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WHITE PAPER

Performance Across the Generations: Processor and Interconnect Technologies

HPC Performance Results—ANSYS CFD 12

Key Findings

Improve Time-to-Solutions by Completing Simulations Faster

- IBM® System x® iDataPlex®, along with Intel's latest Xeon 5500 (Nehalem) processors and the QLogic TrueScale™ InfiniBand® cluster running ANSYS® CFD®, is 76 percent faster than a similar cluster using previous-generations of Intel processors.
- TrueScale InfiniBand provides 400 percent better performance than the same cluster connected with gigabit Ethernet.

Better Designs Through Speed and Scalability

- Performance is improved by 99 percent from each additional server added to the IBM cluster by connecting these servers with TrueScale InfiniBand instead of gigabit Ethernet.
- The iDataPlex cluster with TrueScale InfiniBand interconnect scales 93 percent better for the three largest/complex ANSYS CFD models. The same cluster with gigabit Ethernet interconnect achieves a scaling efficiency of only 46 percent.

Reduced Product Development Costs

- The need for physical prototyping is reduced by leveraging more complex models in a compressed time frame. A large 111-million cell model runs up to 100 percent faster on the iDataPlex cluster with the Intel Xeon 5500 processors versus Intel's previous generation processors.

ANSYS® IBM® intel®

Executive Summary

Today's engineering, research, and development applications demand increasing amounts of processing power and performance. In many cases, these performance requirements can only be met with the latest in high-performance computing (HPC) clustering technologies. A well-designed and implemented HPC cluster can help businesses refine their products and get them to market faster, thereby making them more competitive in the marketplace. HPC clusters that combine the latest in server, processor, and interconnect technologies provide the optimal architecture for achieving the objectives described in the following table.

Business Objective	HPC Cluster Capabilities
Improve time-to-solution	Performance to reduce elapsed time for simulation completion.
Enhance product design	Resources and performance to run models with higher accuracy and in less time than a non-HPC system.
Reduce the need and cost for physical prototyping	Efficiently scale a cluster to simulate a final design that closely approximates the actual product.
Improve the productivity of an engineering team	Improved cluster performance, and the ability to simultaneously run multiple simulations.

Introduction

Working together, ANSYS, Intel®, IBM, and QLogic® have implemented a test environment at the QLogic NETtrack Developer Center (NDC) in Shakopee, Minnesota. The NDC provides an environment to test the performance and workload characterizations of commercial software for research and development environments. This white paper summarizes the results of testing the ANSYS CFD 12 using Intel's latest generation of Intel Xeon® 5500 processors against its previous generation, as well as the impact of HPC cluster interconnect technology.

ANSYS CFD Benchmark Overview

IBM and QLogic used a new set of ANSYS benchmark cases, covering a large range of problem sizes, physical models, and solvers representing typical industry usage. Five cases were run by QLogic, ranging in size from 2 million cells to over 100 million cells. Both segregated and coupled implicit solvers were used, as well as hexahedral, mixed, and polyhedral cell cases. This broad coverage demonstrated the breadth of ANSYS CFD performance on a variety of hardware platforms, interconnects, and test cases.

The ANSYS CFD benchmark cases were run on two different HPC clusters. The first cluster, Harpertown (the code name for the Intel Xeon 5400 processors), consisted of 32 Intel servers. Each server contained dual, quad-core Intel Xeon 5472 processors running at 3.0GHz, providing a total of 256 cores for the cluster. Each node was configured with 16GB of memory, for a total of 512GB of memory.

The second cluster, Q-Blue, consisted of iDataPlex with 16 servers and 1 network file system (NFS) server node. Each compute node contained dual, quad-core Intel Xeon 5570 (Nehalem) 2.93GHz CPUs and 24GB (6 × 4G DIMMS) of memory. The Intel Xeon 5570 processor is the latest in Intel processor technology. The Q-Blue cluster had a total of 128 cores and 384GB of memory.

Both clusters had QLogic TrueScale InfiniBand interconnect for MPI and file system I/O traffic. Standard onboard gigabit Ethernet interconnects were also used/tested for comparison purposes.

The benchmark tests in the following table were run with ANSYS CFD 12.0.15 using HP-MPI.

