ADVANCED NETWORKING (SENG 3308)

Chapter III

Advanced Internetworking

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Contents

- Introduction
- The Network Layer Control Plane and Data Plane
- SDN
- IPv6
- Multicast
- Multiprotocol Label Switching (MPLS)
- Routing in Mobile Devices

What is IP

Introduction

- IP stands for Internet Protocol
- Key tool used today to build scalable, heterogeneous internetworks
- It runs on all the nodes in a collection of networks and defines the infrastructure that allows these nodes and networks to function as a single logical internetwork

Packet Delivery Model

Connectionless and Best-effort delivery (unreliable service)

Introduction cont….

- Three important routing elements :
  - ✓ algorithm
  - ✓ database
  - ✓ protocol
- Algorithm : can be differentiate based on several key characteristics
- Database : table in routers or routing table
- Protocol: the way information for routing to be gathered and distributed

Routing tables

- Routing is carried out in a router by consulting/accessing a routing table.
- Routing algorithms uses the most similar path (i.e., a path with the highest similarity to the given network by its prefix) to route a packet.
- No unique format for routing tables, typically table contains:

Destination/Mask	Proto	Pre	Cost	Flags	NextHop	Interface
1.1.1.0/24	ISIS-L1	15	20	D	2.2.2.1	GigabitEthernet 0/0/0
10.10.10.0/24	EBGP	255	0	RD	17.17.17.1	Ethernet0/0/0
11.11.11.0/24	EBGP	255	2	RD	17.17.17.1	Ethernet0/0/0
12.12.12.0/24	EBGP	255	1	RD	17.17.17.1	Ethernet0/0/0
13.13.13.0/24	EBGP	255	1	RD	17.17.17.1	Ethernet0/0/0
17.17.17.0/24	Direct	0	0	D	17.17.17.2	Ethernet0/0/0
17.17.17.2/32	Direct	0	0	D	127.0.0.1	Ethernet0/0/0
127.0.0.0/8	Direct	0	0	D	127.0.0.1	InLoopBack0
127.0.0.1/32	Direct	0	0	D	127.0.0.1	InLoopBack0

address of a destination

IP address of next hop router

network interface to be used

subnet mask for the this interface

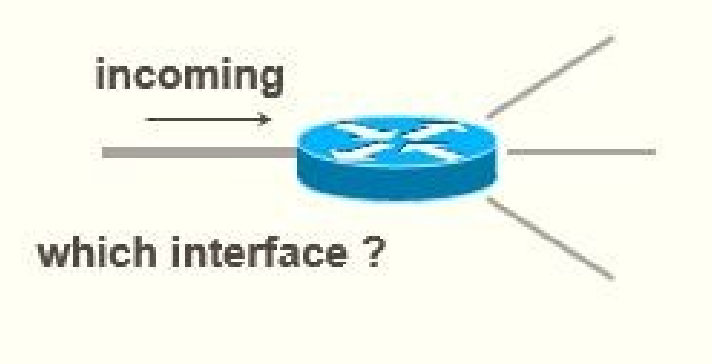
distance to the destination

IP Routing

IP performs:

- *search for a matching host address*
- *search for a matching network address*
- *search for a default entry*

Routing done by IP router, when it searches the routing table and decide which interface to end a packet out.



How path can be selected?

The following priorities can be made:

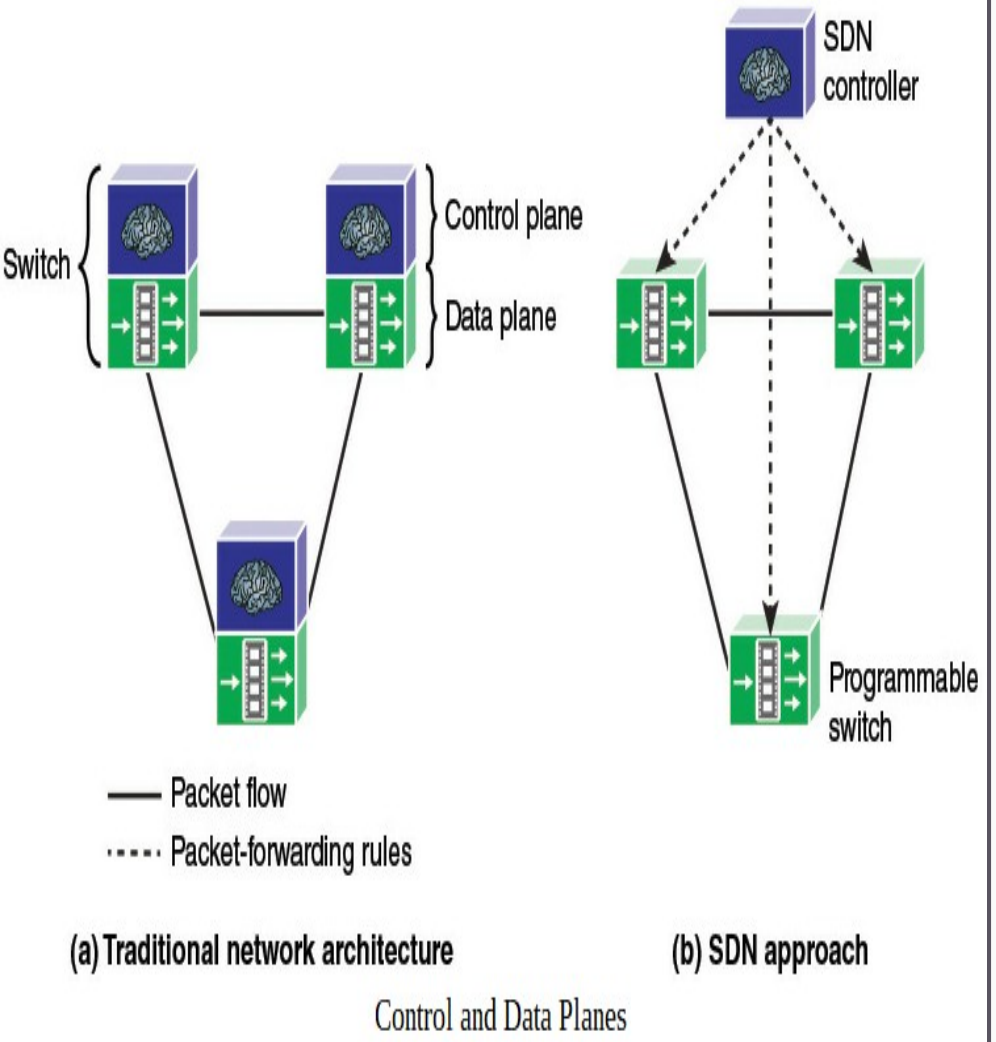
1. Most similar path (i.e., similarity in most network address bits of the destination IP address with the network address in the routing table).
2. Better preference value
3. Default path
4. Discard the packet

Routers follows the above order starting from the first one to the last in order to select the path for packet routing.

