MPLS as a Service Enabler in Metro Area Networks?

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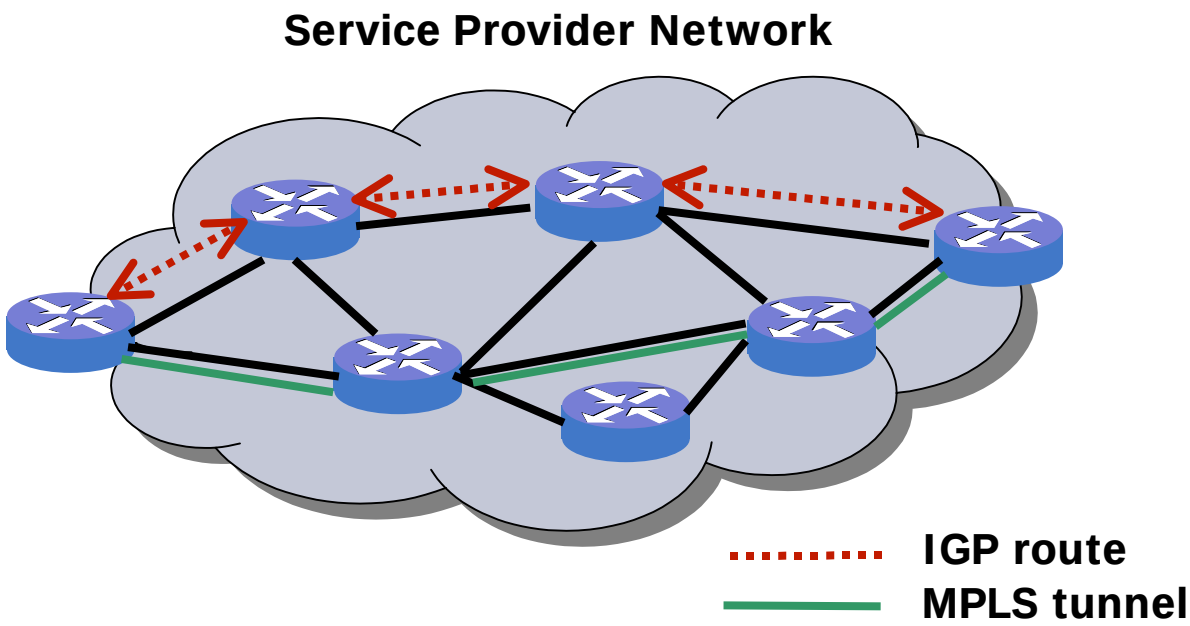
Service Provider Challenges
The Driving Needs for MPLS

- **Provide a high quality service to their customers**
  - **High availability**
  - **High reliability**
  - **High performance**
- **Offer new services**
  - **Tiered services**
  - **Guaranteed services**
  - **VPN services**
  - **Transparent LAN services**
- **Maintain a scalable network**

Service Provider Requirements

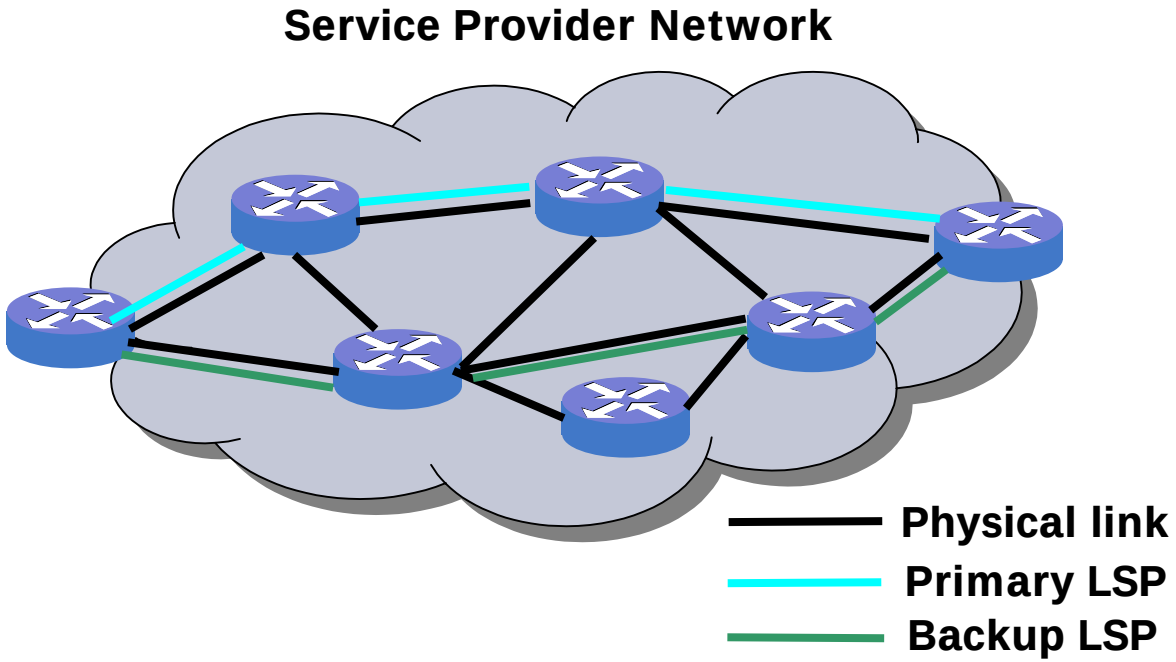
- High Availability
  - Ability to dynamically recover from node or link failures
    - Automatic re-route
    - Path restoral
- High Reliability
  - Node/Link Redundancy
    - Path protection
- High Performance
  - Minimize congestion using traffic engineered paths
  - Load balancing

