txt
-rw-r--r--   1 cloudera cloudera       2249 2016-09-06 19:29 data/story.txt
[cloudera@quickstart ~]$
```

Step3: Now run the program by using the wordCount.jar created in previous steps

```
hadoop jar wordcount.jar Wordcount data/story.txt output_map
```

```
[cloudera@quickstart workspace]$ pwd
/home/cloudera/workspace
[cloudera@quickstart workspace]$ jar -tf wordcount.jar
META-INF/MANIFEST.MF
.project
Wordcount$Map.class
Wordcount$Reduce.class
Wordcount.class
.classpath
[cloudera@quickstart workspace]$ hadoop jar wordcount.jar Wordcount data/story.t
xt output_map
```

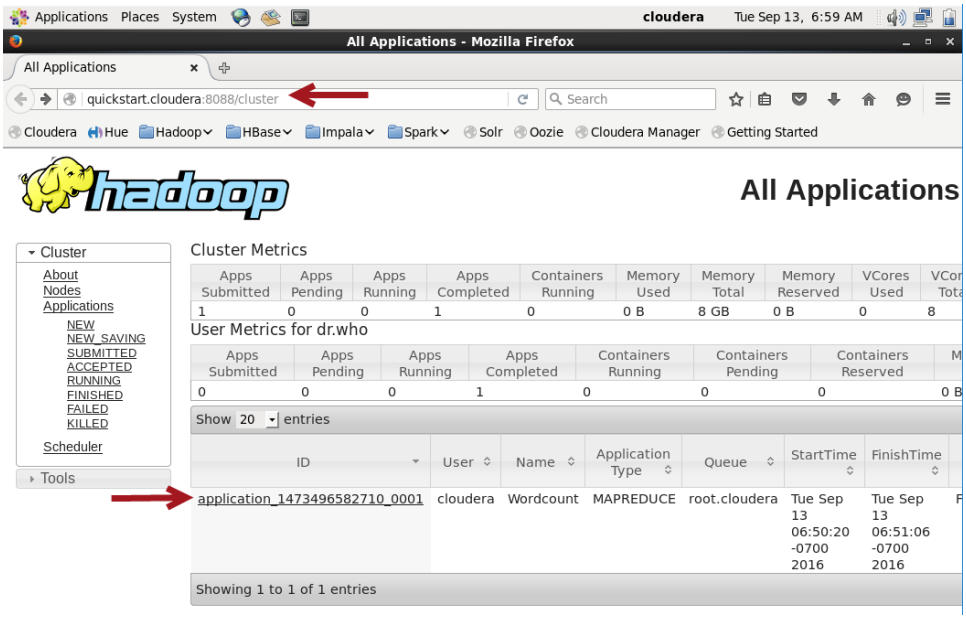

```
      16/09/13 06:51:07 INFO mapreduce.Job:  map 100% reduce 100%
16/09/13 06:51:08 INFO mapreduce.Job: Job job_1473496582710_0001 completed
successfully
16/09/13 06:51:08 INFO mapreduce.Job: Counters: 49
      File System Counters
            FILE: Number of bytes read=2906
            FILE: Number of bytes written=234627
            FILE: Number of read operations=0
            FILE: Number of large read operations=0
            FILE: Number of write operations=0
            HDFS: Number of bytes read=2374
            HDFS: Number of bytes written=2035
            HDFS: Number of read operations=6
            HDFS: Number of large read operations=0
            HDFS: Number of write operations=2
      Job Counters
            Launched map tasks=1
            Launched reduce tasks=1
            Data-local map tasks=1
            Total time spent by all maps in occupied slots (ms)=10457
            Total time spent by all reduces in occupied slots (ms)=11396
            Total time spent by all map tasks (ms)=10457
            Total time spent by all reduce tasks (ms)=11396
            Total vcore-seconds taken by all map tasks=10457
            Total vcore-seconds taken by all reduce tasks=11396
```

```
            Total megabyte-seconds taken by all map tasks=10707968
            Total megabyte-seconds taken by all reduce tasks=11669504
      Map-Reduce Framework
            Map input records=17
            Map output records=354
            Map output bytes=3656
            Map output materialized bytes=2906
            Input split bytes=125
            Combine input records=354
            Combine output records=217
            Reduce input groups=217
            Reduce shuffle bytes=2906
            Reduce input records=217
            Reduce output records=217
            Spilled Records=434
            Shuffled Maps =1
            Failed Shuffles=0
            Merged Map outputs=1
            GC time elapsed (ms)=246
            CPU time spent (ms)=1530
            Physical memory (bytes) snapshot=385163264
            Virtual memory (bytes) snapshot=3007664128
            Total committed heap usage (bytes)=354357248
      Shuffle Errors
            BAD_ID=0
            CONNECTION=0
            IO_ERROR=0
            WRONG_LENGTH=0
            WRONG_MAP=0
            WRONG_REDUCE=0
      File Input Format Counters
            Bytes Read=2249
      File Output Format Counters
            Bytes Written=2035
[cloudera@quickstart workspace]$
```

Check the output file:

```
[cloudera@quickstart workspace]$ hdfs dfs -ls output_map
Found 2 items
-rw-r--r--   1 cloudera cloudera          0 2016-09-13 06:51 output_map/_SUCCESS
-rw-r--r--   1 cloudera cloudera       2035 2016-09-13 06:51 output_map/part-r-0
0000
```

The same counters and job status can be checked from Resource Manager URL http://quickstart.cloudera:8088/cluster



Exercise 4: Launching Spark

- Spark shell can be launched in two ways i.e. Scala and Python.
- To launch Scala spark shell, follow below steps

```
$ spark-shell
```

```
[cloudera@quickstart ~]$ spark-shell
SLF4J: Class path contains multiple SLF4J bindings.
SLF4J: Found binding in [jar:file:/usr/lib/zookeeper/lib/slf4j-log4j12-1.7.5.jar!/org/
slf4j/impl/StaticLoggerBinder.class]
SLF4J: Found binding in [jar:file:/usr/jars/slf4j-log4j12-1.7.5.jar!/org/slf4j/impl/St
aticLoggerBinder.class]
SLF4J: See http://www.slf4j.org/codes.html#multiple_bindings for an explanation.
SLF4J: Actual binding is of type [org.slf4j.impl.Log4jLoggerFactory]
Setting default log level to "WARN".
To adjust logging level use sc.setLogLevel(newLevel).
Welcome to
      ____              __
     / __/__  ___ _____/ /__
    _\ \/ _ \/ _ `/ __/  '_/
   /___/ .__/\_,_/_/ /_/\_\   version 1.6.0
      /_/

Using Scala version 2.10.5 (Java HotSpot(TM) 64-Bit Server VM, Java 1.7.0_67)
```

You will see several INFO and WARNING message on the command prompt after launching spark-shell, which can be disregarded.

Logs will appear as below and finally you will get Scala Prompt

```
SQL context available as sqlContext.

scala>
```

- Spark creates a SparkContext object called sc, verify that the object exists

```
scala> sc
res0: org.apache.spark.SparkContext = org.apache.spark.SparkContext@a23c46d
```

- To know various SparkContext methods which are available, type sc. (sc followed by dot) and then TAB key

```
scala> sc.
accumulable                    accumulableCollection
accumulator                    addFile
addJar                         addSparkListener
appName                        applicationAttemptId
applicationId                  asInstanceOf
binaryFiles                    binaryRecords
broadcast                      cancelAllJobs
cancelJobGroup                 clearCallSite
clearFiles                     clearJars
clearJobGroup                  defaultMinPartitions
defaultMinSplits               defaultParallelism
emptyRDD                       externalBlockStoreFolderName
files                          getAllPools
getCheckpointDir               getConf
getExecutorMemoryStatus        getExecutorStorageStatus
getLocalProperty               getPersistentRDDs
getPoolForName                 getRDDStorageInfo
getSchedulingMode              hadoopConfiguration
hadoopFile                     hadoopRDD
initLocalProperties            isInstanceOf
isLocal                        isStopped
jars                           killExecutor
killExecutors                  makeRDD
```

Spark is based on the concept of Resilient Distributed Dataset (RDD), which is fault tolerant collection of elements that can be operated in parallel.

- Invoke python spark shell by using 'pyspark'

```
[cloudera@quickstart ~]$ pyspark
Python 2.6.6 (r266:84292, Jul 23 2015, 15:22:56)
[GCC 4.4.7 20120313 (Red Hat 4.4.7-11)] on linux2
Type "help", "copyright", "credits" or "license" for more information.
```

```
Welcome to
      ____              __
     / __/__  ___ _____/ /__
    _\ \/ _ \/ _ `/ __/  '_/
   /__ / .__/\_,_/_/ /_/\_\   version 1.6.0
      /_/

Using Python version 2.6.6 (r266:84292, Jul 23 2015 15:22:56)
SparkContext available as sc, HiveContext available as sqlContext.
>>> 
```

Two ways to create RDDs:

- Parallelizing an existing collection
- Referencing a dataset from an External Storage System

Parallelized collection:

To create a parallelized collection holding numbers 1 to 6, use **sc.parallelize** method

```
val data = Array (1,2,3,4,5,6)

val distData = sc.parallelize(data)
```

Once 'distData' RDD is created, we can perform **Action** such as:

- Finding the sum, mean & variance

```
distData.sum

distData.mean

distData.variance
```

External Storage System:

Spark can create distributed datasets from any storage system supported by Hadoop, Spark supports text files, Sequence Files and any other Hadoop Input Format.

Load a file from your Local Filesystem say story.txt using **sc.textFile** method.

```
val textFile = sc.textFile("file:/home/cloudera/datasets/story.txt")
```

Operations on RDD will be discussed in next section.

Exploring Data using RDD operations:

Transformations

filter

Return a new dataset formed by selecting those elements of the source on which *func* returns true.

```
val a = sc.parallelize(1 to 10)

val b = a.filter(_% 2 == 0)

b.collect
```

```
scala> val a = sc.parallelize(1 to 10)
a: org.apache.spark.rdd.RDD[Int] = ParallelCollectionRDD[0] at parallelize at <console>:21

scala> val b = a.filter(_% 2 == 0)
b: org.apache.spark.rdd.RDD[Int] = MapPartitionsRDD[1] at filter at <console>:23

scala> b.collect
16/08/30 06:59:25 INFO spark.SparkContext: Starting job: collect at <console>:26
```

```
16/08/30 06:59:28 INFO scheduler.DAGScheduler: ResultStage 0 (collect at <console>:26) finished in 0.316 s
16/08/30 06:59:28 INFO scheduler.TaskSetManager: Finished task 0.0 in stage 0.0 (TID 0) in 233 ms on localhost (1/1)
16/08/30 06:59:28 INFO scheduler.TaskSchedulerImpl: Removed TaskSet 0.0, whose tasks have all completed, from pool
16/08/30 06:59:28 INFO scheduler.DAGScheduler: Job 0 finished: collect at <console>:26, took 2.285340 s
res0: Array[Int] = Array(2, 4, 6, 8, 10)
```

map

Return a new distributed dataset formed by passing each element of the source through a function *func*.

```
val a = sc.parallelize(List("dog", "salmon", "salmon", "rat", "elephant"))

val b = a.map(_.length)

val c = a.zip(b)

c.collect
```

```
scala> val a = sc.parallelize(List("dog", "salmon", "salmon", "rat", "elephant"))
a: org.apache.spark.rdd.RDD[String] = ParallelCollectionRDD[2] at parallelize at <console>:21

scala> val b = a.map(_.length)
b: org.apache.spark.rdd.RDD[Int] = MapPartitionsRDD[3] at map at <console>:23

scala> val c = a.zip(b)
c: org.apache.spark.rdd.RDD[(String, Int)] = ZippedPartitionsRDD2[4] at zip at <console>:25

scala> c.collect
16/08/30 07:03:58 INFO spark.SparkContext: Starting job: collect at <console>:28



16/08/30 07:03:58 INFO executor.Executor: Finished task 0.0 in stage 1.0 (TID 1). 1147 bytes result sent to driver
16/08/30 07:03:58 INFO scheduler.DAGScheduler: ResultStage 1 (collect at <console>:28) finished in 0.062 s
16/08/30 07:03:58 INFO scheduler.DAGScheduler: Job 1 finished: collect at <console>:28, took 0.108580 s
16/08/30 07:03:58 INFO scheduler.TaskSetManager: Finished task 0.0 in stage 1.0 (TID 1) in 64 ms on localhost (1/1)
res1: Array[(String, Int)] = Array((dog,3), (salmon,6), (salmon,6), (rat,3), (elephant,8))
```

Using Python Shell:

```
nums = sc.parallelize([1, 2, 3, 4])

squared = nums.map(lambda x: x * x).collect()

for num in squared: print "%i " % (num)
```

```
>>> for num in squared: print "%i " % (num)
...
1
4
9
16
>>>
```

distinct

Return a new dataset that contains the distinct elements of the source dataset.