Type of routing algorithms

- Static V.S. Dynamic
- Source routing V.S. Hop-by-hop
- Centralize V.S. Distributed
- Distance vector V.S. Link state

The Network Layer Control Plane and Data Plane



Control and Data Planes

- The **control plane** is the part of a network that carries signalling traffic and is responsible for network routing.
- The control plane performs the following functions:

➢ creates routing tables

➢ manages network traffic

➢ maintains network topology

➢ provides security and load balancing

- **Data Plane**
- The data plane is responsible for processing data-carrying packets using a set of rules specified by the control plane. The data plane may be implemented in physical hardware switches or in software implementations
  - ❖ forwards the IP packets;
  - ❖ depends on the control plane to perform its functions;
  - ❖ forwards packets based on the control plane logic;
  - ❖ performs packet switching; and
  - ❖ includes decrementing time to live, IP

SDN

enables the network to be intelligently and centrally controlled, or 'programmed,' using software applications. This helps operators manage the entire network consistently and holistically, regardless of the underlying network technology.

- Challenges of Traditional networking are:

❖ New network services may require additional hardware appliances.

❖ New hardware means additional capital expenditures.

❖ Skill gaps to design, integrate, and operate new appliances.

❖ Hardware-based appliances rapidly reach end of life

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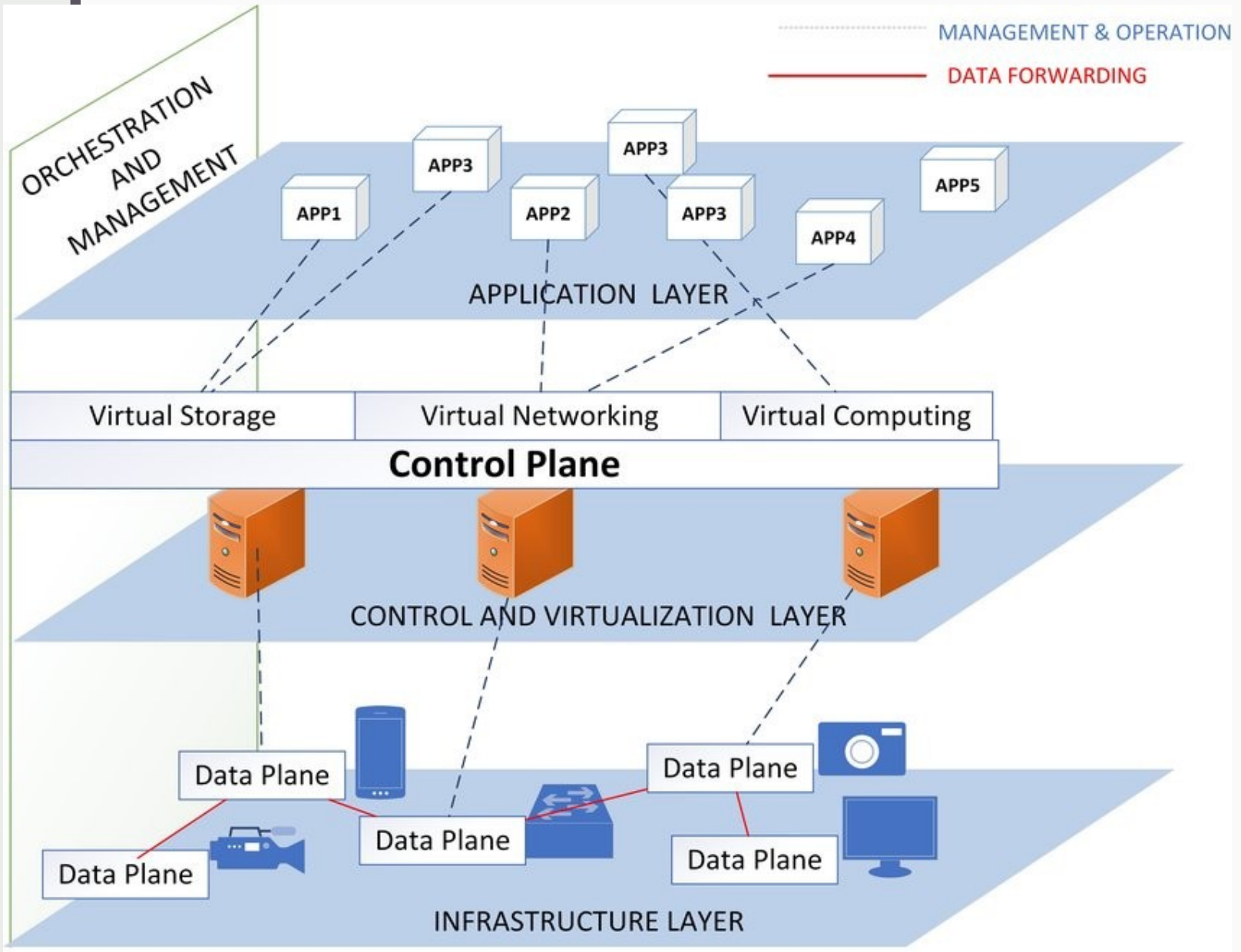
SDN


MANAGEMENT & OPERATION
DATA FORWARDING
ORCHESTRATION AND MANAGEMENT
APP1
APP3
APP2
APP3
APP3
APP4
APP5
APPLICATION LAYER
Virtual Storage
Virtual Networking
Virtual Computing
Control Plane
CONTROL AND VIRTUALIZATION LAYER
Data Plane
Data Plane
Data Plane
Data Plane
Data Plane
INFRASTRUCTURE LAYER

SDN

- There are four critical areas in which SDN technology can make a difference for an organization.

❖ Network programmability

❖ Logically centralize intelligence and control

❖ Abstraction of the network

❖ Openness

SDN elements

SDN

- An SDN architecture delivers a centralized, programmable network and consists of the following:
- A controller, the core element of an SDN architecture, that enables centralized management and control, automation, and policy enforcement across physical and virtual network environments
- Southbound APIs that relay information between the controller and the individual network devices (such as switches, access points, routers, and firewalls)
- Northbound APIs that relay information between the controller and the

