# CSCE 735 Parallel Computing

## HW 4: Parallel Programming with MPI − Hypercube Quicksort

**1.** Completed the code to include MPI calls and executed The following commands:

```
[satyabhama@grace1 HW4-735]$ mpirun -np 2 ./qsort_hypercube.exe 4 -1
[Proc: 0] number of processes = 2, initial local list size = 4, hypercube quicksort time = 0.001979
[Proc: 0] check_list: local_error = 0
[Proc: 1] check_list: local_error = 0
[Proc: 0] Congratulations. The list has been sorted correctly.
```

```
[satyabhama@grace1 HW4-735]$ mpirun -np 4 ./qsort_hypercube.exe 4 -2
[Proc: 0] number of processes = 4, initial local list size = 4, hypercube quicksort time = 0.002538
[Proc: 0] check_list: local_error = 0
[Proc: 1] check_list: local_error = 0
[Proc: 2] check_list: local_error = 0
[Proc: 3] check_list: local_error = 0
[Proc: 0] Congratulations. The list has been sorted correctly.
```

```
[satyabhama@grace1 HW4-735]$ mpirun -np 8 ./qsort_hypercube.exe 4 -1
[Proc: 0] number of processes = 8, initial local list size = 4, hypercube quicksort time = 0.002704
[Proc: 0] check_list: local_error = 0
[Proc: 1] check_list: local_error = 0
[Proc: 2] check_list: local_error = 0
[Proc: 3] check_list: local_error = 0
[Proc: 4] check_list: local_error = 0
[Proc: 5] check_list: local_error = 0
[Proc: 6] check_list: local_error = 0
[Proc: 7] check_list: local_error = 0
[Proc: 0] Congratulations. The list has been sorted correctly.
```

```
[satyabhama@grace1 HW4-735]$ mpirun -np 16 ./qsort_hypercube.exe 4 0
[Proc: 0] number of processes = 16, initial local list size = 4, hypercube quicksort time = 0.005753
[Proc: 0] check_list: local_error = 0
[Proc: 1] check_list: local_error = 0
[Proc: 2] check_list: local_error = 0
[Proc: 3] check_list: local_error = 0
[Proc: 4] check_list: local_error = 0
[Proc: 5] check_list: local_error = 0
[Proc: 6] check_list: local_error = 0
[Proc: 7] check_list: local_error = 0
[Proc: 8] check_list: local_error = 0
[Proc: 9] check_list: local_error = 0
[Proc: 10] check_list: local_error = 0
[Proc: 11] check_list: local_error = 0
[Proc: 12] check_list: local_error = 0
[Proc: 13] check_list: local_error = 0
[Proc: 14] check_list: local_error = 0
[Proc: 15] check_list: local_error = 0
[Proc: 0] Congratulations. The list has been sorted correctly.
```

```
[satyabhama@grace1 HW4-735]$ mpirun -np 16 ./qsort_hypercube.exe 20480000 0
[Proc: 0] number of processes = 16, initial local list size = 20480000, hypercube quicksort time = 2.971607
[Proc: 0] check_list: local_error = 0
[Proc: 1] check_list: local_error = 0
[Proc: 2] check_list: local_error = 0
[Proc: 3] check_list: local_error = 0
[Proc: 4] check_list: local_error = 0
[Proc: 5] check_list: local_error = 0
[Proc: 6] check_list: local_error = 0
[Proc: 7] check_list: local_error = 0
[Proc: 8] check_list: local_error = 0
[Proc: 9] check_list: local_error = 0
[Proc: 10] check_list: local_error = 0
[Proc: 11] check_list: local_error = 0
[Proc: 12] check_list: local_error = 0
[Proc: 13] check_list: local_error = 0
[Proc: 14] check_list: local_error = 0
[Proc: 15] check_list: local_error = 0
[Proc: 0] Congratulations. The list has been sorted correctly.
```

