

# OpenFOAM Performance Benchmark and Profiling

October 2010

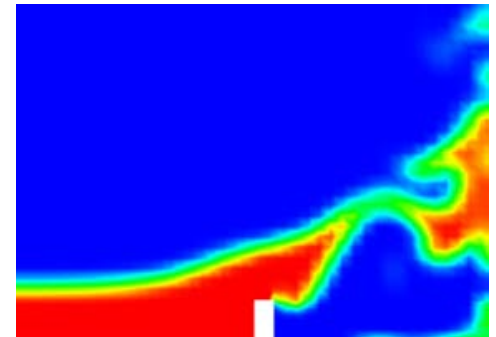
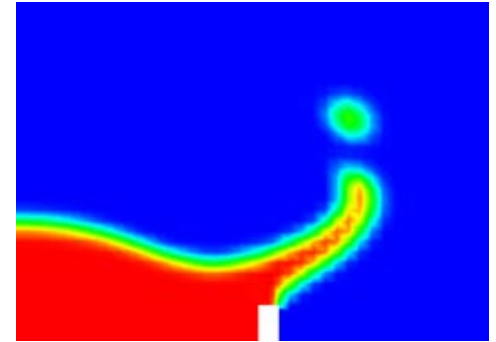


- **The following research was performed under the HPC Advisory Council activities**
  - Participating vendors: Dell, Intel, Mellanox
  - Compute resource: HPC Advisory Council Cluster Center
  
- **For more info please refer to**
  - <http://www.dell.com>
  - <http://www.intel.com>
  - <http://www.mellanox.com>
  - <http://www.openfoam.com/>

- **OpenFOAM® (Open Field Operation and Manipulation) CFD**

**Toolbox can simulate**

- Complex fluid flows involving
  - Chemical reactions
  - Turbulence
  - Heat transfer
- Solid dynamics
- Electromagnetics
- The pricing of financial options



- **OpenFOAM is Open source, produced by OpenCFD Ltd**

- **The following was done to provide best practices**
  - OpenFOAM performance benchmarking
  - Interconnect performance comparisons
  - Understanding OpenFOAM communication patterns
  - Power-efficient simulations
  
- **The presented results will demonstrate**
  - The scalability of the compute environment to provide nearly linear application scalability
  - The capability of OpenFOAM to achieve scalable productivity
  - Considerations for power saving through balanced system configuration

