# CS553 Cloud Computing

# Assignment #2

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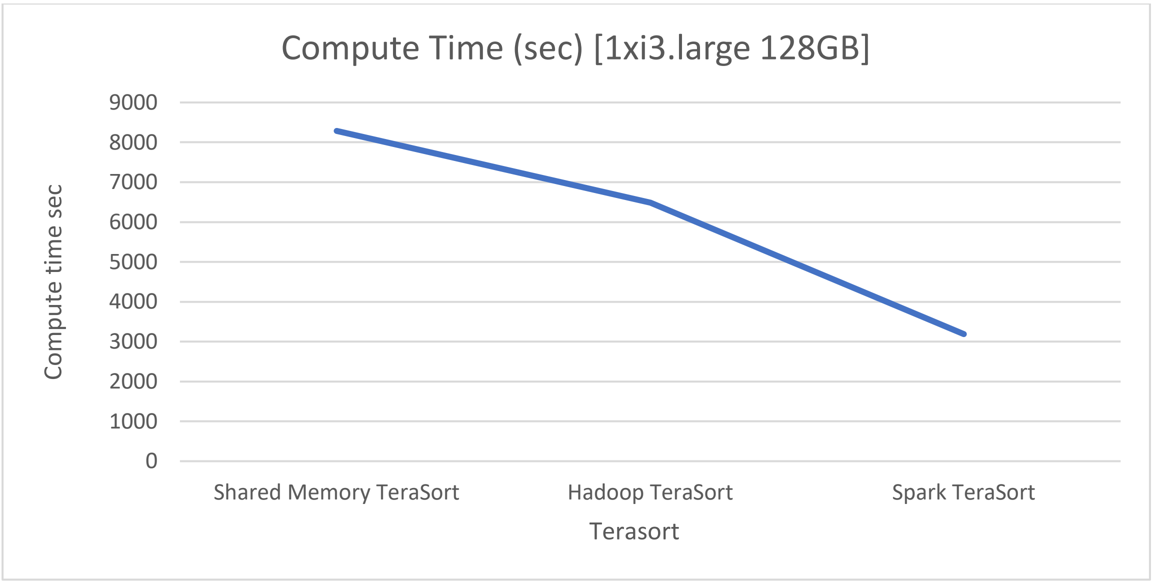
## Contents

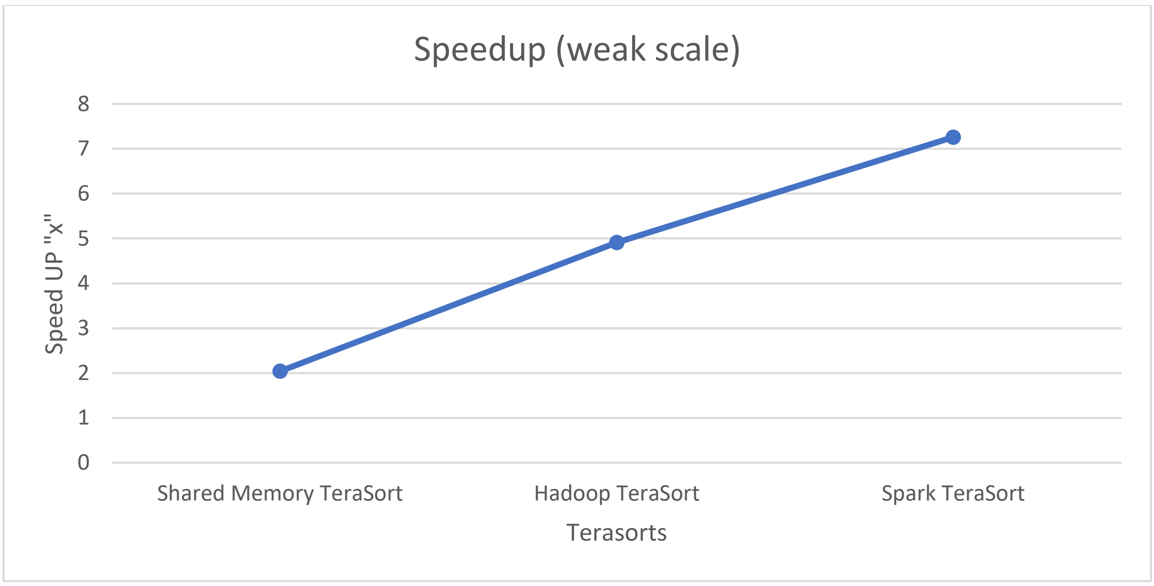
## Performance Evaluation of Terasort

| Experiment (instance/dataset) | Shared Memory TeraSort | Hadoop TeraSort | Spark TeraSort |
|---|---|---|---|
| Compute Time (sec) [1xi3.large 128GB] | 8286 | 6484 | 3189 |
| Data Read (GB) [1xi3.large 128GB] | 7.6x128 | 10x128 | 2x128 |
| Data Write (GB) [1xi3.large 128GB] | 7.6x128 | 4x128 | 2x128 |
| I/O Throughput (MB/sec) [1xi3.large 128GB] | 15.45 | 19.74 | 40.14 |
| Compute Time (sec) [1xi3.4xlarge 1TB] | 32456 | 12563 | 3700 |
| Data Read (GB) [1xi3.4xlarge 1TB] | 10.7x1002 | 16x1002 | 2x1002 |
| Data Write (GB) [1xi3.4xlarge 1TB] | 10.7x1002 | 4x1002 | 2x1002 |
| I/O Throughput (MB/sec) [1xi3.4xlarge 1TB] | 30.87 | 79.76 | 270.81 |
| Compute Time (sec) [8xi3.large 1TB] | N/A | 10563 | 3512 |
| Data Read (GB) [8xi3.large 1TB] | N/A | 80x1002 | 2x1002 |
| Data Write (GB) [8xi3.large 1TB] | N/A | 32x1002 | 2x1002 |
| I/O Throughput (MB/sec) [8xi3.large 1TB] | N/A | 94.85941494 | 285.3075171 |
| Speedup (weak scale) | 2.04x | 4.91x | 7.26x |
| Efficiency (weak scale) | 25.53% | 61.38% | 90.80% |



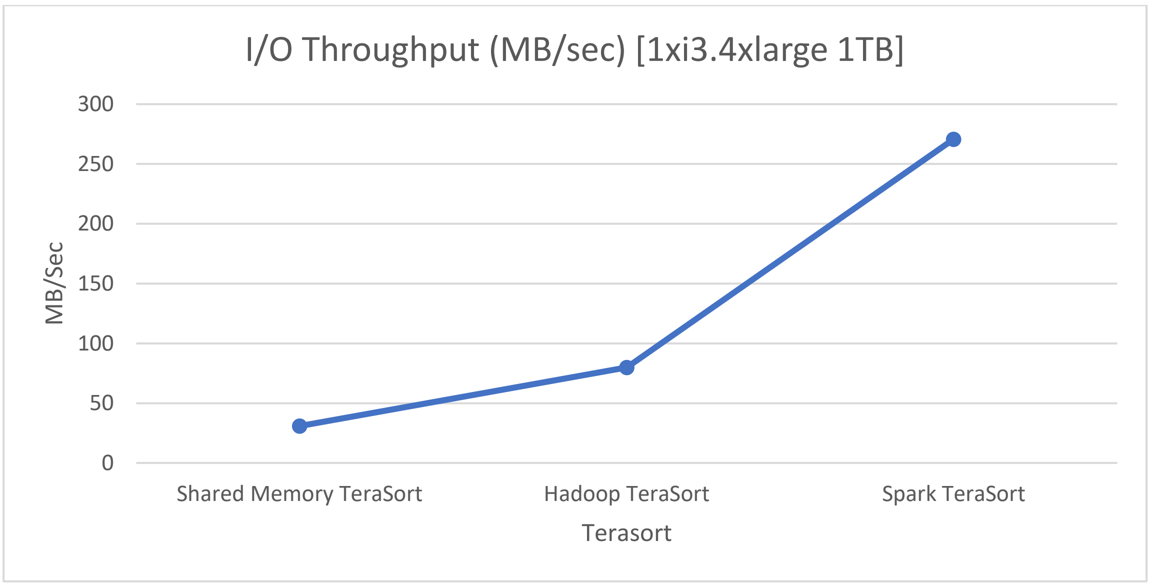
It takes more time for the Computation of same amount of data in the following way

Shared Memory Terasort>Hadoop Terasort>Spark Terasort



The Speed up is been improved on the following scale

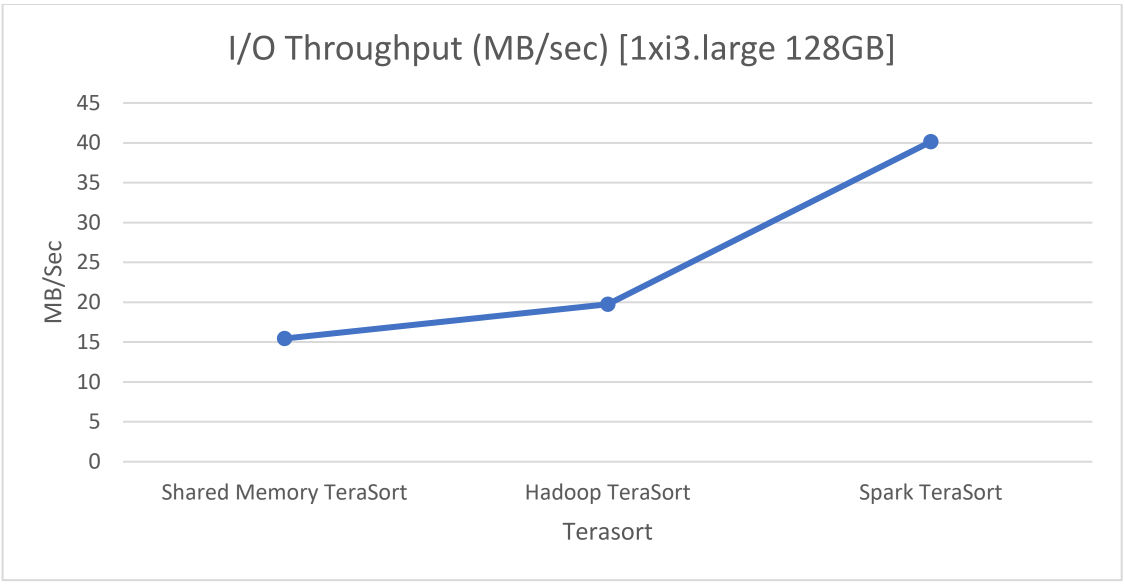
Spark Terasort>Hadoop Terasort > Shared Memory Terasort



In reference to the http://docs.aws.amazon.com/AWSEC2/latest/UserGuide/EBSOptimized.html link the through put that can be maximum achieved in a i3.4x large instance is 437.5 MB/sec where the maximum achieved in the above graph is 270 MB/sec for the spark terasort where the performance can be improved and optimized to the maximum level mentioned above.

The I/O Through put in MB/sec is been achieved in the way where the performance is increased in the following fashion

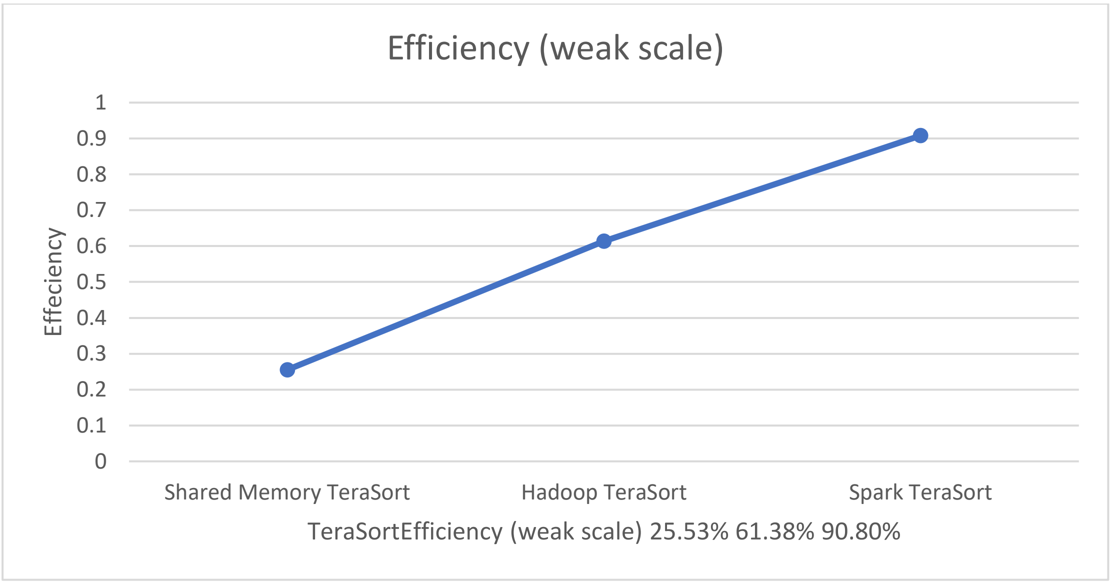
Spark Terasort> Hadoop Terasort >Shared Memory Terasort



In reference to the http://docs.aws.amazon.com/AWSEC2/latest/UserGuide/EBSOptimized.html link the through put that can be maximum achieved in a i3 large instance is 53.13 MB/sec where the maximum achieved in the above graph is 40 MB/sec for the spark terasort where the performance can be improved and optimized to the maximum level mentioned above.

The I/O Through put in MB/sec is been achieved in the way where the performance is increased in the following fashion

Spark Terasort> Hadoop Terasort >Shared Memory Terasort



The efficiency of the Spark Terasort is way ahead of the shared memory terasort, where as Hadoop Terasort is the midrange.

## Shared Memory

We have implemented the Shared-Memory Sort application using Java and measured its performance on single node of the below mentioned instances.

1) i3.large
2) i3.4xlarge

We have used multi-threading , (1-2 and 4 ) threads in i3.large and 2 threads in i3.4xlarge and measured the time to sort application on 128 GB and 1TB in the respective instances mentioned in the requirement.

### Commands to run the SharedMemory 128 GB

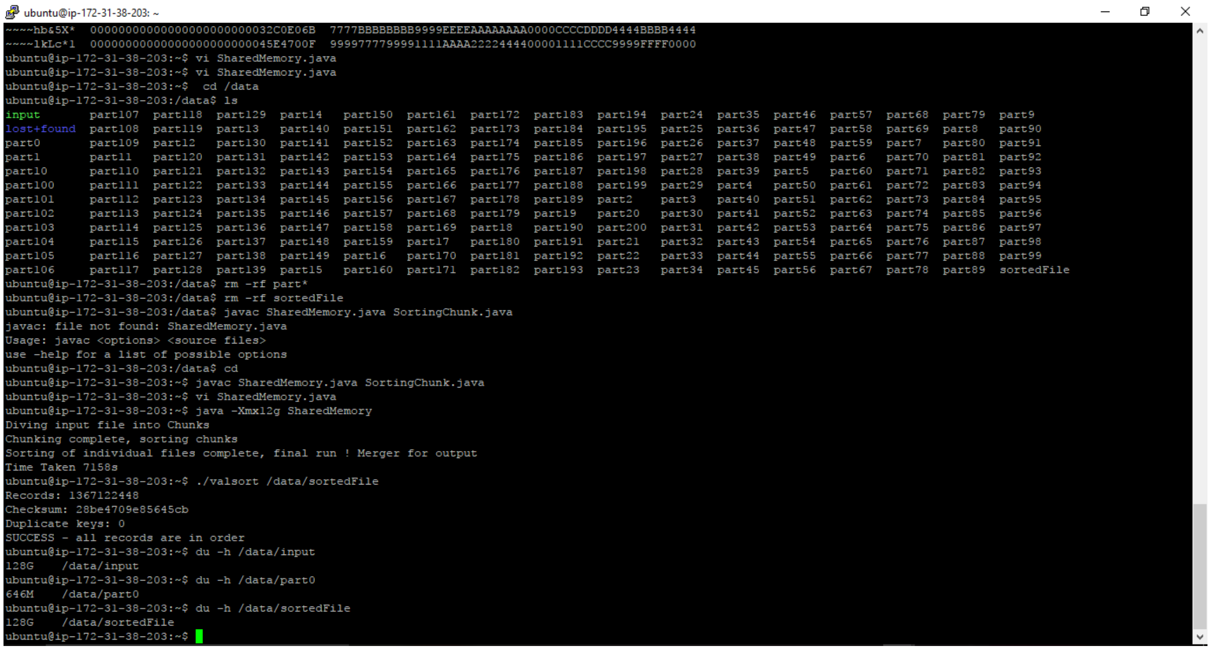
```
echo "Configuration Settings"

sudo apt-get update

sudo apt-get install mdadm

echo "Creating file system"

lsblk

sudo file -s /dev/nvme0n1

sudo mkfs -t ext4 /dev/nvme0n1

sudo mkdir /data

sudo mount /dev/nvme0n1 /data

echo "Installing Java Installables"

sudo apt-get install default-jdk

java -version

sudo apt-get install ant

echo " Generating data"

wget http://www.ordinal.com/try.cgi/gensort-linux-1.5.tar.gz

tar -xvf gensort-linux-1.5.tar.gz

cd 64

./gensort -a 1367122448 /data/input

echo "Running the Program"

javac SharedMemory.java SortingChunk.java

java -Xmx12g SharedMemory

echo "Validating the output"

./valsort /data/sortedFile
```

### The running of the program in for 128 GB in i3.large

| Input Data Size | Chunk Size | No. of Threads | Compute Time(seconds) |
|---|---|---|---|
| 128 GB | 646MB | 1 | 7158 |
| 128 GB | 646MB | 2 | 6854 |
| 128 GB | 646MB | 4 | 8286 |

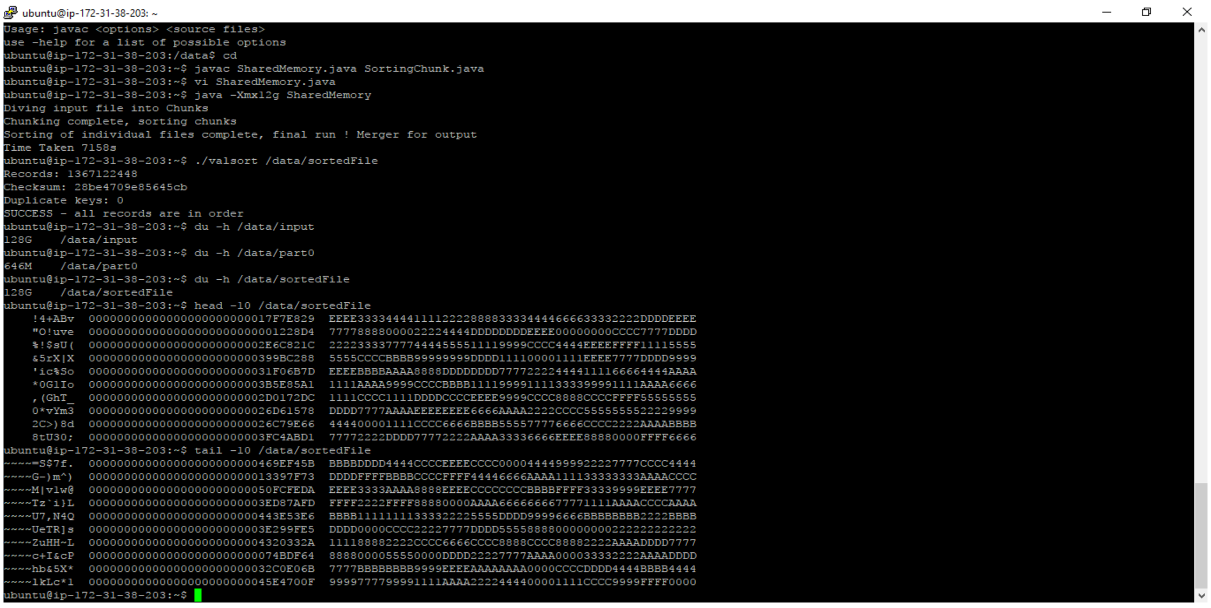
## Instance used for the 128 GB SharedMemory program run

