Sample Sort Using MPI

Experimentation data for Serial computation

For serial computation we have chosen the serial code with 12 buckets and obtained the runtimes with size = 120000, 1200000, 12000000, 120000000. These results will be used as the baseline to compare with the parallel models.

(N)	Runtime (sec)
120000	0.058558
1200000	0.407464
12000000	3.881106
120000000	44.601656

MPI Implementation

Overview of the Algorithm and suggested optimization

1. Rank 0 creates the data set and scatters it to the P processes.
2. Each process does local sorting.
3. Each process select p-1 splitters.
4. All the p(p-1) splitters are gathered to rank 0.
5. Rank 0 selects a set of p-1 global splitters and sorting the sample of p(p-1) splitters and broadcasted that to P processes.
6. Each process put its local data set into local buckets based on the splitters set.
7. Each process rearranges its buckets using MPI_Alltoall so that P0 has all the data < splitter[0] and soon.
8. Each process finally sorts their local buckets.

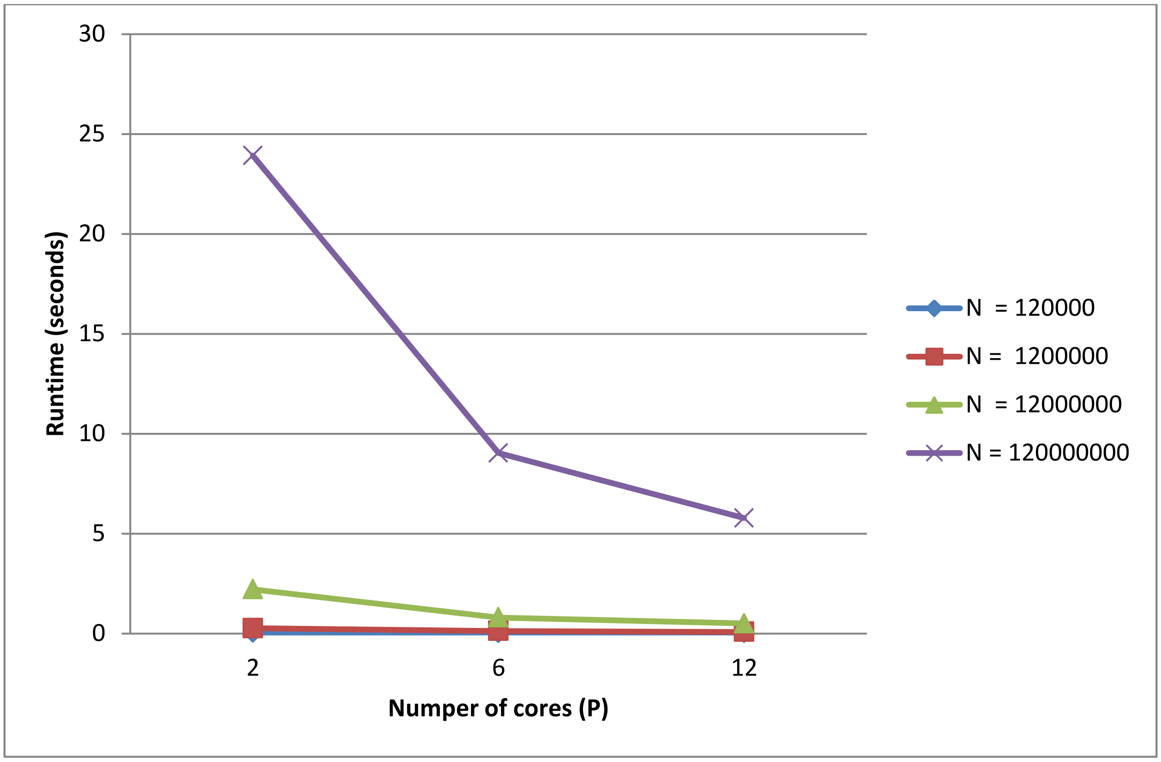
Experimentation data

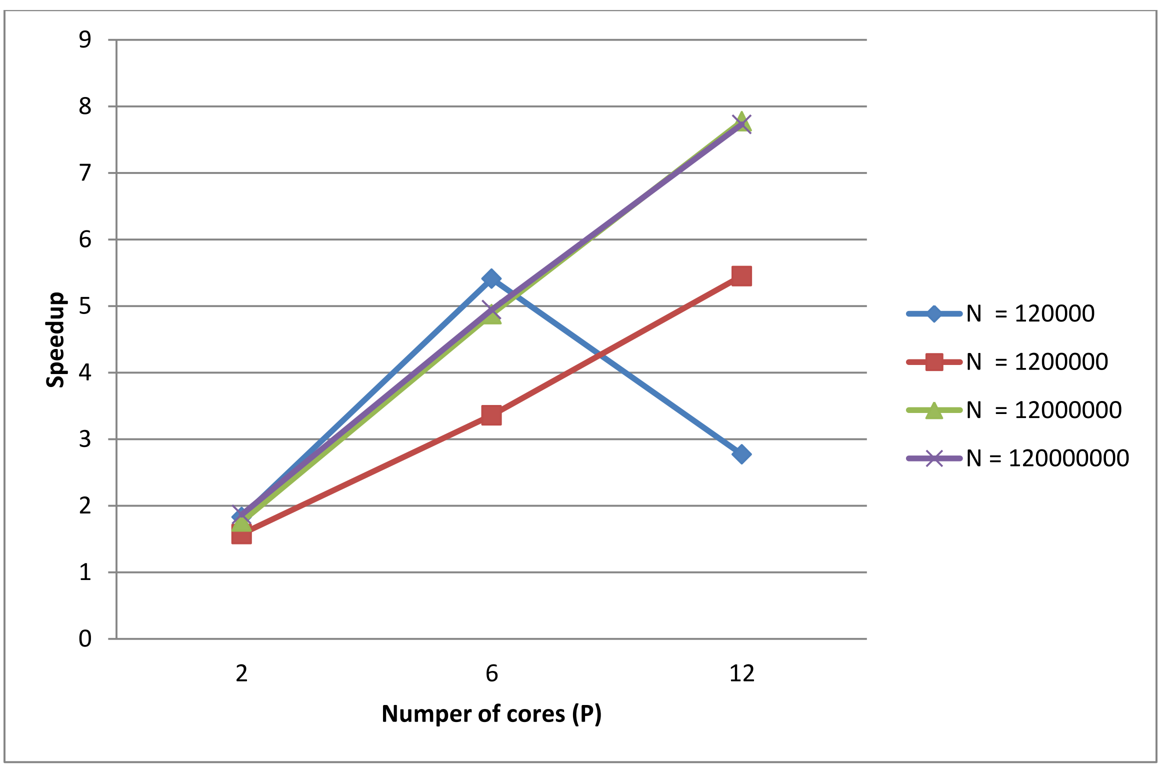
Tabular Representation

Note: The speedup is calculated using (serial runtime calculated above / runtime for P).

P	Runtime (seconds)	Speedup
N = 120000		
2	.032027	1.828349
6	.010830	5.407017
12	.021130	2.771294
N = 1200000		
2	.258872	1.573996
6	.1213530	3.357675
12	.074790	5.4480497
N = 12000000		
2	2.206225	1.759161
6	.796015	4.875664
12	.499257	7.773751
N = 120000000		
2	23.916551	1.864886
6	9.023845	4.942643
12	5.772662	7.726357

Graphical Representation





Analysis

Q. Discuss the results you obtained. Were you able to gain a linear or near-linear speedup? Why or why not?

Answer.

Discussion on results

1. For N = 120000, the speedup drops down after P = 6.
   - Here the communication cost involved when P > 6 is much greater than the computation gain by sharing the workload among processors and as a result the performance degrades after P = 6.

2. For a given N, the speedup increases with value of P.
   - With more number of P, the workload per process (N/P) decreases leading to better overall performance (or lesser runtime).

3. With very large values of P, the performance curve breaks the linear behavior.
   - Let take the example of N=1200000. Had the curve been linear, then the expected value of speedup at P = 12 is 6.71535, but we got 5.448. Similarly, for N = 12000000, the obtained value of speedup is 7.73 at P = 12 which degrades from the expected value of 9.75 (which should be if the curve is linear). The same is true for N = 120000000.
     In the examples mentioned above, the communication cost involved when P = 12 is much greater than the computation gain by sharing the workload among processors and as a result the performance degrades at P = 12.

