Project Assignment #2

TeraSort on Hadoop/Spark: Project report

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1. Performance:

Table 1: Performance evaluation of TeraSort

Experiment (instance/dataset)	Shared Memory TeraSort	Hadoop TeraSort	Spark TeraSort
Compute Time (sec) [1xi3.large 128GB]	*Testing With Chameleon 6GB on 1 x m1.small:* 420.01359787 sec ≒ 7 mins	51568 (Map+Reduce Tasks)	8964 sec = 2.49 hrs 9.4328796 (ea. of 954 tasks)
Data Read (GB) [1xi3.large 128GB]	6 * 2 = 12 GB	128.000792596 GB (HDFS)	128.043712512 GB
Data Write (GB) [1xi3.large 128GB]	6 * 2 = 12 GB	124 GB (HDFS)	134.18668 GB
I/O Throughput (MB/sec) [1xi3.large 128GB]	28.5705035762 MB/sec	15.48217 MB/sec	14.2842160321 MB/sec
Compute Time (sec) [1xi3.4xlarge 1TB]	*Testing With Chameleon 48GB on 1 x m1.xlarge:* 9720.363837sec ≒ 2.7hrs	407833 sec (Map+Reduce Tasks)	35820 sec = 9.95 hrs 4.8074 (ea. of 7451 tasks)
Data Read (GB) [1xi3.4xlarge 1TB]	48 * 2 = 96 GB	1000.00899236600003 GB (HDFS)	1000.056291328 GB
Data Write (GB) [1xi3.4xlarge 1TB]	48 * 2 = 96 GB	997 GB (HDFS)	1048.333509 GB
I/O Throughput (MB/sec) [1xi3.4xlarge 1TB]	9.876173527 MB/sec	17.4520 MB/sec	27.9189361063 MB/sec
Compute Time (sec) [8xi3.large 1TB]	**N/A**	61650 sec = 17.125hrs (Map+Reduce tasks)	44100 sec = 12.25hrs (7451 tasks on 8 slave nodes)
Data Read (GB) [8xi3.large 1TB]	**N/A**	1000.009655856 GB	1000.163255 GB
Data Write (GB) [8xi3.large 1TB]	**N/A**	998.2591 GB	1081.85113 GB
I/O Throughput (MB/sec) [8xi3.large 1TB]	**N/A**	16.10321507 GB	22.92270019 GB
Speedup (weak scale)	48 / 6 * (420.01359787 / 9720.363837) = 32%	1000 / 128 * (51568 / 61650) = 6.53487429035 ≒ 653.49%	1000 / 128 * (8964 / 44100) = 1000 / 128 * (8964 / 44100) 1.58801020408 ≒ 158.8%
Efficiency (weak scale)	420.01359787 / 9720.363837 = 0.04320965809 ≒ 4%	51568 / 61650 = 0.8364639092 ≒ 84%	8964 / 44100 = 0.2032653061 ≒ 20%

2. Evaluation:

For source code implementation, please check "*readme.txt*":

a. **Shared memory:**
   The speedup actually decrease to 32% which means it decrease 68% of the throughput.

b. **Hadoop:**
   The speed up is 653.49% which means it increases almost 7x times of the performance for 1 node.

c. **Spark:**
   The speed up is 158.8% which means it increases almost 2x times of the performance for 1 node.

3. Conclusion:

For these experiments, we believe that the bottleneck for these sortings are in the disk and the network (if applied). Since we are using external-sort, test file is large than our memory capacity. We have to split the file into disk. In this case, the speed of the disk will be critical. Also, with 8 nodes, network speed can also be a critical performance parameter.

For the speedup, as we can see for Table 1., the shared memory sort throughput decreases when we use larger test file on the instance with higher spec. Our team think that this may cause by the hardware of Chameleon is not faster enough or our code for shared memory needs to be optimized. Basically, we might need to improve the parallelism of our multi-processing.

On the other hand, for Hadoop and Spark, for the 8 nodes there is an performance improvement. Thus, our conclusion is with the correct configuration more nodes do increase the throughput.

4. Challenge faced:

a. AWS instance limitation for creating more than 2 instances:
   Solution: Contact the AWS support to increase our limitation.

b. Connection broken (Pipe Broken):
   Solution: Log our outputs into files.

c. The size of boot disk is comparably small (Although we are using mounted disks):
   Solution: Move the complete setup to the mounted disk.

d. Chameleon recourses insufficiently and frequent outage for long period of time:
   Solution: Wait for resources to be available.

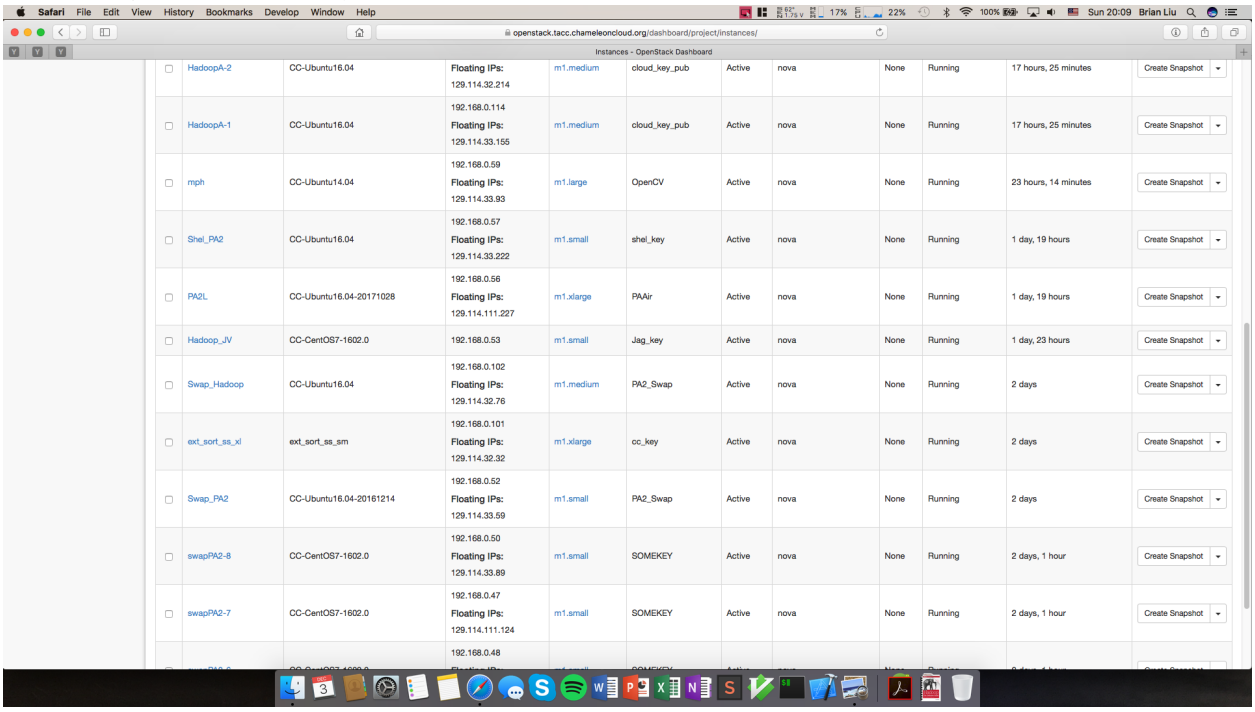
e. While launching spark cluster, it takes at least 10 minutes to launch a single node cluster:
   Solution: Wait the cluster to launch.

f. Run out of AWS credit, forced to run shared memory on Chameleon:
   Solution: Running our test on Chameleon for shared memory.

5. Appendix:

Screen Shots:

For testing shared-memory sort, we tested on Chameleon. For the rest, we used AWS:



HadoopA-2	CC-Ubuntu16.04	Floating IPs: 129.114.32.214	m1.medium	cloud_key_pub	Active	nova	None	Running	17 hours, 25 minutes	Create Snapshot
HadoopA-1	CC-Ubuntu16.04	192.168.0.114 Floating IPs: 129.114.33.155	m1.medium	cloud_key_pub	Active	nova	None	Running	17 hours, 25 minutes	Create Snapshot
mph	CC-Ubuntu14.04	192.168.0.59 Floating IPs: 129.114.33.93	m1.large	OpenCV	Active	nova	None	Running	23 hours, 14 minutes	Create Snapshot
Shel_PA2	CC-Ubuntu16.04	192.168.0.57 Floating IPs: 129.114.33.222	m1.small	shel_key	Active	nova	None	Running	1 day, 19 hours	Create Snapshot
PA2L	CC-Ubuntu16.04-20171028	192.168.0.56 Floating IPs: 129.114.111.227	m1.xlarge	PAAir	Active	nova	None	Running	1 day, 19 hours	Create Snapshot
Hadoop_JV	CC-CentOS7-1602.0	192.168.0.53	m1.small	Jag_key	Active	nova	None	Running	1 day, 23 hours	Create Snapshot
Swap_Hadoop	CC-Ubuntu16.04	192.168.0.102 Floating IPs: 129.114.32.76	m1.medium	PA2_Swap	Active	nova	None	Running	2 days	Create Snapshot
ext_sort_ss_xl	ext_sort_ss_sm	192.168.0.101 Floating IPs: 129.114.32.32	m1.xlarge	cc_key	Active	nova	None	Running	2 days	Create Snapshot
Swap_PA2	CC-Ubuntu16.04-20161214	192.168.0.52 Floating IPs: 129.114.33.59	m1.small	PA2_Swap	Active	nova	None	Running	2 days	Create Snapshot
swapPA2-8	CC-CentOS7-1602.0	192.168.0.50 Floating IPs: 129.114.33.89	m1.small	SOMEKEY	Active	nova	None	Running	2 days, 1 hour	Create Snapshot
swapPA2-7	CC-CentOS7-1602.0	192.168.0.47 Floating IPs: 129.114.111.124	m1.small	SOMEKEY	Active	nova	None	Running	2 days, 1 hour	Create Snapshot
		192.168.0.48								

1. **Virtual Cluster (1-node i3.large):**

Disk mounted:

```
ubuntu@ip-172-31-46-79:~$ lsblk -o "NAME,MAJ:MIN,RM,SIZE,RO,FSTYPE,MOUNTPOINT,UUID"
NAME    MAJ:MIN RM   SIZE RO FSTYPE MOUNTPOINT UUID
xvda    202:0    0     8G  0
└xvda1 202:1    0     8G  0 ext4   /          bf9a017a-931d-4191-84bc-b8434dbba527
nvme0n1 259:0    0 442.4G  0 ext4   /mnt       dd4fee80-1fe1-426b-b288-f69581f74eb3
ubuntu@ip-172-31-46-79:~$
```

Generate data (128GB):

```
ubuntu@ip-172-31-32-8:/mnt/TeraSort-on-Cloud$ ls -l
total 125000304
drwxrwxr-x 2 ubuntu ubuntu         4096 Dec  3 15:34 Config
-rwxrwxr-x 1 ubuntu ubuntu       141045 Dec  3 15:34 gensort
-rw-rw-r-- 1 ubuntu ubuntu         1074 Dec  3 15:34 LICENSE
-rwxrwxr-x 1 ubuntu ubuntu 128000000000 Dec  3 23:37 pinput
-rw-rw-r-- 1 ubuntu ubuntu         1115 Dec  3 15:34 README.md
drwxrwxr-x 2 ubuntu ubuntu         4096 Dec  3 19:07 Scripts
drwxrwxr-x 2 ubuntu ubuntu         4096 Dec  3 22:36 src
-rwxrwxr-x 1 ubuntu ubuntu       134558 Dec  3 15:34 valsort
```

```
ubuntu@ip-172-31-32-8:~/hadoop/etc/hadoop$ jps
11445 NodeManager
10952 DataNode
10792 NameNode
11148 SecondaryNameNode
11708 Jps
11310 ResourceManager
ubuntu@ip-172-31-32-8:~/hadoop/etc/hadoop$
```

```
ubuntu@ip-172-31-32-8:/mnt/TeraSort-on-Cloud$ hdfs dfs -ls /input
Found 1 items
-rw-r--r--   1 ubuntu supergroup 128000000000 2017-12-03 16:05 /input/pinput
ubuntu@ip-172-31-32-8:/mnt/TeraSort-on-Cloud$ sudo rm -rf pinput
ubuntu@ip-172-31-32-8:/mnt/TeraSort-on-Cloud$ df -h
Filesystem      Size  Used Avail Use% Mounted on
udev            7.5G     0  7.5G   0% /dev
tmpfs           1.5G  8.8M  1.5G   1% /run
/dev/xvda1      7.7G  4.1G  3.7G  54% /
tmpfs           7.5G     0  7.5G   0% /dev/shm
tmpfs           5.0M     0  5.0M   0% /run/lock
tmpfs           7.5G     0  7.5G   0% /sys/fs/cgroup
tmpfs           1.5G     0  1.5G   0% /run/user/1000
/dev/nvme0n1    436G  121G  293G  30% /mnt
ubuntu@ip-172-31-32-8:/mnt/TeraSort-on-Cloud$ hdfs dfs -df -h
Filesystem                 Size     Used  Available  Use%
hdfs://localhost:9000  435.3 G  120.2 G    293.0 G   28%
ubuntu@ip-172-31-32-8:/mnt/TeraSort-on-Cloud$
```

```
ubuntu@ip-172-31-32-8:/mnt/TeraSort-on-Cloud$ ./valsort pinput
First unordered record is record 2
Records: 1280000000
Checksum: 2625aa9ecff4f117
ERROR - there are 640005287 unordered records
```

a. Shared-Memory TeraSort:

```
[*]  Done reading 1 chunk
[*]  Chunk sorted
[*]  Split file 11
[*]  Done reading 1 chunk
[*]  Chunk sorted
[*]  Split file 12
Duration: 420.01359787
```

