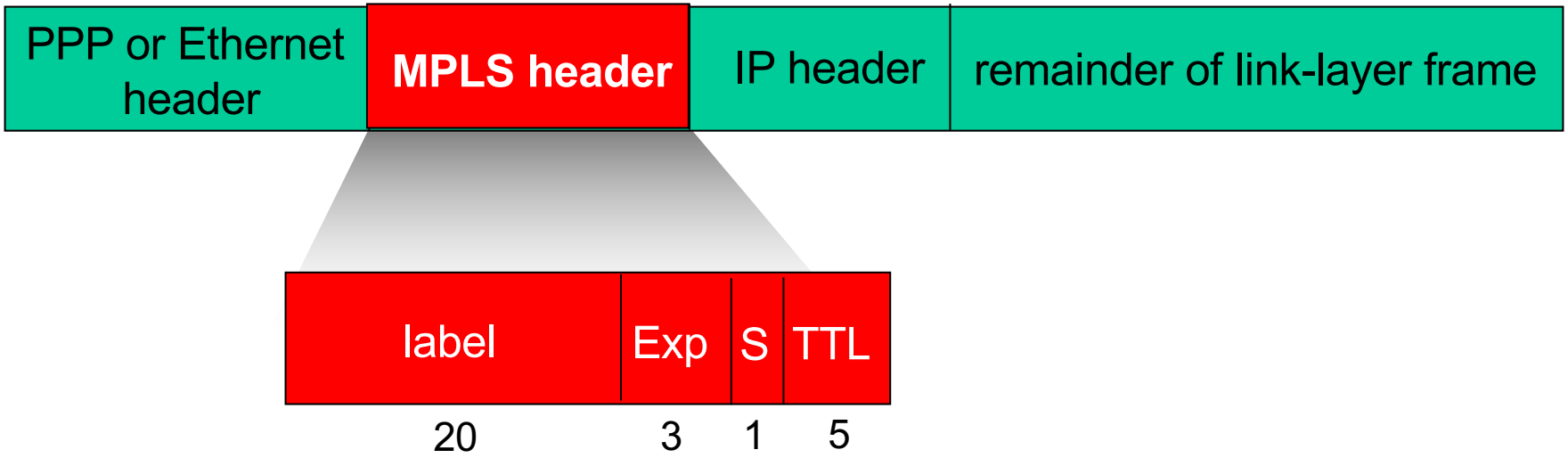
MPLS

Multiprotocol Label Switching

Multiprotocol label switching (MPLS)

a) initial goal: high-speed IP forwarding using fixed length label (instead of IP address)

- fast lookup using fixed length identifier (rather than shortest prefix matching)
- borrowing ideas from Virtual Circuit (VC) approach



MPLS capable routers

a) a.k.a. label-switched router

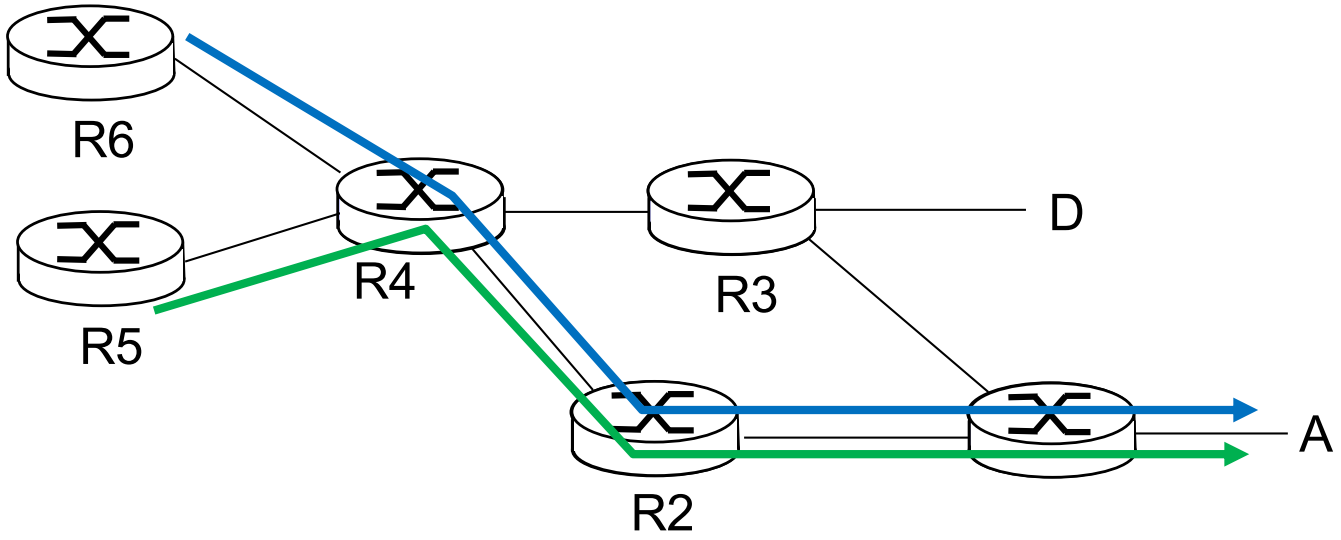
b) forward packets to outgoing interface based only on label value (*don't inspect IP address*)

