



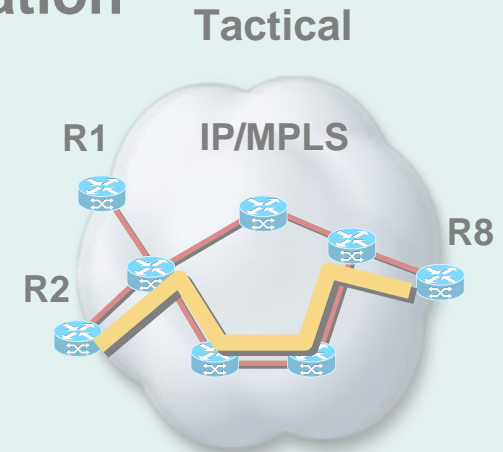
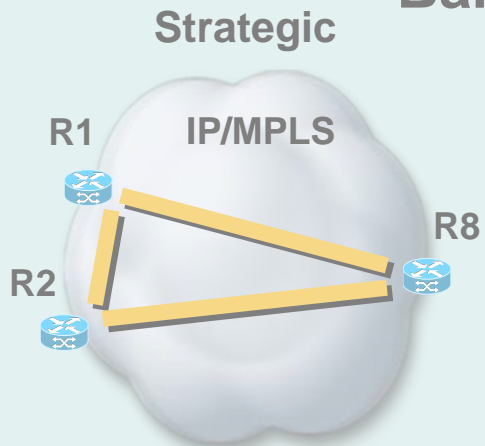
MPLS Traffic Engineering Traffic Protection using Fast Re-route (FRR)



