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Transmitting Timing over Packet networks: Hardware, and Network design considerations

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Agenda

- Timing transmission over packet.
- MPLS, and Network Design
- Network Maintenance Procedures
- Jitter & Delay Variation
- Testing Network Hardware.
- Network Hardware, some experiences, and designs
- Conclusions.

Scope of timing transmission

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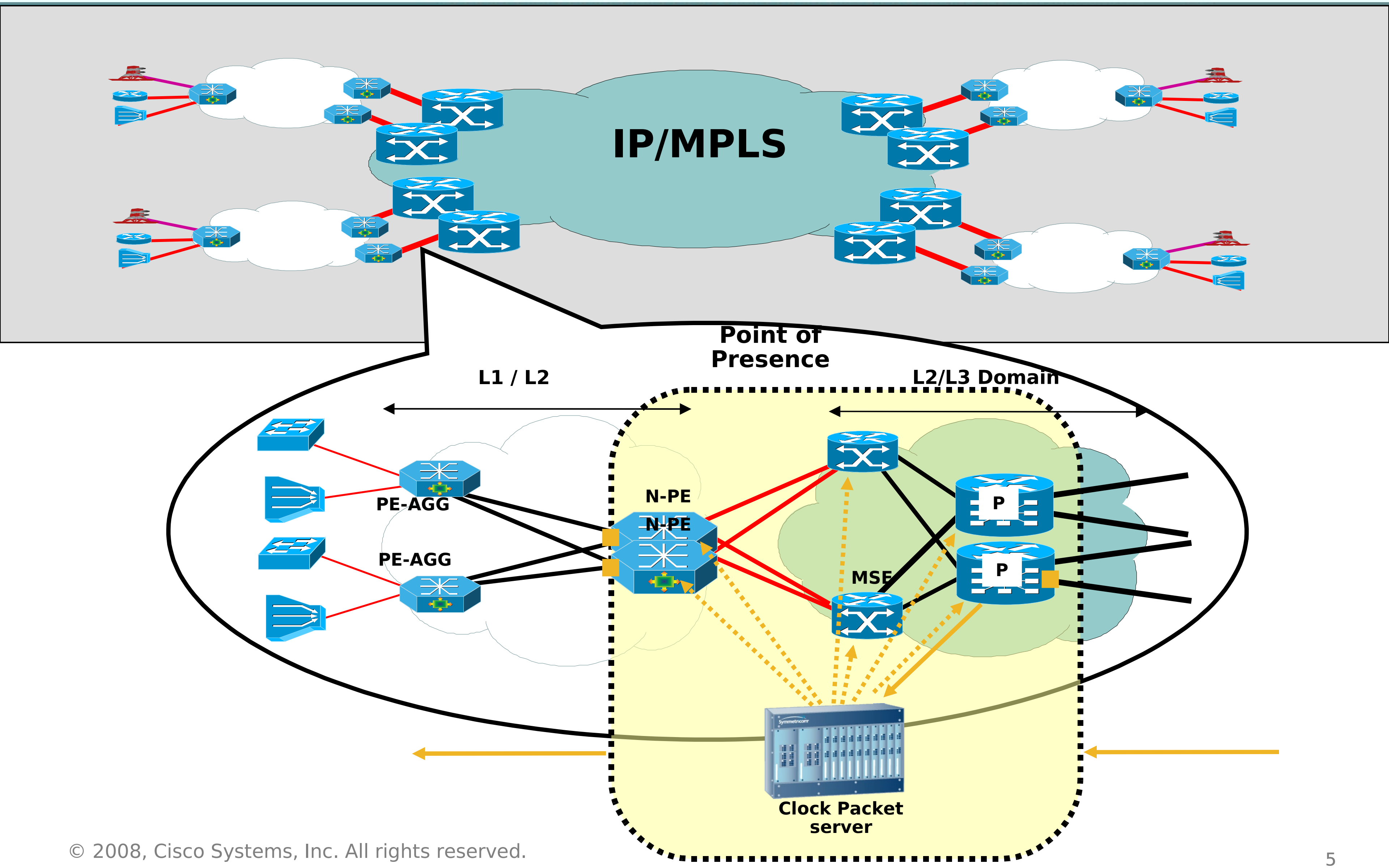
- Local distribution
  - Local ethernet/MPLS Metro rings
  - CO to CO connectivity
- Long Haul transmission
  - Sync Ethernet
  - Sync over Packet
- TDM Circuit Emulation

Timing distribution and MPLS network design.

