Abaqus 6.13-2 Performance Benchmark and Profiling

July 2014

Note

- **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.hp.com/go/hpc

- **For more information on the application:**
 - http://www.simulia.com

- **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
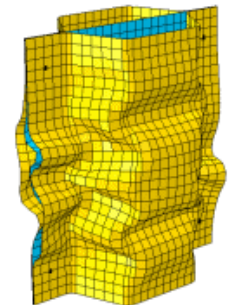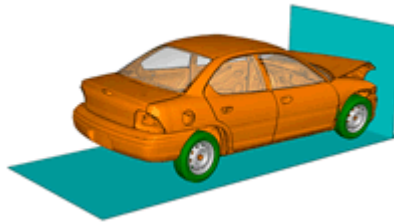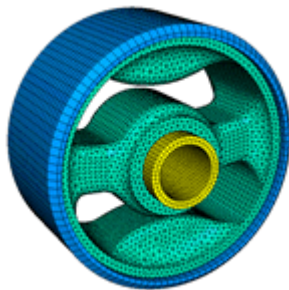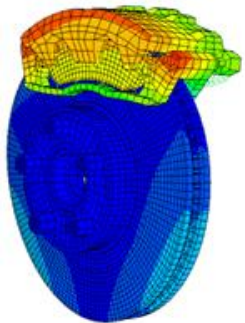
- **The presented research was done to provide best practices**

  – 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

Test Cluster Configuration

- **HP ProLiant SL230s Gen8 4-node "Athena" cluster**

  – Processors: Dual-Socket 10-core Intel Xeon E5-2680v2 @ 2.8 GHz CPUs

  – Memory: 32GB per node, 1600MHz DDR3 Dual-Ranked DIMMs

  – OS: RHEL 6 Update 2, OFED 2.2-1.0.1 InfiniBand SW stack

- **Mellanox Connect-IB FDR InfiniBand adapters**

- **Mellanox ConnectX-3 VPI Ethernet adapters**

- **Mellanox SwitchX SX6036 56Gb/s FDR InfiniBand and Ethernet VPI Switch**

- **MPI: Platform MPI 8.3 (vendor provided)**

- **Application: Abaqus 6.13-2 (unless otherwise stated)**

- **Benchmark Workload:**

 – Abaqus/Explicit benchmarks: E6: Concentric Spheres
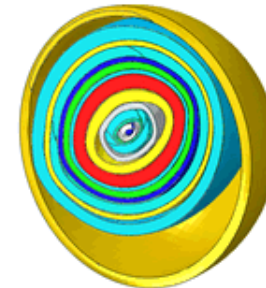
About HP ProLiant SL230s Gen8

Item	HP ProLiant SL230s Gen8 Server
Processor	Two Intel® Xeon® E5-2600 v2 Series, 4/6/8/10/12 Cores,
Chipset	Intel® Xeon E5-2600 v2 product family
Memory	(256 GB), 16 DIMM slots, DDR3 up to 1600MHz, ECC
Max Memory	256 GB
Internal Storage	Two LFF non-hot plug SAS, SATA bays or Four SFF non-hot plug SAS, SATA, SSD bays Two Hot Plug SFF Drives (Option)
Max Internal Storage	8TB
Networking	Dual port 1GbE NIC/ Single 10G Nic
I/O Slots	One PCIe Gen3 x16 LP slot 1Gb and 10Gb Ethernet, IB, and FlexF abric options
Ports	Front: (1) Management, (2) 1GbE, (1) Serial, (1) S.U.V port, (2) PCIe, and Internal Micro SD card & Active Health
Power Supplies	750, 1200W (92% or 94%), high power chassis
Integrated Management	iLO4 hardware-based power capping via SL 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	16P/8GPUs/4U chassis

