InfiniBand and OpenFabrics Successes and Future Requirements:

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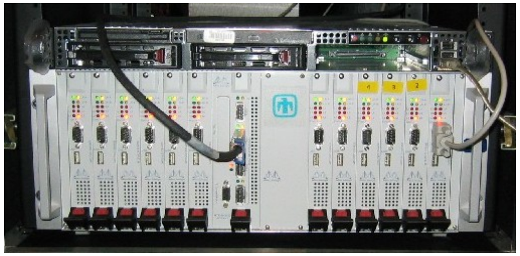
Outline

- DOE InfiniBand Clusters
- InfiniBand Cluster Experiences
- Early Experiences using OpenFabrics Enterprise Distribution
- Future Petascale InfiniBand Cluster Requirements
- How do we reach these goals?

DOE/ASC has Evaluated Several Generations of InfiniBand



2001-2002: Nitro I & II: IB blade reference designs (SNL) 2.2 GHz Xeon processors, small clusters, funded early MPI/IB work, and Cadillac (LANL) 128 node cluster

2003: Catalyst: 128 nodes 4X PCI-X IB (SNL), Blue Steel: 256 dual nodes 4X PCI-X (LANL), 96 nodes 4X PCI-X Viz Red RoSE (SNL)

2004: Catalyst: Added 85 nodes 4X PCIe IB, 288 port IB switch(SNL), ~300 nodes 4X PCIe Viz Red Rose (SNL)

2005: Thunderbird and Talon: 4,480 and 128 dual 3.6 Ghz nodes, 4X PCIe IB (SNL)

Lustre/IB production @ SNL Red RoSE

2006: 2,048 + 1,500 nodes IB (LANL) 1,800 nodes (LLNL)