↑ Sorting complete

```
cc@pa2-liu:~$ ./valsort  outnput
Records: 60000000
Checksum: 1c9baf9f5e81489
Duplicate keys: 0
SUCCESS - all records are in order
```

↑ Valsort validation post sort:

b. Hadoop TeraSort:

```
ubuntu@ip-172-31-32-8:/mnt/TeraSort-on-Cloud/src$ hadoop jar sort.jar  HadoopSort /input/pinput /poutput
17/12/04 20:43:30 INFO client.RMProxy: Connecting to ResourceManager at master/127.0.0.1:8032
17/12/04 20:43:30 WARN mapreduce.JobResourceUploader: Hadoop command-line option parsing not performed. Implement the Tool interface and execute your application with ToolR
unner to remedy this.
17/12/04 20:43:30 INFO input.FileInputFormat: Total input files to process : 1
17/12/04 20:43:31 INFO mapreduce.JobSubmitter: number of splits:954
17/12/04 20:43:31 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_1512414945766_0004
17/12/04 20:43:31 INFO impl.YarnClientImpl: Submitted application application_1512414945766_0004
17/12/04 20:43:31 INFO mapreduce.Job: The url to track the job: http://ip-172-31-32-8.ec2.internal:8088/proxy/application_1512414945766_0004/
17/12/04 20:43:31 INFO mapreduce.Job: Running job: job_1512414945766_0004
17/12/04 20:43:38 INFO mapreduce.Job: Job job_1512414945766_0004 running in uber mode : false
17/12/04 20:43:38 INFO mapreduce.Job:  map 0% reduce 0%
17/12/04 20:44:40 INFO mapreduce.Job:  map 1% reduce 0%
17/12/04 20:46:11 INFO mapreduce.Job:  map 2% reduce 0%
```

```
17/12/04 17:21:50 INFO mapreduce.Job:  map 91% reduce 18%
17/12/04 17:21:53 INFO mapreduce.Job:  map 100% reduce 18%
17/12/04 17:21:55 INFO mapreduce.Job:  map 100% reduce 35%
17/12/04 17:21:56 INFO mapreduce.Job:  map 100% reduce 45%
17/12/04 17:22:00 INFO mapreduce.Job:  map 100% reduce 60%
17/12/04 17:22:02 INFO mapreduce.Job:  map 100% reduce 80%
17/12/04 17:22:08 INFO mapreduce.Job:  map 100% reduce 96%
17/12/04 17:22:11 INFO mapreduce.Job:  map 100% reduce 100%
```

```
Found 955 items
-rw-r--r--   1 ubuntu supergroup          0 2017-12-04 19:40 /poutput/_SUCCESS
-rw-r--r--   1 ubuntu supergroup   92876983 2017-12-04 19:35 /poutput/part-00000
-rw-r--r--   1 ubuntu supergroup  140379638 2017-12-04 19:35 /poutput/part-00001
-rw-r--r--   1 ubuntu supergroup  184494311 2017-12-04 19:35 /poutput/part-00002
-rw-r--r--   1 ubuntu supergroup  125972656 2017-12-04 19:35 /poutput/part-00003
-rw-r--r--   1 ubuntu supergroup  122111653 2017-12-04 19:36 /poutput/part-00004
-rw-r--r--   1 ubuntu supergroup  156795912 2017-12-04 19:36 /poutput/part-00005
-rw-r--r--   1 ubuntu supergroup  148765203 2017-12-04 19:36 /poutput/part-00006
-rw-r--r--   1 ubuntu supergroup  193776468 2017-12-04 19:36 /poutput/part-00007
-rw-r--r--   1 ubuntu supergroup  129205683 2017-12-04 19:37 /poutput/part-00009
-rw-r--r--   1 ubuntu supergroup  115318327 2017-12-04 19:37 /poutput/part-00010
-rw-r--r--   1 ubuntu supergroup  100908034 2017-12-04 19:37 /poutput/part-00011
-rw-r--r--   1 ubuntu supergroup  129718566 2017-12-04 19:37 /poutput/part-00012
-rw-r--r--   1 ubuntu supergroup  197707477 2017-12-04 19:38 /poutput/part-00013
-rw-r--r--   1 ubuntu supergroup  179849406 2017-12-04 19:38 /poutput/part-00014
-rw-r--r--   1 ubuntu supergroup  154687022 2017-12-04 19:38 /poutput/part-00015
-rw-r--r--   1 ubuntu supergroup  153215932 2017-12-04 19:38 /poutput/part-00016
-rw-r--r--   1 ubuntu supergroup  165256485 2017-12-04 19:39 /poutput/part-00017
-rw-r--r--   1 ubuntu supergroup  115573623 2017-12-04 19:39 /poutput/part-00018
-rw-r--r--   1 ubuntu supergroup  116262501 2017-12-04 19:39 /poutput/part-00019
```

⬆ 954 part files generated:

ubuntu@ip-172-31-32-8:/mnt/TeraSort-on-Cloud$ hdfs dfs -ls /poutput

```
ubuntu@ip-172-31-32-8:/mnt/TeraSort-on-Cloud$ ./valsort output128GB
Records: 1280000000
Checksum: 2625aa9ecff4f117
Duplicate keys: 0
SUCCESS - all records are in order
ubuntu@ip-172-31-32-8:/mnt/TeraSort-on-Cloud$
```

⬆ Valsort validation post sort

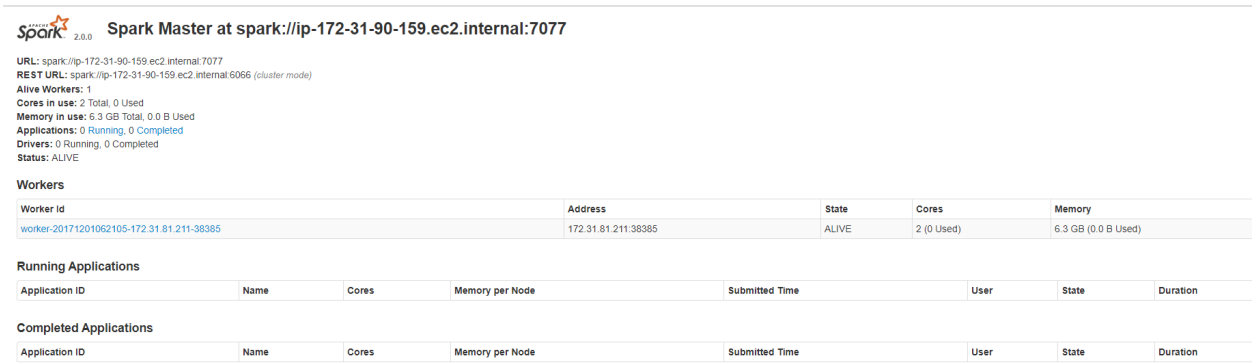
c. Spark TeraSort:

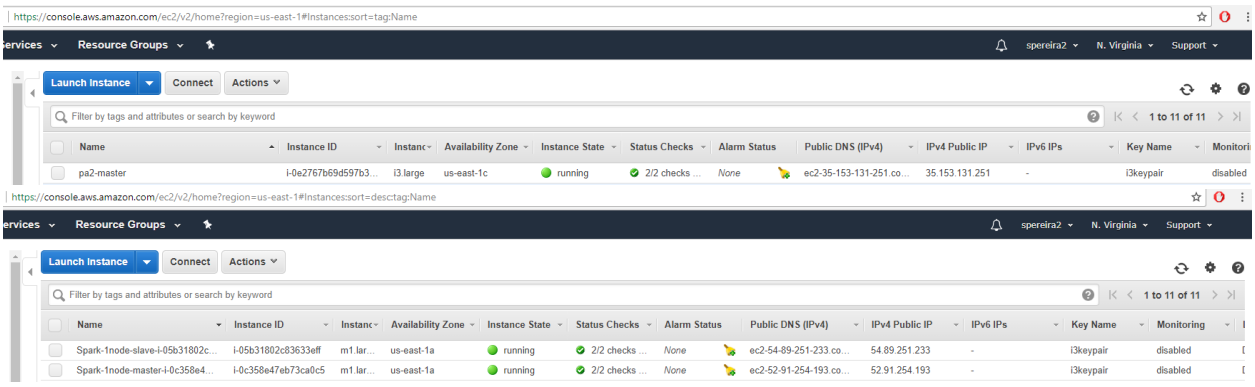
To launch sparkCluster:

./spark-ec2 -k i3keypair -i ~/i3keypair.pem --instance-type=i3.xlarge launch Spark-1node

```
ubuntu@ip-172-31-32-8:/usr/local/spark/ec2$ ./spark-ec2 -k i3keypair -i ~/i3keypair.pem  launch Spark-1node --resume
Searching for existing cluster Spark-1node in region us-east-1...
Found 1 master, 1 slave.
Waiting for cluster to enter 'ssh-ready' state.

Warning: SSH connection error. (This could be temporary.)
Host: ec2-34-227-114-189.compute-1.amazonaws.com
SSH return code: 255
SSH output: ssh: connect to host ec2-34-227-114-189.compute-1.amazonaws.com port 22: Connection refused

.

Warning: SSH connection error. (This could be temporary.)
Host: ec2-34-227-114-189.compute-1.amazonaws.com
SSH return code: 255
SSH output: ssh: connect to host ec2-34-227-114-189.compute-1.amazonaws.com port 22: Connection refused

.

Warning: SSH connection error. (This could be temporary.)
Host: ec2-34-227-114-189.compute-1.amazonaws.com
SSH return code: 255
SSH output: ssh: connect to host ec2-34-227-114-189.compute-1.amazonaws.com port 22: Connection refused

.

Warning: SSH connection error. (This could be temporary.)
Host: ec2-34-227-114-189.compute-1.amazonaws.com
SSH return code: 255
SSH output: ssh: connect to host ec2-34-227-114-189.compute-1.amazonaws.com port 22: Connection refused
```

```
Persistent HDFS installed, won't start by default...
[timing] persistent-hdfs setup:  00h 00m 05s
Setting up mapreduce
Pseudo-terminal will not be allocated because stdin is not a terminal.
RSYNC'ing /root/mapreduce/conf to slaves...
ec2-52-91-162-190.compute-1.amazonaws.com
[timing] mapreduce setup:  00h 00m 01s
Setting up spark-standalone
RSYNC'ing /root/spark/conf to slaves...
ec2-52-91-162-190.compute-1.amazonaws.com
RSYNC'ing /root/spark-ec2 to slaves...
ec2-52-91-162-190.compute-1.amazonaws.com
ec2-52-91-162-190.compute-1.amazonaws.com: no org.apache.spark.deploy.worker.Worker to stop
no org.apache.spark.deploy.master.Master to stop
starting org.apache.spark.deploy.master.Master, logging to /root/spark/logs/spark-root-org.apache.spark.deploy.master.Master-1-ip-172-31-90-159.ec2.internal.out
ec2-52-91-162-190.compute-1.amazonaws.com: starting org.apache.spark.deploy.worker.Worker, logging to /root/spark/logs/spark-root-org.apache.spark.deploy.worker.Worker-1-ip
-172-31-81-211.ec2.internal.out
[timing] spark-standalone setup:  00h 00m 31s
Setting up rstudio
spark-ec2/setup.sh: line 110: ./rstudio/setup.sh: No such file or directory
[timing] rstudio setup:  00h 00m 00s
Setting up ganglia
RSYNC'ing /etc/ganglia to slaves...
ec2-52-91-162-190.compute-1.amazonaws.com
Shutting down GANGLIA gmond:                               [FAILED]
Starting GANGLIA gmond:                                    [  OK  ]
Shutting down GANGLIA gmond:                               [FAILED]
Starting GANGLIA gmond:                                    [  OK  ]
Connection to ec2-52-91-162-190.compute-1.amazonaws.com closed.
Shutting down GANGLIA gmetad:                              [FAILED]
Starting GANGLIA gmetad:                                   [  OK  ]
Stopping httpd:                                            [FAILED]
Starting httpd: httpd: Syntax error on line 154 of /etc/httpd/conf/httpd.conf: Cannot load /etc/httpd/modules/mod_authz_core.so into server: /etc/httpd/modules/mod_authz_co
re.so: cannot open shared object file: No such file or directory
                                                           [FAILED]
[timing] ganglia setup:  00h 00m 01s
Connection to ec2-34-227-114-189.compute-1.amazonaws.com closed.
Spark standalone cluster started at http://ec2-34-227-114-189.compute-1.amazonaws.com:8080
Ganglia started at http://ec2-34-227-114-189.compute-1.amazonaws.com:5080/ganglia
Done!
ubuntu@ip-172-31-32-8:/usr/local/spark/ec2$ ls
```





