Solution Brief:

Manufacturing

Bringing New Levels of Performance to CAE Applications

Contents

Abstract

Computer Aided Engineering (CAE) is used to help manufacturers bring products to market faster while maintaining a high-level of quality. The faster companies can conduct tests and perform product analysis, the bigger the benefits of using CAE. Advances in software and server hardware have set the stage for faster results, but manufacturers should not overlook a major performance-robbing bottleneck: the server interconnect. To gain dramatic improvements in CAE performance, manufacturing firms are turning to Voltaire's InfiniBand-based solutions to speed the movement of data between clustered servers.

The Manufacturer's Challenge

Bringing products to market fast while meeting quality requirements and adhering to safety standards has become a daunting challenge to manufacturers. To remain competitive, manufacturers must deliver products as fast as possible. But if quality suffers, customers won't return. If safety levels decline, significant recalls, lawsuits or harmful publicity could ensue.

This is why manufacturing companies rely so heavily on Computer Aided Engineering (CAE), which helps simulate production and product performance ahead of time. CAE allows problems to be corrected before products reach the production stage and end up in the hands of customers. The challenge that has emerged today is how to run commercially-available CAE software faster and with more accuracy. Many software vendors offer capable products, but bottlenecks commonly occur in the hardware that runs the simulations and analyzes the production processes.

Without sufficient computing power, these tests sometimes take days and weeks to run. And because the tests take longer to run, product-development teams are often forced to run fewer tests in order to meet tight timeframes and to remain competitive. This can lead to inaccurate testing that often goes undetected until the products hit the assembly line—when the cost to make changes to the design of the products grows exponentially.

Solving this application run-time challenge will allow manufacturers to analyze their processes in the fastest time possible and conduct more granular testing. This in turn will allow for quicker and more efficient production. A key element to running tests more rapidly is choosing the right hardware to run the CAE applications.

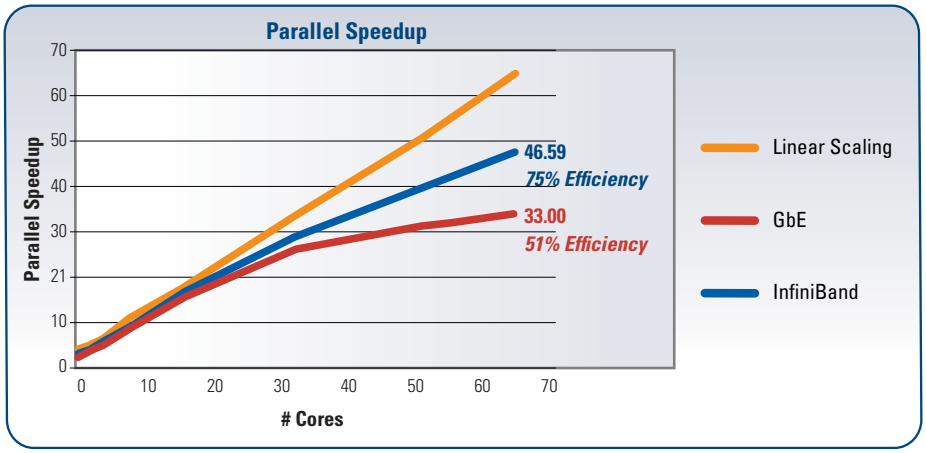
Today's Solution

Large symmetric multi-processing machines (SMPs) used to be the answer for generating compute power in the data center. However, these proprietary, expensive systems gave way to cluster and grid architectures consisting of low-cost commodity elements that offer comparable performance.

Some companies try to scale CAE clusters by adding more servers or moving to servers with multiple cores. This approach can work for smaller, simpler simulations, but the more complex the analysis, the more likely the need to run simulations across multiple servers where latency is a major factor in determining performance. The answer to speeding analysis and maximizing return on CAE investments is not simply buying more or bigger servers, but rather eliminating bottlenecks to performance by employing the use of a high performance interconnect.