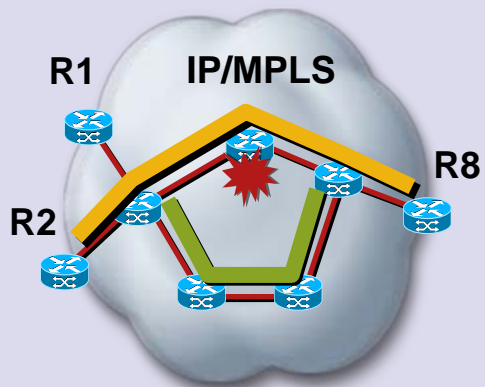
Santiago Álvarez
August 2008

MPLS TE Use Cases

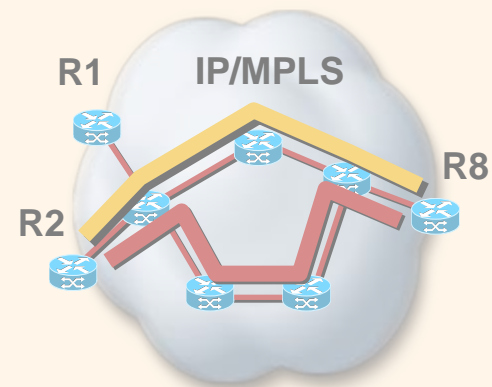
Bandwidth Optimization



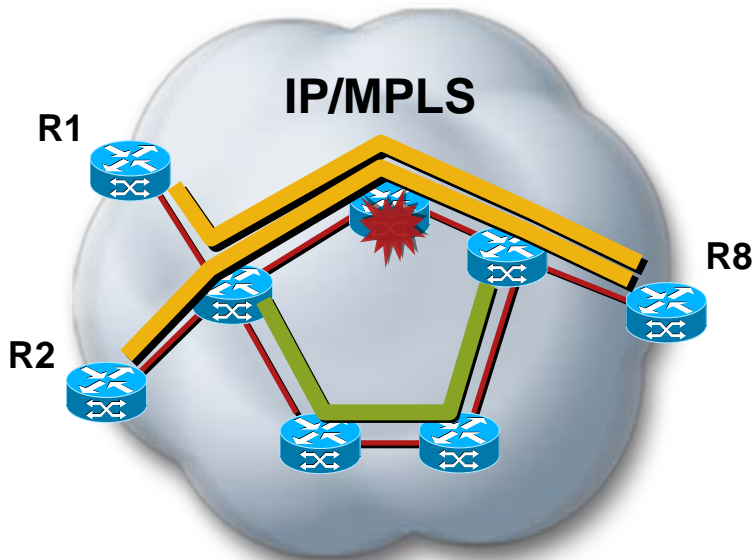
Protection



Point-to-Point SLA



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



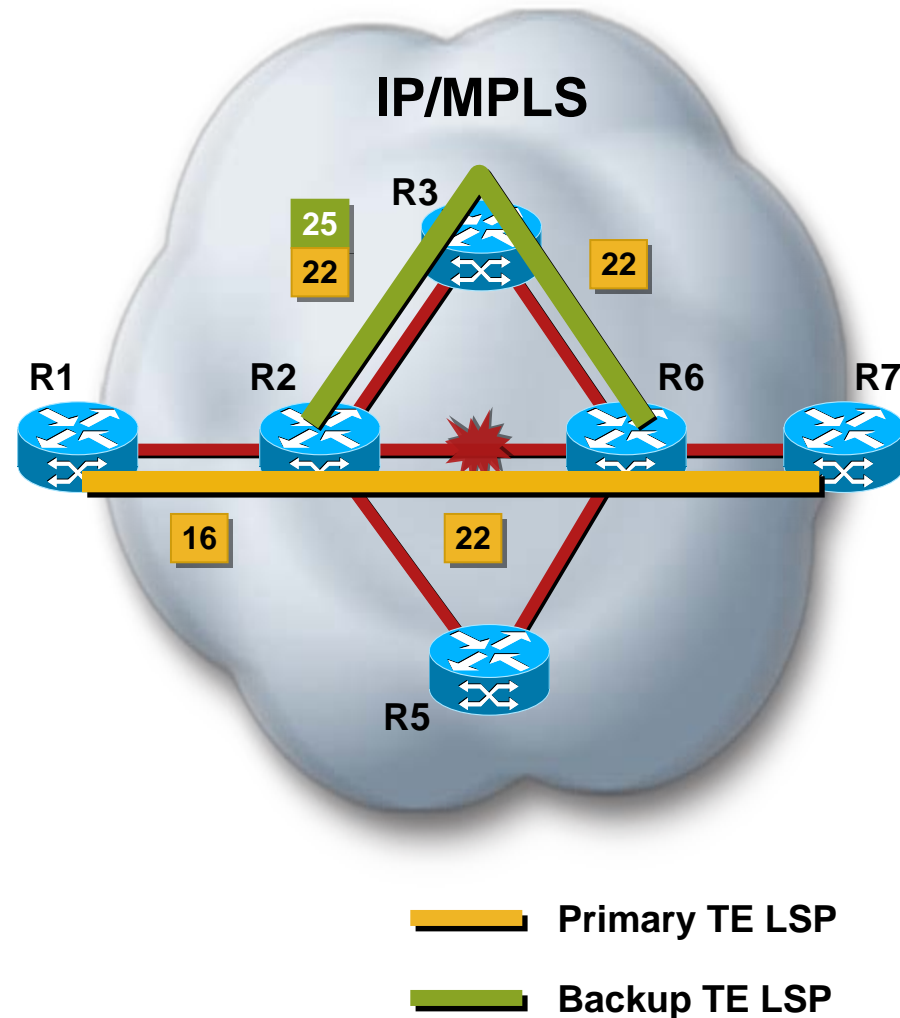
 Primary TE LSP

 Backup TE LSP

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

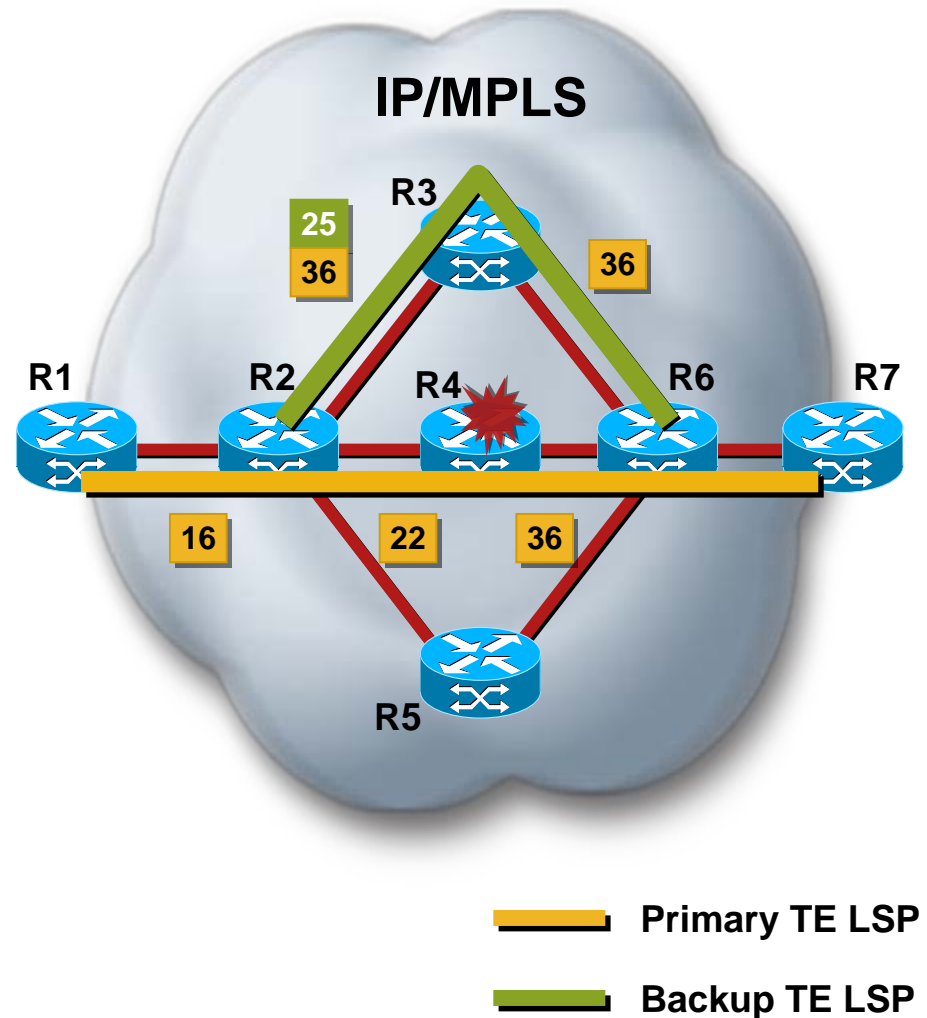
FRR Link Protection Operation

- 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



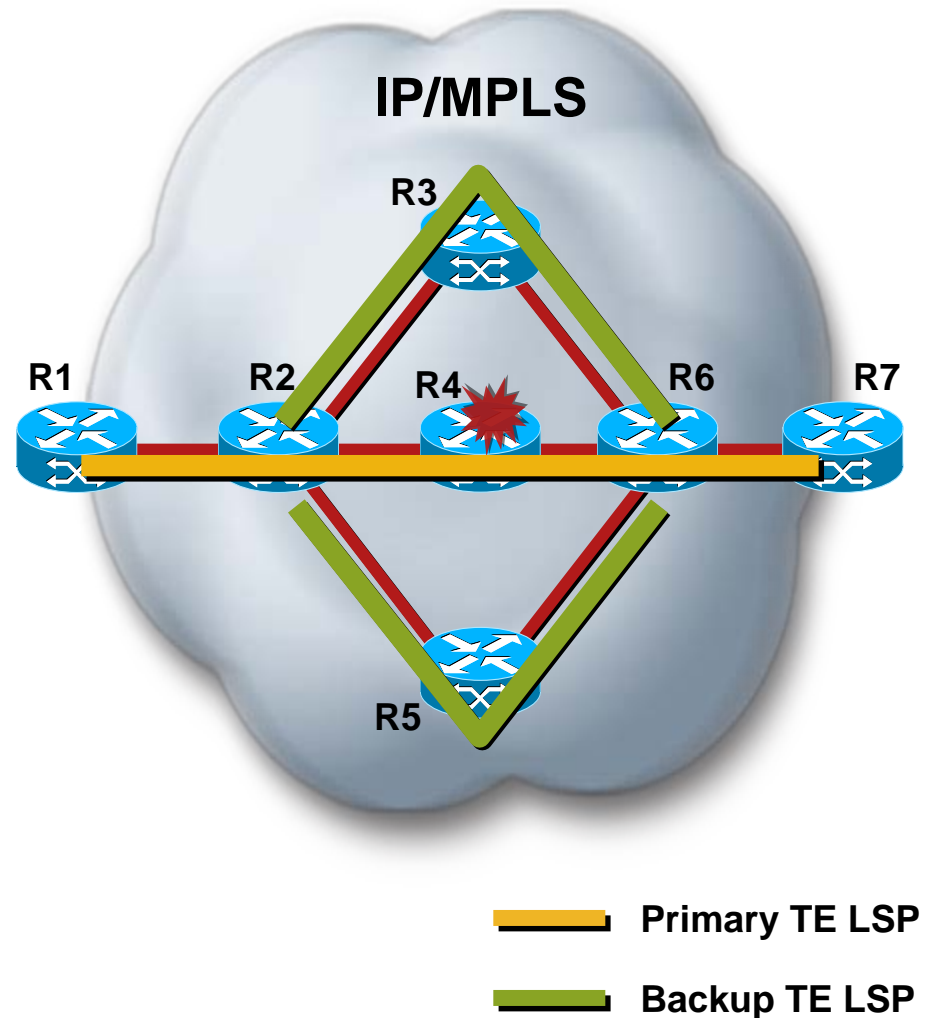
FRR Node Protection Operation

- 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



Bandwidth Protection


- Backup tunnel with associated bandwidth capacity
- Backup tunnel may or may not actually signal bandwidth
- PLR will decide best backup to protect primary (nhop/nnhop, backup-bw, class-type, node-protection flag)



Configuring FRR (Cisco IOS)

Primary Tunnel


```
interface Tunnell
  description FROM-ROUTER-TO-DST1-FRR
  ip unnumbered Loopback0
  tunnel destination 172.16.255.2
  tunnel mode mpls traffic-eng
  tunnel mpls traffic-eng bandwidth 20000
  tunnel mpls traffic-eng path-option 10 dynamic
  tunnel mpls traffic-eng fast-reroute