2. **Weak Scalability Result:** n = 20480000, p = 1, 2, 4, 8, 16, 32, 64 and type = 0

| n | p | Quicksort Time | Corresponding n for p=1 | Time taken for p=1 |
|---|---|---|---|---|
| 20480000 | 1 | 2.183904 | 20480000 | 2.183904 |
| 20480000 | 2 | 2.595101 | 40960000 | 4.637854 |
| 20480000 | 4 | 2.502849 | 81920000 | 9.436110 |
| 20480000 | 8 | 2.740898 | 163840000 | 19.395817 |
| 20480000 | 16 | 3.112912 | 327680000 | 39.856118 |
| 20480000 | 32 | 4.295966 | 655360000 | 81.452634 |
| 20480000 | 64 | 9.768737 | 1310720000 | 167.130486 |

**Logs:**

[Proc: 0] number of processes = 1, initial local list size = 20480000, hypercube quicksort time = 2.183904

[Proc: 0] number of processes = 2, initial local list size = 20480000, hypercube quicksort time = 2.595101

[Proc: 0] number of processes = 4, initial local list size = 20480000, hypercube quicksort time = 2.502849

[Proc: 0] number of processes = 8, initial local list size = 20480000, hypercube quicksort time = 2.740898

[Proc: 0] number of processes = 16, initial local list size = 20480000, hypercube quicksort time = 3.112912

[Proc: 0] number of processes = 32, initial local list size = 20480000, hypercube quicksort time = 4.295966

[Proc: 0] number of processes = 64, initial local list size = 20480000, hypercube quicksort time = 9.768737

[Proc: 0] number of processes = 1, initial local list size = 40960000, hypercube quicksort time = 4.637854

