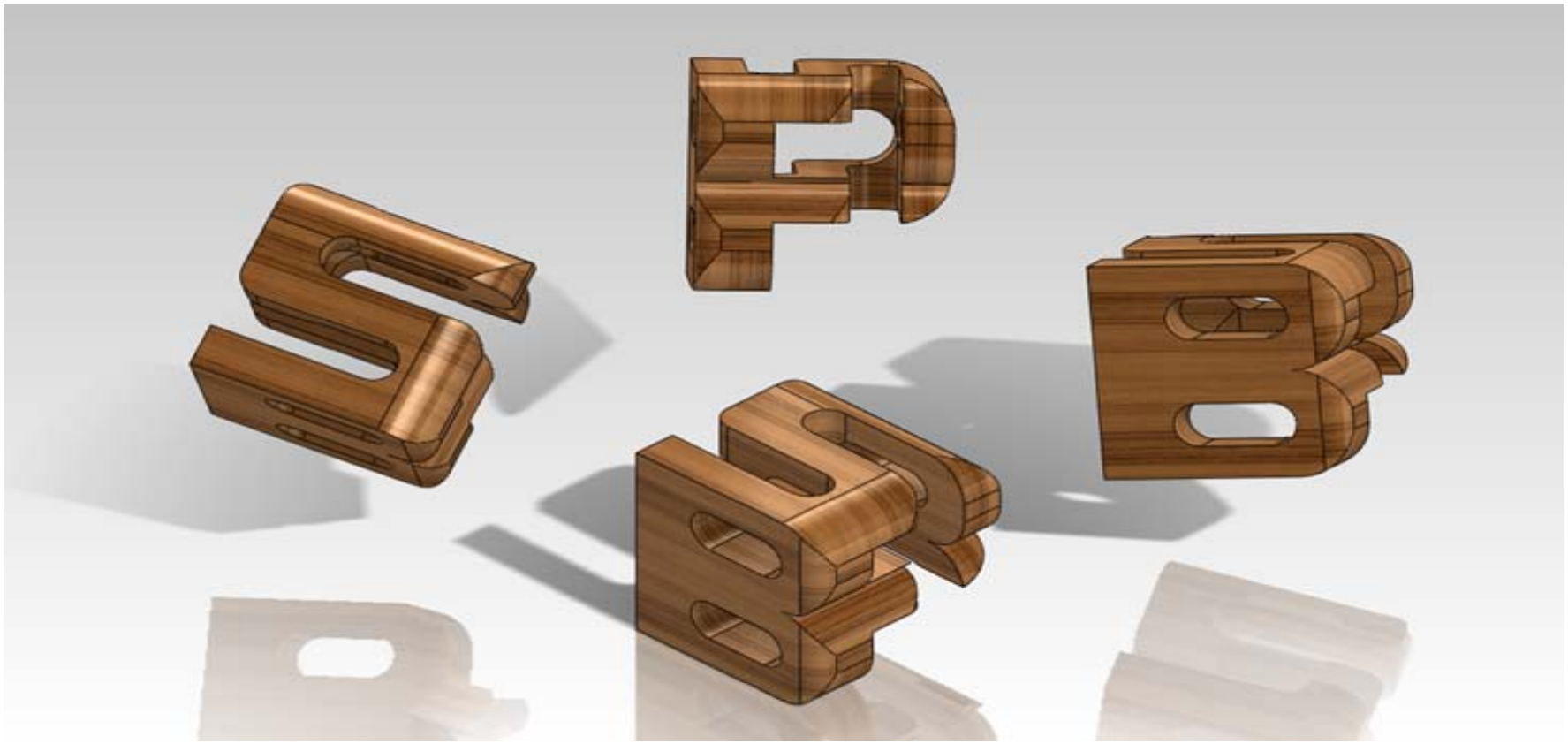

Introduction to Shortest Path Bridging IEEE 802.1aq

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October 12

AGENDA

- Introduction
- What is SPB
- SPB Details
- SPB Applications/Futures
- References