SNL, LANL, LLNL have ~11,000 nodes of IB today and more to come

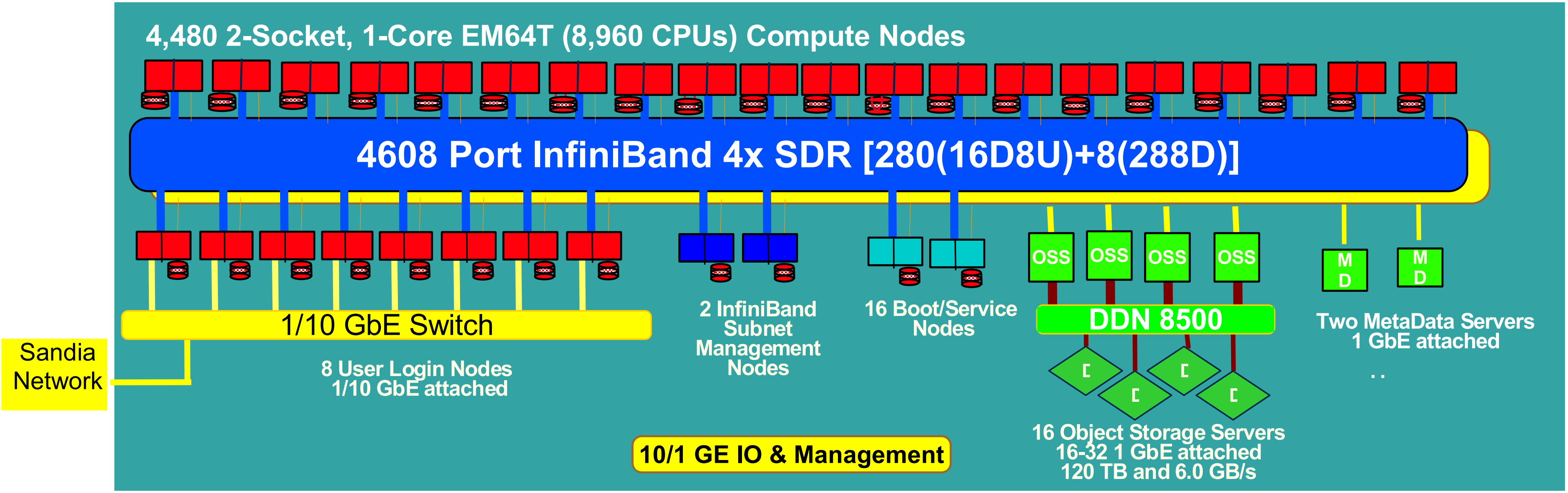
DOE Goals for InfiniBand

- To accelerate the development of an Linux IB software stack for HPC
  - High performance (high bandwidth, low latency, low CPU overhead)
  - Scalability
  - Robustness
  - Portability
  - Reliability
  - Manageability
  - Single open source SW stack, diagnostic and management tools supported across multiple (i.e. all) system vendors
  - Integrate IB SW stack into mainline Linux kernel at kernel.org
  - Get stack into Linux distributions (RedHat, SuSE, etc.)

OpenFabrics was formed around these goals

DOE ASC PathForward program has been funding OpenFabrics development since early 2005

