

# LS-DYNA Performance Benchmarking and Profiling

August 2010



**LSTC**  
Livermore Software  
Technology Corp.

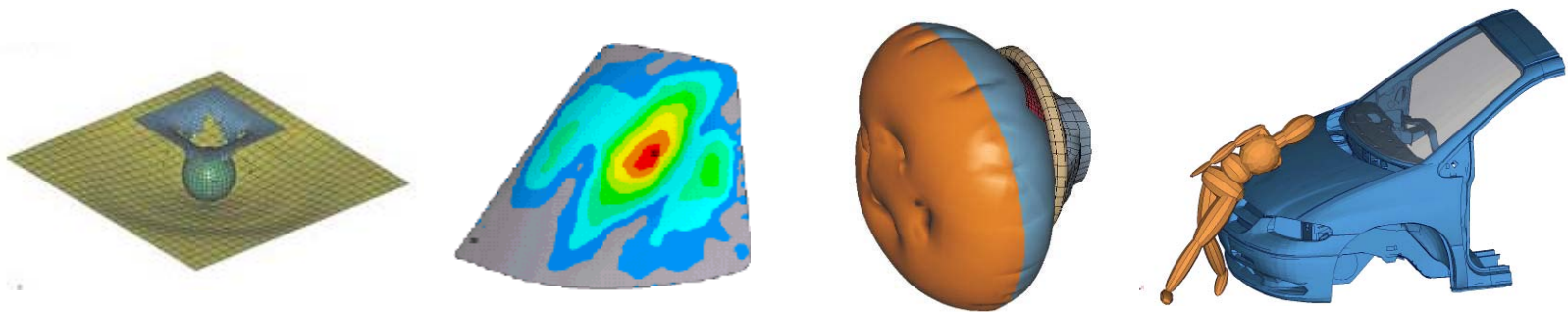


- **The following research was performed under the HPC Advisory Council activities**
  - Participating vendors: HP, Mellanox, LSTC
  - Compute resource - HPC Advisory Council Cluster Center
  
- **For more info please refer to**
  - [www.mellanox.com](http://www.mellanox.com)
  - <http://www.hp.com/go/hpc>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

- **LS-DYNA**
  - A general purpose structural and fluid analysis simulation software package capable of simulating complex real world problems
  - Developed by the Livermore Software Technology Corporation (LSTC)
- **LS-DYNA used by**
  - Automobile
  - Aerospace
  - Construction
  - Military
  - Manufacturing
  - Bioengineering



- **LS-DYNA SMP (Shared Memory Processing)**
  - Optimize the power of multiple CPUs within single machine
- **LS-DYNA MPP (Massively Parallel Processing)**
  - The MPP version of LS-DYNA allows to run LS-DYNA solver over High-performance computing cluster
  - Uses message passing (MPI) to obtain parallelism

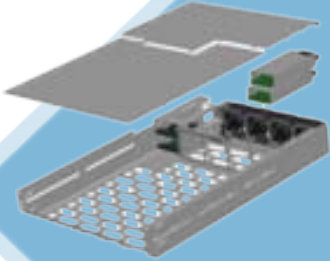


- **The presented research was done to provide best practices**
  - LS-DYNA performance benchmarking
    - Interconnect performance comparisons
  - Ways to increase LS-DYNA productivity
  - Power-efficient simulations
- **The presented results will demonstrate**
  - The scalability of the compute environment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

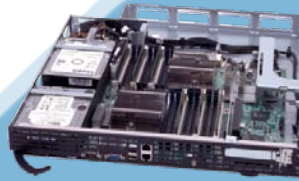
- **HP ProLiant SL2x170z G6 16-node cluster**
  - Six-Core Intel X5670 @ 2.93 GHz CPUs
  - Memory: 24GB per node
  - OS: CentOS5U4, OFED 1.5.1 InfiniBand SW stack
- **Mellanox ConnectX-2 adapters and switches**
- **Fulcrum based 10GigE switch**
- **MPI: Platform MPI 7.1**
- **Application: LS-DYNA MPP971\_s\_R5.0**
- **Benchmark Workload**
  - Three Vehicle Collision Test simulation