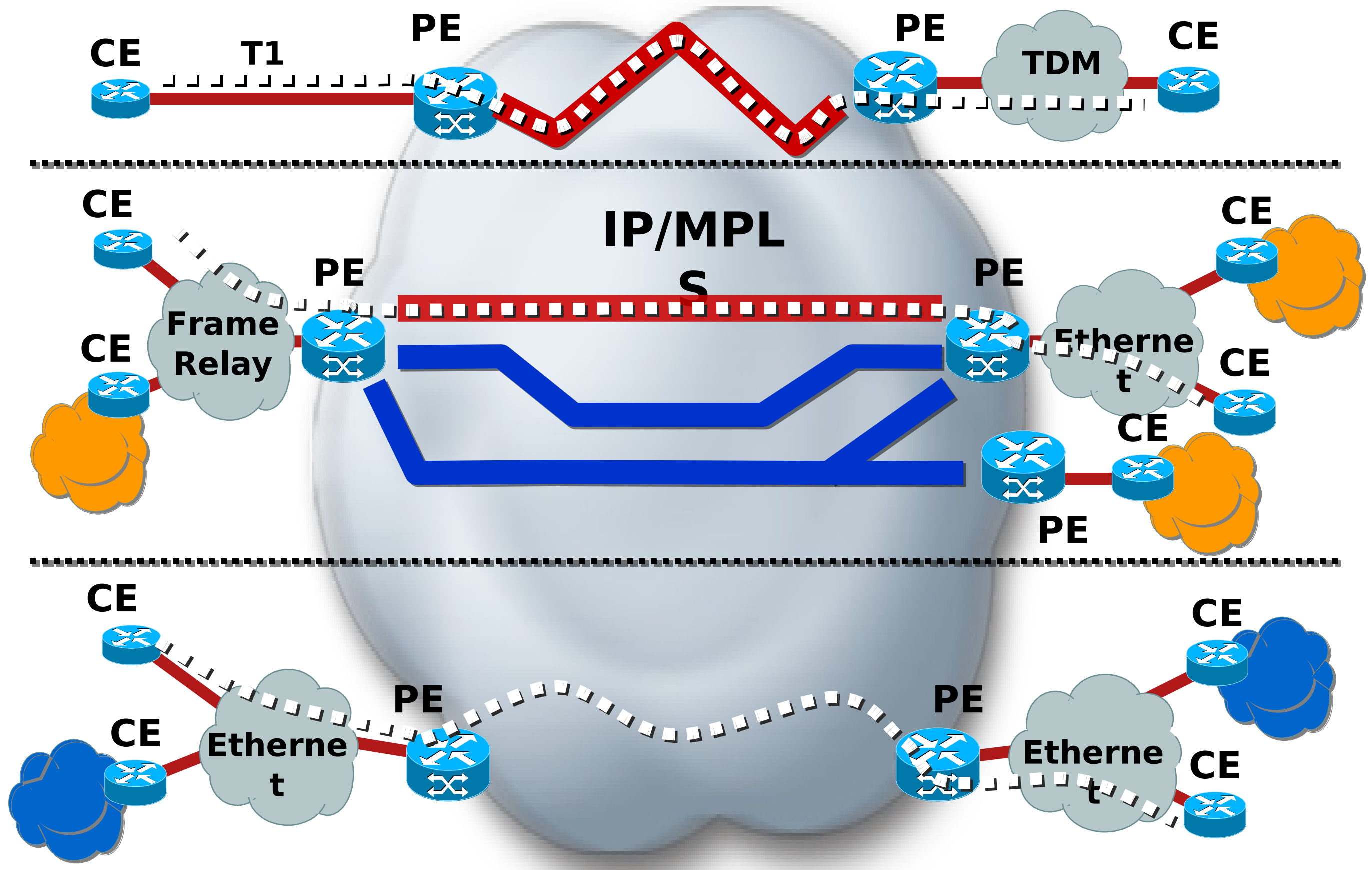
- **Network Design Goals:**
  - •Reduce Jitter and long term delay variation.
  - •Provide very high availability.
  - •Optimize network utilization.
- **Ultimately : Reduce Cost.**

Local Access Networks.



