Practical 5: Hybrid MPI and OpenMP

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I.   AIM

Demonstrating Hybrid `MPI` and `OpenMP` code.

II.   INTRODUCTION

The goal is to demonstrate the hybrid `OpenMP` and `MPI` code for below configurations:

- 1 node and 1 core

- 1 node and 4 cores

- 2 nodes and 1 core

- 2 nodes and 2 cores

- 2 nodes and 4 cores

III.   IMPLEMENTATION

```
1   //
    ↪ -----------------------------------------------------------------------------------------------
2   // Author: Gahan Saraiya
3   // GiT: http://github.com/gahan9/
4   // StackOverflow: https://stackoverflow.com/users/story/7664524
5   // Website: http://gahan9.github.io/
6   //
    ↪ -----------------------------------------------------------------------------------------------
7   // Hybrid implementation of Openmp and MPI
8   // Node x Core
9   // 1 x 1
10  // 1 x 4
11  // 2 x 1
12  // 2 x 2
13  // 2 x 4
14
15  #include <stdio.h>
16  #include <string.h>
17  #include "mpi.h"
```

```
18    #include <stdlib.h>
19    #include <stddef.h>
20    #include <math.h>
21
22    #define ARRAY_SIZE 4000
23    #define REPEAT     1
24    #define NUM_THREADS 2
25
26    #define CHUNKSIZE 100
27
28    void worker_code(double* vector1, double* vector2, double* result){
29            int len;
30            char processor_name[200];
31            int tid, i, chunk;
32            // initialize arraysc
33            chunk = CHUNKSIZE;
34            int total_threads = NUM_THREADS;
35            MPI_Get_processor_name(processor_name, &len);
36            #pragma omp parallel shared(vector1, vector2, result, total_threads,
                ↪  chunk) private(i,tid) num_threads(total_threads)
37            // #pragma omp parallel shared(vector1, vector2, result, total_threads,
                ↪  chunk) private(i,tid)
38            {
39                    tid = omp_get_thread_num();
40                    // #pragma omp parallel for num_threads(total_threads)
41                    #pragma omp for schedule(dynamic, chunk)
42                    for (i=0; i<ARRAY_SIZE; i++){
43                            result[i] = vector1[i] + vector2[i];
44                            printf("[%s:%d]: result[%d] is %f\n", processor_name, tid,
                                ↪  i, result[i]);
45                    }
46            }
47    }
48
49    double* generate_array(int no_of_elements) {
50            int i;
51        // no_of_elements : Generate array of `no_of_elements` number of elements
52            double* array = (double*) malloc(no_of_elements*sizeof(double));
53            for(i=0; i<no_of_elements; i++)
54                    array[i] = rand()%10000;
55            return array;
56    }
```

```
57
58  int main(int argc, char **argv ) {
59          // Generate input vectors and destination vector
60          double *vector1 = generate_array(ARRAY_SIZE);
61          double *vector2 = generate_array(ARRAY_SIZE);
62          double *result_vector = (double*) malloc(ARRAY_SIZE*sizeof(double));
63
64          char message[20];
65          int i, rank, size, type=99;
66
67          MPI_Status status;
68          MPI_Init(&argc, &argv);
69          MPI_Comm_size(MPI_COMM_WORLD,&size);
70          MPI_Comm_rank(MPI_COMM_WORLD, &rank);
71          if(rank == 0) {
72                  strcpy(message, "Valar Morgholis!!");
73                  for (i=1; i<size; i++)
74                          MPI_Send(message, 20, MPI_CHAR, i, type, MPI_COMM_WORLD);
75          }
76          else
77                  MPI_Recv(message, 20, MPI_CHAR, 0, type, MPI_COMM_WORLD,
                      ↪ &status);
78          worker_code(vector1, vector2, result_vector);
79          //all MPI processes run OpenMP code, no message passing
80          printf("Kingslayer-%d send you a message : %s\n", rank, message);
81          MPI_Finalize();
82          return 0;
83  }
```

IV.   OUTPUTS

I.   Result for 1 node and 1 core

```
[master:0]: result[0] is 17205.000000
[master:0]: result[1] is 7758.000000
[master:0]: result[2] is 11007.000000
[master:0]: result[3] is 9072.000000
[master:0]: result[4] is 12274.000000
[master:0]: result[5] is 10080.000000
[master:0]: result[6] is 8952.000000
[master:0]: result[7] is 9645.000000
```

```
[master:0]: result[8] is 7241.000000
[master:0]: result[9] is 7962.000000
[master:0]: result[10] is 9432.000000
[master:0]: result[11] is 5485.000000
[master:0]: result[12] is 18528.000000
[master:0]: result[13] is 6644.000000
[master:0]: result[14] is 13979.000000
[master:0]: result[15] is 5350.000000
[master:0]: result[16] is 9079.000000
[master:0]: result[17] is 4618.000000
[master:0]: result[18] is 10255.000000
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[master:0]: result[34] is 7987.000000
[master:0]: result[35] is 17922.000000
[master:0]: result[36] is 10638.000000
[master:0]: result[37] is 16940.000000
[master:0]: result[38] is 13919.000000
[master:0]: result[39] is 14231.000000
```

$$\vdots$$

```
[master:0]: result[3059] is 14115.000000
[master:0]: result[3060] is 11771.000000
[master:0]: result[3061] is 12737.000000
[master:0]: result[3062] is 8961.000000
[master:0]: result[3063] is 10971.000000
[master:0]: result[3064] is 4127.000000
```

```
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```