Acknowledgements

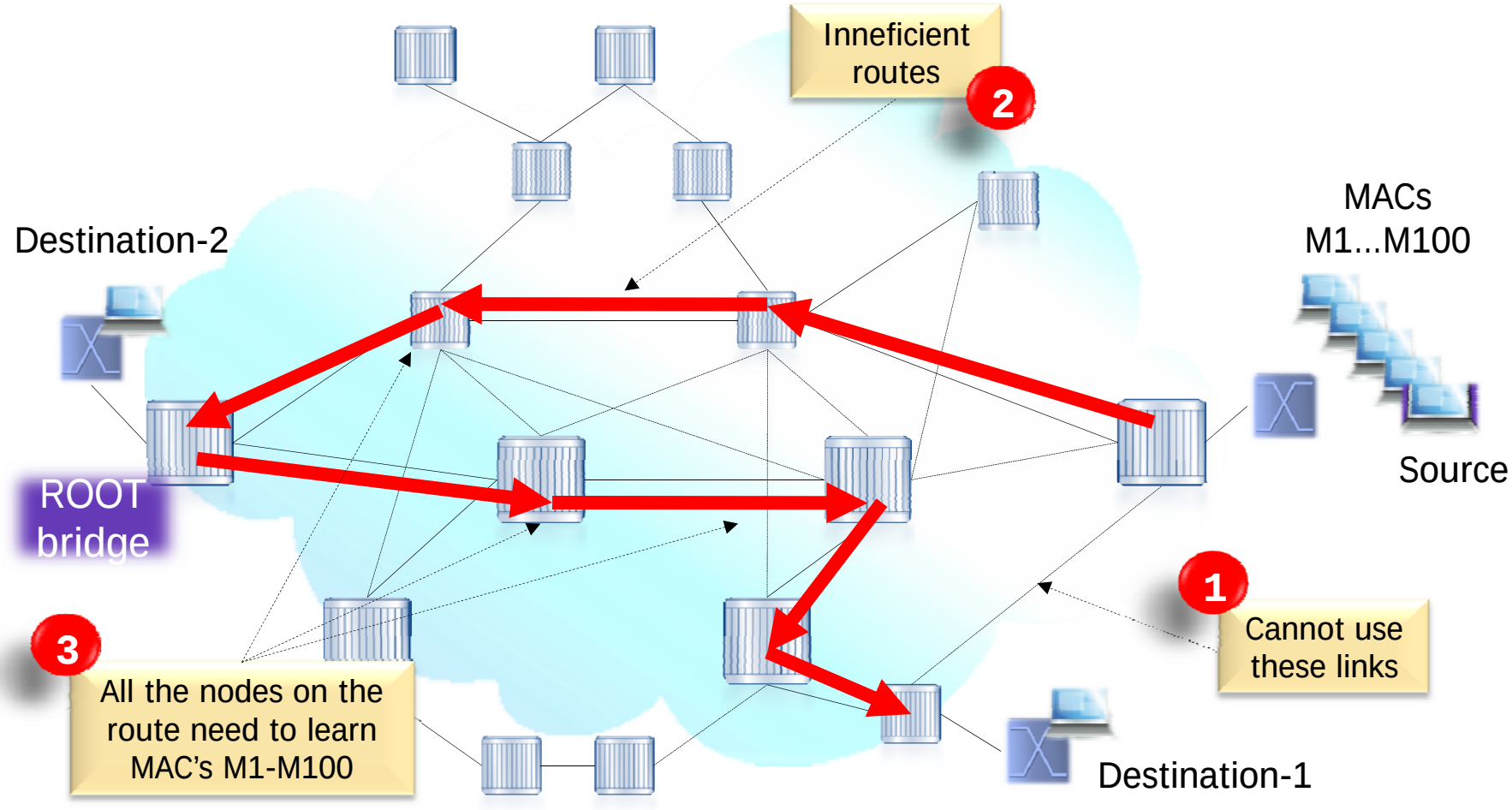
- SPB was a large Project in IEEE 802 over a number of years ~6. One of the longer running 802. projects.
- Many people contributed from many companies to get the work of standardization done.
- This presentation uses some material from:
  - Peter Ashwood-Smith Huawei[peter.ashwoodsmith@huawei.com]
- Other notable contributors to the project were:
  - Mick Seaman, Janos Farkas , Nigel Bragg, Paul Unbehagen, David Allan

Ethernet Network Challenges

- Layer 2 networks that scale.
- Use of arbitrary mesh topologies.
- Use of (multiple) shortest paths.
- Efficient broadcast/multicast routing and replication points.
- Avoid address learning by tandem devices.
- Get recovery times into 100's of millisecond range for larger topologies.
- Good scaling without loops.
- Allow creation of very many logical L2 topologies (subnets) of arbitrary span.
- Maintain all L2 properties within the logical L2 topologies
- Reuse all existing Ethernet OA&M 802.1ag/Y.1731

But Moore's law and technology trends are on our side!

The Problem:
Scaling Native Ethernet (Spanning Tree)

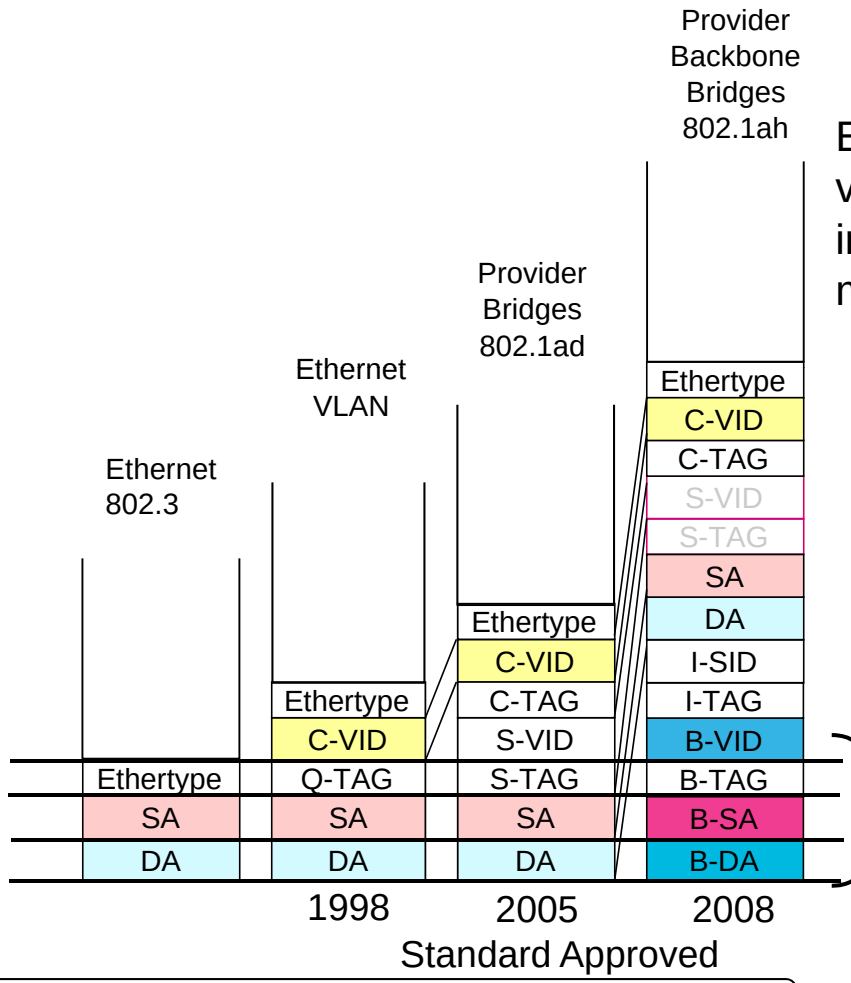


The IEEE 802.1 Solution: SPB

- SPB is a Link State Control protocol for Ethernet
- Specifically an instance of IS-IS protocol for exchanging Bridge Properties:
  - SystemIDs + Priority = Bridge Identifiers
  - Link Attributes (Metrics)
  - Backbone MAC addresses & Multicast I-SIDs (SPBM)
  - SPB Has Two Modes
    - SPB for MACs (SPBM) for PBB or MAC in MAC (MAC Learning on the Edge)
    - SPB for VIDs (SPBV) for QinQ of VLAN bridges. (MAC Learning)
- All Ethernet data planes existed prior to SPB (next Chart)
- What SPB provides Topology for:
  - Shortest path Unicast/Multicast
  - Efficient Multicast replication

What are Ethernet data planes?

