

PP Lab 4: Collective Communication and Error Handling in MPI

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1.) Write a MPI program using N processes to find $1! + 2! + \dots + N!$ Use scan. Also, handle different errors using error handling routines.

Code:

```
#include <mpi.h>
#include <stdio.h>
#include <string.h>
#define BUFSIZE 100

void Error_Handler(int error_code);

int main(int argc, char *argv[])
{
    int size, rank;

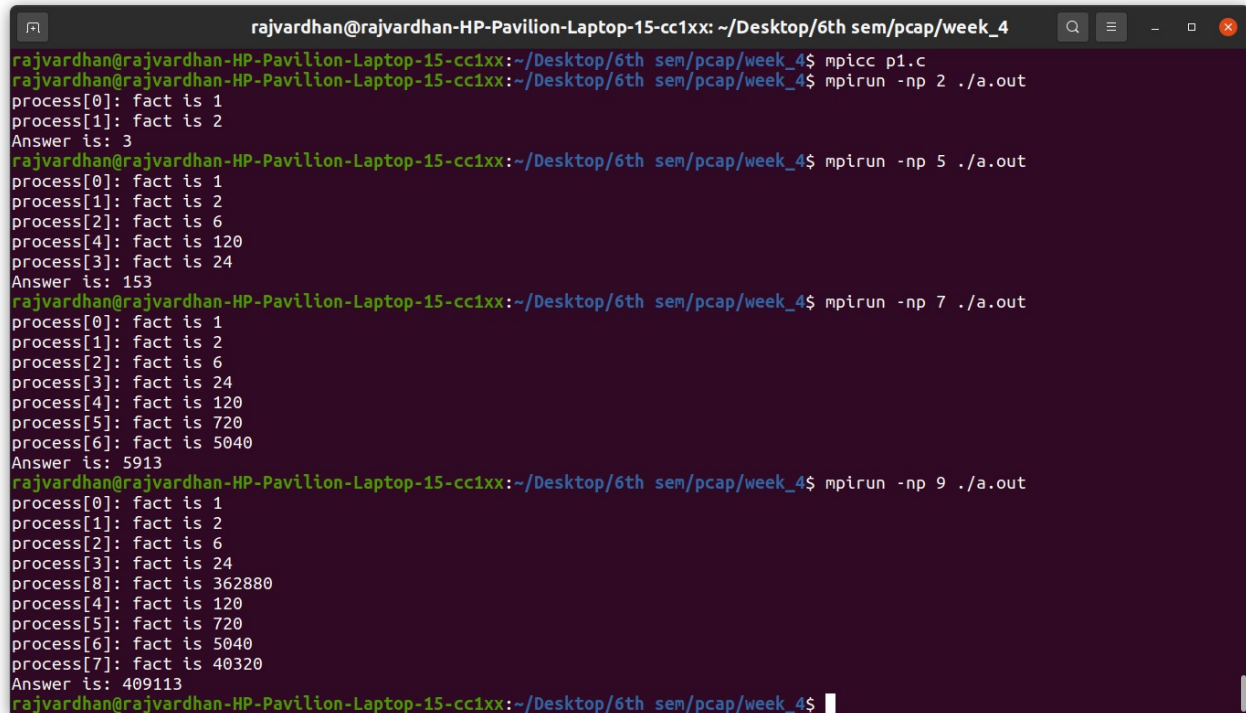
    int sum=0;
    int fact=1;
    MPI_Init(&argc, &argv);
    MPI_Errhandler_set(MPI_COMM_WORLD, MPI_ERRORS_RETURN);
    int error_code;
    error_code = MPI_Comm_size(MPI_COMM_WORLD, &size);
    error_code = MPI_Comm_rank(MPI_COMM_WORLD, &rank);

    Error_Handler(error_code);
    int sendval = rank+1;
    MPI_Scan(&sendval, &fact, 1, MPI_INT, MPI_PROD, MPI_COMM_WORLD);
    fprintf(stdout, "process[%d]: fact is %d\n", rank, fact);
    fflush(stdout);
    MPI_Scan(&fact, &sum, 1, MPI_INT, MPI_SUM, MPI_COMM_WORLD);
    if(rank==size-1)
        printf("Answer is: %d\n", sum);
    return 0;
}

void Error_Handler(int error_code)
{
    if(error_code!= MPI_SUCCESS)
    {
        char error_string[BUFSIZE];
        int length_of_error_string, error_class;
        MPI_Error_class(error_code, &error_class);
        MPI_Error_string(error_code, error_string, &length_of_error_string);
        printf("%d %s\n", error_class, error_string);
    }
}
```

```
}
```

