COMP 633: Parallel Computing
Programming Assignment 1(b)
Parallel all-pairs n-body simulation

Assigned: Thu Sep 17
Due: Thu Oct 1 (at start of class)

In this assignment you will use OpenMP to parallelize the two sequential n-body programs constructed in PA1(a). First update your PA1(a) sequential all-pair and half-pair programs as needed for correctness and performance. Verify the resulting programs compute approximately the same results as the all-pair reference implementation. Your half-pairs solution must make use of Newton's third law, \( f_{ij} = -f_{ji} \), to halve the number of force calculations needed compared to the all-pairs solution. I have posted the all-pair and half-pair solutions (written in C) that I benchmarked in class for pa1a. You can use or adapt these sequential solutions, if you wish, as a starting point for this assignment.

Programming Assignment

1. Plot the performance of your all-pairs and half-pairs sequential n-body programs for \( k = 6 \) time steps with values of \( n \in \{10, 20, 50, 100, 200, 500, 1000, 2000, 5000, 10000\} \) on the x axis and the observed interaction rate \( R(n, p) = \frac{kn^2}{t_p} \) on the y axis (in units of millions of interactions per second). Here \( t_p \) is the wall-clock time to perform \( k \) time steps. Add the complete command line used to compile the programs on the plot or on an attached sheet.

2. Add OpenMP parallelization directives to your two n-body programs in (1) and experiment to maximize performance. Insure the final versions maintain approximately the same results using the reference implementation. Use the \texttt{omp_get_wtime()} function from OpenMP in the master thread to obtain \( t_p \), the elapsed time in seconds.

3. Plot the parallel performance of your two programs in (2) on separate graphs. The x-axis of the graph is the number of bodies \( n \in \{200, 500, 1000, 2000, 5000, 10000, 20000\} \), and the y-axis is the performance \( R(n, p) \) in millions of interactions per second. For each \( p \in \{1, 4, 8, 16, 18, 20\} \) plot and connect the points \((n, R(n, p))\). Add the complete command line used to compile the programs and the settings of any OMP-specific environment variables such as \texttt{KMP_AFFINITY} or \texttt{GOMP_AFFINITY} and \texttt{OMP_NUM_THREADS}.

Submission

Submit your code like pa1a: send me the three performance plots before the start of class on the due date along with a listing of your parallel all-pairs and half-pairs n-body programs developed in (3) above. You can work together with a partner, if you wish just as in pa1a (be sure to include both names on the submission).