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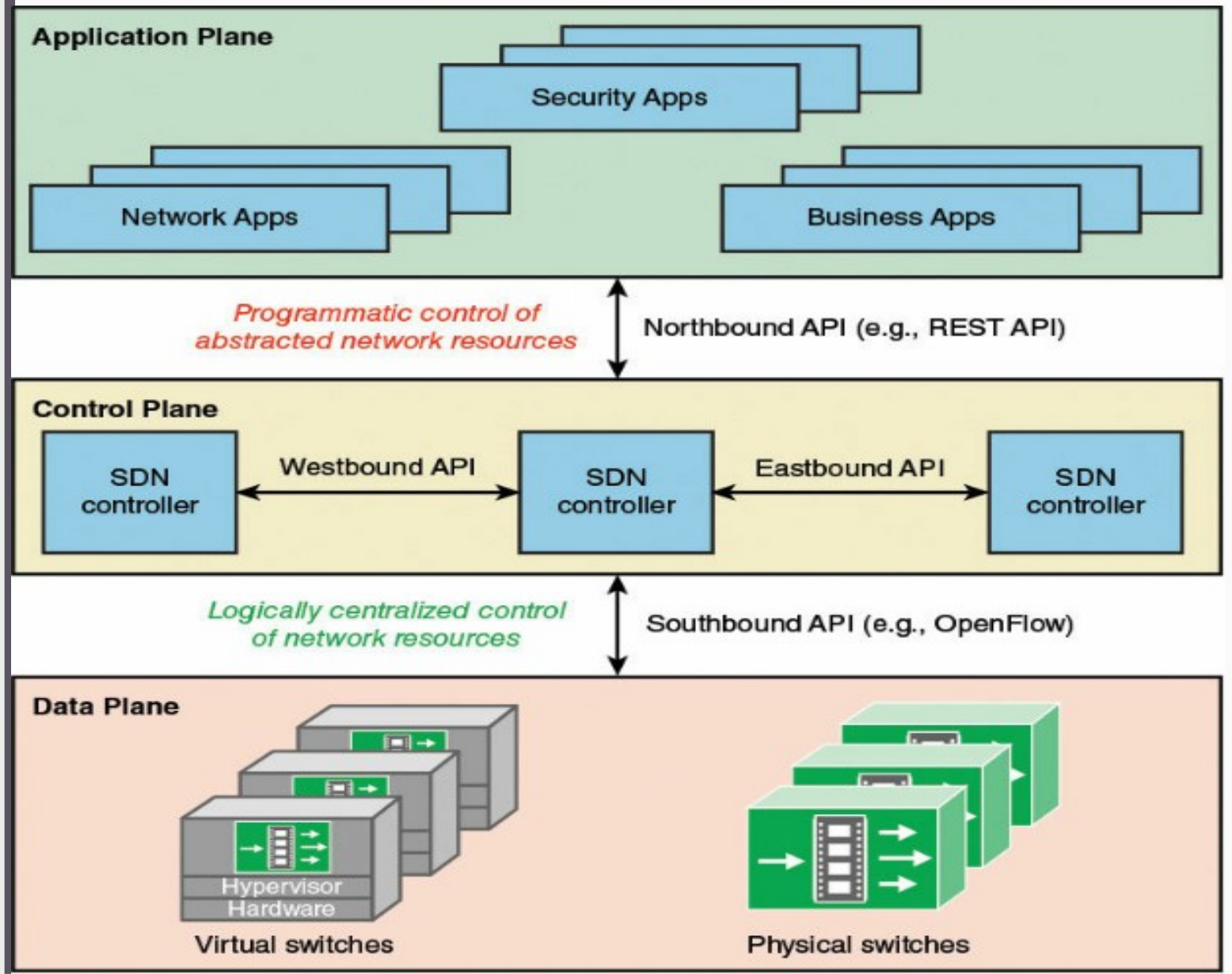
SDN



Major Features

- 128-bit addresses
- Multicast
- Real-time service
- Authentication and security
- Auto-configuration
- End-to-end fragmentation
- Enhanced routing functionality, including support for mobile hosts

IPv6

Classless addressing/routing (similar to CIDR)

Notation: x:x:x:x:x:x:x:x (x = 16-bit hex number)

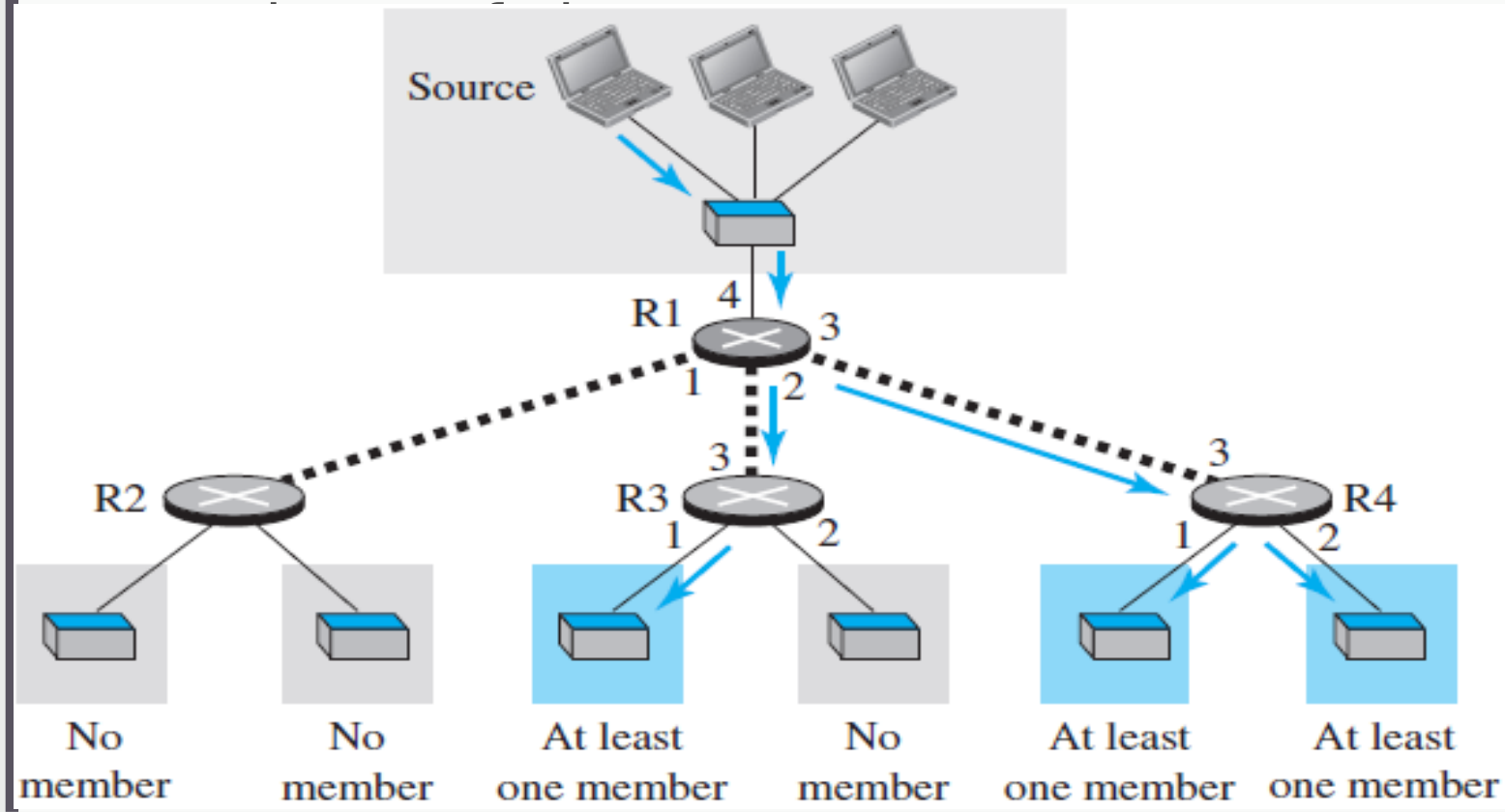
- contiguous 0s are compressed:
  47CD::A456:0124
- IPv6 compatible IPv4 address: ::128.42.1.87