MPLS TE Integration with Network Services

A TE LSP provides transport for network services



Low-Latency, BW Protected TE LSP

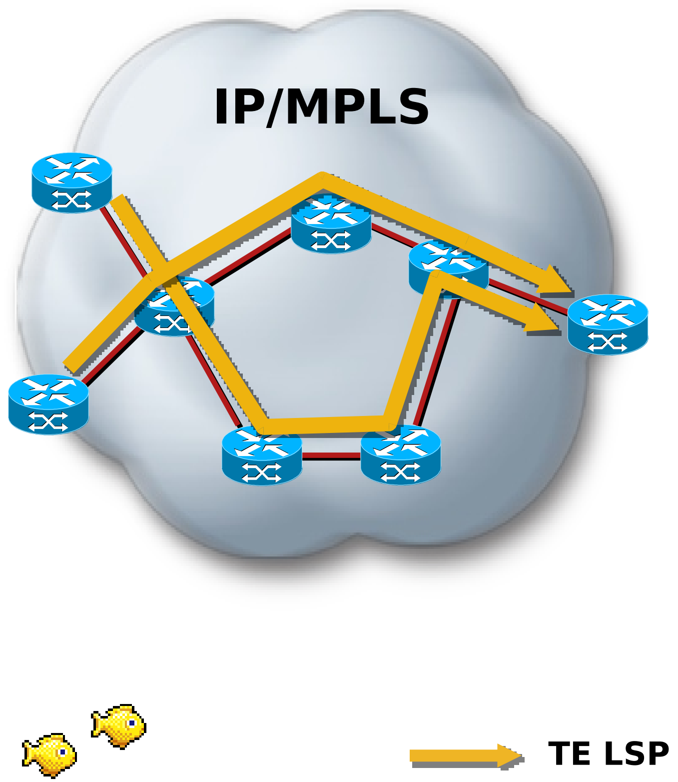
TE LSP with Reserved BW

L2VPN (Pseudowire)

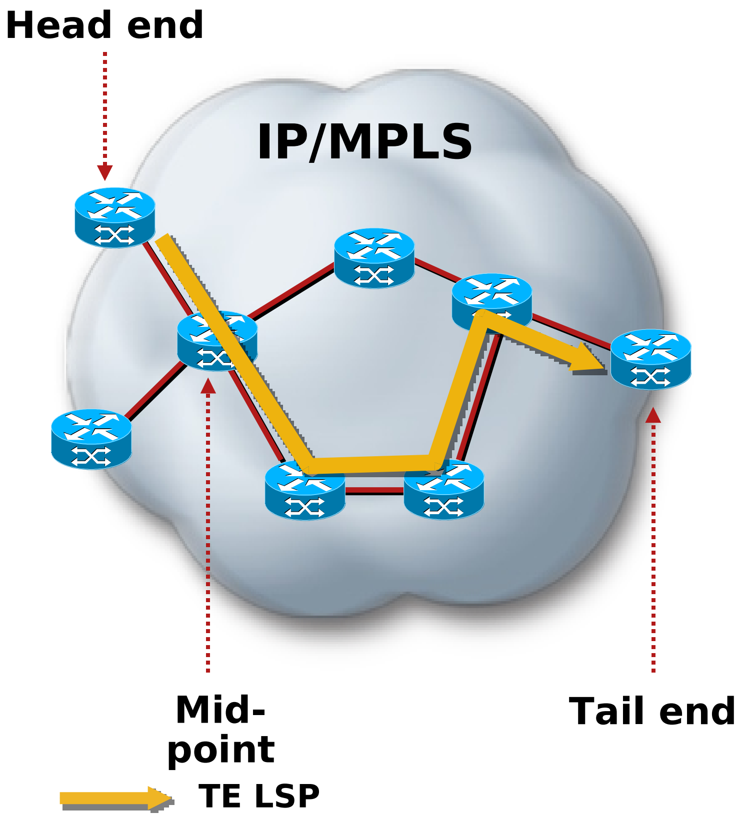
IP (VPN) Service

MPLS TE Overview

- Introduces **explicit routing**
- Supports **constrained-based routing**
- Supports **admission control**
- Provides **protection** capabilities
- Uses **RSVP-TE** to establish LSPs
- Uses **ISIS and OSPF extensions** to advertise link attributes



