MPLS Concepts

- MPLS: Multi Protocol Label Switching
- MPLS is a layer 2+ switching
- Developed to integrate IP and ATM
- MPLS forwarding is done in the same way as in ATM switches
- Packet forwarding is done based on Labels

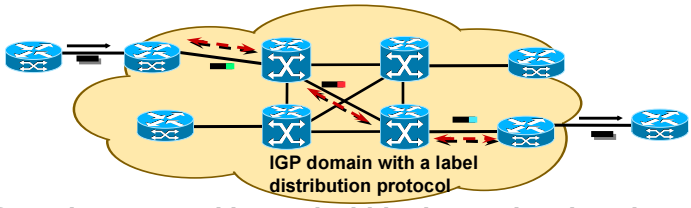
MPLS Concepts

- **Unlike IP, classification/label can be based on:**
  - **Destination Unicast address**
  - **Traffic Engineering**
  - **VPN**
  - **QoS**
- **FEC: Forwarding Equivalence Class**
- **A FEC can represent a: Destination address prefix, VPN, Traffic Engineering tunnel, Class of Service.**

LSRs and Labels

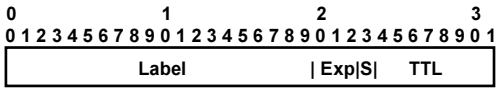
- LSR: Label Switch Router
- Edge-LSR: LSRs that do label imposition and disposition

LSRs and Labels



- **An IP routing protocol is used within the routing domain (e.g.:OSPF, i-ISIS)**
- **A label distribution protocol is used to distribute address/label mappings between adjacent neighbors**
- **The ingress LSR receives IP packets, performs packet classification, assign a label, and forward the labelled packet into the MPLS network**
- **Core LSRs switch packets/cells based on the label value**
- **The egress LSR removes the label before forwarding the IP packet outside the MPLS network**

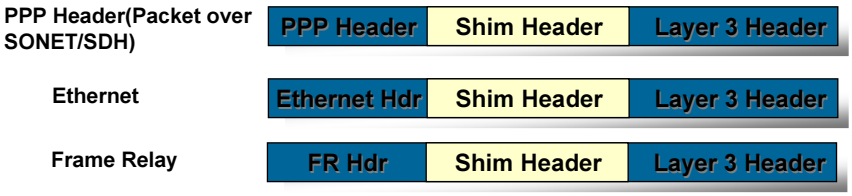
LSRs and Labels



Label = 20 bits
Exp = Experimental, 3 bits
S = Bottom of stack, 1bit
TTL = Time to live, 8 bits

- Uses new Ethertypes/PPP PIDs/SNAP values/etc
- More than one Label is allowed -> Label Stack
- MPLS LSRs always forward packets based on the value of the label at the top of the stack

LSRs and Labels



Label Assignment and Distribution

- **Labels have link-local significance**
  - **Each LSR binds his own label mappings**
- **Each LSR assign labels to his FECs**
- **Labels are assigned and exchanged between adjacent neighboring LSR**
- **Applications may require non-adjacent neighbors**

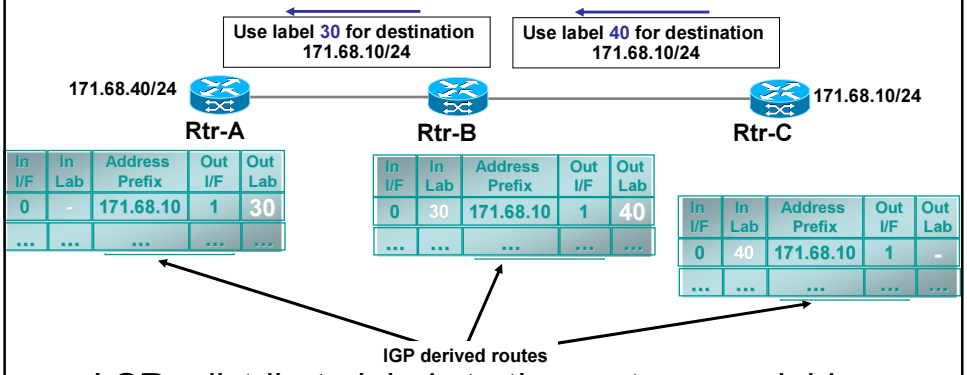
Label Assignment and Distribution

Upstream and Downstream LSRs

- Rtr-C is the downstream neighbor of Rtr-B for destination 171.68.10/24
- Rtr-B is the downstream neighbor of Rtr-A for destination 171.68.10/24
- LSRs know their downstream neighbors through the IP routing protocol
  - Next-hop address is the downstream neighbor

