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This presentation is a project of the SNIA Education Committee.
Abstract

- Consolidating I/O over Ethernet
  - The audience will learn how hardware, software, standards and innovation are all needed to derive the vision of a unified fabric utilizing 10GE for the data center of the future. The unification of fabrics is not an all or nothing approach. There is a clearly defined unified fabric sweet spot within a data center. The audience will learn to identify and assess if this approach is right for their data center and business level objectives. In this session you will learn the differences between reactive innovation vs proactive innovation and how it applies to 10G, Acceleration, OS virtualization, HW virtualization and the evolution of storage fabrics.
Agenda

- Overview of Ethernet Technology
  - Ethernet Evolution
  - Frame Format

- 10 Gigabit Ethernet Technology
  - Demand for 10GbE
  - 10GbE PHY technology

- I/O Consolidation over Ethernet
  - Ethernet enhancements for “lossless” fabric

- Next Generation Ethernet
  - 40G / 100G
Original Ethernet

June 1976 National Computer Conference
Nearly all of the traffic on the Internet either originates or terminates with an Ethernet connection.
Ethernet Evolution

Ethernet has a long history of increasing data rates along with capabilities.


1983: 802.3 – 10Mbps Ethernet

1985: 802.3u - Fast Ethernet (100 Mbps) Fiber, TP

1995: 802.3z - Gig Ethernet (1 Gbps) Fiber

1998: 802.3ab - Gig Ethernet Twisted Pair

1998: 802.3z - Gig Ethernet Twisted Pair

2002: 802.3ae - 10G Ethernet (10 Gbps) Fiber

2006: 802.3an - 10G Ethernet Twisted Pair

40/100GbE: backward compatibility

Next Data Rates: 40G/100G Ethernet

Fast Ethernet

Gigabit Ethernet

10Gb Ethernet

Ethernet Technology

Network Capabilities

Ethernet Technology

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Network Topologies

Original Ethernet – Shared Bus Topology
- Single Coaxial bus
- Half duplex operation
- Media contention managed using CSMA/CD protocol
- Low utilization

Today: Star Topology
- Point-to-Point connections
- Full Duplex operation
- No Media contention
- Higher Aggregate bandwidth

Modern implementations of Ethernet are all Switched
OSI Reference Model

IEEE 802.3 Reference Model

<table>
<thead>
<tr>
<th>OSI Reference Model</th>
<th>IEEE 802.3 Reference Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application</td>
<td>Higher Layer protocols</td>
</tr>
<tr>
<td>Presentation</td>
<td>Logical Link Control (802.2)</td>
</tr>
<tr>
<td>Session</td>
<td>Bridging (802.1)</td>
</tr>
<tr>
<td>Transport</td>
<td>Media Access (MAC) (802.3)</td>
</tr>
<tr>
<td>Network</td>
<td>Physical (PHY) (802.3)</td>
</tr>
<tr>
<td>Data Link</td>
<td></td>
</tr>
<tr>
<td>Physical</td>
<td></td>
</tr>
</tbody>
</table>

**MAC Function:**
- Data Encapsulation
- Error Detection
- Initiating frame transmission

**PHY Function:**
- Encoding
- Mux / Demux
- Signal Transmitters
- Auto-negotiation
Ethernet Frame Format

<table>
<thead>
<tr>
<th>PRE</th>
<th>SFD</th>
<th>DA</th>
<th>SA</th>
<th>Length/Type</th>
<th>Data</th>
<th>Pad</th>
<th>FCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>1</td>
<td>6</td>
<td>6</td>
<td>4</td>
<td>46-1500</td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

- **Ethernet address: Source / Destination Address**
  - Unique and controlled by IEEE
  - High order address bit is 1 for multicast and broadcast
  - A destination address of only 1s is accepted by all stations

- **Length / Type**
  - IEEE 802.3 / Ethernet V2. Majority implementations are V2
  - Field value less than 1500 indicates bytes in data field
  - Field value greater than 1536 indicates type of frame

- **Data**
  - Filler or padding added if data is less than 46 bytes

- **FCS**
  - 32-bit CRC created by source MAC
IEEE 802.3 Reference Model

- **Higher Layer protocols**
- **Media Access (MAC)** (802.3)
- **Physical (PHY)** (802.3)

**Sublayers**
- **Medium-independent sublayers**
  - MII: Medium-independent interface
  - MDI: Media-dependent interface
- **Media-dependent sublayers**
  - PCS: Physical coding sublayer
  - PMA: Physical medium attachment

- **Reconciliation**
- **Auto-negotiation**
- **Medium**
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10 Gigabit Ethernet demand

Multi-Core CPU architecture allowing faster execution of multiple applications on the same processor

Growing need for storage network is driving the demand for higher bandwidth network

Consolidation of multiple virtual servers on a physical servers demands more network bandwidth per server

Server Virtualization and Network Storage are driving the need for higher bandwidth network connections
10GbE Standards

802.3ae

Media Access Controller (MAC) Full-Duplex

10 Gigabit Media Independent Interface (XGMII) or 10 Gigabit Attachment Unit Interface (XAUI)

LAN PHY (8B/10B)
Serial LAN PHY (64B/66B)
Serial WAN PHY (64B/66B + WIS)

Various Optical Technologies

10G BaseT
10G Backplane
Cat6/7 Cable
802.3an
802.3ap

802.3an and 802.3ap make 10GbE even more compelling for data center applications
Changes with 10GbE

- **802.3ae defines 10GbE**
  - 10Gbps Data Rates
  - Full-duplex only; no more carrier-sensing multi-access / collision detection (CSMA/CD)
  - Optical Physical Layer
    - LAN PHY and WAN PHY options
      - WAN PHY compatible with SONET