Output:



```
rajvardhan@rajvardhan-HP-Pavilion-Laptop-15-cc1xx: ~/Desktop/6th sem/pcap/week_4
rajvardhan@rajvardhan-HP-Pavilion-Laptop-15-cc1xx:~/Desktop/6th sem/pcap/week_4$ mpicc p1.c
rajvardhan@rajvardhan-HP-Pavilion-Laptop-15-cc1xx:~/Desktop/6th sem/pcap/week_4$ mpirun -np 2 ./a.out
process[0]: fact is 1
process[1]: fact is 2
Answer is: 3
rajvardhan@rajvardhan-HP-Pavilion-Laptop-15-cc1xx:~/Desktop/6th sem/pcap/week_4$ mpirun -np 5 ./a.out
process[0]: fact is 1
process[1]: fact is 2
process[2]: fact is 6
process[4]: fact is 120
process[3]: fact is 24
Answer is: 153
rajvardhan@rajvardhan-HP-Pavilion-Laptop-15-cc1xx:~/Desktop/6th sem/pcap/week_4$ mpirun -np 7 ./a.out
process[0]: fact is 1
process[1]: fact is 2
process[2]: fact is 6
process[3]: fact is 24
process[4]: fact is 120
process[5]: fact is 720
process[6]: fact is 5040
Answer is: 5913
rajvardhan@rajvardhan-HP-Pavilion-Laptop-15-cc1xx:~/Desktop/6th sem/pcap/week_4$ mpirun -np 9 ./a.out
process[0]: fact is 1
process[1]: fact is 2
process[2]: fact is 6
process[3]: fact is 24
process[8]: fact is 362880
process[4]: fact is 120
process[5]: fact is 720
process[6]: fact is 5040
process[7]: fact is 40320
Answer is: 409113
rajvardhan@rajvardhan-HP-Pavilion-Laptop-15-cc1xx:~/Desktop/6th sem/pcap/week_4$
```

2.) Write a MPI program to calculate π -value by integrating $f(x) = 4/(1+x^2)$. Area under the curve is divided into rectangles and the rectangles are distributed to the processors. Also handle different errors using error handling routines.