```
val c = sc.parallelize(List("Gnu", "Cat", "Rat", "Dog", "Gnu", "Rat"), 2)

c.distinct.collect
```

```
scala> val c = sc.parallelize(List("Gnu", "Cat", "Rat", "Dog", "Gnu", "Rat"), 2)
c: org.apache.spark.rdd.RDD[String] = ParallelCollectionRDD[5] at parallelize at <console>:21

scala> c.distinct.collect
16/08/30 07:07:16 INFO spark.SparkContext: Starting job: collect at <console>:24



16/08/30 07:07:19 INFO executor.Executor: Finished task 1.0 in stage 3.0 (TID 5). 1171 bytes result sent to driver
16/08/30 07:07:19 INFO scheduler.TaskSetManager: Finished task 1.0 in stage 3.0 (TID 5) in 76 ms on localhost (2/2)
16/08/30 07:07:19 INFO scheduler.TaskSchedulerImpl: Removed TaskSet 3.0, whose tasks have all completed, from pool
16/08/30 07:07:19 INFO scheduler.DAGScheduler: ResultStage 3 (collect at <console>:24) finished in 0.385 s
16/08/30 07:07:19 INFO scheduler.DAGScheduler: Job 2 finished: collect at <console>:24, took 2.185199 s
res2: Array[String] = Array(Dog, Cat, Gnu, Rat)
```

cartesian

When called on datasets of types T and U, returns a dataset of (T, U) pairs (all pairs of elements).

```
val x = sc.parallelize(List(1,2,3,4,5))

val y = sc.parallelize(List(6,7,8,9,10))

x.cartesian(y).collect
```

```
scala> val x = sc.parallelize(List(1,2,3,4,5))
x: org.apache.spark.rdd.RDD[Int] = ParallelCollectionRDD[9] at parallelize at <console>:21

scala> val y = sc.parallelize(List(6,7,8,9,10))
y: org.apache.spark.rdd.RDD[Int] = ParallelCollectionRDD[10] at parallelize at <console>:21

scala> x.cartesian(y).collect
16/08/30 07:10:11 INFO spark.SparkContext: Starting job: collect at <console>:26


16/08/30 07:10:11 INFO scheduler.DAGScheduler: ResultStage 4 (collect at <console>:26) finished in 0.145 s
16/08/30 07:10:11 INFO scheduler.DAGScheduler: Job 3 finished: collect at <console>:26, took 0.264577 s
16/08/30 07:10:11 INFO scheduler.TaskSetManager: Finished task 0.0 in stage 4.0 (TID 6) in 153 ms on localhost (1/1)
16/08/30 07:10:11 INFO scheduler.TaskSchedulerImpl: Removed TaskSet 4.0, whose tasks have all completed, from pool
res3: Array[(Int, Int)] = Array((1,6), (1,7), (1,8), (1,9), (1,10), (2,6), (2,7), (2,8), (2,9), (2,10), (3,6), (3,7), (3,8), (3,
9), (3,10), (4,6), (4,7), (4,8), (4,9), (4,10), (5,6), (5,7), (5,8), (5,9), (5,10))
```

coalesce

Decrease the number of partitions in the RDD to numPartitions. Useful for running operations more efficiently after filtering down a large dataset.

```
val y = sc.parallelize(1 to 10, 10)

val z = y.coalesce(2, false)

z.partitions.length
```

```
scala> val y = sc.parallelize(1 to 10, 10)
y: org.apache.spark.rdd.RDD[Int] = ParallelCollectionRDD[12] at parallelize at <console>:21

scala> val z = y.coalesce(2, false)
z: org.apache.spark.rdd.RDD[Int] = CoalescedRDD[13] at coalesce at <console>:23

scala> z.partitions.length
res4: Int = 2
```

filterByRange

Returns an RDD containing only the items in the key range specified.

```
val randRDD = sc.parallelize(List( (2,"cat"), (6, "mouse"),(7, "cup"), (3,
"book"), (4, "tv"), (1, "screen"), (5, "heater")), 3)

val sortedRDD = randRDD.sortByKey()
```

```
sortedRDD.filterByRange(1,3).collect
```

```
16/08/30 07:14:40 INFO executor.Executor: Finished task 0.0 in stage 7.0 (TID 13). 1357 bytes result sent to driver
16/08/30 07:14:40 INFO scheduler.DAGScheduler: ResultStage 7 (collect at <console>:26) finished in 0.080 s
16/08/30 07:14:40 INFO scheduler.DAGScheduler: Job 5 finished: collect at <console>:26, took 0.527731 s
res5: Array[(Int, String)] = Array((1,screen), (2,cat), (3,book))
```

flatMap

Similar to map, but each input item can be mapped to 0 or more output items (so *func* should return a Seq rather than a single item).

```
val a = sc.parallelize(1 to 10, 5)

a.flatMap(1 to _).collect
```

```
16/08/30 07:18:44 INFO executor.Executor: Finished task 4.0 in stage 9.0 (TID 20). 974 bytes result sent to
16/08/30 07:18:44 INFO scheduler.TaskSetManager: Finished task 4.0 in stage 9.0 (TID 20) in 24 ms on localho
16/08/30 07:18:44 INFO scheduler.DAGScheduler: ResultStage 9 (collect at <console>:24) finished in 0.141 s
16/08/30 07:18:44 INFO scheduler.DAGScheduler: Job 7 finished: collect at <console>:24, took 0.193634 s
res6: Array[Int] = Array(1, 1, 2, 1, 2, 3, 1, 2, 3, 4, 1, 2, 3, 4, 5, 1, 2, 3, 4, 5, 6, 1, 2, 3, 4, 5, 6, 7,
, 8, 1, 2, 3, 4, 5, 6, 7, 8, 9, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10)
```

```
val b = sc.parallelize(List(1, 2, 3), 2).flatMap(x => List(x, x,
x)).collect

res85: Array[Int] = Array(1, 1, 1, 2, 2, 2, 3, 3, 3)
```

```
16/08/30 07:17:29 INFO executor.Executor: Running task 1.0 in stage 8.0 (TID 15)
16/08/30 07:17:29 INFO executor.Executor: Finished task 1.0 in stage 8.0 (TID 15). 922 bytes result sent to driver
16/08/30 07:17:29 INFO scheduler.DAGScheduler: ResultStage 8 (collect at <console>:23) finished in 0.104 s
16/08/30 07:17:29 INFO scheduler.DAGScheduler: Job 6 finished: collect at <console>:23, took 0.126929 s
b: Array[Int] = Array(1, 1, 1, 2, 2, 2, 3, 3, 3)
```

```
val lines = sc.parallelize(List("hello world", "hi"))

val words = lines.flatMap(line => line.split(" "))

words.first()  // returns "hello"
```

```
16/08/30 07:21:01 INFO scheduler.DAGScheduler: ResultStage 10 (first at <console>:26) finished in 0.006 s
16/08/30 07:21:01 INFO scheduler.DAGScheduler: Job 8 finished: first at <console>:26, took 0.035576 s
res7: String = hello
```

Using python shell:

```
lines = sc.parallelize(["hello world", "hi"])

words = lines.flatMap(lambda line: line.split(" "))
```

```
words.first()  # returns "hello"
```

```
>>> lines = sc.parallelize(["hello world", "hi"])
>>> words = lines.flatMap(lambda line: line.split(" "))
>>> words.first()
16/09/17 09:38:59 INFO spark.SparkContext: Starting job: runJob at PythonRDD.sca
la:393

'hello'
>>>
```

groupBy

```
val a = sc.parallelize(1 to 9, 3)

a.groupBy(x => { if (x % 2 == 0) "even" else "odd" }).collect
```

```
16/08/30 07:23:14 INFO scheduler.DAGScheduler: ResultStage 12 (collect at <console>:26) finished in 0.182 s
16/08/30 07:23:14 INFO scheduler.DAGScheduler: Job 9 finished: collect at <console>:26, took 0.447740 s
res8: Array[(String, Iterable[Int])] = Array((even,CompactBuffer(2, 4, 6, 8)), (odd,CompactBuffer(1, 3, 5, 7
, 9)))
```

keys

Extracts the keys from all contained tuples and returns them in a new RDD.

```
val a = sc.parallelize(List("dog", "tiger", "lion", "cat", "panther",
"eagle"), 2)

val b = a.map(x => (x.length, x))

b.keys.collect
```

```
16/08/30 07:25:04 INFO scheduler.DAGScheduler: ResultStage 13 (collect at <console>:28) finished in 0.089 s
16/08/30 07:25:04 INFO scheduler.DAGScheduler: Job 10 finished: collect at <console>:28, took 0.131419 s
res9: Array[Int] = Array(3, 5, 4, 3, 7, 5)
```

union

```
val seta = sc.parallelize(1 to 10)

val setb = sc.parallelize(5 to 15)

(seta union setb).collect
```

```
16/08/30 07:26:33 INFO scheduler.DAGScheduler: ResultStage 14 (collect at <console>:26) finished in 0.143 s
16/08/30 07:26:33 INFO scheduler.DAGScheduler: Job 11 finished: collect at <console>:26, took 0.318252 s
res10: Array[Int] = Array(1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15)
```

zip

Joins two RDDs by combining the i-th of either partition with each other. The resulting

RDD will consist of two-component tuples which are interpreted as key-value pairs by the methods provided by the PairRDDFunctions extension.

```
val a = sc.parallelize(1 to 100, 3)
val b = sc.parallelize(101 to 200, 3)
a.zip(b).collect
```

```
16/08/30 07:30:02 INFO scheduler.TaskSetManager: Finished task 2.0 in stage 15.0 (TID 34) in 35 ms on localh
ost (3/3)
16/08/30 07:30:02 INFO scheduler.TaskSchedulerImpl: Removed TaskSet 15.0, whose tasks have all completed, fr
om pool
res11: Array[(Int, Int)] = Array((1,101), (2,102), (3,103), (4,104), (5,105), (6,106), (7,107), (8,108), (9,
109), (10,110), (11,111), (12,112), (13,113), (14,114), (15,115), (16,116), (17,117), (18,118), (19,119), (2
0,120), (21,121), (22,122), (23,123), (24,124), (25,125), (26,126), (27,127), (28,128), (29,129), (30,130),
(31,131), (32,132), (33,133), (34,134), (35,135), (36,136), (37,137), (38,138), (39,139), (40,140), (41,141)
, (42,142), (43,143), (44,144), (45,145), (46,146), (47,147), (48,148), (49,149), (50,150), (51,151), (52,15
2), (53,153), (54,154), (55,155), (56,156), (57,157), (58,158), (59,159), (60,160), (61,161), (62,162), (63,
163), (64,164), (65,165), (66,166), (67,167), (68,168), (69,169), (70,170), (71,171), (72,172), (73,173), (7
4,174), (75,175), (76,176), (77,177), (78...
scala>
```

Action

collect

Return all the elements of the dataset as an array at the driver program. This is usually useful after a filter or other operation that returns a sufficiently small subset of the data.

```
val c = sc.parallelize(List("Gnu", "Cat", "Rat", "Dog", "Gnu", "Rat"), 2)

c.collect
```

```
16/08/30 07:31:52 INFO scheduler.TaskSetManager: Finished task 1.0 in stage 16.0 (TID 36) in 7 ms on localho
st (2/2)
16/08/30 07:31:52 INFO scheduler.TaskSchedulerImpl: Removed TaskSet 16.0, whose tasks have all completed, fr
om pool
16/08/30 07:31:52 INFO scheduler.DAGScheduler: ResultStage 16 (collect at <console>:24) finished in 0.010 s
16/08/30 07:31:52 INFO scheduler.DAGScheduler: Job 13 finished: collect at <console>:24, took 0.018261 s
res12: Array[String] = Array(Gnu, Cat, Rat, Dog, Gnu, Rat)
```

collectAsMap

Similar to collect, but works on key-value RDDs and converts them into Scala maps to preserve their key-value structure.

```
val a = sc.parallelize(List(1, 2, 1, 3), 1)

val b = a.zip(a)
```

```
b.collectAsMap
```

```
16/08/30 07:33:33 INFO scheduler.TaskSetManager: Finished task 0.0 in stage 17.0 (TID 37) in 145 ms on local
host (1/1)
16/08/30 07:33:33 INFO scheduler.TaskSchedulerImpl: Removed TaskSet 17.0, whose tasks have all completed, fr
om pool
res13: scala.collection.Map[Int,Int] = Map(2 -> 2, 1 -> 1, 3 -> 3)
```

count

Return the number of elements in the dataset.

```
val c = sc.parallelize(List("Gnu", "Cat", "Rat", "Dog"), 2)

c.count

res2: Long = 4
```

```
16/08/30 07:34:52 INFO scheduler.TaskSetManager: Finished task 1.0 in stage 18.0 (TID 39) in 11 ms on localh
ost (2/2)
16/08/30 07:34:52 INFO scheduler.TaskSchedulerImpl: Removed TaskSet 18.0, whose tasks have all completed, fr
om pool
16/08/30 07:34:52 INFO scheduler.DAGScheduler: ResultStage 18 (count at <console>:24) finished in 0.040 s
16/08/30 07:34:52 INFO scheduler.DAGScheduler: Job 15 finished: count at <console>:24, took 0.054256 s
res14: Long = 4
```

reduce

Aggregate the elements of the dataset using a function *func* (which takes two arguments and returns one). The function should be commutative and associative so that it can be computed correctly in parallel.

```
val a = sc.parallelize(1 to 100, 3)

a.reduce(_+_)
```

```
16/08/30 08:32:49 INFO scheduler.TaskSchedulerImpl: Removed TaskSet 19.0, whose tasks have all completed, fr
om pool
16/08/30 08:32:49 INFO scheduler.DAGScheduler: ResultStage 19 (reduce at <console>:24) finished in 0.099 s
16/08/30 08:32:49 INFO scheduler.DAGScheduler: Job 16 finished: reduce at <console>:24, took 0.315500 s
res15: Int = 5050
```

take

Return an array with the first *n* elements of the dataset.