Address assignment

- provider-based

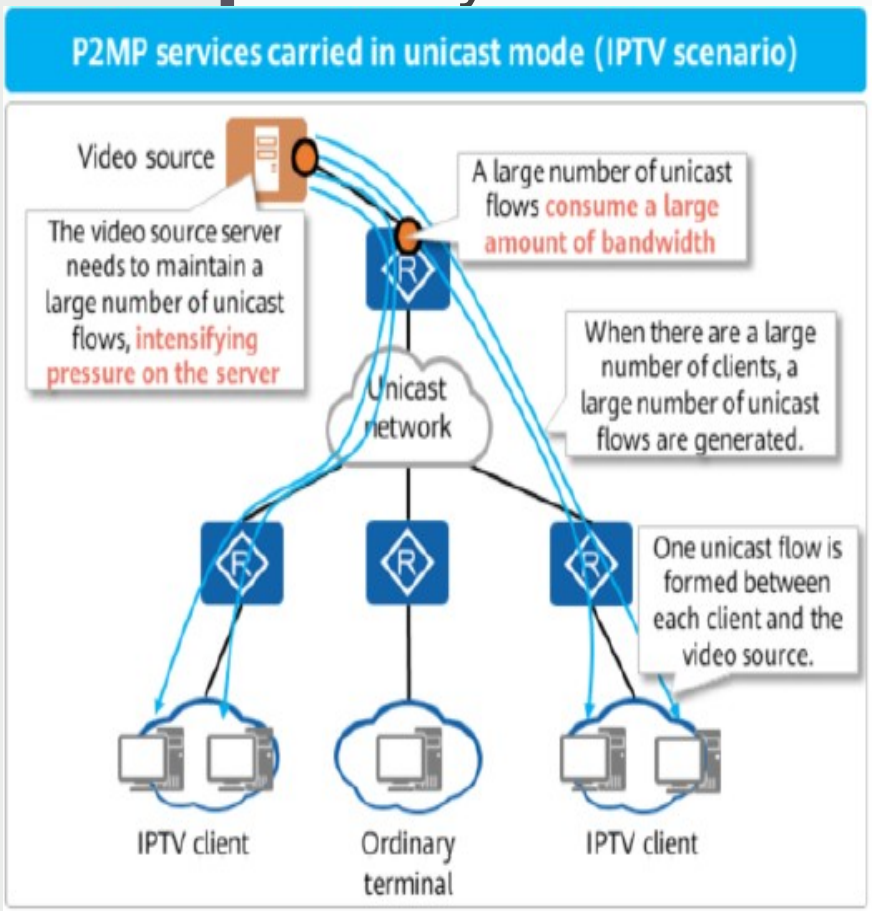
Multicast

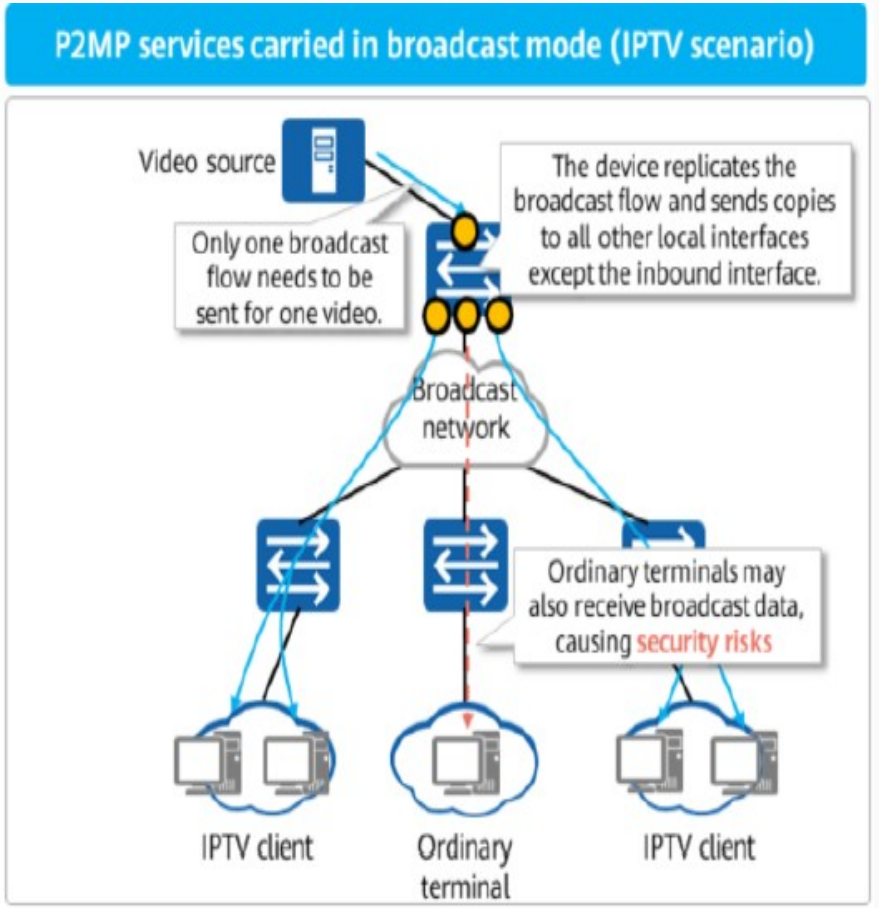
- It is a way of sending a packet from a source to the members of a multicast address group.
- In multicasting, there is one source and a group of destinations.
- The group address defines the



Multicast

- P2MP services can be carried in unicast, multicast or broadcast mode. However, some inherent problems occur if unicast or broadcast is used to carry P2MP services.