- MPLS forwarding table distinct from IP forwarding tables

c) *flexibility:* MPLS forwarding decisions can *differ* from those of IP

- use destination *and* source addresses to route flows to same destination differently (traffic engineering)
- re-route flows quickly if link fails: pre-computed backup paths (useful for VoIP)

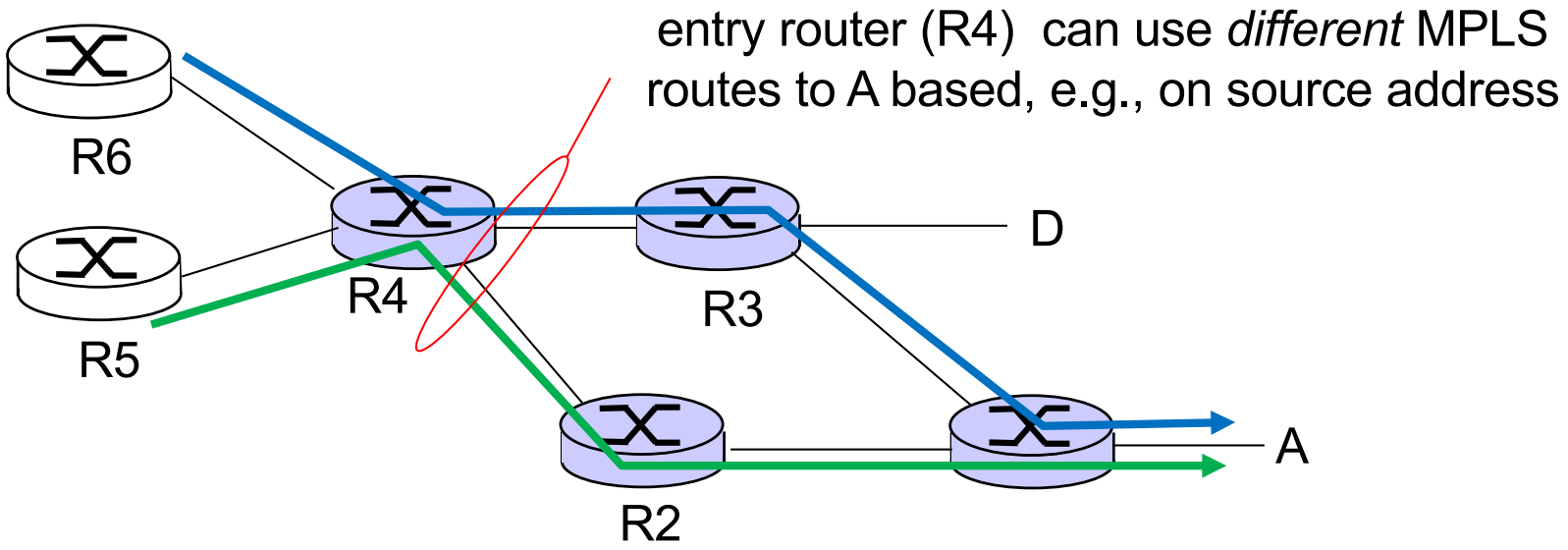
MPLS versus IP paths



