RESULT REPORT

Let us first look at the result produced in serial execution.

```
-TW-F---- 1 kraman1 iit104 3407872 Dec 7 15:43 im1
-rw-r--r-- 1 kraman1 iit104 3407872 Dec 7 15:44 im2
-rw-r--r-- 1 kraman1 iit104 7694 Dec 7 15:38 MPI_collcomm2.c
-rw-r--r-- 1 kraman1 iit104 8915 Dec 7 17:16 MPI_sendrecv1.c
-rw-r--r-- 1 kraman1 iit104 3407872 Dec 7 17:16 MPI_sendrecv1.c
-rw-r--r-- 1 kraman1 iit104 3932672 Dec 7 17:27 outputMatrix
-rw-r--r-- 1 kraman1 iit104 13744 Dec 7 17:27 sequentialprogram
-rw-r--r-- 1 kraman1 iit104 4813 Dec 7 17:27 sequentialprogram
-rw-r--r-- 1 kraman1 iit104 13452 Dec 7 15:38 TaskDataparallel.c
[kraman1@comet-ln3 project]$ rm MPI_collcomm2.c
[kraman1@comet-ln3 project]$ ll
total 14100
-rw-r--r-- 1 kraman1 iid
       total 14100
-rw-r--r-- 1 kraman1 iit104 3407872 Dec 7 15:43 im1
-rw-r--r-- 1 kraman1 iit104 3407872 Dec 7 15:44 im2
-rw-r--r-- 1 kraman1 iit104 8915 Dec 7 17:16 MPI_sendrecv1.c
-rw-r--r-- 1 kraman1 iit104 3407872 Dec 7 17:27 outputMatrix
-rw-r--r-- 1 kraman1 iit104 3932672 Dec 7 17:27 outputMatrix
-rw-r--x-- 1 kraman1 iit104 13744 Dec 7 17:27 sequentialprogram
-rw-r--r-- 1 kraman1 iit104 13452 Dec 7 17:27 sequentialprogram.c
-rw-r--r-- 1 kraman1 iit104 13452 Dec 7 15:38 TaskDataparallel.c
[kraman1@comet-ln3 project]$ rm MPI_sendrecv1.c
[kraman1@comet-ln3 project]$ rm TaskDataparallel.c
[kraman1@comet-ln3 project]$ ll
total 14062
-rw-r--r-- 1 kraman1 iit104 3407872 Dec 7 15:43 im1
     total 14062
-rw-r-r-- 1 kraman1 iit104 3407872 Dec 7 15:43 im1
-rw-r-r-- 1 kraman1 iit104 3407872 Dec 7 15:44 im2
-rw-r-- 1 kraman1 iit104 3407872 Dec 7 15:44 out
-rw-r-- 1 kraman1 iit104 3932672 Dec 7 17:27 outputMatrix
-rw-r-- 1 kraman1 iit104 3932672 Dec 7 17:27 sequentialprogram
-rw-r-- 1 kraman1 iit104 13744 Dec 7 17:27 sequentialprogram
-rw-r--r- 1 kraman1 iit104 4813 Dec 7 17:27 sequentialprogram.c
[kraman1@comet-ln3 project]$ gcc sequentialprogram.c -o sequentialprogram -lm
       CS546 Project - Koushik Raman A20388858
      Sequential program
      Output matrix has been generated and stored in outputMatrix file
Time taken for the serial computation = 0.130000 sec
[kraman1@comet-ln3 project]$
```

Computation time = 0.13 sec = 130 ms

Now let us look at the execution of the various types mentioned in the question.

a. MPI send and recv:

Using 8 process:

```
□ kraman1@comet-ln2:~/project
rw-r--r-- 1 kraman1 iit104 252 Dec 8 14:45 MPItaskdataBash.sh
rwxr-xr-x 1 kraman1 iit104  110904 Dec  8 14:51 MPItaskdataparallel
-rw-r--r-- 1 kraman1 iit104
                           207 Dec 8 14:52 MPItaskdataparallel.13193892.co
met-23-04.out
-rw-r--r-- 1 kraman1 iit104
                           12516 Dec 8 14:51 MPItaskdataparallel.c
-rw-r--r-- 1 kraman1 iit104 3932672 Dec 8 16:50 outputMatrixSendRecv
-rw-r--r-- 1 kraman1 iit104 3932672 Dec 8 14:52 outputTaskDataParallel
-rw-r--r-- 1 kraman1 iit104
                            237 Dec 8 16:42 sendrecvBash.sh
-rwxr-xr-x 1 kraman1 iit104   13744 Dec  8 14:09 sequentialprogram
-rw-r--r-- 1 kraman1 iit104 4813 Dec 7 17:46 sequentialprogram.c
[kraman1@comet-ln2 project]$ cat MPIsendAndRecv.13196265.comet-11-30.out
Program using MPI_Send and MPI_Recv
Output matrix has been generated and stored in outputMatrixSendRecv file
Time taken for the computation = 7.927179 ms
Communication time = 33.164024 ms
[kraman1@comet-ln2 project]$
```

Speedup = sequential time/ parallel execution time

= 130ms / 7.927ms

= 16.4

Computation time = 7.927ms Communication time = 33.164ms

Using 4 process:

```
🔊 🖨 📵 kraman1@comet-ln2:~/project
                                 252 Dec 8 14:45 MPItaskdataBash.sh
0904 Dec 8 14:51 MPItaskdataparallel
 rw-r--r-- 1 kraman1 iit104
 rwxr-xr-x 1 kraman1 iit104 110904 Dec
 rw-r--r-- 1 kraman1 iit104
                                207 Dec 8 14:52 MPItaskdataparallel.13193892.co
met-23-04.out
 rw-r--r-- 1 kraman1 iit104
                               12516 Dec 8 14:51 MPItaskdataparallel.c
 rw-r--r-- 1 kraman1 iit104 3407872 Dec
                                            7 15:44 out
 rw-r--r-- 1 kraman1 iit104 3932672 Dec 8 14:09 outputMatrix
 rw-r--r-- 1 kraman1 iit104 3932672 Dec 8 17:14 outputMatrixSendRecv
 rw-r--r-- 1 kraman1 iit104 3932672 Dec 8 14:52 outputTaskDataParallel
rw-r--r-- 1 kraman1 iit104 237 Dec 8 16:56 sendrecvBash.sh
 rwxr-xr-x 1 kraman1 iit104
                                13744 Dec 8 14:09 sequentialprogram
                                4813 Dec 7 17:46 sequentialprogram.c
-rw-r--r-- 1 kraman1 iit104
[kraman1@comet-ln2 project]$ cat MPIsendAndRecv.13197323.comet-03-63.out
Program using MPI Send and MPI Recv
Output matrix has been generated and stored in outputMatrixSendRecv file
Time taken for the computation = 11.274815 ms
Communication time = 24.796724 ms
[kraman1@comet-ln2 project]$
```

Speedup = Serial execution time / parallel execution time

= 130ms / 11.27ms

= 11.54

Computation time = 11.27ms Communication time = 24.8ms

Using 2 process:

Speedup = Serial time / Parallel time

= 130ms / 17.8ms

= 7.3

Computation time = 17.8ms Communication time = 24.61ms

Using 1 process:

```
😰 🖨 🕕 kraman1@comet-ln2:~/project
-rwxr-xr-x 1 kraman1 iit104 110904 Dec 8 14:51 MPItaskdataparallel
-rw-r--r-- 1 kraman1 iit104
                               207 Dec 8 14:52 MPItaskdataparallel.13193892.co
met-23-04.out
-rw-r--r-- 1 kraman1 iit104
                             12516 Dec 8 14:51 MPItaskdataparallel.c
-rw-r--r-- 1 kraman1 iit104 3407872 Dec
                                         7 15:44 out
                                         8 14:09 outputMatrix
-rw-r--r-- 1 kraman1 iit104 3932672 Dec
-rw-r--r-- 1 kraman1 iit104 3932672 Dec
                                         8 17:39 outputMatrixCollComm
 rw-r--r-- 1 kraman1 iit104 3932672 Dec 8 17:39 outputMatrixSendRecv
 rw-r--r-- 1 kraman1 iit104 3932672 Dec 8 14:52 outputTaskDataParallel
 rw-r--r-- 1 kraman1 iit104
                               237 Dec 8 17:29 sendrecvBash.sh
rwxr-xr-x 1 kraman1 iit104
                              13744 Dec 8 14:09 sequentialprogram
4813 Dec 7 17:46 sequentialprogram.c
 rw-r--r-- 1 kraman1 iit104
[kraman1@comet-ln2 project]$ cat MPIsendAndRecv.13197618.comet-06-05.out
Program using MPI_Send and MPI_Recv
Output matrix has been generated and stored in outputMatrixSendRecv file
Time taken for the computation = 31.067610 ms
Communication time = 31.074047 ms
[kraman1@comet-ln2 project]$
```

Speedup = Serial execution time / Parallel execution time

= 130ms / 31.1ms

= 4.18

b. MPI collective calls:

Using 8 process:

```
ng | kraman1@comet-ln2:~/project
 rw-r--r-- 1 kraman1 iit104     252 Dec  8 14:45 MPItaskdataBash.sh
rwxr-xr-x 1 kraman1 iit104  110904 Dec  8 14:51 MPItaskdataparallel
                                                  207 Dec 8 14:52 MPItaskdataparallel.13193892.co
 rw-r--r-- 1 kraman1 iit104
 net-23-04.out
 rw-r--r-- 1 kraman1 iit104 12516 Dec
rw-r--r-- 1 kraman1 iit104 3407872 Dec
                                              12516 Dec 8 14:51 MPItaskdataparallel.c
 .... rw.r. kramani iiti104 3407872 Dec 7 15:31 mpitaskdatap
rw-r--r-- 1 kramani iiti04 3932672 Dec 8 14:09 outputMatrix
rw-r--r-- 1 kramani iiti04 3932672 Dec 8 17:39 outputMatrix
rw-r--r-- 1 kramani iiti04 3032673 Dec 8 17:39 outputMatrix
                                                                8 17:39 outputMatrixCollComm
-rw-r--r-- 1 kraman1 tit104 3932672 Dec 8 17:39 outputMatitXCottComm
-rw-r--r-- 1 kraman1 tit104 3932672 Dec 8 14:52 outputTaskDataParallel
-rw-r--r-- 1 kraman1 tit104 237 Dec 8 17:29 sendrecvBash.sh
 rwxr-xr-x 1 kraman1 iit104
rw-r--r-- 1 kraman1 iit104
                                               13744 Dec 8 14:09 sequentialprogram
                                                4813 Dec 7 17:46 sequentialprogram.c
[kraman1@comet-ln2 project]$ vim MPIcollcommBash.sh
[kraman1@comet-ln2 project]$ cat MPI_collcomm2.13197614.comet-12-11.out
Program using collective calls
Output matrix has been generated and stored in outputMatrix file
Time taken for the computation = 7.849216 ms
Communication time = -1512783568629.796387 ms
[kraman1@comet-ln2 project]$
```