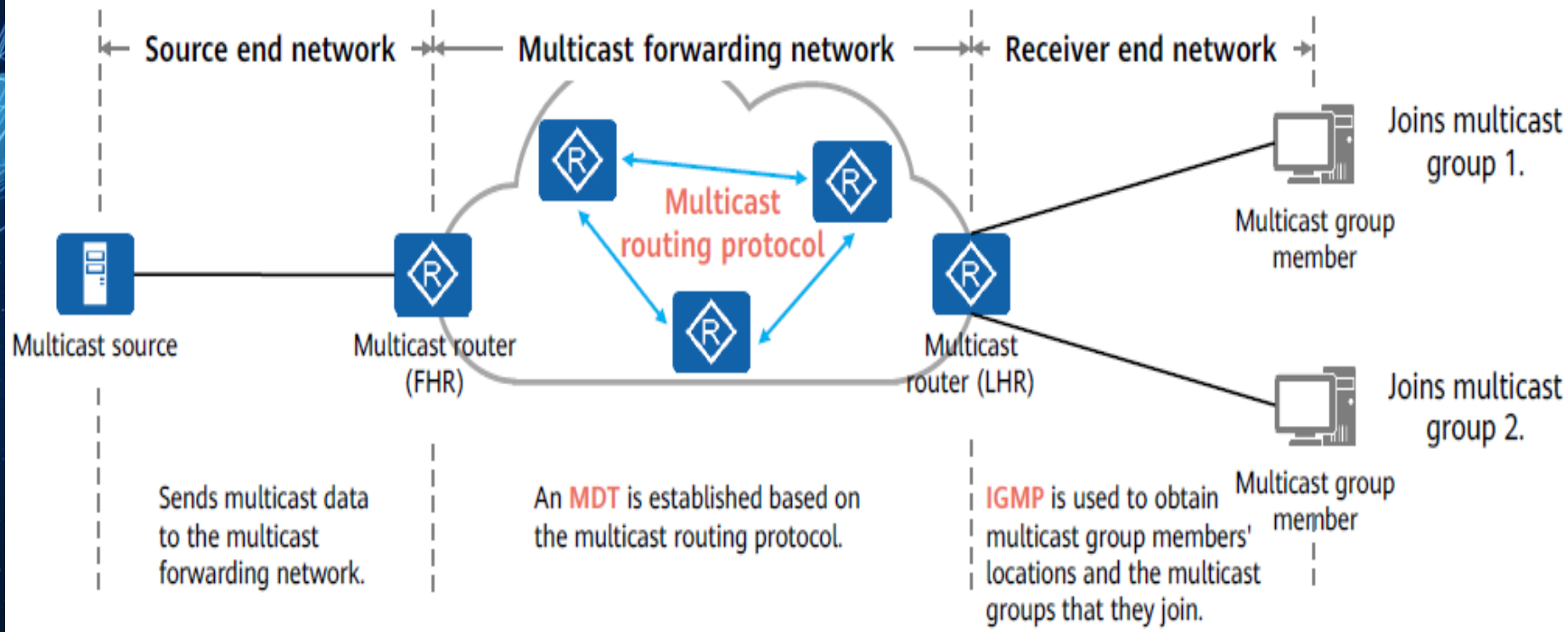




Multicast

A multicast network can be divided into three parts:

- Source end networks
- Multicast forwarding network
- Receiver end network



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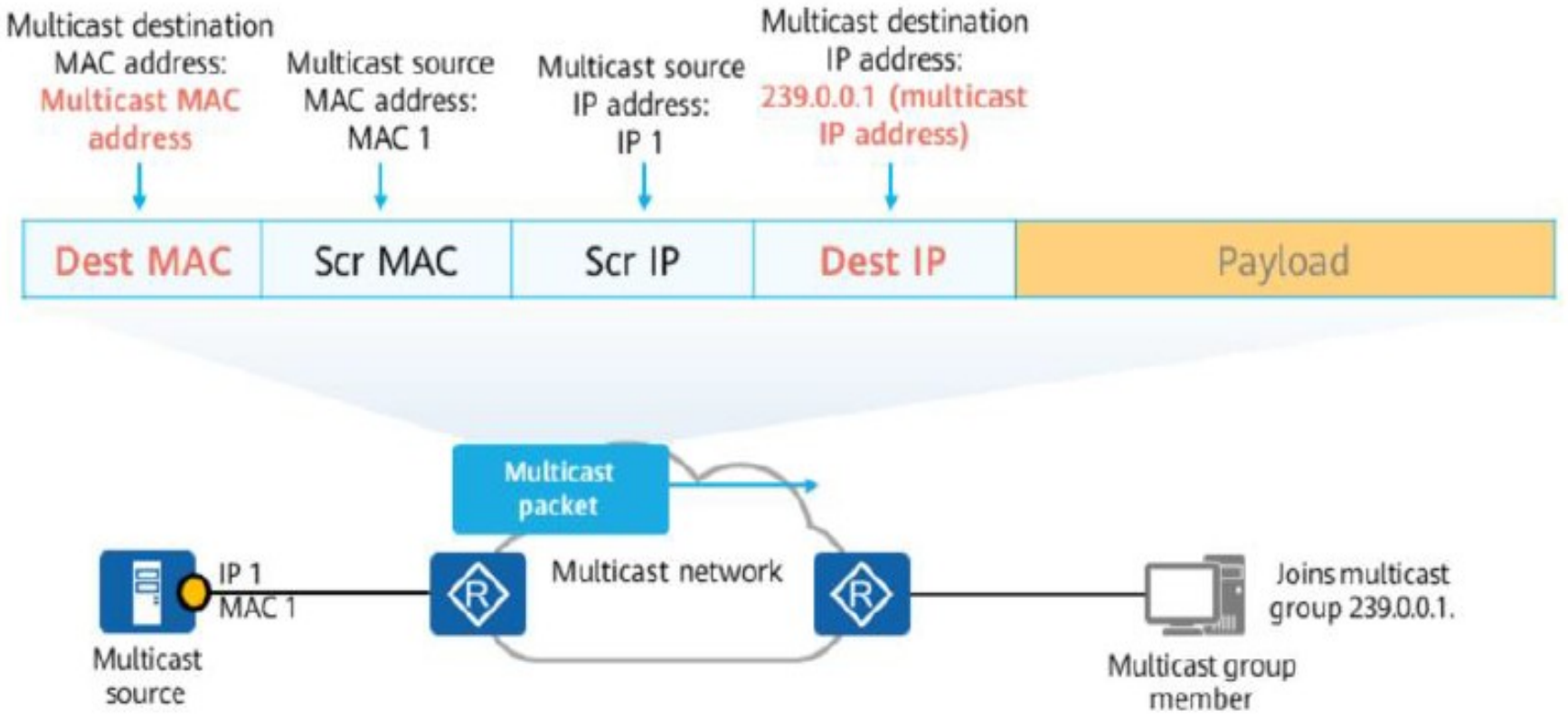
Multicast

Multicast data packet structure



Multicast

- If a new group is formed with some active members, an authority can assign an unused multicast address to this group to uniquely define it.
- A host which is a member of n groups, actually has (n + 1) addresses.
- In classful addressing, all of class D was composed of these addresses;
- Classless addressing used the same block, but it was referred to as the block 224.0.0.0/4 (from 224.0.0.0 to 239.255.255.255).
- Four bits define the block; the rest of the bits are used as the identifier for the group.
- The multicast address selection

