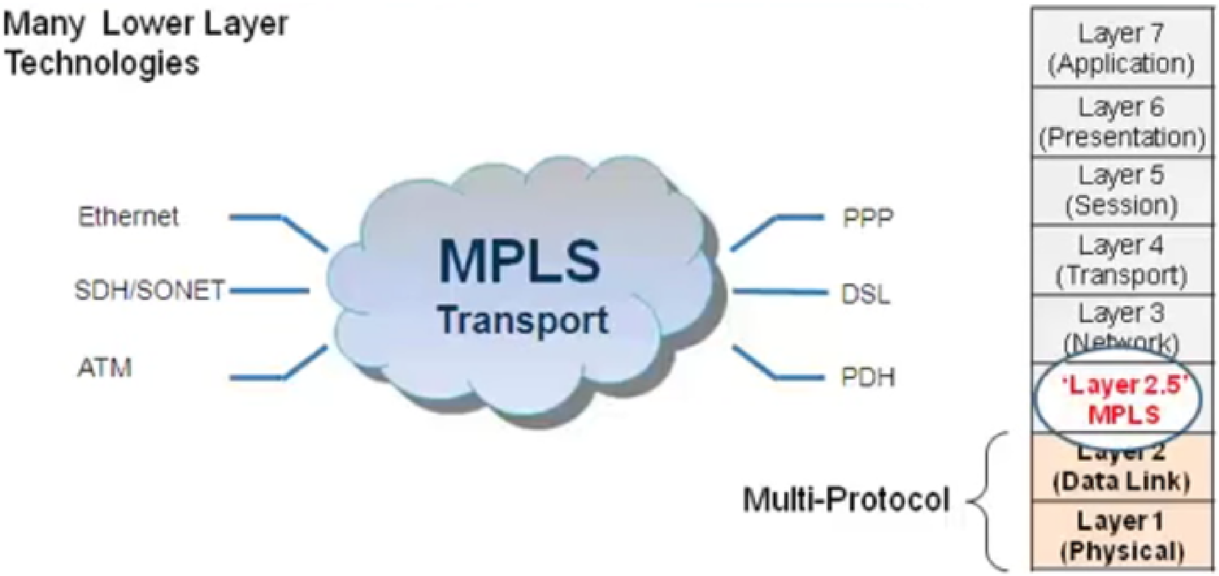
Chapter 08 - MPLS (Multi Protocol Label Switching)

Concepts

- **Multi-Protocol**: MPLS does not care what underlying protocol is used. It simply maps on the layer-2 protocol and provides an efficient & fast transport method over the packet switch network.
  - The layer-2 protocol could be Ethernet, ATM, SDH, etc.

- Where does MPLS sit in OSI 7 layer model? **MPLS operates between layer-2 and layer-**3, thus often referred as **"2.5" layer**.



> *Why **routers is slower than switch**?*
> ***Router** relies on the routing table to match the IP address v/s the longest network masks in descending order. This **consumes more processing time** and significantly **delay the fwd-ing** process.*
> ***Switch** holds a simple table of input port ID and its packet reference ID, and output port ID and its packet ref ID, respectively. Packet in and out will be swapped with new reference ID.*

