MPLS Primer

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Before we start…

- Mainly of interest to providers/ISP/Carriers
  - Some interest in enterprise
- To support MPLS in your network you **MUST** have
  - Fully working IP network. If it's broken MPLS won't fix it.
  - Hardware and Software support. Depends on vendors
    - Juniper
      - All our routers (M-Series, T-Series, J-Series, E-Series)

Things I want you to know

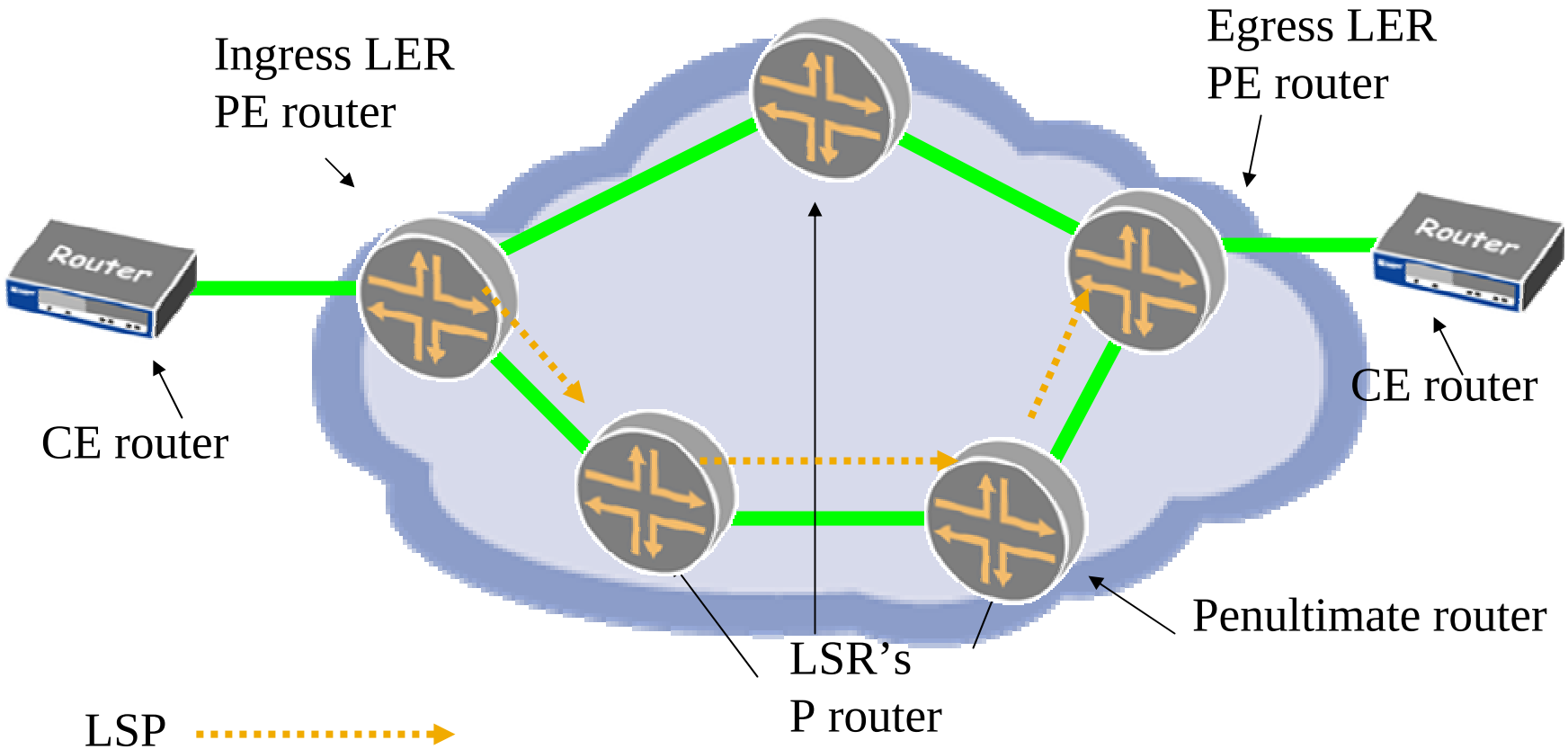
- MPLS is a tool to solve problems
  - Not everyone has the same problems or pain
- In other words reason to deploy (choose 1+)
  - Traffic Engineering
  - Traffic Protection
  - Provider provisioned VPN's
    - Layer 3 and/or Layer 2
- Or in other words
  - Save money
  - Make money

What is MPLS?

- Multiprotocol Label Switching
- Connection Orientated Virtual Circuits over IP implemented with label switching
- Grew out of
  - Cisco's Tag switching
  - Ipsilon (Nokia) IP switching
  - IBM ARIS
  - 3Com's FAST IP
- Expanding area's of application
  - Cost savings
  - New services
- Promise of Multiprotocol Unification (Core NOT edge)
- Defined by RFC 3031, RFC 3032

