



# Abaqus 6.14-2 Performance Benchmark and Profiling

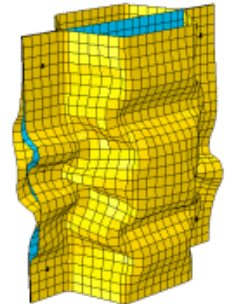
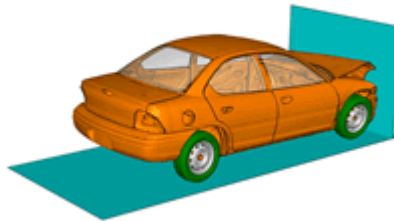
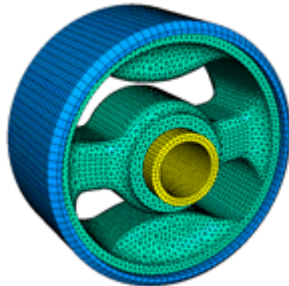
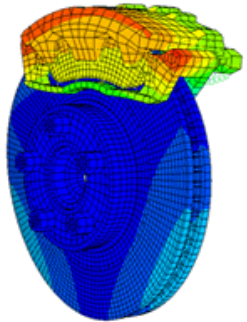
March 2015



- **The following research was performed under the HPC Advisory Council activities**
  - Special thanks for: HP, Mellanox
- **For more information on the supporting vendors solutions please refer to:**
  - [www.mellanox.com](http://www.mellanox.com), <http://www.hp.com/go/hpc>
- **For more information on the application:**
  - <http://www.3ds.com/products-services/simulia/>



- **Abaqus Unified FEA product suite offers powerful and complete solutions for both routine and sophisticated engineering problems covering a vast spectrum of industrial applications**
- **The Abaqus analysis products listed below focus on:**
  - Nonlinear finite element analysis (FEA)
  - Advanced linear and dynamics application problems
- **Abaqus/Standard**
  - General-purpose FEA that includes broad range of analysis capabilities
- **Abaqus/Explicit**
  - Nonlinear, transient, dynamic analysis of solids and structures using explicit time integration



- **The presented research was done to provide best practices**
  - Abaqus performance benchmarking
  - Interconnect performance comparisons
  - MPI performance comparison
  - Understanding Abaqus communication patterns
  
- **The presented results will demonstrate**
  - The scalability of the compute environment to provide nearly linear application scalability

- **HP Apollo 6000 “Heimdall” cluster**
  - HP ProLiant XL230a Gen9 10-node “Heimdall” cluster
  - Processors: Dual-Socket 14-core Intel Xeon E5-2697v3 @ 2.6 GHz CPUs (Turbo Mode on; Home Snoop as default)
  - Memory: 64GB per node, 2133MHz DDR4 DIMMs
  - OS: RHEL 6 Update 6, OFED 2.4-1.0.0 InfiniBand SW stack
- **Mellanox Connect-IB FDR InfiniBand adapters**
- **Mellanox ConnectX-3 Pro Ethernet adapters**
- **Mellanox SwitchX SX6036 56Gb/s FDR InfiniBand and Ethernet VPI Switch**
- **MPI: Platform MPI 9.1.2 and Intel MPI 4.1.3**
- **Application: Abaqus 6.14-2 (unless otherwise stated)**
- **Benchmark Workload: Abaqus/Standard and Abaqus/Explicit benchmarks**