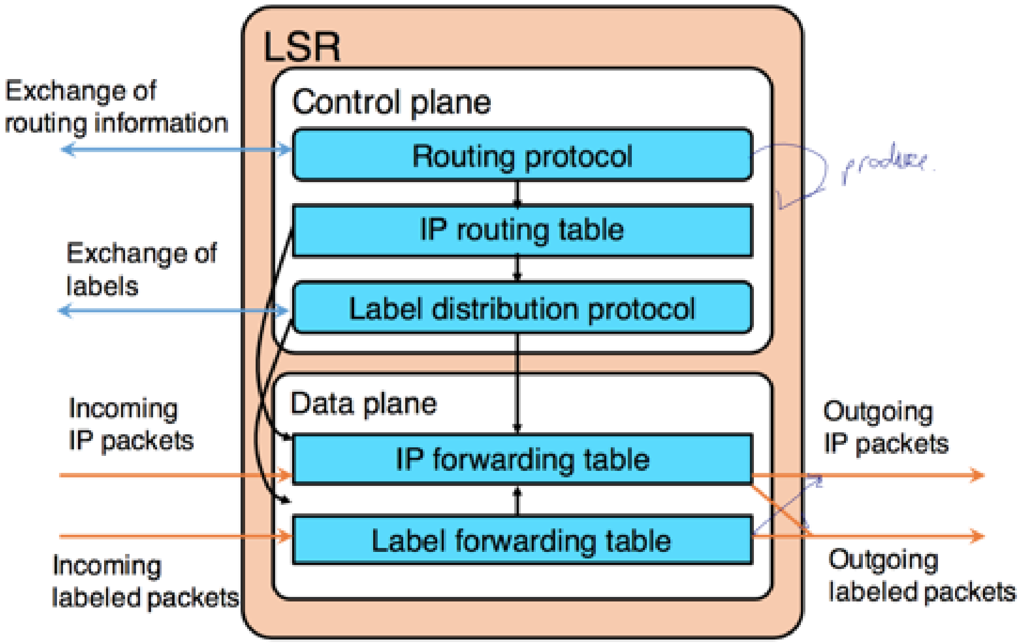
> *This is a much faster forwarding process.*

- MPLS uses both routing and switching in combination.

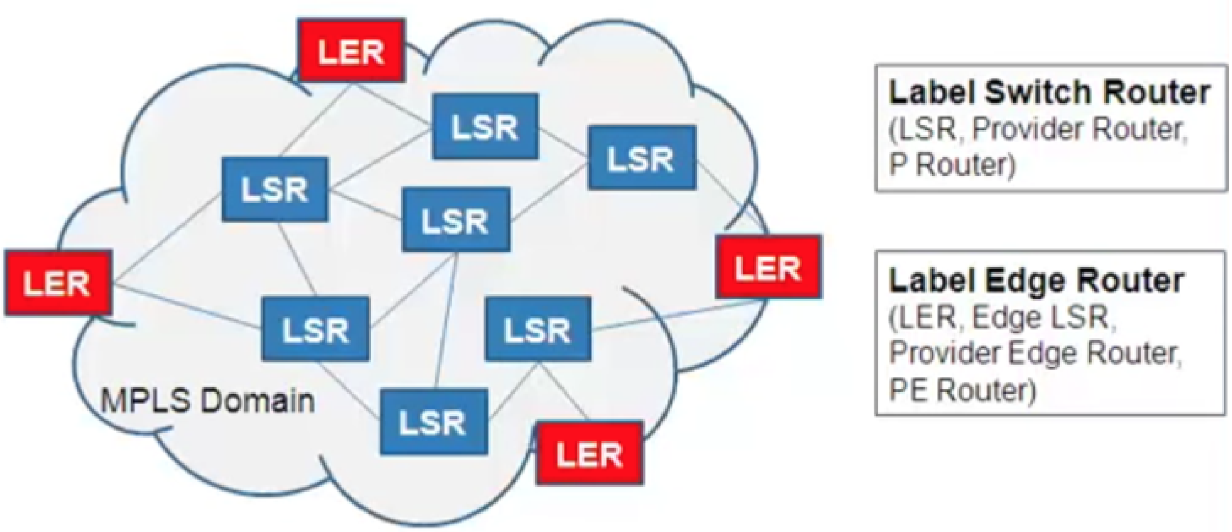
LSR (Label Switch Router)

- LSR is a **combination of a switch and a router**.

- Each LSR has 2 routing protocol: IP routing table, or Label distribution protocol.



