BRIEF

Extending innovation in virtual product development with the IBM Cluster Solution powered by the Intel Xeon processor 5500 series for Computer Aided Engineering (CAE)

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Introduction

Multiple recent studies[1, 2] have concluded that Computer-Aided Engineering (CAE) use is growing at about 10 percent in companies of all sizes ranging from large manufacturers to even their smallest suppliers. The availability of flexible and cost-effective cluster computing solutions compatible with desktop Computer Aided Design (CAD) environments has further helped energize CAE adoption among "generalist" engineers, designers, and smaller suppliers.

Challenges to CAE adoption for clusters include the use of a diverse mix of applications for industrial CAE environments and the fact that the cluster configuration requirements vary for various finite element and computational fluid dynamics (CFD) applications. In addition, many companies do not realize how easily non-specialist engineers can become competent with CAE tools if they are spared from the arduous tasks of managing IT complexity.

Substantial CAE opportunities for pre-tested, integrated, and optimized clusters arise from the inability of conventional "white box" computing clusters to meet business and technical objectives of companies that plan to broaden the deployment and use of CAE solutions from specialists to generalist engineers and designers.

IBM CAE cluster[3] solutions powered by the Intel Xeon processor 5500[4] series will be delivered jointly with leading CAE application providers to leverage existing IBM channels – both direct and through business partners. These integrated and optimized solutions deliver significant value differentiators with up to three times the performance over the previous generation of cluster systems, improved productivity, and lower energy and total cost of ownership. Manufacturing companies of all sizes will be able to use powerful CAE applications more broadly and significantly enhance interdisciplinary analysis and optimization throughout the collaborative product development value chain.

CAE Market Trends

CAE has revolutionized the process of design and development in the automotive, aerospace, process and chemical, and other industries. CAE slashes production time, optimizes designs, and prevents expensive rework. As a result, CAE has grown in importance earlier in the product development cycle, and no longer just consigned to the final stages of the design and manufacturing process.

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[1] Cyon Research, "Classes of MCAE Software: Clarifying the Market", A Cyon Research White Paper, July 9, 2008.
[2] 01Consulting, "MCAE Europe – 2007", http://www.01consulting.net/02_services_h_research_McaeEur07_ES.html
[3] IBM System x and BladeCenter HPC cluster solutions,
http://www-03.ibm.com/systems/x/solutions/infrastructure/departmentalclusters/
[4] Intel Xeon Processor 5000 Sequence Based Server Platforms Performance summary, http://www.intel.com/performance/server/xeon/summary.htm?iid=perf_server_lhn+dp_sum

Large manufacturers

This increased, routine use of CAE - structural analysis and computational fluid dynamics - is often tightly coupled to the Computer Aided Design (CAD) and manufacturing processes. This has substantially decreased the reliance on more expensive experimental techniques for applications such as stress and vibration analysis, crash analysis, metalforming, external aerdynamics, noise and vibration mitigation studies, and engine performance.

For example, the combination of ever-more complex and realistic crash analyses, new high-performance computing (HPC) clusters, and significantly more sophisticated digital computer models of driver and passenger dummies (virtual crash test dummies) enable large automakers to produce safer cars.

Suppliers

In order to be competitive, small and medium suppliers to the large manufacturers are increasingly using CAE solutions that need High Performance Computing (HPC) systems. This complements their traditional CAD solutions and enables collaborative product development and design optimization throughout the iterative product development cycle.

Larger and more complex CAE analyses are increasingly the norm within smaller suppliers who have limited skills and resources. These suppliers are increasingly engaged in more sophisticated analysis applications like crash analysis, non-linear metal forming, and computational fluid dynamics in addition to traditional structural analyses.

The availability of flexible and cost-effective cluster computing solutions compatible with desktop CAD environments has further energized increased CAE adoption among suppliers.

Independent Software Vendors (ISVs)

CAE software from major ISVs has become better integrated with CAD environments. This enables the effective and rapid deployment of design and analysis solutions. Smaller than the CAD market in terms of market size, but growing much faster, the CAE market has been growing steadily for almost three decades. Many CAE solvers have matured and been available for at least 10 to 15 years and are used routinely.

