Outline

- Background
- MPLS: Fundamentals
- MPLS: Terminology
- GMPLS
- GMPLS: Recovery techniques
- Summary
- Resources

Background

- What is MPLS?
  - Mechanism that directs data from one network node to the next based on on path labels rather than network addresses.
  - MPLS switches packets (IP packets) instead of routing packets to transport the data
- Why MPLS?
  - Provide a highly scalable mechanism that was topology driven rather than flow driven
  - Load balance traffic to utilize network bandwidth efficiently
  - Allow core routers/networking devices to switch packets based on a simplified header
  - Remove the complexity and overhead of network managements (Assemble and reassemble IP packets)

MPLS was conceived, why?

- The shortest path routing protocols like IS-IS and OSPF
  - Did not take capacity characteristics into account while making the routing decisions
  - The outcome is, segmentation over the network which leads to congestion, while others remain under-utilized.
- MPLS reduces the complexity and redundancies by adding new network functionalities.

MPLS Fundamentals

- Main idea:
  - attach a short fixed-length label to packets at the ingress to an MPLS domain
  - the labels are used to make the forwarding decisions.
- MPLS consists of a forwarding and a control plane. Though they are decoupled and independent from each other.
- Supports explicit routed path.
- Provides Quality of Service (QoS) if it is implemented with Diff-Serv and Constraint-based routing.

Diff-Serv and Constraint-based routing

- Differentiated Services
  - A network architecture for classifying and managing network traffic and provide QoS on modern IP networks.
  - it is used to provide low-latency to critical network traffic. (Media, VOIP).
- Constraint-based routing
  - It is a routing technique where resource availability and traffic characterization are taken into account.
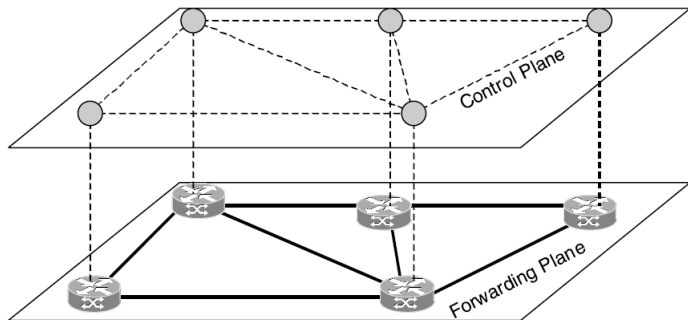
Fig. 2. Conceptual view of MPLS control plane and forwarding plane.

MPLS Fundamentals: Control Plane

MPLS Fundamentals: Forwarding Plane

MPLS architecture

MPLS: Terminology

- FEC (Forwarding Equivalence Class)
  - Group of IP packets which are forwarded in the same manner (e.g. over the same path, with the same priority and the same label)
- Label
  - Short fixed length identifier which is used to identify a FEC
- Label Swapping
  - Looking up the oncoming label to determine the outgoing label, encapsulation and port
- Label switched path (LSP)
  - Path through one or more LSR for a particular FEC
- Label switching router (LSR)
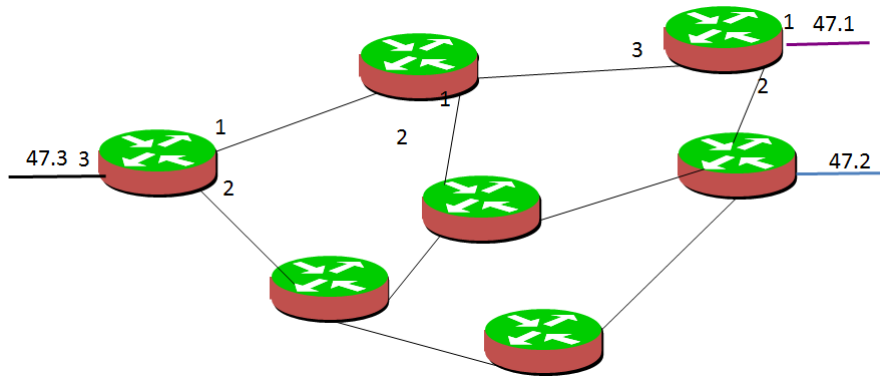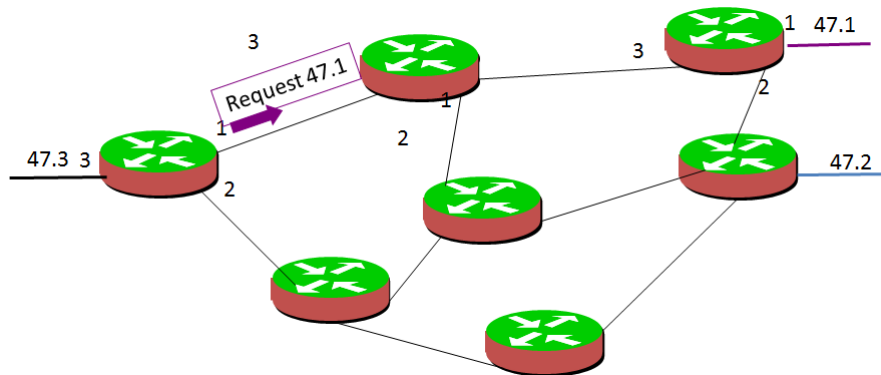 - an MPLS capable router

FEC

Advantages?

