

HPC4M Workshop 3

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1 Exercise 2

First, we generate the matrix B in process rank 0. Then, broadcast matrix B to all processes. In each process, we first generate a row of matrix A , called AA , then do matrix multiplication between this row vector AA and matrix B . After that, we can get a row vector CC in each process. Waiting until all processes finish computation, we gather all row vectors CC into matrix C , which is stored in process rank 0 and is our final result of matrix multiplication. We write the matrix C into a txt file called "result.txt" to store the result.

```
1
2 #include <stdio.h>
3 #include "mpi.h"
4 #include <iostream>
5 using namespace std;
6
7 int main()
8 {
9     int rank, nproc, sum, N = 4;
10    int A[N][N];
11    int B[N][N];
12    int C[N][N];
13    int AA[N], CC[N];
14
15
16    //initialize MPI
17    MPI_Init(NULL, NULL);
18    MPI_Comm_size(MPI_COMM_WORLD, &nproc);
19    MPI_Comm_rank(MPI_COMM_WORLD, &rank);
20
21    //generate matrix B in process rank 0
22    if (rank == 0){
23        for(int i = 0; i < N; i++){
24            for(int j = 0; j < N; j++){
25                B[i][j] = (j+i+2)*(N-(j+1)+1);
26            }
27        }
28    }
29
30    //broadcast matrix B to all processes
31    MPI_Bcast(B, N*N, MPI_INT, 0, MPI_COMM_WORLD);
32
```

```

33
34 //perform in all processes
35 for (int k = 0; k < N; k++){
36     //generate kth row of matrix A
37     if (rank == k){
38         for(int i = 0; i < N; i++){
39             AA[i]=(N-(i+1)+(k+1)+1)*(k+1);
40         }
41
42         //perform vecotr multiplication
43         for (int i = 0; i < N; i++){
44             sum = 0;
45             for (int j = 0; j < N; j++){
46                 sum = sum + AA[j] * B[j][i];
47             }
48             CC[i] = sum;
49         }
50     }
51 }
52
53 //gather results from all processes
54 MPI_Gather(CC, N, MPI_INT, C, N, MPI_INT, 0, MPI_COMM_WORLD);
55 MPI_Barrier(MPI_COMM_WORLD);
56 //end MPI
57 MPI_Finalize();
58
59 //output results into a file
60 if (rank == 0){
61     FILE *f = fopen("result.txt", "w");
62     for (int i = 0; i < N; i++) {
63         for (int j = 0; j < N; j++) {
64             fprintf(f, "%d\t", C[i][j]);
65         }
66         fprintf(f, "\n");
67     }
68     fclose(f);
69 }
70 }

```

For example, for $N = 4$, the result is

$$C = \begin{pmatrix} 176 & 174 & 144 & 86 \\ 464 & 456 & 376 & 224 \\ 864 & 846 & 696 & 414 \\ 1376 & 1344 & 1104 & 656 \end{pmatrix}.$$