In recent years, the CAE software market has consolidated through mergers and acquisition, and more consolidation is expected in the future. To drive growth, the larger vendors prefer acquiring proven technologies from smaller vendors to complement their existing profitable, robust solutions. For example, in 2006, Fluent, Inc. a major provider of CFD software merged with ANSYS, Inc.

CAE Solution Challenges and Opportunities

Challenges

Industrial CAE environments rarely rely on just one kind of application. Instead, they often run a mix of primarily finite element application software largely provided by a few key software developers such as ABAQUS, ANSYS, CD-ADAPCO, ESI, LSTC, and MSC Software.

Finite element implicit structural analysis applications require cluster nodes with large memory and high performance I/O. At the same time, many crash analysis and CFD applications require large number of the fastest cluster nodes tied together with high-performance scalable interconnects, and not that much I/O.

Suppliers are often reluctant to embrace CAE because they incorrectly believe only highly paid analysis specialists can grasp and apply CAE tools. The reality is that although some of the high-end tools for

complex analyses require specialists, engineers can become competent in many available CAE tools with some basic training and practice.

Opportunities

A class of problems in CFD and non-linear structural analysis that are interdisciplinary with novel algorithms and domain-decomposition techniques scale very well on large clusters with highly scalable architectures, and are being increasingly used by production engineers. However, traditional "bread and butter" implicit structural analysis workloads do not distribute easily across a large number of memory partitions.

Moreover, HPC application performance is not solely tied to parallel capability. It is also closely related to file I/O throughput and other components of the computing environment. Conventional "white box" computing clusters just can not offer the high-performance I/O solution and architectural flexibility often needed for finite element analyses.

Furthermore, white box systems simply cannot meet all the business objectives for smaller manufacturing organizations that are often limited in skills and resources to manage and deploy distributed computing solutions. Specifically, they fail when it comes to working to reduce total cost of cluster ownership, reverse the challenges of managing disparate servers, execute numerous CAE applications concurrently, and achieve more flexible resource management.

To reduce the total cost of ownership for manufacturers and their suppliers, a flexible, balanced cluster environment with an optimized implementation of major CAE applications is needed.

IBM Cluster Solutions Tailored to Maximize Total Value of Ownership for CAE

The IBM System x cluster is a portfolio of robust cluster servers built on IBM X-Architecture that enable a customer to jumpstart the production of applications or products faster than the competition. This is realized through research, experience, innovation, and support from IBM and Intel, delivered and proven over the years.

The latest Intel Xeon processor 5500 series incorporates dynamic scalability, Turbo Boost technology, improvised Hyper-Threading, and scalable shared memory based on QuickPath technology for up to 3.5 times the peak performance over the previous generation Intel micro-architecture.

Enhanced by the capabilities of intelligent management tools, leadership offerings in energy-efficiency, consolidation and virtualization, security, and remote maintenance, the data center gets the much needed optimization and cost reduction that is critical for the business's growth. Multiple layers of redundancy, memory protection, high availability tools, incorporated into the System x servers are a part of the system design from IBM.

HPC offerings in System x from IBM consist of internet-scale computing iDataPlex, BladeCenter, Cluster 1350, and Storage servers and can be powered by the Intel Xeon processor 5500 series.

Intel Xeon processor 5500 series

This processor architecture design draws on the benefits of hafnium-based Intel 45nm high-k metal gate silicon technology, for parallel processing performance. Intel's QuickPath Interconnect (QPI) delivers substantial increase in bandwidth from a scalable shared memory by incorporating an integrated DDR3 memory controller onto the processor die in lieu of the previously bottlenecking Front-Side Bus (FSB). The processor can run two threads per core simultaneously with Intel Hyper-Threading technology which equates to 8 threads per 2 socket server. Multi-level shared cache reduces latency to frequently used data

