MASSIVELY PARALLEL COMPUTING WITH CONSUMER ELECTRONICS

SCIENTIFIC ACHIEVEMENT: Until very recently, the ability to perform large-scale computer simulations was tightly constrained by the limited availability of time on large institutionally-owned, very expensive supercomputers. We, and a large number of other researchers, have overcome these limitations by designing and building a series of massively parallel cluster computers using low-priced high-performance consumer electronics. This paradigm of the Beowulf cluster has increased the amount of computing power available to us by orders of magnitude, and allowed us to pursue new and exciting research directions. The basic idea of a Beowulf cluster is to assemble a large number of conventional PCs, usually containing a Pentium-family chip, into a network connected by ethernet communication. The software is provided by a Linux operating system and MPI-based parallel computer codes. We have built two generations of clusters, with a third generation cluster on order. While the first system consisted of 36 nodes running 450MHz Pentium III computers connected by 100 megabit ethernet, Moore's Law increases in performance over less than a four-year period means that the system currently on order will consist of 100 Pentium 4 computers running at 2.6GHz connected together by gigabit ethernet. In direct head-to head tests of our applications, each node on our second generation 700MHz Pentium III cluster outperformed the nodes on Cray T3E supercomputer. Our third generation cluster will be 3-4 times faster yet. The availability of such massive computer resources in-house has enabled us to tackle qualitatively new problems, involving the atomic-level simulation of grain growth and deformation in polycrystalline materials, large scale simulations of ferroelectricity in perovskite materials, and simulations of phonon-based heat transport in nanostructures.

SIGNIFICANCE: The capability for individual researchers or small groups of researchers to build a supercomputer for under $100k, is revolutionizing materials simulation. The relentless increase in performance of consumer computers will continue to allow rapid increases in computing power and the provide the ability to tackle evermore complex materials problems.

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Massively Parallel Computing with Consumer Electronics

Hardware

Odin I Beowulf Cluster

36 nodes - 450MHz Pentium III (9/1999)
Upgraded to 1GHz PIII (5/2001)

Odin II Beowulf Cluster

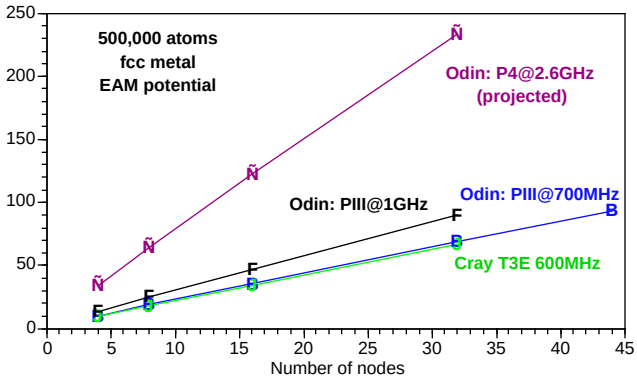
100 nodes - 700MHz Pentium III (8/2000)

Odin III Beowulf Cluster
100 nodes - 2.6GHz Pentium 4 (6/2003)

Odin II

Software

Red Hat Linux
MPI
Pentium Group Fortran



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