[Proc: 0] number of processes = 1, initial local list size = 81920000, hypercube quicksort time = 9.436110
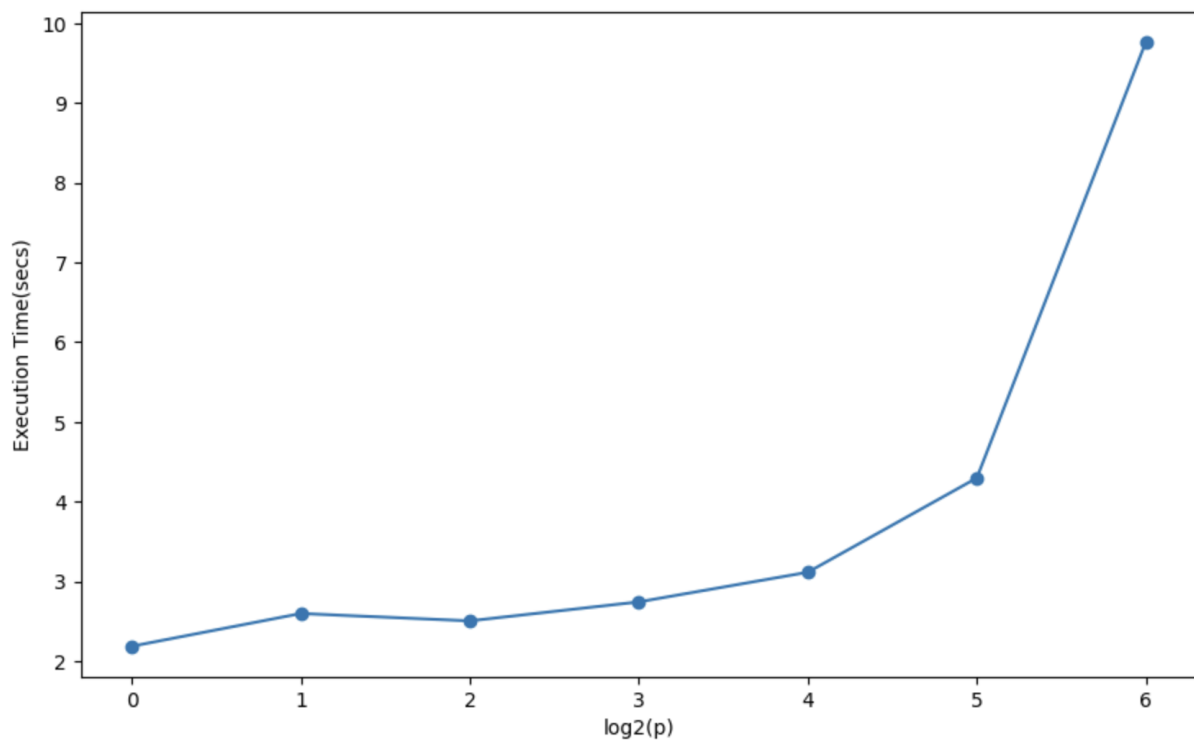
[Proc: 0] number of processes = 1, initial local list size = 163840000, hypercube quicksort time = 19.395817