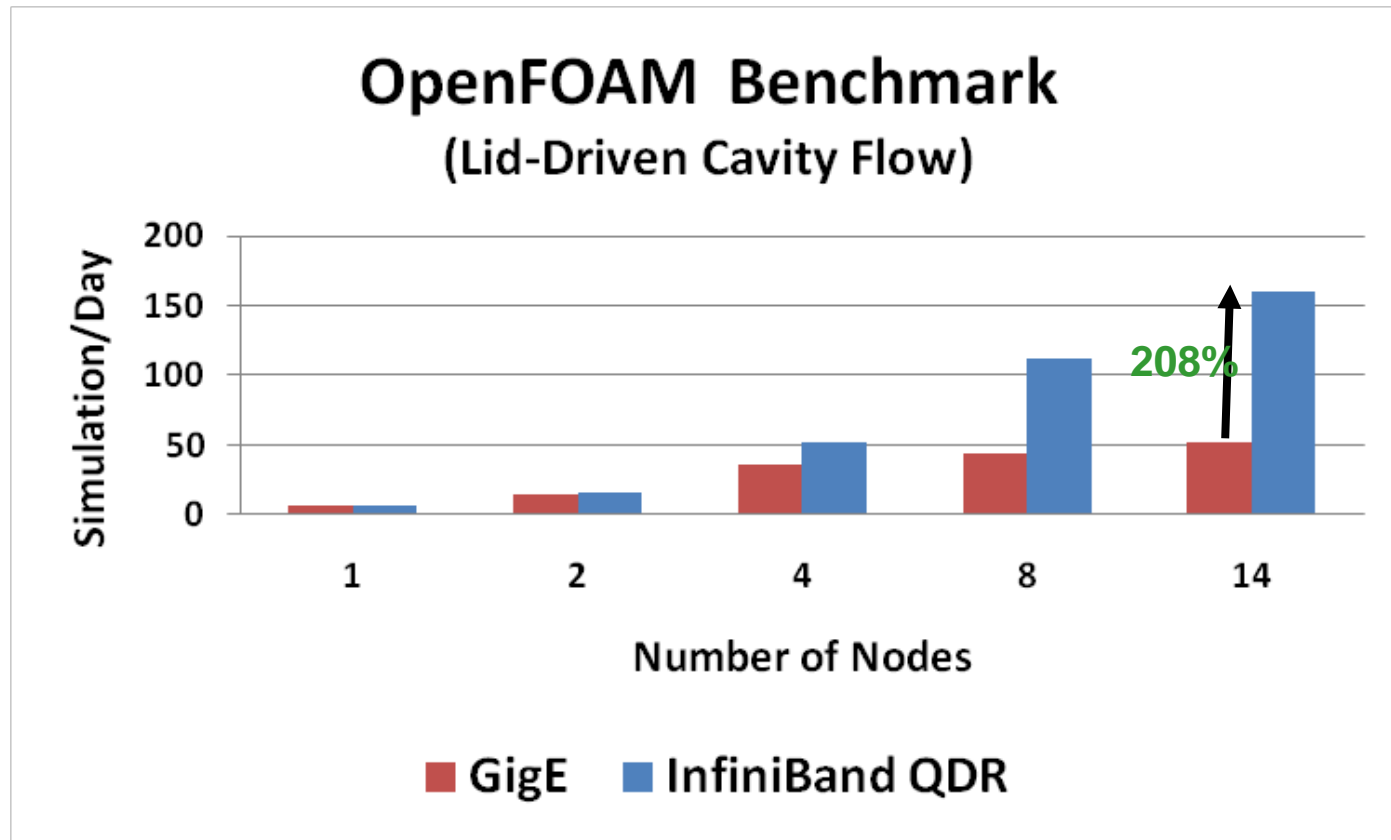
- **Dell™ PowerEdge™ M610 14-node cluster**
  - Six-Core Intel X5670 @ 2.93 GHz CPUs
  - Memory: 24GB per node
  - OS: CentOS5U4, OFED 1.5.1 InfiniBand SW stack
- **Mellanox ConnectX-2 InfiniBand adapters and switches**
- **MPI: Open MPI 1.4.1, Platform MPI 7.1**
- **Application: OpenFOAM 1.7.1**
- **Benchmark Workload**
  - Lid-driven cavity flow (icoFoam, 2D, 1 Million Cells)

- **Intel® Cluster Ready systems make it practical to use a cluster to increase your simulation and modeling productivity**
  - Simplifies selection, deployment, and operation of a cluster
- **A single architecture platform supported by many OEMs, ISVs, cluster provisioning vendors, and interconnect providers**
  - Focus on your work productivity, spend less management time on the cluster
- **Select Intel Cluster Ready**
  - Where the cluster is delivered ready to run
  - Hardware and software are integrated and configured together
  - Applications are registered, validating execution on the Intel Cluster Ready architecture
  - Includes Intel® Cluster Checker tool, to verify functionality and periodically check cluster health



