

# WHAT'S GOING ON WITH ETHERNET?

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### Introduction

- Several maturing, new and emerging technologies are being developed for Ethernet networks in the IEEE, IETF, INCITS, ITU-T and MEF
- This presentation provides an introduction and overview of each technology
  - 40 Gigabit and 100 Gigabit Ethernet: higher speed interfaces
  - EEE: efficient power utilization on NICs and switches
  - ERPS, Carrier Ethernet and OAM: carrier-grade Ethernet services
  - DCB/CEE: converged datacenter networks
  - TRILL and SPB: shortest path forwarding in Layer 2 networks

# Agenda

- Relevant Standards Organizations
- 40 Gigabit and 100 Gigabit Ethernet
- Energy Efficient Ethernet (EEE)
- Ethernet Ring Protection Switching (ERPS)
- Carrier Ethernet
- Operations, Administration, and Management (OAM)
- Data Center Bridging (DCB)
- Shortest Path Forwarding

# **Standards Organizations and You**

Name	Role	Primary Players
Customers	Buy Your Services	
You	Run Networks	
Hardware Vendors	Make Equipment	
	Ethernet Service Definitions, Standards and Certification	Hardware Vendors, SPs, IXs
	Higher Layer Protocol Standards	Hardware Vendors, SPs
THEFFTATIONAL TO SALE AND	Fibre Channel over Ethernet (FCoE) Standards (T11) Ethernet Standards (802.1, 802.3) Telecom Standards (SG15)	Component and Hardware Vendors
OIF OFFICAL INTERNETWORKING FORUM	Component Interface Standards	Component and Hardware Vendors

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# Summary of Recent 40 Gigabit and 100 Gigabit Ethernet Developments

- We're done with 802.3ba!!!
- Proceeded to state of "STOP MAKING CHANGES" in March 2010
- Final Draft 3.2 submitted for approval on April 29, 2010
- IEEE 802.3ba standard approved June 17, 2010
  - 457 pages will be added to IEEE 802.3-2008





# 40 Gigabit and 100 Gigabit Ethernet Physical Layer Specifications

Physical Layer Reach	1 m Backplane	7 m Copper Cable	100 m OM3, 125 m OM4 MMF	2 km SMF	10 km SMF	40 km SMF
40 Gigabit Ethernet	: Target Application	s – Servers, Data C	enter, Campus, Me	tro, Backbone		
Name	40GBASE-KR4	40GBASE-CR4	40GBASE-SR4	40GBASE-FR	40GBASE- LR4	
Signaling on Media	4 x 10 Gb/s	4 x 10 Gb/s	4 x 10 Gb/s	1 x 40 Gb/s	4 x 10 Gb/s	
Media	Conner	Twinax Cable	MPO MMF	Duplex SMF	Duplex SMF	
Module/Connector	Backplane	QSFP Module, CX4 Interface	QSFP Module	CFP Module	CFP Module, QSFP Module	
Availability	No Known Development	2010	2010	2011-2012	CFP 2010 QSFP 2011-2012	
Price	\$\$	\$\$	\$\$	\$\$\$\$	\$\$\$\$	
100 Gigabit Ethernet: Target Applications – Data Center, Campus, Metro, Backbone, WAN						
Name		100GBASE-CR10	100GBASE-SR10		100GBASE-LR4	100GBASE-ER4
Signaling on Media		10 x 10 Gb/s	10 x 10 Gb/s		4 x 25 Gb/s	4 x 25 Gb/s
Media		Twinax Cable	MPO MMF		Duplex SMF	Duplex SMF
Module/Connector		CXP Module	CXP Module, CFP Module		CFP Module	CFP Module
Availability		2010	2010		2010	2011-2012

\$\$\$

\$\$\$

Price

\$\$\$\$\$\$

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# **Second Generation Technology**