```
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```

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```

```
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```

```
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```

```
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```

```
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```

```
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[master:0]: result[3924] is 18224.000000
[master:0]: result[3925] is 13671.000000
```

```
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[master:0]: result[3964] is 2637.000000
[master:0]: result[3965] is 16609.000000
[master:0]: result[3966] is 12122.000000
```

```
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[master:0]: result[3980] is 15985.000000
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[master:0]: result[3991] is 6125.000000
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[master:0]: result[3993] is 12189.000000
[master:0]: result[3994] is 4087.000000
[master:0]: result[3995] is 13266.000000
[master:0]: result[3996] is 11502.000000
[master:0]: result[3997] is 12562.000000
[master:0]: result[3998] is 5991.000000
[master:0]: result[3999] is 11967.000000
Kingslayer-0 send you a message : Valar Morgholis!!
```

II.   Result for 1 node and 4 core

```
[master:3]: result[0] is 17205.000000
[master:3]: result[1] is 7758.000000
```

```
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[master:3]: result[4] is 12274.000000
[master:3]: result[5] is 10080.000000
[master:3]: result[6] is 8952.000000
[master:3]: result[7] is 9645.000000
[master:3]: result[8] is 7241.000000
[master:3]: result[9] is 7962.000000
[master:3]: result[10] is 9432.000000
[master:3]: result[11] is 5485.000000
[master:3]: result[12] is 18528.000000
[master:3]: result[13] is 6644.000000
[master:3]: result[14] is 13979.000000
[master:3]: result[15] is 5350.000000
[master:3]: result[16] is 9079.000000
[master:3]: result[17] is 4618.000000
[master:3]: result[18] is 10255.000000
[master:3]: result[19] is 7908.000000
[master:3]: result[20] is 12388.000000
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[master:3]: result[24] is 12024.000000
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[master:3]: result[35] is 17922.000000
[master:3]: result[36] is 10638.000000
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[master:3]: result[38] is 13919.000000
[master:3]: result[39] is 14231.000000
```

$\vdots$

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[master:1]: result[3308] is 9847.000000
[master:1]: result[3309] is 5174.000000
```

```
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[master:1]: result[3350] is 13529.000000
```

```
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```

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```

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```

```
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```

```
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```

```
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```

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[master:2]: result[1767] is 5655.000000
[master:2]: result[1768] is 4788.000000
[master:2]: result[1769] is 18016.000000
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[master:2]: result[1774] is 9596.000000
[master:2]: result[1775] is 12237.000000
[master:2]: result[1776] is 10482.000000
[master:2]: result[1777] is 5600.000000
[master:2]: result[1778] is 11048.000000
```

```
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[master:2]: result[1781] is 10641.000000
[master:2]: result[1782] is 12732.000000
[master:2]: result[1783] is 13188.000000
[master:2]: result[1784] is 8782.000000
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[master:2]: result[1789] is 3456.000000
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[master:2]: result[1798] is 16539.000000
[master:2]: result[1799] is 10904.000000
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[master:0]: result[209] is 9372.000000
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[master:0]: result[213] is 13348.000000
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[master:0]: result[215] is 14677.000000
[master:0]: result[216] is 7228.000000
[master:0]: result[217] is 8322.000000
[master:0]: result[218] is 10061.000000
[master:0]: result[219] is 6410.000000
```

```
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[master:0]: result[221] is 6206.000000
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[master:0]: result[225] is 10192.000000
[master:0]: result[226] is 10593.000000
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[master:0]: result[243] is 8696.000000
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[master:0]: result[246] is 9727.000000
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[master:0]: result[248] is 4270.000000
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[master:0]: result[253] is 11575.000000
[master:0]: result[254] is 9562.000000
[master:0]: result[255] is 10949.000000
[master:0]: result[256] is 18119.000000
[master:0]: result[257] is 16509.000000
[master:0]: result[258] is 13002.000000
[master:0]: result[259] is 14754.000000
[master:0]: result[260] is 12350.000000
```

```
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[master:0]: result[262] is 14697.000000
[master:0]: result[263] is 9007.000000
[master:0]: result[264] is 8828.000000
[master:0]: result[265] is 9407.000000
[master:0]: result[266] is 5842.000000
[master:0]: result[267] is 13337.000000
[master:0]: result[268] is 2221.000000
[master:0]: result[269] is 15156.000000
[master:0]: result[270] is 4279.000000
[master:0]: result[271] is 10759.000000
[master:0]: result[272] is 6251.000000
[master:0]: result[273] is 10028.000000
[master:0]: result[274] is 15808.000000
[master:0]: result[275] is 7047.000000
[master:0]: result[276] is 15977.000000
[master:0]: result[277] is 1887.000000
[master:0]: result[278] is 7776.000000
[master:0]: result[279] is 12951.000000
[master:0]: result[280] is 8027.000000
[master:0]: result[281] is 11266.000000
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[master:0]: result[283] is 13077.000000
[master:0]: result[284] is 9193.000000
[master:0]: result[285] is 2258.000000
[master:0]: result[286] is 14026.000000
[master:0]: result[287] is 17313.000000
[master:0]: result[288] is 15119.000000
[master:0]: result[289] is 9733.000000
[master:0]: result[290] is 4772.000000
[master:0]: result[291] is 3821.000000
[master:0]: result[292] is 4740.000000
[master:0]: result[293] is 19470.000000
[master:0]: result[294] is 9181.000000
[master:0]: result[295] is 3568.000000
[master:0]: result[296] is 5229.000000
[master:0]: result[297] is 11375.000000
[master:0]: result[298] is 9609.000000
[master:0]: result[299] is 3803.000000
Kingslayer-0 send you a message : Valar Morgholis!!
```

