CP 431/631 Assignment 2  
**By group 2 (Omer Tal, Elizabeth Gorbonos, Tianran Wang)**

1. Assignment description:

The assignment is to write the parallel merging algorithm to merge two large randomly generated sorted arrays *A* and *B*.

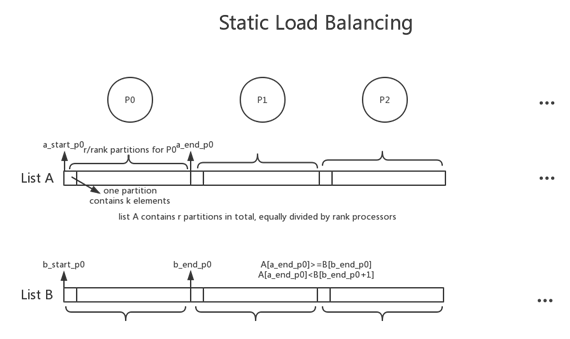
To accomplish this, we have written a MPI python 3 program ([appendix 1](#_Appendix_1_:)).

We assume the arrays are of the same length which is a power of two (), *k* is a command line parameter.

First, we calculate the number of partitions to split both arrays into. Each partition of array A will consist of *k* elements, besides possibly the last one. We then generate the two random sorted arrays *A* and *B* of length *n* in process 0 and broadcast them to all other processes.

The work division is done by a method of static load balancing, each process calculates the range of partitions in array *A* to works on according to: .

Each process’s range starts from partition: .



For each partition we perform a binary search to find the index in array *B* which stores the largest element (in B) that is smaller than the largest element in . is the upper bound of the corresponding partition . The lower bound of is equal to the upper bound of .

The lower bound of for all *p* > 0 is received from process *p*-1 (upper bound +1 of ).

Every partition is then merged by its process and added to a list in an ascending order. The merged lists are gathered by process 0, resulting in a sorted list of lists.

The final product is tested for correctness and written to a file by process 0.

1. Results:

We benchmarked the parallel section of the program, neglecting the array generation and output. The following benchmarks are based on merging arrays *A* and *B* of size each.

The serial benchmark was recorded for the “serial mode” of the program, no parallel overhead computations were done. We can see the serial program performs better for this task then our parallel version. We believe that a parallel merge algorithm will provide better results in a shared-memory architecture where no communication is required for this task.

Due to the large size of the output files we are only attaching the logs of Orca’s sqsub ([appendix 2](#_Appendix_2:_Program)) and a print screen of a sample output. The full output files are available in /scratch/otwluq1/a2/.

|  |  |  |  |
| --- | --- | --- | --- |
| Data size (n) | Number of CPUs | Time (seconds) | Perfect Speed(seconds) |
|  | 1 | 1.93 | 1.93 |
| 2 | 8.67 | 0.97 |
| 3 | 6.21 | 0.64 |
| 4 | 4.82 | 0.48 |
| 5 | 4.25 | 0.39 |
| 6 | 3.41 | 0.32 |
| 7 | 2.98 | 0.28 |
| 8 | 2.92 | 0.24 |

# Appendix 1 : Program code:











# Appendix 2: Program logs

1 Processor (Serial):

Done with input stage

Total time to compute: 1.936928 seconds

Tested and found correct

Sucessfully wrote results to file /scratch/otwluq1/a2/output\_28409.txt

--- SharcNET Job Epilogue ---

job id: 10946869

exit status: 0

cpu time: 29s / 600s (4 %)

elapsed time: 30s / 600s (5 %)

virtual memory: 691.2M / 2.0G (33 %)

Job completed successfully

--------------------------------------------------------------------------

2 Processor:  
  
Done with input stage  
Total time to compute: 8.667797 seconds  
Tested and found correct  
Sucessfully wrote results to file /scratch/otwluq1/a2/output\_12098.txt  
--- SharcNET Job Epilogue ---  
 job id: 10927619  
 exit status: 0  
 cpu time: 50s / 2.0h (0 %)  
 elapsed time: 33s / 1.0h (0 %)  
 virtual memory: 784.9M / 1.0G (76 %)  
  
Job completed successfully  
  
--------------------------------------------------------------------------  
3 Processor:  
  
Done with input stage  
Total time to compute: 6.214778 seconds  
Tested and found correct  
Sucessfully wrote results to file /scratch/otwluq1/a2/output\_12165.txt  
--- SharcNET Job Epilogue ---  
 job id: 10927620  
 exit status: 0  
 cpu time: 64s / 3.0h (0 %)  
 elapsed time: 32s / 1.0h (0 %)  
 virtual memory: 263.3M / 1.0G (25 %)  
  
Job completed successfully  
  
--------------------------------------------------------------------------  
4 Processor:  
  
Done with input stage  
Total time to compute: 4.816678 seconds  
Tested and found correct  
Sucessfully wrote results to file /scratch/otwluq1/a2/output\_11544.txt  
--- SharcNET Job Epilogue ---  
 job id: 10927621  
 exit status: 0  
 cpu time: 79s / 4.0h (0 %)  
 elapsed time: 32s / 1.0h (0 %)  
 virtual memory: 401.4M / 1.0G (39 %)  
  
Job completed successfully  
  
--------------------------------------------------------------------------  
5 Processor:  
  
Done with input stage  
Total time to compute: 4.247634 seconds  
Tested and found correct  
Sucessfully wrote results to file /scratch/otwluq1/a2/output\_9748.txt  
--- SharcNET Job Epilogue ---  
 job id: 10927622  
 exit status: 0  
 cpu time: 104s / 5.0h (0 %)  
 elapsed time: 31s / 1.0h (0 %)  
 virtual memory: 520.8M / 1.0G (50 %)  
  
Job completed successfully  
  
--------------------------------------------------------------------------  
6 Processor:  
Done with input stage  
Total time to compute: 3.405965 seconds  
Tested and found correct  
Sucessfully wrote results to file /scratch/otwluq1/a2/output\_27651.txt  
--- SharcNET Job Epilogue ---  
 job id: 10927623  
 exit status: 0  
 cpu time: 105s / 6.0h (0 %)  
 elapsed time: 24s / 1.0h (0 %)  
  
Job completed successfully  
  
  
--------------------------------------------------------------------------  
7 Processor:  
  
Done with input stage  
Total time to compute: 2.980946 seconds  
Tested and found correct  
Sucessfully wrote results to file /scratch/otwluq1/a2/output\_27727.txt  
--- SharcNET Job Epilogue ---  
 job id: 10927624  
 exit status: 0  
 cpu time: 121s / 7.0h (0 %)  
 elapsed time: 28s / 1.0h (0 %)  
 virtual memory: 613.4M / 1.0G (59 %)  
  
Job completed successfully  
  
  
--------------------------------------------------------------------------  
8 Processor:  
  
Done with input stage  
Total time to compute: 2.916491 seconds  
Tested and found correct  
Sucessfully wrote results to file /scratch/otwluq1/a2/output\_27803.txt  
--- SharcNET Job Epilogue ---  
 job id: 10927625  
 exit status: 0  
 cpu time: 136s / 8.0h (0 %)  
 elapsed time: 27s / 1.0h (0 %)  
 virtual memory: 117.2M / 1.0G (11 %)  
  
Job completed successfully

Output File Sample:

