MPLS Architectural Considerations for OAM
MPLS Japan

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Motivation

• Overview of MPLS OAM Issues
• Structure tools to focus in strength areas
Agenda

- Challenges
- MPLS Architecture
- ITU defined OAM
- LSP Ping
- Application Specific OAM
- MIB Overview
- Cisco Network Health Monitor
- Summary
Challenges

• One tool does not fit all
• Fault monitoring
• Fault detection
• Service Level Agreement Management
• Quality of Service
• Tools that are appropriate
## Challenges: An Example

### Virtual Circuits vs. Label Switched Paths

<table>
<thead>
<tr>
<th>Virtual Circuits</th>
<th>Label Switched Paths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Established via ATM Signaling or Management</td>
<td>Establishment tied closely to control planes</td>
</tr>
<tr>
<td>Bi-directional</td>
<td>Usually Uni-directional</td>
</tr>
<tr>
<td>Connection oriented</td>
<td>Can be “connectionless”</td>
</tr>
<tr>
<td>Single route</td>
<td>May use ECMP</td>
</tr>
<tr>
<td>No penultimate popping</td>
<td>Penultimate hop popping</td>
</tr>
<tr>
<td>Fixed hierarchy VP/VC</td>
<td>Variable Label Stack</td>
</tr>
</tbody>
</table>

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Agenda

- Challenges
- **MPLS Architecture**
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Applications & Labels

- Applications can directly manipulate label bindings
- Forwarding component
  Simple label-swapping paradigm
- Separation allows flexibility

Traffic Engineering
Differentiated Services
Unicast Routing
Virtual Private Networks
Frame Relay
Efficient lookup and forwarding
Per-Label Forwarding, Queuing, and Multicast Mechanisms
Label Stack

- Arbitrary number of labels
- Label Stack Operations
  - Push: add a label to the stack
  - Swap: replace the top label
  - Pop: remove the top label
- Allows multiple control planes to act on a packet
- Eases the integration of applications
MPLS & IP Routing

- IP offers a connectionless service
- The primary function of LDP is to distribute labels to support IP routing
- Labels distributed by LDP are under control of the IGP
- IGP LSPs are not static entities
- These LSPs may be rerouted at any node at any time
Equal Cost Multi-Path (ECMP)

- IP uses shortest path routing
- Traffic can be split across multiple shortest paths
- Most deployed label switching boxes use the bottom most label in their ECMP algorithm

⚠️ Adding an OAM label at the bottom may change the behavior that is being measured
Penultimate hop popping

<table>
<thead>
<tr>
<th>Address Prefix</th>
<th>Out Label</th>
<th>Out IF</th>
<th>In Label</th>
<th>Out Label</th>
<th>Out IF</th>
</tr>
</thead>
<tbody>
<tr>
<td>128.89.10</td>
<td>3</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>171.69</td>
<td>4</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.225.1.1</td>
<td>6</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

LER forwards Packet on IP Header

128.89.10

One lookup is more efficient than two

Label is no longer available for LSP identification

To 171.69
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ITU MPLS OAM - Y.1711

- Follows closely ATM OAM (I.610)
- Three functions defined
  - Connectivity Verification (CV)
  - Forward Defect Indication (FDI)
  - Reverse Defect Indication (RDI)
- OAM Alert Label
  - Reserved label value (14)
  - Added at bottom of stack to identify OAM packet
Y.1711 OAM Format

44 byte Payload

Function Type (1 byte)
Trail Termination Source ID (20 bytes)
  IPv6 Node ID (16 bytes)
  LSP ID (4 bytes)
BIP-16 (2 bytes)
Other bytes specific to function type
Drawbacks of Y.1711

- LSP Identification (TTSI)
- Equal cost multi-path
- Penultimate hop popping
- Assumption of a fixed path
- Requirement for a reverse path
- Fixed interval between CV Packets
LSP Identification (TTSI)

- LSP ID is not a well defined term
- Each application manages its LSPs independently – no coordination of LSP identification across applications
- Only point of commonality is a low level label database to ensure uniqueness
- 4 byte LSP ID field defined in Y.1711 is too small to use application’s native identification
- Use of this field would require a unique space to be managed across applications and that LSP IDs be added to all forms of MPLS signaling
Requirement for a reverse path

