

# STAR-CCM+ Performance Benchmarking and Profiling

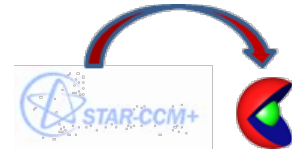
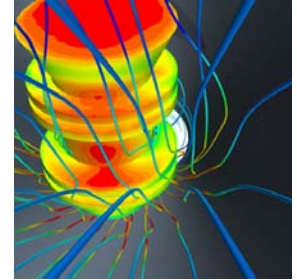
July 2010



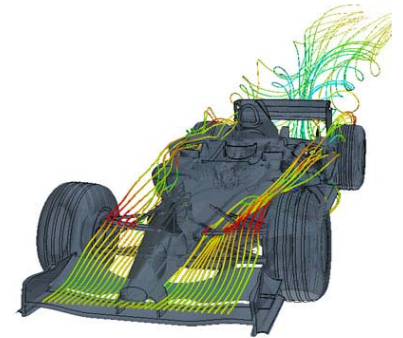
- **The following research was performed under the HPC Advisory Council activities**
  - Participating vendors: CD-adapco, HP, Mellanox
  - Compute resource - HPC Advisory Council Cluster Center
  
- **For more info please refer to**
  - [www.mellanox.com](http://www.mellanox.com)
  - <http://www.hp.com/go/hpc>
  - <http://www.cd-adapco.com>

- **STAR-CCM+**

- An engineering process-oriented CFD tool
- Client-server architecture, object-oriented programming
- Delivers the entire CFD process in a single integrated software environment



- **Developed by CD-adapco**

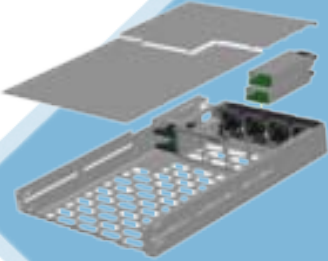


- **The presented research was done to provide best practices**
  - CD-adapco performance benchmarking
    - Interconnect performance comparisons
  - Ways to increase CD-adapco productivity
  - Power-efficient simulations
- **The presented results will demonstrate**
  - The scalability of the compute environment
  - Considerations for power saving through balanced system configuration

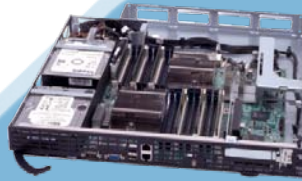
- **HP ProLiant SL2x170z G6 16-node cluster**
  - Six-Core Intel X5670 @ 2.93 GHz CPUs
  - Memory: 24GB per node
  - OS: CentOS5U4, OFED 1.5.1 InfiniBand SW stack
- **Mellanox ConnectX-2 adapters and switches**
- **Fulcrum based 10GigE switch**
- **MPI: HP-MPI 2.3.1**
- **Application: STAR-CCM+ Version 5.04.006, STAR-CD Version 4.12.022**
- **Benchmark Workload**
  - STAR-CCM+: Lemans\_Poly\_17M (Epsilon Euskadi Le Mans car external aerodynamics)

# About HP ProLiant SL6000 Scalable System

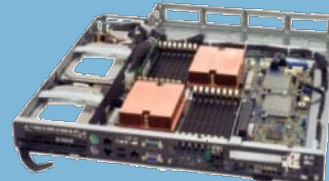
- **Solution-optimized for extreme scale out**



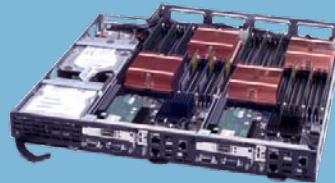
ProLiant z6000 chassis  
Shared infrastructure  
– fans, chassis, power



ProLiant SL160z G6    ProLiant SL165z G7  
Large memory  
-memory-cache apps



ProLiant SL170z G6  
Large storage  
-Web search and database apps



ProLiant SL2x170z G6  
Highly dense  
- HPC compute and  
web front-end apps

Save on cost and energy -- per node, rack and data center

Mix and match configurations

Deploy with confidence



#1  
Power  
Efficiency\*

\* SPECpower\_ssj2008  
[www.spec.org](http://www.spec.org)  
17 June 2010, 13:28