MPLS Based Solutions
Traffic Engineering



- *Current routing protocols follow the shortest path leading to :*
  - *Over-utilized northern route*
  - *Under-utilized southern route*
- *MPLS allows explicitly routed LSP's to be set up*
  - *e.g. set up path via routers with low latency*
- *MPLS policies define how traffic is mapped on different LSP's*
  - *e.g. all RTP traffic follows the green LSP*

MPLS Based Solutions
Path Redundancy

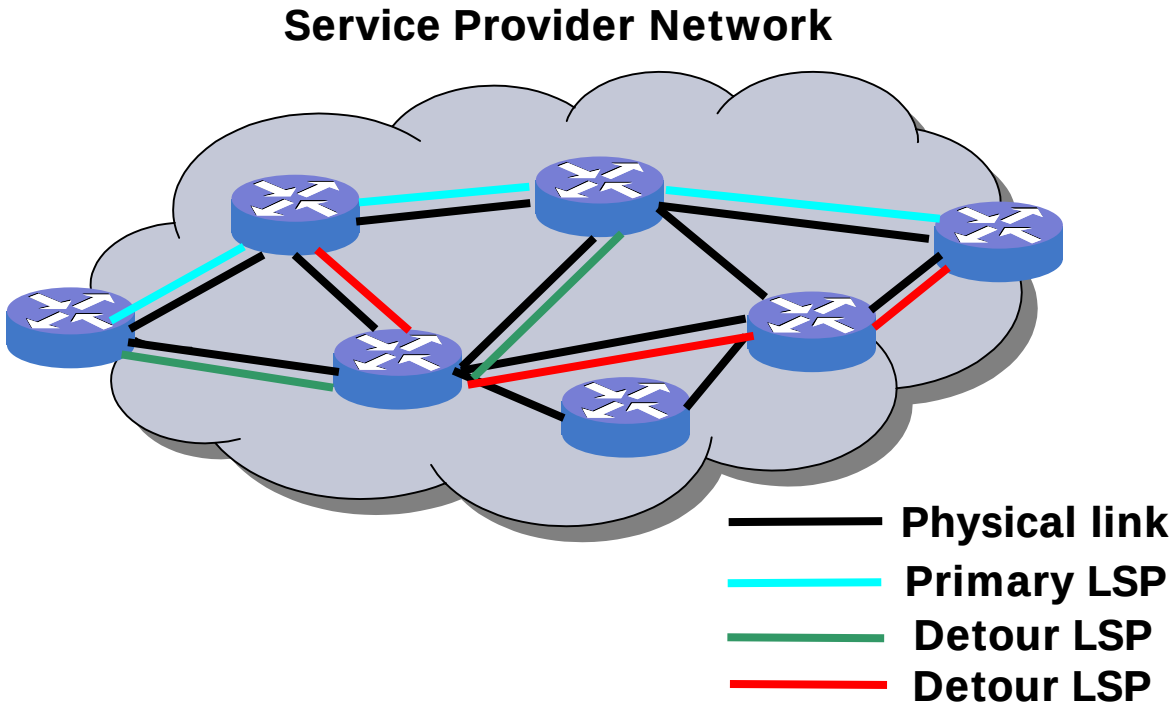


- *Redundant LSP's can be setup for traffic protection*
- *Backup LSP can be a hot standby LSP or dynamically signaled upon failure of the primary LSP*
  - *If blue LSP fails, switch traffic to green LSP if available or signal green LSP (ER-LSP preferably)*