To create run jobs on cluster created above:

```
./spark-submit /mnt/TeraSort-on-Cloud/src/sparksort.py /input/pinput /sparkout
```

```
ubuntu@ip-172-31-32-8:/usr/local/spark/bin$ ./spark-submit /mnt/TeraSort-on-Cloud/src/sparksort.py /input/pinput /sparkout
Input file is:  /input/pinput
Number of arguemnts passed are:  3
Input is in /input/pinput
Output will be stored in  /sparkout
17/12/03 16:11:36 INFO spark.SparkContext: Running Spark version 2.1.2
17/12/03 16:11:37 INFO spark.SecurityManager: Changing view acls to: ubuntu
17/12/03 16:11:37 INFO spark.SecurityManager: Changing modify acls to: ubuntu
17/12/03 16:11:37 INFO spark.SecurityManager: Changing view acls groups to:
17/12/03 16:11:37 INFO spark.SecurityManager: Changing modify acls groups to:
17/12/03 16:11:37 INFO spark.SecurityManager: SecurityManager: authentication disabled; ui acls disabled; users  with view permissions: Set(ubuntu); groups with view permis
sions: Set(); users  with modify permissions: Set(ubuntu); groups with modify permissions: Set()
17/12/03 16:11:37 INFO util.Utils: Successfully started service 'sparkDriver' on port 33124.
17/12/03 16:11:37 INFO spark.SparkEnv: Registering MapOutputTracker
17/12/03 16:11:37 INFO spark.SparkEnv: Registering BlockManagerMaster
17/12/03 16:11:37 INFO storage.BlockManagerMasterEndpoint: Using org.apache.spark.storage.DefaultTopologyMapper for getting topology information
17/12/03 16:11:37 INFO storage.BlockManagerMasterEndpoint: BlockManagerMasterEndpoint up
17/12/03 16:11:37 INFO storage.DiskBlockManager: Created local directory at /tmp/blockmgr-7d3ccb4c-c752-4dec-bbf1-8ecd70c3fdaa
17/12/03 16:11:37 INFO memory.MemoryStore: MemoryStore started with capacity 366.3 MB
17/12/03 16:11:37 INFO spark.SparkEnv: Registering OutputCommitCoordinator
```

```
17/12/03 18:55:17 INFO scheduler.TaskSetManager: Finished task 46.0 in stage 2.0 (TID 1954) in 9246 ms on localhost (executor driver) (47/954)
17/12/03 18:55:26 INFO python.PythonRunner: Times: total = 8683, boot = -479, init = 481, finish = 8681
17/12/03 18:55:28 INFO executor.Executor: Finished task 47.0 in stage 2.0 (TID 1955). 3158 bytes result sent to driver
17/12/03 18:55:28 INFO scheduler.TaskSetManager: Starting task 48.0 in stage 2.0 (TID 1956, localhost, executor driver, partition 48, ANY, 6033 bytes)
17/12/03 18:55:28 INFO executor.Executor: Running task 48.0 in stage 2.0 (TID 1956)
17/12/03 18:55:28 INFO scheduler.TaskSetManager: Finished task 47.0 in stage 2.0 (TID 1955) in 10746 ms on localhost (executor driver) (48/954)
17/12/03 18:55:28 INFO rdd.HadoopRDD: Input split: hdfs://localhost:9000/input/pinput:6442450944+134217728
17/12/03 18:55:36 INFO python.PythonRunner: Times: total = 8700, boot = -2046, init = 2048, finish = 8698
17/12/03 18:55:38 ERROR executor.Executor: Exception in task 48.0 in stage 2.0 (TID 1956)
```

```
ubuntu@ip-172-31-32-8:/mnt/spark/bin
17/12/03 21:47:52 INFO executor.Executor: Finished task 951.0 in stage 1.0 (TID 1905). 2234 bytes result sent to driver
17/12/03 21:47:52 INFO scheduler.TaskSetManager: Starting task 952.0 in stage 1.0 (TID 1906, localhost, executor driver, partition 952, ANY, 6111 bytes)
17/12/03 21:47:52 INFO scheduler.TaskSetManager: Finished task 951.0 in stage 1.0 (TID 1905) in 5146 ms on localhost (executor driver) (952/954)
17/12/03 21:47:52 INFO executor.Executor: Running task 952.0 in stage 1.0 (TID 1906)
17/12/03 21:47:52 INFO rdd.HadoopRDD: Input split: hdfs://localhost:9000/input/pinput:127775277056+134217728
17/12/03 21:47:57 INFO python.PythonRunner: Times: total = 5139, boot = -1, init = 3, finish = 5137
17/12/03 21:47:57 INFO executor.Executor: Finished task 952.0 in stage 1.0 (TID 1906). 2234 bytes result sent to driver
17/12/03 21:47:57 INFO scheduler.TaskSetManager: Starting task 953.0 in stage 1.0 (TID 1907, localhost, executor driver, partition 953, ANY, 6111 bytes)
17/12/03 21:47:57 INFO scheduler.TaskSetManager: Finished task 952.0 in stage 1.0 (TID 1906) in 5145 ms on localhost (executor driver) (953/954)
17/12/03 21:47:57 INFO executor.Executor: Running task 953.0 in stage 1.0 (TID 1907)
17/12/03 21:47:57 INFO rdd.HadoopRDD: Input split: hdfs://localhost:9000/input/pinput:127909494784+90505216
17/12/03 21:48:00 INFO python.PythonRunner: Times: total = 3481, boot = -1, init = 7, finish = 3475
17/12/03 21:48:00 INFO executor.Executor: Finished task 953.0 in stage 1.0 (TID 1907). 2097 bytes result sent to driver
17/12/03 21:48:00 INFO scheduler.TaskSetManager: Finished task 953.0 in stage 1.0 (TID 1907) in 3486 ms on localhost (executor driver) (954/954)
17/12/03 21:48:00 INFO scheduler.TaskSchedulerImpl: Removed TaskSet 1.0, whose tasks have all completed, from pool
17/12/03 21:48:00 INFO scheduler.DAGScheduler: ResultStage 1 (sortByKey at /mnt/TeraSort-on-Cloud/src/sparksort.py:31) finished in 4956.482 s
17/12/03 21:48:00 INFO scheduler.DAGScheduler: Job 1 finished: sortByKey at /mnt/TeraSort-on-Cloud/src/sparksort.py:31, took 4956.537934 s
Duration for Sorting on Spark is(ms):  9432.87966204
```

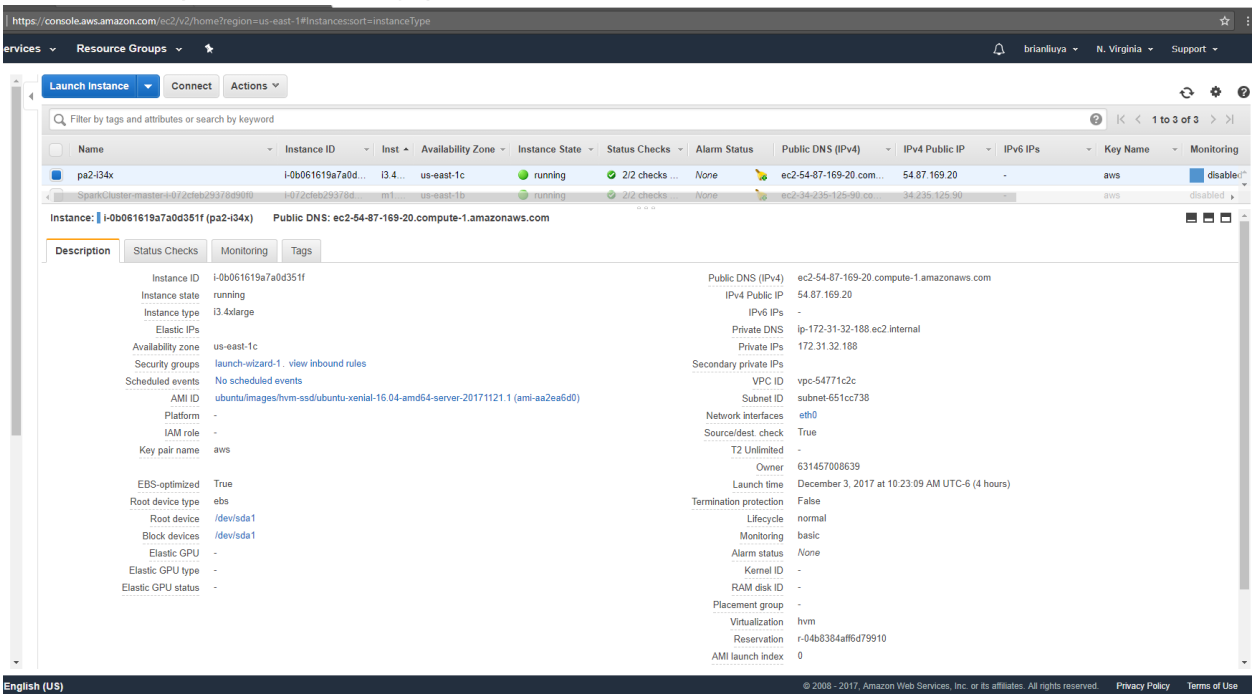
```
17/12/03 21:56:49 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@3a099514{/stages/stage/kill,null,UNAVAILABLE,@Spark}
17/12/03 21:56:49 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@14a9d1b5{/jobs/job/kill,null,UNAVAILABLE,@Spark}
17/12/03 21:56:49 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@2d5a6b0b{/api,null,UNAVAILABLE,@Spark}
17/12/03 21:56:49 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@5ac921b8{/,null,UNAVAILABLE,@Spark}
17/12/03 21:56:49 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@67c928fc{/static,null,UNAVAILABLE,@Spark}
17/12/03 21:56:49 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@126565f0{/executors/threadDump/json,null,UNAVAILABLE,@Spark}
17/12/03 21:56:49 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@258a5dcf{/executors/threadDump,null,UNAVAILABLE,@Spark}
17/12/03 21:56:49 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@75b91085{/executors/json,null,UNAVAILABLE,@Spark}
17/12/03 21:56:49 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@2ceb3646{/executors,null,UNAVAILABLE,@Spark}
17/12/03 21:56:49 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@6efb247a{/environment/json,null,UNAVAILABLE,@Spark}
17/12/03 21:56:49 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@7aa558cd{/environment,null,UNAVAILABLE,@Spark}
17/12/03 21:56:49 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@19480866{/storage/rdd/json,null,UNAVAILABLE,@Spark}
17/12/03 21:56:49 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@3f3fadbe{/storage/rdd,null,UNAVAILABLE,@Spark}
17/12/03 21:56:49 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@1780695a{/storage/json,null,UNAVAILABLE,@Spark}
17/12/03 21:56:49 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@42a4255f{/storage,null,UNAVAILABLE,@Spark}
17/12/03 21:56:49 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@7acb835c{/stages/pool/json,null,UNAVAILABLE,@Spark}
17/12/03 21:56:49 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@47dde955{/stages/pool,null,UNAVAILABLE,@Spark}
17/12/03 21:56:49 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@215e95e4{/stages/stage/json,null,UNAVAILABLE,@Spark}
17/12/03 21:56:49 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@ea6ce34{/stages/stage,null,UNAVAILABLE,@Spark}
17/12/03 21:56:49 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@d2601ab{/stages/json,null,UNAVAILABLE,@Spark}
17/12/03 21:56:49 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@2f492587{/stages,null,UNAVAILABLE,@Spark}
17/12/03 21:56:49 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@51ffd519{/jobs/job/json,null,UNAVAILABLE,@Spark}
17/12/03 21:56:49 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@60ec7df6{/jobs/job,null,UNAVAILABLE,@Spark}
17/12/03 21:56:49 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@436c3439{/jobs/json,null,UNAVAILABLE,@Spark}
17/12/03 21:56:49 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@3f182a13{/jobs,null,UNAVAILABLE,@Spark}
17/12/03 21:56:49 INFO ui.SparkUI: Stopped Spark web UI at http://172.31.32.8:4040
17/12/03 21:56:49 INFO spark.MapOutputTrackerMasterEndpoint: MapOutputTrackerMasterEndpoint stopped!
17/12/03 21:56:50 INFO memory.MemoryStore: MemoryStore cleared
17/12/03 21:56:50 INFO storage.BlockManager: BlockManager stopped
17/12/03 21:56:50 INFO storage.BlockManagerMaster: BlockManagerMaster stopped
17/12/03 21:56:50 INFO scheduler.OutputCommitCoordinator$OutputCommitCoordinatorEndpoint: OutputCommitCoordinator stopped!
17/12/03 21:56:50 INFO spark.SparkContext: Successfully stopped SparkContext
17/12/03 21:56:50 INFO util.ShutdownHookManager: Shutdown hook called
```