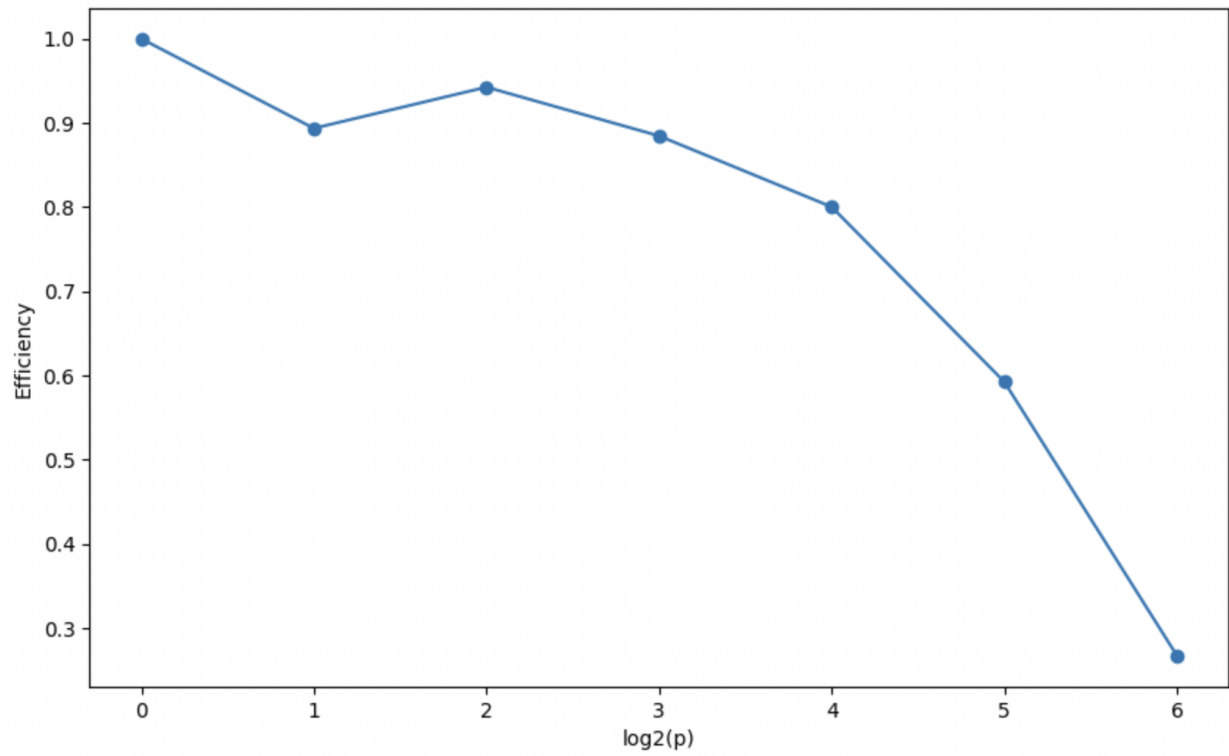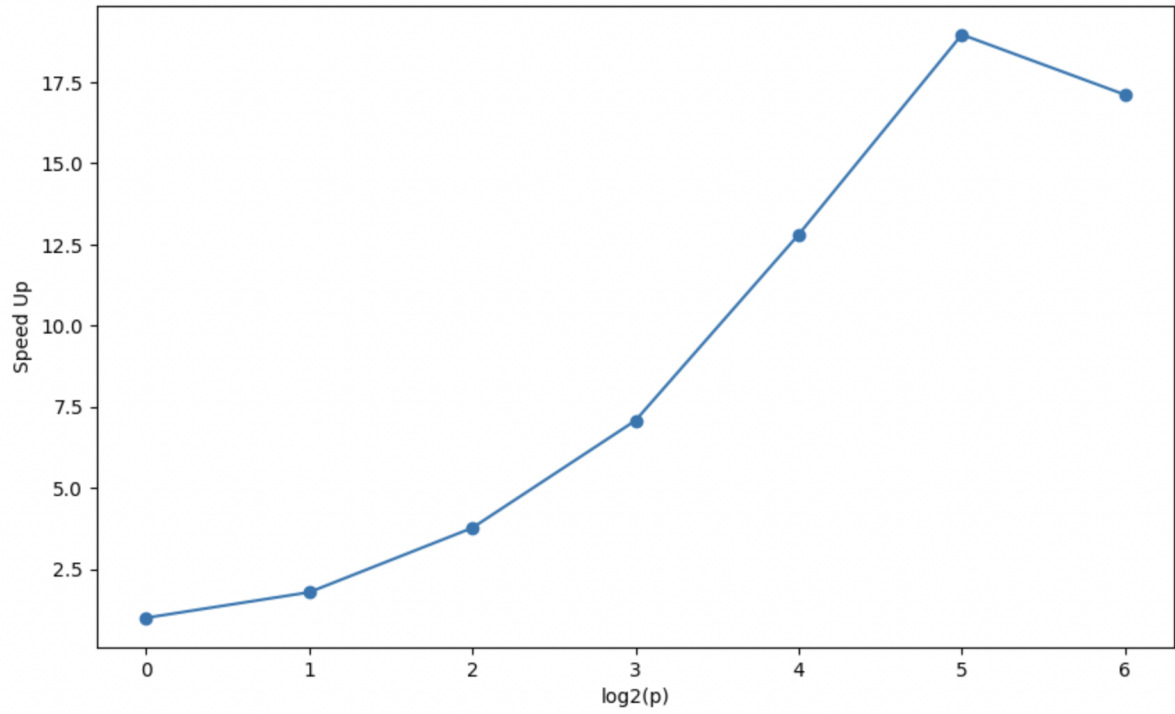
[Proc: 0] number of processes = 1, initial local list size = 327680000, hypercube quicksort time = 39.856118