```
val b = sc.parallelize(List("dog", "cat", "ape", "salmon", "gnu"), 2)

b.take(2)
```

```
16/08/30 08:34:15 INFO scheduler.TaskSchedulerImpl: Removed TaskSet 20.0, whose tasks have all completed, fr
om pool
16/08/30 08:34:15 INFO scheduler.DAGScheduler: ResultStage 20 (take at <console>:24) finished in 0.035 s
16/08/30 08:34:15 INFO scheduler.DAGScheduler: Job 17 finished: take at <console>:24, took 0.142047 s
res16: Array[String] = Array(dog, cat)
```

```
val b = sc.parallelize(1 to 100, 5)

b.take(30)
```

```
16/08/30 08:35:57 INFO scheduler.TaskSchedulerImpl: Removed TaskSet 22.0, whose tasks have all completed, fr
om pool
16/08/30 08:35:58 INFO scheduler.DAGScheduler: ResultStage 22 (take at <console>:24) finished in 0.004 s
16/08/30 08:35:58 INFO scheduler.DAGScheduler: Job 19 finished: take at <console>:24, took 0.064874 s
res17: Array[Int] = Array(1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23,
 24, 25, 26, 27, 28, 29, 30)
```

first

Return the first element of the dataset (similar to take(1)).

```
val c = sc.parallelize(List("Gnu", "Cat", "Rat", "Dog"), 2)

c.first
```

```
16/08/30 08:37:15 INFO scheduler.TaskSchedulerImpl: Removed TaskSet 23.0, whose tasks have all completed, fr
om pool
16/08/30 08:37:15 INFO scheduler.DAGScheduler: ResultStage 23 (first at <console>:24) finished in 0.006 s
16/08/30 08:37:15 INFO scheduler.DAGScheduler: Job 20 finished: first at <console>:24, took 0.016040 s
res18: String = Gnu
```

countByValue

Returns a map that contains all unique values of the RDD and their respective occurrence counts.

```
val b = sc.parallelize(List(1,2,3,4,5,6,7,8,2,4,2,1,1,1,1,1))

b.countByValue
```

```
16/08/30 08:38:18 INFO scheduler.DAGScheduler: ResultStage 25 (countByValue at <console>:24) finished in 0.0
40 s
16/08/30 08:38:18 INFO scheduler.DAGScheduler: Job 21 finished: countByValue at <console>:24, took 0.495353
s
res19: scala.collection.Map[Int,Long] = Map(5 -> 1, 1 -> 6, 6 -> 1, 2 -> 3, 7 -> 1, 3 -> 1, 8 -> 1, 4 -> 2)
```

lookup

Scans the RDD for all keys that match the provided value and returns their values as a Scala sequence.

```
val a = sc.parallelize(List("dog", "tiger", "lion", "cat", "panther",
"eagle"), 2)

val b = a.map(x => (x.length, x))

b.lookup(5)
```

```
16/08/30 08:39:47 INFO scheduler.TaskSchedulerImpl: Removed TaskSet 26.0, whose tasks have all completed, fr
om pool
16/08/30 08:39:47 INFO scheduler.DAGScheduler: ResultStage 26 (lookup at <console>:28) finished in 0.087 s
16/08/30 08:39:47 INFO scheduler.DAGScheduler: Job 22 finished: lookup at <console>:28, took 0.188596 s
res20: Seq[String] = WrappedArray(tiger, eagle)
```

max

Returns the largest element in the RDD

```
val y = sc.parallelize(10 to 30)

y.max
```

```
16/08/30 08:41:08 INFO scheduler.TaskSchedulerImpl: Removed TaskSet 27.0, whose tasks have all completed, fr
om pool
16/08/30 08:41:08 INFO scheduler.DAGScheduler: ResultStage 27 (max at <console>:24) finished in 0.042 s
16/08/30 08:41:08 INFO scheduler.DAGScheduler: Job 23 finished: max at <console>:24, took 0.115601 s
res21: Int = 30
```

```
val a = sc.parallelize(List((10, "dog"), (3, "tiger"), (9, "lion"), (18,
"cat")))

a.max
```

```
16/08/30 08:42:29 INFO scheduler.TaskSchedulerImpl: Removed TaskSet 28.0, whose tasks have all completed, fr
om pool
16/08/30 08:42:29 INFO scheduler.DAGScheduler: ResultStage 28 (max at <console>:24) finished in 0.031 s
16/08/30 08:42:29 INFO scheduler.DAGScheduler: Job 24 finished: max at <console>:24, took 0.054414 s
res22: (Int, String) = (18,cat)
```

min

Returns the smallest element in the RDD

```
val y = sc.parallelize(10 to 30)

y.min
```

```
16/08/30 08:43:49 INFO executor.Executor: Finished task 0.0 in stage 29.0 (TID 53). 1031 bytes result sent t
o driver
16/08/30 08:43:49 INFO scheduler.DAGScheduler: ResultStage 29 (min at <console>:24) finished in 0.075 s
16/08/30 08:43:49 INFO scheduler.DAGScheduler: Job 25 finished: min at <console>:24, took 0.170125 s
res23: Int = 10
```

```
val a = sc.parallelize(List((10, "dog"), (3, "tiger"), (9, "lion"), (8,
"cat")))

a.min
```

```
16/08/30 08:45:21 INFO scheduler.TaskSchedulerImpl: Removed TaskSet 30.0, whose tasks have all completed, fr
om pool
16/08/30 08:45:21 INFO scheduler.DAGScheduler: ResultStage 30 (min at <console>:24) finished in 0.012 s
16/08/30 08:45:21 INFO scheduler.DAGScheduler: Job 26 finished: min at <console>:24, took 0.020695 s
res24: (Int, String) = (3,tiger)
```

mean

Calls stats and extracts the mean component.

```
val a = sc.parallelize(List(9.1, 1.0, 1.2, 2.1, 1.3, 5.0, 2.0, 2.1, 7.4,
7.5, 7.6, 8.8, 10.0, 8.9, 5.5), 3)

a.mean
```

```
16/08/30 08:46:49 INFO scheduler.TaskSchedulerImpl: Removed TaskSet 31.0, whose tasks have all completed, fr
om pool
16/08/30 08:46:49 INFO scheduler.DAGScheduler: ResultStage 31 (mean at <console>:24) finished in 0.425 s
16/08/30 08:46:49 INFO scheduler.DAGScheduler: Job 27 finished: mean at <console>:24, took 0.526866 s
res25: Double = 5.3
```

variance

Calls stats and extracts either variance-component or corrected sampleVariance-component.

```
val a = sc.parallelize(List(9.1, 1.0, 1.2, 2.1, 1.3, 5.0, 2.0, 2.1, 7.4,
7.5, 7.6, 8.8, 10.0, 8.9, 5.5), 3)
a.variance
```

```
16/08/30 08:48:05 INFO scheduler.TaskSchedulerImpl: Removed TaskSet 32.0, whose tasks have all completed, fr
om pool
16/08/30 08:48:05 INFO scheduler.DAGScheduler: ResultStage 32 (variance at <console>:24) finished in 0.018 s
16/08/30 08:48:05 INFO scheduler.DAGScheduler: Job 28 finished: variance at <console>:24, took 0.032808 s
res26: Double = 10.605333333333332
```

PairRDD

countByKey

Only available on RDDs of type (K, V). Returns a hashmap of (K, Int) pairs with the count of each key.

```
val c = sc.parallelize(List((3, "Gnu"), (3, "Yak"), (5, "Mouse"), (3, "Dog")), 2)

c.countByKey
```

```
16/08/30 08:49:39 INFO scheduler.TaskSchedulerImpl: Removed TaskSet 34.0, whose tasks have all completed, fr
om pool
16/08/30 08:49:39 INFO scheduler.DAGScheduler: ResultStage 34 (countByKey at <console>:24) finished in 0.073
 s
16/08/30 08:49:39 INFO scheduler.DAGScheduler: Job 29 finished: countByKey at <console>:24, took 0.384196 s
res27: scala.collection.Map[Int,Long] = Map(3 -> 3, 5 -> 1)
```

groupByKey

When called on a dataset of (K, V) pairs, returns a dataset of (K, Iterable<V>) pairs.

```
val a = sc.parallelize(List("dog", "tiger", "lion", "cat", "spider", "eagle"), 2)

val b = a.keyBy(_.length)

b.groupByKey.collect
```

```
16/08/30 08:51:02 INFO executor.Executor: Finished task 1.0 in stage 36.0 (TID 68). 1703 bytes result sent t
o driver
16/08/30 08:51:02 INFO scheduler.DAGScheduler: ResultStage 36 (collect at <console>:26) finished in 0.042 s
16/08/30 08:51:02 INFO scheduler.DAGScheduler: Job 30 finished: collect at <console>:26, took 0.415007 s
res28: Array[(Int, Iterable[String])] = Array((4,CompactBuffer(lion)), (6,CompactBuffer(spider)), (3,Compact
Buffer(dog, cat)), (5,CompactBuffer(tiger, eagle)))
```

reduceByKey

When called on a dataset of (K, V) pairs, returns a dataset of (K, V) pairs where the values for each key are aggregated using the given reduce function *func*, which must be of type (V,V) => V

```
val a = sc.parallelize(List("dog", "cat", "owl", "gnu", "ant"), 2)

val b = a.map(x => (x.length, x))

b.reduceByKey(_ + _).collect
```

```
16/08/30 08:52:58 INFO scheduler.TaskSetManager: Finished task 1.0 in stage 38.0 (TID 72) in 25 ms on localh
ost (2/2)
16/08/30 08:52:58 INFO scheduler.DAGScheduler: ResultStage 38 (collect at <console>:28) finished in 0.033 s
16/08/30 08:52:58 INFO scheduler.DAGScheduler: Job 31 finished: collect at <console>:28, took 0.413629 s
res29: Array[(Int, String)] = Array((3,dogcatowlgnuant))
```

fold

When called on a dataset of (K, V) pairs, returns a dataset of (K, V) pairs where the values for each key are aggregated using the given reduce function *func*, which must be of type (V,V) => V

```
val employeeData = List(("Jack",1000.0),("Bob",2000.0),("Carl",7000.0))
 val employeeRDD = sc.makeRDD(employeeData)
val dummyEmployee = ("dummy",0.0)
val maxSalaryEmployee = employeeRDD.fold(dummyEmployee)((acc,employee) => {
if(acc._2 < employee._2) employee else acc})
println("employee with maximum salary is"+maxSalaryEmployee)
```

```
scala> println("employee with maximum salary is"+maxSalaryEmployee)
employee with maximum salary is(Carl,7000.0)
```

foldByKey

Very similar to *fold*, but performs the folding separately for each key of the RDD. This function is only available if the RDD consists of two-component tuples.

```
val deptEmployees = List(
      ("cs",("jack",1000.0)),
      ("cs",("bron",1200.0)),
      ("phy",("sam",2200.0)),
      ("phy",("ronaldo",500.0))
    )
  val employeeRDD = sc.makeRDD(deptEmployees)


  val maxByDept = employeeRDD.foldByKey(("dummy",0.0))((acc,element)=>
if(acc._2 > element._2) acc else element)


  println("maximum salaries in each dept" + maxByDept.collect().toList)
```

```
scala> println("maximum salaries in each dept" + maxByDept.collect().toList)
maximum salaries in each deptList((phy,(sam,2200.0)), (cs,(bron,1200.0)))
```

cogroup

When called on datasets of type (K, V) and (K, W), returns a dataset of (K, (Iterable<V>, Iterable<W>)) tuples.

```
val a = sc.parallelize(List(1, 2, 1, 3), 1)

val b = a.map((_, "b"))

val c = a.map((_, "c"))

b.cogroup(c).collect
```

```
16/08/30 08:58:50 INFO executor.Executor: Finished task 0.0 in stage 43.0 (TID 77). 2177 bytes result sent t
o driver
16/08/30 08:58:50 INFO scheduler.DAGScheduler: ResultStage 43 (collect at <console>:28) finished in 0.249 s
16/08/30 08:58:50 INFO scheduler.DAGScheduler: Job 33 finished: collect at <console>:28, took 0.668327 s
res31: Array[(Int, (Iterable[String], Iterable[String]))] = Array((1,(CompactBuffer(b, b),CompactBuffer(c, c
))), (3,(CompactBuffer(b),CompactBuffer(c))), (2,(CompactBuffer(b),CompactBuffer(c))))
```

```
val x = sc.parallelize(List((1, "apple"), (2, "banana"), (3, "orange"), (4,
"kiwi")), 2)

val y = sc.parallelize(List((5, "computer"), (1, "laptop"), (1, "desktop"),
(4, "iPad")), 2)

x.cogroup(y).collect
```

```
16/08/30 09:00:55 INFO executor.Executor: Finished task 1.0 in stage 46.0 (TID 83). 2189 bytes result sent t
o driver
16/08/30 09:00:55 INFO scheduler.DAGScheduler: ResultStage 46 (collect at <console>:26) finished in 0.123 s
16/08/30 09:00:55 INFO scheduler.DAGScheduler: Job 34 finished: collect at <console>:26, took 0.624333 s
res32: Array[(Int, (Iterable[String], Iterable[String]))] = Array((4,(CompactBuffer(kiwi),CompactBuffer(iPad
))), (2,(CompactBuffer(banana),CompactBuffer())), (1,(CompactBuffer(apple),CompactBuffer(laptop, desktop))),
 (3,(CompactBuffer(orange),CompactBuffer())), (5,(CompactBuffer(),CompactBuffer(computer))))
```

Join

Performs an inner join using two key-value RDDs.