III.   Result for 2 node and 1 core

```
[master:0]: result[0] is 17205.000000
[master:0]: result[1] is 7758.000000
[master:0]: result[2] is 11007.000000
[master:0]: result[3] is 9072.000000
[master:0]: result[4] is 12274.000000
[master:0]: result[5] is 10080.000000
[master:0]: result[6] is 8952.000000
[master:0]: result[7] is 9645.000000
[master:0]: result[8] is 7241.000000
[master:0]: result[9] is 7962.000000
[master:0]: result[10] is 9432.000000
[master:0]: result[11] is 5485.000000
[master:0]: result[12] is 18528.000000
[master:0]: result[13] is 6644.000000
[master:0]: result[14] is 13979.000000
[node:0]: result[0] is 17205.000000
[node:0]: result[1] is 7758.000000
[node:0]: result[2] is 11007.000000
[master:0]: result[15] is 5350.000000
[master:0]: result[16] is 9079.000000
[node:0]: result[3] is 9072.000000
[node:0]: result[4] is 12274.000000
[node:0]: result[5] is 10080.000000
[node:0]: result[6] is 8952.000000
[node:0]: result[7] is 9645.000000
[node:0]: result[8] is 7241.000000
[master:0]: result[17] is 4618.000000
[node:0]: result[9] is 7962.000000
[node:0]: result[10] is 9432.000000
[node:0]: result[11] is 5485.000000
[master:0]: result[18] is 10255.000000
[node:0]: result[12] is 18528.000000
[node:0]: result[13] is 6644.000000
[node:0]: result[14] is 13979.000000
[master:0]: result[19] is 7908.000000
[master:0]: result[20] is 12388.000000
[node:0]: result[15] is 5350.000000
[node:0]: result[16] is 9079.000000
[node:0]: result[17] is 4618.000000
[master:0]: result[21] is 12240.000000
```

:

```
[master:0]: result[2304] is 17047.000000
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[master:0]: result[2307] is 15526.000000
[master:0]: result[2308] is 13943.000000
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[master:0]: result[2309] is 13861.000000
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[master:0]: result[2313] is 12423.000000
[node:0]: result[763] is 12661.000000
[master:0]: result[2314] is 3478.000000
[master:0]: result[2315] is 7209.000000
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[node:0]: result[771] is 15718.000000
[master:0]: result[2323] is 4983.000000
[master:0]: result[2324] is 7330.000000
[node:0]: result[772] is 7892.000000
```

```
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[node:0]: result[774] is 11689.000000
[master:0]: result[2327] is 9912.000000
[master:0]: result[2328] is 7595.000000
[node:0]: result[775] is 11312.000000
[master:0]: result[2329] is 12386.000000
[node:0]: result[776] is 7595.000000
[node:0]: result[777] is 7908.000000
[master:0]: result[2330] is 10523.000000
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[master:0]: result[2332] is 13094.000000
[master:0]: result[2333] is 17167.000000
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[node:0]: result[784] is 5978.000000
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[master:0]: result[2340] is 15113.000000
[node:0]: result[785] is 16255.000000
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[master:0]: result[2345] is 9986.000000
[node:0]: result[790] is 9702.000000
[master:0]: result[2346] is 3192.000000
[node:0]: result[791] is 8924.000000
```

```
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[master:0]: result[2348] is 7396.000000
[node:0]: result[793] is 6298.000000
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[node:0]: result[801] is 16337.000000
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[node:0]: result[813] is 10848.000000
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```
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[node:0]: result[825] is 8208.000000
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```

```
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```

```
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[master:0]: result[2430] is 8378.000000
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```

```
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[master:0]: result[2473] is 8938.000000
```

```
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[node:0]: result[937] is 10397.000000
[master:0]: result[2938] is 8168.000000
```