MPLS Based Solutions
Failure detection

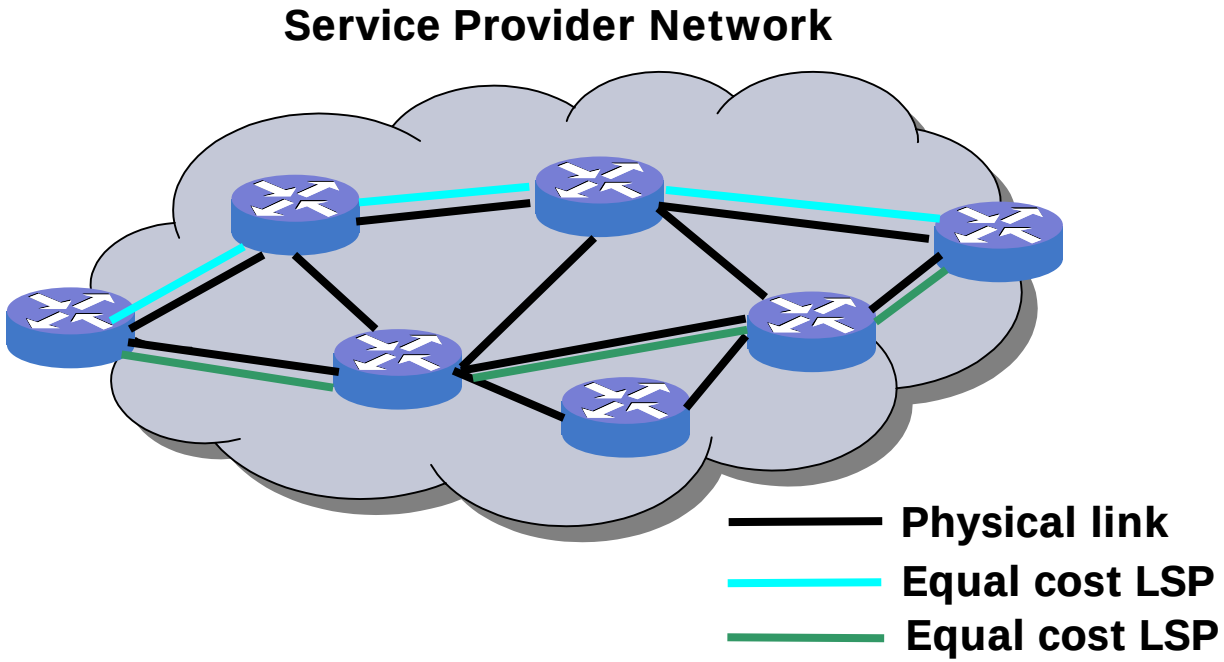
- **Link Layer indication**
- **Signaling**
  - **RSVP Hello**
    - **Node is considered down after 20 ms**
      - **Sonet-like protection is possible**
  - **LDP Hello/Keepalive**