# About HP ProLiant SL6000 Scalable System

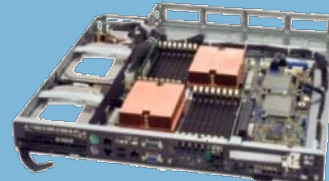
- **Solution-optimized for extreme scale out**



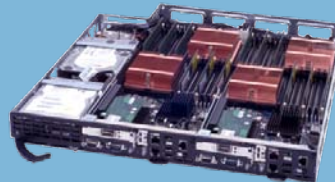
ProLiant z6000 chassis  
Shared infrastructure  
– fans, chassis, power



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

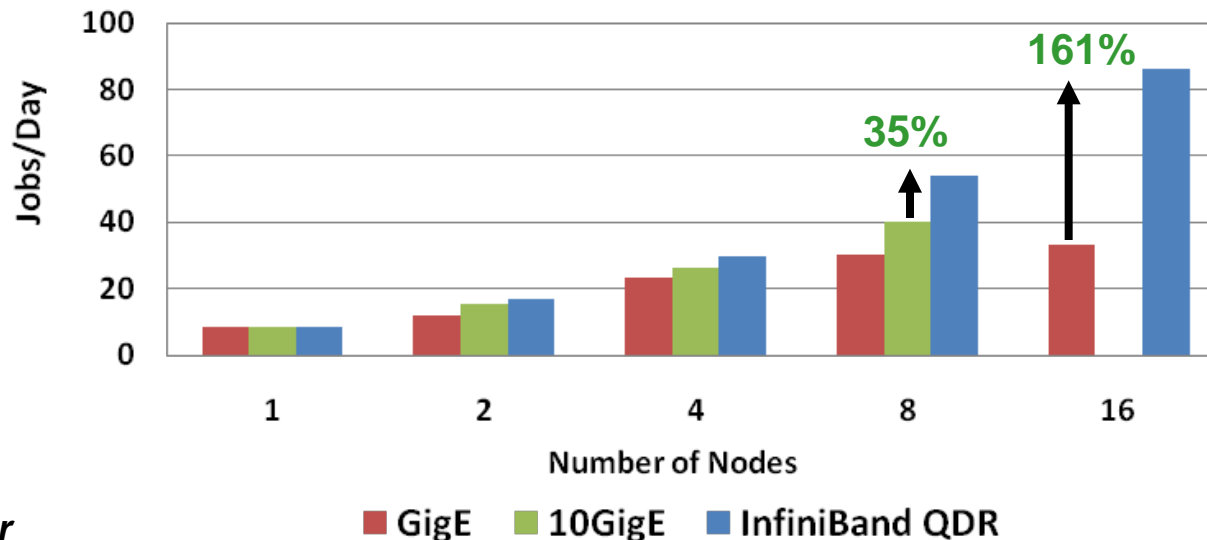


#1  
Power  
Efficiency\*

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

- **Input Dataset**
  - 3 Vehicle Collision (0.8 million elements)
- **InfiniBand QDR enables higher scalability**
  - 161% higher performance than GigE at 16 nodes
  - 35% higher performance than 10GigE 8 nodes
  - Expected more performance gain as cluster size increases
- **InfiniBand reduces electrical energy/job by**
  - 61% or more compared to GigE
  - 26% or more compare to 10GigE

