Data Center Evolution and Network Convergence

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Abstract

Data Center Evolution and Network Convergence

- FC, FCoE, NAS, iSCSI, DCB, traditional LAN, internet/WAN, HPC, clusters, clouds, server virtualization, storage virtualization, network virtualization, and more are all colliding in your data center. Redundancy, resiliency, security, I/O consolidation, network convergence, dynamic application distribution, and thin provisioning with high levels of service are desired at all layers and all data center sizes across a broad spectrum of use cases. You worry about operational separation, buying decisions, investment protection, cost and energy savings, and evolving standards while maintaining very high levels of service and security. Is the technology evolving to a dream come true or a nightmare? If that doesn’t keep you up at night nothing will.

- This tutorial will untangle, define, and illustrate the main ideas and concepts behind Data Center Evolution and Network Convergence to give context and a solid foundation for discussions with your vendors as well as for your further reading and investigation. The point of view taken for this presentation is that of the network and transport characteristics in the face of the changes taking place.
Agenda

- What is Network Convergence?
  - Definitions

- Why would Data Centers Evolve in this direction?
  - Trends & Pressures
  - Advantages

- How do Deployments and Infrastructure change
  - Deployment models
  - Supporting Protocols
Data Center LAN (today)

built from Multi-Tier Trees

- Servers → Servers, NAS, Campus/MAN/WAN across switched network
- Multi-Tier
- 100’s to many1000’s of ports
- multi-link redundancy
- 100s of meters max diameter
  - oversubscribed
  - East-West Latency can be a problem
- Ethernet carrying predominantly IP traffic
- Firewalls and security in aggregation layer
  - have to be distribute in the data path due to efficiency forced by oversubscription
Data Center FC SAN (today)

- Servers → Storage across switched network
- Core – Edge or Edge – Core – Edge
  - In effect one level of tier collapse is done
- 10’s to 1000’s of ports
- Full Dual Rail Redundancy
- 100s of meters max diameter
  - High Bandwidth, Low Latency
  - Lossless Links
- Fabric Services provide Discovery, Access Control, and Change Notification
- Gateways and specialized extension devices provide remote access for BC/DR
- Attached Appliances provide data services
  - Encryption, Block Virtualization
Network Convergence

- Running disparate network traffic types across common physical infrastructure

- Disparate network traffic
  - Block Storage (FC, FCoE, iSCSI)
  - Networked file systems (NFS, CIFS/SMB, CAS)
  - Server LAN access
  - High speed clustering and transactions

- Common Physical Infrastructure
  - Ethernet with multi-protocol switches
  - Fabric based distributed switches
  - Infiniband
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Convergence is in progress, but there is a balance between various factors influencing the adoption rate.

**INHIBITORS**

- Existing Operational Models and Infrastructure
- Cost of 10G/40G Infrastructure
- Politics / Team Issues
- Technology Maturity

**ACCELERATORS**

- Development of best practices for phased deployment of convergence
- 10GE Performance Cost Reductions
- Convergence Solves Actual problems of scale, flexibility, and complexity
- Server Virtualization Network Evolution New Data Center Models

On the whole the Accelerators are outpacing the Inhibitors.
Overall Trends...

- **First Model**
  - isolated systems
  - direct attach storage

- **Second Model**
  - limited networking
  - direct attach storage

- **Third Model**
  - Networking Explosion
  - direct attach storage + local cluster server-server storage

- **Third and a half Model**
  - Flexible storage via NAS and network file systems

- **Fourth Model**
  - SANs for block storage attach plus fully entrenched NAS

- **Fifth Model (‘current one’)**
  - Server Virtualization drives first hop I/O consolidation, increased SAN attach
  - “Cloud” (pooled resources of all kinds with uniform distributed access)

- **Evolving Model**
  - Network Convergence
    - Protocols for SAN and LAN on same infrastructure
    - Network Scaling via virtualization and simplification (tier collapsing, distributed control planes)
…reflected in the Data Center

Consolidation

- Mega DCs; 400K sq ft
- 4K racks, 200K servers

DC Scale

Server Trends

- Multi-core (8->16 >32,...,128,...)
- Virtualization and VMs

Want Low Oversubscription

Application Trends

- SOA, Web 2.0
- MapReduce, Hadoop, Grids

Increased East-West traffic

Interconnect Trends

- Convergence to 10 GE
- Enhancements to Ethernet

Large speed increases 10/40/100 GE
Servers and Storage Attach

<table>
<thead>
<tr>
<th>High End Servers with high IOPS &amp; performance MF / Unix</th>
<th>Storage is High End High IOPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid range servers Unix / Wintel</td>
<td>Storage with Reasonable balance of capability &amp; performance</td>
</tr>
<tr>
<td>Rack Dense &amp; blade servers Wintel / Linux</td>
<td>Storage with minimal load, no persistent data, just VM images</td>
</tr>
</tbody>
</table>