- *IP routing: path to destination determined by destination address alone*

IP router

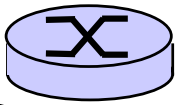
MPLS versus IP paths



- *IP routing:* *path to destination determined by destination address alone*

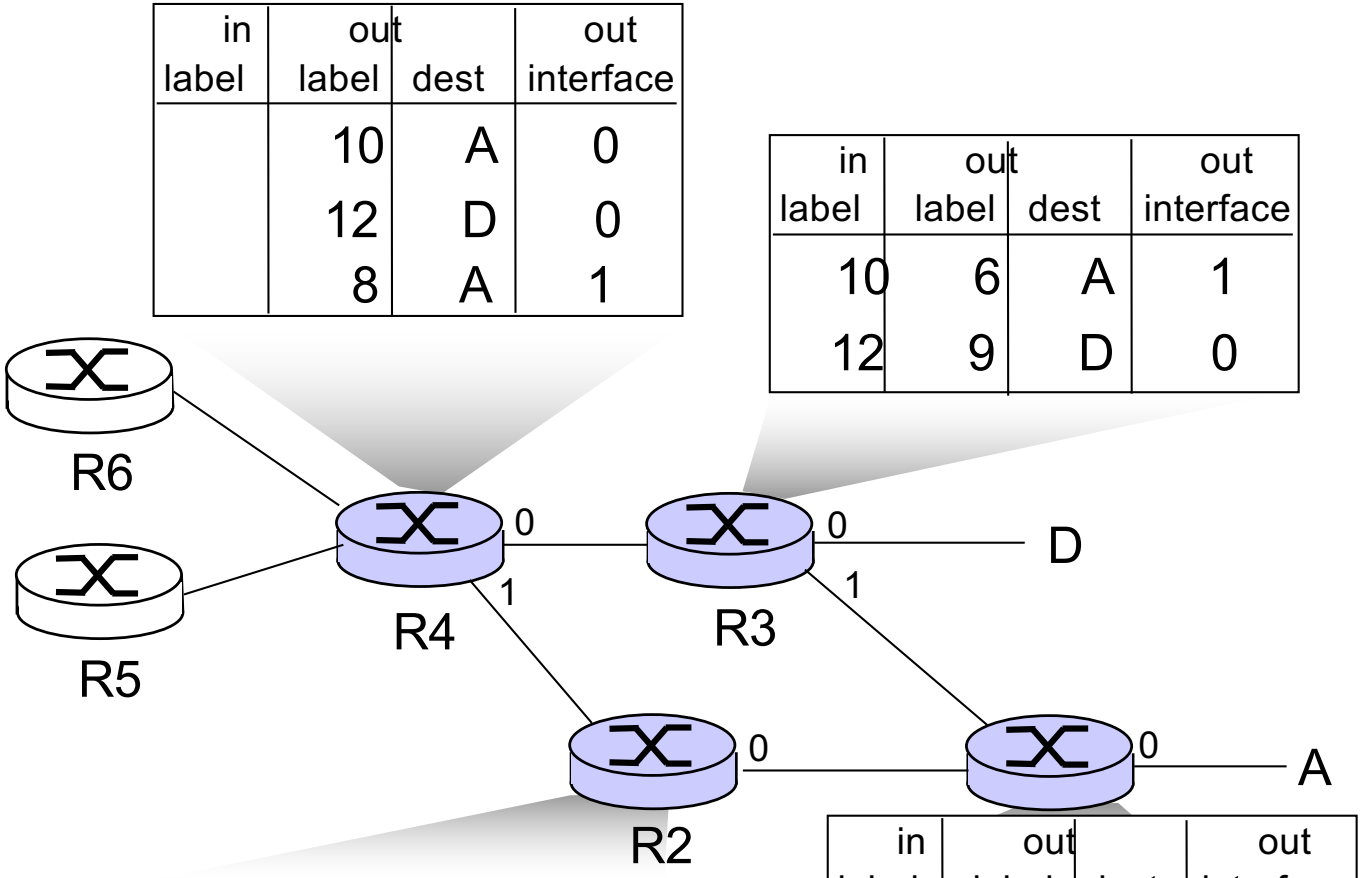
IP-only router

- *MPLS routing:* path to destination can be based on source *and* destination address
  - *fast reroute:* precompute backup routes in case of link failure