# HP ProLiant XL230a Gen9 Server

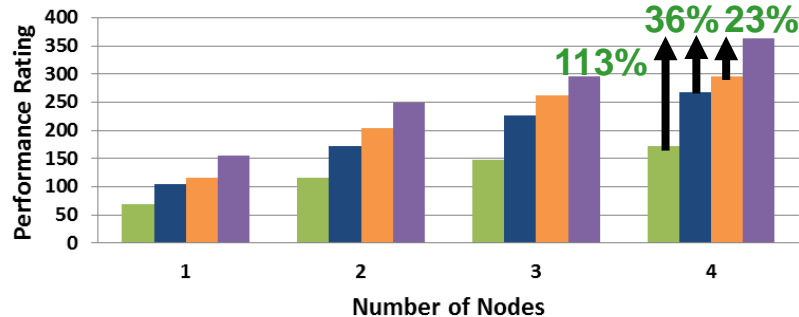
Item	HP ProLiant XL230a Gen9 Server
Processor	Two Intel® Xeon® E5-2600 v3 Series, 6/8/10/12/14/16 Cores
Chipset	Intel Xeon E5-2600 v3 series
Memory	512 GB (16 x 32 GB) 16 DIMM slots, DDR3 up to DDR4; R-DIMM/LR-DIMM; 2,133 MHz
Max Memory	512 GB
Internal Storage	1 HP Dynamic Smart Array B140i SATA controller HP H240 Host Bus Adapter
Networking	Network module supporting various FlexibleLOMs: 1GbE, 10GbE, and/or InfiniBand
Expansion Slots	1 Internal PCIe: 1 PCIe x 16 Gen3, half-height
Ports	Front: (1) Management, (2) 1GbE, (1) Serial, (1) S.U.V port, (2) PCIe, and Internal Micro SD card & Active Health
Power Supplies	HP 2,400 or 2,650 W Platinum hot-plug power supplies delivered by HP Apollo 6000 Power Shelf
Integrated Management	HP iLO (Firmware: HP iLO 4) Option: HP Advanced Power Manager
Additional Features	Shared Power & Cooling and up to 8 nodes per 4U chassis, single GPU support, Fusion I/O support
Form Factor	10 servers in 5U chassis



# Abaqus/Explicit Performance – System Generation

- **Intel E5-2697V3 (Haswell) cluster outperforms prior system generations**
  - Performs 113% higher vs Westmere cluster, 36% vs Sandy Bridge cluster, and 23% vs Ivy Bridge cluster at 4 nodes
- **System components used:**
  - Heimdall (HSW): 2-socket 14-core Intel E5-2697v3 @ 2.6GHz, 2133MHz DIMMs, FDR IB, 1HDD
  - Athena (IVB): 2-socket 10-core Intel E5-2680v2 @ 2.7GHz, 1600MHz DIMMs, FDR IB, 1HDD
  - Athena (SNB): 2-socket 8-core Intel E5-2680 @ 2.7GHz, 1600MHz DIMMs, FDR IB, 1HDD
  - Plutus (WSM): 2-socket 6-core Intel X5670 @ 2.93GHz, 1333MHz DIMMs, QDR IB, 1HDD

**Abaqus/Explicit Performance  
(E6)**



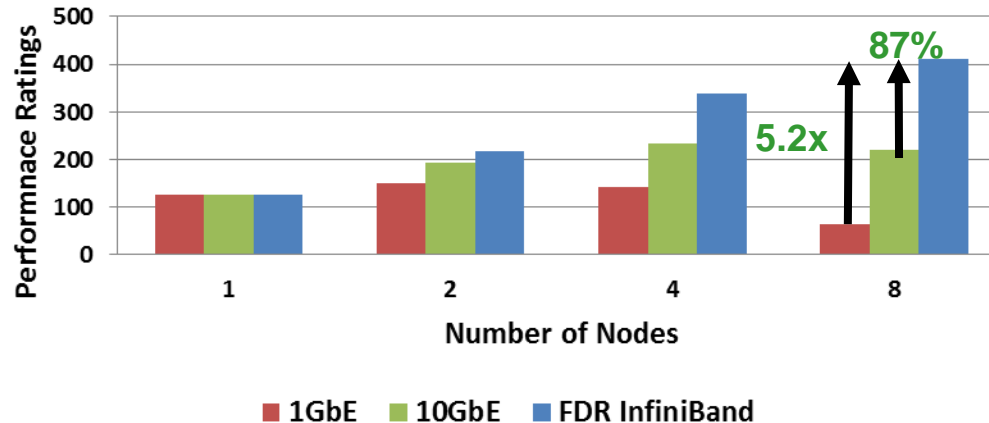
■ Plutus-WSM ■ Athena-SNB ■ Athena-IVB ■ Heimdall-HSW

*Performance Rating: based on total runtime*

*Higher is better*

- **FDR InfiniBand is the most efficient network interconnect for Abaqus/Explicit**
  - FDR IB outperforms 1GbE by 5.2x at 8 nodes (224 MPI processes)
  - FDR IB outperforms 10GbE by 87% at 8 nodes (224 MPI processes)

