Introduction to Multi-Protocol Label Switching (MPLS)

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Agenda

History of MPLS Standardisation

MPLS Architecture

Control Plane

QoS and Traffic Engineering

Protection and Resiliency

MPLS Based Services:

- Layer 3 Virtual Private Networks
- Layer 2 Virtual Private Networks & Pseudowires
IP/MPLS in Carrier Networks

- Enhance forwarding performance of router networks
- Service convergence over MPLS including VPLS
- Service enabling the edge
  - L3 based MPLS VPN
- Business enabling the core
  - MPLS attempt to enhance network resilience
  - MPLS-enhanced QoS
- Infrastructure optimization
  - Traffic engineering
  - Hierarchical core design

MPLS Applications

MPLS Standardisation Activities

- 2005+
  - Multi-segment PWs, Multicast in VPLS / IPVPNs / pt-mp LSPs
- 2001-2004
  - Development of pseudowires / L2VPNs
  - Unified Control Plane for Non-Packet and Packet Networks
- 1999-2000
  - Enhanced Network Resilience
- 1998
  - Traffic Engineering
  - Virtual Private Networks
- 1996-1997
  - Forwarding Performance

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Multiprotocol Label Switching Architecture

MPLS Shim label added to each packet
Forwarding decisions are based on label, to follow a label switched path (LSP)
Runs over many link layers – SDH, Ethernet, etc
MPLS Control Plane

Distribute FEC/Label bindings between LSRs

- Label Distribution Protocol (LDP) for non-TE LSPs
  - Simple protocol that exchanges label bindings with peer LSRs

- RSVP-TE for traffic engineered LSPs
  - Soft-state protocol enabling BW parameters & path to be signalled

Use label Y to reach FEC X
Use label Z to reach FEC X
QoS and Traffic Engineering

MPLS Label:

- 20 Bit label
- EXP
- TTL

Encode CoS and/or DP

Control plane to determine LSP path and reserve resources along path

**Label Inferred LSP**
Drop precedence determined by EXP bits
LSRs schedule according to label context

Classified according to L2 or L3 criteria

Policing/Shaping applied

**EXP Inferred LSP**
EXP bits determine CoS / DP
LSRs schedule according to EXP bits context

RSVP-TE signals resource requirements along LSP path
Protection and Resiliency

MPLS provides a common protection layer, independent of underlying transport mechanisms.

Path protection:
- Protected LSP
- Backup LSP

Load balancing:
- Demand/2

Local protection:
- Detour A-E
- Detour B-E
- Detour C-E
- Detour D-E

Wide range of options
MPLS based Services and Virtual Private Networks

Two VPN classes:
Layer 3 VPNs: IP
Layer 2 VPNs:
- Virtual Private Wire Service (pt-pt Ethernet, FR, ATM, etc)
- Virtual Private LAN Service (mp-mp Ethernet)

IETF RFC 4664
Border Gateway Protocol (BGP) Layer 3 VPNs

MP-BGP* exchanges VPN membership/reachability info

Customer routes

Virtual Routing & Forwarding

IP Service

*IETF RFC 4364

*MP-BGP: Multiprotocol BGP
Pseudowires are building blocks of layer 2 VPNs.
Virtual Private LAN Service (VPLS)

**Transparent L2 VPN for Ethernet**
- Learns MAC addresses per PW
- Forwarding based on MAC addresses
- Split-horizon forwarding for loop prevention
  - Does not use Spanning Tree
- Uses hierarchy to improve scaling (H-VPLS)

IETF RFC 4762
OAM in a Converged MPLS Network

OAM tools for each layer of the converged network

- **Bidirectional Forwarding Detection (BFD)**
  Lightweight hello protocol

- **LSP Ping/Trace**
  Modeled after ICMP ping /traceroute

- **Virtual Circuit Connectivity Verification (VCCV)**
  PW Connectivity verification

- **LDP Status Signalling**
  Defect notifications

- **Ethernet**
- **Frame relay**
- **ATM**
- **TDM, etc**
Summary: Why is MPLS Important?

MPLS adds label to a packet to enable it to be switched through a PSN
- Full set of TE, OAM, and protection mechanisms
- Enhance to support both Layer 2 and Layer 3 services

Core carrier networks moving rapidly to using MPLS
- Driven by expected lower CAPEX/OPEX of a converged network and demands of new services
  - Ethernet services need MPLS QoS/TE/Protection
  - Enables Ethernet transport layer to support range of legacy (TDM, ATM...) and new services