InfiniBand Essentials Every HPC Expert Must Know

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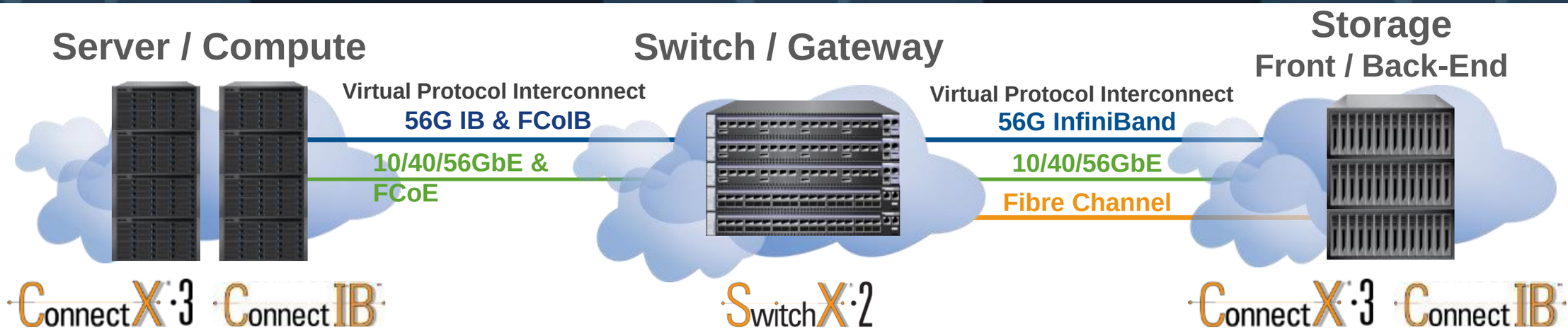
Mellanox TECHNOLOGIES

Connect. Accelerate. Outperform.™

HPC

- IB Principles
  - Targets
  - Fabric Components
  - Fabric architecture
- Fabric Discovery Stages
  - Topology discovery
  - Information Gathering
  - Forwarding Tables
  - Fabric SDN
  - Fabric Activation
- Protocol Layers Principle
  - Supported Upper Layer protocols
  - Transport layer
  - Link Layer
  - Physical Layer
- Mellanox Products
  - InfiniBand Switches
  - Channel Adapters
  - Cabling
  - Fabric Management

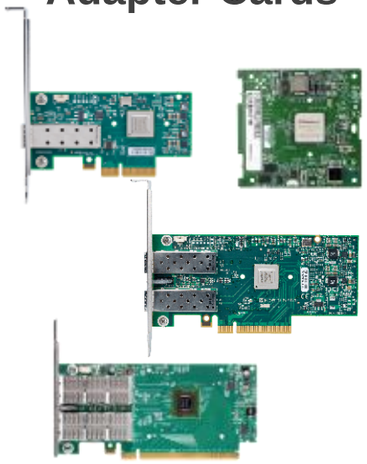
Leading Supplier of End-to-End Interconnect Solutions



Comprehensive End-to-End InfiniBand and Ethernet Portfolio

ICs

Adapter Cards



Switches/Gateways

Host/Fabric Software

Cables

Mellanox Common Target Implementations

HPC

Up to 10X Performance and Simulation Runtime

33% Higher GPU Performance

Unlimited Scalability

Web 2.0

2X Hadoop Performance

13X Memcached Performance

4X Price/ Performance

DB/Enterprise

10X Database Query Performance

4X Faster VM Migration

More VMs per Server and More Bandwidth per VM

Cloud

12X More Throughput

Support More Users at Higher Bandwidth

Improve and Guarantee SLAs

Financial Services

Lowest Latency

62% Better Execution Time

42% Faster Messages Per Second

Storage

Mellanox storage acceleration software provides >80% more IOPS (I/O operations per second)

Mellanox VPI Interconnect Solutions

ConnectX®-3 VPI Adapter

redhat. Novell suse Microsoft vmware OPENFABRICS SOFTWARE

Applications

Networking | Storage | Clustering | Management

Acceleration Engines

PCI EXPRESS™ 3.0

Ethernet: 10/40 Gb/s

InfiniBand:10/20/40/ 56 Gb/s

LOM

Adapter Card

Mezzanine Card

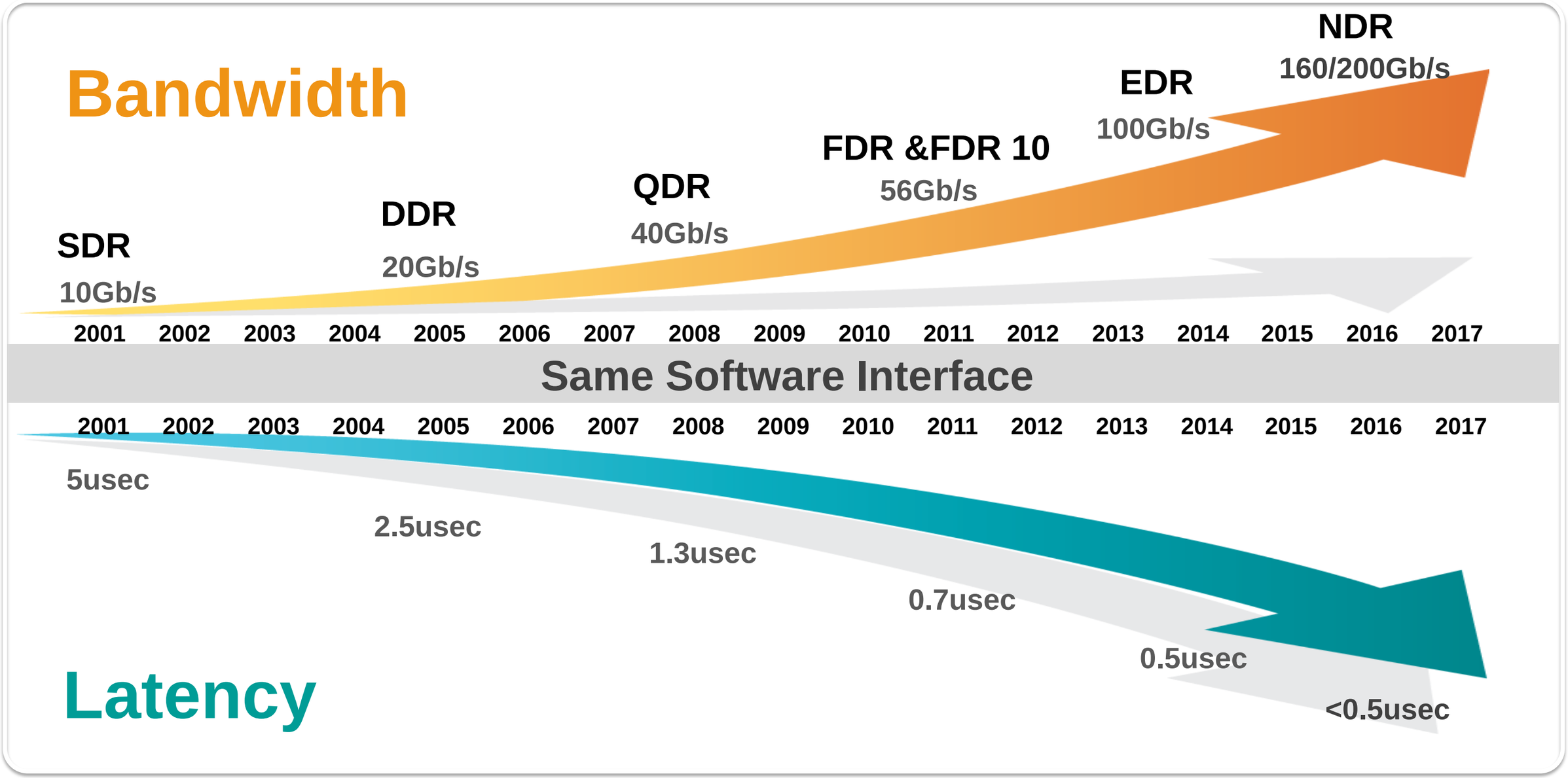
SwitchX®-2 VPI Switch

Unified Fabric Manager

Switch OS Layer

64 ports 10GbE
36 ports 40GbE
48 10GbE + 12 40GbE
36 ports IB up to 56Gb/s
8 VPI subnets

Leading Interconnect, Leading Performance



InfiniBand Trade Association (IBTA)

- Founded in 1999
- Actively markets and promotes InfiniBand from an industry perspective through public relations engagements, developer conferences and workshops
- InfiniBand software is developed under OpenFabrics Open Source Alliance
  http://www.openfabrics.org/index.html
- InfiniBand standard is developed by the InfiniBand Trade Association (IBTA)
  http://www.infinibandta.org/home

Steering Committee Members:

InfiniBand is a Switch Fabric Architecture

- Interconnect technology connecting CPUs and I/O

- Super high performance
  - High bandwidth (starting at 10Gb/s and up to 100Gb/s)
  - Low latency– fast application response across the cluster **< 1µs end to end**

    (Mellanox switches 170 nanosec per HOP)
  - Low CPU utilization with RDMA (Remote Direct Memory Access) –
    Unlike Ethernet, TRAFFIC communication bypasses the OS and the CPU's.

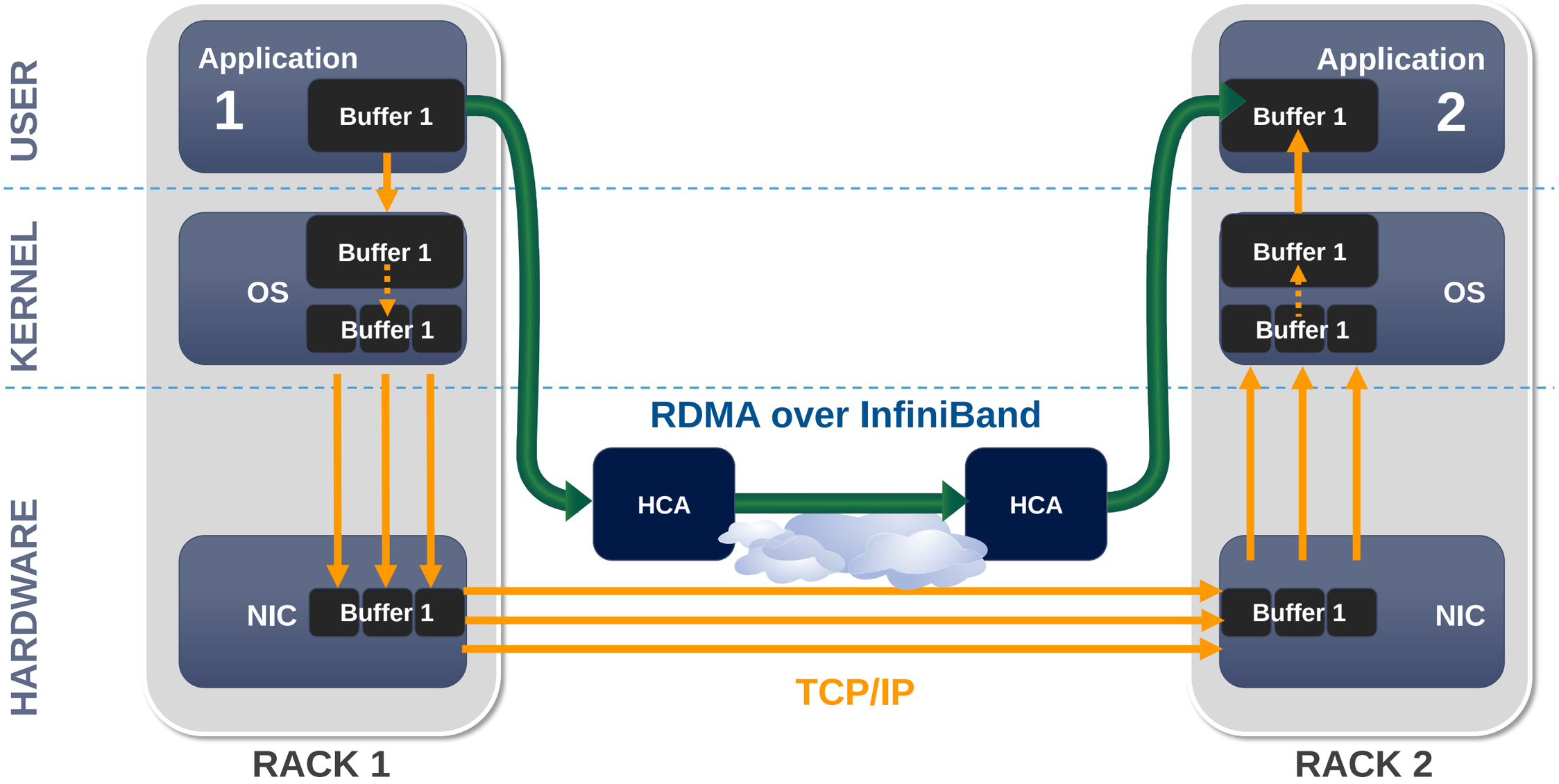
First industry standard high speed interconnect!

InfiniBand is a Switch Fabric Architecture

- InfiniBand was originally designed for large-scale grids and clusters
- Increased application performance
- Single port solution for all LAN, SAN, and application communication
- High reliability CLUSTER management (Redundant Subnet Manager)
- Automatic Cluster switches and ports configuration performed by the Subnet Manager SW

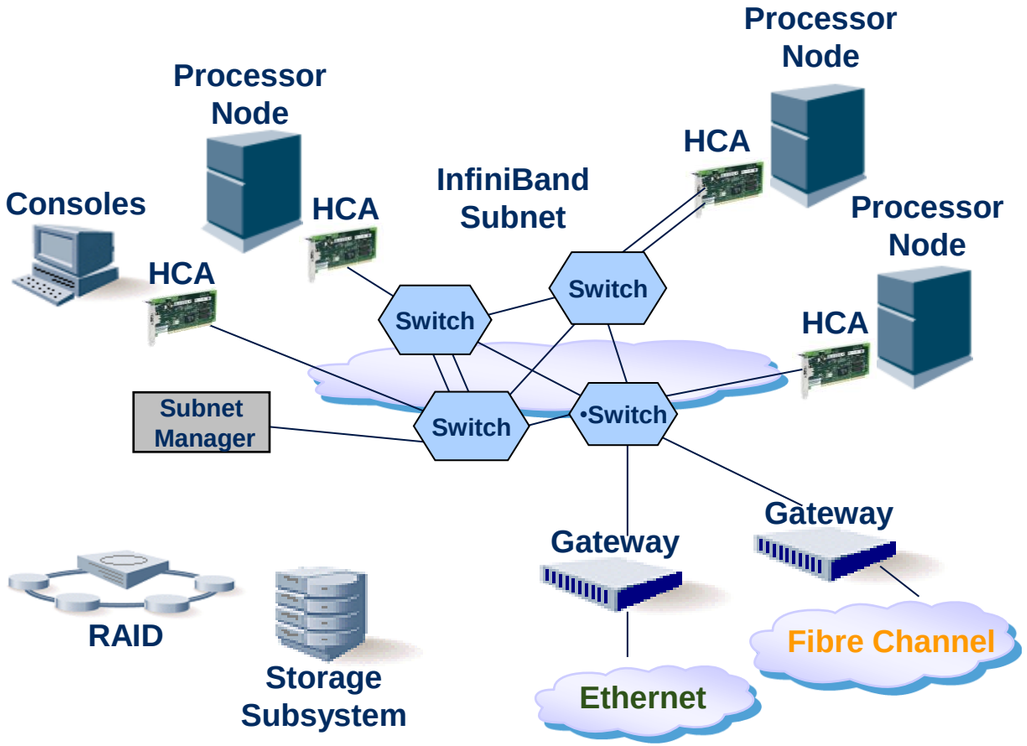
First industry-standard high speed interconnect!

