

**Intel[®] Architecture
Based InfiniBand^{*} Cluster**
TeraFlops Off-The-Shelf (TOTS)

High-Performance Computing Is Achieved With Off-The-Shelf Solutions and Industry Standard Interconnect

To say that high performance computing places the ultimate demands on architectures, switches, software and processors is to state the obvious. Massively powerful supercomputers need rugged, robust interconnects, stable and trustworthy applications, and the capability to do more with less. Proprietary systems with thousands of processors that come at a high price may no longer be necessary to achieve HPC cluster requirements. At SuperComputing 2003, Intel and a host of industry leaders including ATI Technologies, Callident, Ciara Technologies, InfiniCon, Mellanox Technologies, OSU, Rackable Systems, Raritan, Sandia National Laboratories, SourceForge, Topspin and Voltaire demonstrate ease of High Performance Computing with "TeraFlop-Off-the-Shelf" (TOTS) on the floor for the first time – tapping the bleeding-edge power and performance of Intel® Xeon™ processors, industry standard InfiniBand* architecture and next generation PCI Express* local I/O interconnect technology. At one trillion mathematical operations per second, TeraFlop is the Holy Grail of supercomputing milestones. Only five years ago, Cray broke the TeraFlop barrier with 1,480 processors. Now, with the successful demonstration of TOTS, the message is loud and clear: Intel architecture clustering is inexpensive and easy to deploy – yet, unparalleled in performance and power.

The TOTS demonstration features a 192-node Dual Xeon processor based cluster, with the InfiniBand fabric serving as the cluster backbone as well as an I/O (Fibre Channel and Ethernet) gateway. PCI Express technology – the industry's choice as its next generation local I/O interconnect – is featured within the cluster's workstation graphics controller. With a combination of powerful Xeon processor based servers clustered together within an InfiniBand fabric, TeraFlop computing is attained with off-the-shelf solutions and open-source applications.

The power of Intel Architecture server platforms

HPC clusters assembled with Intel Architecture based Xeon processors are revolutionizing high-performance clustering by making deployments both more cost effective and easier to deploy and therefore attainable for more users. Featuring innovative technologies such as the Intel NetBurst® microarchitecture and Hyper-Threading Technology, Intel Xeon processor based clusters offer outstanding platform dependability, value, versatility and higher processing throughput for HPC applications through increased utilization of CPU resources. NetBurst can exploit instruction level parallelism and execute instructions at a very high rate to deliver high cluster performance. The Xeon processors also deliver superior price/performance, reductions in operating costs, increases in I/O throughput speed and increases in compute power for today's HPC applications. HPC clusters consist of networked, high-performance server or workstation platforms, each running an image of an operating system, built around dual-processor or multi-processor platforms. The innovative Three-Level cache architecture of the Xeon processor family significantly enhances the data handling capabilities of HPC applications that deal with large datasets.

The Power of InfiniBand Architecture

InfiniBand architecture has assumed a firm foothold in the world of supercomputing. Sandia National Laboratories, National Center for Supercomputing Applications (NCSA), Mississippi State University and Cornell University are but four of the institutions that have chosen the fabric-based interconnect technology to run high-performance computer clusters. InfiniBand architecture's vastly increased bandwidth and scalability reduces application and model run-times in high-performance computer (HPC) clustering, storage and networking. Additionally, the technology's support of a wide array of protocols means information technology officials can implement InfiniBand solutions utilizing existing platforms.

InfiniBand architecture brings to HPC computing a new level of performance opportunities in terms of lower latency, 10Gb/sec interconnect bandwidth that promotes fast message routing, and offers a single wire solution for unified system-to-system messaging. Maximizing I/O throughput is a key to InfiniBand architecture's value; by handling multiple I/O streams simultaneously, an InfiniBand fabric eliminates bottlenecks and improves overall data throughput for server systems. InfiniBand architecture's low latency enables 32-bit and 64-bit computing to scale more efficiently, providing the best application performance possible on a server cluster for both Xeon processor and Itanium® processor based clusters. The TOTS demonstration utilizes the Ohio State University's Message Passing Interface (MPI) protocol over the open-source SourceForge InfiniBand Access Layer (IBAL). It also utilizes IP over IB to transfer the graphics stream between the compute cluster and the display nodes. Additionally, the demonstration highlights how InfiniBand enables I/O aggregation and virtualization by allowing multiple servers to connect to Storage and Ethernet networks over a single Fibre Channel or Ethernet gateway without requiring a HBA or a NIC card in each server. The entire cluster is managed using VoltaireVision advanced

InfiniBand* fabric management software running in the Voltaire ISR9600 Switch Router.