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What is a Label?

Figure: This is the initial phase

Label Distribution in MPLS and how LSP works

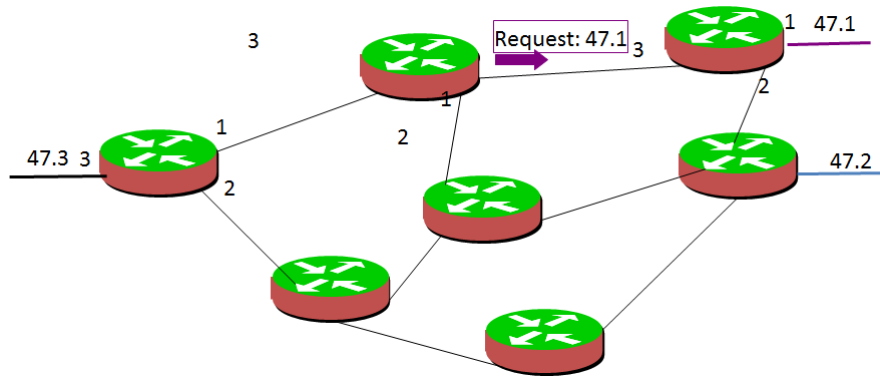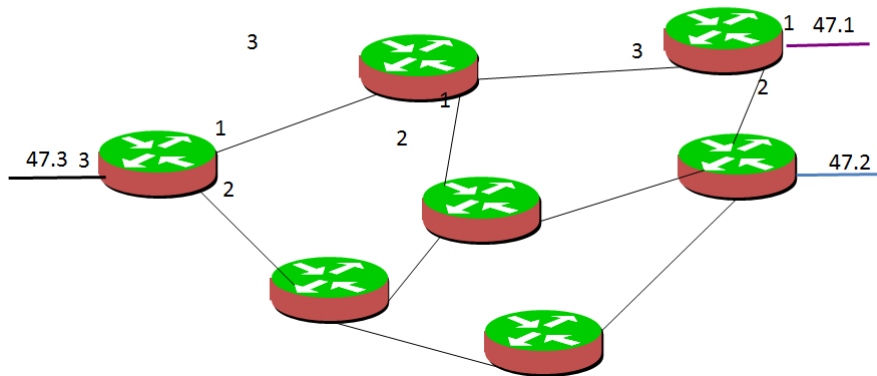Figure: Request a path to a specific node, send to the lowest cost possible router

Figure: Route the message to the destination node

Label Distribution in MPLS and how LSP works

Intf In	Label In	Dest	Intf Out
3	0.40	47.1	1

Figure: A label table is initialized with information that when it receives the given label id, it is for this router 47.1

Label Distribution in MPLS and how LSP works

Intf In	Label In	Dest	Intf Out
3	0.40	47.1	1
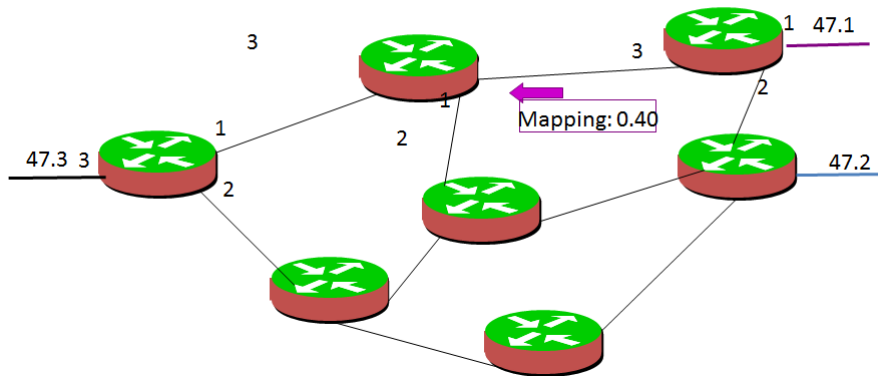
Figure: Map its label id to the router that sent request