- There is already demand for other interfaces beyond the scope of 802.3ba
  - Standard defines a flexible architecture that enables many implementations as technology changes
- Work on a new 40 Gigabit Ethernet standard has already started in the IEEE
  - 4 x 10 Gb/s electrical interface with a 1 x 40 Gb/s optical output over 2 km SMF
  - IEEE P802.3bg 40G Ethernet SMF Fibre PMD Task Force: http://www.ieee802.org/3/40GSMF/index.html
- Two new projects are expected to start in the IEEE later this year
  - 100 GbE backplane and short reach copper cable using 4 x 25 Gb/s electrical signaling
  - Lower cost 100 GbE 2 km SMF using 4 x 25 Gb/s optical signaling and new QSFP2 media
- Strong interest in the operator community to support a low cost non-standard 100 GbE CFP that uses 10 x 10 Gb/s signaling over 2 4 km SMF

# Second Generation Technology and Beyond

- The second generation of 100 Gigabit Ethernet will use 4 x 25 Gb/s interfaces
  - The OIF is doing fundamental work on 28 Gb/s electrical signaling which will make newer interfaces and optics modules possible (CEI-28G-SR/CEI-28G-VSR)
  - The 4 x 25 Gb/s electrical interface is being defined in the OIF and should be finished in April 2011
  - A 4 x 25 Gb/s 100 GbE MMF interface will need to be defined in the IEEE and might complete in 2012/2013
- The need for Terabit Ethernet is already being discussed in the industry and by network operators
  - Terabit Ethernet is currently technically and economically unfeasible
  - 400 Gb/s Ethernet is a possible choice in several years by expanding 4 x 25 Gb/s to 16 x 25 Gb/s signaling
- Ethernet will continue to evolve as network and bandwidth requirements change to meet scale and cost requirements
  - 100 Gb/s backplane, duplex MMF, WDM MMF, 40 km 40 Gb/s, 4 x 25 Gb/s MMF and copper form factors

# What You Should Expect This Year

- Lots of announcements from vendors... already started in April at Interop
- Shipping interfaces by end of 2010/beginning of 2011
- First generation technology will be expensive and low density compared to current 10 GbE prices
  - Technology cost choices were chosen so 100 GbE will be cheaper than 10 x 10 GbE as the industry matures
  - Initially an application for early adopters
  - In the near term, n x 10 GbE LAG may be more cost effective for you
  - Terabit router architectures and higher speed interfaces make 10 GbE denser and cheaper
- Consider the whole cost of a link when comparing prices of n x 10 GbE LAG vs 40 or 100 GbE
  - Router line cards, ports and optics
  - Optical and transport gear
  - Fiber
  - Provisioning, management and troubleshooting

## Ethernet Average Selling Price (ASP) Trends



- Based on historical GbE and 10 GbE prices, we expect 40 GbE and 100 GbE prices to fall significantly in 2011/2012
  - Optics and component costs are initially significantly higher
  - Volume production and 2nd generation technology will increase density and lower prices

#### **References and More Information**

• IEEE P802.3ba 40Gb/s and 100Gb/s Ethernet Task Force public area:

http://www.ieee802.org/3/ba/public/

Technology overview white paper (no product pitches):

http://www.brocade.com/forms/getFile?p=documents/ white\_papers/40\_100\_GbE\_Are\_Here\_WP.pdf

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# IEEE 802.3az: Energy Efficient Ethernet (EEE) Overview

- Defines a mechanism in Ethernet chips to reduce power consumption during periods of low link utilization
- New protocol to coordinate transitions of speeds/power consumption levels between NICs and switches
  - Transmit at the fastest link speed available that is the most energy efficient (Joules/bit)
  - Twisted pair cabling
    - Fast Ethernet (100BASE-TX)
    - Gigabit Ethernet (1000BASE-T)
    - 10 Gigabit Ethernet (10GBASE-T)
  - Backplane
    - Gigabit Ethernet (1000BASE-KX)
    - 10 Gigabit Ethernet (10GBASE-KX4, 10GBASE-KR)
- Standard approved September 30 2010 (802.3az-2010), products 201?