Enter PCI Express*

PCI Express offers an effortless, unifying and smooth connectivity between peripheral components for a wide variety of computing and communication platforms. The vision is a single interconnect that can provide the versatility to meet all peripheral I/O needs – the high performance required in servers, the cost-effective performance required in desktop systems, the power efficiency needed for mobile systems. When PCI Express hits the market in 2004, Intel architecture servers based on this innovative industry-standard I/O technology will offer a powerful computing platform that provides significant return on investment (ROI). By taking advantages of bandwidth advancements achieved by 2.5 Gb/s to 10 Gb/s, PCI Express will tie together best-of-breed solutions, giving IT managers data center-level reliability, availability and serviceability (RAS), and management features that will serve as the foundation for advancing enterprise computing. Additionally, PCI Express offers a scalable width, higher bandwidth and graphics speed bump; it can be implemented to consolidate I/O, and has a layered architecture that maximizes reliability, availability, and advanced power management. PCI Express supports new form factors, such as hot plug/hot swap functionality. And, because it allows for virtual channels, quality of service and isochrony features, PCI Express interconnect is the premium choice for next-generation multimedia and high-performance glitch-free graphics. The combination of PCI Express for inside-the-box I/O and InfiniBand fabrics for outside-the-box I/O - offers a powerful, unique cluster solution for the HPC community.

Graphics Performance

The graphics industry constantly demands superior interconnect performance, long ago abandoning the PCI bus for AGP technology. That performance demand has been fulfilled by PCI Express, a revolutionary peripheral interconnect. With AGP 8x representing the last revision of the successful graphics interconnect, the industry has turned to x16 PCI Express for future performance improvements. The TOTS demonstration features a x16 PCI Express-enabled ATI Technologies Graphics controller, connected directly to the Tumwater chipset, to fuel a quadrupling of graphics capability vs AGP 8x.

Open Source and TOTS

Over the last decade, HPC buyers continuously faced the dilemma of whether to seek out solutions based on proprietary, specialized systems or to use industry-standard, open-source architecture. The answer is clear and resounding: a dramatic shift from proprietary systems to industry-standard, open-source solutions. According to IDC, in 1993 custom/proprietary architecture-based solutions accounted for 84.6% of the overall HPC market, in term of dollars spent. By 2002, custom/proprietary solution spending had dwindled to only 5.9%. This strong momentum towards Open-source solutions is unstoppable.

One of the most important messages conveyed by the TOTS demo is the offering of open-source solutions and off-the-shelf products for the HPC community. Open source solutions are cheaper to deploy and operate, and more secure; because the resources are public, any flaws are discovered easily and advancements incorporated at a faster pace. Open-source initiatives produce the most cost-effective solution that offers the best technology. The open-source SourceForge IBAL stack, powerful Linux-based Callident RX OS*, OpenSM* and OSU-MPI - all came together in TOTS to offer a simple and less expensive, yet ultra-powerful off-the-shelf solution with outstanding performance at the lowest possible cost.

The Demonstration

The TOTS demo features a cluster of 192 DP Xeon processor based servers from Ciara Technologies and Rackable Systems. The cluster interconnected with InfiniBand links, features HCA (Host Channel Adapters) from Mellanox and Topspin. The IBA switches are provided by InfiniCon, Mellanox, Topspin and Voltaire. The whole cluster is connected via twelve 24-port MTS2400 and InfinIOTM 7000 switches and these MTS2400 and InfinIOTM 7000 switches, in turn, are interconnected by one 96-port Voltaire ISR9600 Switch Router (see figure below). A Topspin90 switch is also connected to the cluster through the Voltaire ISR9600 and allows each of the server nodes in the cluster to connect to the Storage and Ethernet network by virtualizing Fibre Channel and Ethernet I/O over one single InfiniBand fabric.

Raritan provides the KVM switches for the whole cluster. Callident provides the open source CMS Linux RX OS. The InfiniBand drivers come from SourceForge, Mellanox and Voltaire. The OpenSM is an integral part

of the VoltaireVision InfiniBand* Fabric Management Software embedded in Voltaire's Switch, which manages the entire cluster. The MPI library, called OSU-MIBAPICH (MPI over IBAL) is provided by Dr. DK Panda of Department of Computer and Information Science at Ohio State University.

ATI Technologies, the first vendor to implement the PCI Express* interconnect to accelerate movement of information between the central processor and visual processors, provides the PCI Express graphics controller for the display nodes that run ParaView-client application to provide real-life visualization of high-performance computations.