- **802.3an adds twisted pair cabling**
  - Cat 6 and Cat 7

- **802.3ap adds backplane specifications**
  - Blade servers and communications equipment
Several options targeted for specific application, span length, and media

Fibre (Optical)
- Single Mode Fibre
- Multi-mode Fibre
- Many choices

Copper
- 10G Base-T
- Serial 10G Copper Cable

Backplane
- XAUI (4 x 3.125)
- 10GBase-KX4
- 10G Base-KR
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I/O Consolidation over Ethernet

- Reduced CapEx: Fewer ports from server, fewer fabrics, fewer cables
- Reduced OpEx: Simplified management, less power/thermal, reduced installation costs
- I/O Consolidation for Storage:
  - iSCSI and FCoE
- 10GbE drives I/O convergence

IO consolidation delivers lower TCO
Ethernet Enhancements for Data Center

- Traffic Differentiation: Priority Groups
  - Provides end-to-end traffic differentiation for LAN, SAN and IPC traffic

- “Lossless” Fabric: Reliable Transport in Ethernet
  - Transient congestion - Priority Based Flow Control
  - Persistent congestion - Backward Congestion Notification

- Bi-sectional Bandwidth: Shortest-Path Bridging
  - Allow L2-Multipathing within Data Center

Moving Ethernet from Best Effort to a deterministic fabric
Resource association

PG's allow latency optimization for one application while allowing throughput optimization for other application
Priority-based Flow Control

Link Pause

Whole link is blocked

Only targeted queue is affected

Ethernet Technology
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Congestion Notification (IEEE 802.1Qau)

AQM: Active Queue Management

GRL: Granular Rate Limiting

QCN = Congestion Notification gets generated when a device experiences congestion. Request is generated to the ingress node to slow down

GRL = Ingress node slows down the flows causing the congestion

Priority based Flow Control = Provides insurance against sharp spikes in the confluence traffic: avoids packet drops

QCN = When congestion disappears, positive notification is generated to the ingress device allowing to grow the rate
Shortest Path Bridging (IEEE 802.1Qaq)

- An incremental advance to MSTP
- Builds a spanning tree (ST) for each bridge
  - Uses the ST rooted at the source switch for shortest path bridging

Ensures forward and reverse paths are aligned
  - Reflection Vector and other ideas being investigated to “align” spanning trees
Gluing it all together

- Capability Exchange Protocol allows discovery of compliant devices, capabilities
- Allows formation of cloud of compliant devices
- Allows incremental deployment – rack at a time
IEEE Enhancements for Data Center

Effort underway to provide DC enhancements in IEEE
- 25+ companies actively championing in IEEE
- Work is called Data Center Bridging (DCB)

IEEE projects necessary for IO Consolidation in Data Center
- Congestion Notification: Approved project IEEE 802.1Qau
- Shortest Path Bridging: Approved project IEEE 802.1Qaq
- Virtual Links (Priority Groups): Approved project IEEE 802.1Qaz
- Priority based Flow Control: In consideration in IEEE 802.1
- DCB Capability Exchange Protocol: Part of various projects above

DCB Standards trending for ratification in ~2009
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40/100 GbE Networking

Source: IEEE 802.3 Higher Speed Study Group - TUTORIAL
Ethernet Evolution continues …

Higher Speed study group objectives

- Full duplex operation only
- Preserve 802.3 frame format and size
- Support BER better than or equal to 10-12
- Support 40 Gb/s data rate (different cable types)
- Support 100 Gb/s data rate (different cable types)

Target completion - 2010
Q&A / Feedback

Please send any questions or comments on this presentation to SNIA: tracknetworking@snia.org

Many thanks to the following individuals for their contributions to this tutorial.
- SNIA Education Committee

Sunil Ahluwalia (Author)
Manoj Wadekar (Author)
Howard Goldstein (Tutorial Review)
Walter Dey (Tutorial Review)
Backup
Congestion Management in DCB

Attached simulation shows how DCB congestion management (QCN+PAUSE) improves aggregate throughput in the network.

- Red line shows throughput collapse without DCB.
- Green line shows throughput with DCB.

Without BCN, TP[all] oscillates just above 250 MB/s; with BCN, TP[all] rapidly converges on ~1012 MB/s.

CSMA/CD

- Carrier Sense Multiple Access / Collision Detect
  
  - Listen for the media to be quiet
  - If quiet, you can transmit
  - Listen while you transmit to make sure it is just what you are sending
  - If not, then someone else is sending at the same time – COLLISION
  - Backoff and repeat process

sis – muh, see - dee
The SFP+ MSA has been kicked off to develop a low cost and low power 10G serial optical interface and leverages existing SFP standard

- The SFP+ MSA Rev 1.0 released next week and expect stability by next Rev.
- ~30 companies actively participating in this effort
- ~65 companies monitoring activities

Key difference versus existing XFP optical modules

- SFP+ removes a 10G retiming stage (saving size, cost, and power)
- SFP+ is a smaller form factor (~46% Area Savings)
- SFP+ Power target for up to 10km optical links (>800mW)

Mechanical Specification – SFF-8432 improved but compatible with existing SFP
The demand for XFP and SFP+ are for port density and lower cost.

- Rack spacing and port density equates to real states

**Screw attach to faceplate**
- Establishes **consistent compression** of EMI gasket between housing & face plate of system
- Prevents oil-canning of face plate

**Optional Screw attach points**
- Secures stacked connector (assembly to host board for handling purposes)

**Optional Screw attach points**
- Secures stacked guide (assembly to base of enclosure)