### SharedMemory 1 thread



ubuntu@ip-172-31-38-203: ~

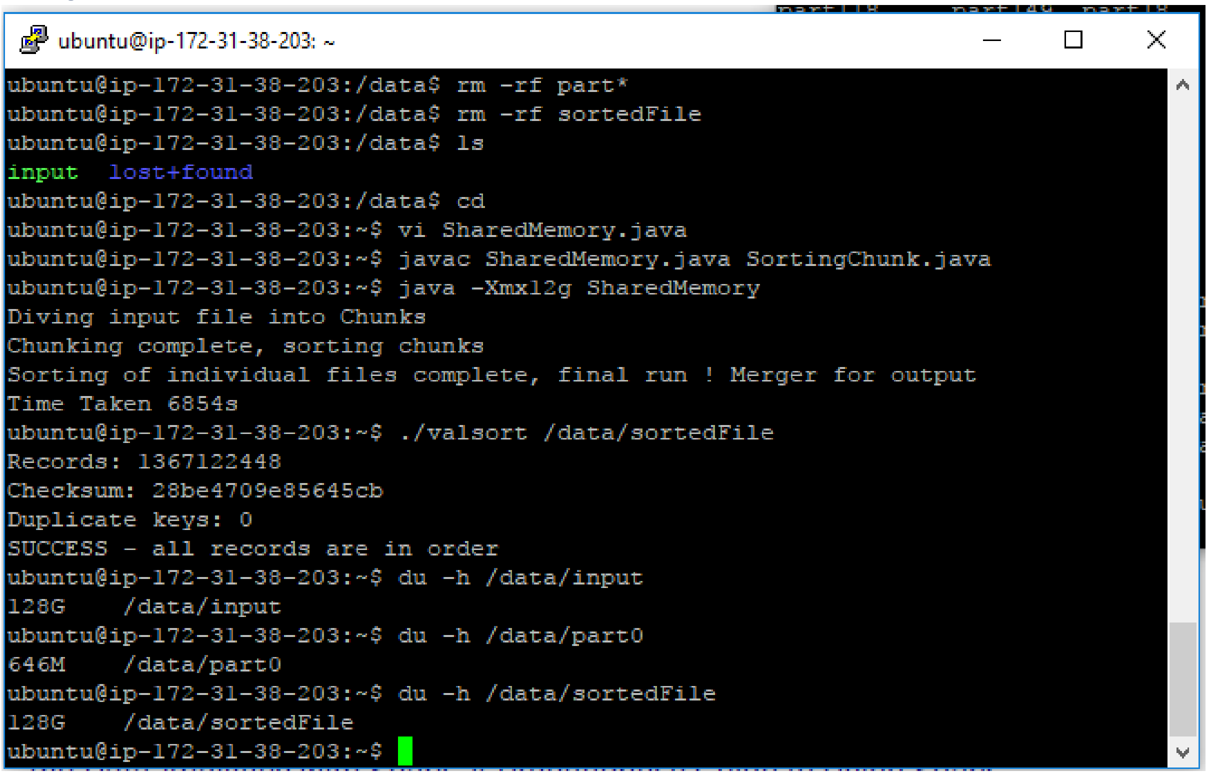
```
~~~~hb&5X*  00000000000000000000000032C0E06B  7777BBBBBBBB9999EEEEAAAAAAAA0000CCCCDDDD4444BBBB4444
~~~~lkLc*l  00000000000000000000000045E4700F  9999777799991111AAAA2222444400001111CCCC9999FFFF0000
ubuntu@ip-172-31-38-203:~$ vi SharedMemory.java
ubuntu@ip-172-31-38-203:~$ vi SharedMemory.java
ubuntu@ip-172-31-38-203:~$  cd /data
ubuntu@ip-172-31-38-203:/data$ ls
input       part107  part118  part129  part14   part150  part161  part172  part183  part194  part24   part35  part46  part57  part68  part79  part9
lost+found  part108  part119  part13   part140  part151  part162  part173  part184  part195  part25   part36  part47  part58  part69  part8   part90
part0       part109  part12   part130  part141  part152  part163  part174  part185  part196  part26   part37  part48  part59  part7   part80  part91
part1       part11   part120  part131  part142  part153  part164  part175  part186  part197  part27   part38  part49  part6   part70  part81  part92
part10      part110  part121  part132  part143  part154  part165  part176  part187  part198  part28   part39  part5   part60  part71  part82  part93
part100     part111  part122  part133  part144  part155  part166  part177  part188  part199  part29   part4   part50  part61  part72  part83  part94
part101     part112  part123  part134  part145  part156  part167  part178  part189  part2    part3    part40  part51  part62  part73  part84  part95
part102     part113  part124  part135  part146  part157  part168  part179  part19   part20   part30   part41  part52  part63  part74  part85  part96
part103     part114  part125  part136  part147  part158  part169  part18   part190  part200  part31   part42  part53  part64  part75  part86  part97
part104     part115  part126  part137  part148  part159  part17   part180  part191  part21   part32   part43  part54  part65  part76  part87  part98
part105     part116  part127  part138  part149  part16   part170  part181  part192  part22   part33   part44  part55  part66  part77  part88  part99
part106     part117  part128  part139  part15   part160  part171  part182  part193  part23   part34   part45  part56  part67  part78  part89  sortedFile
ubuntu@ip-172-31-38-203:/data$ rm -rf part*
ubuntu@ip-172-31-38-203:/data$ rm -rf sortedFile
ubuntu@ip-172-31-38-203:/data$ javac SharedMemory.java SortingChunk.java
javac: file not found: SharedMemory.java
Usage: javac <options> <source files>
use -help for a list of possible options
ubuntu@ip-172-31-38-203:/data$ cd
ubuntu@ip-172-31-38-203:~$ javac SharedMemory.java SortingChunk.java
ubuntu@ip-172-31-38-203:~$ vi SharedMemory.java
ubuntu@ip-172-31-38-203:~$ java -Xmx12g SharedMemory
Diving input file into Chunks
Chunking complete, sorting chunks
Sorting of individual files complete, final run ! Merger for output
Time Taken 7158s
ubuntu@ip-172-31-38-203:~$ ./valsort /data/sortedFile
Records: 1367122448
Checksum: 28be4709e85645cb
Duplicate keys: 0
SUCCESS - all records are in order
ubuntu@ip-172-31-38-203:~$ du -h /data/input
128G    /data/input
ubuntu@ip-172-31-38-203:~$ du -h /data/part0
646M    /data/part0
ubuntu@ip-172-31-38-203:~$ du -h /data/sortedFile
128G    /data/sortedFile
ubuntu@ip-172-31-38-203:~$
```



ubuntu@ip-172-31-38-203: ~

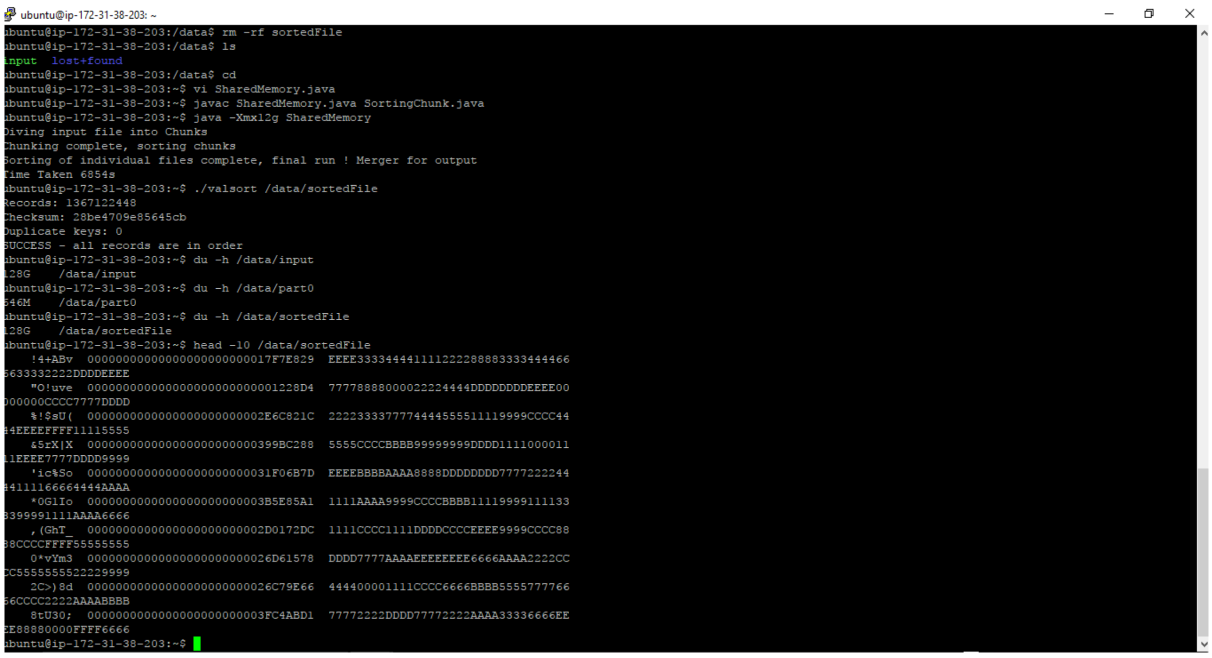
```
Usage: javac <options> <source files>
use -help for a list of possible options
ubuntu@ip-172-31-38-203:/data$ cd
ubuntu@ip-172-31-38-203:~$ javac SharedMemory.java SortingChunk.java
ubuntu@ip-172-31-38-203:~$ vi SharedMemory.java
ubuntu@ip-172-31-38-203:~$ java -Xmx12g SharedMemory
Diving input file into Chunks
Chunking complete, sorting chunks
Sorting of individual files complete, final run ! Merger for output
Time Taken 7158s
ubuntu@ip-172-31-38-203:~$ ./valsort /data/sortedFile
Records: 1367122448
Checksum: 28be4709e85645cb
Duplicate keys: 0
SUCCESS - all records are in order
ubuntu@ip-172-31-38-203:~$ du -h /data/input
128G    /data/input
ubuntu@ip-172-31-38-203:~$ du -h /data/part0
646M    /data/part0
ubuntu@ip-172-31-38-203:~$ du -h /data/sortedFile
128G    /data/sortedFile
ubuntu@ip-172-31-38-203:~$ head -10 /data/sortedFile
    !4+ABv  00000000000000000000000017F7E829  EEEE3333444411112222888833334444666633332222DDDDEEEE
    "O!uve  000000000000000000000000001228D4  7777888800002222444DDDDDDDDEEEE00000000CCCC7777DDDD
    %!$sU(  0000000000000000000000002E6C821C  2222333377774444555511119999CCCC4444EEEEFFFF11115555
    &5rX|X  000000000000000000000000399BC288  5555CCCCBBBB99999999DDDD111100001111EEEE7777DDDD9999
    'ic%So  00000000000000000000000031F06B7D  EEEEBBBBAAAA8888DDDDDDDD77772222444411116666444AAAA
    *0GlIo  0000000000000000000000003B5E85A1  1111AAAA9999CCCCBBBB11119999111133339999111AAAA6666
    ,(GhT_  0000000000000000000000002D0172DC  1111CCCC1111DDDDCCCCEEEE9999CCCC8888CCCCFFFF55555555
    0*vYm3  00000000000000000000000026D61578  DDDD7777AAAAEEEEEEEE6666AAAA2222CCCC555555552222999
    2C>)8d  00000000000000000000000026C79E66  444400001111CCCC6666BBBB55557777666CCCC2222AAAABBBB
    8tU30;  0000000000000000000000003FC4ABD1  77772222DDDD77772222AAAA33336666EEEE88880000FFFF6666
ubuntu@ip-172-31-38-203:~$ tail -10 /data/sortedFile
~~~~=S$7f.  000000000000000000000000469EF45B  BBBBDDDD4444CCCCEEEECCCC000044449999222277777CCCC4444
~~~~G-)m^)  00000000000000000000000013397F73  DDDDFFFFBBBBCCCCFFFF44446666AAAA111133333333AAAACCCC
~~~~M|vlw@  00000000000000000000000050FCFEDA  EEEE3333AAAA8888EEEECCCCCCCCBBBBFFFF33339999EEEE7777
~~~~Tz`i}L  0000000000000000000000003ED87AFD  FFFF2222FFFF88880000AAAA666666667777111AAAACCCCAAAA
~~~~U7,N4Q  000000000000000000000000443E53E6  BBBB11111111333322225555DDDD99996666BBBBBBBB2222BBBB
~~~~UeTR]s  0000000000000000000000003E299FE5  DDDD0000CCCC22227777DDDD5555888800000000222222222222
~~~~ZuHH~L  0000000000000000000000004320332A  11118888222CCCC6666CCCC8888CCCC88882222AAAADDDD7777
~~~~c+I&cP  00000000000000000000000074BDF64  888800005555000DDDD22227777AAAA00003333222AAAADDDD
~~~~hb&5X*  00000000000000000000000032C0E06B  7777BBBBBBBB9999EEEEAAAAAAAA0000CCCCDDDD4444BBBB4444
~~~~lkLc*l  00000000000000000000000045E4700F  9999777799991111AAAA2222444400001111CCCC9999FFFF0000
ubuntu@ip-172-31-38-203:~$
```

## Sorting 128GB with 2 threads



ubuntu@ip-172-31-38-203: ~

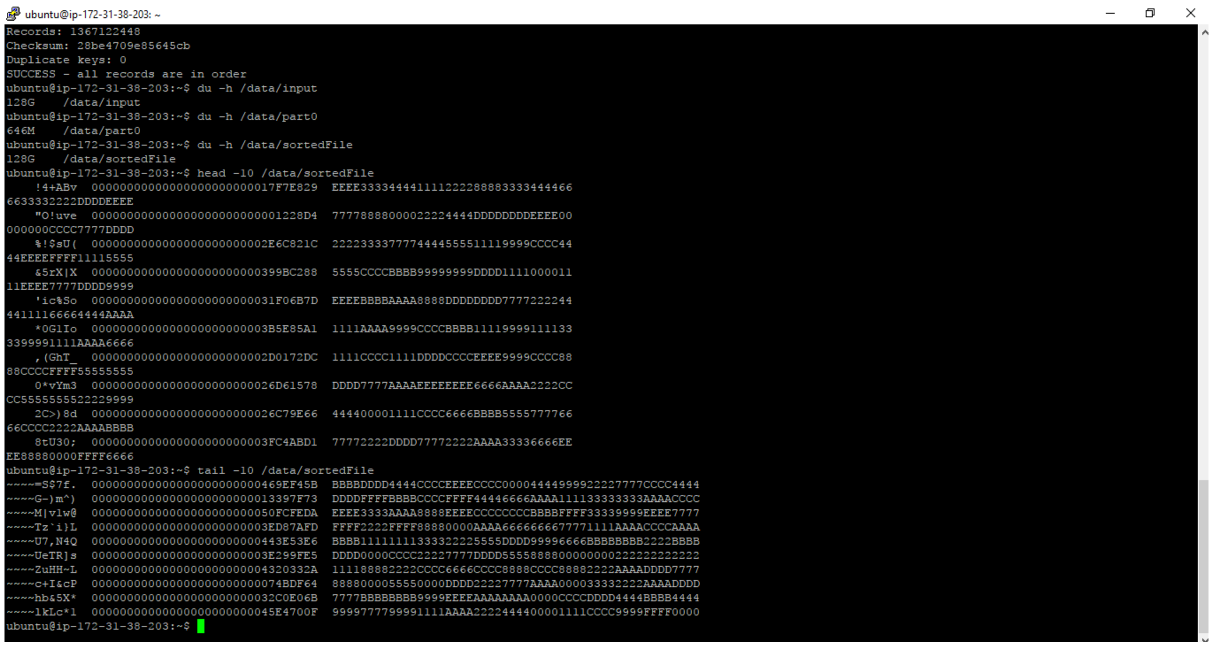
```
ubuntu@ip-172-31-38-203:/data$ rm -rf part*
ubuntu@ip-172-31-38-203:/data$ rm -rf sortedFile
ubuntu@ip-172-31-38-203:/data$ ls
input  lost+found
ubuntu@ip-172-31-38-203:/data$ cd
ubuntu@ip-172-31-38-203:~$ vi SharedMemory.java
ubuntu@ip-172-31-38-203:~$ javac SharedMemory.java SortingChunk.java
ubuntu@ip-172-31-38-203:~$ java -Xmx12g SharedMemory
Diving input file into Chunks
Chunking complete, sorting chunks
Sorting of individual files complete, final run ! Merger for output
Time Taken 6854s
ubuntu@ip-172-31-38-203:~$ ./valsort /data/sortedFile
Records: 1367122448
Checksum: 28be4709e85645cb
Duplicate keys: 0
SUCCESS - all records are in order
ubuntu@ip-172-31-38-203:~$ du -h /data/input
128G    /data/input
ubuntu@ip-172-31-38-203:~$ du -h /data/part0
646M    /data/part0
ubuntu@ip-172-31-38-203:~$ du -h /data/sortedFile
128G    /data/sortedFile
ubuntu@ip-172-31-38-203:~$
```



ubuntu@ip-172-31-38-203: ~

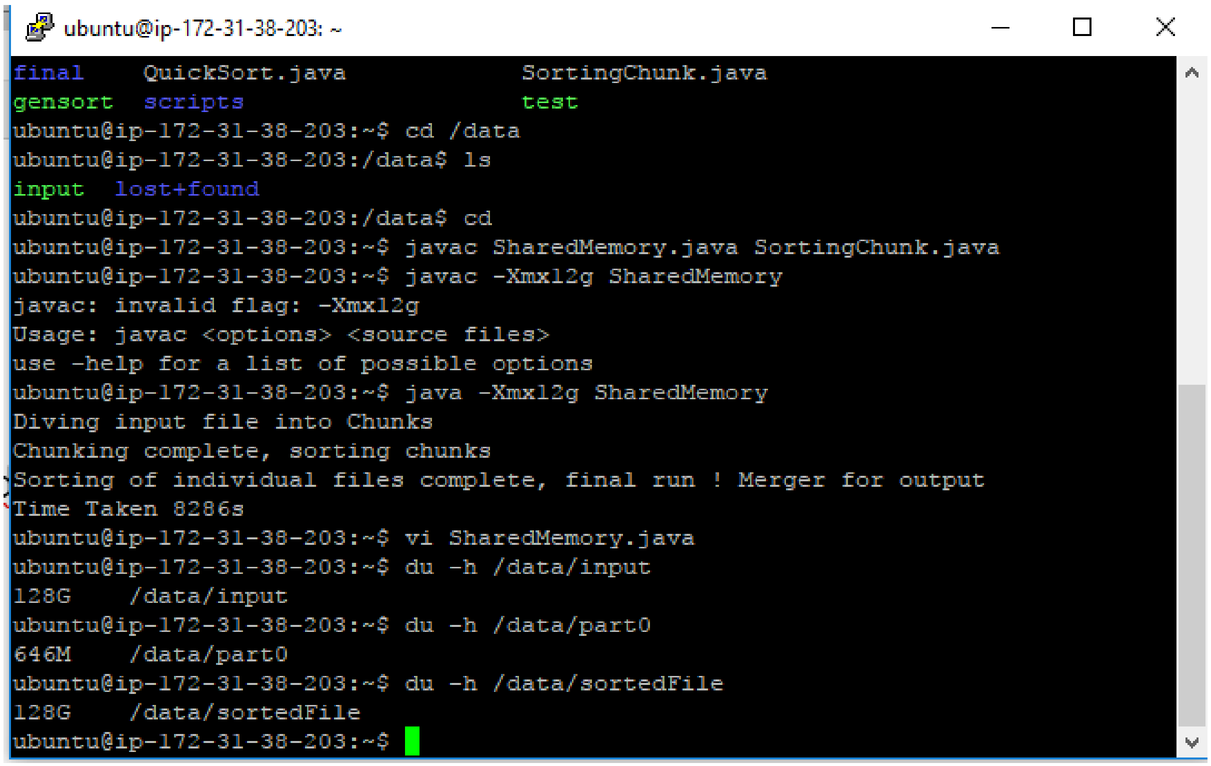
```
ubuntu@ip-172-31-38-203:/data$ rm -rf sortedFile
ubuntu@ip-172-31-38-203:/data$ ls
input  lost+found
ubuntu@ip-172-31-38-203:/data$ cd
ubuntu@ip-172-31-38-203:~$ vi SharedMemory.java
ubuntu@ip-172-31-38-203:~$ javac SharedMemory.java SortingChunk.java
ubuntu@ip-172-31-38-203:~$ java -Xmx12g SharedMemory
Diving input file into Chunks
Chunking complete, sorting chunks
Sorting of individual files complete, final run ! Merger for output
Time Taken 6854s
ubuntu@ip-172-31-38-203:~$ ./valsort /data/sortedFile
Records: 1367122448
Checksum: 28be4709e85645cb
Duplicate keys: 0
SUCCESS - all records are in order
ubuntu@ip-172-31-38-203:~$ du -h /data/input
128G    /data/input
ubuntu@ip-172-31-38-203:~$ du -h /data/part0
646M    /data/part0
ubuntu@ip-172-31-38-203:~$ du -h /data/sortedFile
128G    /data/sortedFile
```

```
ubuntu@ip-172-31-38-203:~$ head -10 /data/sortedFile
    !4+ABv  0000000000000000000000017F7E829  EEEE3333444411112222888833334444466
5633332222DDDDEEEE
    "O!uve  00000000000000000000000001228D4  7777888800002222444DDDDDDDEEEE00
000000CCCC7777DDDD
    %!$sU(  000000000000000000000002E6C821C  22223333777744445555111199999CCCC44
44EEEEFFFF11115555
    &5rX|X  000000000000000000000000399BC288  5555CCCCBBBB99999999DDDD1111000011
11EEEE7777DDDD9999
    'ic%So  0000000000000000000000031F06B7D  EEEEBBBBAAAA8888DDDDDDDD7777222244
4411116666444AAAA
    *0GlIo  000000000000000000000003B5E85A1  1111AAAA9999CCCCBBBB1111999911133
3399991111AAAA6666
    ,(GhT_  000000000000000000000002D0172DC  1111CCCC1111DDDDCCCCEEEE9999CCCC88
88CCCCFFFF55555555
    0*vYm3  000000000000000000000026D61578  DDDD7777AAAAEEEEEEEE6666AAAA2222CC
CC5555555522229999
    2C>)8d  000000000000000000000026C79E66  44440000111CCCC6666BBBB555777766
66CCCC2222AAAABBBB
    8tU30;  000000000000000000000003FC4ABD1  77772222DDDD77772222AAAA33336666EE
EE88880000FFFF6666
ubuntu@ip-172-31-38-203:~$
```



