CS515 Parallel Programming: Assignment #3

Due on May 18th, 2016 at 11:59pm

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Implementation details

Main logic of the Assignment was implemented according to the given specifications, without any assumptions about data distribution, except that is is a set of integers. If assumed that data is a list of of contiguous integers $1 \ldots n$, then memory management becomes easy - just need to allocate additional buffer of the same size as input and move items to this buffer according to the bucket policy, since pivot is equal to $bucket\ size - 1$ in this case.

When there is no assumptions, we have two options: 1. Allocate $n \times len(buf)$ bucket arrays, where n is number of processes, which is not possible for large inputs. 2. Allocate each bucket dynamically as data comes in (introduces performance overhead).
I used the second option by creating a bucket structure, each bucket initial size is 8, and it doubles when the bucket filled.

After data is received and distributed among buckets, it needs to be sent to appropriate process to be sorted, this is done by sending two messages - 1. size of the incoming buffer, and 2. the buffer itself. Additional third message indicates number of elements previously sent, this information is needed for saving the data. Upon receiving messages processes sort the data and write it to a file, (name of the file = "sorted" + size + "_" + dataFileName, for example: sorted32_1000.txt). View of the file is set to the number of elements in total of elements before this bucket.

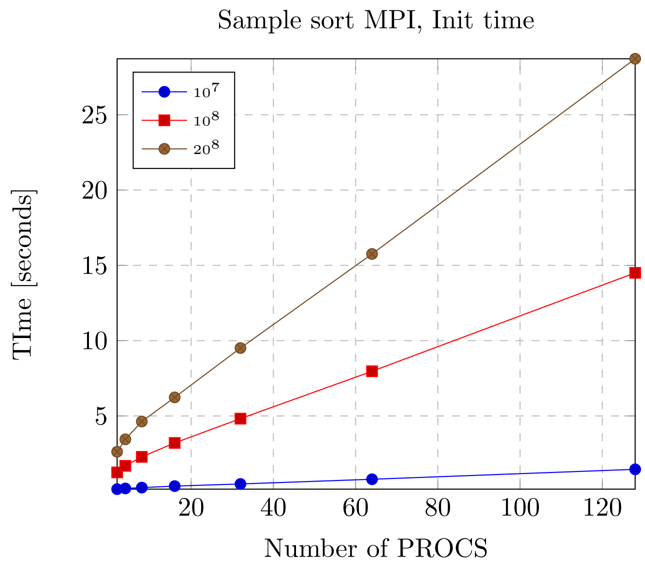
Performance Analysis

The assignment was testes on the linuxlab cluster, with the provided set of hosts, with one exception: machines "kororaa, scanner and snares", were not available at the time of testing. It total 56 machines were used. The program was executed against three randomly generated (by provided datagen) sets: $10^7, 10^8,\ and\ 20^8$. The size of data sets is limited by "CAT disk quota", so I could't generate any larger data size. Each set wast tested with $2, 4, 8, 16, 32, 64, 128$ procs, distributed among the host by "mpirun" routine. Wall clock was measured by "rank 0" and set of check points, where all procs were synchronized by MPI_Barrier(), and validated by running the program in linux "time" utility without any additional synchronization. Use of additional sync routines added in average $\%2 - \%3$ delay.

The following time intervals are measured:

1. Total run time.
2. Data set read time.
3. Sort time.
4. Initialization time (division of data among buckets).
5. Time to send all gathered info to participating threads.
6. And total IO time.