- **InfiniBand enables higher scalability**

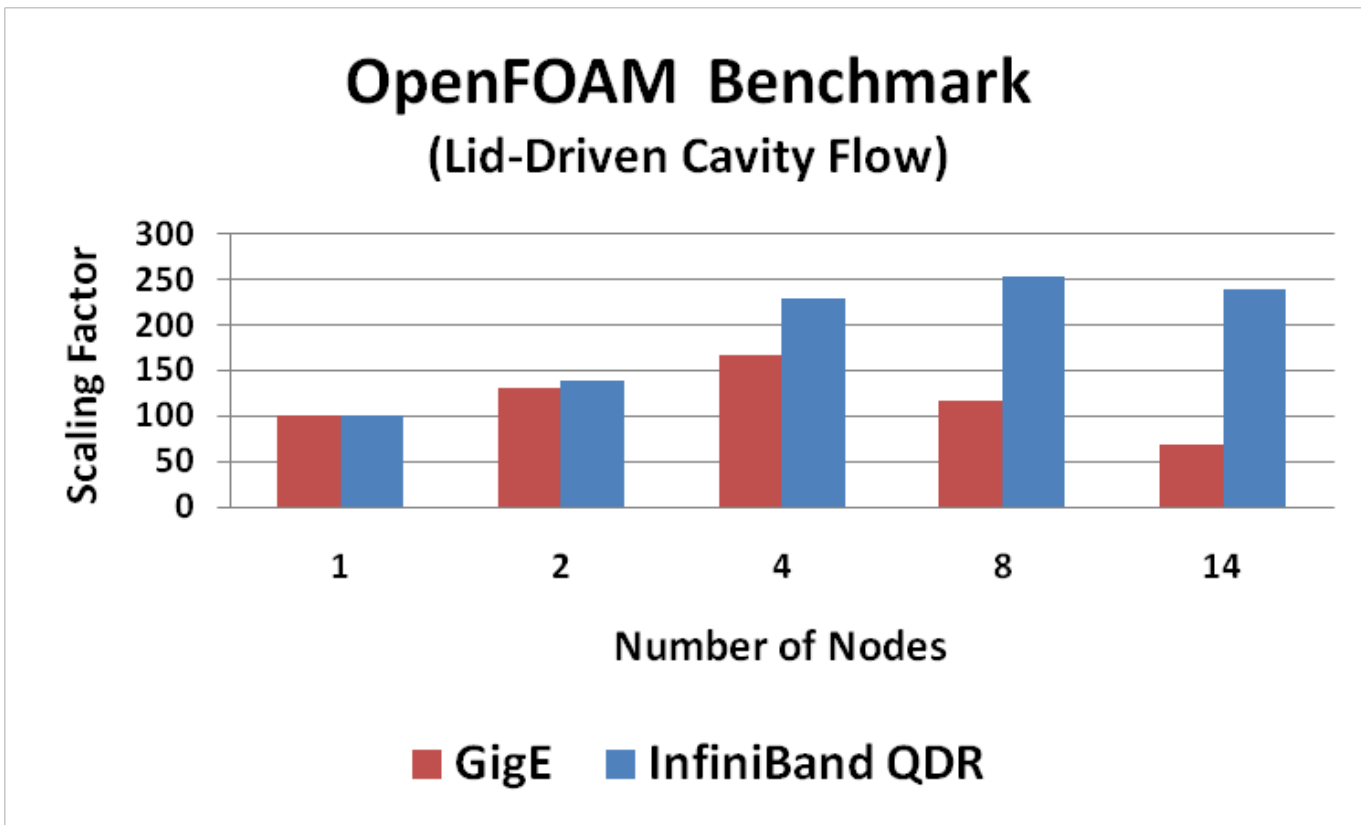
- Up to 208% higher performance than Ethernet at 14 nodes
- 4 InfiniBand connected servers deliver nearly the same performance vs 14 Ethernet connected servers



*Higher is better*

12 Cores/Node

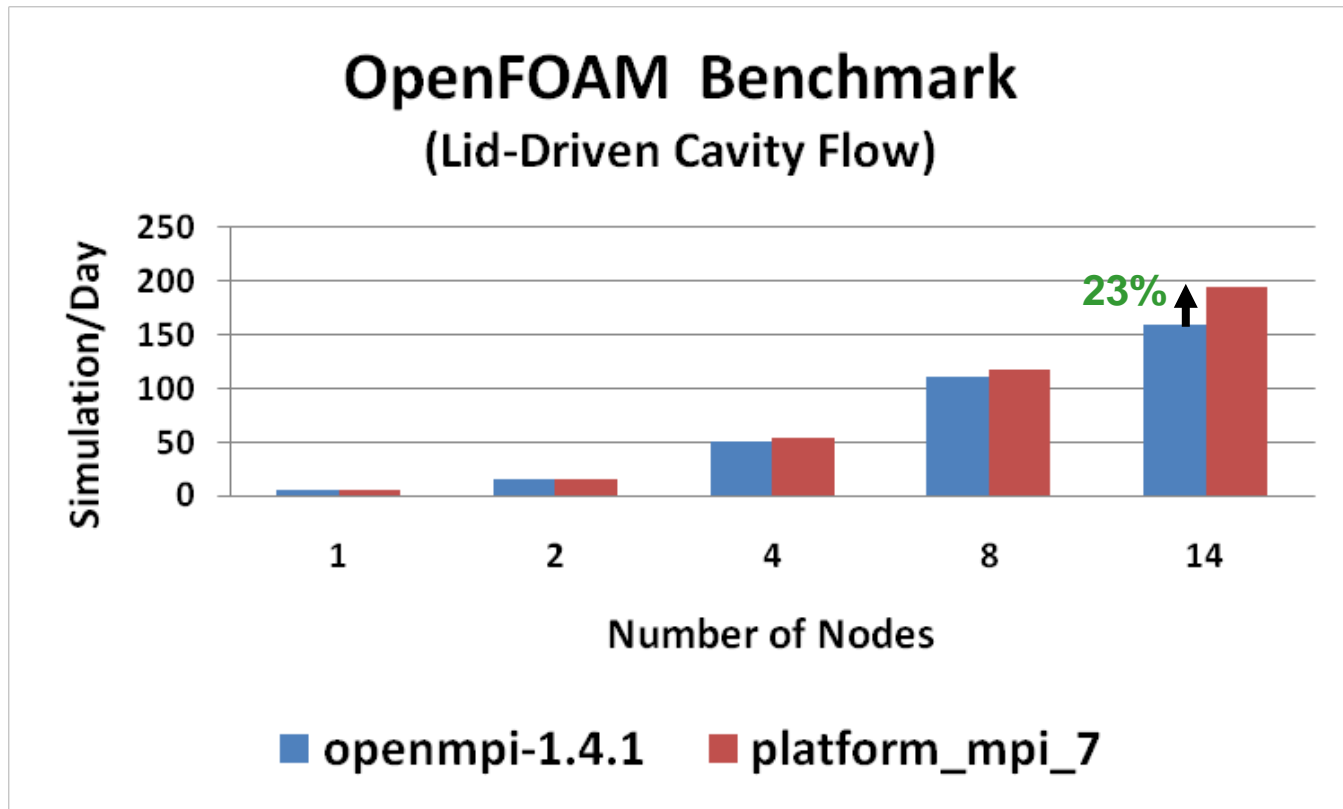
- **InfiniBand enables higher scalability**
  - Performs better as the number of nodes increase
  - Continues to scale as Ethernet scalability drops after 4 servers.