ParaView, the featured application in this demonstration, is an open-source application provided by Sandia National Labs. It is a compute intensive application that stresses the cluster and measures system throughput and graphics performance. It is designed to visualize large data sets – in this case, NASA's Impinging Jet data set – in a distributed environment with an open and flexible user interface. ParaView will run on the 192-node Dual Xeon processor based cluster, spread over two racks – 128-nodes rack from Ciara Technologies, and 64-nodes rack from Rackable Systems. Each of the 192 Linux-servers runs one server-instance of the ParaView application, renders a portion of the large dataset, combines individual pieces of images to construct the final image and finally sends it over to the client PCI Express machines for display.

As shown in the figure below, parallel visualization of large data is accomplished with each node storing part of the data to be rendered. Each time a view is drawn, the nodes render the data they have stored locally. Then, the drawing's color and depth information are retrieved from the video card's framebuffer over the system bus. The nodes exchange portions of their framebuffer information over the network – again, through the system bus – with other nodes and combine their color and depth information from the two image regions until every node has a small region of the framebuffer containing a rendering of the entire dataset (instead of a full framebuffer containing a small portion of the dataset).

This algorithm incurs a constant overhead per rendering, but increases linearly with the number of pixels to be rendered. As tiled displays have become popular, the number of pixels has grown beyond the size of video card framebuffers. Ice-T handles this by making multiple rendering passes on every node, combining image data with each pass. Obviously, this puts a large burden on the system bus and is expected to be much faster with PCI Express enabled graphics solutions than with AGP. The dataset shown in the demonstration particularly highlights the graphics benefits delivered by this configuration.

Fig. 1 The TeraFlops Demonstration Overview

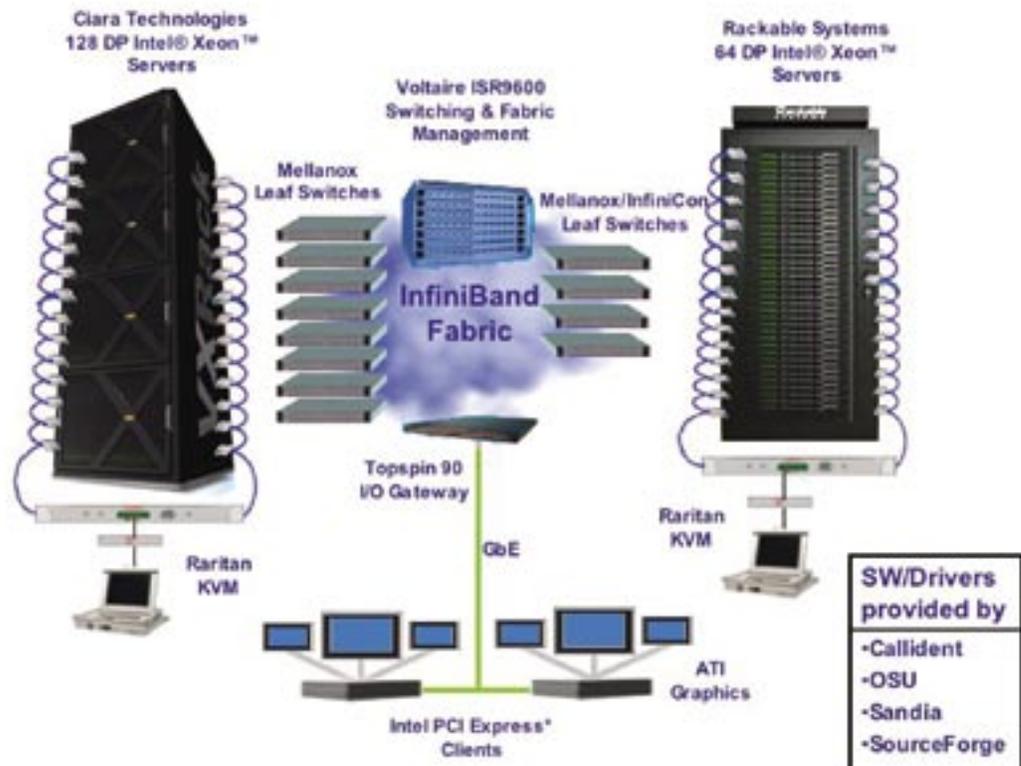
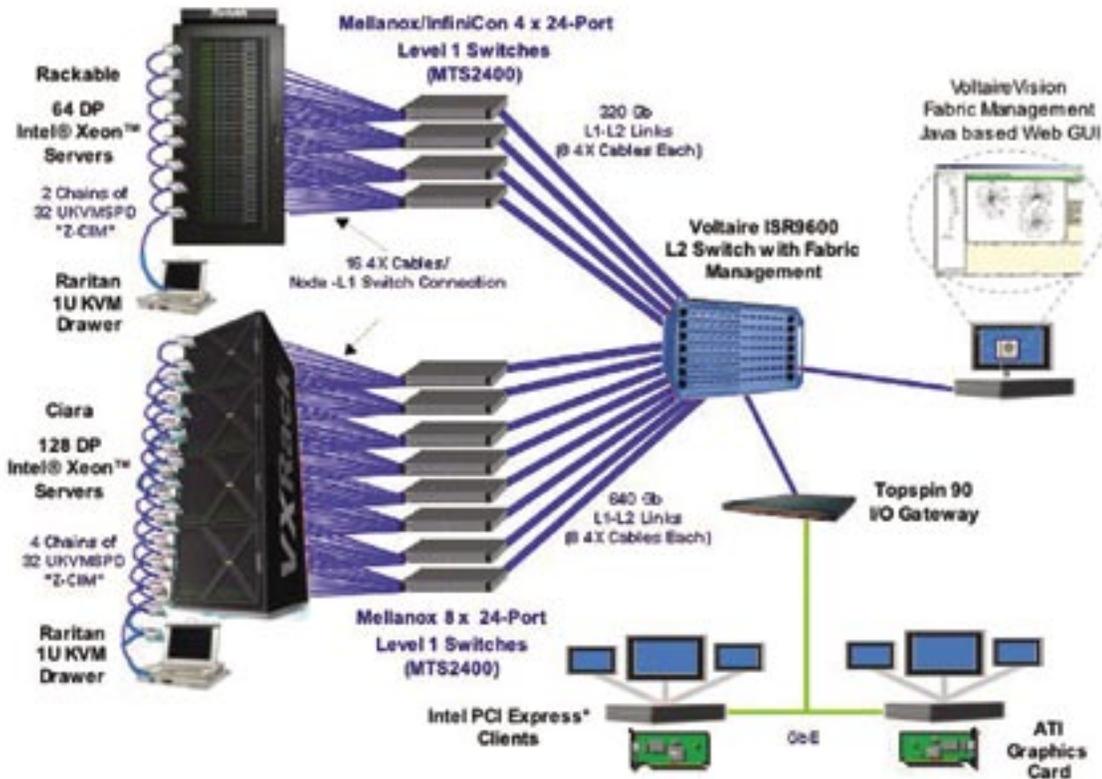


