Cisco Server Fabric Switching (InfiniBand)

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# High-Performance Computing Applications
## Not Just for Research and Labs Anymore!

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<th>Applications</th>
<th>Technical Requirements</th>
<th>Cisco’s Strength</th>
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<td>Crash Simulation, Aerodynamics</td>
<td>Fluent, Powerflow, LSDyna</td>
<td>Bandwidth High Availability Support</td>
<td>Enterprise Class</td>
</tr>
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<td>Unified Management</td>
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<tr>
<td>Life Sciences</td>
<td>Disease Research, Drug Design, etc.</td>
<td>Amber, Blast, Charmm, Schrodinger</td>
<td>Bandwidth Low Latency Support</td>
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<tr>
<td>Energy</td>
<td>Seismic and Geophysical Modeling</td>
<td>Geoquest, Geodepth</td>
<td>Bandwidth Multicast Support</td>
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<tr>
<td>Financial</td>
<td>Financial Analytics (Monte Carlo Simulation)</td>
<td>Barra, Sungard, RMG</td>
<td>Bandwidth High Availability Support</td>
<td>OpenFabrics Leadership</td>
</tr>
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<td>Quality Support</td>
</tr>
<tr>
<td>Digital Media</td>
<td>Digital Image Rendering, Animation</td>
<td>Discreet, Renderman</td>
<td>Bandwidth Multicast Low Latency Support</td>
<td></td>
</tr>
</tbody>
</table>

Bandwidth
Multicast
Low Latency
High Availability
Support

Technical Requirements
Bandwidth
Low Latency
High Availability
Support

Cisco’s Strength
Enterprise Class
Performance
Latency
Unified Management
OpenFabrics Leadership
Quality Support
Why Interconnects Matter?

Fluent Perf Study – IB versus GigE

3.6M call model on 1 to 16 cores

Almost linear speedup with Infiniband

GigE does not scale beyond small clusters
InfiniBand Overview
InfiniBand (IB) Overview

- High-bandwidth, low latency interconnect
- Standardized by InfiniBand Trade Association (IBTA) in 1999
- Variety of software protocols to handle high speed communication over RDMA
- Supports server and storage attachments
- Bandwidth Capabilities (SDR/DDR)
  - 1x—2.5/5 Gbps: 2/4 Gbps actual data rate (base rate for InfiniBand)
  - 4x—10/20 Gbps: 8/16 Gbps actual data rate
  - 12x—30/60 Gbps: 24/28 Gbps actual data rate
- Built-in RDMA as core capability for inter-CPU communication

  RDMA = Remote Direct Memory Access
# Infiniband Advantage

<table>
<thead>
<tr>
<th>Adapter</th>
<th>Bandwidth per port</th>
<th>Power per port</th>
<th>RDMA</th>
<th>Full Offload</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infiniband</td>
<td>10 Gbps or 20 Gbps</td>
<td>4-7 W</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Fibre Channel</td>
<td>4 Gbps</td>
<td>7-11 W</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>10 Gb Ethernet</td>
<td>10 Gbps</td>
<td>12-25 W</td>
<td>Depends on adapter</td>
<td>Depends on adapter</td>
</tr>
</tbody>
</table>
InfiniBand Cabling/Speeds

- High-speed, bi-directional serial links between devices
- Include 1x, 4x or 12x wide full-duplex links
- Uses 8b/10b encoding

<table>
<thead>
<tr>
<th>Link</th>
<th>SDR half duplex signal rate</th>
<th>SDR half duplex usable bandwidth [1]</th>
<th>DDR half duplex signal rate</th>
<th>DDR half duplex usable bandwidth [1]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1x</td>
<td>2.5 Gbps</td>
<td>2 Gbps (250 MBps)</td>
<td>5 Gbps</td>
<td>4 Gbps (500 MBps)</td>
</tr>
<tr>
<td>4x</td>
<td>10 Gbps</td>
<td>8 Gbps (1 GBps)</td>
<td>20 Gbps</td>
<td>16 Gbps (2 GBps)</td>
</tr>
<tr>
<td>12x</td>
<td>30 Gbps</td>
<td>24 Gbps (3 GBps)</td>
<td>60 Gbps</td>
<td>48 Gbps (6 GBps)</td>
</tr>
</tbody>
</table>
InfiniBand Distance Limitations

