Shortest Path Bridging IEEE 802.1aq Overview

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Monday, 12 July 2010

Abstract

802.1aq Shortest Path Bridging is being standardized by the IEEE as an evolution of the various spanning tree protocols. 802.1aq allows for true shortest path Ethernet forwarding, multiple equal cost trees, much larger native Ethernet topologies, faster convergence, full leverage of the IEEE 802.1 data plane, head end and/or transit multicast replication, all while supporting the full suit of 802.1 OA&M. Additionally combined with PBB, capabilities such as single point provisioning for logical membership (E-LINE, E-LAN, E-TREE) and abstraction of attached device MAC addresses from the transit devices by encapsulation are provided.

Outline

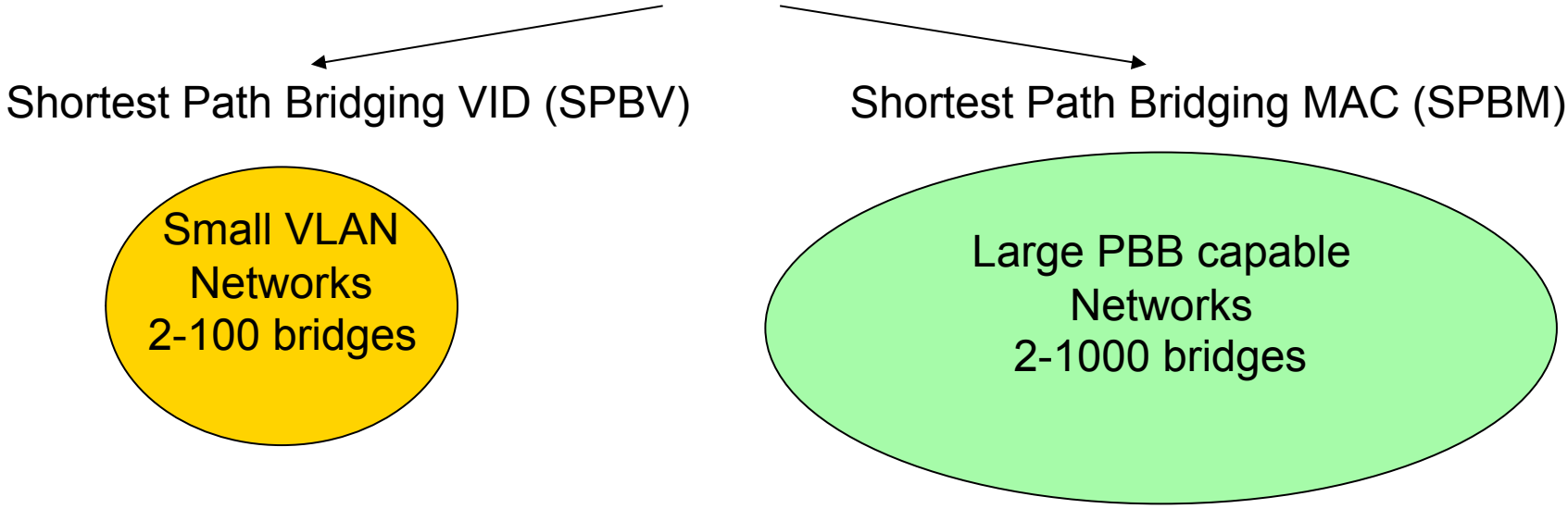
1. Introduction
2. Requirements
3. Features/Mechanisms
4. Data Center Application
5. References
6. Glossary

Introduction

- Spanning Tree Protocol has been around for over 25 years
- Interest in Shortest Path Trees (SPT) has increased over the last few years
- SPT technologies are being standardized in the IEEE and IETF
- Why now? From an IEEE 802.1 Ethernet Perspective:
  - New Provider Backbone Bridging (MAC in MAC) encapsulation
  - New Ethernet Connectivity Fault Management (CFM or OAM)
  - Need to build larger bridged networks
  - Need to support arbitrary network topologies
  - Computing prices falling, processing capabilities increasing
  - Scalability of all networks not just Ethernet
  - More responsive an resilient networks