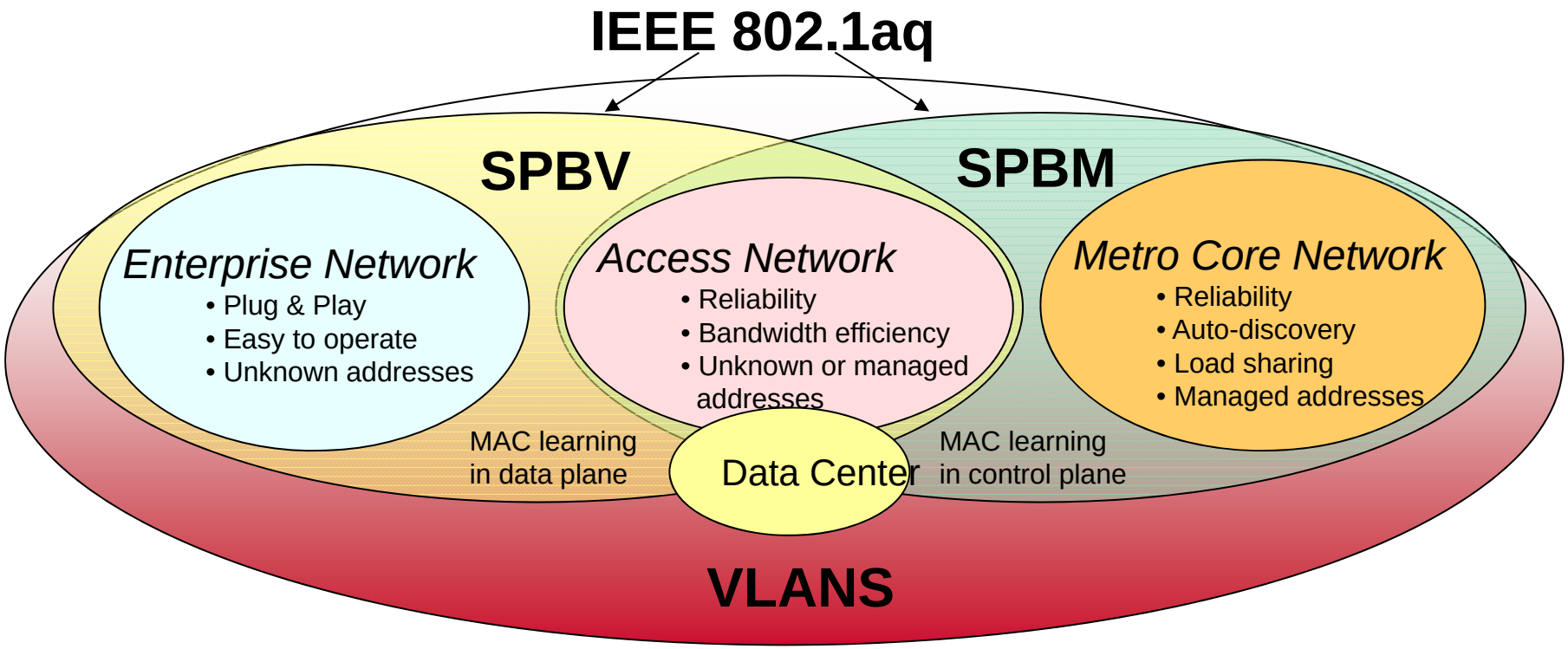
SA = Source MAC address
DA = Destination MAC address
VID = VLAN ID
C-VID = Customer VID
S-VID = Service VID
I-SID = Service ID
B-VID = Backbone VID
B-DA = Backbone DA
B-SA = Backbone SA



Encapsulation for virtualization is important in many networks

It is a very good Data Plane!

