INF5050 - Protocols and routing in internet

Multiprotocol Label Switching (MPLS) / Generalized Multiprotocol Label Switching (GMPLS)

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Outline

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

Background

- What is MPLS?
  - MPLS is a scalable data-carrying mechanism that directs data from one network node to the next based on short path labels rather than network addresses.
  - Every network packet is assigned at least one label and packet-forwarding decisions are based on them exclusivly, rather than the content of the packets.
  - Operates somewhere between layer 2 (data link layer) and layer 3 (network layer). Considered a "layer 2.5" protocol.
- Why MPLS?
  - Avoids complex lookups in a routing table.
  - Create end-to-end circuits using any protocol over any transport medium.
  - Provide a highly scalable mechanism that was topology driven rather than flow driven.

Background

- 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.

MPLS Fundamentals

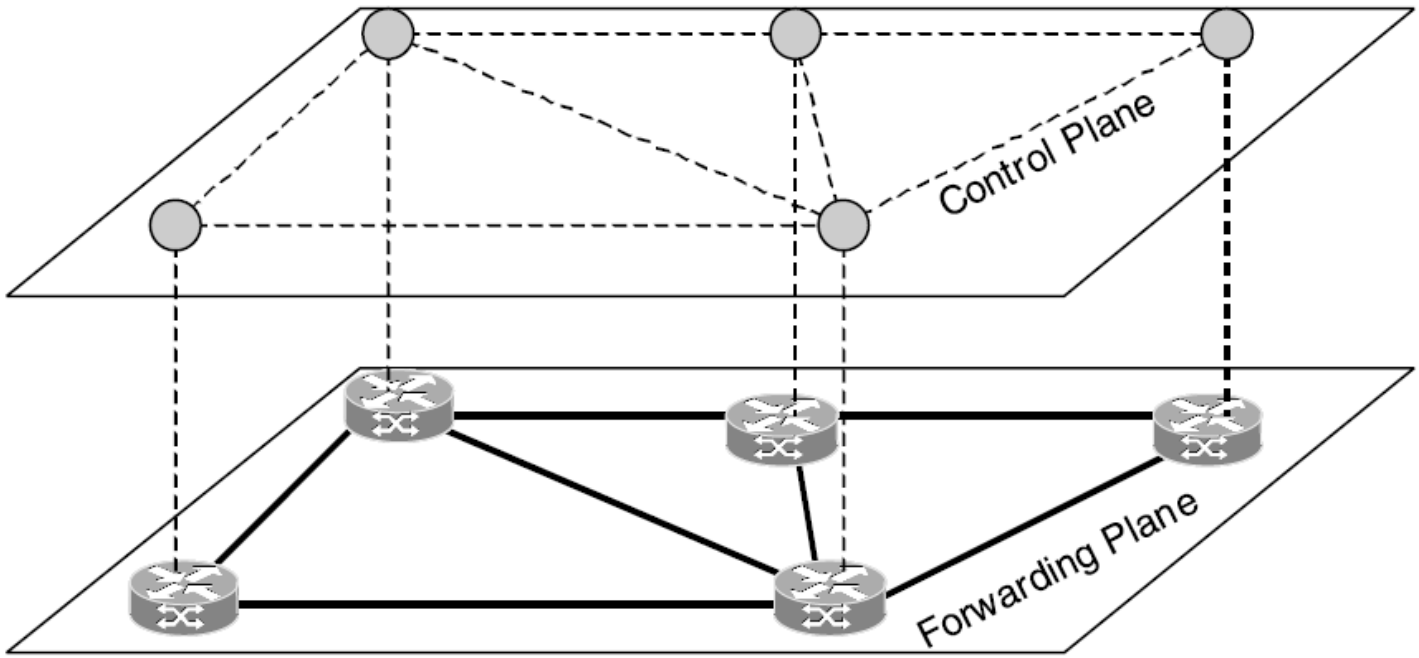

Fig. 2. Conceptual view of MPLS control plane and forwarding plane.

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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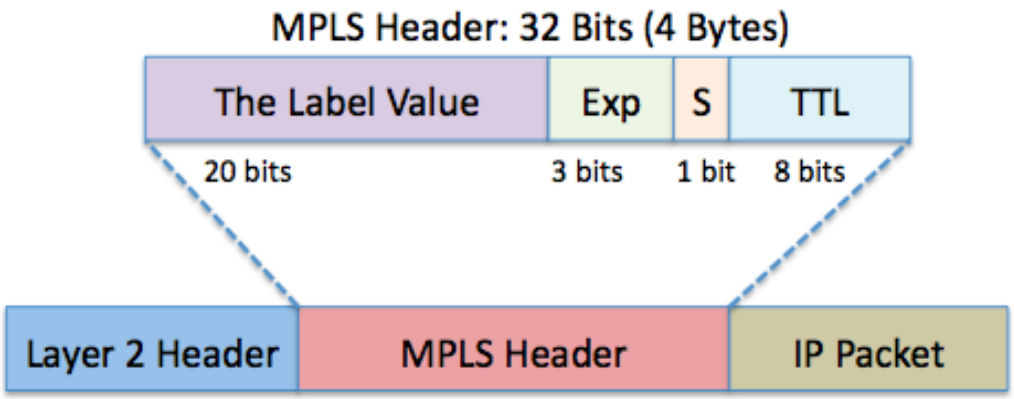
What is a Label?

- an extra layer that "sits" between L2 and L3 layer known as header 2.5 (or "shim")
- don't need to lookup at the routing table, you use the label information to find the next hop
- creates a VPN rather than public networks
- isolates other traffics running on the network



What is a Label?