Applicability

Shortest Path Bridging
IEEE 802.1aq



Plug and play
Efficient
Low delay
Backwards Compatible

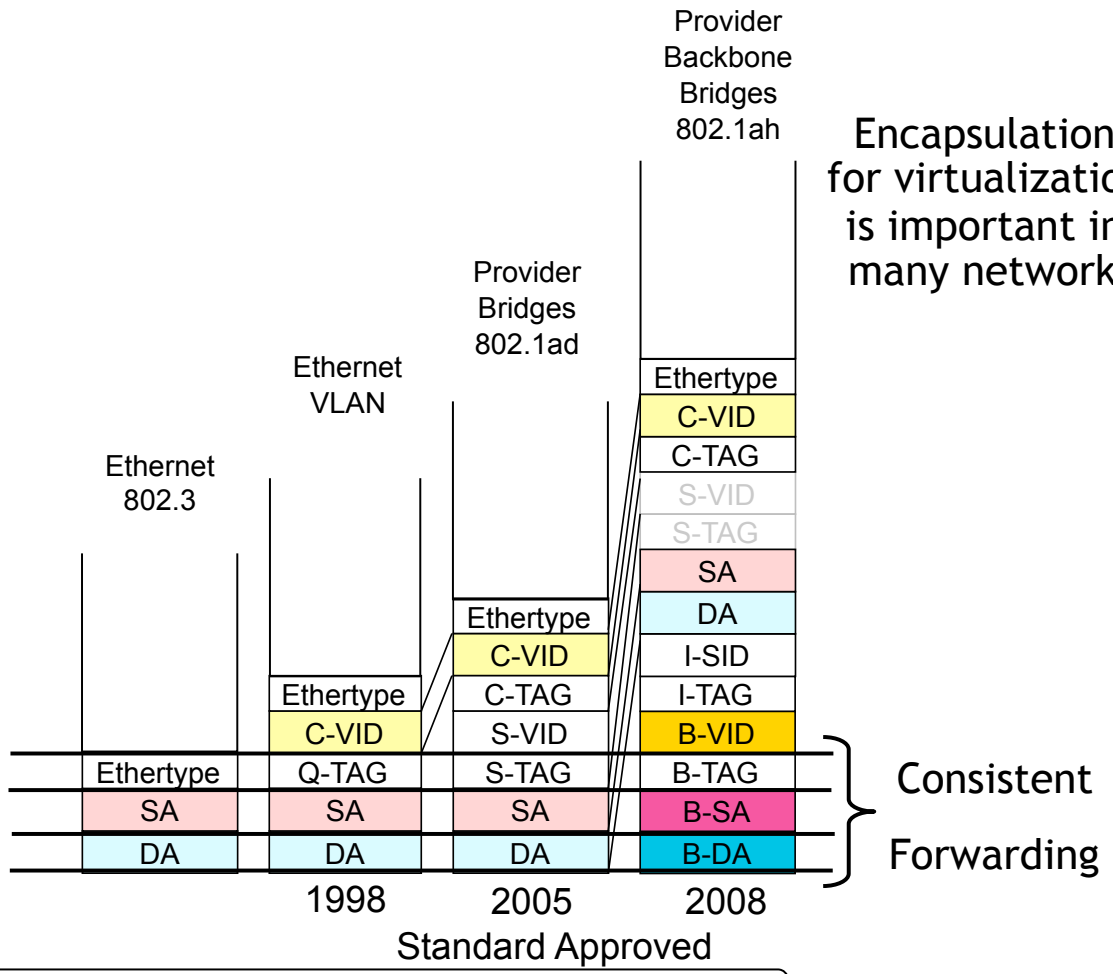
E-Line, E-Tree, E-LAN Services

Carrier Grade
Fast convergence
Efficient use of resources
B-VLAN Partitioned Forwarding Compatible

E-Line, E-Tree, E-LAN Services

802.1Q 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

SPB Works for all VLAN (802.1) Frames

IEEE 802.1 Data Plane Requirements

Must Support Data Plane Congruency

- Forward and Reverse Path Congruency
- Unicast, Broadcast and Multicast Congruency

Must support the complete 802.1Q data plane and be backwards compatible

- C-VLANs, S-VLANs/B-VLANs

Must Support Loop Prevention

- Loop Free by never forwarding a frame that could loop

New Support for Loop Mitigation

- Discard potential looping frames on Ingress
- Allows faster population of forwarding

Shortest Path Requirements

Create an Equal Cost Tree for the "Region" of shortest Path Bridging

- A Set of Shortest Path Trees (SPT) for the whole Region.
- One SPT for every source per SPT Set.
- Every subset of an SPT is an SPT.
- Support multiple trees (multiple Sets)
  - Example Data center Fat Trees, Bushy Trees
  - Support Link Aggregation (LAG)
- Tree Computation: deterministic and minimize disruption during changes
- Interwork with SPT protocols at the Shortest Path Tree region Boundary
- Support upgrading of the topology and the network with minimal interruption
  - Load balancing on short path trees by service

Loop Prevention/Mitigation Policy and Mechanism

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)