#### Single-port PCIe 10/100/1000 Mb/s Controller (MAC plus PHY)



Source: Intel, Intel® 82573L Gigabit Ethernet Controller, 130 nm "Idle" = no traffic

"Active" = bi-directional, line-rate traffic

# IEEE 802.3az: Energy Efficient Ethernet (EEE) Operation



Source: Intel, Configuration: Traffic profile = "Trace\_VOIP\_\*.txt", low-power idle initialization wait = 10 ms, sleep time = 1 ms, wake time = 10 ms

# IEEE 802.3az: Energy Efficient Ethernet (EEE) Operation

- Everything works as normal
  - Link status stays up during transitions
  - No frames in transit are dropped or corrupted during power consumption level transitions
  - The transition time is transparent to upper layer protocols and applications
- When there is no data to send reduce power by turning off unused circuits
- LLDP extensions and auto-negotiation is used for EEE configuration and negotiation

### **References and More Information**

- Introduction to Energy Efficient Ethernet:
  - (lots of information and background on link utilization and power consumption)
  - http://www.ieee802.org/802\_tutorials/07-July/IEEE-tutorialenergy-efficient-ethernet.pdf
- IEEE P802.3az Energy Efficient Ethernet Task Force public area:

http://www.ieee802.org/3/az/public/

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# ITU-T G.8032 Ethernet Ring Protection Switching (ERPS)

- Automatic Protection Switching (APS) protocol and protection switching mechanism for Ethernet ring topologies with sub-50 ms failover capabilities
- Loop free Ethernet topology, no need for xSTP or proprietary ring protocols
- Protocol uses standard Ethernet bridging and OAM, no hardware changes required
- Ring failures detected in two ways
  - 802.1ag/Y.1731 OAM
  - Signal Fail (SF) messages to RPL owner
- G.8032v1 (June 2008)
  - Single ring
- G.8032v2 (July 2010)
  - Interconnecting rings
  - Optimizations and administrative enhancements
  - Multiple ERP instances on a ring



**RPL** – Ring Protection Link

## **References and More Information**

• ITU-T G.8032: Ethernet ring protection switching: http://www.itu.int/rec/T-REC-G.8032-201003-P/en

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#### **Carrier Ethernet Overview**

- Ethernet has become a standardized plug-and-play service offered to Enterprise and business users
- The Metro Ethernet Forum (MEF) has defined carriergrade attributes that distinguish "Carrier Ethernet Services" from the familiar LAN-based Ethernet services
- MPLS, MPLS-TP, PBB, and PBB-TE features and capabilities can be used to deliver Carrier Ethernet services

# MEF Carrier Ethernet Services Attributes

- Standardized Services
  - E-Line, E-LAN, and E-Tree services
- Scalability
  - Accommodate a wide variety of applications and the ability to scale bandwidth from 1 Mbps to 10 Gbps and beyond in small granular increments
- Reliability
  - Network detects and recovers from faults without impacting the service
- Quality of Service
  - Support a wide range of quality of service options
- Service Management
  - Monitor, diagnose, and centrally manage the network using carrier-class OAM tools

- MEF defines several services for hardware vendors, ISPs and customers to use as a common language
- Certifications are available for hardware and networks
- Ethernet Virtual Connection (EVC)
  - An association of two or more UNIs that limits the exchange of frames to UNIs in the Ethernet Virtual Connection





#### • E-Line

An Ethernet service type that is based on a point-to-point EVC



- Services
  - Ethernet Private Lines
    - Single UNI
    - Similar to a TDM circuit
  - Virtual Private Lines
    - Single UNI used for multiple virtual connections
    - Similar to Frame Relay or ATM

Definition and image reprinted with permission from the Metro Ethernet Forum (MEF)