Header information

- **Label value:**

Label distribution in MPLS and how LSP works

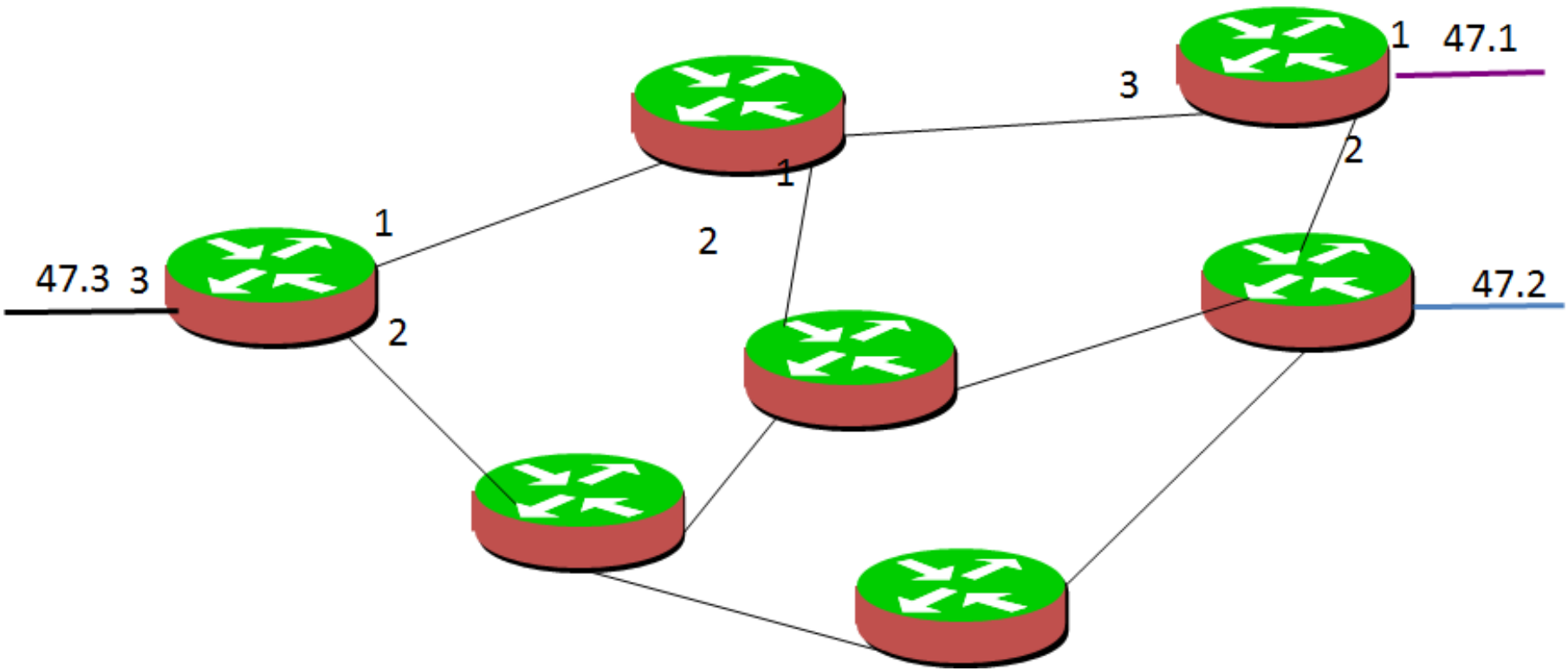


Figure: This is the initial phase

Label distribution in MPLS and how LSP works

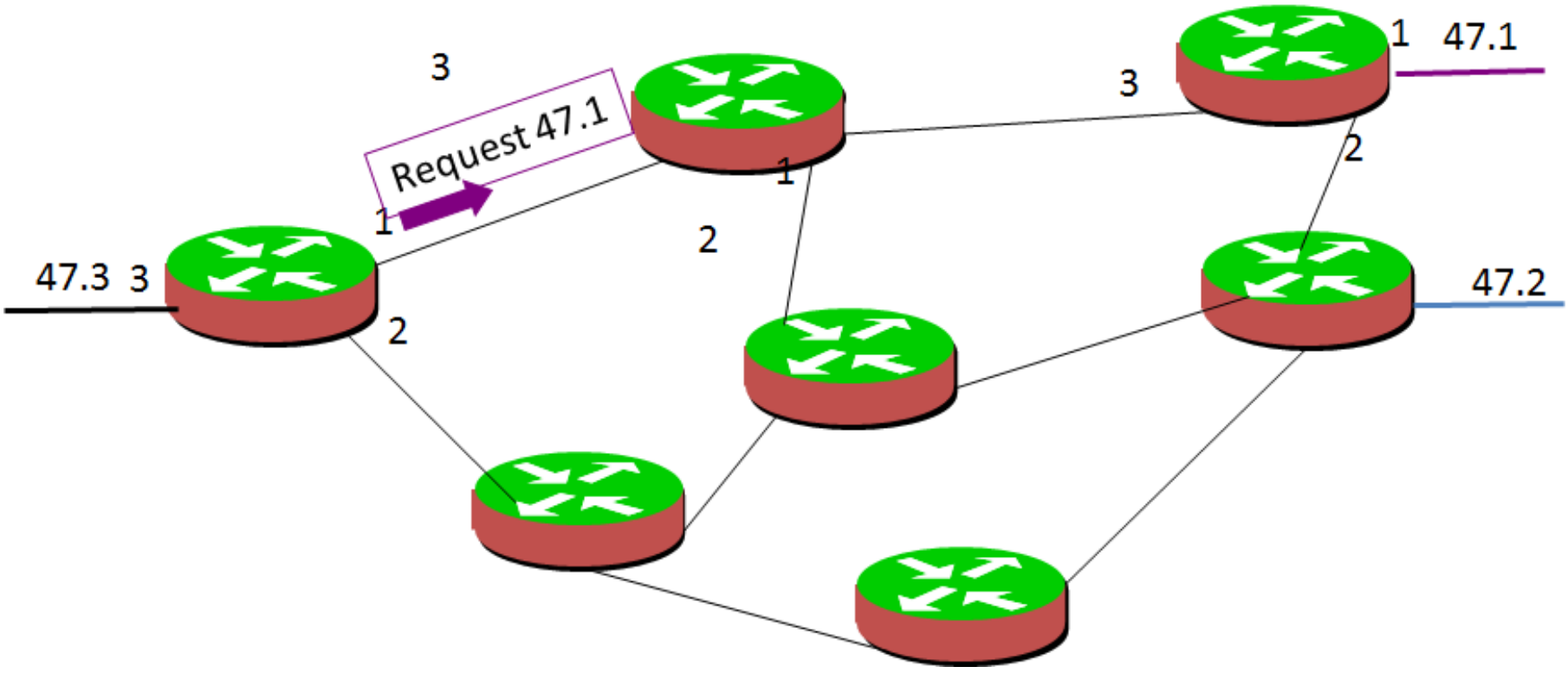