- **Copper (passive)**
  - Up to 15m for 4x (SDR) connections
  - Up to 11m for 12x (SDR) connections
  - Up to 8m for 4x (DDR) connections

- **Copper (active)**
  - *Coming soon (10, 12, 15, 20m)*

- **Optical (active)**
  - Up to 200m via optical transceiver (SDR)
    - Up to 75m via 62.5/125µm 200 Mhz.km fiber
    - Up to 125m via 50/125 µm 500 Mhz.km fiber
    - Up to 200m via 50/125 µm 2000 Mhz.km fiber
  - Long Haul possible via DWDM
Active and Optical Cable Overview

- **Active Wires**
  - Look like traditional CX4 InfiniBand cables
  - Include “active component” in connector for signal management
  - Draw ~1W per connection
  - Allow signals to go further on thinner cables
  - Projected max reach: 25 meters SDR, 20 meters DDR

- **Optical Wires**
  - Have CX4 connectors with fiber between connectors
  - Optics embedded in connector
  - Draw ~1.6W per connection
  - Projected max reach: 100 meters, SDR and DDR
Remote Direct Memory Access (RDMA)

- RDMA enables data to be moved between application (user) memory space without CPU intervention
- RDMA is transport agnostic
- InfiniBand has native support for RDMA
- Ethernet RDMA and TOE NICs can support RDMA
- RDMA can significantly increase application and transport performance
  - Kernel bypass
  - Zero copy data transfer
  - No CPU intervention
Traditional Server I/O architecture

- Bus Based architecture with I/O memory pool
- Access to I/O resource handled by BIOS
- A data packet is typically copied across the bus three times
  - CPU Interrupts, Bus bandwidth constrained, Memory bus constrained
Remote Direct Memory Access (RDMA) and Kernel Bypass

Traditional Model

User
Kernel

Application

Sockets Layer

TCP/IP Transport

Driver

Hardware

Kernel Bypass Model

User
Kernel

Application

Sockets Layer

TCP/IP Transport

Driver

Hardware

RDMA ULP
RDMA I/O Architecture

- Compute resource on one server can access application memory in a remote server over InfiniBand connection
## InfiniBand Performance

*Measured Results*

<table>
<thead>
<tr>
<th></th>
<th>Sockets API</th>
<th>MPI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TCP</td>
<td>SDP</td>
</tr>
<tr>
<td>IP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IPoIB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gigabit Ethernet</td>
<td>10 GE</td>
<td>SDR IB</td>
</tr>
<tr>
<td>Latency (us)</td>
<td>45.7</td>
<td>25.8</td>
</tr>
<tr>
<td>Bandwidth MB/s</td>
<td>118</td>
<td>1214</td>
</tr>
<tr>
<td>CPU</td>
<td>9%</td>
<td>25%</td>
</tr>
</tbody>
</table>
# InfiniBand Protocol Summary

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Summary</th>
<th>Application Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPoIB (IP over InfiniBand)</td>
<td>Enables IP-based applications to run over InfiniBand transport.</td>
<td>Standard IP-based applications. When used in conjunction with Ethernet Gateway, allows connectivity between IB network and LAN.</td>
</tr>
<tr>
<td>SDP (Sockets Direct Protocol)</td>
<td>Accelerates sockets-based applications using RC and/or RDMA.</td>
<td>Communication between database nodes and application nodes, as well as between database instances.</td>
</tr>
<tr>
<td>DAL (Datagram Acceleration Layer)</td>
<td>Accelerates IP multicast applications.</td>
<td>Applications that use IP multicast include Wombat, 29West, Tibco Rendezvous/RV, Reuters RMDS. Applicable for Java too.</td>
</tr>
<tr>
<td>SRP (SCSI RDMA Protocol)</td>
<td>Allows InfiniBand-attached servers to utilize block storage devices.</td>
<td>When used in conjunction with the Fibre Channel gateway, allows connectivity between IB network and SAN.</td>
</tr>
<tr>
<td>RDS (Reliable Datagram Socket)</td>
<td>Reliable datagram IPC in OpenFabrics (Linux) based on socket API</td>
<td>Interprocess communication for Oracle RAC nodes (Oracle 10g RAC and later).</td>
</tr>
<tr>
<td>MPI (Message Passing Interface)</td>
<td>Low latency protocol used widely in HPC environments.</td>
<td>HPC applications.</td>
</tr>
</tbody>
</table>
Designing an Infiniband Fabric
Architecture of an InfiniBand Solution