Fig. 2 The TeraFlops switch configuration



HW and SW list of the Demo

ATI Technologies: PCI Express* Graphics Card

Callident: Callident RX/OS – Linux based Cluster Distribution

Ciara Technologies: VXRACK* cluster solution with 128 DP Xeon processor based servers built on Intel E7501 chipsets

InfiniCon: InfiniOTM 7000 - 24-port 4x InfiniBand* Switch

Intel: Intel workstations featuring the PCI Express enabled Tumwater chipset

Mellanox Technologies: HCAs, MTS9600, MTS2400, IB Cables

OSU: OSU-MPI library called, OSU-MIBAPICH

Rackable Systems: Dense cluster solution with 64 DP Xeon processor based servers built on Intel E7501 chipsets

Raritan: KVM switches: Paragon* and Z-Series*

Sandia: Open Source application, ParaView

SourceForge: InfiniBand Access Layer (IBAL) Stack

Topspin: TS 90 IO Gateway

Voltaire: ISR9600 Switch Router with VoltaireVision InfiniBand Fabric Management

Conclusion

There doesn't need to be any mystery, apprehension or high cost surrounding high-performance computing. This SuperComputing 2003 demonstration proves that: Intel architecture Xeon processors, InfiniBand architecture, PCI Express technology, Linux RX OS, SourceForge stack, OSU-MPI can deliver huge computing power simply, easily and for a low cost. The open nature of this TeraFlop cluster offers the high-performance computing world the ability to achieve a highly flexible, cost-effective and efficient computing environment, without the proprietary solutions and thousands of processors traditionally associated with high-performance computing. The message of TOTS is a loud and clear one: Intel architecture clustering is easy and simple, yet unmatched in power and performance.

