Introduction to Label switched Multicast : P2MP-TE & mLDP

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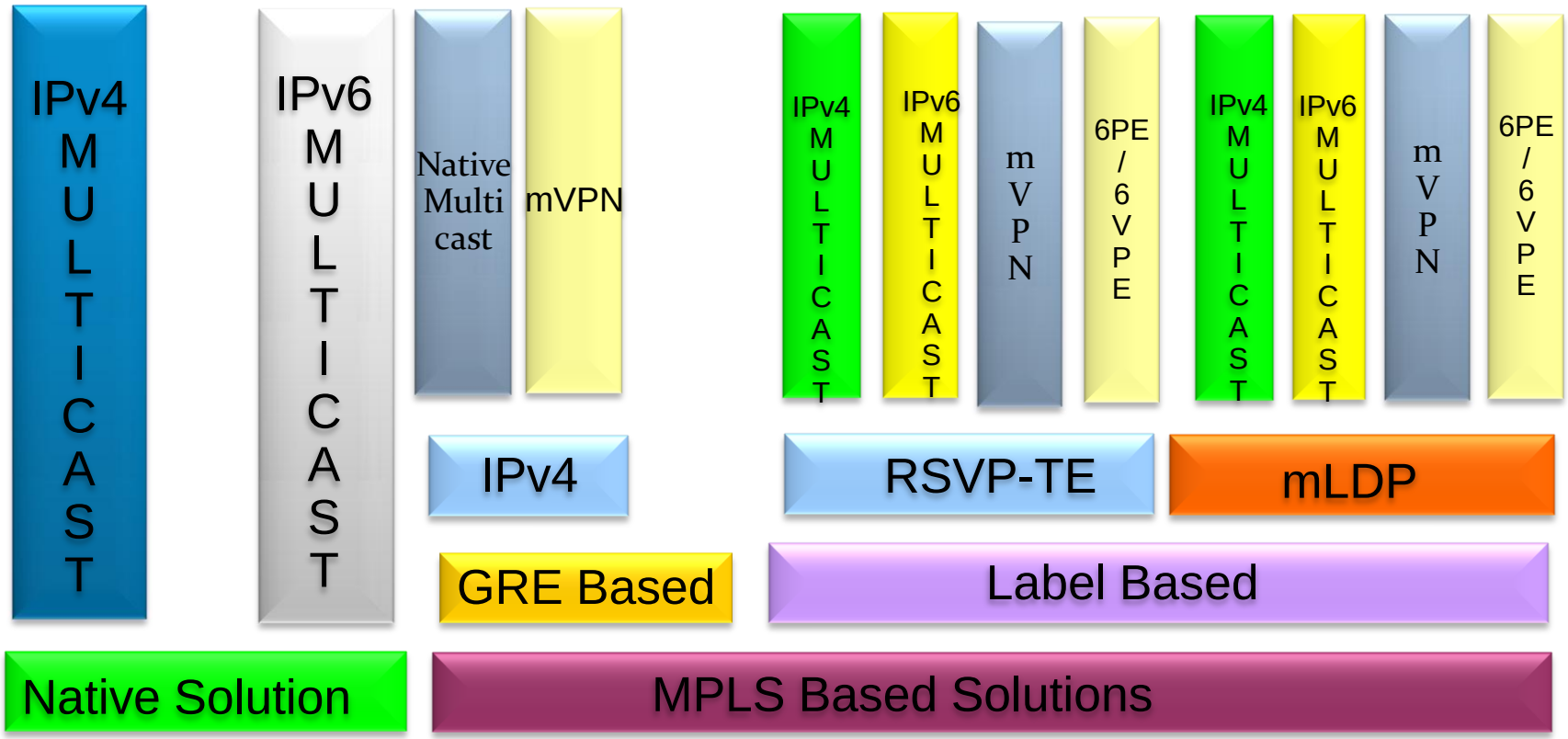
Agenda

- Motivation
- Multicast Solutions
- TE introduction
- P2MP TE Overview
- P2MP TE sample config
- LDP introduction
- mLDP Overview
- Reference
- Q and A

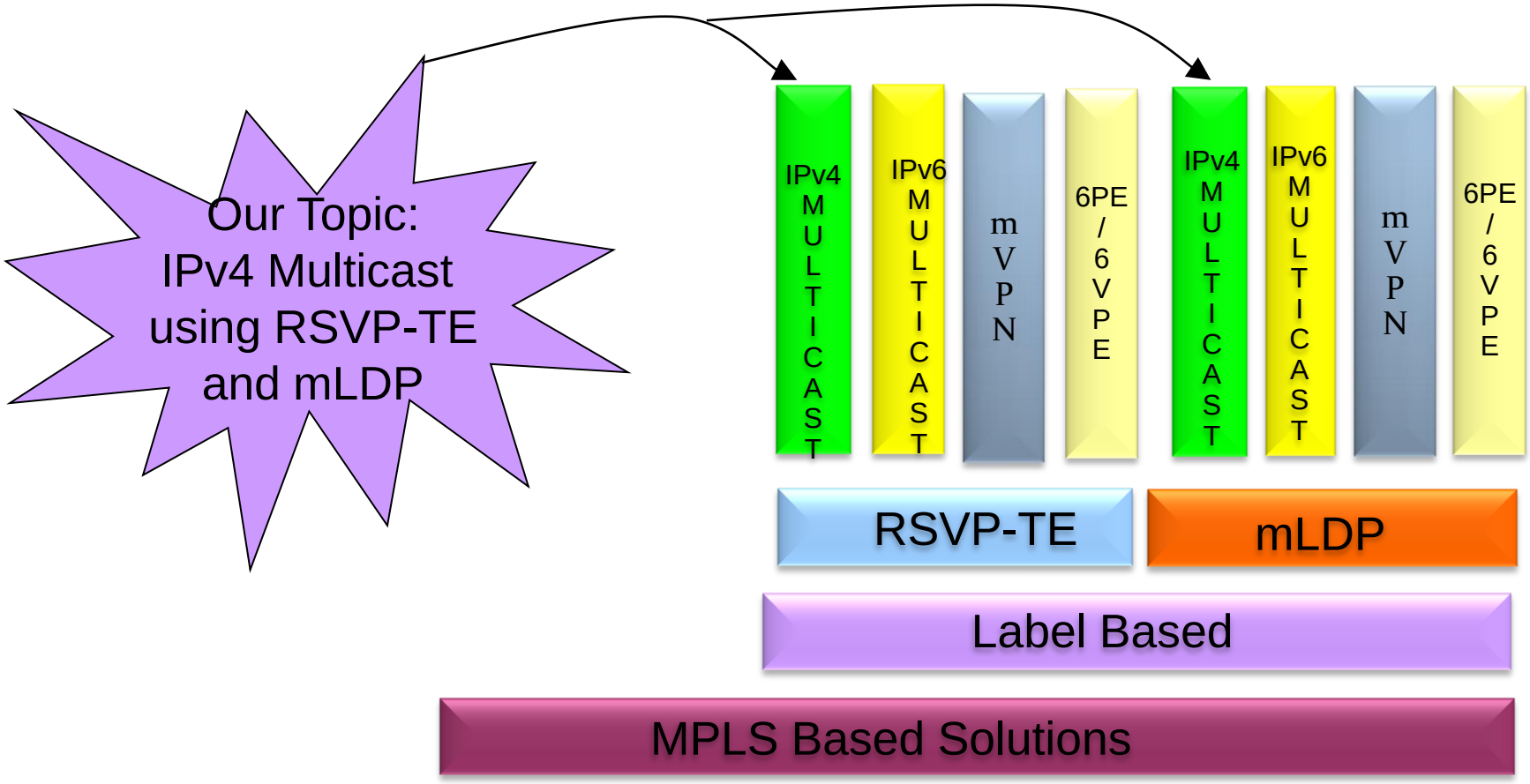
Motivation

- Service Providers using MPLS infrastructure want to offer Multicast Services to their customers using the same data plane used to offer unicast services.
- Simplify service/operational maintenance of MPLS core by removing PIM configuration requirements from within MPLS core.
- Route Multicast traffic on a non-optimal path using TE.
- Leverage Fast Re-route Capability (FRR) for multicast traffic.