Pushing Scale in Ethernet Single Domain networks



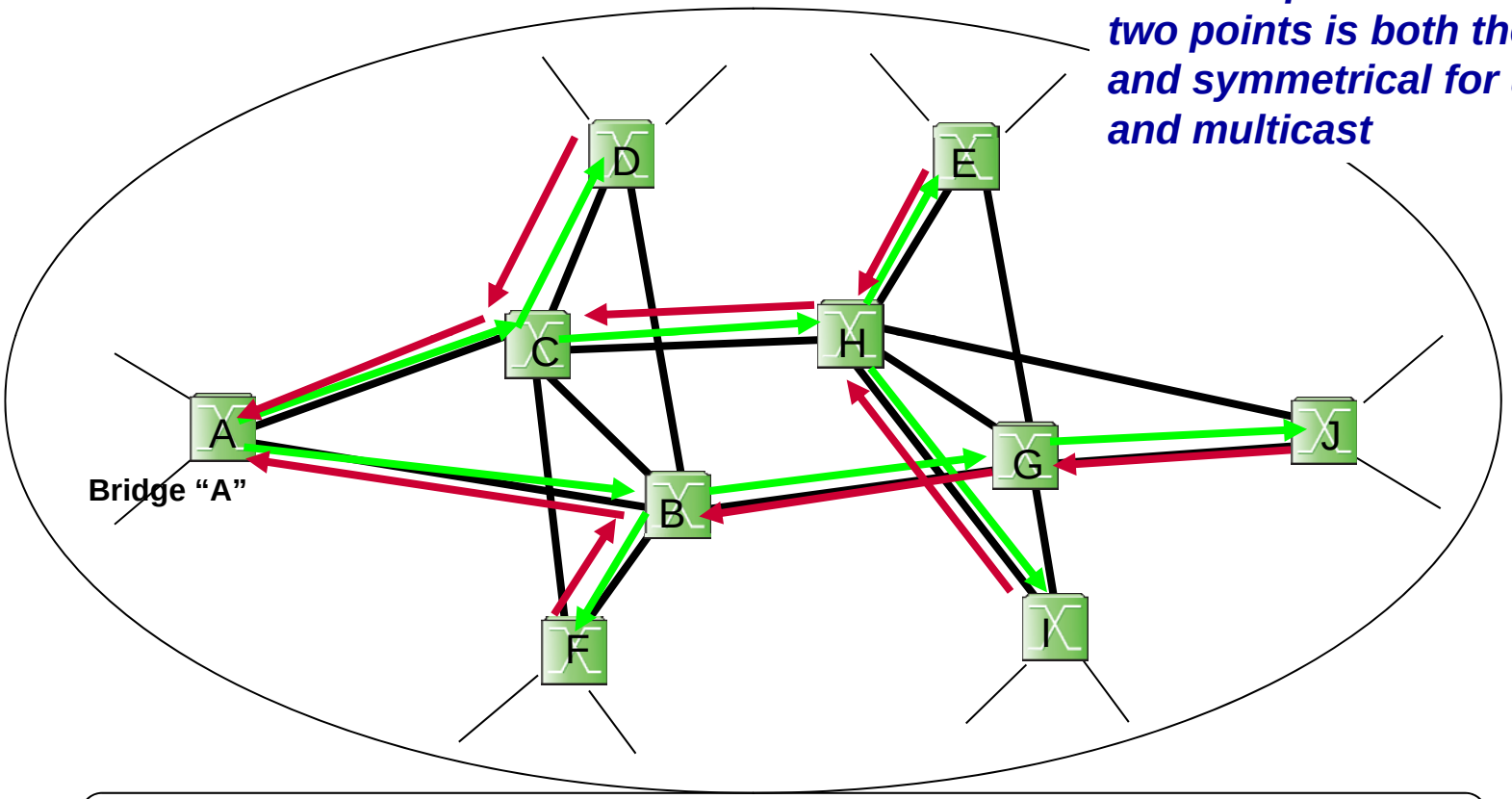
Using Scale today of IS-IS (one SPBM Domain of 1000 nodes)
Easily address Millions of devices
Why? Orthogonal Address, Service and Topology

Properties of the Ethernet Data Plane

- Congruency
  - Multicast and Unicast
- Symmetry
  - Forward path and Reverse Path
- Determinism
  - Allows parallel computation of paths
- MAC Learning/Flood Containment
  - Plug and play operations
  - Contain MAC Learning in SPBM BMACs distributed, Edge learning only
- OAM Capable
  - Congruency, Determinism, Symmetry enable CCM, LBM, LTM, performance etc

Congruency & Symmetry

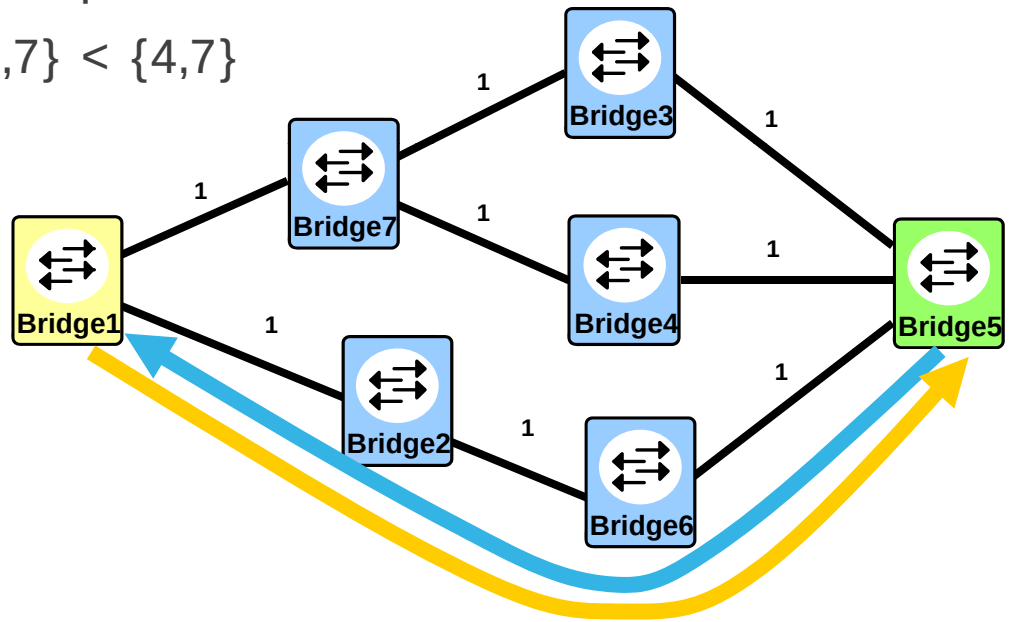
Shortest path between any two points is both the same and symmetrical for unicast and multicast