Server Farm
- CPU
- Mem Ctrlr
- System Memory
- Host Channel Adapter

InfiniBand Server Fabric with Subnet Manager
- Provide Gateway to Intranet / Internet and SAN

Intranet / Internet
- Ethernet GW
- Fibre Channel GW
- SAN / Storage
IB is a centrally managed network

- The IB Subnet Manager (SM) is responsible for network management.
- SM Required to run at all times; can run on node or switch.
- It is responsible for:
  - Sweeping the network (discovery, routing, port bringup)
  - Monitoring the network (device insertion, removal, state changes, port counters, etc.)
  - Maintaining and presenting network information (partitions, multicast groups, services, paths, etc.)
- The SM can run on an SFS switch (enabled by default on switches) or on a host (when purchased separately).
- The switch based SM can be controlled though CLI, or EM. The host based SM can only be controlled though a stand-alone CLI.
InfiniBand Host Driver Stack

Options for Linux and Windows:
- Cisco commercial stack
- Open Fabrics stack

Notes:
- Cisco TAC currently supports Cisco SFS/InfiniBand solutions using either Cisco commercial or Open Fabrics Linux stack.
- Any MPI library can be used with Cisco SFS.

InfiniBand support on AIX, Solaris, HP-UX available from IBM, Sun, HP.
Cisco
SFS/InfiniBand
Portfolio
InfiniBand Market Transition

**SDR to DDR**

- InfiniBand Interconnect is transitioning from 10G (SDR) to 20G (DDR)
- DDR performance is required to drive quad-core CPU I/O
- Transition supported by maturity of DDR Products and increased cable options in 2007
- Growing maturity within Linux & Windows drivers in the Open Source Community
- Strong backing for DDR in HPC community
- Availability of ultra-low latency HCAs

**DDR InfiniBand offers**

- 2-3µs latency
- 16Gbps of usable bandwidth
# Cisco InfiniBand Product Line

<table>
<thead>
<tr>
<th>Server Fabric Switch (SDR/DDR)</th>
<th>SFS 7000P/D</th>
<th>SFS 7008P (SDR)</th>
<th>SFS 7012P/D</th>
<th>SFS 7024P/D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(24) 4XIB</td>
<td>(96) 4XIB</td>
<td>(144) 4XIB</td>
<td>(288) 4XIB</td>
</tr>
<tr>
<td>SFS 3012R (SDR)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(24) 4XIB + 12 Gateways</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Blade Server</th>
<th>IBM BladeCenter H</th>
<th>Dell PowerEdge 1855</th>
<th>HP c-Class</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SDR embedded switch</td>
<td>SDR passthru module</td>
<td>SDR not available</td>
</tr>
<tr>
<td></td>
<td>DDR passthru module</td>
<td>DDR switch components</td>
<td>DDR embedded switch</td>
</tr>
</tbody>
</table>

| HCA                           | Tall/short bracket, single/dual port, memfree/128MB, remote bootable |

<table>
<thead>
<tr>
<th>Mgmt</th>
<th>High Performance Subnet Manager</th>
<th>Embedded Subnet Manager</th>
<th>CiscoWorks – Unified Mgmt</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Device Fault Manager</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Resource Manager Essential</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Host Drivers</th>
<th>Cisco Commercial stack for Linux, Windows Drivers</th>
<th>OpenFabrics Linux, WinOF</th>
<th>AIX, Solaris, HP-UX available</th>
</tr>
</thead>
</table>
# Introducing the SFS 3504