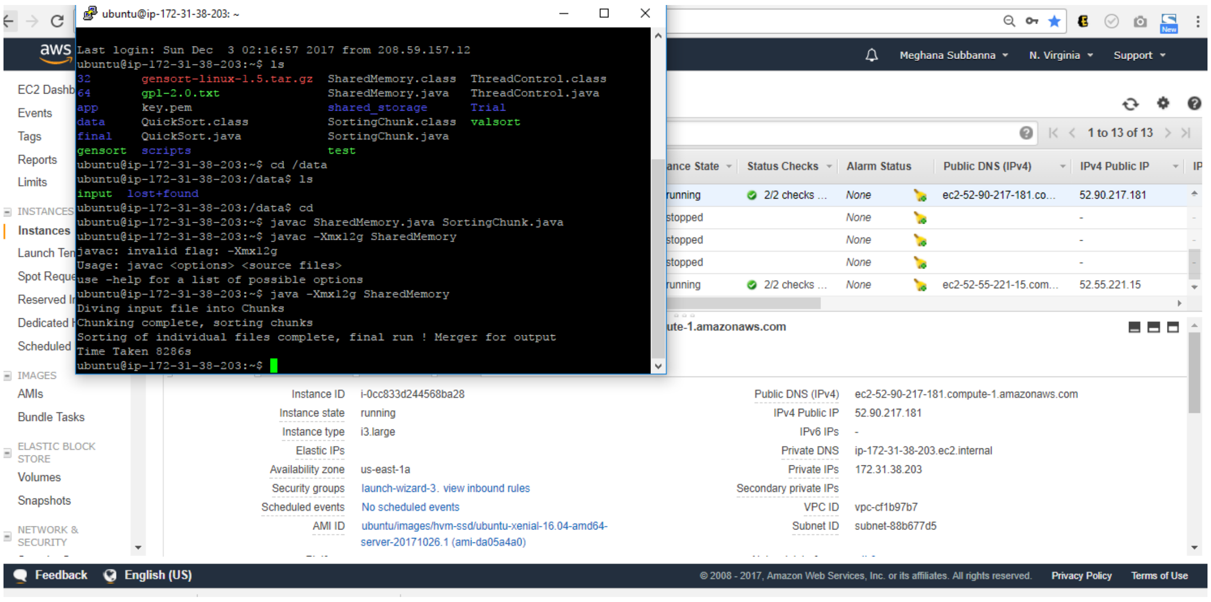
```
Records: 1367122448
Checksum: 28be4709e85645cb
Duplicate keys: 0
SUCCESS - all records are in order
ubuntu@ip-172-31-38-203:~$ du -h /data/input
128G    /data/input
ubuntu@ip-172-31-38-203:~$ du -h /data/part0
646M    /data/part0
ubuntu@ip-172-31-38-203:~$ du -h /data/sortedFile
128G    /data/sortedFile
ubuntu@ip-172-31-38-203:~$ head -10 /data/sortedFile
    !4+ABv  00000000000000000000000017F7E829  EEEE333344441111222288883333444466
6633332222DDDDEEEE
    "O!uve  000000000000000000000000001228D4  7777888800002222444DDDDDDDDEEEE00
000000CCCC7777DDDD
    %!$sU(  0000000000000000000000002E6C821C  22223333777744445555111199999CCCC44
44EEEEFFFF11115555
    &5rX|X  000000000000000000000000399BC288  5555CCCCBBBB99999999DDDD1111000011
11EEEE7777DDDD9999
    'ic%So  00000000000000000000000031F06B7D  EEEEBBBBAAAA8888DDDDDDDD7777222244
44111166664444AAAA
    *0GlIo  0000000000000000000000003B5E85A1  1111AAAA9999CCCCBBBB11119999111133
3399991111AAAA6666
    ,(GhT_  0000000000000000000000002D0172DC  1111CCCC1111DDDDCCCCEEEE9999CCCC88
88CCCCFFFF55555555
    0*vYm3  00000000000000000000000026D61578  DDDD7777AAAAEEEEEEEE6666AAAA2222CC
CC555555552222999 9
    2C>)8d  00000000000000000000000026C79E66  44440000111CCCC6666BBBB555577776 6
66CCCC2222AAAABBBB
    8tU30;  0000000000000000000000003FC4ABD1  77772222DDDD77772222AAAA33336666EE
EE88880000FFFF6666
ubuntu@ip-172-31-38-203:~$ tail -10 /data/sortedFile
~~~~=S$7f.  000000000000000000000000469EF45B  BBBBDDDD4444CCCCEEEECCCC00004444999922227777CCCC4444
~~~~G-)m^)  00000000000000000000000013397F73  DDDDFFFFBBBBCCCCFFFF44446666AAAA111133333333AAAACCCC
~~~~M|v1w@  00000000000000000000000050FCFEDA  EEEE3333AAAA8888EEEECCCCCCCCBBBBFFFF33339999EEEE7777
~~~~Tz`i}L  0000000000000000000000003ED87AFD  FFFF2222FFFF88880000AAAA66666666777711111AAAACCCCAAAA
~~~~U7,N4Q  000000000000000000000000443E53E6  BBBB11111111333322225555DDDD99996666BBBBBBBB2222BBBB
~~~~UeTR]s  0000000000000000000000003E299FE5  DDDD0000CCCC22227777DDDD55558888000000002222222222222
~~~~ZuHH~L  0000000000000000000000004320332A  111188882222CCCC6666CCCC8888CCCC88882222AAAADDDD7777
~~~~c+I&cP  000000000000000000000000074BDF64  888800005555000DDDD22227777AAAA000033332222AAAADDDD
~~~~hb&5X*  00000000000000000000000032C0E06B  7777BBBBBBBB9999EEEEAAAAAAAA0000CCCCDDDD4444BBBB4444
~~~~lkLc*l  00000000000000000000000045E4700F  9999777799991111AAAA222244440000111 1CCCC9999FFFF0000
ubuntu@ip-172-31-38-203:~$
```

ThreadCount: 4



```
final    QuickSort.java            SortingChunk.java
gensort  scripts                   test
ubuntu@ip-172-31-38-203:~$ cd /data
ubuntu@ip-172-31-38-203:/data$ ls
input  lost+found
ubuntu@ip-172-31-38-203:/data$ cd
ubuntu@ip-172-31-38-203:~$ javac SharedMemory.java SortingChunk.java
ubuntu@ip-172-31-38-203:~$ javac -Xmx12g SharedMemory
javac: invalid flag: -Xmx12g
Usage: javac <options> <source files>
use -help for a list of possible options
ubuntu@ip-172-31-38-203:~$ java -Xmx12g SharedMemory
Diving input file into Chunks
Chunking complete, sorting chunks
Sorting of individual files complete, final run ! Merger for output
Time Taken 8286s
ubuntu@ip-172-31-38-203:~$ vi SharedMemory.java
ubuntu@ip-172-31-38-203:~$ du -h /data/input
128G    /data/input
ubuntu@ip-172-31-38-203:~$ du -h /data/part0
646M    /data/part0
ubuntu@ip-172-31-38-203:~$ du -h /data/sortedFile
128G    /data/sortedFile
ubuntu@ip-172-31-38-203:~$
```

Time Taken for 128 GB – 4Threads

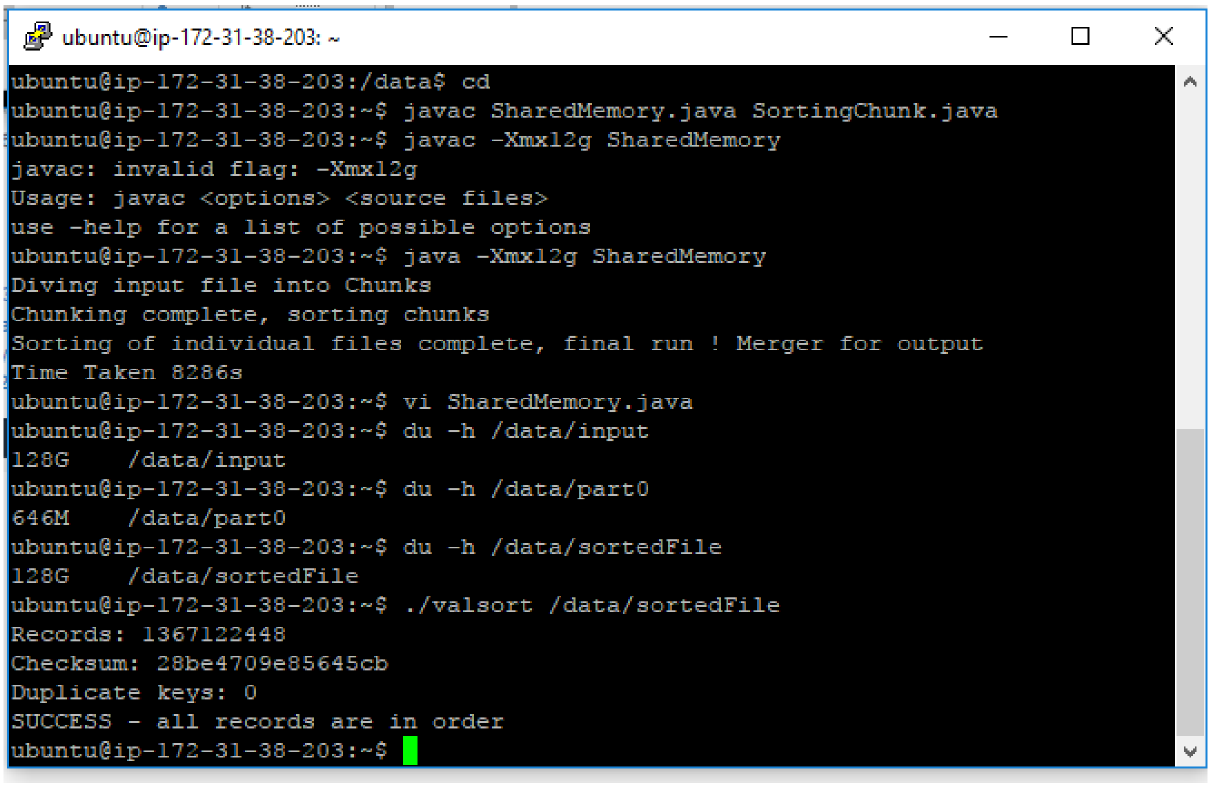


```
Last login: Sun Dec  3 02:16:57 2017 from 208.59.157.12
ubuntu@ip-172-31-38-203:~$ ls
32       gensort-linux-1.5.tar.gz  SharedMemory.class   ThreadControl.class
64       gpl-2.0.txt               SharedMemory.java    ThreadControl.java
app      key.pem                   shared_storage       Trial
data     QuickSort.class           SortingChunk.class   valsort
final    QuickSort.java            SortingChunk.java
gensort  scripts                   test
ubuntu@ip-172-31-38-203:~$ cd /data
ubuntu@ip-172-31-38-203:/data$ ls
input  lost+found
ubuntu@ip-172-31-38-203:/data$ cd
ubuntu@ip-172-31-38-203:~$ javac SharedMemory.java SortingChunk.java
ubuntu@ip-172-31-38-203:~$ javac -Xmx12g SharedMemory
javac: invalid flag: -Xmx12g
Usage: javac <options> <source files>
use -help for a list of possible options
ubuntu@ip-172-31-38-203:~$ java -Xmx12g SharedMemory
Diving input file into Chunks
Chunking complete, sorting chunks
Sorting of individual files complete, final run ! Merger for output
Time Taken 8286s
ubuntu@ip-172-31-38-203:~$
```

| ance State | Status Checks | Alarm Status | Public DNS (IPv4) | IPv4 Public IP |
|---|---|---|---|---|
| running | 2/2 checks ... | None | ec2-52-90-217-181.co... | 52.90.217.181 |
| stopped | | None | | - |
| stopped | | None | | - |
| stopped | | None | | - |
| running | 2/2 checks ... | None | ec2-52-55-221-15.com... | 52.55.221.15 |

| | | | |
|---|---|---|---|
| Instance ID | i-0cc833d244568ba28 | Public DNS (IPv4) | ec2-52-90-217-181.compute-1.amazonaws.com |
| Instance state | running | IPv4 Public IP | 52.90.217.181 |
| Instance type | i3.large | IPv6 IPs | - |
| Elastic IPs | | Private DNS | ip-172-31-38-203.ec2.internal |
| Availability zone | us-east-1a | Private IPs | 172.31.38.203 |
| Security groups | launch-wizard-3. view inbound rules | Secondary private IPs | |
| Scheduled events | No scheduled events | VPC ID | vpc-cf1b97b7 |
| AMI ID | ubuntu/images/hvm-ssd/ubuntu-xenial-16.04-amd64-server-20171026.1 (ami-da05a4a0) | Subnet ID | subnet-88b677d5 |

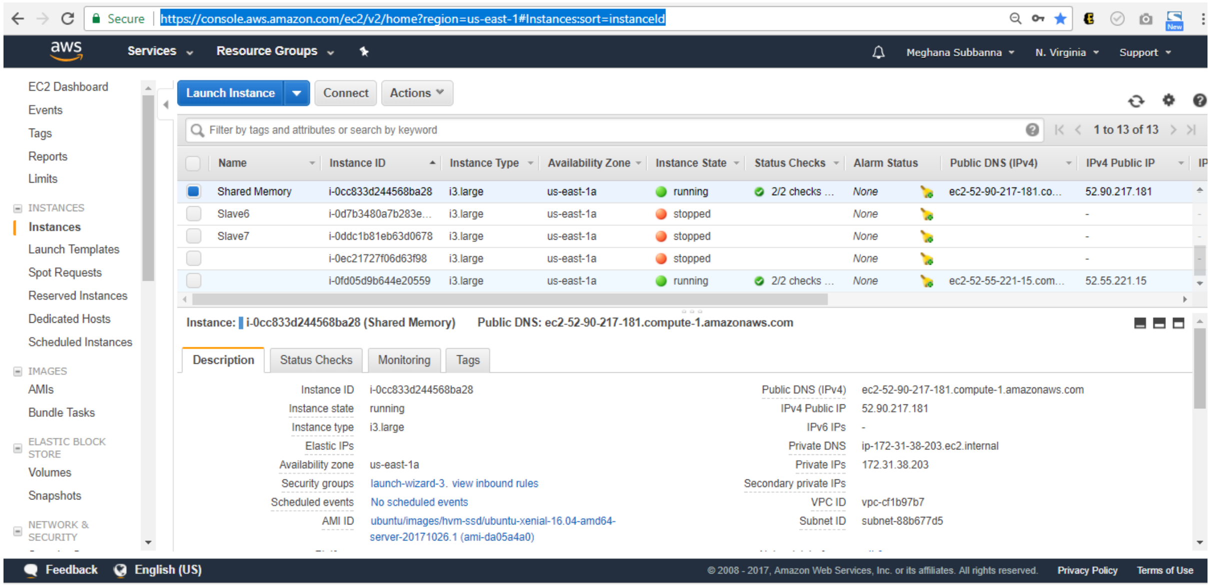
## ValSort Output



ubuntu@ip-172-31-38-203: ~

```
ubuntu@ip-172-31-38-203:/data$ cd
ubuntu@ip-172-31-38-203:~$ javac SharedMemory.java SortingChunk.java
ubuntu@ip-172-31-38-203:~$ javac -Xmx12g SharedMemory
javac: invalid flag: -Xmx12g
Usage: javac <options> <source files>
use -help for a list of possible options
ubuntu@ip-172-31-38-203:~$ java -Xmx12g SharedMemory
Diving input file into Chunks
Chunking complete, sorting chunks
Sorting of individual files complete, final run ! Merger for output
Time Taken 8286s
ubuntu@ip-172-31-38-203:~$ vi SharedMemory.java
ubuntu@ip-172-31-38-203:~$ du -h /data/input
128G    /data/input
ubuntu@ip-172-31-38-203:~$ du -h /data/part0
646M    /data/part0
ubuntu@ip-172-31-38-203:~$ du -h /data/sortedFile
128G    /data/sortedFile
ubuntu@ip-172-31-38-203:~$ ./valsort /data/sortedFile
Records: 1367122448
Checksum: 28be4709e85645cb
Duplicate keys: 0
SUCCESS - all records are in order
ubuntu@ip-172-31-38-203:~$
```

## Instance Used

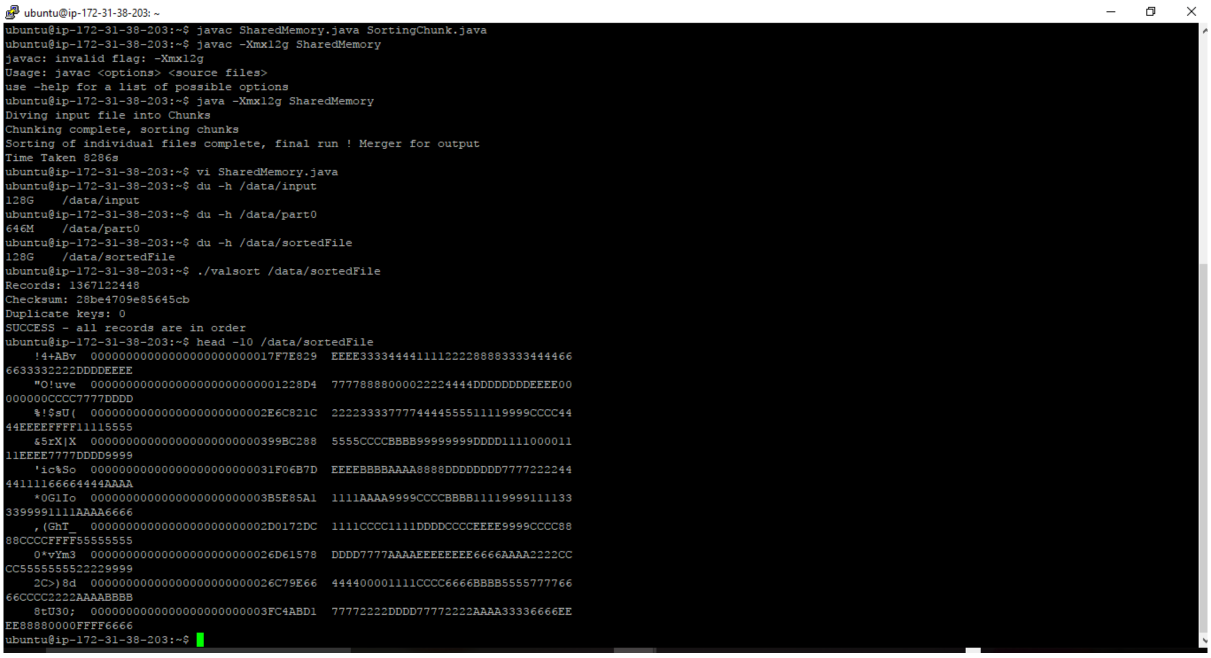


| Name | Instance ID | Instance Type | Availability Zone | Instance State | Status Checks | Alarm Status | Public DNS (IPv4) | IPv4 Public IP |
|---|---|---|---|---|---|---|---|---|
| Shared Memory | i-0cc833d244568ba28 | i3.large | us-east-1a | running | 2/2 checks ... | None | ec2-52-90-217-181.co... | 52.90.217.181 |
| Slave6 | i-0d7b3480a7b283e... | i3.large | us-east-1a | stopped | | None | | - |
| Slave7 | i-0ddc1b81eb63d0678 | i3.large | us-east-1a | stopped | | None | | - |
| | i-0ec21727f06d63f98 | i3.large | us-east-1a | stopped | | None | | - |
| | i-0fd05d9b644e20559 | i3.large | us-east-1a | running | 2/2 checks ... | None | ec2-52-55-221-15.com... | 52.55.221.15 |

Instance: i-0cc833d244568ba28 (Shared Memory) Public DNS: ec2-52-90-217-181.compute-1.amazonaws.com

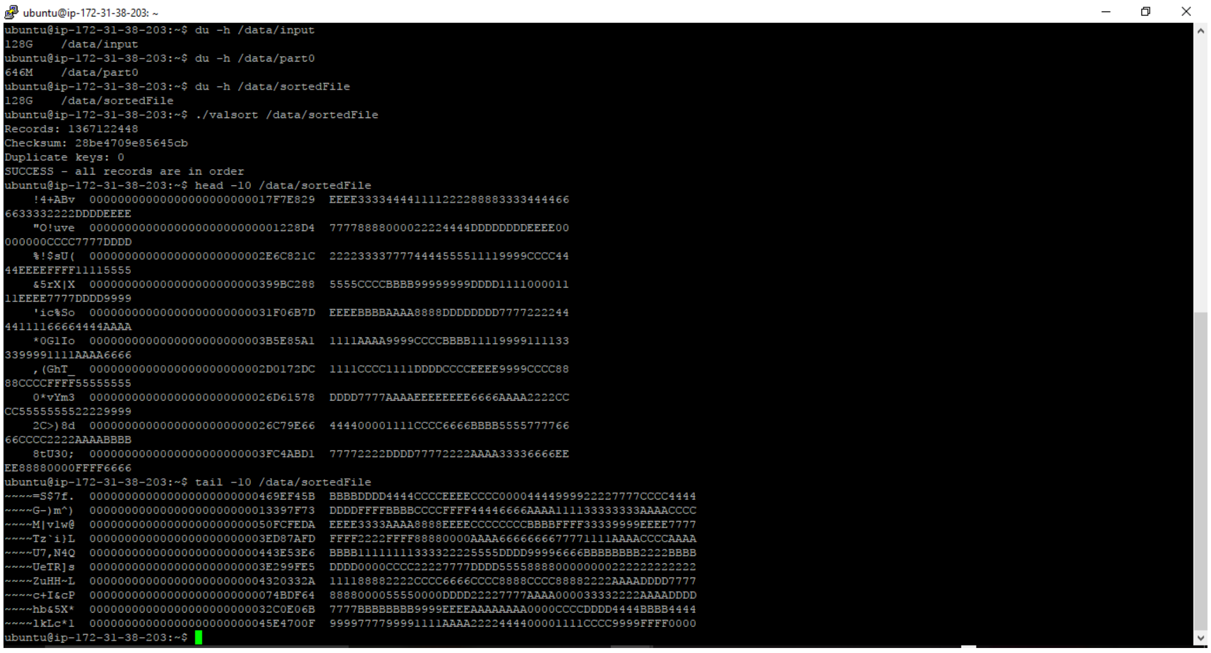
| | | | |
|---|---|---|---|
| Instance ID | i-0cc833d244568ba28 | Public DNS (IPv4) | ec2-52-90-217-181.compute-1.amazonaws.com |
| Instance state | running | IPv4 Public IP | 52.90.217.181 |
| Instance type | i3.large | IPv6 IPs | - |
| Elastic IPs | | Private DNS | ip-172-31-38-203.ec2.internal |
| Availability zone | us-east-1a | Private IPs | 172.31.38.203 |
| Security groups | launch-wizard-3. view inbound rules | Secondary private IPs | |
| Scheduled events | No scheduled events | VPC ID | vpc-cf1b97b7 |
| AMI ID | ubuntu/images/hvm-ssd/ubuntu-xenial-16.04-amd64-server-20171026.1 (ami-da05a4a0) | Subnet ID | subnet-88b677d5 |