Speedup = Serial execution time / Parallel execution time

= 130ms / 7.85ms

= 16.56

Computation time = 7.85ms

Using 4 process:

```
🔊 🖨 🗊 kraman1@comet-ln2:~/project
 rw-r--r-- 1 kraman1 iit104
                              8248 Dec 8 16:31 MPIsendAndRecv.c
rw-r--r-- 1 kraman1 iit104
                              252 Dec 8 14:45 MPItaskdataBash.sh
rwxr-xr-x 1 kraman1 iit104 110904 Dec 8 14:51 MPItaskdataparallel
rw-r--r-- 1 kraman1 iit104
                               207 Dec 8 14:52 MPItaskdataparallel.13193892.co
met-23-04.out
 rw-r--r-- 1 kraman1 iit104 12516 Dec
                                        8 14:51 MPItaskdataparallel.c
 rw-r--r-- 1 kraman1 iit104 3407872 Dec
                                        7 15:44 out
 rw-r--r-- 1 kraman1 iit104 3932672 Dec
                                       8 14:09 outputMatrix
 rw-r--r-- 1 kraman1 iit104 3932672 Dec
                                       8 17:51 outputMatrixCollComm
 rw-r--r-- 1 kraman1 iit104 3932672 Dec 8 17:39 outputMatrixSendRecv
 rw-r--r-- 1 kraman1 iit104 3932672 Dec 8 14:52 outputTaskDataParallel
 rw-r--r-- 1 kraman1 iit104
                              237 Dec 8 17:29 sendrecvBash.sh
 rwxr-xr-x 1 kraman1 iit104
                             13744 Dec 8 14:09 sequentialprogram
 rw-r--r-- 1 kraman1 iit104
                             4813 Dec 7 17:46 sequentialprogram.c
[kraman1@comet-ln2 project]$ cat MPIcollcomm.13197735.comet-13-38.out
Program using collective calls
Output matrix has been generated and stored in outputMatrix file
Time taken for the computation = 11.277914 ms
Communication time = -1512784290959.070068 ms
[kraman1@comet-ln2 project]$
```

Speedup = Serial execution time / parallel execution time

= 130ms / 11.28ms

= 11.52

Computation time = 11.28ms

Using 2 process:

```
rw-r--r-- 1 kraman1 iit104 8248 Dec 8 16:31 MPIsendAndRecv.c
-rw-r--r-- 1 kraman1 iit104     252 Dec  8 14:45 MPItaskdataBash.sh
-rwxr-xr-x 1 kraman1 iit104  110904 Dec  8 14:51 MPItaskdataparallel
 rw-r--r-- 1 kraman1 iit104
                                    207 Dec 8 14:52 MPItaskdataparallel.13193892.co
net-23-04.out
 rw-r--r-- 1 kraman1 iit104
                                  12516 Dec
                                              8 14:51 MPItaskdataparallel.c
 rw-r--r-- 1 kraman1 iit104 3407872 Dec  7 15:44 out
 rw-r--r-- 1 kraman1 iit104 3932672 Dec 8 14:09 outputMatrix
 rw-r--r-- 1 kraman1 iit104 3932672 Dec 8 18:02 outputMatrixCollCommrw-r--r-- 1 kraman1 iit104 3932672 Dec 8 17:39 outputMatrixSendRecv
 rw-r--r-- 1 kraman1 iit104 3932672 Dec 8 14:52 outputTaskDataParallel
-rw-r--r-- 1 kraman1 iit104
-rwxr-xr-x 1 kraman1 iit104
                                   237 Dec 8 17:29 sendrecvBash.sh
                                  13744 Dec 8 14:09 sequentialprogram
4813 Dec 7 17:46 sequentialprogram.c
 rw-r--r-- 1 kraman1 iit104
[kraman1@comet-ln2 project]$ cat MPIcollcomm.13197810.comet-05-18.out
Program using collective calls
Output matrix has been generated and stored in outputMatrix file
Time taken for the computation = 17.837048 ms
Communication time = -1512784950794.129150 ms
[kraman1@comet-ln2 project]$
```