- **Intel E5-2680 V2 (Ivy Bridge) cluster outperforms prior CPU generation**
  - Performs 73% higher than Westmere (X5670)cluster at 4 nodes
  - Performs 11% higher than Sandy Bridge (E5-2680) cluster at 4 nodes
- **System components used:**
  - Athena-IVB: 2-socket Intel E5-2680 @ 2.7GHz, 1600MHz DIMMs, FDR IB, 1HDD
  - Athena-SNB: 2-socket Intel E5-2680 @ 2.7GHz, 1600MHz DIMMs, FDR IB, 1HDD
  - Plutus-WSM: 2-socket Intel X5670 @ 2.93GHz, 1333MHz DIMMs, QDR IB, 1HDD

Abaqus/Explicit Performance
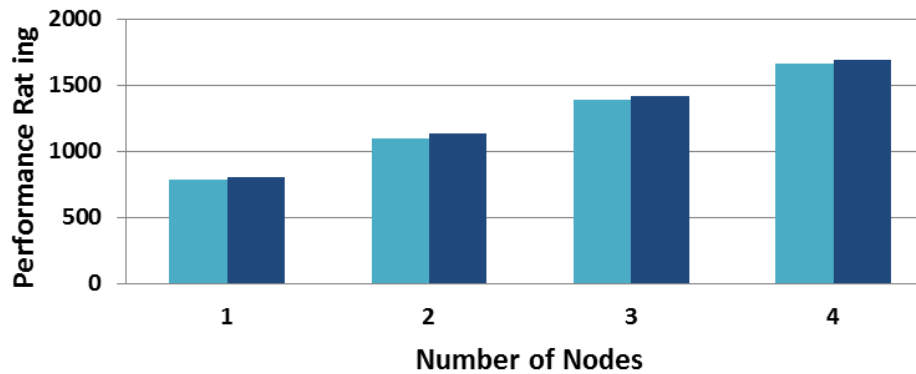### (E6)
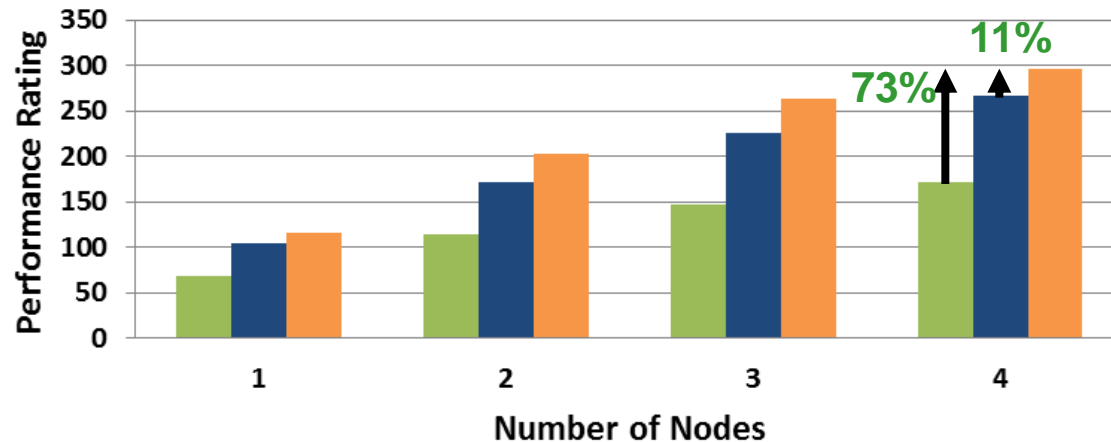
All measurement based on v6.12.2

