**Final Year B. Tech., Sem VII 2022-23**

**High Performance Computing Lab**

**PRN: 2020BTECS00206**

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**Batch: B4**

**Assignment No. 7**

1. **Implement Matrix-Vector Multiplication using MPI. Use different number of processes and analyze the performance.**

#include <mpi.h>

#include <stdio.h>

#include <stdlib.h>

// size of matrix

#define N 100

int main(int argc, char \*argv[])

{

int np, rank, numworkers, rows, i, j, k;

// a\*b = c

double a[N][N], b[N], c[N];

MPI\_Status status;

MPI\_Init(&argc, &argv);

MPI\_Comm\_rank(MPI\_COMM\_WORLD, &rank);

MPI\_Comm\_size(MPI\_COMM\_WORLD, &np);

numworkers = np - 1; // total process - 1 ie process with rank 0

// rank with 0 is a master process

int dest, source;

int tag;

int rows\_per\_process, extra, offset;

// master process, process with rank = 0

if (rank == 0)

{

printf("Running with %d tasks.\n", np);

// matrix a and b initialization

for (i = 0; i < N; i++)

for (j = 0; j < N; j++)

a[i][j] = 1;

for (i = 0; i < N; i++)

b[i] = 1;

// start time

double start = MPI\_Wtime();

// Send matrix data to other worker processes

rows\_per\_process = N / numworkers;

extra = N % numworkers;

offset = 0;

tag = 1;

// send data to other nodes

for (dest = 1; dest <= numworkers; dest++)

{

rows = (dest <= extra) ? rows\_per\_process + 1 : rows\_per\_process;

MPI\_Send(&offset, 1, MPI\_INT, dest, tag, MPI\_COMM\_WORLD);

MPI\_Send(&rows, 1, MPI\_INT, dest, tag, MPI\_COMM\_WORLD);

MPI\_Send(&a[offset][0], rows \* N, MPI\_DOUBLE, dest, tag, MPI\_COMM\_WORLD);

MPI\_Send(&b, N, MPI\_DOUBLE, dest, tag, MPI\_COMM\_WORLD);

offset = offset + rows;

}

// receive data from other nodes and add it to the ans matrix c

tag = 2;

for (i = 1; i <= numworkers; i++)

{

source = i;

MPI\_Recv(&offset, 1, MPI\_INT, source, tag, MPI\_COMM\_WORLD, &status);

MPI\_Recv(&rows, 1, MPI\_INT, source, tag, MPI\_COMM\_WORLD, &status);

MPI\_Recv(&c[offset], N, MPI\_DOUBLE, source, tag, MPI\_COMM\_WORLD, &status);

}

// print multiplication result

// printf("Result Matrix:\n");

// for (i = 0; i < N; i++)

// {

// printf("%6.2f ", c[i]);

// }

// printf("\n");

double finish = MPI\_Wtime();

printf("Done in %f seconds.\n", finish - start); // total time spent

}

// all other process than process with rank = 0

if (rank > 0)

{

tag = 1;

// receive data from process with rank 0

MPI\_Recv(&offset, 1, MPI\_INT, 0, tag, MPI\_COMM\_WORLD, &status);

MPI\_Recv(&rows, 1, MPI\_INT, 0, tag, MPI\_COMM\_WORLD, &status);

MPI\_Recv(&a, rows \* N, MPI\_DOUBLE, 0, tag, MPI\_COMM\_WORLD, &status);

MPI\_Recv(&b, N, MPI\_DOUBLE, 0, tag, MPI\_COMM\_WORLD, &status);

// calculate multiplication of given rows

for (i = 0; i < rows; i++)

{

c[i] = 0.0;

for (j = 0; j < N; j++)

c[i] = c[i] + a[i][j] \* b[j];

}

// send result back to process with rank 0

tag = 2;

MPI\_Send(&offset, 1, MPI\_INT, 0, tag, MPI\_COMM\_WORLD);

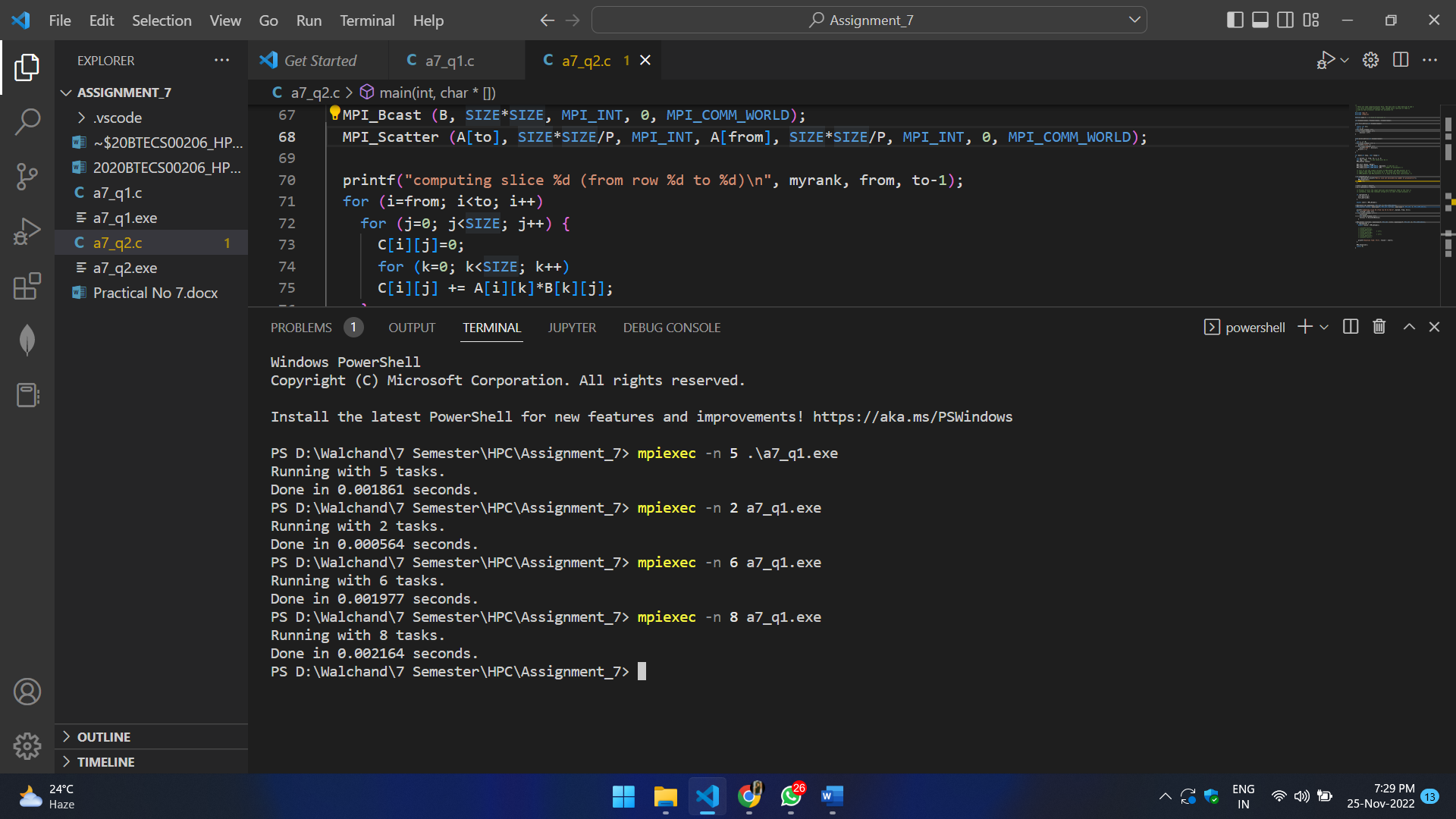
MPI\_Send(&rows, 1, MPI\_INT, 0, tag, MPI\_COMM\_WORLD);