Multicast Solutions



Label based Multicast solutions –Today's Topic



RFC's for Label Switched Multicast Solutions

P2MP RSVP-TE

1. Extensions to RSVP-TE for Point-to-Multipoint TE Label Switched Paths
   - RFC 4875
2. Signaling Requirements for Point-to-Multipoint Traffic-Engineered MPLS Label Switched Paths
   - RFC 4461

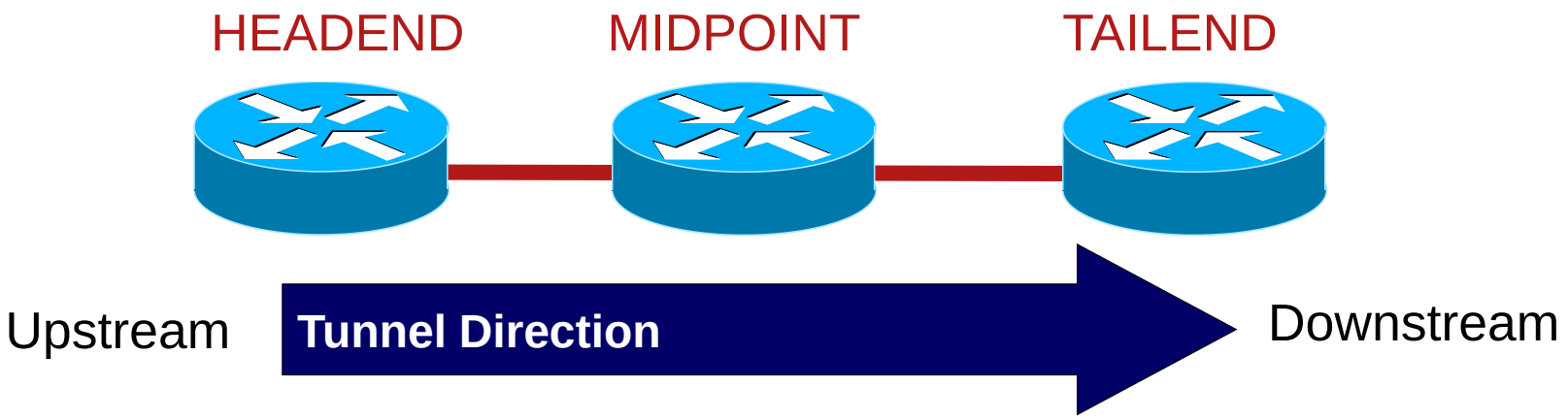
mLDP

1. Multicast LDP (mLDP)

   Label Distribution Protocol Extensions for Point-to-Multipoint and Multipoint-to-Multipoint Label Switched Paths
   - draft-ietf-mpls-ldp-p2mp-09.txt – Apr. 30, 2010

TE Introduction

Traffic Engineering Basics



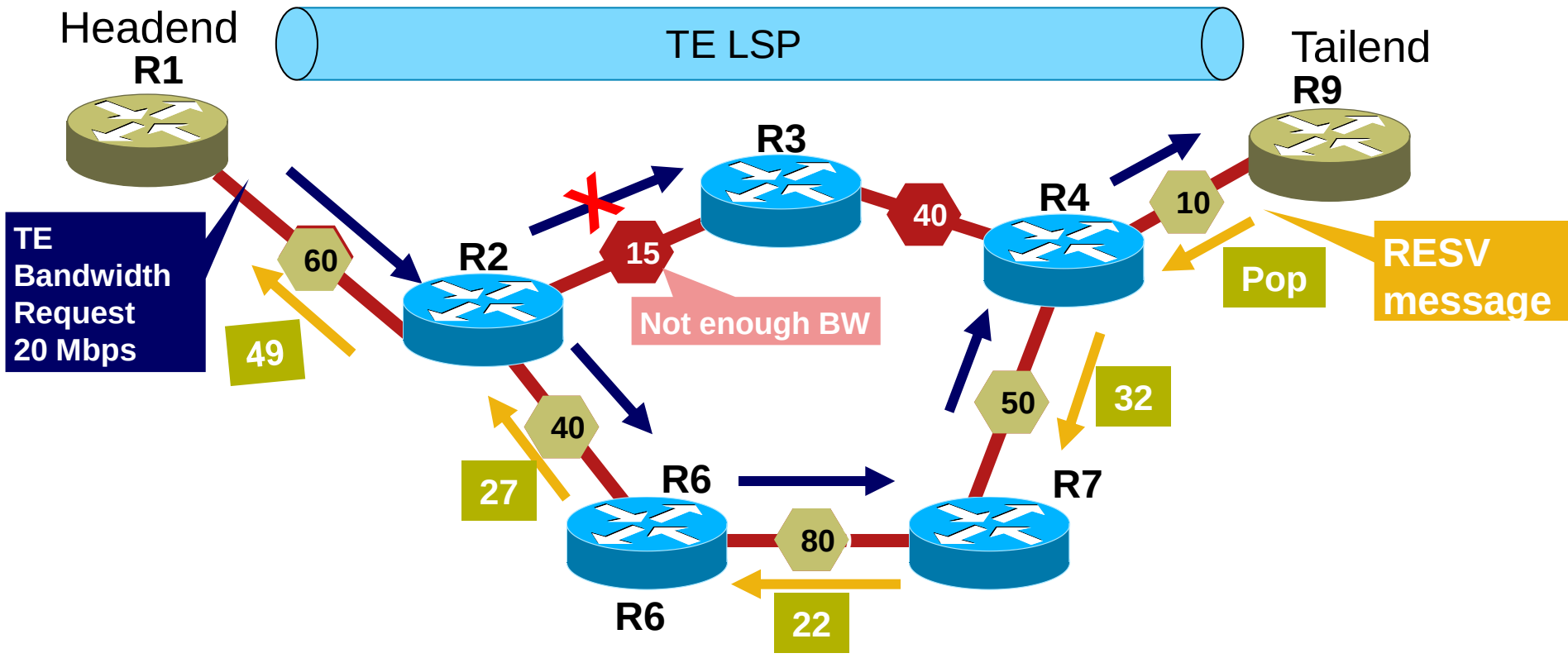
Tunnels are always uni-directional

Traffic Engineering Basics..

TE LSP's setup mechanism:

1. All the routers in the network build a TE topology database using IGP extension & link attributes.
2. Tunnel at the head-end makes the request for a path across the network from head to tail .
   - The path request can be either Dynamic or Explicit.
3. Paths are signaled across the network using RSVP signaling mechanism.
4. On receipt of RSVP Signalling message, all downstream routers either accept or reject based on the requested resources availability.
5. If accepted , RESV messages carrying LABEL are sent from downstream routers towards upstream and the PATH message are forwarded towards the downstream routers.
6. When successful RESV messages reach the headend from all the downstream routers, LSP TE is set up.

TE LSP Setup Example



RSVP PATH: R1 → R2 → R6 → R7 → R4 → R9

RSVP RESV: Returns labels and reserves bandwidth on each link

80 Bandwidth available

49 Returned label via RESV message

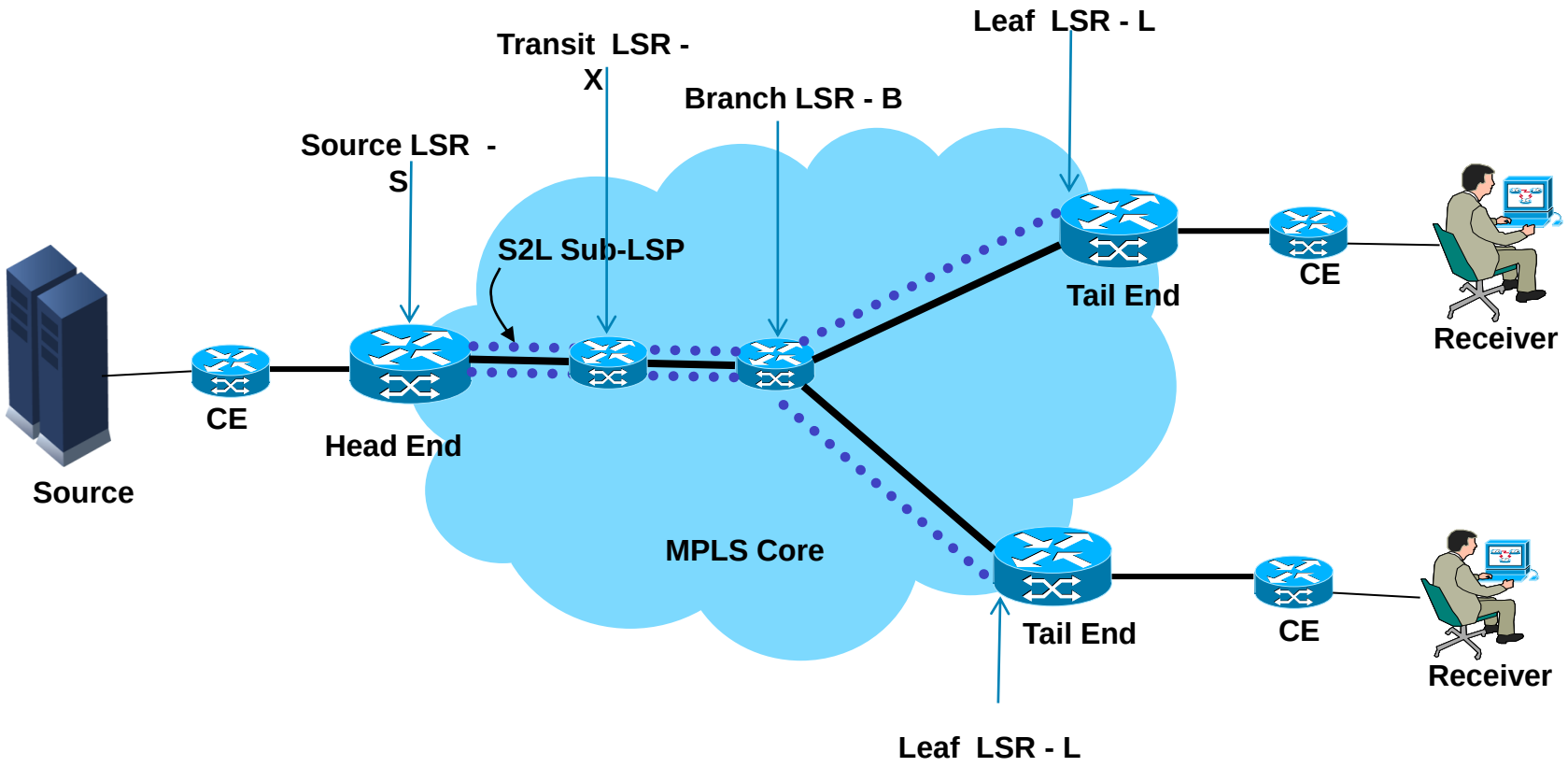
P2MP TE Overview

P2MP TE overview

- RSVP-TE based LSPs are built from the head end router in MPLS core to the tail end(s) router (s) with one head end and one or more tail ends
- Control Plane and Forwarding Plane mechanisms for P2MP TE are the same as P2P TE
- No PIM required in the core. PIM is needed only at the edge of the MPLS network.
- Multicast Groups (S,G) are mapped onto P2MP-TE tunnels. One or more (S, G) can be mapped onto the same P2MP Tunnel
- With PIM working at edge of the MPLS network, the overall flow would look like:

PIM --> P2MP-TE --> PIM

Terminologies used in P2MP TE



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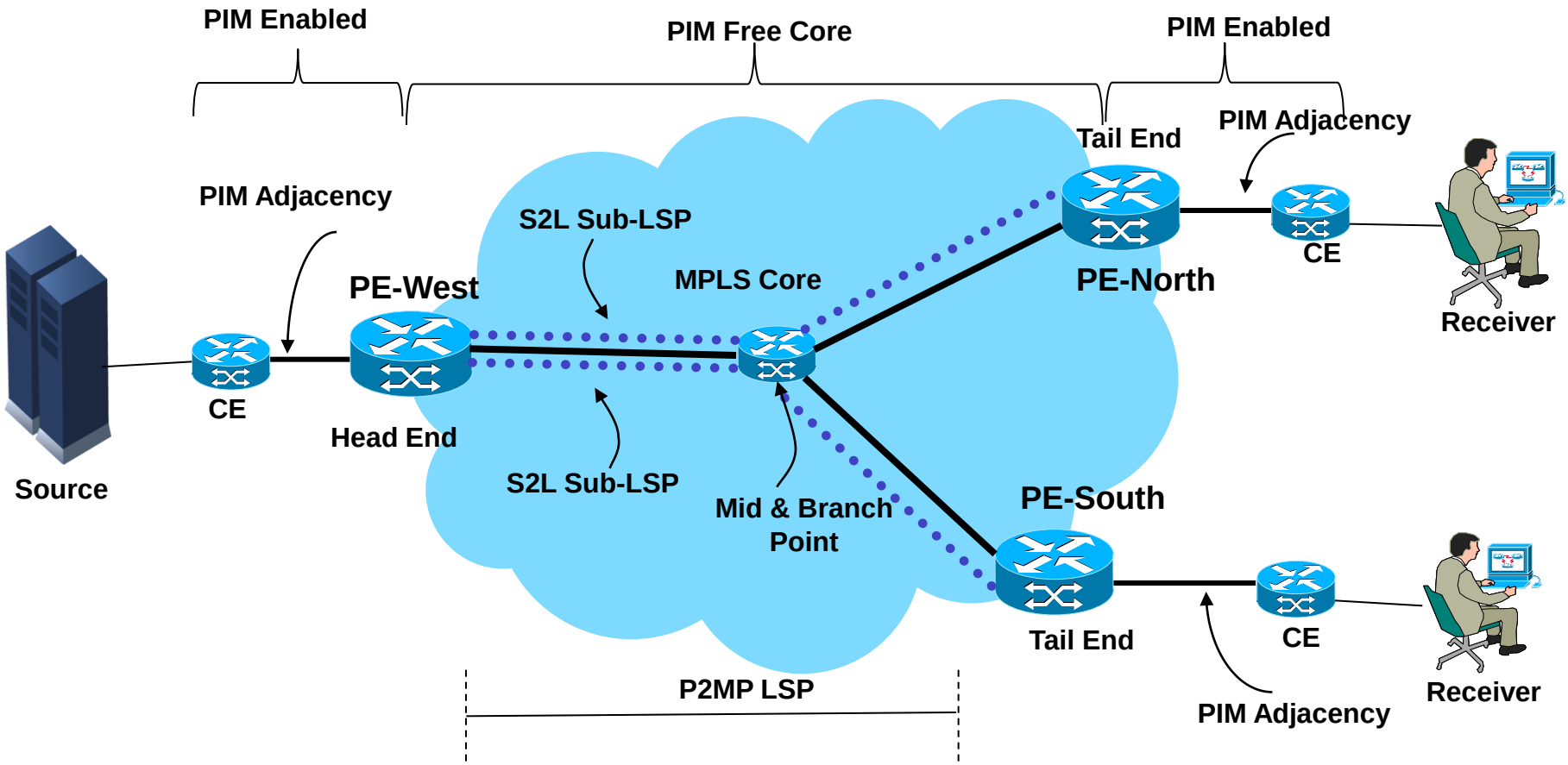
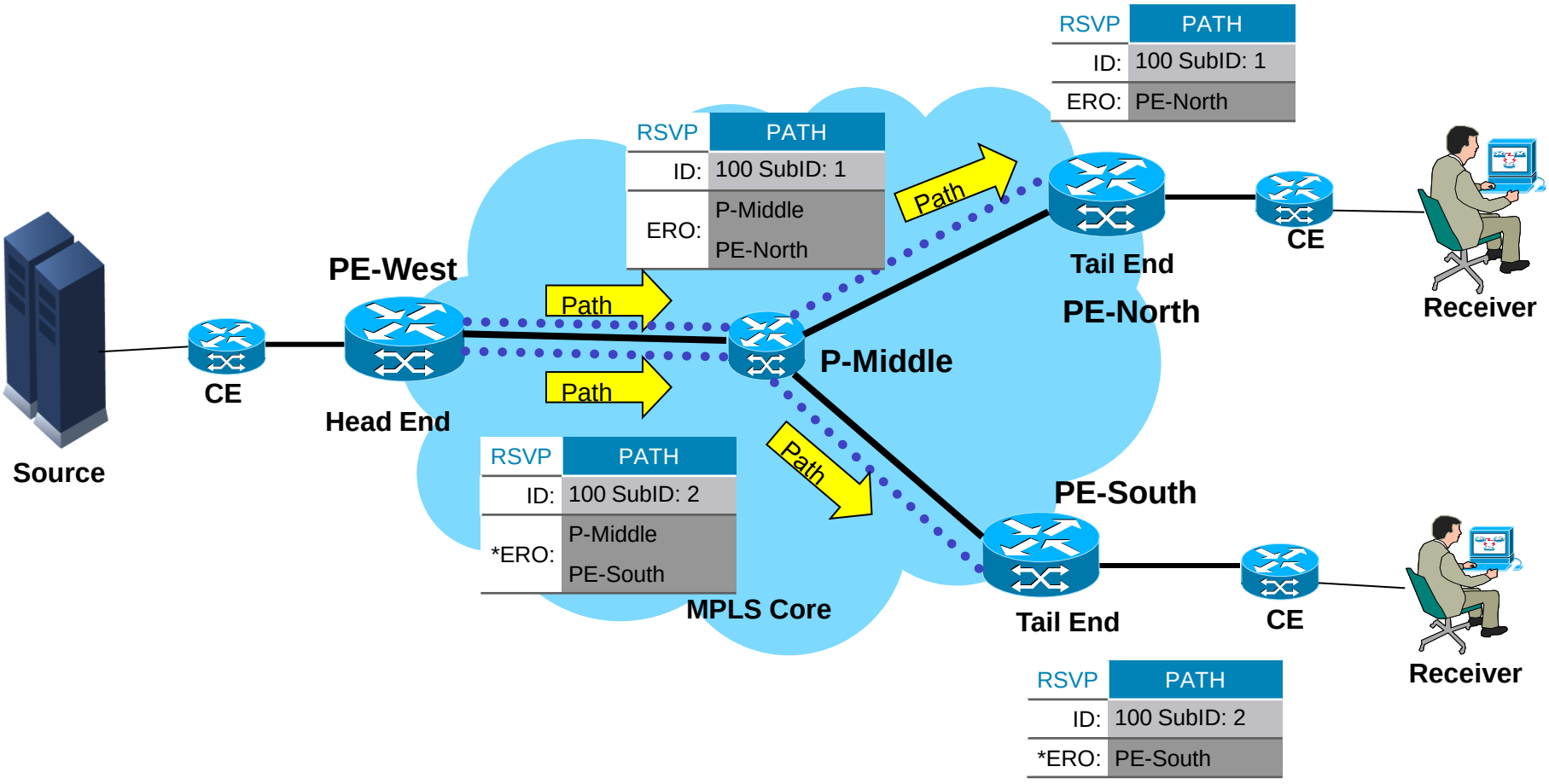
- S2L sub-LSP: The path from the source to one specific leaf.
- S2PL sub-LSP: The path from the source to a set of leaves.
- B2AL sub-LSP: The path from a branch LSR to all downstream leaves.
- X2X sub-LSP: A component of the P2MP LSP that is a simple path that does not branch.