Because of the ready-availability of Ethernet, many of today's clusters are built with Ethernet as the interconnect. While Gigabit Ethernet-based clustering is cheaper than SMP-based architectures, it can be very inefficient. For applications that rely on bandwidth or memory sharing, the efficiency (percentage of a server-CPU dedicated to communications overhead) can be a concern.

Today, many manufacturers run CAE systems that take advantage of InfiniBand-based high-speed interconnect support incorporated into CAE software. Voltaire InfiniBand interconnects eliminate I/O bottlenecks allowing applications to run faster and more efficiently.



\Figure 1. Voltaire InfiniBand-based solution improves performance by 50%

A Better Way

Voltaire InfiniBand solutions help CAE applications run faster. Voltaire offers high-performance (10, 20 and 40 Gbps), low-latency (< 2 microseconds) interconnect solutions for CAE applications. Benchmark testing has found that Voltaire interconnect solutions reduce CAE-runtime by as much as 50 percent.

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In addition to offering InfiniBand switch-technology, Voltaire works directly with CAE software-vendors to create the most efficient, fastest, and lowest-latency solutions in the industry. By combining the leading CAE software with Voltaire InfiniBand-based solutions, manufacturing organizations can now analyze products faster and more efficiently to gain a clear competitive advantage.

As today's price and performance leader in the industry, Voltaire builds its solutions using standards-based InfiniBand technology. InfiniBand is an industry-standard interconnect for high-performance computing (HPC) and enterprise applications. The combination of high bandwidth, low latency and scalability makes InfiniBand the interconnect-of-choice to power many of the world's largest and fastest computer systems and commercial data centers. Voltaire solutions support most major server vendors, operating systems, storage solutions and chip manufacturers.

	1 Gb Ethernet	10 Gb Ethernet	Myrinet	InfiniBand
Bandwidth	1 Gb/sec	10 Gb/sec	2.5 Gb/sec	10, 20 & 40 Gb/sec
Latency		~10 us	2.5 - 5.5 us	< 2 us
Average Efficiency	53%	No Entries	68%	74%
Price Per Gig/Port	~$350.00	>~$700.00	~$225.00	<$100.00

Table 1. Price/performance advantages for InfiniBand

Building CAE Clusters

Voltaire offers complete end-to-end server interconnect solutions for speeding CAE applications. The two major elements of the solution include:

- High-speed, low latency InfiniBand switches
- Fast storage connectivity

High-performance InfiniBand Switches

Voltaire's InfiniBand-based solutions deliver high performance and scalability to compute clusters. Voltaire offers a complete portfolio of products including a scalable line of InfiniBand switches, high performance I/O gateways (for seamless connectivity to Ethernet and Fibre Channel networks) and fabric management software. Voltaire solutions use the Open Fabric Alliance's OFED drivers and the OpenMPI (Message Passing Interface) libraries to optimize application performance for both MPI-based and socket-based applications.

Figure 2. Voltaire Grid Director 9024 for small-to-medium sized clusters ranging from 16 to 24 nodes.

For small-to-medium sized clusters, Voltaire offers the Voltaire Grid Director™ 9024. It is a 1U device with twenty-four 10 Gbps (SDR) or 20 Gbps (DDR) InfiniBand ports. The switch is a high performance, low latency, fully non-blocking edge or leaf-switch with a throughput of 480 Gbps.

It is well-suited for small InfiniBand fabrics with up to 24 nodes because it includes all of the necessary management capabilities to function as a stand-alone switch. The Grid Director 9024 is internally managed and offers comprehensive device and fabric management capabilities. Designed for high-availability (high MBTF)

and easy maintenance, the switch is simple to install and features straightforward initialization. The solution is scalable as additional switches can be added to support additional nodes.

For larger clusters ranging from 25-96 compute nodes, Voltaire offers the Grid Director™ 2004 multi-service switch — the industry's highest performing multi-service switch for medium-to-large clusters and grids. The switch enables high performance non-blocking configurations and features an enterprise-level, high availability design. The Grid Director 2004 supports up to 96 InfiniBand 4X ports (20 Gbps) and is scalable through the use of additional, hot-swappable modules. The Grid Director 2004 also features 10 GbE and Fibre Channel ports so the solution can provide high-performance, integrated SAN and LAN connectivity.