954 part files generated:

```
ubuntu@ip-172-31-32-8:/mnt/TeraSort-on-Cloud$ hdfs dfs -ls /sparkout
Found 955 items
-rw-r--r--   1 ubuntu supergroup          0 2017-12-03 19:40 /sparkout/_SUCCESS
-rw-r--r--   1 ubuntu supergroup   92876983 2017-12-03 19:35 /sparkout/part-00000
-rw-r--r--   1 ubuntu supergroup  140379638 2017-12-03 19:35 /sparkout/part-00001
-rw-r--r--   1 ubuntu supergroup  184494311 2017-12-03 19:35 /sparkout/part-00002
-rw-r--r--   1 ubuntu supergroup  125972656 2017-12-03 19:35 /sparkout/part-00003
-rw-r--r--   1 ubuntu supergroup  122111653 2017-12-03 19:36 /sparkout/part-00004
-rw-r--r--   1 ubuntu supergroup  156795912 2017-12-03 19:36 /sparkout/part-00005
-rw-r--r--   1 ubuntu supergroup  148765203 2017-12-03 19:36 /sparkout/part-00006
-rw-r--r--   1 ubuntu supergroup  193776468 2017-12-03 19:36 /sparkout/part-00007
-rw-r--r--   1 ubuntu supergroup  148391360 2017-12-03 19:37 /sparkout/part-00008
-rw-r--r--   1 ubuntu supergroup  129205683 2017-12-03 19:37 /sparkout/part-00009
-rw-r--r--   1 ubuntu supergroup  115318327 2017-12-03 19:37 /sparkout/part-00010
-rw-r--r--   1 ubuntu supergroup  100908034 2017-12-03 19:37 /sparkout/part-00011
-rw-r--r--   1 ubuntu supergroup  129718566 2017-12-03 19:37 /sparkout/part-00012
-rw-r--r--   1 ubuntu supergroup  197707477 2017-12-03 19:38 /sparkout/part-00013
-rw-r--r--   1 ubuntu supergroup  179849406 2017-12-03 19:38 /sparkout/part-00014
-rw-r--r--   1 ubuntu supergroup  154687022 2017-12-03 19:38 /sparkout/part-00015
-rw-r--r--   1 ubuntu supergroup  153215932 2017-12-03 19:38 /sparkout/part-00016
-rw-r--r--   1 ubuntu supergroup  165256485 2017-12-03 19:39 /sparkout/part-00017
-rw-r--r--   1 ubuntu supergroup  115573623 2017-12-03 19:39 /sparkout/part-00018
-rw-r--r--   1 ubuntu supergroup  116262501 2017-12-03 19:39 /sparkout/part-00019
-rw-r--r--   1 ubuntu supergroup  120259297 2017-12-03 19:39 /sparkout/part-00020
-rw-r--r--   1 ubuntu supergroup  128443975 2017-12-03 19:39 /sparkout/part-00021
-rw-r--r--   1 ubuntu supergroup  153473990 2017-12-03 19:40 /sparkout/part-00022
```

```
ubuntu@ip-172-31-32-8:/mnt/TeraSort-on-Cloud$ ./valsort output128_Spark
Records: 1280000000
Checksum: 2625aa9ecff4f117
Duplicate keys: 0
SUCCESS - all records are in order
ubuntu@ip-172-31-32-8:/mnt/TeraSort-on-Cloud$
```

2. Virtual Cluster (1-node i3.4xlarge):




```
ubuntu@ip-172-31-32-188:/mnt/raid$  lsblk -o "NAME,MAJ:MIN,RM,SIZE,RO,FSTYPE,MOUNTPOINT,UUID"
NAME    MAJ:MIN RM  SIZE RO FSTYPE           MOUNTPOINT UUID
xvda    202:0    0    8G  0
└─xvda1 202:1    0    8G  0 ext4             /          512611f4-b05a-4d8a-b743-438b71c5385d
nvme0n1 259:1    0  1.7T  0 linux_raid_member           b91b56c7-b7c0-44aa-3e95-93448a6d5be7
└─md127   9:127  0  3.5T  0 ext4             /mnt/raid  1b02d33e-d61d-47fd-b495-cefb41429efd
nvme1n1 259:0    0  1.7T  0 linux_raid_member           b91b56c7-b7c0-44aa-3e95-93448a6d5be7
└─md127   9:127  0  3.5T  0 ext4             /mnt/raid  1b02d33e-d61d-47fd-b495-cefb41429efd
ubuntu@ip-172-31-32-188:/mnt/raid$ jps
61746 Jps
13317 NodeManager
12506 NameNode
12925 SecondaryNameNode
13150 ResourceManager
12687 DataNode
ubuntu@ip-172-31-32-188:/mnt/raid$
```

Generate data (1TB):

```
ubuntu@ip-172-31-32-188:/mnt/raid/spark/bin$ hdfs dfs -df -h
Filesystem              Size     Used  Available  Use%
hdfs://localhost:9000  3.4 T  938.6 G      1.4 T   27%
ubuntu@ip-172-31-32-188:/mnt/raid/spark/bin$ hdfs dfs -ls /input/
Found 1 items
-rw-r--r--   1 ubuntu supergroup 1000000000000 2017-12-03 19:02 /input/pinput
ubuntu@ip-172-31-32-188:/mnt/raid/spark/bin$
```

```
ubuntu@ip-172-31-32-188:/mnt/raid/TeraSort-on-Cloud$ ./valsort pinput
First unordered record is record 2
Records: 10000000000
Checksum: 12a06cd06eeb64b16
ERROR - there are 4999998439 unordered records
ubuntu@ip-172-31-32-188:/mnt/raid/TeraSort-on-Cloud$
```

a. Shared-Memory TeraSort:

```
[*]  Done reading 1 chunk
[*]  Chunk sorted
[*]  Split file 10
[*]  Done reading 1 chunk
[*]  Chunk sorted
[*]  Split file 11
Duration: 9720.363837
```

↑ Sorting complete

```
cc@pa2l:~/TeraSort-on-Cloud$ ./valsort output
Records: 480000000
Checksum: e4e1b37400a3080
Duplicate keys: 0
SUCCESS - all records are in order
```

↑ Valsort validation post sort

b. Hadoop TeraSort:

```
ubuntu@ip-172-31-32-188:/mnt/raid/TeraSort-on-Cloud/src$ hadoop jar sort.jar HadoopSort /input/pinput /poutput
17/12/03 19:25:46 INFO client.RMProxy: Connecting to ResourceManager at localhost/127.0.0.1:8032
17/12/03 19:25:47 WARN mapreduce.JobResourceUploader: Hadoop command-line option parsing not performed. Implement the Tool interface and execute your application with ToolR
unner to remedy this.
17/12/03 19:25:47 INFO input.FileInputFormat: Total input files to process : 1
17/12/03 19:25:47 INFO mapreduce.JobSubmitter: number of splits:7451
17/12/03 19:25:47 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_1512324157502_0001
17/12/03 19:25:47 INFO impl.YarnClientImpl: Submitted application application_1512324157502_0001
17/12/03 19:25:47 INFO mapreduce.Job: The url to track the job: http://ip-172-31-32-188.ec2.internal:8088/proxy/application_1512324157502_0001/
17/12/03 19:25:47 INFO mapreduce.Job: Running job: job_1512324157502_0001
17/12/03 19:25:54 INFO mapreduce.Job: Job job_1512324157502_0001 running in uber mode : false
```

```
17/12/04 17:21:50 INFO mapreduce.Job:  map 91% reduce 18%
17/12/04 17:21:53 INFO mapreduce.Job:  map 100% reduce 18%
17/12/04 17:21:55 INFO mapreduce.Job:  map 100% reduce 35%
17/12/04 17:21:56 INFO mapreduce.Job:  map 100% reduce 45%
17/12/04 17:22:00 INFO mapreduce.Job:  map 100% reduce 60%
17/12/04 17:22:02 INFO mapreduce.Job:  map 100% reduce 80%
17/12/04 17:22:08 INFO mapreduce.Job:  map 100% reduce 96%
17/12/04 17:22:11 INFO mapreduce.Job:  map 100% reduce 100%
```

7451 part files generated:

ubuntu@ip-172-31-32-188:/mnt/TeraSort-on-Cloud$ hdfs dfs -ls /poutput

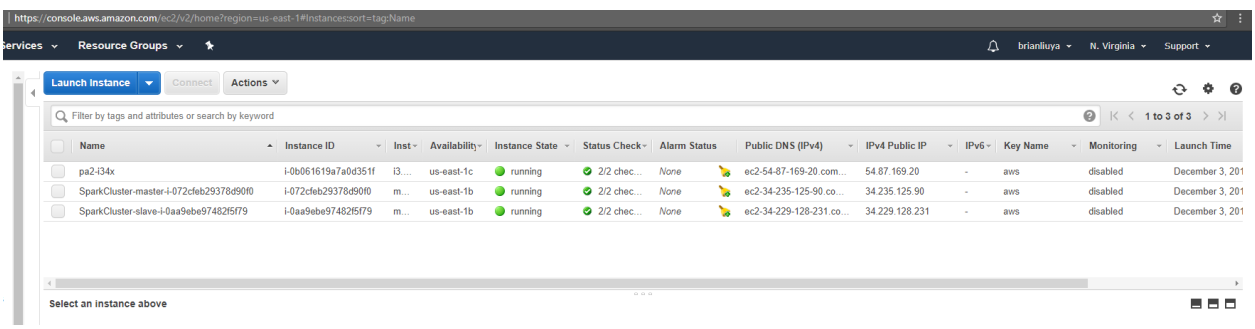
```
Found 7452 items
-rw-r--r--   1 ubuntu supergroup          0 2017-12-04 19:40 /poutput/_SUCCESS
-rw-r--r--   1 ubuntu supergroup   92876983 2017-12-04 19:35 /poutput/part-00000
-rw-r--r--   1 ubuntu supergroup  140379638 2017-12-04 19:35 /poutput/part-00001
-rw-r--r--   1 ubuntu supergroup  184494311 2017-12-04 19:35 /poutput/part-00002
-rw-r--r--   1 ubuntu supergroup  125972656 2017-12-04 19:35 /poutput/part-00003
-rw-r--r--   1 ubuntu supergroup  122111653 2017-12-04 19:36 /poutput/part-00004
-rw-r--r--   1 ubuntu supergroup  156795912 2017-12-04 19:36 /poutput/part-00005
-rw-r--r--   1 ubuntu supergroup  148765203 2017-12-04 19:36 /poutput/part-00006
-rw-r--r--   1 ubuntu supergroup  193776468 2017-12-04 19:36 /poutput/part-00007
-rw-r--r--   1 ubuntu supergroup  129205683 2017-12-04 19:37 /poutput/part-00009
-rw-r--r--   1 ubuntu supergroup  115318327 2017-12-04 19:37 /poutput/part-00010
-rw-r--r--   1 ubuntu supergroup  100908034 2017-12-04 19:37 /poutput/part-00011
-rw-r--r--   1 ubuntu supergroup  129718566 2017-12-04 19:37 /poutput/part-00012
-rw-r--r--   1 ubuntu supergroup  197707477 2017-12-04 19:38 /poutput/part-00013
-rw-r--r--   1 ubuntu supergroup  179849406 2017-12-04 19:38 /poutput/part-00014
-rw-r--r--   1 ubuntu supergroup  154687022 2017-12-04 19:38 /poutput/part-00015
-rw-r--r--   1 ubuntu supergroup  153215932 2017-12-04 19:38 /poutput/part-00016
-rw-r--r--   1 ubuntu supergroup  165256485 2017-12-04 19:39 /poutput/part-00017
-rw-r--r--   1 ubuntu supergroup  115573623 2017-12-04 19:39 /poutput/part-00018
-rw-r--r--   1 ubuntu supergroup  116262501 2017-12-04 19:39 /poutput/part-00019
```

```
ubuntu@ip-172-31-32-188:/mnt/raid/TeraSort-on-Cloud$ ./valsort 1TBoutput
Records: 10000000000
Checksum: 12a06cd06eeb64b16
Duplicate keys: 0
SUCCESS - all records are in order
ubuntu@ip-172-31-32-188:/mnt/raid/TeraSort-on-Cloud$
```

c. Spark TeraSort:

./spark-ec2 -k aws -i ~/aws.pem --instance-type=i3.4xlarge launch SparkCluster

```
Setting up mapreduce
Pseudo-terminal will not be allocated because stdin is not a terminal.
RSYNC'ing /root/mapreduce/conf to slaves...
ec2-34-229-128-231.compute-1.amazonaws.com
[timing] mapreduce setup:  00h 00m 01s
Setting up spark-standalone
RSYNC'ing /root/spark/conf to slaves...
ec2-34-229-128-231.compute-1.amazonaws.com
RSYNC'ing /root/spark-ec2 to slaves...
ec2-34-229-128-231.compute-1.amazonaws.com
ec2-34-229-128-231.compute-1.amazonaws.com: no org.apache.spark.deploy.worker.Worker to stop
no org.apache.spark.deploy.master.Master to stop
starting org.apache.spark.deploy.master.Master, logging to /root/spark/logs/spark-root-org.apache.spark.deploy.master.Master-1-ip-172-31-25-133.ec2.in
ternal.out
ec2-34-229-128-231.compute-1.amazonaws.com: starting org.apache.spark.deploy.worker.Worker, logging to /root/spark/logs/spark-root-org.apache.spark.de
ploy.worker.Worker-1-ip-172-31-21-3.ec2.internal.out
[timing] spark-standalone setup:  00h 00m 44s
Setting up rstudio
spark-ec2/setup.sh: line 110: ./rstudio/setup.sh: No such file or directory
[timing] rstudio setup:  00h 00m 00s
Setting up ganglia
RSYNC'ing /etc/ganglia to slaves...
ec2-34-229-128-231.compute-1.amazonaws.com
Shutting down GANGLIA gmond:                               [FAILED]
Starting GANGLIA gmond:                                    [  OK  ]
Shutting down GANGLIA gmond:                               [FAILED]
Starting GANGLIA gmond:                                    [  OK  ]
Connection to ec2-34-229-128-231.compute-1.amazonaws.com closed.
Shutting down GANGLIA gmetad:                              [FAILED]
Starting GANGLIA gmetad:                                   [  OK  ]
Stopping httpd:                                            [FAILED]
Starting httpd: httpd: Syntax error on line 154 of /etc/httpd/conf/httpd.conf: Cannot load /etc/httpd/modules/mod_authz_core.so into server: /etc/http
d/modules/mod_authz_core.so: cannot open shared object file: No such file or directory
                                                           [FAILED]
[timing] ganglia setup:  00h 00m 07s
Connection to ec2-34-235-125-90.compute-1.amazonaws.com closed.
Spark standalone cluster started at http://ec2-34-235-125-90.compute-1.amazonaws.com:8080
Ganglia started at http://ec2-34-235-125-90.compute-1.amazonaws.com:5080/ganglia
Done!
ubuntu@ip-172-31-32-188:/usr/local/spark/ec2$
```