```



Indicate the desire for local protection during signaling

Backup Tunnel

```
interface Tunnell
  description NNHOP-BACKUP
  ip unnumbered Loopback0
  tunnel destination 172.16.255.2
  tunnel mode mpls traffic-eng
  tunnel mpls traffic-eng path-option 10 explicit name PATH1
```



Explicitly routed backup to 172.16.255.2 with zero bandwidth


```
!
interface POS1/0/0
  ip address 172.16.192.5 255.255.255.254
  mpls traffic-eng tunnels
  mpls traffic-eng backup-path Tunnell
  ip rsvp bandwidth
```

Use Tunnell as backup for protected LSPs through POS1/0/0

Configuring FRR (Cisco IOS XR)

Primary Tunnel


```
interface tunnel-te1
  description FROM-ROUTER-TO-DST1-FRR
  ipv4 unnumbered Loopback0
  signalled-bandwidth 30000
  destination 172.16.255.2
  fast-reroute
  path-option 10 dynamic
!
```



Indicate the desire for local protection during signaling

Backup Tunnel

```
interface tunnel-te1
  description NHOP-BACKUP
  ipv4 unnumbered Loopback0
  destination 172.16.255.130
  path-option 10 explicit name PATH1
!
mpls traffic-eng
  interface POS0/3/0/0
    backup-path tunnel-te 1
!
```



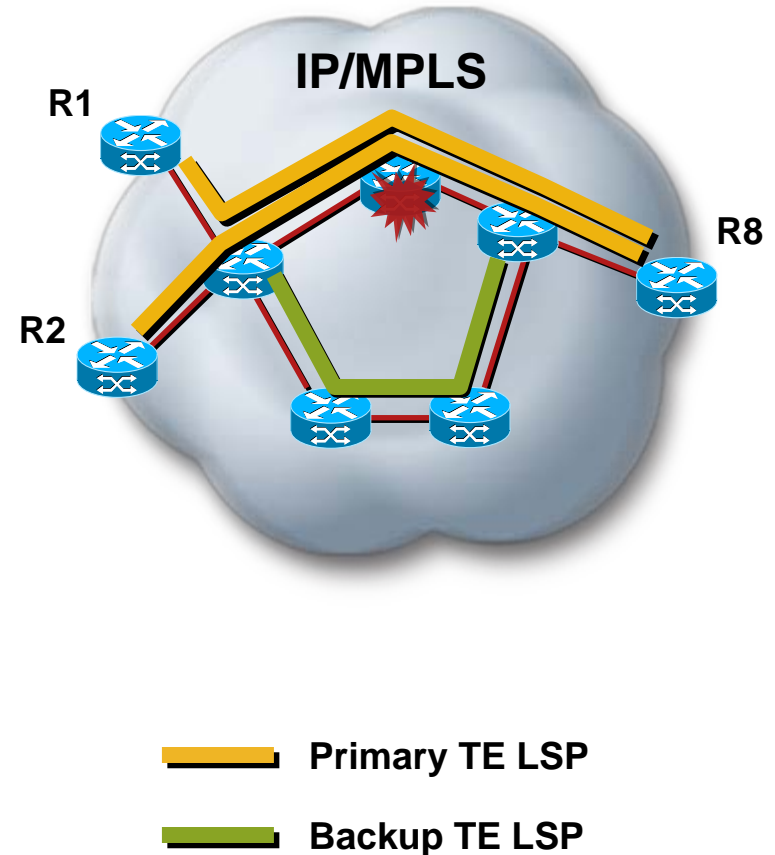
Explicitly routed backup to 172.16.255.130 with zero bandwidth