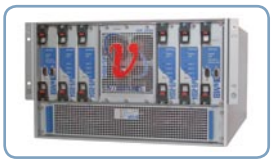

Figure 3. Voltaire Grid Director 2004 for scalable clusters ranging from 24-96 compute nodes.

For very large clusters and grids, Voltaire offers the Grid Director™ 2012, a larger version of the Grid Director 2004. The Grid Director 2012 features integrated storage and LAN connectivity, and it supports up to 288 InfiniBand 4X ports (20 Gbps).

Fast Storage Connectivity

For companies looking to incorporate storage into their InfiniBand cluster, Voltaire solutions offer fast I/O capabilities for storage. Voltaire solutions combine scalable compute and storage capabilities by using parallel file systems. Running scalable file systems over Voltaire InfiniBand solutions creates the most scalable solution in the industry—with more than 1000 nodes on a single name space—and delivers high performance connectivity for the storage and client nodes.

Manufacturing applications can now have effective file I/O rates of 350MB/s compared with the 50MB/s previously available using NFS.

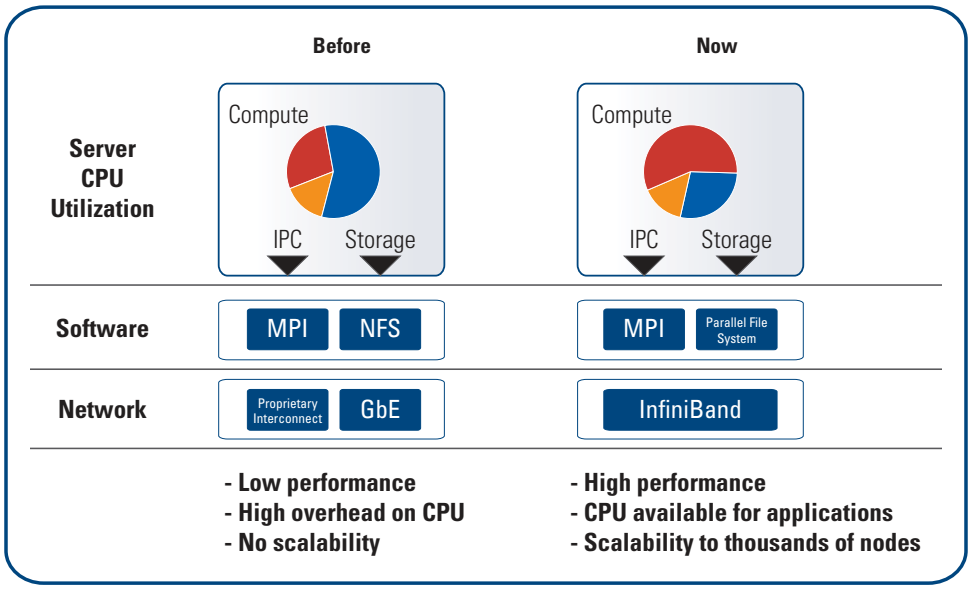

Figure 4. The advantages of combining IPC and File I/O with Voltaire Solutions.

At the heart of the solution is the Voltaire Grid Director 2004 multi-service switch (described in the above "Scalable Solutions" section). Voltaire's director-class, multi-service switches offer seamless InfiniBand, GbE and Fibre Channel connectivity. This enables MPI and storage traffic to run on the same network, a capability Ethernet and proprietary fabrics do not offer. By enabling IPC and high-performance storage on a single network, Voltaire solutions allow companies to leave behind the limitations of network file systems (NFS) and move to parallel file systems over InfiniBand. This provides far greater scalability.

Manufacturing applications can now have effective File I/O rates of 350MB/s compared with the 50MB/s previously available by using NFS. Additionally, the size of compute clusters is no longer limited because of the limitations imposed by NFS.