Same Forward and Reverse Shortest Path
Learning SPBV, OAM, Frame Ordering

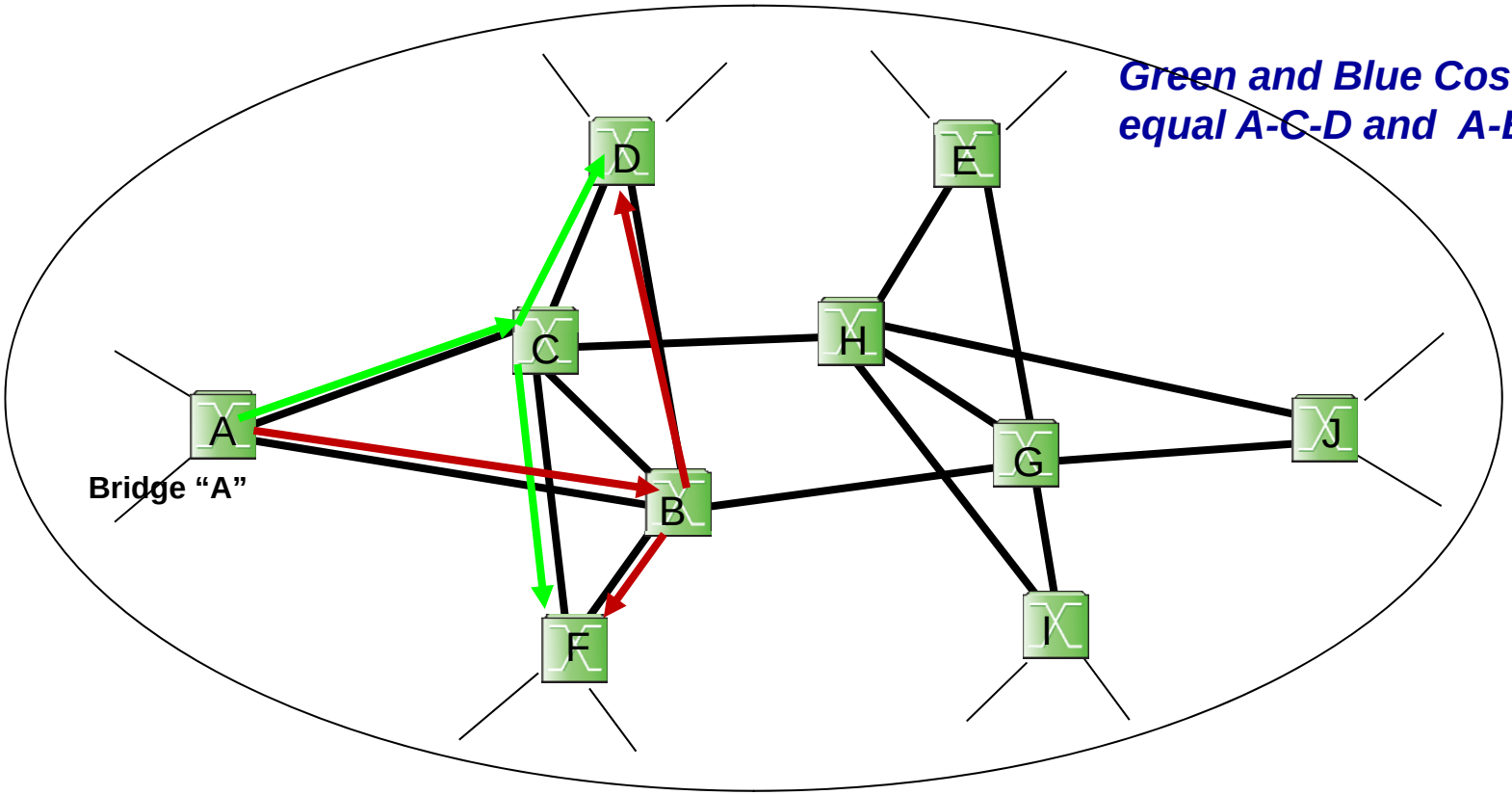
Implementation of Congruency & Symmetry

- Tie-breaking extension to Dijkstra for the case of equal cost multiple paths
  - Sorted List of transit node IDs comprising a path are unique/deterministic. Ranking them produce deterministic default winner.
  - {2,6} < {3,7} < {4,7}



- Same algorithm is used both for unicast and multicast

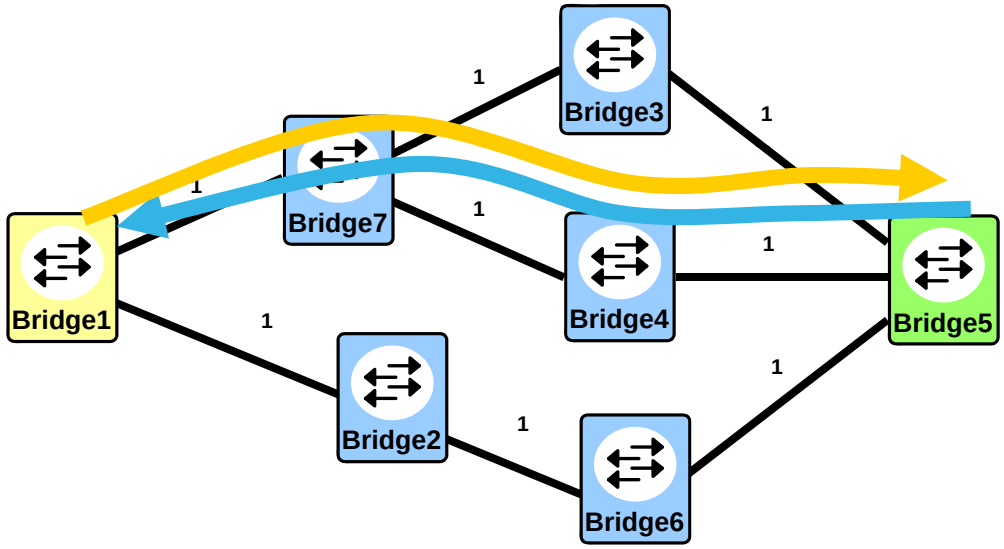
Equal Cost Trees (ECTs)