```
val a = sc.parallelize(List("dog", "salmon", "salmon", "rat", "elephant"),
3)

val b = a.keyBy(_.length)

val c =
sc.parallelize(List("dog","cat","gnu","salmon","rabbit","turkey","wolf","be
ar","bee"), 3)

val d = c.keyBy(_.length)

b.join(d).collect
```

```
16/08/30 09:02:41 INFO scheduler.TaskSchedulerImpl: Removed TaskSet 49.0, whose tasks have all completed, fr
om pool
16/08/30 09:02:41 INFO scheduler.DAGScheduler: ResultStage 49 (collect at <console>:30) finished in 0.470 s
16/08/30 09:02:41 INFO scheduler.DAGScheduler: Job 35 finished: collect at <console>:30, took 1.019005 s
res33: Array[(Int, (String, String))] = Array((6,(salmon,salmon)), (6,(salmon,rabbit)), (6,(salmon,turkey)),
 (6,(salmon,salmon)), (6,(salmon,rabbit)), (6,(salmon,turkey)), (3,(dog,dog)), (3,(dog,cat)), (3,(dog,gnu)),
 (3,(dog,bee)), (3,(rat,dog)), (3,(rat,cat)), (3,(rat,gnu)), (3,(rat,bee)))
```

leftOuterJoin

Performs an left outer join using two key-value RDDs.

```
val a = sc.parallelize(List("dog", "salmon", "salmon", "rat", "elephant"),
3)

val b = a.keyBy(_.length)

val c =
sc.parallelize(List("dog","cat","gnu","salmon","rabbit","turkey","wolf","be
ar","bee"), 3)

val d = c.keyBy(_.length)

b.leftOuterJoin(d).collect
```

```
16/08/30 09:03:59 INFO scheduler.DAGScheduler: Job 36 finished: collect at <console>:30, took 0.675634 s
16/08/30 09:03:59 INFO scheduler.TaskSchedulerImpl: Removed TaskSet 52.0, whose tasks have all completed, fr
om pool
res34: Array[(Int, (String, Option[String]))] = Array((6,(salmon,Some(salmon))), (6,(salmon,Some(rabbit))),
(6,(salmon,Some(turkey))), (6,(salmon,Some(salmon))), (6,(salmon,Some(rabbit))), (6,(salmon,Some(turkey))),
(3,(dog,Some(dog))), (3,(dog,Some(cat))), (3,(dog,Some(gnu))), (3,(dog,Some(bee))), (3,(rat,Some(dog))), (3,
(rat,Some(cat))), (3,(rat,Some(gnu))), (3,(rat,Some(bee))), (8,(elephant,None)))
```

rightOuterJoin

Performs an right outer join using two key-value RDDs.

```
val a = sc.parallelize(List("dog", "salmon", "salmon", "rat", "elephant"),
3)

val b = a.keyBy(_.length)

val c =
sc.parallelize(List("dog","cat","gnu","salmon","rabbit","turkey","wolf","be
ar","bee"), 3)

val d = c.keyBy(_.length)

b.rightOuterJoin(d).collect
```

```
16/08/30 09:05:30 INFO scheduler.TaskSchedulerImpl: Removed TaskSet 55.0, whose tasks have all completed, fr
om pool
16/08/30 09:05:30 INFO scheduler.DAGScheduler: ResultStage 55 (collect at <console>:30) finished in 0.181 s
16/08/30 09:05:30 INFO scheduler.DAGScheduler: Job 37 finished: collect at <console>:30, took 1.003812 s
res35: Array[(Int, (Option[String], String))] = Array((6,(Some(salmon),salmon)), (6,(Some(salmon),rabbit)),
(6,(Some(salmon),turkey)), (6,(Some(salmon),salmon)), (6,(Some(salmon),rabbit)), (6,(Some(salmon),turkey)),
(3,(Some(dog),dog)), (3,(Some(dog),cat)), (3,(Some(dog),gnu)), (3,(Some(dog),bee)), (3,(Some(rat),dog)), (3,
(Some(rat),cat)), (3,(Some(rat),gnu)), (3,(Some(rat),bee)), (4,(None,wolf)), (4,(None,bear)))
```

keyBy

Constructs two-component tuples (key-value pairs) by applying a function on each data item. The result of the function becomes the key and the original data item becomes the value of the newly created tuples.

```
val a = sc.parallelize(List("dog", "salmon", "salmon", "rat", "elephant"),
3)

val b = a.keyBy(_.length)

b.collect
```

```
16/08/30 09:14:29 INFO scheduler.TaskSetManager: Finished task 2.0 in stage 56.0 (TID 113) in 7 ms on localh
ost (3/3)
16/08/30 09:14:29 INFO scheduler.TaskSchedulerImpl: Removed TaskSet 56.0, whose tasks have all completed, fr
om pool
16/08/30 09:14:29 INFO scheduler.DAGScheduler: ResultStage 56 (collect at <console>:26) finished in 0.053 s
16/08/30 09:14:29 INFO scheduler.DAGScheduler: Job 38 finished: collect at <console>:26, took 0.073531 s
res36: Array[(Int, String)] = Array((3,dog), (6,salmon), (6,salmon), (3,rat), (8,elephant))
```

mapValues

Takes the values of a RDD that consists of two-component tuples, and applies the provided function to transform each value. Then, it forms new two-component tuples using the key and the transformed value and stores them in a new RDD.

```
val a = sc.parallelize(List("dog", "tiger", "lion", "cat", "panther",
"eagle"), 2)

val b = a.map(x => (x.length, x))

b.mapValues("x" + _ + "x").collect
```

```
16/08/30 09:21:21 INFO executor.Executor: Finished task 1.0 in stage 57.0 (TID 115). 1118 bytes result sent
to driver
16/08/30 09:21:21 INFO scheduler.DAGScheduler: ResultStage 57 (collect at <console>:28) finished in 0.082 s
16/08/30 09:21:21 INFO scheduler.DAGScheduler: Job 39 finished: collect at <console>:28, took 0.182411 s
res37: Array[(Int, String)] = Array((3,xdogx), (5,xtigerx), (4,xlionx), (3,xcatx), (7,xpantherx), (5,xeaglex
))
```

cache

The cache( ) method is a shorthand for using the default storage level, which is StorageLevel.MEMORY_ONLY (store deserialized objects in memory)

```
val c = sc.parallelize(List("Gnu", "Cat", "Rat", "Dog", "Gnu", "Rat"), 2)

c.getStorageLevel
```

```
scala> val c = sc.parallelize(List("Gnu", "Cat", "Rat", "Dog", "Gnu", "Rat"), 2)
c: org.apache.spark.rdd.RDD[String] = ParallelCollectionRDD[99] at parallelize at <console>:21

scala> c.getStorageLevel
res38: org.apache.spark.storage.StorageLevel = StorageLevel(false, false, false, false, 1)
```

```
c.cache

c.getStorageLevel
```

```
scala> c.cache
res39: c.type = ParallelCollectionRDD[99] at parallelize at <console>:21

scala> c.getStorageLevel
res40: org.apache.spark.storage.StorageLevel = StorageLevel(false, true, false, true, 1)
```

repartition

Reshuffle the data in the RDD randomly to create either more or fewer partitions and balance it across them. This always shuffles all data over the network.

```
val rdd = sc.parallelize(List(1, 2, 10, 4, 5, 2, 1, 1, 1), 3)

rdd.partitions.length

val rdd2 = rdd.repartition(5)

rdd2.partitions.length
```

```
scala> val rdd = sc.parallelize(List(1, 2, 10, 4, 5, 2, 1, 1, 1), 3)
rdd: org.apache.spark.rdd.RDD[Int] = ParallelCollectionRDD[102] at parallelize at <console>:21

scala> rdd.partitions.length
res43: Int = 3

scala> val rdd2 = rdd.repartition(5)
rdd2: org.apache.spark.rdd.RDD[Int] = MapPartitionsRDD[106] at repartition at <console>:23

scala> rdd2.partitions.length
res44: Int = 5
```

Developing with Spark

REPL

Example: Counting the occurrence of lines having a particular word in it

```
val textFile = sc.textFile("file:/home/cloudera/datasets/Joyce.txt")

textFile.count() //Return the number of elements in the dataset
```

```
16/08/30 09:34:43 INFO executor.Executor: Finished task 0.0 in stage 59.0 (TID 136). 2082 bytes result sent
to driver
16/08/30 09:34:43 INFO scheduler.DAGScheduler: ResultStage 59 (count at <console>:24) finished in 2.238 s
16/08/30 09:34:43 INFO scheduler.DAGScheduler: Job 41 finished: count at <console>:24, took 2.310447 s
res45: Long = 33056
```

```
textFile.first() //Return the first element of the dataset
```

```
16/08/30 09:35:03 INFO executor.Executor: Finished task 0.0 in stage 60.0 (TID 137). 2101 bytes result sent
to driver
16/08/30 09:35:03 INFO scheduler.DAGScheduler: ResultStage 60 (first at <console>:24) finished in 0.035 s
16/08/30 09:35:03 INFO scheduler.DAGScheduler: Job 42 finished: first at <console>:24, took 0.091601 s
res46: String = The Project Gutenberg EBook of Ulysses, by James Joyce
```

```
val linesWithJoyce = textFile.filter(line => line.contains("Joyce"))

linesWithJoyce.count() //How many lines contains "Joyce"
```

```
16/08/30 09:35:26 INFO executor.Executor: Finished task 0.0 in stage 61.0 (TID 138). 2082 bytes result sent
to driver
16/08/30 09:35:26 INFO scheduler.DAGScheduler: ResultStage 61 (count at <console>:26) finished in 0.064 s
16/08/30 09:35:26 INFO scheduler.DAGScheduler: Job 43 finished: count at <console>:26, took 0.094628 s
res47: Long = 4
```

Example: Add up the sizes of all the lines

```
val lineLength = textFile.map(s => s.length)

val totalLength = lineLength.reduce((a, b) => a + b) //Aggregate the
elements of the dataset using a function
```

```
16/08/30 09:40:54 INFO executor.Executor: Finished task 0.0 in stage 62.0 (TID 139). 2160 bytes result sent
to driver
16/08/30 09:40:54 INFO scheduler.DAGScheduler: ResultStage 62 (reduce at <console>:31) finished in 0.262 s
16/08/30 09:40:54 INFO scheduler.DAGScheduler: Job 44 finished: reduce at <console>:31, took 0.337723 s
totalLength: Int = 1506967
```

Example: To find out the line with maximum words