- E-LAN
  - An Ethernet service type that is based on a multipoint-tomultipoint EVC



- Services
  - Multipoint L2 VPNs
  - Transparent LAN service

#### • E-Tree

• Services

 An Ethernet service type that is based on a rooted multipoint EVC



- Provides traffic separation between leaf endpoints
  - Root can send to any leaf
  - Leafs only communicate with the root

Definition and image reprinted with permission from the Metro Ethernet Forum (MEF)

### **MPLS Carrier Ethernet Services**

- Multi-Protocol Label Switching (MPLS) is a packet forwarding mechanism often referred to as a "Layer 2.5" protocol
- Leverages existing IP infrastructures and facilitates traffic engineering
- Enables multiservice transport of IP packets and Ethernet frames for L2 and L3 services
- Provides resiliency and QoS
- Stable, widely deployed, mature and proven
- Not optimized for transport models
  - Transport models will be supported with MPLS-TP extensions

Layer	Function
3	IP
"2.5"	MPLS
2	Ethernet, SONET/SDH, Frame Relay, ATM
1	Copper, Fiber, Wireless



- P Provider
- PE Provider Edge
- CE Customer Edge
- LSR Label Switch Router
- LER Label Edge Router
- LSP Label Switched Path

# **MPLS-TP Carrier Ethernet Services**

- Set of enhancements to a simplified version of MPLS to support traditional optical transport operational models
  - Connection-oriented connectivity
  - Manual provisioning and provisioning by network management
  - High level of protection and availability
  - Quality of Service (QoS)
  - Extensive OAM capabilities
- Uses the existing MPLS/PWE3 architecture, MPLS data plane, and GMPLS/PWE3 control
- Excludes traditional MPLS functions not required by transport models
- Adds path-based and in-band OAM protection mechanisms common in traditional transport technologies

#### MPLS vs. MPLS-TP

PHP LSP Merge ECMP LDP IP Forwarding

MPLS/PWE3 Architecture MPLS Forwarding GMPLS/PWE3 Control Plane Provisioning Protection QoS OAM

MPLS

MPLS-TP

### **PBB Carrier Ethernet Services**

- Provider Backbone Bridges (PBB) was developed to address the scalability limitations of the Provider Bridges (PB) standard and to add additional capabilities
- Adds a hierarchy to Ethernet bridging by encapsulating PB frames with a PBB header
- Supports over 16 million service instances
- Isolates SP and customer address spaces
- Security with customer/carrier separation
- When combined with VPLS, PBB increases VPLS scalability
- Relies on xSTP or G.8032 ERPS to determine the active topology



### **PBB-TE Carrier Ethernet Services**

- Provide Backbone Bridge Traffic Engineering (PBB-TE) allows carriers to provision engineered unidirectional Ethernet paths in a PBB network
- Traffic engineering and resiliency
- Fast protection switching, deterministic delivery
- Security with customer/carrier separation
- External management plane for operational simplicity
- Service and transport layer independence
  - Services inside the tunnel could be Ethernet, IP, VLL, or VPLS
- Doesn't integrate well with transport systems because it's designed for Ethernet



BCB – Backbone Core Bridge BEB – Backbone Edge Bridge

### **Carrier Ethernet Technology Summary**

	MPLS	MPLS-TP	PBB	PBB-TE
Network Services	Multiservice IP, L2 Carrier Ethernet and L3 VPNs Services	Transport-level Carrier Ethernet Services	L2 Metro and Aggregation Carrier Ethernet Services	Carrier Ethernet Services Over PBB Networks
Carrier Ethernet Services	E-Line (VLL) E-LAN (VPLS)	E-Line (VLL) E-LAN (VPLS)	E-Line E-LAN	E-Line
Standard Status	Mature IETF Standards	IETF Work in Progress	IEEE 802.1ah (2008)	IEEE 802.1Qay (2009)
Widely Implemented	$\checkmark$	Not Yet	Limited	Limited
Widely Deployed	$\checkmark$	Not Yet	$\checkmark$	×
Market Trend	$\checkmark$	$\checkmark$	×	×
Future Development	Point-to-multipoint LSP Extensions Extensions to OAM TE for Multi-area/ Multi-AS	Framework OAM	×	×