MPLS and IP router

MPLS forwarding tables



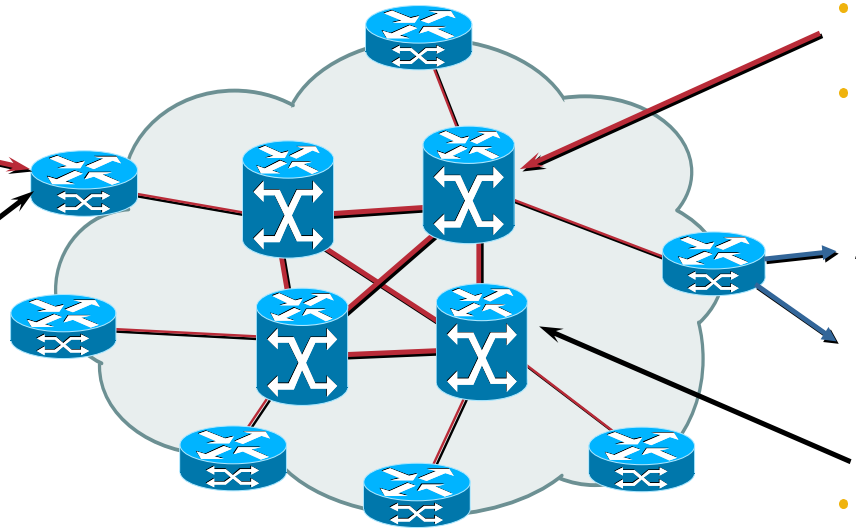
MPLS Concepts and Components

At Edge:
- Classify packets
- Label them

Label Imposition

Edge Label Switch Router (ATM Switch or Router)

- **Protocols:**
  - IGP for Core
  - MPLS Header (Label)
  - Label Distribution Protocol & Label



- **Devices**
  - Label Switching Routers
  - Edge Label Switching Routers

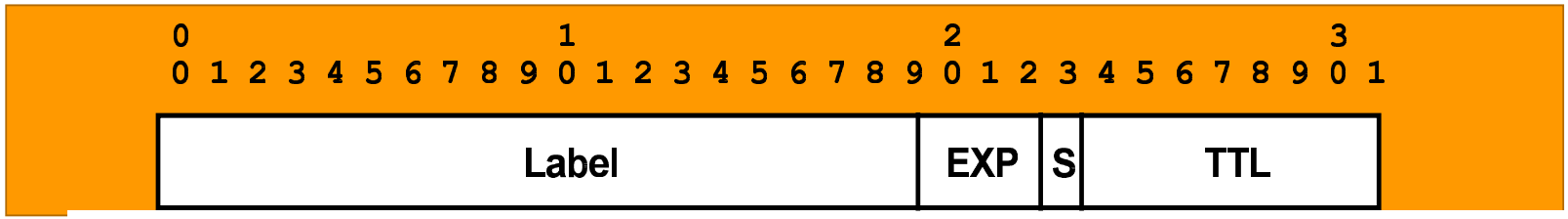
In Core:
- Forward using labels (as opposed to IP addr)
- Label indicates service class and destination

Label Swapping or Switching

At Edge:
Remove Labels and forward packets

Label Disposition

Label Switch Router (LSR)
- Router
- ATM switch + Label Switch Controller



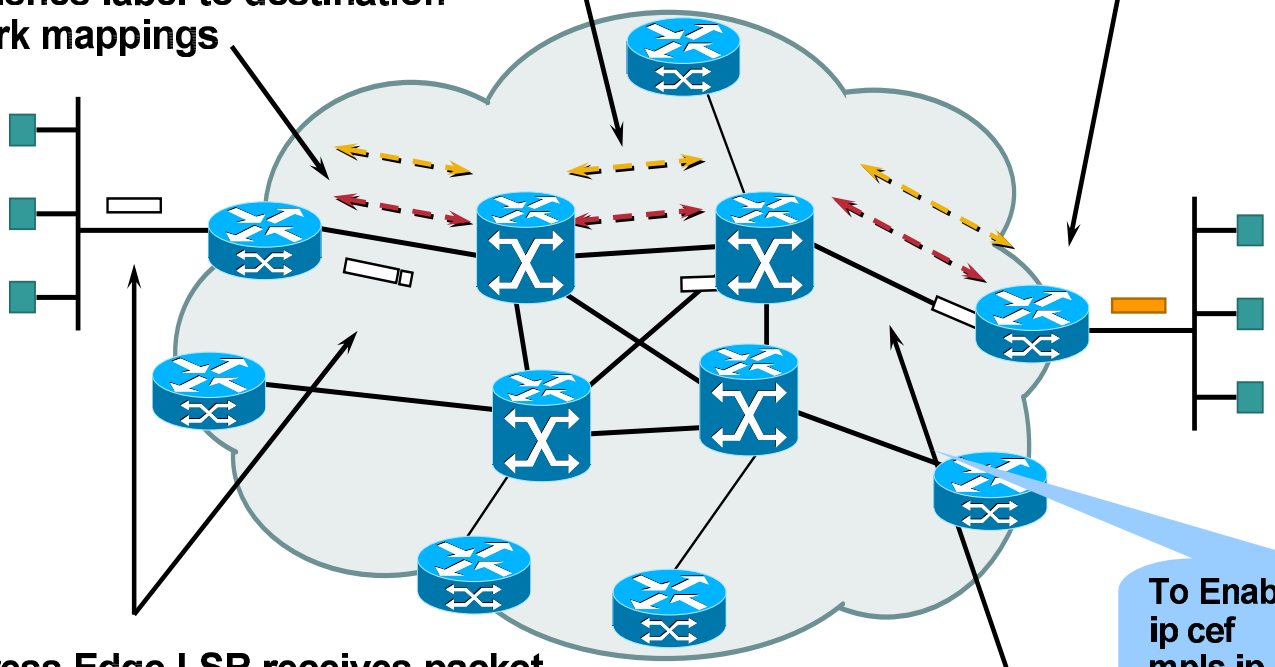
Label = 20 bits; COS/EXP = Class of Service, 3 bits; S = Bottom of Stack, 1 bit
TTL = Time to Live, 8 bits