## Abaqus/Explicit Profiling (E6) Number of MPI Calls



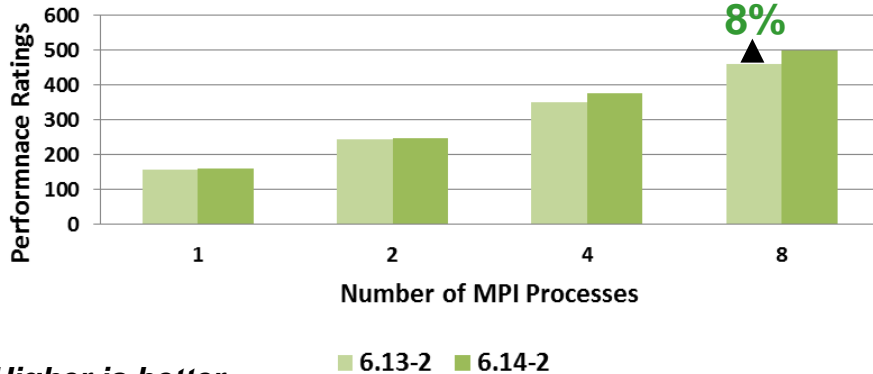
*Higher is better*



# Abaqus Performance – Software Versions

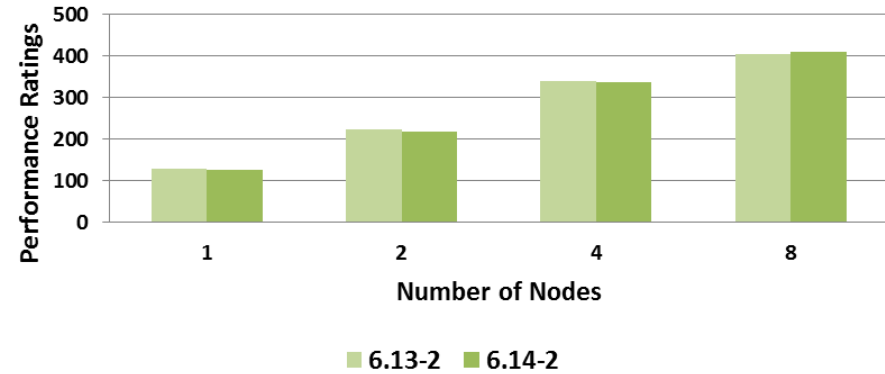
- **Abaqus/Standard performs faster than the previous version**
  - 6.14-2 outperforms 6.13-2 by 8% at 8 nodes / 224 cores
  - MPI library versions have also changed
- **The gain on Abaqus/Explicit for the newer version is not as dramatic**
  - Only slight gain can be seen on the dataset tested

**Abaqus/Standard Profiling**  
(S4D)  
Number of MPI Calls



*Higher is better*

**Abaqus/Explicit Profiling**  
(E6)  
Number of MPI Calls

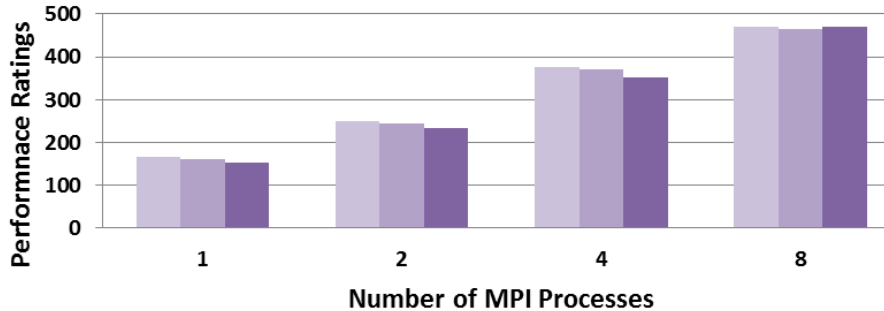


- **Changing QPI Snoop Configuration may improve performance in certain workload**
  - Home Snoop provide high memory bandwidth in average NUMA environment (default)
  - Early Snoop may decrease memory latency but lower bandwidth
  - Cluster on Die may provide increased memory bandwidth in highly optimized NUMA workloads
  - Only slight improvement is seen using Early Snoop for Abaqus/Standard, no difference in Explicit