- There are lots of LSRs in a MPLS Domain Routers

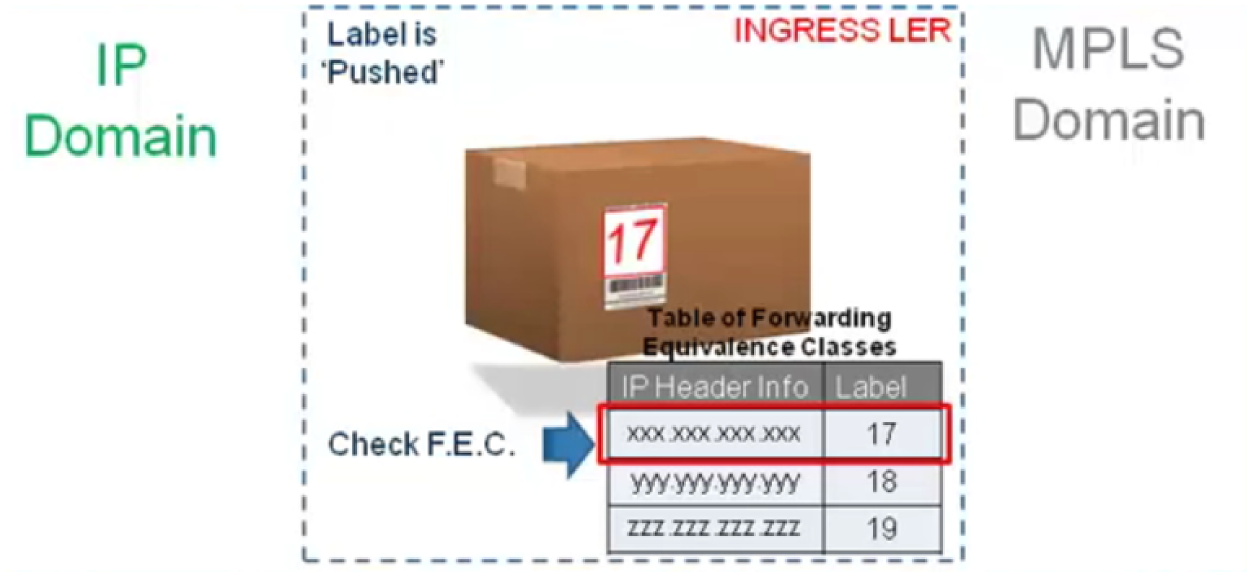


- when LSRs are at the edge of the MPLS domain, it becomes LER (Label Edge Router) or Edge

LSR

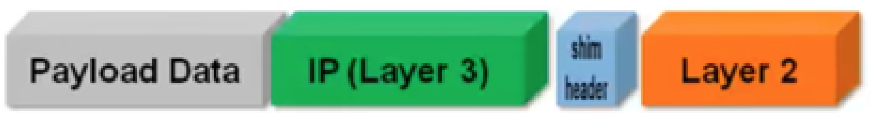
MPLS Process

1. Packet arrives at the Ingress LER

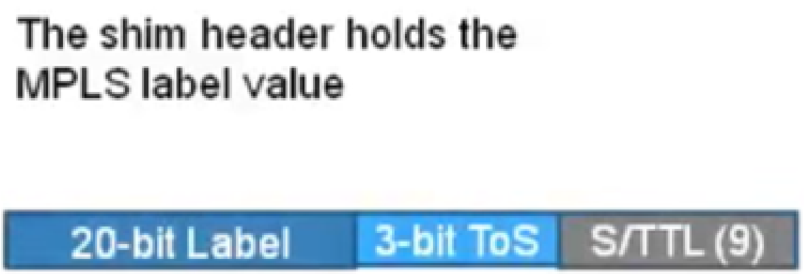


1. A packet arrives at the an Ingress LER from the IP domain.
2. The LER checks the layer-3 (IP) information on the packet.
3. Then it checks its lookup table to find a forwarding equivalence class for that packet type.
4. The label of the class is added (or "pushed") onto the packet.
5. The packet is then forwarded to the MPLS domain.

The **label** is stored in a header called "**shim header**", which sits between L2 and L3 headers.