```
textFile.map(line => line.split(" ").size).reduce((a,b) => if(a>b) a else
b)
```

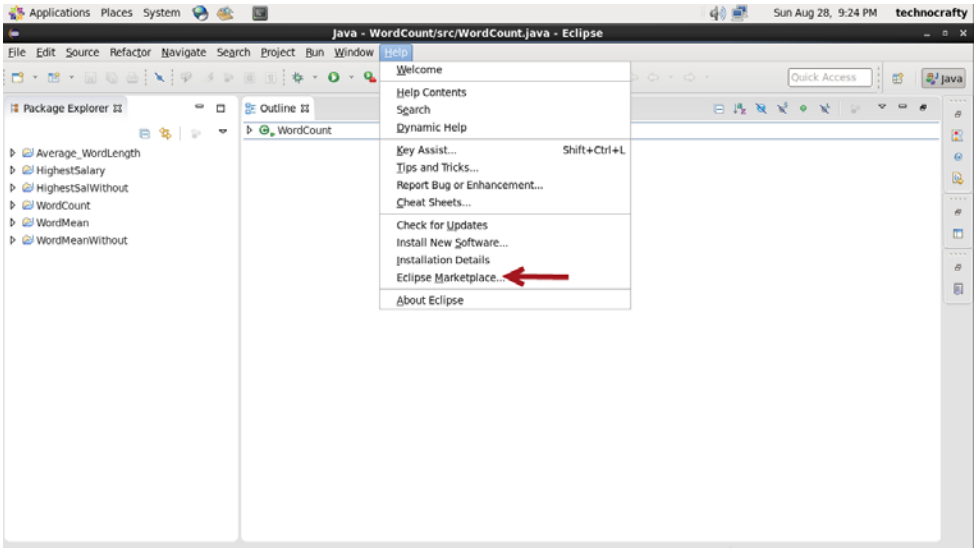
```
16/08/30 09:41:48 INFO executor.Executor: Finished task 0.0 in stage 63.0 (TID 140). 2160 bytes result sent
to driver
16/08/30 09:41:48 INFO scheduler.DAGScheduler: ResultStage 63 (reduce at <console>:30) finished in 1.048 s
16/08/30 09:41:48 INFO scheduler.DAGScheduler: Job 45 finished: reduce at <console>:30, took 1.070554 s
res48: Int = 22
```

Exercise 5: Building Spark Application using Eclipse IDE

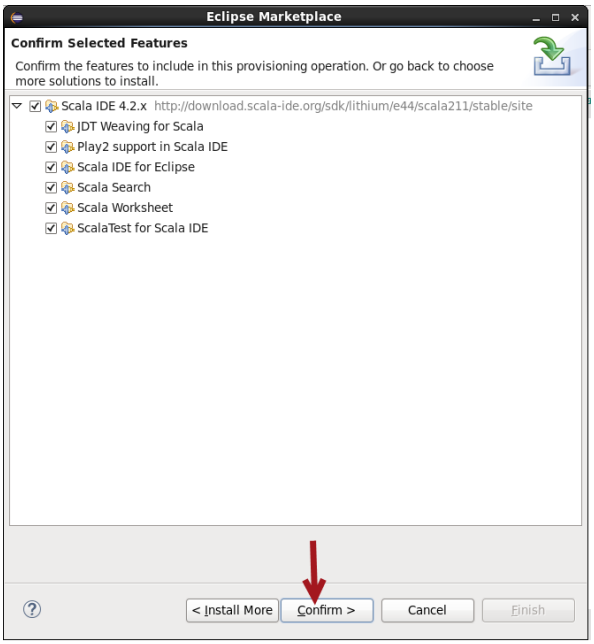
Goal: Create a scala project for Spark. Use maven for lib management.

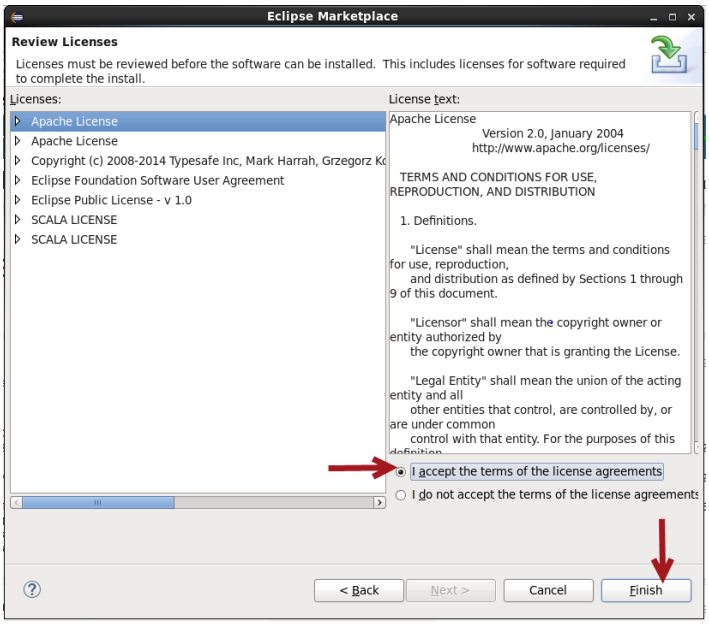
1. Install Scala IDE for Eclipse from Eclipse Marketplace

Note: Scala IDE is already installed for this training.


Applications Places System
Sun Aug 28, 9:24 PM technocrafty
Java - WordCount/src/WordCount.java - Eclipse
File Edit Source Refactor Navigate Search Project Run Window Help
Welcome
Help Contents
Search
Dynamic Help
Key Assist... Shift+Ctrl+L
Tips and Tricks...
Report Bug or Enhancement...
Cheat Sheets...
Check for Updates
Install New Software...
Installation Details
Eclipse Marketplace...
About Eclipse
Package Explorer
Average_WordLength
HighestSalary
HighestSalWithout
WordCount
WordMean
WordMeanWithout
Outline
WordCount

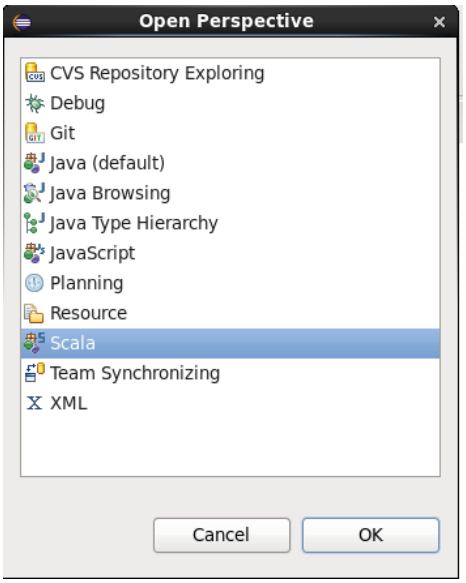

Eclipse Marketplace
Eclipse Marketplace
Select solutions to install. Press Finish to proceed with installation.
Press the information button to see a detailed overview and a link to more information.
Search Recent Popular Installed August Newsletter
Find: Scala IDE
All Markets
All Categories
Go
Scala IDE 4.2.x
The Scala IDE for Eclipse is centered around seamless integration with the Eclipse Java tools, providing many of the features Eclipse users have come to expect... more info
by scala-ide.org, BSD
scala functional programming fileExtension_scala
61
Installs: 103K (4,457 last month)
Install
Scalastyle 0.7.0
Scalastyle examines your Scala code and indicates potential problems with it. If you have come across Checkstyle for Java, then you'll have a good idea what... more info
by Scalastyle, Apache 2.0
Marketplaces
< Back
Install Now >
Cancel
Finish



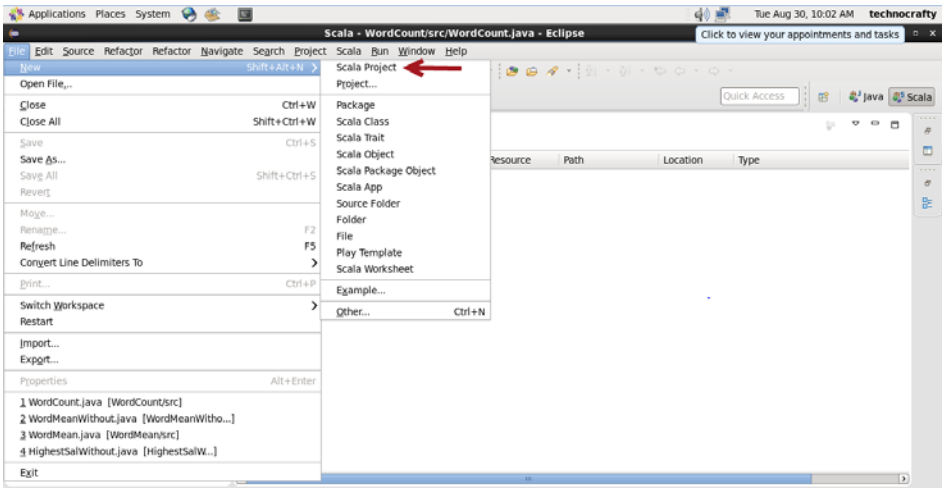


2. Switch to Scala perspective.

Window > Perspectives > Open Perspective > Other ... > Scala > *Click OK*



3. Create new Scala Project using the menu bar option File > New > Scala Project. Give a name of your choice for the project.

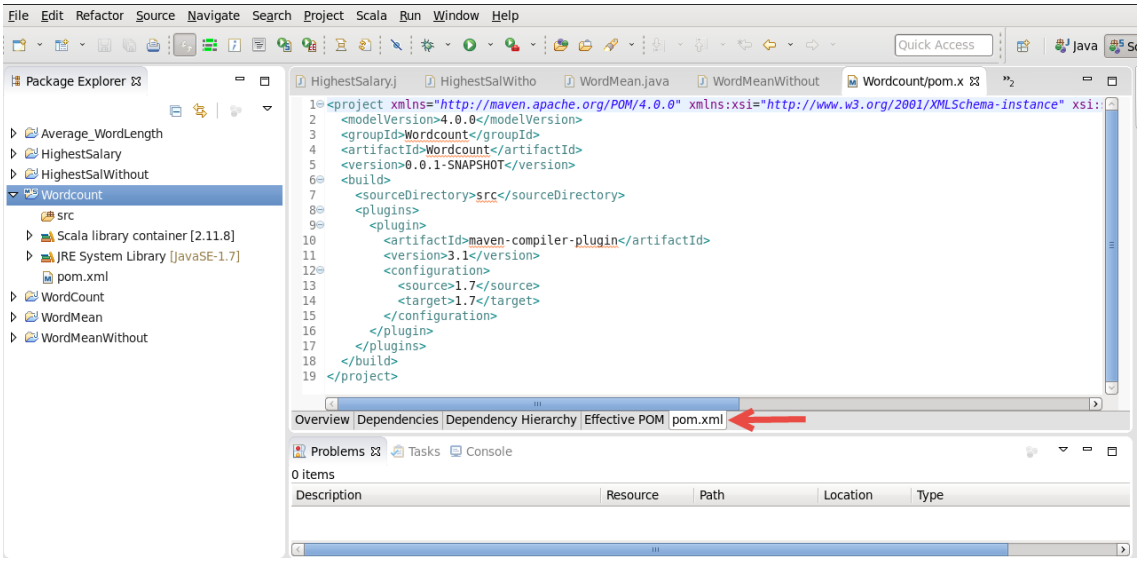


4. Right click on the project and configure it as a Maven project. No need change any configuration, however group Id usually takes form like com.mycompany.projectname.

5. Spark 1.6 is supported on Scala 2.10. So set Scala library to version 2.10. *Right Click* > Configure > Convert to Maven Project.

6. Update the maven pom.xml with the following dependences. Keep other content of pom xml as is. Remember to add the below content right under the xml root called *<project>.*

```
<properties>
 <sparkVersion>1.6.1</sparkVersion>
 <scalaVersion>2.10</scalaVersion>
 </properties>
 <packaging>jar</packaging>
 <dependencies>
 <dependency>
 <groupId>org.apache.spark</groupId>
 <artifactId>spark-core_${scalaVersion}</artifactId>
 <version>${sparkVersion}</version>
 <scope>provided</scope>
 </dependency>
 <dependency>
 <groupId>org.apache.spark</groupId>
 <artifactId>spark-streaming_${scalaVersion}</artifactId>
 <version>${sparkVersion}</version>
 </dependency>
 <dependency>
 <groupId>org.apache.spark</groupId>
 <artifactId>spark-sql_${scalaVersion}</artifactId>
 <version>${sparkVersion}</version>
 </dependency>
<dependency>
<groupId>org.apache.spark</groupId>
<artifactId>spark-mllib_${scalaVersion}</artifactId>
<version>${sparkVersion}</version>
</dependency>
<dependency>
<groupId>org.apache.spark</groupId>
<artifactId>spark-graphx_${scalaVersion}</artifactId>
<version>${sparkVersion}</version>
</dependency>
 </dependencies>
```



7. Now add a new Scala object file "Sample" to project.

```scala
import org.apache.spark.{SparkContext, SparkConf}


object WordCount {
  def main(args: Array[String]): Unit = {

    val conf = new SparkConf()

    conf.setAppName("sample demo")
    conf.setMaster("local[*]")
    val sc = new SparkContext(conf)
    sc.textFile("/user/cloudera/spark/wordCount/input").
      flatMap(_.split("\\W+")).
      filter(_.length > 0).
      map((_, 1)).
      reduceByKey(_+_).
      saveAsTextFile("/user/cloudera/spark/wordCount/output")
  }
}


```

8. Select the file and run it locally from Menu bar Run > Run. This step creates a build configuration. You might fails complaining that input does not exist, that is fine.

Now create a input directory and create a test file inside it. Refresh the project. If you find a folder called "output", delete it and delete it before every time you try to run the program again from Eclipse.

9. Now, right click on the project select Run As > Maven Install. This will create a jar file and place under the "target" folder. You have refresh the project to see the jar file.

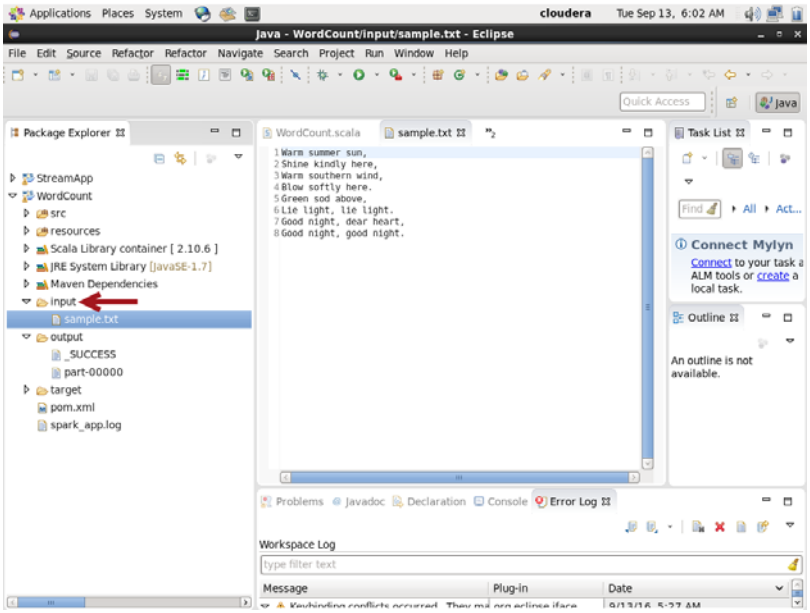
10. Take this jar and submit using spark-submit command

```
cd /usr/lib/spark/bin

./spark-submit --class WordCount
/home/cloudera/Desktop/Spark/Code/WordCount/target/WordCount-0.0.1-
SNAPSHOT.jar
```

```
[cloudera@quickstart target]$ spark-submit --class WordCount --master local[*] W
ordCount-0.0.1-SNAPSHOT.jar --verbose
Usage: WordCount <input path> <output path>
```

Input



Output

```
[cloudera@quickstart bin]$ hdfs dfs -cat /user/cloudera/spark/wordCount/output/part-00000
(summer,1)
(Warm,2)
(above,1)
(Blow,1)
(softly,1)
(here,2)
(wind,1)
(lie,1)
(Lie,1)
(night,3)
(southern,1)
(light,2)
(Shine,1)
(dear,1)
(sod,1)
(good,1)
(kindly,1)
(Good,2)
(Green,1)
(heart,1)
(sun,1)
```

Note: Ensure to remove output folder every time you run the program.

Additional Configuration for Logging

Create directory "resources" and log4j.properties file inside it with the following content.

