CS224 Project proposal - Distributed hierarchical spatial decomposition

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Hierarchical space partitioning (HSP) is an essential step in many geometric algorithms, like exact nearest neighbors, collision detection, or generalized n-body problems. I propose to research the distributed parallel construction and use of HSP methods for the n-body problem.

Classically, the n-body problem was researched in astrophysics to study the dynamics of gravitation in the galaxy. In my research, I translate the partial differential equations describing the behavior of fault systems in the Earth's crust into a convolution over the boundary of the domain – a boundary integral equation. EQUATIONS. Then, by representing each integral as the sum of a number of carefully placed points, quadrature methods convert an integral equation into an n-body problem. The difficulty with this method is that naive algorithms for n-body problems require $O(n^2)$ time, because each particle must interact with each other particle. Approximate $O(n)$ or $O(n \log n)$ time methods have been developed by approximating the far-field interactions. These methods are generally called "fast" n-body solvers. Fast n-body solvers necessarily use some hierarchical spatial decomposition (normally octrees) in order determine which interactions are in the far-field and which interactions are in the near-field.

Why distribute the data structure?

Strong and weak scaling

Ball trees and median finding.

MPI vs Actors

Data replication across nodes

Comparison between kd-trees, ball trees, octrees, sliding-midpoint kdtrees.

What else?