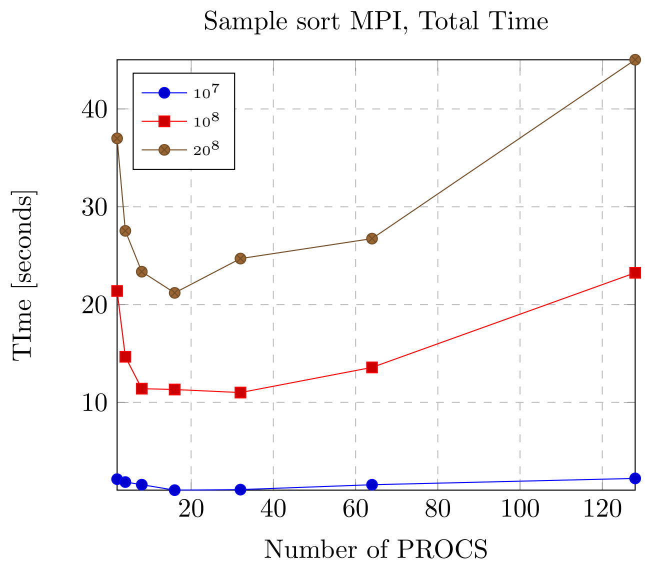
Test results showed similar to OMP quicksort picture, with sweet spot procs number = 16 for all data sets. Main bottleneck is data initialization, since data distribution was previously unknown, variable size buckets were implemented, with use of realloc(). According to realloc documentation, if it is unable to find appropriate chunk of memory, new memory is allocated with followed data move.

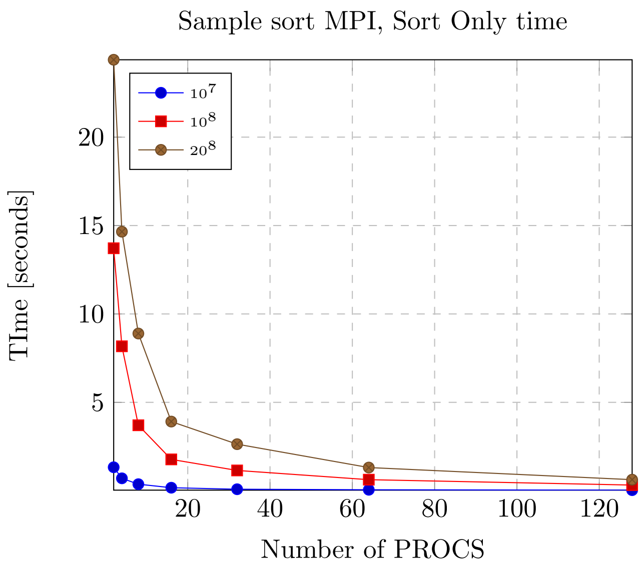


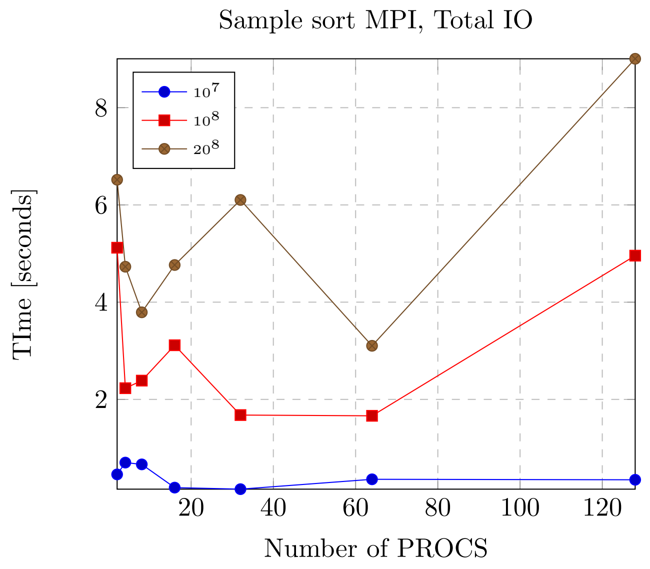
Although it is not clear for me why this operation was the slowest performer, especially on larger number of procs, since it is always executed only by the host machine. Initialization time was linearly increasing with number of participating procs, i.e. only number of procs affected init performance but not the data set size.

