HPC
ADVISORY COUNCIL

SPECFEM3D Performance Benchmark and Profiling

December 2009

Note

- **The following research was performed under the HPC Advisory Council activities**
  - Participating vendors: Jülich, ParTec, and Mellanox
  - Compute resource - Jülich Supercomputer JUROPA
- **For more info please refer to**
  - www.mellanox.com, http://www.fz-juelich.de/jsc/, http://www.parastation.com/

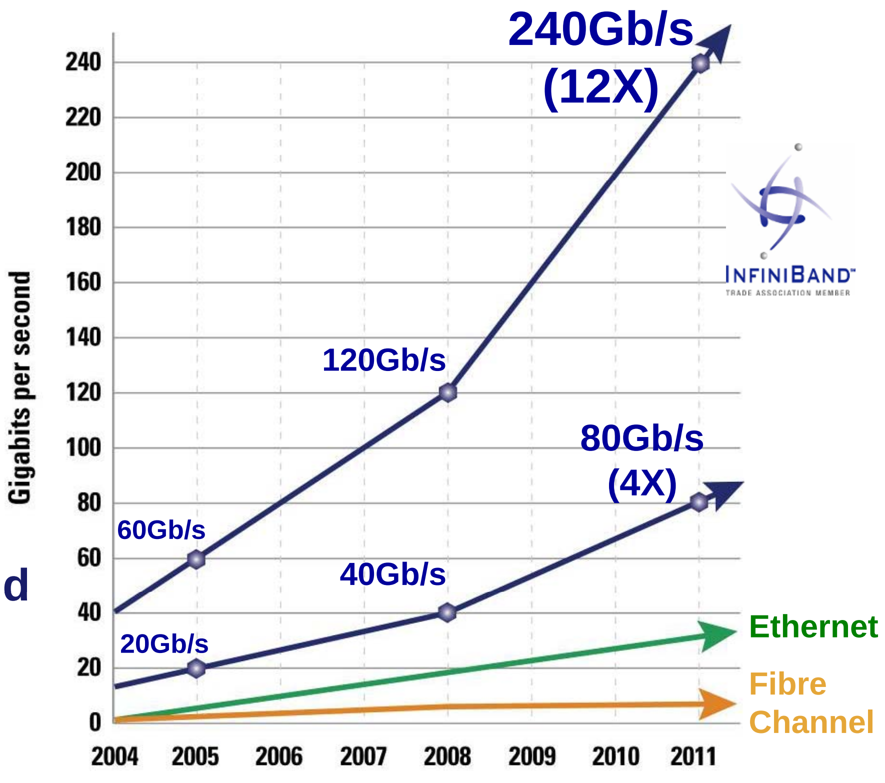
SPECFEM3D

- **SPECFEM3D**
  - Simulates seismic wave propagation in sedimentary basin
  - Can be used to simulate seismic wave propagation in complex three-dimensional geological models such as
    - Anisotropy
    - Attenuation
    - Fluid-solid interfaces
    - Rotation, self-gravitation
    - Crustal and mantle models
- **The package is written in Fortran90 and based on MPI**
- **SPECFEM3D is open source developed by**
  - Dimitri Komatitsch at University of Pau, France
  - California Institute of Technology
  - Princeton University

Mellanox InfiniBand Solutions

- **Industry Standard**
  - Hardware, software, cabling, management
  - Design for clustering and storage interconnect
- **Performance**
  - 40Gb/s node-to-node
  - 120Gb/s switch-to-switch
  - 1us application latency
  - Most aggressive roadmap in the industry
- **Reliable with congestion management**
- **Efficient**
  - RDMA and Transport Offload
  - Kernel bypass
  - CPU focuses on application processing
- **Scalable for Petascale computing & beyond**
- **End-to-end quality of service**
- **Virtualization acceleration**
- **I/O consolidation including storage**