```
log4j.rootLogger=INFO,console,file
```

```
log4j.appender.console=org.apache.log4j.ConsoleAppender

log4j.appender.console.Threshold=WARN

log4j.appender.console.target=System.err

log4j.appender.console.layout=org.apache.log4j.PatternLayout

log4j.appender.console.layout.ConversionPattern=%d{yy/MM/dd HH:mm:ss} %p %c{
2}: %m%n



log4j.appender.file=org.apache.log4j.RollingFileAppender

log4j.appender.file.Threshold=INFO

log4j.appender.file.File=spark_app.log

log4j.appender.file.MaxFileSize=10MB

log4j.appender.file.MaxBackupIndex=10

log4j.appender.file.layout=org.apache.log4j.PatternLayout

log4j.appender.file.layout.ConversionPattern=%d{yyyy-MM-dd HH:mm:ss} %-
5p %c{1}:%L - %m%n
```

Right click on the resources folder > Build Path > Use As Source Folder

Now, if you run the above WordCount.scala program again, you will see less debug message. You can control using log handler "file" and "console".

Additional Exercise

Analyze Movie Lens Dataset using RDD

Source: http://grouplens.org/datasets/movielens/

Objective: What are the occupations of the users who have rated the iconic movie Titanic as 5?

Information about Dataset:

RATINGS FILE DESCRIPTION

All ratings are contained in the file "**ratings.dat**" and are in the following format:

UserID::MovieID::Rating::Timestamp

UserIDs range between 1 and 6040

MovieIDs range between 1 and 3952

Ratings are made on a 5-star scale (whole-star ratings only)

Timestamp is represented in seconds since the epoch as returned by time(2)

Each user has at least 20 ratings

USERS FILE DESCRIPTION

User information is in the file "**users.dat**" and is in the following format:

UserID::Gender::Age::Occupation::Zip-code

All demographic information is provided voluntarily by the users and is not checked for accuracy. Only users who have provided some demographic information are included in this data set.

Gender is denoted by a "M" for male and "F" for female

Age is chosen from the following ranges:

1: "Under 18"

18: "18-24"

25: "25-34"

35: "35-44"

45: "45-49"

50: "50-55"

56: "56+"

Occupation is chosen from the following choices:

0: "other" or not specified

1: "academic/educator"

2: "artist"

3: "clerical/admin"

4: "college/grad student"

5: "customer service"

6: "doctor/health care"

7: "executive/managerial"

8: "farmer"

9: "homemaker"

10: “K-12 student”

11: “lawyer”

12: “programmer”

13: “retired”

14: “sales/marketing”

15: “scientist”

16: “self-employed”

17: “technician/engineer”

18: “tradesman/craftsman”

19: “unemployed”

20: “writer”

MOVIES FILE DESCRIPTION

Movie information is in the file “**movies.dat**” and is in the following format:

MovieID::Title::Genres

Titles are identical to titles provided by the IMDB (including year of release)

Genres are pipe-separated and are selected from the following genres:

Action, Adventure, Animation, Children's, Comedy, Crime, Documentary, Drama, Fantasy, Film-Noir, Horror, Musical, Mystery, Romance, Sci-Fi, Thriller, War, Western

Steps:

Load the files ‘movies.dat’, ‘users.dat’ and ‘ratings.dat’ into HDFS from local filesystem

1. Create 3 RDD for movies, users and ratings respectively

```
val movies = sc.textFile("file:/home/cloudera/datasets/movies.dat")
val users = sc.textFile("file:/home/cloudera/datasets/users.dat")
val ratings =
sc.textFile("file:/home/cloudera/datasets/ratings.dat")
```

2. Print first 10 lines from the movies rdd

```
movies.take(10).foreach(println)
```

```
16/08/31 23:41:52 INFO scheduler.DAGScheduler: Job 0 finished: take at <console>
:24, took 1.564272 s
1::Toy Story (1995)::Animation|Children's|Comedy
2::Jumanji (1995)::Adventure|Children's|Fantasy
3::Grumpier Old Men (1995)::Comedy|Romance
4::Waiting to Exhale (1995)::Comedy|Drama
5::Father of the Bride Part II (1995)::Comedy
6::Heat (1995)::Action|Crime|Thriller
7::Sabrina (1995)::Comedy|Romance
8::Tom and Huck (1995)::Adventure|Children's
9::Sudden Death (1995)::Action
10::GoldenEye (1995)::Action|Adventure|Thriller
```

3. Find out the id of the movie Titanic

```
movies.filter{_.contains("Titanic")}.collect
```

```
16/08/31 23:42:52 INFO scheduler.TaskSchedulerImpl: Removed TaskSet 1.0, whose t
asks have all completed, from pool
res1: Array[String] = Array(1721::Titanic (1997)::Drama|Romance, 2157::Chamberma
id on the Titanic, The (1998)::Romance, 3403::Raise the Titanic (1980)::Drama|Th
riller, 3404::Titanic (1953)::Action|Drama)
```

4. Print 10 lines from ratings RDD

```
ratings.take(10).foreach(println)
```

```
16/08/31 23:43:47 INFO scheduler.TaskSchedulerImpl: Removed TaskSet 2.0, whose t
asks have all completed, from pool
1::1193::5::978300760
1::661::3::978302109
1::914::3::978301968
1::3408::4::978300275
1::2355::5::978824291
1::1197::3::978302268
1::1287::5::978302039
1::2804::5::978300719
1::594::4::978302268
1::919::4::978301368
```

5. Create a filtered rdd based on the users who have rated Titanic as 1

```
val titanicRating1 = ratings.map(_.split("::")).filter{rec =>
rec(0).toInt == 1721 && rec(2).toInt == 5}
```

```
titanicRating1.take(10).foreach(rec => println(rec.mkString("\t")))
```

```
16/08/31 23:44:48 INFO scheduler.TaskSchedulerImpl: Removed TaskSet 3.0, whose t
asks have all completed, from pool
1721    3087    5       974709030
1721    1485    5       974706178
1721    3247    5       974706026
1721    2463    5       974708897
1721    2321    5       974707939
1721    1569    5       974706315
1721    3397    5       974708938
1721    2918    5       974708773
```

6. Convert the previous RDD by assigning user id as key

```
val byUser = titanicRating1.keyBy(_(1))

byUser.take(3)
```

```
res4: Array[(String, Array[String])] = Array((3087,Array(1721, 3087, 5, 97470903
0)), (1485,Array(1721, 1485, 5, 974706178)), (3247,Array(1721, 3247, 5, 97470602
6)))
```

7. Show some sample values from users rdd

```
users.take(10).foreach(println)
```

```
16/08/31 23:47:02 INFO scheduler.TaskSchedulerImpl: Removed TaskSet 5.0, whose t
asks have all completed, from pool
1::F::1::10::48067
2::M::56::16::70072
3::M::25::15::55117
4::M::45::7::02460
5::M::25::20::55455
6::F::50::9::55117
7::M::35::1::06810
8::M::25::12::11413
9::M::25::17::61614
10::F::35::1::95370
```

8. Create pair RDD pairRddUsers from users rdd using userid as key

```
val pairRddUsers = users.keyBy(_.split("::")(0))

pairRddUsers.take(3)
```

```
16/08/31 23:47:53 INFO scheduler.DAGScheduler: Job 6 finished: take at <console>
:26, took 0.354851 s
res6: Array[(String, String)] = Array((1,1::F::1::10::48067), (2,2::M::56::16::7
0072), (3,3::M::25::15::55117))
```

9. Join the last Pair RDD to users RDD

```
val rddJoined = byUser.join(pairRddUsers)

rddJoined.take(3)
```

```
16/08/31 23:49:35 INFO scheduler.TaskSchedulerImpl: Removed TaskSet 9.0, whose t
asks have all completed, from pool
res7: Array[(String, (Array[String], String))] = Array((3247,(Array(1721, 3247,
5, 974706026),3247::M::35::15::92649)), (3397,(Array(1721, 3397, 5, 974708938),3
397::M::25::5::55414)), (1485,(Array(1721, 1485, 5, 974706178),1485::F::25::9::8
0538)))
```

10. Extract the occupations of the users from the joined RDD

```
rddJoined.map(_._2._2.split("::")(3)).distinct.collect
```

```
16/08/31 23:50:12 INFO scheduler.DAGScheduler: Job 8 finished: collect at <conso
le>:34, took 1.229909 s
res8: Array[String] = Array(7, 15, 5, 9, 12, 13, 1)
```

Assignment:

Objective: Using above transformation and action, Analyse Crime Data from San Francisco Police Department.

Steps:

1. Create an RDD with crime incident data.
2. Take first five records of RDD created and print the same.
3. Reference each field with an index map.
4. Show the first value of an RDD.
5. Check number of partition.

6. Capture the line containing header in RDD.
7. Create an RDD with only records eliminating the header.
8. Find the number of incident records?
9. List all the categories from incident data?
10. Find total number of categories?
11. What are the total number of incidents in each category?
12. Find out on which day each of incidents occurred most?

Exercise 6: Dataframe and Spark SQL

Two ways to create Spark Dataframes:

1. Create from an existing RDD
2. Create from other data sources

Creating DataFrames from Existing RDD:

1. Infer schema by Reflection
   a. Convert RDD containing case classes.
   b. Use when schema is known.

2. Construct schema programmatically
   a. Schema is dynamic
   b. Number of fields in case class is more than 22 fields.

Infer schema by Reflection (case class)

Steps:

1. Import necessary classes
2. Create RDD
3. Define case class
4. Convert RDD into RDD of case objects.
5. Implicitly covert resulting RDD of case objects into DataFrames.
6. Register DataFrame as table.

Exercise: Analyze SFPD Crime Dataset using Spark Dataframes.

1. Upload the file 'crime_incidents.csv' from datasets directory on local filesystem to HDFS.

2. Create a base RDD from the file 'crime_incidents'.

```
val rdd =
sc.textFile("file:/home/cloudera/datasets/crime_incidents.csv")

rdd.take(5).foreach(println)
```

```
IncidntNum,Category,Descript,DayOfWeek,Date,Time,PdDistrict,Resolution,Address,X
,Y,Location
050436712,ASSAULT,BATTERY,Wednesday,04/20/2005 12:00:00 AM,04:00,MISSION,NONE,18
TH ST / CASTRO ST,-122.435002864271,37.7608878061245,"(37.7608878061245, -122.43
5002864271)"
080049078,LARCENY/THEFT,GRAND THEFT FROM A BUILDING,Sunday,01/13/2008 12:00:00 A
M,18:00,PARK,NONE,1100 Block of CLAYTON ST,-122.446837820235,37.7622550270122,"(
37.7622550270122, -122.446837820235)"
130366639,ASSAULT,AGGRAVATED ASSAULT WITH A KNIFE,Sunday,05/05/2013 12:00:00 AM,
04:10,INGLESIDE,"ARREST, BOOKED",0 Block of SGTJOHNVYOUNG LN,-122.444707063455,3
7.7249307267936,"(37.7249307267936, -122.444707063455)"
030810835,DRIVING UNDER THE INFLUENCE,DRIVING WHILE UNDER THE INFLUENCE OF ALCOH
OL,Tuesday,07/08/2003 12:00:00 AM,01:00,SOUTHERN,"ARREST, BOOKED",MASON ST / TUR
K ST,-122.408953598286,37.7832878735491,"(37.7832878735491, -122.408953598286)"
```

3. Cache the RDD since we are going to process is several times

```
rdd.cache

rdd.count
```

```
16/09/01 02:32:12 INFO scheduler.DAGScheduler: Job 1 finished: count at <console
>:24, took 13.574773 s
res2: Long = 1888568
```

4. Create a filtered RDD by removing the headers

