CS 133 Parallel and Distributed Computing
Winter 2020
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Homework #2

Due Date: 1/30/20 10:00AM

Reading assignment:
Lecture notes 4, 5, and 6.

Homework problems:

1. Given an integer array *a[ ]* of *N* elements of value between *1* to *m* as the input, please write an efficient OpenMP function to generate the histogram *h* for array *a[ ]* such that *h[i]* is the number of elements in *a* with value *i (1 <= i <= m).* The function header is: `void histogram(int *a, int *h).` In addition, you can use constant variables *N* and *m* in your function directly. Is there a possibility for race condition in your implementation? If so, how do you handle it?

2. Please write an OpenMP program to compute the numerical value of the integration of the function $\text{sqrt}(x)/(1+x^3)$ between 0 and 1 using 16 threads. Your goal is to make it as efficient as possible. Please present two ways to deal with possible race conditions and compare their efficiency.

3. Given the following OpenMP program (segment) running on four CPU cores using four threads, assuming that the computation of function *f(i, j*) takes one minute on a single CPU core, and we ignore that scheduling overhead. You are asked to experiment with different scheduling methods. Please estimate the completion time under each of the following schedule schemes:

    a. default scheduling
    b. schedule (dynamic, 2)
    c. schedule (guided, 1)

```
#pragma omp parallel for
for (int i = 0; i < 12; i++)
        for (int j = 0; j <= i; j++)
                a[i][j] = f(i, j);
```

4. How one may use large memory bandwidth to hide high memory latency? Please outline two ways and discuss the additional resources needed.

5. Given the baseline processor described in Lecture 5 (1Ghz clock frequency with two multiply-add units), assuming that it has a cache of 32KB with a cache line size of 64B (8 words), if we want to perform the dot-product of two integer vectors of length 1024 each, what is the best memory layout to achieve the highest performance? (Note that each integer is 1 word = 4B.)

6. Given the processor in #5, if we want to multiply two integer matrices of 1024x1024 each, please compute the best tile size, and estimate the peak performance (in terms of GOP/sec) for the tiled matrix multiplication program discussed in Lecture 5.

Late submission policy:
We allow one-day delay with 10% penalty. After that, no submission will be accepted and the solutions may be discussed in the discussion sessions.