<table>
<thead>
<tr>
<th>Feature</th>
<th>Benefit</th>
</tr>
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<tbody>
<tr>
<td>4U/4S chassis with 60Gbps/Slot</td>
<td>Future ready: Upto 60Gbps per gateway slot.</td>
</tr>
<tr>
<td>Integrated Switch and DDR IB Port Card</td>
<td>Cost optimized architecture. Single chip architecture.</td>
</tr>
<tr>
<td>Cisco VSAN Support on FC Gateway</td>
<td>Connectivity to multiple Fibre Channel Sub Fabrics.</td>
</tr>
<tr>
<td>IPV6 ready Ethernet gateway</td>
<td>Compliant with Federal Requirements</td>
</tr>
<tr>
<td>10GbE Ethernet Gateway</td>
<td>Within two quarters of FCS</td>
</tr>
<tr>
<td>Availability</td>
<td>December 2007</td>
</tr>
</tbody>
</table>

![SFS 3504 Image]

- E-Port Interoperable with leading FC Switches
- 10GbE Link Speed Capable
- DDR speeds for external and internal IB Ports
I/O Simplification: Data Center Resources Converge

Server Farm

Multiple Fabrics
High CapEx and High TCO

Single Server Fabric
Low CapEx and Optimal TCO

InfiniBand is the only fabric technology that can efficiently and cost-effectively converge the data center
I/O Simplication with I/O Gateways

- FC port sharing capability
  - lower cost
  - easier deployment
- Heterogeneous host OS support
  - no changes required to apps
- Virtualization features
  - LUN mapping/masking
  - multiple WWNs

- NIC implementation
  - transparent to all Ethernet network topologies
- Provides Ethernet Port Sharing capability
  - lower cost, easier deployment
- Heterogeneous host O/S support
  - no changes required to applications
- Advanced Ethernet features
  - Ethernet link aggregation
HP BladeSystem c-Class Server Products

HP c7000 Enclosure with Blades

HP BL460c Server Blade

HP 4x DDR (Mellanox) InfiniBand Switch

HP 4x Cheetah DDR InfiniBand HCA mezzanine card (single port)

Dual-port HCA available by end of 2007
IBM BladeCenter H: DDR Components

- OFED Linux drivers support only
- available in Oct 2007
IBM BladeCenter H: Cisco IB Components

BladeCenter H Rear View

InfiniBand Host Channel Adapter (dual port)

Cisco InfiniBand Module
IBM Octopus (12x to 4x) Cable

• IBM designed 12x to 3 4x IB Break-out Cable

• 4x connector labeled 16 corresponds to lowest numbered port in the Trio

• For example, if the Octopus Cable is connected to the 12x Port on Switch labeled (19,20,21), then

  4x cable connector labeled 16 = Port 19
  4x cable connector labeled 17 = Port 20
  4x cable connector labeled 16 = Port 21
Cisco InfiniBand for Dell PE 1x55 (9g) Blades

- 10-blade chassis
- Plug one daughter card into each server blade
- Each blade gets one or two 4x (10Gbps) IB connections
- One or two pass through modules per chassis
- Requires custom low-profile Glacier cables
Dell Next Gen 10g “Noble” Blade Chassis

- DDR IB Blade Switch from Cisco for Dell Noble Chassis
- Unmanaged switch (requires external subnet manager)
- 50% Blocking switch (16 blades / 8 uplinks)
- ConnectX HCA Daughter card from Mellanox
- Driver support by Cisco based on OFED
- Available in January 2008
HPC Fabric Design
Planning for building a cluster

- InfiniBand network pre-planning strategies
  - Topology and switch choices
  - Network blocking factors
  - I/O considerations
  - Rack & floor plan layout
  - Environmental considerations

- InfiniBand network topologies
  - CLOS-style networks
  - Calculating fabric size / components
  - Common single switch configurations
  - Common 2-tier configurations
  - Blocking factors
Fat trees

- **What is a fat tree?:**
  - All hosts (HCAs) connect to network at leaves of tree. Each leaf switch connects to each interior switch in its section at the layer above. Multiple roots (spines or cores) of the tree.