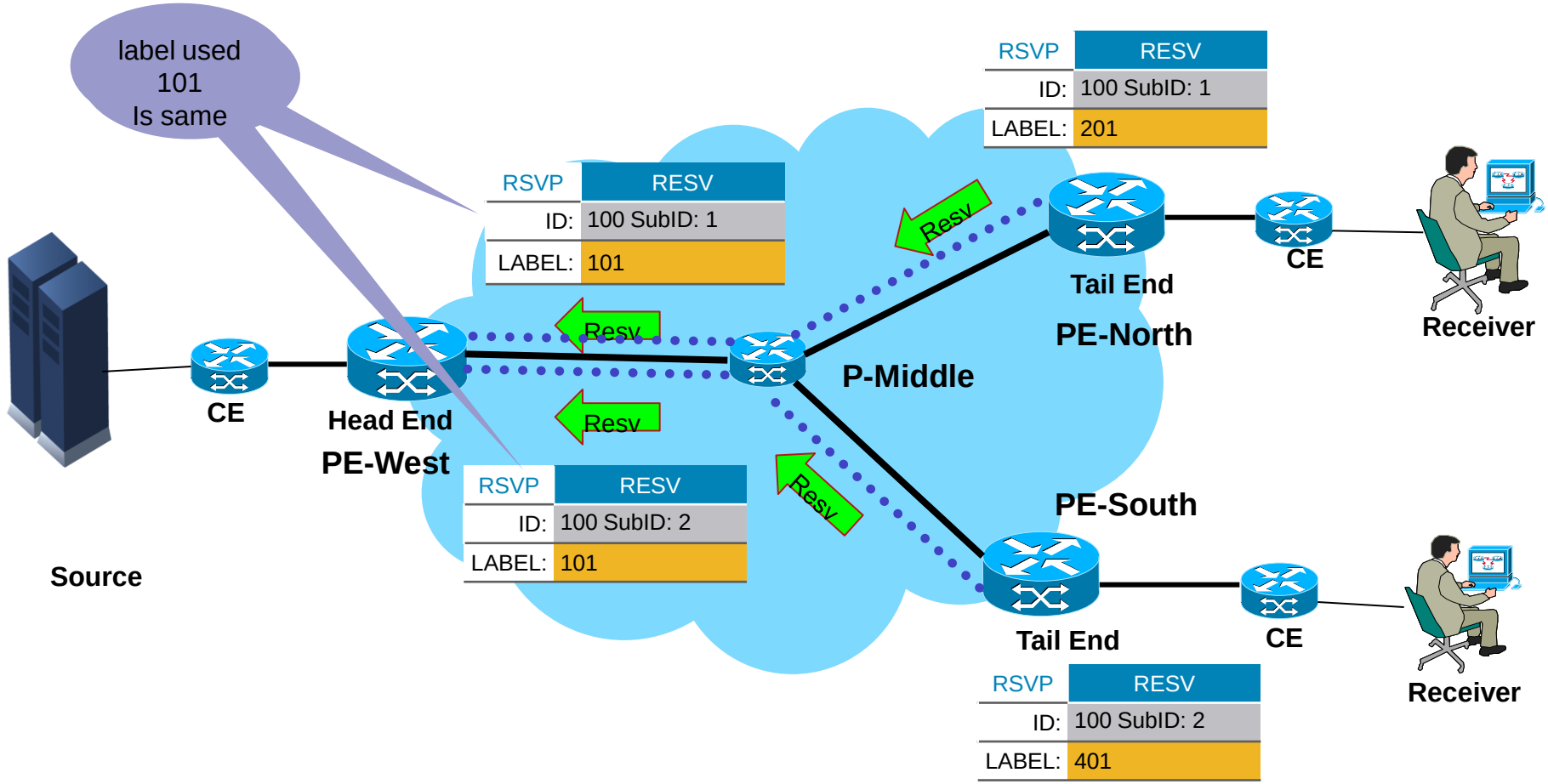
P2MP TE Architecture



P2MP TE Control Plane Signalling

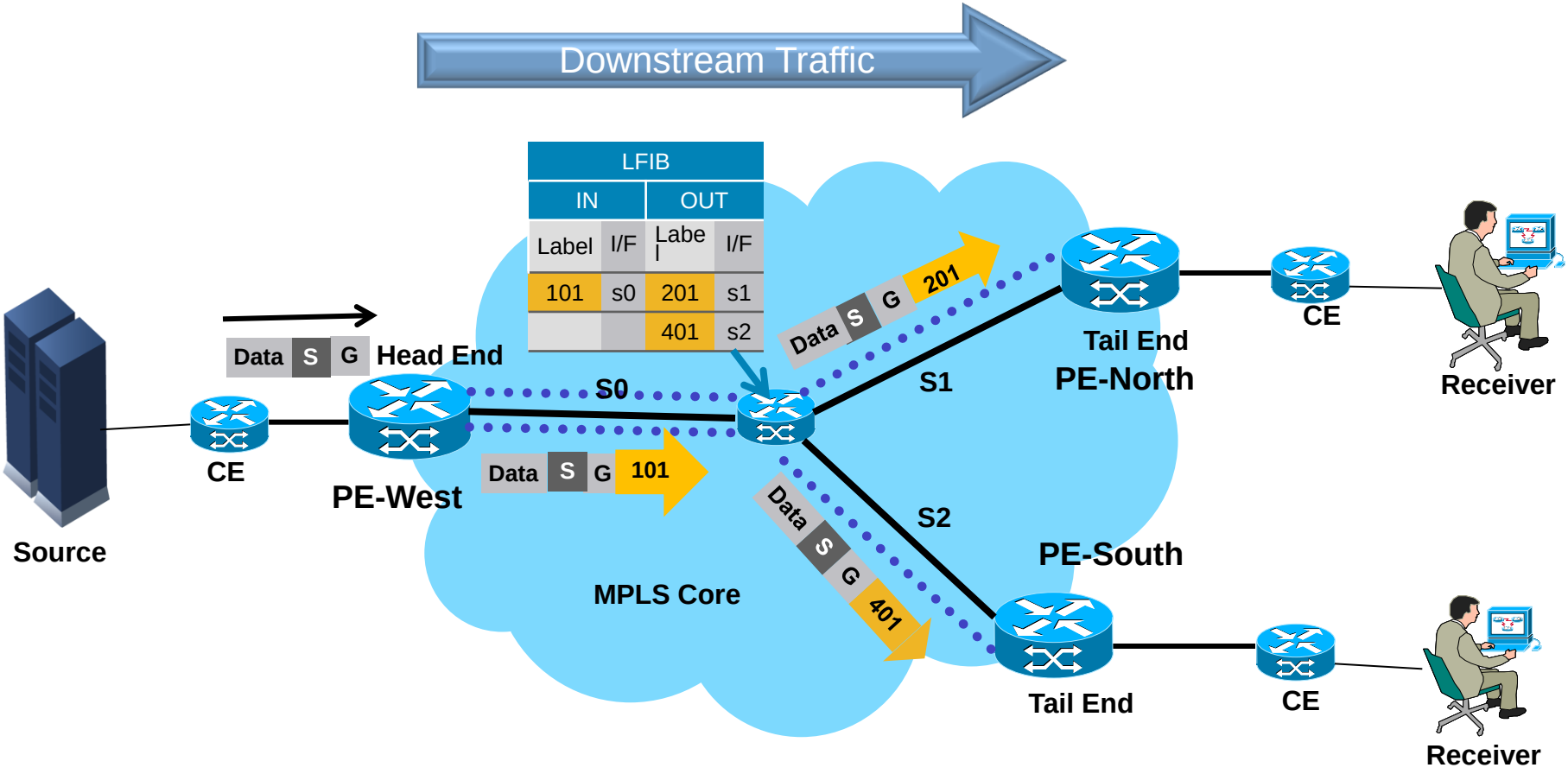


P2MP TE Signalling



- **LFIB populated with labels allocated by RESV messages**
- **Multicast state built by reusing sub-LSP labels at branches**