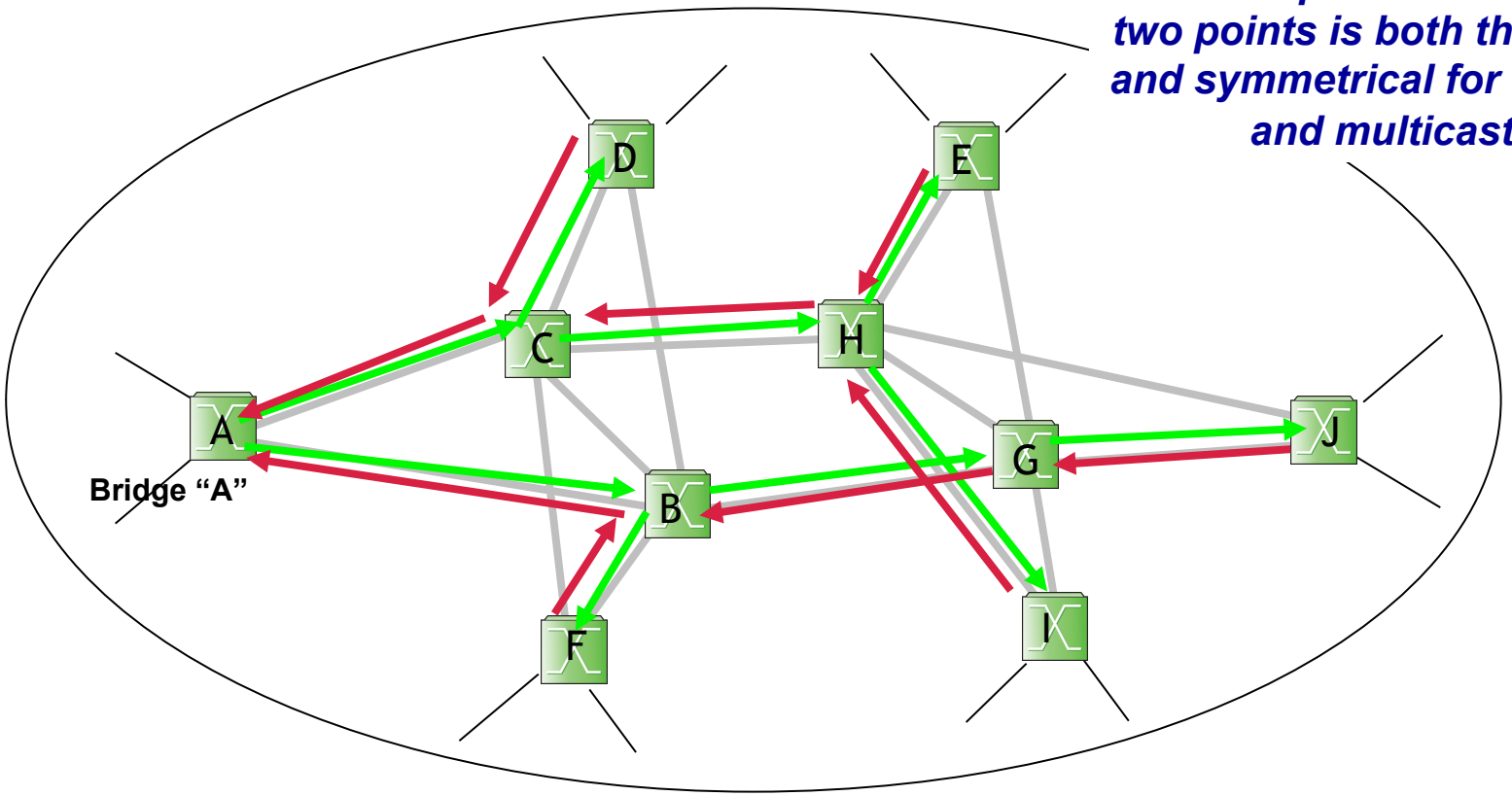
- Policy: Discard potential looping frames
- “Never accept a Frame from a neighbor node that you do not expect”
- Mechanism: Ingress check. Source DA/VID must be expected. Local Policy.