Putting It All Together

Key Features & Benefits

Voltaire solutions for manufacturing offer many compelling benefits to users:

- **High Bandwidth:** Voltaire solutions provide bandwidth of 20 Gbps to allow for faster and more frequent analysis by CAE applications.
- **Low Latency:** Voltaire solutions provide latency as low as 1.3 microseconds. Moreover, Voltaire's InfiniBand-based solutions leverage Remote Direct Memory Access (RDMA) with CPU and OS bypass-technologies that greatly reduce memory-copy overheads and associated CPU utilization.
- **Standards-Based:** Voltaire solutions are based on InfiniBand: the only industry-standard, high-performance interconnect.
- **Flexibility:** Grids and clusters that use Voltaire solutions can be built as a fully non-blocking 20 Gbps fabric or as a lower-bandwidth fabric based on the needs of the application. Moreover, Voltaire switches are upgradeable in a non-disruptive, hot-pluggable manner.
- **Fast I/O for Storage:** Voltaire solutions enable parallel file systems over InfiniBand, which offers far-greater performance and scalability than NFS solutions.

Tested & Certified with Leading Applications

By working closely with leading server and software vendors on integration and testing, Voltaire offers the fastest and most efficient high-speed interconnect solutions for the CAE market.

Voltaire solutions support many leading CAE applications, MPI offerings, operating systems and parallel file systems.

Applications	Abaqus-Abaqus, Ansys-Ansys, CD-Adapco-StarCD, ESI-Group-PamCrash, ESI-Group PamFlow, EXA-PowerFlow, Fluent-FLUENT, LSTC-LS-Dyna, Mecalog-Radioss, MSC Software-Nastran, Ricardo-Vectis
MPI Support	OpenMPI, HP-MPI, Intel MPI, SGI MPT, Scali MPI Connect, MVAPICH, ParaStation MPI, Microsoft MPI (MS CCS)
OS Support	Linux Enterprise Edition from Novell (SUSE SLES) and Red Hat (EL/AS)
Supported Parallel File Systems	Lustre, HP SFS, IBM GPFS, Panasas, IBRIX, TerraScale's TeraGrid
Systems & Platform Partners	HP, IBM, SUN, NEC, SGI, NEC, Intel, AMD

Leading Application Benchmarks

Voltaire and its OEM/ISV partners have conducted numerous benchmark tests that showcase the performance-boost that Voltaire's InfiniBand-based solutions provide to leading CAE applications. This section presents the results from a few select benchmarks:

ANSYS-HP-voltaire Benchmark

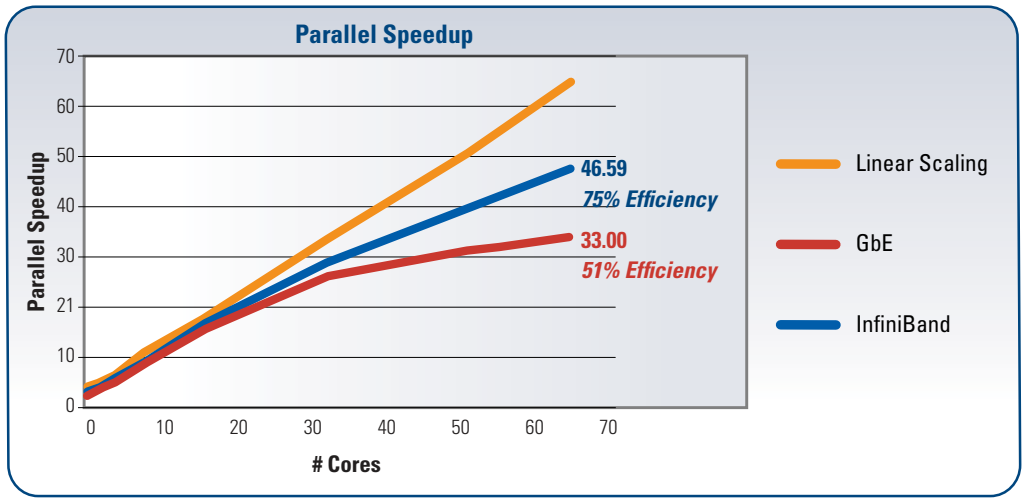

Figure 5. The graph above compares Voltaire InfiniBand and GbE using the ANSYS structure code. Voltaire InfiniBand's efficiency is 75% while GbE is only utilizing 51% of the available cycles. ANSYS runs faster using Voltaire InfiniBand because InfiniBand uses more of the CPU cycles. (Source: HP Fall 2005)

