Solution to Homework 2a(CS 553)

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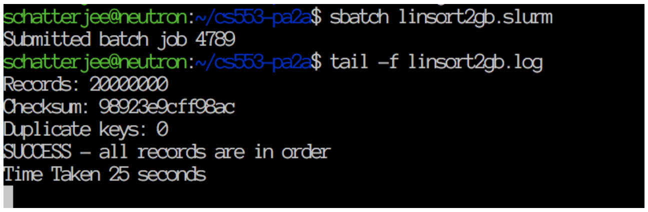
April 15, 2018

1 Performance Table (In seconds)

Experiment	Shared Memory (2GB)	Linux Sort (2GB)	Shared Memory (20GB)	Linux Sort (20GB)
Compute Time (sec)	129.634	25	1027.842	481
Data Read (GB)	2GB	2GB	80GB	60GB
Data Write (GB)	2GB	2GB	80GB	60GB
I/O Throughput (MB/sec)	31.59MBPS	163.84 MBPS	79.70MBPS	170MBPS

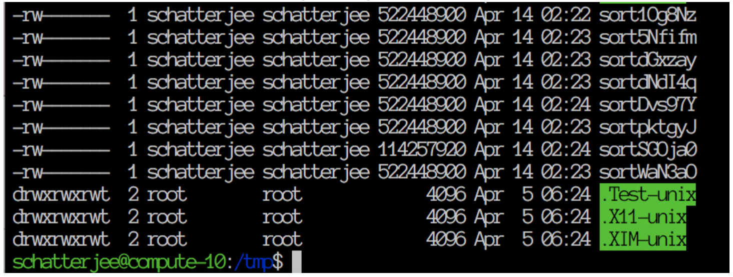
2 Analysis

Linux Sort (1VM 2GB) : Linux performs in-memory sort . So time taken is significantly low. Even lower than 60 sec. Validated the output file linsort2gb.out using valsort and output is kept at /exports/home/schatterjee/cs553-pa2a/linsort2gb.log.



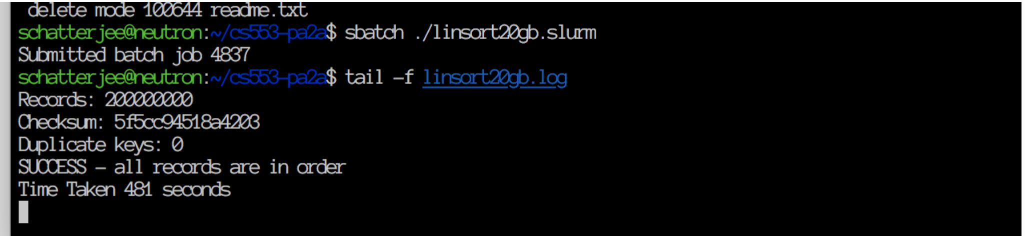
```
schatterjee@neutron:~/cs553-pa2a$ sbatch linsort2gb.slurm
Submitted batch job 4789
schatterjee@neutron:~/cs553-pa2a$ tail -f linsort2gb.log
Records: 20000000
Checksum: 98923e9cff98ac
Duplicate keys: 0
SUCCESS - all records are in order
Time Taken 25 seconds
```

Linux Sort (1VM 20GB) : Linux performs in external sort when data to be sorted is more than the available memory. We don't need to pass any extra params for this. Following image shows the internal created files



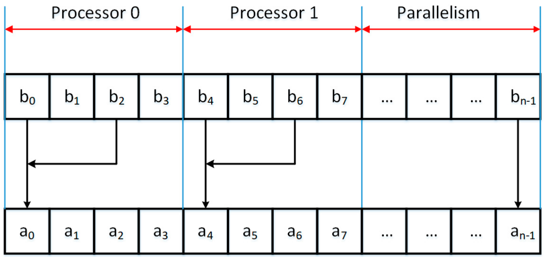
```
-rw-------  1 schatterjee schatterjee 522448900 Apr 14 02:22 sort10g8Nz
-rw-------  1 schatterjee schatterjee 522448900 Apr 14 02:23 sort5Nfifm
-rw-------  1 schatterjee schatterjee 522448900 Apr 14 02:23 sortdGxzay
-rw-------  1 schatterjee schatterjee 522448900 Apr 14 02:23 sortdNdI4q
-rw-------  1 schatterjee schatterjee 522448900 Apr 14 02:24 sortDvs97Y
-rw-------  1 schatterjee schatterjee 522448900 Apr 14 02:23 sortpktgyJ
-rw-------  1 schatterjee schatterjee 114257920 Apr 14 02:24 sortSG0ja0
-rw-------  1 schatterjee schatterjee 522448900 Apr 14 02:23 sortWaN3a0
drwxrwxrwt  2 root        root             4096 Apr  5 06:24 .Test-unix
drwxrwxrwt  2 root        root             4096 Apr  5 06:24 .X11-unix
drwxrwxrwt  2 root        root             4096 Apr  5 06:24 .XIM-unix
schatterjee@compute-10:/tmp$
```