Multicast

- The following gives some of the common subblocks:
  - ❖ Local Network Control Block (224.0.0.0/24)
  - ❖ Administratively Scoped Block (239.0.0.0/8)
  - ❖ GLOP Block (233.0.0.0/8): this block defines a range of addresses that can be used inside an autonomous system (AS). One can insert the AS number as the two middle octets (233.x.y.0 to 233.x.y.255), in which x.y is the AS number.
  - ❖ Internetwork Control Block

Converting IP Multicast Address to Data-Link Layer Multicast Address

- In order to deliver the packet to the destination host we need a data-link layer multicast addresses.
- Most LANs support physical multicast addressing. For example Ethernet
- An Ethernet physical address (MAC address) is six octets (48 bits) long. If the first 25 bits in an Ethernet address are 00000001 00000000 01011110 0, this identifies a physical multicast address for the TCP/IP protocol (i.e. 01:00:5E:00:00:00 to 01:00:5E:7F:FF:FF).
- The remaining 23 bits can be used to define a group. To convert an IP multicast address into an Ethernet address, the multicast router extracts the least significant 23 bits of a

Collecting Information about Groups

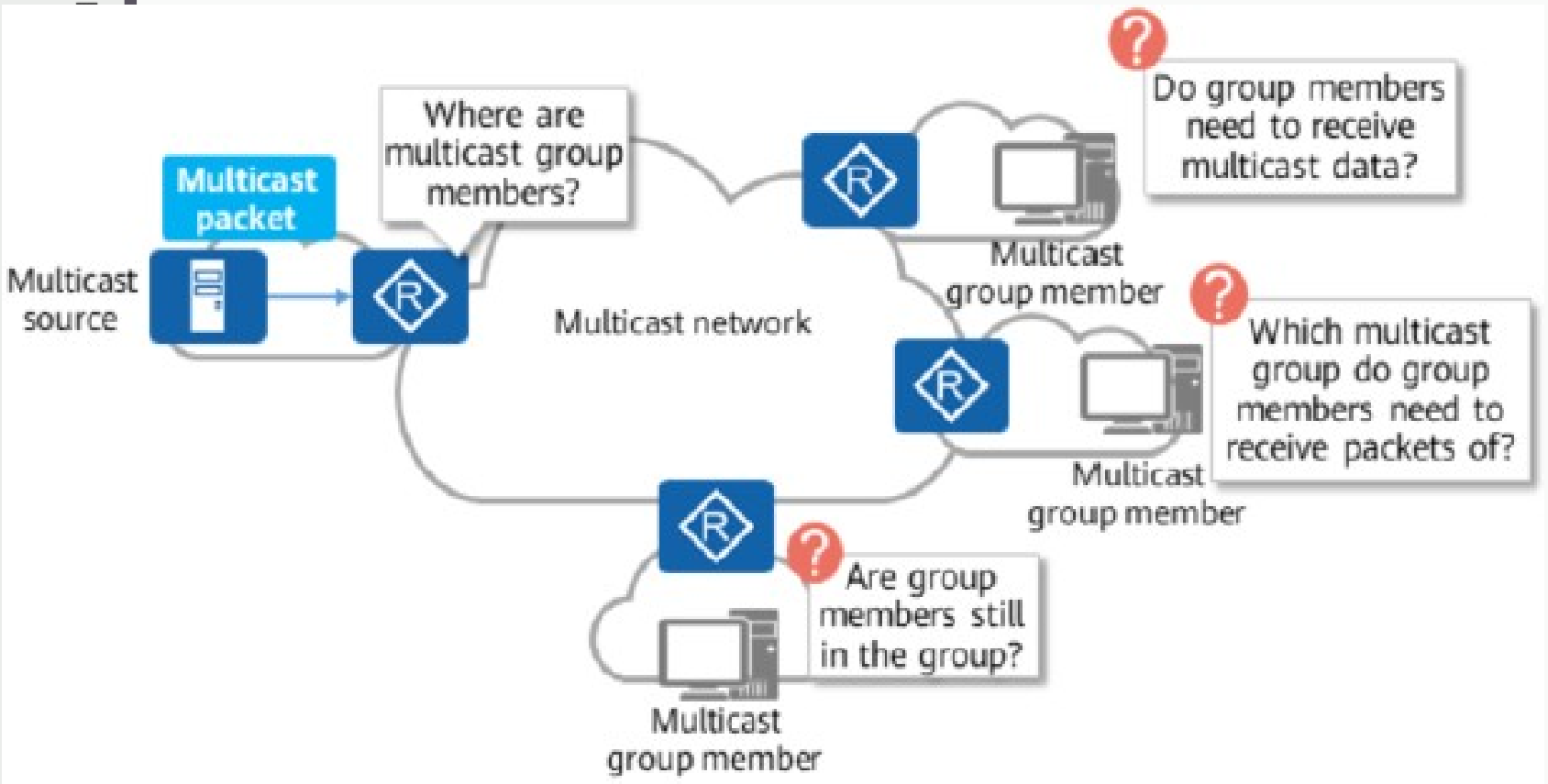
multicast routing involves two steps:

1. A router needs to know to which destinations it is connected.

2. Each router needs to propagate information obtained in the first step to all other routers.

- *The collection of multicast information is not automatic because of two reasons:*
- *First, a router does not know which host in the attached network is a member of a particular group based on IP address.*
- *Second, the membership is not a fixed attribute of a host.*
- *A router needs help to find out which groups are active in each of its*

Multicast


Multicast packet
Where are multicast group members?
Multicast source
Multicast network
Do group members need to receive multicast data?
Multicast group member
Which multicast group do group members need to receive packets of?
Multicast group member
Are group members still in the group?
Multicast group member