RDMA – How Does it Work



The InfiniBand Architecture

- Industry-standard defined by the InfiniBand Trade Association
- Defines System Area Network architecture
  - Comprehensive specification: from physical to applications
- Architecture supports
  - Host Channel Adapters (HCA)
  - Switches
  - Routers



InfiniBand Components Overview

- Host Channel Adapter (HCA)
  - Device that terminates an IB link and executes transport-level functions and support the verbs interface

- Switch
  - A device that moves packets from one link to another of the same **IB** Subnet

- Router
  - A device that transports packets between different IBA subnets

- Bridge/Gateway
  - **InfiniBand** to **Ethernet**

Host Channel Adapters (HCA)

- Equivalent to a NIC (Ethernet)
  - GUID Global Unique ID
- Converts PCI to InfiniBand
- CPU offload of transport operations
- End-to-end QoS and congestion control
- HCA bandwidth options:
  - **Single Data Rate 2.5GB/S * 4 = 10**
  - **Double Data Rate 5 GB/S * 4 = 20**
  - **Quadruple Data Rate 10GB/S * 4 = 40**
  - **Fourteen Data Rate 14 Gb/s * 4 = 56**
  - **Enhanced Data Rate 25 Gb/s * 4 = 100**

Global Unique Identifier (GUID) – Physical Address

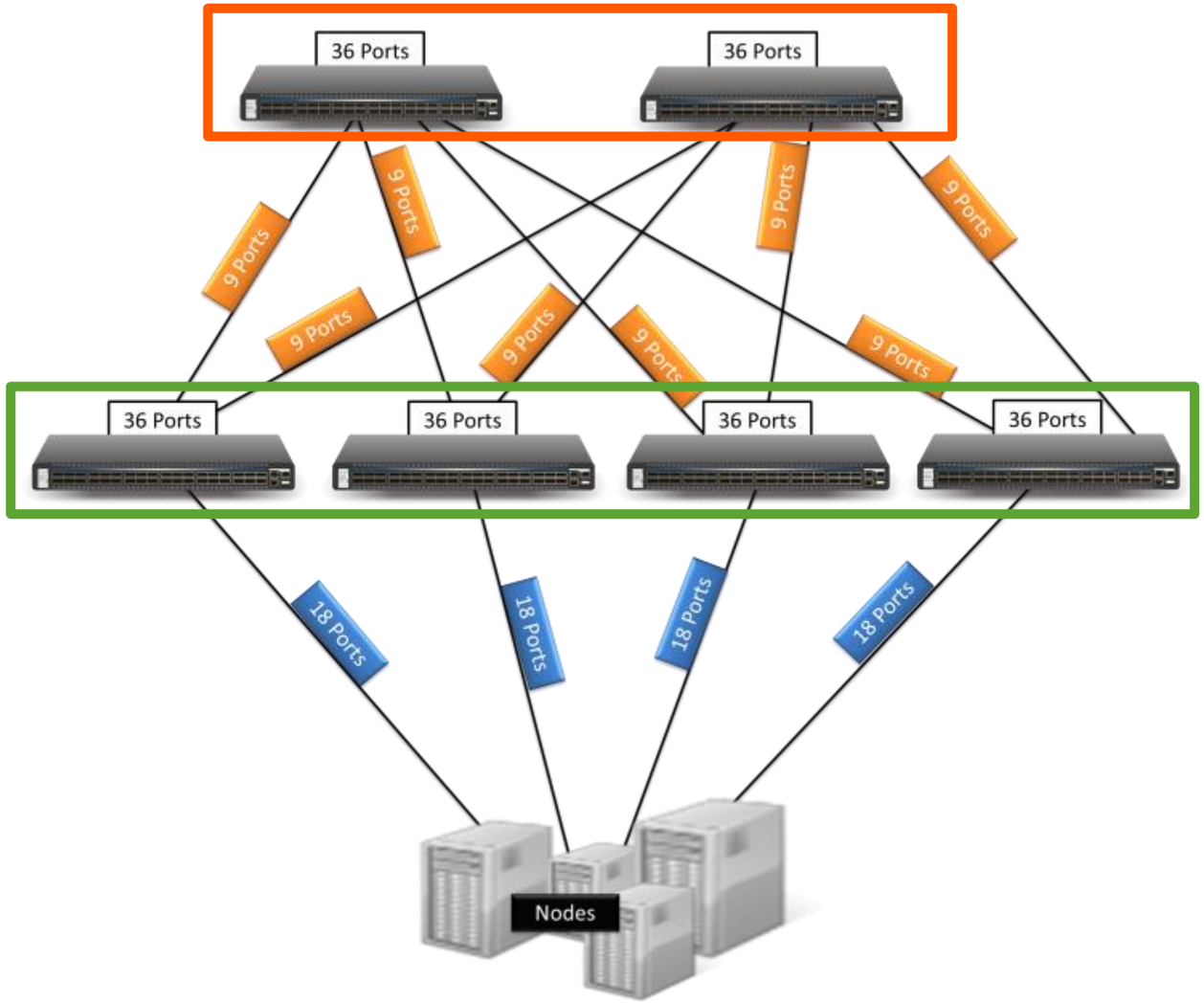
- Any InfiniBand node requires GUID&LID addresses

- GUID (Global Unique Identifier)- 64 bits address, “Like a Ethernet MAC address”
  - Assigned by IB vendor
  - Persistent through reboots

- IB Switch “Multiple” Address GUIDS
  - **Node** = Is meant to identify the HCA as a entity
  - **Port** = Identifies the port as a port
  - **System** = Allows to combine multiple GUIDS creating one entity

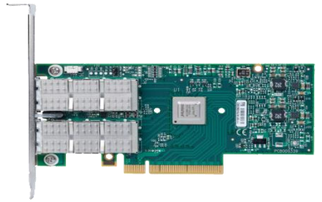
The IB Fabric Basic Building Block

- A single 36 ports IB switch chip, is the Basic Block for every IB switch module
- We create a multiple ports switching module using multiple chips
- In this example we create 72 ports switch, using 6 identical chips:
  - 4 chips will function as **lines**
  - 2 chips will function as **core**



IB Fabric L2 Switching Addressing Local Identifier (LID)

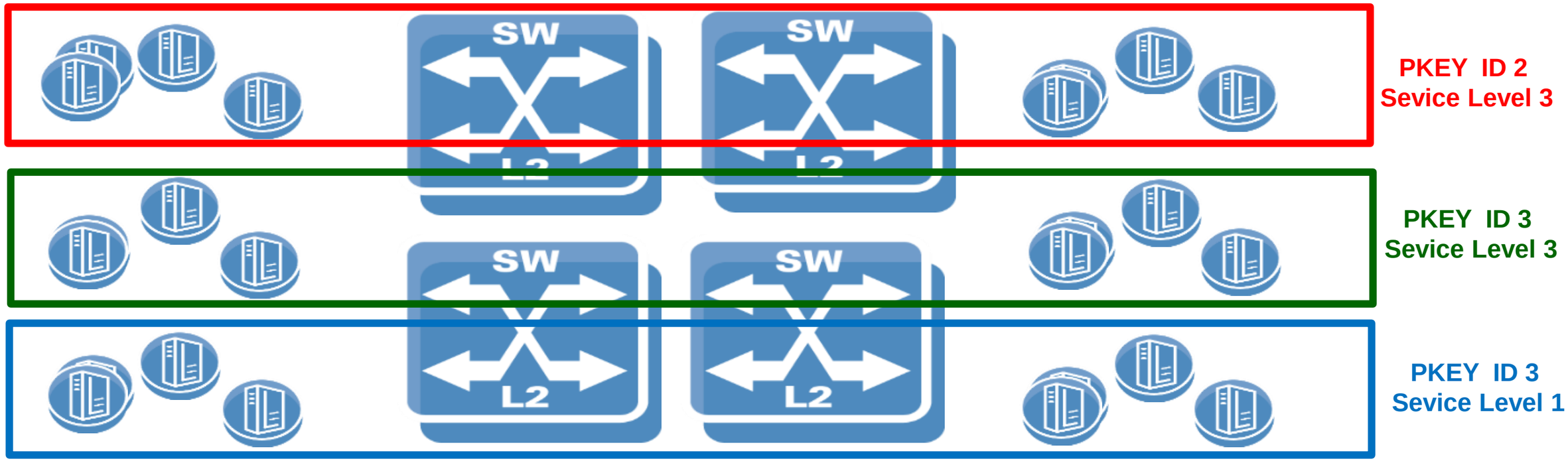
- Local Identifier- 16 bit L2 Address
  - Assigned by the Subnet Manager when port becomes active
  - Not persistent through reboots



- LID Address Ranges
  - 0x 0000 = Reserved
  - 0x0001 = 0xBFFF = Unicast
  - 0xc001 = 0xFFFE = Multicast
  - 0xFFFF = Reserved for special use

InfiniBand Network Segmentation – Partitions

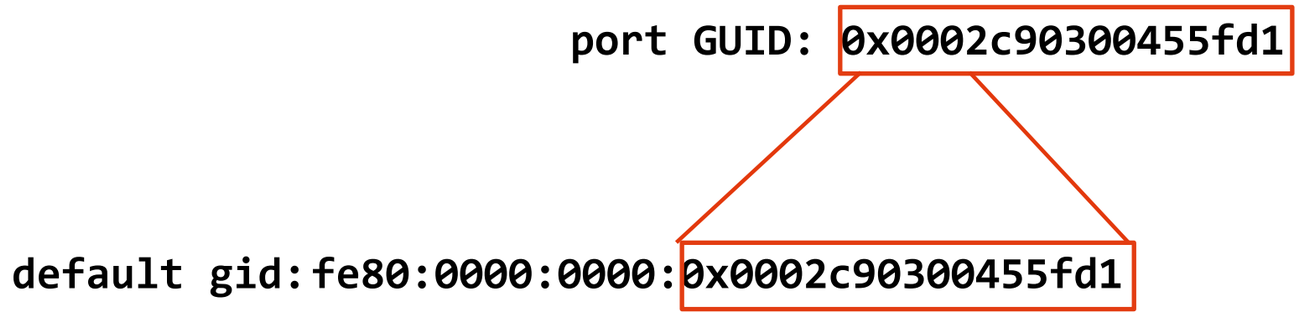
- Define different partitions for different customers
- Define different partitions for different applications
- Allows fabric partitioning for security purposes
- Allows fabric partitioning for Quality of Service (QoS)
- Each partition has an Identifier named PKEY



GID - Global Identifier

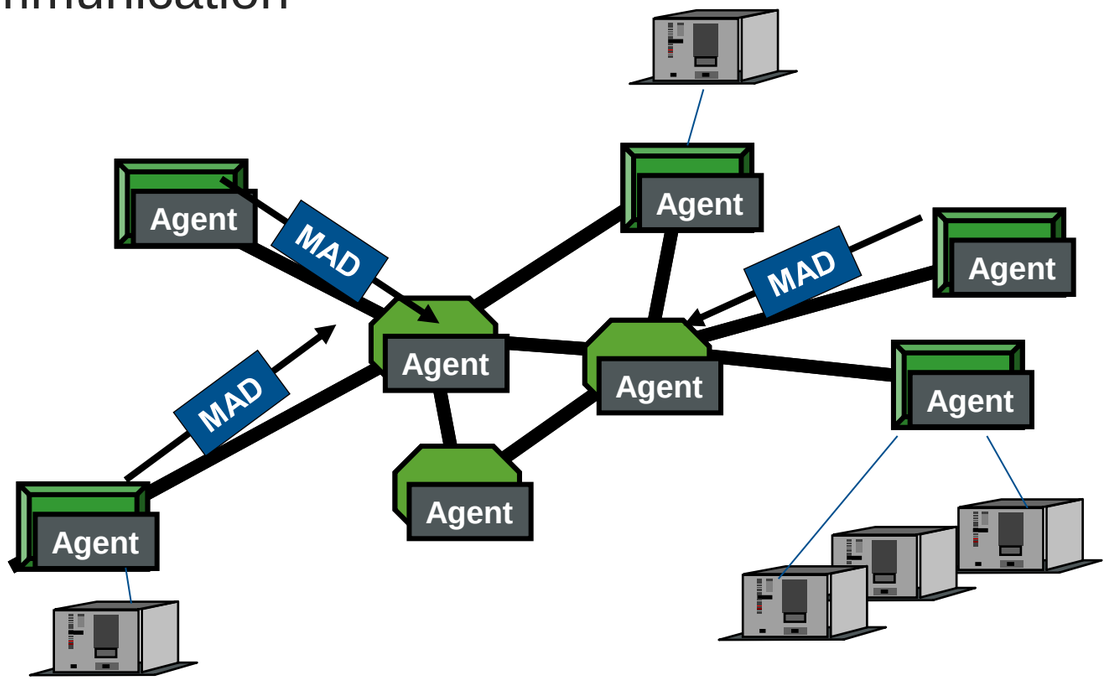
- Usage
  - A 128 bit field in the Global Routing Header (GRH) used to route packets between different IB subnets
  - Multicast groups port identifier IB & IPOIB

- Structure
  - GUID- 64 bit identifier provided by the manufacturer
  - IPv6 type header
  - Subnet Prefix: A 0 to 64-bit:
    - Identifier used to uniquely identify a set of end-ports which are managed by a common Subnet Manager



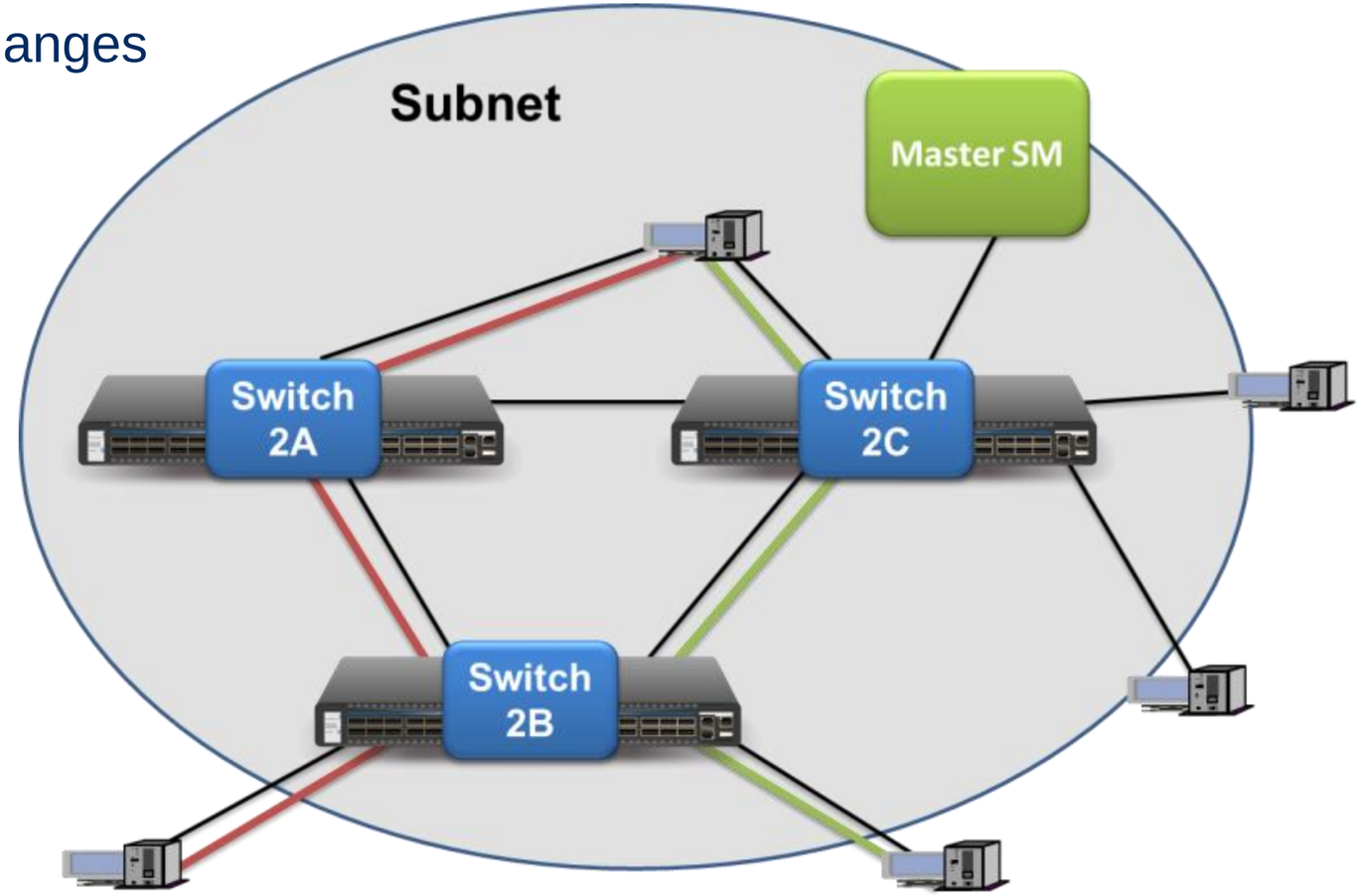
IB Basic Management Concepts

- Node: any managed entity– End Node, Switch, Router
- Manager: active entity; sources commands and queries
  - The subnet manager (SM)
- Agent: passive (mostly) entity that will reside on every node, responds to Subnet Managers queries
- Management Datagram (MAD):
  - Standard message format for manager–agent communication
  - Carried in an unreliable datagram (UD)



Objectives of Subnet Management

- Initialization and configuration of the subnet elements
- Establishing best traffic paths between source to destination through the subnet
- Fault isolation
- Continue these activities during topology changes
- Prevent unauthorized Subnet Managers



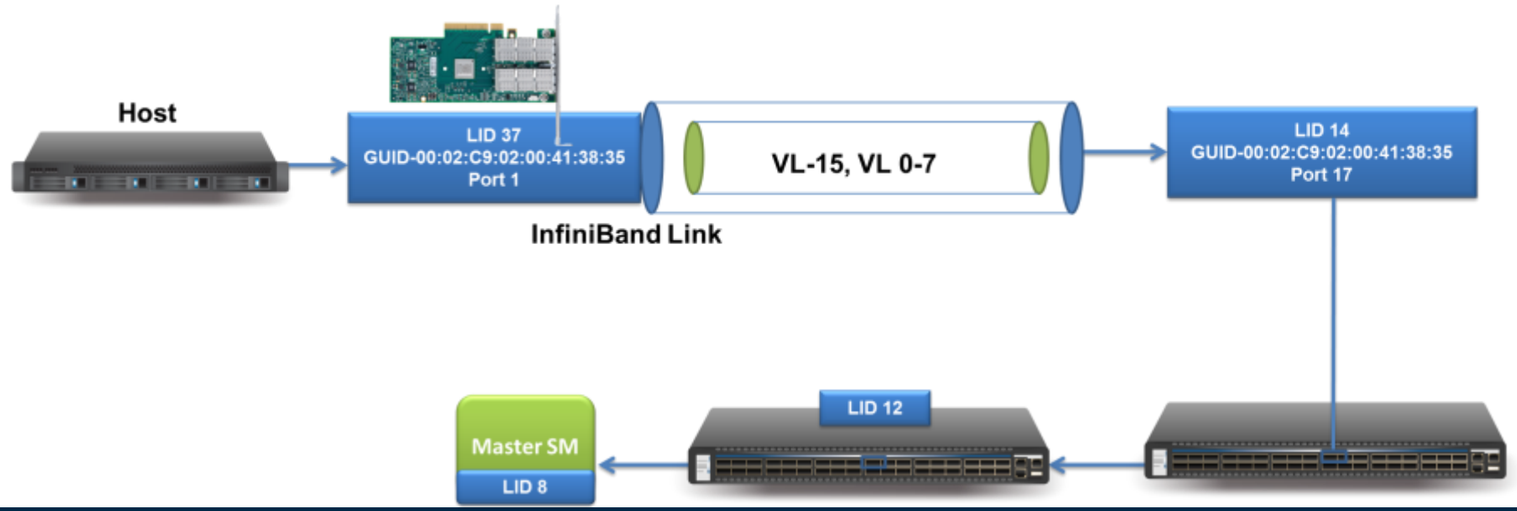
Node & Switch Main identifiers

IB Port Basic Identifiers

- Host Channel Adapter– HCA (IB “NIC”)
- Port number
- Global Universal ID– GUID 64 bit (like mac) ex. 00:02:C9:02:00:41:38:30
  - Each 36 ports “basic “ switch has its own switch & system GUID
  - All ports belong to the same “basic “ switch will share the switch GUID
- Local Identifier - LID