Linear or near linear speedup

- The speedup that we obtain **is near linear.**
  - With initial incremental values of P, the speedup is increasing proportionately as the workload is distributed proportionately among the processes. But with larger values of P, the communication cost outweighs the gain with workload distribution and as a result the speedup curve started degrading at values where the computation/communication ratios are low. (This is substantiated in Analysis 3 above.)

Histogram Sort Using MPI

Experimentation data for Serial computation

For serial computation we have chosen the serial code with 12 buckets and obtained the runtimes with size = 120000, 1200000, 12000000, 120000000. These results will be used as the baseline to compare with the parallel models.

(N)	Runtime (sec)
120000	0.060661
1200000	0.449810
12000000	4.006512
120000000	45.562630

MPI Implementation

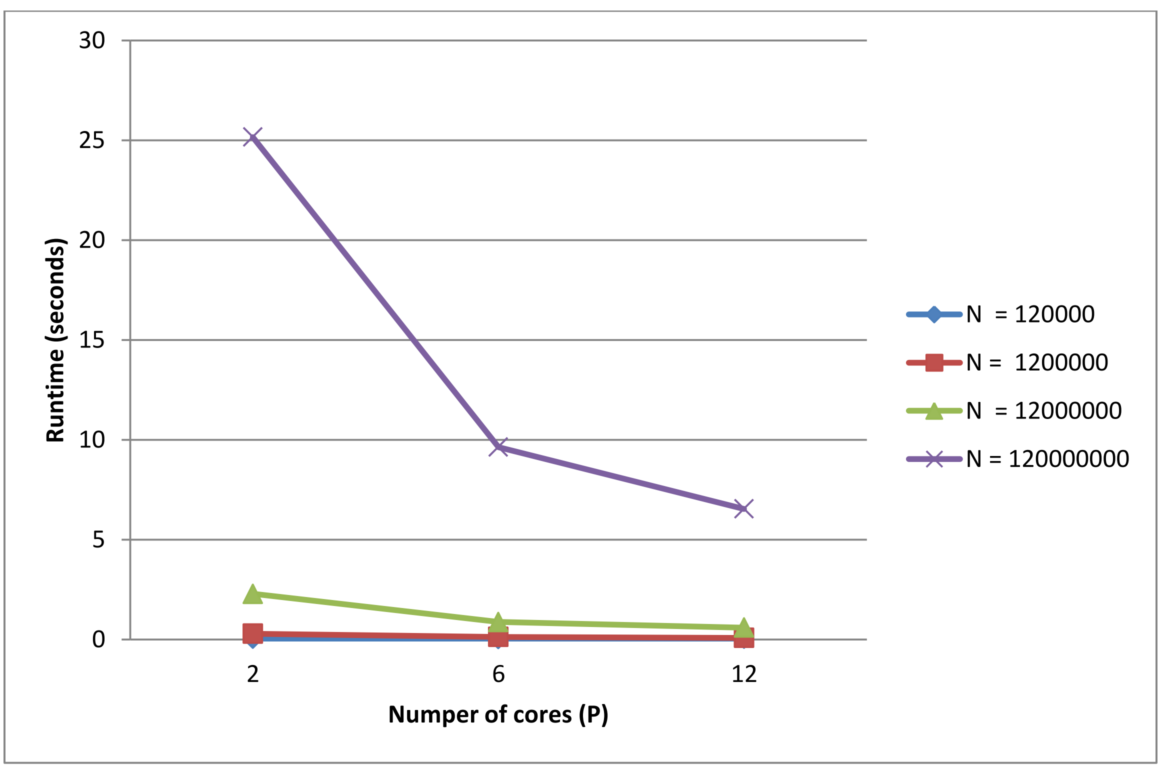
Experimentation data

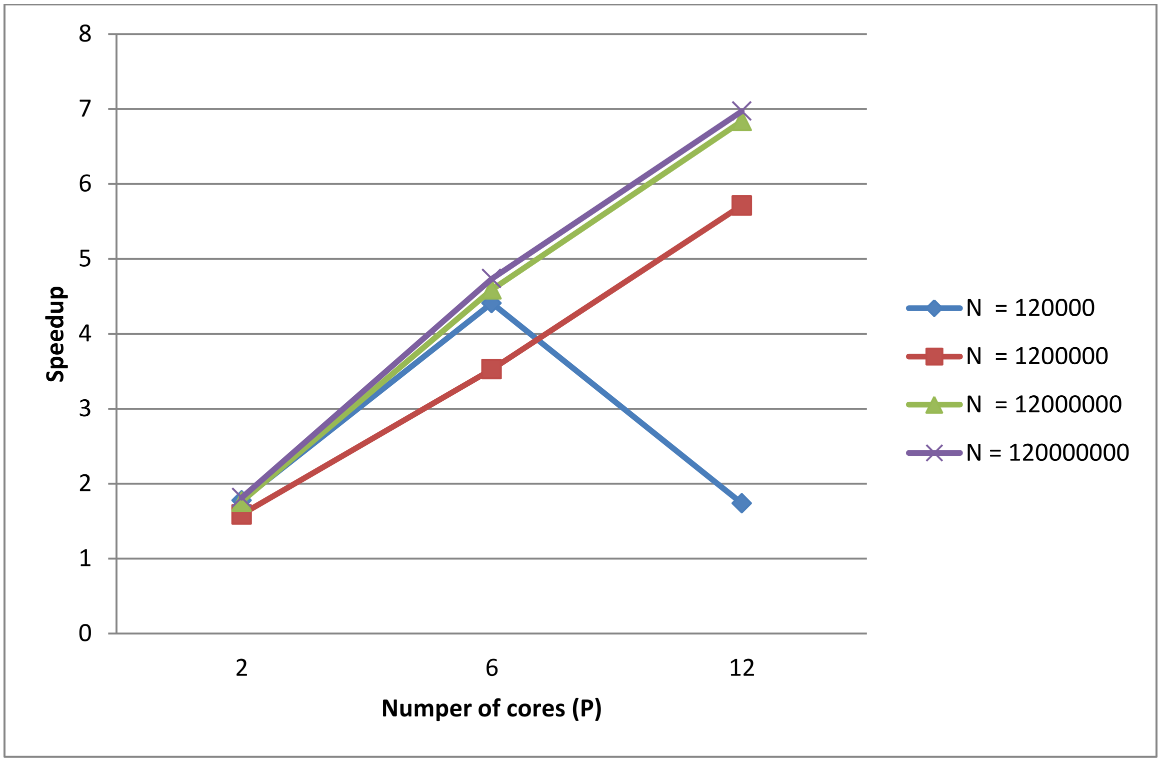
Tabular Representation

Note: The speedup is calculated using (serial runtime calculated above / runtime for P).

P	Runtime (seconds)	Speedup
N = 120000		
2	.034180	1.774720
6	.013763	4.407349
12	.034938	1.736207
N = 1200000		
2	.283378	1.587312
6	.127599	3.525173
12	.078755	5.711481
N = 12000000		
2	2.280247	1.757051
6	.873000	4.589360
12	.5860612	6.836337
N = 120000000		
2	25.159230	1.810970
6	9.624384	4.734082
12	6.537176	6.969772

Graphical Representation





Analysis

Q. Discuss the results you obtained. Were you able to gain a linear or near-linear speedup? Why or why not?

Answer.

Discussion on results

1. For N = 120000, the speedup drops down after P = 6.
    - Here the communication cost involved when P > 6 is much greater than the computation gain by sharing the workload among processors and as a result the performance degrades after P = 6.

2. For a given N, the speedup increases with value of P.
    - With more number of P, the workload per process (N/ P) decreases leading to better overall performance (or lesser runtime).

3. With very large values of P, the performance curve breaks the linear behavior.
    - Let take the example of N=1200000. Had the curve been linear, then the expected value of speedup at P = 12 is 7.05, but we got 5.711481. Similarly, for N = 12000000, the obtained value of speedup is 6.83 at P = 12 which degrades from the expected value of 9.17 (which should be if the curve is linear). The same is true for N = 120000000.
    In the examples mentioned above, the communication cost involved when P = 12 is much greater than the computation gain by sharing the workload among processors and as a result the performance degrades at P = 12.

Linear or near linear speedup

- The speedup that we obtain **is near linear.**
  - With initial incremental values of P, the speedup is increasing proportionately as the workload is distributed proportionately among the processes. But with larger values of P, the communication cost outweighs the gain with workload distribution and as a result the speedup curve started degrading at values where the computation/communication ratios are low. (This is substantiated in Analysis 3 above.)