Optional Multipath Load Balancing different services

Implementation of ECTs

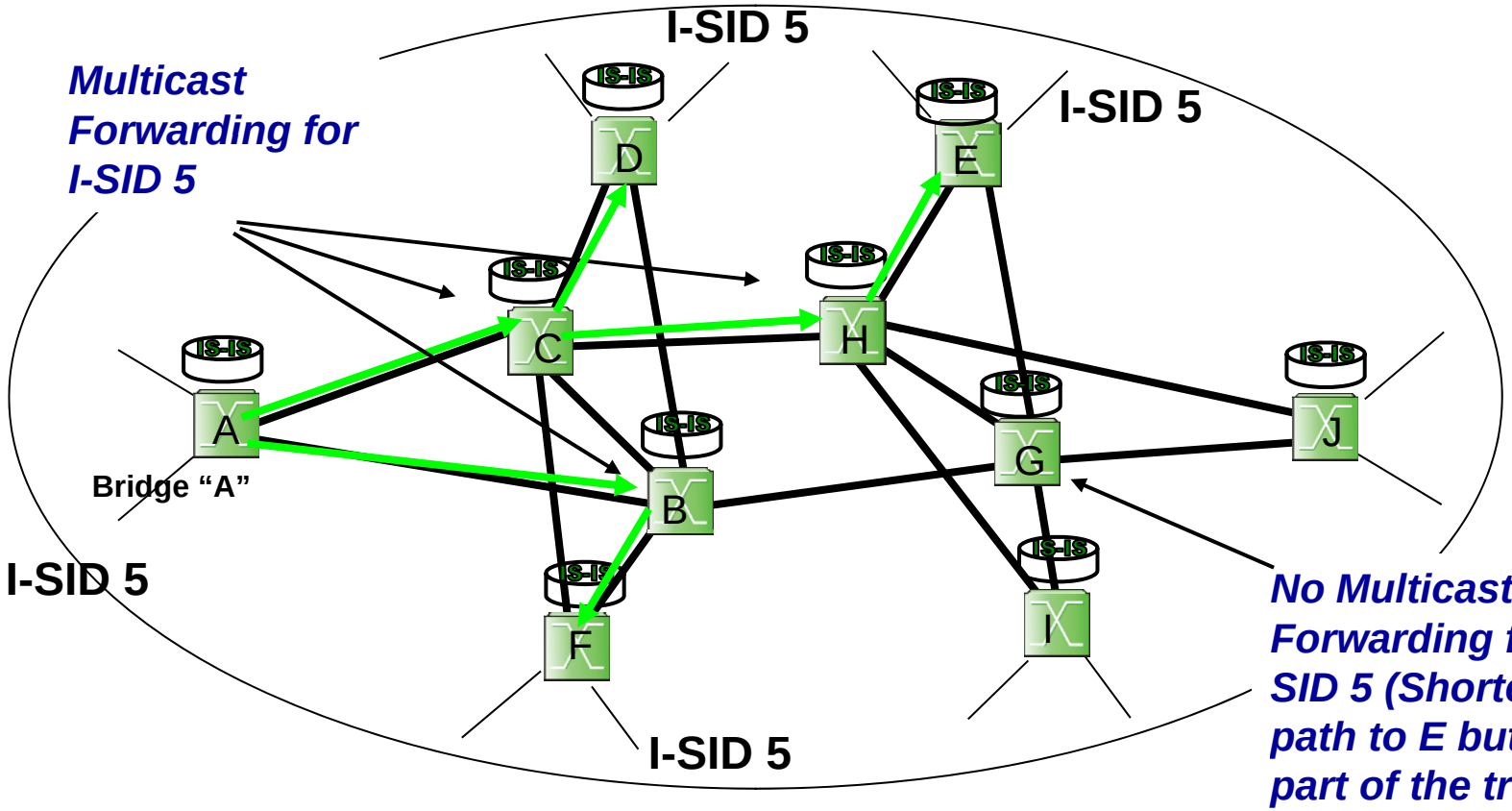
- 16 trees are created by applying the previous algorithm AFTER XORing BridgeID's with 16 different bit-masks.
- Example XORing with 0xff...ff (invert) selects largest ranked path so {~7,~4} wins..



	MASKS | B-VID
Low →	0x00
	0x11
	0x22
	0x33
	0x44
	0x55
	0x66
	0x77
	0x88
	0x99
	0xAA
	0xBB
	0xCC
	0xDD
	0xEE
High →	0xFF

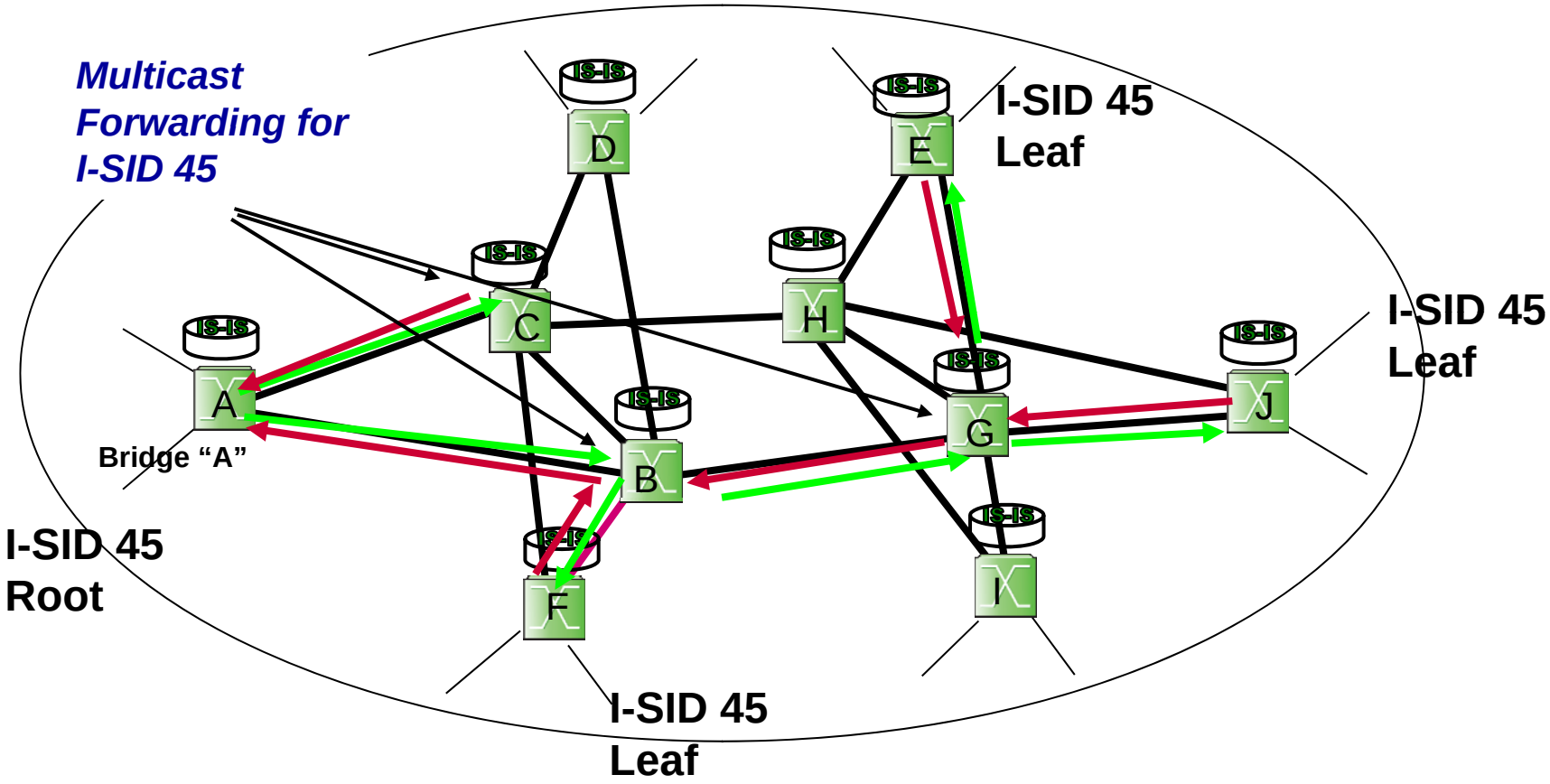
- Each mask is assigned to a B-VID (SPBM mode)