## Abaqus/Standard Profiling

(S4D)

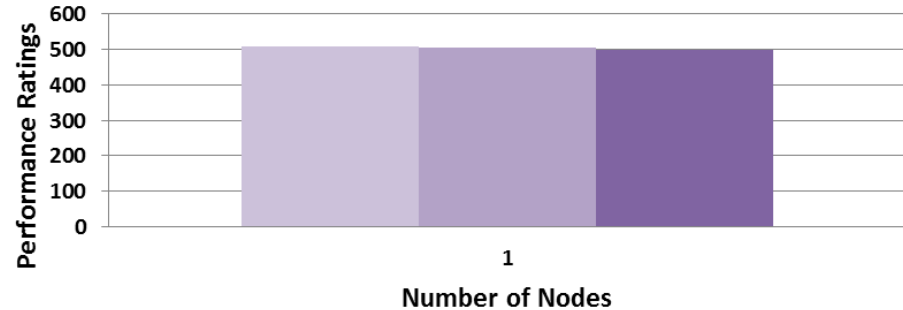
Number of MPI Calls



## Abaqus/Explicit Profiling

(E2)

Number of MPI Calls



Higher is better

Early Snoop

Home Snoop

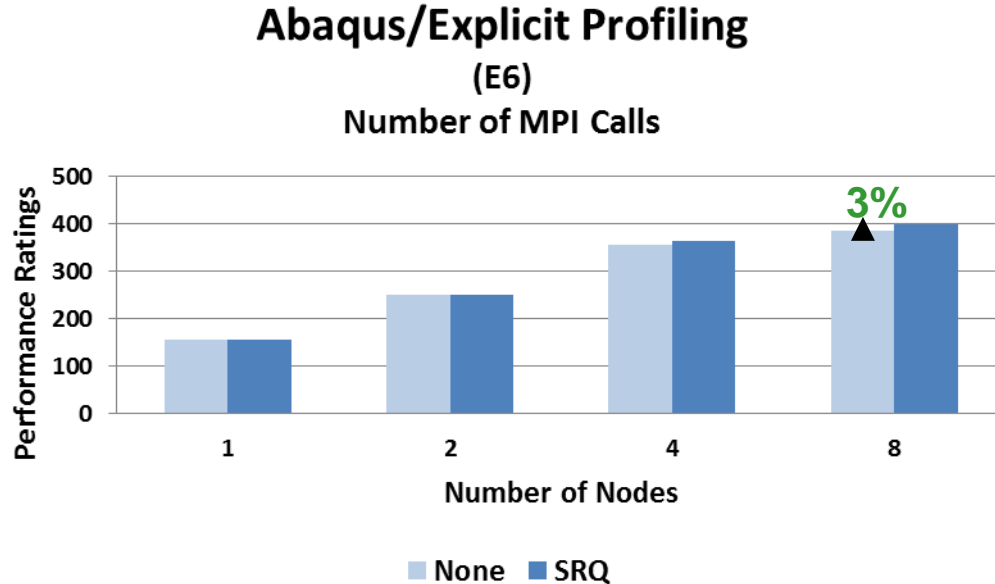
Cluster On Die

Cluster On Die

Early Snoop

Home Snoop

- **Abaqus/Explicit performs marginally faster with SRQ enabled**
  - Enabling SRQ performs 3% faster at 8 nodes / 224 cores