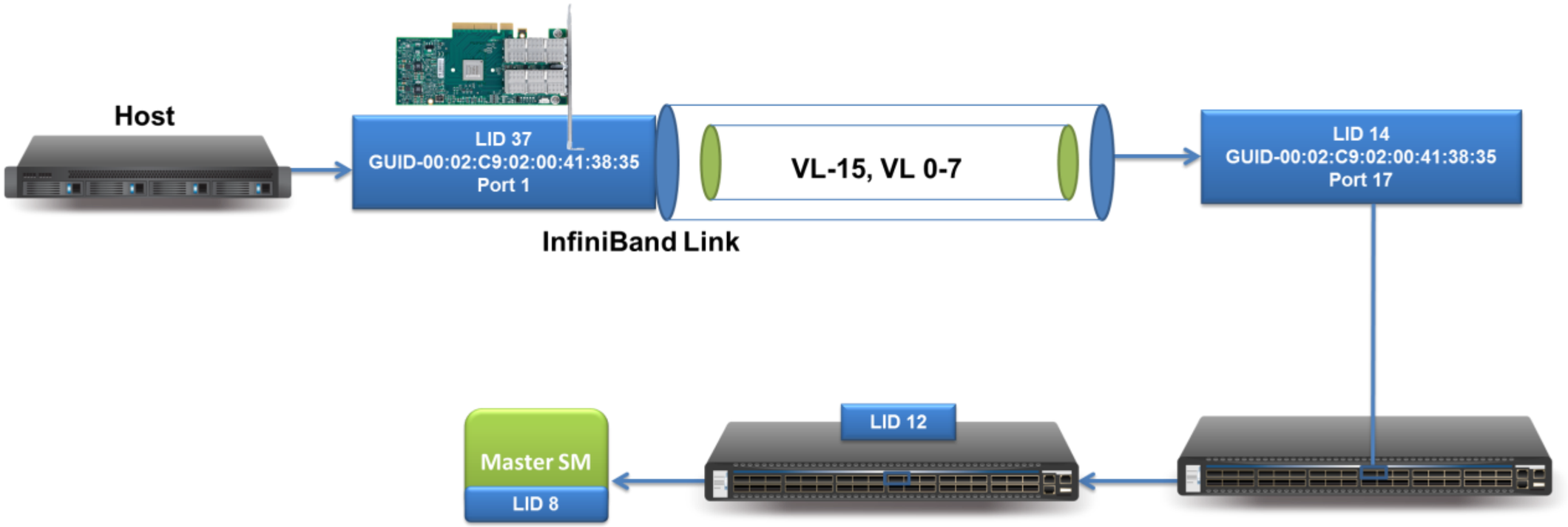
LID

- Local Identifier that is assigned to any IB device by the SM and used for packets switching within an IB fabric .
- All ports of the same ASIC unit are using the same LID

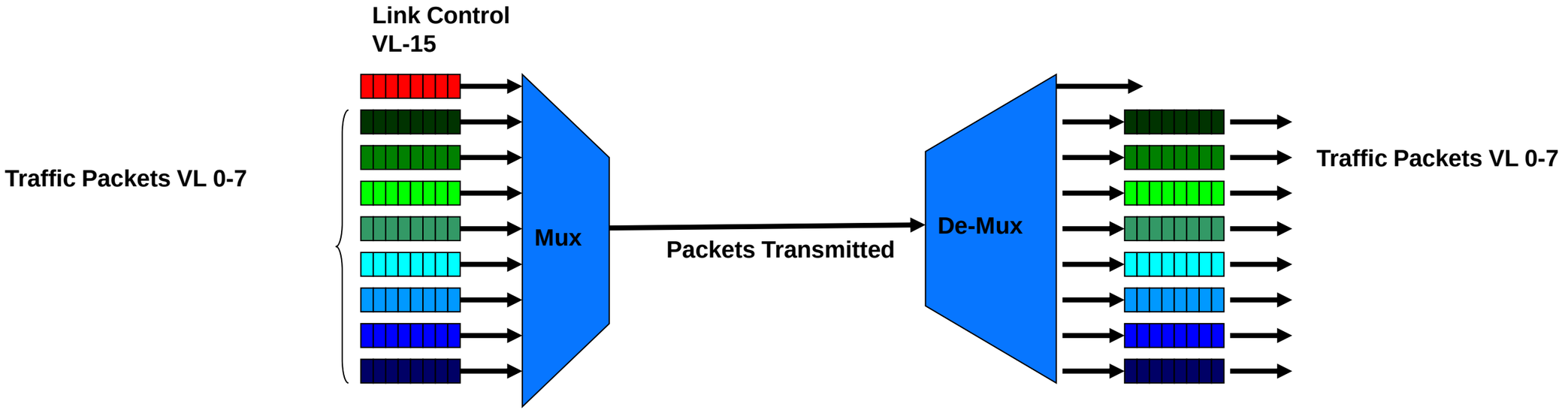


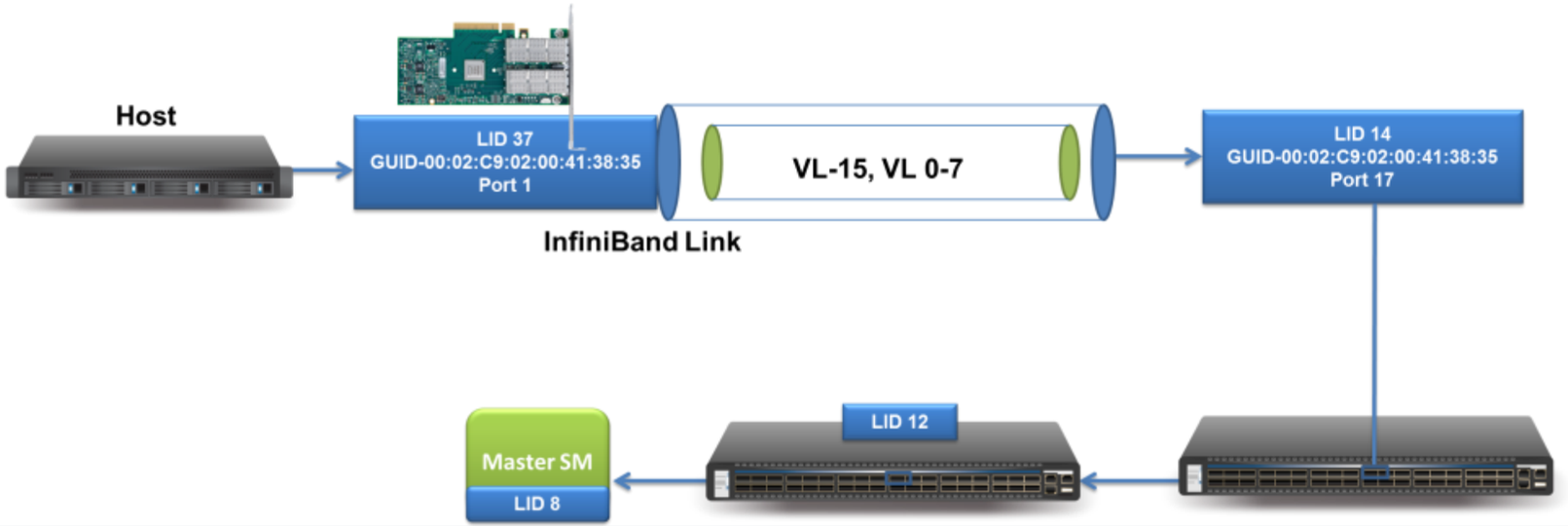
Node & Switch Main identifiers

- Virtual Lane
  - Each Virtual Lane uses different buffers to send its packet towards the other side
  - VL 15 is used for management only SM traffic
  - VL 0-7 are used for traffic
  - Used to separate different bandwidth & QoS using same physical port



Node & Switch Main identifiers





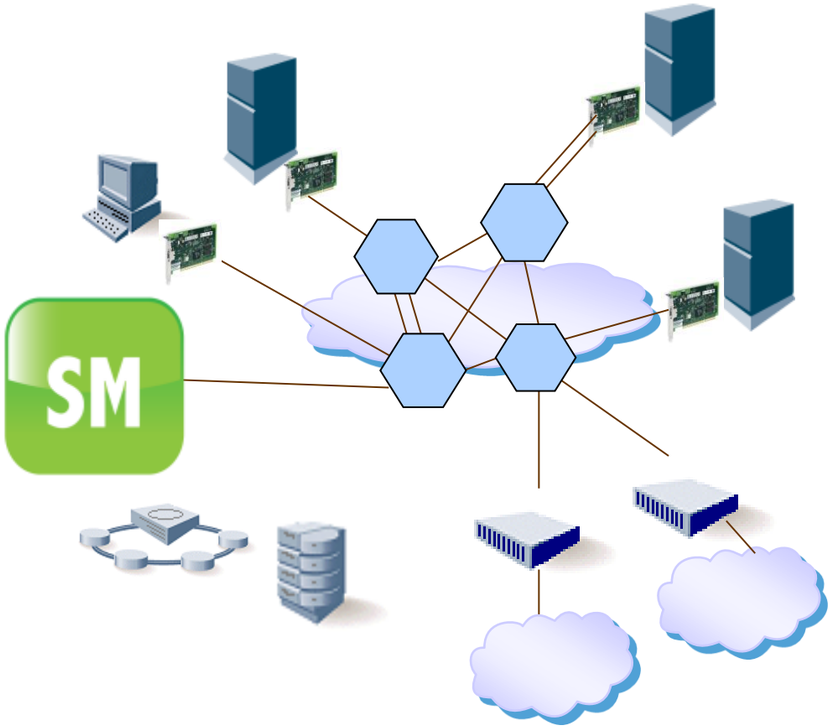
Subnet Manager Cluster Discovery

Subnet Manager & Fabric configuration Process

1. Physical Subnet Establishment
2. Subnet Discovery
3. Information Gathering
4. LID Assignment
5. Path Establishment
6. Port Configuration
7. Switch Configuration
8. Subnet Activation

Subnet Manager (SM) Rules & Roles

- Every subnet must have at least one
  - Manages all elements in the IB fabric
  - Discover subnet topology
  - Assign LIDs to devices
  - Calculate and program switch chip forwarding tables (LFT pathing)
  - Monitor changes in subnet
- Implemented anywhere in the fabric
  - Node, Switch, Specialized device
- No more than one **active** SM allowed
  - 1 Active (Master) and remaining are Standby (HA)



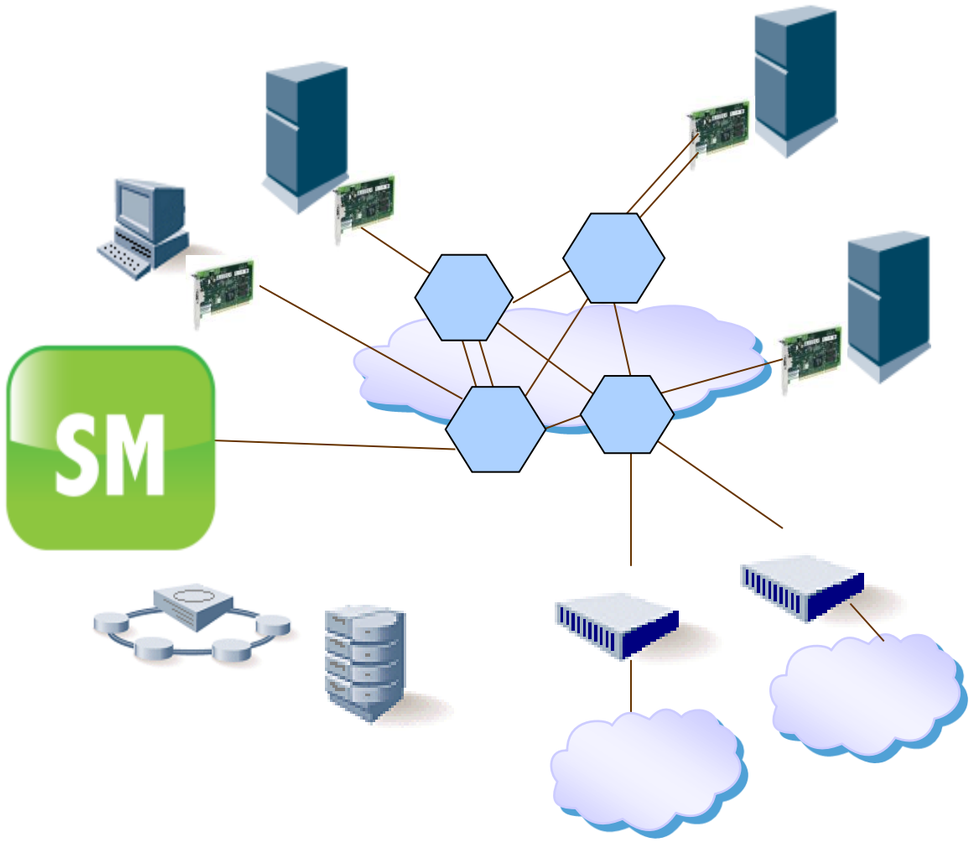

```
[root@l-supp-18 ~]# sminfo
sminfo: sm lid 44 sm guid 0x2c9030010392b, activity count 1372449 priority 14 state 3 SMINFO_MASTER
[root@l-supp-18 ~]# saquery -s
IsSM ports
PortInfoRecord dump:
```

Fabric Discovery (A)

1. The **SM wakes up** and starts the Fabric Discovery process

2. The SM starts “ **conversation** “ with every node , over the InfiniBand link it is connected to .
   in this stage the **discovery stage,** the SM collects :
   - Switch Information followed by port information
   - Host information

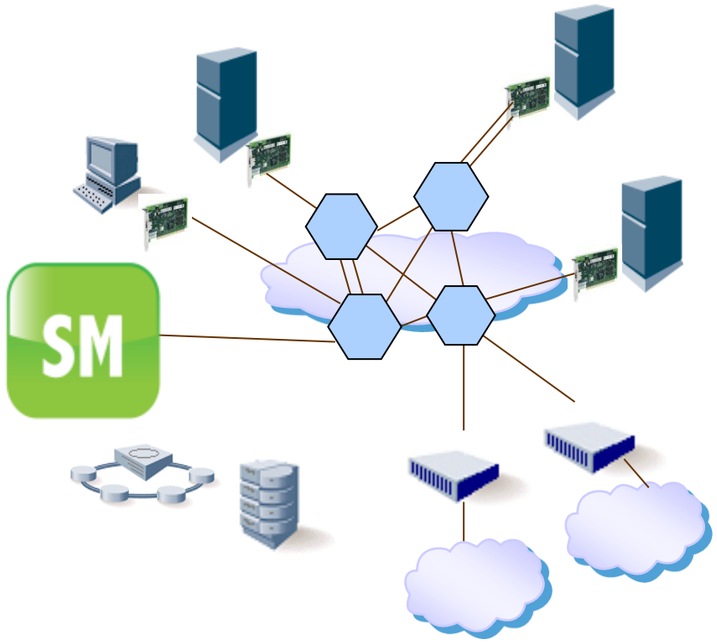
3. Any switch which is already discovered , will be used as a gate for the SM , for further discovery of all **this switch links** and the switches it is connected to known also as its neighbors.



Fabric Discovery (B)

4. The SM gathers information by sending and receiving SMPs (**S**ubnet **M**anagement **P**ackets)
   a. These special management packets are sent on **V**irtual **L**ane 15 (VL15)
      - VL15 is a special NON flow controlled VL

   b. Two primary “types” of SMPs creating Cluster routing table:
      - Directed routing (DR) table based on Nodes GUIDS & port number
      - This is the type primarily used by OpenSM
   c. LID routing (LR)
      - Topology and than packets routing table , Based on the LIDS which have been assigned to each node by the SM



Fabric Information Gathering During Discovery

- Node Info Gathered
  - Node type
  - Num of ports
  - GUID
  - Partition table size
- Port Info Gathered
  - Forwarding Database size
  - MTU
  - Width
  - VLs

Table 142 NodeInfo (Continued)

Component	Access	Length (bits)	Offset (bits)	Description
NumPorts[a]	RO	8	24	Number of physical ports on this node.
SystemImageGUID[a]	RO	64	32	GUID associating this node with other nodes controlled by common supervisory code. Provides a means for system software to indicate the availability of multiple paths to the same destination via multiple nodes. Set to zero if indication of node association is not desired. The SystemImageGUID may be the NodeGUID of one of the associated nodes if that node is not field-replaceable.
NodeGUID[a]	RO	64	96	GUID of the HCA, TCA, switch, or router itself. All ports on the same node **shall** report the same NodeGUID. Provides a means to uniquely identify a node within a subnet and determine co-location of ports.
PortGUID[b]	RO	64	160	GUID of this port itself. One port within a node can return

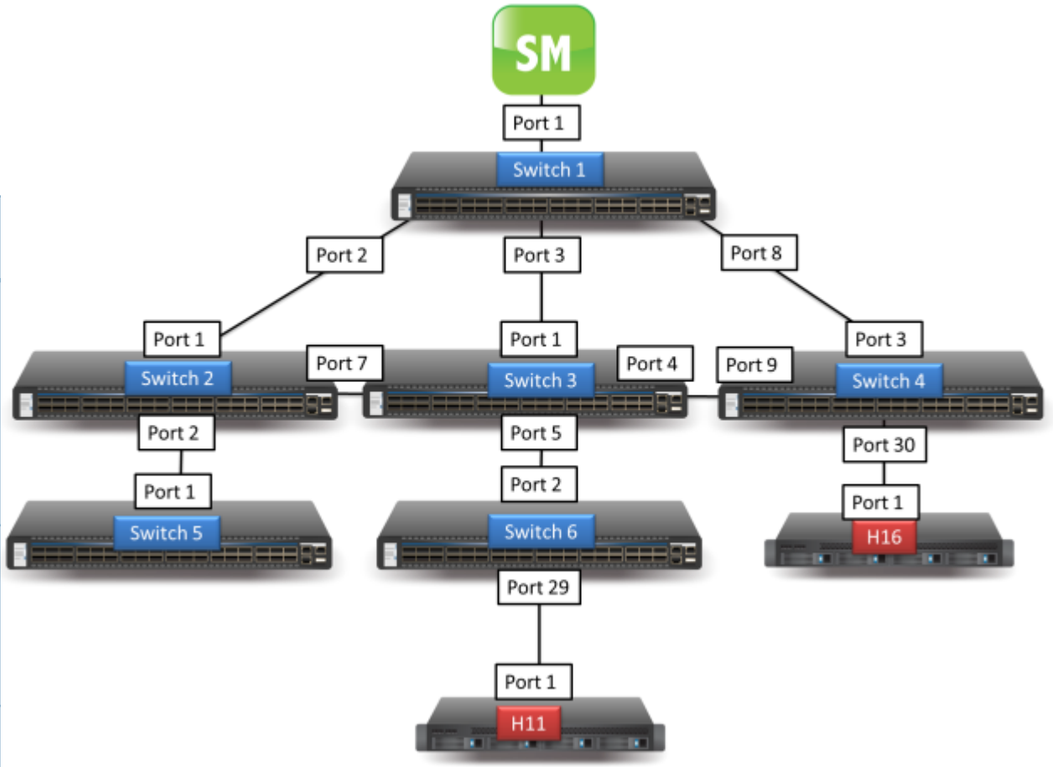
Table 146 PortInfo

Component	Used By					Access	Length (bits)	Offset (bits)	Description
	CA	Router	Sw Ext.	Base SP0	Enh. SP0				
M_Key	X	X		X	X	RW	64	0	The 8-byte management key. See 14.2.4 Management Key on page 809.
GidPrefix	X	X		X	X	RW	64	64	GID prefix for this port.
LID	X	X		X	X	RW	16	128	The base LID of this port.
MasterSMLID	X	X		X	X	RW	16	144	The LID of the master SM that is managing this port.

