Tutorial-05:OpenMP

1. Explain the differences between the following three pieces of code. Are they all correct? Assume the array v has length m and the values in array indices range from 0 to m.

1)
```
#pragma omp parallel for default(none) shared(v, indices, n)
for (i = 0; i < n; i++)
    v[ indices[i] ] += f(i);
```

2)
```
#pragma omp parallel for default(none) shared(v, indices, n)
for (i = 0; i < n; i++)
    #pragma omp critical
    v[ indices[i] ] += f(i);
```

2. Given the following code, assume that the code is executed by two threads, iterations are distributed in two big chunks, one per thread, and function f(i) takes i ms to execute.

Answer the questions below.

```
#pragma omp parallel
{
    #pragma omp for schedule(static)
    for (i = 1; i < n; i++)
        f(i);
    #pragma omp for schedule(static)
    for (i = 1; i < n; i++)
        f(n-i);
}
```

a) How long would each thread take to execute the parallel region? How much of that time is spent in waiting for the other thread?

b) How would change the execution time if we used schedule(static,1) in both for directives? Would it improve if we used schedule(dynamic, 1)?

Is there an openmp clause that allows to eliminate the waiting time? How long would each thread take when using this clause?

3. In this task you will estimate the value of π using the Monte Carlo method. Given a probability P, the Monte Carlo method relies on the generation of random samples (events) to compute a numerical approximation of P.

Consider a circle inscribed in a square (Fig. 1);

The method simply consists in generating random points (x, y) within the square range. Given the probability that the points lie within the circle, and the actual number of generated random points that do so, we can estimate π.

First, what is the probability of random points ending up within the area of the circle? The answer is to find the relationship between the geometry of the square and the circle. The area of the square is $4R^2$ and the area of the circle is πR^2.

Now, the ratio of the area of the circle over the area of the square is $\pi/4$

. That is, the probability that a random point within the square lies also within the circle is $P = \pi/4$, and thus $\pi = 4P$.

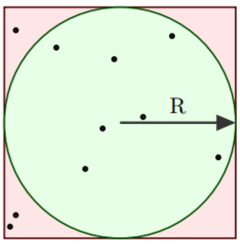

Fig:1

i. Draw the graph for Number of points vs the Pi values.
    1. 10,10^2, 10^4, 10^6, 10^7, 10^8,10^9.

ii. Draw the relationship between the error in the estimate of pi and the sample size.

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4. Question : Implement a parallel traversal of a binary tree using OpenMP to compute the sum of all node values. Ensure thread safety and efficient parallelism.

5. Question : Implement BFS and DFS traversals using OpenMP. Ensure thread safety and efficient parallelism.
6. Write an OpenMP program to determine the default scheduling of your OpenMP implementation of choice. Assume it is one of static, dynamic, or guided.

Optional :

In this task you will parallelize a given sequential code that solves a **steady-state heat conduction problem over a thin square plate**. The code simulates the diffusion of heat on a plate to determine at which temperature it stabilizes.

a. The initial temperature of the surface is 50 degrees, and a constant temperature is applied at the boundaries. Specifically, the left, top and right boundaries are kept constant at 100 degrees while the bottom boundary is kept at 0 degrees