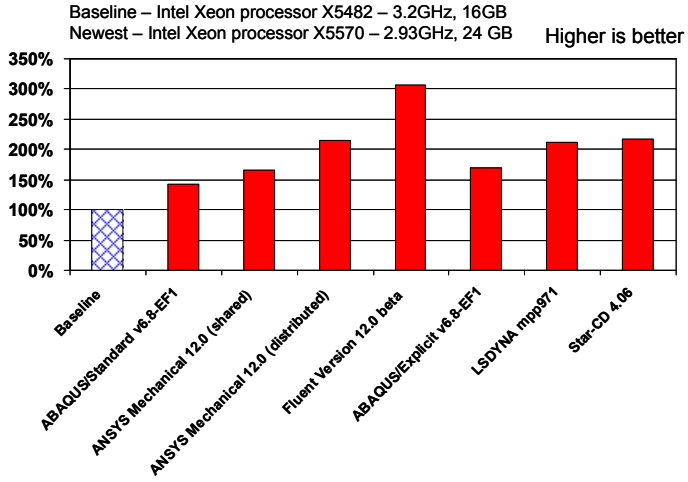
thereby improving performance and efficiency significantly. Intel Turbo Boost Technology increases performance of both multi-threaded and single threaded workloads. This technology is activated when the Operating System requests the highest processor performance state.

The maximum frequency of Intel Turbo Boost Technology is dependent on the number of active cores. While the length of time the processor spends in the Intel Turbo Boost Technology state depends on the workload and operating environment, it provides the performance a user needs when and where the user or application needs it.

For a given workload, the number of active cores, estimated electricity consumption, or processor temperature can set the upper limit of Intel Turbo Boost technology. When the processor is operating below these limits and the user's workload demands additional performance, the processor frequency will dynamically increase by 133 MHz on short and regular intervals until the upper limit is met or the maximum possible upside for the number of active cores is reached. Conversely, when any of the limits are reached or exceeded, the processor frequency will automatically decrease by 133 MHz until the processor is again operating within its limits with the stated frequency as a lower bound. For example, a database query, which doesn't use any of the processor's floating point silicon can take advantage of that thermal headroom and increase the frequency of all 4 cores.

Early benchmarks on the newest Intel Xeon processor 5500 series for a wide range of CAE applications record up to three times the performance over the previous generation Intel architecture. Memory bandwidth sensitive applications like crash analysis and CFD applications benefit most from the newest Intel Xeon processor 5500 series. This is particularly beneficial for CAE as these applications are often the ones most bottlenecked by CPU performance.

Exceptional performance improvement for CAE applications with the Intel Xeon processor 5500 series



- All results shown have Hyper-Threading and Turbo Boost disabled
- Data obtained from the Intel Corporation http://www.intel.com/performance/server/xeon/hpc.htm

IBM System x iDataPlex

The System x iDataPlex internet-scale computing server solution from IBM is uniquely positioned to help enterprise clients overcome compute density and energy efficiency constraints. The iDataPlex supports massive scale-out data centers and high performance computing solutions.

The iDataPlex is a half-depth server solution, optimized both mechanically and component-wise for maximum power and cooling efficiency. It is an industry-standard based server platform designed to minimize utilization of data center floor space (doubles the compute density/square foot compared to a 1U rack), and power and cooling infrastructure (20% less cooling and 63% less fan power). An easily maintainable solution with individually serviceable servers, front access hard drives/cabling, and common tools across the System x portfolio for management at the node, rack, or data center level, it is configurable for customer-specific compute, storage, or I/O needs and delivered pre-configured for rapid deployment.

Large scale CFD and non-linear finite element analysis problems with over 3-5 million unknowns scale very well on the iDataPlex. Interdisciplinary problems with multiple physics and/or complex, coupled, problems in design optimization and parametric studies iterating over thousands of input parameters, and chemically reacting flows with multiple species perform extremely well on the high performance scalable iDataPlex system. Also, hundreds of parametric simulations can be done concurrently on multiple iDataPlex partitions. This significantly reduces the time to results for large-scale CAE problems.

IBM BladeCenter

By integrating servers, storage and networking, IBM BladeCenter is helping manufacturing companies sweep aside complexity. Its wide application solution blades, truly efficient chassis, and open design, are packed into an answer to today's straggling racks and overheated server rooms.

IBM Cluster 1350 server

IBM Cluster 1350 Server reduces deployment time for Linux clusters and Windows clusters from Microsoft, benefits power and cooling through IBM Systems innovation, and offers integrated global hardware support. CAE clients can speed up installation of an HPC cluster, simplify its management and support, and reduce mean time to payback.