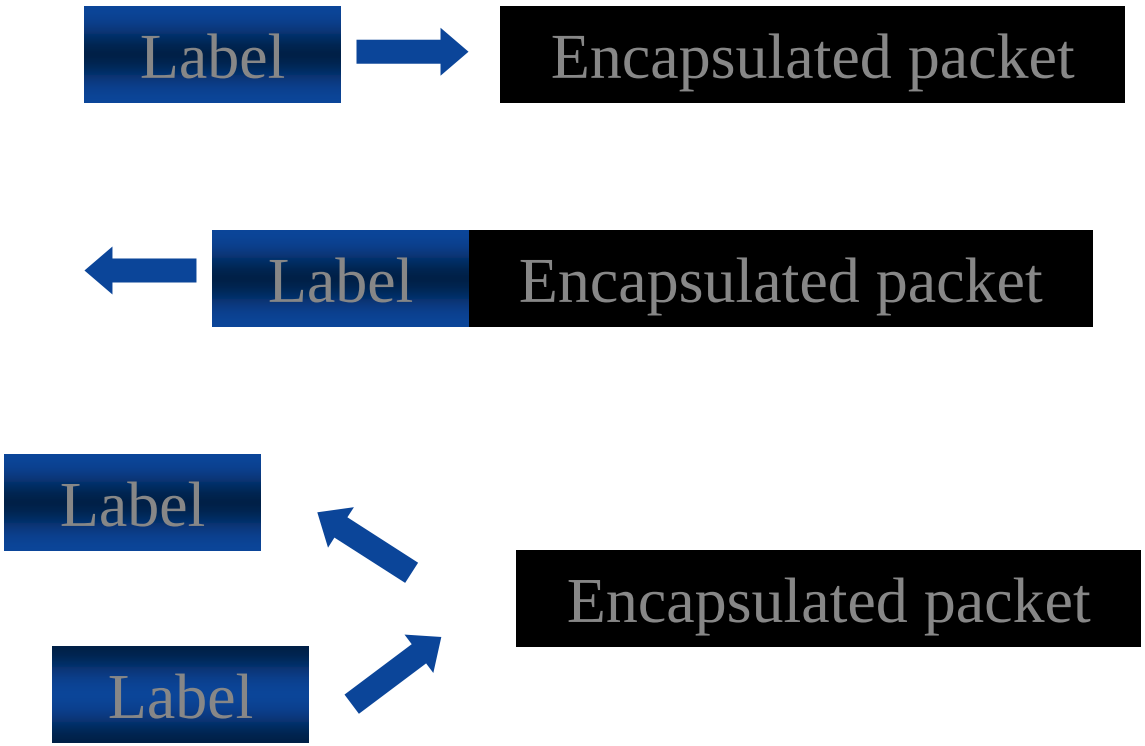
MPLS Terminology

-An LSP is a unidirectional flow of traffic

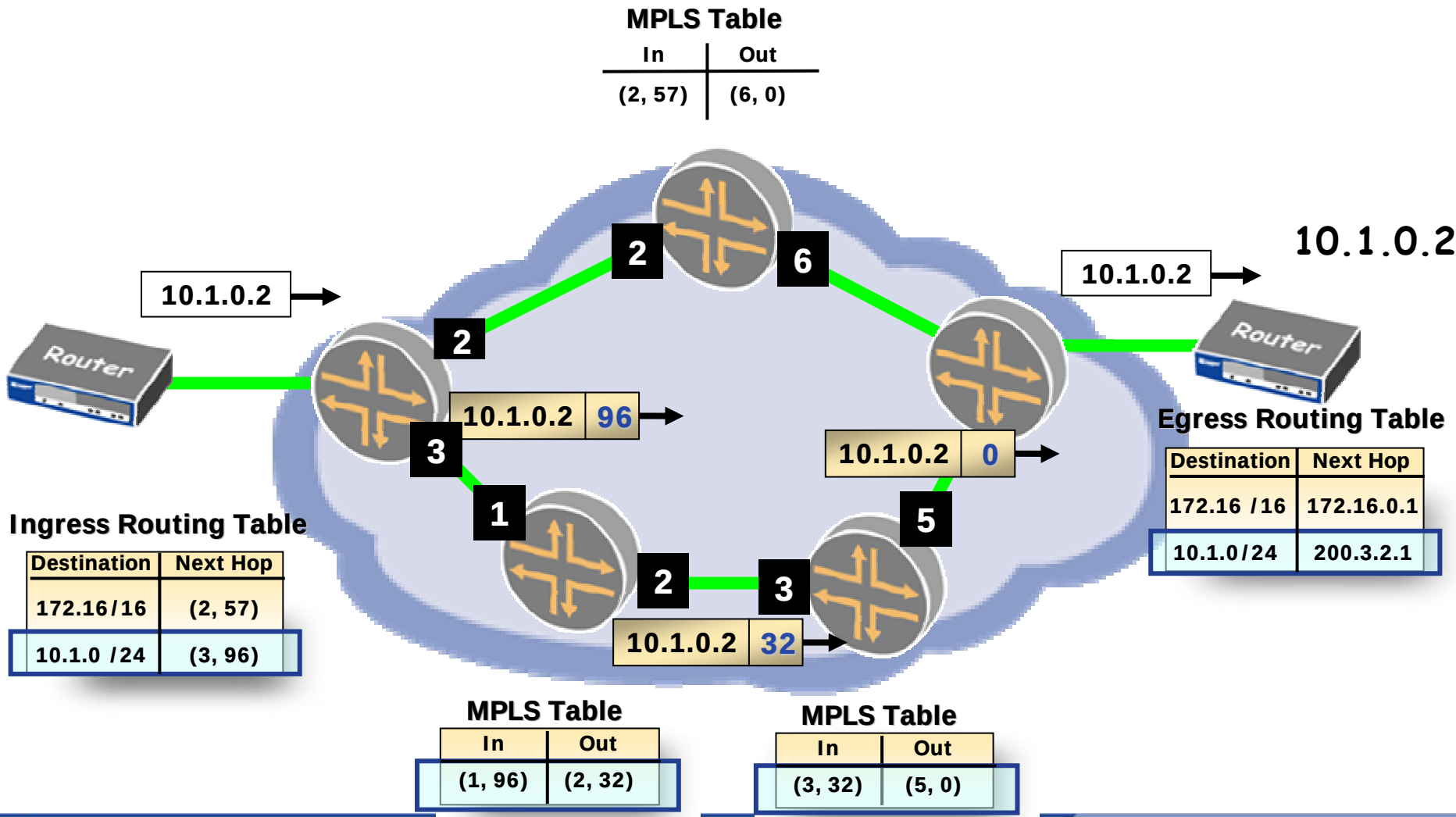


Push, Pop, Swap

- Push
- Pop
- Swap

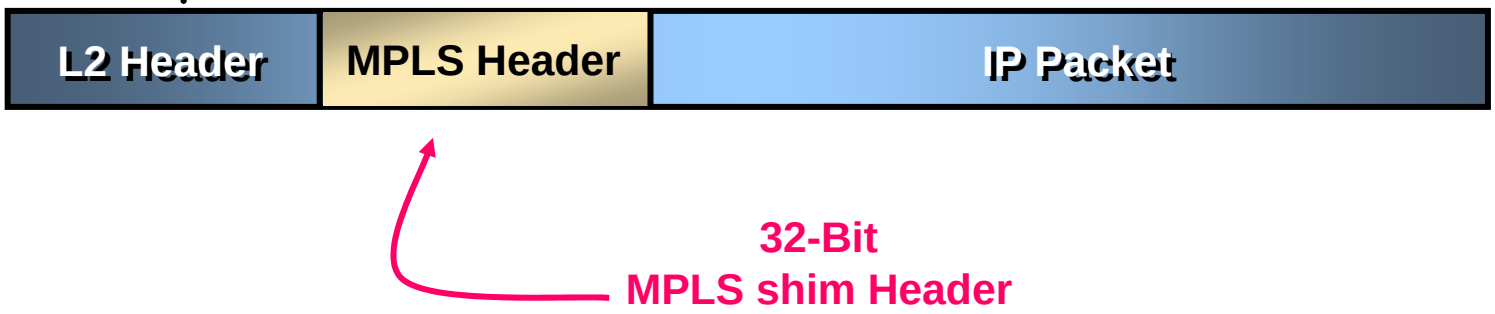


MPLS Forwarding Plane



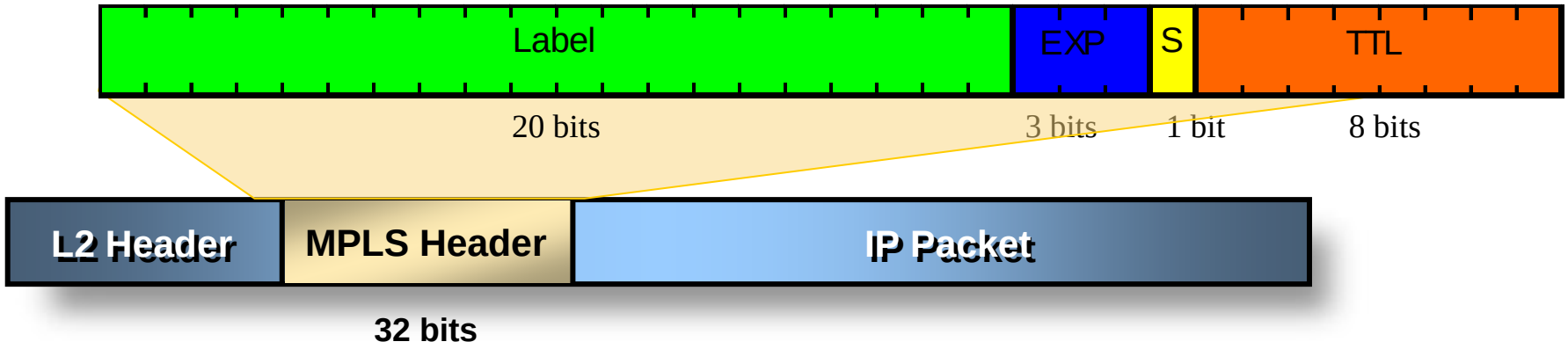
Labeled Packets

- MPLS header is prepended to packet with a *push* operation at ingress node
  - Label is added immediately after Layer 2 encapsulation header



- Packet is restored at the end of the LSP with a *pop* operation
  - Normally the label stack is popped at penultimate node

The Label



- Label
  - Used to identify virtual circuit
- EXP
  - Experimental. Currently this is used to identify class of servce (CoS)
- S (Stack Bit)
  - Used to indicate if there is another label inside this packet or is it the original encapsulated data
- TTL
  - Time to live, functionally equivalent to IP TTL.

Example - Ethernet

0 0 1 0 1 1 1 1 0 1 0 0 0 1 0 1 1

My Web Page

TCP | port = 80 (www)

IP Header | Protocol = TCP

Label = 23 | EXP = BE | S = 0 | TTL = 254

Label = 47 | EXP = BE | S = 1 | TTL = 240

Dest. MAC Src. MAC Type = 8347

FEC – Forwarding Equivalency class

- All traffic with the same FEC will follow the same path and experience same level of service
- E.g. of FEC
  - Destination IP address
  - BGP next hop
  - VPN membership
  - Source address
  - Any combination of above

What label is pushed onto what packet?