Sandia Thunderbird Architecture



4,480 2-Socket, 1-Core EM64T (8,960 CPUs) Compute Nodes

4608 Port InfiniBand 4x SDR [280(16D8U)+8(288D)]

1/10 GbE Switch

Sandia Network

8 User Login Nodes
1/10 GbE attached

2 InfiniBand Subnet Management Nodes

16 Boot/Service Nodes

OSS

DDN 8500

16 Object Storage Servers
16-32 1 GbE attached
120 TB and 6.0 GB/s

M D

Two MetaData Servers
1 GbE attached

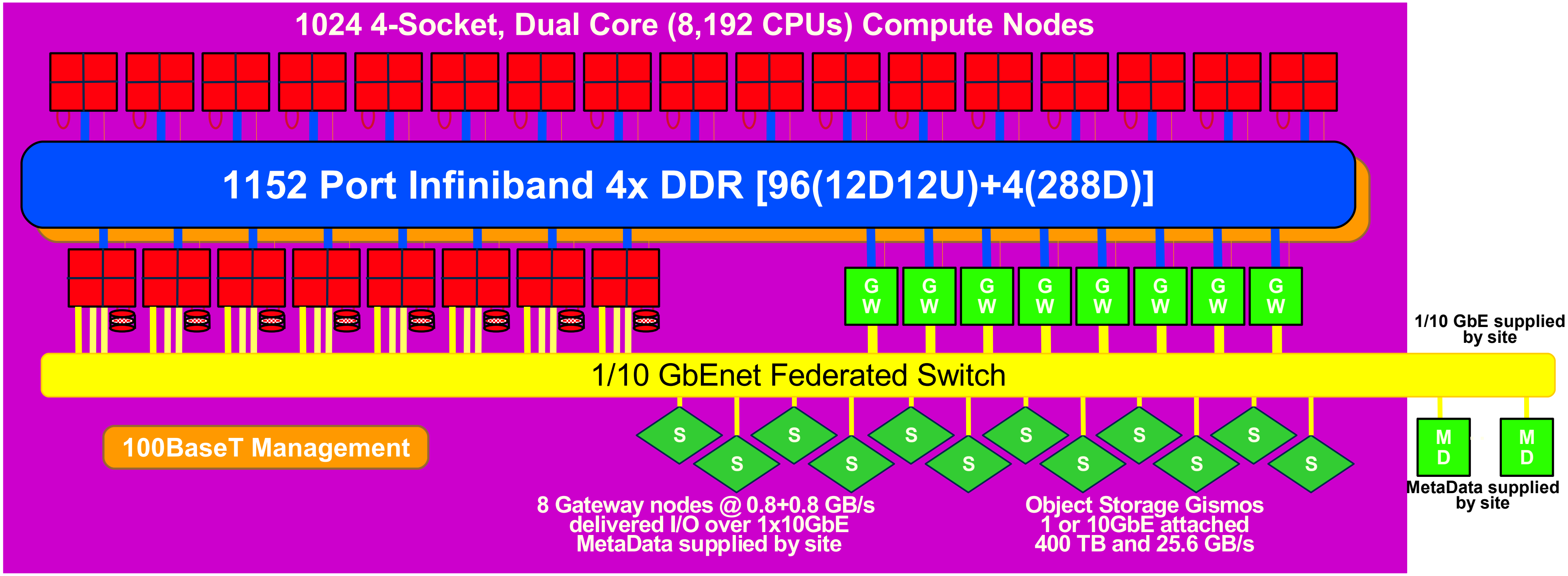
10/1 GE IO & Management

System Parameters

- 14.4 GF/s dual socket 3.6 GHz single core Intel SMP nodes DDR-2 400 SDRAM
- 50% blocking (2:1 oversubscription of InfiniBand fabric)
- ~300 InfiniBand switches to manage
- ~9,000 InfiniBand ports
- ~33,600 meters (or 21 miles) of 4X InfiniBand copper cables
- ~10,000 meters (or 6 miles) of copper Ethernet cables
- 26,880 1 GB DDR-2 400 SDRAM modules
- 1.8 MW of power, 400 tons of cooling
- Up to 2000 nodes Linpack efficiency was ~82%

#5 in Top500
38.2 Tflops on 3721 nodes
71% efficiency

LLNL Peloton Clusters


1024 4-Socket, Dual Core (8,192 CPUs) Compute Nodes
1152 Port Infiniband 4x DDR [96(12D12U)+4(288D)]
G W
1/10 GbE supplied by site
1/10 GbEnet Federated Switch
100BaseT Management
S
M D
MetaData supplied by site
8 Gateway nodes @ 0.8+0.8 GB/s delivered I/O over 1x10GbE MetaData supplied by site
Object Storage Gismos 1 or 10GbE attached 400 TB and 25.6 GB/s

System Parameters

- Three clusters 1024, 512, and 256 nodes
- Quad socketdual core AMD Opterons
- 4X DDR PCIe InfiniBand – Full fat-tree
- DDR2 667 DRAM
- <3 us, 1.8 GB/s MPI latency and Bandwidth over IBA 4x
- Support 800 MB/s transfers to Archive over quad Jumbo Frame Gb-Enet and IBA links from each Login node. Some solutions have 10GbE
- No local disk, remote boot and SRP target for root and swap partitions on RAID5 device for improved RAS
- Software for build and acceptance 3 provided software stack distributions (all based on several common key components: RedHat, Lustre, OpenFabrics, MPICH or OpenMPI)

Thunderbird and Peloton Infiniband Software

- Sandia Thunderbird (4,480 nodes; 8,960 processors)
  - Production computing resource (~1 yr)
  - Running Cisco/Mellanox VAPI proprietary software stack
  - CiscoSM and Cisco diagnostics
  - MVAPICH1 and OpenMPI
  - Starting to test OFED-1.0 with RHEL4U4 and OpenMPI
- LLNL Peloton (~1024+512+256 nodes; ~14,400 processors)
  - First large IB cluster build using only OFED software
  - First cluster of 512 nodes is undergoing hardware and software “burned in”
  - Using an OFED-1.0 based stack with RedHat
  - Using OpenSM and OpenFabrics diagnostics/management tools

InfiniBand Successes

- Large IB clusters are running DOE production capacity computing workloads
- OFED-1.0 (and updates) available in RHEL4U4 and SLES10
- Several DOE clusters are now using OFED or have plans to upgrade to OFED
- OFED-1.0 RHEL4U4 is undergoing testing this week up to 1024 nodes (2048 processors)
- Stability and ease of use of OFED has been much better than proprietary stacks
- Sandia Thunderbird will likely move OFED into production with RHEL4U5
- OpenMPI is proving to be more scalable than MVAPICH
- OpenFabrics diagnostics and management tools provide good basic (static) information about the IB fabric