Loop Prevention is sufficient, but Loop Mitigation is faster during changes

- Loop Prevention for Multicast and Loop Mitigation for Multicast and Unicast

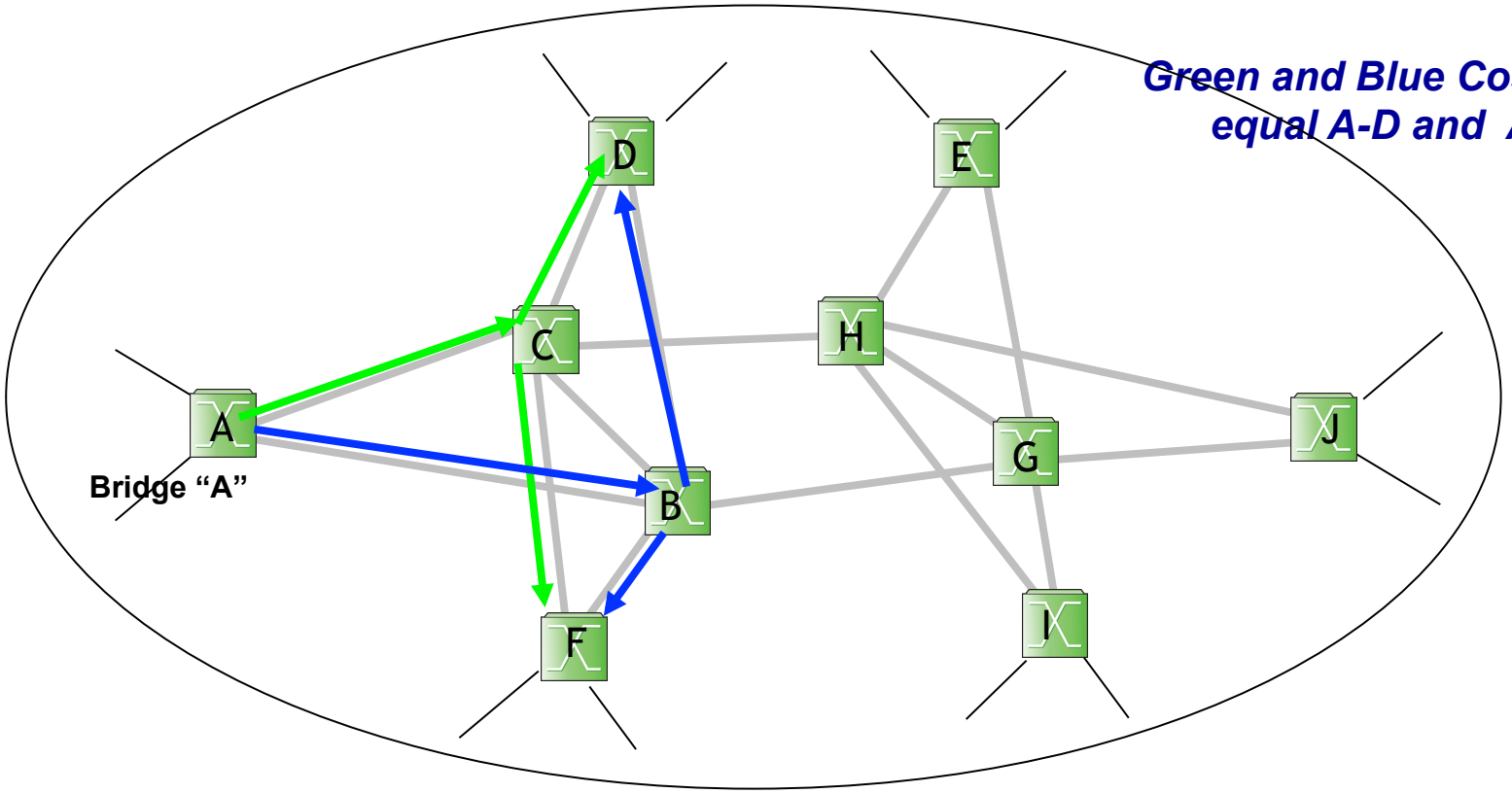
Congruency

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



Same Forward and Reverse Shortest Path

Equal Cost Trees

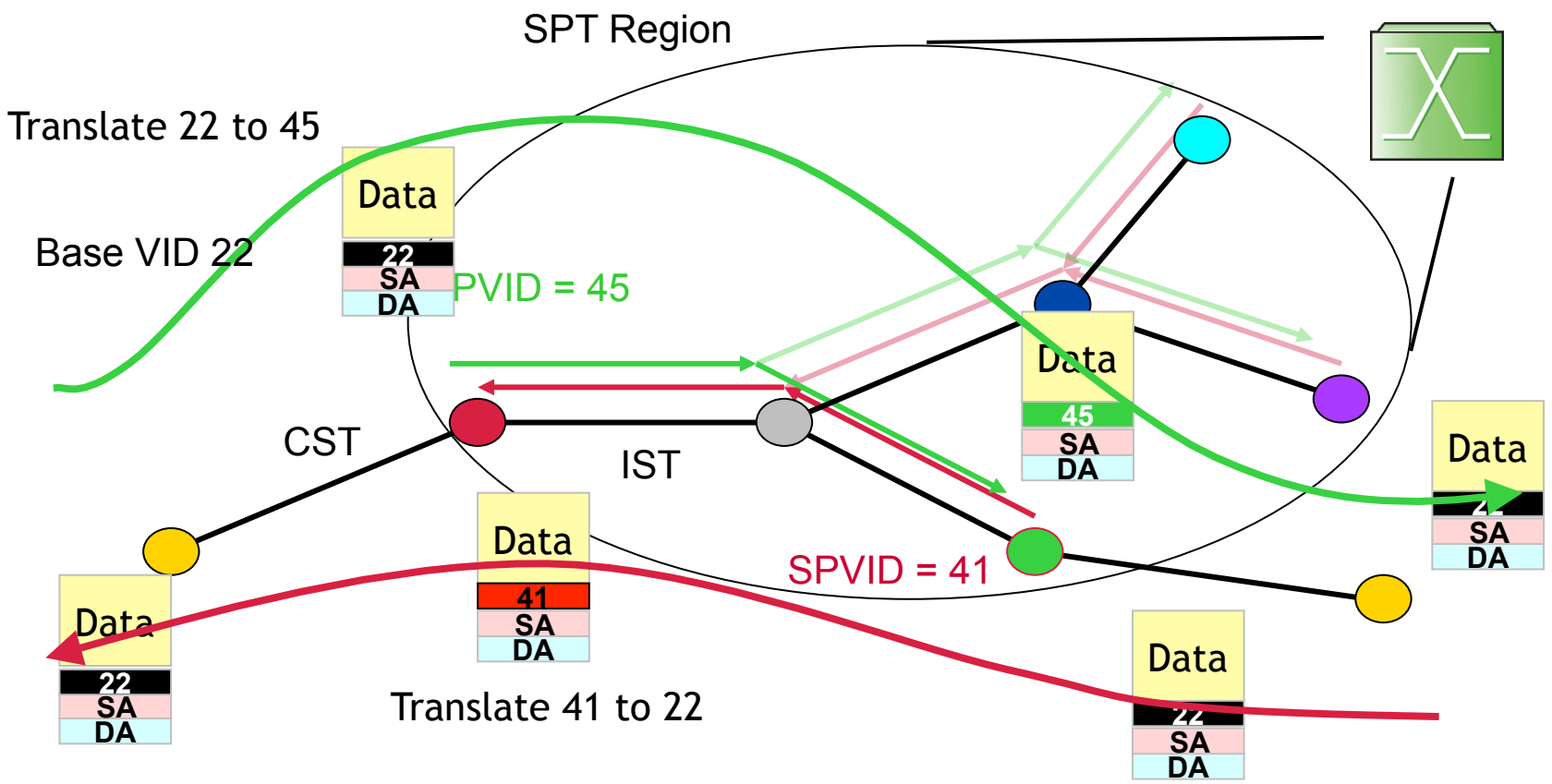


Optional Multipath Load Balancing different services

Shortest Path Bridging VID Mode (SPBV)

- Based on VLAN ID
  - Each source uses a VLAN ID to identify the source
  - VLANS are translated on the Region Boundary
  - Shared learning using a single FID
  - Preserves Learning mode
  - Backward compatible with STP using MSTP region concept
- Integrated with SPBM
  - Only IS-IS within the region
  - Allows sparse mode SPBV

SPBV Concepts



To outside the Region looks like a Bridge – MSTP concept

Shortest Path Bridging MAC Mode (SPBM)

New PBB data plane and new capabilities

- No learning for B-MAC addresses
  - Small number of Unicast B-MACs per node (typically 1)
  - Computed multicast B-MACs
    - I-SIDs membership determines connectivity per service
- Granularity of broadcast and multicast is controllable

SPBM Multicast Addresses

By constructing local IEEE Multicast Addresses the Control Plane has complete flexibility to build multicast trees.