Packet

Label

Signaling

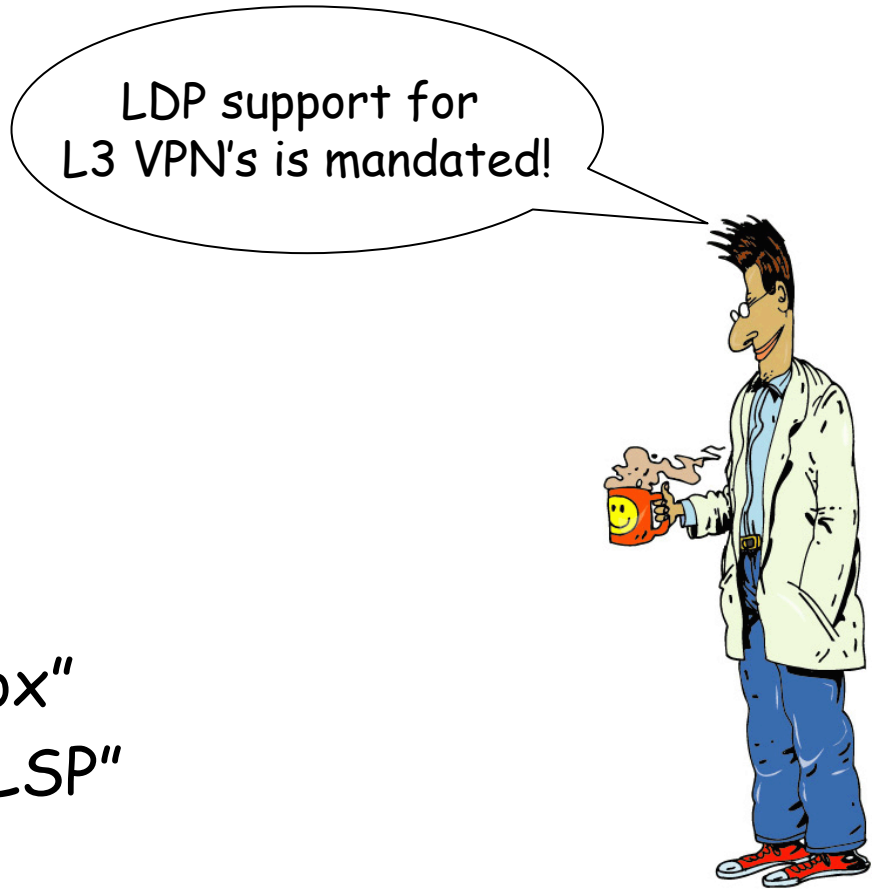
- Protocols that are used to setup maintain and tear down LSP's.
- Can behave differently depending on function
- Let's describe a language / concepts to understand these differences in operation

Signalling Protocols

- LDP
  - Label Distribution Protocol
- RSVP-TE
  - Resource Reservation Protocol with Traffic Engineering Extensions
- MBGP
  - Multi-protocol BGP

Which to choose…

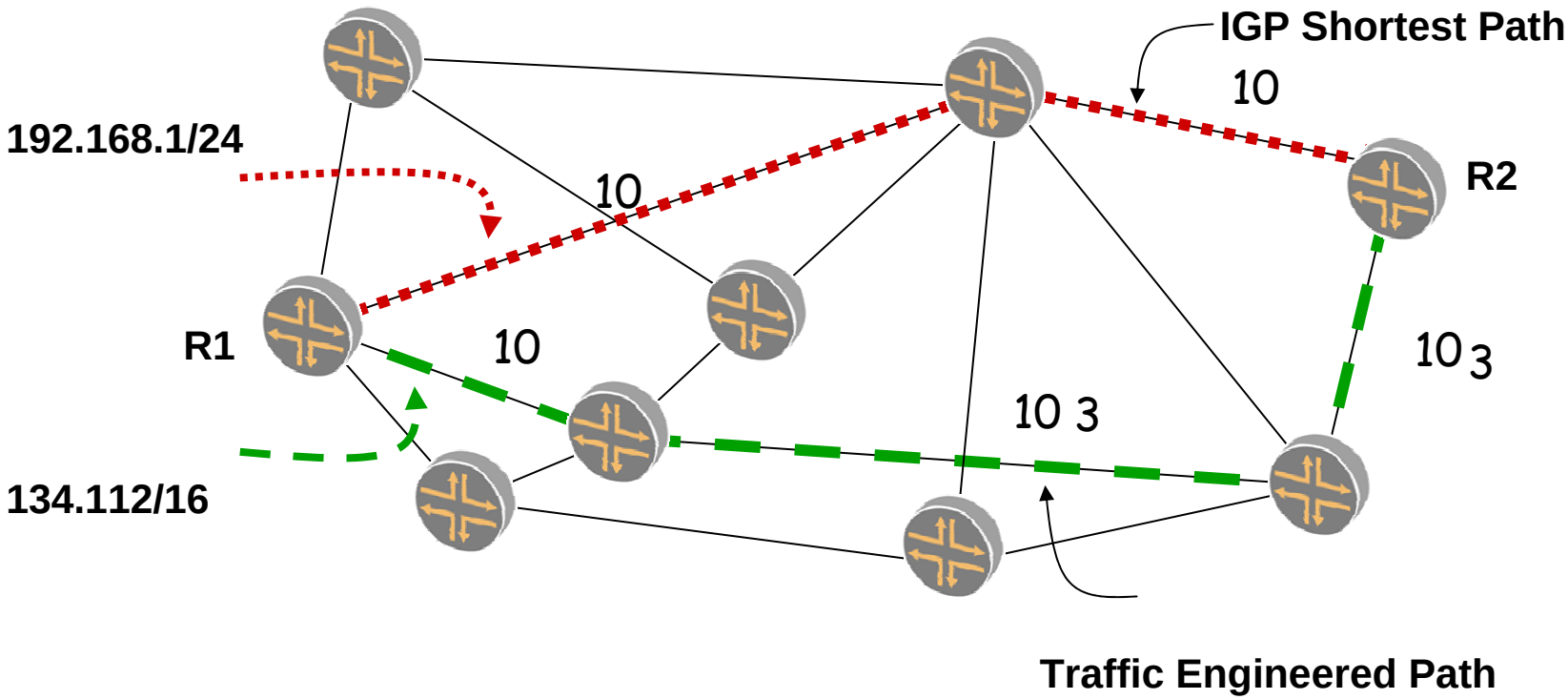
- Traffic Engineering, Traffic Protection
  - RSVP
  - Link State protocol
- VPN's
  - LDP or RSVP (all LSR's)
  - MBGP (PE's only)
- Why use LDP at all?
  - Configuration scaling
  - LDP configuration is "per box"
  - RSVP configuration is "per LSP"



Traffic Engineering Defined

- Sub Optimal routing
- Network Engineering is putting bandwidth where the traffic is. Traffic Engineering is putting the traffic where the bandwidth is!
- To meet one of two requirements
  - To better utilize network capacity and resources.
  - To put traffic on a path that can support it's requirements
- Incorporate Traffic Protection to achieve SONET like failure recovery.