This is the shim header is 4 bytes length, has this below structure:



2. Packet's label is swapped at the LSRs

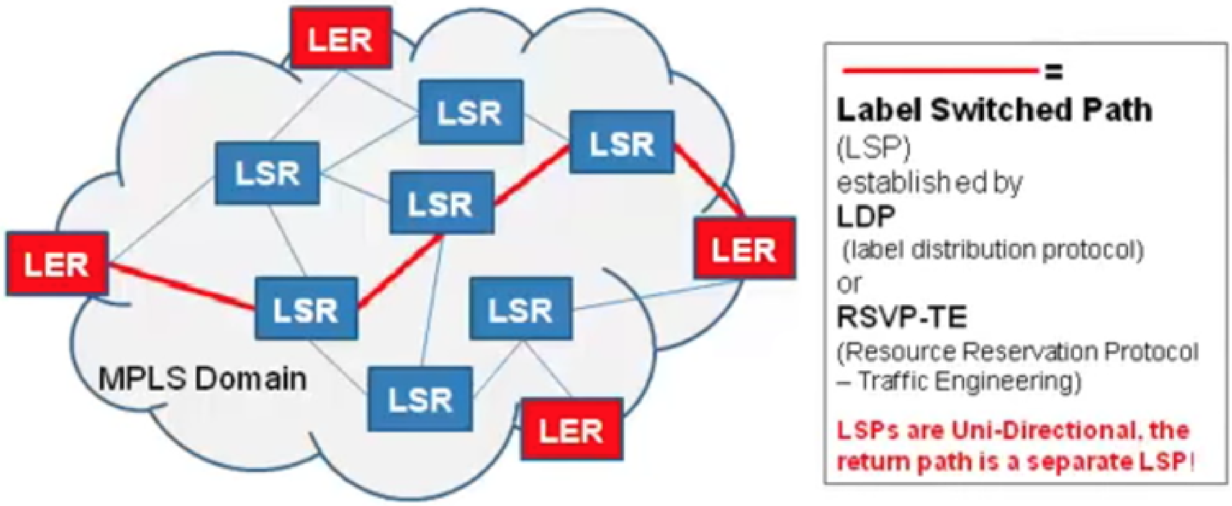
1. Inside the MPLS domain, the packet arrives at a LSR.
2. The LSR checks the packet's label in its **LIB** (label information base)
3. The LSR then swaps the old label (17) with the new label (26) and forward it on to the MPLS domain.

3. Packet arrives at the Egress LER (edge of the MPLS domain)

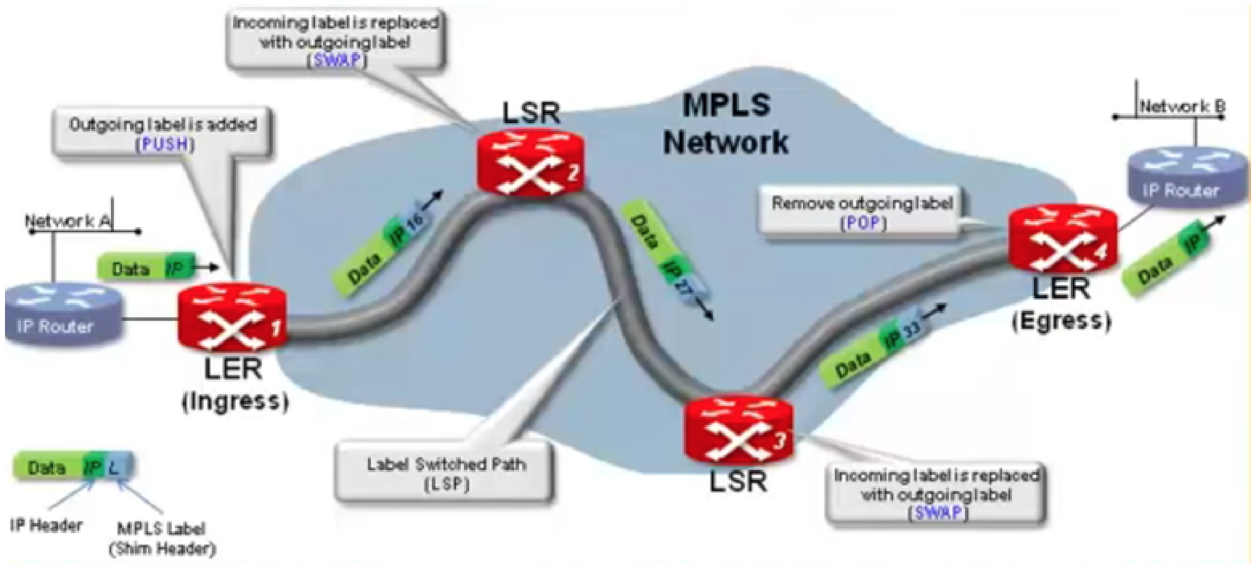
1. The packet finally arrives at an edge LSR.
2. The label is removed (or popped off) the packet.
3. The packet is then forwarded on according to normal IP rules.