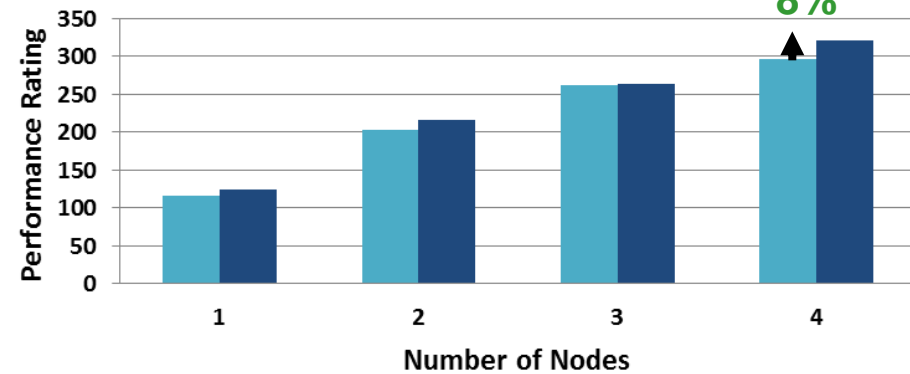*Performance Rating: based on total runtime*

Abaqus Performance – Software Versions

- **Abaqus/Explicit performs faster than the previous version**
  - 6.13-2 outperforms 6.12-2 by 8% at 4 nodes / 80 cores
- **Difference Abaqus/Standard with the newer version is not as clear**
  - Only slight gain can be seen on the dataset tested

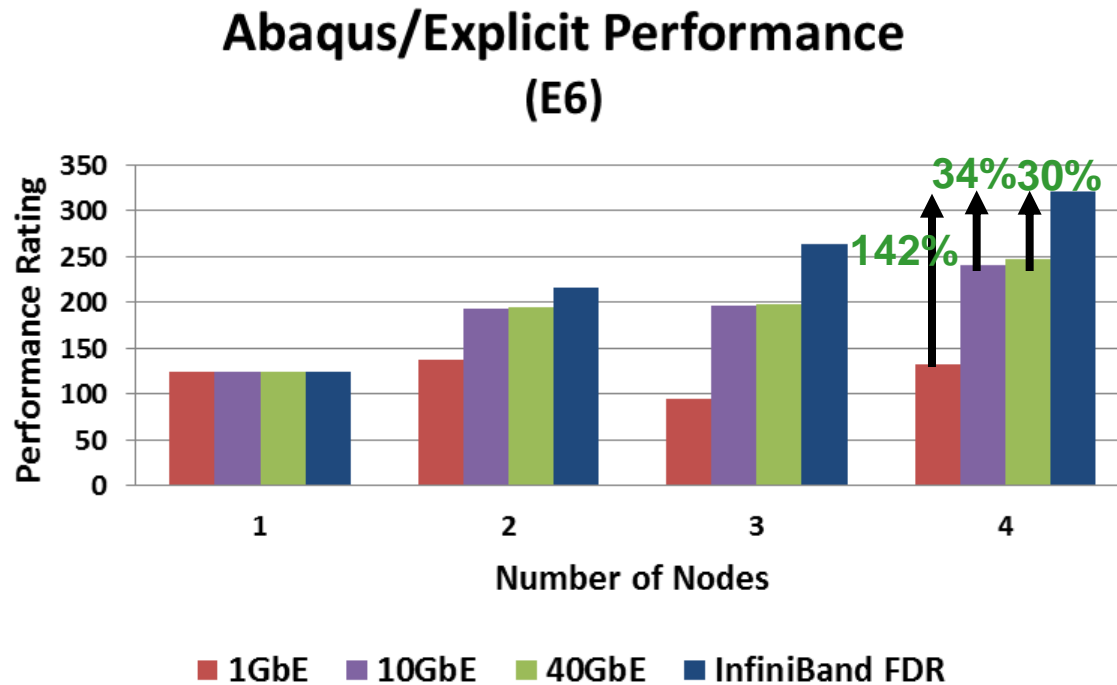
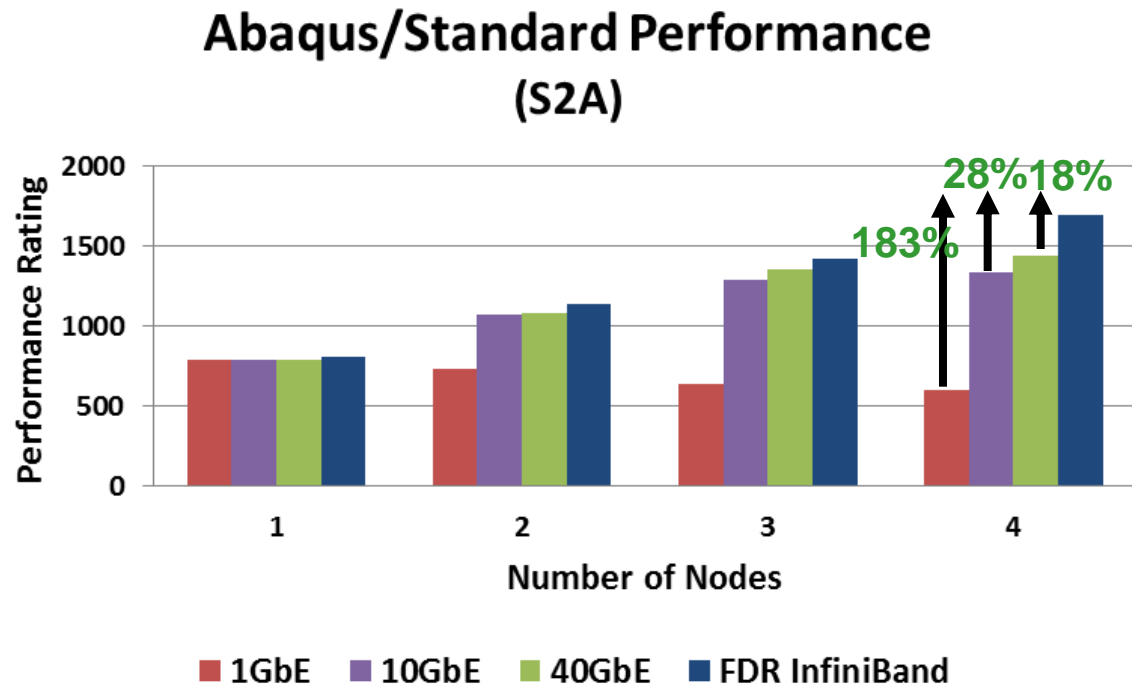**Abaqus/Standard Performance (S2A)** and **Abaqus/Explicit Performance (E6)** charts comparing Abaqus 6.12-2 and Abaqus 6.13-2 across Number of Nodes. *Higher is better*