```
val data = rdd.filter(line => !line.startsWith("IncidntNum"))

data.take(5).foreach(println)
```

```
16/09/01 02:33:04 INFO scheduler.TaskSchedulerImpl: Removed TaskSet 2.0, whose t
asks have all completed, from pool
050436712,ASSAULT,BATTERY,Wednesday,04/20/2005 12:00:00 AM,04:00,MISSION,NONE,18
TH ST / CASTRO ST,-122.435002864271,37.7608878061245,"(37.7608878061245, -122.43
5002864271)"
080049078,LARCENY/THEFT,GRAND THEFT FROM A BUILDING,Sunday,01/13/2008 12:00:00 A
M,18:00,PARK,NONE,1100 Block of CLAYTON ST,-122.446837820235,37.7622550270122,"(
37.7622550270122, -122.446837820235)"
130366639,ASSAULT,AGGRAVATED ASSAULT WITH A KNIFE,Sunday,05/05/2013 12:00:00 AM,
04:10,INGLESIDE,"ARREST, BOOKED",0 Block of SGTJOHNVYOUNG LN,-122.444707063455,3
7.7249307267936,"(37.7249307267936, -122.444707063455)"
030810835,DRIVING UNDER THE INFLUENCE,DRIVING WHILE UNDER THE INFLUENCE OF ALCOH
OL,Tuesday,07/08/2003 12:00:00 AM,01:00,SOUTHERN,"ARREST, BOOKED",MASON ST / TUR
K ST,-122.408953598286,37.7832878735491,"(37.7832878735491, -122.408953598286)"
130839567,OTHER OFFENSES,TRAFFIC VIOLATION ARREST,Friday,10/04/2013 12:00:00 AM,
20:53,TENDERLOIN,"ARREST, BOOKED",TURK ST / LEAVENWORTH ST,-122.414056291891,37.
7827931071006,"(37.7827931071006, -122.414056291891)"
```

5. Parse the data using regex. Regex allows to handle fields that contain the field seperators comma

```
val pattern = """([^"]*)"|(?<=,|^)([^,]*)(?=,|$)""".r

val dataParsed = data.map(pattern.findAllIn(_).toArray)

dataParsed.take(5).foreach(rec => println(rec.mkString(",")))
```

```
16/09/01 02:34:42 INFO scheduler.TaskSchedulerImpl: Removed TaskSet 3.0, whose t
asks have all completed, from pool
050436712,ASSAULT,BATTERY,Wednesday,04/20/2005 12:00:00 AM,04:00,MISSION,NONE,18
TH ST / CASTRO ST,-122.435002864271,37.7608878061245,"(37.7608878061245, -122.43
5002864271)"
080049078,LARCENY/THEFT,GRAND THEFT FROM A BUILDING,Sunday,01/13/2008 12:00:00 A
M,18:00,PARK,NONE,1100 Block of CLAYTON ST,-122.446837820235,37.7622550270122,"(
37.7622550270122, -122.446837820235)"
130366639,ASSAULT,AGGRAVATED ASSAULT WITH A KNIFE,Sunday,05/05/2013 12:00:00 AM,
04:10,INGLESIDE,"ARREST, BOOKED",0 Block of SGTJOHNVYOUNG LN,-122.444707063455,3
7.7249307267936,"(37.7249307267936, -122.444707063455)"
030810835,DRIVING UNDER THE INFLUENCE,DRIVING WHILE UNDER THE INFLUENCE OF ALCOH
OL,Tuesday,07/08/2003 12:00:00 AM,01:00,SOUTHERN,"ARREST, BOOKED",MASON ST / TUR
K ST,-122.408953598286,37.7832878735491,"(37.7832878735491, -122.408953598286)"
130839567,OTHER OFFENSES,TRAFFIC VIOLATION ARREST,Friday,10/04/2013 12:00:00 AM,
20:53,TENDERLOIN,"ARREST, BOOKED",TURK ST / LEAVENWORTH ST,-122.414056291891,37.
7827931071006,"(37.7827931071006, -122.414056291891)"
```

Create Dataframe using case class objects

6. Create a case class that we will capsulate the incident records into

```
case class Incident(

    IncidntNum:String,

    Category:String,
```

```
    Description:String,
    DayOfWeek:String,
    DateOfIncident:String,
    TimeOfIncident:String,
    PdDistrict:String,
    Resolution:String,
    Address:String,
    X:String,
    Y:String,
    Location:String)
```

7. Create a new rdd from dataParsed by converting the records into case class objects

```
val incidentCaseObjects = dataParsed.map(rec => Incident(rec(0),
rec(1), rec(2), rec(3), rec(4), rec(5), rec(6), rec(7), rec(8),
rec(9), rec(10), rec(11)))
incidentCaseObjects.take(5).foreach(println)
```

8. Convert the rdd of the case class objects into a dataframe

```
val incidentsDF = incidentCaseObjects.toDF
incidentsDF.show
```

```
incidentsDF: org.apache.spark.sql.DataFrame = [IncidntNum: string, Category: string, Description: string, DayOfWeek: string, DateOfIncident: string, TimeOfIncident: string, PdDistrict: string, Resolution: string, Address: string, X: string, Y: string, Location:
 string]
+---------+----------------+--------------------+---------+--------------+--------------+----------+--------------------+--------------------+--------------+--------------+--------------------+
|IncidntNum|        Category|         Description|DayOfWeek|DateOfIncident|TimeOfIncident|PdDistrict|          Resolution|             Address|             X|             Y|            Location|
+---------+----------------+--------------------+---------+--------------+--------------+----------+--------------------+--------------------+--------------+--------------+--------------------+
| 050436712|         ASSAULT|             BATTERY|Wednesday|04/20/2005 12:00:...|         04:00|   MISSION|                NONE| 18TH ST / CASTRO ST|-122.435002064271|37.7608878061245|"(37.760887806124...|
| 080049078|   LARCENY/THEFT|GRAND THEFT FROM ...|   Sunday|01/13/2008 12:00:...|         18:00|      PARK|                NONE|1100 Block of CLA...|-122.446837020235|37.7622550270122|"(37.762255027012...|
| 130366639|         ASSAULT|AGGRAVATED ASSAUL...|   Sunday|05/05/2013 12:00:...|         04:10| INGLESIDE|    "ARREST, BOOKED"|0 Block of SGTJOH...|-122.444707063455|37.7249307267936|"(37.724930726793...|
| 030810835|DRIVING UNDER THE...|DRIVING WHILE UND...|  Tuesday|07/08/2003 12:00:...|         01:00|  SOUTHERN|    "ARREST, BOOKED"|  MASON ST / TURK ST|-122.408953598286|37.7832878735491|"(37.783287873549...|
| 130839567|   OTHER OFFENSES|TRAFFIC VIOLATION...|   Friday|10/04/2013 12:00:...|         20:53|TENDERLOIN|    "ARREST, BOOKED"|TURK ST / LEAVENW...|-122.414056291891|37.7827931071006|"(37.782793107100...|
| 070838580|         BURGLARY|"BURGLARY OF APAR...|  Tuesday|08/14/2007 12:00:...|         07:00|  NORTHERN|                NONE|3100 Block of FRA...|-122.426730544229|37.8034674969672|"(37.803467496967...|
| 080233102|   DRUG/NARCOTIC|POSSESSION OF MAR...|  Tuesday|03/04/2008 12:00:...|         14:23| INGLESIDE|     "ARREST, CITED"|MISSION ST / PERS...| -122.43597721703|37.7231288306727|"(37.723128830672...|
| 060711805|   OTHER OFFENSES|"DRIVERS LICENSE,...|Wednesday|07/05/2006 12:00:...|         15:50| INGLESIDE|     "ARREST, CITED"|2300 Block of SAN...|-122.447241159611|37.7201577971255|"(37.720157797125...|
| 040062593|   LARCENY/THEFT|GRAND THEFT FROM ...|Wednesday|12/10/2003 12:00:...|         09:30| INGLESIDE|                NONE|0 Block of MOFFIT...|-122.432787775164|37.7371566745272|"(37.737156674527...|
| 110051822|     NON-CRIMINAL|"STAY AWAY OR COU...|   Monday|01/17/2011 12:00:...|         15:35| INGLESIDE|                NONE|600 Block of CAMP...|-122.408761072232|37.7159000951041|"(37.715900095104...|
| 060027038|   LARCENY/THEFT|GRAND THEFT FROM ...| Saturday|01/07/2006 12:00:...|         22:00|  NORTHERN|                NONE|100 Block of HEML...|-122.420815202607|37.7872360476925|"(37.787236047692...|
| 110929398|   LARCENY/THEFT| PETTY THEFT BICYCLE|   Sunday|11/13/2011 12:00:...|         18:00|   MISSION|                NONE|3000 Block of 22N...|-122.416014728293|37.7555464259209|"(37.755546425920...|
```

9. Use Dataframe API to run analytics on dataframe

```
incidentsDF.groupBy($"Category").count().sort($"count".desc).show
```

```
+--------------------+------+
|            Category| count|
+--------------------+------+
|       LARCENY/THEFT|385774|
|      OTHER OFFENSES|269250|
|        NON-CRIMINAL|200942|
|             ASSAULT|165324|
|       VEHICLE THEFT|114258|
|       DRUG/NARCOTIC|111436|
|           VANDALISM| 96350|
|            WARRANTS| 89782|
|            BURGLARY| 78968|
|      SUSPICIOUS OCC| 67788|
|      MISSING PERSON| 55584|
|             ROBBERY| 48713|
|               FRAUD| 36004|
|FORGERY/COUNTERFE...| 21804|
```

10. Cache the dataframe and compare the size of the dataframe in memory with that of the rdd cached earlier

```
incidentsDF.cache

incidentsDF.count
```

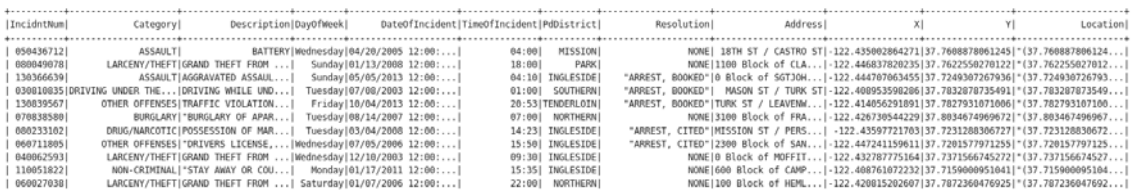
```
res91: incidentsDF.type = [IncidntNum: string, Category: string, Description: string, DayOfWeek: string, DateOfIncident:
res92: Long = 1888567
```

11. Register the data frame as temporary table in Spark SQL

```
incidentsDF.registerTempTable("incidents")
```

12. Run SQL query on top of newly created table

```
sqlContext.sql("select * from incidents").show
```



IncidntNum	Category	Description	DayOfWeek	DateOfIncident	TimeOfIncident	PdDistrict	Resolution	Address	X	Y	Location
050436712	ASSAULT	BATTERY	Wednesday	04/20/2005 12:00:...	04:00	MISSION	NONE	18TH ST / CASTRO ST	-122.435002864271	37.7608878061245	"(37.7608878061246...
080049078	LARCENY/THEFT	GRAND THEFT FROM ...	Sunday	01/13/2008 12:00:...	18:00	PARK	NONE	1100 Block of CLA...	-122.446837020235	37.7622550270122	"(37.7622550270122...
130366639	ASSAULT	AGGRAVATED ASSAUL...	Sunday	05/05/2013 12:00:...	04:10	INGLESIDE	"ARREST, BOOKED"	0 Block of SGTJOH...	-122.444707063455	37.7249307267936	"(37.7249307267936...
030810035	DRIVING UNDER THE...	DRIVING WHILE UND...	Tuesday	07/08/2003 12:00:...	01:00	SOUTHERN	"ARREST, BOOKED"	MASON ST / TURK ST	-122.408953590206	37.783287873549	"(37.783287873549...
130839567	OTHER OFFENSES	TRAFFIC VIOLATION...	Friday	10/04/2013 12:00:...	20:53	TENDERLOIN	"ARREST, BOOKED"	TURK ST / LEAVENW...	-122.414056291891	37.7827931071066	"(37.7827931071066...
070838580	BURGLARY	"BURGLARY OF APAR...	Tuesday	08/14/2007 12:00:...	07:00	NORTHERN	NONE	3100 Block of FRA...	-122.426730544229	37.8034674969672	"(37.8034674969672...
080233102	DRUG/NARCOTIC	POSSESSION OF MAR...	Tuesday	03/04/2008 12:00:...	14:23	INGLESIDE	"ARREST, CITED"	MISSION ST / PERS...	-122.435977217035	37.7231288306727	"(37.7231288306727...
060711805	OTHER OFFENSES	"DRIVERS LICENSE,...	Wednesday	07/05/2006 12:00:...	15:50	INGLESIDE	"ARREST, CITED"	2300 Block of SAN...	-122.447241159611	37.7201577971255	"(37.7201577971255...
040062593	LARCENY/THEFT	GRAND THEFT FROM ...	Wednesday	12/10/2003 12:00:...	09:30	INGLESIDE	NONE	0 Block of MOFFIT...	-122.432787775164	37.7371566745272	"(37.7371566745272...
110051822	NON-CRIMINAL	"STAY AWAY OR COU...	Monday	01/17/2011 12:00:...	15:35	INGLESIDE	NONE	600 Block of CAMP...	-122.408761072232	37.7159000951041	"(37.7159000951041...
060027038	LARCENY/THEFT	GRAND THEFT FROM ...	Saturday	01/07/2006 12:00:...	22:00	NORTHERN	NONE	100 Block of HEML...	-122.420815202607	37.7872360476925	"(37.7872360476925...

Programmatically

Steps:

1. Create an RDD of Rows from the original RDD
2. Create a schema represented by a StructType matching the structure of Rows in the RDD created in step1.
3. Create DataFrame by applying schema to Row RDD.

Create Dataframe Dynamically (…without case class objects)

1. Create a schema programmatically