Advantages of MPLS

- The path across the network is established even before the packet starts its journey.



- for each Forwarding Equivalence Class, there is a **LSP** (Label Switched Path), which is a **predictable rule** that is put in place by one of the 2 protocols running on all LSRs: **LDP** (Label Distribution Protocol) or **RSVP-TE** (Resource Reservation Protocol - Traffic Engineering)
- **LSP is uni-directional**, i.e. the return path is a separate LSP and may take a different route.
- The **LSP** are **derived from IGP routing information**, and may **diverge from IGP shortest path**.
- The FEC (routing info) does not change, only the label is change during the transporting of the packet in an MPLS domain.



In this example:

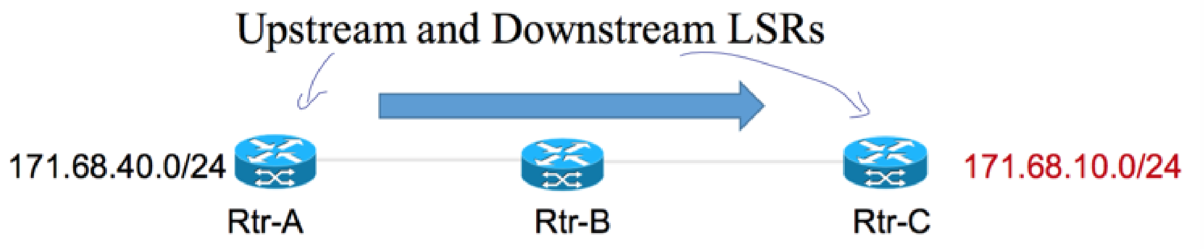
- The MPLS network has 4 LSRs, including 2 LER (1 Ingress, 1 Egress).
- Initially, the LPS (Label Switched Path) in gray color is established using MPLS protocol.

1. An IP packet arrives from network A at the Ingress LER.
2. The Ingress LER checks and assigns the packet to an FEC and pushes label 16 onto the packet.
3. The packet continues to an LSR, which checks the entry of the label base on its LFBIS (Label Forwarding Information Base). It finds the new label, 27, and swaps the label.

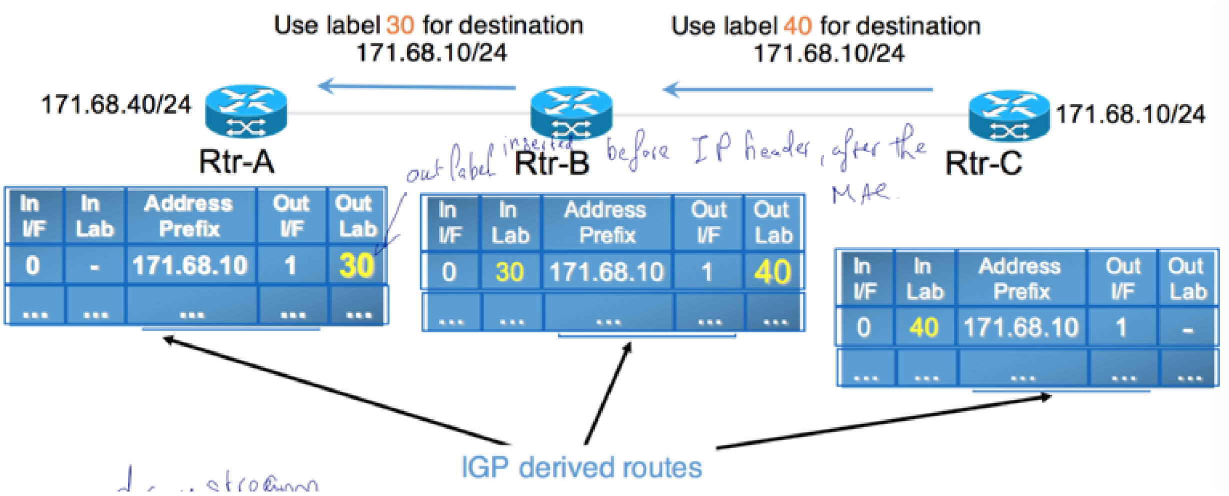
4. The packet continues to an LSR, which does the same thing and swap the label with new label 33.
5. During all these steps, the FEC has NOT changed, only the label does.
6. Finally, the packet arrives at the Egress LER, which pops the label off, and forward the packet (without the label) to network B.