MPLS Based Solutions
Fast Rerouting



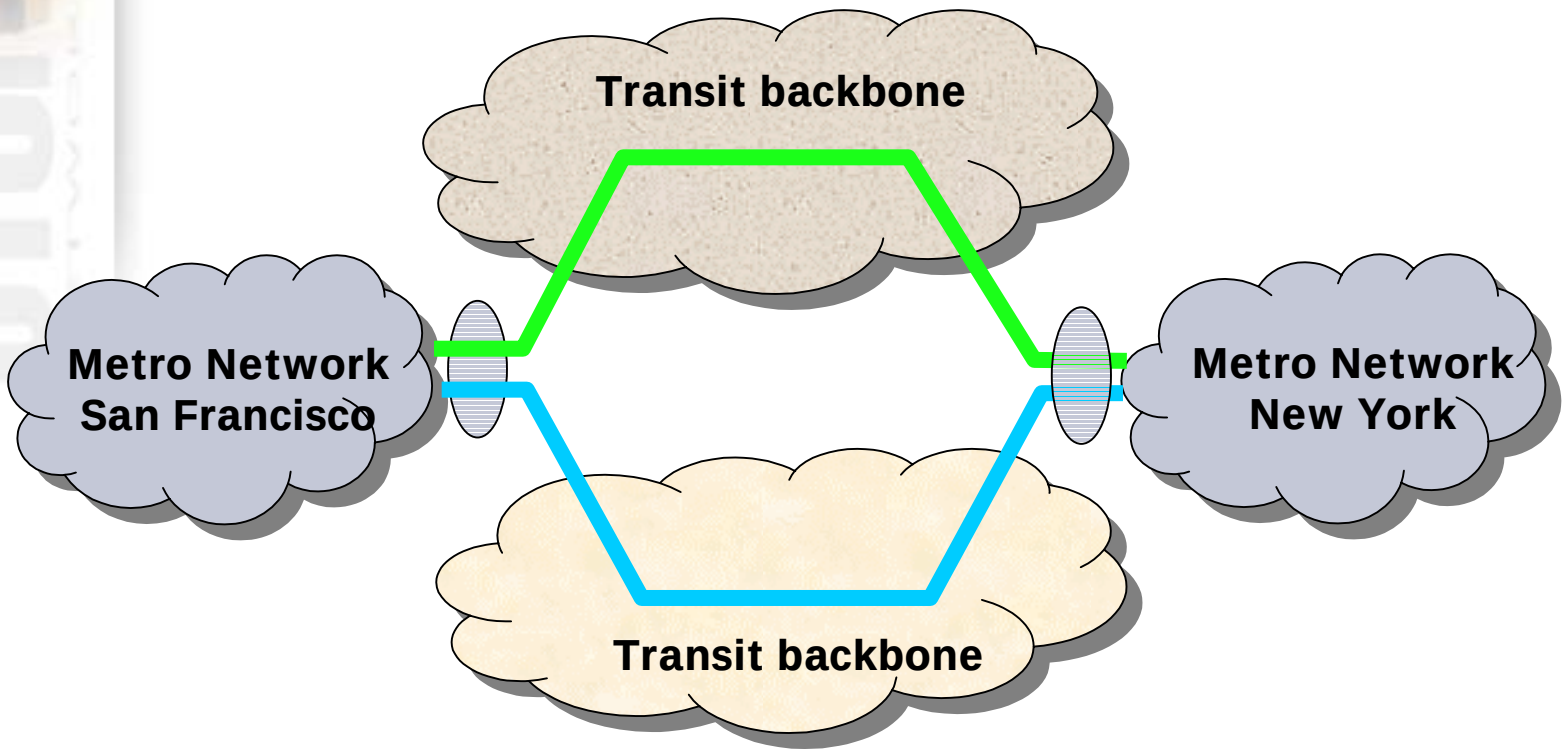
- *Fast Reroute signaling option to create detour paths*
  - *Alternate detour around failure used while ingress LER is notified to re-compute new ER-LSP*

MPLS Based Solutions
Load Balancing



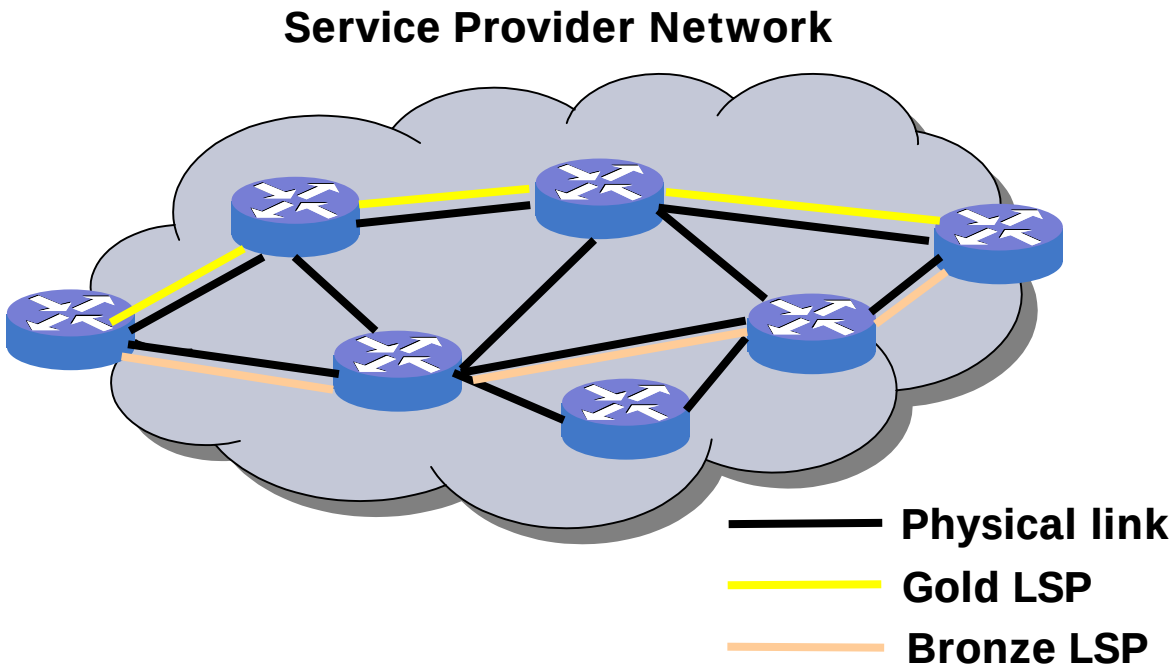
- *Traffic can be load balanced across multiple equal cost LSP's*
  - *If one of the LSP's fails, traffic will automatically be sent across the other links*
    - *High priority traffic will go first*