Industry Perspectives

ATI Technologies

ATI Technologies Inc. is proud to lead the transition to PCI Express* by providing “best of class” graphic solutions for Servers and Workstations in the High Performance Computing (HPC) market. Customers continue to depend on ATI Technologies to deliver a well-designed, stable product that is feature rich and can process enormous amounts of graphic data. High Performance Servers and Workstations need to ensure all peripheral operations, including graphics, complement but do not interfere with the computational processes. With separate graphics subsystems like ATI Technologies’s board or integrated graphics solutions overall system performance is improved. For more information on ATI Technologies’s products please visit our web site at www.ati.com.

Callident

Callident is showcasing Callident Rx, a Linux cluster distribution for high performance computational clusters that includes cluster middleware, management, and monitoring software in a single integrated platform. Rx offers customizable, automated, and scalable cluster installation methods. For this technology demonstration, InfiniBand* software stacks, drivers, and message-passing software were integrated into Callident Rx. As a result, Callident Rx now provides a turnkey open source cluster software solution with InfiniBand support. Callident also contributed cluster building, software installation, and Linpack benchmark expertise for the demonstration. Callident Rx represents a one-stop software shopping experience for the Linux cluster customer.

Ciara Technologies

Ciara Technologies presents the world’s most powerful rack cluster by introducing their new VXRACK cluster solution. VXRACK accommodates up to 256 of the new 3.2GHz Intel Xeon processors in a single 7 foot cabinet! Combine with the latest InfiniBand technology from Mellanox, VXRACK can distribute more than 1TFlops (1.15TFlops of Linpack Rmax) of processing power from one single rack. InfiniBand enhances tremendously VXRACK performance in the HPC segment. Ciara Technologies is providing InfiniBand solutions to fit customers’ extreme needs. VXRACK, the most compact, space saving cluster solution available today, is designed for hosting up to 128 VXBLADE* based on Intel’s latest E7501 or soon E8870 chipset for Itanium2 processor based systems within a standard 84” high rack enclosure and is the world’s first to accommodate up to 256 Intel processors (128 nodes), up to 1.5TB’s of SDRAM DDR ECC/Registered and up to 51TB of aggregate local. It is suited for the intensive computing applications.

InfiniCon Systems

With its award-winning InfinIO* Architecture – the first systems solution based on InfiniBand to deliver affordable 10Gbps networking to commodity servers while integrating seamlessly with existing Fibre Channel and Ethernet networks – InfiniCon Systems provides the high-performance, low-latency infrastructure required to enable next-generation data centers. Leveraging the switching and shared I/O capabilities of the InfinIO platform, IT organizations can cluster server resources together to create larger, more powerful computing environments; provision resources to match business demands; and slash operational costs for server deployments through greatly simplified connectivity to distributed storage and networking applications. InfiniCon-based HPC clusters are deployed in some of the largest Linux clusters. InfiniCon’s InfinIO* Switch Series is being deployed as a 512-node, non-blocking, 10Gbps full bisectional bandwidth (FBB) InfiniBand fabric by Japan’s Institute of Physical and Chemical Research (RIKEN) to accelerate biotechnology research. Also featured are Fujitsu’s newly developed Linux* based PRIMERGY servers containing 2,048 Intel Xeon processors and deliver a peak performance of 12.4 trillion FLOPs (floating point operations per second), which vaults it to the third position in the Top 500 rankings of the world’s most powerful supercomputers. In addition, InfiniCon offers the only complete end-to-end solution that has been certified by the InfiniBand Trade Association (IBTA), <http://www.infinibandta.org/itinfo/IL> this includes the host environment, management suite along with Host Channel Adapters (HCA) and Switching platforms.

Intel

Intel architecture server platforms featuring Xeon and Itanium 2 processors provide HPC users with unmatched performance for building HPC clusters. Intel has a history of leadership in the HPC arena and continues to provide best in breed processors, platforms and HPC solutions.

Mellanox Technologies

There are many HUGE research issues facing mankind around the world and some of these can’t be solved today because of computation barriers. Particular research areas demanding ever more compute resources are geology, weather, genomics, cancer and other medical research. One example of a compute resources limitation is protein flow analysis. To achieve one-tenth second of data it currently takes more than 10,000 computers operating continuously for years to compute this complex analysis.

This TOTS demo represents a huge step forward in computation power as it clearly demonstrates the ability to deploy a huge computation power, simply, easily and affordably. Just two years ago there were only 12 computers in the whole world that ranked over 1 TeraFlop and these systems cost on average greater than \$20M per teraflop. It is now possible for almost any university, lab, or commercial research facility in the world to deploy TeraFlop levels of computing power to solve truly complex issues.