[Proc: 0] number of processes = 1, initial local list size = 655360000, hypercube quicksort time = 81.452634

[Proc: 0] number of processes = 1, initial local list size = 1310720000, hypercube quicksort time = 167.130486

| Number of Processes (p) | Execution Time (secs) | Speed Up | Efficiency |
|---|---|---|---|
| 1 | 2.183904 | 1.0 | 1.0 |
| 2 | 2.595101 | 1.787 | 0.894 |
| 4 | 2.502849 | 3.77 | 0.943 |
| 8 | 2.740898 | 7.076 | 0.885 |
| 16 | 3.112912 | 12.803 | 0.8 |
| 32 | 4.295966 | 18.96 | 0.593 |
| 64 | 9.768737 | 17.109 | 0.267 |

**3. Strong Scalability Result:** n = 20480000/p, p = 1, 2, 4, 8, 16, 32, 64 and type = 0

| n | p | Quicksort Time |
|---|---|---|
| 20480000 | 1 | 2.134755 |
| 10240000 | 2 | 1.081577 |
| 5120000 | 4 | 0.555740 |
| 2560000 | 8 | 0.276164 |
| 1280000 | 16 | 0.149852 |
| 640000 | 32 | 0.090947 |
| 320000 | 64 | 0.113592 |

**Logs:**
[Proc: 0] number of processes = 1, initial local list size = 20480000, hypercube quicksort time = 2.134755
[Proc: 0] number of processes = 2, initial local list size = 10240000, hypercube quicksort time = 1.081577
[Proc: 0] number of processes = 4, initial local list size = 5120000, hypercube quicksort time = 0.555740
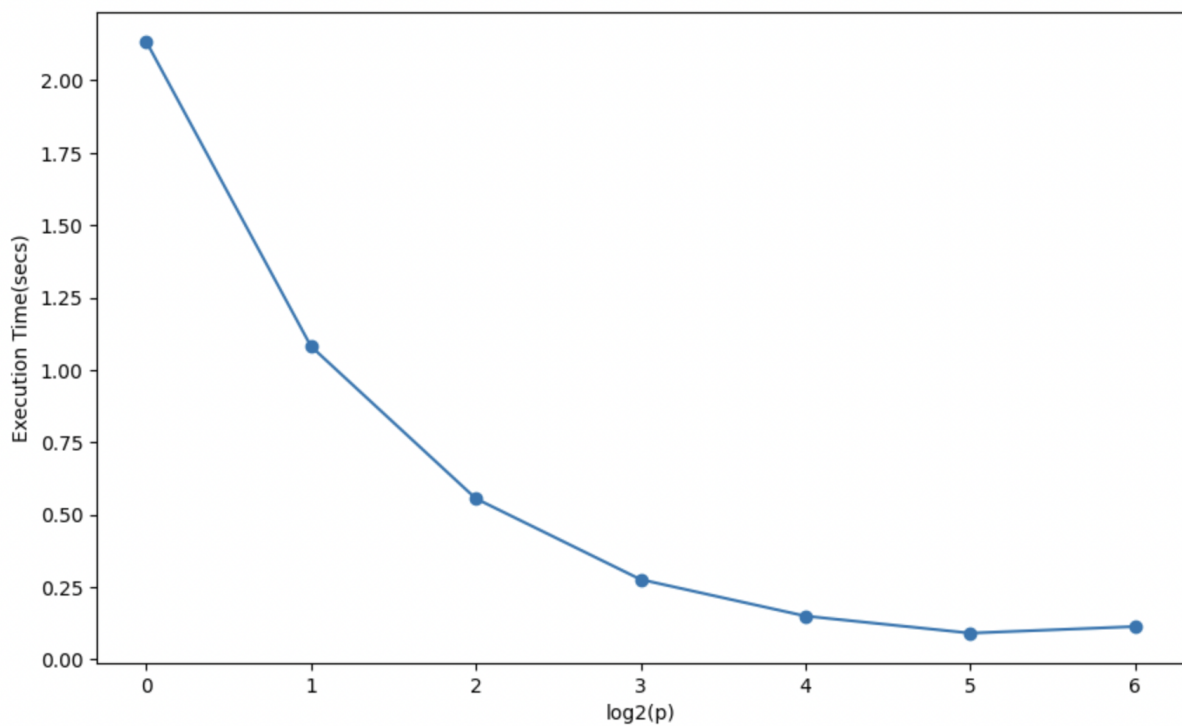[Proc: 0] number of processes = 8, initial local list size = 2560000, hypercube quicksort time = 0.276164
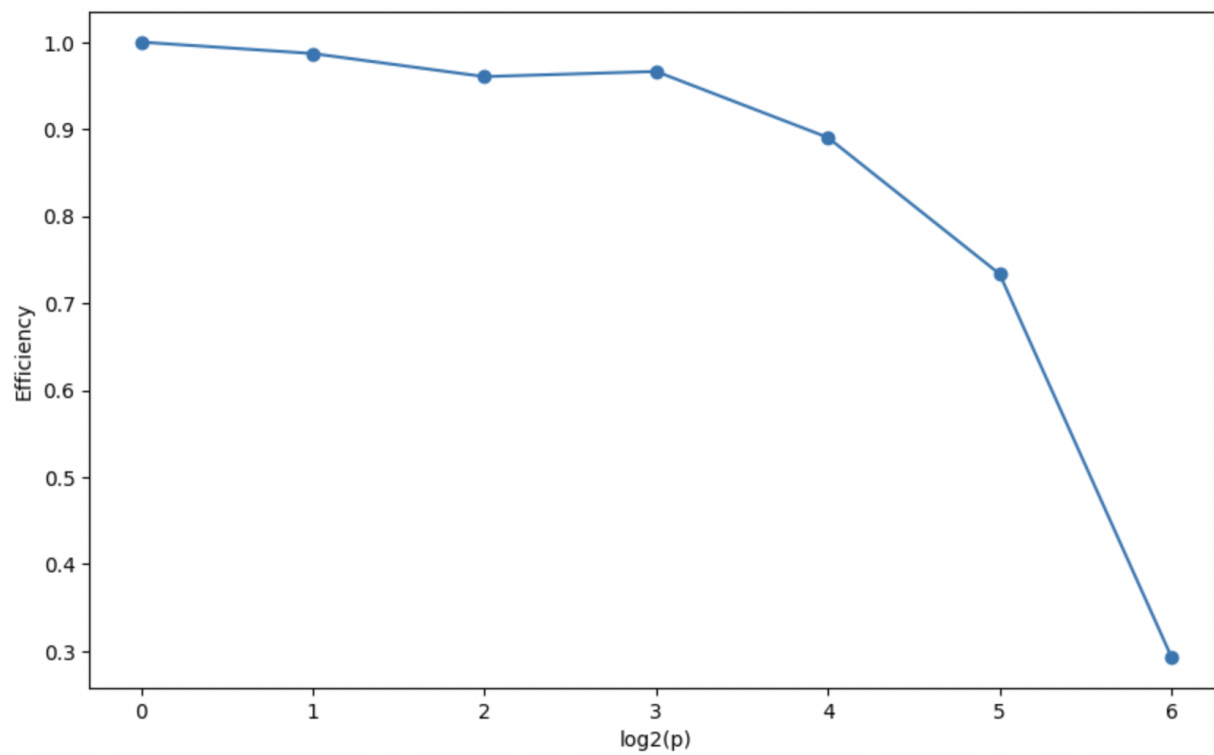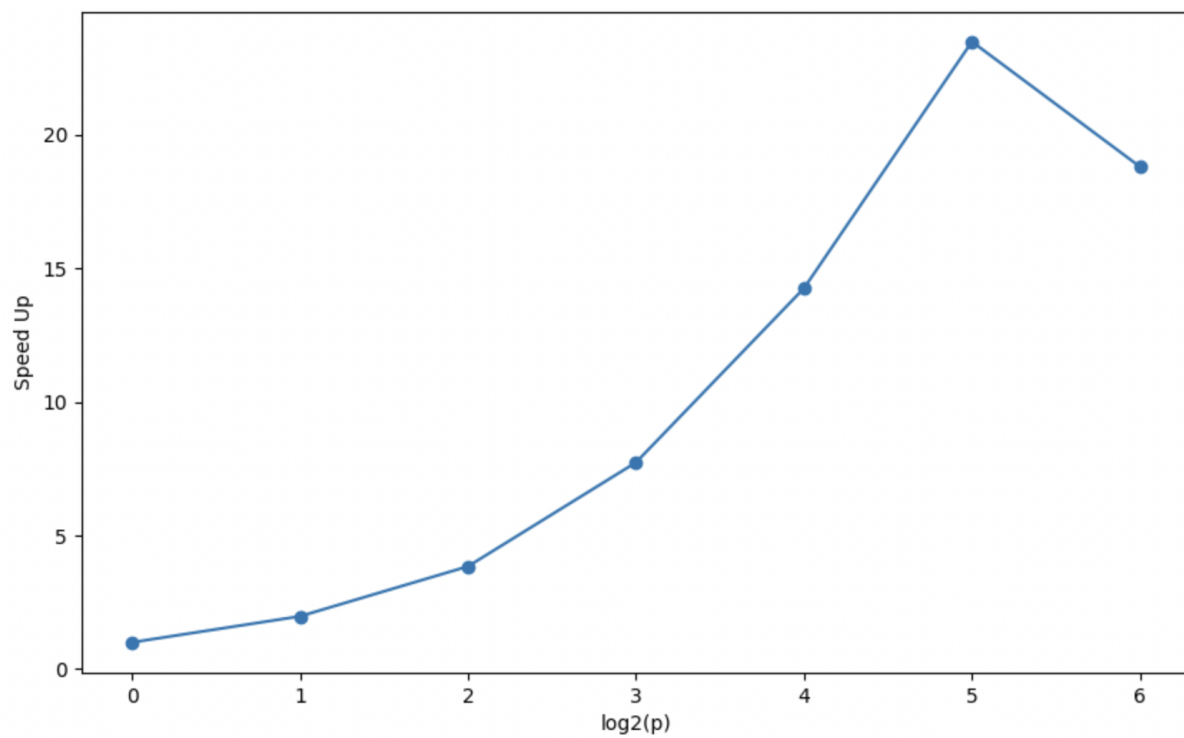[Proc: 0] number of processes = 16, initial local list size = 1280000, hypercube quicksort time = 0.149852
[Proc: 0] number of processes = 32, initial local list size = 640000, hypercube quicksort time = 0.090947
[Proc: 0] number of processes = 64, initial local list size = 320000, hypercube quicksort time = 0.113592

