Walchand College of Engineering, Sangli
Department of Computer Science and Engineering

Class: Final Year (Computer Science and Engineering)

Year: 2023-24 **Semester:** 1

Course: High Performance Computing Lab

Practical No. 2

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Exam Seat No: 2020BTECS00057

Title of practical: Study and implementation of basic OpenMP clauses

Implement following Programs using OpenMP with C:

1. Vector Scalar Addition
2. Calculation of value of Pi
   Analyse the performance of your programs for different number of threads and Data size.

Problem Statement 1:

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

#define VECTOR_SIZE 10000

int main() {
    float vector[VECTOR_SIZE];
    int scalar = 5;
    for (int i = 0; i < VECTOR_SIZE; i++) {
        vector[i] = i + 100.987;
    }

    double start_time_serial = omp_get_wtime();
    for (int i = 0; i < VECTOR_SIZE; i++) {
        vector[i] += scalar;
    }

    double end_time_serial = omp_get_wtime();
    printf("Serial Method Time: %f seconds\n", (end_time_serial -
start_time_serial));

    for (int i = 0; i < VECTOR_SIZE; i++) {
        vector[i] = i + 100.987;
```

```
    }

    double start_time_parallel = omp_get_wtime();

    #pragma omp parallel for private(scalar) num_threads(100)
        for (int i = 0; i < VECTOR_SIZE; i++) {
                vector[i] += scalar;
            }
    double end_time_parallel = omp_get_wtime();
    printf("Parallel Method Time: %f seconds\n", (end_time_parallel -
start_time_parallel));
    return 0;
}
```

Screenshots:

Keeping number of threads constant and varying size of Data.

Threads = 8(default) Vector size = 100

```
mrunal@mrunal:~/Desktop/HPC$ cc -fopenmp 3.c
mrunal@mrunal:~/Desktop/HPC$ ./a.out
Serial Method Time: 0.000072 seconds
Parallel Method Time: 0.004335 seconds
mrunal@mrunal:~/Desktop/HPC$
```

Threads = 8(default) Vector size = 1000

```
mrunal@mrunal:~/Desktop/HPC$ cc -fopenmp 3.c
mrunal@mrunal:~/Desktop/HPC$ ./a.out
Serial Method Time: 0.000006 seconds
Parallel Method Time: 0.004080 seconds
mrunal@mrunal:~/Desktop/HPC$
```

Threads = 8(default) Vector size = 10000

```
mrunal@mrunal:~/Desktop/HPC$ cc -fopenmp 3.c
mrunal@mrunal:~/Desktop/HPC$ ./a.out
Serial Method Time: 0.000006 seconds
Parallel Method Time: 0.000434 seconds
mrunal@mrunal:~/Desktop/HPC$
```

Threads = 8(default) Vector size = 100000

```
mrunal@mrunal:~/Desktop/HPC$ cc -fopenmp 3.c
mrunal@mrunal:~/Desktop/HPC$ ./a.out
Serial Method Time: 0.000007 seconds
Parallel Method Time: 0.018040 seconds
mrunal@mrunal:~/Desktop/HPC$
```

Keeping data constant and increasing number of threads.

Threads = 10 Vector size = 10000

```
mrunal@mrunal:~/Desktop/HPC$ cc -fopenmp 3.c
mrunal@mrunal:~/Desktop/HPC$ ./a.out
Serial Method Time: 0.000006 seconds
Parallel Method Time: 0.000433 seconds
mrunal@mrunal:~/Desktop/HPC$
```

Threads = 100 Vector size = 10000

```
mrunal@mrunal:~/Desktop/HPC$ cc -fopenmp 3.c
mrunal@mrunal:~/Desktop/HPC$ ./a.out
Serial Method Time: 0.000006 seconds
Parallel Method Time: 0.004434 seconds
mrunal@mrunal:~/Desktop/HPC$
```

Threads = 1000 Vector size = 10000