IBM Storage servers

IBM storage servers come at versatile ranges of entry level disk storage servers, mid-range disk storage systems—the IBM TotalStorage Enterprise Storage Server (ESS) and the IBM TotalStorage DS4000 series, the Network attached storage or N series products, and IBM's TotalStorage SAN solutions.

Innovative software environment

Together IBM and Intel drive toward simplicity in the software design to take advantage of system features that deliver high performance at consistent reliability and security. The programming and administration environment is based on familiar programming languages, libraries, job management tools, and parallel file systems. Design engineers and analysts greatly benefit from these innovative software components without facing a steep learning curve.

IBM System x clusters are highly optimized to reduce the deployment time for Linux clusters and Windows clusters. A Linux HPC Cluster is equipped with computing power at low-cost, collective intelligence of open standards, portability, flexibility and high availability. Likewise, the Windows HPC Server 2008 on IBM System x clusters and the BladeCenter servers provide reliable, cost-effective, and growth-oriented HPC cluster solutions. Windows HPC Server 2008 is designed to simplify the deployment, administration and management of the client's entire system with scalable performance, an easy-to-use scheduler and a new management interface that facilitates a familiar Windows environment so that supercomputing is more accessible.

Additional HPC cluster software available on IBM clusters includes the General Parallel File System (GPFS) for Linux and Tivoli Workload Scheduler LoadLeveler for Linux. GPFS is the top performing

cluster-wide file system providing superior scalability and high reliability. Tivoli Workload Scheduler LoadLeveler is a job scheduler designed to maximize resource utilization and job throughput to get the most out of the available resources. IBM clusters also support other workload management solutions available from partners. These integrated software tools sustain highly productive environments with thousands of server nodes running large parallel computational workloads typical in CFD and non-linear finite element analysis.

IBM differentiation for CAE

IBM CAE Cluster Solutions powered by the Intel Xeon processor 5500 series are delivered jointly with leading CAE application providers in order to leverage new and existing IBM channels – both direct and through business partners. These certified, optimized, and customizable solutions aggregate and optimize a portfolio of hardware, software, and services components from IBM, Intel, Microsoft, major CAE application providers, and other business partners. Some of the key IBM and Intel value differentiators for suppliers and manufacturers are to:

- Enable increased innovation in virtual product development
- Offer access to pre-engineered and optimized cluster configurations based on sizing expertise to run versions of leading CAE applications providers including ABAQUS, ANSYS, CD-ADAPCO, ESI, FLUENT, LSTC, MSC Software, and others
- Reduce risk, time, and costs associated with cluster installation and deployment
- Provide deep CAE expertise to enable, significantly improve, and optimize applications workloads
- Deliver an affordable, scalable, and flexible environment that can be tailored to a customer-specific CAE environment with superior technology components from
    - Intel – Multi-core Xeon processor 5500 series
    - The open source community – Linux, Message Passing Interface (MPI)
    - Microsoft – Windows HPC Server 2008
    - IBM unique technology components include:
        - Enhanced networking connectivity with power accelerator technologies
        - Superior thermal and energy management with Cool Blue
        - Cluster Systems Management
        - Deep Computing Visualization
        - High performance I/O systems – IBM General Parallel File System (GPFS) and Memory mapped IO (MIO)

The IBM Cluster Solution with several hundreds of multi-core Intel Xeon nodes has been deployed for crash analysis and CFD at several automotive and airframe manufacturers. These customers and others will now obtain a large performance boost from this new generation of IBM System x clusters powered by the Intel Xeon processor 5500 series.

IBM provides access to a wide range of HPC systems through the Computing on Demand (CoD) cloud center. CAE applications developers and prospective users can test out and get in-depth experience on these systems in a cost-effective manner. This computing capacity has been used to study large problems and generate solutions in interdisciplinary non-linear analysis and CFD on very large clusters.

Using an IBM Cluster Solution maximizes the total value of ownership for CAE environments and extends innovation in virtual product development for manufacturers and suppliers alike. Affordable, scalable, and flexible solutions, IBM clusters have been deployed to advance the science of CAE by solving some of the most challenging interdisciplinary research problems.