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 am posting the all-pair and half-pair solutions that I benchmarked in class. You can use 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 $R(n, p) = kn^2/t_p$ 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 `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 KMP_AFFINITY or GOMP_AFFINITY and OMP_NUM_THREADS.

Submission

Submit your code like pa1a: turn in the three performance plots at 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 (be sure to include both names on the submission).