LS Dyna-Intel-Voltaire Benchmark

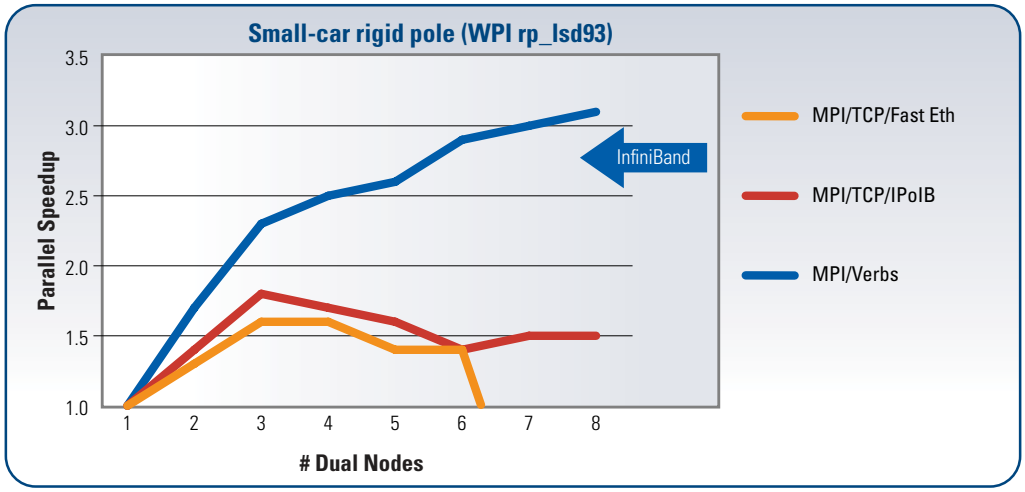

Figure 6: When running LS-Dyna, InfiniBand increases the performance by a factor of 2 over Ethernet. (Source: Intel Parallel Applications Center, presented at IDF 2003)