./spark-submit /mnt/raid/TeraSort-on-Cloud/src/sparksort.py /input/pinput /sparkout

```
ubuntu@ip-172-31-32-188:/mnt/raid/spark/bin$ hdfs dfs -ls /input
Found 1 items
-rw-r--r--   1 ubuntu supergroup 1000000000000 2017-12-04 00:46 /input/pinput
ubuntu@ip-172-31-32-188:/mnt/raid/spark/bin$
```

```
ubuntu@ip-172-31-32-188:/mnt/raid/spark/bin$ ./spark-submit /mnt/raid/TeraSort-on-Cloud/src/sparksort.py /input/pinput /sparkout
Input file is: /input/pinput
Number of arguemnts passed are: 3
Input is in /input/pinput
Output will be stored in /sparkout
17/12/04 00:51:52 INFO spark.SparkContext: Running Spark version 2.1.2
17/12/04 00:51:52 INFO spark.SecurityManager: Changing view acls to: ubuntu
17/12/04 00:51:52 INFO spark.SecurityManager: Changing modify acls to: ubuntu
17/12/04 00:51:52 INFO spark.SecurityManager: Changing view acls groups to:
17/12/04 00:51:52 INFO spark.SecurityManager: Changing modify acls groups to:
17/12/04 00:51:52 INFO spark.SecurityManager: SecurityManager: authentication disabled; ui acls disabled; users  with view permissions: Set(ubuntu); groups with view permis
sions: Set(); users  with modify permissions: Set(ubuntu); groups with modify permissions: Set()
17/12/04 00:51:53 INFO util.Utils: Successfully started service 'sparkDriver' on port 34940.
17/12/04 00:51:53 INFO spark.SparkEnv: Registering MapOutputTracker
17/12/04 00:51:53 INFO spark.SparkEnv: Registering BlockManagerMaster
17/12/04 00:51:53 INFO storage.BlockManagerMasterEndpoint: Using org.apache.spark.storage.DefaultTopologyMapper for getting topology information
17/12/04 00:51:53 INFO storage.BlockManagerMasterEndpoint: BlockManagerMasterEndpoint up
17/12/04 00:51:53 INFO storage.DiskBlockManager: Created local directory at /tmp/blockmgr-0f0bcd21-2035-415c-ad29-7614962b6a67
17/12/04 00:51:53 INFO memory.MemoryStore: MemoryStore started with capacity 366.3 MB
17/12/04 00:51:53 INFO spark.SparkEnv: Registering OutputCommitCoordinator
17/12/04 00:51:53 INFO util.log: Logging initialized @1873ms
```

```
17/12/04 08:08:37 INFO rdd.HadoopRDD: Input split: hdfs://localhost:9000/input/pinput:900600954880+134217728
17/12/04 08:08:41 INFO python.PythonRunner: Times: total = 3883, boot = 1, init = 0, finish = 3882
17/12/04 08:08:41 INFO executor.Executor: Finished task 6710.0 in stage 0.0 (TID 6710). 1807 bytes result sent to driver
17/12/04 08:08:41 INFO scheduler.TaskSetManager: Starting task 6711.0 in stage 0.0 (TID 6711, localhost, executor driver, partition 6711, ANY, 6121 bytes)
17/12/04 08:08:41 INFO executor.Executor: Running task 6711.0 in stage 0.0 (TID 6711)
17/12/04 08:08:41 INFO scheduler.TaskSetManager: Finished task 6710.0 in stage 0.0 (TID 6710) in 3886 ms on localhost (executor driver) (6711/7451)
17/12/04 08:08:41 INFO rdd.HadoopRDD: Input split: hdfs://localhost:9000/input/pinput:900735172608+134217728
17/12/04 08:08:44 INFO python.PythonRunner: Times: total = 3873, boot = 1, init = 0, finish = 3872
17/12/04 08:08:44 INFO executor.Executor: Finished task 6711.0 in stage 0.0 (TID 6711). 1807 bytes result sent to driver
17/12/04 08:08:44 INFO scheduler.TaskSetManager: Starting task 6712.0 in stage 0.0 (TID 6712, localhost, executor driver, partition 6712, ANY, 6121 bytes)
17/12/04 08:08:44 INFO executor.Executor: Running task 6712.0 in stage 0.0 (TID 6712)
17/12/04 08:08:44 INFO scheduler.TaskSetManager: Finished task 6711.0 in stage 0.0 (TID 6711) in 3876 ms on localhost (executor driver) (6712/7451)
17/12/04 08:08:44 INFO rdd.HadoopRDD: Input split: hdfs://localhost:9000/input/pinput:900869390336+134217728
```

```
17/12/04 19:40:12 INFO spark.SparkContext: Invoking stop() from shutdown hook
17/12/04 19:40:12 INFO server.ServerConnector: Stopped Spark@64ed239a{HTTP/1.1}{0.0.0.0:4040}
17/12/04 19:40:12 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@4a47141f{/stages/stage/kill,null,UNAVAILABLE,@Spark}
17/12/04 19:40:12 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@686f703f{/jobs/job/kill,null,UNAVAILABLE,@Spark}
17/12/04 19:40:12 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@19c76c42{/api,null,UNAVAILABLE,@Spark}
17/12/04 19:40:12 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@1bf114e8{/,null,UNAVAILABLE,@Spark}
17/12/04 19:40:12 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@2610835e{/static,null,UNAVAILABLE,@Spark}
17/12/04 19:40:12 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@1bad4e93{/executors/threadDump/json,null,UNAVAILABLE,@Spark}
17/12/04 19:40:12 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@620c171b{/executors/threadDump,null,UNAVAILABLE,@Spark}
17/12/04 19:40:12 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@316187ab{/executors/json,null,UNAVAILABLE,@Spark}
17/12/04 19:40:12 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@26f37e76{/executors,null,UNAVAILABLE,@Spark}
17/12/04 19:40:12 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@4cb6bdd4{/environment/json,null,UNAVAILABLE,@Spark}
17/12/04 19:40:12 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@2fff9824{/environment,null,UNAVAILABLE,@Spark}
17/12/04 19:40:12 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@60220fb{/storage/rdd/json,null,UNAVAILABLE,@Spark}
17/12/04 19:40:12 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@61416dd1{/storage/rdd,null,UNAVAILABLE,@Spark}
17/12/04 19:40:12 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@123e3295{/storage/json,null,UNAVAILABLE,@Spark}
17/12/04 19:40:12 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@12f76463{/storage,null,UNAVAILABLE,@Spark}
17/12/04 19:40:12 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@394bdde7{/stages/pool/json,null,UNAVAILABLE,@Spark}
17/12/04 19:40:12 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@4506c152{/stages/pool,null,UNAVAILABLE,@Spark}
17/12/04 19:40:12 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@216425a5{/stages/stage/json,null,UNAVAILABLE,@Spark}
17/12/04 19:40:12 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@775b9994{/stages/stage,null,UNAVAILABLE,@Spark}
17/12/04 19:40:12 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@1d9c25b0{/stages/json,null,UNAVAILABLE,@Spark}
17/12/04 19:40:12 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@7c731ead{/stages,null,UNAVAILABLE,@Spark}
17/12/04 19:40:12 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@5c714311{/jobs/job/json,null,UNAVAILABLE,@Spark}
17/12/04 19:40:12 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@7fdba05{/jobs/job,null,UNAVAILABLE,@Spark}
17/12/04 19:40:12 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@1e1ff229{/jobs/json,null,UNAVAILABLE,@Spark}
17/12/04 19:40:12 INFO handler.ContextHandler: Stopped o.s.j.s.ServletContextHandler@20454d6{/jobs,null,UNAVAILABLE,@Spark}
17/12/04 19:40:12 INFO ui.SparkUI: Stopped Spark web UI at http://172.31.32.188:4040
17/12/04 19:40:12 INFO spark.MapOutputTrackerMasterEndpoint: MapOutputTrackerMasterEndpoint stopped!
17/12/04 19:40:13 INFO memory.MemoryStore: MemoryStore cleared
17/12/04 19:40:13 INFO storage.BlockManager: BlockManager stopped
17/12/04 19:40:13 INFO storage.BlockManagerMaster: BlockManagerMaster stopped
17/12/04 19:40:13 INFO scheduler.OutputCommitCoordinator$OutputCommitCoordinatorEndpoint: OutputCommitCoordinator stopped!
17/12/04 19:40:13 INFO spark.SparkContext: Successfully stopped SparkContext
17/12/04 19:40:13 INFO util.ShutdownHookManager: Shutdown hook called
17/12/04 19:40:13 INFO util.ShutdownHookManager: Deleting directory /tmp/spark-a2a0f765-46a0-468c-801c-0c30af8b26da
17/12/04 19:40:13 INFO util.ShutdownHookManager: Deleting directory /tmp/spark-a2a0f765-46a0-468c-801c-0c30af8b26da/pyspark-274f0018-585b-48e9-a5db-7d3ee11dcc54
ubuntu@ip-172-31-32-188:/mnt/raid/spark/bin$
```

7452 part files generated:

```
Found 7452 items
-rw-r--r--   1 ubuntu supergroup          0 2017-12-04 19:40 /sparkout/_SUCCESS
-rw-r--r--   1 ubuntu supergroup   92876983 2017-12-04 19:35 /sparkout/part-00000
-rw-r--r--   1 ubuntu supergroup  140379638 2017-12-04 19:35 /sparkout/part-00001
-rw-r--r--   1 ubuntu supergroup  184494311 2017-12-04 19:35 /sparkout/part-00002
-rw-r--r--   1 ubuntu supergroup  125972656 2017-12-04 19:35 /sparkout/part-00003
-rw-r--r--   1 ubuntu supergroup  122111653 2017-12-04 19:36 /sparkout/part-00004
-rw-r--r--   1 ubuntu supergroup  156795912 2017-12-04 19:36 /sparkout/part-00005
-rw-r--r--   1 ubuntu supergroup  148765203 2017-12-04 19:36 /sparkout/part-00006
-rw-r--r--   1 ubuntu supergroup  193776468 2017-12-04 19:36 /sparkout/part-00007
-rw-r--r--   1 ubuntu supergroup  148391360 2017-12-04 19:37 /sparkout/part-00008
-rw-r--r--   1 ubuntu supergroup  129205683 2017-12-04 19:37 /sparkout/part-00009
-rw-r--r--   1 ubuntu supergroup  115318327 2017-12-04 19:37 /sparkout/part-00010
-rw-r--r--   1 ubuntu supergroup  100908034 2017-12-04 19:37 /sparkout/part-00011
-rw-r--r--   1 ubuntu supergroup  129718566 2017-12-04 19:37 /sparkout/part-00012
-rw-r--r--   1 ubuntu supergroup  197707477 2017-12-04 19:38 /sparkout/part-00013
-rw-r--r--   1 ubuntu supergroup  179849406 2017-12-04 19:38 /sparkout/part-00014
-rw-r--r--   1 ubuntu supergroup  154687022 2017-12-04 19:38 /sparkout/part-00015
-rw-r--r--   1 ubuntu supergroup  153215932 2017-12-04 19:38 /sparkout/part-00016
-rw-r--r--   1 ubuntu supergroup  165256485 2017-12-04 19:39 /sparkout/part-00017
-rw-r--r--   1 ubuntu supergroup  115573623 2017-12-04 19:39 /sparkout/part-00018
-rw-r--r--   1 ubuntu supergroup  116262501 2017-12-04 19:39 /sparkout/part-00019
-rw-r--r--   1 ubuntu supergroup  120259297 2017-12-04 19:39 /sparkout/part-00020
-rw-r--r--   1 ubuntu supergroup  128443975 2017-12-04 19:39 /sparkout/part-00021
-rw-r--r--   1 ubuntu supergroup  153473990 2017-12-04 19:40 /sparkout/part-00022
```

```
ubuntu@ip-172-31-32-188:/mnt/raid/TeraSort-on-Cloud$ ./valsort 1TBoutput_spark
Records: 10000000000
Checksum: 12a06cd06eeb64b16
Duplicate keys: 0
SUCCESS - all records are in order
ubuntu@ip-172-31-32-188:/mnt/raid/TeraSort-on-Cloud$
```