Fabric Direct Route Information Gathering

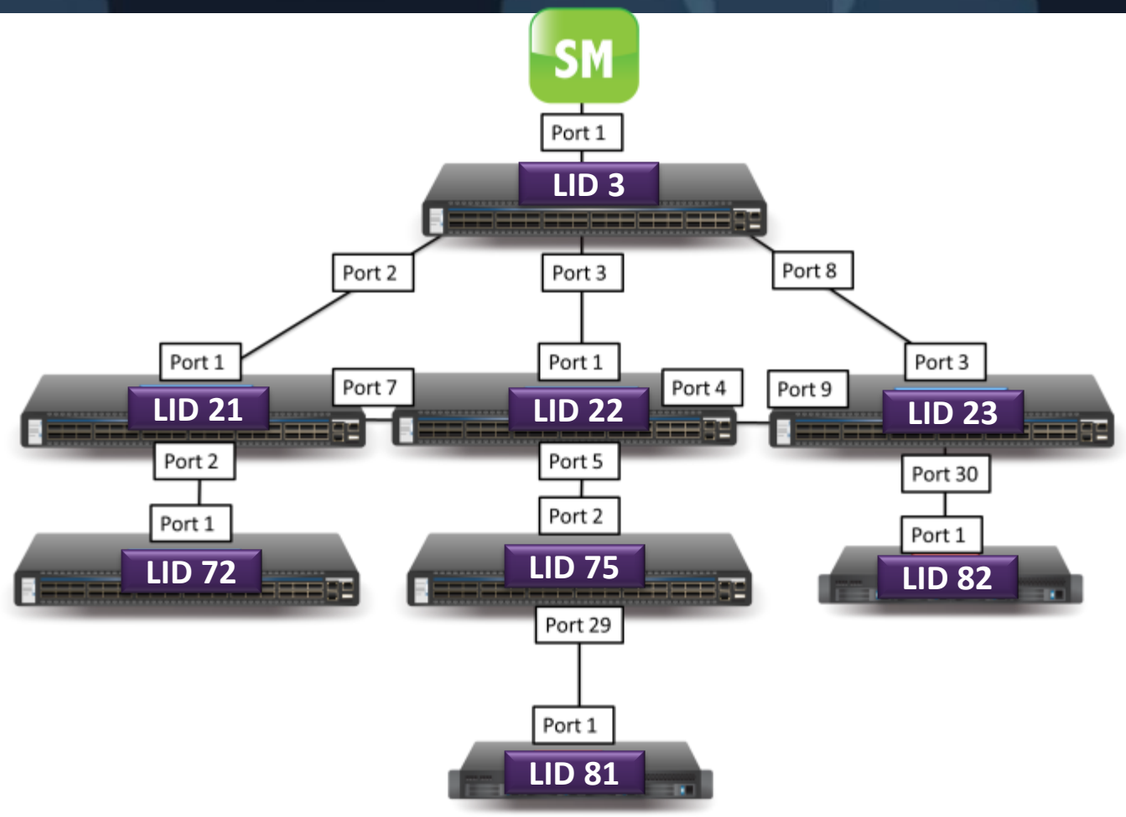
- **Building** the direct routing table from & to each one of the fabric elements
- Each node in a path is identified by its port number & GUID
- The table content is saved in the SM LMX table

Switch-1	Switch-2	Switch-5	Switch-3	Switch-6	Switch-4	H-11	H-16
Switch-1	Port2	Port2 Switch2 Port2	Port 3	Port 3 Switch 3 Port 5	Port 8	Port 3 Switch 3_Port5 Switch 7_Port29	Port 8 Switch 4_Port 30 Switch 3_Port 5 Switch 6_Port 29
Switch-1						Port 8 Switch 5_Port9 Switch 3_Port5	
H11	Port 1 Switch 6_Port2 Switch 3_Port4 Switch 4_Port30	Port 1 Switch 6_Port2 Switch 3_Port1 Switch1_Port2 Switch2_Port2	Port 1 Switch6_Port2	Port 1	Port 1 Switch 6_Port2 Switch 3_Port4		Port 1 Switch 6_Port 2 Switch 3_Port 4 Switch 4_Port 30



LID Assignment

- After the SM finished gathering any needed subnet information, it assigns a base LID and LMC to each one of the attached end ports
  - The LID is assigned to at the port rather than device level
  - Switch external ports do not get/need LIDs
- The DLID is used as the main address for InfiniBand packet switching
- Each **Switch port** can be identified by the **combination** of LID & port number

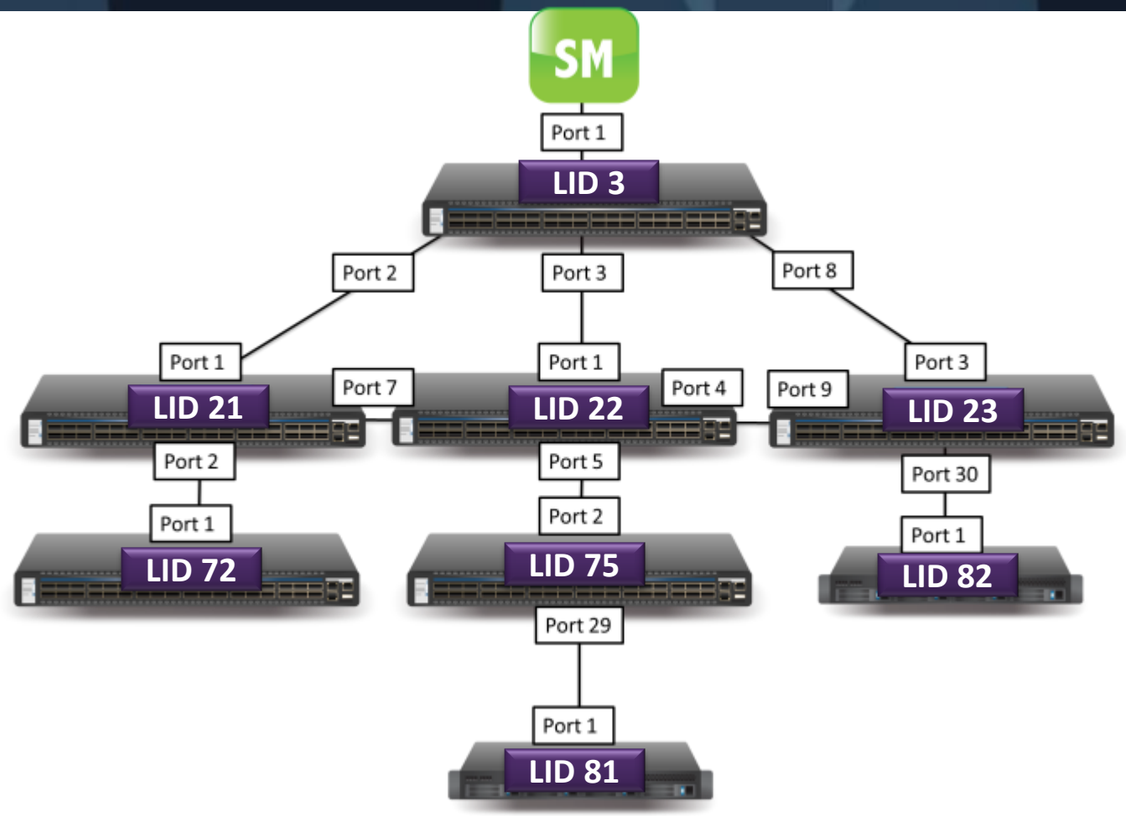



```
[root@v-sup25 ~]# ibswitches
Switch  : 0x0008f105006000de ports 36 "Mellanox sLB-4018
 #4700-B9B8" enhanced port 0 lid 13 lmc 0
Switch  : 0x0008f10500650c4a ports 36 "Mellanox sLB-4018
#4700-B9B8" enhanced port 0 lid 9 lmc 0
```

```
[root@v-sup25 ~]# saquery LFTR 9
LFT Record dump:
                LID.....................9
                Block...................0
                LFT:
                LID     Port Number
                0       255
                1       255
```

Linear Forwarding Table Establishment (Path Establishment)

- After the SM finished gathering all Fabric information , including direct route tables , it assigns a LID to each one of the NODES
- At this stage the LMX table will be populated with the relevant route options to each one of the nodes
- The output of the LMX will provide the Best Route to Reach a DLID as well as the other Routes .
- The Best Path Result Will be based on Shortest Path First (SPF) algorithm



PORT / D-LID				
21	1	2	3	1
22	2	1	2	1
23	3	2	1	1
75	3	2	3	2
81	4	3	4	3
82	4	3	2	2

The Dest. LID	Best Route/ exit port
21	2
22	3
23	8
75	3
81	3
82	8

LID Routed (LR) Forwarding

- Uses the LFT tables
- Based on the data gathered on the LMX – Direct Routing
- It is the standard routing of packets used by switches
- Uses regular link-level headers to define destination and other information, such as:
  - DLID = LID of the final destination
  - SL = Service Level of the path
  - Each switch uses the forwarding table and SL to VL table to decide on the packet's output port/VL

```
[root@v-sup25 ~]# saquery LFTR 9
LFT Record dump:
                LID.......................9
                Block.....................0
                LFT:
                LID     Port Number
                0       255
                1       255
```

LFT Switch_1

The Destination LID	Best Route/ exit port
21	2
22	3
23	8
75	3
81	3
82	8

LID Routed (LR) Forwarding

- LRH: Local Routing Header :
  - Source & Destination LID
  - Service Level-SL
  - Virtual Lane-VL
  - Packet Length

InfiniBand Data Packet

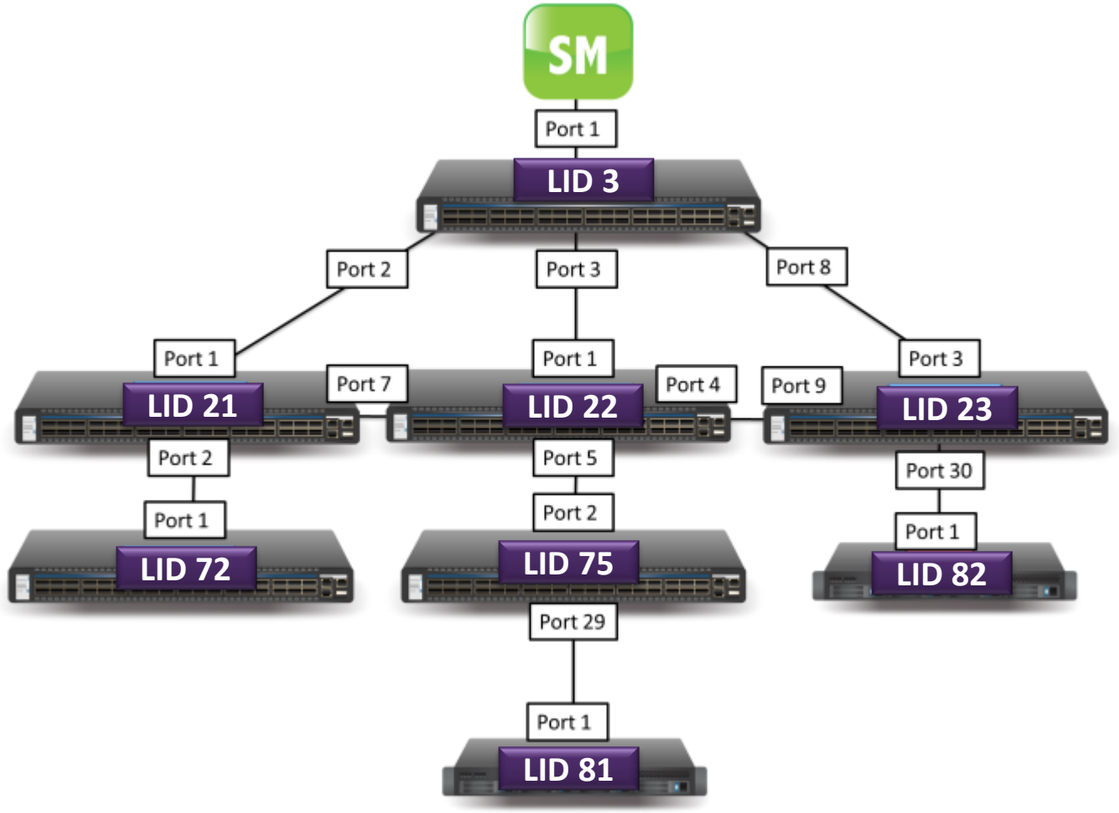
LFT Switch_1

The Dest. LID	Best Route/ exit port
21	2
22	3
23	8
75	3
81	3
82	8

Tracking FABRIC STATUS – SM Sweeps

- **Light sweep :**
  - Routine sweep of the Subnet Manager
  - By default runs every 30 second
  - Requires all switches to switch and port info

- **Light Sweep traces** :
  - Ports status change
  - New SM speaks on the subnet
  - Subnet Manager changes priority



Tracking FABRIC STATUS – SM Sweeps

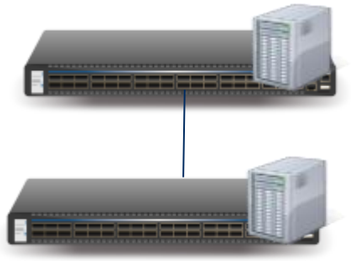
- Any change traced by the light sweep will cause **Heavy Sweep**
- **IB TRAP**
  - Changes of status of a switch will cause an on line IB TRAP that will be sent to the Subnet Manager and cause **Heavy Sweep**
- **Heavy Sweep**
  - Will cause all SM fabric discovery to be performed from scratch

```
log_trap_info: Received Generic Notice type:1 num:128 (Link state change) Producer:2 (Switch) from LID:3 TID
log_notice: Reporting Generic Notice type:1 num:128 (Link state change) from LID:3 GID:fe80::2:c903:83:8481
log_notice: Reporting Generic Notice type:3 num:65 (GID out of service) from LID:2 GID:fe80::2:c903:4c:46e1
drop_mgr_remove_port: Removed port with GUID:0x0002c903004c46e1 LID range [12, 12] of node:ib-cert-sv02 HCA-
```

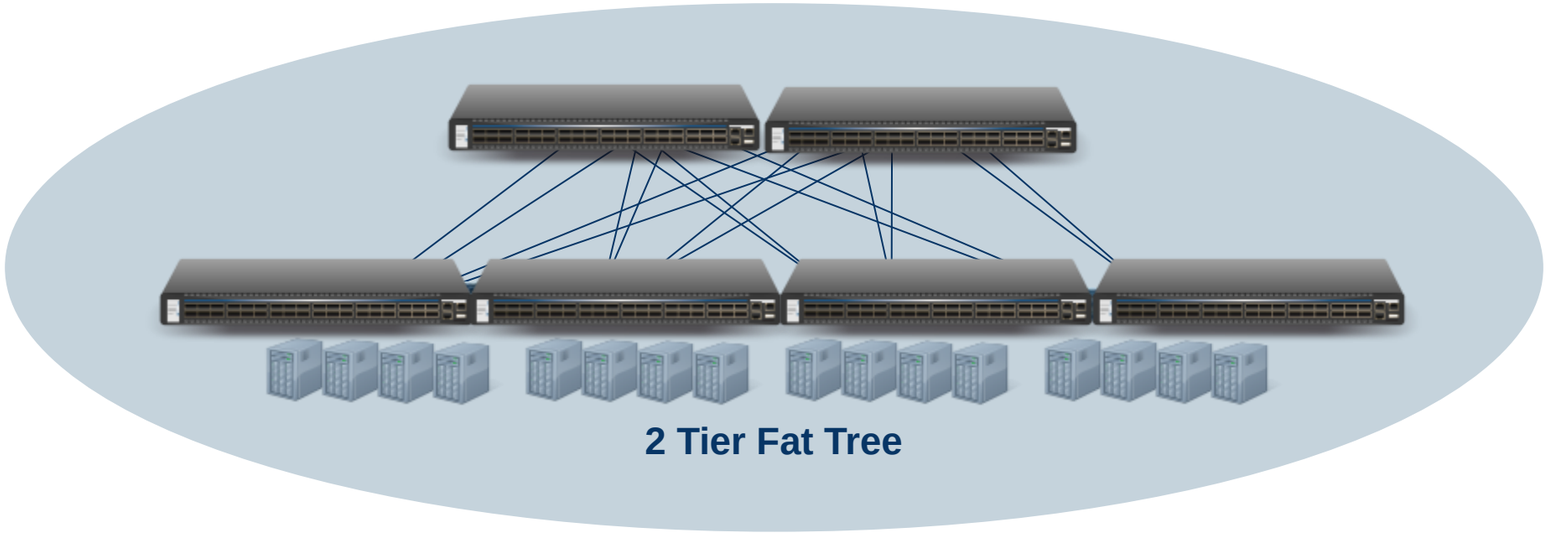
InfiniBand Fabric Topologies

InfiniBand Fabric Commonly Used Topologies

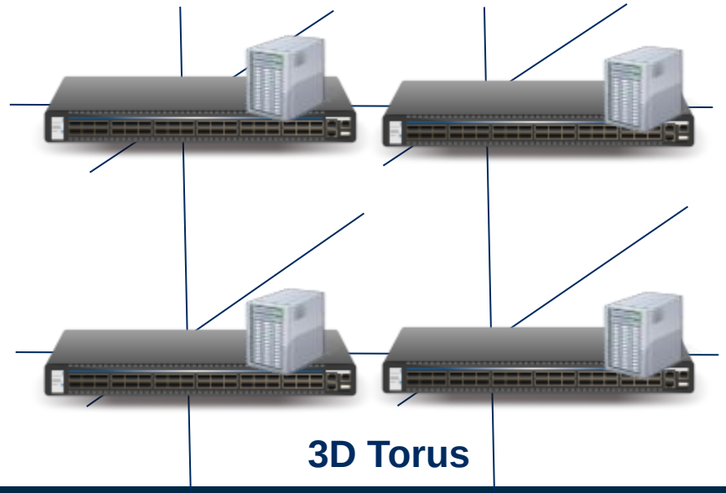
Modular switches are based on Fat Tree architecture:



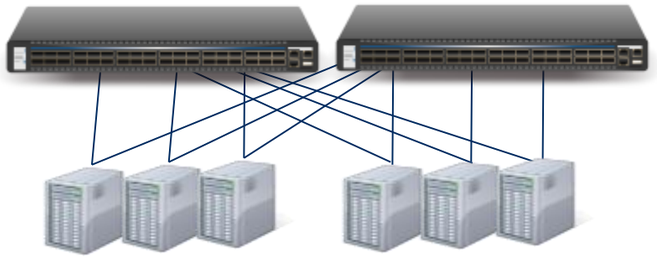
Back to Back



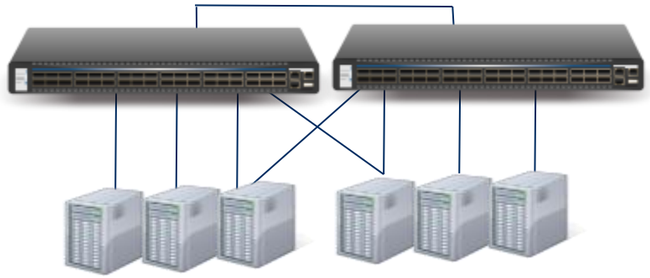
2 Tier Fat Tree



3D Torus



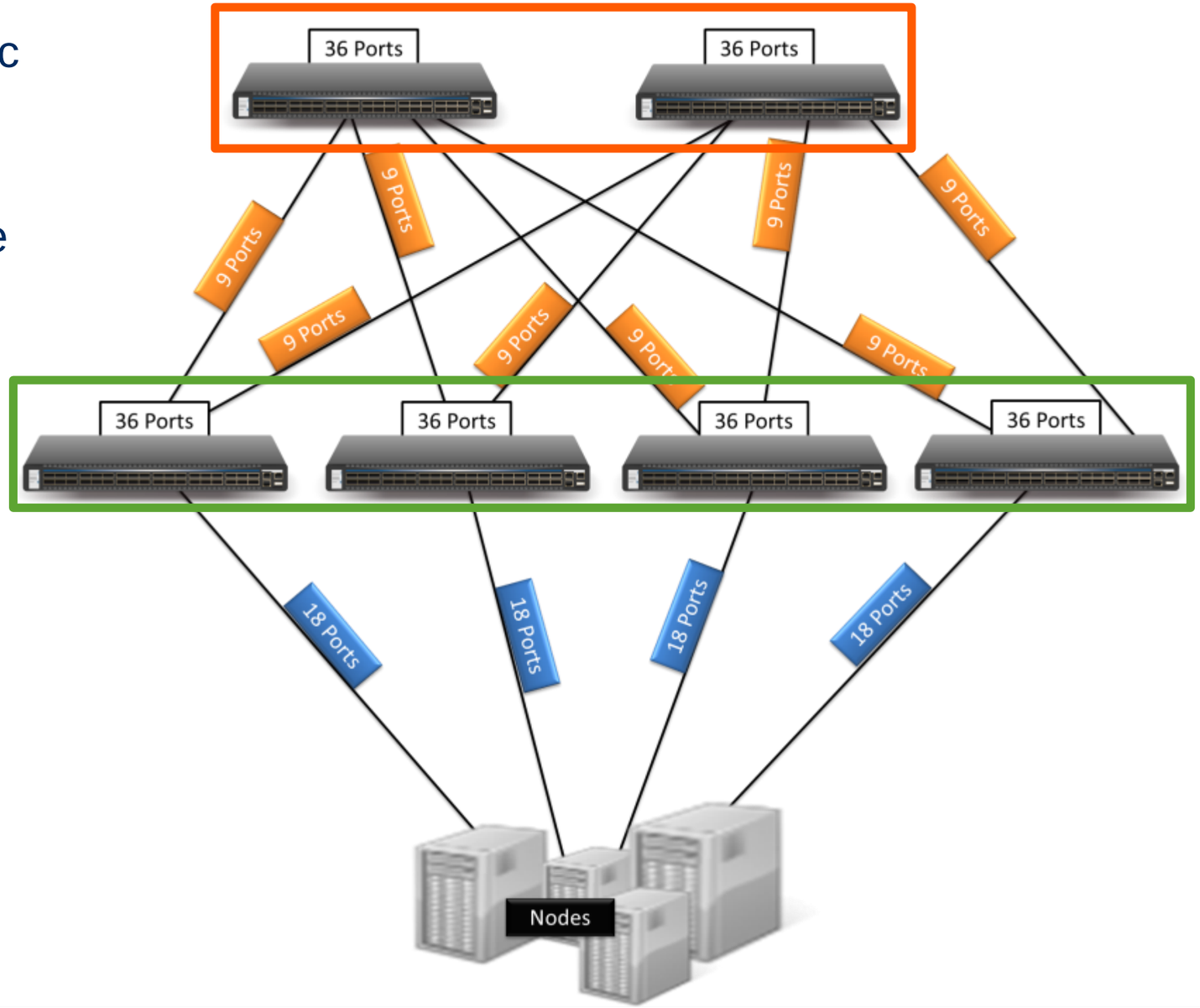
Dual Star



Hybrid

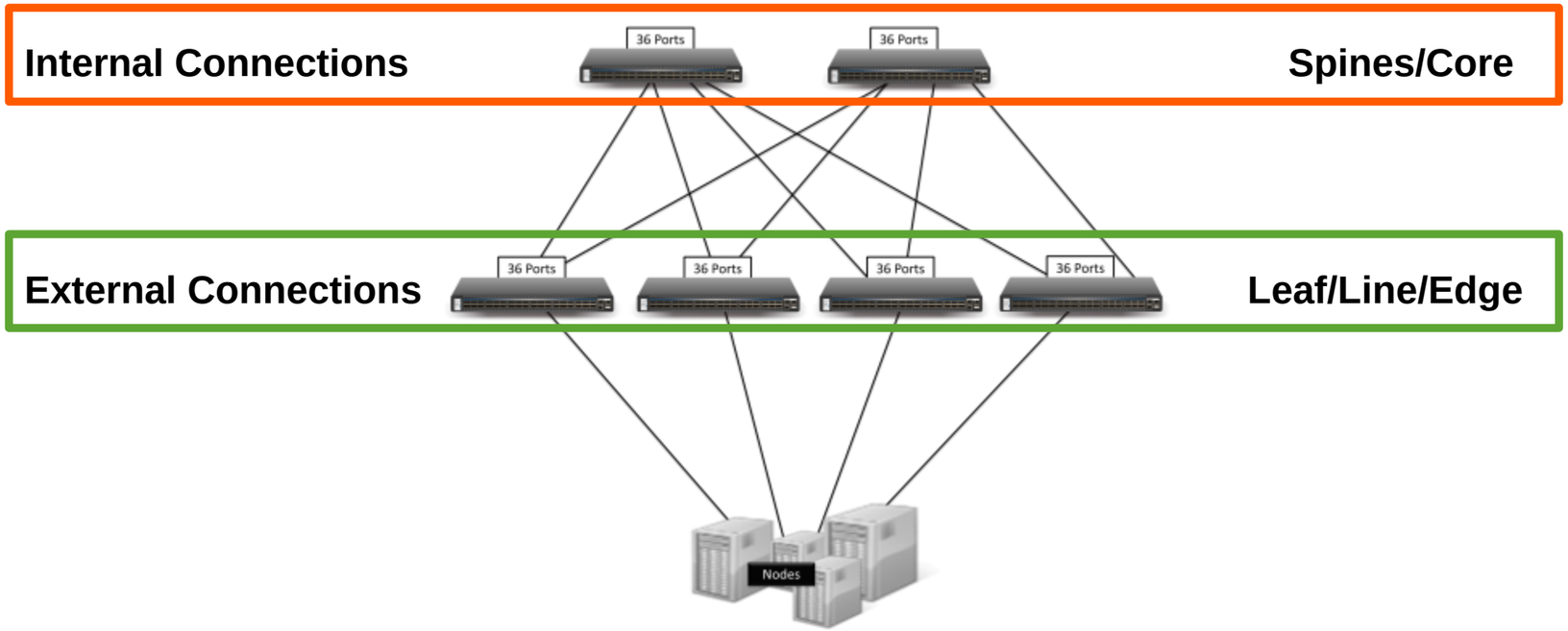
The IB Fabric Basic Building Block

- A single 36 ports IB switch chip, is the Basic block for every IB switch module
- We create a multiple ports switching Module using multiple chips
- In this example we create 72 ports switch, using 6 identical chips
  - 4 chips will function as **lines**
  - 2 chips will function as **core**



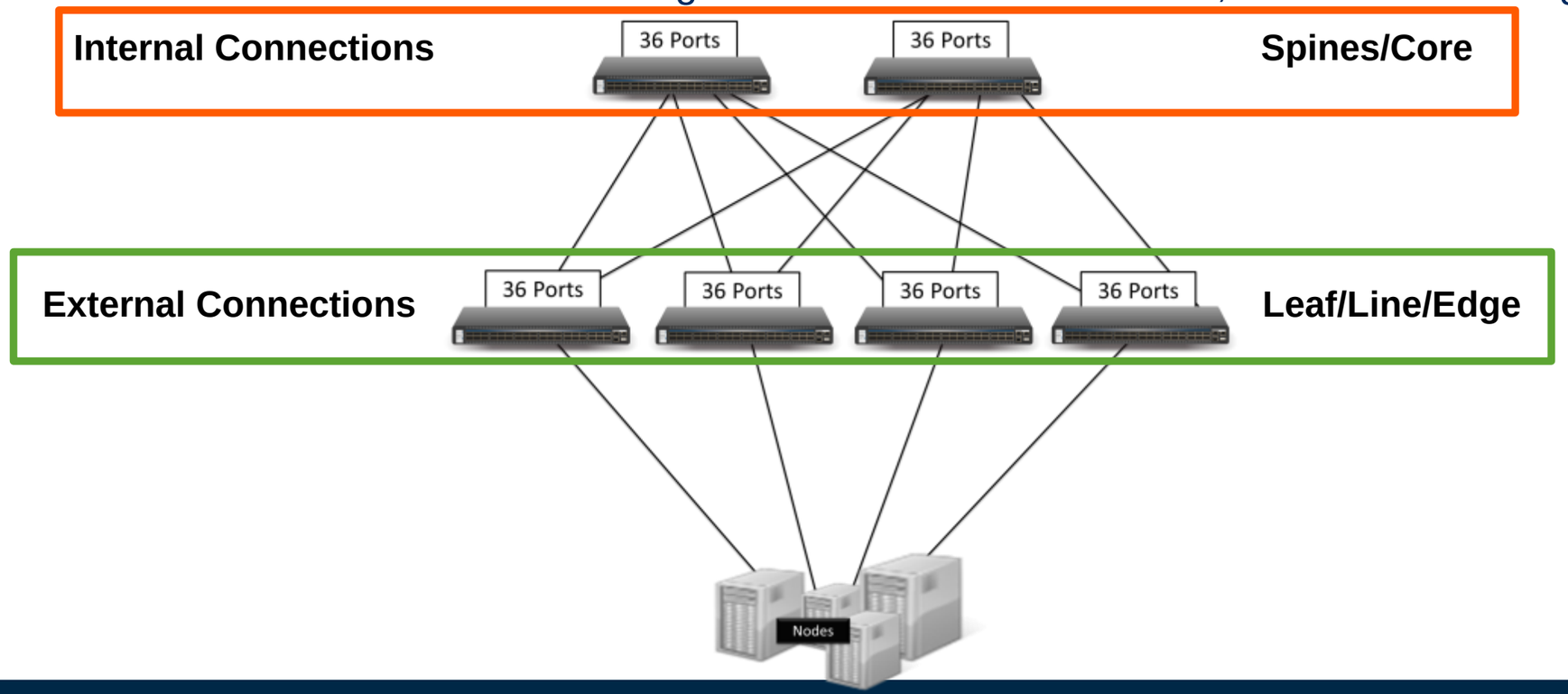
CLOS Topology

- Pyramid Shape Topology
- The switches at the top of the pyramid are called Spines/Core
  - The Core/Spine switches are interconnected to the other switch environments
- The switches at the bottom of the Pyramid are called Leafs/Lines/Edges
  - The Leaf/Lines/Edge are connected to the fabric nodes/hosts
- In a non blocking CLOS fabric there are **equal number** of external and internal connections



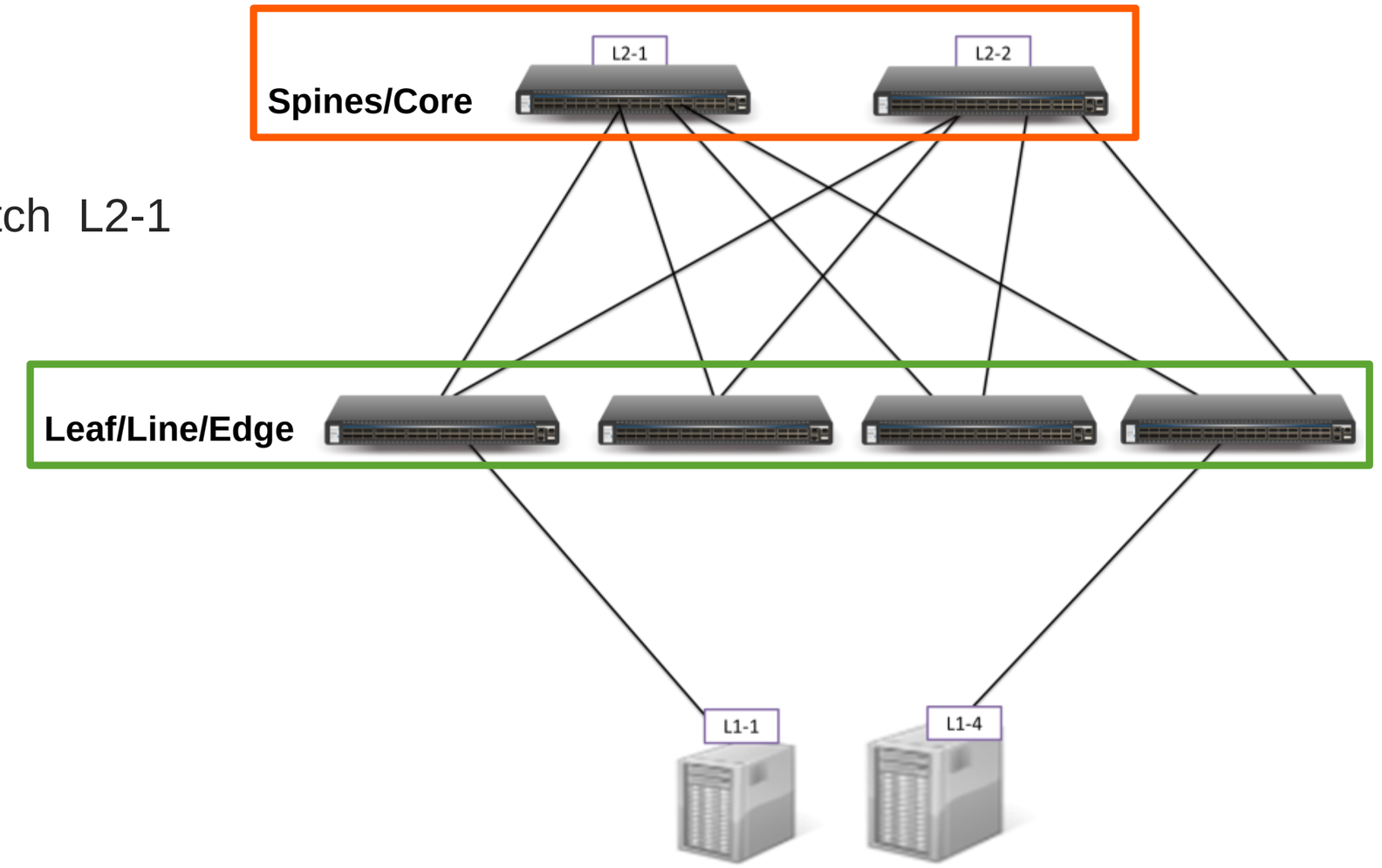
CLOS Topology

- External connections :
  - The connections between the hosts and the Line switches
- Internal Connections
  - The connections between the core and the Line switches
- In a non blocking fabric there is always a balanced cross bisectional bandwidth
- In case the number of external connections is higher than internal connections, we have a blocking configuration