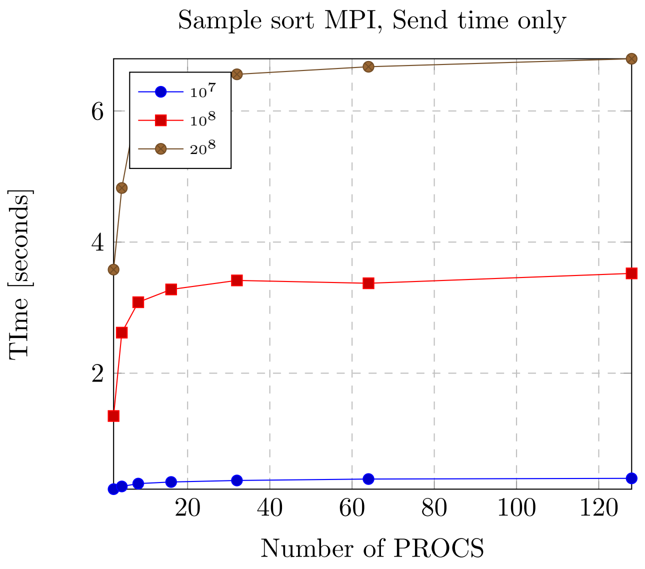
Other intervals behaved as expected:

- Sort stage performance increase is log(n), where n is number of procs.
- Data send time decrease is log(n), where n is number of procs (more messages however each message has smaller size).
- File read time is minuscule compared to all other operations (about %0.7 in average for all cases).
- Total IO (read data set + save results), is mostly affected by the save stage. Save stage pattern is similar to the patter of Total Time, with the sweet spot being nporcs = 64. This was expected since larger number of procs will have more data movements across network.