InfiniBand* and extremely fast Intel processors in today's servers create an inflection point in computing. The high bandwidth low latency 10 Gb/sec InfiniBand interconnect enables today's industry standard servers to be clustered together, with open software, to create massive amounts of compute power quickly and inexpensively.

With Intel standard servers and InfiniBand it is now possible for many more researchers to build and obtain greater computing resources. What was nearly unimaginable compute power just two years ago, is within a budget that MOST research organizations can afford. For well funded, commercial and government research programs it is now even feasible to deploy systems achieving many tens of TeraFlops performance. With more than a 10 fold reduction in the cost per TeraFlop more researchers can apply more compute power to the critical research issues that the world needs addressed today.

OSU

InfiniBand is emerging as an open standard and cost-effective networking technology for building next generation HPC clusters and datacenters. The Network-Based Computing Laboratory at OSU-CIS, in collaboration with Ohio Supercomputer Center (OSC), has been involved in designing a high performance Message Passing Interface (MPI) implementation over InfiniBand. The goals of this project are to design and develop elegant solutions to pass the performance of native InfiniBand and its unique features to the MPI layer so that scalable HPC clusters can be designed with InfiniBand to deliver maximum performance to the end applications. The TOTS demo is a clear testimony to these goals. Current MPI releases by the Lab include MVAPICH (MPI-1 over InfiniBand using the VAPI layer), MIBAPICH (MPI-1 over InfiniBand using the open source IBAL), and MVAPICH2 (MPI-2 over InfiniBand using the VAPI layer).

Rackable Systems

The world's first ever 'TeraFlop on the Floor' demo at SC2003 contains 192 Intel Dual Xeon processor based nodes, 64 of which are provided by Rackable Systems. Each node in the 36U cabinet consists of dual 2.66 Intel Xeon processors on the SE7501WV2 motherboard, with the InfiniBand HCA installed in each. Rackable Systems server innovations provide the flexibility to support dual Intel Xeon processors with InfiniBand connectivity in a half-depth form factor enabling patented 'back-to-back' rack mounting – resulting in greater CPU density and thermal efficiency. Built on the Intel platform, this configuration can be tailored for the level of performance demanded by today's high-performance clusters without compromising the flexibility of options required by customers. All Rackable Systems servers provide key competitive advantages in the areas of density, thermal management, power consumption and reliability.

Raritan

An HPC by its very nature presents real challenges to an Administrator requiring BIOS-level access to each server in the rack. "Crash cart" access at a rack with such density is inefficient and tedious. Raritan provides IT professionals with five core building blocks to enable them to build the perfect solution for access, control and management of servers and other IT devices -- anytime, anywhere.

1. KVM Switches Offer seamless support for all server platforms running any operating system
2. Serial Console Control Provide out-of-band management of serial devices including UNIX servers and other IT equipment.
3. Remote Access and Control An array of solutions for extending KVM access to servers and other IT devices - including the power of connecting over IP
4. Centralized Enterprise Control For enterprises that deploy multiple Raritan KVM switches and serial console appliances connected to hundreds or thousands of servers and other IT devices, Raritan's CommandCenter provides an intelligent, centralized solution to manage all target devices from anywhere via a simple but secure browser interface.

The two products that control the 192 Dual Xeon – processor based node cluster in the demo are Paragon and Z-Series: Paragon is Raritan's flagship product and the pioneer of Cat5 based KVM switches. Paragon gives IT professionals the power to access and control their servers and other network devices any way they want, anytime they want, from anywhere they want. Paragon offers Cat5 Simplicity and multi-platform support - PS/2, Sun, USB, Serial - for 2 to 64 users having direct control of 16 to 10,000 servers. It is the most flexible, scalable KVM switch on the market today. Z-Series offers a "zero-U" KVM solution that enables access and control of multiple servers from a single user console (keyboard, monitor, and mouse), without consuming precious rack space. Z-Series employs Raritan's Cat5 Simplicity™ and unique communication technology to control up to 42 servers without the traditional KVM switch box and all the usual hard-to-manage, switch-to-server cable. It is designed to be scalable up to more than 1,000 servers.

"It's clear that the advancements made in computing power delivered by Intel processors and the InfiniBand interconnect technology have created an inflection point in computing that has dropped the price of high performance technical computing power by 10 fold," said Michael J. Fister, Senior Vice President & General Manager, Enterprise Platforms Group

Sandia

The mission requirements of Sandia National Laboratories demand powerful but economic computing capabilities. Sandia has been working to address these needs by exploring advanced architectures for cluster computing. Recent research has been directed towards InfiniBand*. This work has shown InfiniBand to have the characteristics of a high performance cluster interconnect, namely high bandwidth, low latency, low CPU overhead, and remote direct memory access (RDMA). Sandia's current InfiniBand research focuses on large-scale Linux visualization clusters for the Red Storm system, capacity computing, and scalable system and parallel software development. Two early applications being tested on Sandia's InfiniBand cluster are desktop delivery of visualization and simulation of turbulent reacting flows.