*Higher is better*

*12 Cores/Node*

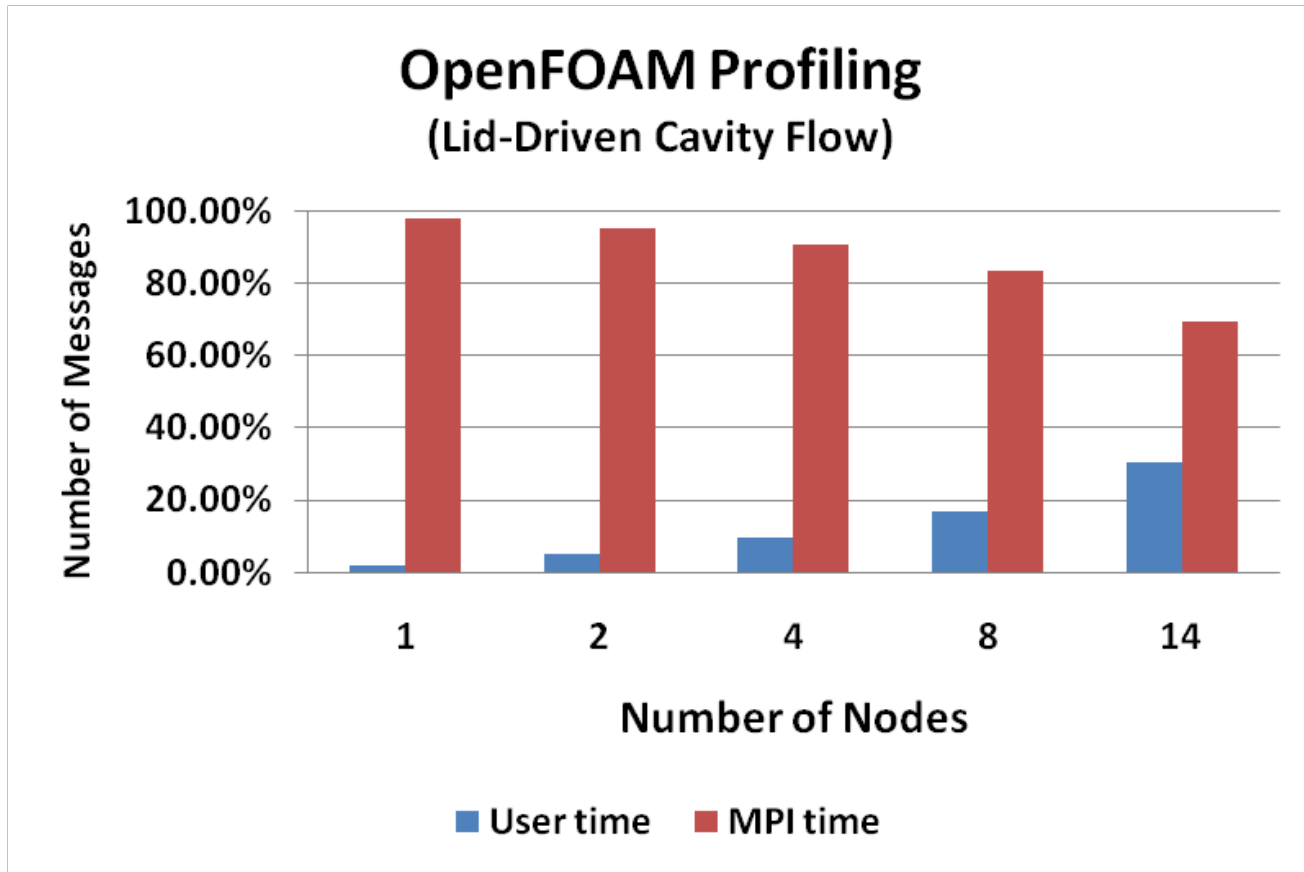
- **Platform MPI demonstrates better performance over Open MPI**
  - 23% gain compared to Open MPI at 14-node
  - Shows dramatic difference especially on larger number of nodes