Code:

```
#include <mpi.h>
#include <stdio.h>
#include <string.h>
```

```
int main (int argc, char *argv[])
{
```

```
int rank, size;
int i = 0, j;
int k = 0, fac=1, ans[1000], sum=0;
int n, a[100][100], b[100];
float x, y, area, pi1;
```

```
MPI_Init(&argc, &argv);
```

```
MPI_Comm_rank(MPI_COMM_WORLD, &rank);
```

```
// Set the error handler to MPI_ERRORS_RETURN
MPI_Errhandler_set(MPI_COMM_WORLD, MPI_ERRORS_RETURN);
```

```
MPI_Comm_size(MPI_COMM_WORLD, &size);
```

```

int error = MPI_Bcast(&size, 1, MPI_INT, 0, MPI_COMM_WORLD);

    if (error != MPI_SUCCESS)
    {
    char s[100];
    int len, class1;
    MPI_Error_string(error, s, &len);
    MPI_Error_class(error, &class1);
    fprintf(stderr, "Error description is %s", s);
    fflush(stderr);
    fprintf(stderr, "Error class is %d", class1);
    fflush(stderr);
    }

x = (float)(rank+1)/size;
y = 4.f/(1+x*x);
area = (1/(float)size)*y;

MPI_Reduce(&area, &pi1, 1, MPI_FLOAT, MPI_SUM, 0, MPI_COMM_WORLD);

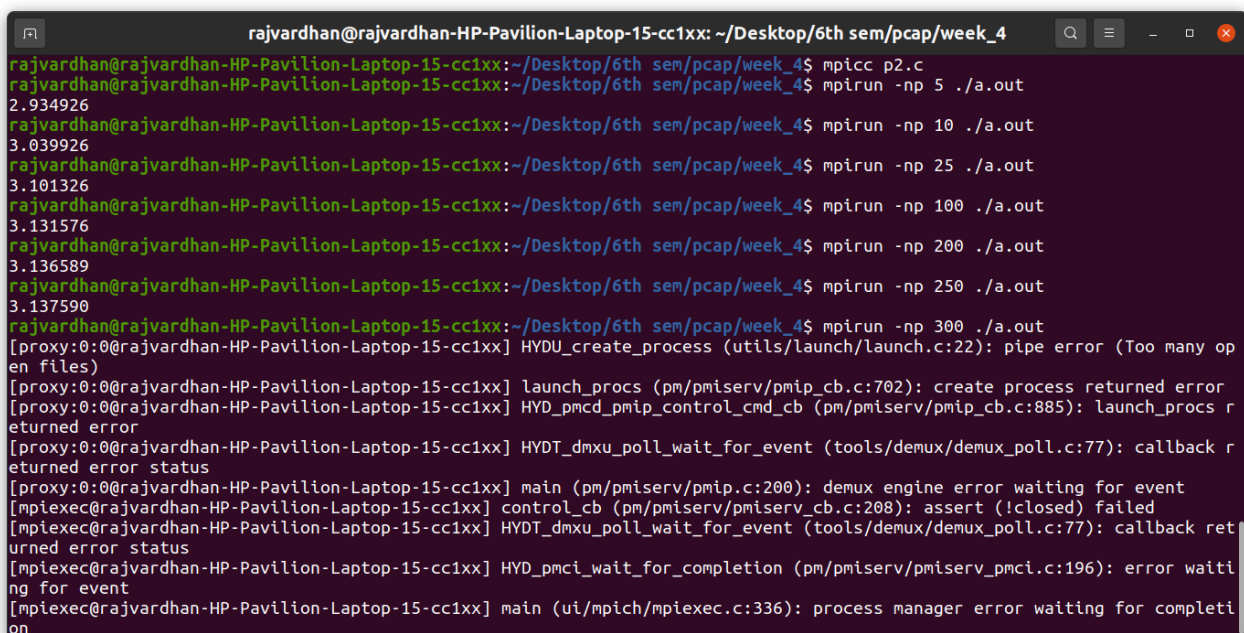
if (rank == 0)
{
fprintf(stdout, "%f\n", pi1);
fflush(stdout);
}

MPI_Finalize();

return 0;
}