Use tunnel-te1 as backup for protected LSPs through POS0/3/0/0

AutoTunnel: Primary Tunnels

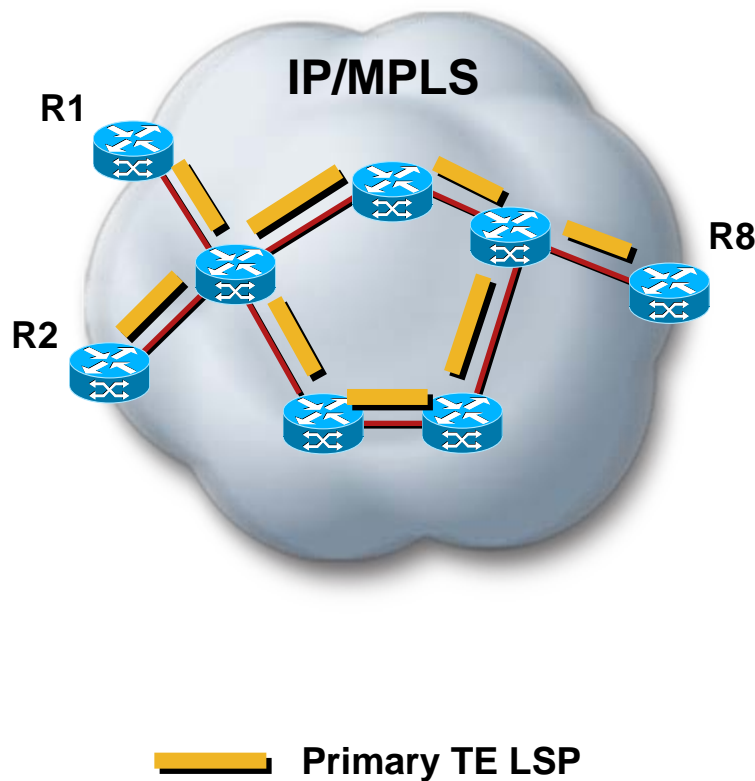
What's the Problem?

- FRR can protect TE Traffic
- No protection mechanism for IP or LDP traffic
- How to leverage FRR for all traffic?
- What if protection desired without traffic engineering?



AutoTunnel: Primary Tunnels

What's the Solution?



- Forward all traffic through a one-hop protected primary TE tunnel
- Create protected one-hop tunnels on all TE links

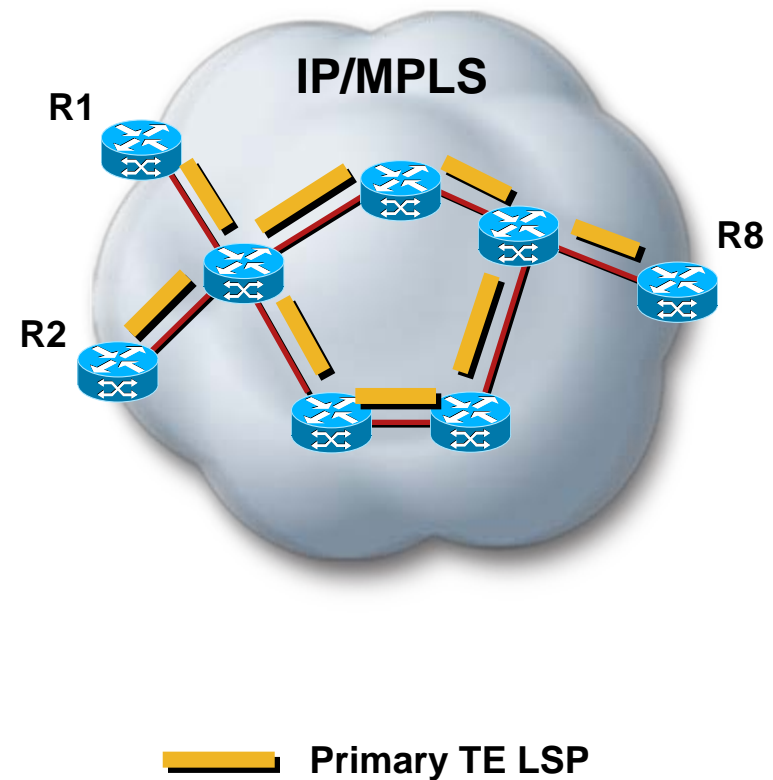
Priority	7/7
Bandwidth	0
Affinity	0x0/0xFFFF
Auto-BW	OFF
Auto-Route	ON
Fast-Reroute	ON
Forwarding-Adj	OFF
Load-Sharing	OFF

- Tunnel interfaces not shown on router configuration
- Configure desired backup tunnels (manually or automatically)

AutoTunnel: Primary Tunnels

Why One-Hop Tunnels?