MPLS-Based Traffic Engineering



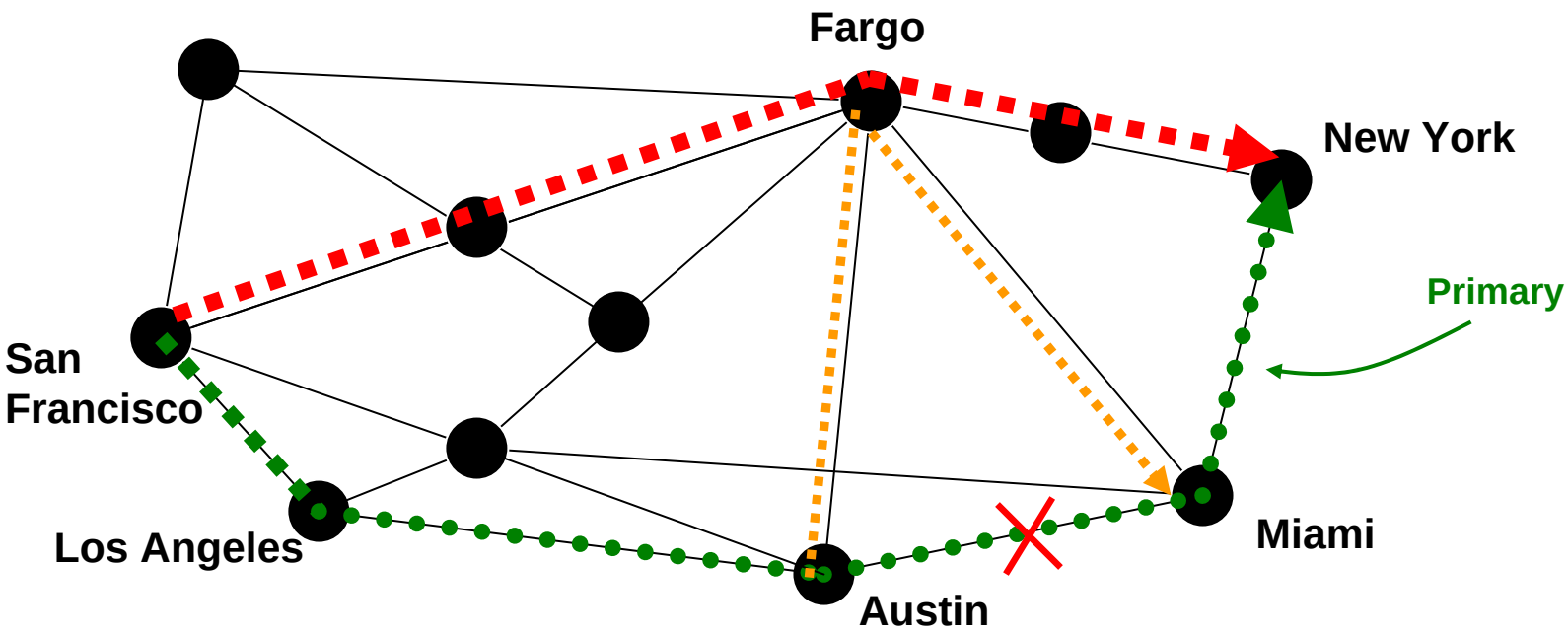
Traffic Engineering Options

- Can we do this another way
  - IGP metrics ☹
  - Flow = all traffic with same destination
- MPLS because
  - Granularity of flows
  - Flow = all traffic with same FEC
  - One network for all services
  - Less expensive

Traffic Protection

- Working definition
  - Reduce time of disruption
  - Reduce Packet Loss
  - "SONET like" sub millisecond recovery under failure conditions
- Can we do this another way
  - SONET/SDH
  - Lower IGP timers
- MPLS because
  - No extra capital – config change only
  - Pick which traffic needs it
  - One network for all services
  - Less expensive

Traffic Protection – example



Traffic Protection Variations

- Juniper
  - Fast reroute
- Multi-Vendor
  - Link Protection
  - Link-Node Protection

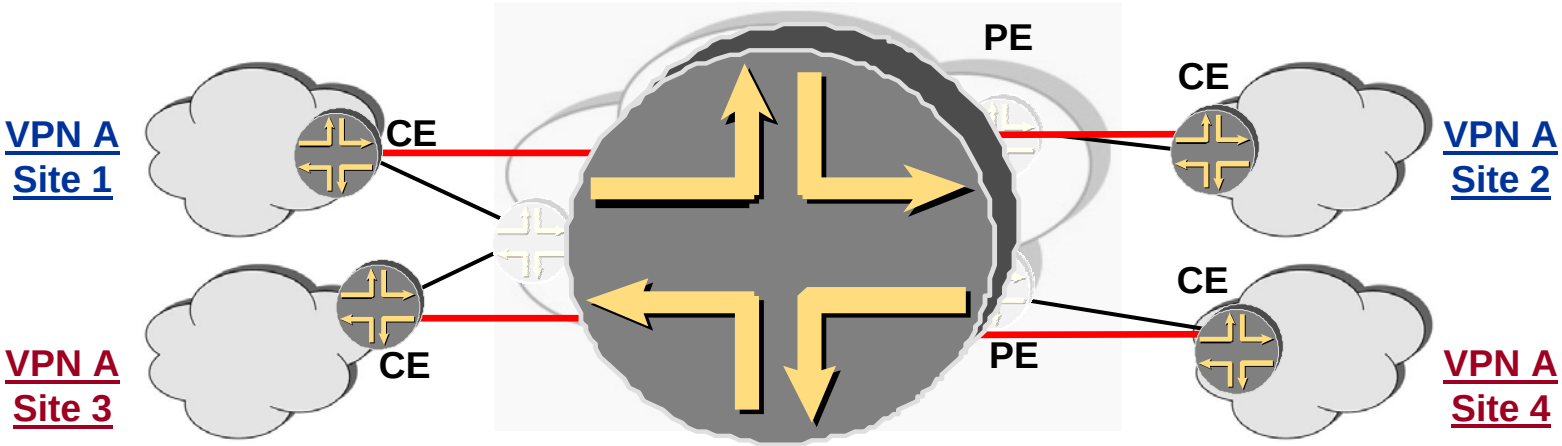
Layer 3 VPN's (2547bis BGP/MPLS VPN's)

Provider provisioned VPN

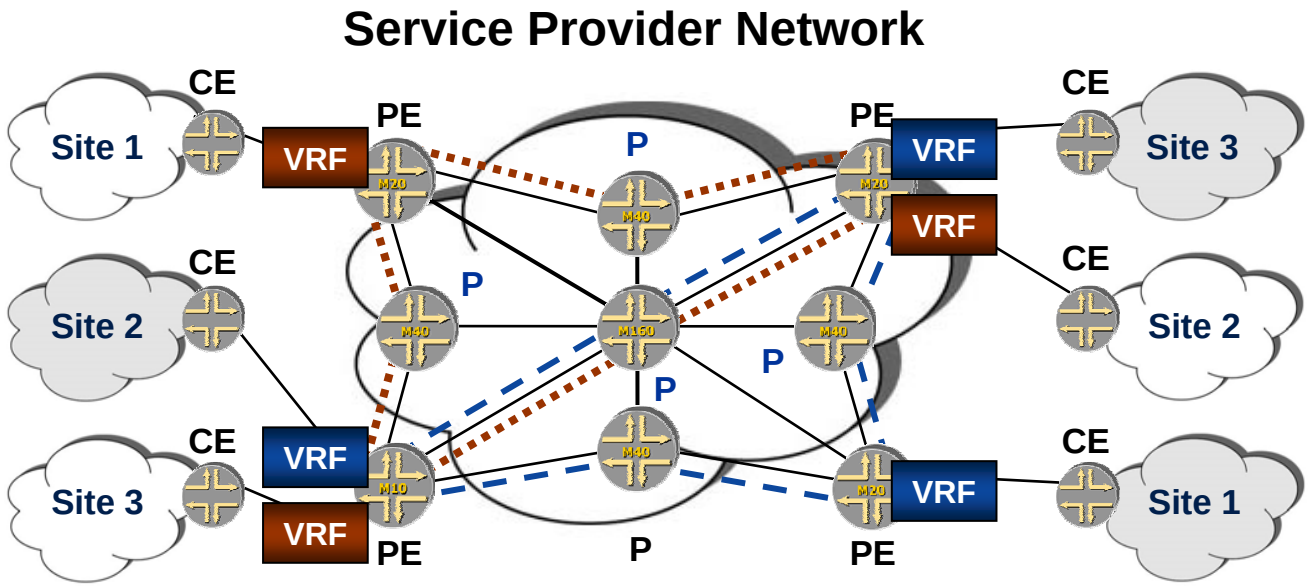
- ISP runs backbone for customer
  - Customer can be another ISP!
- Attractive to
  - Customer who do not want to run their own backbone
- Not attractive to
  - Customer who doesn't trust carrier
  - Customers who's jobs are threatened