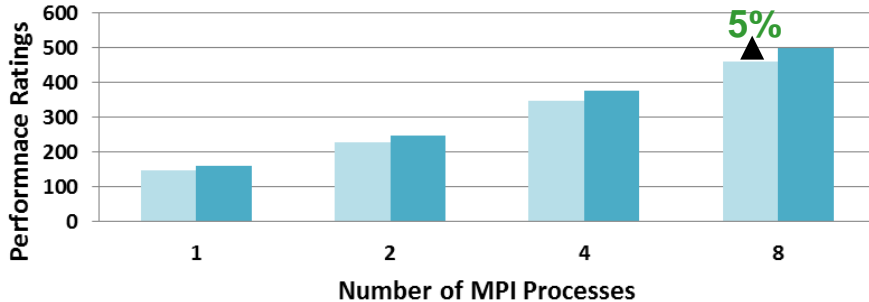


*Higher is better*

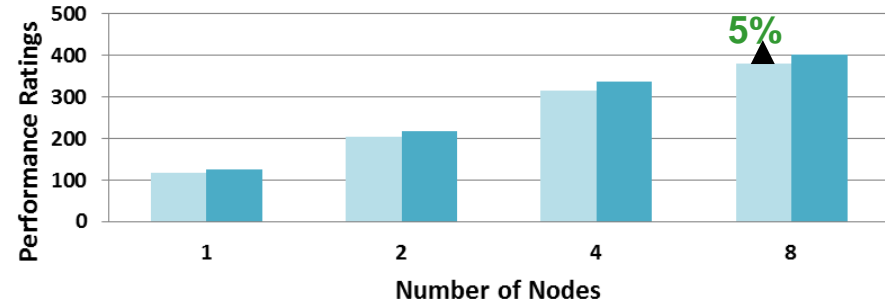
# Abaqus Performance – Turbo Mode

- **Some improvement is observed by enabling Turbo Mode in Abaqus**
  - About 5% improvement seen for both Abaqus/Standard and Abaqus/Explicit
  - The CPU clock runs at a higher clock frequency when turbo is enabled
  - Additional power use can occur when Turbo Mode is on