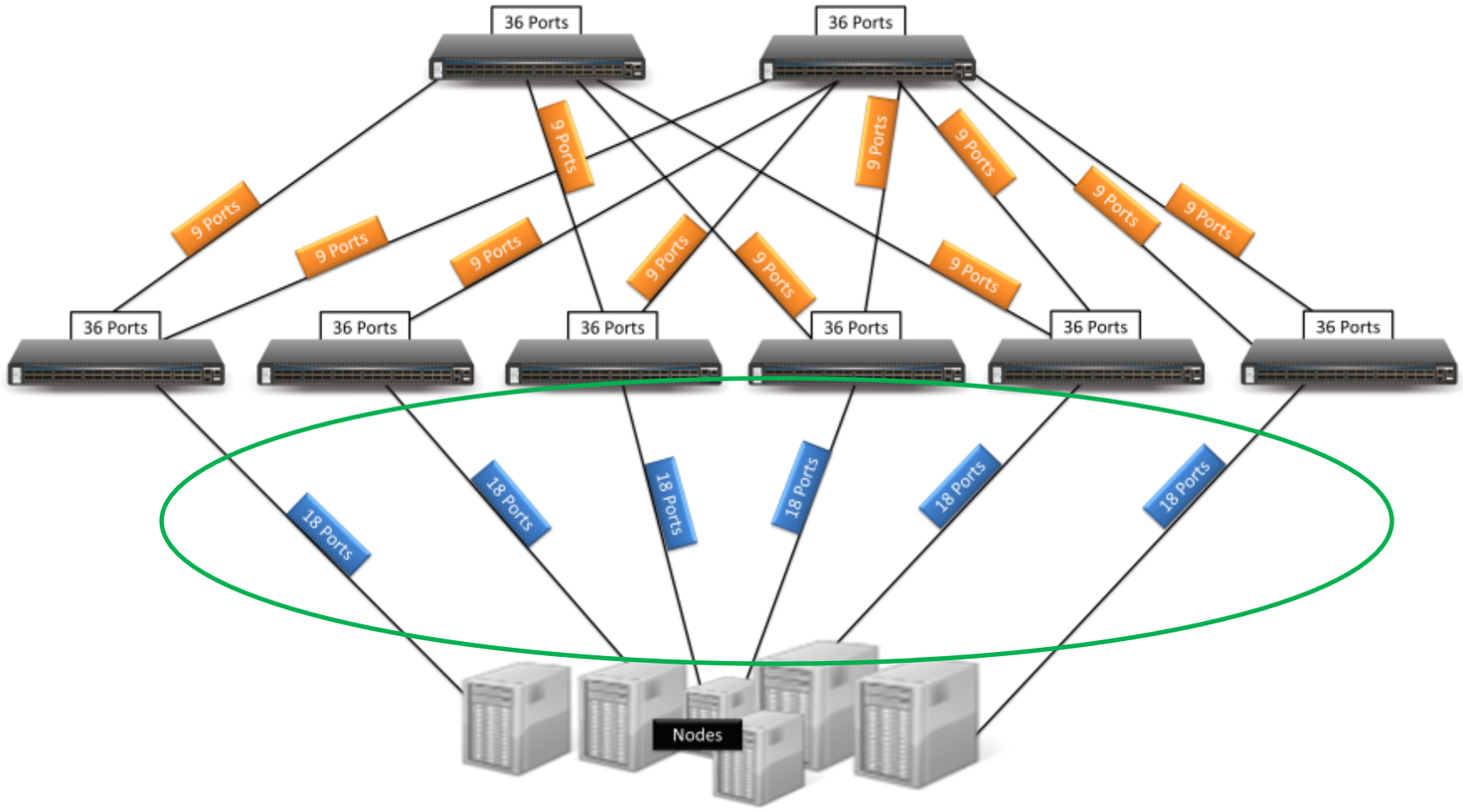
CLOS - 3

- The topology detailed here is called CLOS 3
- The maximum traffic path between source to destination includes 3 HOPS (3 switches)
- Example a session between A to B
  - One Hop from A to switch L1-1
  - Next Hop from switch L1-1 to switch L2-1
  - Last Hop from L2-1 to L1-4



CLOS - 3

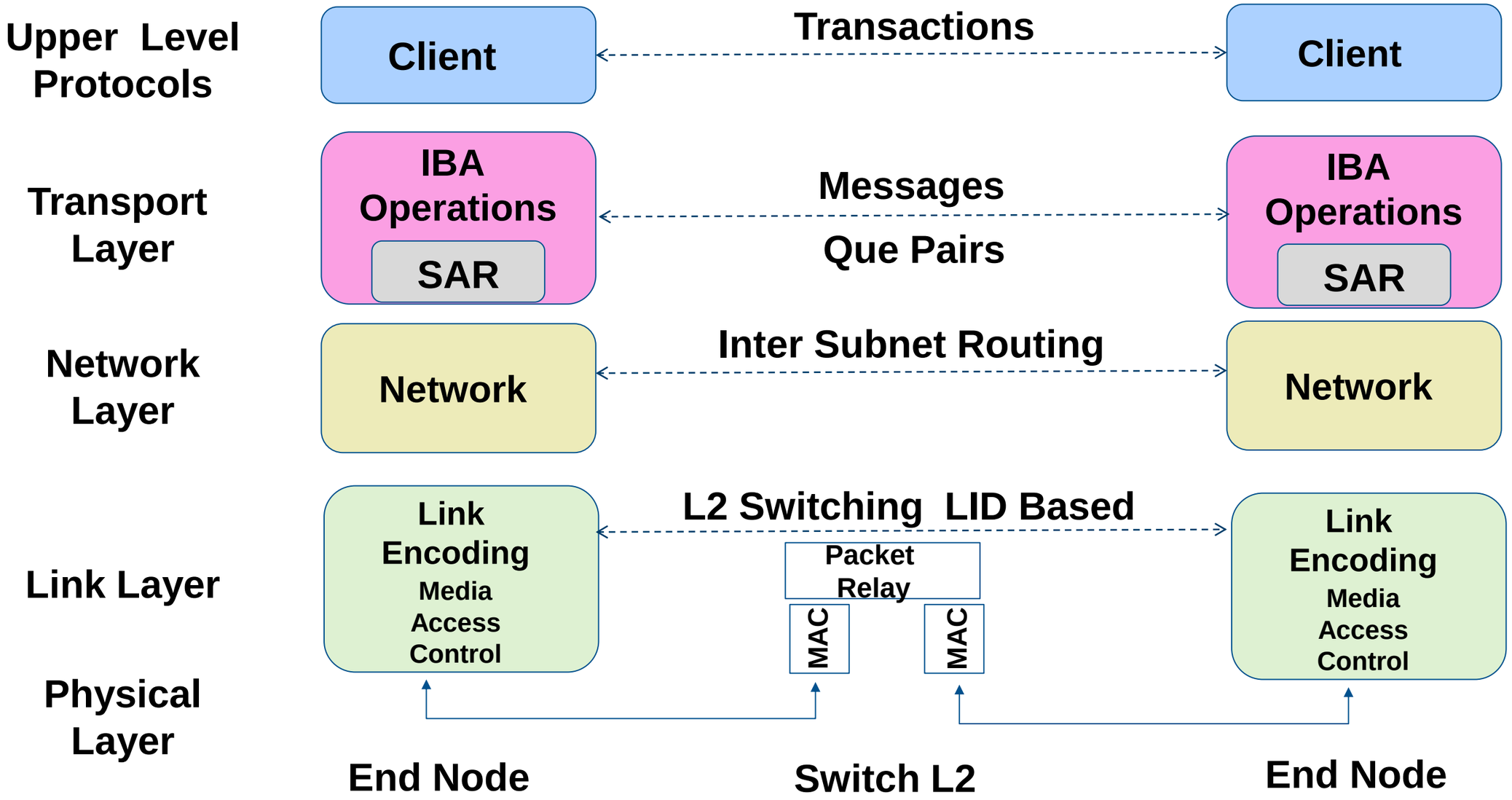
- In this example we can see 108 non blocked fabric
  - 108 hosts are connected to the line switches
  - 108 links connect between the line switches to the core switches to enable non blocking interconnection of the line switches



18*6=108

IB Fabric Protocol Layers

IB Switch - L2


Upper Level Protocols
Client
Transactions
Client
Transport Layer
IBA Operations
SAR
Messages
Que Pairs
IBA Operations
SAR
Network Layer
Network
Inter Subnet Routing
Network
Link Layer
Link Encoding
Media Access Control
L2 Switching LID Based
Packet Relay
MAC
MAC
Link Encoding
Media Access Control
Physical Layer
End Node
Switch L2
End Node

IB Architecture Layers

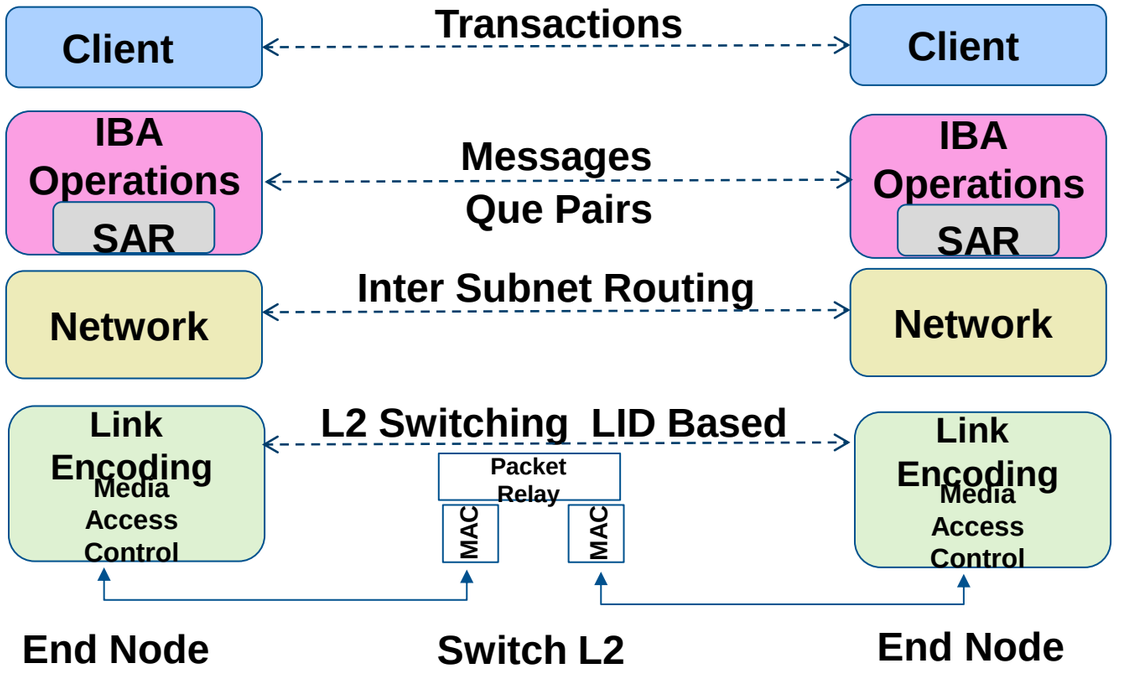
- **Software Transport Verbs and Upper Layer Protocols:**
  - Interface between application programs and hardware.
  - Allows support of legacy protocols such as TCP/IP
  - Defines methodology for management functions

- **Transport:**
  - Delivers packets to the appropriate Queue Pair;
    Message Assembly/De-assembly, access rights, etc.

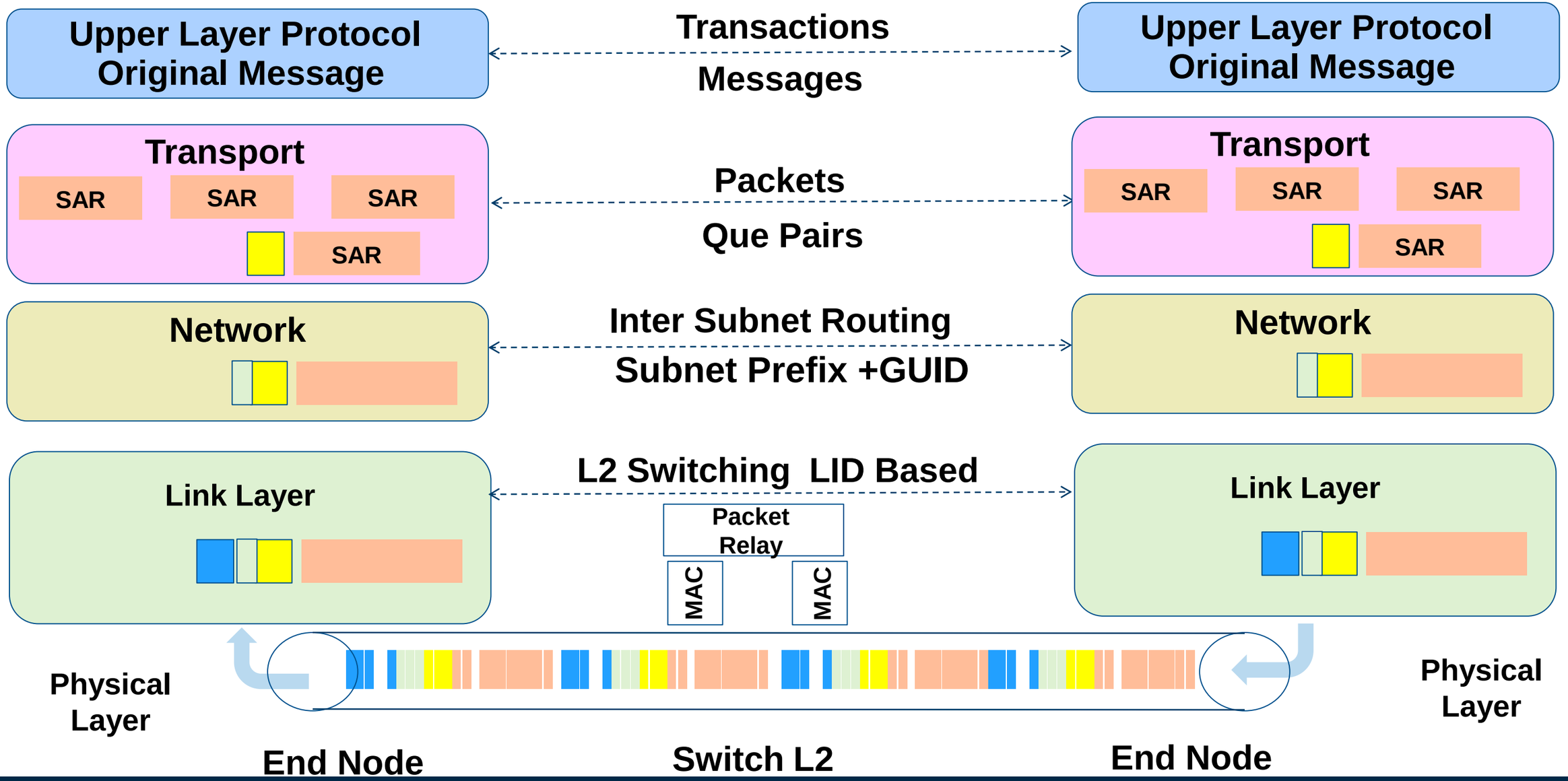
- **Network:**
  - How packets are routed between different partitions/subnets

- **Data Link (symbols and framing):**
  - From source to destination on the same partition subnet
    Flow control (credit-based); How packets are routed

- **Physical:**
  - Signal levels and frequency, media, connectors

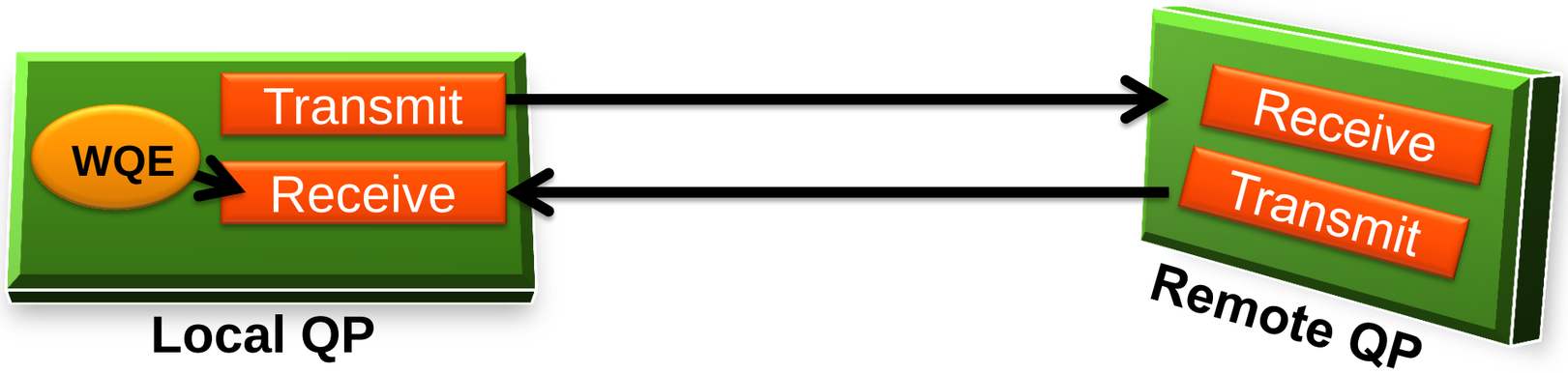


InfiniBand Header Structure

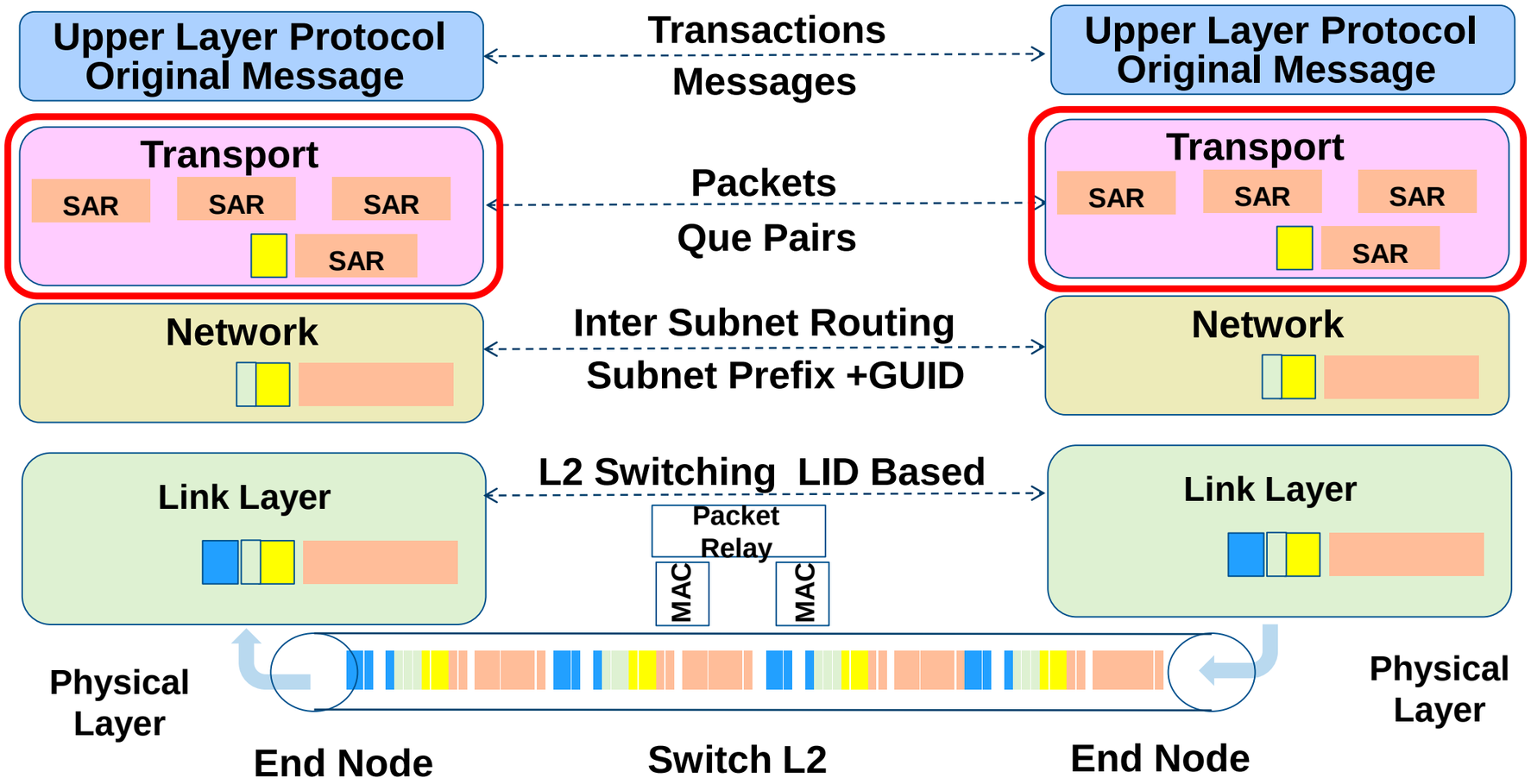


Transport Layer – Responsibilities

- The **Network** and **Link** protocols deliver a packet to the desired destination.
- The **Transport** Layer
  - **S**egmenting **A**ssembly & **R**eassembly of :
    -Messages data payload coming from the Upper Layer, into multiple packets that will suit valid **MTU** size
  - Delivers the packet to the proper Queue Pair (assigned to a specific session)
  - Instructs the **QP** how to process the packet's data (**W**ork **R**equest **E**element)
  - Reassembles the packets arriving from the other side into messages