P2MP TE Data Path



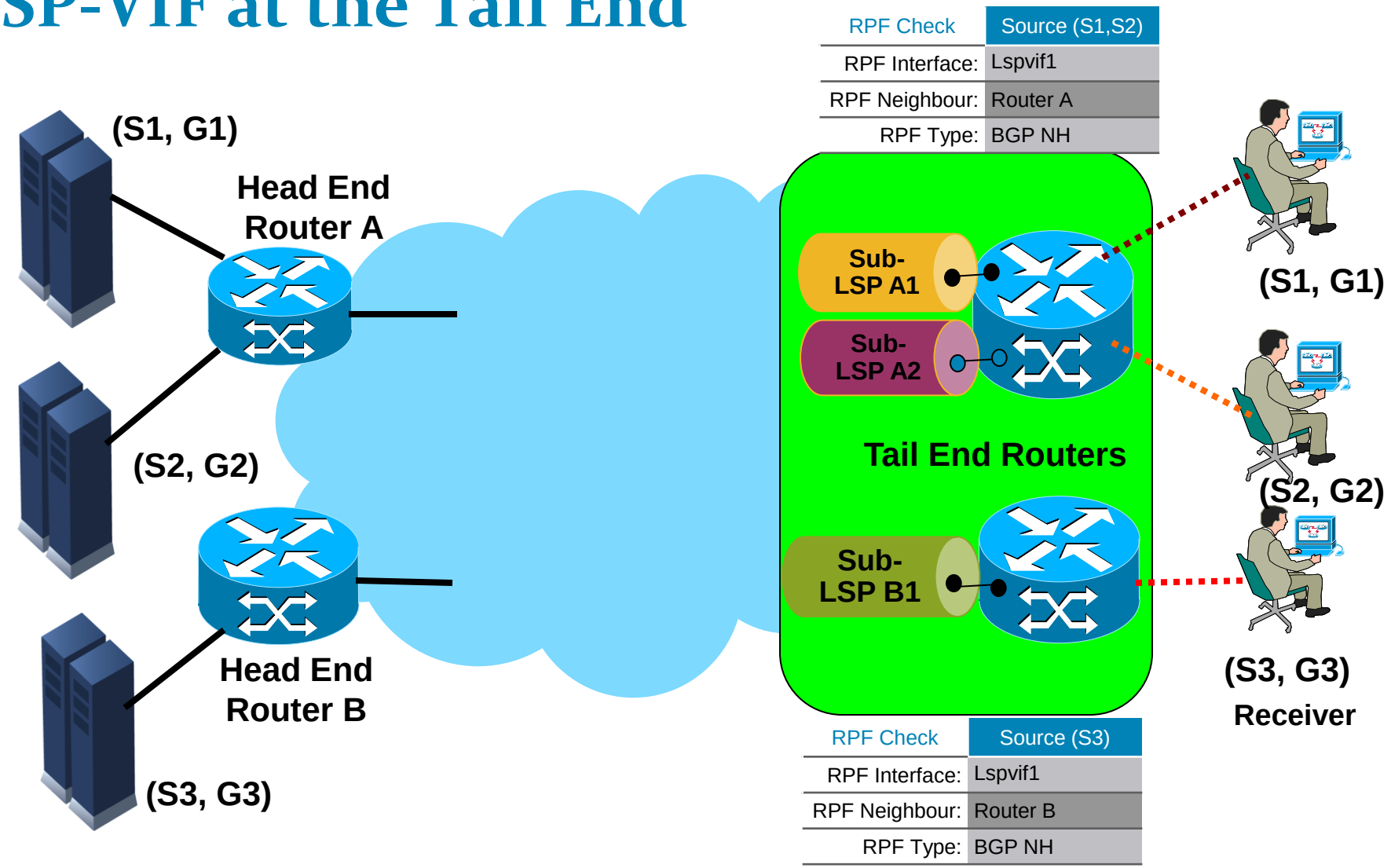
- **Branch point creates single LFIB entry from ingress**

  {101} → {201} and {401} at branching point

RPF Check

- RPF Check is done at TE Tail end routers on inbound interfaces
- Since Sub LSP tail has no interface, LSP virtual interfaces (LSP-VIF) are created automatically to represent the inbound Sub LSPs
- RPF check modified to use LSP-VIF for source
- Every Tail end router will have one LSP-VIF for the corresponding head-end router.
- One LSP-VIF may represent one or more Sub LSP from the same head end

LSP-VIF at the Tail End



- **An LSP-VIF represents all Sub-LSPs from a unique head end**
- **The LSP-VIF is used for the multicast RPF check**

P2MP TE Sample Configuration

Head End config : IOS-XR

```
RP/0/RP1/CPU0:ajanta#sh run interface tunnel-mte 1
interface tunnel-mte1
 ipv4 unnumbered Loopback0
 destination 100.0.0.1 ← First Tunnel  destination Instance
path-option 1 explicit name PE1_228_1_1_1 <= Explicit Path
 !
 destination 100.0.0.3 ← Second Tunnel destination  Instance
path-option 1 explicit name PE2_228_2_2_2 <= Explicit Path
 !
explicit-path name PE1_228_1_1_1
 index 1 next-address strict ipv4 unicast 1.1.1.2
 index 2 next-address strict ipv4 unicast 1.2.2.2

explicit-path name PE2_228_2_2_2
 index 1 next-address strict ipv4 unicast 1.1.1.2
 index 2 next-address strict ipv4 unicast 1.3.3.3
```

TE Head End config – IOS-XR

```
RP/0/RP1/CPU0:ajanta#sh run router ospf
router ospf 1
 nsr
 router-id 1.1.1.1
 area 0
  mpls traffic-eng
  interface Loopback0
  interface TenGigE0/2/0/0
   mpls traffic-eng router-id Loopback0
!
```

```
rsvp
 interface TenGigE0/2/0/0
  bandwidth
 !
!

mpls traffic-eng
 interface TenGigE0/2/0/0
 !
!
```

MPLS Label – First Branching

```
RP/0/RP1/CPU0:ajanta#show mpls forwarding p2mp
Local  Outgoing    Prefix          Outgoing     Next Hop      Bytes
Label  Label       or ID           Interface                 Switched
------ ----------- ------------------ ------------ --------------- ------------
21028  101         P2MP TE:1  Te0/2/0/0                10.1.1.1      0
```

Head End router – Single LSP

P2MP TE branch :

```
RP/0/RP0/CPU0:ellora#show mpls forwarding p2mp
Local  Outgoing    Prefix          Outgoing     Next Hop      Bytes
Label  Label       or ID           Interface                 Switched
------ ----------- ------------------ ------------ --------------- ------------
101 201        P2MP TE:1        PO0/9/0/3    9.1.11.2       0
    401        P2MP TE:1        Te0/2/2/0    47.47.43.2     0
```

Mid router – Two outgoing labels

P2MP Configuration: TE Midpoint

```
router ospf 1
 router-id 1.1.1.2
area 0
  mpls traffic-eng
  interface Loopback0
  !
 interface TenGigE0/2/2/0
  !
  interface POS 0/9/0/0
  !
!
  interface TenGigE0/1/0/0
  !
 !
 mpls traffic-eng router-id Loopback0
!
```

```
rsvp
 interface TenGigE0/1/0/0
  bandwidth
 !
 interface TenGigE0/2/2/0
  bandwidth
 !
 interface POS 0/9/0/0
  bandwidth
 !
mpls traffic-eng
 interface TenGigE0/1/0/0
 !
 interface TenGigE0/2/2/0
 !
 interface POS 0/9/0/0
```

- P2MP TE config is similar to P2P Midpoint router configuration.
- Midpoint LSR must support P2MP signaling extensions

P2MP TE Configuration: Tail End

```
router ospf 1
 router-id 1.1.1.3
  area 0
  mpls traffic-eng
  interface Loopback0
  !
  interface GigabitEthernet0/1/1/2
  !
!
  interface TenGigE0/1/0/0
  !
 !
mpls traffic-eng router-id Loopback0
!
```

```
rsvp
 interface TenGigE0/1/0/0
  bandwidth
 !
mpls traffic-eng
 interface TenGigE0/1/0/0
 !
```

```
multicast-routing
 address-family ipv4
  core-tree-protocol rsvp-te
  ssm range ssm
  interface all enable
 !
router igmp
 interface GigabitEthernet0/1/1/2
!
```

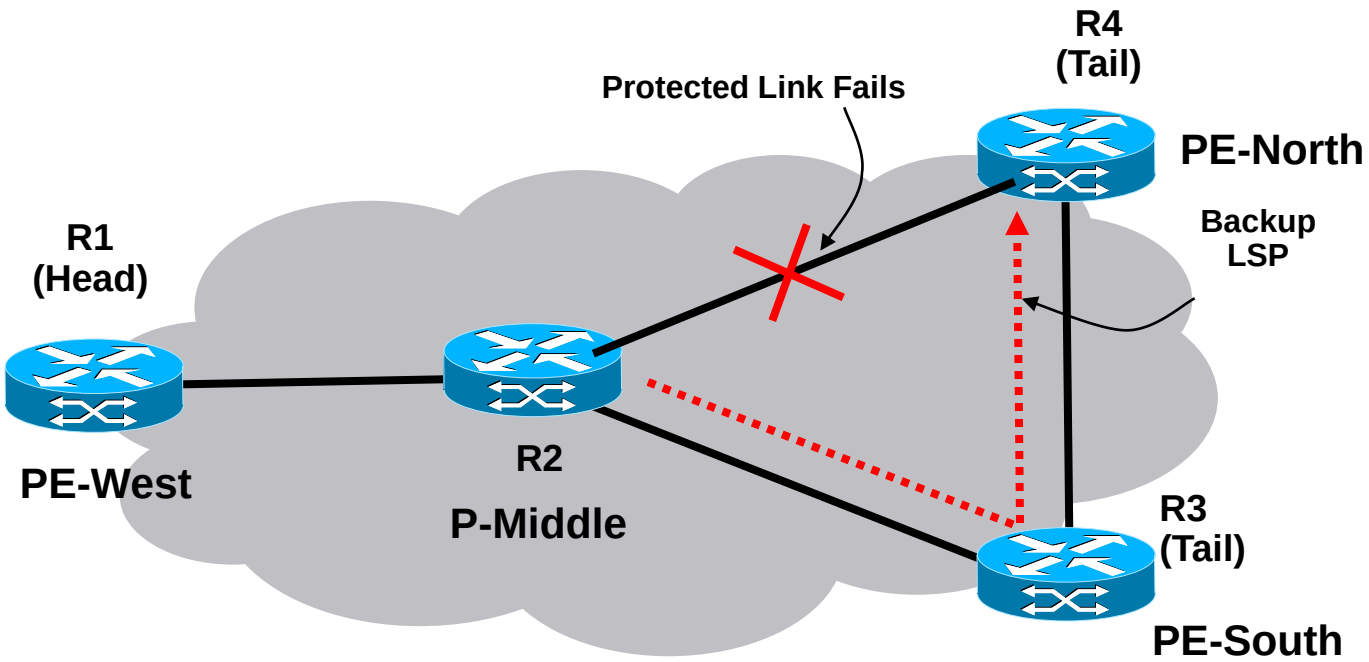
- Configurations at P2MP TE tail need to create LSP-VIF for RPF check