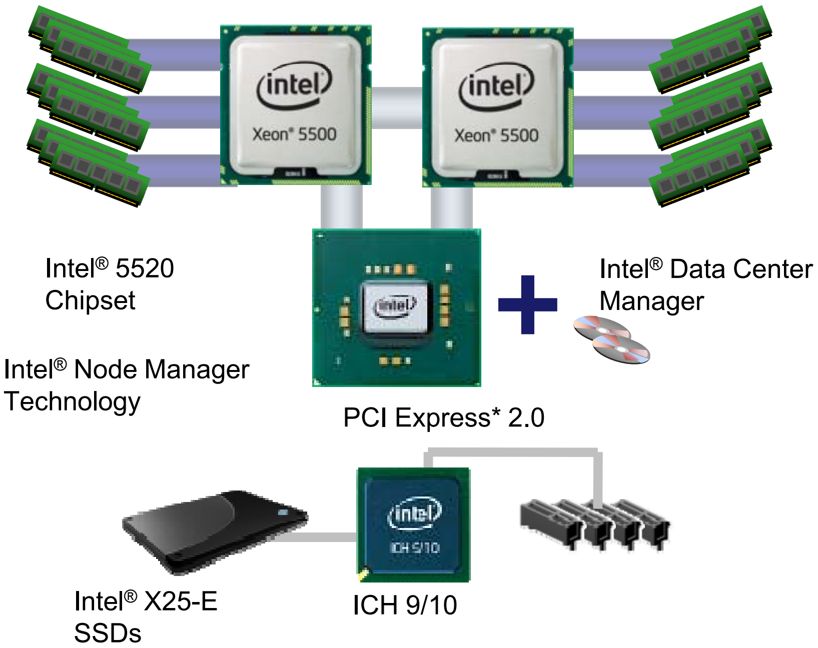
The InfiniBand Performance Gap is Increasing



InfiniBand Delivers the Lowest Latency

Delivering Intelligent Performance

Next Generation Intel® Microarchitecture



Intel® 5520 Chipset

Intel® Node Manager Technology

Intel® Data Center Manager

PCI Express* 2.0

Intel® X25-E SSDs

ICH 9/10

Bandwidth Intensive

- Intel® QuickPath Technology
- Integrated Memory Controller

Threaded Applications

- 45nm quad-core Intel® Xeon® Processors
- Intel® Hyper-threading Technology

Performance on Demand

- Intel® Turbo Boost Technology
- Intel® Intelligent Power Technology

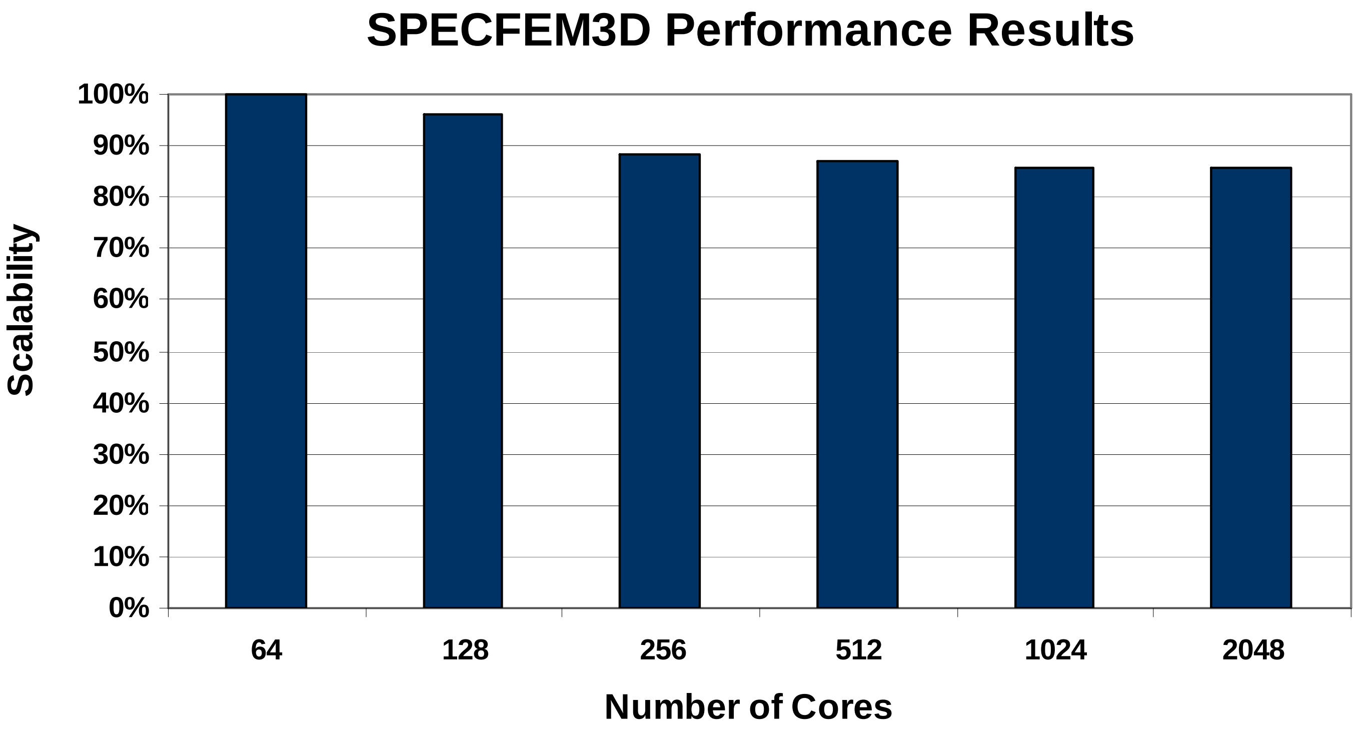
Performance That Adapts to The Software Environment