- **FDR InfiniBand is the most efficient network interconnect for Abaqus/Explicit**
  - Outperforms 1GbE by 142%, 10GbE by 34%, and 40GbE by 30% at 4 nodes

Abaqus/Explicit Performance (E6)


Higher is better

- **InfiniBand enables higher cluster productivity among the interconnects tested**

  - Reducing the runtime by 183% versus 1GbE

  - Up to 28% higher performance versus 10GbE

  - Up to 18% higher performance versus 40GbE

Abaqus/Standard Performance
(S2A)

Higher is better

Legend: ■ 1GbE ■ 10GbE ■ 40GbE ■ FDR InfiniBand

Abaqus/Explicit Profiling – MPI Time Ratio

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- **FDR InfiniBand reduces the MPI communication time**

  - InfiniBand FDR consumes about 37% of total runtime at 4 nodes

  - Ethernet solutions consume from 53% to 72% at 4 nodes

Abaqus/Explicit Profiling
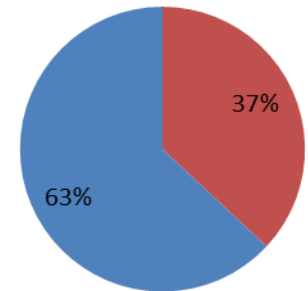**(E6, 80 processes, 1GbE)**
MPI/User Time Ratio