```
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```

```
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[node:0]: result[977] is 7778.000000
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[node:0]: result[979] is 13076.000000
[node:0]: result[980] is 8479.000000
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[node:0]: result[981] is 5220.000000
[node:0]: result[982] is 9241.000000
[node:0]: result[983] is 7879.000000
```

```
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[node:0]: result[985] is 16260.000000
[node:0]: result[986] is 11958.000000
[master:0]: result[2977] is 10952.000000
[master:0]: result[2978] is 14391.000000
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[node:0]: result[988] is 5487.000000
[node:0]: result[989] is 15738.000000
[master:0]: result[2979] is 6565.000000
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[master:0]: result[2981] is 19470.000000
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[node:0]: result[995] is 11564.000000
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[node:0]: result[1003] is 10145.000000
[node:0]: result[1004] is 10047.000000
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[node:0]: result[1006] is 9374.000000
[node:0]: result[1007] is 10369.000000
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```

```
[node:0]: result[1009] is 10057.000000
[node:0]: result[1010] is 9797.000000
```

IV.   Result for 2 node and 2 core

```
[master:0]: result[0] is 17205.000000
[master:0]: result[1] is 7758.000000
[node:0]: result[0] is 17205.000000
[node:0]: result[1] is 7758.000000
[node:0]: result[2] is 11007.000000
[node:0]: result[3] is 9072.000000
[node:0]: result[4] is 12274.000000
[master:0]: result[2] is 11007.000000
[master:0]: result[3] is 9072.000000
[master:0]: result[4] is 12274.000000
[master:0]: result[5] is 10080.000000
[node:0]: result[5] is 10080.000000
[node:0]: result[6] is 8952.000000
[node:0]: result[7] is 9645.000000
[master:1]: result[100] is 1125.000000
[node:0]: result[8] is 7241.000000
[node:0]: result[9] is 7962.000000
[node:0]: result[10] is 9432.000000
[master:1]: result[101] is 3458.000000
[node:0]: result[11] is 5485.000000
[node:0]: result[12] is 18528.000000
[master:1]: result[102] is 9437.000000
[master:1]: result[103] is 9188.000000
[node:0]: result[13] is 6644.000000
[node:0]: result[14] is 13979.000000
[node:0]: result[15] is 5350.000000
[master:1]: result[104] is 10547.000000
[node:0]: result[16] is 9079.000000
[master:1]: result[105] is 9623.000000
[master:1]: result[106] is 2656.000000
[node:1]: result[100] is 1125.000000
[master:1]: result[107] is 4038.000000
[node:1]: result[101] is 3458.000000
[master:1]: result[108] is 6702.000000
```

```
[master:1]: result[109] is 4256.000000
[node:1]: result[102] is 9437.000000
[node:1]: result[103] is 9188.000000
[master:1]: result[110] is 13955.000000
[master:1]: result[111] is 933.000000
[node:1]: result[104] is 10547.000000
```

:

```
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```

```
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```

```
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```

```
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```

```
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```

```
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```