- Some OAM functions assume that a reverse LSP exists which can be associated with the forward path.
- This kind of association is the exception rather than the rule for most MPLS applications.
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Rationales for IP based OAM

- MPLS is IP-based
- All MPLS control protocols are based on the IP protocol suite
  - LDP / BGP / RSVP / PIM
Rationales for IP based OAM (2)

• The majority of MPLS applications carry IP traffic
  Even most Frame Relay & ATM traffic has IP as its payload

• The primary goal of OAM is to ensure the customer is receiving the expected service
LSP Ping

• Similar to ICMP (IP) Ping
  Sequence Number
  Timestamps
  Sender Identification
• Full identification of FEC based on syntax and semantics of the application
• Variable length for MTU discovery
• Support for tunnel tracing
LSP Ping

- Destination address in local host range (127.0.0/24)
  Detects lack of MPLS connectivity even if there is IP connectivity
  Range allows coverage of Equal Cost Multi-Paths
- Reply can be via IP or control plane or no reply
- IP reply uses Router Alert to avoid LSPs
- Extensions to support recursive traceroute
  GTTP – Generalized Tunnel Trace Protocol
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One Size does not Fit All

- OAM is trying to measure application performance
- Most MPLS applications are IP related like MPLS BGP VPN, RSVP-TE
- However, some of the services targeted for PWE3 have OAM requirements beyond those provided by the current IP OAM suite
PWE3 does not run exclusively over MPLS
PSN Tunnel may be MPLS, IPSEC, L2TP, GRE,…
Should PWE3 OAM be tied closely to MPLS?
Monitoring the tunnel

- Tunnels may be MPLS, IPSEC, L2TP, GRE,…
- One tunnel can serve many pseudo-wires
- IP based tools (including MPLS ping) are sufficient to monitor the PSN tunnel
- Verifies PE to PE connectivity
- Frequent monitoring may be appropriate
### Pseudo-Wire Protocol Layers

<table>
<thead>
<tr>
<th>Layer</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Payload</td>
<td>May be null</td>
</tr>
<tr>
<td>Encapsulation</td>
<td>Usually null</td>
</tr>
<tr>
<td>Virtual Circuit</td>
<td>Pseudo-Wire Demux</td>
</tr>
<tr>
<td>PSN Convergence</td>
<td>MPLS, L2TP, IPSEC, etc.</td>
</tr>
<tr>
<td>PSN</td>
<td></td>
</tr>
<tr>
<td>MAC/Data-link</td>
<td></td>
</tr>
<tr>
<td>Physical</td>
<td></td>
</tr>
</tbody>
</table>

- Encapsulation could be used to flag OAM
- Alert label before or after Virtual Circuit could also be used
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MPLS MIB Overview at a Glance

MPLS
- MPLS-TE MIB
- MPLS-FTN-MIB
- MPLS-LINK-BUNDLING-MIB
- MPLS-LDP-MIB

MPLS-TC MIB

PWE3
- PW-TC MIB
- PW-CEM MIB
- PW-MPLS MIB

Service-specific MIBs...

PPVPN
- PPVPN-TC MIB
- PPVPN-MPLS-VPN MIB

CCAMP
- LMP MIB
- GMPLS-LSR/TE/Label Table/TC MIBs?

 Depends on RFC2233

Depends on

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Cisco Health Monitor Application

- Application residing in IOS that is responsible for:
  - Periodically verifying PW VC connection status using MPLS LSP Ping/GTTP.
  - Continually monitoring the quality of a VC (e.g.: packet loss, jitter, etc...)
  - Automatically take user-programmed corrective actions under curtain circumstances (e.g.: notify tunnel manager to choose alternative tunnel that meets user requirements).

Significantly automates health monitoring tasks!
Summary

Solution must address MPLS needs
- Independence of control planes
- Uni-directional LSPs
- Penultimate hop popping
- Equal Cost Multi-Path
- Flexible binding up & down label stack
Summary (2)

- Most current applications offer an IP related service
- IP is the basis of MPLS control planes
- IP based tools make sense
Summary (3)

- Applications vary widely in their OAM requirements
- Adaptable & tunable to application needs
- One size does not fit all
- MIBs enhance tool box
- Cisco Network Health Monitor
- Progress continues!
Thank You