*Higher is better*

**12 Cores/Node**

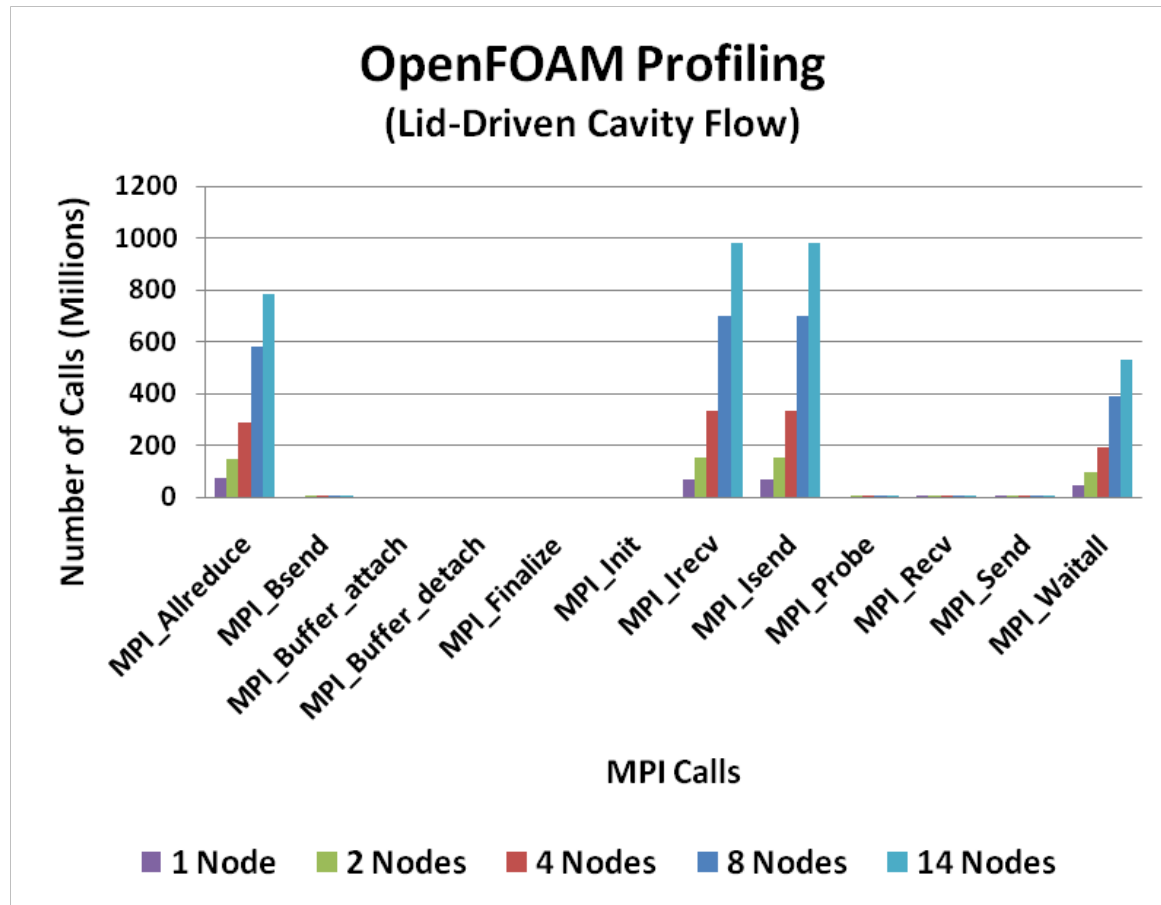
- **The ratio of MPI communication time to user time**
  - decreases as the number of nodes increases