SourceForge

The SourceForge InfiniBand open source project exists at <http://infiniband.sourceforge.net>. The day-to-day working data base for the open source project resides at <http://infiniband.bkbits.net>. This open source software project contains Linux open source code for the InfiniBand Architecture. It features the basic OS plumbing (InfiniBand Access Layer (IBAL)), InfiniBand Subnet Manager, OpenSM, and upper level protocols for IP over IB, sockets direct protocol, SDP, and DAPL. The OSU MPI used in the demo uses the IBAL to provide user-mode access to the HCA hardware to provide very low latency message passing for IPC applications. IBAL is a vendor neutral implementation that allows any HCA hardware vendor to develop drivers for their hardware that plug into the IBAL infrastructure. HCAs from multiple vendors can interoperate simultaneously making IBAL the preferred choice of software for customers that don't want to get locked into a single vendor's proprietary solution. As shown in the demo, IBAL operates with multiple vendors HCA hardware and switches. Future DAPL SourceForge work will add support for additional types of channels, such as RDMA enabled ethernet NICs.

Topspin

For several decades, HPC systems and inter-connects were proprietary and extremely expensive. Traditionally, these were referred to as "supercomputers". But a major shift has occurred toward scalable cluster systems built from standards-based CPU, network, and storage components. Although industry-standard CPUs have dramatically increased in speed, fast I/O connectivity has lagged behind, inhibiting this trend.

The Topspin Switched Computing System (Topspin 90, Topspin 170 and Topspin 360) is a new high-speed, unified fabric designed for HPC systems. These non-blocking, InfiniBand-based fabrics interconnect Compute Clusters for inter-process communication (IPC) at 10Gbps throughput speeds and sub-10 microsecond latencies, enabling industry-standard components to operate with exceptional price/performance. Topspin's Fibre Channel and Ethernet Gateways, which use our Transparent Topology Emulation also provides these Compute Clusters plug-and-play interoperability with existing Fibre Channel and Ethernet networks, extending the value of the Compute Cluster to the rest of the network.

Voltaire

Voltaire offers a complete family of InfiniBand solutions for HPC applications that balance high-performance hardware with a production-ready, standards-based software stack for HPC clusters and enterprise data centers. The result is unmatched performance within InfiniBand clusters of all sizes and seamless connectivity with the existing infrastructure. Voltaire's InfiniBand clusters are deployed at the most prestigious national labs and universities. Voltaire's ISR 9600 is the highest port-count (96 ports) to be certified by the InfiniBand Trade Association (IBTA), distinguishing it as the most scalable, certified InfiniBand switch on the market today.

Profiles

ATI Technologies

Founded in 1985, ATI Technologies Inc. is a world leader in the design and manufacture of innovative visual processor solutions. A pioneer, an innovator and a market leader in the graphics industry, ATI Technologies provides cutting-edge visual processor technologies for the PC, Macintosh, workstation and notebook markets plus consumer markets including hand-held, set-top box and digital TVs.

Callident

Incorporated in 2002, Callident's top priority is to make Linux clusters easy to use. To this end, Callident constantly is improving the ways in which Linux clusters are installed, configured, deployed, managed, and utilized. Callident makes Linux cluster technology easily accessible to the masses, and helps cluster users accelerate their experimentation, design, workflows, and time to market -- regardless of their industry.

Ciara Technologies

Ciara Technologies designs, develops, manufactures, markets, services, and supports a variety of computer systems. Computer systems include desktop computer systems, high-end graphic workstations, network servers, Intel Blade Server, storage products and the newly announced VXRACK Cluster Technology.

InfiniCon Systems

Leveraging the breakthrough advances of the InfiniBand* architecture, InfiniCon Systems offers a complete systems solution for enabling data centers to migrate to a fabric/grid model of computing. Our award-winning InfiniIO product family provides the dynamic infrastructure required for designing and managing highly scalable, highly available clustered server environments that integrate seamlessly into today's Fibre Channel and Ethernet networks. For additional information, visit www.infinicon.com, or contact us at info@infinicon.com.