How MPLS TE Works



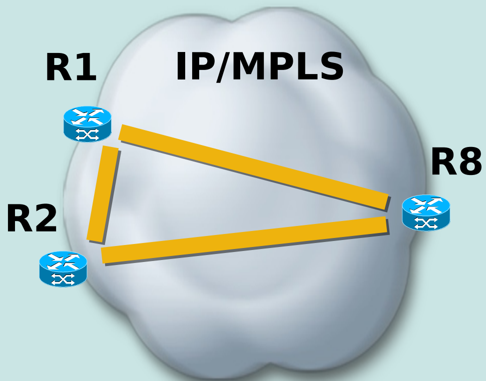
- **Link information Distribution***
  - ISIS-TE
  - OSPF-TE
- **Path Calculation (CSPF)***
- **Path Setup (RSVP-TE)**
- **Forwarding Traffic down Tunnel**
  - Auto-route
  - Static
  - PBR
  - CBTS
  - Forwarding Adjacency
  - Tunnel select

*** Optional**

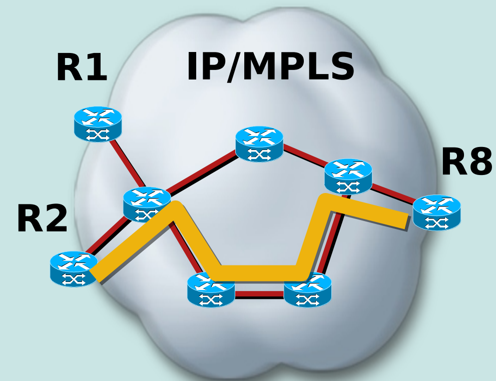