Customer View of L3VPN

- Make the cloud look like a router
- Single site provisioning



Layer 3 PP-VPNs: RFC 2547bis (1 of 2)



- Application: Outsource VPN
  - PE router maintains VPN-specific forwarding tables for each of its directly connected VPNs
  - Conventional IP routing between CE and PE routers
  - VPN routes distributed using MP-BGP
    - Uses extended communities
  - VPN traffic forwarded across provider backbone

Layer 3 PP-VPNs: RFC 2547bis (2 of 2)

- LDP or RSVP is used to set up PE-to-PE LSPs
- MP-BGP is used to distribute information about the VPN
  - Routing and reachability for the VPN
  - Labels for customer sites (tunneled in PE-PE LSP)
- Constrain connectivity by route filtering
  - Flexible, policy-based control mechanism

L3 VPN Options

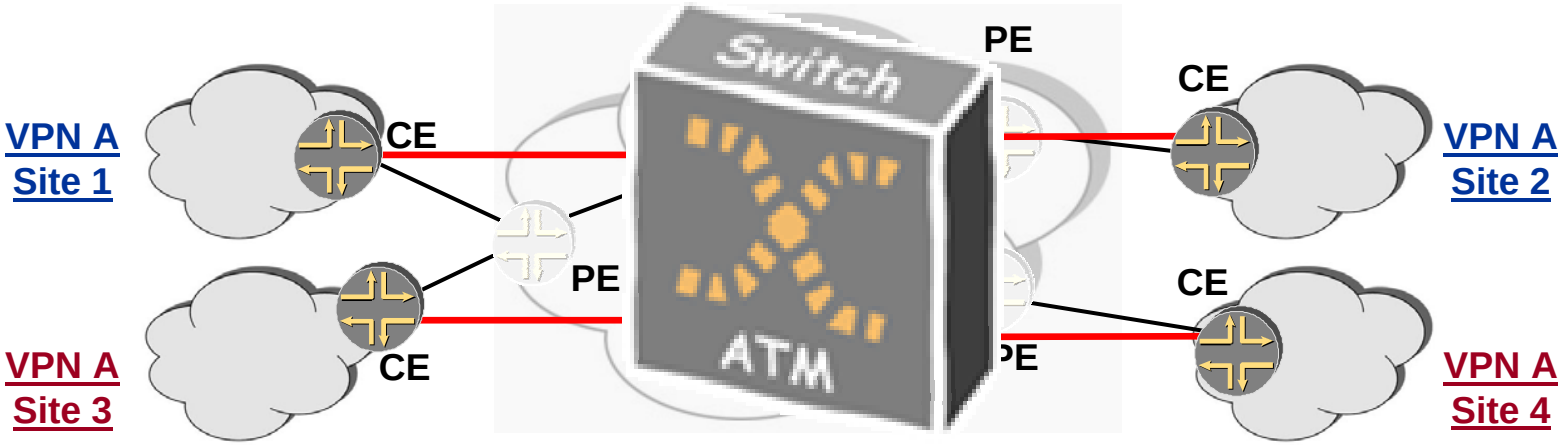
- Can we do it another way
  - Separate Physical routers
  - Separate Logical Routers
- MPLS because
  - Scaling
  - Single site provisioning
  - Less expensive

Layer 2 VPN's

- Provider provisioned VPN
  - ISP runs backbone for customer
    - Customer can be another ISP!
- Attractive to
  - Customers who want to preserve current CE technology
  - Customers who don't trust provider with L3
  - Carriers who want to offer another service
- Not Attractive to
  - Customers who do not want to run their own backbone

Customer View of L2VPN

- Make the cloud look like a ATM/FR network



L2 VPN Options

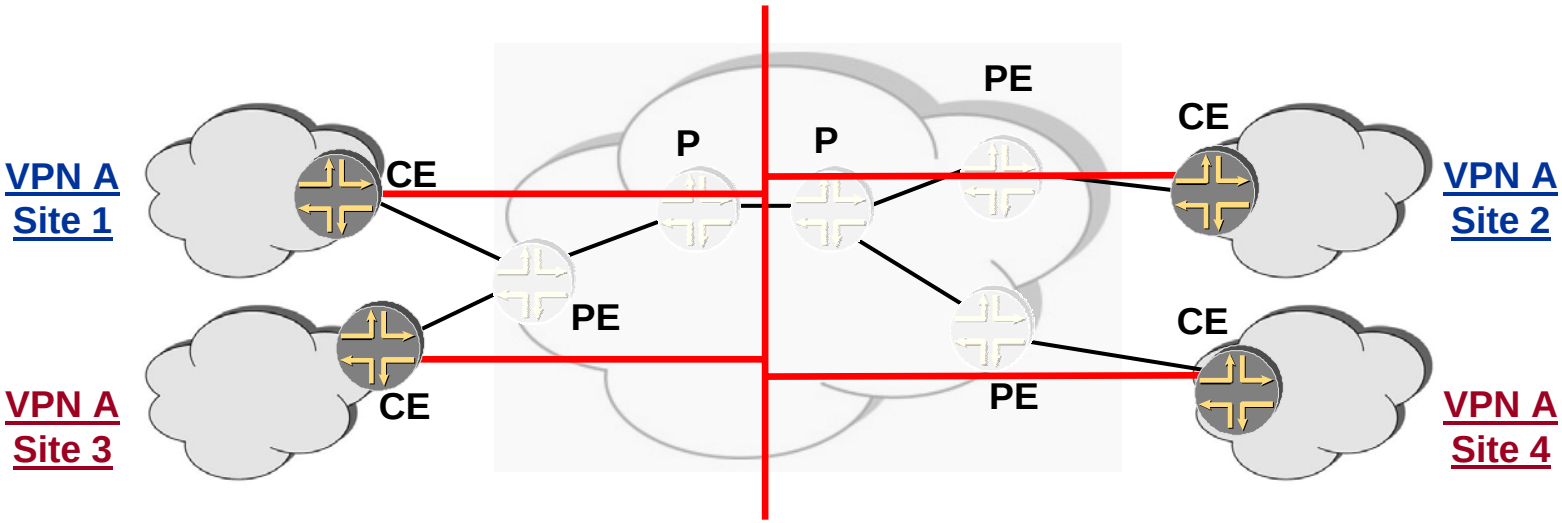
- Can we do it another way?
  - Traditional ATM/FR/leased line infrastructure
- MPLS because
  - One network for all services
  - Less expensive
  - Scaling
  - Single site provisioning *

VPLS

- Virtual Private LAN Service
- Attractive to
  - Customers who like ethernet as CE
  - Lots of locations close together with 'high' WAN bandwidth requirements (kiosks)
  - No routing required
- Not attractive to
  - Customers who like control and visibility of core. "what can I ping to identify fault-domain?"
  - Controlling broadcasts