28%

72%
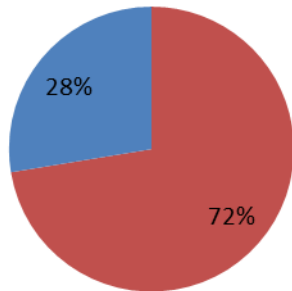
■ MPI time ■ User time

Abaqus/Explicit Profiling
(E6, 80 processes, 10GbE)
MPI/User Time Ratio

47%

53%
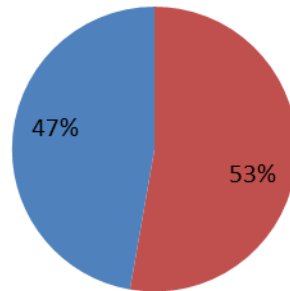
■ MPI time ■ User time

Abaqus/Explicit Profiling
(E6, 80 processes, FDR IB)
MPI/User Time Ratio

37%

63%

■ MPI time ■ User time

NETWORK OF EXPERTISE
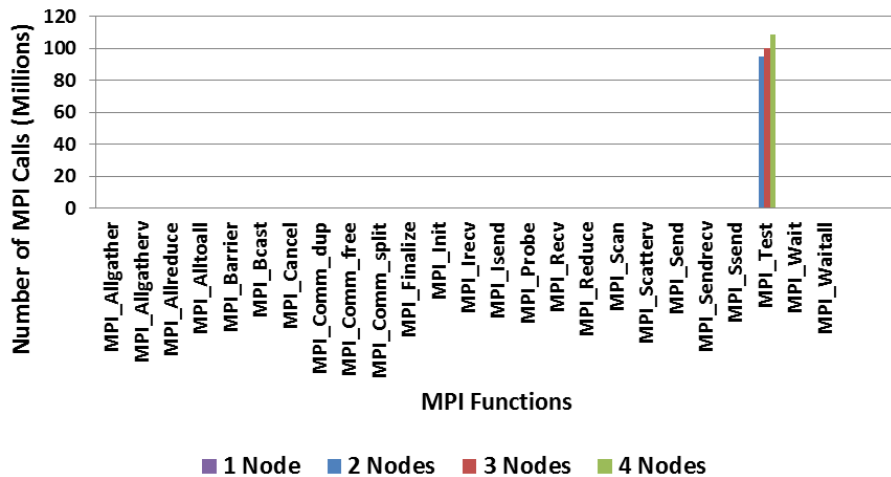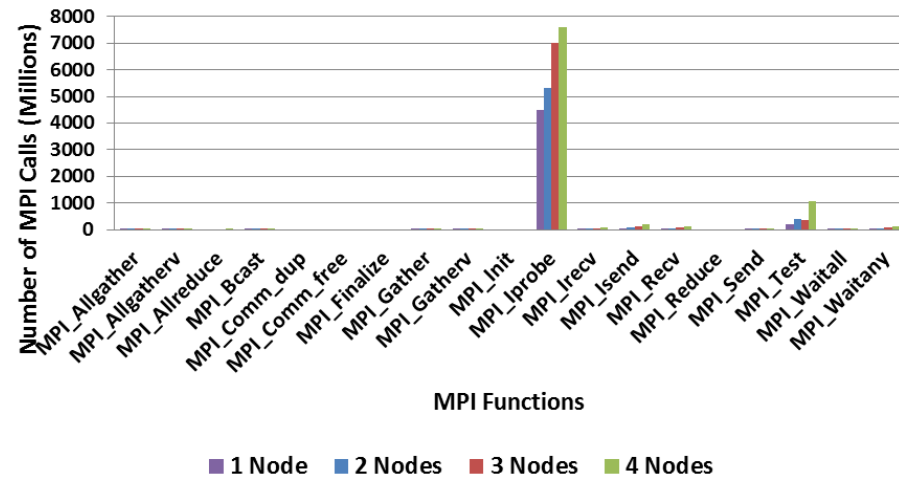
Abaqus/Explicit Profiling – MPI calls