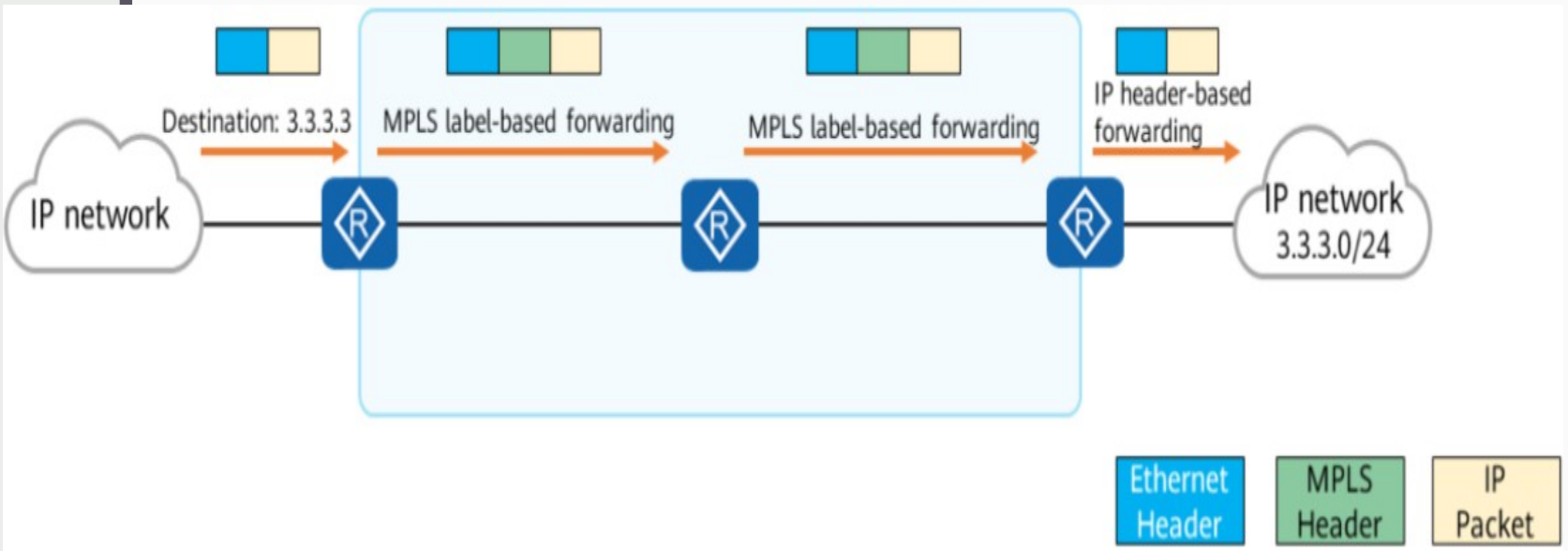
- Each router needs to create a separate tree for each source-group combination.
- In other words, if there are m groups and n sources in the internet, a router needs to create (m × n) routing trees.

Group-Shared Tree Approach

- The designate router to act as the phony source for each group.
- The designated router, which is called the core router (rendezvous point router), acts as the representative for the group. Any source that has a packet to send to a member of that group sends it to the core centre and the core centre is responsible for multicasting.
- The core centre creates one single

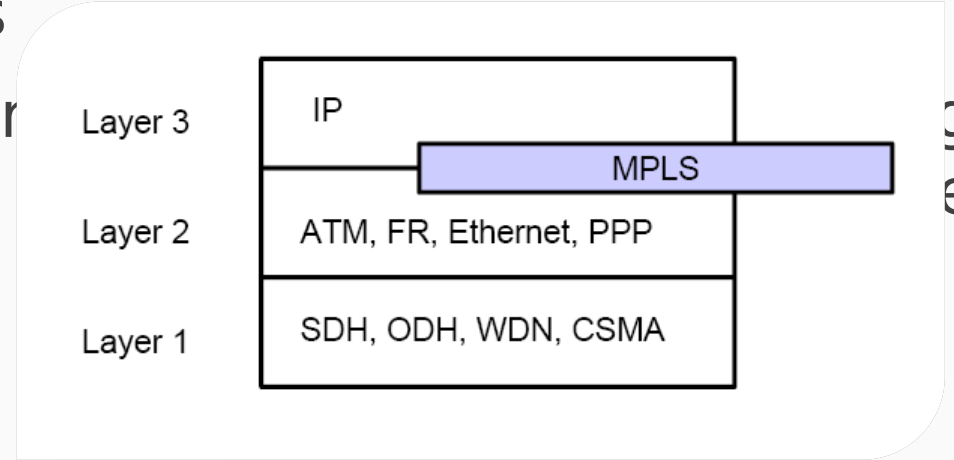
Multiprotocol Label Switching (MPLS)

- MPLS is located between the data link and network layer in the TCP/IP protocol stack and can provide services for all network layers.
- In MPLS the data can be forwarded quickly based on the Label field in the MPLS header.



Need for MPLS

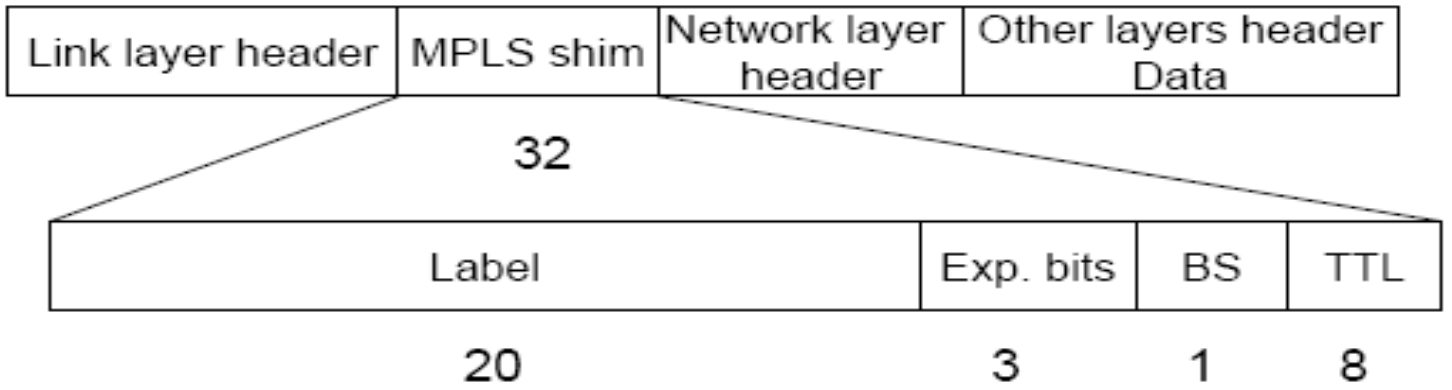
- Forwarding function of a conventional router
  - a capacity demanding procedure
  - constitutes a bottle neck with increase in line speed
- MPLS simplifies forwarding function by introducing a connection oriented mechanism inside the connectionless IP networks
- Multi Pr g is arranged er 3.