## Head -10 /data/sortedFile



```
ubuntu@ip-172-31-38-203:~$ javac SharedMemory.java SortingChunk.java
ubuntu@ip-172-31-38-203:~$ javac -Xmx12g SharedMemory
javac: invalid flag: -Xmx12g
Usage: javac <options> <source files>
use -help for a list of possible options
ubuntu@ip-172-31-38-203:~$ java -Xmx12g SharedMemory
Diving input file into Chunks
Chunking complete, sorting chunks
Sorting of individual files complete, final run ! Merger for output
Time Taken 8286s
ubuntu@ip-172-31-38-203:~$ vi SharedMemory.java
ubuntu@ip-172-31-38-203:~$ du -h /data/input
128G    /data/input
ubuntu@ip-172-31-38-203:~$ du -h /data/part0
646M    /data/part0
ubuntu@ip-172-31-38-203:~$ du -h /data/sortedFile
128G    /data/sortedFile
ubuntu@ip-172-31-38-203:~$ ./valsort /data/sortedFile
Records: 1367122448
Checksum: 28be4709e85645cb
Duplicate keys: 0
SUCCESS - all records are in order
ubuntu@ip-172-31-38-203:~$ head -10 /data/sortedFile
    !4+ABv  000000000000000000000000017F7E829  EEEE33334444111122228888333344446
6633332222DDDDEEEE
    "O!uve  00000000000000000000000000001228D4  7777888800002222444DDDDDDDDEEEE00
000000CCCC7777DDDD
    %!$sU(  0000000000000000000000002E6C821C  2222333377774444555511119999CCCC44
44EEEEFFFF11115555
    &5rX|X  000000000000000000000000399BC288  5555CCCCBBBB99999999DDDD1111000011
11EEEE7777DDDD9999
    'ic%So  000000000000000000000000031F06B7D  EEEEBBBBAAAA8888DDDDDDDD7777222244
44111166664444AAAA
    *0GlIo  000000000000000000000000003B5E85A1  1111AAAA9999CCCCBBBB11119999111133
33999911111AAAA6666
    ,(GhT_  000000000000000000000000002D0172DC  1111CCCC1111DDDDCCCCEEEE9999CCCC88
88CCCCFFFF55555555
    0*vYm3  000000000000000000000000026D61578  DDDD7777AAAAEEEEEEEE6666AAAA2222CC
CC555555522229999
    2C>)8d  000000000000000000000000026C79E66  444400001111CCCC6666BBBB5555777766
66CCCC2222AAAABBBB
    8tU30;  000000000000000000000000003FC4ABD1  77772222DDDD77772222AAAA33336666EE
EE88880000FFFF6666
ubuntu@ip-172-31-38-203:~$
```

## Tail -10 /data/sortedFile



```
ubuntu@ip-172-31-38-203:~$ du -h /data/input
128G    /data/input
ubuntu@ip-172-31-38-203:~$ du -h /data/part0
646M    /data/part0
ubuntu@ip-172-31-38-203:~$ du -h /data/sortedFile
128G    /data/sortedFile
ubuntu@ip-172-31-38-203:~$ ./valsort /data/sortedFile
Records: 1367122448
Checksum: 28be4709e85645cb
Duplicate keys: 0
SUCCESS - all records are in order
ubuntu@ip-172-31-38-203:~$ head -10 /data/sortedFile
    !4+ABv  000000000000000000000000017F7E829  EEEE33334444111122228888333344446
6633332222DDDDEEEE
    "O!uve  00000000000000000000000000001228D4  7777888800002222444DDDDDDDDEEEE00
000000CCCC7777DDDD
    %!$sU(  0000000000000000000000002E6C821C  2222333377774444555511119999CCCC44
44EEEEFFFF11115555
    &5rX|X  000000000000000000000000399BC288  5555CCCCBBBB99999999DDDD1111000011
11EEEE7777DDDD9999
    'ic%So  000000000000000000000000031F06B7D  EEEEBBBBAAAA8888DDDDDDDD7777222244
44111166664444AAAA
    *0GlIo  000000000000000000000000003B5E85A1  1111AAAA9999CCCCBBBB11119999111133
33999911111AAAA6666
    ,(GhT_  000000000000000000000000002D0172DC  1111CCCC1111DDDDCCCCEEEE9999CCCC88
88CCCCFFFF55555555
    0*vYm3  000000000000000000000000026D61578  DDDD7777AAAAEEEEEEEE6666AAAA2222CC
CC555555522229999
    2C>)8d  000000000000000000000000026C79E66  444400001111CCCC6666BBBB5555777766
66CCCC2222AAAABBBB
    8tU30;  000000000000000000000000003FC4ABD1  77772222DDDD77772222AAAA33336666EE
EE88880000FFFF6666
ubuntu@ip-172-31-38-203:~$ tail -10 /data/sortedFile
~~~~=S$7f.  000000000000000000000000000469EF45B  BBBBDDDD4444CCCCEEEECCCC000044449999222277777CCCC4444
~~~~G-)m^)  0000000000000000000000000013397F73  DDDDFFFFBBBBCCCCFFFF44446666AAAA111133333333AAAACCCC
~~~~M|vlw@  00000000000000000000000000050FCFEDA  EEEE3333AAAA8888EEEECCCCCCCCBBBBFFFF33339999EEEE7777
~~~~Tz`i}L  00000000000000000000000003ED87AFD  FFFF2222FFFF88880000AAAA66666666777711111AAAACCCCAAAA
~~~~U7,N4Q  0000000000000000000000000443E53E6  BBBB111111113333222255555DDDD99996666BBBBBBBB2222BBBB
~~~~UeTR]s  00000000000000000000000003E299FE5  DDDD0000CCCC22227777DDDD5555888800000000222222222222
~~~~ZuHH~L  00000000000000000000000004320332A  111188882222CCCC6666CCCC8888CCCC88882222AAAADDDD7777
~~~~c+I&cP  000000000000000000000000074BDF64  88880000555500000DDDD22227777AAAA0000333332222AAAADDDD
~~~~hb&5X*  00000000000000000000000032C0E06B  7777BBBBBBBB9999EEEEAAAAAAAA0000CCCCDDDD4444BBBB4444
~~~~lkLc*l  000000000000000000000000045E4700F  999977779999111111AAAA22224444000011111CCCC9999FFFF0000
ubuntu@ip-172-31-38-203:~$
```

## Shared Memory 1 TB 6GB:

The SharedMemory Program for 1 TB ran for nearly , 71285 seconds but for the calculation we have taken the theoretical value. For 2 thread program, we could not further test the program for other threads as we ran out of AWS credits and no instance was available in Chameleon.

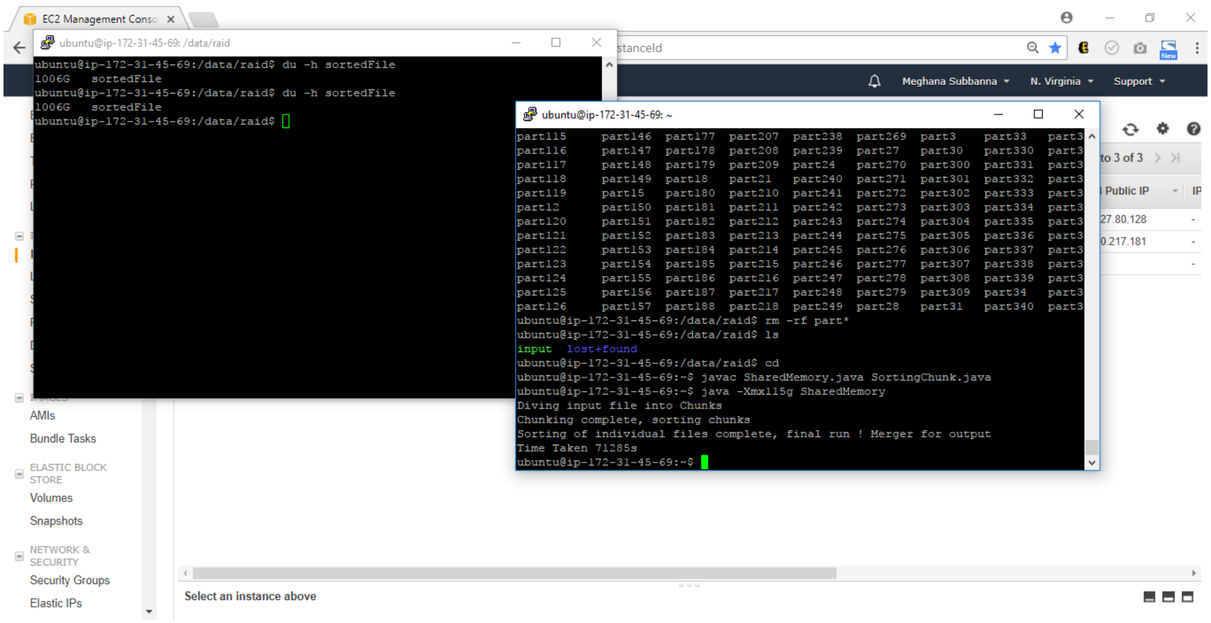
## The steps to run the SharedMemory program on 1TB is

Commands to run the SharedMemory 128 GB:

echo "Configuration Settings"

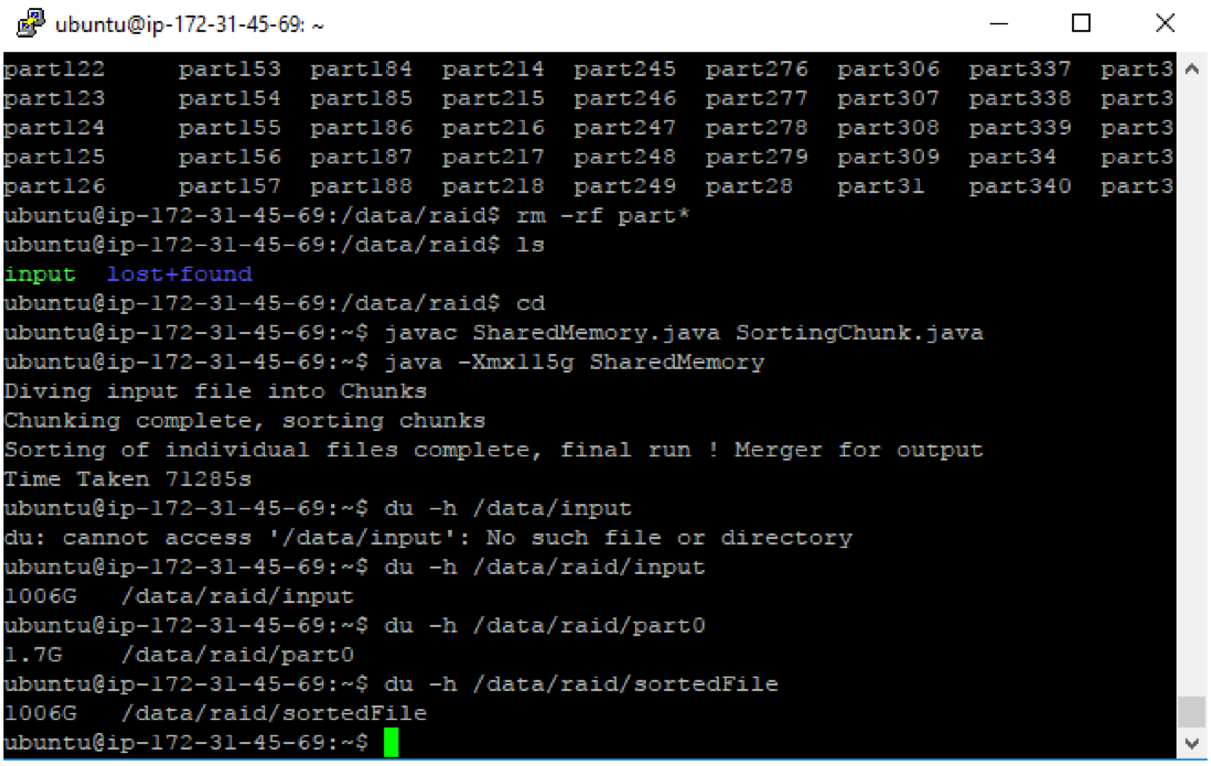
sudo apt-get update

```
sudo apt-get install mdadm

echo "Creating file system"

lsblk

sudo mdadm --create --verbose /dev/md0 --level=0 --name=Cloud --raid-devices=2 /dev/nvme0n1 /dev/nvme1n1

sudo mkfs.ext4 -L Cloud /dev/md0

sudo mkdir -p /data/raid

sudo mount LABEL=Cloud /data/raid

echo "Installing Java Installables"

sudo apt-get install default-jdk

java -version

sudo apt-get install ant

echo " Generating data"

wget http://www.ordinal.com/try.cgi/gensort-linux-1.5.tar.gz

tar -xvf gensort-linux-1.5.tar.gz

cd 64

./gensort -a 10801224480 /data/input

echo "Running the Program"

javac SharedMemory.java SortingChunk.java

java -Xmx115g SharedMemory

echo "Validating the output"

./valsort /data/sortedFile
```



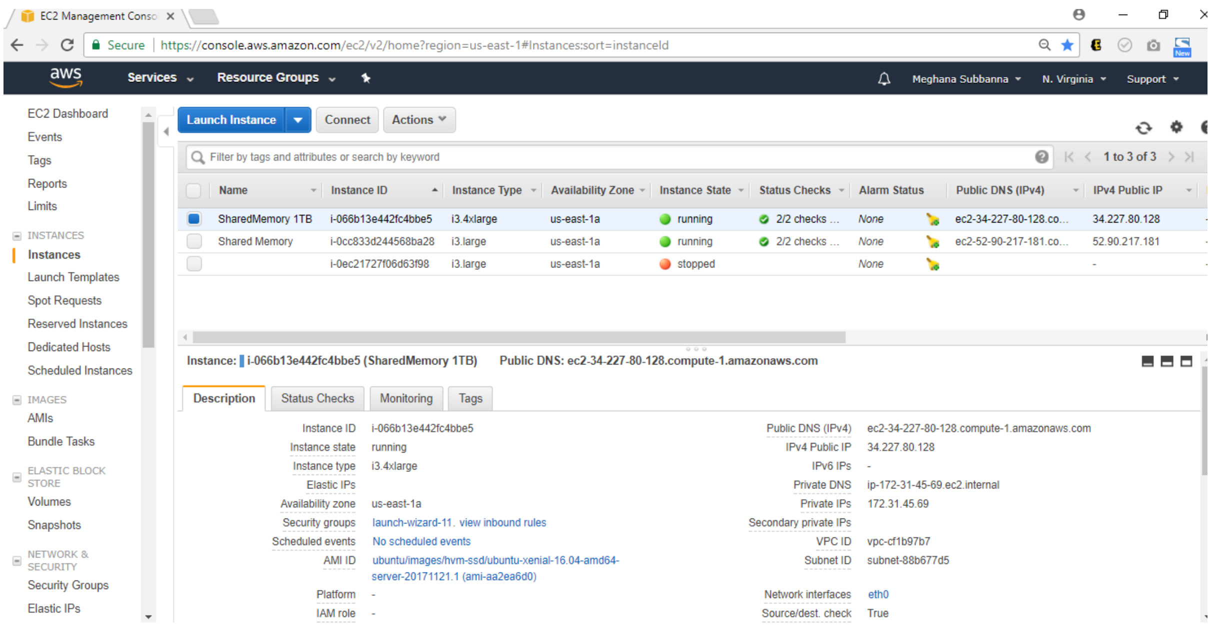
```
ubuntu@ip-172-31-45-69:/data/raid$ du -h sortedFile
1006G   sortedFile
ubuntu@ip-172-31-45-69:/data/raid$ du -h sortedFile
1006G   sortedFile
ubuntu@ip-172-31-45-69:/data/raid$
```

```
part115     part146  part177  part207  part238  part269  part3    part33   part3
part116     part147  part178  part208  part239  part27   part30   part330  part3
part117     part148  part179  part209  part24   part270  part300  part331  part3
part118     part149  part18   part21   part240  part271  part301  part332  part3
part119     part15   part180  part210  part241  part272  part302  part333  part3
part12      part150  part181  part211  part242  part273  part303  part334  part3
part120     part151  part182  part212  part243  part274  part304  part335  part3
part121     part152  part183  part213  part244  part275  part305  part336  part3
part122     part153  part184  part214  part245  part276  part306  part337  part3
part123     part154  part185  part215  part246  part277  part307  part338  part3
part124     part155  part186  part216  part247  part278  part308  part339  part3
part125     part156  part187  part217  part248  part279  part309  part34   part3
part126     part157  part188  part218  part249  part28   part31   part340  part3
ubuntu@ip-172-31-45-69:/data/raid$ rm -rf part*
ubuntu@ip-172-31-45-69:/data/raid$ ls
input  lost+found
ubuntu@ip-172-31-45-69:/data/raid$ cd
ubuntu@ip-172-31-45-69:~$ javac SharedMemory.java SortingChunk.java
ubuntu@ip-172-31-45-69:~$ java -Xmx115g SharedMemory
Diving input file into Chunks
Chunking complete, sorting chunks
Sorting of individual files complete, final run ! Merger for output
Time Taken 71285s
ubuntu@ip-172-31-45-69:~$
```



ubuntu@ip-172-31-45-69: ~

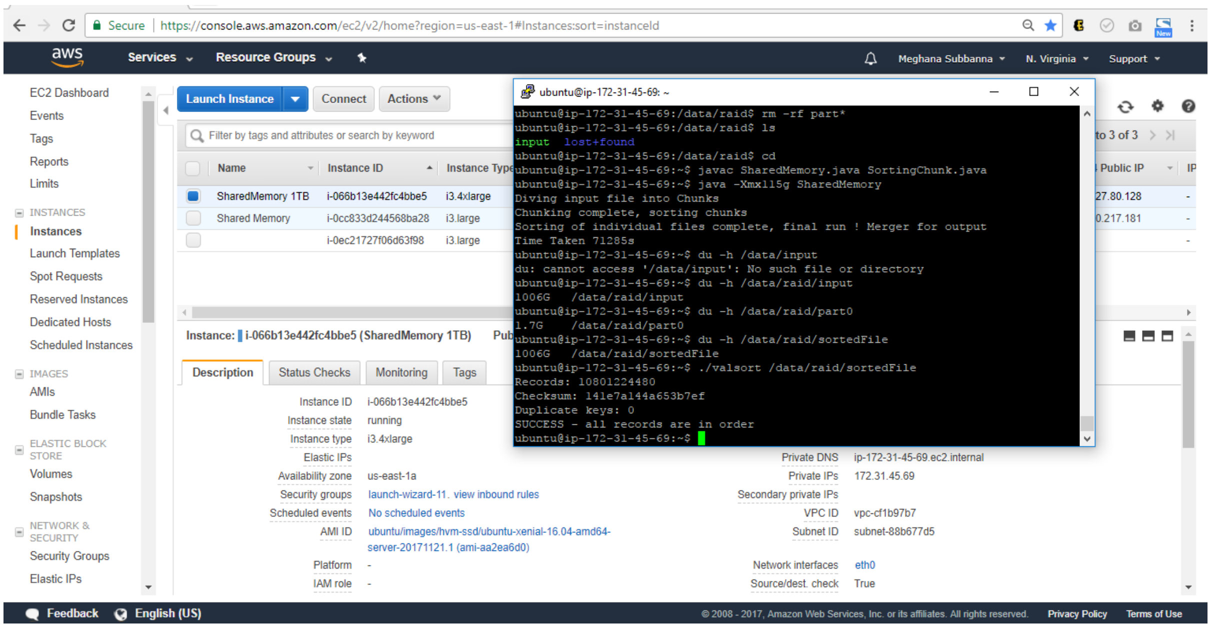
```
part122     part153  part184  part214  part245  part276  part306  part337  part3
part123     part154  part185  part215  part246  part277  part307  part338  part3
part124     part155  part186  part216  part247  part278  part308  part339  part3
part125     part156  part187  part217  part248  part279  part309  part34   part3
part126     part157  part188  part218  part249  part28   part31   part340  part3
ubuntu@ip-172-31-45-69:/data/raid$ rm -rf part*
ubuntu@ip-172-31-45-69:/data/raid$ ls
input  lost+found
ubuntu@ip-172-31-45-69:/data/raid$ cd
ubuntu@ip-172-31-45-69:~$ javac SharedMemory.java SortingChunk.java
ubuntu@ip-172-31-45-69:~$ java -Xmx115g SharedMemory
Diving input file into Chunks
Chunking complete, sorting chunks
Sorting of individual files complete, final run ! Merger for output
Time Taken 71285s
ubuntu@ip-172-31-45-69:~$ du -h /data/input
du: cannot access '/data/input': No such file or directory
ubuntu@ip-172-31-45-69:~$ du -h /data/raid/input
1006G   /data/raid/input
ubuntu@ip-172-31-45-69:~$ du -h /data/raid/part0
1.7G    /data/raid/part0
ubuntu@ip-172-31-45-69:~$ du -h /data/raid/sortedFile
1006G   /data/raid/sortedFile
ubuntu@ip-172-31-45-69:~$ 
```



| Name | Instance ID | Instance Type | Availability Zone | Instance State | Status Checks | Alarm Status | Public DNS (IPv4) | IPv4 Public IP |
|---|---|---|---|---|---|---|---|---|
| SharedMemory 1TB | i-066b13e442fc4bbe5 | i3.4xlarge | us-east-1a | running | 2/2 checks ... | None | ec2-34-227-80-128.co... | 34.227.80.128 |
| Shared Memory | i-0cc833d244568ba28 | i3.large | us-east-1a | running | 2/2 checks ... | None | ec2-52-90-217-181.co... | 52.90.217.181 |
| | i-0ec21727f06d63f98 | i3.large | us-east-1a | stopped | | None | | - |