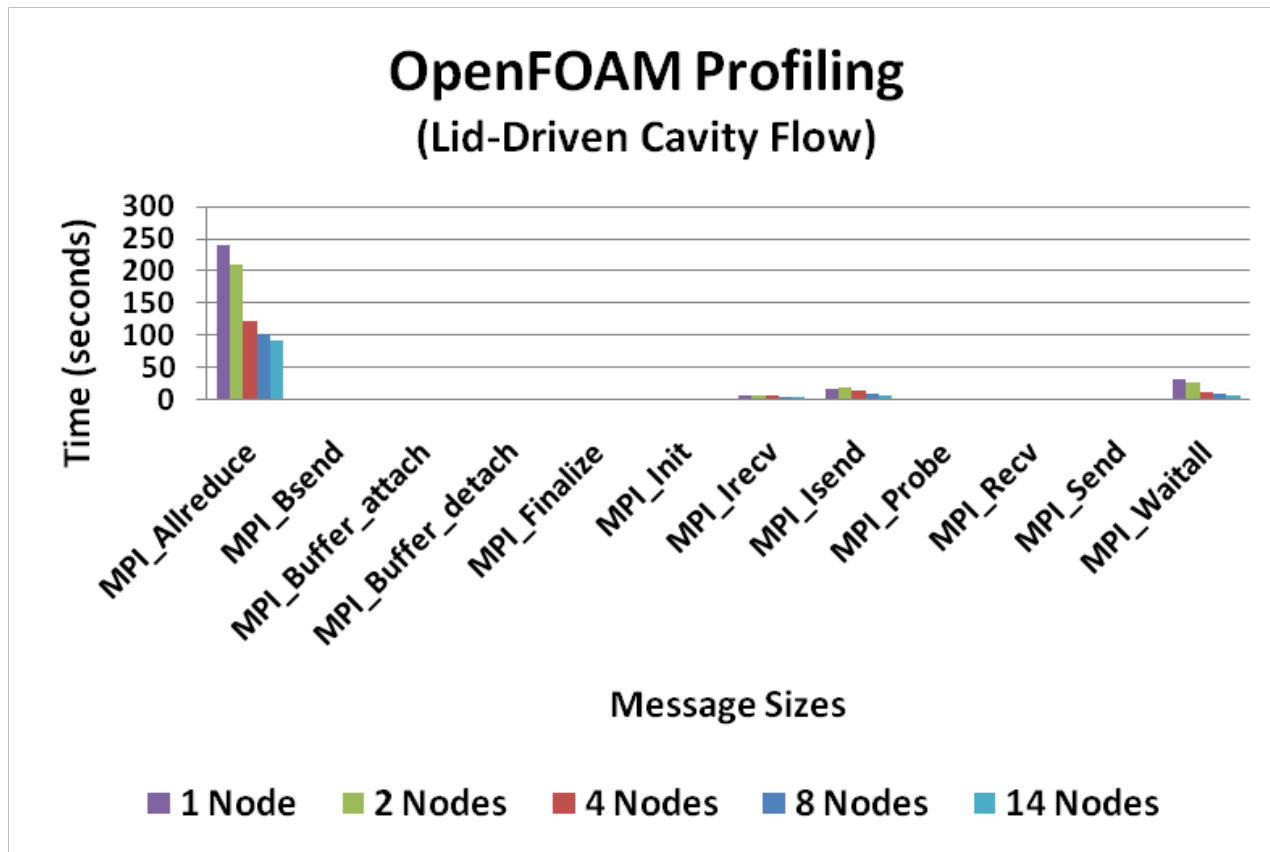
*Higher is better*

12 Cores/Node

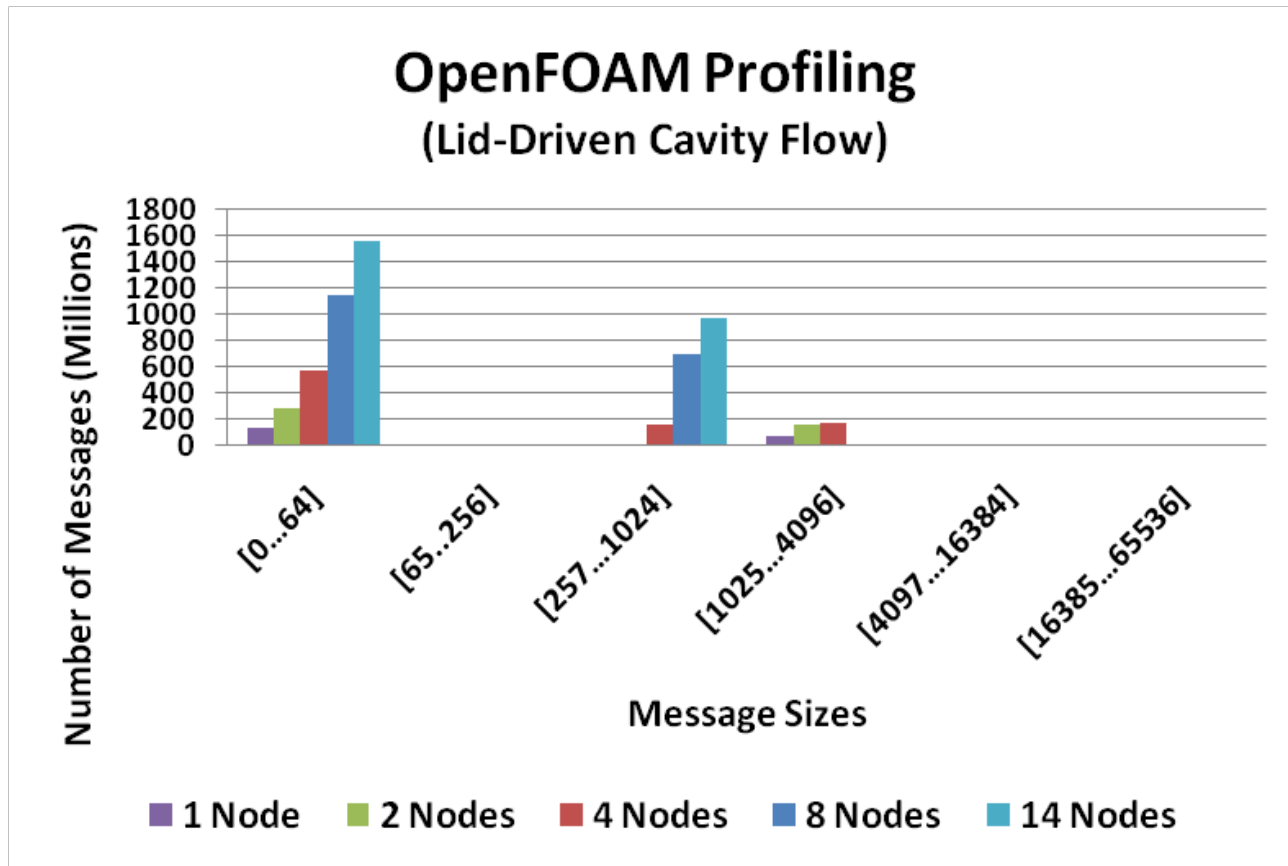
- **MPI\_Allreduce, MPI\_Irecv, MPI\_Isend and MPI\_Waitall** are most used calls
  - Percentage time is relatively consistent as number of nodes increases



- **Majority of MPI communication time is spent on MPI\_Allreduce**
  - Time is relatively consistent as number of nodes increases



- **Majority of messages are small messages**
  - Messages below 64B and 256 to 1KB are mostly used
- **Number of messages increases dramatically with the number of nodes**



- **Interconnects effect to OpenFOAM performance**
  - InfiniBand enables higher performance/scalability
- **Running in parallel mode enables better system utilization**
- **Platform MPI performs better on larger node count**
- **The ratio of MPI communication over user time decreases as the cluster scales**
- **MPI\_Allreduce, MPI\_Irecv, MPI\_Isend and MPI\_Waitall are most used calls**
- **Majority of communication time is spent on MPI\_Allreduce**
- **Message with sizes below 64B and between 256B to 1KB mostly used**

# Thank You

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