



CD-adapco STAR-CCM+ on HP Cluster Platform with QLogic TrueScale™

Performance testing—high-performance interconnect for CD-adapco computer-aided engineering solutions

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Executive summary

Companies that make products for the aerospace, automotive, high-tech electronics, and consumer markets can realize significant benefits from today's high-performance computing (HPC) technologies, especially given the latest advances in multicore/multiprocessor performance. These cluster computing resources can be interconnected with a high-performance network to eliminate bottlenecks and improve the efficiency of key applications. An optimized HPC cluster has a number of benefits including the following:

- Improved time-to-solution through faster simulations
- Better design accuracy through the use of larger models with greater resolution
- Improved designs through the ability to consider more designs in a given period of time
- Increased design/engineering team efficiency through the ability to run multiple simulations in parallel
- Reduced costs through better simulations and fewer physical prototypes

HP Cluster Platform with QLogic® TrueScale InfiniBand provides a high-performance computing system that can dramatically accelerate your design and engineering team's completion of process simulation, modeling, and optimization so your products get to market faster with much lower prototype and final production costs.

HP and QLogic, working in concert with CD-adapco and Intel®, tested STAR-CCM+ 4.02 on a range of configurations and interconnects. The results of this testing proved that STAR-CCM+ on HP Cluster Platform with TrueScale InfiniBand increases a company's ability to model and simulate complex designs in a shorter period of time. QLogic's TrueScale InfiniBand solution is one of the critical factors for creating high-performance computing clusters (HPCC) that maximize STAR-CCM+ simulation performance. This means more design alternatives can be tested to refine product features, simplify product use, and increase product quality in a significantly shorter time and at a lower cost. More thorough simulations can reduce or eliminate the cost of physical prototypes.

Key findings

Improves time-to-solution by completing simulations faster—HP Cluster Platform with TrueScale InfiniBand configuration running STAR-CCM+ is up to 14 times faster than a multicore workstation/server and up to 244% faster versus Gigabit Ethernet at scale (128 cores).

Better designs through speed and scalability—You can run three times as many large/complex simulations in a given period of time compared to Ethernet-based clusters. HP Cluster Platform with QLogic TrueScale InfiniBand performance scales well as nodes and cores are added to the cluster, with up to 85%+ scaling efficiency.

Improved engineering team productivity—Concurrent simulation run times on the HP Cluster Platform with TrueScale InfiniBand complete within 2% of the standalone run times.

Reduced product development costs—You can reduce the number of physical prototypes by leveraging more complex models in less time.

Reduced costs of computing infrastructure—HP Cluster Platform with TrueScale InfiniBand reduces the number of servers needed to deliver the equivalent performance of an Ethernet cluster. TrueScale InfiniBand interconnect protects your cluster investment by delivering increased application performance as you add computing resources.

Business value of HP Cluster Platform with TrueScale

Improve time-to-solution through faster simulations

When running optimization programs that refine a design, reducing the time-to-solution is one of the keys accelerating a product's time-to-market. Interconnecting your cluster computing network using QLogic TrueScale solutions can reduce this critical metric—so the end result is faster time-to-market and higher product quality levels:

- Run more than 14 times faster than a multicore workstation with the HP Cluster Platform based on HP ProLiant BL280c G6 blades with TrueScale 40 Gbps (4x QDR) InfiniBand
- Up to 7 times faster with TrueScale as the interconnect than dual multicore workstation/server connected with Ethernet
- 150% to 250% faster (depending on the test) than Gigabit Ethernet at scale (128 cores)

Better designs through speed and scalability

QLogic TrueScale InfiniBand solutions enable companies to effectively scale cluster configurations, run larger data sets, and expand simulation complexities in computer-aided design (CAD). The HP Cluster Platform connected with TrueScale InfiniBand produces better designs by running larger data sets without dramatic increases in run time. You can run almost three times as many large/complex simulations with QLogic TrueScale InfiniBand than with Ethernet-based clusters in the same amount of time. Furthermore, QLogic TrueScale InfiniBand performance scales well as nodes and cores are added to the cluster, with up to 85% scaling efficiency.