3. Virtual Cluster of 8 nodes:

Filter by tags and attributes or search by keyword — 1 to 11 of 11

Name	Instance ID	Inst	Availability Zone	Instance State	Status Checks	Alarm Status	Public DNS (IPv4)	IPv4 Public IP	IPv6	Key Name	Monitoring	Launch Ti
pa2-master	i-0e2767b69d597b3...	i3.l...	us-east-1c	running	2/2 checks ...	None	ec2-35-153-131-251.compute-...	35.153.131.251	-	i3keypair	disabled	December
slave1	i-01e32a662efd32150	i3.l...	us-east-1c	running	2/2 checks ...	None	ec2-34-238-170-236.compute-...	34.238.170.236	-	i3keypair	disabled	December
slave2	i-02d79ec06c1262988	i3.l...	us-east-1c	running	2/2 checks ...	None	ec2-52-90-26-110.compute-1.a...	52.90.26.110	-	i3keypair	disabled	December
slave3	i-089faba2873eede90	i3.l...	us-east-1c	running	2/2 checks ...	None	ec2-54-81-154-100.compute-1....	54.81.154.100	-	i3keypair	disabled	December
slave4	i-0ee5fb599ccbc95c9	i3.l...	us-east-1c	running	2/2 checks ...	None	ec2-54-197-10-240.compute-1....	54.197.10.240	-	i3keypair	disabled	December
slave5	i-07baf1849c6ad1cdb	i3.l...	us-east-1c	running	2/2 checks ...	None	ec2-52-90-184-0.compute-1.a...	52.90.184.0	-	i3keypair	disabled	December
slave6	i-0e6da9de5775ef62c	i3.l...	us-east-1c	running	2/2 checks ...	None	ec2-54-210-70-194.compute-1....	54.210.70.194	-	i3keypair	disabled	December
slave7	i-0ccd158d1acc82eaa	i3.l...	us-east-1c	running	2/2 checks ...	None	ec2-52-55-229-42.compute-1.a...	52.55.229.42	-	i3keypair	disabled	December
slave8	i-01099dff106d56a78	i3.l...	us-east-1c	running	2/2 checks ...	None	ec2-54-174-167-123.compute-...	54.174.167.123	-	i3keypair	disabled	December
Spark-1node-master-i-0c358e4...	i-0c358e47eb73ca0c5	m1...	us-east-1a	running	2/2 checks ...	None	ec2-52-91-254-193.compute-1....	52.91.254.193	-	i3keypair	disabled	December
Spark-1node-slave-i-05b31802c...	i-05b31802c83633eff	m1...	us-east-1a	running	2/2 checks ...	None	ec2-54-89-251-233.compute-1....	54.89.251.233	-	i3keypair	disabled	December

Instance: i-0e2767b69d597b375 (pa2-master) Public DNS: ec2-35-153-131-251.compute-1.amazonaws.com

Description | Status Checks | Monitoring | Tags

Instance ID	i-0e2767b69d597b375	Public DNS (IPv4)	ec2-35-153-131-251.compute-1.amazonaws.com
Instance state	running	IPv4 Public IP	35.153.131.251
Instance type	i3.large	IPv6 IPs	-
Elastic IPs		Private DNS	ip-172-31-32-8.ec2.internal
Availability zone	us-east-1c	Private IPs	172.31.32.8
Security groups	launch-wizard-3. view inbound rules	Secondary private IPs	
Scheduled events	No scheduled events	VPC ID	vpc-48f26930
AMI ID	ubuntu/images/hvm-ssd/ubuntu-xenial-16.04-amd64-server-20171121.1 (ami-aa2ea6d0)	Subnet ID	subnet-3c28ff61
Platform	-	Network interfaces	eth0
IAM role	-	Source/dest. check	True
Key pair name	i3keypair	T2 Unlimited	-
		Owner	582343665751
EBS-optimized	True	Launch time	December 3, 2017 at 9:31:54 AM UTC-6 (30 hours)
Root device type	ebs	Termination protection	False

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vi /etc/hosts

ubuntu@ip-172-31-32-8: ~/hadoop/etc/hadoop

```
#127.0.0.1 localhost

# The following lines are desirable for IPv6 capable hosts
::1 ip6-localhost ip6-loopback
fe00::0 ip6-localnet
ff00::0 ip6-mcastprefix
ff02::1 ip6-allnodes
ff02::2 ip6-allrouters
ff02::3 ip6-allhosts

172.31.32.8 master
172.31.40.193 slave1
172.31.34.91 slave2
172.31.33.63 slave3
172.31.47.55 slave4
172.31.39.5 slave5
172.31.46.244 slave6
172.31.43.173 slave7
172.31.34.26 slave8
```

~/.ssh/config in master node:

ubuntu@ip-172-31-32-8: ~/hadoop/etc/hadoop

```
Host master
  User ubuntu
  HostName ec2-35-153-131-251.compute-1.amazonaws.com
  IdentityFile ~/.ssh/i3keypair.pem

Host slave1
  User ubuntu
  HostName ec2-34-238-170-236.compute-1.amazonaws.com
  IdentityFile ~/.ssh/i3keypair.pem

Host slave2
  User ubuntu
  HostName ec2-52-90-26-110.compute-1.amazonaws.com
  IdentityFile ~/.ssh/i3keypair.pem

Host slave3
  User ubuntu
  HostName ec2-54-81-154-100.compute-1.amazonaws.com
  IdentityFile ~/.ssh/i3keypair.pem

Host slave4
  User ubuntu
  HostName ec2-54-197-10-240.compute-1.amazonaws.com
  IdentityFile ~/.ssh/i3keypair.pem

Host slave5
  User ubuntu
  HostName ec2-52-90-184-0.compute-1.amazonaws.com
  IdentityFile ~/.ssh/i3keypair.pem

Host slave6
  User ubuntu
  HostName ec2-54-210-70-194.compute-1.amazonaws.com
  IdentityFile ~/.ssh/i3keypair.pem

Host slave7
  User ubuntu
  HostName ec2-52-55-229-42.compute-1.amazonaws.com
  IdentityFile ~/.ssh/i3keypair.pem

Host slave8
  User ubuntu
  HostName ec2-54-174-167-123.compute-1.amazonaws.com
  IdentityFile ~/.ssh/i3keypair.pem
```

slaves file in hadoop config :

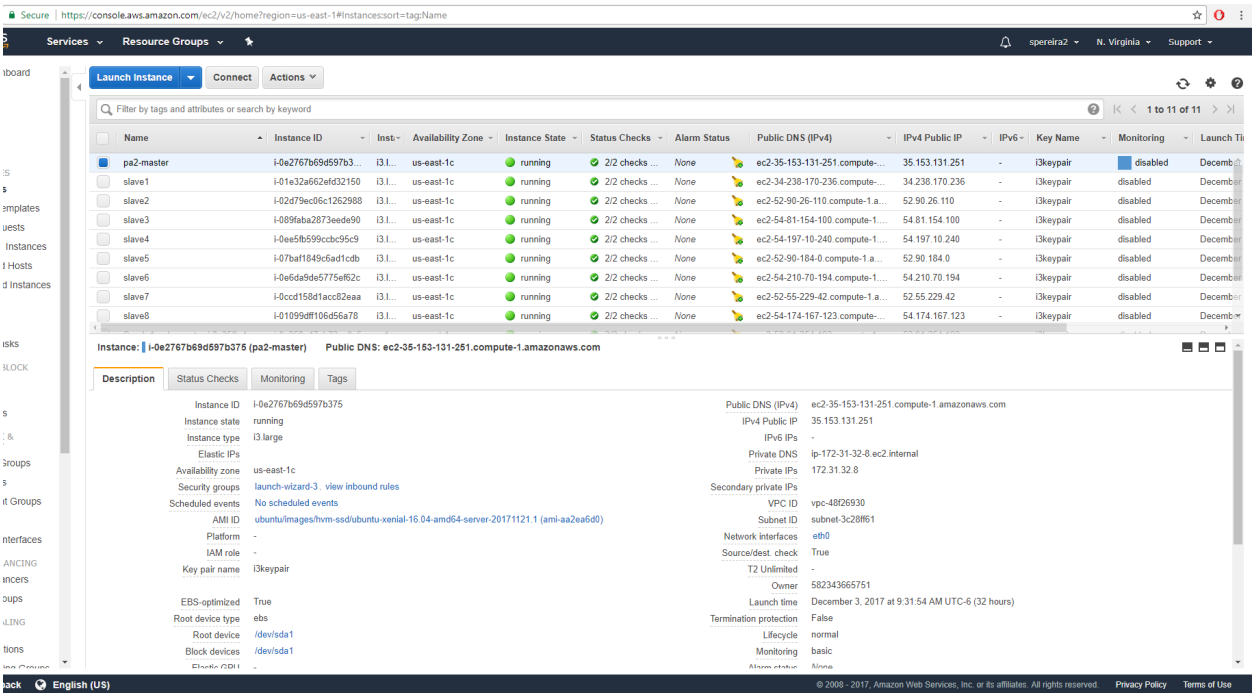
ubuntu@ip-172-31-32-8: ~/hadoop/etc/hadoop

```
#localhost
slave1
slave2
slave3
slave4
slave5
slave6
slave7
slave8
```

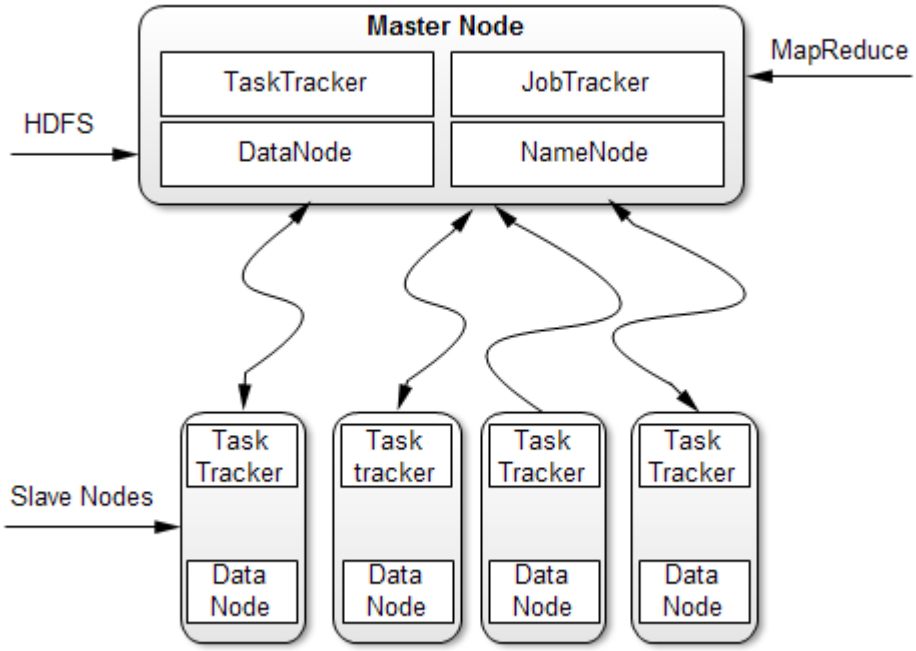
Starting the services on hadoop master and slave using *start-all.sh*

```
This script is Deprecated. Instead use start-dfs.sh and start-yarn.sh
Starting namenodes on [master]
master: starting namenode, logging to /mnt/hadoop/logs/hadoop-ubuntu-namenode-ip-172-31-32-8.out
slave1: starting datanode, logging to /mnt/hadoop/logs/hadoop-ubuntu-datanode-ip-172-31-40-193.out
slave2: starting datanode, logging to /mnt/hadoop/logs/hadoop-ubuntu-datanode-ip-172.31.34.91.out
slave3: starting datanode, logging to /mnt/hadoop/logs/hadoop-ubuntu-datanode-ip-172.31.33.63.out
slave4: starting datanode, logging to /mnt/hadoop/logs/hadoop-ubuntu-datanode-ip-172.31.47.55.out
slave5: starting datanode, logging to /mnt/hadoop/logs/hadoop-ubuntu-datanode-ip-172.31.39.5.out
slave6: starting datanode, logging to /mnt/hadoop/logs/hadoop-ubuntu-datanode-ip-172.31.46.244.out
slave7: starting datanode, logging to /mnt/hadoop/logs/hadoop-ubuntu-datanode-ip-172.31.43.173.out
slave8: starting datanode, logging to /mnt/hadoop/logs/hadoop-ubuntu-datanode-ip-172.31.34.26.out
starting yarn daemons
starting resourcemanager, logging to /mnt/hadoop/logs/yarn-ubuntu-resourcemanager-ip-172-31-32-8.out
master: starting nodemanager, logging to /mnt/hadoop/logs/yarn-ubuntu-nodemanager-ip-172-31-32-8.out
ubuntu@ip-172-31-32-8:/mnt/TeraSort-on-Cloud$
```

Hadoop:



Master-slave working of Hadoop MapReduce framework:




```
ubuntu@ip-172-31-32-8:/mnt/TeraSort-on-Cloud/src$ hadoop jar sort.jar  HadoopSort /input/pinput /poutput
17/12/04 20:43:30 INFO client.RMProxy: Connecting to ResourceManager at master/127.0.0.1:8032
17/12/04 20:43:30 WARN mapreduce.JobResourceUploader: Hadoop command-line option parsing not performed. Implement the Tool interface and execute your application with ToolR
unner to remedy this.
17/12/04 20:43:30 INFO input.FileInputFormat: Total input files to process : 1
17/12/04 20:43:31 INFO mapreduce.JobSubmitter: number of splits:954
17/12/04 20:43:31 INFO mapreduce.JobSubmitter: Submitting tokens for job: job_1512414945766_0004
17/12/04 20:43:31 INFO impl.YarnClientImpl: Submitted application application_1512414945766_0004
17/12/04 20:43:31 INFO mapreduce.Job: The url to track the job: http://ip-172-31-32-8.ec2.internal:8088/proxy/application_1512414945766_0004/
17/12/04 20:43:31 INFO mapreduce.Job: Running job: job_1512414945766_0004
17/12/04 20:43:38 INFO mapreduce.Job: Job job_1512414945766_0004 running in uber mode : false
17/12/04 20:43:38 INFO mapreduce.Job:  map 0% reduce 0%
17/12/04 20:44:40 INFO mapreduce.Job:  map 1% reduce 0%
17/12/04 20:46:11 INFO mapreduce.Job:  map 2% reduce 0%
```

```
17/12/04 17:21:55 INFO mapreduce.Job:  map 98% reduce 75%
17/12/04 17:21:55 INFO mapreduce.Job:  map 99% reduce 76%
17/12/04 17:21:55 INFO mapreduce.Job:  map 99% reduce 78%
17/12/04 17:21:55 INFO mapreduce.Job:  map 99% reduce 80%
17/12/04 17:21:55 INFO mapreduce.Job:  map 100% reduce 81%
17/12/04 17:21:55 INFO mapreduce.Job:  map 100% reduce 82%
17/12/04 17:21:55 INFO mapreduce.Job:  map 100% reduce 83%
17/12/04 17:21:55 INFO mapreduce.Job:  map 100% reduce 85%
17/12/04 17:21:55 INFO mapreduce.Job:  map 100% reduce 86%
17/12/04 17:21:55 INFO mapreduce.Job:  map 100% reduce 88%
17/12/04 17:21:55 INFO mapreduce.Job:  map 100% reduce 90%
17/12/04 17:21:55 INFO mapreduce.Job:  map 100% reduce 91%
17/12/04 17:21:55 INFO mapreduce.Job:  map 100% reduce 92%
17/12/04 17:21:55 INFO mapreduce.Job:  map 100% reduce 94%
17/12/04 17:21:55 INFO mapreduce.Job:  map 100% reduce 95%
17/12/04 17:21:55 INFO mapreduce.Job:  map 100% reduce 96%
17/12/04 17:21:55 INFO mapreduce.Job:  map 100% reduce 97%
17/12/04 17:21:55 INFO mapreduce.Job:  map 100% reduce 98%
17/12/04 17:21:55 INFO mapreduce.Job:  map 100% reduce 99%
17/12/04 17:21:55 INFO mapreduce.Job:  map 100% reduce 100%
```

