

## File: piCalculate.c

```
/*
This exercise presents a simple program to determine the value of pi.
The algorithm suggested here is chosen for its simplicity. The method
evaluates the integral of  $4/(1+x^2)$  between 0 and 1. The method is
simple: the integral is approximated by a sum of n intervals; the
approximation to the integral in each interval is  $(1/n)*4/(1+x^2)$ . The
master process (rank 0) asks the user for the number of intervals; the
master should then broadcast this number to all of the other processes.
Each process then adds up every n'th interval ( $x = \text{rank}/n$ ,
 $\text{rank}/n + \text{size}/n, \dots$ ). Finally, the sums computed by each process are added
together using a reduction.
*/
```

You may want to use these MPI routines in your solution:

MPI\_Bcast MPI\_Reduce

```
*****/
```

```
#include "mpi.h"
#include <math.h>
#include <stdio.h>
#include <stdlib.h>

#define MAX_NAME 80 /* length of characters for naming a process */

int main(argc,argv)
int argc;
char *argv[];
{
    int n,
    rank, /* rank variable to identify the process */
    numprocs, /* number of processes */
    i,
    len; /* variable for storing name of processes */
    double PI25DT = 3.141592653589793238462643; /* 25-digit-PI*/
    double mypi, /* value from each process */
    pi, /* value of PI in total*/
    step, /* the step */
    sum, /* sum of area under the curve */
    x,
    startTime, /* starting time */
    endTime; /* ending time */

    char name[MAX_NAME]; /* char array for storing the name of
each process */

    /*Initialize MPI execution environment */
    MPI_Init(&argc,&argv);
    MPI_Comm_size(MPI_COMM_WORLD,&numprocs);
    MPI_Comm_rank(MPI_COMM_WORLD,&rank);
    MPI_Get_processor_name(name, &len);

    if (rank == 0) {
        printf("Number of processing units: %d\n",numprocs);
        printf("Enter the number of intervals: (0 quits) ");
        scanf("%d",&n);
    }
    MPI_Bcast(&n, 1, MPI_INT, 0, MPI_COMM_WORLD);
    if (n == 0) exit(0);
}
```

```

//Broadcast the number of bins to all processes
/* This broadcasts an integer which is n, from the master to all
processes */
//Calculating for each core
startTime = MPI_Wtime();
step = 1.0 / (double) n;
sum = 0.0;
for (i = rank + 1; i <= n; i += numprocs) {
    x = step * ((double)i - 0.5);
    sum += 4.0 / (1.0 + x*x);
}
mypi = step * sum;

printf("This is my sum: %.16f from rank: %d name: %s\n", mypi,
rank, name);

//Now we can reduce all those sums to one value which is pi
MPI_Reduce(&mypi, &pi, 1, MPI_DOUBLE, MPI_SUM, 0,
MPI_COMM_WORLD);

if (rank == 0){
    printf("pi is approximately %.16f, Error is %.16f\n", pi,
fabs(pi - PI25DT));
    endTime = MPI_Wtime();
    printf("Time of calculation PI is: %f\n", endTime-startTime);
}
//Terminate MPI execution environment
MPI_Finalize();
return 0;
}

```

#### #OUTPUT:

##### 1 Node:

The screenshot shows a terminal window titled 'student@node2: /home/ibm'. The user has executed the command 'mpirun -np 12 -host node1 ./piCalculate'. The output shows the program running on 12 processors. Each processor prints its local sum and rank. The master process (rank 0) prints the final value of pi and the error. The time of calculation is 0.092713 seconds.

```

student@node2: /home/ibm$ mpirun -np 12 -host node1 ./piCalculate
Number of processing units: 12
Enter the number of intervals: (0 quits) 1000
This is my sum: 0.2640498684137977 from rank: 0 name: node1
This is my sum: 0.2638827058653734 from rank: 1 name: node1
This is my sum: 0.2637153742335374 from rank: 2 name: node1
This is my sum: 0.2607168601078259 from rank: 8 name: node1
This is my sum: 0.2605503582258470 from rank: 9 name: node1
This is my sum: 0.2635478743516046 from rank: 3 name: node1
This is my sum: 0.2613812068029122 from rank: 4 name: node1
This is my sum: 0.2612153709208150 from rank: 5 name: node1
This is my sum: 0.2610493672886828 from rank: 6 name: node1
This is my sum: 0.2603836919273075 from rank: 10 name: node1
This is my sum: 0.2602168620455291 from rank: 11 name: node1
This is my sum: 0.2608831967398937 from rank: 7 name: node1
pi is approximately 3.1415927369231262, Error is 0.0000000833333331
Time of calculation PI is: 0.092713
student@node2: /home/ibm$

```

## 2 Nodes Machine File:

machine.txt:

node1:4

node2:4

```
student@node2: /home/ibm
student@node2:/home/ibm$ mpiexec -np 12 -f machine.txt ./piCalculate
Number of processing units: 12
Enter the number of intervals: (0 quits) 1000
This is my sum: 0.2640498684137977 from rank: 0 name: node1
This is my sum: 0.2613812068029122 from rank: 4 name: node2
This is my sum: 0.2637153742335374 from rank: 2 name: node1
This is my sum: 0.2608831967398937 from rank: 7 name: node2
This is my sum: 0.2610493672886828 from rank: 6 name: node2
This is my sum: 0.2612153709208150 from rank: 5 name: node2
This is my sum: 0.2635478743516046 from rank: 3 name: node1
This is my sum: 0.2607168601078259 from rank: 8 name: node1
This is my sum: 0.2603836919273075 from rank: 10 name: node1
This is my sum: 0.2638827058653734 from rank: 1 name: node1
This is my sum: 0.2602168620455291 from rank: 11 name: node1
This is my sum: 0.2605503582258470 from rank: 9 name: node1
pi is approximately 3.1415927369231262, Error is 0.0000000833333331
Time of calculation PI is: 0.047710
student@node2:/home/ibm$
```

## 3 Nodes:

```
student@node2: /home/ibm
student@node2:/home/ibm$ mpiexec -np 12 -host node1,node2,node3 ./piCalculate
Number of processing units: 12
Enter the number of intervals: (0 quits) 1000
This is my sum: 0.2637153742335374 from rank: 2 name: node3
This is my sum: 0.2612153709208150 from rank: 5 name: node3
This is my sum: 0.2607168601078259 from rank: 8 name: node3
This is my sum: 0.2602168620455291 from rank: 11 name: node3
This is my sum: 0.2640498684137977 from rank: 0 name: node1
This is my sum: 0.2638827058653734 from rank: 1 name: node2
This is my sum: 0.2635478743516046 from rank: 3 name: node1
This is my sum: 0.2608831967398937 from rank: 7 name: node2
This is my sum: 0.2610493672886828 from rank: 6 name: node1
This is my sum: 0.2603836919273075 from rank: 10 name: node2
This is my sum: 0.2605503582258470 from rank: 9 name: node1
This is my sum: 0.2613812068029122 from rank: 4 name: node2
pi is approximately 3.1415927369231262, Error is 0.0000000833333331
Time of calculation PI is: 0.015973
student@node2:/home/ibm$
```