MPLS Based Solutions
Link Bundling



- *For route diversity, inter-metro connection uses separate providers*
- *Two diverse paths can be bundled to form a resilient bigger pipe*
- *Additional LSP's can be added to the pipe as traffic grows*

MPLS Based Solutions
Mapping IP ToS to LSPs

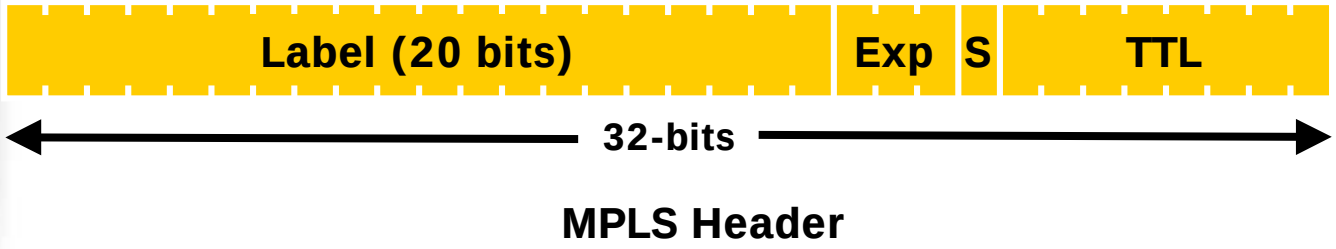


- ***Multiple differentiated paths can be set up to satisfy some soft quality of service requirements***
  - ***High priority traffic such as voice is carried over a gold LSP***
    - ***Gold LSP is traffic engineered to meet voice latency/jitter requirements***
  - ***Best effort traffic such as Internet data traffic is carried over a bronze LSP***

MPLS Based Solutions
LSP Preemption

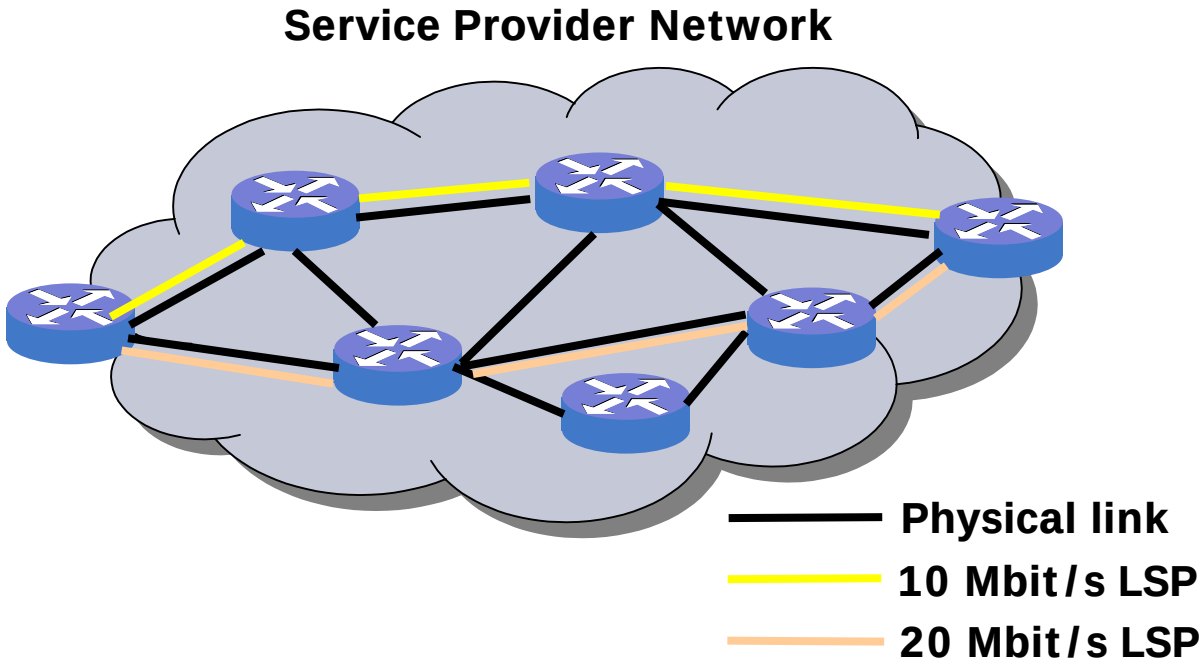
- If an LSP can not be established because of insufficient resources, that LSP can preempt other LSP's of lower priority
  - Setup priority > Holding priority
- If the gold LSP goes down and there are no resources available to set up a new one, the gold LSP will preempt the bronze LSP

