Twenty Alpha workstations form Super-Computer

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When Assistant Professor Jonathan Freund of UCLA's Department of Mechanical and Aerospace Engineering took delivery of twenty Compaq XP1000 Professional Workstations in July 1999, this was another milestone of a project that began three and a half years ago. The 20-node Beowulf-class cluster is one of the first Alpha-based super-computer clusters at an educational institution.

An evaluation XP1000, which is based on the EV6 (21264 series) Alpha chip, was delivered in May 1999. At that time, the Linux operating system did not yet have certified support from Compaq. It was up to Robert Lindsay, of VLSystems, a systems and software engineering firm in Irvine CA, to devise an installation procedure, and to indicate to Compaq those modifications required for successful installation and maintenance of a relatively stable, running system.

After considerable effort, and meshing with the work being performed by Compaq engineers, the struggle paid off. VLSystems delivered to UCLA the first XP1000 Professional Workstation running Red Hat Linux v.5.2 with a uni-processor kernel modified by Compaq, which has since been released as Red Hat Linux v.6.0.

Why the XP1000?

The Alpha-based XP1000 was selected because of its high-speed floating-point computational ability and its low cost per flop (floating point operation). Equally important, however, was that this high-performance permitted forming a cluster with far fewer CPUs, greatly reducing the "hassle factor," as Prof. Freund put it, of having to deal with a larger number of computers.

Software Application Requires Super-Computer

The scientific software application that requires this computer-power calculates from first principles aircraft jet noise produced by the flow turbulence. It solves the exact equations that govern the behavior of the flow. The flow is solved on a fine mesh of 25 million points and approximately 50,000 time intervals.

A particularly knotty problem is to resolve at the same time, both the large dimensions (the entire jet flow) and small dimensions (the length of a turbulence eddy).

Professor Freund and Professor John Kim, of the same department, intend to also use the system to study means of controlling turbulence for enhanced mixing in high-speed jet exhaust and turbulence boundary-layer drag. The system is also a teaching tool for graduate students of the department, so the development of the super-computer cluster itself has been its own laboratory.

Running the jet noise application on previous computer systems required 1 to 2 months of continuous operation to produce a solution. In the course of the simulation the solution is checkpointed frequently so it can be re-started in the event of a hardware or software malfunction.

If the study of turbulence is not sufficient to fully utilize this new super-computer, Prof. Freund is also studying microscale fluid mechanics using molecular dynamics simulation, which tracks the motion of individual atoms!

It is clear that we will never have a super-computer that is "fast enough."

Current state of the cluster

The clustering software being used is a variant of the MPI (Message Passing Interface) standard free-ware, called MPICH, which provides libraries for passing data between the computers in the cluster.

Performance

So far, performance comparisons have only been made for a single-CPU. For example, fast Fourier transforms on the XP1000 ran at 650 Mflops, compared to 330 Mflops on the previous version of the processor, the EV5 (21164 series) Alpha.

For further comparisons, a single processor of an SGI Origin 2000 (32-processor array), running at 195 MHz was measured at 280 Mflops. A 300 MHz Pentium workstation clocked at 120 Mflops and a 300 MHz Pentium laptop ran at only 60 Mflops!

When Professor John Kim benchmarked the performance of a simulation of turbulent flow between flat plates, the XP1000 ran at one-fourth the speed of a Cray C90, while NOT using the optimized Compaq compiler, which has since been released. In fact, Compaq

declares this new Alpha 21264 chip offers the same performance of a Cray C90 at one-fortieth the price! Preliminary results on the current system indicate the Compaq compiler will greatly boost performance.

Conclusion

Arrays of high-performance, low-cost workstations provide computer-power orders of magnitude more cost-effectively than traditional super-computers. And, whenever a performance barrier is broken, it suddenly becomes feasible to tackle classes of problems that previously were unthinkable to attempt. Thus, the contribution to society of a machine like the XP1000 goes far beyond merely speeding up mundane operations.

Dr. Liss received his Ph.D. in Applied Mechanics from the Polytechnic University of New York, in 1969, where he used an IBM 7040 (transistor computer) to predict collapse depths of submarine hulls. Results were displayed on the first Calcomp digital plotter. Later, while working as a project civil engineer and suffering the inadequacies of available computer programs to perform civil engineering geometric design, he and a colleague began developing a multi-user CADD system on a Digital mini-computer, with a completely protected, user-friendly interface. That system, with graphics born out of his experience developing graphics software for the Calcomp plotter, was called VANGO, and led to his co-founding VLSystems, in 1978.