- **Abaqus/Standard uses a wide range of MPI APIs**
  - MPI_Test dominates the MPI function calls (over 97%)
- **Abaqus/Explicit shows high usage for testing non-blocking messages**
  - MPI_Iprobe (95%), MPI_Test (3%)

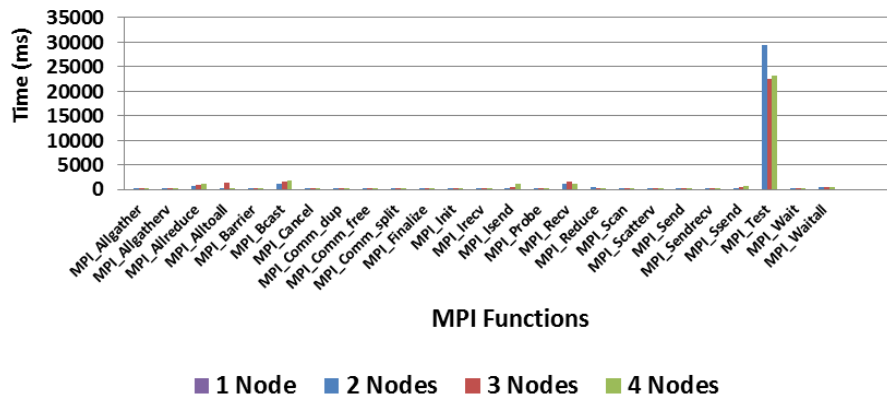**Abaqus/Standard Profiling**
(S2A)
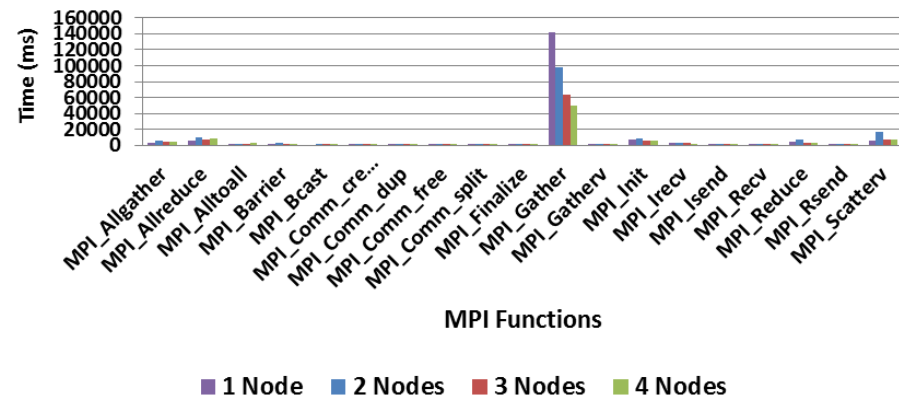**Number of MPI Calls**