Test Name	Benchmark Name
External Flow Over an Aircraft Wing	aircraft_2M
External Flow Over a Passenger Sedan	sedan_4M
External Flow Over a Truck Body	truck_14M
External Flow Over a Truck Body with a Polyhedral Mesh	truck_poly_14M
External Flow Over a Truck Body	truck_111m

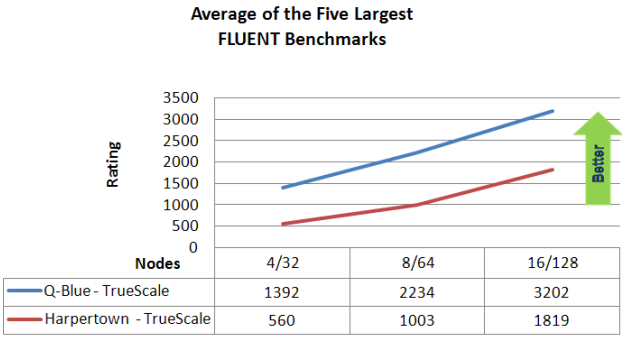
The primary metric that reports ANSYS CFD performance results is the *rating* measurement. This measurement is the number of benchmarks that can be run on a given machine (in sequence) in a 24-hour period. It is computed by dividing the number of seconds in a day (86,400 seconds) by the number of seconds required to run the benchmark. ***A higher rating means faster performance***.

Results for ANSYS CFD Benchmark Tests

The following sections and charts summarize the results for ANSYS CFD testing on the Harpertown and Q-Blue clusters.

Q-Blue with Xeon 5500 and TrueScale InfiniBand Performance

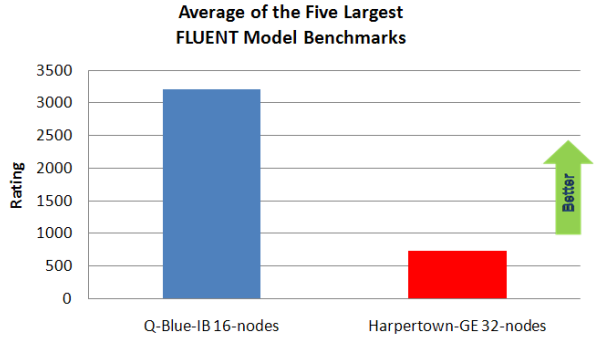
The Q-Blue cluster with the TrueScale InfiniBand interconnect provided sizable performance benefits over the previous Intel Xeon 5400 Harpertown processing architecture. The following chart represents the average of all five ANSYS CFD tests, and shows the Q-Blue cluster having a 76-percent performance advantage over the Harpertown cluster at 16 nodes/128 cores.



Nodes	4/32	8/64	16/128
Q-Blue - TrueScale	1392	2234	3202
Harpertown - TrueScale	560	1003	1819

Upgrade to High Performance Processors and an Interconnect Cluster

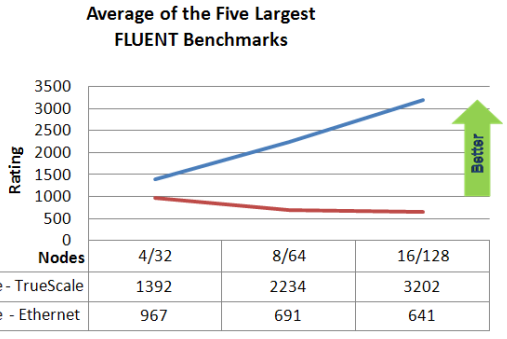
Moving from the previous generation of processor and interconnect technologies can mean a substantial increase in performance for business models and simulations. For example, the Q-Blue cluster with 16 nodes and TrueScale InfiniBand provides 3.34 times faster performance than a Harpertown cluster interconnected with gigabit Ethernet, as shown in the following graph.



From a customer perspective, power, air-conditioning, administrative/management, and application licensing fees represent a considerable savings. Implementing a cluster built around the latest and fastest HPC technologies—Nehalem processors and TrueScale interconnect—will make a difference at the both the top and bottom lines for today's businesses.

TrueScale InfiniBand Maximizes Intel Xeon 5500 Nehalem Performance

The cluster interconnect that joins each node of the cluster can make a marked difference in total cluster performance. Obtaining maximum performance benefit from the latest Intel Xeon 5500 Nehalem processors requires a cluster interconnect that matches Nehalem's performance capabilities. Otherwise, the interconnect becomes a bottleneck that impedes the cluster's performance and decreases the application results. TrueScale InfiniBand interconnect, with its high bandwidth and very low-latency capabilities, can support the Nehalem processors contained in each node of the cluster. The Q-Blue cluster, when run with TrueScale InfiniBand, achieved 400 percent better performance (starting at 16 nodes/128 cores) than the same cluster connected with gigabit Ethernet, as shown in the following figure.



