MPLS/GMPLS for Next Generation Optical and Carrier Ethernet Networks
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Objectives for Carrying Ethernet over a SONET/SDH Transport Network

- Enable scalability for Ethernet Services over SONET/SDH infrastructure
- Provide fast reroute for Ethernet Service protection
- Efficient bandwidth usage over SONET/SDH network
- Enable TDM service to be carried in conjunction with the packet based services
- Simplify Service Operations versus provisioning a router
- Provide “Point and Click, End to End” provisioning
- Allow Carriers to build on SONET/SDH resiliency and provide Carrier Ethernet Service SLAs with QoS
- OAM – Optical + ethernet + MPLS
GMPLS Background

- Used by SONET/SDH MSPP to automate service provisioning
- Each network element running GMPLS supports:
  - OSPF-TE routing
  - RSVP-TE signaling
  - Label distribution through RSVP
- GMPLS is a partial superset of MPLS
  - Common traffic engineering (TE)
  - Implicit vs. explicit labels
  - Bi-directional labels
  - Label sets, link bundling
- Overlay, peer and hybrid models

Turin GMPLS solution

- Distributed, GMPLS based control plane
- Neighbor discovery, topology discovery and distribution
- OSPF based routing protocol with support for unnumbered interfaces
- Traffic engineering (OSPF-TE) and TE database
- OSPF-TE extensions with opaque LSA (RFC 3630)
  - Per-area type 10 opaque LSA
- Path computation on ingress node (CSPF)
  - Support for fully strict, loose, and partially constrained paths
  - 1+1 path protection - node and link diverse paths
- RSVP-TE (with support for hot-standby/redundancy)
- Generalized, switch managed labels
- Support for e2e low-order services
Bridging the MPLS and GMPLS domain

- Ethernet cards in MSPPs can be adapted to exchange the necessary routing information to allow MPLS and GMPLS domains to communicate
- These Ethernet cards will be responsible for
  - Receiving and sending RSVP requests
  - Switching MPLS labels
  - Performing normal Ethernet (L2 switch) related operations
- The adapted Ethernet cards are simply a client interface into the existing GMPLS control plane
- Use existing GMPLS control plane to
  - Establishing a forwarding adjacency (FA)
  - Exchanging IP routing information
- The adapted Ethernet cards are simply a client interface into the existing GMPLS control plane

End to End Ethernet Service Provisioning

- User points and clicks at Nodes A to Z, and network setup the connection
- D-LSPs are routed & switched on the intelligent Ethernet card
- G-LSPs continue to created on optical switching nodes
MPLS over SONET/SDH migration

- Introduce LSR functionality as the services grow
- SONET/SDH partitioned to carry MPLS
- Partitioning can be static or dynamic

Data LSPs over Optical LSP

Ingress LER | Egress LER
---|---
FWD adjacency | Equivalent

- ADM
- Fwd - Adjacency TDM

LSP (LSP - TDM)
LSPs Set up steps

User requests EVC between UNI ports

- Eth Switch
- EoM Mapper
- MoS Mapper

G-LSP (optical LSP)

- 1+1 path protection
- Bundled VCAT pipe + LCAS

- te-LSP (data lsp)
- Protected LSP

Efficient Path Bandwidth Management

- Dynamic resizing of bandwidth for optimal sizing of service routes
- Dynamic resizing of te-LSP 59
- Dynamic resizing of g-LSP 49
- Use of VCAT/LCAS to allow hitless resizing

- ADM
- LSR or LER
- Optical Path (g-LSP)
**Pseudo-wire tunnel (PWE)**

- Equivalent to Ethernet Packet
- PSN Tunnel Label
- FA-PSC Site Z Site Z Site Z Site Z
- CE - Site A Site Z Site Z Site Z Site Z

**MP2MP service (VPLS)**

**Operation:**
- Full mesh of point to point LSPs
- Support for customer port (untagged) or multiple VLANs with subscriber VLAN tags
- Learning and forwarding based on MAC addresses, Flooding on per VSI-x basis
- Loop free topology with split horizon (no forwarding from one VSI-x trunk port to another VSI-x trunk port)
- Failure recovery based on FRR (RSVP-TE)
- Membership discovery based on provisioned information from management plane
Protection schemes

- No Protection
- Optical protection
  - Ring based schemes (UPSR/2f-BLSR)
  - Mesh based (node/link diverse path)
- te-LSP protection
  - Path protection (source based)
  - Local protection with fast reroute (FRR)
    - Link failure
    - Node failure
    - 1:1 protection
    - 1:N protection
- Failure detection and notification
- Bi-directional failure detection (BFD) protocol

Te-LSP based Path Protection

- Source computes working and protect LSP paths
- Resources can be reserved before failure (double booking)
- Fastest with pre-computation and pre-signaling
- Detection at ingress may be slow, but allows complete QoS control of secondary path
1:1 Protection

- Segment of working LSP protected by a backup LSP
- Point of local repair (PLR) and merge point (MP)
- Can protect against link failures
- Backup link is called a ‘detour’
- PLR calculates and signals detour path during primary path setup resulting in creation of MPLS forwarding state ate PLR, MP and transit nodes (3,5 in example)
- PLR detects failure and swaps incoming label to that of the detour path
- MP understands relationship between working and protect paths
- Increased state in MP/PLR
- Support for working path QoS along protect path
**N:1 (facility protection)**

Every N working LSPs protected by a single LSP

- Label stack
- Based on label swap and insert of protect LSP label into label stack at PLR
- Can protect against node/link failures
- No new forwarding state at MP
- Penultimate-hop popping (PHP) on last transit node along protection path
- BW protection
- Interaction of FRR and path protection
- Scalability – new LSPs, increased forwarding state
Conclusion

- Turin solution builds on existing GMPLS based control plane
- Allows Ethernet switching layers to request optical tunnel setup
- Hitless addition/removal of optical BW using VCAT/LCAS
- Selective upgrades to mesh network along spans that are heavily used
- Allows TDM/Ethernet/MPLS switching to co-exist on the same network element
- MPLS encapsulation of Ethernet (EoMPLS) and pseudo-wires
- Fast-reroute based protection of the RSVP tunnels
- Enable an evolutionary change from TDM to packet switched networks (pay as you grow)
- Unified control plane model leverages the best of TDM/packet worlds to provide optimal solutions

Thank you

- Questions?