- **Input Dataset**

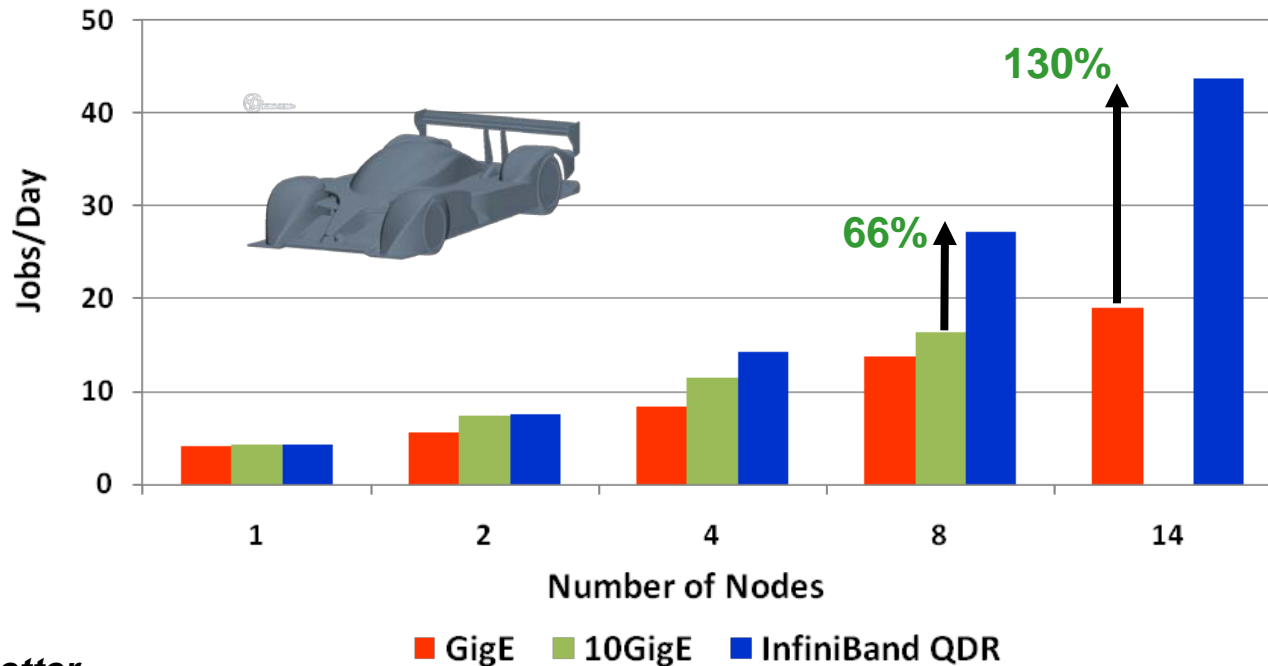
- Lemans\_Poly\_17M

- **InfiniBand QDR enables higher scalability**

- InfiniBand reduces electrical energy/job by 57% or more compared to GigE
- 130% higher performance than GigE at 14 nodes and 66% than 10GigE at 8 nodes



