

COMP3080 Module 3—In-Class Exercise #8

Consider the following C program using the OpenMP mechanism for implicit thread creation:

```
const int UPPER = 500;
int sum; // shared variable

void increment() {
    for (int i = 1; i <= UPPER; ++i){
        ++sum;
    }
}

int main() {
    sum = 0;

    // create concurrent instances of function increment
    #pragma omp parallel
    {
        increment();
    }

    printf("sum == %d\n", sum);
    return 0;
}
```

Note: Recall that the OpenMP compiler directive `#pragma omp parallel` creates a separate thread for each “virtual processor” available on the host system, and then runs the associated block of code in each of the threads.

- 1) **(10 points)** If the host system has **two** virtual processors, determine the actual lower bound and upper bound on the final value of the shared variable **sum** output by this concurrent program. **Explain your answer.**
(Assume that the two threads created by OpenMP can execute at any relative speed; and that due to the host system architecture, a memory value such as **sum** can only be incremented by a thread after it has been loaded into a register by a separate machine instruction, and then the register value must be stored back into memory by a third machine instruction.)
- 2) **(5 points)** Now suppose that the host system has ***N*** virtual processors, and that the resulting ***N*** threads are permitted to execute concurrently under the assumptions of part (1). What effect will this modification have on the range (lower and upper bounds) of final values of **sum**? **Explain your answer.**

A caveat: Although the program shown above can be compiled and executed (if you include the required header files!), you will not be guaranteed to get the actual lower bound under the stated assumptions in a reasonable number of runs. You must use an analytical approach for this problem, in which the actual lower bound represents a “worst case” scenario.

(When your group is finished, your group’s Recorder should submit your answer as a PDF or MS Word file, or simply in a submission comment. In the submission comment, include the names of the team members who actually participated today.)