MPLS Operation

1a. Existing routing protocols (ie: OSPF, IS-IS, EIGRP) establish reachability to destination networks

1b. Label Distribution Protocol (LDP) establishes label to destination network mappings

4. Edge LSR at egress removes label and delivers packet

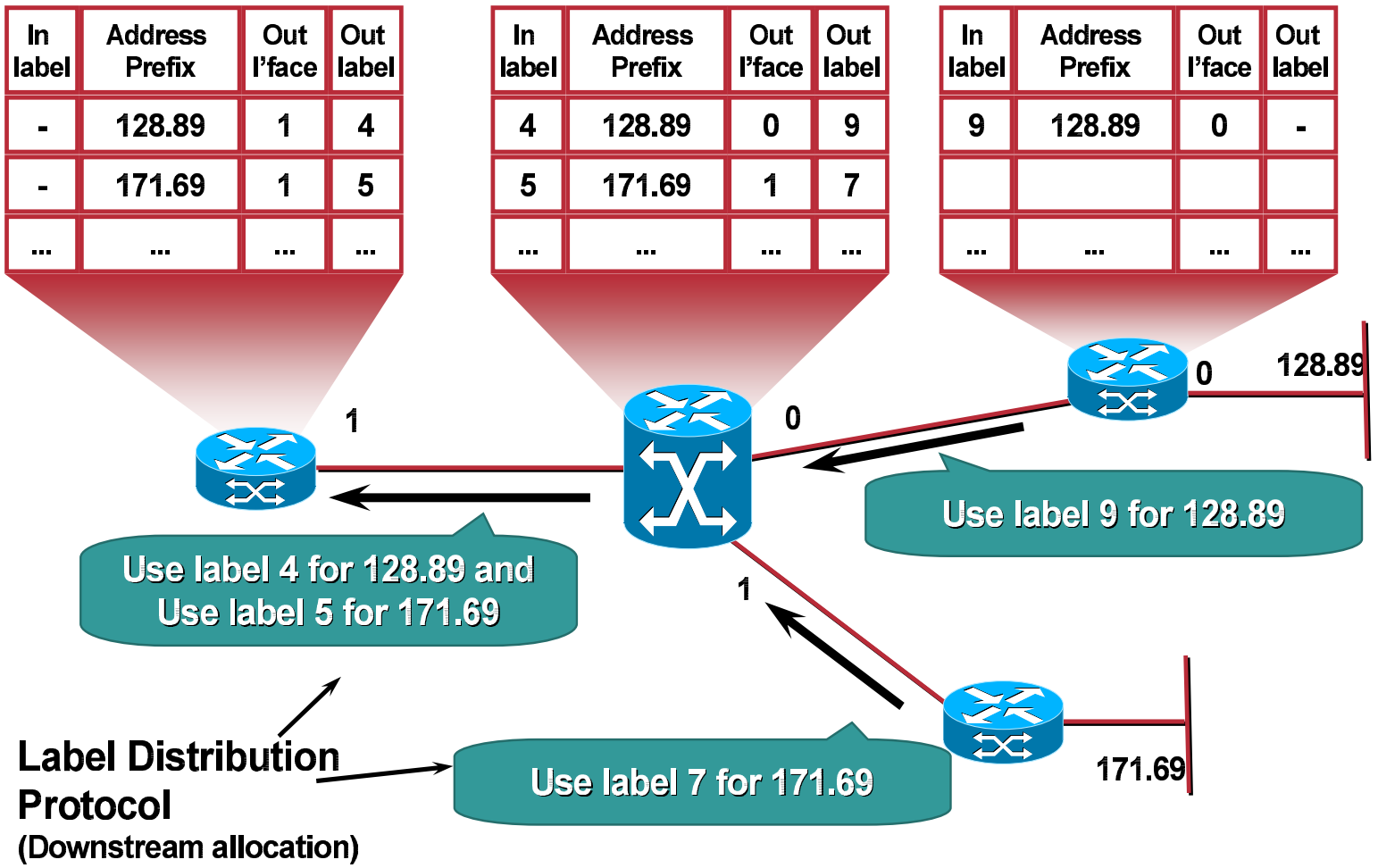


2. Ingress Edge LSR receives packet, performs Layer 3 value-added services, and "labels" packets

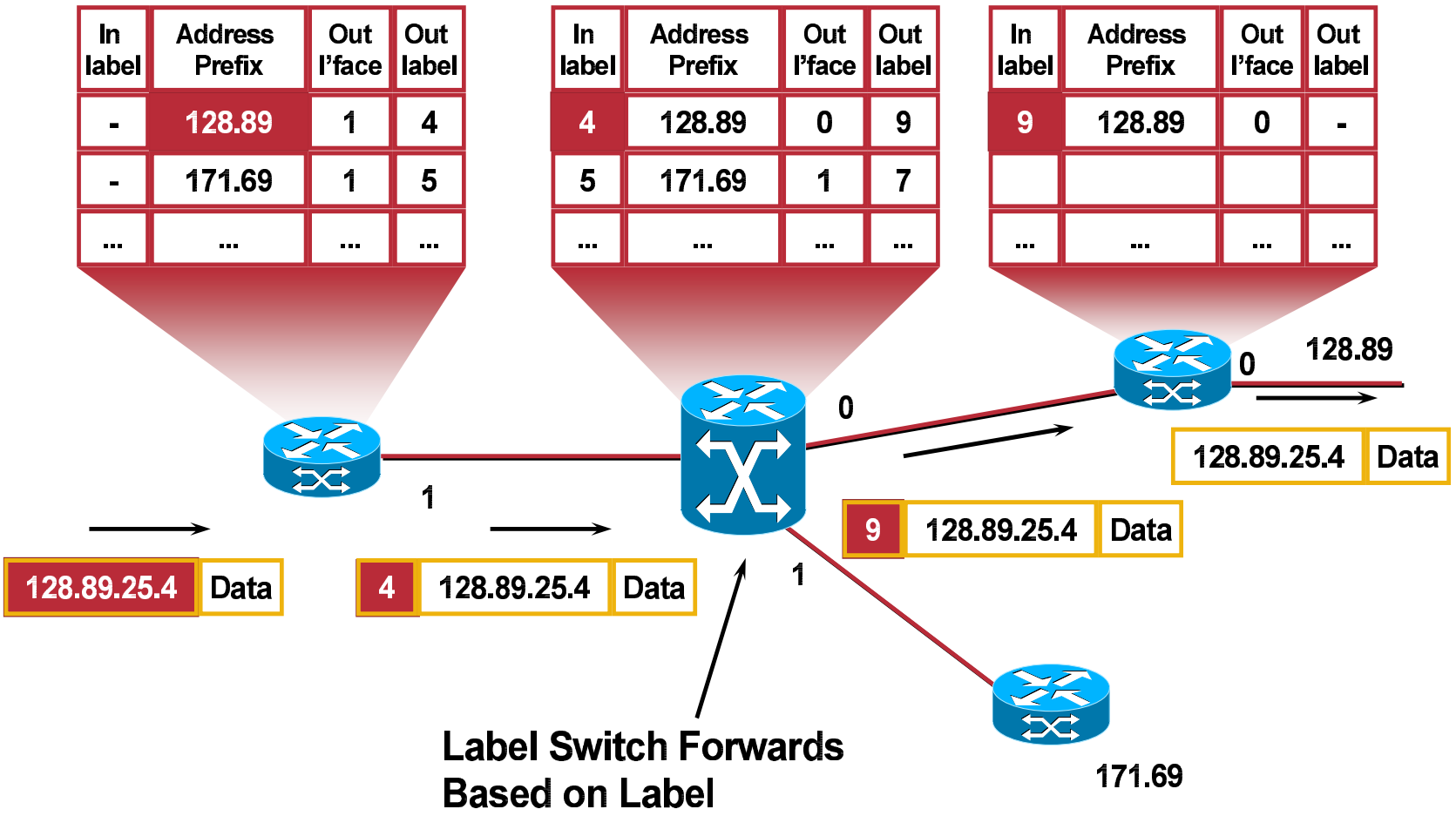
3. LSR switches packets using label swapping

