BROADBAND AND HIGH SPEED NETWORKS

7

Multiprotocol Label Switching (MPLS)

TOPICS TO BE COVERED

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WHAT IS MPLS?

❑ <u>Multi Protocol</u> – supports protocols even other than IP.

- It supports IPv4, IPv6, IPX, and AppleTalk at the *network layer*.

- It supports Ethernet, Token Ring, FDDI, ATM, Frame Relay, and PPP at the *data link layer*.

❑ <u>Label</u> – short fixed length identifier to determine a route.

- Labels are added to the top of the IP packet.

- Labels are assigned when the packet enters the MPLS domain.

❑ <u>Switching</u> – forwarding a packet.

- Packets are forwarded based on the label value.

- NOT on the basis of IP header information.

TERMINOLOGY / COMPONENTS

- **LSR (Label Switched Router)**
    - High speed routers which switch data traffic within MPLS domain.
    - Swaps labels on packets in core of networks.
- **LSP (Label Switch Path)**
    - A unidirectional path to transport packets within MPLS domain
    - The path is setup before the data transmission similar to circuit switching
    - Path through network based on a FEC (Forwarding Equivalent Class).
- **LER (Label Edge Router)**
    - Attach labels to packets based on a FEC.
    - Operates at the edge of the access network & MPLS network.
    - Responsible for assignment and removal of labels.
    - Support Multiple Protocols connected to dissimilar networks (such as frame relay, ATM and Ethernet).
- **LIB (Label Information Base)**
    - Table maintained by the Routers.
    - MPLS equivalent to IP routing table, contains FEC-to-Label bindings.
- **FEC (Forwarding Equivalent Class)**
    - Group of packets sharing the same type of transport.
    - A path is a representation of a FEC.
- **LDP (Label Distribution Protocol)**
    - IETF defined protocol for explicit signaling and management.