Intel

Intel, the world's largest chipmaker, is also a leading manufacturer of computer, networking and communications products. Additional information about Intel is available at www.intel.com/pressroom.

Mellanox Technologies

Mellanox Technologies is the leading supplier of InfiniBand semiconductors, providing complete solutions including switches, host channel adapters, and target channel adapters to the server, communications, data storage, and embedded markets. Mellanox is now delivering the 3rd generation InfiniScale III* switch that provides 24-Ports of 10Gb/sec in a single device. Mellanox has delivered more than 100,000 InfiniBand ports over the first two generations of 10 Gb/sec InfiniBand devices including the InfiniBridge*, InfiniScale* and InfiniHost* devices. Mellanox InfiniBand low latency interconnect solutions today provide over eight times the performance of Ethernet, and over three times the performance of proprietary interconnects.

OSU

Network-Based Computing Laboratory at OSU-CIS is engaged in state-of-the-art research related to following directions: 1) new designs for high performance clusters and datacenters by taking advantages of modern networking technologies and computing systems; 2) design and development of better middleware, API, and programming environments so that modern network-based computing applications can be developed and implemented in a scalable and high performance manner. Additional information about the Network-Based Computing Laboratory is available at <http://nowlab.cis.ohio-state.edu>.

Rackable Systems

Founded in 1999 and headquartered in San Jose, California, Rackable Systems® leads the industry in large-scale data center solutions. Through innovative design, patented technology and commitment to customer service, the company offers a broad line of server products that can be rapidly deployed in data centers and other demanding IT environments. Serving leading-edge technology companies, universities and research & development organizations, Rackable Systems customers include Biogen, Cold Springs Harbor Laboratories, Deutsche Bank, Electronic Arts, Lawrence Livermore National Laboratory, nVidia, Pfizer, SLAC, Sony America, Tellme Networks, Webex and Yahoo!.

Raritan

Raritan Computer is the leading provider of KVM (keyboard/video/mouse) and remote management solutions for access and control of servers and other network devices. With 18 consecutive years of profitable growth and technical innovation, Raritan makes products that are used to control millions of servers at more than 50,000 network data centers, computer test labs, and multi-workstation environments around the world. From the small business to the global enterprise, Raritan's compatible and scalable KVM, serial, and remote connectivity products offer IT professionals the most reliable, flexible and secure out-of-band solutions. Our complete line of products not only helps to manage IT equipment, but also improves operational productivity.

Sandia

Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin company, for the U.S. Department of Energy's National Nuclear Security Administration. Sandia has major R&D responsibilities in national security, energy and environmental technologies, and economic competitiveness. Since 1956, Sandia National Laboratories/California has operated as the lab's second main facility, based in Livermore, Calif., where its unique role of providing engineering support and systems integration for nuclear weapons and related national security R&D efforts has been carried out. Sandia/California has responsibilities for meeting national needs in four key areas – ensuring the nation's nuclear weapons stockpile is safe, secure and reliable; reducing the nation's vulnerability to threats of proliferation and weapons of mass destruction; addressing new, emerging threats to national security; and enhancing the surety of energy and other critical infrastructures.

SourceForge

SourceForge.net is the world's largest Open Source software development web site, providing free hosting to tens of thousands of projects. The mission of SourceForge.net is to enrich the Open Source community by providing a centralized place for Open Source developers to control and manage Open Source software development. To fulfill this mission goal, we offer a variety of services to projects we host, and to the Open Source community.

Topspin

Topspin is a systems company that provides the foundation for switched computing, a new computing model enabling industry-standard computing resources to be rapidly deployed to match the dynamic needs of business applications. Topspin delivers a compelling return on investment by improving server and network utilization, promoting resource flexibility, and dramatically reducing equipment and management costs. Headquartered in Silicon Valley, Topspin has assembled a first-rate management team and world-class investors, blending together a wealth of experience in the four key technology areas that converge on the enterprise data center: server, storage, networking, and applications. Additional information is available at www.topspin.com or by calling 1-866-TOPSPIN.

Voltaire

Voltaire is a leading provider of high performance InfiniBand* solutions for enterprise data centers and HPC environments. Voltaire's InfiniBand solutions deliver significant return on investment to the data center by improving the performance and utilization of clustered databases, shared servers, and storage. For HPC customers, Voltaire leads the industry with the largest InfiniBand Trade Association-certified switch to support clusters scaling from hundreds to thousands of nodes. With business headquarters near Boston, Massachusetts, Voltaire is certified by the IBTA's Integrator's List. More information about Voltaire is available at www.voltaire.com or by calling 1-800-865-8247.