Test Cluster Configuration

- **Jülich - JuRoPa**
  - Quad core Intel Xeon X5570 2.93 GHz
  - Mellanox IB QDR HCAs and Mellanox based switches
  - Fat tree, non blocking fabric
  - Memory: 24GB memory per node (DDR3, 1066 MHz)
- **OS: SUSE SLES 11, OFED 1.4.1 InfiniBand SW stack**
- **MPI: ParTec MPI**
- **Application: SPECFEM3D-1.4.3**

SPECFEM3D Benchmark Results

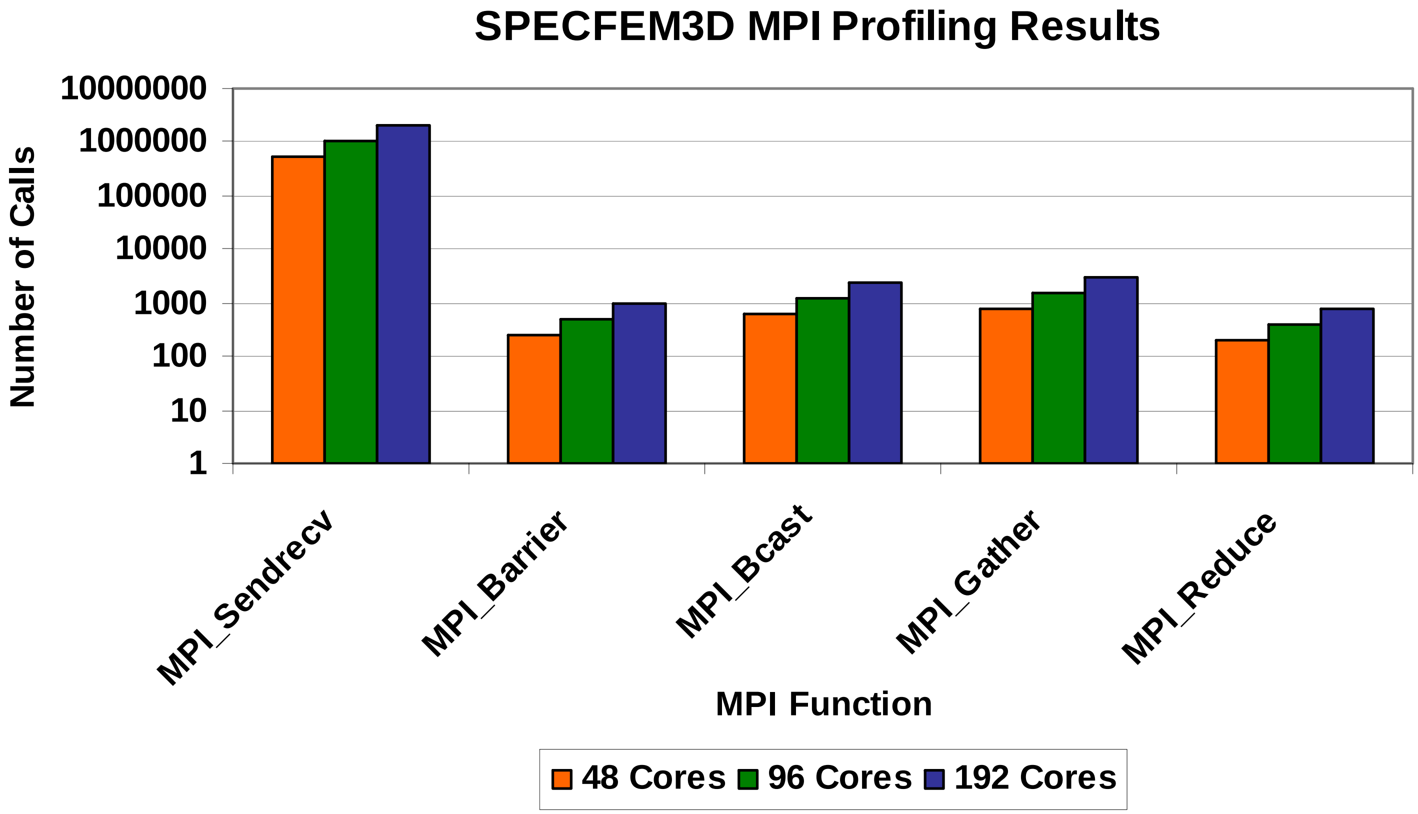
- **Input Dataset - Harvard_LA**