MPLS TE Deployment Models

Bandwidth Optimization

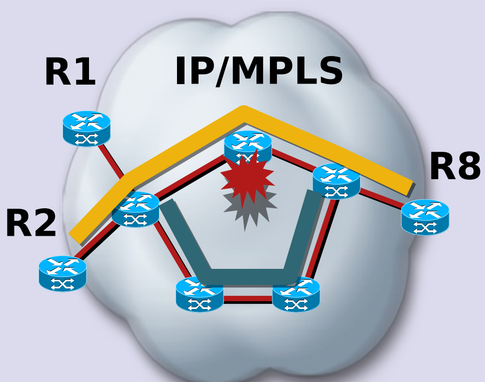
Strategic



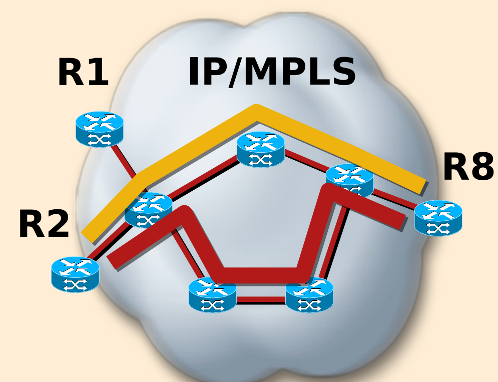
Tactical



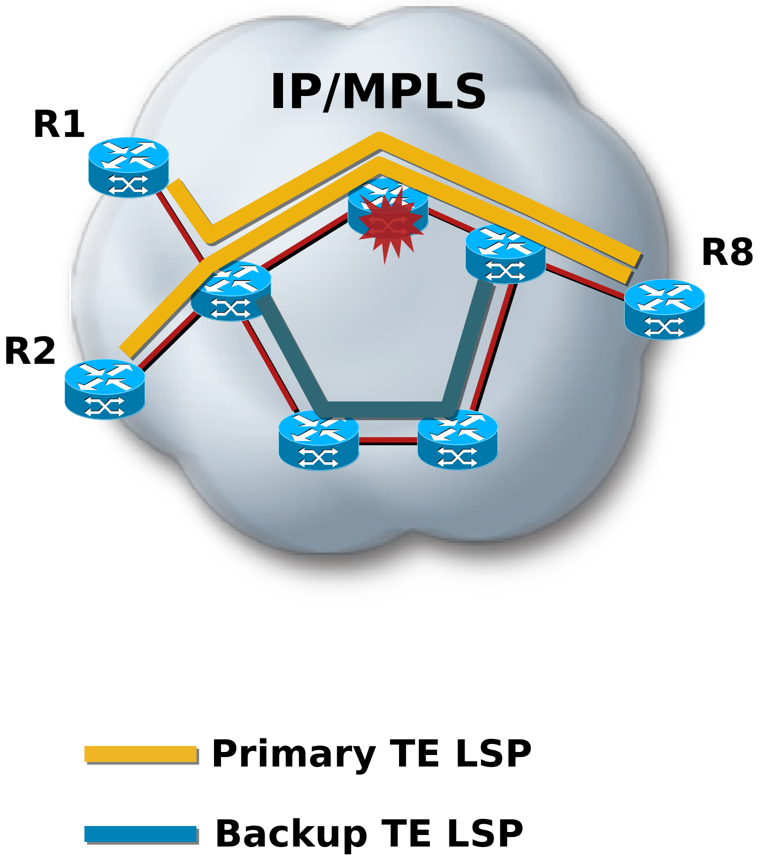
Protection



Point-to-Point SLA



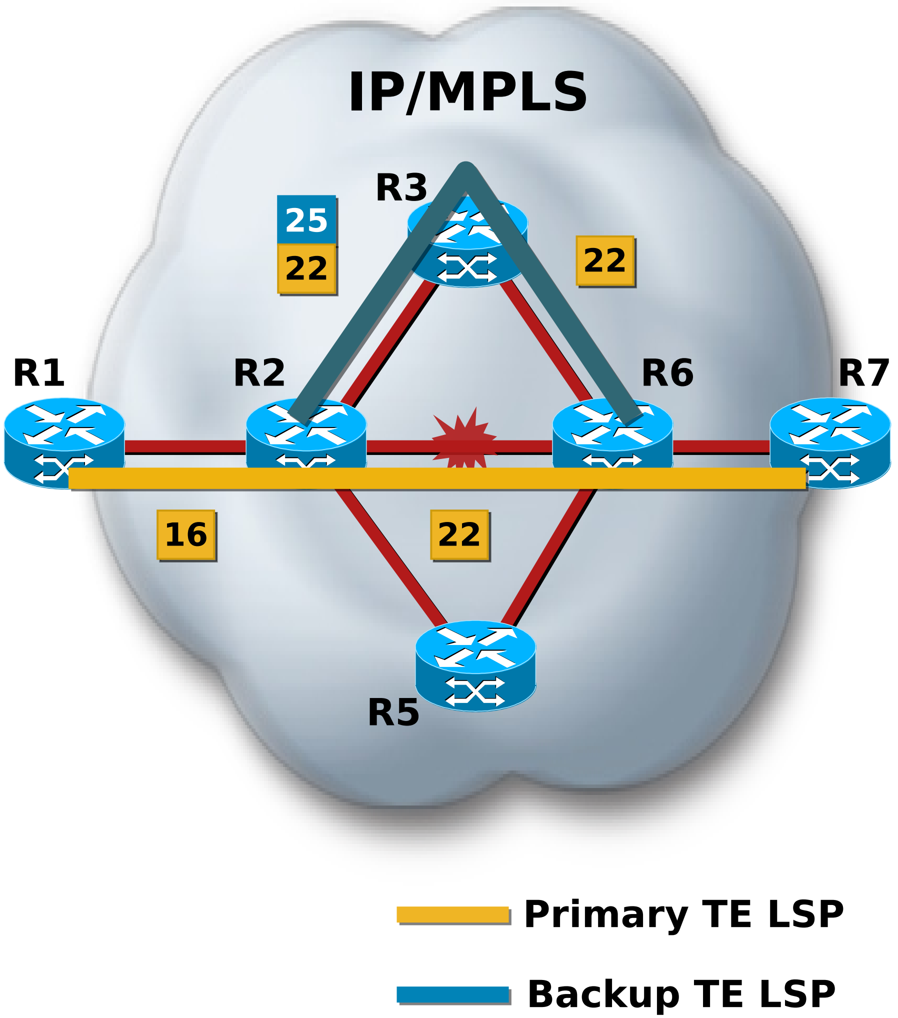
Traffic Protection Using MPLS TE Fast Re-Route (FRR)