Figure: Ingress node makes a routing lookup and assigns a label

Label distribution in MPLS and how LSP works

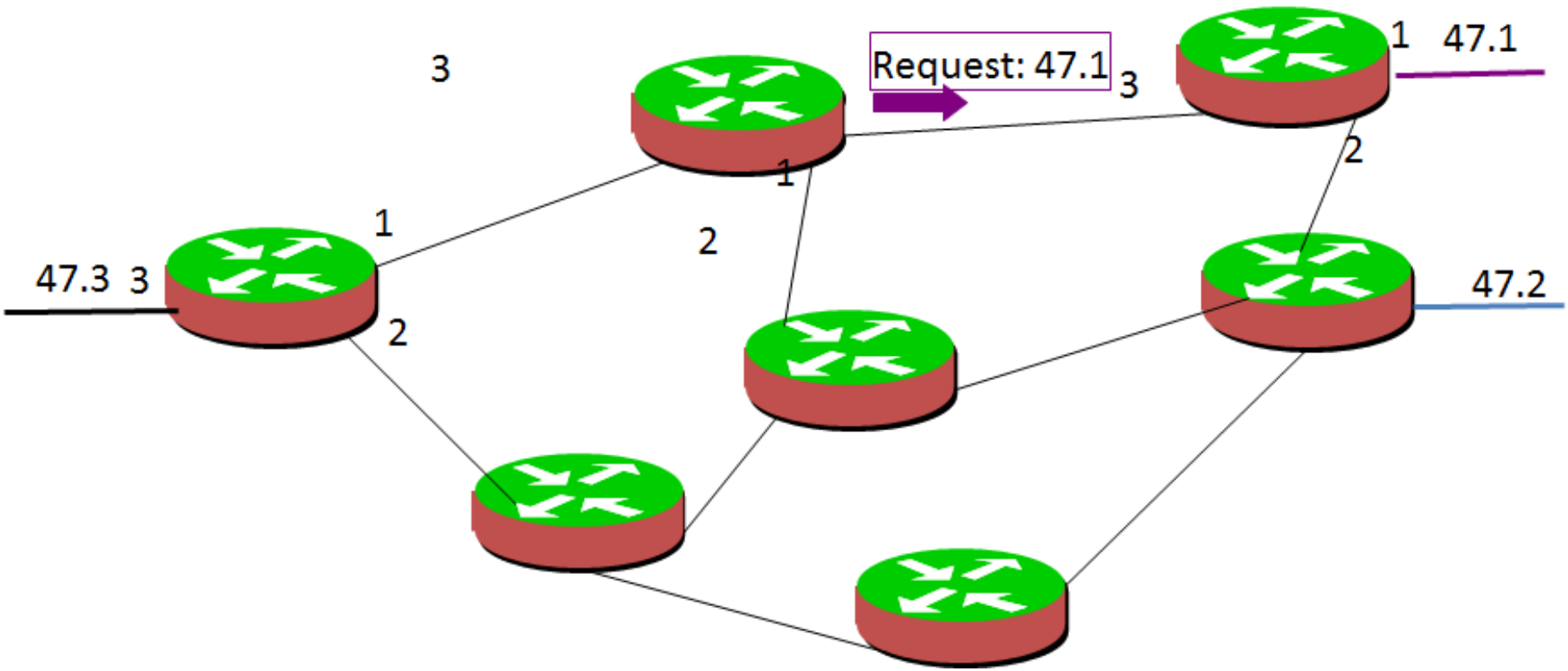


Figure: Route the message to the destination node