Instance: i-066b13e442fc4bbe5 (SharedMemory 1TB)    Public DNS: ec2-34-227-80-128.compute-1.amazonaws.com

| | | | |
|---|---|---|---|
| Instance ID | i-066b13e442fc4bbe5 | Public DNS (IPv4) | ec2-34-227-80-128.compute-1.amazonaws.com |
| Instance state | running | IPv4 Public IP | 34.227.80.128 |
| Instance type | i3.4xlarge | IPv6 IPs | - |
| Elastic IPs | | Private DNS | ip-172-31-45-69.ec2.internal |
| Availability zone | us-east-1a | Private IPs | 172.31.45.69 |
| Security groups | launch-wizard-11. view inbound rules | Secondary private IPs | |
| Scheduled events | No scheduled events | VPC ID | vpc-cf1b97b7 |
| AMI ID | ubuntu/images/hvm-ssd/ubuntu-xenial-16.04-amd64-server-20171121.1 (ami-aa2ea6d0) | Subnet ID | subnet-88b677d5 |
| Platform | - | Network interfaces | eth0 |
| IAM role | - | Source/dest. check | True |



Secure | https://console.aws.amazon.com/ec2/v2/home?region=us-east-1#Instances:sort=instanceId

Meghana Subbanna · N. Virginia · Support

| Name | Instance ID | Instance Type | Public IP |
|---|---|---|---|
| SharedMemory 1TB | i-066b13e442fc4bbe5 | i3.4xlarge | 27.80.128 |
| Shared Memory | i-0cc833d244568ba28 | i3.large | 0.217.181 |
|  | i-0ec21727f06d63f98 | i3.large |  |

Instance: i-066b13e442fc4bbe5 (SharedMemory 1TB)

| | |
|---|---|
| Instance ID | i-066b13e442fc4bbe5 |
| Instance state | running |
| Instance type | i3.4xlarge |
| Elastic IPs | |
| Availability zone | us-east-1a |
| Security groups | launch-wizard-11. view inbound rules |
| Scheduled events | No scheduled events |
| AMI ID | ubuntu/images/hvm-ssd/ubuntu-xenial-16.04-amd64-server-20171121.1 (ami-aa2ea6d0) |
| Platform | - |
| IAM role | - |
| Private DNS | ip-172-31-45-69.ec2.internal |
| Private IPs | 172.31.45.69 |
| Secondary private IPs | |
| VPC ID | vpc-cf1b97b7 |
| Subnet ID | subnet-88b677d5 |
| Network interfaces | eth0 |
| Source/dest. check | True |

ubuntu@ip-172-31-45-69: ~

```
ubuntu@ip-172-31-45-69:/data/raid$ rm -rf part*
ubuntu@ip-172-31-45-69:/data/raid$ ls
input  lost+found
ubuntu@ip-172-31-45-69:/data/raid$ cd
ubuntu@ip-172-31-45-69:~$ javac SharedMemory.java SortingChunk.java
ubuntu@ip-172-31-45-69:~$ java -Xmx115g SharedMemory
Diving input file into Chunks
Chunking complete, sorting chunks
Sorting of individual files complete, final run ! Merger for output
Time Taken 71285s
ubuntu@ip-172-31-45-69:~$ du -h /data/input
du: cannot access '/data/input': No such file or directory
ubuntu@ip-172-31-45-69:~$ du -h /data/raid/input
1006G   /data/raid/input
ubuntu@ip-172-31-45-69:~$ du -h /data/raid/part0
1.7G    /data/raid/part0
ubuntu@ip-172-31-45-69:~$ du -h /data/raid/sortedFile
1006G   /data/raid/sortedFile
ubuntu@ip-172-31-45-69:~$ ./valsort /data/raid/sortedFile
Records: 10801224480
Checksum: 141e7a144a653b7ef
Duplicate keys: 0
SUCCESS - all records are in order
ubuntu@ip-172-31-45-69:~$
```

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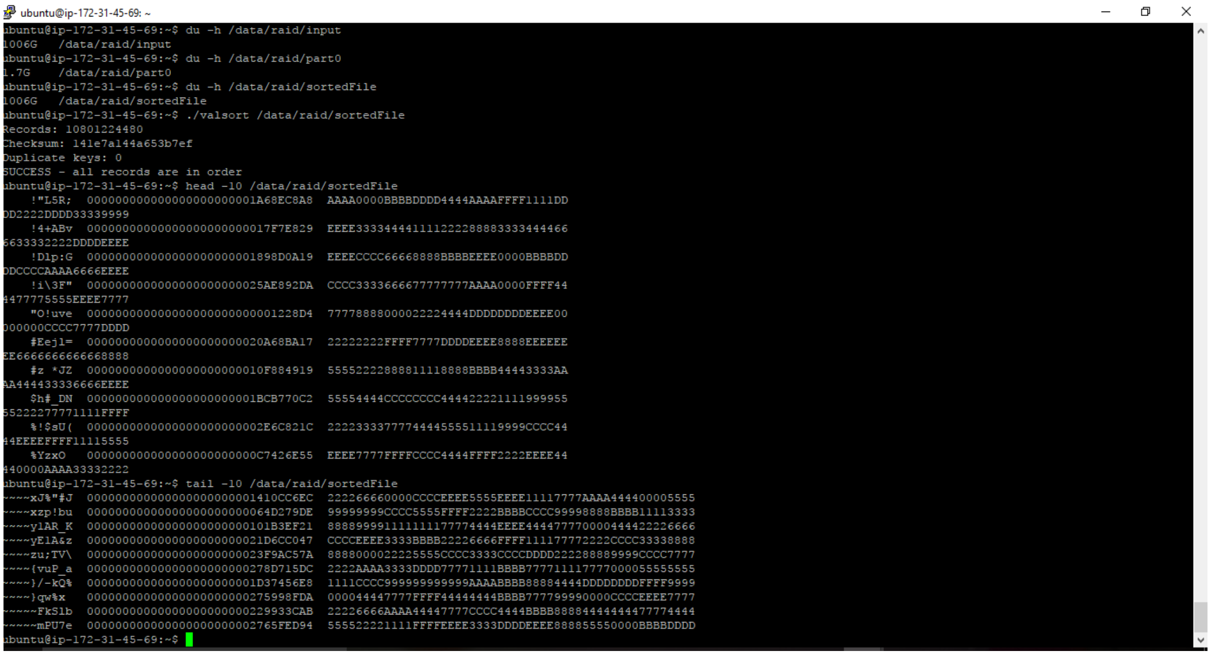


ubuntu@ip-172-31-45-69: ~

```
ubuntu@ip-172-31-45-69:~$ du -h /data/raid/input
1006G   /data/raid/input
ubuntu@ip-172-31-45-69:~$ du -h /data/raid/part0
1.7G    /data/raid/part0
ubuntu@ip-172-31-45-69:~$ du -h /data/raid/sortedFile
1006G   /data/raid/sortedFile
ubuntu@ip-172-31-45-69:~$ ./valsort /data/raid/sortedFile
Records: 10801224480
Checksum: 141e7a144a653b7ef
Duplicate keys: 0
SUCCESS - all records are in order
ubuntu@ip-172-31-45-69:~$ head -10 /data/raid/sortedFile
    !"L5R;  000000000000000000000001A68EC8A8  AAAA0000BBBBDDDD4444AAAAFFFF1111DD
DD2222DDDD33339999
    !4+ABv  0000000000000000000000000017F7E829  EEEE33334444111122228888333344446 6
6633332222DDDDEEEE
    !Dlp:G  000000000000000000000001898D0A19  EEEECCCC66668888BBBBEEEE0000BBBBDD
DDCCCCAAAA6666EEEE
    !i\3F"  000000000000000000000025AE892DA  CCCC3333666677777777AAAA0000FFFF44
4477775555EEEE7777
    "O!uve  00000000000000000000000000001228D4  7777888800002222444 4DDDDDDDDEEEE00
000000CCCC7777DDDD
    #Eejl=  0000000000000000000000020A68BA17  22222222FFFF7777DDDDEEEE8888EEEEEE
EE6666666666668888
    #z *JZ  0000000000000000000000010F884919  5555222288881111888 8BBBB44443333AA
AA444433336666EEEE
    $h#_DN  000000000000000000000001BCB770C2  55554444CCCCCCCC44442222111199995 5
5522227777 1111FFFF
    %!$sU(  000000000000000000000000002E6C821C  22223333777744445555111 19999CCCC44
44EEEEFFFF11115555
    %YzxO   00000000000000000000000000C7426E55  EEEE7777FFFFCCCC4444FFFF2222EEEE44
440000AAAA33332222
ubuntu@ip-172-31-45-69:~$ tail -10 /data/raid/sortedFile
~~~~xJ%"#J  000000000000000000000001410CC6EC  222266660000CCCCEEEE5555EEEE11117777AAAA444400005555
~~~~xzp!bu  000000000000000000000000064D279DE  99999999CCCC5555FFFF2222BBBBCCCC99998888BBBB11113333
~~~~ylAR_K  0000000000000000000000101B3EF21  88889999111111117777 4444EEEE44447777000044442222 6666
~~~~yElA&z  000000000000000000000021D6CC047  CCCCEEEE3333BBBB22226666FFFF111177772222CCCC33338888
~~~~zu;TV\  000000000000000000000023F9AC57A  888800002222555 5CCCC3333CCCCDDDD222288889999CCCC7777
~~~~{vuP_a  0000000000000000000000278D715DC  2222AAAA3333DDDD77771111BBBB77771111777700005555 5555
~~~~}/-kQ%  00000000000000000000001D37456E8  1111CCCC9999999999 99AAAABBBB88884444DDDDDDDDFFFF9999
~~~~}qw%x   000000000000000000000000275998FDA  000044447777FFFF44444444BBBB77779999 0000CCCCEEEE7777
~~~~~FkSlb  0000000000000000000000000229933CAB  22226666AAAA44447777CCCC4444BBBB88884444444477774444
~~~~~mPU7e  00000000000000000000002765FED94  55552222 1111FFFFEEEE3333DDDDEEEE88885555 0000BBBBDDDD
ubuntu@ip-172-31-45-69:~$
```

## Hadoop Sort

### Performance

| | 128 gb | 1TB |
|---|---|---|
| **Execution Time (Sec)** | **13680** | **21960** |

### Methodology

- The sorting program was written is java
- The Mapper class converts each line into a set of key value pairs key consists of 10 characters and the value consists of the rest of characters.
- The reducer tries to assign the results the number of duplicate / the repeating values in counting occurances of key program as a value for the particular key.
- The final output is the combination of key value pairs at the end of Reducer phase.

### Environmental settings

- **Opertaing System:**

Ubuntu Server 16.04 LTS (HVM),EBS General Purpose (SSD) Volume Type.

- **Hadoop:**

Hadoop-2.8.2

- **Java:**

Java version 8

### Setup and Execution

#### Setting up single Node Cluster For Hadoop

The i3 large instance comes with 1x 475 (SSD) GB with only one disk.So RAID was not needed.

Create a mount point and mount the disk on in a folder

- sudo apt-get update
- sudo apt-get install mdadm
- lsblk
- sudo file -s /dev/nvme0n1
- sudo mkfs -t ext4 /dev/nvme0n1
- sudo mkdir /data
- sudo mount /dev/nvme0n1 /data

Change the directory to data:

Change to root user

- sudo -i
- cd /data

Dowload and install Hadoop:

- wget http://apache.claz.org/hadoop/common/hadoop-2.8.2/hadoop-2.8.2.tar.gz
- tar -zxvf hadoop-2.8.2.tar.gz
- rm -rf hadoop-2.8.2.tar.gz

change to hadoop/etc/hadoop/core-site.xml

Update the following:

```
<configuration>

<property>

<name>fs.default.name</name>
```

```
<value>hdfs://localhost:9000</value>

</property>

<property>

<name>hadoop.tmp.dir</name>

<value>/data/tmp/</value>

</property>

</configuration>
```

Change to hadoop/etc/hadoop/hdfs-site.xml

## Hdfs-site

```
<configuration>

<property>

<name>dfs.replication</name>

<value>1</value>

</property>

<property>

<name>dfs.namenode.name.dir</name>

<value>file:/data/hadoop/hadoop_data/hdfs/namenode</value>

</property>

<property>

<name>dfs.datanode.data.dir</name>

<value>file:/data/hadoop/hadoop_data/hdfs/datanode</value>

</property>

<property>

<name>dfs.permissions</name>

<value>false</value>

</property>

</configuration>
```

**Rename mapred-site.xml.template to mapred-site.xml**

Update the following in hadoop/etc/hadoop mapred-site.xml:

```
<configuration>

<property>

  <name>yarn.app.mapreduce.am.resource.mb</name>

  <value>1228</value>

</property>
```

```
<property>
   <name>yarn.app.mapreduce.am.command-opts</name>
   <value>-Xmx983m</value>
</property>
<property>
   <name>mapreduce.map.memory.mb</name>
   <value>1228</value>
</property>
<property>
   <name>mapreduce.reduce.memory.mb</name>
   <value>1228</value>
</property>
<property>
   <name>mapreduce.map.java.opts</name>
   <value>-Xmx983m</value>
</property>
<property>
   <name>mapreduce.reduce.java.opts</name>
   <value>-Xmx983m</value>
</property>
<property>
<name>mapred.job.shuffle.input.buffer.percent</name>
<value>0.20</value>
</property>
<property>
<name>mapreduce.cluster.local.dir</name>
<value>/data/tmp/mapred/local</value>
</property>
</configuration>
```

mapreduce.map.memory.mb :The upper limit that Hadoop allows to be allocated to a mapper. it was set to 1228 mb.

mapreduce.reduce.memory.mb : The upper limit that Hadoop allows to be allocated to a mapper. it was set to 1228 mb.

mapred.job.shuffle.input.buffer.percent: the mapper buffer size was set to 25%.

mapreduce.cluster.local.dir: It was set to /data/tmp/mapred/local .This is the place where the mapper stores the intermediate values it was spread across .multiple folders inorder to make space for the intermediate results.

Update the following in hadoop/etc/hadoop/yarn-site.xml

```
<configuration>

<property>

<name>yarn.nodemanager.aux-services</name>

<value>mapreduce_shuffle</value>

</property>

<property>

<name>yarn.nodemanager.aux-services.mapreduce.shuffle.class</name>

<value>org.apache.hadoop.mapred.ShuffleHandler</value>

</property>

</configuration>
```

Description:

**Modify the following in the Hadoop-env.sh**

- export JAVA_HOME=/usr/lib/jvm/java-8-openjdk-amd64
- export HADOOP_CONF_DIR=${HADOOP_CONF_DIR:-"/etc/hadoop"}
- export HADOOP_CLASSPATH=$JAVA_HOME/lib/tools.jar

**Install java:**

- apt-get update
- apt-get upgrade
- apt-get install default-jdk

**Update bashrc file:**

- vi .bashrc

```
export JAVA_HOME=/usr/lib/jvm/java-8-openjdk-amd64

export HADOOP_INSTALL=/data/hadoop

export PATH=$PATH:$HADOOP_INSTALL/bin

export PATH=$PATH:$HADOOP_INSTALL/sbin

export HADOOP_MAPRED_HOME=$HADOOP_INSTALL

export HADOOP_COMMON_HOME=$HADOOP_INSTALL

export HADOOP_HDFS_HOME=$HADOOP_INSTALL

export YARN_HOME=$HADOOP_INSTALL

export HADOOP_COMMON_LIB_NATIVE_DIR=$HADOOP_INSTALL/lib/native

export HADOOP_OPTS="-Djava.library.path=$HADOOP_INSTALL/lib"

export HADOOP_OPTS=-Djava.net.preferIPv4Stack=true

export CONF=/data/hadoop/etc/hadoop
```

- source .bashrc

Configure passwordless ssh:

- ssh root@localhost

- ssh-keygen -t rsa
- cd .ssh
- cat id_rsa.pub
- copy the the id_rsa.pub to authorized_keys

**Format the namenode:**

- hdfs namenode -format
- start-dfs.sh
- start-yarn.sh

Start all services: Type jps and see if all nodes are up

## Generating data using gensort

- wget http://www.ordinal.com/try.cgi/gensort-linux-1.5.tar.gz
- tar -zxvf gensort-linux-1.5.tar.gz
- rm -rf gensort-linux-1.5.tar.gz
- cd /64
- ./gensort -a 1367122448 /data/input
- hdfs dfs -mkdir /sortinput
- hdfs dfs -put /data/64/input /sortinput

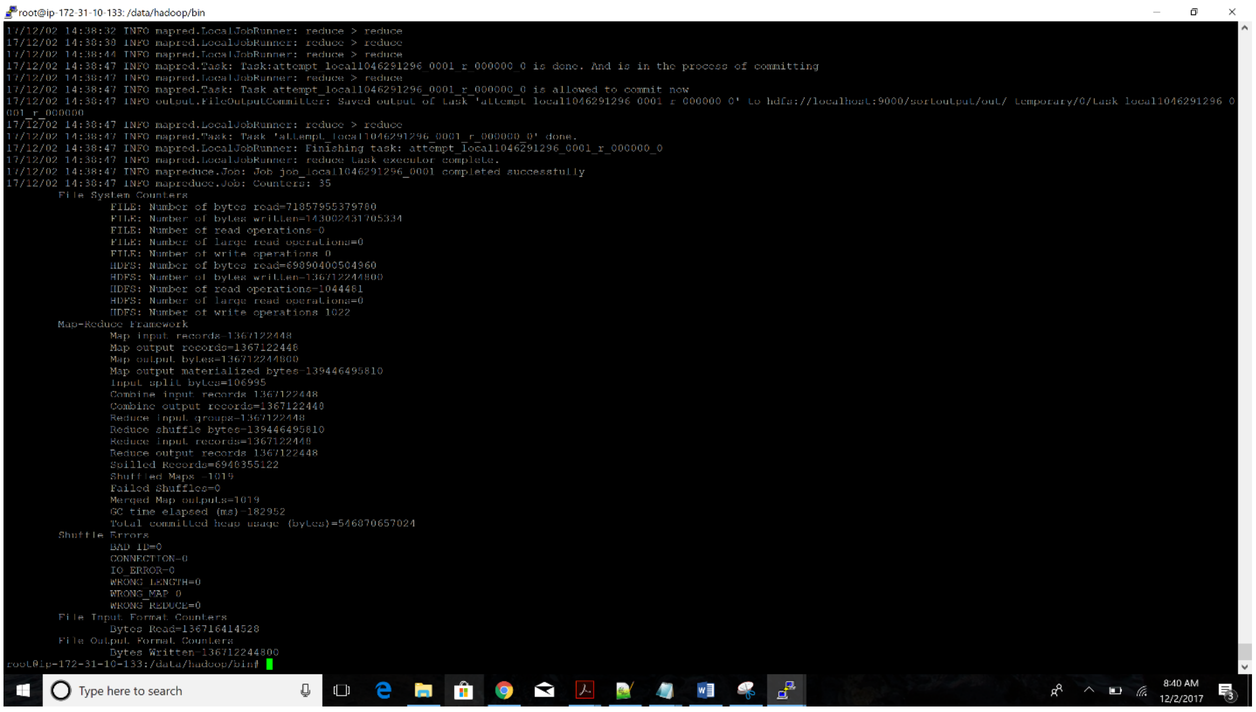
copy the SortHadoop.java inside the hadoop/bin

Execute the program using

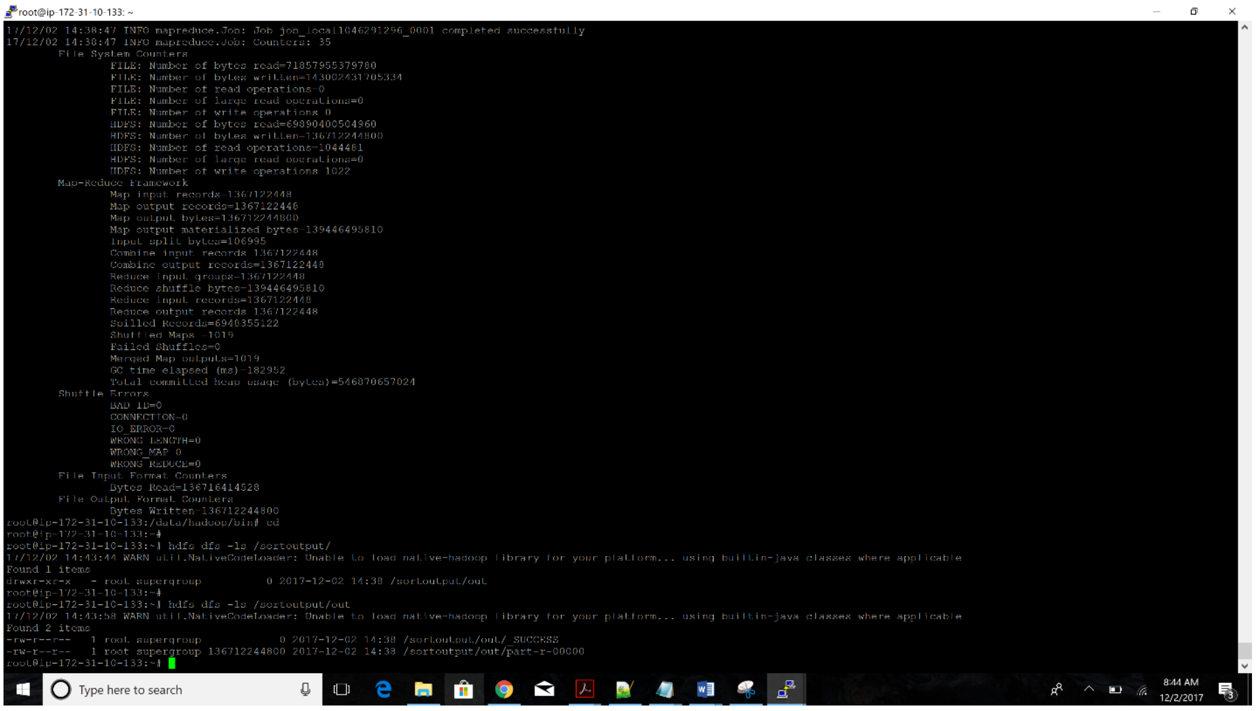
- hadoop com.sun.tools.javac.Main SortHadoop.java
- jar cf hs.jar SortHadoop*.class
- hadoop jar hs.jar SortHadoop /sortinput/input /sortoutput/out