```
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```

```
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[node:1]: result[697] is 10663.000000
[node:1]: result[698] is 9905.000000
[master:1]: result[3240] is 2774.000000
[node:1]: result[699] is 8651.000000
[node:1]: result[700] is 9944.000000
```

```
[master:1]: result[3241] is 13980.000000
[node:0]: result[38] is 13919.000000
[master:1]: result[3242] is 4844.000000
[node:0]: result[39] is 14231.000000
[node:1]: result[701] is 3174.000000
[master:1]: result[3243] is 7213.000000
[node:1]: result[702] is 10314.000000
[master:1]: result[3244] is 15718.000000
[node:1]: result[703] is 15359.000000
[master:1]: result[3245] is 13580.000000
[node:1]: result[704] is 6021.000000
[master:1]: result[3246] is 5620.000000
[node:1]: result[705] is 8419.000000
[master:1]: result[3247] is 4233.000000
[node:1]: result[706] is 421.000000
[master:1]: result[3248] is 8098.000000
[node:1]: result[707] is 1471.000000
[master:1]: result[3249] is 10472.000000
[master:1]: result[3250] is 13330.000000
[node:1]: result[708] is 1756.000000
[master:1]: result[3251] is 14063.000000
[node:1]: result[709] is 11027.000000
[node:1]: result[710] is 7580.000000
[node:1]: result[711] is 11179.000000
[node:1]: result[712] is 6067.000000
[master:1]: result[3252] is 17927.000000
[node:1]: result[713] is 14015.000000
[node:1]: result[714] is 4569.000000
[master:1]: result[3253] is 4716.000000
[node:1]: result[715] is 13895.000000
[master:1]: result[3254] is 9773.000000
[node:1]: result[716] is 13986.000000
[node:1]: result[717] is 4091.000000
[node:1]: result[718] is 11936.000000
[master:1]: result[3255] is 14542.000000
[node:1]: result[719] is 14002.000000
[master:1]: result[3256] is 6303.000000
[node:1]: result[720] is 16685.000000
[node:1]: result[721] is 13918.000000
[master:1]: result[3257] is 1674.000000
[node:1]: result[722] is 9030.000000
```

```
[master:1]: result[3258] is 10208.000000
[node:1]: result[723] is 8309.000000
[master:1]: result[3259] is 10288.000000
[node:1]: result[724] is 14726.000000
[master:1]: result[3260] is 10372.000000
[node:1]: result[725] is 11670.000000
[node:1]: result[726] is 9492.000000
[master:0]: result[2749] is 17388.000000
[node:1]: result[727] is 11939.000000
[master:0]: result[2750] is 17703.000000
[master:0]: result[2751] is 6101.000000
[master:0]: result[2752] is 1156.000000
[node:1]: result[728] is 15038.000000
[node:1]: result[729] is 15749.000000
[master:0]: result[2753] is 9405.000000
[master:0]: result[2754] is 7454.000000
[node:1]: result[730] is 6944.000000
[master:0]: result[2755] is 6018.000000
[node:1]: result[731] is 11334.000000
[node:1]: result[732] is 5275.000000
[master:0]: result[2756] is 4673.000000
[master:0]: result[2757] is 11035.000000
[node:1]: result[733] is 9962.000000
[master:0]: result[2758] is 6948.000000
[node:1]: result[734] is 13046.000000
[node:1]: result[735] is 17649.000000
[master:0]: result[2759] is 12010.000000
[master:0]: result[2760] is 7555.000000
[node:1]: result[736] is 8381.000000
[node:1]: result[737] is 9819.000000
[master:0]: result[2761] is 12544.000000
[node:1]: result[738] is 15472.000000
[master:0]: result[2762] is 4841.000000
[master:0]: result[2763] is 12409.000000
[node:1]: result[739] is 10138.000000
[node:1]: result[740] is 7199.000000
[master:0]: result[2764] is 10201.000000
[master:0]: result[2765] is 12868.000000
[node:1]: result[741] is 13053.000000
[master:0]: result[2766] is 10722.000000
[node:1]: result[742] is 7670.000000
```

```
[master:0]: result[2767] is 15354.000000
[master:0]: result[2768] is 6389.000000
[node:1]: result[743] is 9619.000000
[master:0]: result[2769] is 13451.000000
[master:0]: result[2770] is 9366.000000
[node:1]: result[744] is 7068.000000
[master:0]: result[2771] is 12577.000000
[node:1]: result[745] is 8591.000000
[node:1]: result[746] is 16218.000000
[node:1]: result[747] is 17407.000000
[node:1]: result[748] is 5387.000000
[master:0]: result[2772] is 4457.000000
[master:0]: result[2773] is 14895.000000
[node:1]: result[749] is 4507.000000
[master:0]: result[2774] is 11430.000000
[master:0]: result[2775] is 14612.000000
[node:1]: result[750] is 7761.000000
[master:0]: result[2776] is 15123.000000
[node:1]: result[751] is 8425.000000
[node:1]: result[752] is 18425.000000
[node:1]: result[753] is 16792.000000
[master:0]: result[2777] is 7204.000000
[master:0]: result[2778] is 16382.000000
[node:1]: result[754] is 13086.000000
[master:0]: result[2779] is 10486.000000
[master:0]: result[2780] is 14592.000000
[node:1]: result[755] is 5855.000000
[master:0]: result[2781] is 10438.000000
[node:1]: result[756] is 14814.000000
[master:0]: result[2782] is 9291.000000
[master:0]: result[2783] is 2102.000000
[node:1]: result[757] is 8931.000000
[master:0]: result[2784] is 12548.000000
[master:0]: result[2785] is 9450.000000
[node:1]: result[758] is 4148.000000
[master:0]: result[2786] is 14472.000000
[master:0]: result[2787] is 13573.000000
[node:1]: result[759] is 6204.000000
[master:0]: result[2788] is 16838.000000
[node:1]: result[760] is 7384.000000
[master:0]: result[2789] is 11421.000000
```

```
[master:0]: result[2790] is 5583.000000
[node:1]: result[761] is 7444.000000
[master:0]: result[2791] is 4393.000000
[node:1]: result[762] is 13892.000000
[master:0]: result[2792] is 6670.000000
[master:0]: result[2793] is 6778.000000
[node:1]: result[763] is 12661.000000
[node:1]: result[764] is 13758.000000
[node:1]: result[765] is 9642.000000
[node:1]: result[766] is 6662.000000
[node:1]: result[767] is 8491.000000
[master:0]: result[2794] is 13154.000000
[node:1]: result[768] is 12166.000000
[node:1]: result[769] is 8487.000000
[master:0]: result[2795] is 6871.000000
[master:0]: result[2796] is 2350.000000
[node:1]: result[770] is 14981.000000
[master:0]: result[2797] is 10230.000000
[master:0]: result[2798] is 8578.000000
[node:1]: result[771] is 15718.000000
[node:1]: result[772] is 7892.000000
[master:0]: result[2799] is 11443.000000
[node:1]: result[773] is 9003.000000
[node:1]: result[774] is 11689.000000
[master:0]: result[3300] is 6914.000000
[master:0]: result[3301] is 10762.000000
[node:1]: result[775] is 11312.000000
[master:0]: result[3302] is 5965.000000
[master:0]: result[3303] is 9308.000000
[node:1]: result[776] is 7595.000000
[node:1]: result[777] is 7908.000000
[master:0]: result[3304] is 13689.000000
[node:1]: result[778] is 15071.000000
[master:0]: result[3305] is 10568.000000
[master:0]: result[3306] is 3773.000000
[node:1]: result[779] is 15687.000000
[node:1]: result[780] is 8768.000000
[master:0]: result[3307] is 12902.000000
[node:1]: result[781] is 12833.000000
[master:0]: result[3308] is 9847.000000
[master:0]: result[3309] is 5174.000000
```

```
[node:1]: result[782] is 10464.000000
[node:1]: result[783] is 9897.000000
[master:0]: result[3310] is 10213.000000
[master:0]: result[3311] is 9599.000000
[node:1]: result[784] is 5978.000000
[master:0]: result[3312] is 13554.000000
[node:1]: result[785] is 16255.000000
[node:1]: result[786] is 5754.000000
[master:0]: result[3313] is 7939.000000
```