MPLS OPERATION

1a. Routing protocols (e.g. OSPF) exchange to destination networks

1b. Label Distribution Protocol (LDP) establishes label mappings to destination network
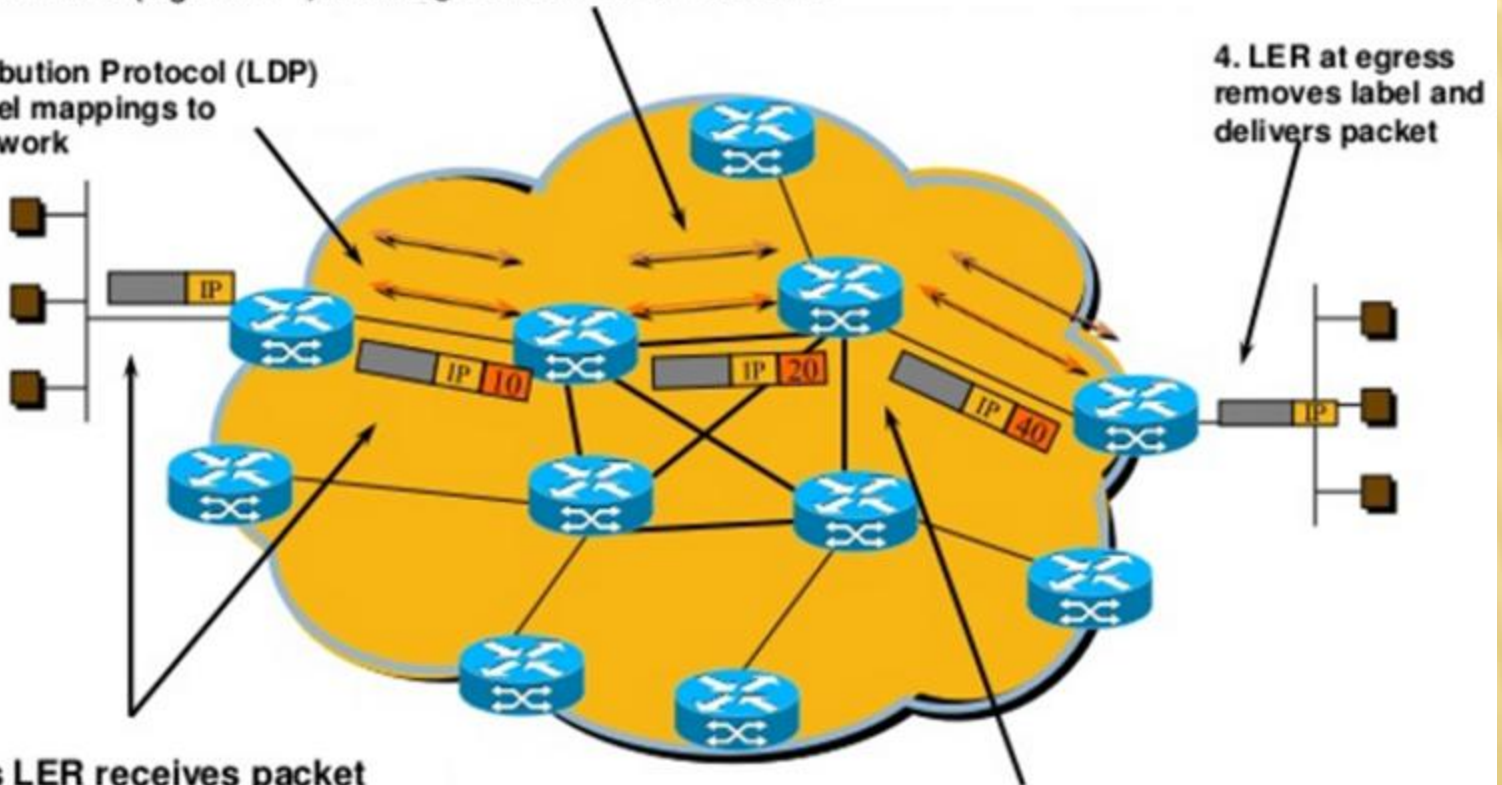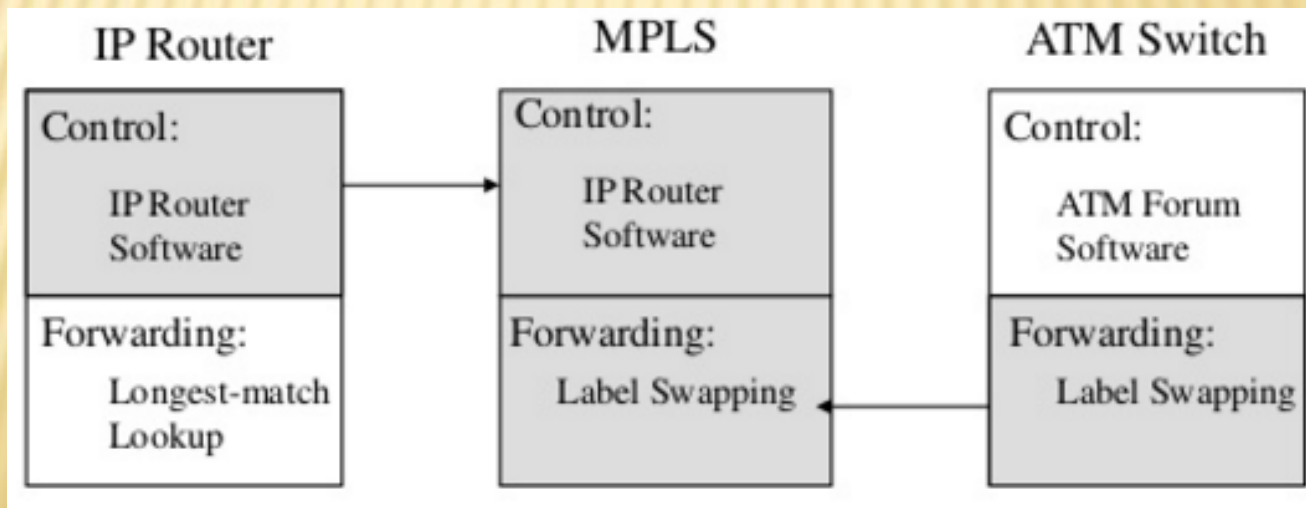
4. LER at egress removes label and delivers packet