MPI\_Send(&c, N, MPI\_DOUBLE, 0, tag, MPI\_COMM\_WORLD);

}

MPI\_Finalize();

}



1. **Implement Matrix-Matrix Multiplication using MPI. Use different number of processes and analyze the performance.**

/\*

\* There are some simplifications here. The main one is that matrices B and C

\* are fully allocated everywhere, even though only a portion of them is

\* used by each processor (except for processor 0)

\*/

#include <mpi.h>

#include <stdio.h>

#define SIZE 4 /\* Size of matrices \*/

int A[SIZE][SIZE], B[SIZE][SIZE], C[SIZE][SIZE];

void fill\_matrix(int m[SIZE][SIZE])

{

static int n=1;

int i, j;

for (i=0; i<SIZE; i++)

for (j=0; j<SIZE; j++)

m[i][j] = n++;

}

void print\_matrix(int m[SIZE][SIZE])

{

int i, j = 0;

for (i=0; i<SIZE; i++) {

printf("\n\t| ");

for (j=0; j<SIZE; j++)

printf("%2d ", m[i][j]);

printf("|");

}

}

int main(int argc, char \*argv[])

{

int myrank, P, from, to, i, j, k;

int tag = 666; /\* any value will do \*/

MPI\_Status status;

MPI\_Init (&argc, &argv);

MPI\_Comm\_rank(MPI\_COMM\_WORLD, &myrank); /\* who am i \*/

MPI\_Comm\_size(MPI\_COMM\_WORLD, &P); /\* number of processors \*/

/\* Just to use the simple variants of MPI\_Gather and MPI\_Scatter we \*/

/\* impose that SIZE is divisible by P. By using the vector versions, \*/

/\* (MPI\_Gatherv and MPI\_Scatterv) it is easy to drop this restriction. \*/

if (SIZE%P!=0) {

if (myrank==0) printf("Matrix size not divisible by number of processors\n");

MPI\_Finalize();

exit(-1);

}

from = myrank \* SIZE/P;

to = (myrank+1) \* SIZE/P;

/\* Process 0 fills the input matrices and broadcasts them to the rest \*/

/\* (actually, only the relevant stripe of A is sent to each process) \*/

if (myrank==0) {

fill\_matrix(A);

fill\_matrix(B);

}

double start = MPI\_Wtime();

MPI\_Bcast (B, SIZE\*SIZE, MPI\_INT, 0, MPI\_COMM\_WORLD);

MPI\_Scatter (A[to], SIZE\*SIZE/P, MPI\_INT, A[from], SIZE\*SIZE/P, MPI\_INT, 0, MPI\_COMM\_WORLD);

printf("computing slice %d (from row %d to %d)\n", myrank, from, to-1);

for (i=from; i<to; i++)

for (j=0; j<SIZE; j++) {

C[i][j]=0;

for (k=0; k<SIZE; k++)

C[i][j] += A[i][k]\*B[k][j];

}

MPI\_Gather (C[from], SIZE\*SIZE/P, MPI\_INT, C[to], SIZE\*SIZE/P, MPI\_INT, 0, MPI\_COMM\_WORLD);

if (myrank==0) {

double finish = MPI\_Wtime();

// printf("\n\n");

// print\_matrix(A);

// printf("\n\n\t \* \n");

// print\_matrix(B);

// printf("\n\n\t = \n");

// print\_matrix(C);

// printf("\n\n");