To Enable mpls:
ip cef
mpls ip
mpls label protocol ldp

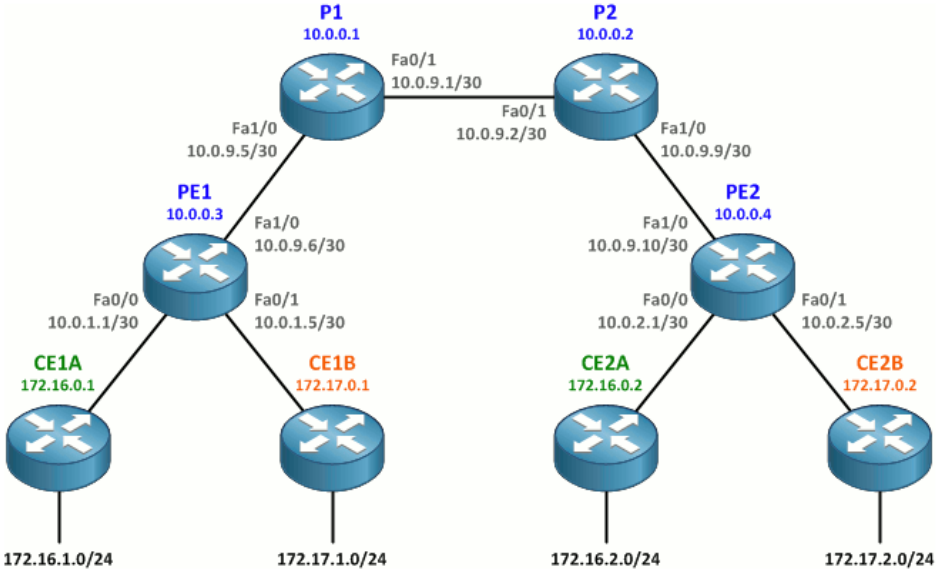
MPLS Control Plane
Assigning and Distributing Labels



MPLS Forwarding Plane
Appending Labels and Forwarding Packets



Creating an MPLS VPN



- P (provider) routers are ISP core routers which don't connect to customer routers and typically run only MPLS
- PE (provider edge) routers connect to customer sites and form the edge of a VPN
- CE (customer edge) routers exist at the edge of a customer site; they have no VPN awareness
- an IGP running among all P and PE routers is used to support LDP and BGP adjacencies within the provider network
- MP-BGP is run only among PE routers
- an IGP (typically) is run between each CE router and its upstream PE router

https://packetlife.net/blog/2011/may/16/creating-mpls-vpn/

MPLS VPN

1. Configuring OSPF on the Provider Network
2. Enabling MPLS
   - LDP (Label Distribution Protocol)
3. VRF – Virtual Routing Forwarding
   - Route Distinguisher
   - Route Target
4. Configure Multiprotocol BGP (MPBGP) between PE routers
5. Configure PE – CE OSPF
6. Configure Route Redistribution
   - CE routes in each VRF into MP-BGP
   - from BGP into the customer OSPF processes

Route Distinguisher

- Purely to make a route unique so customers don't see each other's routes

  Example: differentiate 10.0.0.0/8 in VPN-A from 10.0.0.0/8 in VPN-B

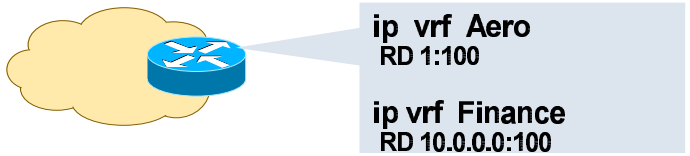
  Makes IPv4 route a VPNv4 routes: VPNv4=RD:IPv4

  Unique route is now RD:IPaddr (96 bits) plus a mask on the IPAddr portion

  So route reflectors make a bestpath decision on something other than 32-bit network + 32-bit mask