P2MP TE FRR (Fast Re-route)

P2MP TE LSP Fast Re-Route Protection

- FRR configuration for P2MP TE is the same as that for P2P TE
- Backup tunnels are always P2P
- A backup tunnel can protect many TE LSPs
  - Point-to-point
  - Point-to-multipoint
  - A combination of both

P2MP TE LSP: FRR Link Protection



Sub-LSP: (R1, R2, R4) ← Primary Path

Backup: (R2, R3, R4) ← Backup Path

P2MP TE FRR Link Protection Configuration

```
interface Tunnel-te 1 ←  Backup Tunnel
 description R2 →R3-> R4 Backup Tunnel
 ip unnumbered Loopback0
 destination 100.0.0.1 ←Loopback address of R4
 path-option 1  explicit name R2-R3-R4 ←Backup Path
!
mpls traffic-eng
 interface POS0/9/0/0
  backup-path tunnel-te 1 ← Link protection Tunnel
```

LDP Introduction

Label Distribution Protocol

- Defined in RFC 3035 and 3036
- LDP is a protocol defined to distribute labels between two peers (called LSR's) for prefixes advertised by unicast routing protocols like OSPF, IS-IS, EIGRP, etc..
- These labels help create Label Switched Paths or LSP's whose endpoints can be either the directly attached neighbors just like IP next-hop or remote neighbors (called targetted ldp peers)
- LDP associates a Forwarding Equivalence Class (FEC) [RFC 3031] with each LSP it creates and "maps" packets onto that LSP

Label Distribution Protocol Operations

- Discover LDP Peers:

  Discover peers by sending LDP Hello message using UDP

- Establish Session and negotiate parameters

  Open a reliable TCP connection (Port 646) with peers and start negotiating various LDP capabilities

- Start exchanging Labels and other Parameters

  Exchange prefix/FEC and label information

  Exchange various LDP capabilities parameters

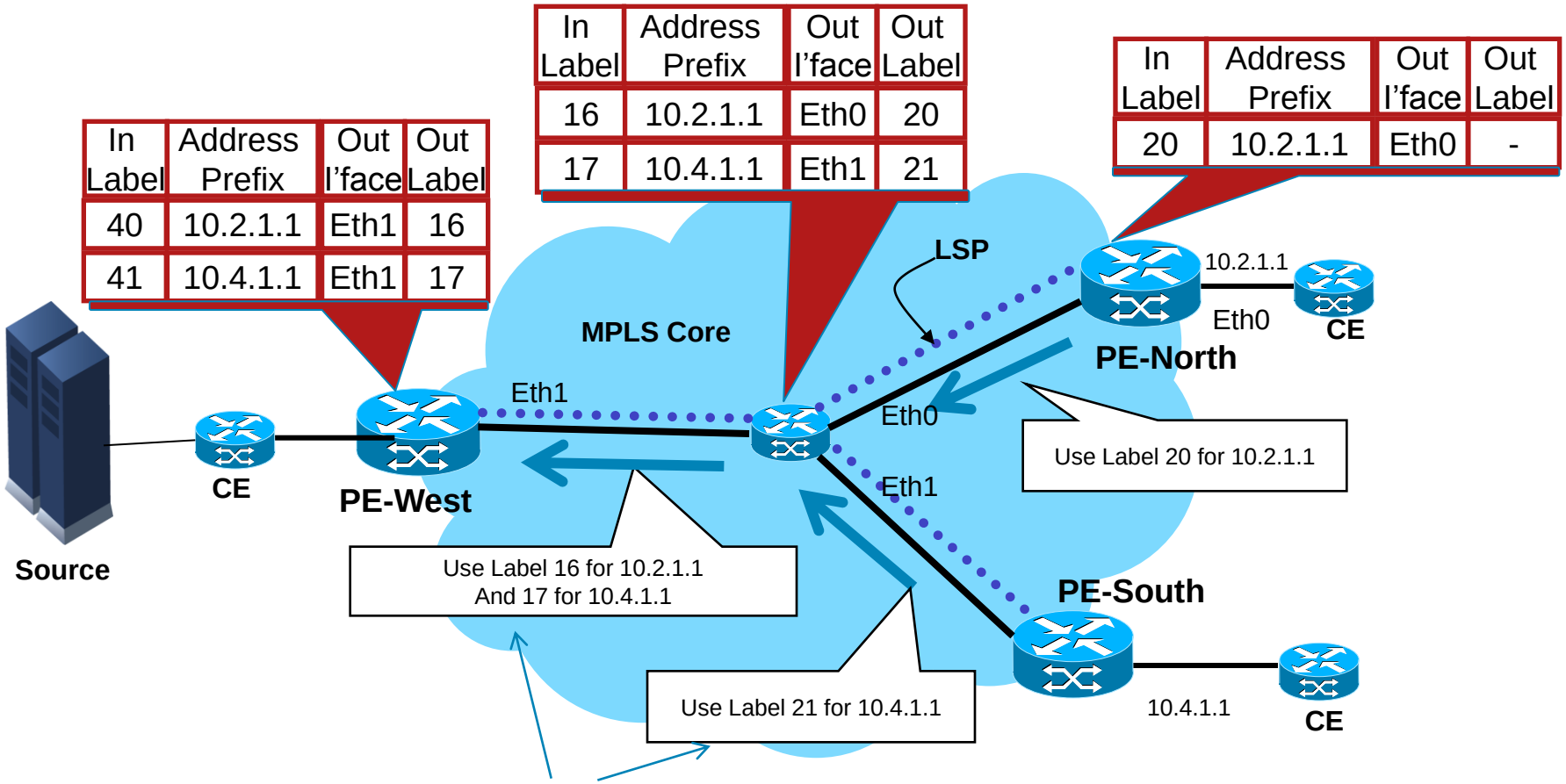
- Maintain and Manage session

LDP Messages

- LDP protocol exchange various kinds of messages like Hello, Initialize, Label Mapping etc.
- Messages may carry additional information in the form of TLVs