2. Ingress LER receives packet and "label's packets

3. LSR forwards packets using label swapping

MPLS

- ❑ A label is assigned for each IP flow
- ❑ LSP is created between ingress and egress
- ❑ Packet forwarding at each router by table lookup (based on label)
- ❑ MPLS supports a range of access technologies, including T1/E1, ATM, Frame Relay, and DSL
- ❑ MPLS is a mechanism in high performance networks that direct data from one network node to the next based on a short path labels rather than long network addresses, avoiding lookups in a routing table.

| IP Router	MPLS	ATM Switch
Control: IP Router Software	Control: IP Router Software	Control: ATM Forum Software
Forwarding: Longest-match Lookup	Forwarding: Label Swapping	Forwarding: Label Swapping

WHAT IS MPLS?

- Standardized by *Internet Engineering Task Force (IETF)*.

- Integration of layer 2 and layer 3.
  - Simplified *connection-oriented forwarding of layer 2*.
  - Flexibility and scalability of *layer 3 routing*.

- MPLS does not replace IP; it supplements IP.

- Traffic can be marked, classified and routed.

- QoS can be achieved through MPLS.

Layer 3	IP
	MPLS
Layer 2	ATM, FR, Ethernet, PPP
Layer 1	SDH
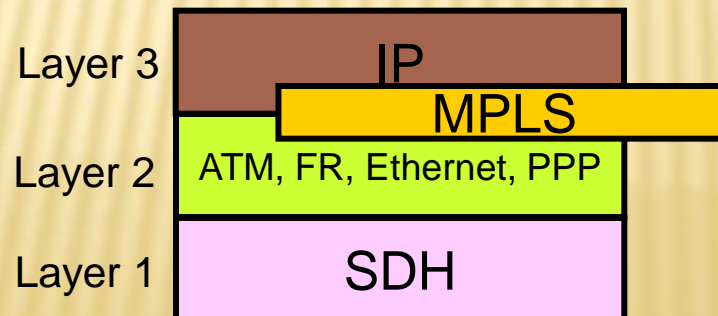
MPLS CONCEPT
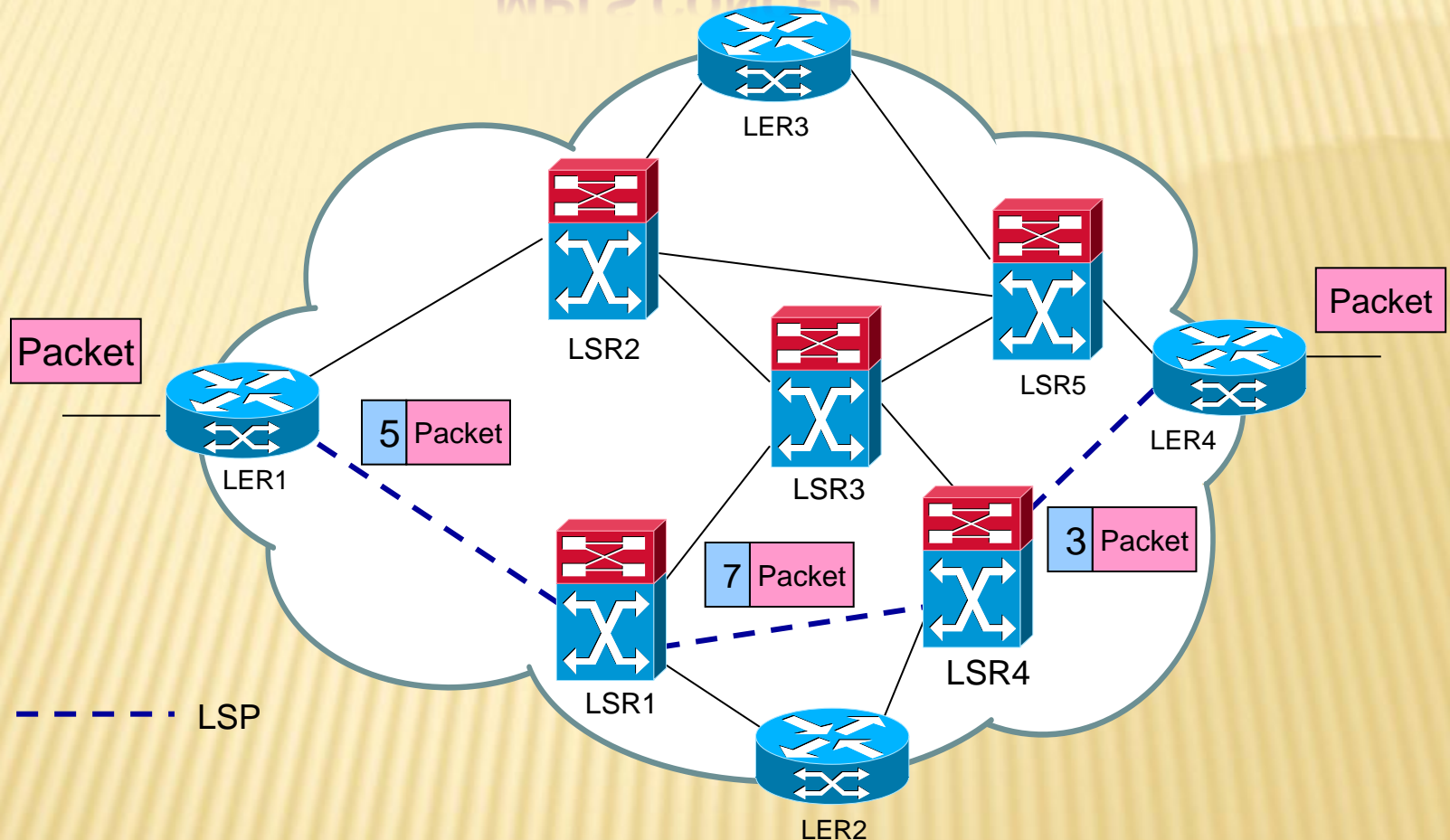
In an MPLS network, all incoming packets before entering the MPLS network are *assigned to labels* by a *Label Edge Router (LER)*. Then, the Packets are traveled along a *Label Switched Path (LSP)* where each *Label-Switched Router (LSR)* performs the forwarding according to the numbered label. At each hop, *the LSR pops the existing label and applies a new label*, which is understood by the next LSR for performing the same procedure popping label and assigning another one. Finally, the *egress LER pops the label* and forwards the packet to its destination outside the MPLS network.