- **Subsecond recovery against node/link failures**
- **Scalable 1:N protection**
- **Greater protection granularity**
- **Cost-effective alternative to 1:1 protection**
- **Bandwidth protection**

FRR Link Protection Operation

- Requires next-hop (NHOP) backup tunnel
- Point of Local Repair (PLR) swaps label and pushes backup label
- Backup terminates on Merge Point (MP) where traffic rejoins primary
- Restoration time expected under ~50 ms



FRR Node Protection Operation

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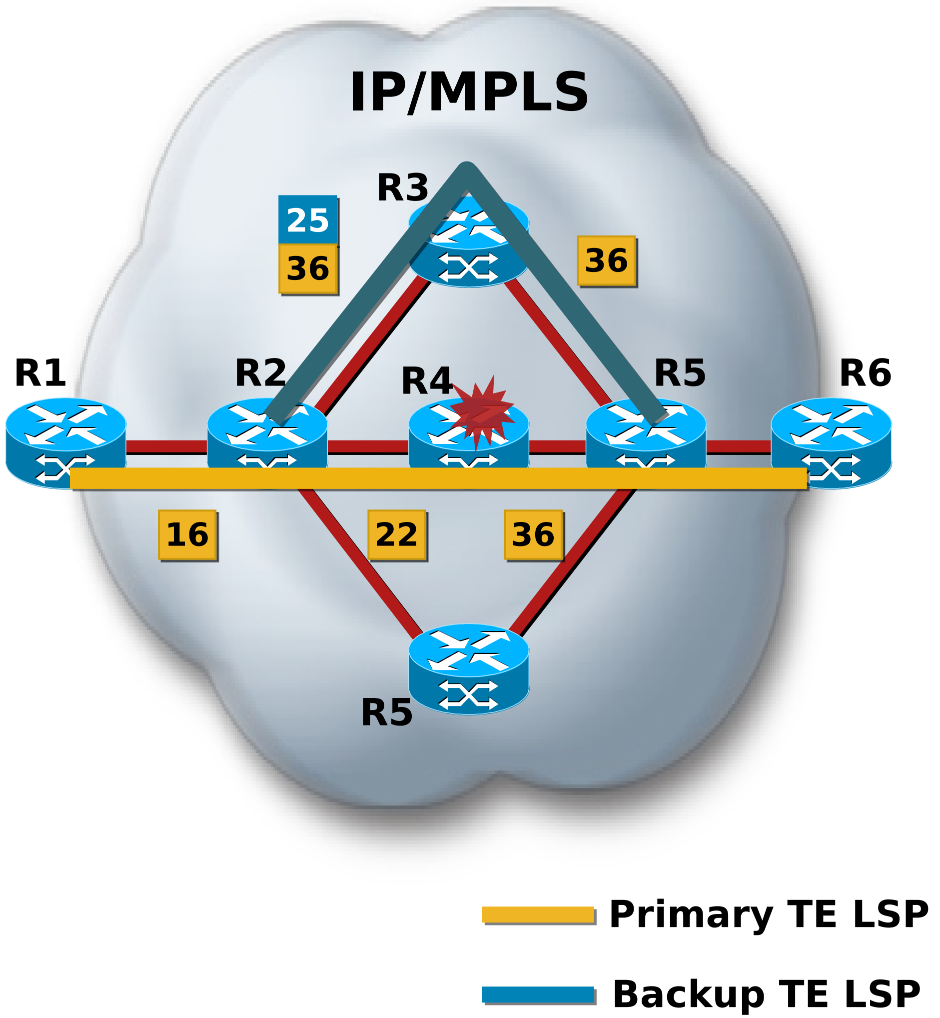
- Requires next-next-hop (NNHOP) backup tunnel
- Point of Local Repair (PLR) swaps next-hop label and pushes backup label
- Backup terminates on Merge Point (MP) where traffic rejoins primary
- Restoration time depends on failure detection time