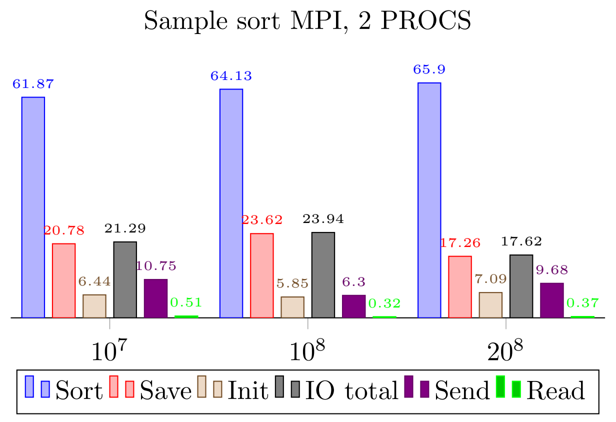


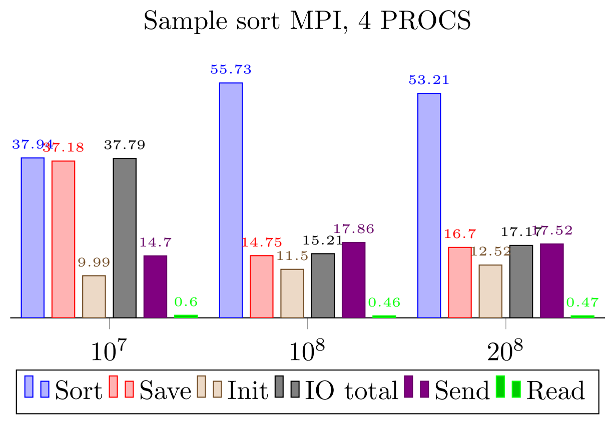




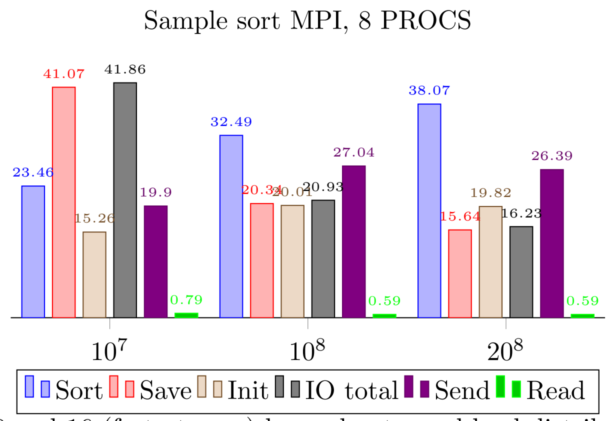


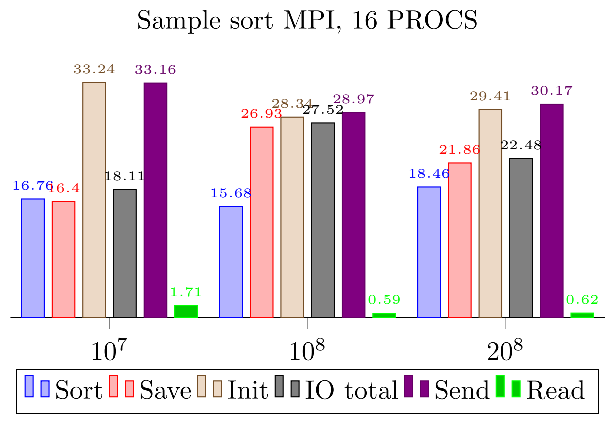
Following bar charts show normalized (to total time = %100) distribution of different program intervals (in percent), each chart represents different number of procs, in the order of $2, 4, 8, 16, 32, 64, 128$





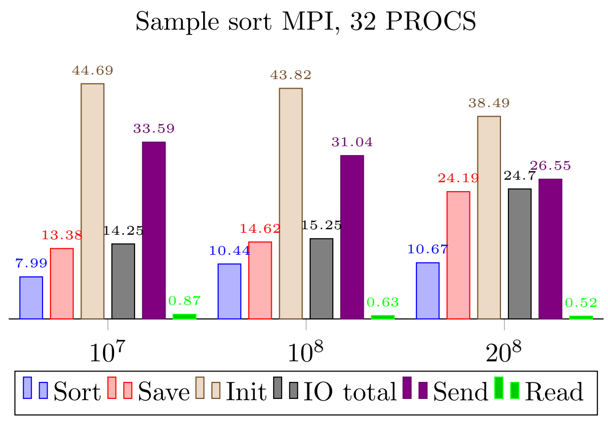
Two and four spend most of the time ≈ %60 in sorting.

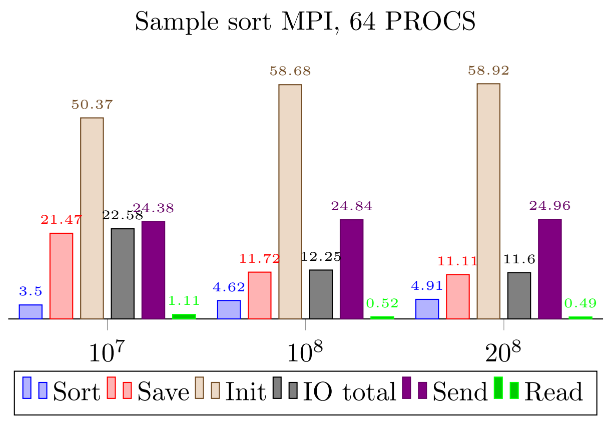


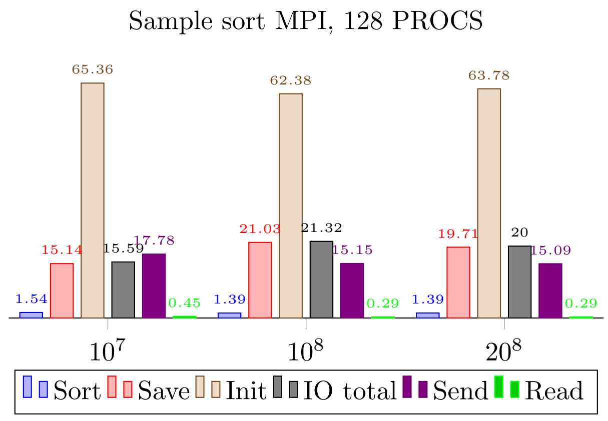


8 and 16 (fastest ones) have about equal load distribution.

All the rest spend most of the time in initialization stage


Sample sort MPI, 32 PROCS
10^7
10^8
20^8
Sort
Save
Init
IO total
Send
Read


Sample sort MPI, 64 PROCS
10^7
10^8
20^8
Sort
Save
Init
IO total
Send
Read


Sample sort MPI, 128 PROCS
10^7
10^8
20^8
Sort
Save
Init
IO total
Send
Read