- 64-bit quantity configured as ASN:YY or IPADDR:YY

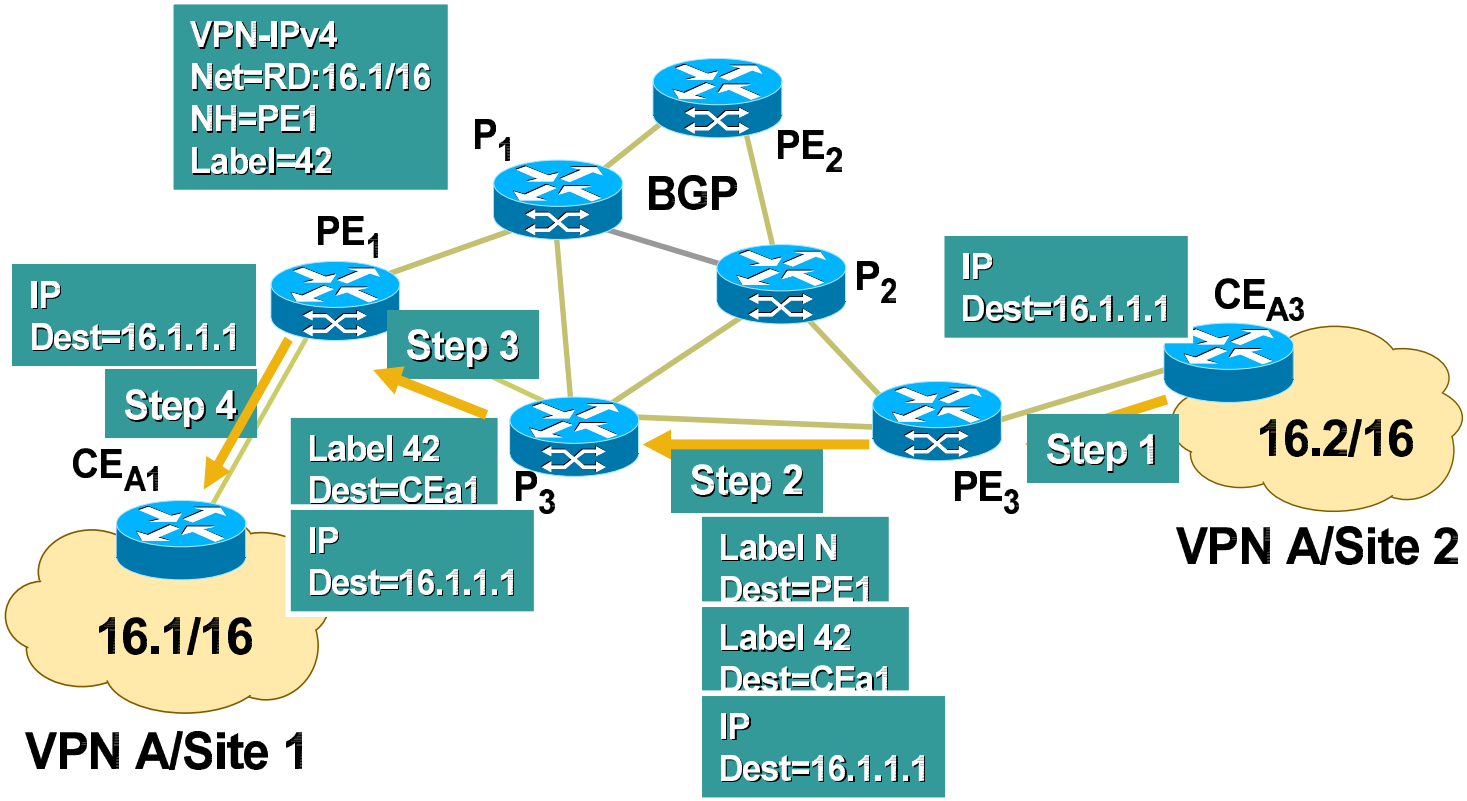
  Almost everyone uses Autonomous System Number (ASN)



Route Target

- To control policy about who sees what routes
- Each VRF ‘imports’ and ‘exports’ one or more RTs
  - Exported RTs are carried in VPNv4 BGP
  - Imported RTs are local to the box
- A PE that imports an RT installs that route in its associated VRF table
- 64-bit quantity (2 bytes type, 6 bytes value) carried as an extended community and typically written as written as ASN:YY

MPLS L3 VPN Forwarding Plane Separates VPN Forwarding Plane traffic



Label N is IGP label to switch traffic through the core from PE3 to PE1
Label 42 is a VPN A Label for CEA1-16.1.xx prefix.