# **References and More Information**

• Metro Ethernet Forum:

http://metroethernetforum.org/InformationCenter

• MPLS IETF Working Group:

http://www.ietf.org/dyn/wg/charter/mpls-charter.html

MPLS-TP IETF Working Group:

http://www.ietf.org/dyn/wg/charter/mpls-charter.html

• PBB: IEEE 802.1ah – Provider Backbone Bridging

http://www.ieee802.org/1/pages/802.1ah.html

• PBB-TE: IEEE 802.1Qay – Provider Backbone Bridge Traffic Engineering

http://www.ieee802.org/1/pages/802.1ay.html

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# **Drivers for Ethernet OAM**

- Essential component for delivering Carrier Ethernet services
  - Fault detection and isolation at every level
  - Performance monitoring and SLA verification
  - Carrier requirements from TDM and OTN technologies



- Standards based end-toend OAM at every level
- Comprehensive Ethernet, MPLS and IP OAM tools

### **OAM Protocols for Carrier Ethernet**



OAM Protocol	Benefits
IEEE 802.3ah: Ethernet in the First Mile (EFM)	Ethernet Link OAM
IEEE 802.1ag: Connectivity Fault Management (CFM)	End-to-end Service OAM
ITU-T Y.1731: OAM functions and mechanisms for Ethernet based networks	End-to-end Service OAM and Performance Management
IP/MPLS Ping and Traceroute	IP/MPLS Core OAM

# IEEE 802.3ah: Ethernet in the First Mile (EFM)

- OAM for point-to-point link connectivity monitoring and troubleshooting
- Key features
  - Discovers OAM support and capabilities per device
  - Link monitoring to detect failed links and errors
  - Fault signaling to other device on the link
  - Remote loopback
- Defined as "EFM" but topology independent
  - Monitors and manages both customer and backbone links
  - Can be used on G.8032 rings



# IEEE 802.1ag: Connectivity Fault Management (CFM)

- OAM for end-to-end service connectivity monitoring and verification
- Supports up to seven Maintenance Associations (MAs) on operational or contractual network boundaries over a bridged or PBB network
  - · Customer, local service provider, backbone operator
  - Allows each MA to be managed end-to-end within the domain
  - Also manages the end-to-end customer service
- Key features
  - Continuity Check Messages for fault detection and notification
  - Remote loopback
  - Traceroute
  - PDUs follow the active topology and are protocol-independent (G.8032, STP, MSTP, RSTP, etc)
- Monitors the following types of endpoints and services
  - Layer 2 VLANs
  - Layer 3 interfaces
  - VPLS endpoints
  - VLL endpoints

# ITU-T Y.1731: OAM Functions and Mechanisms for Ethernet-based Networks

- OAM for end-to-end service connectivity monitoring, verification and measurement
- Similar functionality as 802.1ag CFM but adds measurement capabilities
- Supports high precision on-demand measurement of round-trip parameters
  - Frame Delay (FD)
  - Frame Delay Variation (FDV)
  - Hardware-based time stamping mechanism
  - Measurements with millisecond granularity
- Enables SLA monitoring and verification

### **References and More Information**

- EFM: IEEE 802.3ah Ethernet in the First Mile
  - http://www.ieee802.org/3/ah/index.html
- CFM: IEEE 802.1ag Connectivity Fault Management
  - http://www.ieee802.org/1/pages/802.1ag.html
- ITU-T Y.1731: OAM functions and mechanisms for Ethernet based networks
  - http://www.itu.int/rec/T-REC-Y.1731/enl