Speedup = Serial execution time / Parallel execution time

= 130ms / 17.84ms

= 7.29

Computation time = 17.84ms

Using 1 process:

```
🔊 😑 📵 kraman1@comet-ln2:~/project
 rw-r--r-- 1 kraman1 iit104
                               8248 Dec 8 16:31 MPIsendAndRecv.c
rw-r--r-- 1 kraman1 iit104
                               252 Dec 8 14:45 MPItaskdataBash.sh
rwxr-xr-x 1 kraman1 iit104 110904 Dec 8 14:51 MPItaskdataparallel
rw-r--r-- 1 kraman1 iit104
                                207 Dec 8 14:52 MPItaskdataparallel.13193892.co
met-23-04.out
rw-r--r-- 1 kraman1 iit104
                              12516 Dec 8 14:51 MPItaskdataparallel.c
 rw-r--r-- 1 kraman1 iit104 3407872 Dec
                                         7 15:44 out
 rw-r--r-- 1 kraman1 iit104 3932672 Dec
                                         8 14:09 outputMatrix
 rw-r--r-- 1 kraman1 iit104 3932672 Dec
                                         8 18:14 outputMatrixCollComm
 rw-r--r-- 1 kraman1 iit104 3932672 Dec 8 17:39 outputMatrixSendRecv
 rw-r--r-- 1 kraman1 iit104 3932672 Dec 8 14:52 outputTaskDataParallel
 rw-r--r-- 1 kraman1 iit104
                                237 Dec
                                         8 17:29 sendrecvBash.sh
                              13744 Dec 8 14:09 sequentialprogram
rwxr-xr-x 1 kraman1 iit104
                               4813 Dec 7 17:46 sequentialprogram.c
rw-r--r-- 1 kraman1 iit104
[kraman1@comet-ln2 project]$ cat MPIcollcomm.13197827.comet-16-21.out
Program using collective calls
Output matrix has been generated and stored in outputMatrix file
Time taken for the computation = 31.121254 ms
Communication time = -1512785670844.044922 ms
[kraman1@comet-ln2 project]$
```

Speedup = Serial execution time / Parallel execution time

= 130ms / 31.12ms

= 4.177

Computation time = 31.12ms

c. MPI task and data parallelism:

Using 8 process, so that P1=P2=P3=P4=2:

```
■ kraman1@comet-ln2:~/project
 rw-r--r-- 1 kraman1 iit104
                               8248 Dec
                                         8 16:31 MPIsendAndRecv.c
rw-r--r-- 1 kraman1 iit104
                               252 Dec
                                        8 14:45 MPItaskdataBash.sh
 rwxr-xr-x 1 kraman1 iit104
                            110904 Dec
                                        8 14:51 MPItaskdataparallel
rw-r--r-- 1 kraman1 iit104
                                207 Dec 8 14:52 MPItaskdataparallel.13193892.co
net-23-04.out
rw-r--r-- 1 kraman1 iit104
                              12516 Dec
                                        8 14:51 MPItaskdataparallel.c
 rw-r--r-- 1 kraman1 iit104 3407872 Dec
                                         7 15:44 out
 -w-r--r-- 1 kraman1 iit104 3932672 Dec
                                         8 14:09 outputMatrix
 rw-r--r-- 1 kraman1 iit104 3932672 Dec
                                        8 16:50 outputMatrixSendRecv
 rw-r--r-- 1 kraman1 iit104 3932672 Dec
                                         8 14:52 outputTaskDataParallel
                                237 Dec
 rw-r--r-- 1 kraman1 iit104
                                        8 16:56 sendrecvBash.sh
                              13744 Dec 8 14:09 sequentialprogram
 rwxr-xr-x 1 kraman1 iit104
rw-r--r-- 1 kraman1 iit104
                                        7 17:46 sequentialprogram.c
                              4813 Dec
[kraman1@comet-ln2 project]$ cat MPItaskdataparallel.13193892.comet-23-04.out
Program for Task and Data Parallel
Output matrix has been generated and stored in the file outputTaskDataParallel
Time taken for the computation = 0.005791 ms
Time taken for communication = 0.003583 ms
[kraman1@comet-ln2 project]$
```

Speedup = Serial execution time / parallel execution time

= 130ms / 0.005791ms

= 22413.8

Computation time = 0.005791ms Communication time = 0.003583ms

d. Comparing the results in a-c for the case of 8 process:

METHOD

METHOD	COMPOTATION TIME (IN IIIs)
MPI send and recv	7.927
MPI collective calls	7.85
MPI task & data parallel	0.005791

Comparing the results in the above table, we can clearly see that MPI Task and Data parallelism gives the output in the shortest time. The speedup is extremely good in this case. This is due to the fact that the tasks as well as data is split up among groups of processors, thus making it easy for the individual processors to perform their designated operation on their designated data. Since all these are done in parallel, the total computation time becomes too low, thus making Task & Data Parallelism the fastest method among the 3 methods described above.