- CSPF and SPF yield same results (absence of tunnel constraints)
- Auto-route forwards all traffic through one-hop tunnel
- Traffic logically mapped to tunnel but no label imposed (imp-null)
- traffic is forwarded as if no tunnel was in place



Configuring AutoTunnel Primary Tunnels (Cisco IOS)

```
mpls traffic-eng tunnels
mpls traffic-eng auto-tunnel primary onehop
mpls traffic-eng auto-tunnel primary tunnel-num min 900 max 999
!
```



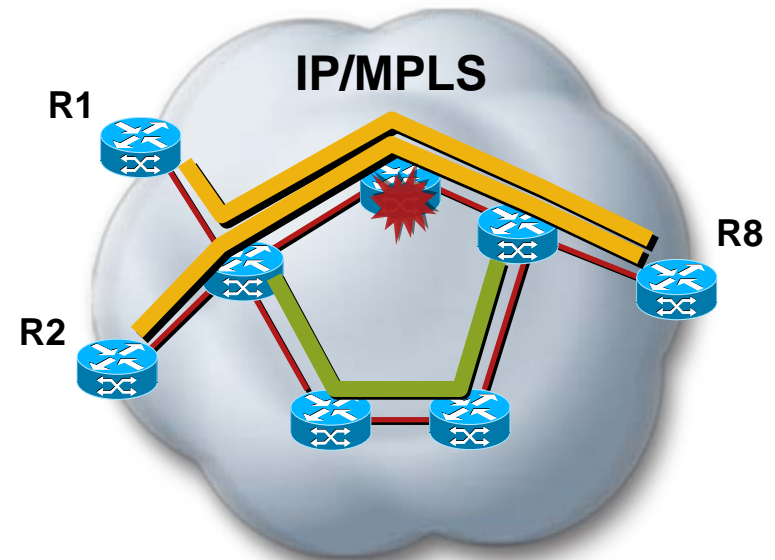
Enable auto-tunnel primary

Range for tunnel interfaces

AutoTunnel: Backup Tunnels

What's the Problem?

- MPLS FRR requires backup tunnels to be preconfigured
- Automation of backup tunnels is desirable

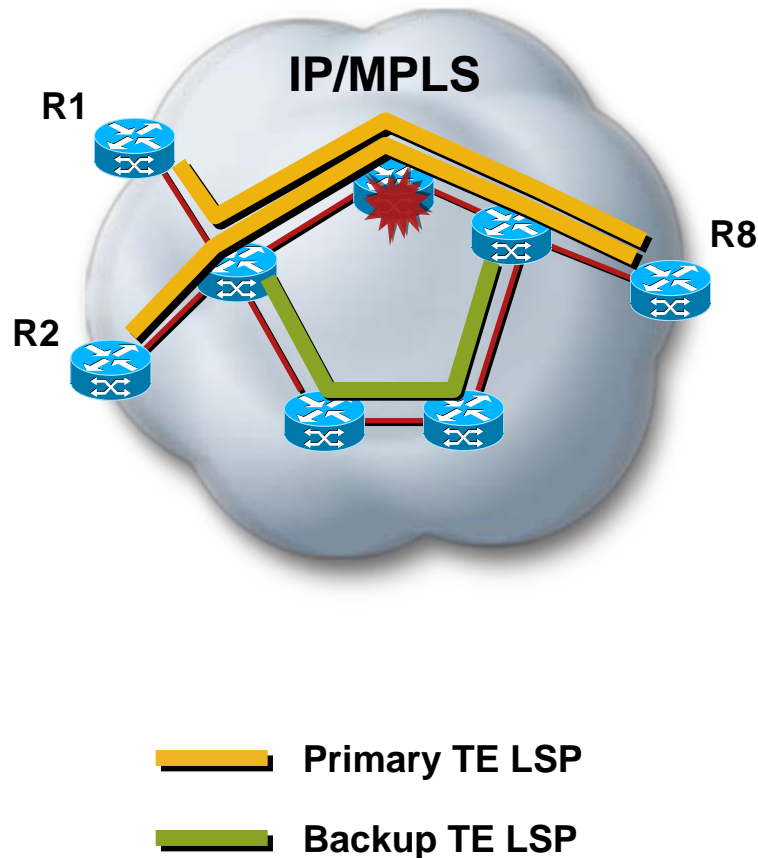


 Primary TE LSP

 Backup TE LSP

AutoTunnel: Backup Tunnels

What's the Solution?

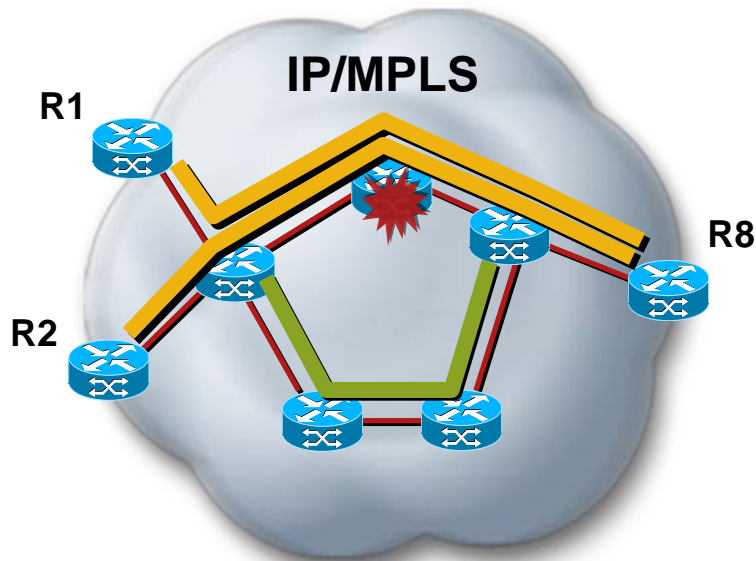


Create backup tunnels automatically as needed

- Detect if a primary tunnel requires protection and is not protected
- Verify that a backup tunnel doesn't already exist
- Compute a backup path to NHOP and NNHOP excluding the protected facility
- Optionally, consider shared risk link groups during backup path computation
- Signal the backup tunnels

AutoTunnel: Backup Tunnels

What's the Solution? (Cont.)