Abaqus/Explicit Profiling
(E6)
Number of MPI Calls

- **Abaqus/Standard shows high usage for testing non-blocking messages**
- **MPI_Gather dominates the MPI communication time in Abaqus/Explicit**
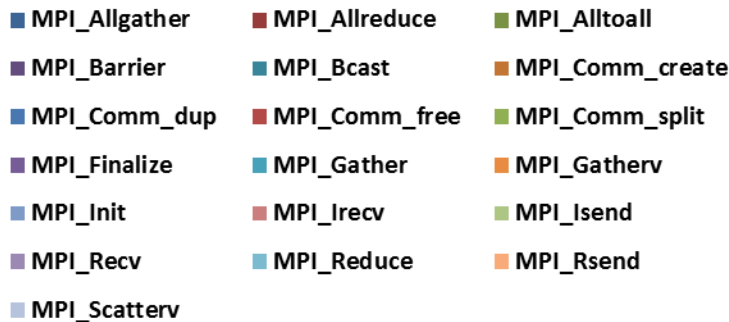
Abaqus/Standard Profiling
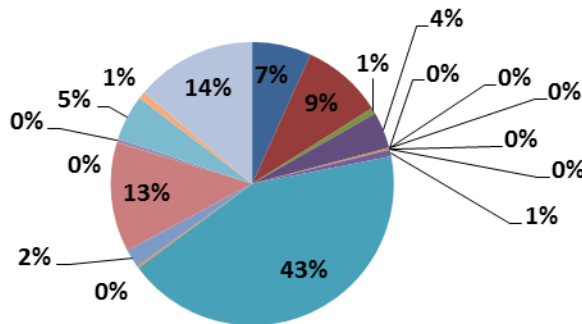(S2A)
Time Spent of MPI Calls

Abaqus/Explicit Profiling
(E6)
Time Spent of MPI Calls

Abaqus/Explicit Profiling – Time Spent in MPI

- **Abaqus/Explicit: More time spent on MPI collective operations:**
  - InfiniBand FDR: MPI_Gather(54%), MPI_Allreduce(9%), MPI_Scatterv(9%)
  - 1GbE: MPI_Gather(43%), MPI_Irecv(13%), MPI_Scatterv(14%)

Abaqus/Explicit Profiling
(E6, 4-node, 1GbE)
% Time Spent of MPI Calls

Abaqus/Explicit Profiling
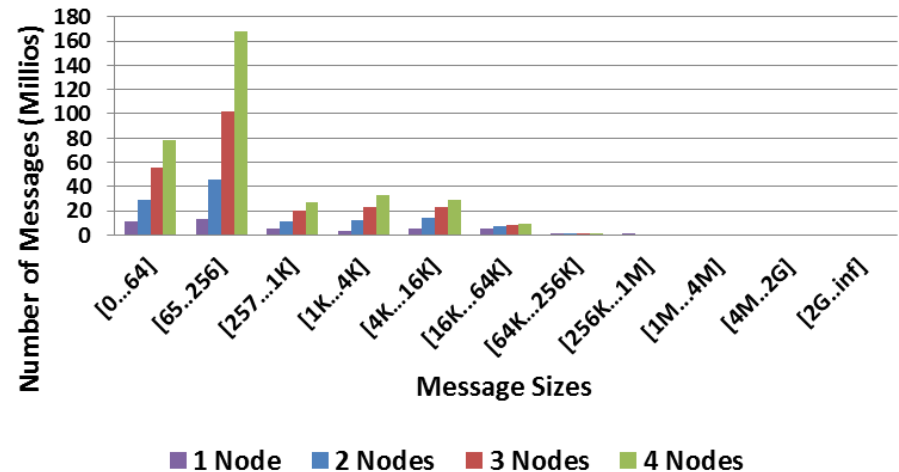(E6, 4-node, FDR IB)
% Time Spent of MPI Calls
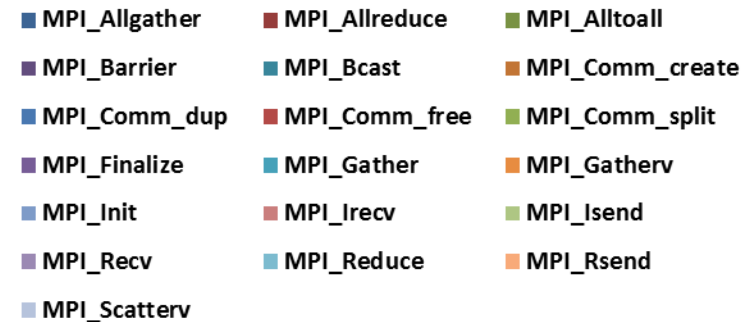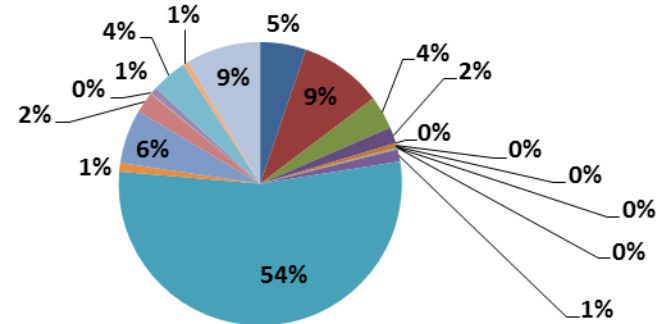
Abaqus Profiling – Message Sizes