Maximize designer/engineer productivity through simultaneous use of the cluster

Optimizing the productivity of an engineering team is one key to remaining competitive in these challenging economic times. HPC clusters making use of TrueScale InfiniBand improve productivity by delivering faster results for each engineer through support of concurrent simulations. Concurrent simulations execute within 2% of their single run times. Shared resources deliver performance that makes the entire engineering team more effective and productive.

Reduced product development costs

A TrueScale-based HPC cluster enables organizations to validate complex designs and perform more detailed simulations to verify designs. All of this can drive cost and time out of the entire development process. Furthermore, by leveraging more complex models in less time, you can reduce or eliminate much of the need to create physical prototypes.

Reduced computing infrastructure costs

By leveraging QLogic TrueScale capabilities, industrial engineering customers can reduce the costs and complexities of deploying and operating HPC clusters. TrueScale-based clusters reduce the number of servers/blades needed to deliver the equivalent performance of an Ethernet cluster. For the two STAR-CCM+ test cases, it requires only half the number of blades using TrueScale InfiniBand as the interconnect to produce the equivalent results of a 16-blade/128-core cluster with Gigabit Ethernet. In addition to the server savings, there are incremental ongoing savings in power and cooling as a result of using fewer blades/servers to achieve the same system throughput.

TrueScale InfiniBand protects your cluster investment by delivering increased application performance when computing resources are added. The STAR-CCM+ Le Mans test case following shows that Gigabit Ethernet achieves its optimal performance at only 4 blades/32 cores, after which performance begins to decline or delivers only marginal gains.

STAR-CCM+ benchmark overview

This benchmark study used CD-adapco's new benchmark cases, which are designed to show a range of problem sizes, physical models, and solvers that represent typical usages. The two benchmark cases are the *LeMans Race Car* and the *Civilian Airline*.

The STAR-CCM+ benchmark cases were run on an HP Cluster Platform system consisting of 16 ProLiant BL280c G6 compute blades and one network file system (NFS) server node.

- Server: HP BladeSystem c7000 enclosure with
 - 16 ProLiant BL280c G6 blades/128 cores of Intel Xeon® Processor 5570 @ 2.93 GHz
 - 24 GB memory/blade
- Interconnects
 - TrueScale Quad Data Rate (QDR) InfiniBand
 - HP BladeSystem c-Class QLogic 4X QDR Host Channel Adapter (HCA)
 - QLogic BLc 4X QDR IB Switch for HP BladeSystem c-Class 32 ports
 - HP GbE2c Ethernet blade switch

TrueScale InfiniBand provided a 40 Gbps interconnect between each blade for message passing interface (MPI) and file system I/O traffic. The Gigabit Ethernet interconnect was tested for comparison purposes. QLogic ran the benchmark tests to determine performance and scaling using clusters based on TrueScale InfiniBand as well as Gigabit Ethernet. QLogic also performed tests to simulate concurrent execution of models of this size and complexity so as to understand if the TrueScale InfiniBand cluster would be able to support an engineering team running simultaneous simulations.

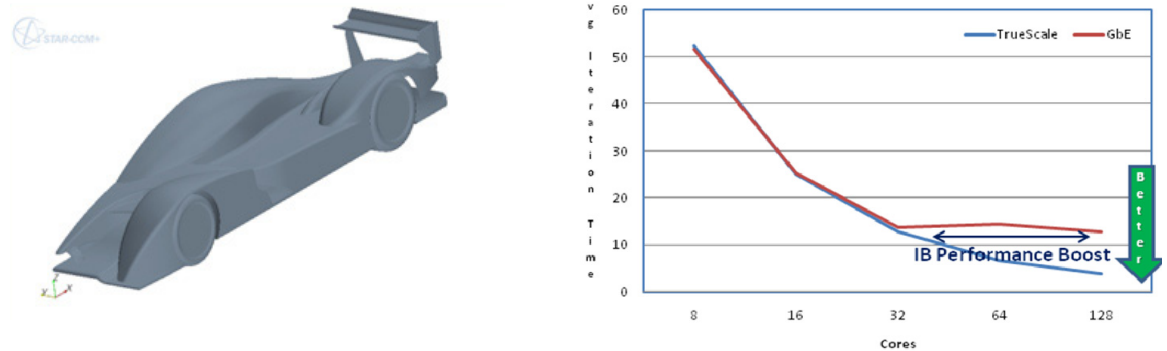
The following sections and charts summarize the results for each STAR-CCM+ case. QLogic ran the HPC cluster using both TrueScale InfiniBand and Gigabit Ethernet interconnects for comparison purposes.