Upstream and Downstream Label Distribution

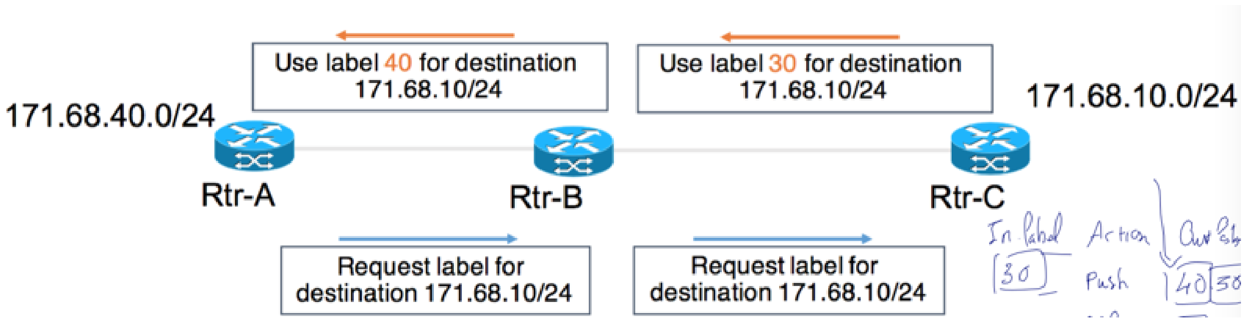
- Upstream and Downstream LSRs: next-hop address is the downstream neighbor.