V. Result for 2 node and 4 core

```
[master:1]: result[0] is 17205.000000
[master:1]: result[1] is 7758.000000
[master:1]: result[2] is 11007.000000
[master:1]: result[3] is 9072.000000
[master:1]: result[4] is 12274.000000
[master:1]: result[5] is 10080.000000
[master:1]: result[6] is 8952.000000
[master:1]: result[7] is 9645.000000
[master:1]: result[8] is 7241.000000
[master:1]: result[9] is 7962.000000
[master:1]: result[10] is 9432.000000
[master:1]: result[11] is 5485.000000
[master:1]: result[12] is 18528.000000
[master:1]: result[13] is 6644.000000
[master:1]: result[14] is 13979.000000
[master:1]: result[15] is 5350.000000
[master:1]: result[16] is 9079.000000
[master:1]: result[17] is 4618.000000
[master:1]: result[18] is 10255.000000
[master:1]: result[19] is 7908.000000
[master:1]: result[20] is 12388.000000
[master:1]: result[21] is 12240.000000
[master:1]: result[22] is 12399.000000
[master:1]: result[23] is 9467.000000
[master:1]: result[24] is 12024.000000
[master:1]: result[25] is 4336.000000
[master:1]: result[26] is 8344.000000
```

```
[master:1]: result[27] is 9214.000000
[master:1]: result[28] is 12653.000000
[master:1]: result[29] is 5185.000000
[master:1]: result[30] is 6847.000000
[master:1]: result[31] is 16211.000000
[master:1]: result[32] is 12944.000000
[master:1]: result[33] is 4206.000000
[master:1]: result[34] is 7987.000000
[master:1]: result[35] is 17922.000000
[master:1]: result[36] is 10638.000000
[master:1]: result[37] is 16940.000000
[master:1]: result[38] is 13919.000000
[master:1]: result[39] is 14231.000000
```