Primary TE LSP

Backup TE LSP

- Backup tunnels are preconfigured

Priority	7/7
Bandwidth	0
Affinity	0x0/0xFFFF
Auto-BW	OFF
Auto-Route	OFF
Fast-Reroute	OFF
Forwarding-Adj	OFF
Load-Sharing	OFF

- Backup tunnel interfaces and paths not shown on router configuration

Configuring AutoTunnel Backup Tunnels (Cisco IOS)

```
mpls traffic-eng tunnels
mpls traffic-eng auto-tunnel backup nhop-only
mpls traffic-eng auto-tunnel backup tunnel-num min 1900 max 1999
mpls traffic-eng auto-tunnel backup timers removal unused 7200
mpls traffic-eng auto-tunnel backup srlg exclude preferred
!
```



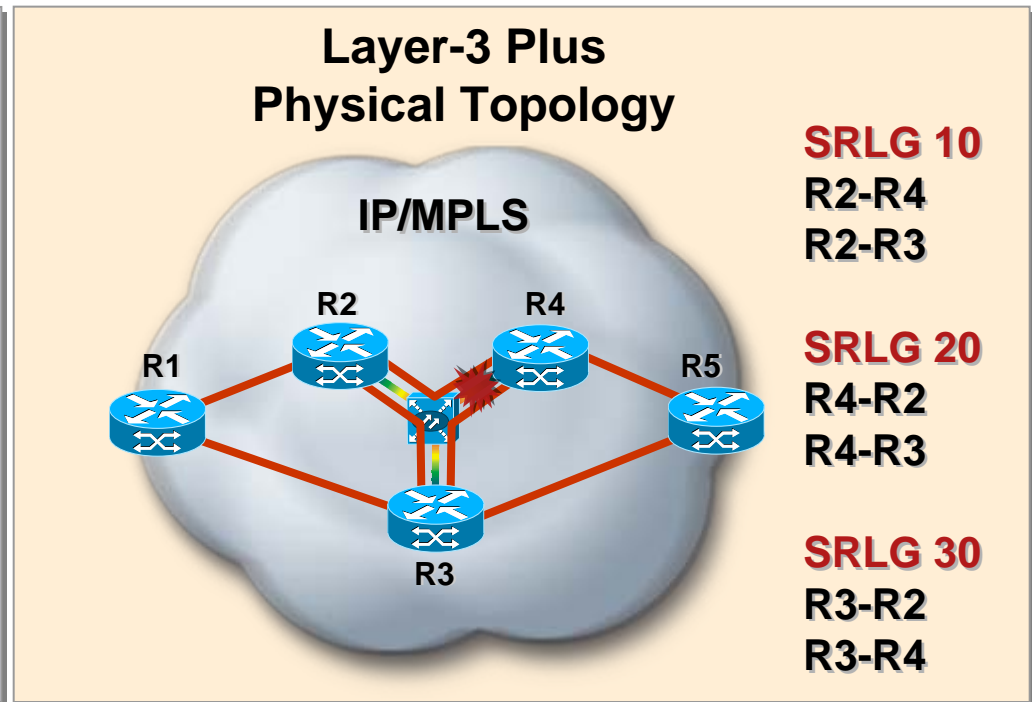
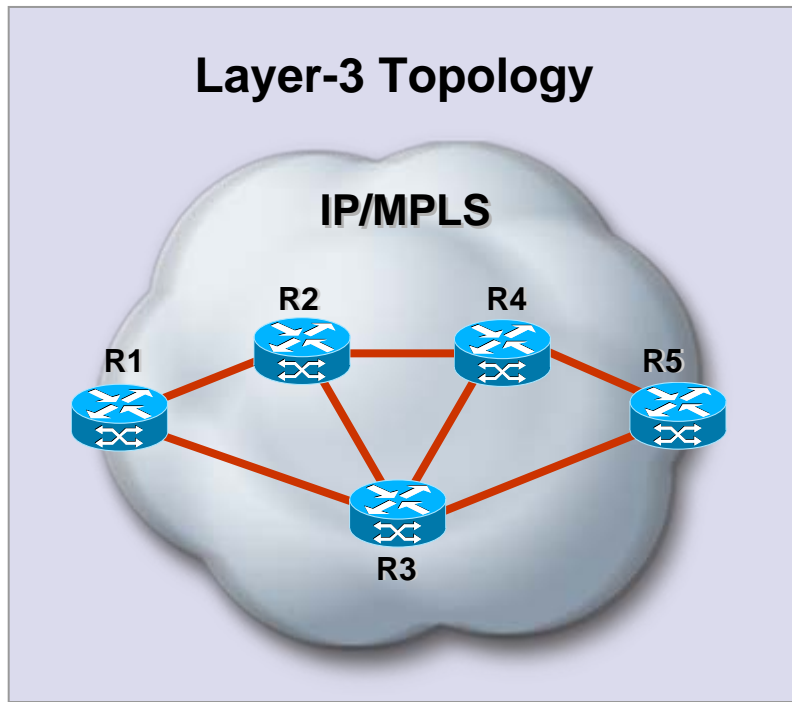
Enable auto-tunnel backup (NHOP tunnels only)

Range for tunnel interfaces

Tear down unused backup tunnels

Consider SRLGs preferably

Shared Risk Link Group (SRLG)