Transferring data to hdfs:

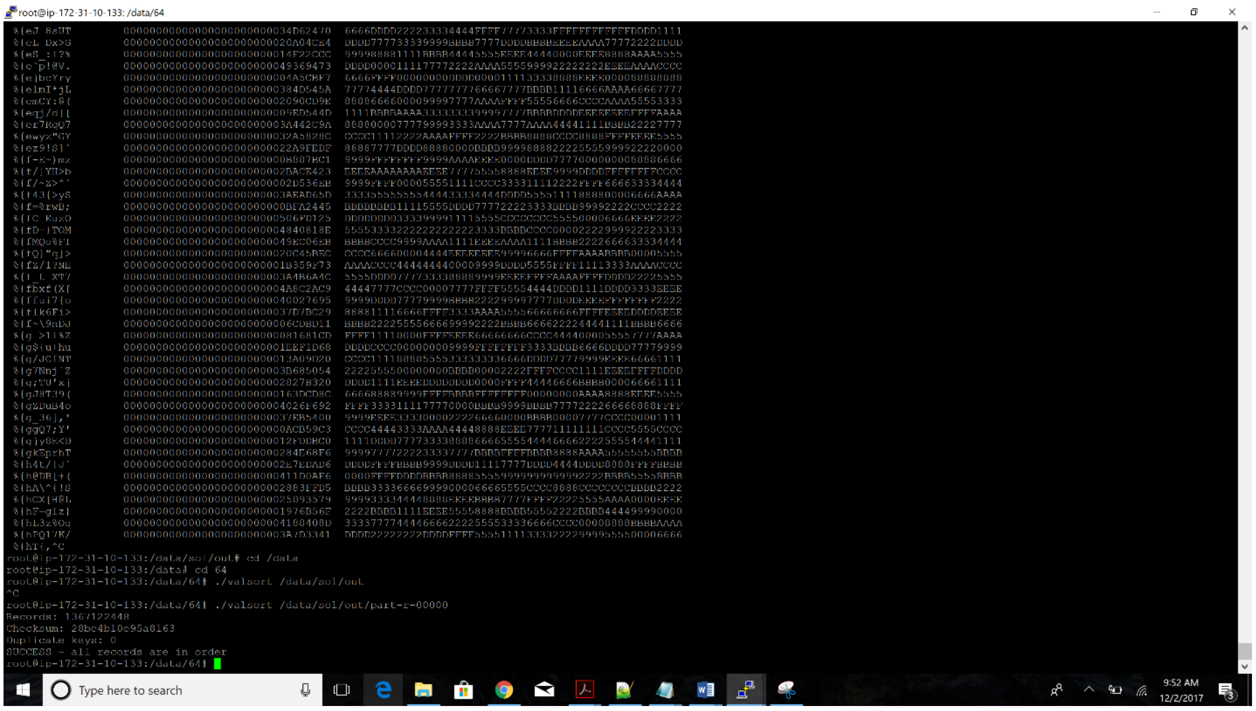
- hdfs dfs -get /sortinput/input /data/sol
- Do valsort on the output



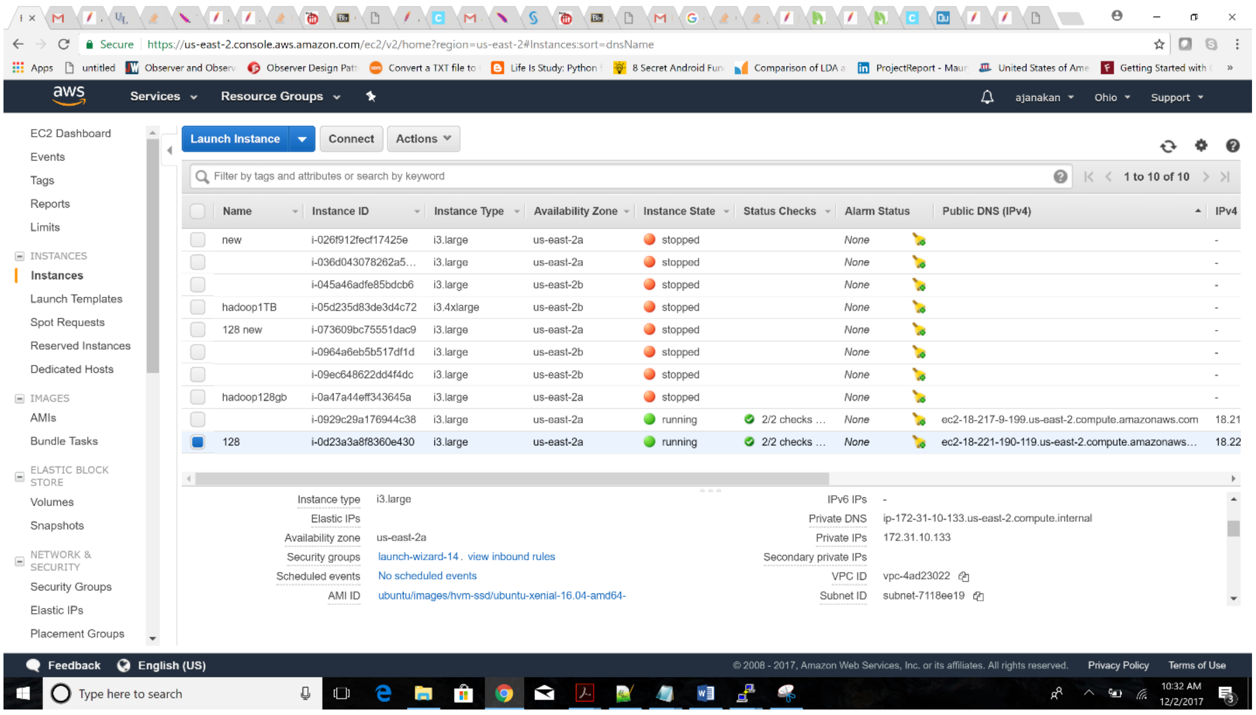
```
root@ip-172-31-10-133: /data/hadoop/bin
17/12/02 14:38:32 INFO mapred.LocalJobRunner: reduce > reduce
17/12/02 14:38:38 INFO mapred.LocalJobRunner: reduce > reduce
17/12/02 14:38:44 INFO mapred.LocalJobRunner: reduce > reduce
17/12/02 14:38:47 INFO mapred.Task: Task:attempt_local1046291296_0001_r_000000_0 is done. And is in the process of committing
17/12/02 14:38:47 INFO mapred.LocalJobRunner: reduce > reduce
17/12/02 14:38:47 INFO mapred.Task: Task attempt_local1046291296_0001_r_000000_0 is allowed to commit now
17/12/02 14:38:47 INFO output.FileOutputCommitter: Saved output of task 'attempt_local1046291296_0001_r_000000_0' to hdfs://localhost:9000/sortoutput/out/_temporary/0/task_local1046291296_0
001_r_000000
17/12/02 14:38:47 INFO mapred.LocalJobRunner: reduce > reduce
17/12/02 14:38:47 INFO mapred.Task: Task 'attempt_local1046291296_0001_r_000000_0' done.
17/12/02 14:38:47 INFO mapred.LocalJobRunner: Finishing task: attempt_local1046291296_0001_r_000000_0
17/12/02 14:38:47 INFO mapred.LocalJobRunner: reduce task executor complete.
17/12/02 14:38:47 INFO mapreduce.Job: Job job_local1046291296_0001 completed successfully
17/12/02 14:38:47 INFO mapreduce.Job: Counters: 35
        File System Counters
                FILE: Number of bytes read=71857955379780
                FILE: Number of bytes written=143002431705334
                FILE: Number of read operations=0
                FILE: Number of large read operations=0
                FILE: Number of write operations=0
                HDFS: Number of bytes read=69890400504960
                HDFS: Number of bytes written=136712244800
                HDFS: Number of read operations=1044481
                HDFS: Number of large read operations=0
                HDFS: Number of write operations=1022
        Map-Reduce Framework
                Map input records=1367122448
                Map output records=1367122448
                Map output bytes=136712244800
                Map output materialized bytes=139446495810
                Input split bytes=106995
                Combine input records=1367122448
                Combine output records=1367122448
                Reduce input groups=1367122448
                Reduce shuffle bytes=139446495810
                Reduce input records=1367122448
                Reduce output records=1367122448
                Spilled Records=6948355122
                Shuffled Maps =1019
                Failed Shuffles=0
                Merged Map outputs=1019
                GC time elapsed (ms)=182952
                Total committed heap usage (bytes)=546870657024
        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=136716414528
        File Output Format Counters
                Bytes Written=136712244800
root@ip-172-31-10-133:/data/hadoop/bin#
```



```
17/12/02 14:38:47 INFO mapreduce.Job: Job job_local1046291296_0001 completed successfully
17/12/02 14:38:47 INFO mapreduce.Job: Counters: 35
        File System Counters
                FILE: Number of bytes read=71857955379780
                FILE: Number of bytes written=143002431705334
                FILE: Number of read operations=0
                FILE: Number of large read operations=0
                FILE: Number of write operations=0
                HDFS: Number of bytes read=69890400504960
                HDFS: Number of bytes written=136712244800
                HDFS: Number of read operations=1044481
                HDFS: Number of large read operations=0
                HDFS: Number of write operations=1022
        Map-Reduce Framework
                Map input records=1367122448
                Map output records=1367122448
                Map output bytes=136712244800
                Map output materialized bytes=139446495810
                Input split bytes=106995
                Combine input records=1367122448
                Combine output records=1367122448
                Reduce input groups=1367122448
                Reduce shuffle bytes=139446495810
                Reduce input records=1367122448
                Reduce output records=1367122448
                Spilled Records=6940355122
                Shuffled Maps =1019
                Failed Shuffles=0
                Merged Map outputs=1019
                GC time elapsed (ms)=182952
                Total committed heap usage (bytes)=546870657024
        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=136716414528
        File Output Format Counters
                Bytes Written=136712244800
root@ip-172-31-10-133:/data/hadoop/bin# cd
root@ip-172-31-10-133:~#
root@ip-172-31-10-133:~# hdfs dfs -ls /sortoutput/
17/12/02 14:43:44 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using builtin-java classes where applicable
Found 1 items
drwxr-xr-x   - root supergroup          0 2017-12-02 14:38 /sortoutput/out
root@ip-172-31-10-133:~#
root@ip-172-31-10-133:~# hdfs dfs -ls /sortoutput/out
17/12/02 14:43:58 WARN util.NativeCodeLoader: Unable to load native-hadoop library for your platform... using builtin-java classes where applicable
Found 2 items
-rw-r--r--   1 root supergroup            0 2017-12-02 14:38 /sortoutput/out/_SUCCESS
-rw-r--r--   1 root supergroup 136712244800 2017-12-02 14:38 /sortoutput/out/part-r-00000
root@ip-172-31-10-133:~#
```



```
 %{eJ 8sUT      00000000000000000000000034D62470  6666DDDD222233334444FFFF77773333FFFFFFFFFFFFDDDD1111
 %{cL Dx>G      00000000000000000000000020A04CE4  DDDD777733339999BBBB7777DDDDBBBBEEEEAAAA77772222DDDD
 %{eS_:|?%      00000000000000000000000014F22CCC  999988881111BBBB44445555EEEE44440000EEEE8888AAAA5555
 %{c`p!@V.      00000000000000000000000049369473  DDDD0000111177772222AAAA555599992222 2222EEEEAAAACCCC
 %{ejbcYry      0000000000000000000000004A5CBF7   6666FFFF00000000DDDD0000111133338888EEEE000088888888
 %{elmI*jL      000000000000000000000000384D545A  77774444DDDD777777776666777 7BBBB11116666AAAA66667777
 %{cmCY:@(      0000000000000000000000002090CD9E  8888666600009999 7777AAAAFFFF55556666CCCCAAAA55553333
 %{eqj/d|[      00000000000000000000000009ED544D  1111BBBBAAAA3333333399997777BBBBDDDDEEEEEEEEFFFFAAAA
 %{cr7RqQ7      0000000000000000000000003A442C9A  88880000777799993333AAAA7777AAAA44441111BBBB22227777
 %{ewyz"GY      00000000000000000000000032A5828C  CCCC11112222AAAAFFFF2222BBBB8888CCCC8888FFFFEEEE5555
 %{ez9!S]`      00000000000000000000000022A9FEDF  88887777DDDD88880000BBBB99998888222255559999 22220000
 %{f-E~)mz      0000000000000000000000000B887BC1  9999FFFFFFFF9999AAAAEEEE0000DDDD7777000000008888 6666
 %{f/]YH>b      0000000000000000000000002BACE423  EEEEAAAAAAAAEEEE777755558888EEEE9999DDDDFFFFFFFFCCCC
 %{f/~Z>^`      0000000000000000000000002D536EB   9999FFFF000055551111CCCC333311112222FFFF66663333 4444
 %{f43{>yS      0000000000000000000000003AEAD65D  3333555555554444333344 44DDDD555511118888 00006666AAAA
 %{f=%rwB;      0000000000000000000000000BFA2445  BBBBBBBB11115555DDDD777722223333BBBB99992222CCCC2222
 %{fC EuzO      000000000000000000000000506FD125  DDDDDDDD333399991111 5555CCCCCCCC555500006666EEEE2222
 %{fD-}TOM      0000000000000000000000004840818E  55553333222222222222 3333BBBBCCCC00002222999922223333
 %{fMQo%F1      00000000000000000000000049EC06EB  BBBBCCCC9999AAAA1111EEEEAAAA1111BBBB222266663333 4444
 %{fQ}"q]>      00000000000000000000000020C45BEC  CCCC66660000 4444EEEEEEEE99996666FFFFAAAABBBB00005555
 %{fZ/1?NE      0000000000000000000000001B359F73  AAAACCCC44444444000099 99DDDD5555FFFF11113333AAAACCCC
 %{f_L XT7      0000000000000000000000003A4B6A4C  5555DDDD777733338888 9999EEEEFFFFAAAAFFFFDDDD22225555
 %{fbxf(X[      0000000000000000000000004A8C2AC9  44447777CCCC00007777FFFF55554444DDDD1111DDDD3333EEEE
 %{ffui7{o      00000000000000000000000040027695  9999DDDD77779999BBBB222299997777DDDDEEEEFFFFFFFF2222
 %{fik6Fi>      00000000000000000000000037D7BC29  888811116666FFFF3333AAAA55556666 6666FFFFEEEEDDDDEEEE
 %{f~\9nDJ      0000000000000000000000006CDBD11   BBBB222255556666999922 22BBBB666622224444 1111BBBB6666
 %{g >1i%Z      000000000000000000000000081681CD  FFFF11110000FFFFEEEE66666666CCCC444400005555 7777AAAA
 %{g${u!hu      0000000000000000000000001EEF1D68  DDDDCCCC000000009999FFFFFFFF3333BBBB6666DDDD77779999
 %{g/JC[NT      00000000000000000000000013A09D20  CCCC11118888555533333333 6666DDDD77779999EEEE66661111
 %{g7Nnj`Z      0000000000000000000000003B685054  22225555 00000000BBBB00002222FFFFCCCC1111EEEEFFFFDDDD
 %{g;TU'x|      0000000000000000000000002827B320  DDDD1111EEEEDDDDDDDD0000FFFF44446666BBBB000066661111
 %{gJ8T39(      000000000000000000000000163DCD8C  666688889999FFFFBBBBFFFFFFFF00000000AAAA8888EEEE5555
 %{gZDuB4o      0000000000000000000000004026F692  FFFF333311117777 0000BBBB9999BBBB7777222266668888FFFF
 %{g_36j,'      00000000000000000000000037EB5400  9999EEEE333300002222 66660000BBBB00007777CCCC00001111
 %{ggQ7;Y'      0000000000000000000000000ACB59C3  CCCC44443333AAAA44448888EEEE777711111111CCCC5555CCCC
 %{gjy8E<D      00000000000000000000000012FDDBC0  1111DDDD777733338888666655554444666622225555 44441111
 %{gkEprhT      000000000000000000000000284E68F6  9999777722223333 7777BBBBFFFFBBBB8888AAAA55555555BBBB
 %{h4t/|J`      0000000000000000000000002E7EDAD6  DDDDFFFFBBBB9999DDDD11117777DDDD4444DDDD8888FFFFBBBB
 %{h@DB[+(      000000000000000000000000411D0AF6  0000FFFFDDDDBBBB88885555999999999999 2222BBBB5555BBBB
 %{hA\^{!S      0000000000000000000000002883FFD5  BBBB3333666699990000666655 55CCCC8888CCCCCCCCBBBB2222
 %{hCX[H@L      00000000000000000000000025093579  99993333444488 88EEEEBBBB7777FFFF22225555AAAA0000EEEE
 %{hF-glz}      0000000000000000000000001976B56F  2222BBBB1111EEEE55558888BBBB55552222BBBB444499990000
 %{hL3z%Oq      00000000000000000000000041B8408D  33337777444466662222555533336666CCCC00008888BBBBAAAA
 %{hPQ1/K/      0000000000000000000000003A7D3341  DDDD22222222DDDDFFFF555511113333222299995555 00006666
 %{hT{,^C
root@ip-172-31-10-133:/data/sol/out# cd /data
root@ip-172-31-10-133:/data# cd 64
root@ip-172-31-10-133:/data/64# ./valsort /data/sol/out
^C
root@ip-172-31-10-133:/data/64# ./valsort /data/sol/out/part-r-00000
Records: 1367122448
Checksum: 28bc4b10c95a8163
Duplicate keys: 0
SUCCESS - all records are in order
root@ip-172-31-10-133:/data/64#
```



https://us-east-2.console.aws.amazon.com/ec2/v2/home?region=us-east-2#Instances:sort=dnsName

1 to 10 of 10

| Name | Instance ID | Instance Type | Availability Zone | Instance State | Status Checks | Alarm Status | Public DNS (IPv4) | IPv4 |
|---|---|---|---|---|---|---|---|---|
| new | i-026f912fecf17425e | i3.large | us-east-2a | stopped | | None | | - |
| | i-036d043078262a5… | i3.large | us-east-2a | stopped | | None | | - |
| | i-045a46adfe85bdcb6 | i3.large | us-east-2b | stopped | | None | | - |
| hadoop1TB | i-05d235d83de3d4c72 | i3.4xlarge | us-east-2b | stopped | | None | | - |
| 128 new | i-073609bc75551dac9 | i3.large | us-east-2a | stopped | | None | | - |
| | i-0964a6eb5b517df1d | i3.large | us-east-2b | stopped | | None | | - |
| | i-09ec648622dd4f4dc | i3.large | us-east-2b | stopped | | None | | - |
| hadoop128gb | i-0a47a44eff343645a | i3.large | us-east-2a | stopped | | None | | - |
| | i-0929c29a176944c38 | i3.large | us-east-2a | running | 2/2 checks … | None | ec2-18-217-9-199.us-east-2.compute.amazonaws.com | 18.21 |
| 128 | i-0d23a3a8f8360e430 | i3.large | us-east-2a | running | 2/2 checks … | None | ec2-18-221-190-119.us-east-2.compute.amazonaws… | 18.22 |

| | |
|---|---|
| Instance type | i3.large |
| Elastic IPs | |
| Availability zone | us-east-2a |
| Security groups | launch-wizard-14 . view inbound rules |
| Scheduled events | No scheduled events |
| AMI ID | ubuntu/images/hvm-ssd/ubuntu-xenial-16.04-amd64- |
| IPv6 IPs | - |
| Private DNS | ip-172-31-10-133.us-east-2.compute.internal |
| Private IPs | 172.31.10.133 |
| Secondary private IPs | |
| VPC ID | vpc-4ad23022 |
| Subnet ID | subnet-7118ee19 |

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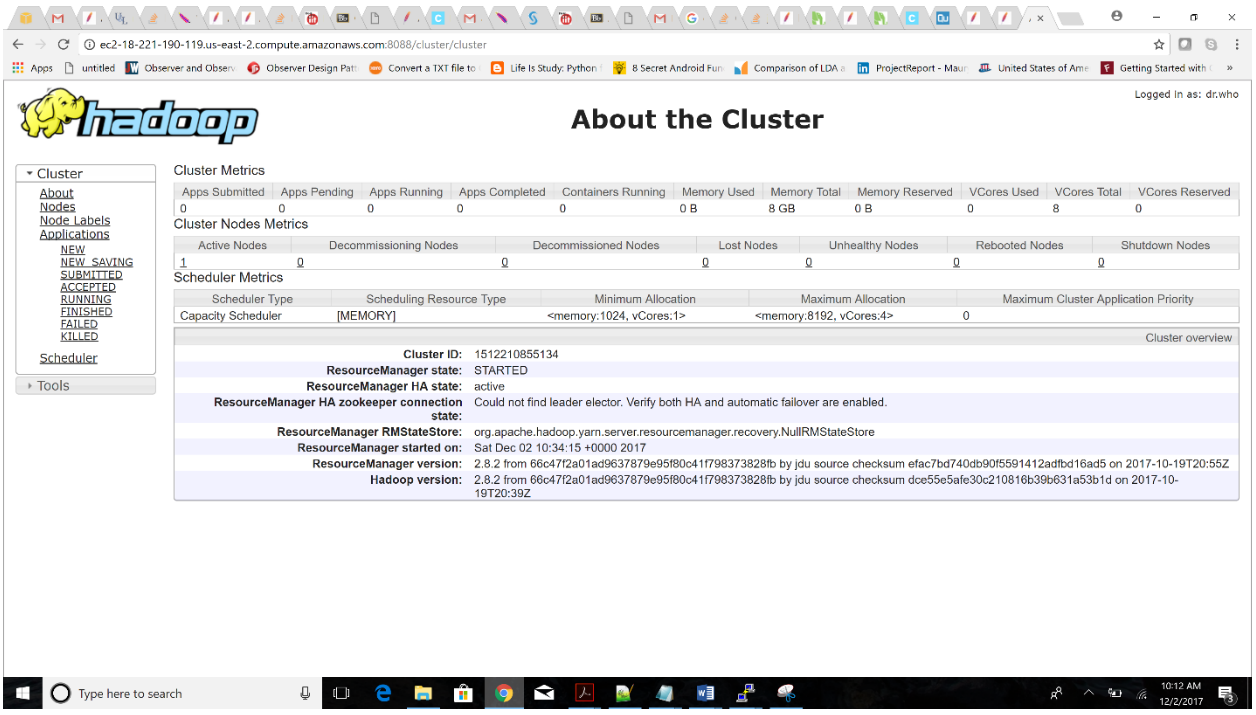


ec2-18-221-190-119.us-east-2.compute.amazonaws.com:8088/cluster/cluster

Logged in as: dr.who

About the Cluster

Cluster Metrics

| Apps Submitted | Apps Pending | Apps Running | Apps Completed | Containers Running | Memory Used | Memory Total | Memory Reserved | VCores Used | VCores Total | VCores Reserved |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 B | 8 GB | 0 B | 0 | 8 | 0 |