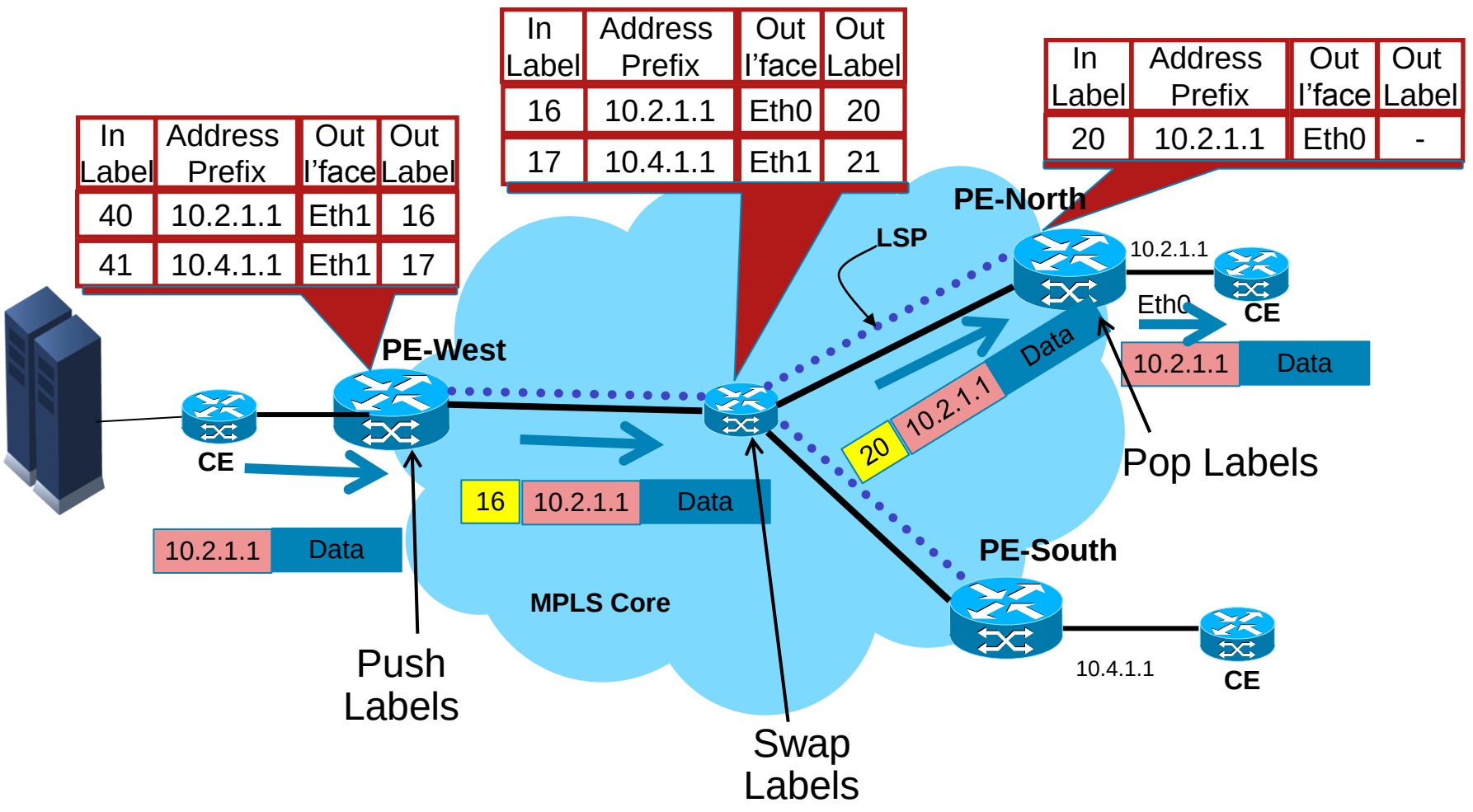
  Example: Label Mapping Message carries FEC TLV, Label TLV etc.
- FEC TLV's carry information regarding which data packets get mapped onto LSP's

MPLS LDP Control plane



Label Distribution Protocol (LDP)
(Downstream Allocation)

MPLS LDP Data forwarding



mLDP Overview

mLDP: Extension of LDP cabailities

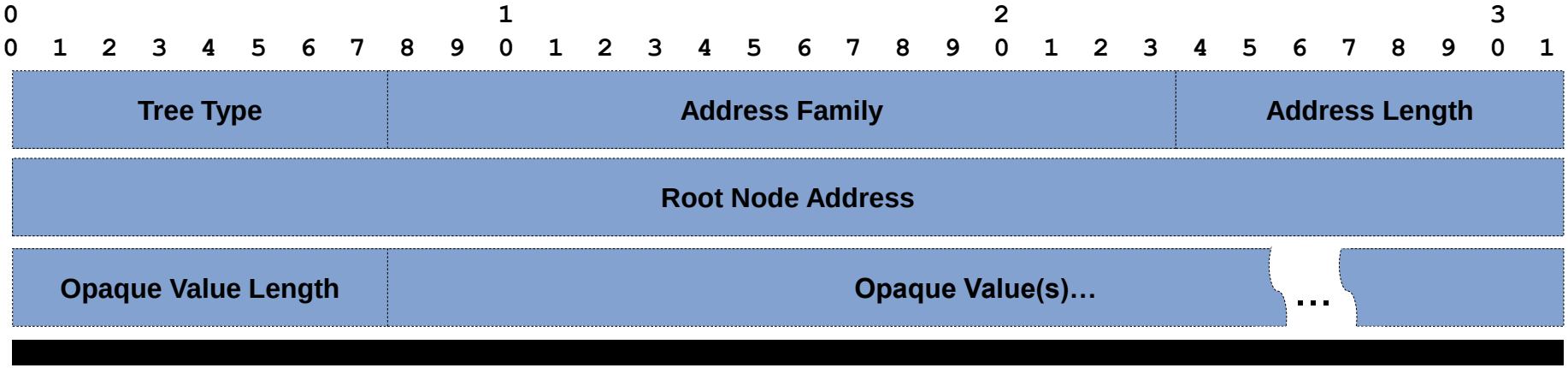
- LDP capabilities are extended to support multicast.
- Addition to the original protocol to allow enhancements is supported through

  draft-ietf-mpls-ldp-capabilities-04
- Capabilities are advertised through LDP message TLVs during LDP Initialisation/LDP session Establishment phase
- mLDP defines new FEC elements

  P2MP FEC element : TLV 0x0508

  MP2MP FEC Element : TLV 0x0509

mLDP FEC Element

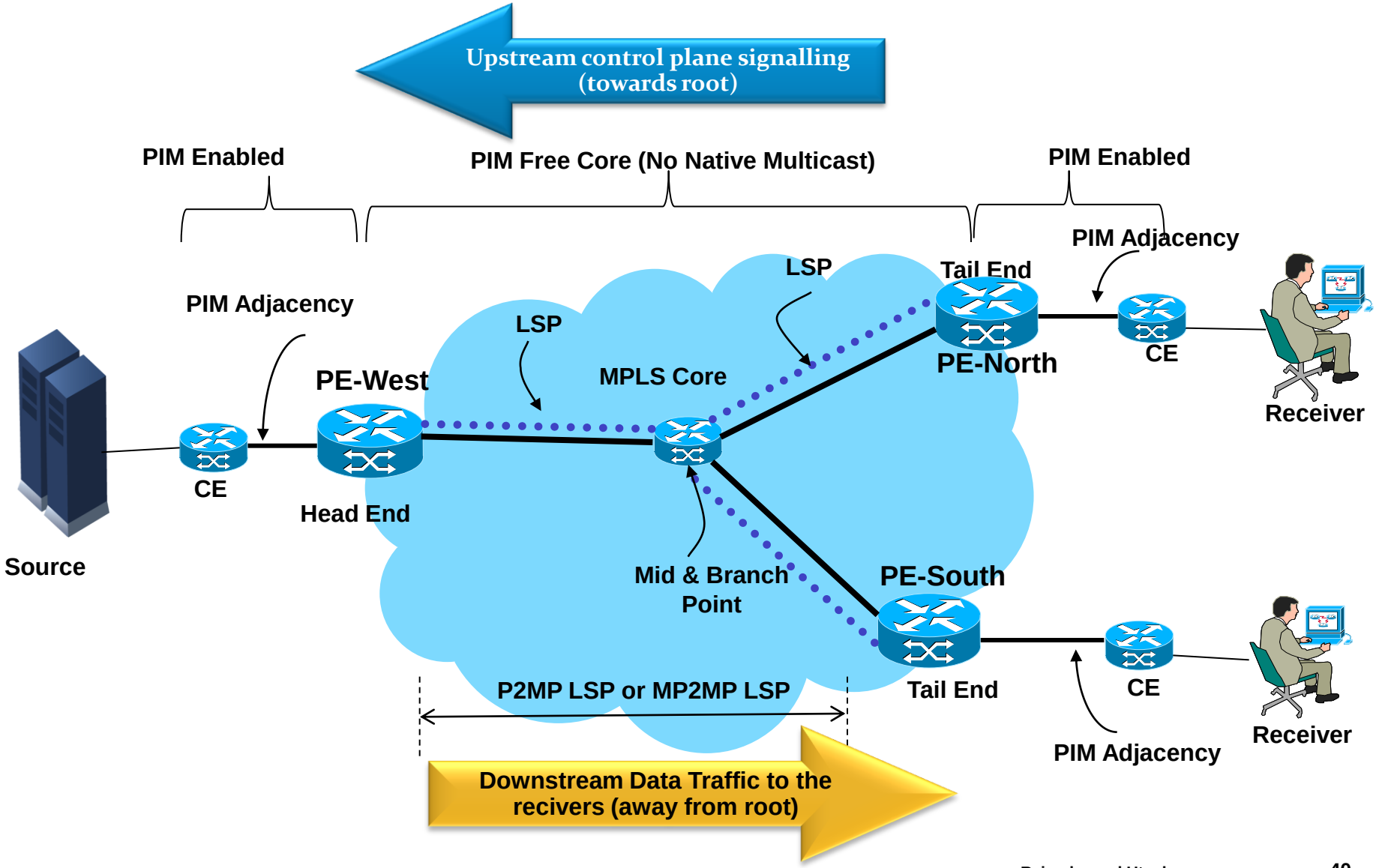


Parameters	Description
Tree Type	P2MP, MP2MP Up, MP2MP Down
Address Family	Root node address format (IPv4 =1 or IPv6 = 2)
Address Length	Number of octets in root address (IPv4 = 4, IPv6 = 16)
Root Node Address	Host address of MP LSP root (within MPLS core)
Opaque Value	One or more TLVs uniquely identifying MP LSP within the in context of the root