- Built only when and where needed but I-SID configuration

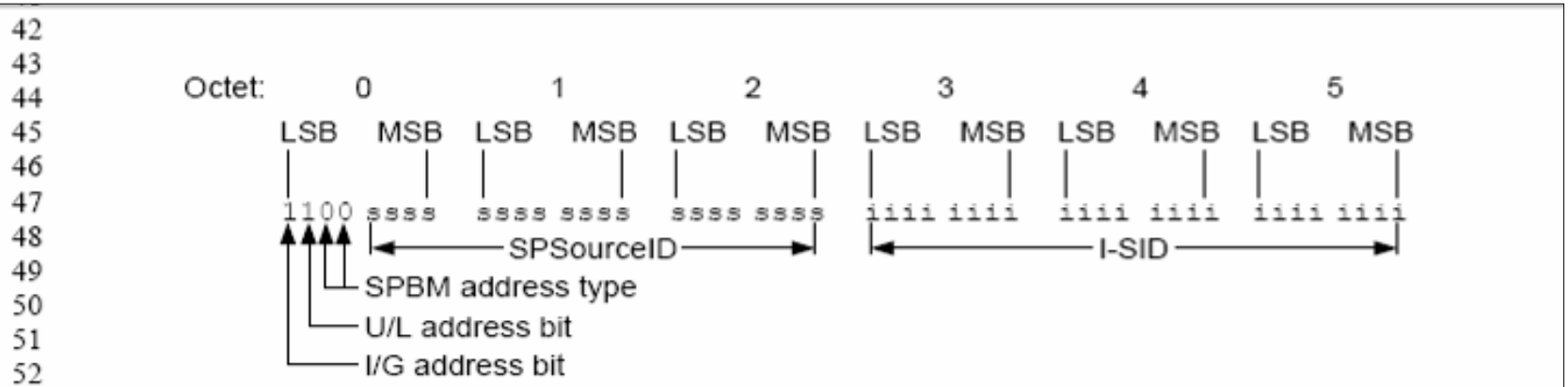
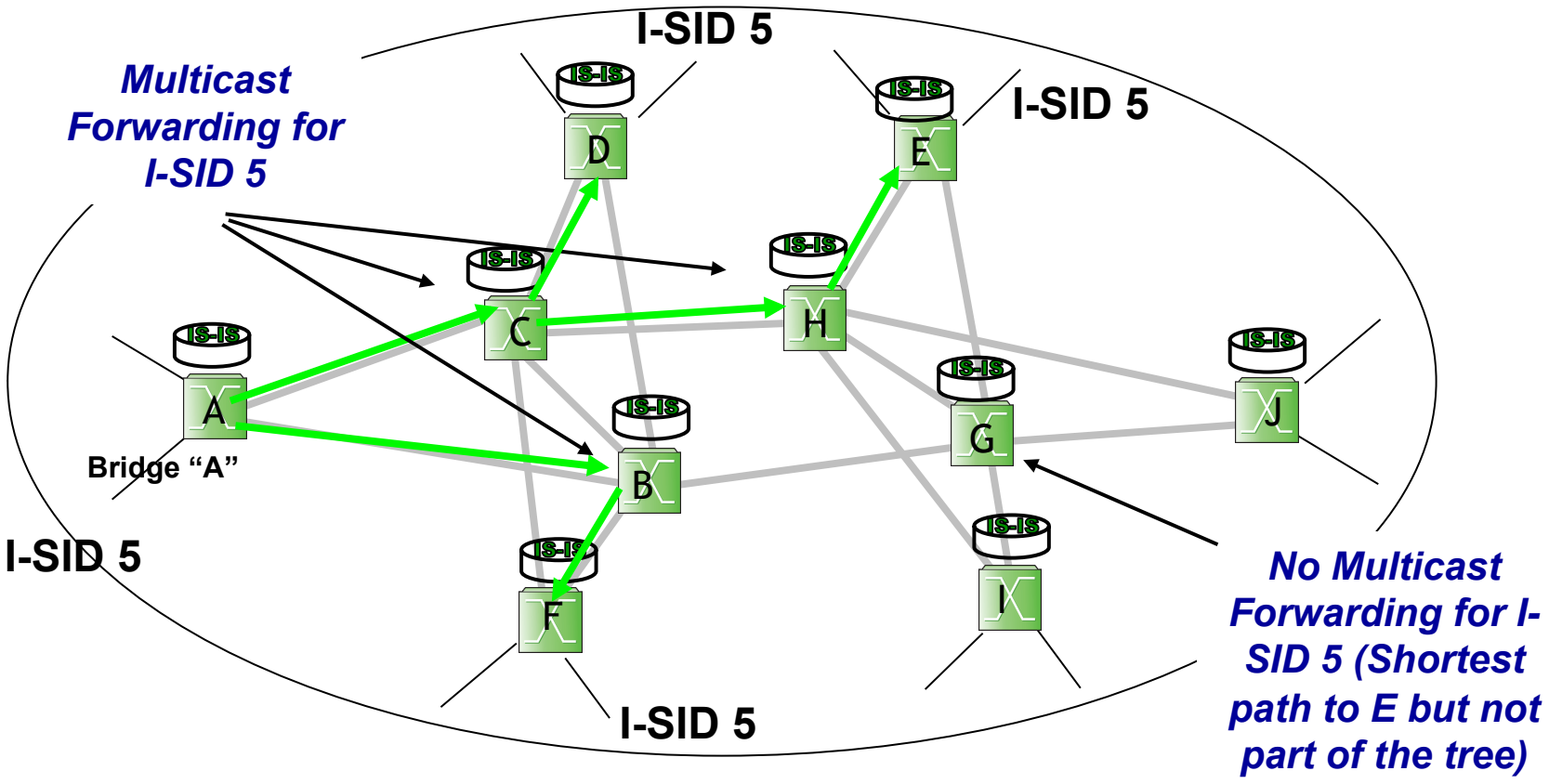


