3460:4/577 LAB 6: ASTRONOMICAL N-BODY PROBLEM

Write an OpenMP program to perform an *N*-body simulation. *N* nodes are randomly scattered over a square, two-dimensional space. Each node is described by an associated mass, position and velocity. Nodes are subjected to an applied force by other nodes within the space. Write a program for simulating the movement of the nodes in time.

Given *N* bodies with positions (x_i,y_i) the total acceleration of body *i* due to its interactions with the other *N* – 1 bodies is obtained by summing all interactions:

$$a_i = Gm_i \sum_{\substack{1 \le j \le N \\ j \ne i}} \frac{m_j d_{ij}}{\left(\left\| d_{ij} \right\|^2 \right)^{3/2}}$$

where *G* is the universal gravitational constant, m_j is the mass of node *j* and d_{ij} is the distance from node *i* to node *j*. ***Note that a direction*** (*x* or *y*) ***is associated with*** a_i.

Once you have the accumulated acceleration a_i at time *t*, the new velocity *v* and position *p* for node *i* at time $t+\delta t$ are calculated using $v^{t+\delta t} = v^t + a_i \delta t$ and $p^{t+\delta t} = p^t + v^t \delta t$.

The initial velocity for each node is 0 and mass is 1. Let *G* be 1 for simplicity. There are 1000 nodes. The positions of these nodes can be found in the `nbodies.dat` file on the web page. Here each line contains *x* and *y* coordinates of a node. The positions of each node are randomly generated within a 200-by-200 space. Simulate 100 steps with each time step δt = 0.01. Use type double to do calculations. If final positions of some nodes are much outside the 200-by-200 range your program probably has some mistakes.

The nearest possible distance between two nodes is 0.1. Only calculate interactions between two nodes which are separated by a distance of more than 0.1. This artificial assumption reduces numerical errors caused by small denominators.

After 100 time steps, every node will have moved to a new position. Print out the positions of the last 20 (981 to 1000) nodes and the computation time.

Write OpenMP code which launches 1000 threads, each of which tracks the progress of a single body. Synchronize at each time step. At the end submit a lab report including code, results, calculation times and discussions for a grade.

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