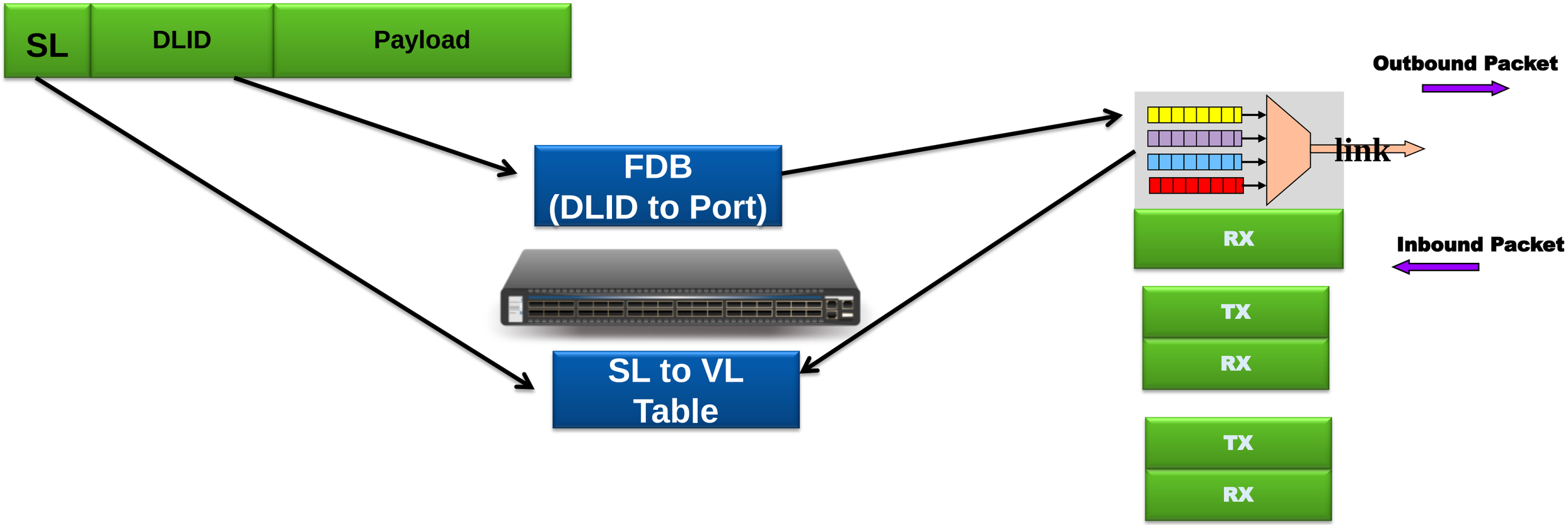


Transport Layer – Responsibilities



Layer 2 Forwarding

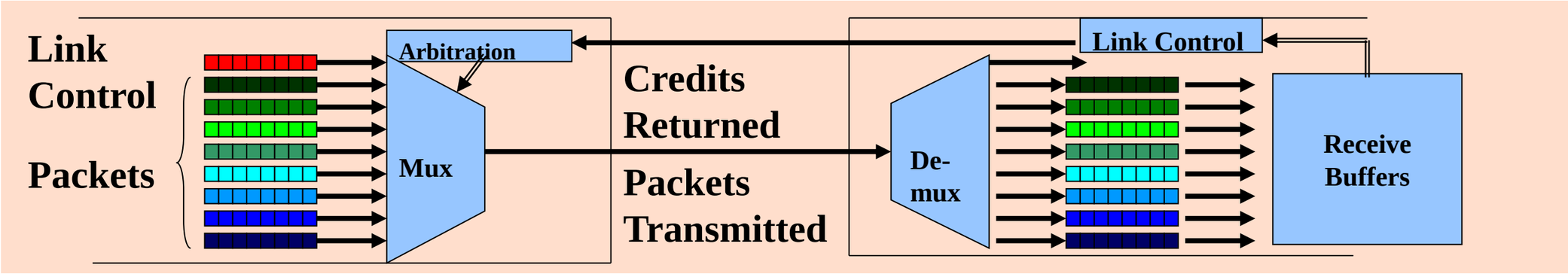
- Switches use FDB (Forwarding Database)
  - Based on DLID and SL, a packet is sent to the correct output port +specific VL



Link Layer – Flow Control

- Credit-based link-level flow control
  - Link Flow Control assures NO packet loss within fabric even in the presence of congestion
  - Link **Receivers** grant packet receive buffer space credits per Virtual Lane
  - Flow Control credits are issued in 64 byte units
- Separate flow control per Virtual Lanes provides:
  - Alleviation of head-of-line blocking
- Virtual Fabrics

  Congestion and latency on one VL, does not impact traffic with guaranteed QoS on another VL, even though they share the same Physical link



Physical Layer- Responsibilities

- InfiniBand is a **Lossless** fabric.
- Maximum Bit Error Rate (BER) allowed by the IB spec is 10e-12.
  Statistically Mellanox fabrics provides around 10e-15
- The Physical layer should guaranty affective signaling to meet this BER requirement

Physical Layer Cont

- Industry standard Media types
  - Copper: 7 Meter QDR , 3 METER FDR
  - Fiber: 100/300m QDR & FDR

- 64/66 encoding on FDR links
  - Encoding makes it possible to send digital high speed signals to a longer distance enhances performance & bandwidth effectiveness
  - X actual data bits are sent on the line by Y signal bits
  - 64/66 * 56 = 54.6Gbps

- 8/10 bit encoding (DDR and QDR)
  - X/Y line efficiency (example 80% * 40 = 32Gbps)

4X QSFP Fiber

4X QSFP Copper

Mellanox Cables – Perceptions Vs. Facts

- Mellanox cables are rebranded from a cable vendor
  - Mellanox cables are manufactured by Mellanox

Passive Copper Cables SFP+

Active Copper Cables

Active Optical Cables

- Our vendor can sell the same cables
  - No other vendor is allowed to sell Mellanox cables
- Mellanox cables use a different assembly procedure
- Mellanox cables are tested with unique test suite
- Vendors' "Finished Goods" fail Mellanox dedicated testing
- Mellanox allows the customers to use any IBTA IB approved cables

Mellanox Passive Copper Cables

- Superior design and qualification process
- Committed to Bit Error Rate (BER), better than 10^{-15}
- Longest reach with Mellanox end-to-end solution

Data Rate	PCC Max Reach
FDR	3 meter
FDR10	5 meter
QDR	7 meter
40GbE	7 meter
10GbE	7 meter

Mellanox Active Fiber Cables

- Superior design and qualification process
- Committed to Bit Error Rate (BER), better than 10^{-15}
- Longest reach with Mellanox end-to-end solution
- Optical Performance Optimization (patent pending)

Data Rate	Max Reach
FDR	300 meter
FDR10	100 meter
QDR	300 meter
40GbE	100 meter

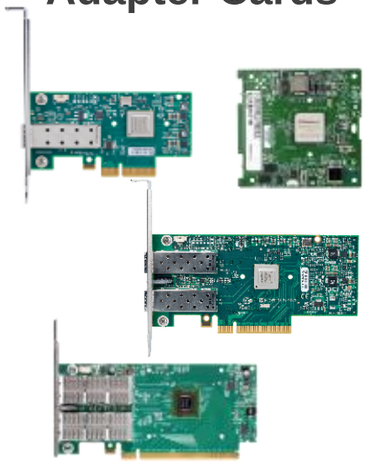
Mellanox Family Products

Leading Supplier of End-to-End Interconnect Solutions

Comprehensive End-to-End InfiniBand and Ethernet Portfolio

ICs

Adapter Cards



Switches/Gateways

Host/Fabric Software

Cables

InfiniBand Switches & Gateways

FDR InfiniBand Switch Portfolio

Modular Switches


648 port


324 port


216 port


108 port

Edge Switches


SX6025 – 36 ports externally managed


SX6036 – 36 ports managed


NEW
SX6015 – 18 ports externally managed


NEW
SX6018 – 18 ports managed


NEW
SX6005 – 12 ports externally managed


NEW
SX6012 – 12 ports managed

Long Distance


NEW

metro X™

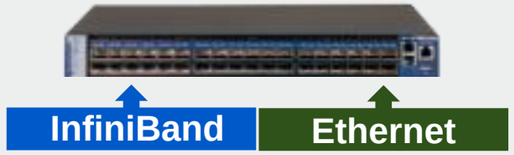
Bridge – VPI

Management

Virtual Protocol Interconnect ® (VPI)
One Switch – Multiple Technologies

1 VPI on Box
Same box runs
InfiniBand OR Ethernet

2 VPI per Port
Same box runs
InfiniBand AND Ethernet



3 VPI Bridging
Same box bridges
InfiniBand AND Ethernet

MetroX™ - Mellanox Long-Haul Solutions

- Provides InfiniBand and Ethernet Long-Haul Solutions of up to 80km for campus and metro applications.
- Connecting between data centers deployed across multiple geographically distributed sites
- Extending InfiniBand RDMA and Ethernet RoCE beyond local data centers and storage clusters.
- Perfect cost-effective, low power, easily managed and scalable solution
- Managed as a single unified network infrastructure.

MetroDX and MetroX Features

		TX6100	TX6240	TX6280
Distance	1KM	10KM	40KM	80KM
Throughput	640Gb/s	240Gb/s	80Gb/s	40Gb/s
Port Density	16p X FDR10 long haul 16p X FDR downlink	6p X 40Gb/s long haul 6p X 56Gb/s downlink	2p X 10/40Gb/s long haul 2p X 56Gb/s downlink	1p X 10/40Gb/s long haul 1p X 56Gb/s downlink
Latency	200ns + 5us/km over fiber	200ns + 5us/km over fiber	700ns + 5us/km over fiber	700ns + 5us/km over fiber
Power	~200W	~200W	~280W	~280W
QoS	One data VL + VL15	One data VL + VL15	One data VL + VL15	One data VL + VL15
Space	1RU	1RU	2RU	2RU

Mellanox Host Channel Adapters (HCA)

Reference to the following Document :
ConnectX®-3 VPI Single and Dual QSFP Port Adapter Card User Manual
http://www.mellanox.com/page/products_dyn?product_family=119&mtag=connectx_3_vpi

HCA ConnectX-3 InfiniBand Main Features

- Up to 56Gb/s InfiniBand or 40 Gigabit Ethernet per port
- PCI Express 3.0 (up to 8GT/s)
- CPU offload of transport operations
- Application offload
- GPU communication acceleration
- End-to-end QoS and congestion control
- Hardware-based I/O virtualization
- Dynamic power management
- Fiber Channel encapsulation (FCoIB or FCoE)
- Ethernet encapsulation (EoIB)

HPC

Database

Cloud Computing

Virtualization

Adapters offering

ConnectX-3 Pro

NVGRE and VxLAN HW off-load

RoCE V2(UDP)

ECN\QCN

ConnectX-3

VPI

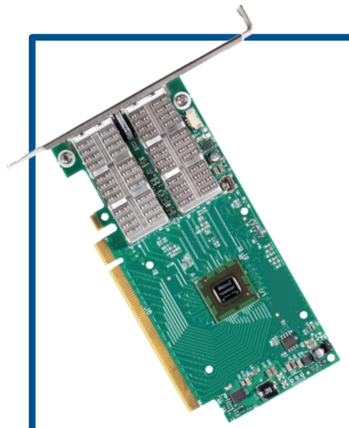
Up to 56Gb IB

Up to 56 GbE

RDMA

CPU off-load

SR-IOV



Connect-IB

Up to 56Gb IB

Greater than 100Gb bi-directional

DC

T10\DIF

PCIE x16

More than 130M message/sec

Fabric Management

Goal of Fabric Utilities in HPC Context

- Enable fast cluster bring-up
  - Point out issues with devices, systems, cables
  - Provide inventory including cables, devices, FW, SW
  - Perform device specific (proprietary) checks
  - Eye-Opening and BER checks
  - Catch cabling mistakes

- Validate Subnet Manager work
  - Verify connectivity at the lowest level possible
  - Report subnet configuration
  - SM agnostic

Goal of Fabric Utilities in HPC Context

- Diagnose L2 communication failures
  - At the entire subnet level
  - On a point to point path

- Monitor the Network Health
  - Continuous and with low overhead

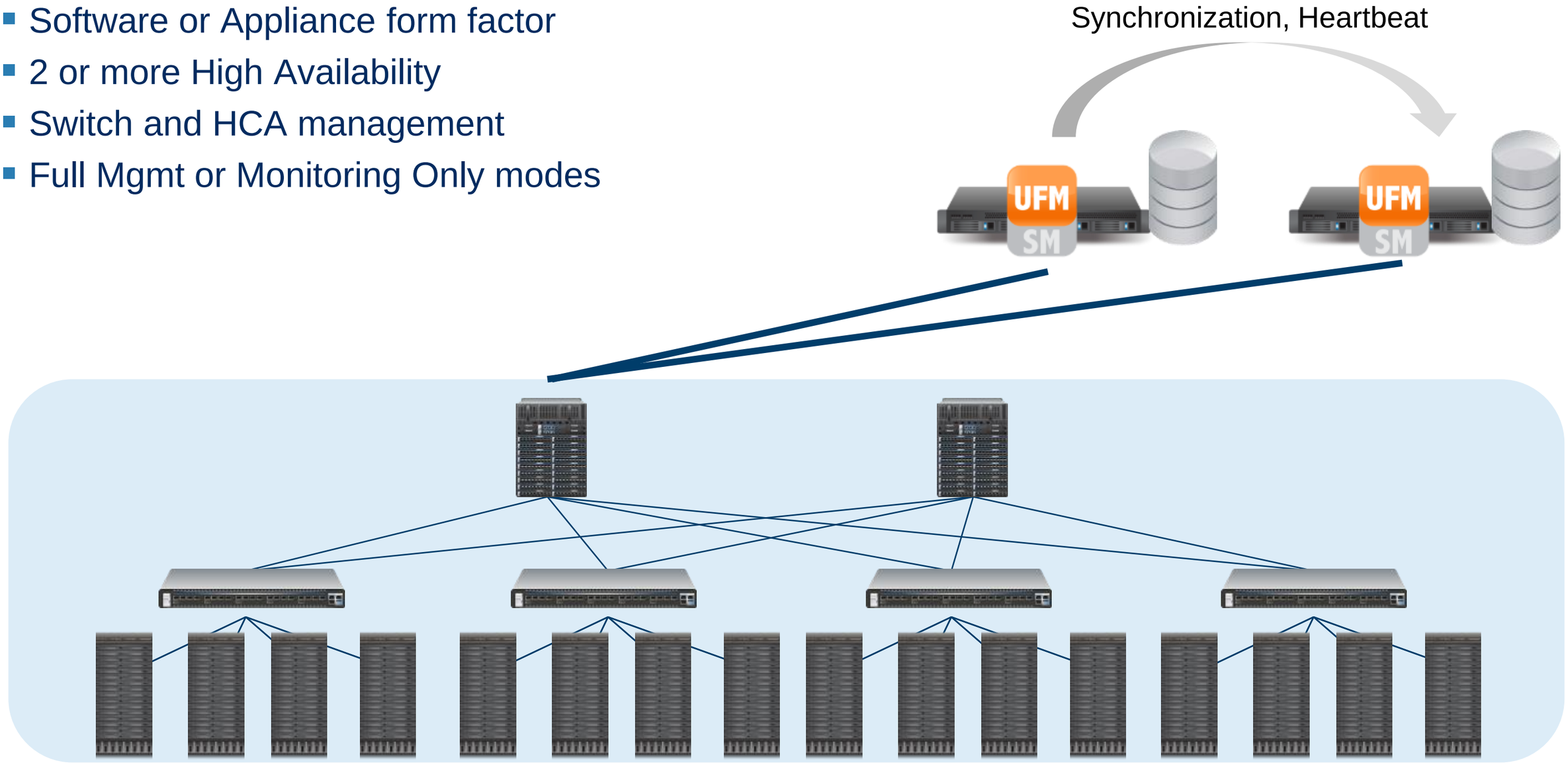
Fabric Management Solution Overview

- ibutils: ibdiagnet/ibdiagpath
  - An automated L2 health analysis procedure
  - Text interface
  - No dedicated “monitoring” mode
  - Significant development past year on features and runtime performance at scale