- **Abaqus/Standard uses small and medium MPI message sizes**
  - Most message sizes are between 0B to 64B, and 65B to 256B
  - Some medium size concentration in 64KB to 256KB
- **Abaqus/Explicit shows a wide distribution of small message sizes**
  - Small messages peak in the range from 65B to 256B

Abaqus/Standard Profiling (S2A) MPI Message Sizes — Number of Messages (Thousands) vs Message Sizes. Legend: 1 Node, 2 Nodes, 3 Nodes, 4 Nodes
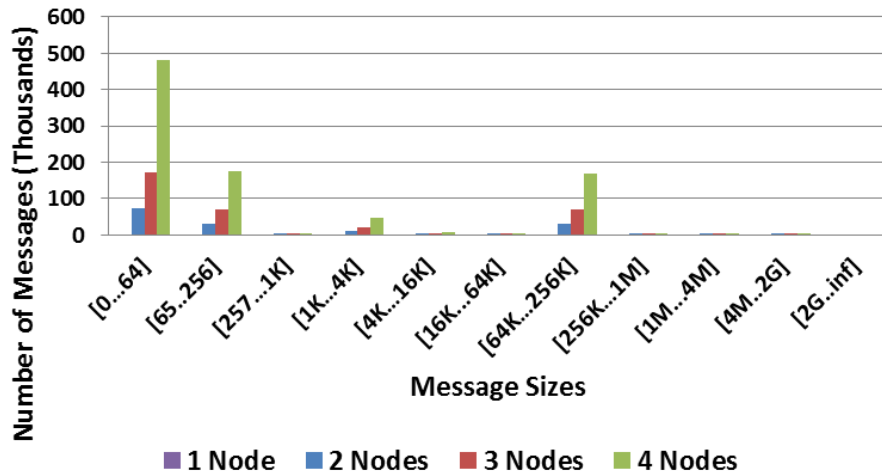
Abaqus/Explicit Profiling (E6) MPI Message Sizes — Number of Messages (Millios) vs Message Sizes. Legend: 1 Node, 2 Nodes, 3 Nodes, 4 Nodes

- **HP ProLiant Gen8 servers delivers better performance than its predecessor**

  – ProLiant Gen8 equipped with Intel E5 2600 V2 series processors and InfiniBand FDR

  – Provided up to 73% higher performance than ProLiant G7 when compared at 4 nodes

  – Outperforms by 11% of higher performance compared to the Intel E5 2600 series processors

- **InfiniBand FDR is the most efficient cluster interconnect for Abaqus**

  – Abaqus/Explicit: Outperforms 1GbE by 142%, 10GbE by 34%, and 40GbE by 30% at 4 nodes

  – Abaqus/Standard: Reducing the runtime by 183% on 1GbE, 28% on 10GbE, and 18% on 40GbE

- **Abaqus/Explicit performs faster than the previous version**

  – Version 6.13-2 outperforms version 6.12-2 by 8% at 4 nodes / 80 cores

- **Abaqus Profiling**

  – InfiniBand FDR reduces communication time; provides more time for computation

  – InfiniBand FDR consumes 37% of total time, compared to 53-72% for Ethernet solutions

Thank You
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