Check the generated files by running below command:

ubuntu@ip-172-31-32-8:/mnt/TeraSort-on-Cloud$ hdfs dfs -ls /poutput

```
Found 7452 items
-rw-r--r--   1 ubuntu supergroup          0 2017-12-04 19:40 /poutput/_SUCCESS
-rw-r--r--   1 ubuntu supergroup   92876983 2017-12-04 19:35 /poutput/part-00000
-rw-r--r--   1 ubuntu supergroup  140379638 2017-12-04 19:35 /poutput/part-00001
-rw-r--r--   1 ubuntu supergroup  184494311 2017-12-04 19:35 /poutput/part-00002
-rw-r--r--   1 ubuntu supergroup  125972656 2017-12-04 19:35 /poutput/part-00003
-rw-r--r--   1 ubuntu supergroup  122111653 2017-12-04 19:36 /poutput/part-00004
-rw-r--r--   1 ubuntu supergroup  156795912 2017-12-04 19:36 /poutput/part-00005
-rw-r--r--   1 ubuntu supergroup  148765203 2017-12-04 19:36 /poutput/part-00006
-rw-r--r--   1 ubuntu supergroup  193776468 2017-12-04 19:36 /poutput/part-00007
-rw-r--r--   1 ubuntu supergroup  129205683 2017-12-04 19:37 /poutput/part-00009
-rw-r--r--   1 ubuntu supergroup  115318327 2017-12-04 19:37 /poutput/part-00010
-rw-r--r--   1 ubuntu supergroup  100908034 2017-12-04 19:37 /poutput/part-00011
-rw-r--r--   1 ubuntu supergroup  129718566 2017-12-04 19:37 /poutput/part-00012
-rw-r--r--   1 ubuntu supergroup  197707477 2017-12-04 19:38 /poutput/part-00013
-rw-r--r--   1 ubuntu supergroup  179849406 2017-12-04 19:38 /poutput/part-00014
-rw-r--r--   1 ubuntu supergroup  154687022 2017-12-04 19:38 /poutput/part-00015
-rw-r--r--   1 ubuntu supergroup  153215932 2017-12-04 19:38 /poutput/part-00016
-rw-r--r--   1 ubuntu supergroup  165256485 2017-12-04 19:39 /poutput/part-00017
-rw-r--r--   1 ubuntu supergroup  115573623 2017-12-04 19:39 /poutput/part-00018
-rw-r--r--   1 ubuntu supergroup  116262501 2017-12-04 19:39 /poutput/part-00019
```

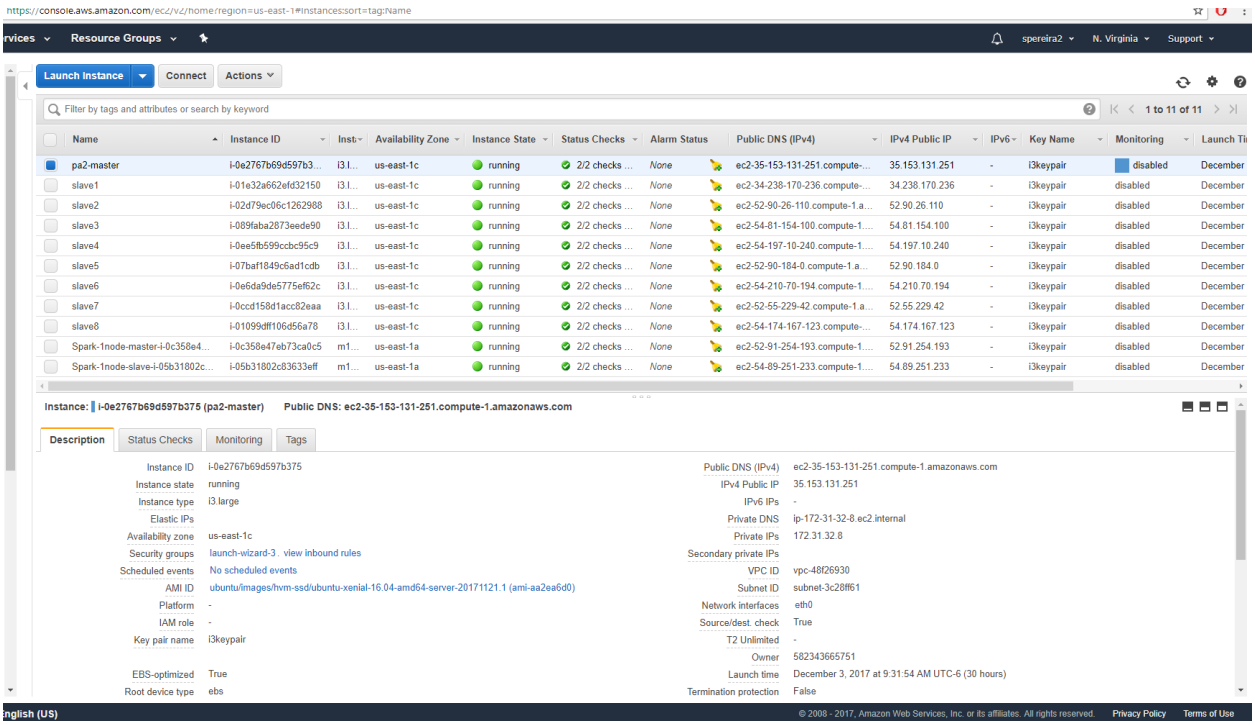
Validating sorted 1TB file by MapReduce:

```
ubuntu@ip-172-31-32-8:/mnt/TeraSort-on-Cloud/src$ ./valsort output1TB_MR
Records: 10000000000
Checksum: 12a06cd06eeb64b16
Duplicate keys: 0
SUCCESS - all records are in order
```

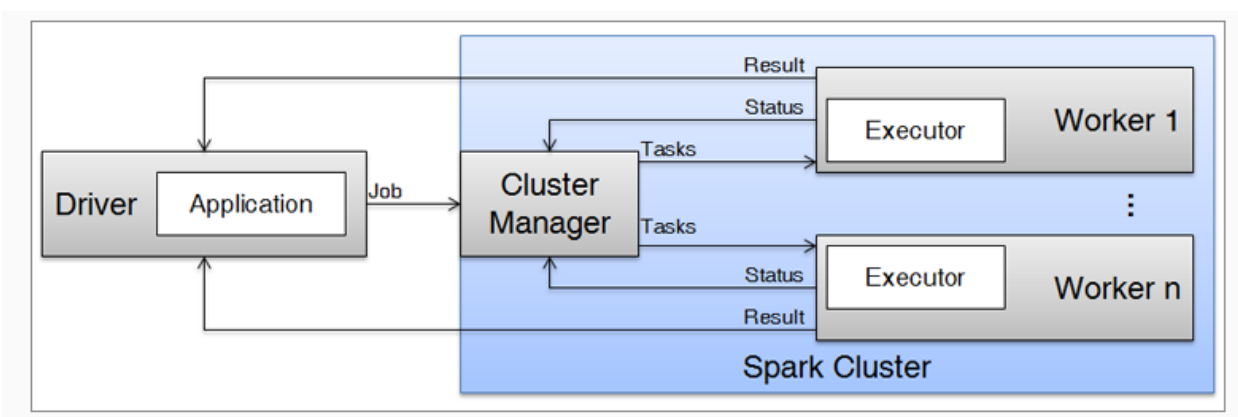
Spark:

To launch sparkCluster:

```
./spark-ec2 -k i3keypair -i ~/i3keypair.pem --instance-type=i3.xlarge  --slaves=8 launch SparkCluster
```



How master-slave config for Spark works.



ubuntu@ip-172-31-32-8:/mnt/spark/ec2$ ./spark-ec2 -k i3keypair -i ~/i3keypair.pem **--slaves=8** --instance-type=i3.large launch SparkNodes

```
Setting up security groups...
Creating security group SparkNode-master
Creating security group SparkNode-slaves
Searching for existing cluster SparkNode in region us-east-1...
Spark AMI: ami-5bb18832
Launching instances...
Launched 8 slave in us-east-1a, regid = r-0764ffe77fb5e24c3
Launched master in us-east-1a, regid = r-04892f637e80f817f
Waiting for AWS to propagate instance metadata...
Applying tags to master nodes
Applying tags to slave nodes
Waiting for cluster to enter 'ssh-ready' state..
```

```
Setting up mapreduce
Pseudo-terminal will not be allocated because stdin is not a terminal.
RSYNC'ing /root/mapreduce/conf to slaves...
ec2-34-229-128-231.compute-1.amazonaws.com
[timing] mapreduce setup:  00h 00m 01s
Setting up spark-standalone
RSYNC'ing /root/spark/conf to slaves...
ec2-34-229-128-231.compute-1.amazonaws.com
RSYNC'ing /root/spark-ec2 to slaves...
ec2-34-229-128-231.compute-1.amazonaws.com
ec2-34-229-128-231.compute-1.amazonaws.com: no org.apache.spark.deploy.worker.Worker to stop
no org.apache.spark.deploy.master.Master to stop
starting org.apache.spark.deploy.master.Master, logging to /root/spark/logs/spark-root-org.apache.spark.deploy.master.Master-1-ip-172-31-25-133.ec2.in
ternal.out
ec2-34-229-128-231.compute-1.amazonaws.com: starting org.apache.spark.deploy.worker.Worker, logging to /root/spark/logs/spark-root-org.apache.spark.de
ploy.worker.Worker-1-ip-172-31-21-3.ec2.internal.out
[timing] spark-standalone setup:  00h 00m 44s
Setting up rstudio
spark-ec2/setup.sh: line 110: ./rstudio/setup.sh: No such file or directory
[timing] rstudio setup:  00h 00m 00s
Setting up ganglia
RSYNC'ing /etc/ganglia to slaves...
ec2-34-229-128-231.compute-1.amazonaws.com
Shutting down GANGLIA gmond:                               [FAILED]
Starting GANGLIA gmond:                                    [  OK  ]
Shutting down GANGLIA gmond:                               [FAILED]
Starting GANGLIA gmond:                                    [  OK  ]
Connection to ec2-34-229-128-231.compute-1.amazonaws.com closed.
Shutting down GANGLIA gmetad:                              [FAILED]
Starting GANGLIA gmetad:                                   [  OK  ]
Stopping httpd:                                            [FAILED]
```