## STAR-CCM+ Benchmark (Lemans\_Poly\_17M)



*Higher is better*

**12 Cores/Node**

# STAR-CCM+ Performance Result - Cores/Socket

- **Input Dataset**

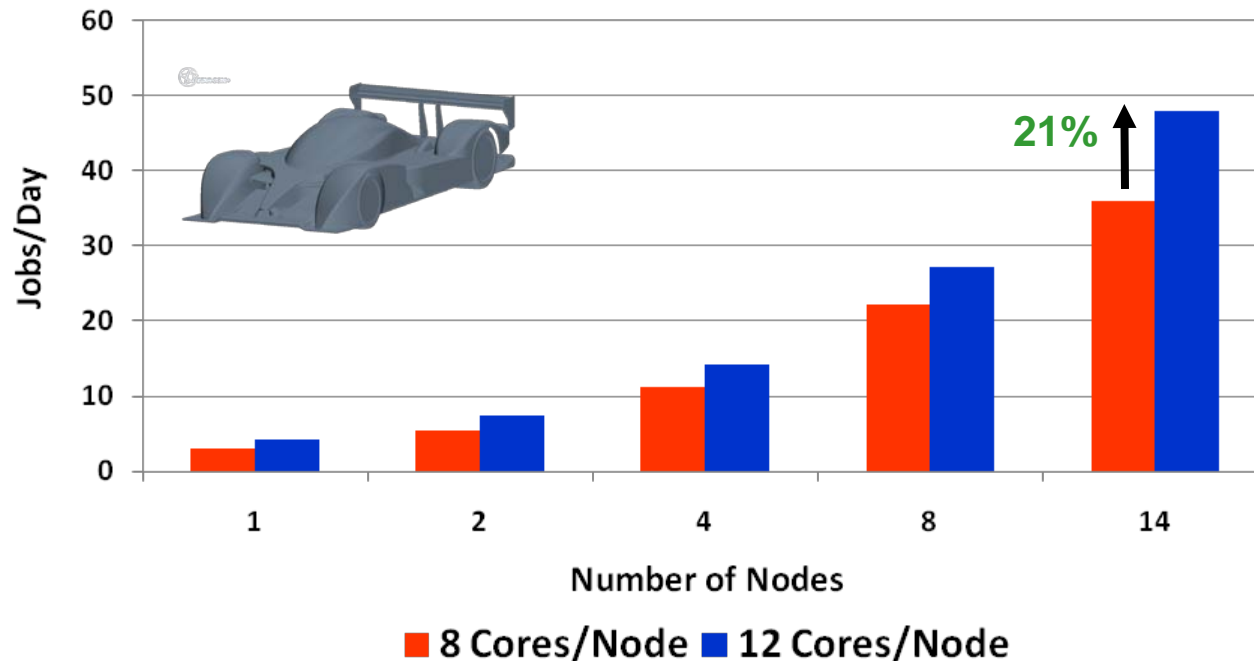
- Lemans\_Poly\_17M

- **Core/socket comparison**

- Using 6 cores/socket (12 cores/node) provides higher performance at all node count
  - Up to 21% higher performance than 8 cores/node



**STAR-CCM+ Benchmark**  
(Lemans\_Poly\_17M)



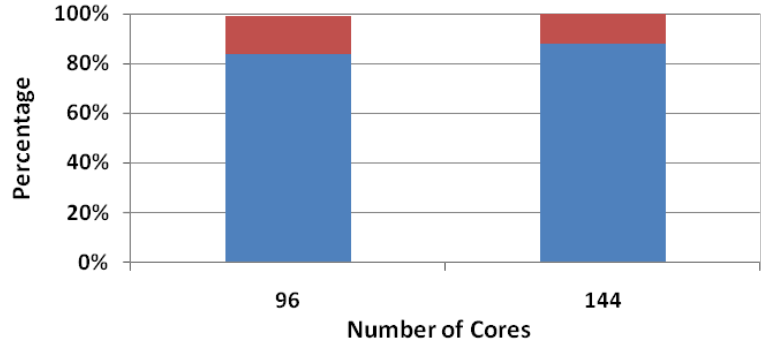
*InfiniBand*

- **Interconnect comparison shows**
  - InfiniBand delivers superior performance in every cluster size
  - Low latency InfiniBand enables better scalability than 10GigE and GigE
- **Cores/Socket Usage**
  - Fully utilizing all the cores in each node yields the best performance
- **InfiniBand QDR saves power**
  - STAR-CCM+
    - InfiniBand reduces power consumption/job by 57% or more compared to GigE