VPLS

- Make the cloud look like an ethernet switch

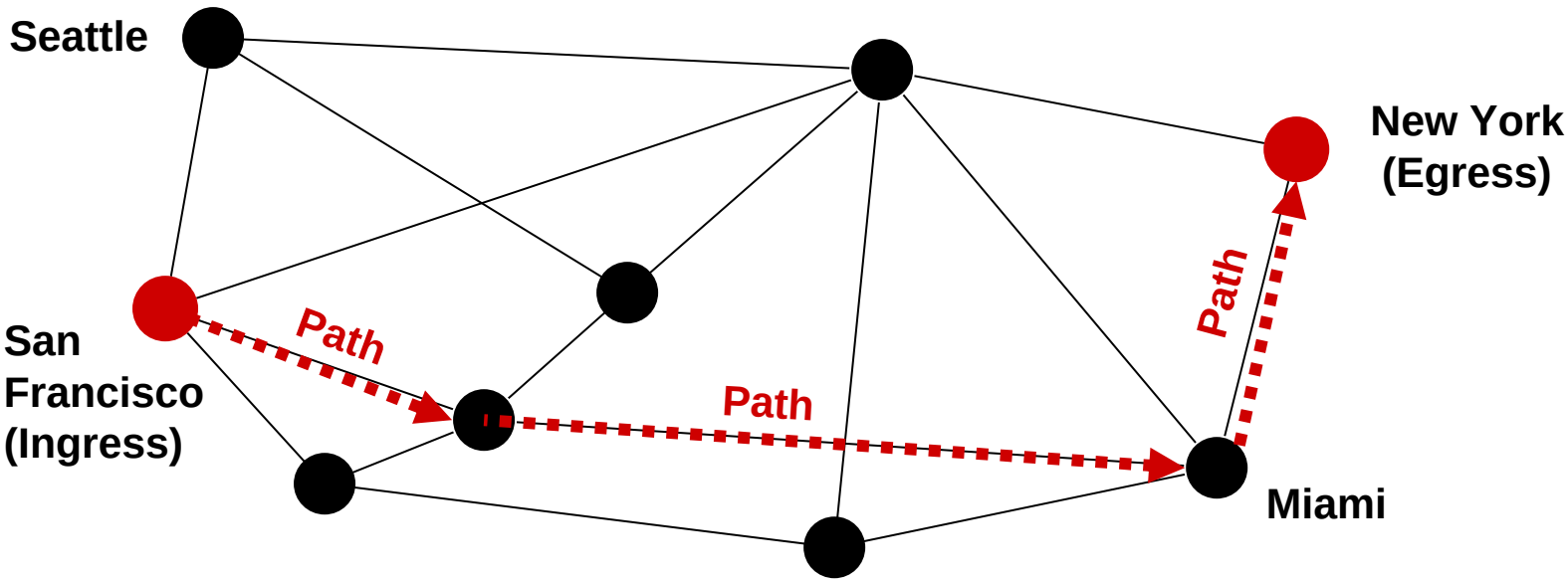


VPLS Options

- Can we do it another way?
  - Separate physical switches tying all customer sites
  - VLAN's over layer 2 backbone
- MPLS because
  - Scaling
  - One network for all services
  - Less expensive

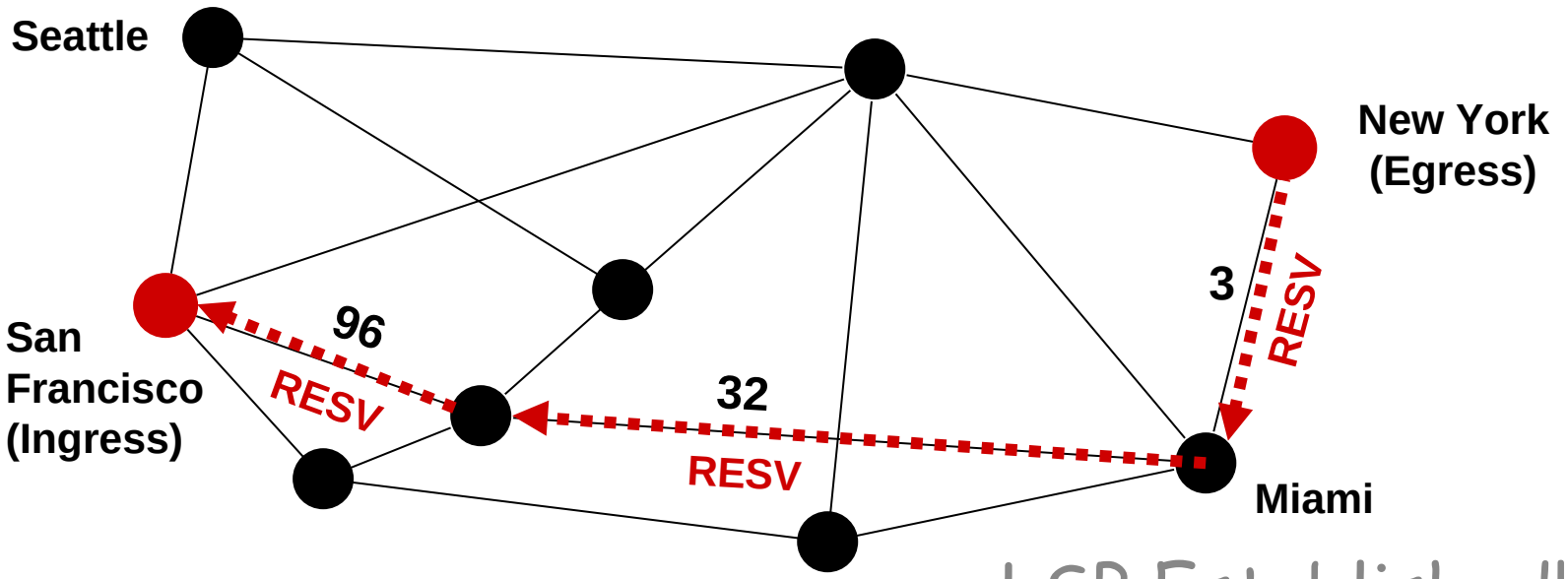
RSVP Signaling Example: Path

RSVP sets up path from San Francisco to New York



RSVP Signaling Example: Reservation

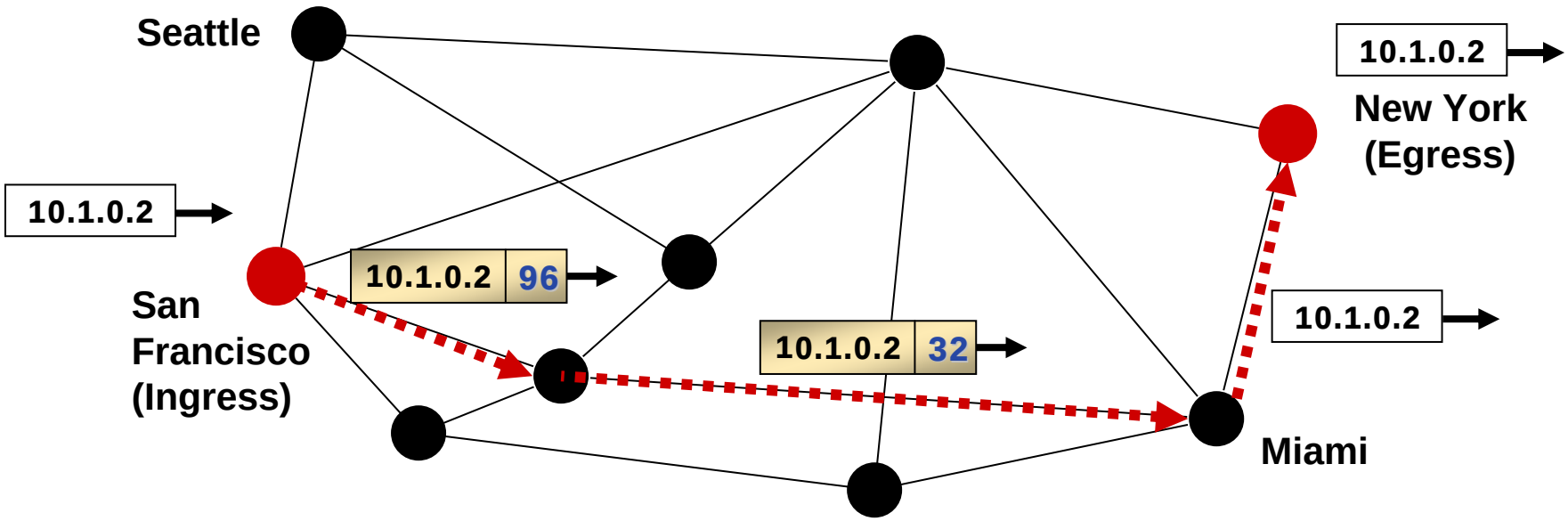
- The resv message visits each router on the path in reverse order
  - Labels assigned hop to hop in the upstream direction



LSP Established!