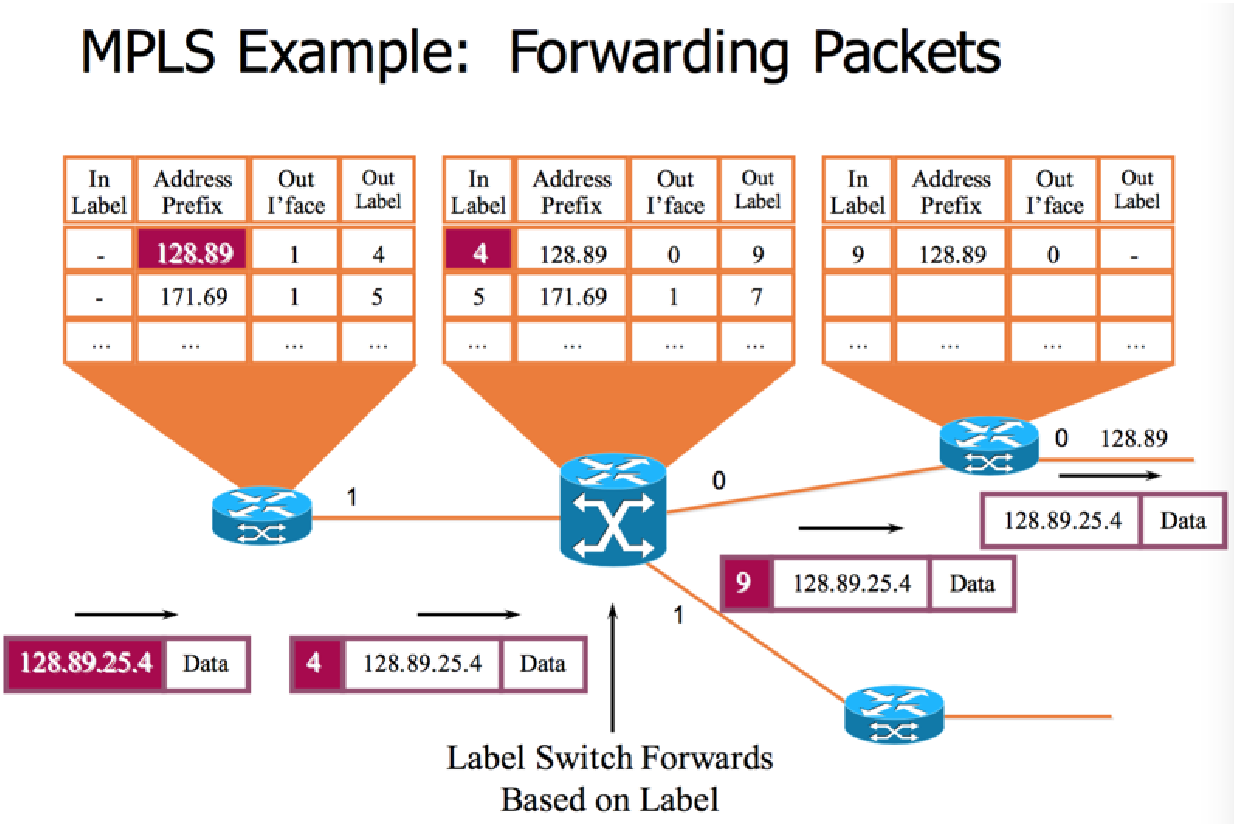


- The label can be distributed from downstream to upstream neighbors in an unsolicited way:

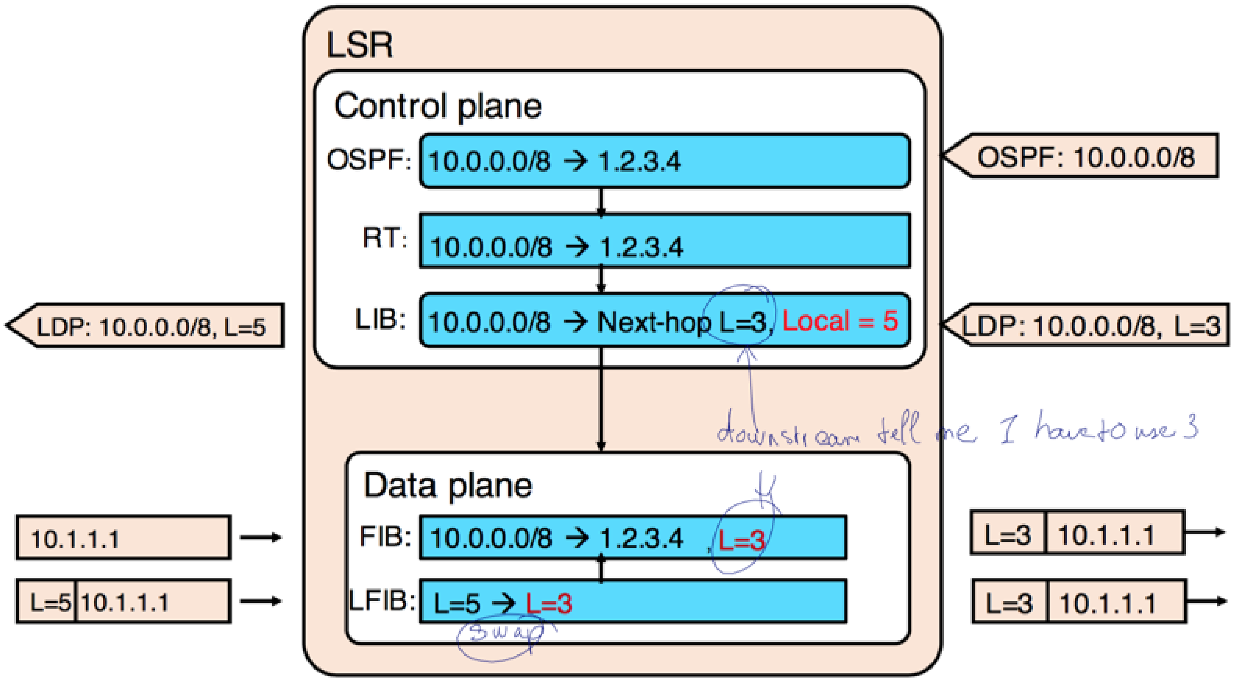


- or the upstream LSRs can also request labels to downstream neighbors, and downstream LSRs distribute labels upon requests:





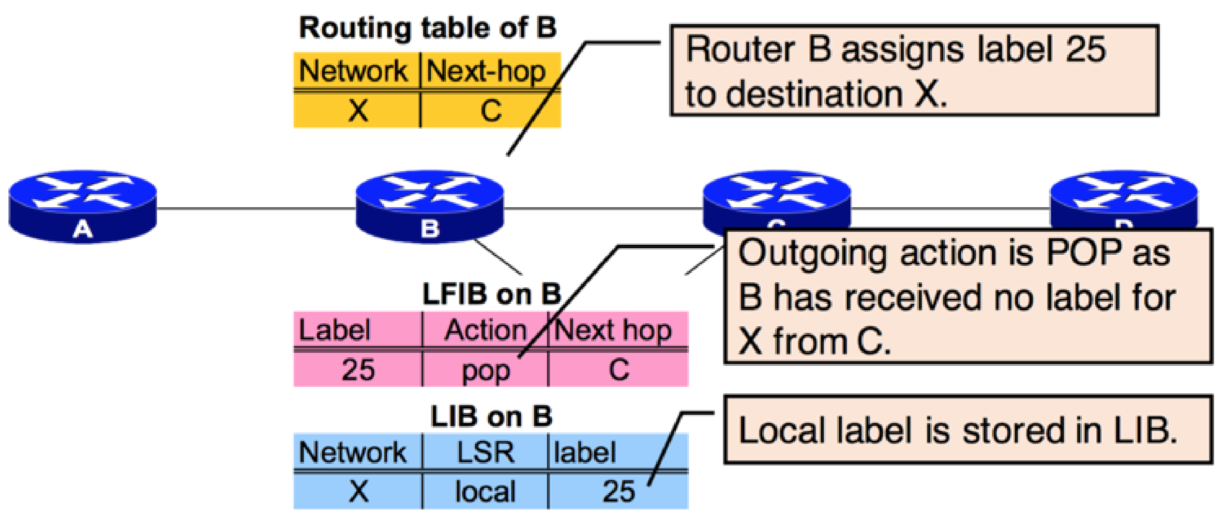
LIB, LFIB, RIB, Control Plane, Data Plane



- In **IP Domain**
  - **RIB - IP Routing Table**: used for routing in IP protocol. Forwarding decisions **are not made here**, just routing table is built here (control plane). That is then parsed and become FIB (Forwarding Information Base), lookup is done in FIB (data plane), not RIB (control plane).
- In **MPLS Domain**

- **LIB - Label Information Base**: similar to the IP RIB, this is where the LSR stores all prefix-label (control plane) it receives from remote peers. Not all labels received from LDP neighbors are used since there will be a best path selected and to be used for forwarding for each prefix.
- **LFIB - Label Forwarding Information Base**: LSR uses LIB to create the LFIB (Label Forwarding Information Base) data or forwarding plane. The lookups are actually done in the LFIB, not in the FIB. How this is determined is based on the close relationship between the LIB, the LFIB and the IP routing table (RIB).

- LFIB v/s LIB on a LSR



LDP

- Different incoming packet through a LSR will be routed differently depending on the LSR routing protocols (OSPF, RT, LDP)
  - IP routing protocols build the IP routing table.
  - LSR assigns a label to each destination in the IP routing table **independently**.
    - labels have local significance.
    - label allocations are async.
  - LSRs announce their assigned labels (LOCAL) to all other LSRs.
  - Every LSR builds its LIB, LFIB