```

Output:



```

rajvardhan@rajvardhan-HP-Pavilion-Laptop-15-cc1xx: ~/Desktop/6th sem/pcap/week_4
rajvardhan@rajvardhan-HP-Pavilion-Laptop-15-cc1xx:~/Desktop/6th sem/pcap/week_4$ mpicc p2.c
rajvardhan@rajvardhan-HP-Pavilion-Laptop-15-cc1xx:~/Desktop/6th sem/pcap/week_4$ mpirun -np 5 ./a.out
2.934926
rajvardhan@rajvardhan-HP-Pavilion-Laptop-15-cc1xx:~/Desktop/6th sem/pcap/week_4$ mpirun -np 10 ./a.out
3.039926
rajvardhan@rajvardhan-HP-Pavilion-Laptop-15-cc1xx:~/Desktop/6th sem/pcap/week_4$ mpirun -np 25 ./a.out
3.101326
rajvardhan@rajvardhan-HP-Pavilion-Laptop-15-cc1xx:~/Desktop/6th sem/pcap/week_4$ mpirun -np 100 ./a.out
3.131576
rajvardhan@rajvardhan-HP-Pavilion-Laptop-15-cc1xx:~/Desktop/6th sem/pcap/week_4$ mpirun -np 200 ./a.out
3.136589
rajvardhan@rajvardhan-HP-Pavilion-Laptop-15-cc1xx:~/Desktop/6th sem/pcap/week_4$ mpirun -np 250 ./a.out
3.137590
rajvardhan@rajvardhan-HP-Pavilion-Laptop-15-cc1xx:~/Desktop/6th sem/pcap/week_4$ mpirun -np 300 ./a.out
[proxy:0:0@rajvardhan-HP-Pavilion-Laptop-15-cc1xx] HYDU_create_process (utils/launch/launch.c:22): pipe error (Too many op
en files)
[proxy:0:0@rajvardhan-HP-Pavilion-Laptop-15-cc1xx] launch_procs (pm/pmiserv/pmip_cb.c:702): create process returned error
[proxy:0:0@rajvardhan-HP-Pavilion-Laptop-15-cc1xx] HYD_pmcd_pmip_control_cmd_cb (pm/pmiserv/pmip_cb.c:885): launch_procs r
eturned error
[proxy:0:0@rajvardhan-HP-Pavilion-Laptop-15-cc1xx] HYDT_dmux_poll_wait_for_event (tools/demux/demux_poll.c:77): callback r
eturned error status
[proxy:0:0@rajvardhan-HP-Pavilion-Laptop-15-cc1xx] main (pm/pmiserv/pmip.c:200): demux engine error waiting for event
[mpiexec@rajvardhan-HP-Pavilion-Laptop-15-cc1xx] control_cb (pm/pmiserv/pmiserv_cb.c:208): assert (!closed) failed
[mpiexec@rajvardhan-HP-Pavilion-Laptop-15-cc1xx] HYDT_dmux_poll_wait_for_event (tools/demux/demux_poll.c:77): callback ret
urned error status
[mpiexec@rajvardhan-HP-Pavilion-Laptop-15-cc1xx] HYD_pmci_wait_for_completion (pm/pmiserv/pmiserv_pmci.c:196): error waiti
ng for event
[mpiexec@rajvardhan-HP-Pavilion-Laptop-15-cc1xx] main (ui/mpich/mpiexec.c:336): process manager error waiting for completi
on

```

3.) Write a MPI program to read a 3 X 3 matrix. Enter an element to be searched in the root process. Find the number of occurrences of this element in the matrix using three processes.

Code:

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

void ErrorHandler(int error_code)
{
    char error_string[MPI_MAX_ERROR_STRING];
    int length_of_error_string,error_class;
    MPI_Error_class(error_code,&error_class);
    MPI_Error_string(error_code,error_string,&length_of_error_string);
    if(error_code!=0)
        printf("error class %d \n error string %s\n",error_class,error_string );
}

void main (int a,char *b[])_
{
    int rank, ele,size;
    int a1[3][3];
    int b1[3];
    int count=0;
    int tc = 0;
    int error_code;
    MPI_Init(&a, &b);
    MPI_Comm_rank(MPI_COMM_WORLD, &rank);
    MPI_Comm_size(MPI_COMM_WORLD, &size);
    MPI_Errhandler_set(MPI_COMM_WORLD,MPI_ERRORS_RETURN);

    error_code=MPI_Comm_size(MPI_COMM_WORLD,&size);
    ErrorHandler(error_code);

    if (rank == 0)
    {
        printf("Enter elements into matrix\n");
        for (int i = 0; i < 3; i++)
        {
            for (int j = 0; j < 3; j++)
            {
                scanf("%d", &a1[i][j]);
            }
        }

        printf("Enter element to count \n");
        scanf("%d", &ele);
    }

    MPI_Bcast(&ele, 1, MPI_INT, 0, MPI_COMM_WORLD);
    MPI_Scatter(a1, 3, MPI_INT, b1, 3, MPI_INT, 0, MPI_COMM_WORLD);
```

```

for (int i = 0; i < 3; i++)_
{
    printf("%d ",b1[i]);
    if (b1[i] == ele)_
    {
        count ++;
    }
}

printf("\nProcess %d found %d occurrences\n",rank,count);
MPI_Reduce(&count, &tc, 1, MPI_INT, MPI_SUM, 0, MPI_COMM_WORLD);

if (rank == 0)
{
    printf("\nNumber of occurrences is %d\n",tc);
}

MPI_Finalize();
}

```

Output:

```

rajvardhan@rajvardhan-HP-Pavilion-Laptop-15-cc1xx:~/Desktop/6th sem/pcap/week_4$ mpicc p3.c
rajvardhan@rajvardhan-HP-Pavilion-Laptop-15-cc1xx:~/Desktop/6th sem/pcap/week_4$ mpirun -np 3 ./a.out
Enter elements into matrix
1 2 3 1 2 3 1 2 3
Enter element to count
3
1 2 3
Process 0 found 1 occurrences
1 2 3
Process 1 found 1 occurrences
1 2 3
Process 2 found 1 occurrences

Number of occurrences is 3
rajvardhan@rajvardhan-HP-Pavilion-Laptop-15-cc1xx:~/Desktop/6th sem/pcap/week_4$ mpirun -np 3 ./a.out
Enter elements into matrix
23 45 67 66 77 77 98 12 234
Enter element to count
66
23 45 67
Process 0 found 0 occurrences
66 77 77
Process 1 found 1 occurrences
98 12 234
Process 2 found 0 occurrences

Number of occurrences is 1
rajvardhan@rajvardhan-HP-Pavilion-Laptop-15-cc1xx:~/Desktop/6th sem/pcap/week_4$

```

4.) Write a MPI program to read 4 X 4 matrix and display the following output using four processes.

Code:

```
#include <mpi.h>
#include <stdio.h>
#include <string.h>

void ErrorHandler(int error_code)
{
    if (error_code != MPI_SUCCESS)
    {
        char error_string[BUFSIZ];
        int length_of_error_string, error_class;
        MPI_Error_class(error_code, &error_class);
        MPI_Error_string(error_code, error_string, &length_of_error_string);
        printf("%d %s\n", error_class, error_string);
    }
}

int main (int argc, char* argv[])
{
    int rank, size, error_code;
    int i = 0, j;
    int k = 0, fac = 1, ans[1000], sum = 0;
    int n, a[100][100], b[100];

    MPI_Init(&argc, &argv);
    error_code = MPI_Comm_rank(MPI_COMM_WORLD, &rank);
    error_code = MPI_Comm_size(MPI_COMM_WORLD, &size);

    if (rank == 0)
    {
        printf("Enter the elements of i/p matrix \n");
        for (i = 0; i < 4; i++)
        {
            for (j = 0; j < 4; j++)
            {
                scanf("%d", &a[i][j]);
            }
        }
        printf("\n");
    }

    error_code = MPI_Scatter(a, 100, MPI_INT, b, 100, MPI_INT, 0, MPI_COMM_WORLD);
    error_code = MPI_Scan(b, ans, 4, MPI_INT, MPI_SUM, MPI_COMM_WORLD);
    ErrorHandler(error_code);

    for (i = 0; i < 4; i++)
    {
```

```
    printf("%d ", ans[i]);  
}  
  
printf("\n");  
MPI_Finalize();  
  
return 0;  
}
```

Output:

```
rajvardhan@rajvardhan-HP-Pavilion-Laptop-15-cc1xx:~/Desktop/6th sem/pcap/week_4$ mpicc p4.c  
rajvardhan@rajvardhan-HP-Pavilion-Laptop-15-cc1xx:~/Desktop/6th sem/pcap/week_4$ mpirun -np 4 ./a.out  
Enter the elements of i/p matrix  
10 20 30 40  
50 60 70 80  
90 100 110 120  
130 140 150 160  
  
10 20 30 40  
60 80 100 120  
150 180 210 240  
280 320 360 400  
rajvardhan@rajvardhan-HP-Pavilion-Laptop-15-cc1xx:~/Desktop/6th sem/pcap/week_4$ mpirun -np 4 ./a.out  
Enter the elements of i/p matrix  
1 2 3 4  
1 2 3 1  
1 1 1 1  
1 2 1 2  
  
1 2 3 4  
2 4 6 5  
3 5 7 6  
4 7 8 8  
rajvardhan@rajvardhan-HP-Pavilion-Laptop-15-cc1xx:~/Desktop/6th sem/pcap/week_4$
```