**Abaqus/Standard Profiling**  
(S4D)  
Number of MPI Calls



**Abaqus/Explicit Profiling**  
(E6)  
Number of MPI Calls

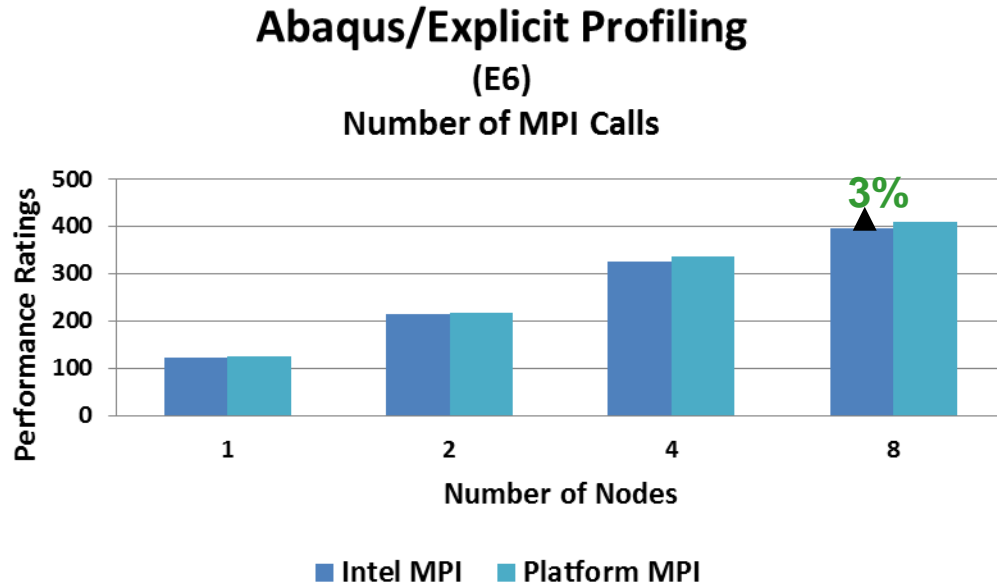


*Higher is better*

TURBO=OFF TURBO=ON

TURBO=OFF TURBO=ON

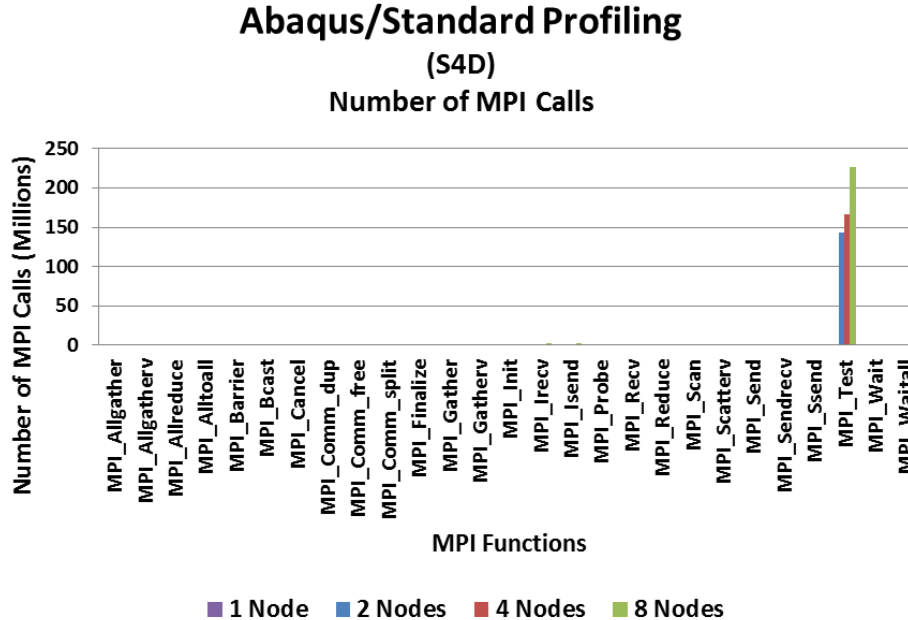
- **Abaqus starts to support Intel MPI starting in version 6.14**
  - Platform MPI performs slightly higher performance than Intel MPI of 3% at 8 nodes