LS DYNA-HP-Voltaire Benchmark

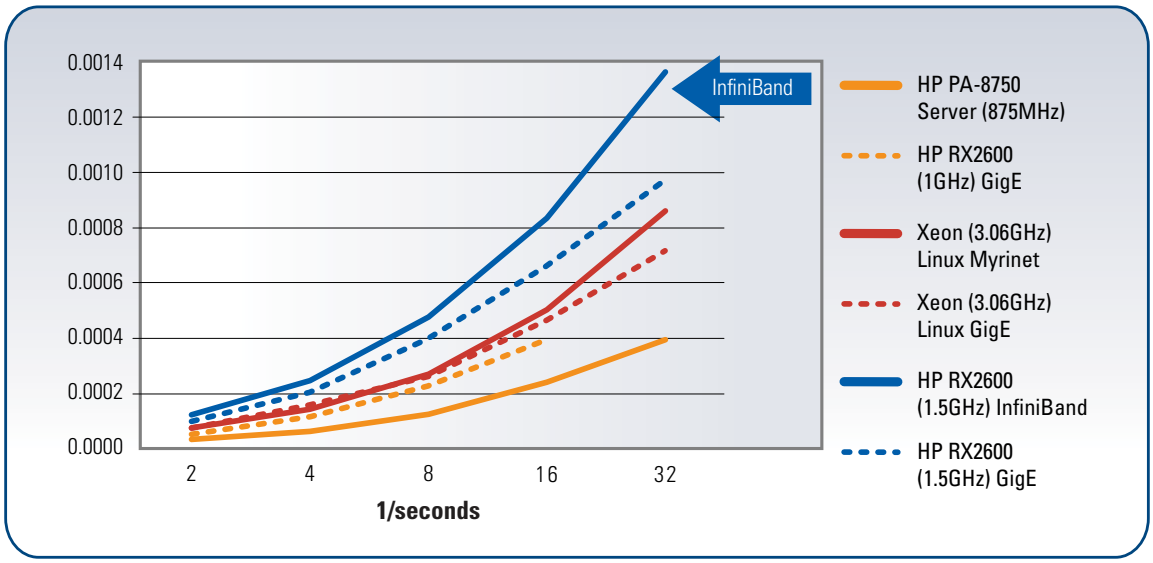

Figure 7: When compared to Myrinet or GbE, InfiniBand is faster and more scalable up through 64 nodes and becomes exponentially faster as the cluster scales beyond 64 nodes. (Reference: Refined LS DYNA NCA Neon model for public benchmarks, 535K elements, posted as of May 1, 2004 at: www.topcrunch.org/benchmark_results.sfe)

ESI-HP-Voltaire

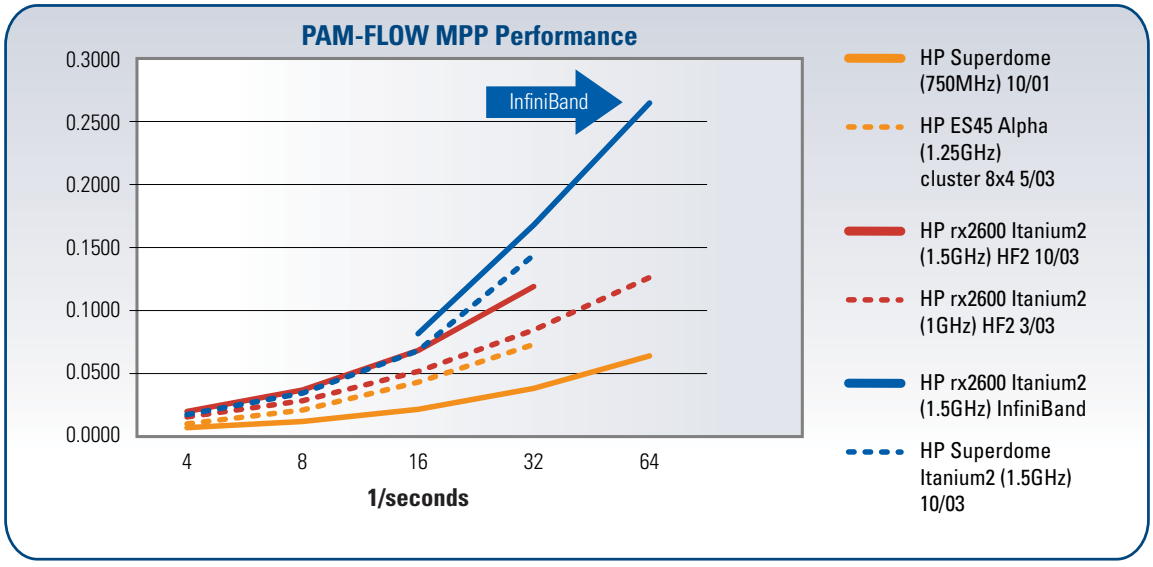

Figure 8. PAM-FLOW MPP Performance on HP. ESI's Pam-Flow application running on Infiniband has close to linear-scaling through 64 nodes while GigE clusters remain anywhere from 50% to 500% slower. Benchmark Detail: Solver CPU-time for external car aerodynamics. Incompressible flow model with SGS turbulence modeling. Mesh of 3.7 mil. tetrahedral grids with 657K finite element nodes.