Label distribution in MPLS and how LSP works

Intf In	Label In	Dest	Intf Out
3	0.40	47.1	1

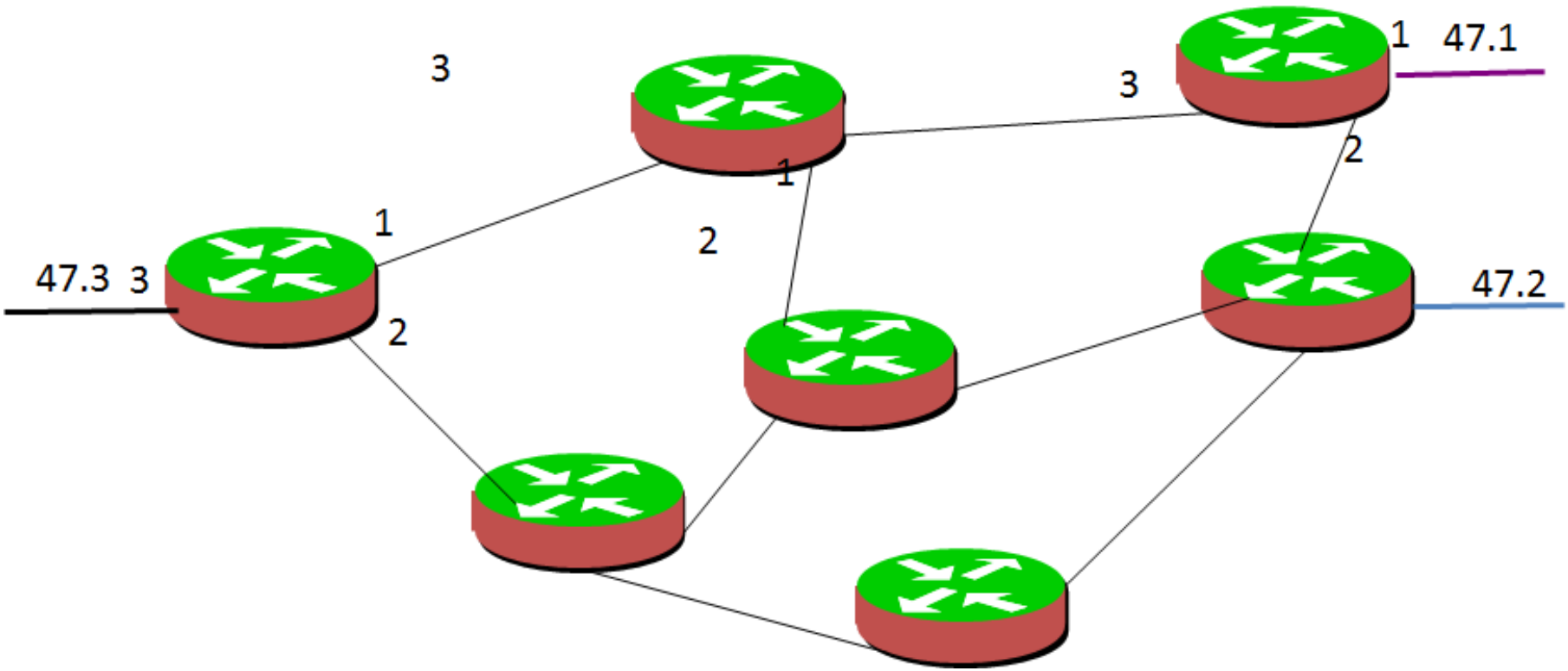


Figure: A label table is initialized with information that when it receives the given label id, it is for this router 47.1