- Some links may share same physical resource (e.g. fiber, conduit)
- AutoTunnel Backup can force or prefer exclusion of SRLG to guarantee diversely routed backup tunnels
- IS-IS and OSPF flood SRLG membership as an additional link attribute

Configuring SRLG (Cisco IOS)

```
mpls traffic-eng tunnels
mpls traffic-eng auto-tunnel backup nhop-only
mpls traffic-eng auto-tunnel backup srlg exclude force
!
interface POS0/1/0
 ip address 172.16.0.0 255.255.255.254
 mpls traffic-eng tunnels
 mpls traffic-eng srlg 15
 mpls traffic-eng srlg 25
 ip rsvp bandwidth
!
interface POS1/0/0
 ip address 172.16.0.2 255.255.255.254
 mpls traffic-eng tunnels
 mpls traffic-eng srlg 25
 ip rsvp bandwidth
!
```



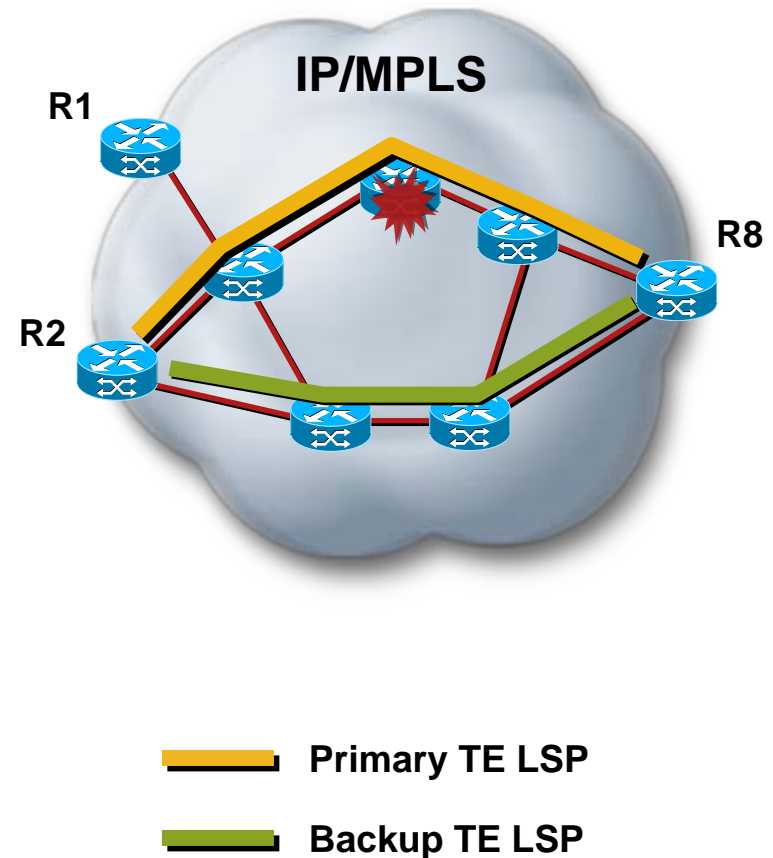
Force SRLG exclusion during backup path computation

Interface member of SRLG 15 and 25

Interface member of SRLG 25

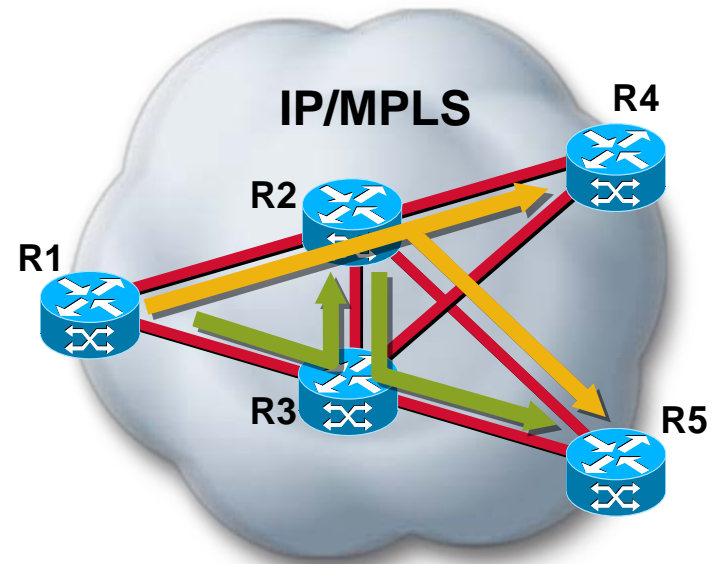
What About Path Protection?

- Primary and backup share head and tail, but diversely routed
- No dynamically computed path diversity
- Expected to result in higher restoration times compared to local protection
- Doubles number of TE LSPs (1:1 protection)
- May be an acceptable solution for restricted topologies (e.g. rings)

