LS-DYNA Performance Benchmarking and Profiling

August 2010
• 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.hp.com/go/hpc
  – www.lstc.com
LS-DYNA

- **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

• **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
Objectives

• 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
Test Cluster 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 SL160z G6: Large memory
    - memory-cache apps
  - ProLiant SL165z G7: Shared infrastructure
    - fans, chassis, power
  - 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

* SPECpower_ssj2008
  www.spec.org
  17 June 2010, 13:28
LS-DYNA Performance Result - Interconnect

- **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 compared to 10GigE

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**LS-DYNA Benchmark Result**

(3 Vehicle Collision)

*Higher is better*

<table>
<thead>
<tr>
<th>Number of Nodes</th>
<th>1</th>
<th>2</th>
<th>4</th>
<th>8</th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jobs/Day</td>
<td>0</td>
<td>10</td>
<td>20</td>
<td>35</td>
<td>100</td>
</tr>
</tbody>
</table>

**12 Cores/Node**
• **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**
LS-DYNA Performance Result – Productivity

• 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

Higher is better

192 cores/16 Nodes
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
LS-DYNA Benchmark Summary

• **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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