| Number of Processes (p) | Execution Time (secs) | Speed Up | Efficiency |
|---|---|---|---|
| 1 | 2.134755 | 1.0 | 1.0 |
| 2 | 1.081577 | 1.974 | 0.987 |
| 4 | 0.55574 | 3.841 | 0.96 |
| 8 | 0.276164 | 7.73 | 0.966 |
| 16 | 0.149852 | 14.246 | 0.89 |
| 32 | 0.090947 | 23.473 | 0.734 |
| 64 | 0.113592 | 18.793 | 0.294 |

**4.** Changed code to sort list in descending order and executed the following commands:

```
[satyabhama@grace1 HW4-735]$ mpirun -np 2 ./qsort_hypercube_descending.exe 4 -1
[Proc: 0] number of processes = 2, initial local list size = 4, hypercube quicksort time = 0.002947
[Proc: 0] Congratulations. The list has been sorted correctly.
```

```
[satyabhama@grace1 HW4-735]$ mpirun -np 4 ./qsort_hypercube_descending.exe 4 -2
[Proc: 0] number of processes = 4, initial local list size = 4, hypercube quicksort time = 0.010431
[Proc: 0] Congratulations. The list has been sorted correctly.
```

```
[satyabhama@grace1 HW4-735]$ mpirun -np 8 ./qsort_hypercube_descending.exe 4 -1
[Proc: 0] number of processes = 8, initial local list size = 4, hypercube quicksort time = 0.006380
[Proc: 0] Congratulations. The list has been sorted correctly.
```

```
[satyabhama@grace1 HW4-735]$ mpirun -np 16 ./qsort_hypercube_descending.exe 4 0
[Proc: 0] number of processes = 16, initial local list size = 4, hypercube quicksort time = 0.006856
[Proc: 0] Congratulations. The list has been sorted correctly.
```

```
[satyabhama@grace1 HW4-735]$ mpirun -np 16 ./qsort_hypercube_descending.exe 20480000 0
[Proc: 0] number of processes = 16, initial local list size = 20480000, hypercube quicksort time = 2.682162
[Proc: 0] Congratulations. The list has been sorted correctly.
```