```
mrunal@mrunal:~/Desktop/HPC$ cc -fopenmp 3.c
mrunal@mrunal:~/Desktop/HPC$ ./a.out
Serial Method Time: 0.000007 seconds
Parallel Method Time: 0.019956 seconds
mrunal@mrunal:~/Desktop/HPC$
```

Information:

Vector and scaler addition is to be performed using sequential and parallel approach. We have to analyse the time both approaches. For parallel approach analysis can be done in two ways, first by keeping data constant and varying number of threads and secondly by keeping number of threads constant and varying size of data.

Analysis:

1)As we go on increasing the size of data the time it takes to execute in parallel also increases.

2)By keeping data constant and increasing number for threads gradually increase the execution time due to increase in logical thread causes extra mapping time.

3) Here Serial time is less than parallel because insufficient data for parallelism which causes extra overhead of communication time.

Number of Threads	Data Size	Sequential Time	Parallel Time
8	100	0.00000	0.002000
8	1000	0.00000	0.002000
8	10000	0.00000	0.002000
8	100000	0.00000	0.002000
10	10000	0.00000	0.002000
100	10000	0.00000	0.004434
1000	10000	0.00000	0.019956

Problem Statement 2:

```
#include <stdio.h>
#include <stdlib.h>
#include <time.h>
#include <omp.h>
int main() {
    int totalPoints = 10000000;
    int pointsInsideCircle = 0;
    double x, y;
    printf("Enter the number of terms: ");
    scanf("%d", &totalPoints);
    double start_time_serial = omp_get_wtime();
    for (int i = 0; i < totalPoints; ++i) {
        x = (double)rand() / RAND_MAX;
        y = (double)rand() / RAND_MAX;
        if (x * x + y * y <= 1.0) {
            pointsInsideCircle++;
        }
    }
    double pi = 4.0 * pointsInsideCircle / totalPoints;
    double end_time_serial = omp_get_wtime();
    printf("serial Method Time: %f seconds\n", (end_time_serial -
start_time_serial));
    printf("Estimated value of pi: %f\n", pi);
    return 0;
}
```

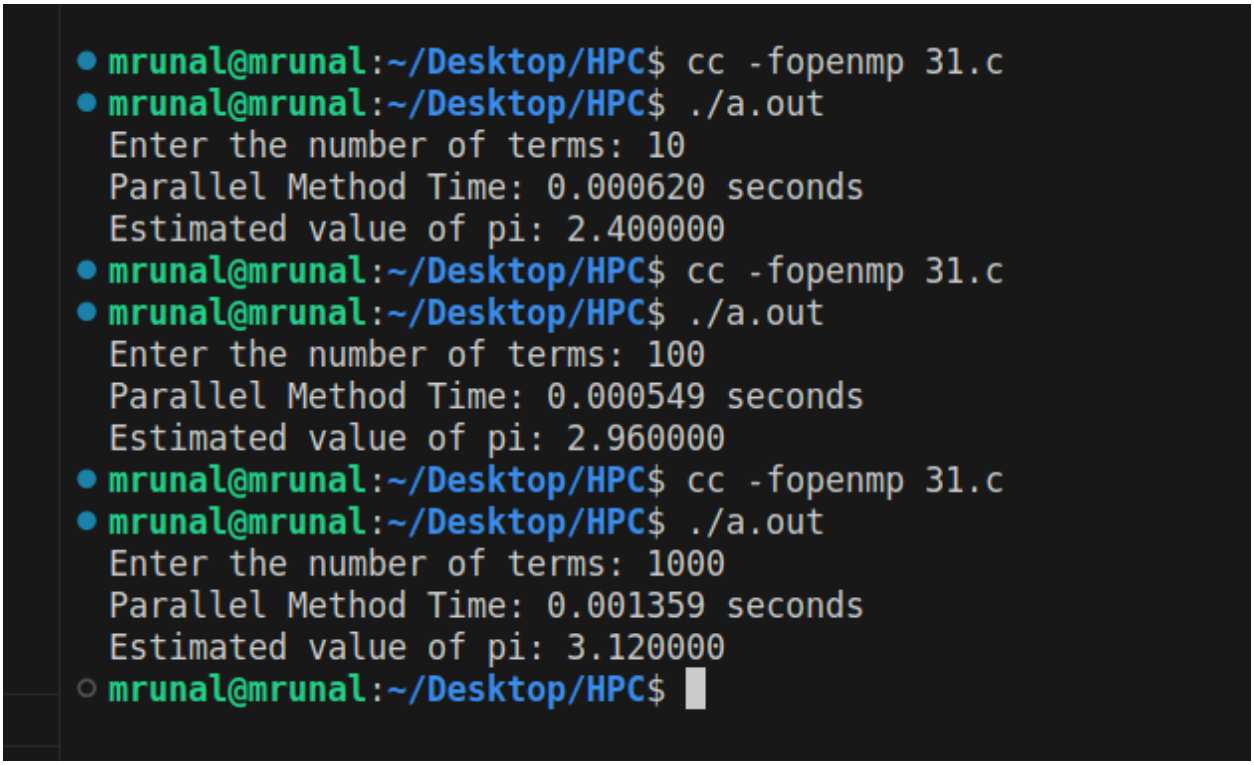
Screenshots:

```
mrunal@mrunal:~/Desktop/HPC$ cc -fopenmp 31.c
mrunal@mrunal:~/Desktop/HPC$ ./a.out
Enter the number of terms: 10
serial Method Time: 0.000002 seconds
Estimated value of pi: 3.200000
mrunal@mrunal:~/Desktop/HPC$ cc -fopenmp 31.c
mrunal@mrunal:~/Desktop/HPC$ ./a.out
Enter the number of terms: 100
serial Method Time: 0.000010 seconds
Estimated value of pi: 3.120000
mrunal@mrunal:~/Desktop/HPC$ cc -fopenmp 31.c
mrunal@mrunal:~/Desktop/HPC$ ./a.out
Enter the number of terms: 1000
serial Method Time: 0.000120 seconds
Estimated value of pi: 3.132000
mrunal@mrunal:~/Desktop/HPC$
```

Parallel

```
#include <stdio.h>
#include <stdlib.h>
#include <time.h>
#include <omp.h>
int main() {
    int totalPoints = 10000000;
    int pointsInsideCircle = 0;
    double x, y;
    printf("Enter the number of terms: ");
    scanf("%d", &totalPoints);
    double start_time_parallel = omp_get_wtime();
    #pragma omp parallel for private(x, y) reduction(+:pointsInsideCircle)
    for (int i = 0; i < totalPoints; ++i) {
        x = (double)rand() / RAND_MAX;
        y = (double)rand() / RAND_MAX;
        if (x * x + y * y <= 1.0) {
            pointsInsideCircle++;
        }
    }
    double pi = 4.0 * pointsInsideCircle / totalPoints;
    double end_time_parallel = omp_get_wtime();
    printf("Parallel Method Time: %f seconds\n", (end_time_parallel -
start_time_parallel));
    printf("Estimated value of pi: %f\n", pi);
    return 0;
}
```

OUTPUT


mrunal@mrunal:~/Desktop/HPC$ cc -fopenmp 31.c
mrunal@mrunal:~/Desktop/HPC$ ./a.out
Enter the number of terms: 10
Parallel Method Time: 0.000620 seconds
Estimated value of pi: 2.400000
mrunal@mrunal:~/Desktop/HPC$ cc -fopenmp 31.c
mrunal@mrunal:~/Desktop/HPC$ ./a.out
Enter the number of terms: 100
Parallel Method Time: 0.000549 seconds
Estimated value of pi: 2.960000
mrunal@mrunal:~/Desktop/HPC$ cc -fopenmp 31.c
mrunal@mrunal:~/Desktop/HPC$ ./a.out
Enter the number of terms: 1000
Parallel Method Time: 0.001359 seconds
Estimated value of pi: 3.120000
mrunal@mrunal:~/Desktop/HPC$