HPC LAB 2 : Vector Multiplication

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Programming Environment: OpenMP
Problem: Vector Multiplication
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Hardware Configuration:

CPU NAME : Intel Core i5-8250U @ 8x 3.4GHz
Number of Sockets : 1
Cores per Socket : 4
Threads per core : 2
L1 Cache size : 32KB
L2 Cache size : 256KB
L3 Cache size(Shared): 6MB
RAM : 8 GB

Serial Code:

```
#include<omp.h>
#include<stdlib.h>
#include<stdio.h>

#define n 10000

int main(int argc, char argv[])
{
   int i = 0;
   double  a[n]; double b[n]; double c[n];
   float start_time; float end_time; float exec_time;

   start_time = omp_get_wtime();
                    for(i = 0; i < n; i = i+1)
                    {
                              for(int j = 0; j < n; j = j+1);
                              a[i] = i * 58.473;
                              b[i] = i * 218.893;
                              c[i] = a[i] * b[i];
                              printf("a[%d] = %lf, b[%d] = %lf, c[%d] = %lf\n", i, a[i], i, b[i], i, c[i]);
                    }
```

```
    end_time = omp_get_wtime();
    exec_time = end_time - start_time;
    printf("%f\n", exec_time);
}
```

Parallel Code:

```
#include<omp.h>
#include<stdlib.h>
#include<stdio.h>

#define n 10000

int main(int argc, char argv[])
{
    int omp_rank;
    int i = 0;
    double  a[n]; double b[n]; double c[n];
    float start_time; float end_time; float exec_time;

    start_time = omp_get_wtime();
    #pragma omp parallel private(i) shared (a, b, c)
    {
        #pragma omp for
            for(i = 0; i < n; i = i+1)
            {
                omp_rank = omp_get_thread_num();
                for(int j = 0; j < n; j = j+1);
                a[i] = i * 58.473;
                b[i] = i * 218.893;
                c[i] = a[i] * b[i];

                printf("a[%d] = %lf, b[%d] = %lf, c[%d] = %lf, Thread ID = %d \n", i, a[i], i,
b[i], i, c[i], omp_rank);
            }
    }
    end_time = omp_get_wtime();
    exec_time = end_time - start_time;
    printf("%f\n", exec_time);
}
```

Compilation and Execution:

For enabling OpenMP environment use -fopenmp flag while compiling using gcc;

gcc -fopenmp openMP_vectormultiplication.c

For execution use;

export OMP_NUM_THREADS = x (Where x is the number of threads we are deploying)
./a.out

OBSERVATION TABLE

No of Threads	Execution Time	Speedup	Parallel Fraction
1	0.333984		
2	0.186523	1.790578106	0.8830423014
4	0.157227	2.124215307	0.7056505701
6	0.109375	3.053568	0.8070171026
8	0.130859	2.552243254	0.6950717913
10	0.092773	3.600012935	0.8024702447
12	0.089844	3.717376786	0.7974470198
16	0.107422	3.1090838	0.7235859602
20	0.09375	3.562496	0.7571557163
24	0.106445	3.137620367	0.710908307
32	0.098633	3.386128375	0.7274090009
64	0.104492	3.196263829	0.6980416132
128	0.149414	2.235292543	0.556982691

Speed up can be found using the following formula;

S(n)=T(1)/T(n) where, S(n) = Speedup for thread count ‘n’
T(1) = Execution Time for Thread count ‘1’ (serial code)
T(n) = Execution Time for Thread count ‘n’ (serial code)

Parallelization Fraction can be found using the following formula;