## LS-DYNA Benchmark Result (3 Vehicle Collision)





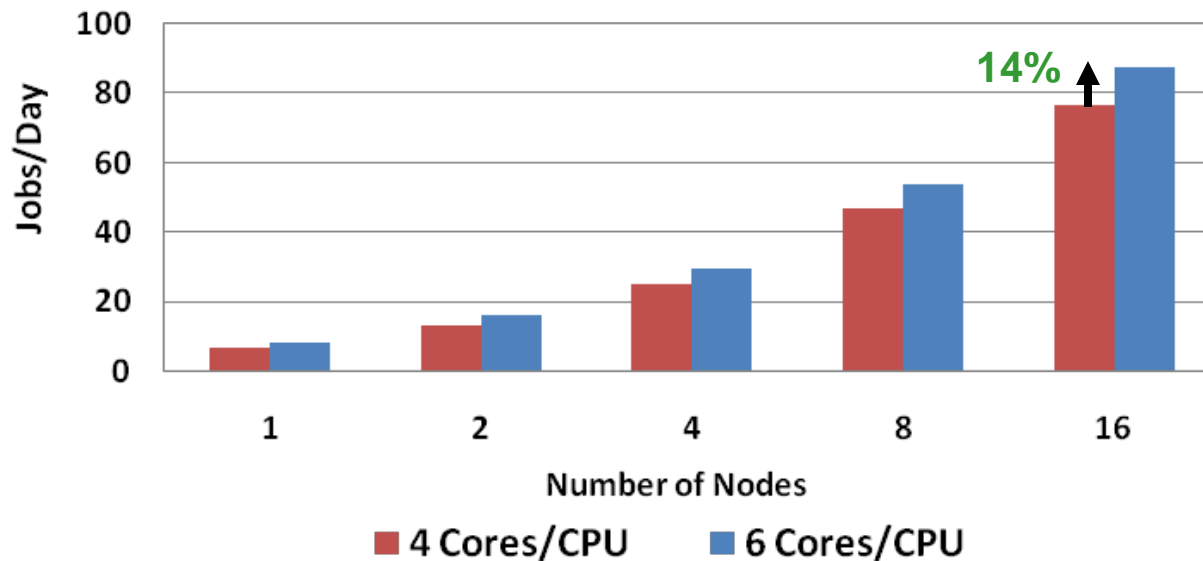
- **Input Dataset**

- 3 Vehicle Collision (0.8 million elements)

- **Core/socket comparison**

- Using 6 cores/socket (12 cores/node) provides higher performance at all node count
- Up to 14% higher performance than 8 cores/node