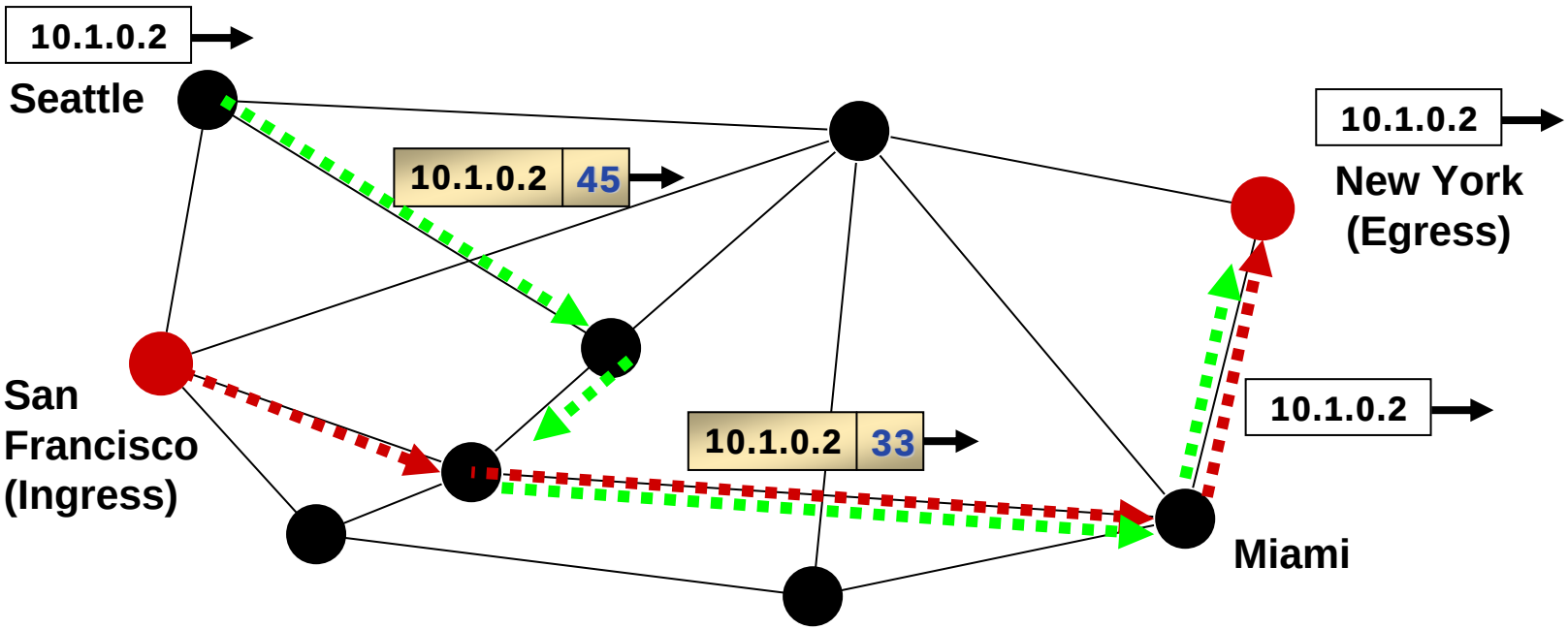
RSVP Signaling Example: Forwarding

RSVP sets up path from San Francisco to New York



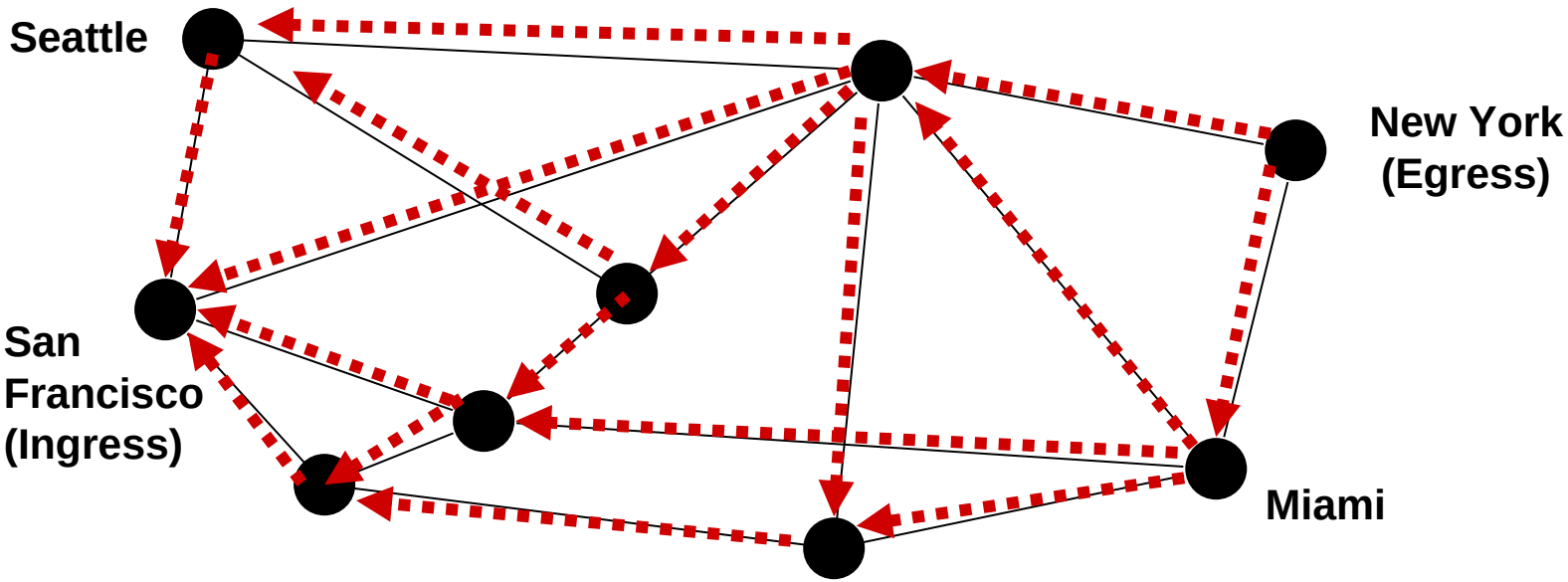
RSVP Signaling Example: Forwarding 2

RSVP sets up path from San Francisco to New York



LDP Signaling Example: Label Binding

- Label Mappings are made for entries in the routing table
  - Labels assigned hop to hop in the upstream direction

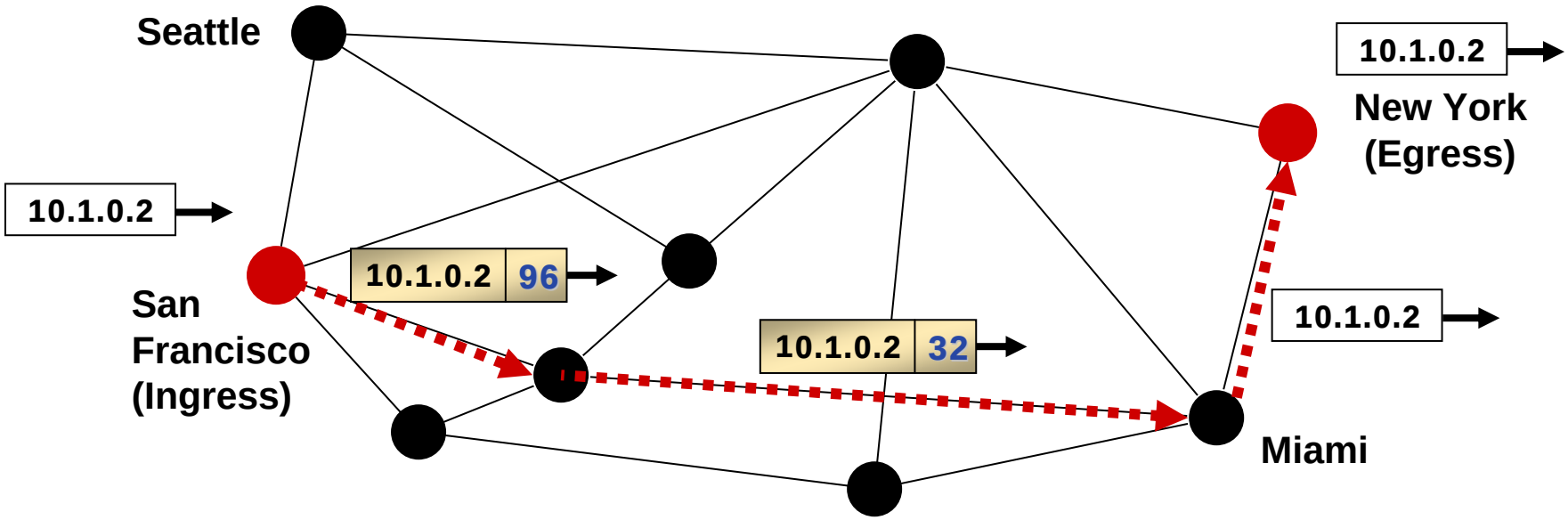


For those who care!