⋮

```
[master:1]: result[2907] is 9944.000000
[master:1]: result[2908] is 5062.000000
[master:1]: result[2909] is 4296.000000
[master:1]: result[2910] is 14829.000000
[master:1]: result[2911] is 7635.000000
[master:1]: result[2912] is 5844.000000
[master:1]: result[2913] is 10747.000000
[master:1]: result[2914] is 3626.000000
[master:1]: result[2915] is 12353.000000
[master:1]: result[2916] is 8669.000000
[master:1]: result[2917] is 19204.000000
[master:1]: result[2918] is 17978.000000
[master:1]: result[2919] is 10904.000000
[master:1]: result[2920] is 1001.000000
[master:1]: result[2921] is 18049.000000
[master:1]: result[2922] is 5632.000000
[master:1]: result[2923] is 7091.000000
[master:1]: result[2924] is 9688.000000
[master:1]: result[2925] is 7095.000000
[master:1]: result[2926] is 12276.000000
[master:1]: result[2927] is 7213.000000
[master:1]: result[2928] is 8720.000000
[master:1]: result[2929] is 7754.000000
[master:1]: result[2930] is 15806.000000
[master:1]: result[2931] is 10959.000000
```

```
[master:1]: result[2932] is 14547.000000
[master:1]: result[2933] is 11544.000000
[master:1]: result[2934] is 6232.000000
[master:1]: result[2935] is 8224.000000
[master:1]: result[2936] is 3594.000000
[master:1]: result[2937] is 3755.000000
[master:1]: result[2938] is 8168.000000
[master:1]: result[2939] is 8656.000000
[master:1]: result[2940] is 8051.000000
[master:1]: result[2941] is 5703.000000
[master:1]: result[2942] is 8996.000000
[master:1]: result[2943] is 10247.000000
[master:1]: result[2944] is 6450.000000
[master:1]: result[2945] is 12622.000000
[master:1]: result[2946] is 15305.000000
[master:1]: result[2947] is 7823.000000
[master:1]: result[2948] is 4531.000000
[master:1]: result[2949] is 5987.000000
[master:1]: result[2950] is 8727.000000
[master:1]: result[2951] is 5532.000000
[master:1]: result[2952] is 16740.000000
[master:1]: result[2953] is 17065.000000
[master:1]: result[2954] is 8975.000000
[master:1]: result[2955] is 12780.000000
[master:1]: result[2956] is 10512.000000
[master:1]: result[2957] is 17605.000000
[master:1]: result[2958] is 16346.000000
[master:1]: result[2959] is 5584.000000
[master:1]: result[2960] is 11711.000000
[master:1]: result[2961] is 8505.000000
[master:1]: result[2962] is 9248.000000
[master:1]: result[2963] is 6260.000000
[master:1]: result[2964] is 12754.000000
[master:1]: result[2965] is 15480.000000
[master:1]: result[2966] is 10836.000000
[master:1]: result[2967] is 16348.000000
[master:1]: result[2968] is 11939.000000
[master:1]: result[2969] is 15357.000000
[master:1]: result[2970] is 11358.000000
[master:1]: result[2971] is 6343.000000
[master:1]: result[2972] is 7412.000000
```

```
[node:2]: result[646] is 8879.000000
[master:1]: result[2973] is 16706.000000
[master:1]: result[2974] is 12942.000000
[master:1]: result[2975] is 6566.000000
[master:1]: result[2976] is 2033.000000
[master:1]: result[2977] is 10952.000000
[master:1]: result[2978] is 14391.000000
[node:2]: result[647] is 9191.000000
[master:1]: result[2979] is 6565.000000
[master:1]: result[2980] is 6940.000000
[node:2]: result[648] is 7955.000000
[node:2]: result[649] is 6084.000000
[node:2]: result[650] is 8082.000000
[node:2]: result[651] is 13973.000000
[node:2]: result[652] is 13967.000000
[node:2]: result[653] is 6434.000000
[master:1]: result[2981] is 19470.000000
[node:2]: result[654] is 13535.000000
[node:2]: result[655] is 13428.000000
[node:2]: result[656] is 13861.000000
[master:1]: result[2982] is 8449.000000
[master:1]: result[2983] is 6385.000000
[node:2]: result[657] is 17341.000000
[node:2]: result[658] is 10367.000000
[node:2]: result[659] is 17588.000000
[master:1]: result[2984] is 12887.000000
[node:2]: result[660] is 5011.000000
[node:2]: result[661] is 9029.000000
[master:1]: result[2985] is 13777.000000
[master:1]: result[2986] is 9166.000000
[node:2]: result[662] is 8825.000000
[node:2]: result[663] is 11260.000000
[node:2]: result[664] is 13207.000000
[master:1]: result[2987] is 6103.000000
[master:1]: result[2988] is 7734.000000
[node:2]: result[665] is 10054.000000
[node:2]: result[666] is 8023.000000
[node:2]: result[667] is 8722.000000
[master:1]: result[2989] is 11865.000000
[node:2]: result[668] is 1438.000000
[node:2]: result[669] is 12929.000000
```

```
[node:2]: result[670] is 6917.000000
[master:1]: result[2990] is 8040.000000
[master:1]: result[2991] is 5798.000000
[node:2]: result[671] is 11661.000000
[node:2]: result[672] is 12710.000000
[node:2]: result[673] is 16495.000000
[master:1]: result[2992] is 16722.000000
[node:2]: result[674] is 15401.000000
[node:2]: result[675] is 8710.000000
[master:1]: result[2993] is 17288.000000
[master:1]: result[2994] is 4762.000000
[node:2]: result[676] is 9097.000000
[node:2]: result[677] is 10633.000000
[master:1]: result[2995] is 9476.000000
[node:2]: result[678] is 14253.000000
[node:2]: result[679] is 9757.000000
[master:1]: result[2996] is 5472.000000
[master:1]: result[2997] is 11950.000000
[node:2]: result[680] is 9422.000000
[master:1]: result[2998] is 12177.000000
[master:1]: result[2999] is 17411.000000
[node:2]: result[681] is 8688.000000
[master:1]: result[3000] is 10012.000000
[node:2]: result[682] is 10082.000000
[node:2]: result[683] is 13390.000000
[master:1]: result[3001] is 9887.000000
[master:1]: result[3002] is 10106.000000
[node:2]: result[684] is 7827.000000
[master:1]: result[3003] is 3776.000000
[node:2]: result[685] is 13619.000000
[master:1]: result[3004] is 12946.000000