Label Assignment and Distribution

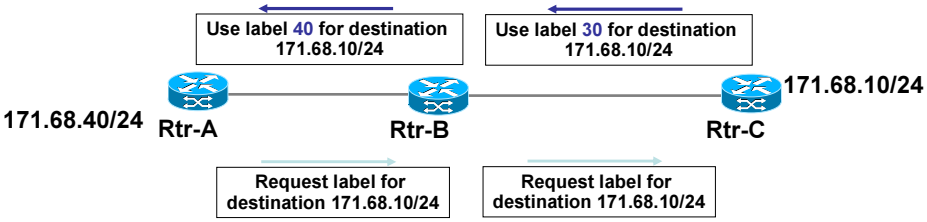
Unsolicited Downstream Distribution



- LSRs distribute labels to the upstream neighbors

Label Assignment and Distribution

On-Demand Downstream Distribution



- **Upstream LSRs request labels to downstream neighbors**
- **Downstream LSRs distribute labels upon request**

Label Assignment and Distribution

Label Retention Modes

- Liberal retention mode
  - LSR retains labels from all neighbors
    - Improve convergence time, when next-hop is again available after IP convergence
    - Require more memory and label space
- Conservative retention mode
  - LSR retains labels only from next-hops neighbors
    - LSR discards all labels for FECs without next-hop
    - Free memory and label space

Label Assignment and Distribution

Label Distribution Modes

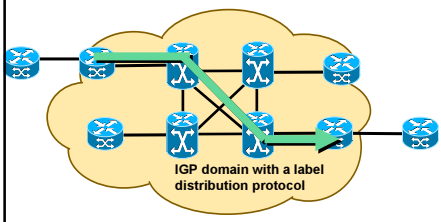
- Independent LSP control
  - LSR binds a Label to a FEC independently, whether or not the LSR has received a Label the next-hop for the FEC
  - The LSR then advertises the Label to its neighbor
- Ordered LSP control
  - LSR only binds and advertise a label for a particular FEC if:
    - it is the egress LSR for that FEC or
    - it has already received a label binding from its next-hop

Label Assignment and Distribution

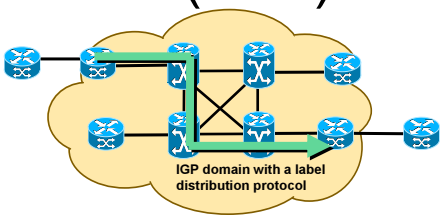
Several protocols for label exchange

- **LDP**
  Maps unicast IP destinations into labels
- **RSVP, CR-LDP**
  Used in traffic engineering
- **BGP**
  External labels (VPN)
- **PIM**
  For multicast states label mapping

Label Switch Path (LSP)



LSP follows IGP shortest path



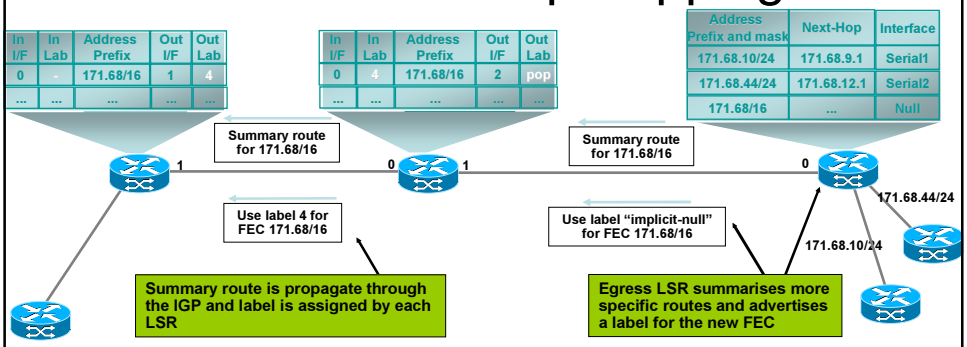
LSP diverges from IGP shortest path

- **LSPs are derived from IGP routing information**
- **LSPs may diverge from IGP shortest path**
  LSP tunnels (explicit routing) with TE
- **LSPs are unidirectional**
  Return traffic takes another LSP