  - 3D model based upon the high-resolution Los Angeles basin
- **InfiniBand QDR enables high performance and scalability**



Higher is better

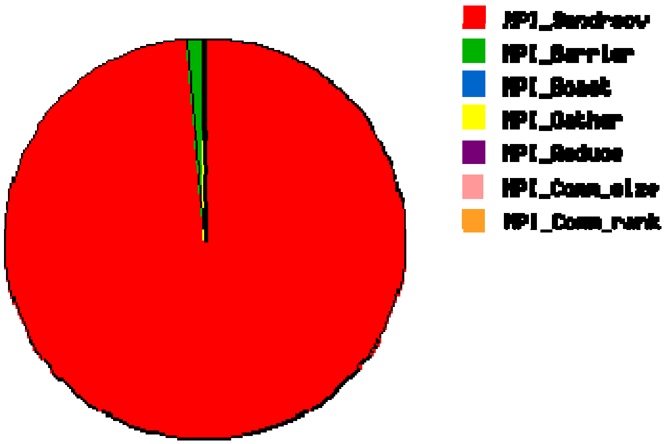
SPECFEM3D Profiling Results

- **Number of messages increases linearly with number of processes**

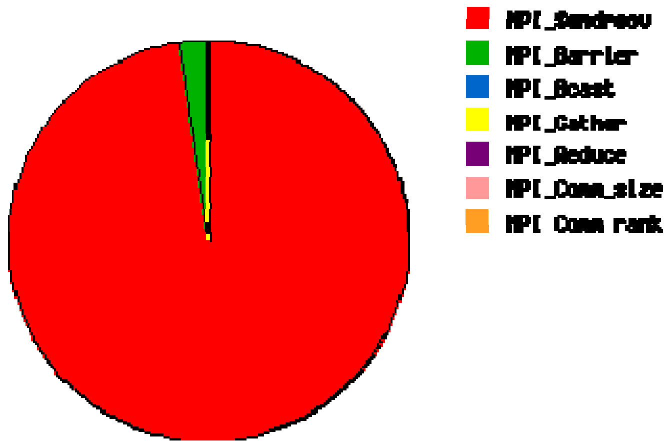


SPECFEM3D Profiling Results

- MPI_Sendrecv creates largest communication overhead
- MPI_Barrier overhead grows as cluster size increases