## LS-DYNA Benchmark Result (3 Vehicle Collision)

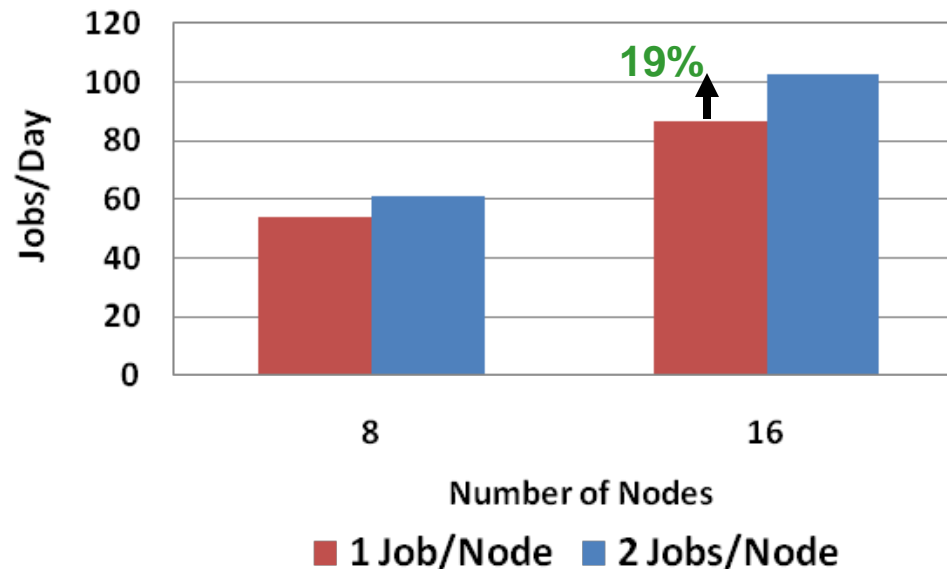


*Higher is better*

*InfiniBand*

- **Input Dataset**
  - 3 Vehicle Collision (0.8 million elements)
- **Performance comparison**
  - 1 job mode: All cores per node used by single job
  - 2 jobs mode: Each job runs over half number of cores per socket
  - Running 2 jobs in parallel delivers 19% higher productivity than single job alone
    - Performance advantage grows as cluster size increases

## LS-DYNA Benchmark Result



*Higher is better*

**192 cores/16Nodes**

# LS-DYNA MPI Profiling – MPI Time

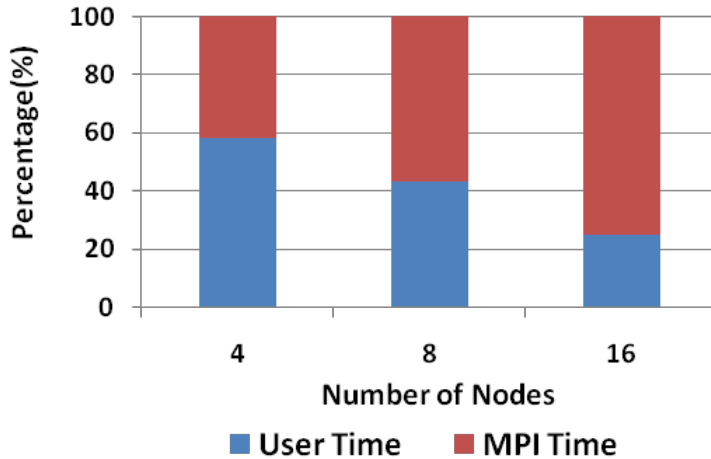
- **Input Dataset**

- 3 Vehicle Collision (0.8 million elements)

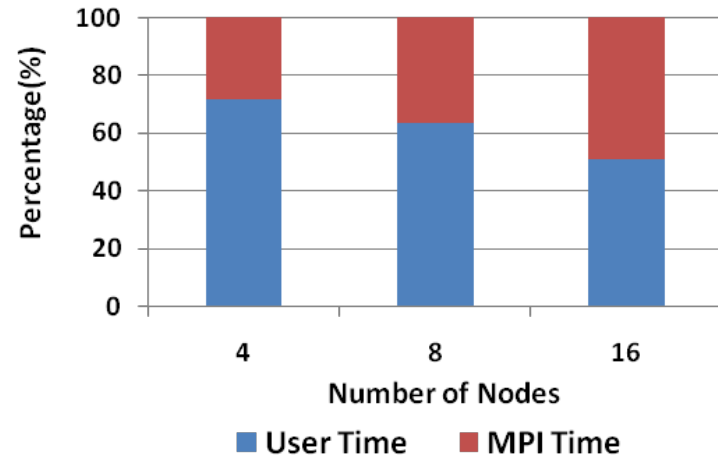
- **Runtime Distribution**

- MPI overhead becomes dominated with GigE as node count increases
- InfiniBand enables much smaller MPI communication overhead comparing to GigE

**Runtime Distribution (GigE)**



**Runtime Distribution (InfiniBand QDR)**



**12 Cores/Node**

- **Interconnect comparison shows**
  - InfiniBand delivers superior performance in every cluster size
  - Low latency InfiniBand enables better scalability than 10GigE and GigE
- **Customized job placement increases application productivity**
  - 19% more jobs can be completed by running 2 jobs concurrently
- **Cores/Socket Usage**
  - Fully utilizing all the cores in each node yields the best performance
- **InfiniBand QDR saves power**
  - Reduces power consumption/job by 61% or more compared to GigE and 26% or more compared to 10GigE

# Thank You

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