Le Mans Race Car benchmark

Le Mans model specifications

Number of cells	17,000,000
Cell type	Polyhedral
Models	Low-speed external aerodynamics
Solver	Segregated solver

Figure 1.



Performance—time-to-solution

- TrueScale InfiniBand cluster is up to 14 times faster than a multicore workstation.
- The TrueScale cluster is 244% faster than Gigabit Ethernet at 128 cores.

Price/Performance—cost of implementation

- TrueScale InfiniBand requires fewer blades/servers for a given level of performance; for instance, 4 blades/32 cores with TrueScale InfiniBand provides better performance than 16 blades/128 cores with Gigabit Ethernet.

Scalability—ability to run more complex model

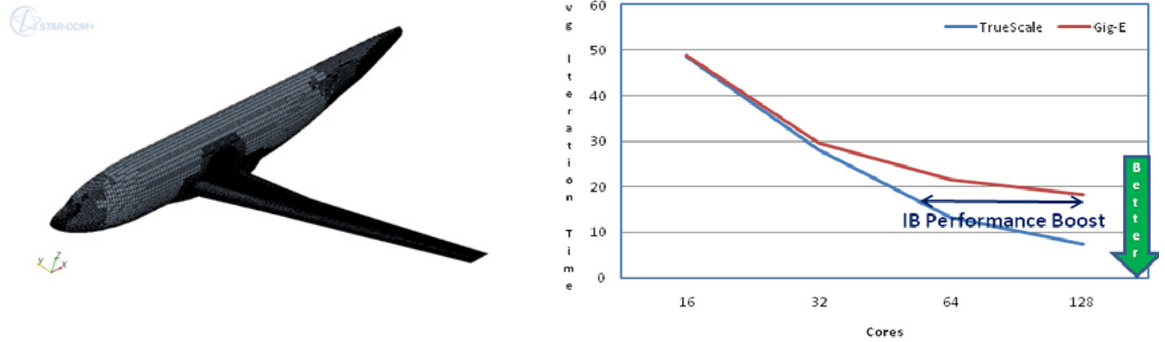
- The TrueScale InfiniBand cluster continues to scale through 16 blades/128 cores.
- Gigabit Ethernet provides marginal or no performance benefits after 4 blades/32 cores.

Civilian Airline benchmark

Civilian Airline model specifications

Number of cells	20,000,000
Cell type	Trimmed
Models	High-speed external aerodynamics (Mach 0.8)
Solver	Segregated solver

Figure 2.



Performance—time-to-solution

- There is more than 5.7 times performance speed-up from 2 to 16 blades when connected with TrueScale InfiniBand.
- The TrueScale cluster is 150% faster than Gigabit Ethernet at 128 cores.

Price/Performance—cost of implementation

- InfiniBand requires fewer blades/servers for a given level of performance.

Scalability—model complexity

- The TrueScale InfiniBand cluster continues to scale through 16 blades/128 cores with an impressive 83.5% scaling efficiency.
- The Gigabit Ethernet cluster shows only a 33% scaling efficiency.

Results for simultaneous simulation runs

HP Cluster Platform with TrueScale InfiniBand provides the flexibility and performance needed to support a dynamic set of concurrent simulations requirements.

