# PARALLEL AND DISTRIBUTED COMPUTING LAB

## REPORT

**NAME:** S Shyam Sundaram

**REG NO:** 19BCE1560

**PROGRAMMING ENVIRONMENT:** MPI

**PROBLEM:** MPI

**DATE:** 1st December, 2021

**HARDWARE CONFIGURATION:**

| | | |
|---|---|---|
| CPU NAME | : | Intel core i5 – 1035G1 @ 1.00 Ghz |
| Number of Sockets: | : | 1 |
| Cores per Socket | : | 4 |
| Threads per core | : | 1 |
| L1 Cache size | : | 320KB |
| L2 Cache size | : | 2MB |
| L3 Cache size (Shared): | | 6MB |
| RAM | : | 8 GB |

## QUESTION

Write an MPI program to sort an array.

### CODE

```
#include <mpi.h>
#include <stdio.h>
#include <stdlib.h>
#include <time.h>

const int n=10000;

void swap(int *a,int *b)
{
   int t=*a;
   *a=*b;
   *b=t;
}

void fillArray(int a[],int x)
{
   srand(time(0));
```

```
    for(int i=0;i<x;++i)
    {
        a[i]=(rand()%(100-1+1))+1;
    }
}

void merge(int a[],int m,int r)
{
    int x[r],c=0;

    int i=0,j=m;

    while(i<m && j<r)
    {
        if(a[i]<a[j])
        x[c++]=a[i++];
        else
        x[c++]=a[j++];
    }

    while(i<m)
    x[c++]=a[i++];

    while(j<r)
    x[c++]=a[j++];

    for(int k=0;k<r;++k)
    a[k]=x[k];
}

int main(int argc,char* argv[])
{
    int a[n];

    fillArray(a,n);

    int id=0,start,siz;
    int comm_size=0;

    MPI_Init(&argc,&argv);

    MPI_Comm_rank(MPI_COMM_WORLD,&id);
    MPI_Comm_size(MPI_COMM_WORLD, &comm_size);
    double t1, t2;
```

```
start=n%comm_size;
siz=n/comm_size;

if(id==0)
{
   printf("Name: S Shyam Sundaram\nReg num: 19BCE1560\n\n");
   t1 = MPI_Wtime();
   if(start!=0)
   {
      int temp;
      for(int i=0;i<start-1;++i)
      {
         for(int j=0;j<start-i-1;++j)
         {
            if(a[j]>a[j+1])
            {
               swap(&a[j],&a[j+1]);
            }
         }
      }
   }
}
int arr[siz];
MPI_Scatter(&a[start],siz,MPI_INT,arr,siz,MPI_INT,0,MPI_COMM_WORLD);

for(int i=0;i<siz-1;++i)
for(int j=0;j<siz-i-1;++j)
{
   if(arr[j]>arr[j+1])
   {
      swap(&arr[j],&arr[j+1]);
   }
}

MPI_Gather(arr,siz,MPI_INT,&a[start],siz,MPI_INT,0,MPI_COMM_WORLD);

if(id==0)
{

   int off=siz;
   if(start!=0)
   {
      off=start+siz;
```

```
    }
    while(off<n)
    {
      merge(a,off,off+siz);
      off=off+siz;
    }

    t2 = MPI_Wtime();
    printf( "Elapsed time is %f\n", t2 - t1 );
  }

  MPI_Finalize();
  return 0;

}
```

## COMMANDS

mpicc sort.c
mpirun --oversubscribe -np 4 ./a.out

## OUTPUT

```
shyam@shyam-Inspiron-14-5408:~/Academics/Lab-Fall-2021/PDC/Challenging_task$ mpicc sort.c
shyam@shyam-Inspiron-14-5408:~/Academics/Lab-Fall-2021/PDC/Challenging_task$ mpirun --oversubscribe -np 1 ./a.out
Name: S Shyam Sundaram
Reg num: 19BCE1560

Elapsed time is 0.000136
shyam@shyam-Inspiron-14-5408:~/Academics/Lab-Fall-2021/PDC/Challenging_task$ mpirun --oversubscribe -np 2 ./a.out
Name: S Shyam Sundaram
Reg num: 19BCE1560

Elapsed time is 0.000486
shyam@shyam-Inspiron-14-5408:~/Academics/Lab-Fall-2021/PDC/Challenging_task$ mpirun --oversubscribe -np 3 ./a.out
Name: S Shyam Sundaram
Reg num: 19BCE1560

Elapsed time is 0.000202
shyam@shyam-Inspiron-14-5408:~/Academics/Lab-Fall-2021/PDC/Challenging_task$ mpirun --oversubscribe -np 4 ./a.out
Name: S Shyam Sundaram
Reg num: 19BCE1560

Elapsed time is 0.000206
shyam@shyam-Inspiron-14-5408:~/Academics/Lab-Fall-2021/PDC/Challenging_task$ mpirun --oversubscribe -np 5 ./a.out
Name: S Shyam Sundaram
Reg num: 19BCE1560

Elapsed time is 0.000384
shyam@shyam-Inspiron-14-5408:~/Academics/Lab-Fall-2021/PDC/Challenging_task$
```