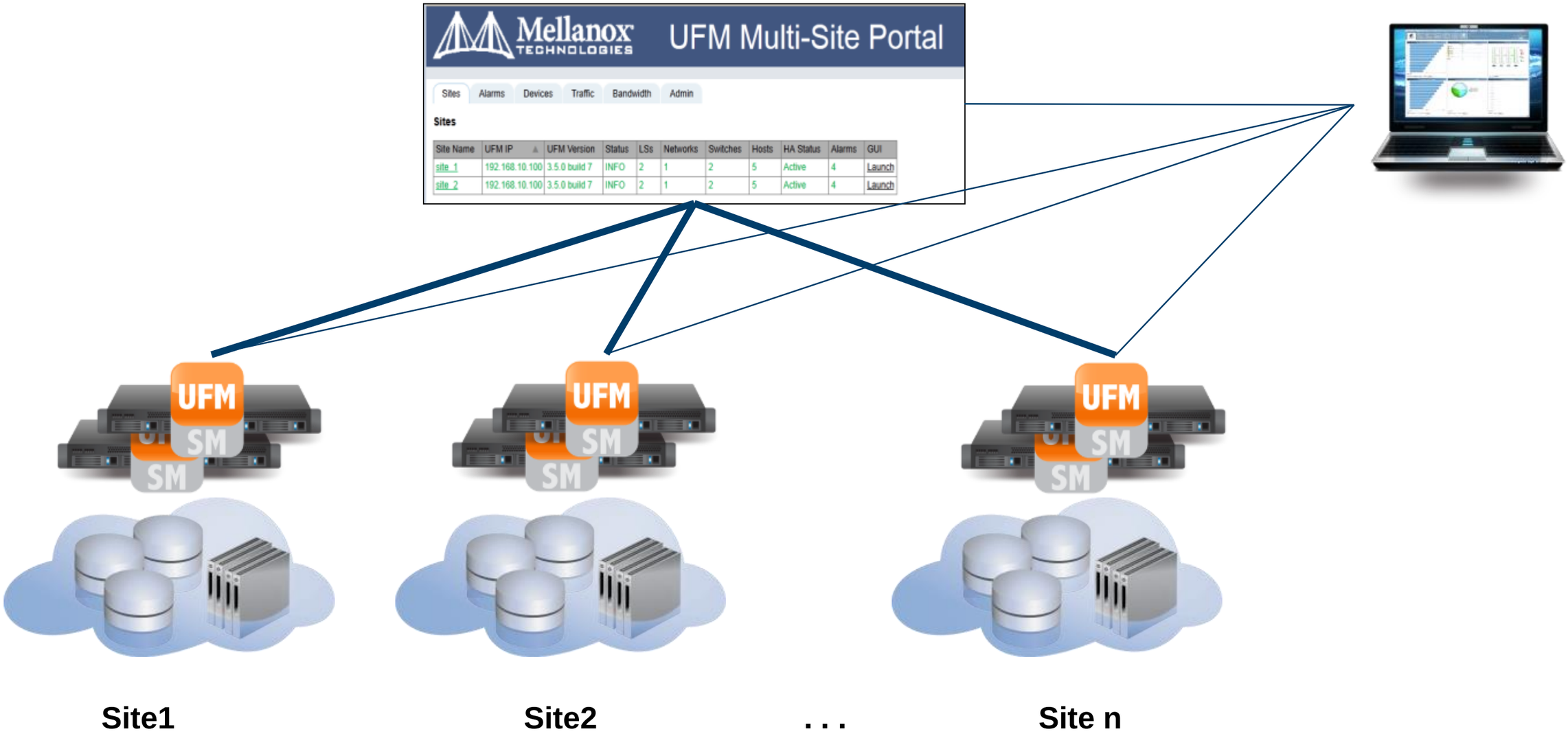
- UFM
  - Highend monitoring and Provisioning capabilities
  - GUI based with CLI options
  - Includes ibutils capabilities with additional features
  - Central device management
    - Fabric dashboard
    - Congestion analysis
  - System Integration Capabilities
    - SMP Traps and Alarms

UFM in the Fabric

- Software or Appliance form factor
- 2 or more High Availability
- Switch and HCA management
- Full Mgmt or Monitoring Only modes

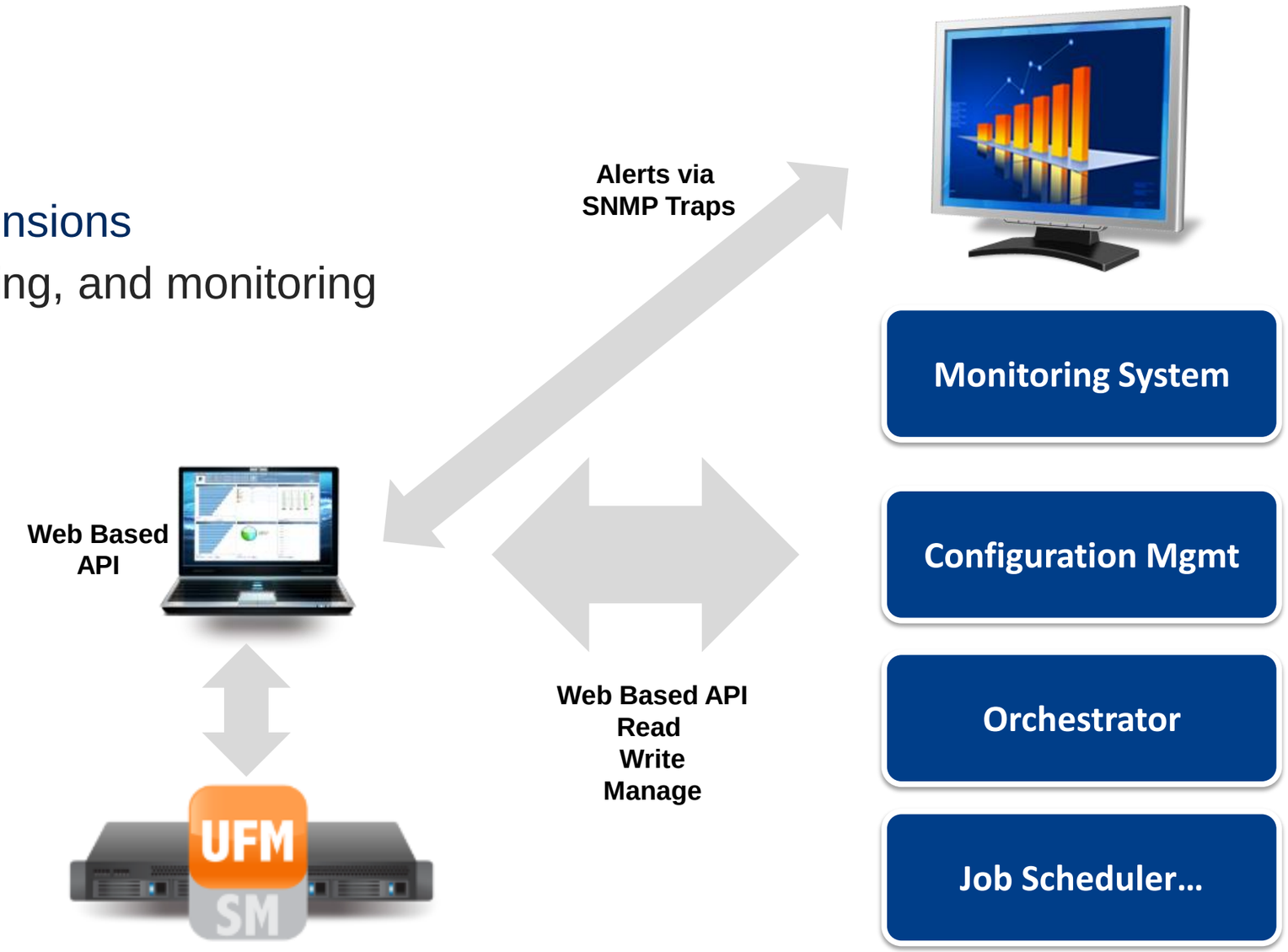


Multi-Site Management

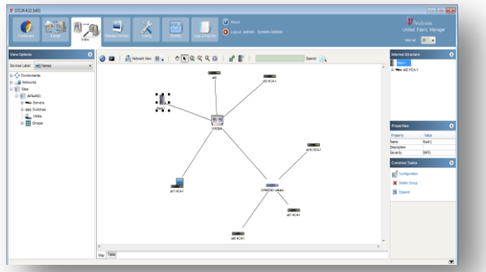


Integration with 3rd Party Systems

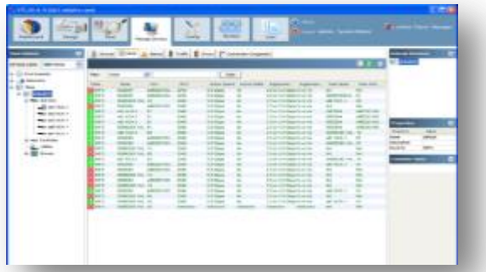
- Extensible architecture
  - Based on Web-services
- Open API for users or 3rd-party extensions
  - Allows simple reporting, provisioning, and monitoring
  - Task automation
  - Software Development Kit
- Extensible object model
  - User-defined fields
  - User-defined menus



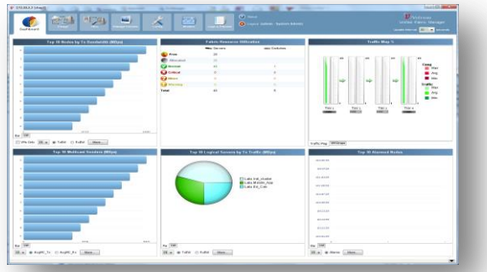
UFM – Comprehensive Robust Management



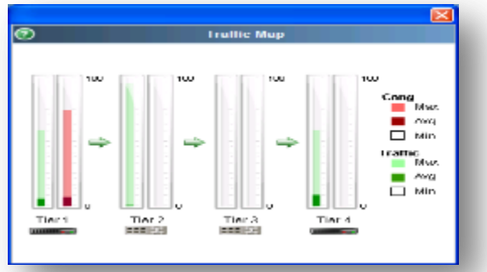
Automatic Discovery



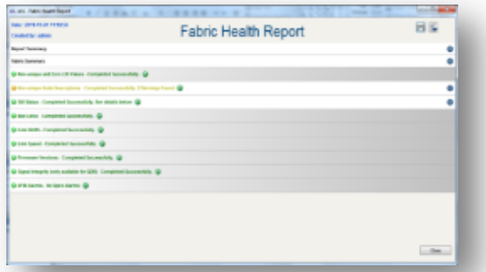
Central Device Management



Fabric Dashboard

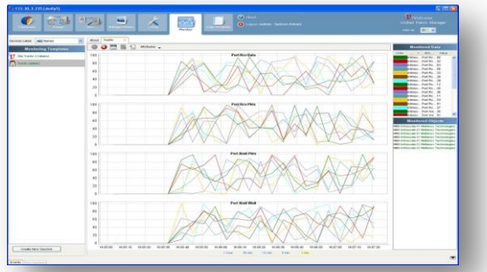


Congestion Analysis



Fabric Health Reports

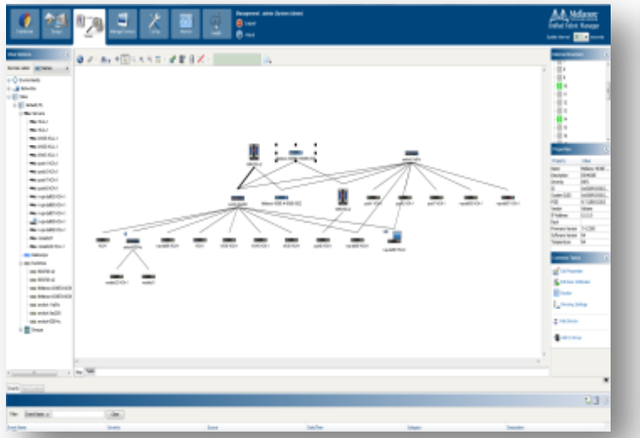
Service Oriented Provisioning



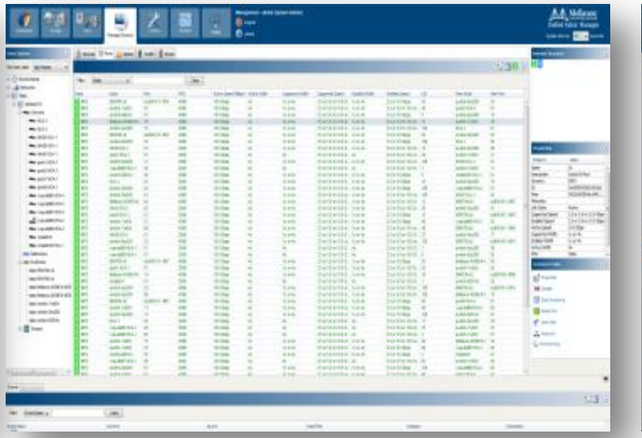
Health & Performance Monitoring

UFM Main Features

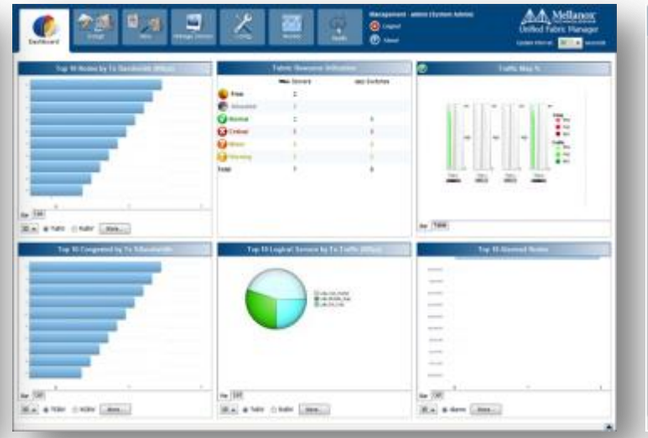
Automatic Discovery



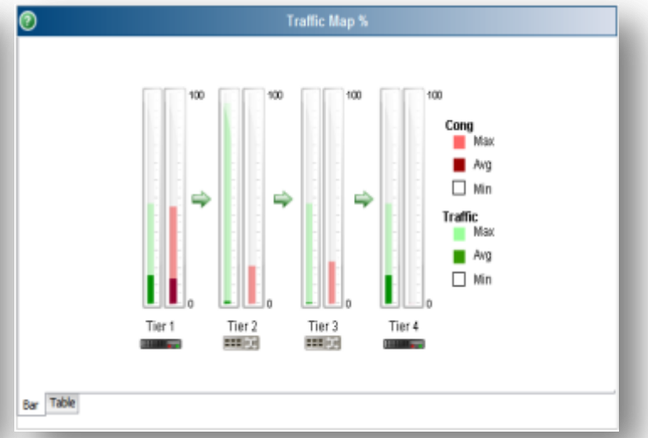
Central Device Mgmt



Fabric Dashboard

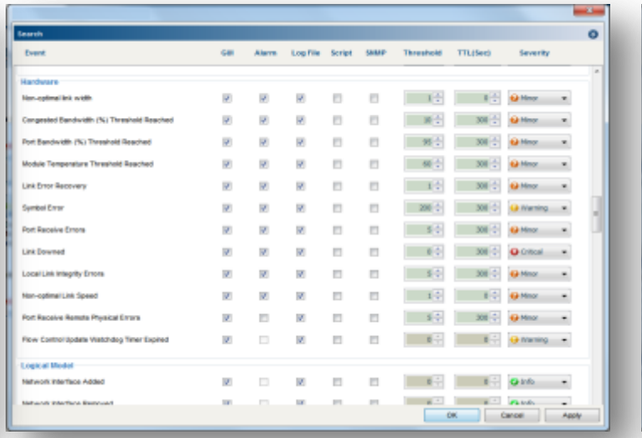


Congestion Analysis

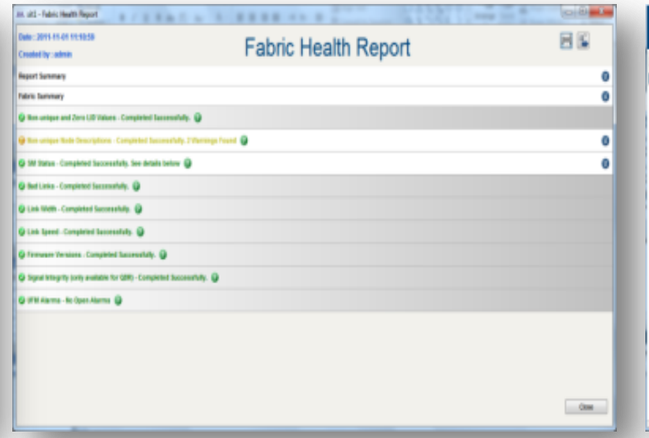


Health & Perf Monitoring

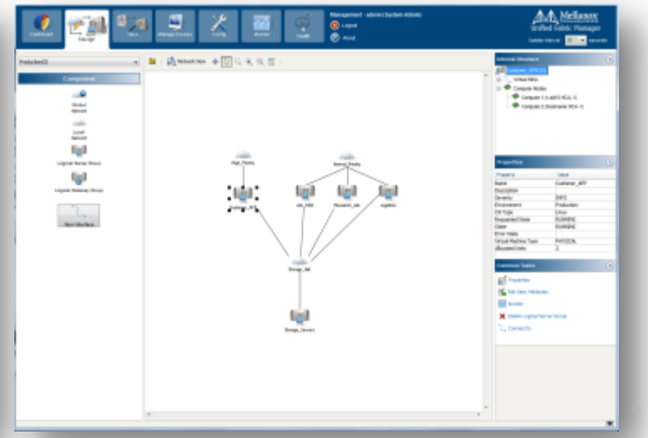
Advanced Alerting



Fabric Health Reports



Service Oriented Provisioning



Advanced Monitoring and Analysis

- Monitor & analyze fabric performance
  - Bandwidth utilization
  - Unique congestion monitoring
  - Dashboard for aggregated fabric view
- Real-time fabric-wide health monitoring
  - Monitor events and errors through-out the fabric
  - Threshold based alarms
  - Granular monitoring of host and switch parameters
- Innovative congestion mapping
  - One view for fabric-wide congestion and traffic patterns
  - Enables root cause analysis for routing, job placement or resource allocation inefficiencies
- All is managed at the job/aggregation level