Label Distribution in MPLS and how LSP works

Intf In	Label In	Dest	Intf Out	Label Out
3	0.50	47.1	1	0.40

Intf In	Label In	Dest	Intf Out
3	0.40	47.1	1
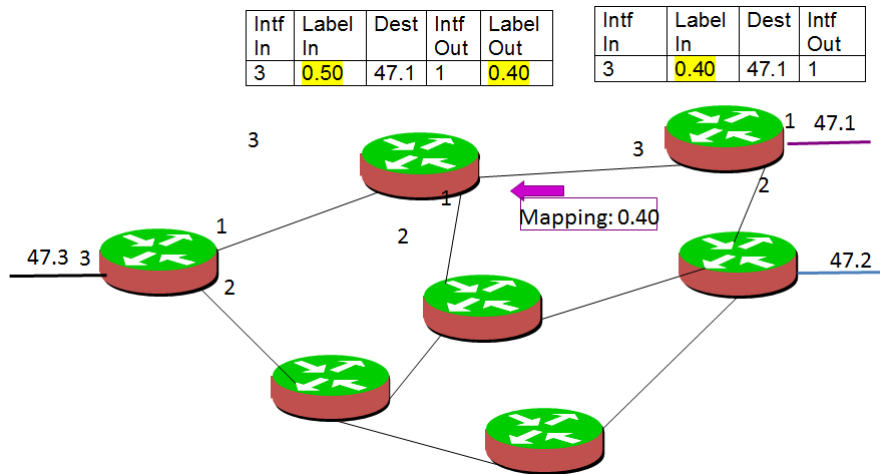
Figure: The router that receives the mapping data, adds it ot its labeltable and generates a "in" label

Label Distribution in MPLS and how LSP works

Intf In	Label In	Dest	Intf Out	Label Out
3	0.50	47.1	1	0.40

Intf In	Label In	Dest	Intf Out
3	0.40	47.1	1
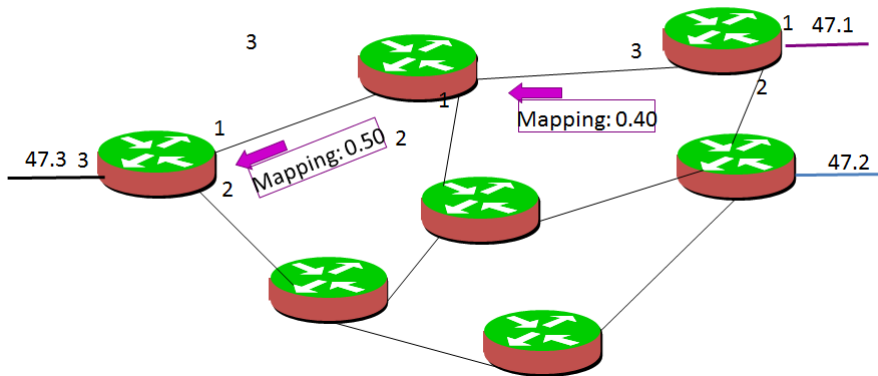
Figure: When finished, the next router sends the mapping date of which label will be added

Label Distribution in MPLS and how LSP works
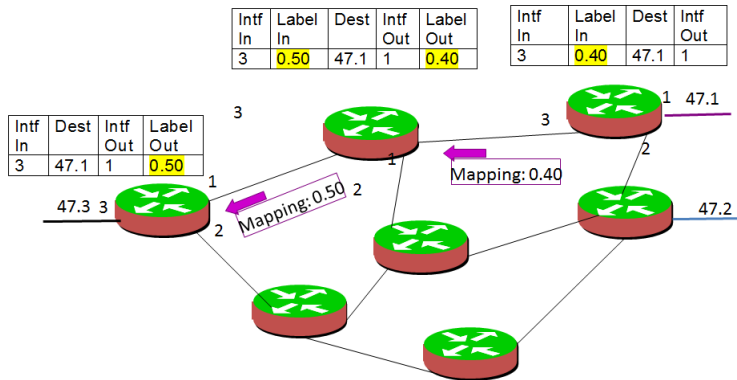
Figure: When it has reached the Ingress node, it will map the given label for the given destination IP

Label Distribution in MPLS and how LSP works

Intf In	Label In	Dest	Intf Out	Label Out
3	0.50	47.1	1	0.40

Intf In	Label In	Dest	Intf Out
3	0.40	47.1	1

Intf In	Dest	Intf Out	Label Out
3	47.1	1	0.50
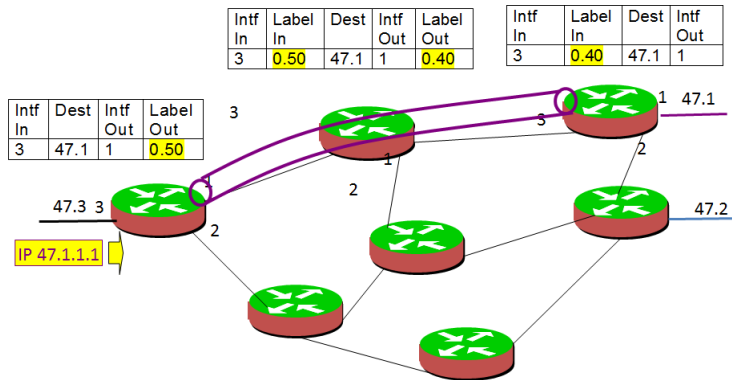
Figure: Send message with packet to 47.1, you have now a path to choose