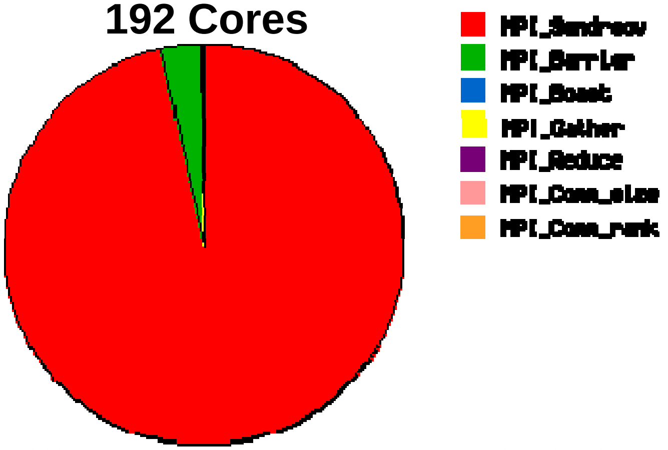


48 Cores



96 Cores

192 Cores

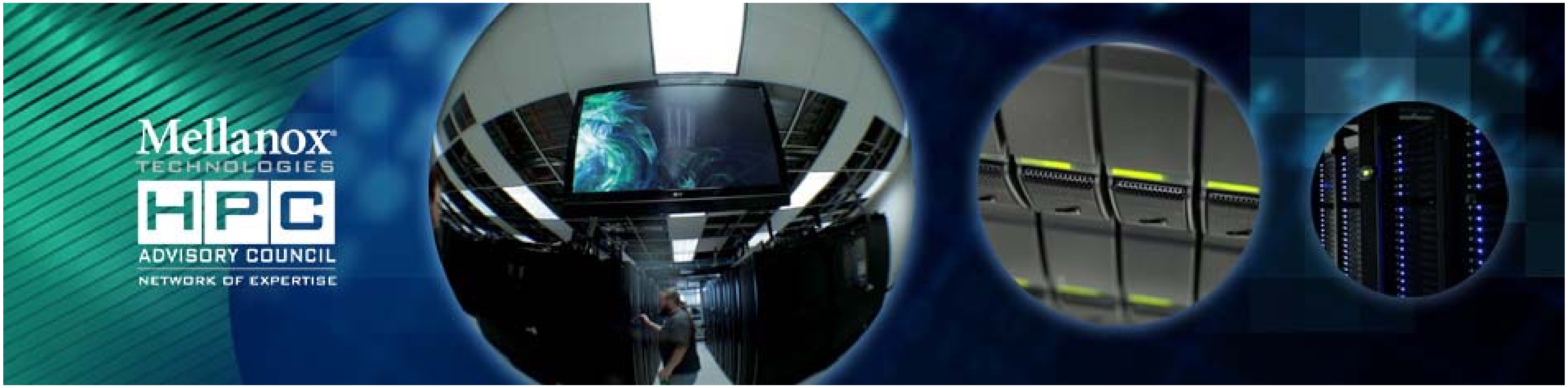


Summary

- **Linear increase of messages impose growing demand of high speed interconnect**
  - The faster interconnect can handle the messages, the better application performance will be achieved
- **Communication overhead of MPI_Barrier increases faster relative to other MPI functions in SPECFEM3D**
  - Mellanox CORE-Direct technology can offload MPI_Barrier to InfiniBand card to accelerate application performance
- **SPECFEM3D demonstrated great scalability over large cluster system**
  - InfiniBand QDR provides low latency and high bandwidth to enable SPECFEM3D scalability
  - ≥86% scalability over 2000 cores
  - Similar scalability is expected over even larger system

Thank You

HPC Advisory Council



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