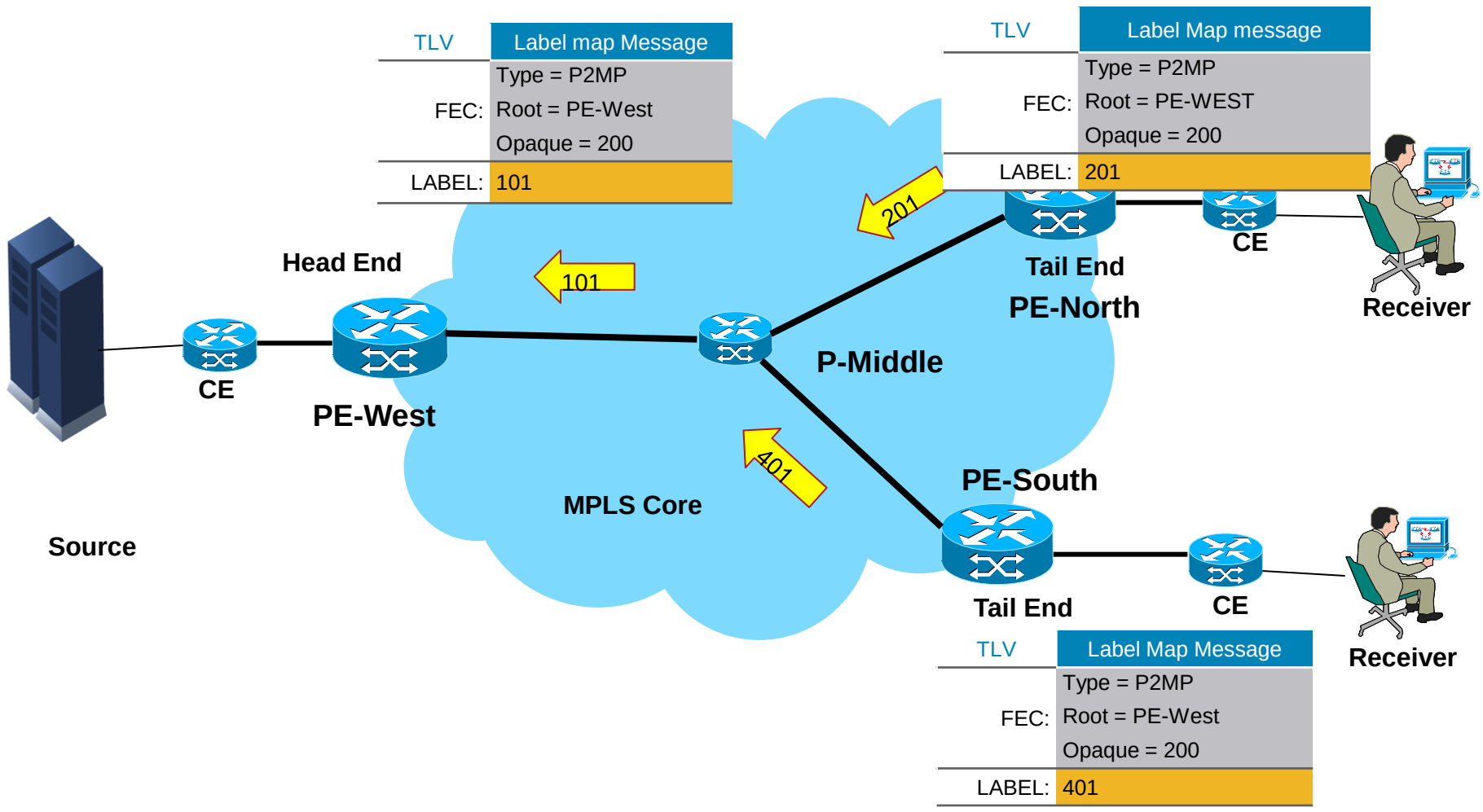
mLDP Protocol Operations:

- Unlike P2MP TE where ingress LSR initiates the tree creation , in mLDP egress LSR's (receiver) initiate tree creation by looking for the root address.
- The root address is derived from BGP next-hop or static configuration.
- Each LSR in the path resolves next-hop of the root address and sends label
- mLDP Signalling discovers the FEC for an LSP, and assigns multicast flow to the LSP.
- Two types of signalling are used:
  - –In-Band Signalling ← We discuss this model here!
  - –Out-Of-Band or Overlay Signalling
- FEC uniquely identifies the MP LSP for both methods

mLDP Architecture

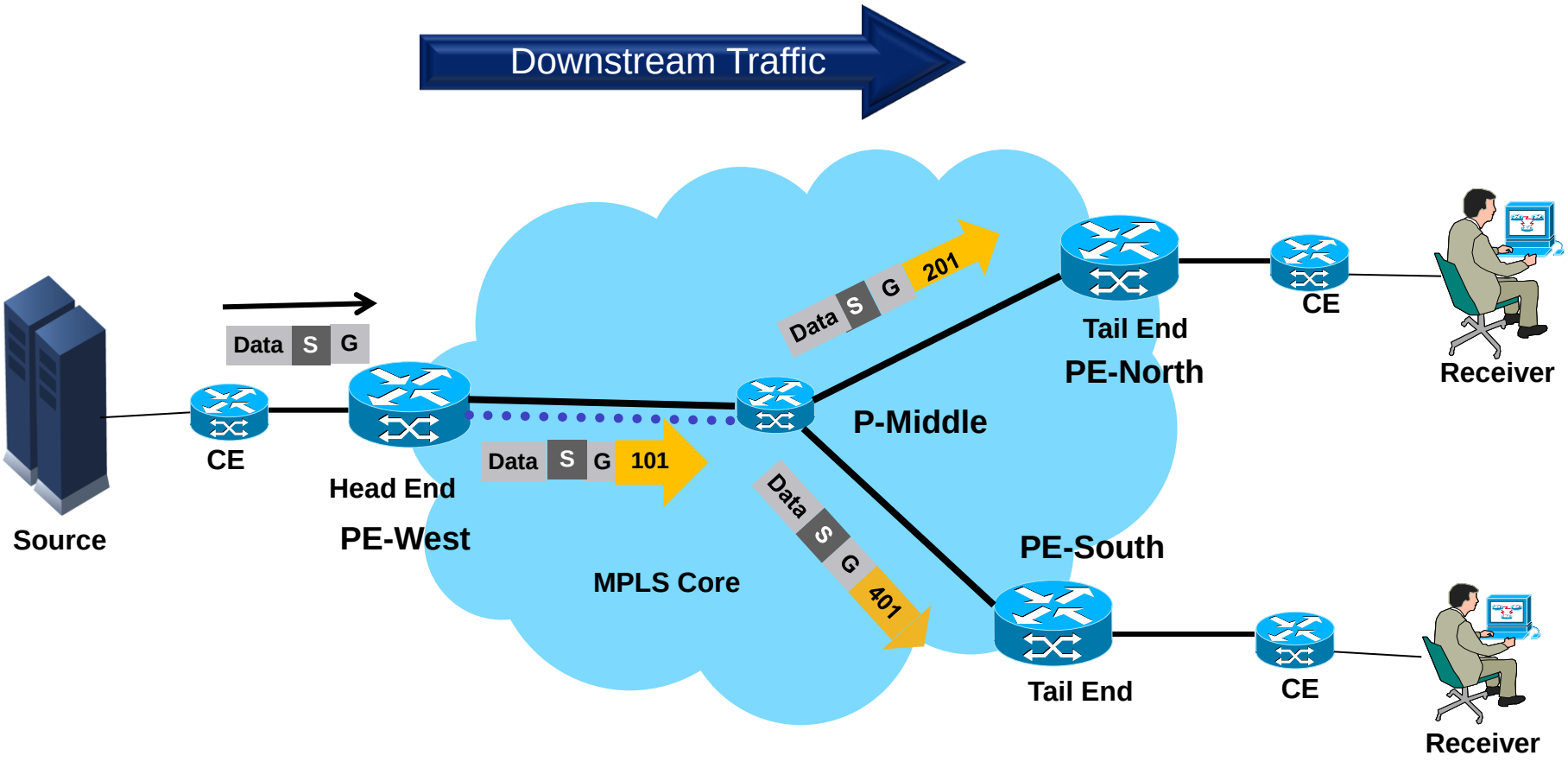


P2MP mLDP operation –Control plane



Downstream on demand Label allocation used

P2MP mLDP operation – Data plane



- PE-West sends Multicast Data Traffic (S, G) on MP-LSP
- Branch LSR (P-Middle) replicates and swaps out two different labels: 101->201 (towards PE-North) and 101->401 (towards PE-South)

Conclusion

- Currently Multicast Services offered by MPLS based Service providers
  - ➢ Require enabling multicast in their MPLS core which demands non-trivial re-engineering of their existing MPLS network .
  - ➢Cannot leverage high availability features of unicast services such as TE-FRR.
- P2MP TE and mLDP based solutions address the above limitation with MPLS based service provider.
- Applications:
  - ➢RSVP TE based solution has high potential for Triple Play Video services & content distribution
  - ➢ mLDP will be more attractive for applications that demand Multipoint to Multipoint such as Telepresence etc

Reference

- RSVP-TE

  RFC 4461 & RFC 4875

- LDP

  RFC 3031 , RFC 3035 & RFC 3036

  draft-ietf-mpls-ldp-capabilities-04

  draft-ietf-mpls-ldp-p2mp-09.txt – Apr. 30, 2010

- CCO Documentation

- Acknowledgement

  • Jeff Apcar

Q & A
THANK YOU