[master:1]: result[3005] is 5754.000000
[node:2]: result[686] is 9522.000000
[node:2]: result[687] is 1688.000000
[master:1]: result[3006] is 10344.000000
[master:1]: result[3007] is 11331.000000
[node:2]: result[688] is 3664.000000
[node:2]: result[689] is 9890.000000
[node:2]: result[690] is 9278.000000
[master:1]: result[3008] is 16706.000000
[node:2]: result[691] is 5027.000000
```

```
[node:2]: result[692] is 5271.000000
[node:2]: result[693] is 4455.000000
[master:1]: result[3009] is 17439.000000
[master:1]: result[3010] is 7896.000000
[node:2]: result[694] is 16288.000000
[node:2]: result[695] is 4831.000000
[master:1]: result[3011] is 6350.000000
[master:1]: result[3012] is 9613.000000
[node:2]: result[696] is 14509.000000
[node:2]: result[697] is 10663.000000
[node:2]: result[698] is 9905.000000
[master:1]: result[3013] is 9050.000000
[node:2]: result[699] is 8651.000000
[master:1]: result[3014] is 9088.000000
[master:1]: result[3015] is 8854.000000
[node:2]: result[700] is 9944.000000
[master:1]: result[3016] is 2827.000000
[node:2]: result[701] is 3174.000000
[node:2]: result[702] is 10314.000000
[master:1]: result[3017] is 4607.000000
[master:1]: result[3018] is 14957.000000
[node:2]: result[703] is 15359.000000
[node:2]: result[704] is 6021.000000
[master:1]: result[3019] is 13266.000000
[master:1]: result[3020] is 12824.000000
[node:3]: result[280] is 8027.000000
[node:3]: result[281] is 11266.000000
[node:3]: result[282] is 9991.000000
[node:3]: result[283] is 13077.000000
[master:1]: result[3021] is 9350.000000
[master:1]: result[3022] is 5416.000000
[node:3]: result[284] is 9193.000000
[node:3]: result[285] is 2258.000000
[master:1]: result[3023] is 5898.000000
[node:3]: result[286] is 14026.000000
[node:3]: result[287] is 17313.000000
[master:1]: result[3024] is 12990.000000
[master:1]: result[3025] is 10179.000000
[node:3]: result[288] is 15119.000000
[node:3]: result[289] is 9733.000000
[master:1]: result[3026] is 11727.000000
```

```
[node:3]: result[290] is 4772.000000
[node:3]: result[291] is 3821.000000
[master:1]: result[3027] is 11167.000000
[master:1]: result[3028] is 8481.000000
[node:3]: result[292] is 4740.000000
[node:3]: result[293] is 19470.000000
[master:1]: result[3029] is 10256.000000
[node:3]: result[294] is 9181.000000
[node:3]: result[295] is 3568.000000
[master:1]: result[3030] is 8579.000000
[master:1]: result[3031] is 14846.000000
[node:3]: result[296] is 5229.000000
[node:3]: result[297] is 11375.000000
[node:3]: result[298] is 9609.000000
[master:1]: result[3032] is 6496.000000
[node:3]: result[299] is 3803.000000
[master:1]: result[3033] is 1390.000000
[master:1]: result[3034] is 8623.000000
[node:0]: result[26] is 8344.000000
[master:1]: result[3035] is 5794.000000
[node:0]: result[27] is 9214.000000
[node:0]: result[28] is 12653.000000
[node:0]: result[29] is 5185.000000
[master:1]: result[3036] is 7144.000000
[master:1]: result[3037] is 11671.000000
[node:0]: result[30] is 6847.000000
[master:1]: result[3038] is 13477.000000
[master:1]: result[3039] is 6554.000000
[node:0]: result[31] is 16211.000000
[node:0]: result[32] is 12944.000000
[master:1]: result[3040] is 5462.000000
[node:0]: result[33] is 4206.000000
[master:1]: result[3041] is 17726.000000
[master:1]: result[3042] is 9258.000000
[node:0]: result[34] is 7987.000000
[node:0]: result[35] is 17922.000000
[master:1]: result[3043] is 15076.000000
[node:0]: result[36] is 10638.000000
[master:1]: result[3044] is 3128.000000
[master:1]: result[3045] is 14698.000000
[node:0]: result[37] is 16940.000000
```

```
[node:0]: result[38] is 13919.000000
[node:0]: result[39] is 14231.000000
[node:0]: result[40] is 7607.000000
[master:1]: result[3046] is 13930.000000
[node:0]: result[41] is 13352.000000
[master:1]: result[3047] is 12307.000000
[master:1]: result[3048] is 5657.000000
[node:0]: result[42] is 6068.000000
[node:0]: result[43] is 6135.000000
[master:1]: result[3049] is 5240.000000
[node:0]: result[44] is 6348.000000
[master:1]: result[3050] is 8277.000000
[master:1]: result[3051] is 14833.000000
[node:0]: result[45] is 12752.000000
[master:1]: result[3052] is 10943.000000
[node:0]: result[46] is 14191.000000
[master:1]: result[3053] is 10045.000000
[master:1]: result[3054] is 17083.000000
[node:0]: result[47] is 11779.000000
[master:1]: result[3055] is 16637.000000
[node:0]: result[48] is 13722.000000
[master:1]: result[3056] is 2928.000000
[master:1]: result[3057] is 15162.000000
[node:0]: result[49] is 4446.000000
[master:1]: result[3058] is 7805.000000
[node:0]: result[50] is 12392.000000
[master:1]: result[3059] is 14115.000000
[master:1]: result[3060] is 11771.000000
[node:0]: result[51] is 6111.000000
[master:1]: result[3061] is 12737.000000
[node:0]: result[52] is 9392.000000
[master:1]: result[3062] is 8961.000000
[master:1]: result[3063] is 10971.000000
[node:0]: result[53] is 14791.000000
[master:1]: result[3064] is 4127.000000
[node:0]: result[54] is 11931.000000
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```

V. CONCLUSION

The result shows that by configuring hybrid parallel approach if the task is independent of individual work and there is no dependency in computation then such an embarrassingly parallel application can be used to implement with such kind of system where we can maximize the utilization of each processor core on each node.

Note that if task has dependency than just to handle accuracy for it one can not achieve more performance as the expected parallelization performance can't be achieved.