Label distribution in MPLS and how LSP works

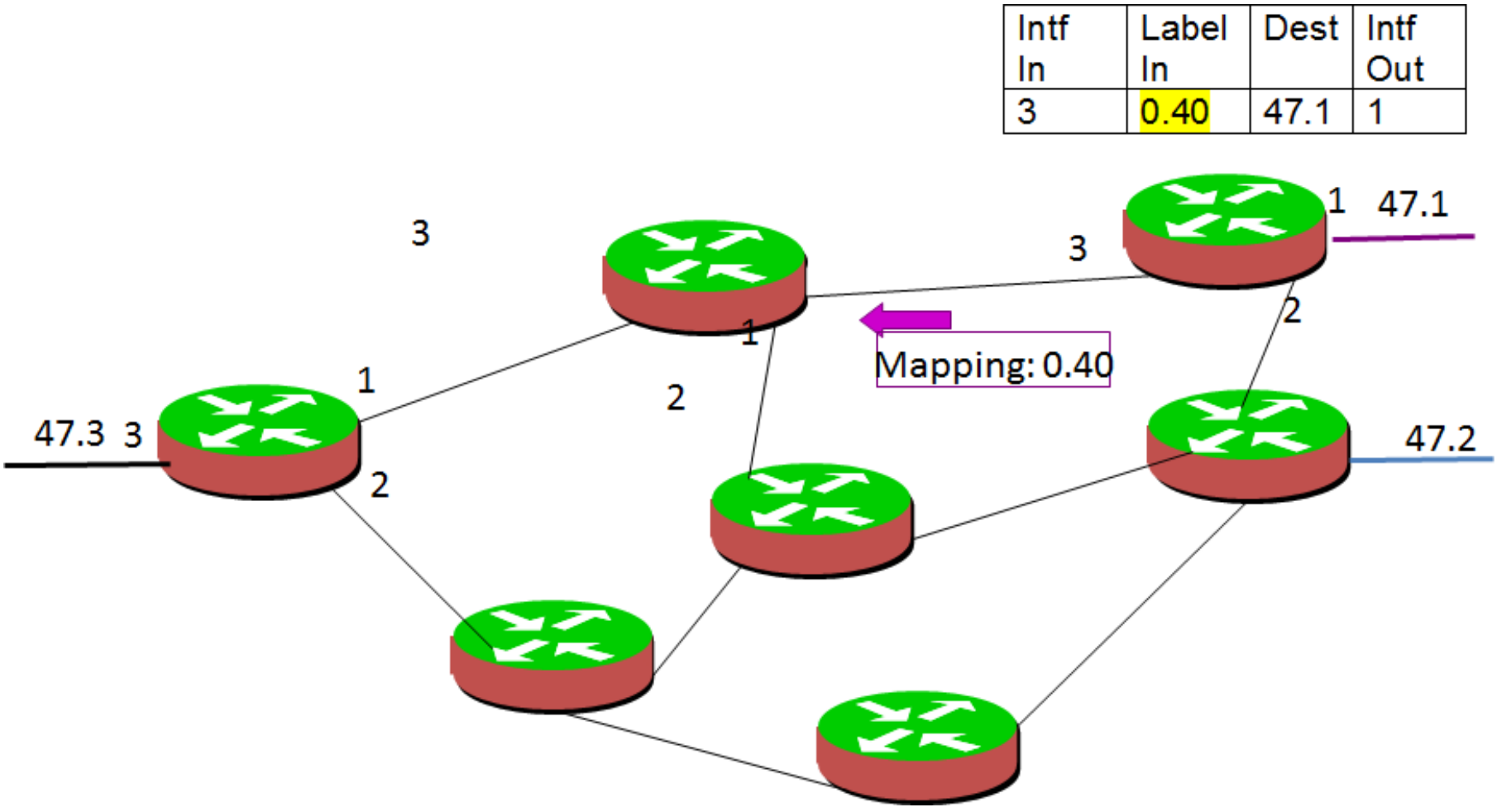


Figure: Map its label id to the router that sent request

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

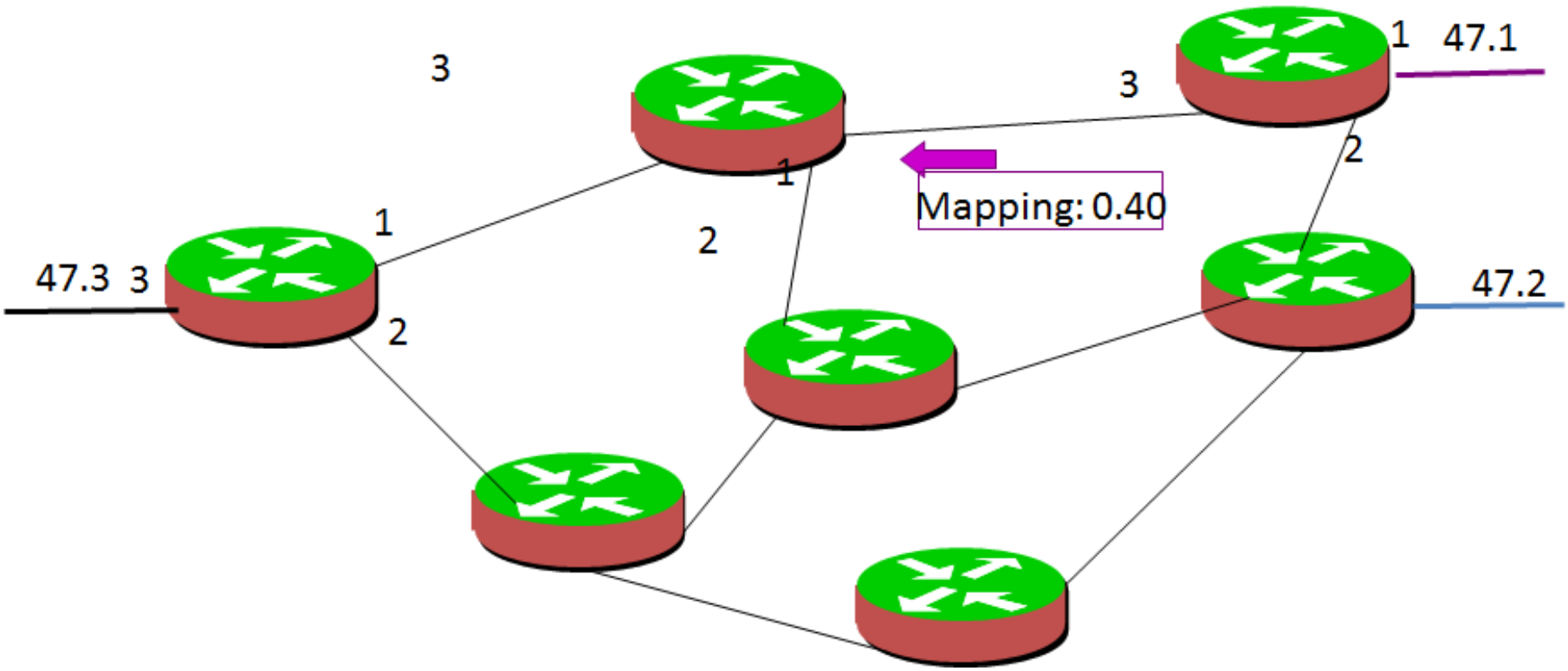


Figure: The router that receives the mapping data, adds it to its forwarding table and generates a "in" label

