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InfiniBand – The Next Paradigm Shift in Storage

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Overview

- A brief history of InfiniBand
- A basic overview of InfiniBand
- The IB Paradigm Shift
- The IB Paradigm Shift and Storage
- Summary

Brief history of InfiniBand

- **Future I/O (FIO) was being developed by IBM, Compaq Computer, Hewlett-Packard, 3Com, Adaptec, and Cisco.**
- **Next Generation I/O (NGIO) was being developed by Intel, Dell Computers, Sun, and others.**
- **FIO and NGIO were competing technologies**
- **Neither would “win” so they combined forces to form Serial I/O (SIO) which combined the best of both technologies**
- **The name** *SIO* **could not escape the powerful clutches of the Intel Marketing department and hence was renamed** *InfiniBand Architecture* **or** *IBA* **for short**

What is InfiniBand?

- A technology used to interconnect processing nodes to I/O nodes to form a System Area Network
- Intended to be a replacement for PCI
- Heavily leverages best-of-breed technologies
- For more information or to get the spec for your reading pleasure visit the InfiniBand Trade Association website at:

http://www.infinibandta.org

What InifiniBand is not....

- InfiniBand is not a replacement for Ethernet.
- InfiniBand is not a wide area network. It is intended to be used within a computer room facility (< 100 meters diameter)
- InfiniBand is not a replacement for Fibre Channel

The Problem

- The need for a cost-effective interconnect technology for building *clusters*
- Bus-based architectures (i.e. PCI) are limited to a single host system and cannot easily extend beyond the confines of the "box"
- Bandwidth and Latency between boxes using existing system area networks are limited and/or expensive
- Not clear that bus-based technologies can scale in bandwidth as easily as serial technologies

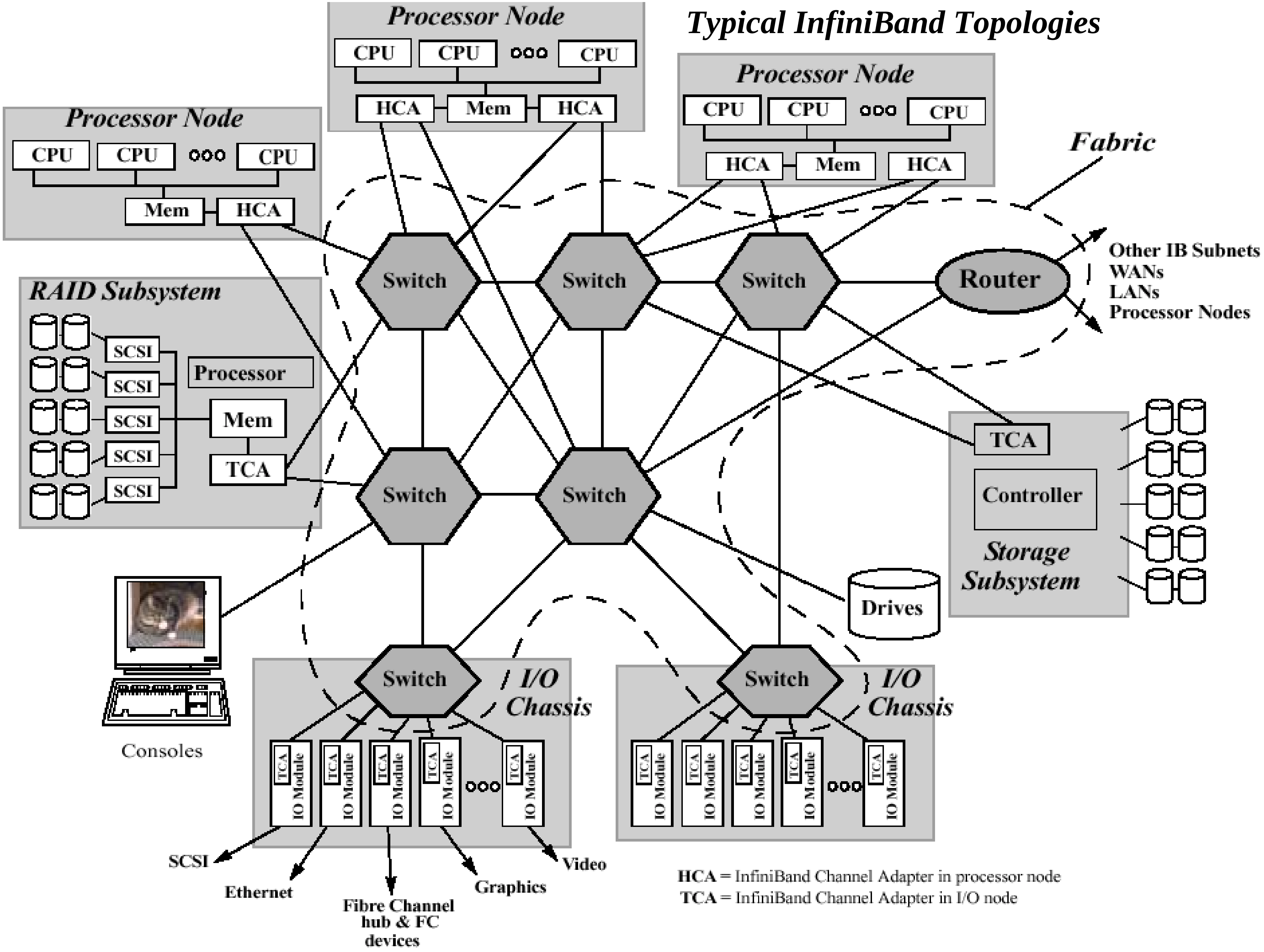
The Solution - InfiniBand

- **Network-based Architecture**
- **Serial communication technology**
- **Supported by a very large consortium – 220 members in the IBTA to date**
- **Targets a volume market in order to take advantage of economies of scale**
- **Not a new technology but rather IB is built on Best-of-Breed technologies**