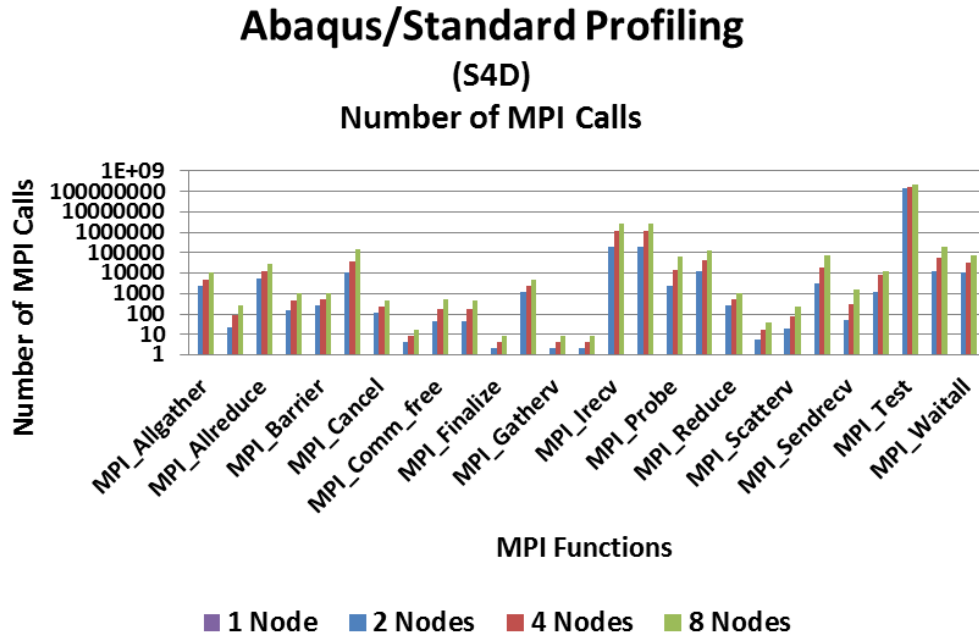
*Higher is better*

# Abaqus/Standard Profiling – MPI calls

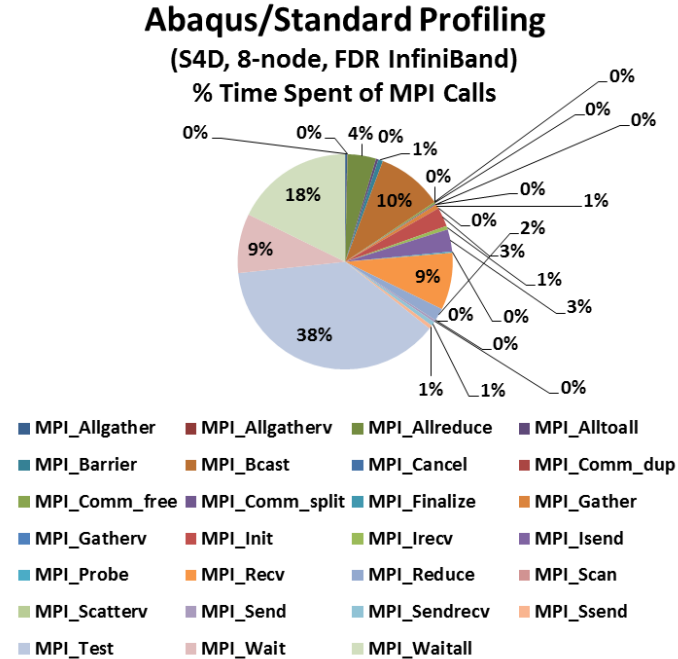
- **Abaqus/Standard uses a wide range of MPI APIs**
  - MPI\_Test dominates the MPI function calls (over 97%)



- Abaqus/Standard shows high usage for testing non-blocking messages

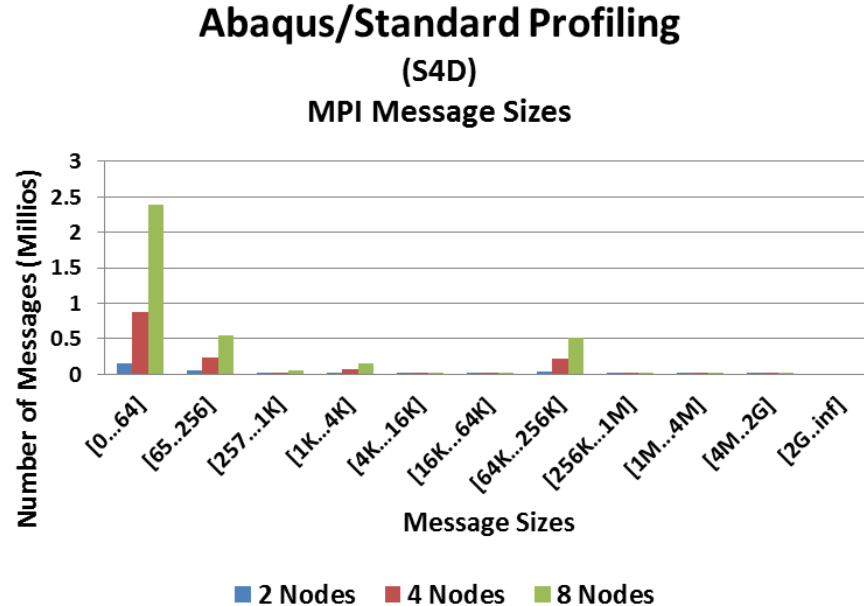


- **Abaqus/Standard: More time spent on MPI collective operations:**
  - InfiniBand FDR: MPI\_Test(38%), MPI\_Waitall(18%), MPI\_Bcast(10%)





- **Abaqus/Explicit shows a wide distribution of small message sizes**
  - Small messages peak in the range from 65B to 256B



- **The HP ProLiant Gen9 servers delivers superior compute power over its predecessor**
  - Intel E5 2600V3 series (Haswell) processors and FDR InfiniBand outperforms prior system generations
  - Performs 113% higher vs Westmere, 36% vs Sandy Bridge, and 23% vs Ivy Bridge on a 4-node cluster
- **InfiniBand FDR is the most efficient cluster interconnect for Abaqus**
  - FDR IB outperforms 1GbE by 5.2 times, 10GbE by 87% at 8 nodes
- **Abaqus/Standard performs faster than the previous version**
  - Version 6.14-2 outperforms version 6.13-2 by 8% at 4 nodes / 80 cores
  - Both Platform MPI and Intel MPI is included in version 6.14-2
  - Enabling SRQ may improve performance at scale

# Thank You

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