Cluster Nodes Metrics

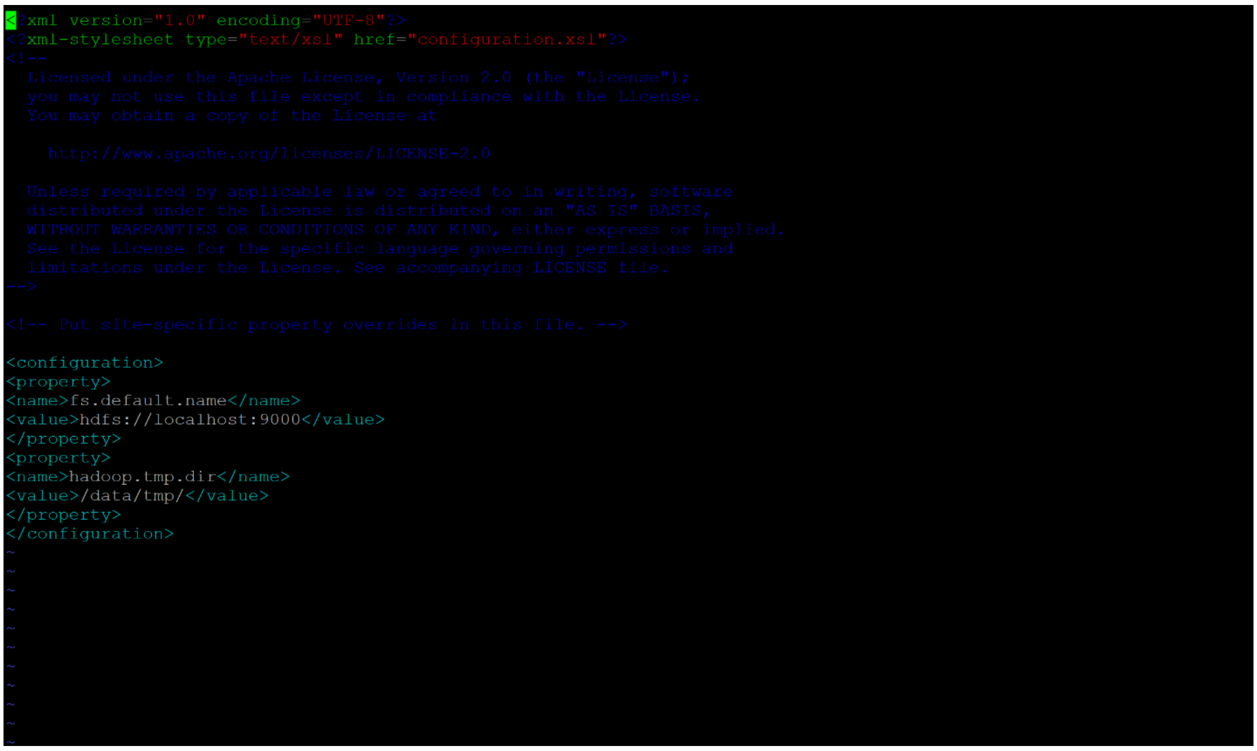
| Active Nodes | Decommissioning Nodes | Decommissioned Nodes | Lost Nodes | Unhealthy Nodes | Rebooted Nodes | Shutdown Nodes |
|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 | 0 | 0 |

Scheduler Metrics

| Scheduler Type | Scheduling Resource Type | Minimum Allocation | Maximum Allocation | Maximum Cluster Application Priority |
|---|---|---|---|---|
| Capacity Scheduler | [MEMORY] | <memory:1024, vCores:1> | <memory:8192, vCores:4> | 0 |

Cluster overview

| | |
|---|---|
| Cluster ID: | 1512210855134 |
| ResourceManager state: | STARTED |
| ResourceManager HA state: | active |
| ResourceManager HA zookeeper connection state: | Could not find leader elector. Verify both HA and automatic failover are enabled. |
| ResourceManager RMStateStore: | org.apache.hadoop.yarn.server.resourcemanager.recovery.NullRMStateStore |
| ResourceManager started on: | Sat Dec 02 10:34:15 +0000 2017 |
| ResourceManager version: | 2.8.2 from 66c47f2a01ad9637879e95f80c41f798373828fb by jdu source checksum efac7bd740db90f5591412adfbd16ad5 on 2017-10-19T20:55Z |
| Hadoop version: | 2.8.2 from 66c47f2a01ad9637879e95f80c41f798373828fb by jdu source checksum dce55e5afe30c210816b39b631a53b1d on 2017-10-19T20:39Z |



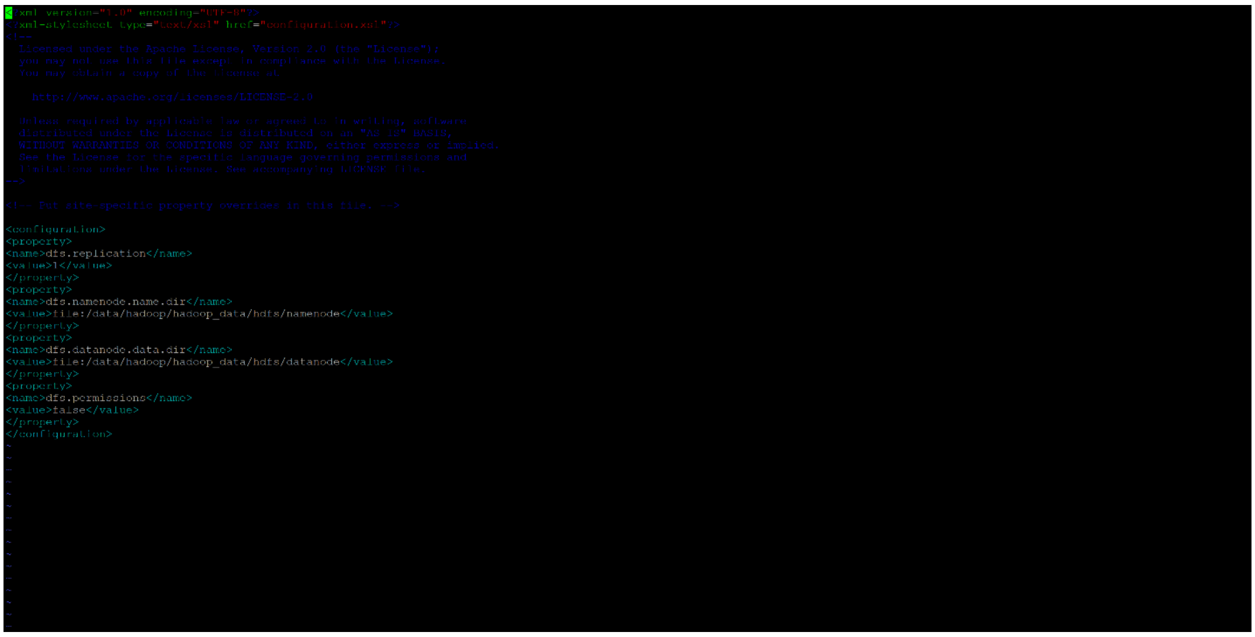
```
<?xml version="1.0" encoding="UTF-8"?>
<?xml-stylesheet type="text/xsl" href="configuration.xsl"?>
<!--
  Licensed under the Apache License, Version 2.0 (the "License");
  you may not use this file except in compliance with the License.
  You may obtain a copy of the License at

    http://www.apache.org/licenses/LICENSE-2.0

  Unless required by applicable law or agreed to in writing, software
  distributed under the License is distributed on an "AS IS" BASIS,
  WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or implied.
  See the License for the specific language governing permissions and
  limitations under the License. See accompanying LICENSE file.
-->

<!-- Put site-specific property overrides in this file. -->

<configuration>
<property>
<name>fs.default.name</name>
<value>hdfs://localhost:9000</value>
</property>
<property>
<name>hadoop.tmp.dir</name>
<value>/data/tmp/</value>
</property>
</configuration>
~
~
~
~
~
~
~
~
~
~
~
```



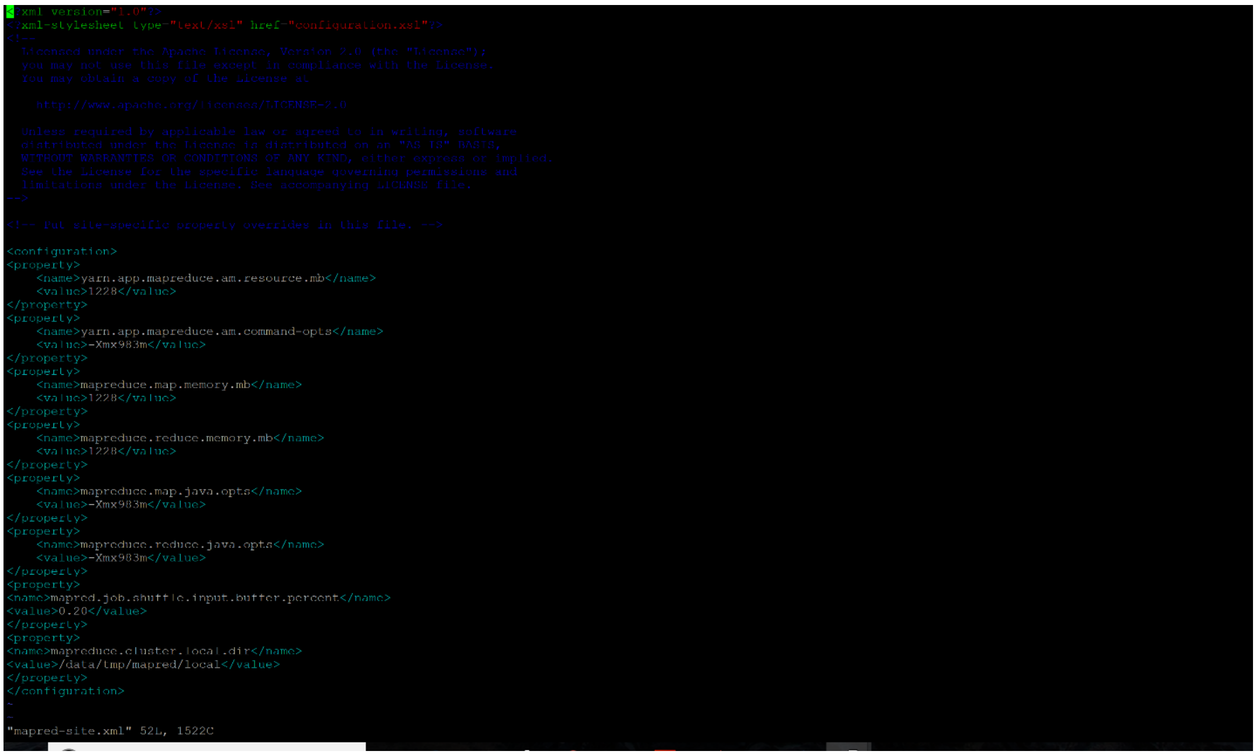
```
<?xml version="1.0" encoding="UTF-8"?>
<?xml-stylesheet type="text/xsl" href="configuration.xsl"?>
<!--
  Licensed under the Apache License, Version 2.0 (the "License");
  you may not use this file except in compliance with the License.
  You may obtain a copy of the License at

    http://www.apache.org/licenses/LICENSE-2.0

  Unless required by applicable law or agreed to in writing, software
  distributed under the License is distributed on an "AS IS" BASIS,
  WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or implied.
  See the License for the specific language governing permissions and
  limitations under the License. See accompanying LICENSE file.
-->

<!-- Put site-specific property overrides in this file. -->

<configuration>
<property>
<name>dfs.replication</name>
<value>1</value>
</property>
<property>
<name>dfs.namenode.name.dir</name>
<value>file:/data/hadoop/hadoop_data/hdfs/namenode</value>
</property>
<property>
<name>dfs.datanode.data.dir</name>
<value>file:/data/hadoop/hadoop_data/hdfs/datanode</value>
</property>
<property>
<name>dfs.permissions</name>
<value>false</value>
</property>
</configuration>
~
~
~
~
~
~
~
~
~
~
~
~
~
~
~
```



```
<?xml version="1.0"?>
<?xml-stylesheet type="text/xsl" href="configuration.xsl"?>
<!--
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  you may not use this file except in compliance with the License.
  You may obtain a copy of the License at

    http://www.apache.org/licenses/LICENSE-2.0

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  distributed under the License is distributed on an "AS IS" BASIS,
  WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or implied.
  See the License for the specific language governing permissions and
  limitations under the License. See accompanying LICENSE file.
-->

<!-- Put site-specific property overrides in this file. -->

<configuration>
<property>
    <name>yarn.app.mapreduce.am.resource.mb</name>
    <value>1228</value>
</property>
<property>
    <name>yarn.app.mapreduce.am.command-opts</name>
    <value>-Xmx983m</value>
</property>
<property>
    <name>mapreduce.map.memory.mb</name>
    <value>1228</value>
</property>
<property>
    <name>mapreduce.reduce.memory.mb</name>
    <value>1228</value>
</property>
<property>
    <name>mapreduce.map.java.opts</name>
    <value>-Xmx983m</value>
</property>
<property>
    <name>mapreduce.reduce.java.opts</name>
    <value>-Xmx983m</value>
</property>
<property>
<name>mapred.job.shuffle.input.buffer.percent</name>
<value>0.20</value>
</property>
<property>
<name>mapreduce.cluster.local.dir</name>
<value>/data/tmp/mapred/local</value>
</property>
</configuration>
~
~
"mapred-site.xml" 52L, 1522C
```

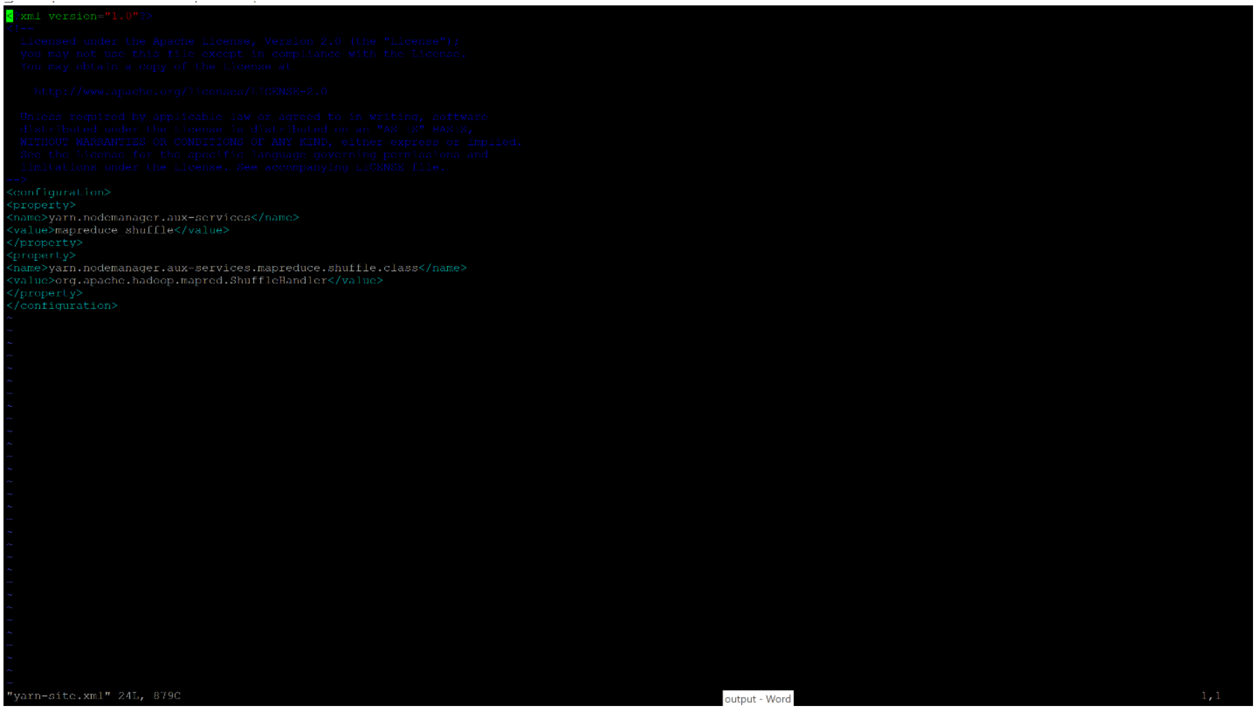

```
<?xml version="1.0"?>
<!--
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  you may not use this file except in compliance with the License.
  You may obtain a copy of the License at

    http://www.apache.org/licenses/LICENSE-2.0

  Unless required by applicable law or agreed to in writing, software
  distributed under the License is distributed on an "AS IS" BASIS,
  WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or implied.
  See the License for the specific language governing permissions and
  limitations under the License. See accompanying LICENSE file.
-->
<configuration>
<property>
<name>yarn.nodemanager.aux-services</name>
<value>mapreduce_shuffle</value>
</property>
<property>
<name>yarn.nodemanager.aux-services.mapreduce.shuffle.class</name>
<value>org.apache.hadoop.mapred.ShuffleHandler</value>
</property>
</configuration>
~
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~
~
"yarn-site.xml" 24L, 879C                                                                     1,1
```
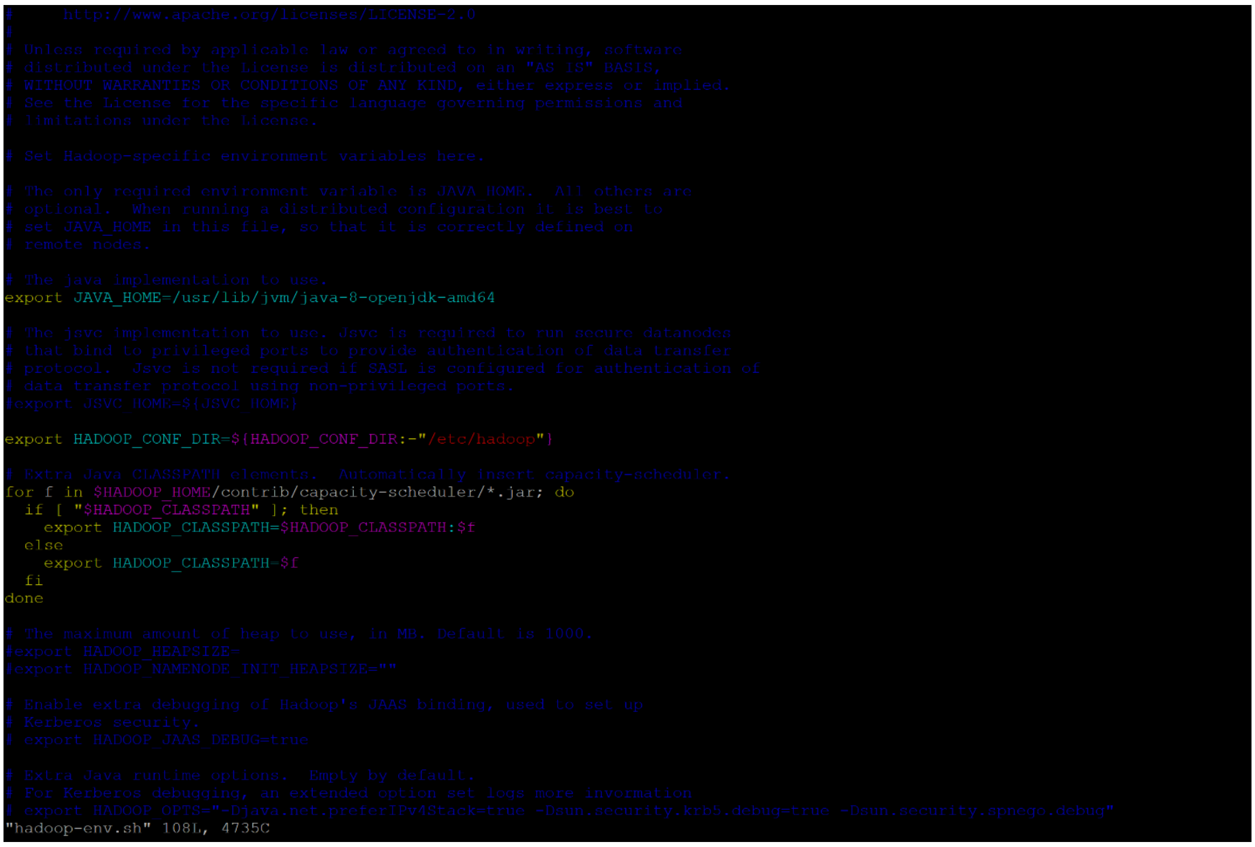
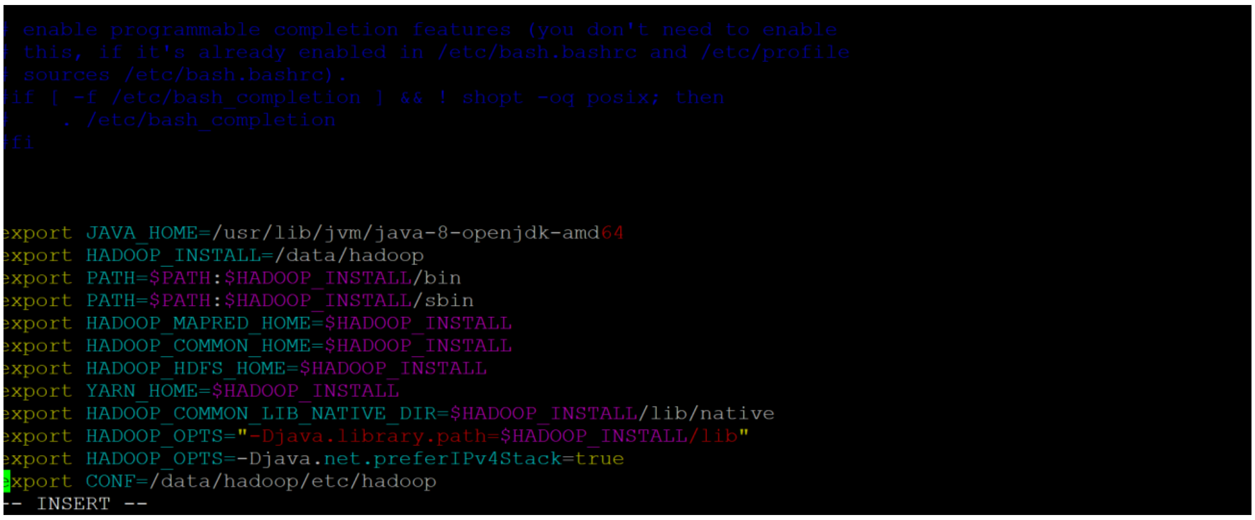
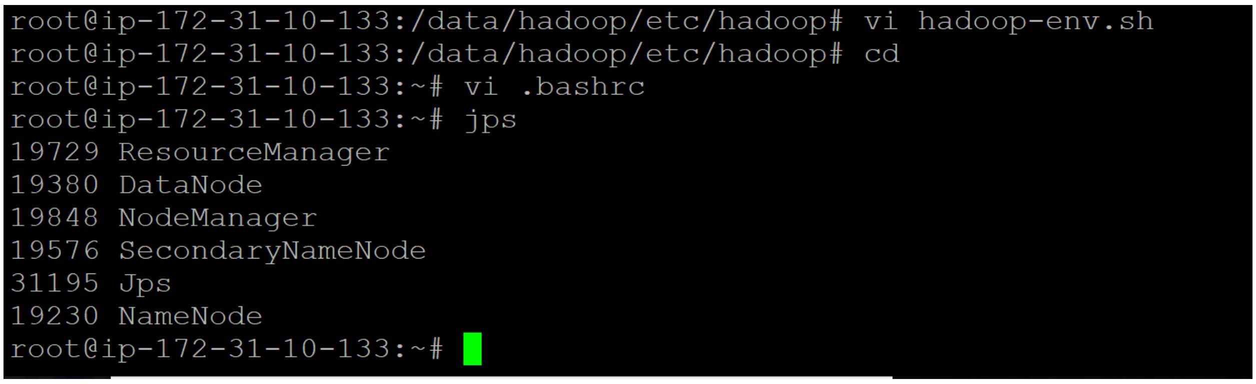



```
#      http://www.apache.org/licenses/LICENSE-2.0
#
# Unless required by applicable law or agreed to in writing, software
# distributed under the License is distributed on an "AS IS" BASIS,
# WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or implied.
# See the License for the specific language governing permissions and
# limitations under the License.

# Set Hadoop-specific environment variables here.

# The only required environment variable is JAVA_HOME.  All others are
# optional.  When running a distributed configuration it is best to
# set JAVA_HOME in this file, so that it is correctly defined on
# remote nodes.

# The java implementation to use.
export JAVA_HOME=/usr/lib/jvm/java-8-openjdk-amd64

# The jsvc implementation to use. Jsvc is required to run secure datanodes
# that bind to privileged ports to provide authentication of data transfer
# protocol.  Jsvc is not required if SASL is configured for authentication of
# data transfer protocol using non-privileged ports.
#export JSVC_HOME=${JSVC_HOME}

export HADOOP_CONF_DIR=${HADOOP_CONF_DIR:-"/etc/hadoop"}

# Extra Java CLASSPATH elements.  Automatically insert capacity-scheduler.
for f in $HADOOP_HOME/contrib/capacity-scheduler/*.jar; do
  if [ "$HADOOP_CLASSPATH" ]; then
    export HADOOP_CLASSPATH=$HADOOP_CLASSPATH:$f
  else
    export HADOOP_CLASSPATH=$f
  fi
done

# The maximum amount of heap to use, in MB. Default is 1000.
#export HADOOP_HEAPSIZE=
#export HADOOP_NAMENODE_INIT_HEAPSIZE=""

# Enable extra debugging of Hadoop's JAAS binding, used to set up
# Kerberos security.
# export HADOOP_JAAS_DEBUG=true

# Extra Java runtime options.  Empty by default.
# For Kerberos debugging, an extended option set logs more invormation
# export HADOOP_OPTS="-Djava.net.preferIPv4Stack=true -Dsun.security.krb5.debug=true -Dsun.security.spnego.debug"
"hadoop-env.sh" 108L, 4735C
```