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

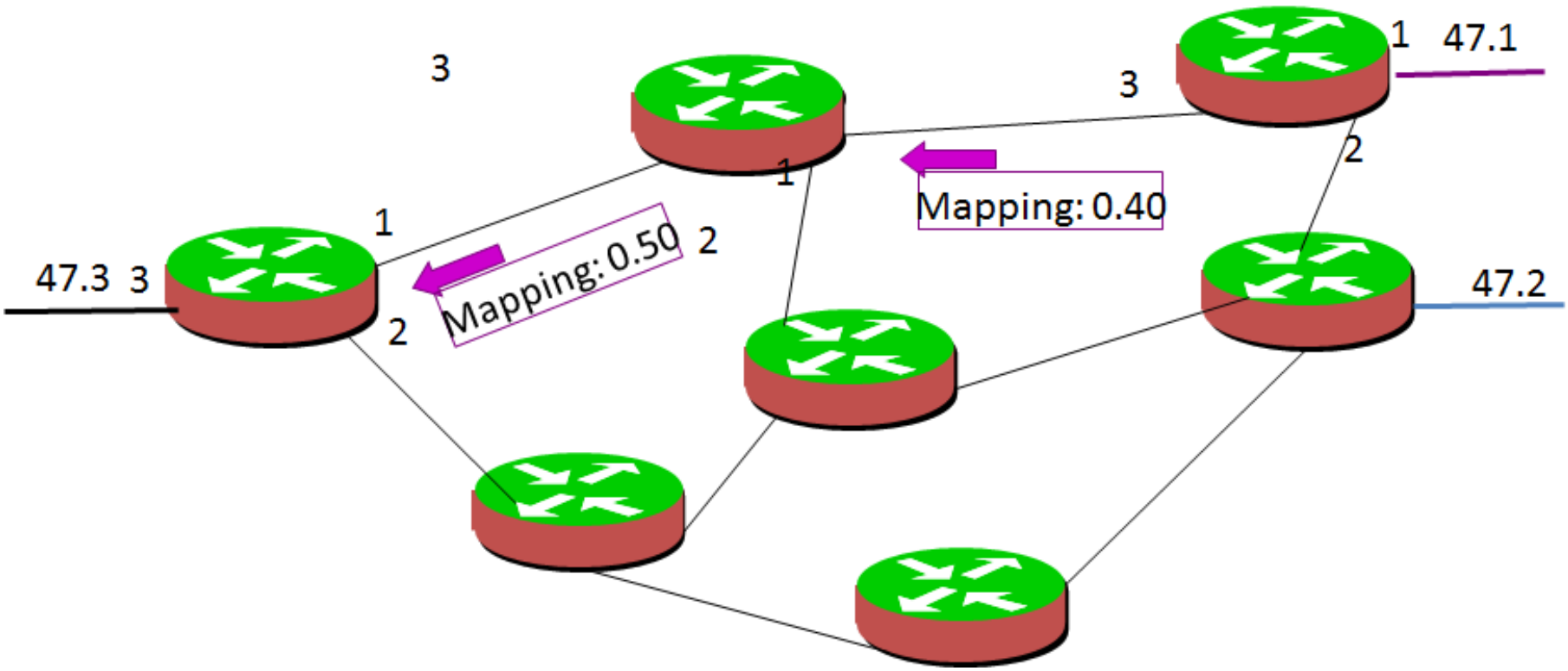


Figure: When finished, the egress node sends the mapping date of which label will be added

Label distribution in MPLS and how LSP works

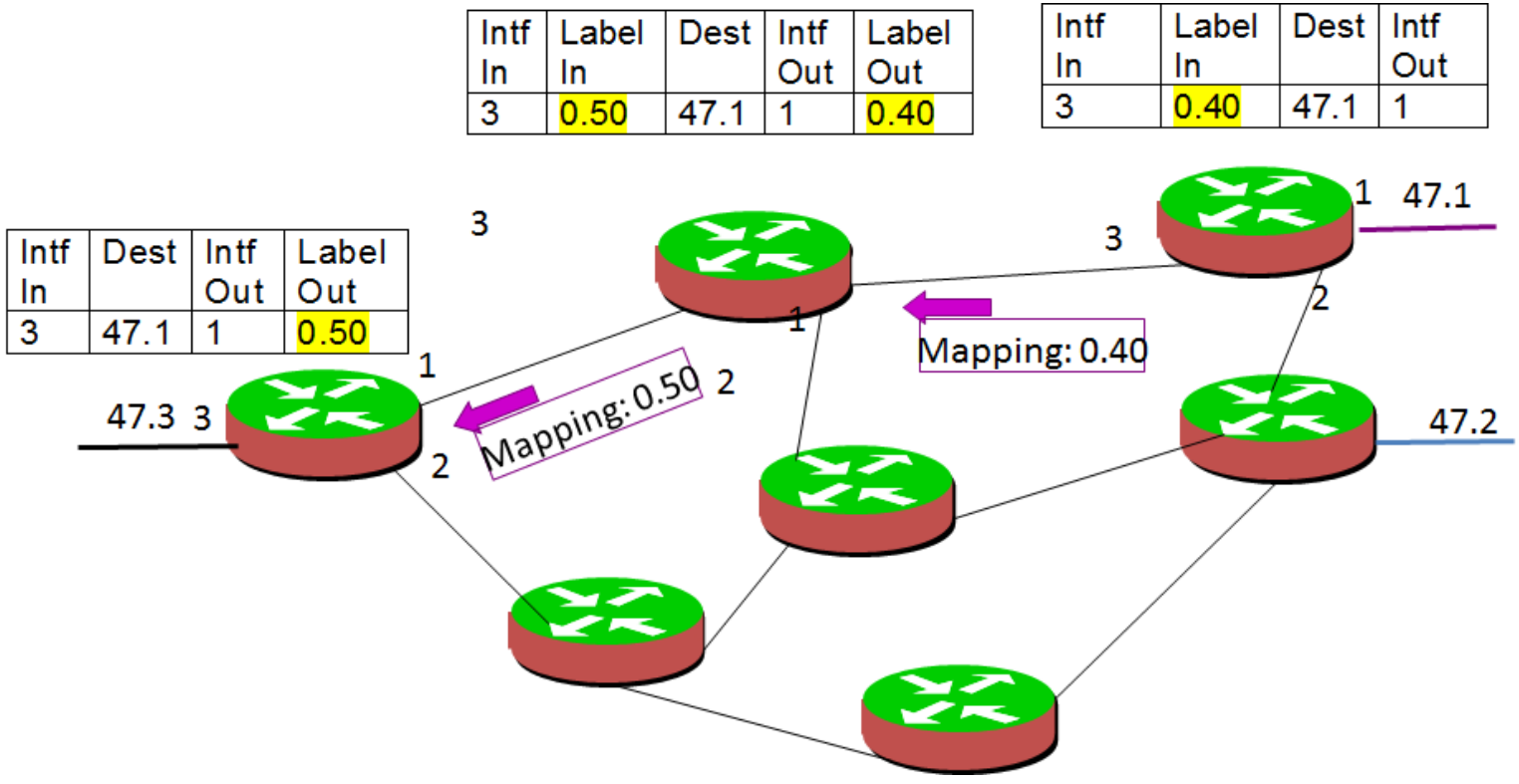


Figure: When it has reached the Ingress node, it will map the given label for the given destination IP