```
import org.apache.spark.sql.types.{StructField, StructType,
StringType}


val schema = StructType(Array(
    StructField("IncidntNum", StringType, false),
    StructField("Category", StringType, false),
    StructField("Description", StringType, false),
    StructField("DayOfWeek", StringType, false),
    StructField("DateOfIncident", StringType, false),
    StructField("TimeOfIncident", StringType, false),
    StructField("PdDistrict", StringType, false),
    StructField("Resolution", StringType, false),
    StructField("Address", StringType, false),
    StructField("X", StringType, false),
    StructField("Y", StringType, false),
    StructField("Location", StringType, false)
))
```

2. Convert the data to RDD of Row objects

```
import org.apache.spark.sql.Row

val incidentRowObjects = dataParsed.map(rec => Row(rec(0), rec(1),
rec(2), rec(3), rec(4), rec(5), rec(6), rec(7), rec(8), rec(9),
rec(10), rec(11)))
```

3. Create the dataframe from RDD of Row objects and dynamic schema

```
val incidentsDF = sqlContext.createDataFrame(incidentRowObjects,
schema)
```

4. Use dataframe api and further, register the data frame as Spark SQL table and run SQL statements on top of it

```
incidentsDF.show
```

```
+-----------+--------------------+--------------------+---------+--------------------+-------------+----------+--------------------+--------------------+-----------------+-----------------+--------------------+
|IncidntNum|            Category|         Description|DayOfWeek|      DateOfIncident|TimeOfIncident|PdDistrict|          Resolution|             Address|                X|                Y|            Location|
+-----------+--------------------+--------------------+---------+--------------------+-------------+----------+--------------------+--------------------+-----------------+-----------------+--------------------+
| 050436712|             ASSAULT|             BATTERY|Wednesday|04/20/2005 12:00:...|        04:00|   MISSION|                NONE| 18TH ST / CASTRO ST|-122.435002864271|37.7608878061245|"(37.760887806124...|
| 080049078|       LARCENY/THEFT|GRAND THEFT FROM ...|   Sunday|01/13/2008 12:00:...|        10:00|      PARK|                NONE|1100 Block of CLA...|-122.446837020235|37.7622550270122|"(37.762255027012...|
| 130366639|             ASSAULT|AGGRAVATED ASSAUL...|   Sunday|05/05/2013 12:00:...|        04:10| INGLESIDE|    "ARREST, BOOKED"|0 Block of SGTJOH...|-122.444707063455|37.7249307267936|"(37.724930726793...|
| 030810835|DRIVING UNDER THE...|DRIVING WHILE UND...|  Tuesday|07/08/2003 12:00:...|        01:00|  SOUTHERN|    "ARREST, BOOKED"|  MASON ST / TURK ST|-122.408953598286|37.7832878735491|"(37.783287873549...|
| 130839567|      OTHER OFFENSES|TRAFFIC VIOLATION...|   Friday|10/04/2013 12:00:...|        20:53|TENDERLOIN|    "ARREST, BOOKED"|TURK ST / LEAVENW...|-122.414056291891|37.7827931071006|"(37.782793107100...|
| 070838580|            BURGLARY|"BURGLARY OF APAR...|  Tuesday|08/14/2007 12:00:...|        07:00|  NORTHERN|                NONE|3100 Block of FRA...|-122.426730544229|37.8034674969672|"(37.803467496967...|
| 080233102|       DRUG/NARCOTIC|POSSESSION OF MAR...|  Tuesday|03/04/2008 12:00:...|        14:23| INGLESIDE|     "ARREST, CITED"|MISSION ST / PERS...| -122.43597721703|37.7231288306727|"(37.723128830672...|
| 060711805|      OTHER OFFENSES|"DRIVERS LICENSE,...|Wednesday|07/05/2006 12:00:...|        15:50| INGLESIDE|     "ARREST, CITED"|2300 Block of SAN...|-122.447241159611|37.7201577971255|"(37.720157797125...|
| 040062593|       LARCENY/THEFT|GRAND THEFT FROM ...|Wednesday|12/10/2003 12:00:...|        09:30| INGLESIDE|                NONE|0 Block of MOFFIT...|-122.432787775164|37.7371566745272|"(37.737156674527...|
| 110051822|       NON-CRIMINAL|"STAY AWAY OR COU...|   Monday|01/17/2011 12:00:...|        15:35| INGLESIDE|                NONE|600 Block of CAMP...|-122.408761072232|37.7159060951041|"(37.715906095104...|
| 060027038|       LARCENY/THEFT|GRAND THEFT FROM ...| Saturday|01/07/2006 12:00:...|        22:00|  NORTHERN|                NONE|100 Block of HEML...|-122.420815202607|37.7872360476925|"(37.787236047692...|
+-----------+--------------------+--------------------+---------+--------------------+-------------+----------+--------------------+--------------------+-----------------+-----------------+--------------------+
```

UDF in Spark Dataframe

There are two type:

1. UDF for Dataframe API
2. UDF for SQL expressions

UDF for Dataframe API

1. Parse string DateOfIncident field into a time stamp

```
import java.text.SimpleDateFormat

import java.util.Locale

import java.sql.Timestamp //  Spark SQL does not support
java.util.Date


def sf = new SimpleDateFormat( "MM/dd/yyyy HH:mm:ss aaa",
Locale.ENGLISH) //Sample value: 10/04/2013 12:00:00 AM

sf.setLenient(true)


def parseDatetimeString(dateStr: String): Timestamp = {

    new Timestamp(sf.parse(dateStr).getTime)

}
```

2. Register the UDF for Dataframe API

```
import org.apache.spark.sql.functions.udf

def toTimestamp = udf(parseDatetimeString _)
```

3. Use the UDF you just created

```
incidentsDF.select($"DateOfIncident",
toTimestamp($"DateOfIncident")).show(10, false)
```

```
+---------------------+---------------------+
|DateOfIncident       |UDF(DateOfIncident)  |
+---------------------+---------------------+
|04/20/2005 12:00:00 AM|2005-04-20 12:00:00.0|
|01/13/2008 12:00:00 AM|2008-01-13 12:00:00.0|
|05/05/2013 12:00:00 AM|2013-05-05 12:00:00.0|
|07/08/2003 12:00:00 AM|2003-07-08 12:00:00.0|
|10/04/2013 12:00:00 AM|2013-10-04 12:00:00.0|
|08/14/2007 12:00:00 AM|2007-08-14 12:00:00.0|
|03/04/2008 12:00:00 AM|2008-03-04 12:00:00.0|
|07/05/2006 12:00:00 AM|2006-07-05 12:00:00.0|
|12/10/2003 12:00:00 AM|2003-12-10 12:00:00.0|
|01/17/2011 12:00:00 AM|2011-01-17 12:00:00.0|
+---------------------+---------------------+
only showing top 10 rows
```

UDF for SQL Expression

1. Register UDF for SQL expression

```
sqlContext.udf.register("toTimestamp", parseDatetimeString _)
```

2. Use UDF in SQL statements that you just created

```
sqlContext.sql("select t.IncidntNum, t.DateOfIncident,
toTimestamp(DateOfIncident) `Timestamp` from incidents t").show(10,
false)
```

Save the Dataframe to filesystem

1. Default format is 'parquet'

```
incidentsDF.write.save("/user/cloudera/datasets/incidents")
```

2. To save in 'JSON' format

```
incidentsDF.write.format("json").save
file:/home/cloudera/datasets/incidents_json")
```

Creating Dataframe from certain file format

If you want to use the spark-shell you can provide the list of packages to import dynamically in your shell with "--packages" like

```
spark-shell --packages com.databricks:spark-csv_2.10:1.4.0
```

```
val incidents = sqlContext.read.format("com.databricks.spark.csv").

options(Map("header" -> "true", "inferSchema" -> "true")).

load("file:/home/cloudera/datasets/crime_incidents.csv")

incidents.show
```

IncidntNum	DateOfIncident	Timestamp
50,436,712	04/20/2005 12:00:00 AM	2005-04-20 12:00:00.0
80,049,078	01/13/2008 12:00:00 AM	2008-01-13 12:00:00.0
130,366,639	05/05/2013 12:00:00 AM	2013-05-05 12:00:00.0
30,810,835	07/08/2003 12:00:00 AM	2003-07-08 12:00:00.0
130,839,567	10/04/2013 12:00:00 AM	2013-10-04 12:00:00.0
70,838,580	08/14/2007 12:00:00 AM	2007-08-14 12:00:00.0
80,233,102	03/04/2008 12:00:00 AM	2008-03-04 12:00:00.0
60,711,805	07/05/2006 12:00:00 AM	2006-07-05 12:00:00.0

Additional Exercise: Creating Dataframe from csv file format

```
// Getting Started with DataFrames!
val df = sqlContext.read.format("com.databricks.spark.csv").
options(Map("header" -> "true", "inferSchema" -> "true")).
load("file:/home/cloudera/datasets/CitiGroup2006_2008")

// Get first 5 rows
df.head(5) // returns an Array
println("\n")
for(line <- df.head(10)){
  println(line)
}
// Get column names
df.columns

// Find out DataTypes
// Print Schema
df.printSchema()

// Describe DataFrame Numerical Columns
df.describe()

// Select columns .transform().action()
df.select("Volume").show()
```

```
// Multiple Columns
df.select($"Date",$"Close").show(2)


// Creating New Columns
val df2 = df.withColumn("HighPlusLow",df("High")-df("Low"))
// Show result
df2.columns
df2.printSchema()


// Recheck Head
df2.head(5)


// Renaming Columns (and selecting some more)
df2.select(df2("HighPlusLow").as("HPL"),df2("Close")).show()
```

Hands on Assignment

1. Use the Netflix_2011_2016.csv file to Answer and complete the commented tasks below!
2. Load the Netflix Stock CSV File, have Spark infer the data types.
3. What are the column names?
4. What does the Schema look like?
5. Print out the first 5 columns.
6. Use describe() to learn about the DataFrame.
7. Create a new dataframe with a column called HV Ratio that
8. is the ratio of the High Price versus volume of stock traded for a day.
9. What day had the Peak High in Price?
10. What is the mean of the Close column?
11. What is the max and min of the Volume column?
12. How many days was the Close lower than $ 600?
13. What percentage of the time was the High greater than $500 ?
14. What is the Pearson correlation between High and Volume?
15. What is the max High per year?
16. What is the average Close for each Calender Month?

Exercise 7: Spark Streaming

Let's start with simple streaming example, to count the number of words in text data received from a data server listening on a TCP socket.

Create a DStream that represents streaming data from a TCP source, specified as hostname (e.g. localhost) and port (e.g. 9999).

Create a Scala project with below inputs:

```
import org.apache.spark.SparkConf
import org.apache.spark.SparkContext._
import org.apache.spark.streaming.StreamingContext
import org.apache.spark.streaming.Seconds
import org.apache.spark.storage.StorageLevel;
import org.apache.spark.streaming.StreamingContext._
object SparkStreamReceiver {
  def main(args: Array[String]): Unit = {
    var port:Int = 9999;
    val conf = new SparkConf()
                .setMaster("local[*]")
                .setAppName("Simple spark streaming")

    val ssc = new StreamingContext(conf, Seconds(3));
    val dstream = ssc.socketTextStream("localhost", port,
StorageLevel.MEMORY_ONLY);
    val words = dstream.flatMap(_.split(" "))
    val pairs = words.map(word => (word, 1))
    val wordcounts = pairs.reduceByKey(_ + _)
    wordcounts.print();
    ssc.start();
    ssc.awaitTermination();
  }
```

```
}
```

Export the jar file i.e. StreamApp.jar

```
[cloudera@quickstart workspace]$ ls -ltr
total 28
drwxrwxr-x 5 cloudera cloudera 4096 Sep 13 06:23 Wordcount
-rw-rw-r-- 1 cloudera cloudera 6055 Sep 13 06:40 wordcount.jar
drwxrwxr-x 7 cloudera cloudera 4096 Sep 13 07:33 StreamApp
drwxrwxr-x 8 cloudera cloudera 4096 Sep 13 07:33 WordCount
-rw-rw-r-- 1 cloudera cloudera 6920 Sep 13 07:45 StreamApp.jar
[cloudera@quickstart workspace]$
```

Run the program using spark-submit

Run Netcat command and open another terminal to submit the job

```
nc -nlk 9999
```

```
[cloudera@quickstart workspace]$ nc -nlk 9999
hello world
hello hadoop
```

```
cd /usr/lib/spark/bin
```

```
spark-submit --class SparkStreamReceiver --master local[3] --verbose
/home/cloudera/Desktop/Spark/Code/StreamApp/target/StreamApp-0.0.1-
SNAPSHOT.jar
```

Any lines typed in the terminal running the netcat server will be counted and printed on screen every second. It will look something like the following

```
16/09/13 08:19:03 INFO executor.Executor: Finished task 0.0 in stage 4.0 (TID 3)
. 1312 bytes result sent to driver
16/09/13 08:19:03 INFO scheduler.TaskSetManager: Finished task 0.0 in stage 4.0
(TID 3) in 10 ms on localhost (1/1)
16/09/13 08:19:03 INFO scheduler.TaskSchedulerImpl: Removed TaskSet 4.0, whose t
asks have all completed, from pool
16/09/13 08:19:03 INFO scheduler.DAGScheduler: ResultStage 4 (print at SparkStre
amReceiver.scala:24) finished in 0.012 s
16/09/13 08:19:03 INFO scheduler.DAGScheduler: Job 2 finished: print at SparkStr
eamReceiver.scala:24, took 0.033085 s
-------------------------------------------
Time: 1473779943000 ms
-------------------------------------------
(hello,2)
(world,1)
(hadoop,1)
```