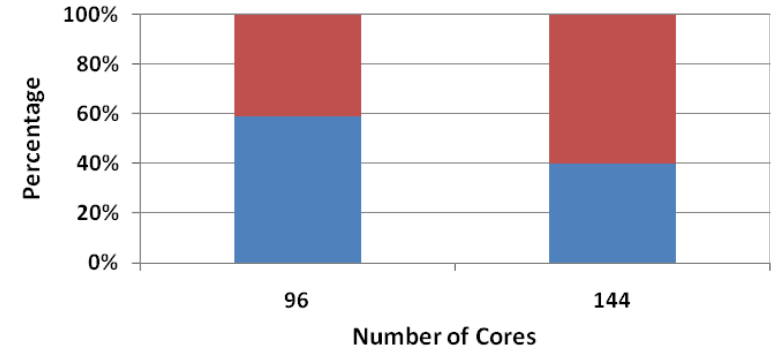
## • Runtime Distribution

- MPI communication overhead remains small with InfiniBand as cluster size scales
- MPI overhead becomes dominated with GigE as node count increases
- MPI overhead over 10GigE grows with cluster size

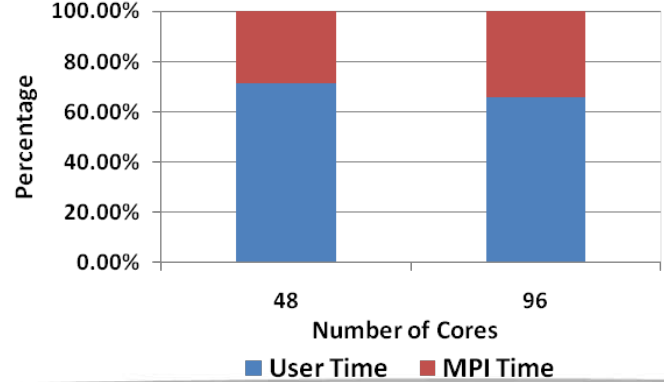
### Runtime Distribution (InfiniBand QDR)



### Runtime Distribution (GigE)



### Runtime Distribution (10GigE)

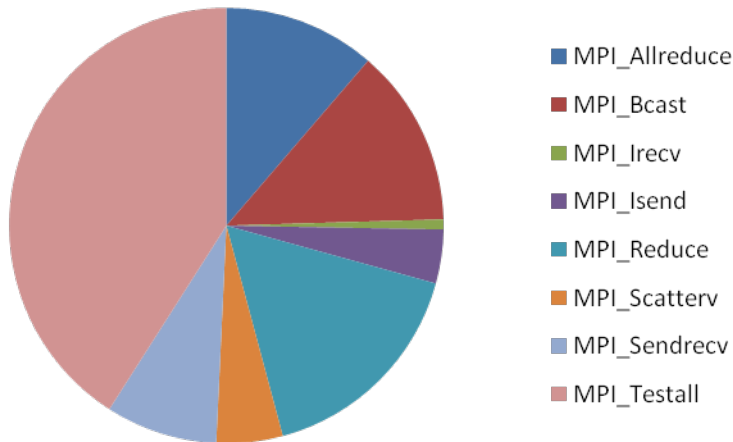


12 Cores/Node

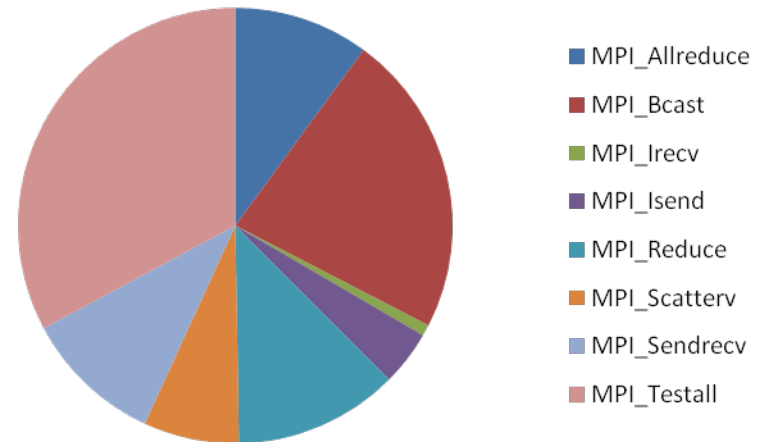
- **Major MPI Functions**

- MPI\_Testall, MPI\_Allreduce, MPI\_Bcast, and MPI\_Reduce
- MPI\_Testall is testing the completion of no-blocking send/recv
- MPI\_Bcast (Collectives) percentage increase as cluster size scales