Label distribution in MPLS and how LSP works

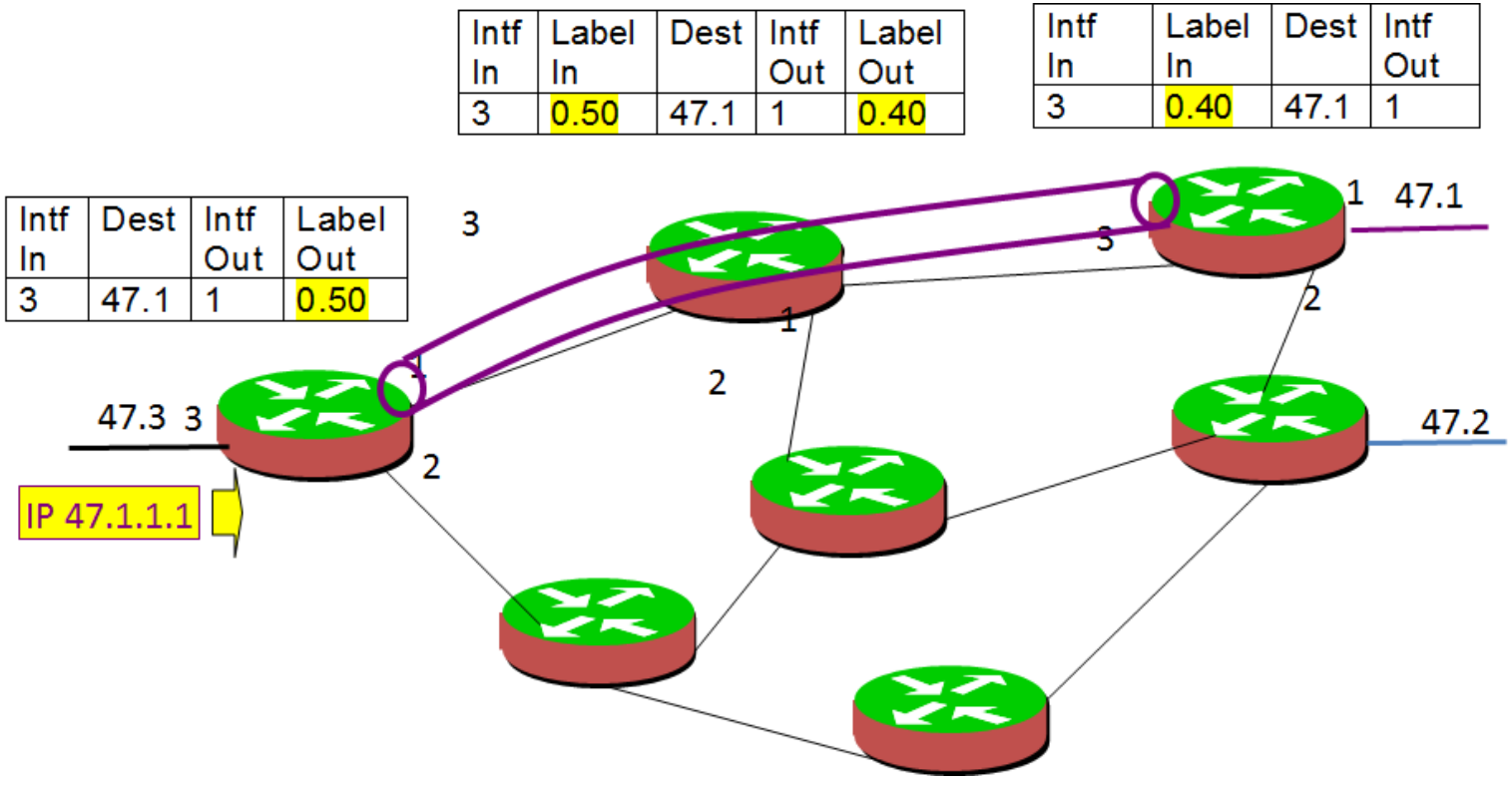


Figure: Send message with packet to 47.1, you have now a path to choose

Label distribution in MPLS and how LSP works

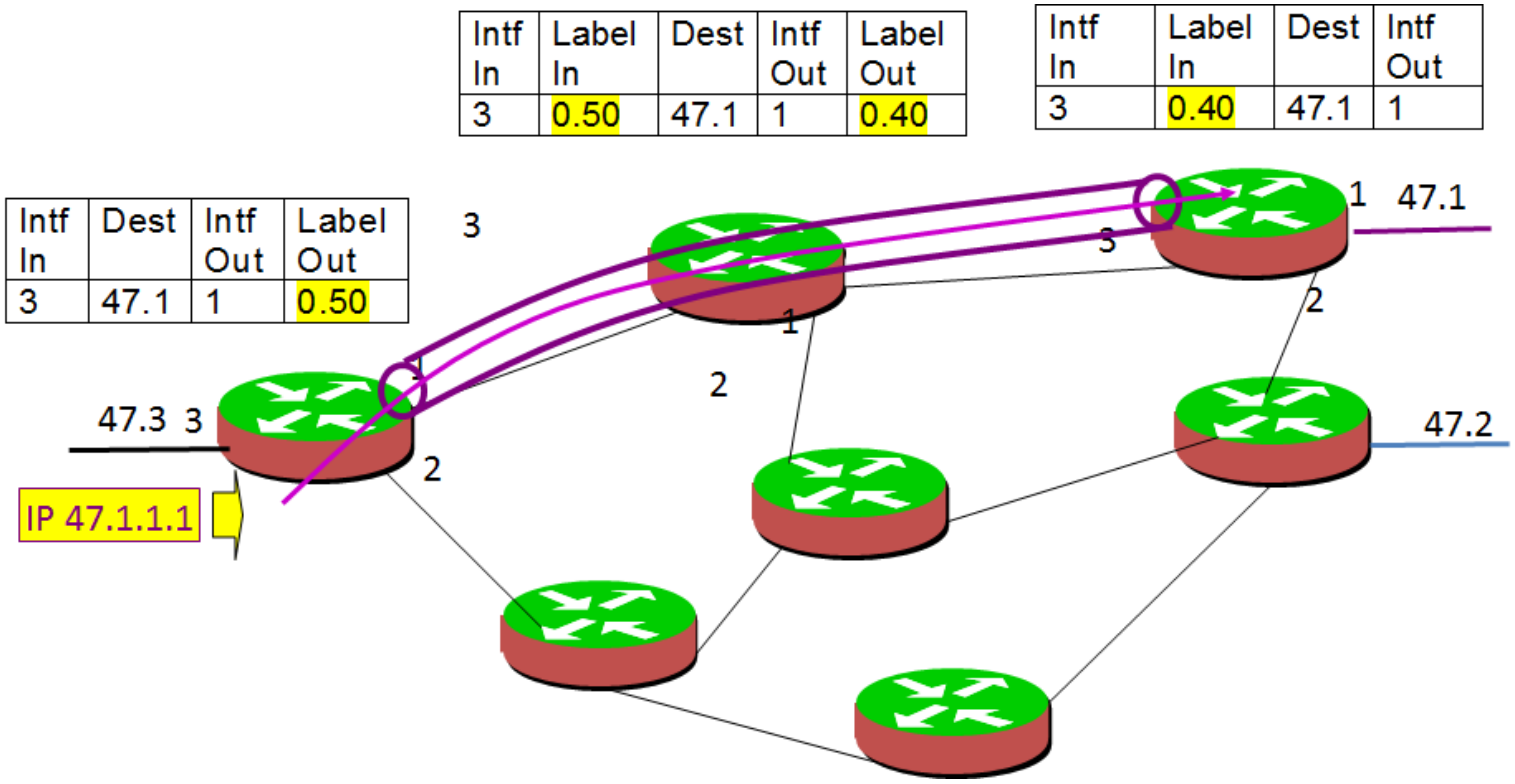


Figure: When forwarded, you add label onto the packet, when it arrives to a node, it checks the label and replaces it to another one and forwards it

Label distribution in MPLS and how LSP works

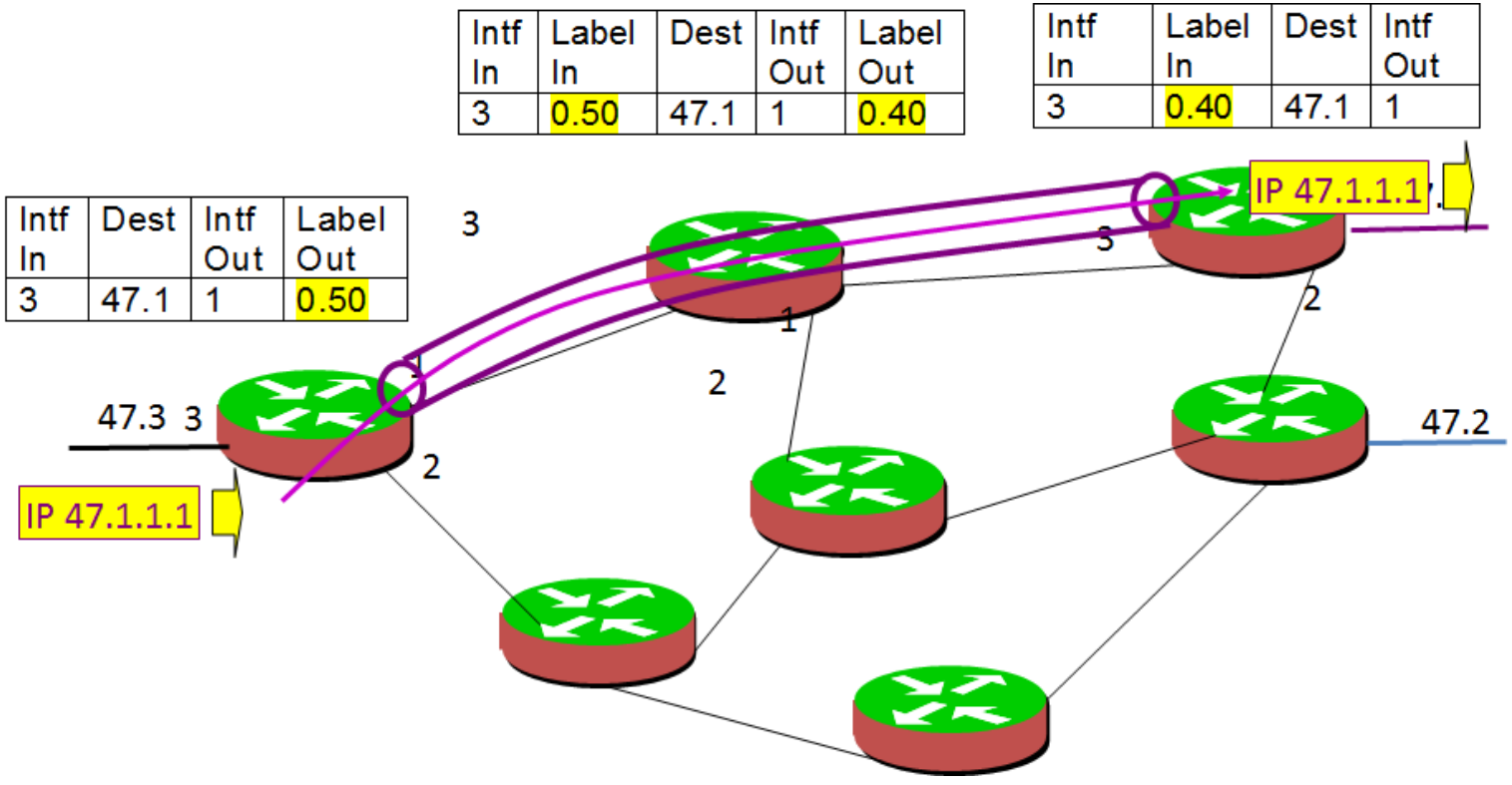


Figure: When reached to the egress node, it will then strip out the label and deliver to the specific destination

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.
- Low visibility and lack of access into the MPLS cloud. How to monitor that your carrier is delivering the correct performance?
  - Trace-route and ping no longer an option.
  - Probes are costly and difficult to maintain.
- 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.