Best of Breed Technologies

- Fibre Channel levels 0, 1, and 2
  - FC0 – Physical level – cable, connectors, signaling frequency
  - FC1 – 8b/10b Encoding
  - FC2 – Framing protocol, ECC, CRC, Header format
- Addressing – IPV6-type 128-bit addresses
- Software API – Virtual Interface Architecture (VIA)

Typical InfiniBand Topologies



HCA = InfiniBand Channel Adapter in processor node
TCA = InfiniBand Channel Adapter in I/O node

Transport Services

- **Reliable Connection – Acknowledged, connection oriented**
- **Unreliable Connection – Unacknowledged, connection oriented**
- **Reliable Datagram – Acknowledged connectionless, multiplexed transmission**
- **Unreliable Datagram - Unacknowledged connectionless, multiplexed transmission**
- **Raw Datagram – Unacknowledged connectionless**

IBA Features

- Zero Copy data transfers – direct user buffer to user buffer data transfer
- High bandwidth
    - 1x, 4x, 12x, and 32x defined
    - X = 2.5Gbit/sec single link speed on initial release
    - 1x and 4x parts are currently being developed
- Low latency – on the order of 10-40 microseconds initially
- Low overhead – Very little kernel involvement
- Memory protection
- Congestion management
- Hot-plug, auto-discovery and configuration subnet management
- Cost effective

Basic Commands

- Send / Receive operations for low overhead, low latency short messages between nodes
- Memory Binding operations for memory protection and security
- RDMA Write and Read operations that perform low overhead, high bandwidth data movement between nodes
- Atomic operations such as Test-and-Set, Increment, …etc. required primitives for resource sharing techniques such as remote semaphores and distributed lock management

Virtual Lanes and Partitioning

- Virtual Lanes (VL)
    - A VL is a send/receive pair of buffers
    - Up to 16 VL’s on each physical channel
    - VL15 is always present for subnet management
    - 15 remaining VL’s are used for data
- Partitions
    - Defines which nodes can communicate with each other

IBA Components

- Hardware
  - Host Channel Adapters (HCA)
  - Target Channel Adapters (TCA)
  - Switches
  - Routers
- Software
  - Subnet Managers
  - Service Agents
- Glueware: Virtual Interface Architecture (VIA)

Channel Adapters

- Channel adapters in general
  - Only two kinds of Channel Adapters: Host and Target
- Host Channel Adapters (HCA)
  - Very Intelligent
  - Capable of handling large numbers of concurrent connections
  - Typically have a large number of send/receive buffers
- Target Channel Adapters (TCA)
  - Not as much intelligence as HCAs due to the limited scope of their function
  - Need only handle a small number of concurrent connections
  - No as much send/receive buffer space as an HCA

Why do I need InfiniBand?

- Envy - Because everyone else will have it
- Allows for clustering – the next wave in high-performance computing and data-intensive I/O
- Cost effectiveness
- Allows for new and interesting storage architectures and storage/system area network topologies
- Because InfiniBand represents a significant ***paradigm shift*** in the storage industry that will present many new opportunities

The Paradigm Shift

- **In the mid-1990's Fibre Channel brought with it the capability to physically share a storage device between multiple computers.**
- **File Systems of that time were not designed to use that capability and it took 5-6 years for "shared" file systems to appear**
- **InfiniBand provides the capability to physically share (tightly couple) computing and other resources between multiple "nodes" on the IB network.**
- **Operating Systems of today are not designed to use this capability – but at least we can learn from our past experiences with Fibre Channel – can't we?**

InfiniBand and Storage

- **Storage devices will become “peers” within the system fabric instead of peripherals**
- **Lower communication latencies between the storage subsystem and other nodes**
- **Employing IB as the interconnect between a computing subsystem and a storage subsystem however implies new communication protocols between the two subsystems**
- **InfiniBand allows for *Extensible* Storage Architectures**

Extensibility

- **Density – the number of bytes/IOPS/bandwidth per unit volume**
- **Scalability – what does that word really mean?…**
    - **Capacity: number of bytes, number of objects, number of files, number of actuators …etc.**
    - **Performance: Bandwidth, IOPs, Latency, …etc.**
    - **Connectivity: number of disks, hosts, arrays, …etc.**
    - **Geographic: LAN, SAN, WAN, …etc.**
    - **Processing Power**
- **Cost – address issues such as $/MB, $/sqft, $/IOP, $/MB/sec, TCO, …etc.**
- **Adaptability – to changing applications**
- **Capability – can add functionality for different applications**
- **Manageability – Can be managed as a system rather than just a box of storage devices**
- **Reliability – Connection integrity capabilities built into IB**
- **Availability – Fail-over capabilities built into IB**
- **Serviceability – Hot-plug capability built into IB**
- **Interoperability – Supported by many vendors and Interoperability is a key issue being addressed at IB Specification time rather than after product rollout**
- **Power – decrease the power per unit volume**

Timescales

- **InfiniBand Specification 1.0 was released October 2000.**
- **InfiniBand sample parts are available from a variety of manufacturers**
- **Intel demonstrated 1x IB at the Intel Developers Forum in Feb 2001**
- **Production volume shipments of simple IB-enabled systems in 12-18 months**
- **More complex IB systems are likely to be 24 months out**

Summary

- IB is the next paradigm shift in the computing industry
- IB has tremendous potential and presents enormous opportunities for system and storage vendors
- IB has tremendous momentum due to it industry-wide backing
- IB is going to happen – it is just a question of “how soon”

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