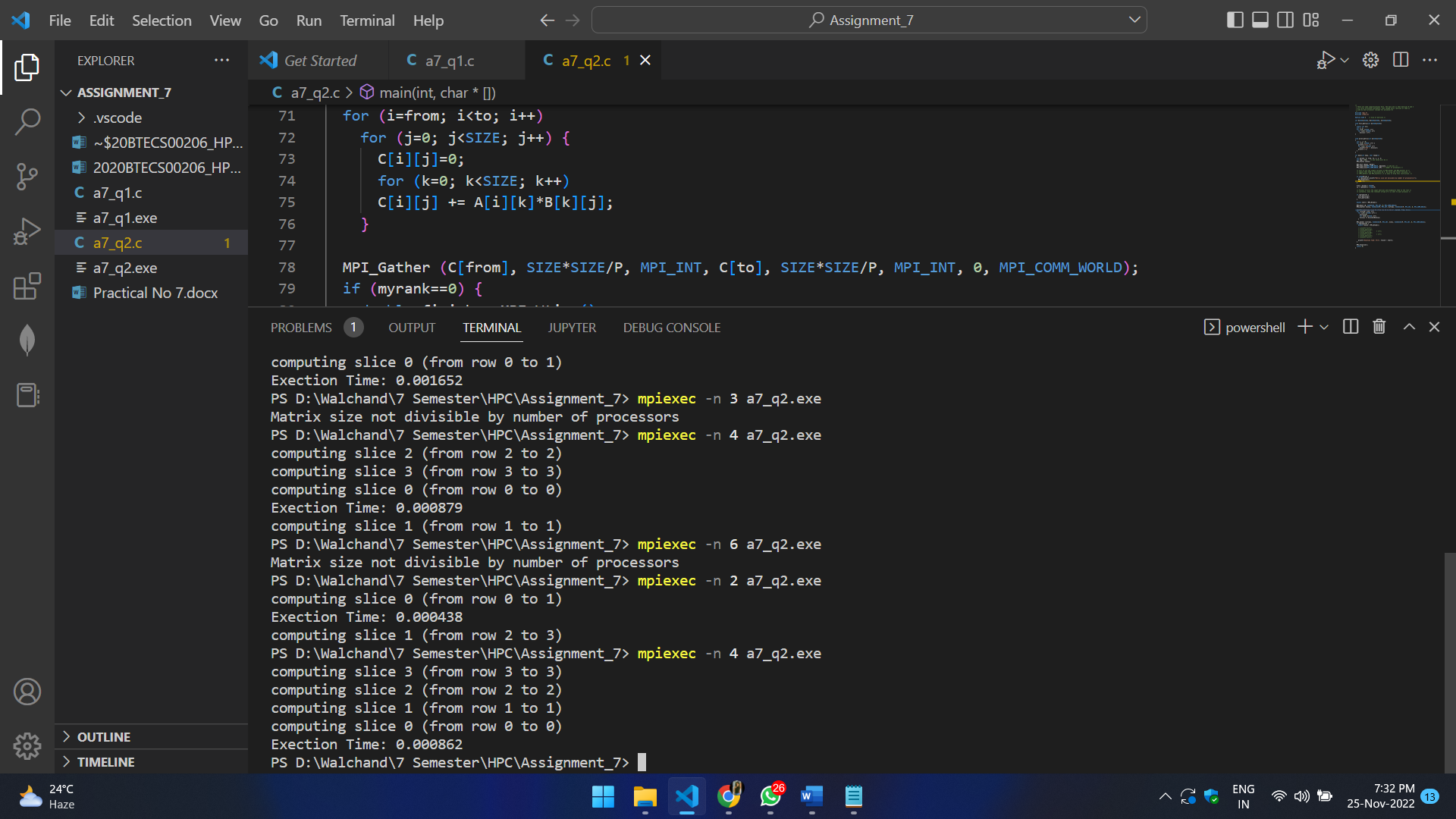
printf("Exection Time: %f\n", finish - start);

}

MPI\_Finalize();

return 0;

}



**Github Link:** [**https://github.com/SayaliDesai4/HPC-Practicals**](https://github.com/SayaliDesai4/HPC-Practicals)