ESI-HP-Voltaire

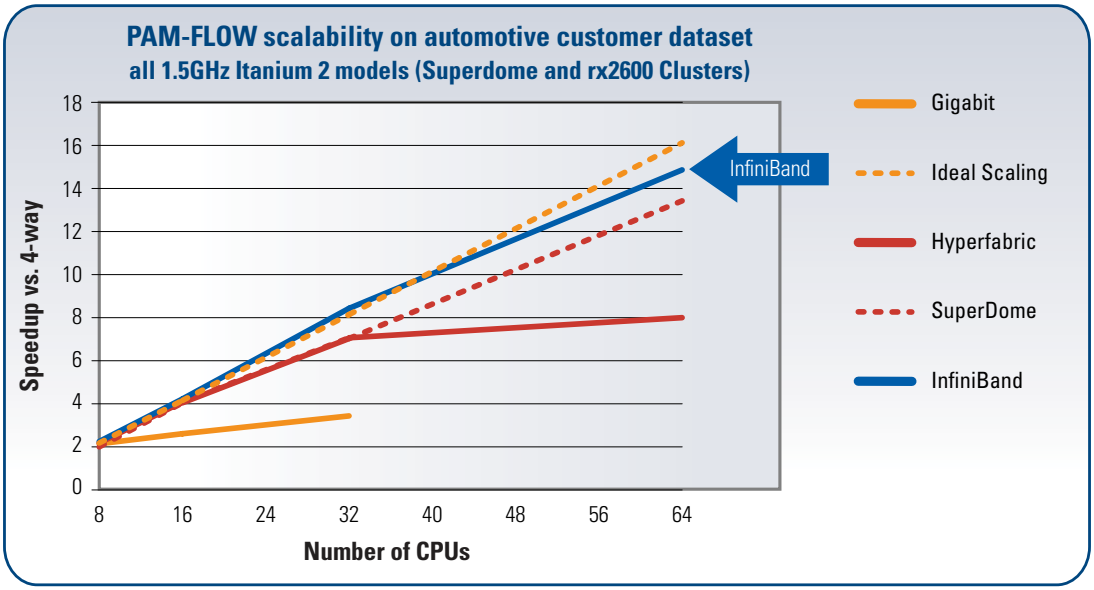

Figure 9. ESI Group PAM-FLOW Scalability on Intel Itanium Benchmark. A customer benchmark with 7 million elements, running 895 cycles. Observations: When comparing the various interconnects to linear scaling, only the InfiniBand solution can scale Itanium2 performance to nearly linear! (Source: Data run by HP February 2004)

Customer Success Stories

Customers in a variety of industries that rely on CAE applications for manufacturing, product design and testing can leverage Voltaire solutions for their cluster interconnects. Companies include consumer-product manufacturers, aerospace companies, and leading automotive companies in the U.S., Europe, Japan and Korea.

German Automotive Company

A leading German automobile-manufacturer turned to Voltaire when the company wanted a robust, high-speed interconnect solution to enable applications to run faster. The manufacturer needed this capability so that it could conduct more frequent analyses.

- 130 Nodes
  - NEC Servers
  - Intel CPUs
- Interconnect
  - Voltaire Grid Director
- Applications
  - EXA- PowerFlow
  - Ricardo-Vectis
  - ESI Group- PamCrash
  - ScaliMPI
- HP-MPI

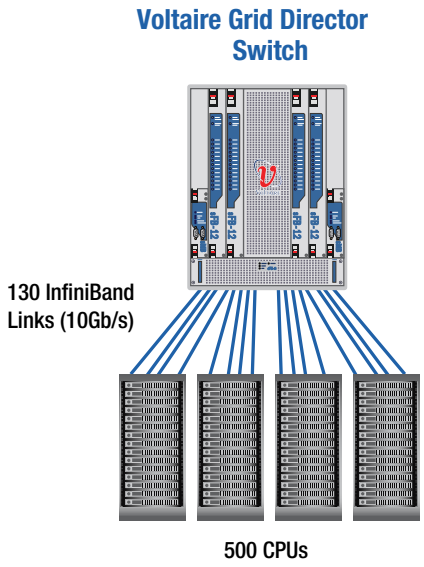

Figure 10. The system configuration as deployed by a leading German automotive company.