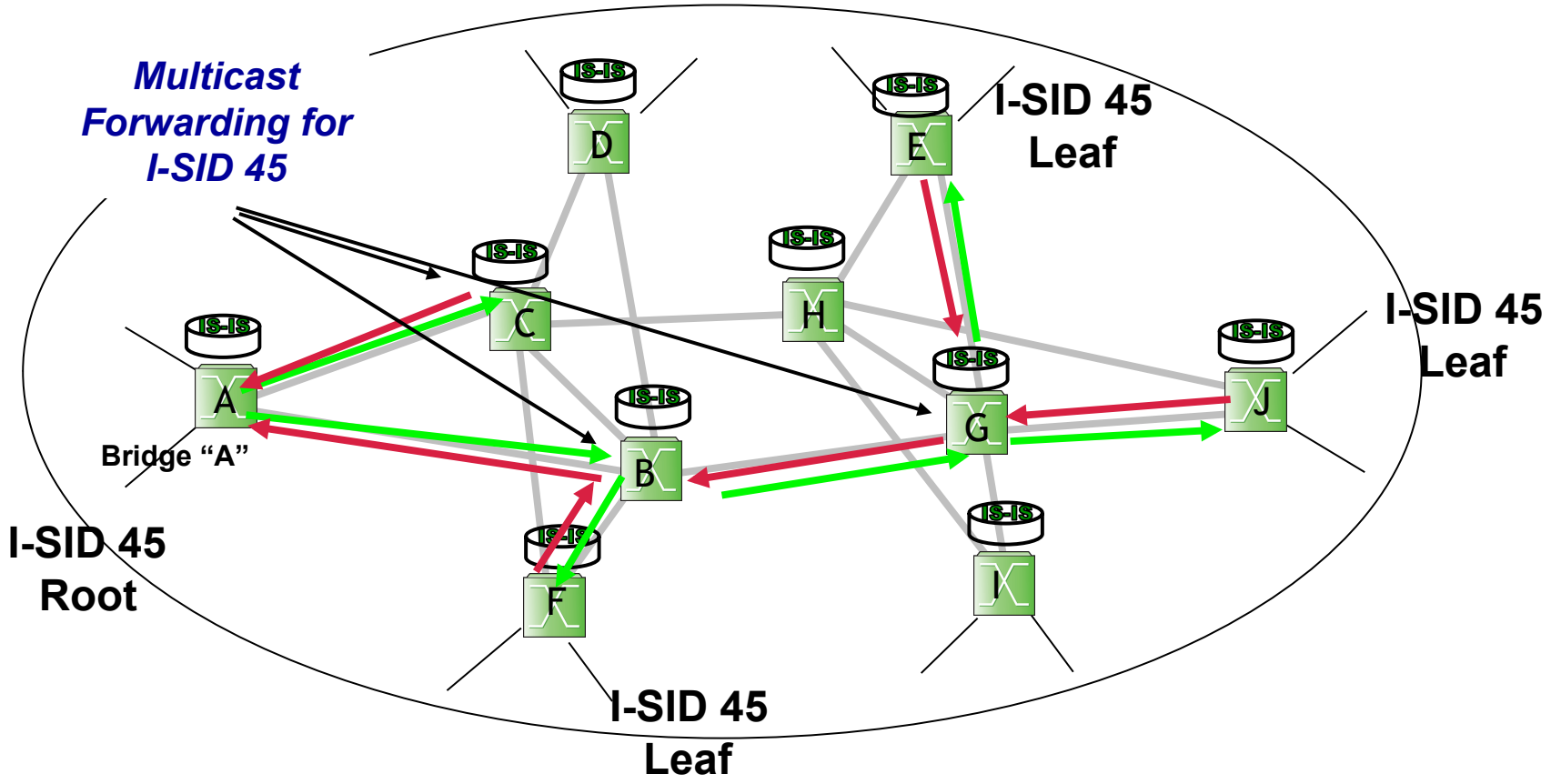
Figure 27-3—SPBM Group MAC Addresses used by this standard