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# Motivation for DCB/CEE/SPF Fabrics

- Consolidation of LAN and SAN data center fabrics as a solution to simplify and operate networks at a lower cost
- Data Center Bridging (DCB)/Converged Enhanced Ethernet (CEE) and Shortest Path Forwarding are technologies developed to enable converged and lossless Ethernet data center fabrics



Convergence of LAN and SAN Traffic over Ethernet

#### **Converged Data Center Network**



# Data Center Bridging (DCB) Overview

- Extends Ethernet so it's capable of carrying LAN and SAN traffic over a converged network
- Adds mechanisms from Fibre Channel (FC) networking to make Ethernet lossless and capable of meeting stringent storage network requirements
  - Storage network protocols get really unhappy and grumpy with packet loss and latency > 2 ms
- Fibre Channel over Ethernet (FCoE) encapsulates the entire FC frame for transport over lossless Ethernet links
- Three new IEEE enhancements to Ethernet and DCBX LLDP extensions for DCB
- Product availability: 1<sup>st</sup> generation 2009/2010, 2<sup>nd</sup> generation 2010/2011



# IEEE 802.1Qbb: Priority-based Flow Control (PFC)

- Eight priorities for flow control based on the 802.1Q tag
- Enables controlling individual data flows on shared lossless links
- Allows FC storage traffic encapsulated in FCoE frames to receive lossless service from a link that is shared with other LAN traffic



# IEEE 802.1Qaz: Enhanced Transmission Selection (ETS)

- Capability to group each type of data flow, such as storage or networking into traffic class groups
- Manage bandwidth on the Ethernet link by allocating percentages of the available bandwidth to each of the groups
- Allows traffic from the different groups to receive their target service rate (8 Gbps for storage and 2 Gbps for LAN)
- Provides quality of service to applications

Priority Group 1: Storage 60%	
Priority Group 2: LAN 30%	
Priority Group 3: IPC 10%	

# IEEE 802.1Qau: Congestion Notification (CN)

- An end-to-end congestion management mechanism that enables throttling of traffic at the end stations
- Switches send a congestion notification message to the end station to reduce its transmission
- End stations discover when congestion eases so that they may resume transmissions at higher rates



### **References and More Information**

- FCoE: INCITS T11 FC-BB-5 <u>http://www.t11.org/fcoe</u>
- IEEE Data Center Bridging Task Group: <u>http://www.ieee802.org/1/pages/dcbridges.html</u>
- CN: IEEE 802.1Qau Congestion Notification
  <a href="http://www.ieee802.org/1/pages/802.1au.html">http://www.ieee802.org/1/pages/802.1au.html</a>
- ETS: IEEE 802.1Qaz Enhanced Transmission Selection
  <a href="http://www.ieee802.org/1/pages/802.1az.html">http://www.ieee802.org/1/pages/802.1az.html</a>
- PFC: IEEE 802.1Qbb Priority-based Flow Control http://www.ieee802.org/1/pages/802.1bb.html
- Data Center Bridging Capabilities Exchange Protocol (DCBX) for LLDP: <u>http://download.intel.com/technology/eedc/dcb\_cep\_spec.pdf</u>

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#### Data Center Network with xSTP Layer 2 Single Path

- All alternate paths are blocked
  - Bandwidth limited to unique paths or MSTP engineering
  - No active-active or fault tolerance ability
- Inefficient use of available links reduces aggregate bandwidth
- The Ethernet header does not contain a hop count (or TTL) field
- Recovering from link or node failure takes too long for converged DCB networks
  - Storage traffic may be flooded during reconvergence



#### Data Center Network with Shortest Path Forwarding Layer 2 Multipath

- New protocols for shortest path frame routing protocol for Layer 2 networks
- Provide a standards-based multipath alternative to networks running \*STP or other proprietary protocols
- Enable multiple L2 paths via load sharing among paths with faster responses to failures
- Reclaim network bandwidth and improves
  utilization
- Backward-compatible with existing infrastructures
- Two emerging standards
  - IETF TRILL (Transparent Interconnection of Lots of Links)
  - IEEE 802.1aq Shortest Path Bridging (SPB)