MPLS COMPONENTS

- FEC: Forwarding Equivalence Class.

- LSR: Label Switching Router.

- LER: Label Edge Router.

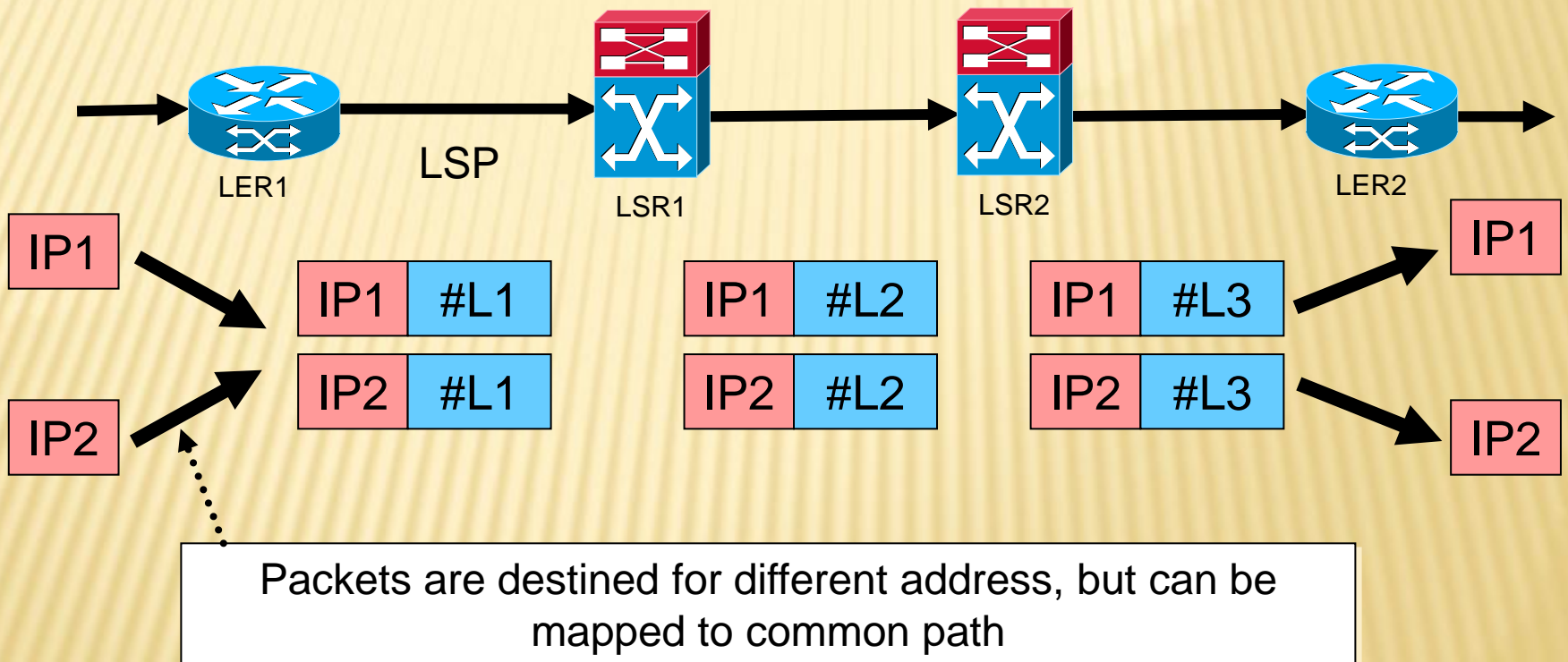- LSP: Label Switched Path.

- LDP: Label Distribution Protocol.

FORWARDING EQUIVALENCE CLASS (FEC)

❑ An **FEC** is *a group of packets share a common path through MPLS domain*.

❑ Packets mapping to FEC based many criteria:

  ❑ Destination IP address.

  ❑ TCP/UDP port.

  ❑ Quality of Services (QoS).

  ❑ Services (VPN).

  ❑ Combination of the above criteria.

❑ Once any packet in the same FEC enters the MPLS domain, it will have the same *initial label*. The result is that the packet will travel through the MPLS domain along the same *label-switched path* until its MPLS header removed at the same exit of the MPLS domain (*egress point*).

❑ The *packet-to-FEC assignment* is done once, at the ingress point of the network. This procedure is called label imposition.

❑ FEC means that a subset of packets that are all treated the same way by a router.

❑ The concept of FECs provides for a great deal of flexibility and scalability.

❑ In *conventional routing*, a packet is assigned to a FEC at each hop (i.e. L3 look-up), in *MPLS*, it is only done once at the network ingress.