InfiniBand Technical Issues

- Current solutions are working but there is still room for much improvement
- InfiniBand Scalability
  - Current scaling is reasonable for small capacity jobs (< 256-512 nodes)
  - Need single job scalability up to 4000 nodes (multipath routing, etc.)
- Network congestion information is still difficult to extract from fabric
  - IB Congestion control architecture is not yet supported
  - Vendors will need to implement congestion control agents in switches
- OpenFabrics SRP and iSER are not production worthy yet, thus DOE production storage purchases have remained Fiber Channel rather than InfiniBand.
- Current OpenFabrics stack is missing a performance manager (PM)
  - Error rates are more helpful than raw errors numbers
  - PM could also provide information about fabric congestion

OpenFabrics Support Issues

- Vendors need to fully support OpenFabrics software in production environments
  - Stop pushing proprietary solutions (still happening)
  - There is no long term value add for customers in proprietary stacks
  - Production environments are multi-vendor (e.g. SNL has Voltaire, Cisco, Silverstorm, Mellanox, and Qlogic)
  - Make sure OpenSM supports your switches and any advanced features (performance manager, congestion manager, etc.)
  - Customers are willing to pay for OpenFabrics support to meet their performance, stability, robustness requirements
  - OFED is a reasonable start but we need vendors to stand behind the OFED product

OpenFabrics Enterprise Distribution (OFED)

- Goals to improve and control the quality of the OF software stack
  - Performance
  - Compliance
  - Stability
  - Reliability
  - Diagnostic tool set
  - Industrial-strength support and rigorous regression testing
- OFED has created a collaborative testing and productization environment
  - Single OpenFabrics software stack supported by all IB vendors and Linux distributions
- OFED is a good first step however …
  - OFED process has been difficult
  - Collaboration is working but it is a constant struggle
  - Need a more robust and smoother release plan and process in order to succeed
  - Release process will only get more complicated with the addition of iWARP
  - Use experiences from the OFED 1.0 and 1.1 release to improve process

Petascale InfiniBand Cluster Requirements

- 4000 nodes with multi-core CPUs feasible in next 2-3 years
- Need InfiniBand to scale beyond the current 512 nodes to 4K nodes
- Scalability to this level will require:
  - < 1us pt2pt latency
  - High performance RC/UD send/recv (near line rate)
  - High message injection rate (15-20M/s) for small/medium sized messages
  - Hardware and OF software support for congestion control architecture
  - OF Performance manager and support in vendor switches
  - Fully adaptive routing (addition to IB spec.)
  - Cheap reliable fiber for 4X/12X DDR and QDR (match the cost of copper)
  - High performance (near line rate – SDR, DDR, QDR) native IB-IB routing
  - Reliable multicast (up to a minimum of 128 peers)
  - SRQ shared receive block (improve flow control for SRQ)
  - Reduce/eliminate memory registration overhead
  - More requirements presented at Sonoma Workshop (http://openfabrics.org/conference/spring2006sonoma/hpc-reqs-openib-0206-v3.pdf)
- *Achieving these goals will be a collaborative effort between OFA, IBTA, and HPC community*

How can OpenFabrics and IBTA Collaborate?

- Complete IB-IB routing specification
- Add fully adaptive routing to InfiniBand specification
- Have joint memberships between IBTA and OpenFabrics?
- More joint workshops
- Continued discussions ...

How do we move forward?

- OFA is making good strides in the development and hardening of an OpenFabrics stack
  - Single multi-vendor software stack included in Linux distributions
- The use of OFED in a production environment is not 6 month out, it is today
  - Need stronger commitment from vendors (from CEO to field engineers)
- Streamlined OFED testing and release process
  - Perhaps using better web-based collaborative tools
- Continue to develop a strong collaboration between OFA, HPC customers, and IBTA

For more information

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