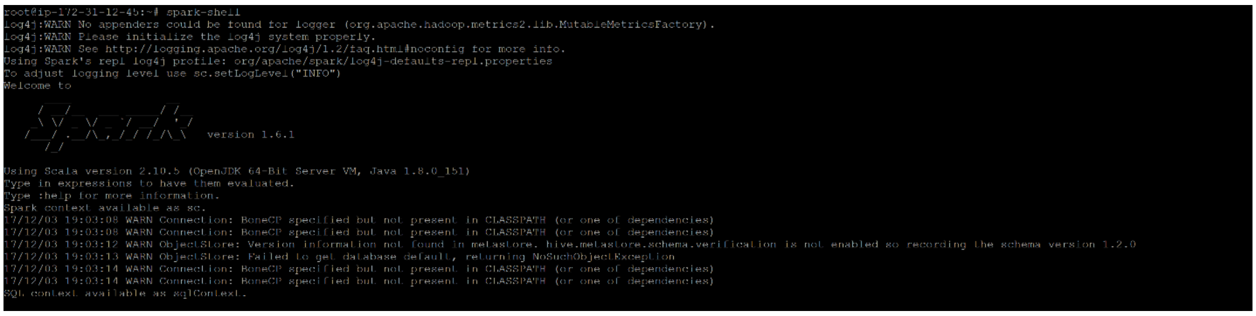


```
# enable programmable completion features (you don't need to enable
# this, if it's already enabled in /etc/bash.bashrc and /etc/profile
# sources /etc/bash.bashrc).
#if [ -f /etc/bash_completion ] && ! shopt -oq posix; then
#    . /etc/bash_completion
#fi



export JAVA_HOME=/usr/lib/jvm/java-8-openjdk-amd64
export HADOOP_INSTALL=/data/hadoop
export PATH=$PATH:$HADOOP_INSTALL/bin
export PATH=$PATH:$HADOOP_INSTALL/sbin
export HADOOP_MAPRED_HOME=$HADOOP_INSTALL
export HADOOP_COMMON_HOME=$HADOOP_INSTALL
export HADOOP_HDFS_HOME=$HADOOP_INSTALL
export YARN_HOME=$HADOOP_INSTALL
export HADOOP_COMMON_LIB_NATIVE_DIR=$HADOOP_INSTALL/lib/native
export HADOOP_OPTS="-Djava.library.path=$HADOOP_INSTALL/lib"
export HADOOP_OPTS=-Djava.net.preferIPv4Stack=true
export CONF=/data/hadoop/etc/hadoop
-- INSERT --
```



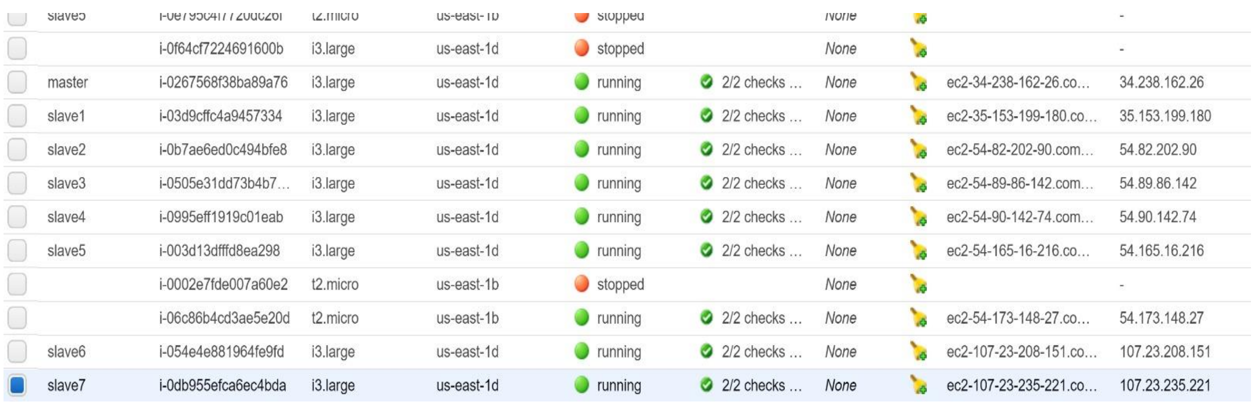
```
root@ip-172-31-10-133:/data/hadoop/etc/hadoop# vi hadoop-env.sh
root@ip-172-31-10-133:/data/hadoop/etc/hadoop# cd
root@ip-172-31-10-133:~# vi .bashrc
root@ip-172-31-10-133:~# jps
19729 ResourceManager
19380 DataNode
19848 NodeManager
19576 SecondaryNameNode
31195 Jps
19230 NameNode
root@ip-172-31-10-133:~#
```

Spark:



```
root@ip-172-31-12-45:~# spark-shell
log4j:WARN No appenders could be found for logger (org.apache.hadoop.metrics2.lib.MutableMetricsFactory).
log4j:WARN Please initialize the log4j system properly.
log4j:WARN See http://logging.apache.org/log4j/1.2/faq.html#noconfig for more info.
Using Spark's repl log4j profile: org/apache/spark/log4j-defaults-repl.properties
To adjust logging level use sc.setLogLevel("INFO")
Welcome to
      ____              __
     / __/__  ___ _____/ /__
    _\ \/ _ \/ _ `/ __/  '_/
   /___/ .__/\_,_/_/ /_/\_\   version 1.6.1
      /_/

Using Scala version 2.10.5 (OpenJDK 64-Bit Server VM, Java 1.8.0_151)
Type in expressions to have them evaluated.
Type :help for more information.
Spark context available as sc.
17/12/03 19:03:08 WARN Connection: BoneCP specified but not present in CLASSPATH (or one of dependencies)
17/12/03 19:03:08 WARN Connection: BoneCP specified but not present in CLASSPATH (or one of dependencies)
17/12/03 19:03:12 WARN ObjectStore: Version information not found in metastore. hive.metastore.schema.verification is not enabled so recording the schema version 1.2.0
17/12/03 19:03:13 WARN ObjectStore: Failed to get database default, returning NoSuchObjectException
17/12/03 19:03:14 WARN Connection: BoneCP specified but not present in CLASSPATH (or one of dependencies)
17/12/03 19:03:14 WARN Connection: BoneCP specified but not present in CLASSPATH (or one of dependencies)
SQL context available as sqlContext.
```

**Hadoop Multi-node**



| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ☐ | slave5 | i-0e795c41772ddc26f | t2.micro | us-east-1b | ● stopped | | None | | | - |
| ☐ | | i-0f64cf7224691600b | i3.large | us-east-1d | ● stopped | | None | | | - |
| ☐ | master | i-0267568f38ba89a76 | i3.large | us-east-1d | ● running | ✓ 2/2 checks ... | None | | ec2-34-238-162-26.co... | 34.238.162.26 |
| ☐ | slave1 | i-03d9cffc4a9457334 | i3.large | us-east-1d | ● running | ✓ 2/2 checks ... | None | | ec2-35-153-199-180.co... | 35.153.199.180 |
| ☐ | slave2 | i-0b7ae6ed0c494bfe8 | i3.large | us-east-1d | ● running | ✓ 2/2 checks ... | None | | ec2-54-82-202-90.com... | 54.82.202.90 |
| ☐ | slave3 | i-0505e31dd73b4b7... | i3.large | us-east-1d | ● running | ✓ 2/2 checks ... | None | | ec2-54-89-86-142.com... | 54.89.86.142 |
| ☐ | slave4 | i-0995eff1919c01eab | i3.large | us-east-1d | ● running | ✓ 2/2 checks ... | None | | ec2-54-90-142-74.com... | 54.90.142.74 |
| ☐ | slave5 | i-003d13dfffd8ea298 | i3.large | us-east-1d | ● running | ✓ 2/2 checks ... | None | | ec2-54-165-16-216.co... | 54.165.16.216 |
| ☐ | | i-0002e7fde007a60e2 | t2.micro | us-east-1b | ● stopped | | None | | | - |
| ☐ | | i-06c86b4cd3ae5e20d | t2.micro | us-east-1b | ● running | ✓ 2/2 checks ... | None | | ec2-54-173-148-27.co... | 54.173.148.27 |
| ☐ | slave6 | i-054e4e881964fe9fd | i3.large | us-east-1d | ● running | ✓ 2/2 checks ... | None | | ec2-107-23-208-151.co... | 107.23.208.151 |
| ■ | slave7 | i-0db955efca6ec4bda | i3.large | us-east-1d | ● running | ✓ 2/2 checks ... | None | | ec2-107-23-235-221.co... | 107.23.235.221 |

## Hadoop 1 Tb configuration

### Prepare RAID for two disks

- "Installing mdadm"
- apt-get update
- apt-get install mdadm
- "changing to raid 0"
- lsblk
- mdadm --create --verbose /dev/md0 --level=0 --name=Cloud --raid-devices=2 /dev/nvme0n1 /dev/nvme1n1
- mkfs.ext4 -L Cloud /dev/md0
- mkdir -p /data/raid
- mount LABEL=Cloud /data/raid

Initially the same set of xml files was used .But transferring there were errors in transferring the data to the hdfs.So the temp folders in core-site and the namenode and datanode directories in the hdfs-site was spread across differernt directories .

Then  transferring the data to  the HDFS happened.But again the map job failed at 0%.

So the following changes were made in the mapred-site.xml.But  due to connectivity issues the reduce job was not complete.

```
<property>

<name>mapred.child.java.opts</name>

<value-Xmx4096m</value>

</property>

<property>

<name>mapreduce.map.java.opts</name>
```

```
<value>-Xmx4g </value>

</property>

<property>

<name>mapreduce.reduce.java.opts</name>

<value>-Xmx4g</value>

</property>

<property>

<name> mapreduce.map.memory.mb</name>
<value>5012</value>

</property>

<property>

<name>mapreduce.reduce.memory.mb</name>

<value>5012</value>

</property>
```

And the following were added in the hadoop-env.sh

export HADOOP-OPTS="-Xmx5096m"

**change to hadoop/etc/hadoop/core-site.xml**

Update the following:

```
<configuration>

<property>

<name>fs.default.name</name>

<value>hdfs://localhost:9000</value>

</property>

<property>

<name>hadoop.tmp.dir</name>

<value>/data/raid/tmp/</value>

</property>

</configuration>
```

**Change the following in hadoop/etc/hadoop/hdfs-site.xml**

### Hdfs-site

```
<configuration>

<property>

<name>dfs.replication</name>

<value>1</value>

</property>

<property>

<name>dfs.namenode.name.dir</name>
```

```
<value>file:/data/raid/hadoop/hadoop_data/hdfs/namenode</value>
</property>
<property>
<name>dfs.datanode.data.dir</name>
<value>file:/data/raid/hadoop/hadoop_data/hdfs/datanode</value>
</property>
<property>
<name>dfs.permissions</name>
<value>false</value>
</property>
</configuration>
```

**Rename mapred-site.xml.template to mapred-site.xml**

Update the following in hadoop/etc/hadoop mapred-site.xml:

```
<configuration>
<property>
   <name>yarn.app.mapreduce.am.resource.mb</name>
   <value>1228</value>
</property>
<property>
   <name>yarn.app.mapreduce.am.command-opts</name>
   <value>-Xmx983m</value>
</property>
<property>
   <name>mapreduce.map.memory.mb</name>
   <value>1228</value>
</property>
<property>
   <name>mapreduce.reduce.memory.mb</name>
   <value>1228</value>
</property>
<property>
   <name>mapreduce.map.java.opts</name>
   <value>-Xmx983m</value>
</property>
<property>
```

```
   <name>mapreduce.reduce.java.opts</name>

   <value>-Xmx983m</value>

</property>

<property>

<name>mapred.job.shuffle.input.buffer.percent</name>

<value>0.20</value>

</property>

<property>

<name>mapreduce.cluster.local.dir</name>

<value>/data/tmp/mapred/local</value>

</property>

</configuration>
```

mapreduce.map.memory.mb :The upper limit that Hadoop allows to be allocated to a mapper. it was set to 1228 mb.

mapreduce.reduce.memory.mb : The upper limit that Hadoop allows to be allocated to a mapper. it was set to 1228 mb.

mapred.job.shuffle.input.buffer.percent: the mapper buffer size was set to 25%.

mapreduce.cluster.local.dir: It was set to /data/tmp/mapred/local .This is the place where the mapper stores the intermediate values it was spread across .multiple folders inorder to make space for the intermediate results.

Update the following in hadoop/etc/hadoop/yarn-site.xml

```
<configuration>

<property>

<name>yarn.nodemanager.aux-services</name>

<value>mapreduce_shuffle</value>

</property>

<property>

<name>yarn.nodemanager.aux-services.mapreduce.shuffle.class</name>

<value>org.apache.hadoop.mapred.ShuffleHandler</value>

</property>

</configuration>
```

## Hadoop Multinode

Create a master node do the configuration.And create an image of it and launch 7 additional instances along with it.

Specify the ip's of the slaves inside the master folder.

Similarly remove localhost from the slaves and put the corresponding ip's in the slaves.

Move the SortHadoop.java program to the Hadoop/bin and execute the program.

Execute the jar file by setting the input and output path.

- hadoop com.sun.tools.javac.Main SortHadoop.java
- jar cf hs.jar SortHadoop*.class

- hadoop jar hs.jar SortHadoop /sortinput/input /sortoutput/out
- hadoop jar hs.jar SortHadoop /sortinput/input /sortoutput/out

## Spark

1)Setting up single node cluster for Spark:

Configure hadoop single node in i3.large instance and Configure spark

Install scala

- apt-get install scala

Download spark

Wget https://archive.apache.org/dist/spark/spark-1.6.1/spark-1.6.1-bin-hadoop2.6.tgz

Untar it.

tar -zxvf spark-1.6.1-bin-hadoop2.6.tgz.

mv spark-1.6.1-bin-hadoop2.6 /spark

Configure the spark path in the .bashrc

Export PATH=$PATH: /root/spark/bin.

You can get into the shell using command

Spark-shell

ii)Setting 8  node cluster with.' spark

Export AWS Access key and the Secret key

Launch the cluster using the following command

./spark-ec2 -k <key> -I <Pem file> -s <no of instances> --spot price <spot price> launch <Cluster name>

Execution

Spark-shell -I <scala file name>"

## Analysis

**What conclusions can you draw? Which seems to be best at 1 node scale? How about 8 nodes? Can you predict which would be best at 100 node scale? How about 1000 node scales? Compare your results with those from the Sort Benchmark [9], specifically the winners in 2013 and 2014 who used Hadoop and Spark. Also, what can you learn from the CloudSort benchmark, a report can be found at [10]**

Spark performs better than Shared Memory or Hadoop for 1 node experiments. If we work with 8 nodes, spark would still perform better as the computations are performed within memory., including the data transfer.

For working with 100 and 1000 node scales, Spark works best, as it's based on a functional programming language scala, which works best in the distributed environment. The in-memory batch processing and reduction in disk read/write makes spark about 10 to 1000 times faster than MapReduce.

### Compare your results with those from the Sort Benchmark specifically the winners in 2013 and 2014 who used Hadoop and Spark.

Answer: The winners in 2013 and 2014 who used Hadoop and Spark:

Winners 2014: Apache Spark.

100 TB in 1 , 1406 seconds

207 Amazon EC2 i2.8xlarge nodes x

(32 vCores – 2.5Ghz Intel Xeon E5- 2670 v2,

244GB memory, 8*800GB SSD)

Winner 2013: Hadoop

100 TB in 1406 seconds

2100 es x

(2.3Ghz hexcore Xeon E5-2630, 64 GB Memory, 12*3 TB Disks)

From 2013 and 2014 winners: Apache spark outperforms Hadoop when performed experiment for sorting around 100 TB. The number of nodes and total memory used across all the nodes on spark is much less than that used for Hadoop and in memory computations and less disk read write gives good edge to spark over Hadoop. When compared to my results, it gives me competitive edge on spark over Hadoop on performing experiment on 8 nodes.

### What can you learn from the CloudSort Benchmark ?

The benchmark suggests to perform the sorting for 128GB of data and 1 TB data using minimum cost on any cloud platform and we could conclude the below reasons to utilize the cloud for sort functions.

Accessibility: Its accessible to everyone at no upfront cost.

Affordability: Running 1TB of data is cheap but we have to be careful on the analysis of usage.

Easy Audit : The auditors can easily run the experiment and verify the result.

The sorting can be done with good results for small or fixed amount of results in Amazon with less cost, working on public cloud will help innovation in IO intensive tasks as the present public cloud offers poor IO intensive workloads.

### Challenges faced while working on experiments:

- We need to have a detailed understanding of the Hadoop working , to perform the current experiments. Also Spark. It was difficult to work with such huge dataset, as it involved a lot of processing time ( i.e data read , data write time ) and also sorting and merging of such big dataset.
- The Experiments were taking time for us to execute which caused more credits in the AWS especially in i3.4x large and multinode experiments.