LSP

LER1   LSR1   LSR2   LER2

IP1

| IP1 | #L1 |
| IP2 | #L1 |

| IP1 | #L2 |
| IP2 | #L2 |

| IP1 | #L3 |
| IP2 | #L3 |

IP1

IP2

IP2

Packets are destined for different address, but can be mapped to common path
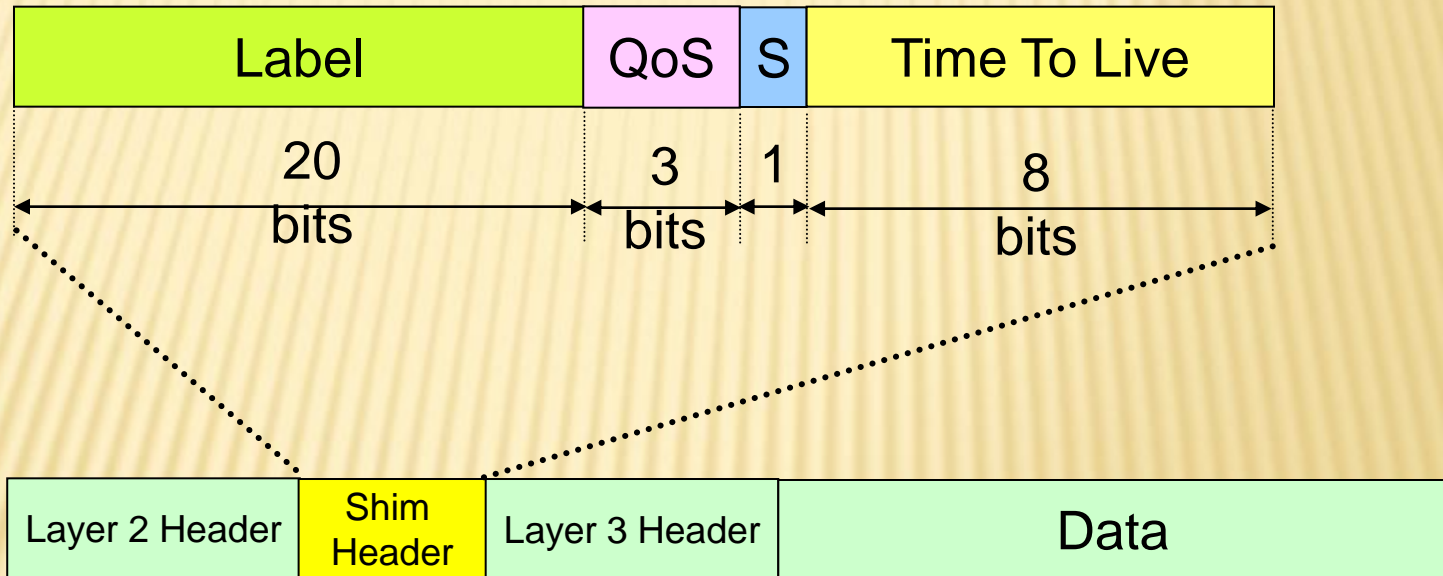
LABEL

❑ A *label* is a fixed-length information inside each packet header, used to identify a FEC.

❑ It can be represented in <u>two</u> ways:

  ❑ In some layer 2 networks such as ATM, Frame Relay, etc., **their own fields can be used for the MPLS label**. For example, when ATM is used, the VPI/VCI field is used to carry a label.

  ❑ In other layer 2 networks such as Ethernet, shim header is used. **This header is placed between the layer 2 and layer 3 headers.**

Label	QoS	S	Time To Live
20 bits	3 bits	1	8 bits

Layer 2 Header	Shim Header	Layer 3 Header	Data

LABEL EDGE ROUTER (LER)

✖ LERs are located at the *boundaries* of a network.

✖ *Ingress LER* performing additional network layer services by **analyzing the IP header packet** and **applying labels to packets.**

✖ *Label popping* is the act of removing the last label from a packet at the *egress LER* before it is forwarded to a neighbor that is outside the MPLS domain.

LABEL SWITCH ROUTER (LSR)

* The LSR is a device that implements the *MPLS forwarding*.

* The LSR forwards a packet based on the value of a *label* encapsulated in the packet.

* **At each hop, the LSR pop the existing label and push the new label which tells the next hop how to forward the packet.**

* High-speed switching of data is possible because the *fixed-length labels* are inserted at the very beginning of the packet or cell and can be used by hardware to switch packets quickly between links.

LABEL SWITCH PATH (LSP)

❑ In MPLS, data transmission occurs on LSPs.

❑ LSPs are a *sequence of labels* at every LSR along the path from the source to the destination.

❑ **The LSP is set up prior to data transmission**.

❑ The LSP setup for an FEC is *unidirectional* in nature.
   ❑ The *return traffic* must take another LSP.

LABEL SWITCH PATH (LSP)

❑ MPLS provides the following <u>two</u> options *to set up an LSP*:

    ❑ **Hop-by-Hop Routing :** Each LSR independently selects the next hop for a given FEC. This methodology is similar to that currently used in IP networks. The LSR uses any available routing protocols, such as OSPF, ...etc.

    ❑ **Explicit routing (ER) :** similar to *source routing*. The *ingress LER* specifies the list of nodes through which the **ER–LSP** traverses. The resources may be reserved to ensure QoS to the data traffic.