- **Why are they good for IB?:**
  - Provides consistent bisectional bandwidth.
  - Easy analysis for forwarding.
  - No “credit loops” (potential deadlocks). Can use up/down theorem to show no deadlocks.
HPC Clusters

- Front End Inter-Nodal Communication TCP, UDP.
- Job Scheduling over SSH, RSH, BPSH (BPROC–Beowulf).
- Node Status (UDP)

Specific Applications
- Animation rendering
- Seismology
- Oil exploration
- Biochemistry
- Financial analysis

Unified Fabric Management Integration
Sandia National Labs – 4600 Nodes Cluster

- **Application:**
  - High Performance SuperComputing Cluster

- **Environment:**
  - 4600 Dell Servers
  - 50% Blocking Ratio
  - 8 SFS 7048
  - 288 SFS 7000’s

- **Benefits:**
  - Compelling Price/Performance
  - Largest IB Cluster ever built

**Diagram Description:**
- **Core Fabric**
  - 8x SFS 7024
  - 288 ports each

- **Edge**
  - 288x SFS 7000
  - 24-ports each

- **Compute Nodes**
  - Dell 1850 Servers
  - Dual 3.6Ghz EMT64 6GB
  - Cisco PCIe HCA

- **9200 Processor**
  - 60TFlop SuperCluster
Large Wall Street Bank
Enterprise Grid Computing

- **Application:**
  - Replace proprietary platforms with standards-based components
  - Build scalable “on-demand” compute grid for financial applications

- **Environment:**
  - 500+ Intel Servers per slice
  - Cisco Server Fabric Switch with Ethernet and Fibre Channel Gateways
  - Hitachi RAID Storage
  - SAN Switches
  - Ethernet Switches

- **Benefits:**
  - 20X Price/Performance Improvement over four years
  - 30-50% Application Performance Improvement
  - Standards-based solution for on-demand computing
  - Environment that scales using 500-node building blocks
Large Service Provider: n-Tier Applications

- **Application:**
  - Replace proprietary platforms with standards-based components
  - Build scalable service oriented architecture for multi-tenant environment

- **Environment:**
  - 100 Sun x86 servers
  - Cisco Server Fabric Switch with Ethernet and Fibre Channel Gateways
  - EMC RAID Storage
  - SAN Switches
  - Ethernet Switches

- **Benefits:**
  - Lower total cost of ownership
  - I/O simplification
  - Strategic service oriented architecture
  - Rapid provisioning
Oracle RAC with Infiniband
Oracle Database 10g RAC

- Oracle Database 10g Real Application Clusters (RAC) provides the ability to build an database platform from multiple clustered servers
- Highly Scaleable
  - Cache-to-cache data shipping
  - Scales off-the-shelf applications with no changes
  - Easily add and delete nodes
- Highly Available
  - Eliminates a node as single point of failure
  - Node failure is transparent to applications
  - Recovers from node failure in 17 seconds - workload independent
  - Pre-warmed cache speeds restart
Oracle RAC: Cluster Interconnect

Major components that use cluster interconnect:

- **Interprocess communication (IPC)** — largest demand on interconnect, e.g. for join, aggregation or load operations involving multiple nodes; useful to re-distribute data and send control messages from one node to another.

- **Cache Fusion** — shipping blocks between nodes, e.g. node A is requesting block that is currently cached on Node B.

- **Cluster Ready Services (CRS)** — each node periodically sends a heartbeat.

Traditionally, all components communicate using UDP protocol on Ethernet network.
Oracle: Infiniband Implementation

- No separate binary or patch needed to use InfiniBand
- Oracle components use InfiniBand drivers in the following way:
  - **IP over InfiniBand (IPoIB) driver:**
    - Cluster Membership voting for Clusterware
    - Membership voting for Automatic Storage Management (ASM)
    - Membership voting for Oracle Cluster File System (OCFS)
    - Cache Fusion and IPC for Real Application Cluster Database (RAC)
    - Oracle Net Clients
  - **SCSI RDMA Protocol (SRP) driver:**
    - Storage for ASM
    - Storage for raw devices
    - Storage for OCFS
  - **Sockets Direct Protocol (SDP) driver:**
    - OracleNet
    - n-Tier applications (e.g. Application to Web Tier)
Oracle RAC with Infiniband: IB Protocols Used