The customer selected a fully non-blocking configuration of 128 NEC dual core AMD Opteron servers—connected by the Voltaire Grid Director InfiniBand switch—to run flow and crash analysis applications from EXA PowerFlow, Ricardo Vectis, and ESI PamCrash.

Japanese Automotive Company

Another leading automobile-manufacturer in Japan selected Voltaire InfiniBand-based solutions to help get the best performance possible from 4 CAE applications and enable faster analysis and deeper simulations. In addition, the company was looking to improve I/O speed to gain access to files in storage. Their development process required constant access to images stored on disks, with clear resolution and quick access to files.

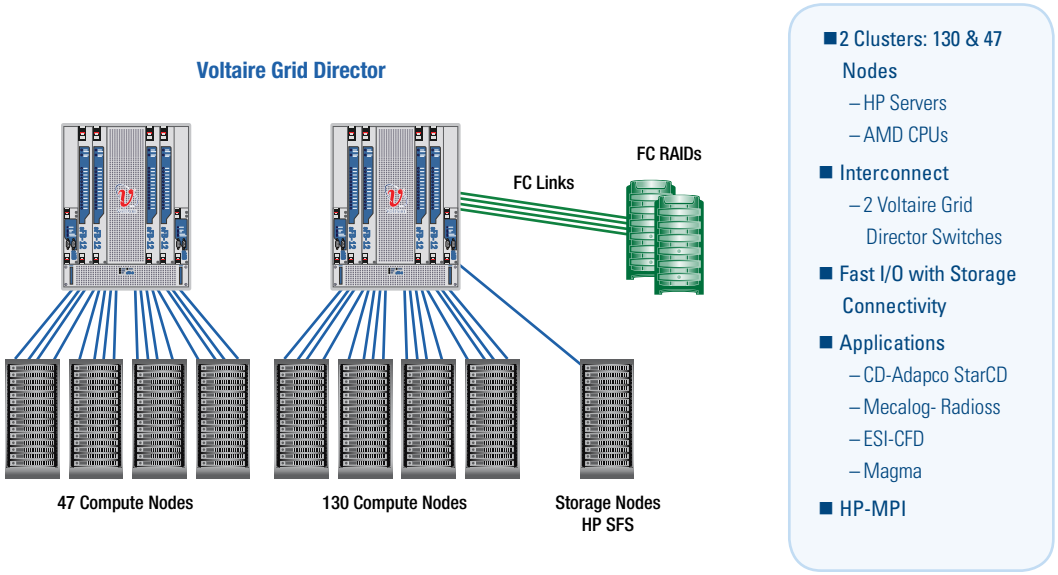

Figure 11. The system configuration as deployed by a leading Japanese automotive company. The Voltaire solution improves the performance of 4 CAE applications both on and between two clusters, enabling faster simulations.

The customer selected a configuration of two clusters consisting of 130 and 47 HP servers with AMD Opteron CPUs—connected by the Voltaire Grid Director switches. The solution leverages the multi-service capabilities of Voltaire's Grid Director switches to enable Fast I/O with storage connectivity. The clusters run multiple CAE applications including CD-Adapco StarCD, Mecalog-Radioss, ESI-CFD and Magma.

About Voltaire

Voltaire (NASDAQ: VOLT) designs and develops server and storage switching and software solutions that enable high-performance grid computing within the data center. Voltaire refers to its server and storage switching and software solutions as the Voltaire Grid Backbone™. Voltaire's products leverage InfiniBand technology and include director-class switches, multi-service switches, fixed-port configuration switches, Ethernet and Fibre Channel routers and standards-based driver and management software. Voltaire's solutions have been sold to a wide range of end customers including governmental, research and educational organizations, as well as market-leading enterprises in the manufacturing, oil and gas, entertainment, life sciences and financial services industries. More information about Voltaire is available at www.voltaire.com or by calling 1-800-865-8247.

Contact Voltaire to Learn More

1.800.865.8247
info@voltaire.com
www.voltaire.com