SAN Attach started at the high end
SAN Attach Penetrating lower
Server virtualization driving towards 100% attach

Server virtualization started at the low end
Steadily penetrating higher
Needs shared storage for VMs
Leading to Infrastructure Explosion

- Function of new services, digital media, application design and deployment topologies
- Fueled by Moore’s law and ever increasing price performance
- Driving issues of managing massive performance and scale

Remember: Complexity increases exponentially with scale

1. Source: IDC
Virtualization OF EVERYTHING

Aggregate up and Virtualize down
- many examples such as storage arrays, servers, ...
- avoid Accidental partitioning
- embrace Deliberate partitioning

Aggregation
- Physical and Software
- Bring together and pool capacity with flexible connectivity

Virtualization
- logical partitions of the aggregated systems to match actual need
- flexibility → fungible resources everywhere
- Utility Infrastructure with just in time & thin provisioning

THIS IS HAPPENING TO NETWORKS AS WELL
Virtualization Drives Storage Connectivity

... because Data Centers are always in flux

Application life cycle
  services introduced, updated, retired

Load on servers and networks constantly changing
  can be unpredictable

Resource management challenge
  ◆ Minimize the need for excess capacity
    › Reconfigure
    › Reclaim/Reuse
  ◆ Adding resources is last resort

Dynamic shared resource pools address these issues

Enabled by Virtualization + Full Connectivity Networks

Any servers potentially needs access to any storage
Drives SAN attach from 20% to near 100%

If you don’t converge you will end up connecting everything to everything anyway but across additional parallel networks.
Virtual to Physical Server Trend

Complexity and Operating Costs are still present

Source: IDC
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Hasn’t Convergence already happened?

- For some aspects of Convergence: YES
  - NAS Allows access to file based storage across the network
  - iSCSI Allows access to block based storage across the network
  - SANs have been bridged across metro and wide area networks for 10 years (FCIP, iFCP, & proprietary)
  - FCoE provides an accepted protocol for FC across an Ethernet

- These are good but not sufficient
  - Data center LANs have issues at scale
  - WAN IP SAN connections do not solve the Local Data Center problem
  - Operational Characteristics of FC based SANs desirable and entrenched for many applications
Network Convergence Benefits

- results in logical overlays for forwarding on single, shared HW infrastructure

Benefits

- stocking of spare FRUs
- combined operations
- fewer stranded resources
- better utilization
- lower latency
- better flexibility
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What does the network look like when you overlay the SAN picture onto the LAN picture?

You can have converged infrastructure at several places in the network.
Convergence Considerations

Protocols for storage access
- Block Storage (FC, FCoE, iSCSI)
- Networked file systems (NFS, CIFS/SMB, CAS)

Physical Infrastructure
- Ethernet with multi-protocol switches
- Fabric based distributed switches
- Infiniband

End to End performance
- Bandwidth & latency & frame processing rate
- Congestion handling
- Logical overlays onto physical infrastructure

MAN and WAN extension for storage
- Under convergence the local network is Ethernet. The devices that make up the local Ethernet are not typically suited to directly support lossless distance extension.
Let’s now focus on the case of FCoE and convergence in a Data Center as an example of the deployments and considerations

Scaling
- FCF at the TOR hits Domain Scaling problems
- FC-BB-6 addressing this with FCF-FDF virtual domains

Configuration of L2/L3 separation
- VLAN → Virtual Fabric mapping
- L2 network as access between server and FCF

Full FC topology overlay onto data center network
- Multi-hop FCoE across multiple L2 networks and several FCFs
- Multiple VLAN/Virtual Fabric Configuration and Management
Multiple network connections
- Separate subnets
- Separate VLANs
- May be separate networks
- May be separate switches in the same network
- Each configured with different QoS settings

For Example Something like this is possible:
- Campus Access (1+)
- LAN Backup NIC (1)
- Application Cluster NIC (1)
- Vmotion NIC (1)
- Presentation to application to database private NICs (1+)
- Storage Access Cards (2)

I/O Consolidation reduces this to 2 NICs per server
(more only if you need the bandwidth)
Converged Deployments for FC/FCoE