IPoIB can be IPoIB-UD or IPoIB-CM
Oracle 10g: Broad Scope of IB Benefits

- Network
  - Load Balancer
  - Ethernet Gateway

- Application Servers
  - Oracle 10g RAC
  - Intra RAC: IPC over IB (IPoIB or RDS)
  - OracleNet: SDP over IB

- Web Servers

- SAN
  - Shared Storage
  - Consolidate and share Storage amongst servers

Benefits:
- 20% improvement in throughput
- 2x improvement in throughput and 45% less CPU
- 3-4x improvement in block updates/sec
- 30% improvement in DB performance

FC gateway: host/lun mapping
What is RDS?

- A low overhead, low latency, high bandwidth, ultra reliable, supportable, IPC protocol and transport system used with Oracle RAC.
- Runs over current Infiniband and, in future, iWARP/RDMA 10Gb Ethernet
- Potential benefits:
  - Up to 3 to 4x higher bandwidth over Gigabit Ethernet
  - Up to 50% less CPU than IPoIB-UD, UDP (Gigabit Ethernet)
  - Up to 50% less Latency of UDP (Gigabit Ethernet)
- Status:
  - RDS beta available on OpenFabrics Enterprise Linux (IB).
  - Cisco currently working with Oracle on certification with Oracle11g. Expect generally availability in 1H 2008.
  - Expect to see RDS support on Solaris and AIX in the near future.
In Closing…
Cisco InfiniBand Differentiators

- **Most Complete DDR Switching Line**
  -- Cisco is *shipping fixed and modular* DDR switches with best in-class bit error rates

- **Scalable InfiniBand Subnet Manager**
  -- Proven scalability of 4600 nodes, Sandia Labs
  -- High availability across multiple SM’s with full database synchronization
  -- Rapid fabric discovery and fabric “bring up”. Less than 60 seconds for 4000 nodes
  -- Optimized routing for SDR/DDR mixed fabrics

- **InfiniBand Host Drivers**

- **Enterprise Class Mgmt and Security**
  - SNMP V3 for capturing chassis failures, performance counters, fabric topology, logging over SNMP
  - SNMP offers integration CiscoWorks and HP OpenView!
  - Imaging upgrading FTP, TFTP, SCP
  - Radius and TACACS+, integrated with Cisco ACS

- **High Performance I/O**
  -- High Performance and Highly Available Ethernet Gateway for Client, NAS & Parallel File System Access
  -- SRP to Fibre Channel Gateway for SAN Access
  -- Remote server boot for virtualization
# Cisco Infiniband Key Benefits

| Experience                  | • Largest IB cluster in the world - Sandia 4700 servers; In production for 1+ year  
|                            | • Largest IB cluster in the enterprise – JPMC 1000 servers; In production for 1+ year |
| Product Design and Quality  | • Scalability and High-Availability is core of product design philosophy  
|                            | • Strict product quality control with reduced Bit Error Rate  
|                            | • Best in class Ethernet and Fibre-channel to Infiniband Gateways |
| Expertise & Support         | • Enterprise class products  
|                            | • Developed core components of Open Fabrics  
|                            | • Drivers have been through EMC E-labs testing  
|                            | • 24 x 7 x 365 Smartnet support |
| Management                  | • Secure Management: TACAC+, RADIUS, SNMPv3, SSH, VSAN RBAC  
|                            | • High Performance Subnet Manager  
|                            | • SNMP MIBs, Syslog  
|                            | • CiscoWorks LMS Integration |
HPC Resources

- Cisco High Performance Computing
  - http://www.cisco.com/go/hpc

- Cisco Server Fabric Switch (Infiniband)

- High Performance Computing Solutions for Financial Markets
  - www.cisco.com/offer/highperformancetrading

- Configuring Oracle RAC on Infiniband (primarily IPoIB) whitepaper

- Pre-sales Support Mailing List
  - Cisco-specific: svbu-seteam@cisco.com

- Cisco SFS/Infiniband Training
  - http://www.fireflycom.net/classes/HPCSFS/