MPLS Based Solutions
Mapping IP ToS to Exp



- **ToS/DSCP/802.1p code points can be mapping to Exp (a.k.a CoS) bits**
  - **Used to choose priority queue, scheduling and drop policies**
  - **Hop by hop processing**

MPLS Based Solutions
Quality of Service



- *Signaled LSP's can specify traffic parameters such as*
  - *Bandwidth/Priority/Affinity*
- *Extended OSPF-TE and ISIS-TE provide real-time feedback on network resources*
  - *Online and offline CSPF computation*
    - *Used to set up differentiated LSP's (e.g. voice,video,data)*

MPLS Based Metro VPN Services

- **Virtual Leased Line (VLL)**
  - **Emulation of a PTP link**
- **Transparent LAN Service (TLS) a.k.a VPLS**
  - **Emulation of a LAN**
  - **Forwarding based on L2 reachability information**
- **Virtual Private Routed Network (VPRN) a.k.a IP VPN's**
  - **Emulation of multi-site routed network**
  - **Forwarding based on L3 reachability information**

Impediments to Metro VPN Services

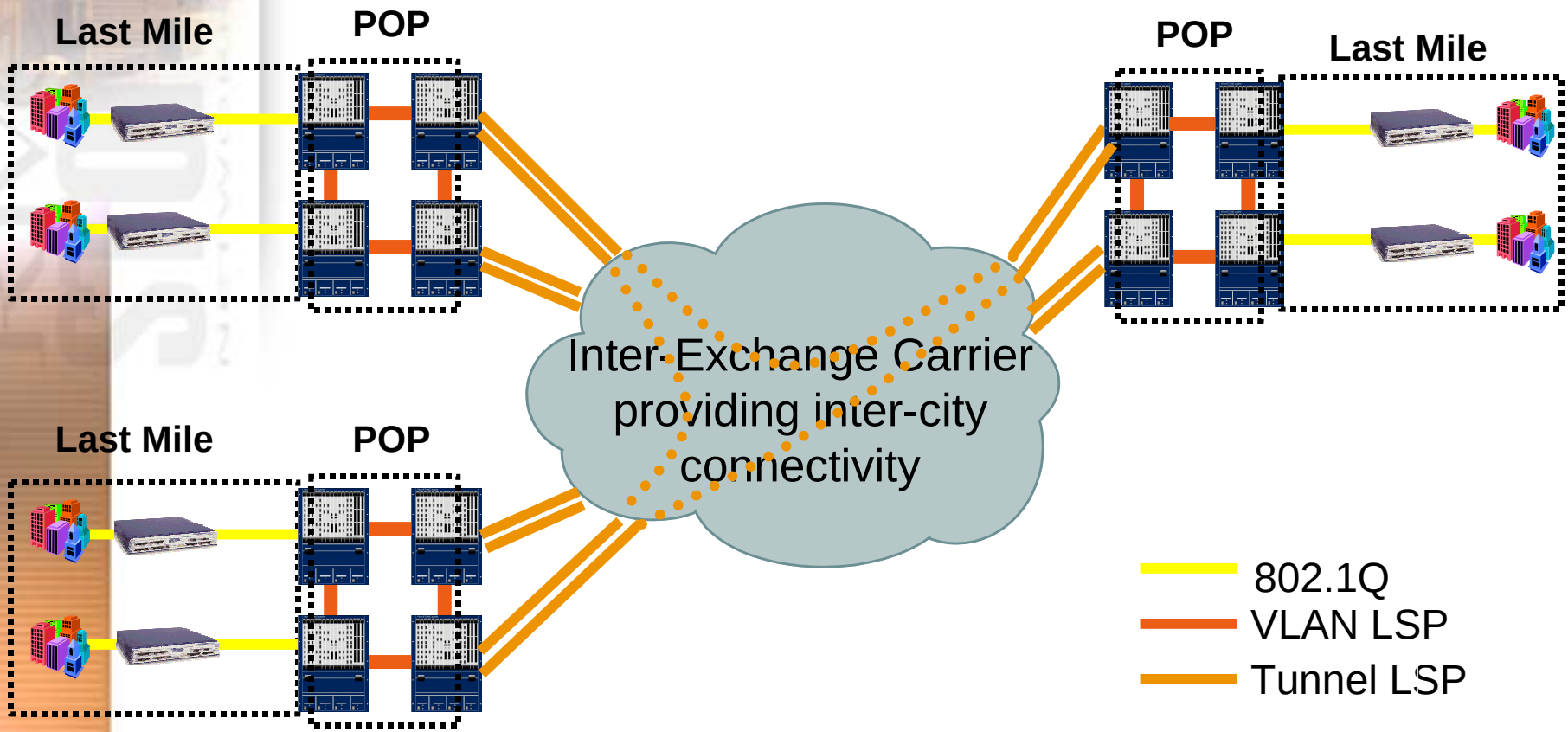
- MPLS standards only specify
  - VLL
  - IP VPN's
- TLS support requires additional extensions
  - Transparent bridging support
    - Broadcast support
    - Address learning
    - Split-horizon
  - L2 FEC's