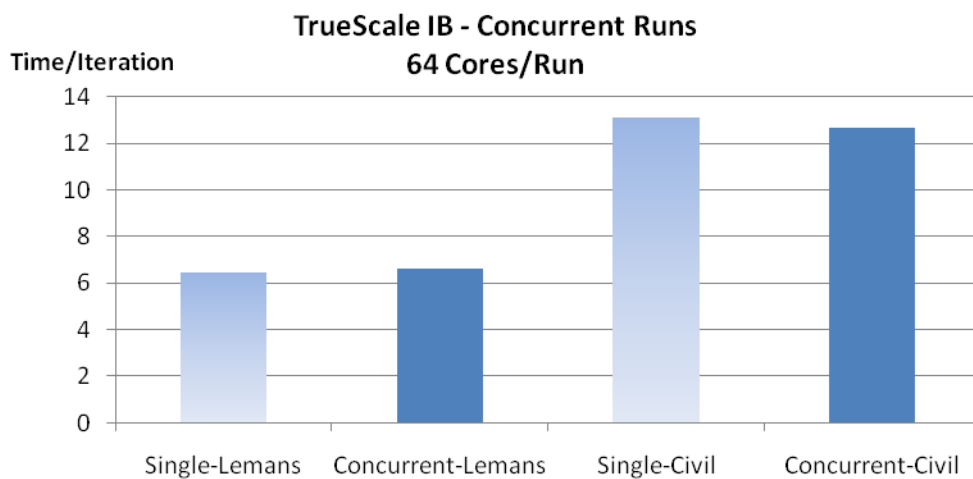
Partitioning the cluster into smaller virtual configurations is one way to effectively create multiple, low-node-count clusters, each capable of supporting concurrent simulations. This is a great way for multiple engineers to simultaneously share the cluster resources, thereby making an entire engineering team more productive. Alternately, a single engineer has the option to run multiple variations on a design, thereby being able to quickly identify the best design alternative.

Two simultaneous simulations test

QLogic ran two separate simulations by launching the Le Mans and Civilian Airline test cases from the same headnode at the same time across separate compute nodes on the cluster. Each case was run on a 16-blade/128-core partition.

The results for the concurrent Le Mans and Civilian Airline test cases are in dark blue. The light blue indicates the results for the single-run test cases on 16 blades/128 cores.

Figure 3.



- TrueScale concurrent simulation run times are within 2% of the single simulation run times.
- Two engineers can run models of the sizes represented by these tests cases without significant impact on performance.

Key technologies

CD-adapco STAR-CCM+

From CAD to post-processing, STAR-CCM+ delivers the entire computational fluid dynamics (CFD) process in a single integrated software environment. This unique approach brings unrivaled ease of use and automation to CAD preparation, meshing, model setup, and iterative design studies, enabling your engineers to deliver better results faster.

Innovations such as built-in surface wrapping, advanced automated meshing (creating either polyhedral or predominantly hexahedral volume meshes), and the ability to “copy and paste” components between models have quickly established STAR-CCM+ with a reputation for producing high-quality results in a single code with minimum user effort.

From its first release in 2004, STAR-CCM+ has impressed the CFD community with its rapid pace of development. Written “from the ground up” using object-oriented programming and the latest software technology combined with outstanding ease of use and accuracy, STAR-CCM+ is an entirely new concept in CFD.

HP Cluster Platforms—high-performance cluster technology

HP is the market leader in high-performance computing, offering the broadest spectrum of high-performance computing solutions, from workgroup and departmental servers to systems designed for the engineering enterprise and supercomputing centers. HP delivers innovative, industry-standard servers that are optimized for scalability, price/performance, and performance/watt to reduce your capital and operating expenses.

Clustering is simple and fast with HP Cluster Platforms, the foundation of the [Unified Cluster Portfolio](#). These systems combine the flexibility of a custom solution with the simplicity, reliability, and value of a preconfigured, factory-built product. Get started with HP [Cluster Platforms](#).