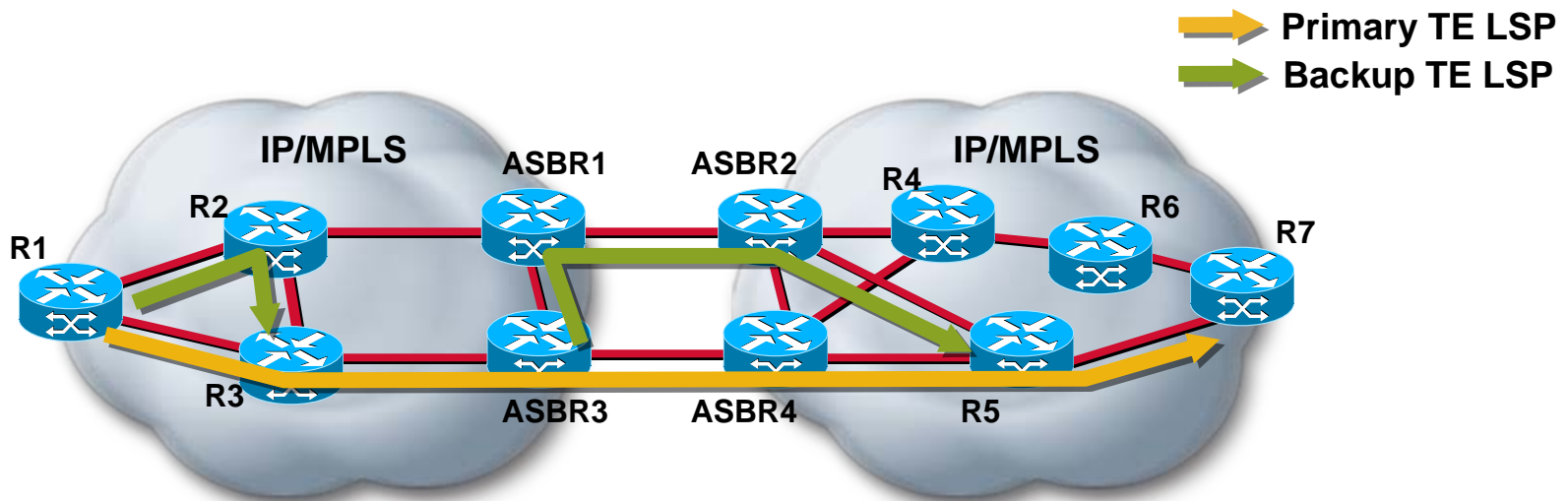


P2MP TE LSP Traffic Protection

- No new protocol extensions to support FRR
- Protection requirement applies to all destinations
- P2P LSP as backup tunnel for a sub-LSP
- No changes to label stacking procedure
- Only link protection supported



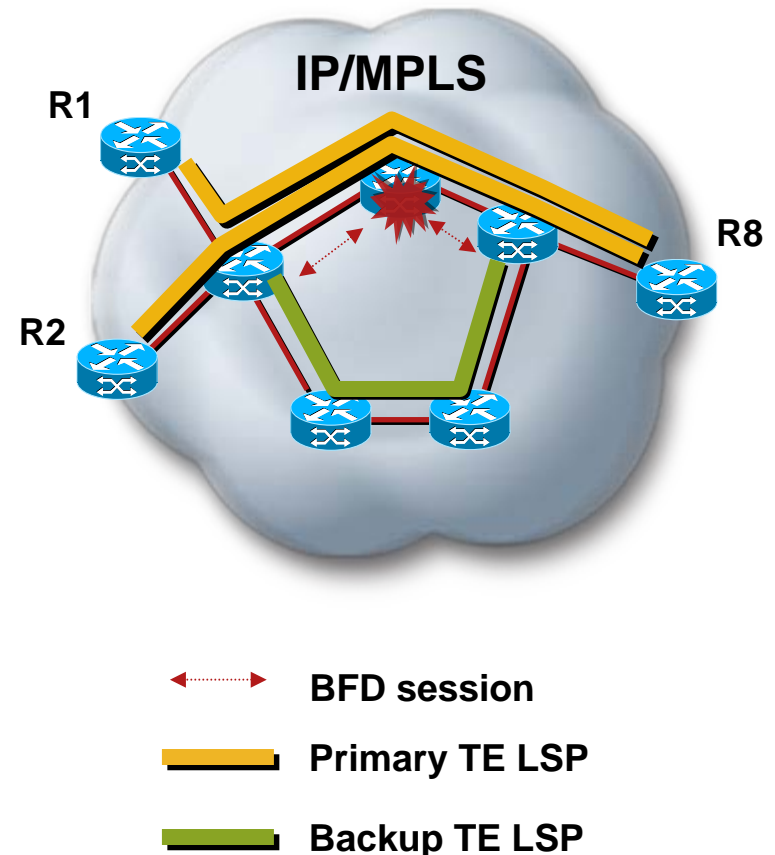
Inter-Domain TE – Fast Re-route



- Same configuration as single domain scenario
- Support for node-id sub-object required to implement ABR/ASBR node protection
- Node-id helps point of local repair (PLR) detect a merge point (MP)

Bidirectional Forwarding Detection Trigger for FRR

- FRR relies on quick PLR failure detection
- Some failures may not produce loss of signal or alarms on a link
- BFD provides lightweight neighbor connectivity failure detection



References



Cisco Documentation

- MPLS TE: Link and Node Protection, with RSVP Hellos Support (with Fast Tunnel Interface Down Detection)

http://www.cisco.com/en/US/partner/docs/ios/12_0s/feature/guide/slnph30.html

- MPLS Traffic Engineering: BFD-triggered Fast Reroute (FRR)

http://www.cisco.com/en/US/docs/ios/mpls/configuration/guide/mp_te_bfd_frr.html

- MPLS Traffic Engineering (TE)--AutoTunnel Primary and Backup

http://www.cisco.com/en/US/partner/docs/ios/12_0s/feature/guide/gautotn.html

- MPLS Traffic Engineering: Shared Risk Link Groups (SRLG)

http://www.cisco.com/en/US/partner/docs/ios/12_0s/feature/guide/s29srlg.html

Standards

- Fast Reroute Extensions to RSVP-TE for LSP Tunnels
<http://www.ietf.org/rfc/rfc4090>
- Routing Extensions in Support of GMPLS
<http://www.ietf.org/rfc/rfc4202>
- OSPF Extensions in Support of GMPLS
<http://www.ietf.org/rfc/rfc4203>
- IS-IS Extensions in Support of GMPLS
<http://www.ietf.org/rfc/rfc4205>
- Definition of a Record Route Object (RRO) Node-Id Sub-Object
<http://www.ietf.org/rfc/rfc4561>



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