*sort.c with 100 elements*

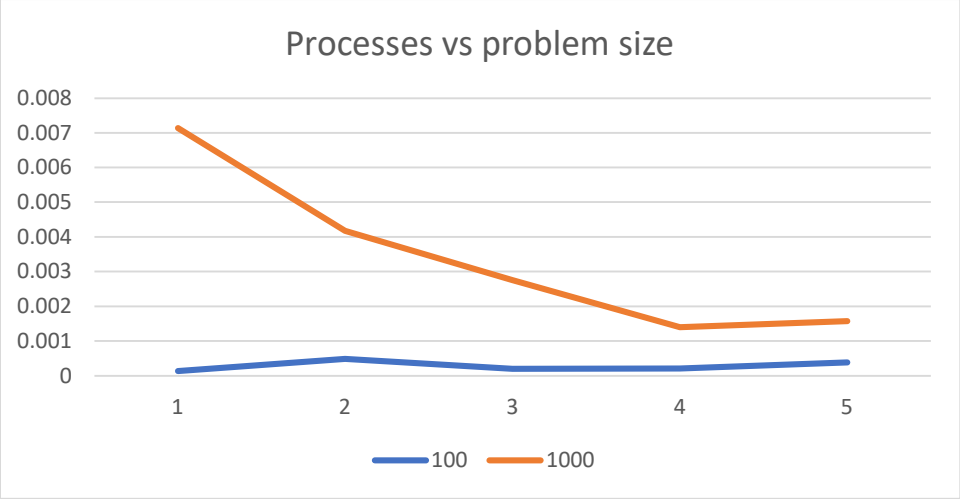
```
shyam@shyam-Inspiron-14-5408:~/Academics/Lab-Fall-2021/PDC/Challenging_task$ mpirun --oversubscribe -np 1 ./a.out
Name: S Shyam Sundaram
Reg num: 19BCE1560

Elapsed time is 0.007139
shyam@shyam-Inspiron-14-5408:~/Academics/Lab-Fall-2021/PDC/Challenging_task$ mpirun --oversubscribe -np 2 ./a.out
Name: S Shyam Sundaram
Reg num: 19BCE1560

Elapsed time is 0.004171
shyam@shyam-Inspiron-14-5408:~/Academics/Lab-Fall-2021/PDC/Challenging_task$ mpirun --oversubscribe -np 3 ./a.out
Name: S Shyam Sundaram
Reg num: 19BCE1560

Elapsed time is 0.002753
shyam@shyam-Inspiron-14-5408:~/Academics/Lab-Fall-2021/PDC/Challenging_task$ mpirun --oversubscribe -np 4 ./a.out
Name: S Shyam Sundaram
Reg num: 19BCE1560

Elapsed time is 0.001402
shyam@shyam-Inspiron-14-5408:~/Academics/Lab-Fall-2021/PDC/Challenging_task$ mpirun --oversubscribe -np 5 ./a.out
Name: S Shyam Sundaram
Reg num: 19BCE1560

Elapsed time is 0.001575
shyam@shyam-Inspiron-14-5408:~/Academics/Lab-Fall-2021/PDC/Challenging_task$
```

*sort.c with 100 elements*

## OBSERVATION

Each process gets a chunk of the array which then sort them in parallel. Then, the master collects them all and merges the received, sorted partitions in order (like in merge sort).

| N | NUMBER OF PROCESSES | TIME |
|---|---|---|
| 100 | 1 | 0.000136 |
| | 2 | 0.000486 |
| | 3 | 0.000202 |
| | 4 | 0.000206 |
| | 5 | 0.000384 |
| 1000 | 1 | 0.007139 |
| | 2 | 0.004171 |
| | 3 | 0.002753 |
| | 4 | 0.001402 |
| | 5 | 0.001575 |
| 10000 | 1 | 0.943478 |
| | 2 | 0.247141 |
| | 3 | 0.121381 |
| | 4 | 0.125787 |
| | 5 | 0.072597 |




## CONCLUSION

We have sorted an array of elements in parallel using MPI.