MPLS Network Design: Keep it simple

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- **The biggest network outage cause is always the Human.**
- **Layered design:**
  - **Core with RSVP LSPs and FRR protection.**
  - **LDP inside RSVP, and LDP hop by hop for protocol redundancy.**
  - **Local RSVP LSP mesh in the access.**
  - **NO TE unless the particular network application results in a significant improvement in Bandwidth utilization.**
-

Network Design: Jitter and traffic

- **Network Congestion is generally a long lasting event.**
- **Network traffic is burty traffic , even when aggregated in large sales (10G)**
- **Total packet delay variation is a sum of the jitter of all hops traversed...**
  - **Ex: 100uS per hop would yield a worst case 1ms for a 10 hop network.**

Network Maintenance Procedures

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- **Well documented, and controlled changes to the network.**
- **Take into account Timing transmission.**
- **Take network elements out of service gracefully**
- **Verify backup network path/elements before maintenance activities**

Inter packet delay variation.

- **It's not a perfect world .....**
  - •Some types of congestion generates Jitter
  - •Even in the “Real time” Priority Queue.
- **Brief Jitter does not affect timing transmission over a packet network.**
- **Long term (minutes/hours) jitter will cause a problem.**

Lab testing

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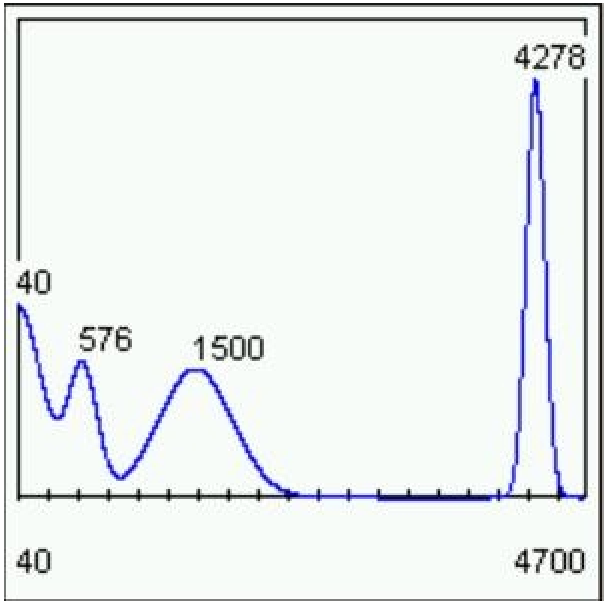
- **Real network conditions are difficult to reproduce.**
  - **Temporal packet and size distributions affect the router behavior.**
  - **Simple “I-Mix” packet distributions simply do not work.**

Example of a Quad modal Gaussian packet size distribution:



Testing Cont'n

- **Requirements to reproduce a real network:**
  - **•Large amount of simulated Ip addresses**
  - **•At least 6 ports active.**
  - **•Quad modal Gaussian distribution.**

Hardware design and Queues

- **Queuing theoretical operation:**
  - **In MDRR (Modified Deficit Round Robin):**
    - **Queues are allocated a precise amount of bandwidth**
    - **In the real time priority queue Packet Jitter is proportional to the time required to transmit the largest possible frame in any queue.**
- **Reality (Scheduler Error):**
  - **% error in queue bandwidth allocation is inversely proportional to the amount of jitter.**
    - **More accurate queues = more jitter**
  - **Real time queue is only real time within a certain number of packets on fast interfaces.**

Hardware design cont'n

- Large MPLS routers are collections of asynchronous functional blocks.
  - •How do we make these look like one big pipeline ?
  - •FIFOs...
- Un-Prioritized FIFOs are only apparent under an almost congested link at approximately 96% utilization.
- A collection of busy routers is additive, which makes the delay variation worse with a larger number of hops.
- A router which is very congested (> 100% offered load) has almost no jitter.

Summary

- Clock transmission over packet networks is easily achieved.
- Network Design is a major component.
- Choosing , and testing the correct network hardware is a key factor.
- Real network worst case conditions can be reproduced in the lab.