SPBM Multicast Groups



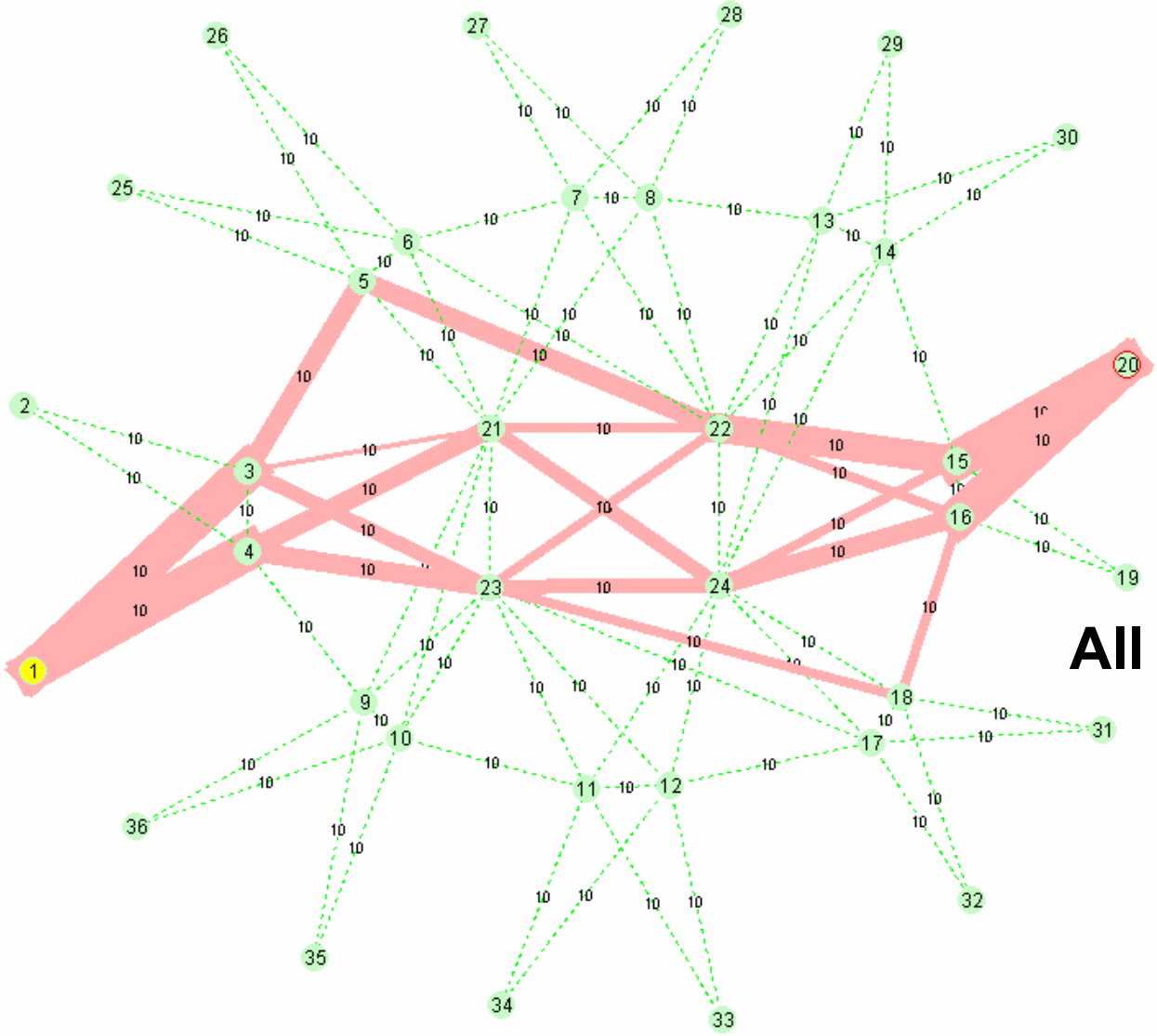
I-SIDs define efficient subsets

SPBM Multicast P2MP



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

End result - Visually



All links usable

Animation Courtesy of
Peter Ashwood-Smith and
Guoli Yin Huawei

Multiple Shortest Path routing + Ethernet OA&M

Data Centre Requirements

- Flexible Connectivity
- Scalable
- High Throughput
- Low Delay
- Resilient
- Adapts to changes
- Multipath, Multi-link
- Low Configuration

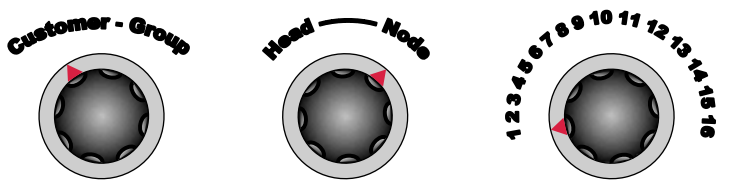
Ethernet is used heavily in Data Centers
Ethernet Bridging + SPB + DCB capabilities

SPB Mechanisms

- Large Ethernet LAN
  - Simplifies provisioning , adds moves and changes
- Shortest Path and Multipath
  - Allows efficient use of resources
- Efficient Broadcast Trees
  - Per Service Granularity
  - Frames go only where needed
- Responsive Control Plane
  - Link State Based
  - Loop mitigation for improved frame delivery during changes
- Plug and Play
  - Existing C-VLAN model is preserved
  - New Auto configuration is added to IS-IS for SPB

SPBM Per I-SID Controls

Aggregation Replication SPT Number



Ethernet Mechanisms

- Ethernet LAN is an established IP connection model
  - LANs simplify router
- VLANs, PB and PBB
  - VLANs allow virtualization
  - PBB Encapsulation provides scalability
- OAM
  - Instrument for fast detection of failure
  - Trace or monitor traffic
  - Source, Destination and VLAN information is self describing
- Backwards compatible with IEEE 802 and IEEE DCB protocols
- High Speed Links 10G, 40G, 100G

Summary

- Ethernet continues to evolve while maintaining desirable attributes
- Shortest Path Bridging standard enhances/simplifies the already existing set
- SPB leverages new techniques while preserving services interfaces
- SPB is an easy way to scale other technologies
- Large Carrier Networks, Data centers and other networks can leverage these technologies

References

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Glossary

B-MAC Backbone MAC
BEB Backbone Edge Bridge
BCB Backbone Core Bridge
C-VID Customer VID
CFM Connectivity Fault Management
CST Common Spanning Tree
ELINE Ethernet Point to Point Service
ELAN Ethernet LAN Service
ETREE Ethernet Hub and Spoke Service
FDB Filtering Data Base
FID Forwarding Identifier
I-SID (802.1ah) Service Identifier
IGP Interior Gateway Protocol (Typically link state)
IS-IS Intermediate System to Intermediate System (IGP)
IST Internal Spanning Tree
LAG Link Aggregation
LAN Local Area Network
MAC Media Access Control
MACinMAC see PBB
MEP Maintenance End point
MIP Maintenance Intermediate point
MMAC Multicast MAC
MSTP Multiple Spanning tree protocol
MMRP Multiple MAC Registration Protocol
OAM Operations, Administration and Maintenance
PB Provider Bridges IEEE 802.1ad
PBB Provider Backbone Bridging IEEE 802.1ah
PBB-TE PBB Traffic Engineering IEEE 802.1Qay
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

Thank You

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