- The last slide assumed LDP was operating in
  - Unsolicited Downstream mode
    - Not downstream-on-demand
  - Ordered Mode
    - Not Independent Mode
  - Liberal label retention
    - Not conservative

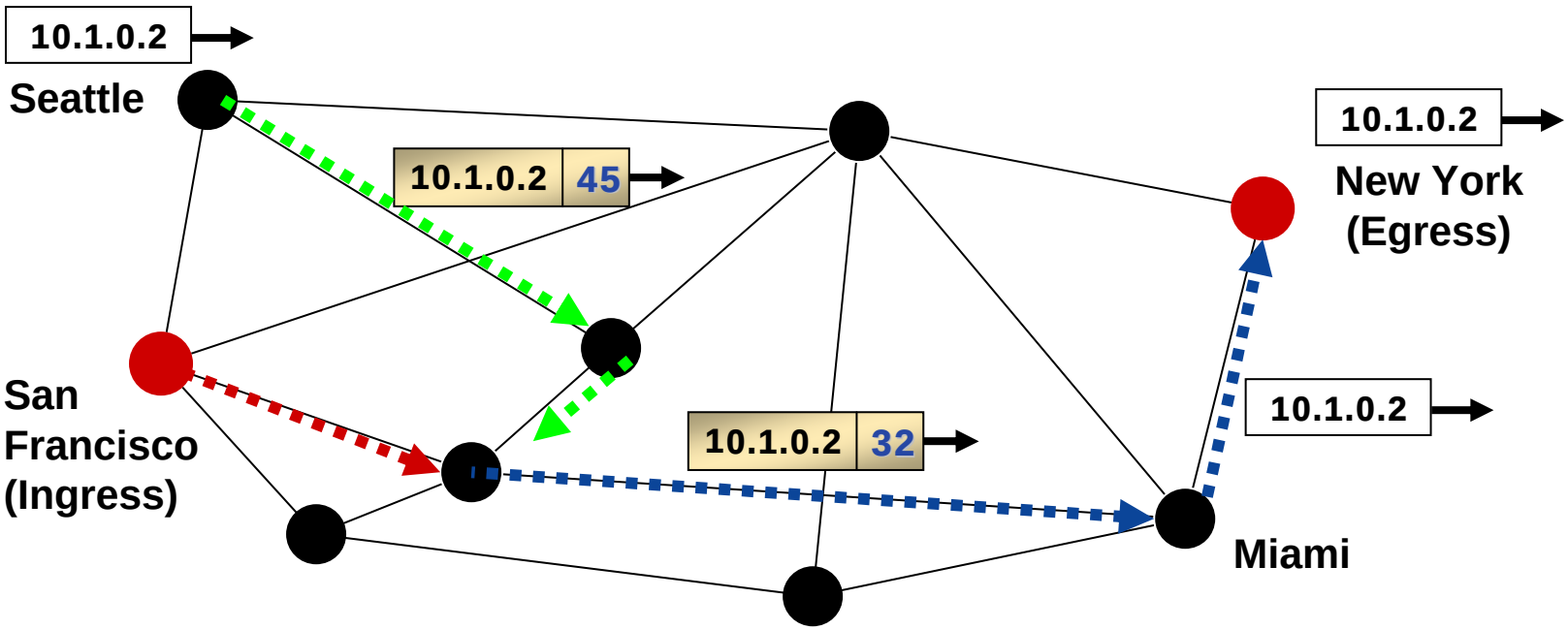
LDP Signaling Example: Forwarding

LDP path available to egress



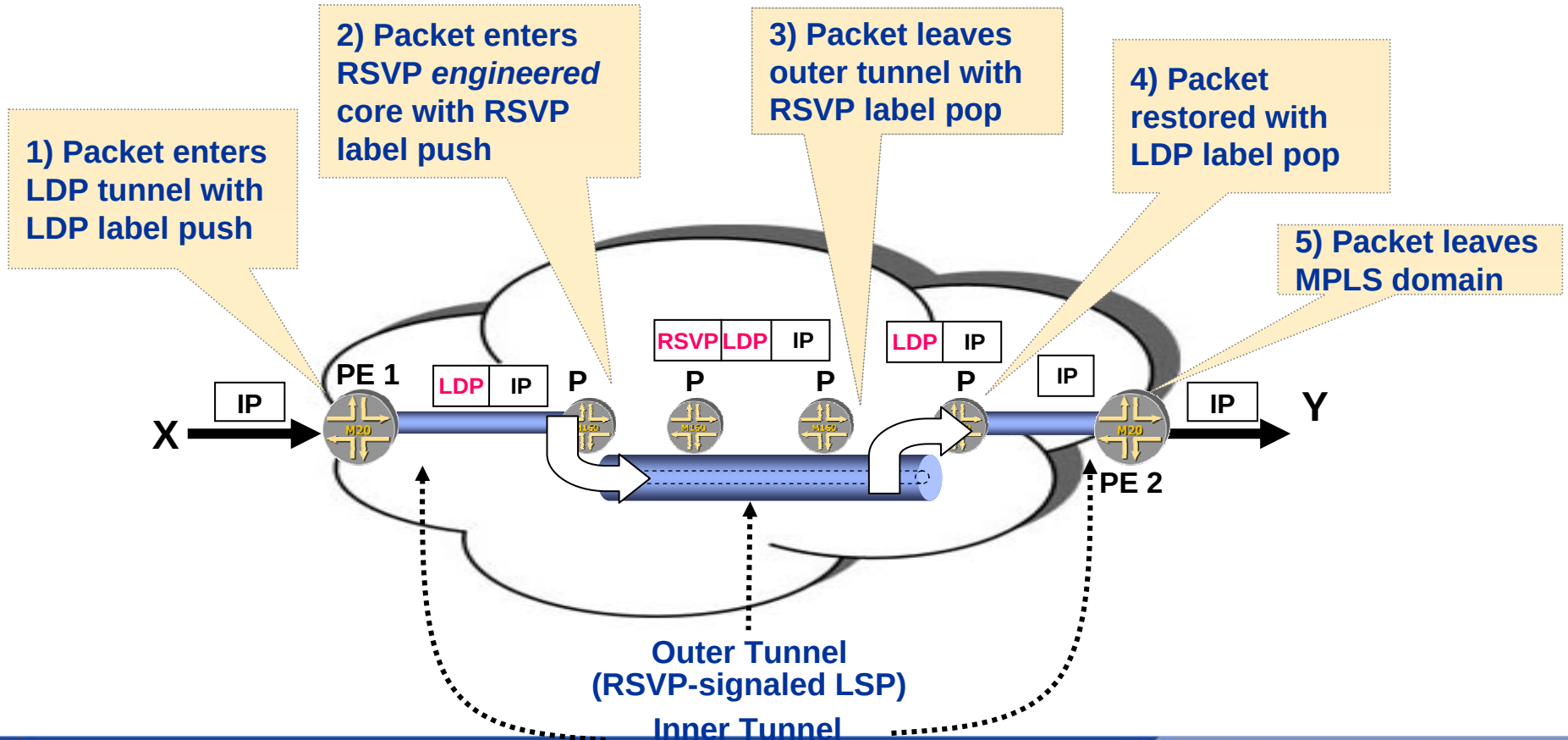
LDP Signaling Example: Forwarding 2

LSP Merging occurs



Label Stacking

- Label stacking improves scalability
  - Similar to ATM's VP and VC hierarchy



Further Reading

1. http://www.juniper.net/solutions/literature/white_papers/
2. http://www.juniper.net/solutions/literature/white_papers/200012.pdf
3. www.mplsrc.com

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Thank You !

Me in Thimphu