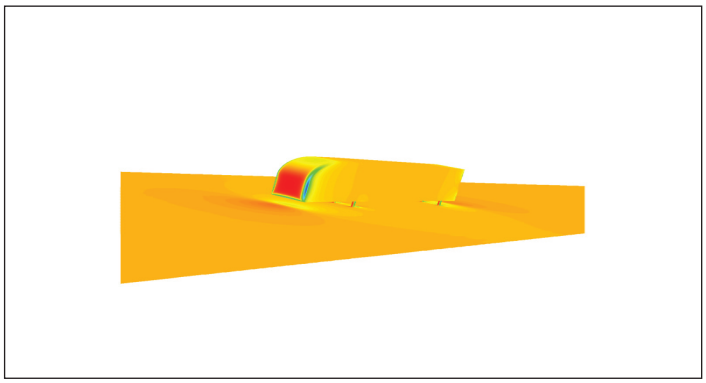
Nodes	4/32	8/64	16/128
Q-Blue - TrueScale	1392	2234	3202
Q-Blue - Ethernet	967	691	641

The iDataPlex/TrueScale-based 4-node/32-core cluster performed as well as the 16-node/128-core iDataPlex/gigabit Ethernet connected cluster. The right interconnect maximizes the performance capabilities of the Nehalem processor, while optimizing the size of the cluster to obtain the highest level of performance.

Maximizing the Benefits from Each Additional Server

The ability for the cluster performance to scale is an important consideration when choosing processor and interconnect technologies. The performance gain from an increase in cluster size is represented by its scaling efficiency percentage: the higher the percentage, the better. The Q-Blue cluster with TrueScale InfiniBand scaled efficiency, especially as the ANSYS CFD model complexity increased. The average scaling efficiency for the three largest/complex CFD models (Truck 14M, Truck_Poly 14M, and Truck 11M) was over 93 percent. The same models, tested with gigabit Ethernet, achieved a scaling efficiency of only 46 percent. Therefore, TrueScale InfiniBand-connected servers provide twice the performance of gigabit Ethernet-connected servers.

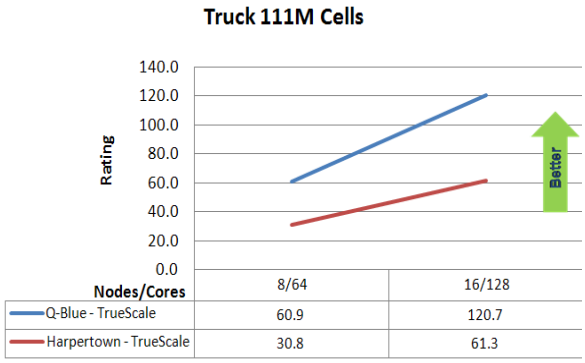
Performance-to-Scale Complexity



The Truck 111M External Flow Over a Truck Body model was the largest and most complex of the CFD test cases. It simulated an external flow over a truck body. The case had 111 million cells of mixed type and used the Detached Eddy Simulation (DES) model with the segregated implicit solver. The components used in this model are listed in the following table.

Number of cells	111,000,000
Cell type	Mixed
Models	DES turbulence
Solver	Segregated implicit

This test demonstrated that ***time-to-solution for more complex models can be cut in half*** by moving from earlier Intel processor technologies to the latest Intel Xeon 5500 processor technology matched with TrueScale InfiniBand. The Q-Blue cluster ran the truck_111m cell model almost 100 percent faster than the Harpertown cluster, as shown in the following figure.



Key Solution Technologies

The following paragraphs summarize the key technologies that comprised this high-performance solution that maximized performance for engineering applications such as computational fluid dynamics.

ANSYS CFD—Computation Fluid Dynamics Software

The ANSYS CFD 12 software takes advantage of the latest advancements in today's HPC computing architectures, from individual desktop to scale-out environments. The advances in processor technology, coupled with high-speed interconnects, becomes an important consideration for maximizing the new features and benefits of ANSYS CFD 12 for gains in:

- Performance
- Price versus performance
- Scalability
- Scalable bandwidth
- Capacity

The broad physical modeling capabilities of ANSYS CFD have been applied to industrial applications ranging from air flow over an aircraft wing to combustion in a furnace, from bubble columns to glass production, from blood flow to semiconductor manufacturing, and from clean-room design to wastewater treatment plants. The ability of the software to model in-cylinder engines, aeroacoustics, turbomachinery, and multi-phase systems attributes to its wide-spread use. Today, thousands of companies world-wide benefit from this engineering design and analysis tool. ANSYS CFD's extensive range of multi-physics capabilities makes it one of the most comprehensive software tools available to the computational fluid dynamics (CFD) community. With its long-standing reputation of being user-friendly and robust, ANSYS CFD can be quickly installed and deployed, providing maximum benefits to its users in a minimum amount of time.