SPBM Multicast Groups



I-SIDs define efficient subsets

SPBM Multicast P2MP



E-TREE I-SIDs Root to/From Leaf only

SPBM Multicast Addresses
The SPBM Trifecta

- By constructing local IEEE Multicast Addresses the Control Plane has complete flexibility to build multicast trees.
- Computation, Source Identification, Service Identification

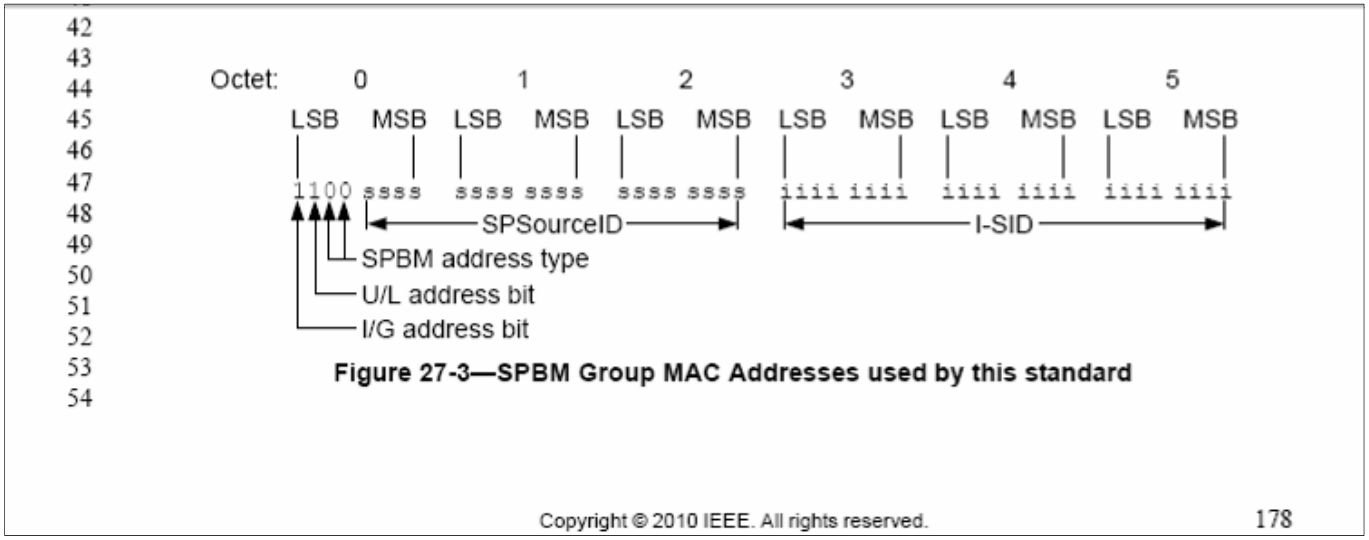


Figure 27-3—SPBM Group MAC Addresses used by this standard

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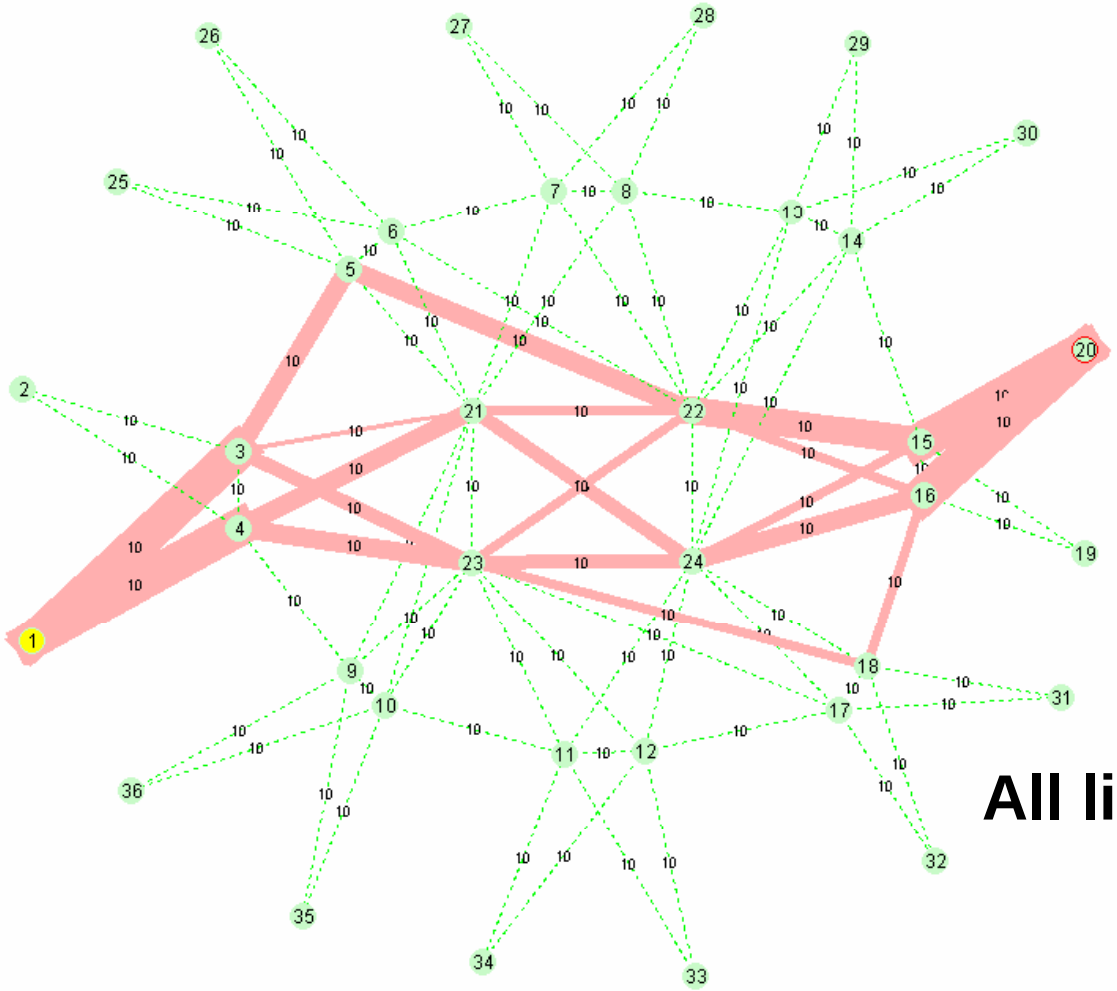
Loop Prevention

- Loop Prevention (Not new)
  - Policy : Loop Free by never allowing a loop to form
  - “Never forward a Frame unless the neighbor node has agreed to accept it”
  - Mechanism: Don’t populate an FDB entry until you synchronize with next-hop neighbor.
- Loop Mitigation (New for Ethernet)
  - Policy: Discard potential looping frames
  - “Never accept a Frame from a neighbor node that you do not expect”
  - Mechanism: Ingress check. Source DA/VID must be expected. Local Policy.
  - Loop Prevention is sufficient, but Loop Mitigation is faster during changes
  - Loop Prevention for Multicast and Loop Mitigation for Multicast and Unicast

Load Sharing - Visually



All links usable

Slide Courtesy of Peter Ashwood-Smith
Huawei

Applications

- Spanning Tree Protocol replacement in native Ethernet networks
- Data Center or layer-2 Internet Exchange Point
  - Allows the creation of a large and scalable layer-2 fabric in the DC where all the links are used (active/active topologies) and VM/servers/routers can freely move anywhere
- Layer-2 VPNs transport
  - Enhances scalability and flexibility for layer-2 VPNs
  - All the MEF services are supported: ELINE, ELAN, ETREE*

Is SPB Real ?

- SPBM Data path (PBB) and OA&M already wide spread use.
- Multiple Vendors shipping product, Alcatel-Lucent, Avaya

INTERWORKING:

- Three Inter-working events. Last one June 27 2011 : Huawei (host), Alcatel-Lucent, Avaya, Solana, Spirent

BASE STANDARDS:

- IETF:
  - RFC 6329.
- IEEE:
  - IEEE 802.1aq Published June 2012

SPBM Futures

- 802.1Qpb Equal Cost Multiple Path
  - Some Ethernet networks have many paths (Fat Tree, Dense Mesh etc.)
  - ECMP enables per hop load balancing
  - Shared Trees for multicast
    - Reduces multicast state
    - Enable ECMP for multicast on per Tree Basis
  - OAM Enhancements
    - Loss of Symmetry and Congruency needs OAM enhancements to maintain OAM capability.
  - Data Plane Enabler
    - New TAG with Flow ID and TTL.
- Traffic Engineering? 802.1 AVB group interest

References

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- RFC 6329 “IS-IS Extensions Supporting IEEE 802.1aq Shortest Path Bridging” http://datatracker.ietf.org/doc/rfc6329/
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- “Shortest Path Bridging – Efficient Control of Larger Ethernet Networks” : IEEE Communications Magazine – Oct 2010
- “Provider Link State Bridging” : IEEE Communications Magazine V46/N9– Sept 2008
- http://ieee802.org/1/files/public/docs2011/aq-ashwood-smith-spbm-3rd-interop-0718-v01.pdf

Thank You

Questions?

Glossary

- B-MAC Backbone MAC
- BEB Backbone Edge Bridge
- BCB Backbone Core Bridge
- CCM Continuity Check Message
- C-VID Customer VID
- CFM Connectivity Fault Management 802.1ag
- ELINE Ethernet Point to Point Service
- ELAN Ethernet LAN Service
- ETREE Ethernet Hub and Spoke Service
- FDB Filtering Data Base
- I-SID (802.1ah) Service Identifier
- IS-IS Intermediate System to Intermediate System (IGP)
- LAN Local Area Network
- LTM Link Trace Message
- LBM Loop back Message
- MAC Media Access Control
- MACinMAC see PBB
- OAM Operations, Administration and Maintenance
- P2MP Point to Multipoint
- PB Provider Bridges IEEE 802.1ad
- PBB Provider Backbone Bridging IEEE 802.1ah
- QinQ see PB
- S-VID Service VID
- SPB Shortest Path Bridging IEEE 802.1aq
- SPBM Shortest Path Bridging MAC
- SPBV Shortest Path Bridging VID
- SPT Shortest Path Tree
- STP Spanning tree protocol
- RSTP Rapid Spanning tree protocol
- TTL Time To Live
- VID VLAN Identifier
- VLAN Virtual LAN