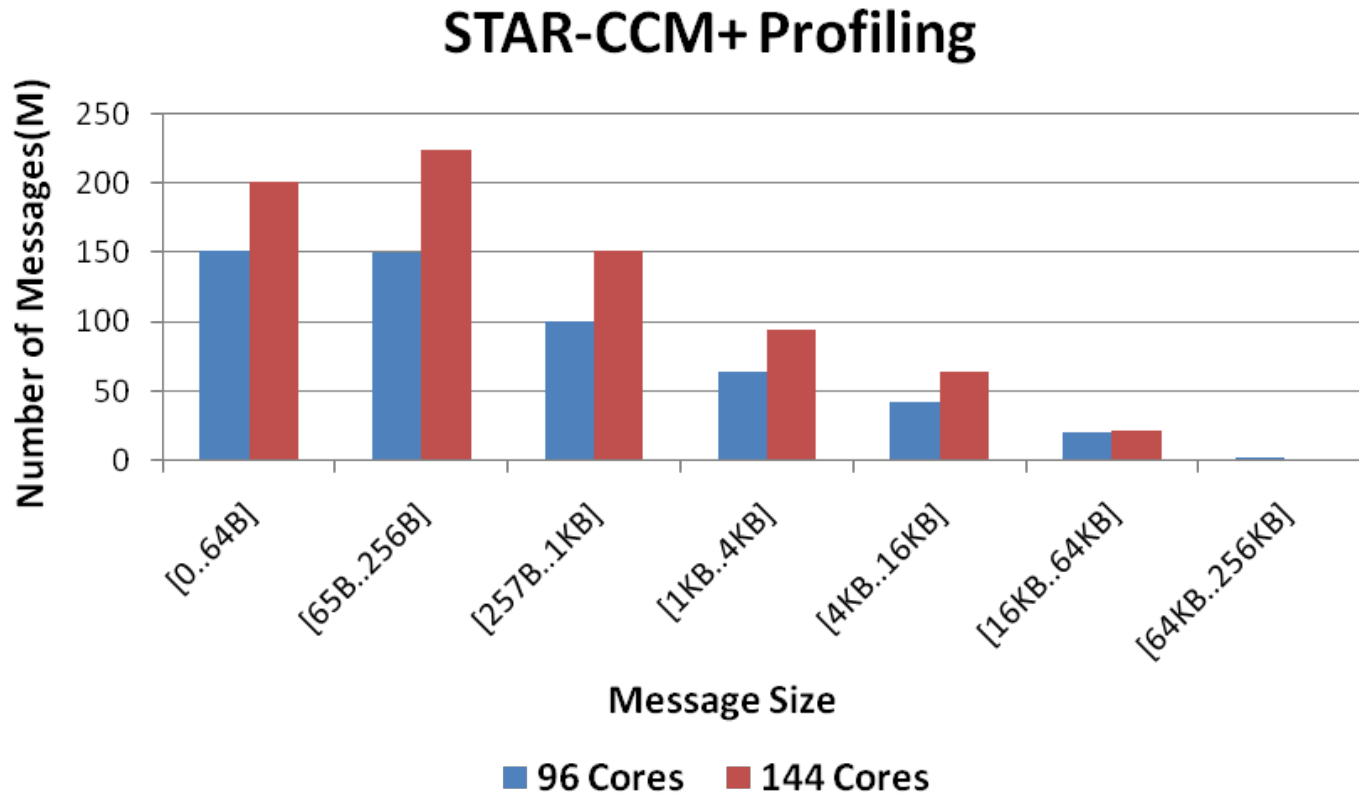
**96 Cores**



**144 Cores**



- Majority messages are small messages
- Number of messages increases as cluster size scales



- **STAR-CCM+ was profiled to understand its communication pattern**
- **Most used message sizes**
  - Small messages
  - Total number of messages increases with cluster size
- **Interconnects effect to STAR-CCM+ performance**
  - Interconnect latency is critical to application performance
  - Communication overhead remains small with InfiniBand
  - GigE creates big communication overhead for application

# Thank You

## HPC Advisory Council



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