Metro VPN Services
MPLS Virtual Leased Line

- *MPLS VLL Service*
  - *pair of LSP's of opposite directions forming a single virtual pipe*
  - *Size of pipe based on traffic characteristics*
    - *Can be dynamically changed*
  - *Explicitly routed L2 tunnel for guaranteed service*
- *Offers a self-healing point to point connection*
- *Requires MPLS L2 tunneling support*
  - *Ethernet in IP/GRE in MPLS*
  - *Martini draft*
- *Requires per LSP rate limiting/shaping*

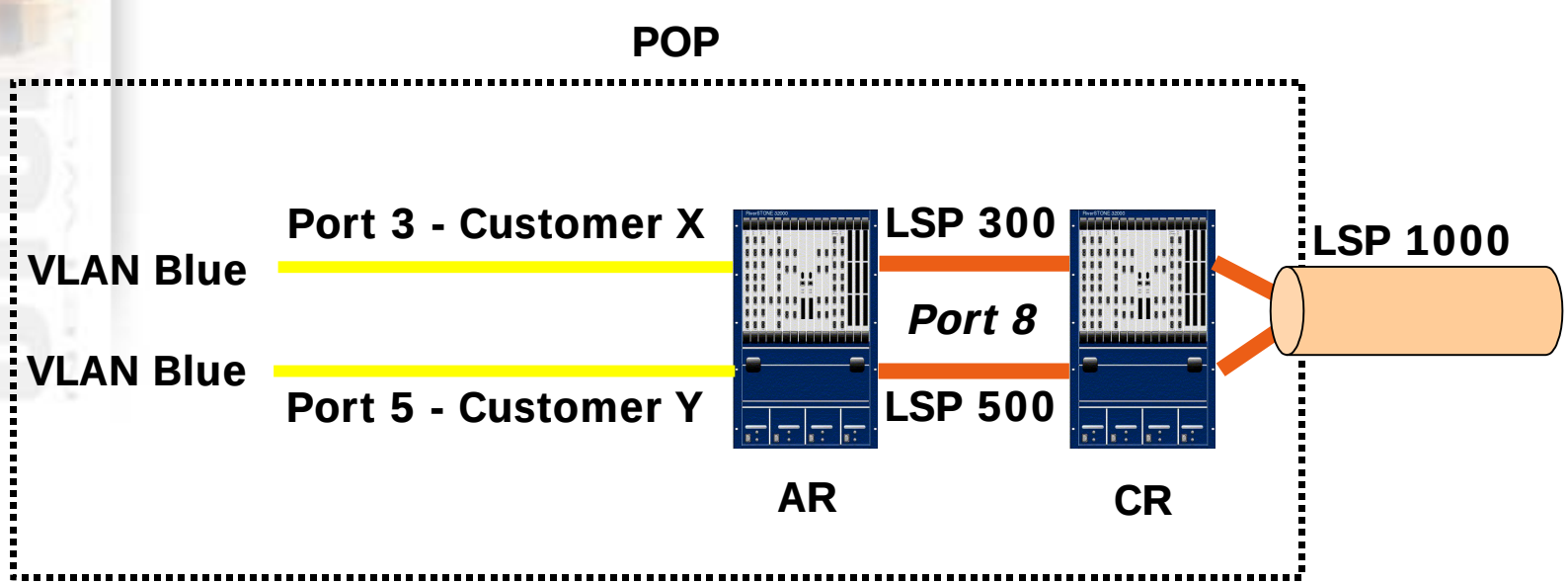
Metro VPN Services

MPLS Transparent LAN Service



- ***.1Q tagged traffic tunneled in LSP's***
  - ***LSP's appear as .1Q trunk LSP's***
- ***.1p mapped into Exp bits or into different QoS LSP's***

Metro VPN Services
MPLS TLS: ZOOM in POP



- *Label hierarchy*
  - *Customers' VLAN 's are mapped to specific "VLAN LSP's" in order to allow private VLAN Id spaces*
  - *"VLAN LSP's" are tunneled in the core within a "Tunnel LSP" used to carry traffic between POP's*
- *L2 policy example*
  - *Traffic from Port 3 & VLAN Blue to be sent to Port 8 & LSP 300*

Metro VPN Services
VLL/TLS Models

- **Martini tunnels**
  - **Carry ATM/Frame Relay/Ethernet**
  - **Sequencing capability**
  - **No fragmentation support**
    - **Requires jumbo frame support**
- **IP/GRE over MPLS tunnels**
  - **Bridged IP traffic**
    - **Can be pre-fragmented**
      - **if transit network can not carry large frames**
      - **if no IP MTU path discovery support**

Metro VPN Services
Two MPLS VPRN models

- **Virtual Router**
  - **per VPN routing protocol instance**
  - **per VPN RIB and FIB**
  - **No protocol extensions**
- **BGP VPN**
  - **MP-BGP exchanges extended VPN-IP addresses between PE routers**
    - **PE translates these CE advertized IP addresses into unique VPN-IP addresses**