- Broad choice of servers, cluster interconnects, and middleware
- Factory integrated and tested, with final onsite installation
- Choice of packaging styles—dense or expandable modular design up to 1024 nodes
- Backed by HP warranty and support, and built to uniform, worldwide specifications
- Comprehensive software selection, tested and verified by HP and/or its partners
- Rapid deployment services, including optional software installation, onsite training, and implementation support

Intel—high-performance processor technology

The Intel Xeon Processor 5500 Series automatically and intelligently adjusts server performance according to the application’s needs for a performance gain up to nine times better than single-core servers (and at 18% less operating power). This processor has a 9:1 server consolidation ratio, which reduces operating costs by up to 90%, resulting in an estimated eight-month return on a new server investment. Two-processor servers based on the Intel Xeon Processor 5500 Series have up to eight computation engines, 16 threads per two-socket platform with Intel Hyper-Threading technology, and as much as 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 greater performance for HPC applications than Intel dual-core processors. Intel recognizes that the need for performance is constantly increasing. That’s 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.

QLogic—high-performance interconnect technology

QLogic offers a comprehensive end-to-end InfiniBand product portfolio that includes Multi-Protocol Fabric Directors, Edge Fabric Switches, Host Channel Adapters (HCAs), and a complete software suite to install, operate, and maintain your high-performance interconnect fabric. QLogic offers the most comprehensive and flexible interconnect fabric solutions on the market. Applications needing 12 to 864 InfiniBand ports can be supported via a single chassis. Multi-chassis fabrics supporting thousands of host nodes can be constructed to meet the most demanding compute cluster requirements. The TrueScale offering, combined with the comprehensive Fabric Management tools—enabling an administrator to install and boot a fabric in minutes, helps to satisfy the growing demand for high-performance computational clusters and grids.

Conclusion and summary

CD-adapco STAR-CCM+ is designed to leverage the latest in today's HPC technologies. The choice of interconnect for the HPC cluster becomes an important consideration for maximizing the new features and benefits of STAR-CCM+. InfiniBand provides the following advantages over Ethernet:

- Performance (low latency/high throughput)
- Price/Performance
- Scalability
- Scalable bandwidth (enables network consolidation)

Performance

When time-to-solution is critical, the value of the InfiniBand-based cluster becomes evident. QLogic TrueScale InfiniBand delivers time-to-solution improvements from 150% to 244%, depending on the size and scale of the cluster when compared to Gigabit Ethernet. TrueScale InfiniBand begins to show its performance advantage with as few as 4 blades/32 cores and increases with the cluster size.

Price/Performance

A TrueScale InfiniBand cluster requires significantly less server resources to complete an equivalent simulation when compared to a Gigabit Ethernet-based cluster. For all of the STAR-CCM+ test cases, it takes less than 8 blades/64 cores utilizing TrueScale to produce the equivalent results of a 16 blades/128 cores cluster interconnected with Gigabit Ethernet. Achieving real saving around computational resources and ongoing operational expenses, such as power and cooling, makes a notable improvement in the bottom line.

Scalability

The value of TrueScale InfiniBand is evident with larger simulations. The Civilian Airline test is a simulation that involves 20 million cells. This scaled very well across the TrueScale InfiniBand interconnect, showing a very impressive 83% scaling efficiency. On the other hand, Gigabit Ethernet shows only 33% scaling efficiency.

Bandwidth

The bandwidth capabilities of InfiniBand—up to 40 Gbps—can be used to architect a solution that consolidates data networking, clustering communications, and storage access over a single fabric. This capability has the benefit of significantly lowering overall power, real estate, and management overhead in data centers. InfiniBand's enhanced Quality of Service (QoS) capabilities support running and managing multiple applications, workloads, and traffic classes. As an example, the TrueScale InfiniBand 40 Gbps fabric was used to concurrently run the MPI inter-processor communication and NFS traffic.

For more information

Web resources

www.hp.com/go/hpc

www.qlogic.com/go/hp

Disclaimer

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