Label Distribution in MPLS and how LSP works

Intf In	Label In	Dest	Intf Out	Label Out
3	0.50	47.1	1	0.40

Intf In	Label In	Dest	Intf Out
3	0.40	47.1	1

Intf In	Dest	Intf Out	Label Out
3	47.1	1	0.50

IP 47.1.1.1
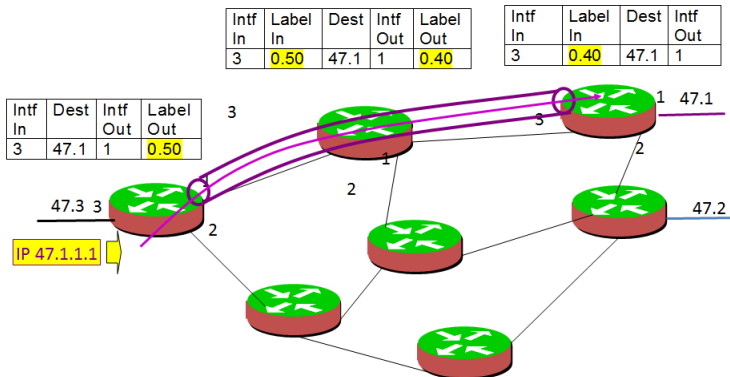
Figure: When forwarded, you add label onto the packet, when it arrives to a node, it checks the label and replaces it to another one and forwards it

Label Distribution in MPLS and how LSP works

Intf In	Label In	Dest	Intf Out	Label Out
3	0.50	47.1	1	0.40

Intf In	Label In	Dest	Intf Out
3	0.40	47.1	1

Intf In	Dest	Intf Out	Label Out
3	47.1	1	0.50

IP 47.1.1.1

47.3 3

IP 47.1.1.1

47.2
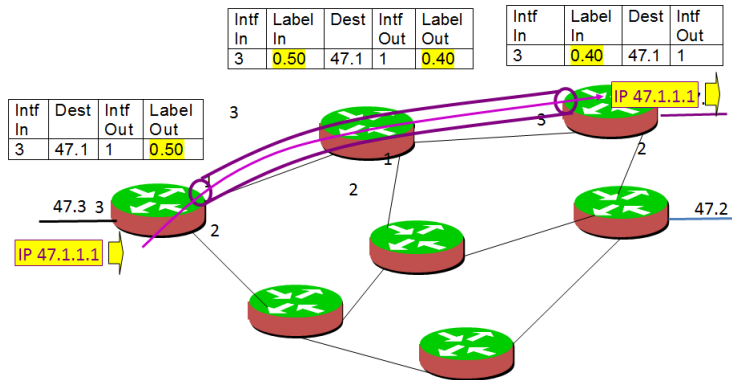
Figure: When reached to the egress node, it will then remove the label and deliver to the specific destination

Disadvantages of MPLS

MPLS has performance issues in the network:

- constraint-based routing
  - Problem with computation of paths for LSPs subject to various types of constraints.
  - NP-complete problem
- traffic partitioning and assignment
  - This problem deals with the optimal partitioning and assignment of traffic to parallel LSPs between pairs of MPLS ingress and egress nodes.
- restoration
  - many proposals for restoration in ATM might be applicable to MPLS.

GMPLS

- What is GMPLS?
    - a protocol suite extending MPLS to manage further classes of interfaces and switching technologies other than packet interfaces and switching, such as time division multiplex, layer-2 switch, wavelength switch and fiber-switch.

GMPLS

- GMPLS is an extended form of MPLS and some of these improvements are:
  - RSVP-TE
  - OSPF and IS-IS
  - New link-management protocol
  - Bi-directional LSP setup
    - Reduce latency
    - Less control overhead
    - Route selection is simpler
    - Cleaner interface
  - MPLS emphasizes the seperation of control plane and network plane
  - GMPLS extends this seperation and allows the control plane to be physically diverse from the associated data plane

GMPLS: Hierarchial LSP

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Summary

- MPLS
- GMPLS

Resources

- Generalized Multiprotocol Label Switching: An Overview of Signaling Enhancements and Recovery Techniques IEEE Communication Magazine, July 2001. A. Banerjee et. al.
- Internet Traffic Engineering Using Multi-Protocol Label Switching (MPLS). Computer Networks 40, Elsevier, 2002 D.O. Awduche and B. Jabbari.