    - **VPN-IP addresses exchanged via MP-BGP only to PE routers member of corresponding VPN**

MPLS IP VPNs: On a collision course

- VR and BGP VPN offer similar services
  - PE/VR and CE routers attached to a specific VPN exchange which addresses are reachable via
    - Static routing
    - RIP/OSPF/BGP
  - MPLS tunnel between PE/VR routers
    - Core routers are VPN unaware

Conclusion

Best of Two Worlds

- MPLS is the evolution of current IP and connection oriented protocols
  - Strength and scalability of IP routing
  - PVC like connectivity
  - ATM like QoS
  - Explicit routing
- Plus
  - Path protection/optimization
  - Load balancing

Scalability of MPLS

- **Smart Routed Edge**
  - **Packet classification**
    - **Prioritization/Marking**
    - **FEC to LSP/Exp mapping**
  - **Rate limiting/shaping**
  - **ACL's**
- **Simple Switched Core**
  - **Label swapping**
  - **Uses extended routing protocols to signal LSP's**

Key MPLS Applications

- Differentiated & Guaranteed services
- Traffic Engineering
- VPNs
  - Transparent LAN Services
  - Virtual Leased Line Services
  - Routed VPNs

Thank You

Acronyms

ACL	Access Control List
ATM	Asynchronous Transfer Mode
BGP	Border Gateway Protocol
CoS	Class of Service
CR-LDP	Constraint based Label Distribution Protocol
CSPF	Constrained Shortest Path First
ER-LSP	Explicitly Routed LSP
FEC	Forward Equivalency Class
GRE	Generic Routing Encapsulation
IGP	Interior Gateway Protocol
ISIS	Intermediate System to Intermediate System
LDP	Label Distribution Protocol
LSP	Label Switched Path
MPLS	Multi-Protocol Label Switching
OSPF	Open Shortest Path First
QoS	Quality of Service
RSVP	Resource Reservation Protocol
TE	Traffic Engineering
TLS	Transparent LAN Service
ToS	Type of Service
VLL	Virtual Leased Line
VPN	Virtual Private Network
VPRN	Virtual Private Routed Network