Submit the spark program using below commands:

ubuntu@ip-172-31-32-8:/mnt/spark/bin$ ./spark-submit /mnt/TeraSort-on-Cloud/src/sparksort.py /input/pinput /sparkout

```
Input file is:  /input/pinput
Number of arguemnts passed are:  3
Input is in /input/pinput
Output will be stored in  /sparkout
17/12/04 00:51:52 INFO spark.SparkContext: Running Spark version 2.1.2
17/12/04 00:51:52 INFO spark.SecurityManager: Changing view acls to: ubuntu
17/12/04 00:51:52 INFO spark.SecurityManager: Changing modify acls to: ubuntu
17/12/04 00:51:52 INFO spark.SecurityManager: Changing view acls groups to:
17/12/04 00:51:52 INFO spark.SecurityManager: Changing modify acls groups to:
17/12/04 00:51:52 INFO spark.SecurityManager: SecurityManager: authentication disabled; ui acls disabled; users  with view permissions: Set(ubuntu); groups with view permis
sions: Set(); users  with modify permissions: Set(ubuntu); groups with modify permissions: Set()
17/12/04 00:51:53 INFO util.Utils: Successfully started service 'sparkDriver' on port 34940.
17/12/04 00:51:53 INFO spark.SparkEnv: Registering MapOutputTracker
17/12/04 00:51:53 INFO spark.SparkEnv: Registering BlockManagerMaster
17/12/04 00:51:53 INFO storage.BlockManagerMasterEndpoint: Using org.apache.spark.storage.DefaultTopologyMapper for getting topology information
17/12/04 00:51:53 INFO storage.BlockManagerMasterEndpoint: BlockManagerMasterEndpoint up
17/12/04 00:51:53 INFO storage.DiskBlockManager: Created local directory at /tmp/blockmgr-0f0bcd21-2035-415c-ad29-7614962b6a67
17/12/04 00:51:53 INFO memory.MemoryStore: MemoryStore started with capacity 366.3 MB
17/12/04 00:51:53 INFO spark.SparkEnv: Registering OutputCommitCoordinator
17/12/04 00:51:53 INFO util.log: Logging initialized @1873ms
17/12/04 00:51:53 INFO server.Server: jetty-9.2.z-SNAPSHOT
17/12/04 00:51:53 INFO handler.ContextHandler: Started o.s.j.s.ServletContextHandler@772e7927{/jobs,null,AVAILABLE,@Spark}
17/12/04 00:51:53 INFO handler.ContextHandler: Started o.s.j.s.ServletContextHandler@99134c5{/jobs/json,null,AVAILABLE,@Spark}
17/12/04 00:51:53 INFO handler.ContextHandler: Started o.s.j.s.ServletContextHandler@5bf351ea{/jobs/job,null,AVAILABLE,@Spark}
17/12/04 00:51:53 INFO handler.ContextHandler: Started o.s.j.s.ServletContextHandler@ddd5cb7{/jobs/job/json,null,AVAILABLE,@Spark}
17/12/04 00:51:53 INFO handler.ContextHandler: Started o.s.j.s.ServletContextHandler@9befb6a{/stages,null,AVAILABLE,@Spark}
17/12/04 00:51:53 INFO handler.ContextHandler: Started o.s.j.s.ServletContextHandler@909c184{/stages/json,null,AVAILABLE,@Spark}
17/12/04 00:51:53 INFO handler.ContextHandler: Started o.s.j.s.ServletContextHandler@48b4bd4e{/stages/stage,null,AVAILABLE,@Spark}
17/12/04 00:51:53 INFO handler.ContextHandler: Started o.s.j.s.ServletContextHandler@2f6b780b{/stages/stage/json,null,AVAILABLE,@Spark}
17/12/04 00:51:53 INFO handler.ContextHandler: Started o.s.j.s.ServletContextHandler@5170b327{/stages/pool,null,AVAILABLE,@Spark}
17/12/04 00:51:53 INFO handler.ContextHandler: Started o.s.j.s.ServletContextHandler@16325d6c{/stages/pool/json,null,AVAILABLE,@Spark}
17/12/04 00:51:53 INFO handler.ContextHandler: Started o.s.j.s.ServletContextHandler@7b01cc29{/storage,null,AVAILABLE,@Spark}
17/12/04 00:51:53 INFO handler.ContextHandler: Started o.s.j.s.ServletContextHandler@fde4862{/storage/json,null,AVAILABLE,@Spark}
17/12/04 00:51:53 INFO handler.ContextHandler: Started o.s.j.s.ServletContextHandler@5be32b35{/storage/rdd,null,AVAILABLE,@Spark}
17/12/04 00:51:53 INFO handler.ContextHandler: Started o.s.j.s.ServletContextHandler@5fbed418{/storage/rdd/json,null,AVAILABLE,@Spark}
17/12/04 00:51:53 INFO handler.ContextHandler: Started o.s.j.s.ServletContextHandler@2aab3b42{/environment,null,AVAILABLE,@Spark}
17/12/04 00:51:53 INFO handler.ContextHandler: Started o.s.j.s.ServletContextHandler@57cbfb2d{/environment/json,null,AVAILABLE,@Spark}
17/12/04 00:51:53 INFO handler.ContextHandler: Started o.s.j.s.ServletContextHandler@15b3d862{/executors,null,AVAILABLE,@Spark}
17/12/04 00:51:53 INFO handler.ContextHandler: Started o.s.j.s.ServletContextHandler@3c04d0d8{/executors/json,null,AVAILABLE,@Spark}
```

```
17/12/04 08:08:21 INFO executor.Executor: Running task 6706.0 in stage 0.0 (TID 6706)
17/12/04 08:08:21 INFO scheduler.TaskSetManager: Finished task 6705.0 in stage 0.0 (TID 6705) in 3916 ms on localhost (executor driver) (6706/7451)
17/12/04 08:08:21 INFO rdd.HadoopRDD: Input split: hdfs://localhost:9000/input/pinput:900064083968+134217728
17/12/04 08:08:25 INFO python.PythonRunner: Times: total = 3873, boot = 1, init = 0, finish = 3872
17/12/04 08:08:25 INFO executor.Executor: Finished task 6706.0 in stage 0.0 (TID 6706). 1720 bytes result sent to driver
17/12/04 08:08:25 INFO scheduler.TaskSetManager: Starting task 6707.0 in stage 0.0 (TID 6707, localhost, executor driver, partition 6707, ANY, 6121 bytes)
17/12/04 08:08:25 INFO executor.Executor: Running task 6707.0 in stage 0.0 (TID 6707)
17/12/04 08:08:25 INFO scheduler.TaskSetManager: Finished task 6706.0 in stage 0.0 (TID 6706) in 3875 ms on localhost (executor driver) (6707/7451)
17/12/04 08:08:25 INFO rdd.HadoopRDD: Input split: hdfs://localhost:9000/input/pinput:900198301696+134217728
17/12/04 08:08:29 INFO python.PythonRunner: Times: total = 3884, boot = 1, init = 0, finish = 3883
17/12/04 08:08:29 INFO executor.Executor: Finished task 6707.0 in stage 0.0 (TID 6707). 1807 bytes result sent to driver
17/12/04 08:08:29 INFO scheduler.TaskSetManager: Starting task 6708.0 in stage 0.0 (TID 6708, localhost, executor driver, partition 6708, ANY, 6121 bytes)
17/12/04 08:08:29 INFO executor.Executor: Running task 6708.0 in stage 0.0 (TID 6708)
17/12/04 08:08:29 INFO scheduler.TaskSetManager: Finished task 6707.0 in stage 0.0 (TID 6707) in 3887 ms on localhost (executor driver) (6708/7451)
17/12/04 08:08:29 INFO rdd.HadoopRDD: Input split: hdfs://localhost:9000/input/pinput:900332519424+134217728
17/12/04 08:08:33 INFO python.PythonRunner: Times: total = 3890, boot = 0, init = 1, finish = 3889
17/12/04 08:08:33 INFO executor.Executor: Finished task 6708.0 in stage 0.0 (TID 6708). 1720 bytes result sent to driver
17/12/04 08:08:33 INFO scheduler.TaskSetManager: Starting task 6709.0 in stage 0.0 (TID 6709, localhost, executor driver, partition 6709, ANY, 6121 bytes)
17/12/04 08:08:33 INFO executor.Executor: Running task 6709.0 in stage 0.0 (TID 6709)
17/12/04 08:08:33 INFO scheduler.TaskSetManager: Finished task 6708.0 in stage 0.0 (TID 6708) in 3892 ms on localhost (executor driver) (6709/7451)
17/12/04 08:08:33 INFO rdd.HadoopRDD: Input split: hdfs://localhost:9000/input/pinput:900466737152+134217728
17/12/04 08:08:37 INFO python.PythonRunner: Times: total = 3886, boot = 1, init = 0, finish = 3885
17/12/04 08:08:37 INFO executor.Executor: Finished task 6709.0 in stage 0.0 (TID 6709). 1807 bytes result sent to driver
17/12/04 08:08:37 INFO scheduler.TaskSetManager: Starting task 6710.0 in stage 0.0 (TID 6710, localhost, executor driver, partition 6710, ANY, 6121 bytes)
17/12/04 08:08:37 INFO executor.Executor: Running task 6710.0 in stage 0.0 (TID 6710)
17/12/04 08:08:37 INFO scheduler.TaskSetManager: Finished task 6709.0 in stage 0.0 (TID 6709) in 3888 ms on localhost (executor driver) (6710/7451)
17/12/04 08:08:37 INFO rdd.HadoopRDD: Input split: hdfs://localhost:9000/input/pinput:900600954880+134217728
17/12/04 08:08:41 INFO python.PythonRunner: Times: total = 3883, boot = 1, init = 0, finish = 3882
17/12/04 08:08:41 INFO executor.Executor: Finished task 6710.0 in stage 0.0 (TID 6710). 1807 bytes result sent to driver
17/12/04 08:08:41 INFO scheduler.TaskSetManager: Starting task 6711.0 in stage 0.0 (TID 6711, localhost, executor driver, partition 6711, ANY, 6121 bytes)
17/12/04 08:08:41 INFO executor.Executor: Running task 6711.0 in stage 0.0 (TID 6711)
17/12/04 08:08:41 INFO scheduler.TaskSetManager: Finished task 6710.0 in stage 0.0 (TID 6710) in 3886 ms on localhost (executor driver) (6711/7451)
17/12/04 08:08:41 INFO rdd.HadoopRDD: Input split: hdfs://localhost:9000/input/pinput:900735172608+134217728
17/12/04 08:08:44 INFO python.PythonRunner: Times: total = 3873, boot = 1, init = 0, finish = 3872
17/12/04 08:08:44 INFO executor.Executor: Finished task 6711.0 in stage 0.0 (TID 6711). 1807 bytes result sent to driver
17/12/04 08:08:44 INFO scheduler.TaskSetManager: Starting task 6712.0 in stage 0.0 (TID 6712, localhost, executor driver, partition 6712, ANY, 6121 bytes)
17/12/04 08:08:44 INFO executor.Executor: Running task 6712.0 in stage 0.0 (TID 6712)
17/12/04 08:08:44 INFO scheduler.TaskSetManager: Finished task 6711.0 in stage 0.0 (TID 6711) in 3876 ms on localhost (executor driver) (6712/7451)
17/12/04 08:08:44 INFO rdd.HadoopRDD: Input split: hdfs://localhost:9000/input/pinput:900869390336+134217728
```

Check the generated files:

ubuntu@ip-172-31-32-8:/mnt/TeraSort-on-Cloud$ hdfs dfs -ls /sparkout

```
Found 7452 items
-rw-r--r--   1 ubuntu supergroup          0 2017-12-04 19:40 /sparkout/_SUCCESS
-rw-r--r--   1 ubuntu supergroup   92876983 2017-12-04 19:35 /sparkout/part-00000
-rw-r--r--   1 ubuntu supergroup  140379638 2017-12-04 19:35 /sparkout/part-00001
-rw-r--r--   1 ubuntu supergroup  184494311 2017-12-04 19:35 /sparkout/part-00002
-rw-r--r--   1 ubuntu supergroup  125972656 2017-12-04 19:35 /sparkout/part-00003
-rw-r--r--   1 ubuntu supergroup  122111653 2017-12-04 19:36 /sparkout/part-00004
-rw-r--r--   1 ubuntu supergroup  156795912 2017-12-04 19:36 /sparkout/part-00005
-rw-r--r--   1 ubuntu supergroup  148765203 2017-12-04 19:36 /sparkout/part-00006
-rw-r--r--   1 ubuntu supergroup  193776468 2017-12-04 19:36 /sparkout/part-00007
-rw-r--r--   1 ubuntu supergroup  148391360 2017-12-04 19:37 /sparkout/part-00008
-rw-r--r--   1 ubuntu supergroup  129205683 2017-12-04 19:37 /sparkout/part-00009
-rw-r--r--   1 ubuntu supergroup  115318327 2017-12-04 19:37 /sparkout/part-00010
-rw-r--r--   1 ubuntu supergroup  100908034 2017-12-04 19:37 /sparkout/part-00011
-rw-r--r--   1 ubuntu supergroup  129718566 2017-12-04 19:37 /sparkout/part-00012
-rw-r--r--   1 ubuntu supergroup  197707477 2017-12-04 19:38 /sparkout/part-00013
-rw-r--r--   1 ubuntu supergroup  179849406 2017-12-04 19:38 /sparkout/part-00014
-rw-r--r--   1 ubuntu supergroup  154687022 2017-12-04 19:38 /sparkout/part-00015
-rw-r--r--   1 ubuntu supergroup  153215932 2017-12-04 19:38 /sparkout/part-00016
-rw-r--r--   1 ubuntu supergroup  165256485 2017-12-04 19:39 /sparkout/part-00017
-rw-r--r--   1 ubuntu supergroup  115573623 2017-12-04 19:39 /sparkout/part-00018
-rw-r--r--   1 ubuntu supergroup  116262501 2017-12-04 19:39 /sparkout/part-00019
-rw-r--r--   1 ubuntu supergroup  120259297 2017-12-04 19:39 /sparkout/part-00020
-rw-r--r--   1 ubuntu supergroup  128443975 2017-12-04 19:39 /sparkout/part-00021
-rw-r--r--   1 ubuntu supergroup  153473990 2017-12-04 19:40 /sparkout/part-00022
```

```
ubuntu@ip-172-31-32-8:/mnt/TeraSort-on-Cloud/src$ ./valsort output1TB_Spark
Records: 10000000000
Checksum: 12a06cd06eeb64b16
Duplicate keys: 0
SUCCESS - all records are in order
```

Stopping all the nodes:

```
This script is Deprecated. Instead use stop-dfs.sh and stop-yarn.sh
Stopping namenodes on [master]
master: stopping namenode
slave1: stopping datanode
slave2: stopping datanode
slave3: stopping datanode
slave4: stopping datanode
slave5: stopping datanode
slave6: stopping datanode
slave7: stopping datanode
slave8: stopping datanode
stopping yarn daemons
stopping resourcemanager
master: stopping nodemanager
ubuntu@ip-172-31-32-8:/mnt/TeraSort-on-Cloud$
```