Total time taken



```
  delete mode 100644 readme.txt
schatterjee@neutron:~/cs553-pa2a$ sbatch ./linsort20gb.slurm
Submitted batch job 4837
schatterjee@neutron:~/cs553-pa2a$ tail -f linsort20gb.log
Records: 200000000
Checksum: 5f5cc94518a4203
Duplicate keys: 0
SUCCESS - all records are in order
Time Taken 481 seconds
```

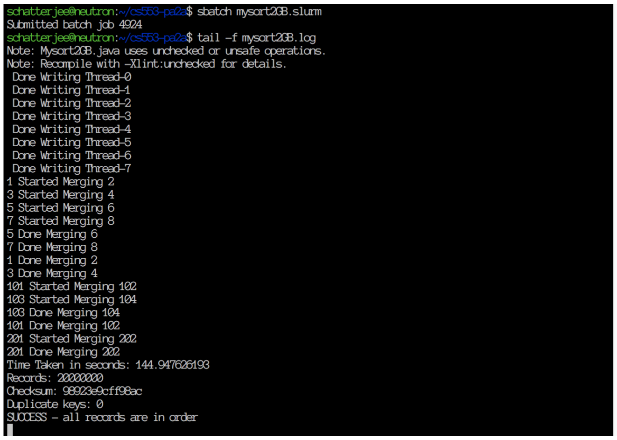
Shared Memory (1VM 2GB) :



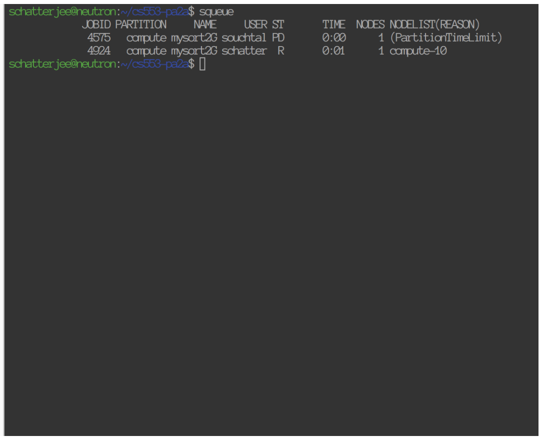
- Performed an In-memory parallel Merge sort for this.
- Broken data into 8 equal part in parallel, and performed Java Collection.sort on all these chunks.
- Stored them in a shared HashMap. Then performed 2 way merge on pair 2 chunks in a hierarchical way.
- The final output is stored in a file /tmp/op2GB and then ran valsort to validate the output
- output is stored in /exports/home/schatterjee/cs553-pa2a/mysort2GB.log

Complexity = Braking the input into chunk + Sorting each input chunk + merging the chunks
Complexity = O(n) + O(n log n) + O(n) = O(n log n)

Though the program ran in 3 level of hierarchy ($log_2 8$) . all the inter mediate operations are in memory so, Total data read = Total data Write = 2GB.