IBM—High Performance Cluster Technology

IBM is the world's leading provider of HPC systems. IBM delivers innovative and powerful breakthrough solutions and technologies, like the System x iDataPlex and the System Cluster 1350. These systems support Linux® and Windows HPC Server 2008®, cloud computing, and IBM research-led HPC initiatives that enable customers to address the demands of intense computation and data manipulation.

IBM System x iDataPlex, a large-scale solution, solves customer problems such as constraints in power, cooling, or physical space. The innovative design of the iDataPlex solution integrates Intel Xeon-based processing into the node, has a rack and data center for efficient power and cooling, and has the compute performance and density customers need. Highlights of this solution include:

- The iDataPlex dx360 M2 is the top-rated server for both performance and energy efficiency in the x86 marketplace.
- A flexible design for large-scale data centers.
- Dramatically reduced cooling costs; air conditioning expense is minimized or even eliminated.
- Up to five times the compute density for efficient space utilization.

The IBM System Cluster 1350—built on the innovative

IBM System x rack, BladeCenter®, and iDataPlex servers—integrates servers, storage, interconnects, and software with a single point-of-contact for support. The Cluster 1350 is an ideal solution for a broad range of application environments, including industrial design and manufacturing, financial services, life sciences, government, and education. These environments typically require excellent price/performance for handling HPC and business-performance computing workloads. Highlights of this solution include:

- Leading-edge technology with flexibility of choice
- High performance
- Energy and space efficient
- Easily deployed, operated, and maintained
- Custom integration with a single point-of-contact for support

The IBM System Cluster with QLogic TrueScale InfiniBand interconnects processors between servers and storage; it is a fully-developed HPC solution with demonstrable gains over competing configurations. These low latency, high-bandwidth, energy-efficient solutions deliver faster time-to-solution and enhanced productivity. For customers, this means superior support and faster return on investment (ROI) on HPC investments.

Intel Xeon 5500 Processor Series

The Intel Xeon processor 5500 series automatically and intelligently adjusts server (performance based on application needs) for a performance gain that is 9 times greater than single-core servers running at 18 percent less operating power. This performance equates to a 9:1 server consolidation ratio, reducing operating costs by up to 90 percent, which results in an estimated 8-month return on a new server investment. Two-processor servers based on the Intel Xeon processor 5500 series have up to 8 computation engines, 16 threads per 2-socket platform (with Intel Hyper-Threading Technology), and up to 3.5 times more bandwidth than previous generations. With intelligent performance technology and a new high-bandwidth interconnect architecture, the Intel Xeon processor 5500 series delivers up to four times more performance for HPC applications compared to Intel dual-core processors. Intel recognizes that the need for performance is always increasing. That is why Intel provides platform-based solutions that maximize performance, improve throughput, and add new embedded technologies that give business, creative, and scientific professionals the tools to solve problems faster, process larger data sets, and meet bigger challenges. Seventy-five percent of the Supercomputing Top 500 results are on Intel processor-based platforms.

Intel micro-architecture (Nehalem) boosts performance even further for critical workloads. Intel turbo boost technology increases core frequency to improve execution speed as needed, while intelligent power technology conserves power on cores when there is less demand. For applications that benefit from parallel, multi-threaded execution, Intel hyper-threading technology reduces computational latency, making optimal use of every cycle.

Technical compute platforms based on the Intel Xeon processor 5500 series support up to 16 simultaneous threads with 32-bit and 64-bit processing capabilities; up to 144GB of memory; and a new, inclusive, shared L3 cache that boosts performance while reducing traffic to the processor cores. These multi-core servers maximize productivity, enhance visualization, and improve flexibility to help researchers, engineers, and developers achieve more in less time.

QLogic InfiniBand Solutions

QLogic offers a comprehensive end-to-end InfiniBand product portfolio that includes multi-protocol fabric directors; edge fabric switches; InfiniBand adapters; and a complete software suite to install, operate, and maintain a high-performance interconnect fabric.

QLogic InfiniBand adapters offer the industry's highest message rate, combined with the lowest MPI latency and the highest effective bandwidth, to enable MPI and TCP applications to scale to thousands of nodes with unprecedented price performance.

QLogic offers the most comprehensive and flexible interconnect fabric solutions on the market. Applications needing 12–864 InfiniBand ports can be supported in a single chassis. Multi-chassis fabrics supporting thousands of host nodes can be built to meet the most demanding compute cluster requirements. This offering, combined with the industry's only fabric management tools, satisfies the growing demand for high-performance computational clusters and grids.

Disclaimer

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