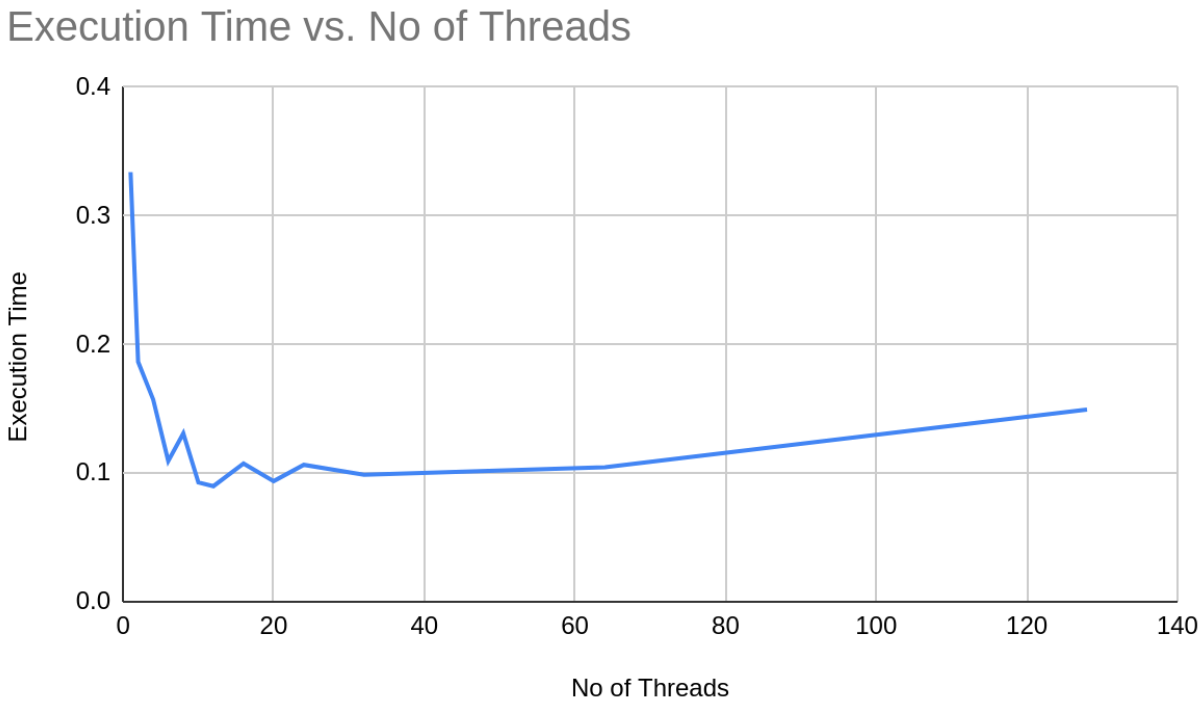
S(n)=1/((1 - p) + p/n where, S(n) = Speedup for thread count ‘n’
n = Number of threads
p = Parallelization fraction

Assumption:

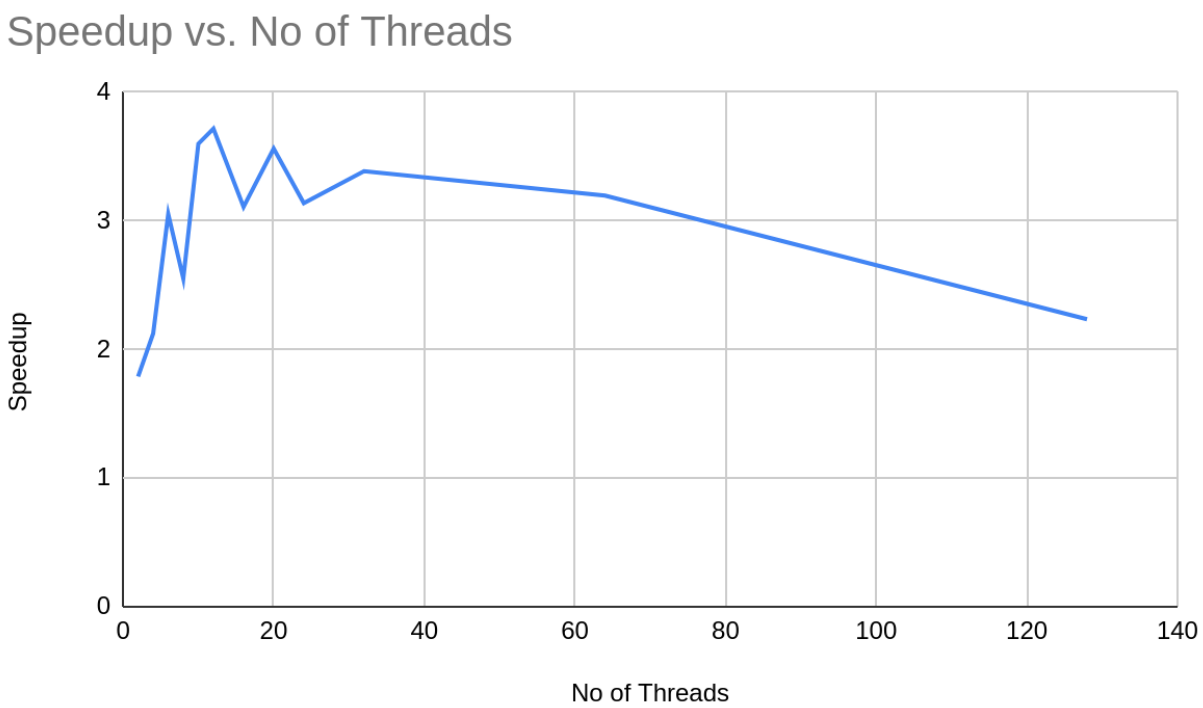
Following extra for loop is added to increase the number of operations in the parallel region to visualize the effect of multi-threading in vector multiplication.

for(int j=0;j<m;j++)

Number of Threads(x axis) vs Execution Time(y axis) :



Number of Threads(x axis) vs Speedup(y axis):



Inference:

(Note: Execution time, graph and inference will be based on hardware configuration)

• At thread count 12 maximum speedup is observed.

• If thread count is more than 12, after thread count 20, the execution time continues increasing and the speedup decreases and tapers out in the end.