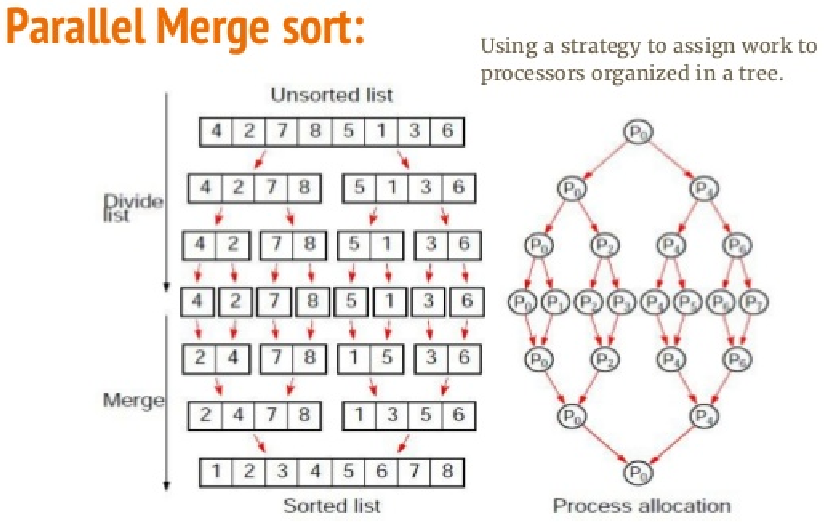


```
schatterjee@neutron:~/cs553-pa2a$ sbatch mysort2GB.slurm
Submitted batch job 4924
schatterjee@neutron:~/cs553-pa2a$ tail -f mysort2GB.log
Note: Mysort2GB.java uses unchecked or unsafe operations.
Note: Recompile with -Xlint:unchecked for details.
 Done Writing Thread-0
 Done Writing Thread-1
 Done Writing Thread-2
 Done Writing Thread-3
 Done Writing Thread-4
 Done Writing Thread-5
 Done Writing Thread-6
 Done Writing Thread-7
1 Started Merging 2
3 Started Merging 4
5 Started Merging 6
7 Started Merging 8
5 Done Merging 6
7 Done Merging 8
1 Done Merging 2
3 Done Merging 4
101 Started Merging 102
103 Started Merging 104
103 Done Merging 104
101 Done Merging 102
201 Started Merging 202
201 Done Merging 202
Time Taken in seconds: 144.947626193
Records: 20000000
Checksum: 98923e9cff98ac
Duplicate keys: 0
SUCCESS - all records are in order
```



```
schatterjee@neutron:~/cs553-pa2a$ squeue
             JOBID PARTITION     NAME     USER ST       TIME  NODES NODELIST(REASON)
              4575   compute mysort2G souchtal PD       0:00      1 (PartitionTimeLimit)
              4924   compute mysort2G schatter  R       0:01      1 compute-10
schatterjee@neutron:~/cs553-pa2a$ 
```

Shared Memory (1VM 20GB) :



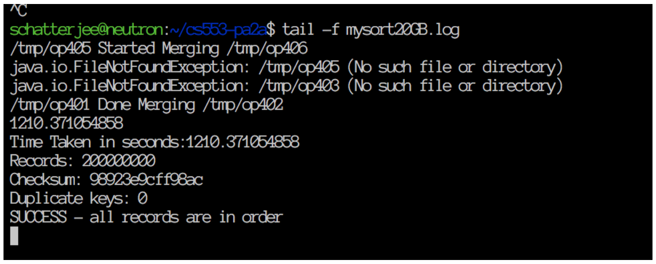
Parallel Merge sort:

Using a strategy to assign work to processors organized in a tree.

- Performed an external Merge sort for this.
- Broken data into 16 equal part, sorted each part in parallel and wrote to file named op1 to op15, Then performed 2 way merge on pair 2 chunks in a hierarchical way.Like merged op1 with op2, op3 with op4 etc... Then performed merges on the output of the previous phase and continued.
- Final output is stored in a file /tmp/401. and then ran valsort to validate the output. output is stored in /exports/home/schatterjee/cs553-pa2a/mysort20GB.log

Complexity = Braking the input into chunk + Sorting each input chunk + merging the chunks
Complexity = O(n) + O(n log n) + O(n) = O(n log n)

The program ran into 4 level of hierarchy ($log_2 16$) , hence the final output file name 401. At each level, we read 20 GB of data from the previous iteration from and wrote to new files to be consumed by next iteration. So total data read = total data write = $20GB \times 4 = 80$ GB.



```
^C
schatterjee@neutron:~/cs553-pa2a$ tail -f mysort20GB.log
/tmp/op405 Started Merging /tmp/op406
java.io.FileNotFoundException: /tmp/op405 (No such file or directory)
java.io.FileNotFoundException: /tmp/op403 (No such file or directory)
/tmp/op401 Done Merging /tmp/op402
1210.371054858
Time Taken in seconds:1210.371054858
Records: 200000000
Checksum: 98923e9cff98ac
Duplicate keys: 0
SUCCESS - all records are in order
█
```

References

[1] Parallel Merge sort

texttt$https : //www.slideshare.net/GARIMASHAKYA1/parallel - sorting - algorithms$

[2] Unix Sort
$https : //www.computerhope.com/unix/usort.htm$

[3] In-memory Parallel
$http : //www.mdpi.com/2073 - 8994/9/9/176$