# TRILL (Transparent Interconnection of Lots of Links)

- TRILL is a new shortest path frame routing protocol for Layer 2 networks developed in the IETF
- Provides a standards-based multipath alternative to networks running \*STP or other proprietary protocols
- Data plane uses TRILL forwarding
  - TRILL header and frame encapsulate L2 payload frames
  - Real L3 protocol with a hop count, L3 addresses, MAC addresses change each hop
- Control plane uses an existing link-state routing protocol
  - IS-IS TLVs specified by the IETF, FSPF works just as well
  - Used for shortest path calculations



Radia Perlman... doing Something Very Interesting Photo courtesy of Peter Lothberg

# **TRILL Status**

- "Rbridges: Base Protocol Specification" I-D is in the RFC editor queue
- Waiting on "TRILL Use of IS-IS" I-D to be finished
  - Still has to go through WG and IETF Last Call
- Both expected to be published as RFCs this year
- Analysts expect shipping implementations in the first half of 2011
- Next steps
  - MIBs
  - OAM

# IEEE 802.1aq: Shortest Path Bridging (SPB)

- Layer 2 frame routing protocol developed by the IEEE as a new control plane for Q-in-Q and MAC-in-MAC
- Data plane uses L2 forwarding built on existing IEEE Ethernet and OAM features
  - Backbone L2 frame encapsulates L2 payload frames
  - SPBV 802.1ad (PB/Q-in-Q)
  - SPBM 802.1ah (PBB/MAC-in-MAC)
  - L2 protocol with no hop count, frames are unchanged during forwarding
- Control plane uses IS-IS
  - Used for shortest path calculations
- Limited interest from vendors or operators to implement widely, major vendor support is now for TRILL
- Current Draft 3.0 (June 2010) is making steady progress
- Expect final standard middle to late 2011

# Shortest Path Forwarding Technology Summary

	TRILL	SPB
Target Application	Data Center	Data Center Metro/ L2VPN
Data Plane	TRILL Encapsulation	L2 Bridging (Q-in-Q or MAC-in-MAC)
Control Plane	IS-IS (or FSPF)	IS-IS
Loop Mitigation	Hop Count	RPF Check
L2 ECMP	$\checkmark$	$\checkmark$
Native Multicast	$\checkmark$	$\checkmark$
DCB Integration	$\checkmark$	$\checkmark$
Widely Supported/ Market Trend	$\checkmark$	×
Standard Expected	By End of 2010	Middle to Late 2011

## **References and More Information**

#### • IETF TRILL WG:

- <u>http://datatracker.ietf.org/wg/trill/charter/</u>
- Rbridges: Base Protocol Specification (draft-ietf-trill-rbridge-protocol-16)
  - http://datatracker.ietf.org/doc/draft-ietf-trill-rbridge-protocol/
- TRILL Use of IS-IS (draft-ietf-isis-trill-01):
  - <u>http://datatracker.ietf.org/doc/draft-ietf-isis-trill/</u>
- RBridges and the IETF TRILL Protocol (NANOG48):
  - <u>http://www.nanog.org/meetings/nanog48/abstracts.php?</u> <u>pt=MTUwNCZuYW5vZzQ4&nm=nanog48</u>
- Shortest Path Bridging IEEE 802.1aq (NANOG49):
  - <u>http://www.nanog.org/meetings/nanog49/abstracts.php?</u> <u>pt=MTYwNSZuYW5vZzQ5&nm=nanog49</u>
- SPB: IEEE 802.1aq Shortest Path Bridging
  - http://www.ieee802.org/1/pages/802.1aq.html



#### Questions?