- Server to FC SAN via NPV Gateway with integrated L2 bridge
Converged Deployments for FC/FCoE

- server to FC SAN via external NPV Gateway
Converged Deployments for FC/FCoE

- server direct to FCF with integrated L2 bridge
Converged Deployments for FC/FCoE

- Server to FCF via L2 bridges
Full Convergence goes beyond I/O Consolidation

- **Separate Networks**
  - No overlap of operations & management
  - separate network characteristics
  - separate teams run them (typically)

- **I/O Consolidation**
  - overlap confined to server and 1st hop
    - team consensus needed
  - several detailed ways to accomplish
    - transit switch L2 to access SAN
    - gateway

- **SAN-LAN Convergence**
  - unified management and operational model
    - run by single team
    - common redundancy
    - shared bandwidth and connectivity
Converged SAN/LAN Using FCoE and FCFs with integrated L2 Bridges

With FC-BB-6, some of these FCFs can be FDFs
Converged Deployments for FC/FCoE

Converged SAN/LAN Using FCoE and FCFs
For this to be a reality
What does convergence need?

- **Transport Convergence**
  - I/O Consolidation out of server
  - Switch forwarding plane aggregation
    - Tier Collapsing
    - Ethernet Fabrics, not to be confused with FC Fabrics

- **Protocol Evolution**
  - FCoE (FC-BB-5/FC-BB-6)
  - iSCSI (especially over DCB networks)
  - DCB for Ethernet is ‘complete’

- **Operational**
  - Collections of physical switches acting as single logical switch
  - Scaling of all management tools and infrastructure
The DC LAN can be built out of L2 Bridges using multi-tier trees

The DC LAN can be built out of a fabric based distributed switch

The DC LAN can be built out of hybrid of one of the above and FCF/FDF integrated L2 Bridges
  - Would typically have the multi-tier tree characteristics
Constructing the DC LAN: Protocols

- In all DC LAN cases the IEEE DCB (Data Center Bridging) and some IETF protocols are required for a properly functioning infrastructure
  - PFC (Priority Flow Control) provides lossless operation
    - Required for FCoE and any high speed SAN traffic where congestion is possible
  - ETS (Enhanced Transmission Selection) – Allows configuration of endpoint bandwidth
  - DCBX – Allows capabilities information to be exchanged
  - CN (Congestion Notification) – Allows the DC LAN to react to congestion by notifying endpoints to slow down
  - L2 multi-path – Allows all physical paths to be utilized
    - Not as important with fabric based infrastructure
  - Non-DCB protocols still important to the DC LAN
    - VLAN – Allows logical organization and overlay onto a physical infrastructure
    - Link Aggregation - Allows multiple physical links between bridges to act as though they were a single link.
    - QoS/CoS – Allows network to manage and prioritize traffic
    - STP (Spanning Tree Protocol)
20 years ago the Ethernet switch was introduced to solve the LAN problem. And it became the basic building block of the network.

And so we wired the data center the same way.

Need more redundancy: STP and disabled links OR lots of VLANs.

SOA Applications etc.

Up to 75% of traffic.

Adding in the complexity of storage networking as well, these pressures force the Ethernet network to change.
Why not Multi-Tier Trees?

Bubbles of Optimal Performance

Appliances and VLANs create Shadows of Accessibility

BECAUSE Location matters in a tree architecture
Instead use Fabric Infrastructure

Simplify the Data Center LAN by aggregation and consolidation

Aggregate Switches
Multiple physical switches that operate as a single logical device for both management and traffic forwarding

Collapse Tiers
Use an aggregated switch to do the work of multiple tiers of switches Allows aggregated access to services

Create A Fabric
Use both techniques at the same time to build a fabric based infrastructure

This gives another way to scale for Network Convergence
Last Words

- Convergence happening along multiple lines
  - I/O Consolidation
    - Well established now and of direct benefit to server
  - SAN-LAN Fabric Convergence
    - Common Equipment, Shared Infrastructure
    - Multiple Protocols Possible
  - Tier Collapse
    - Local networks replaced by high capacity distributed fabrics
    - Flatter, fewer Tiers, higher utilization

- Network Virtualization underway
  - Large benefits derived from scaled and converged components

- Cloud Deployments benefit from Convergence
  - Cloud does not change the fact that there are very large centralized data centers that need scale,
  - one of the levers to achieve scale is network convergence
Please send any questions or comments on this presentation to SNIA: tracktutorials@snia.org

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