Label Switch Path (LSP) Penultimate Hop Popping

- **The label at the top of the stack is removed (popped) by the upstream neighbor of the egress LSR**
- **The egress LSR requests the "popping" through the label distribution protocol**
  - **Egress LSR advertises *implicit-null* label**
- **The egress LSR will not have to do a lookup and remove itself the label**
  - **One lookup is saved in the egress LSR**

Label Switch Path (LSP) Penultimate Hop Popping



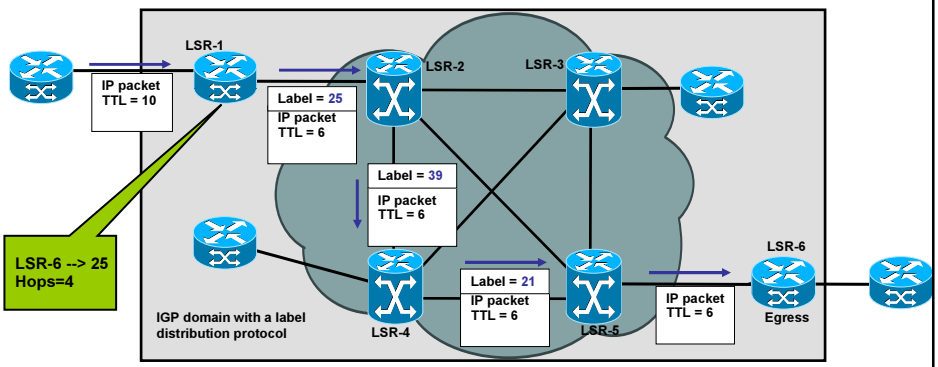
Egress LSR needs to do an IP lookup for finding more specific route

Egress LSR need NOT receive a labelled packet

Loops and TTL

- In IP networks TTL is used to prevent packets to travel indefinitely in the network
- MPLS ***may*** use same mechanism as IP, but not on all encapsulations
  - TTL is present in the label header for PPP and LAN headers (shim headers)

Loops and TTL



- TTL is decremented prior to enter the non-TTL capable LSP

  If TTL is 0 the packet is discarded at the ingress point
- TTL is examined at the LSP exit

LDP Concepts

- **Label Distribution Protocol**
- **Labels map to FECs for Unicast Destination Prefix**
- **LDP works between adjacent/non-adjacent peers**
- **LDP sessions are established between peers**

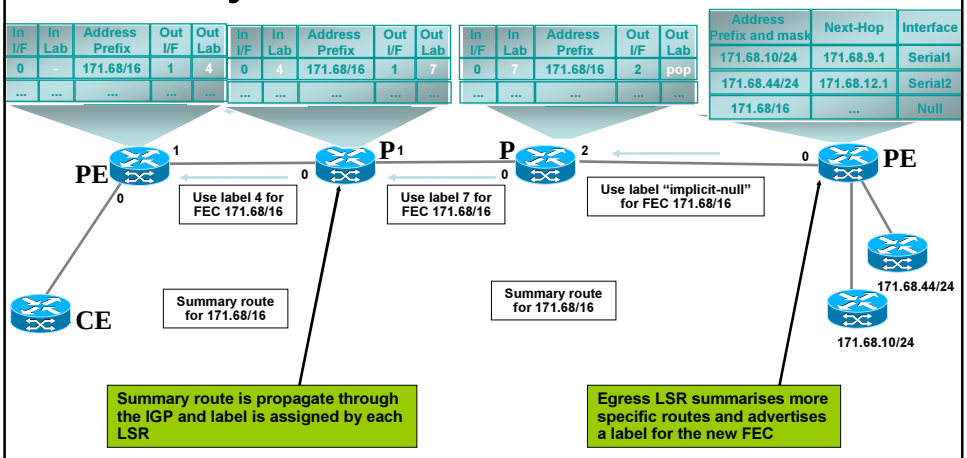
LDP Messages

- **Discovery messages**
  - **Used to discover and maintain the presence of new peers**
  - **Hello packets (UDP) sent to all-routers multicast address**
  - **Once neighbor is discovered, the LDP session is established over TCP**

LDP Messages

- **Session messages**
  - **Establish, maintain and terminate LDP sessions**
- **Advertisement messages**
  - **Create, modify, delete label mappings**
- **Notification messages**
  - **Error signalling**

Day in the life of a Packet



Egress LSR needs to do an IP lookup for finding more specific route