MPLS Characteristics

- Mechanisms to manage traffic flows of various granularities (Flow Management)
- Is independent of Layer-2 and Layer-3 protocols
- Maps IP-addresses to fixed length labels
- Interfaces to existing routing protocols (RSVP, OSPF)
- Supports ATM, Frame-Relay and Ethernet

MPLS header

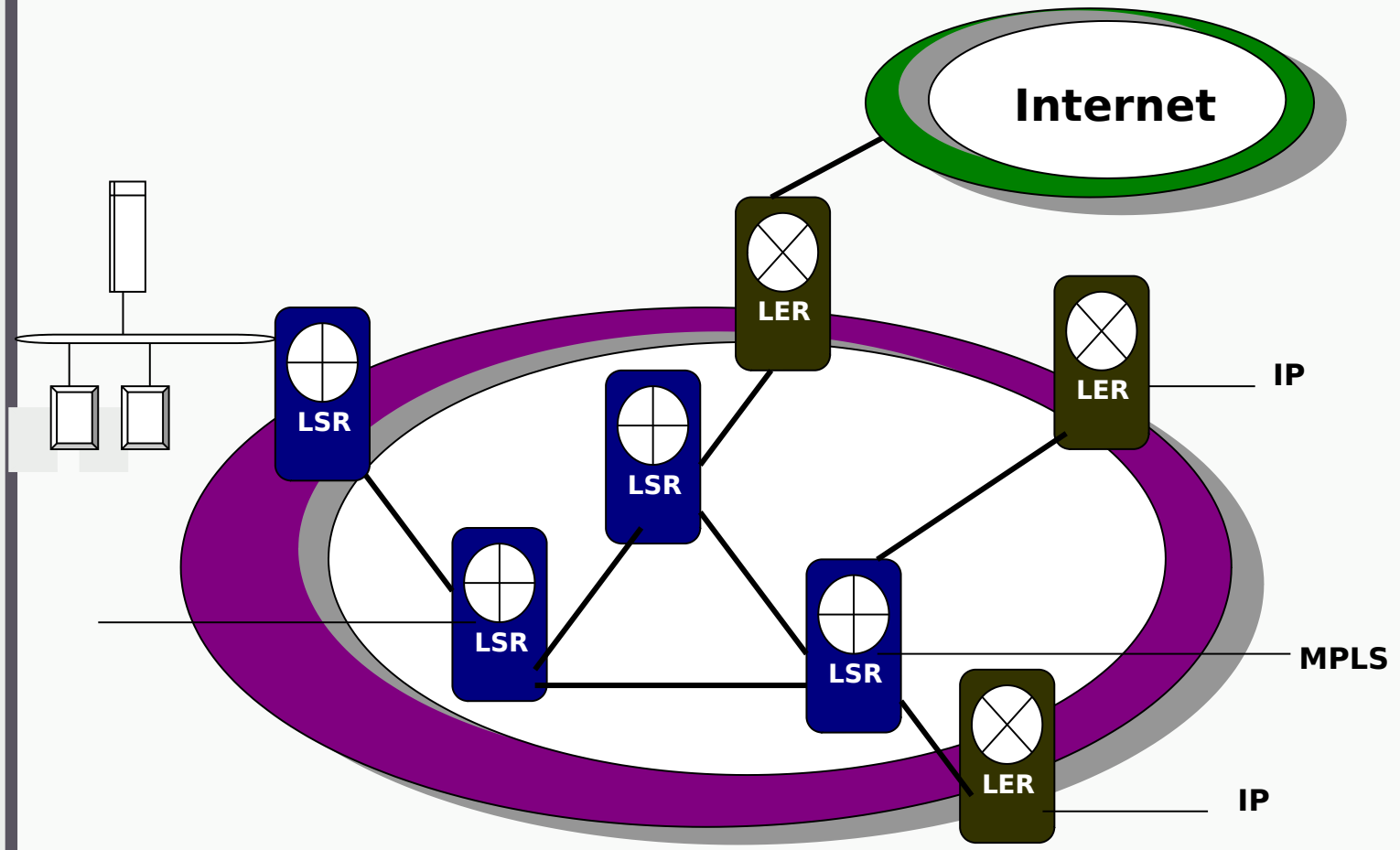


Exp.bits: Experimental Bits, often used for Class of Service
BS: Bottom of Stack bit, is set if no label follows
TTL: Time To Leave, used in the same way like in IP

Label distribution

- MPLS does not specify a single method for label distribution
- BGP has been enhanced to piggyback the label information within the contents of the protocol
- RSVP (Resource Reservation Protocol-Traffic Engineering)has also been extended to support piggybacked exchange of labels.
- IETF has also defined a new protocol known as the label distribution protocol (LDP) for explicit signalling and management
- Extensions to the base LDP protocol have also been defined to support

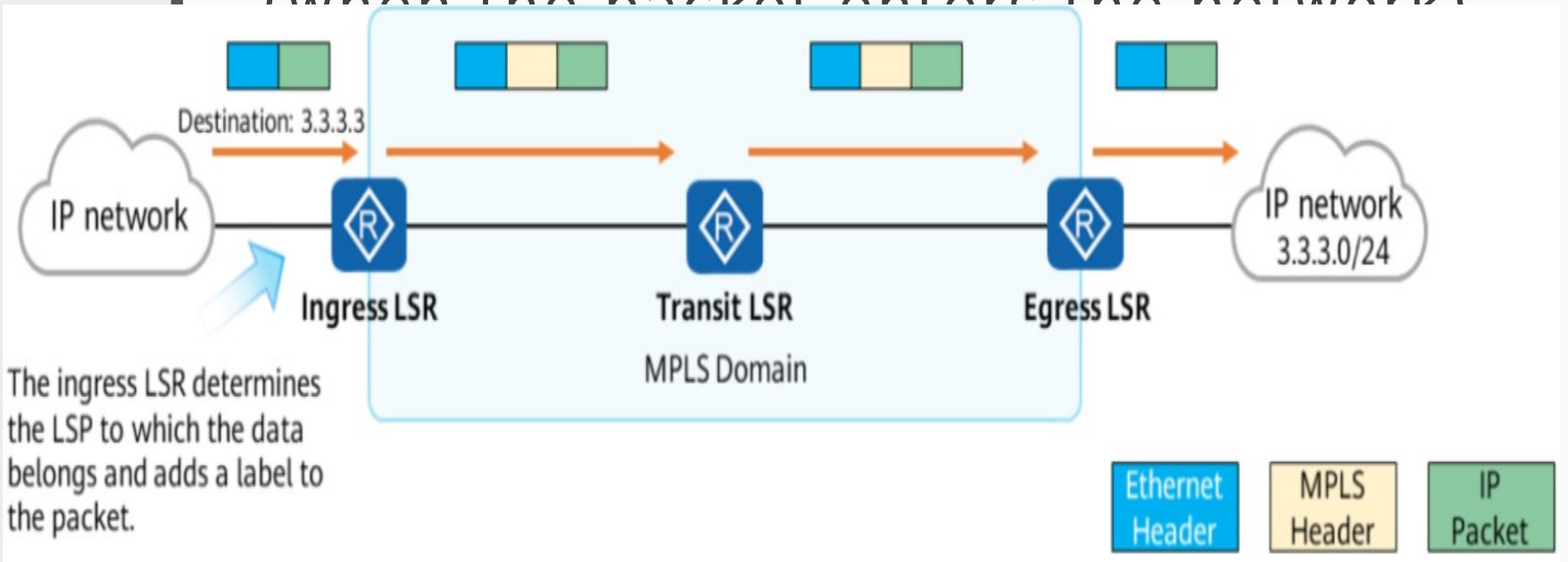
Basic Model for MPLS Network



LSR = Label Switched Router
LER = Label Edge Router

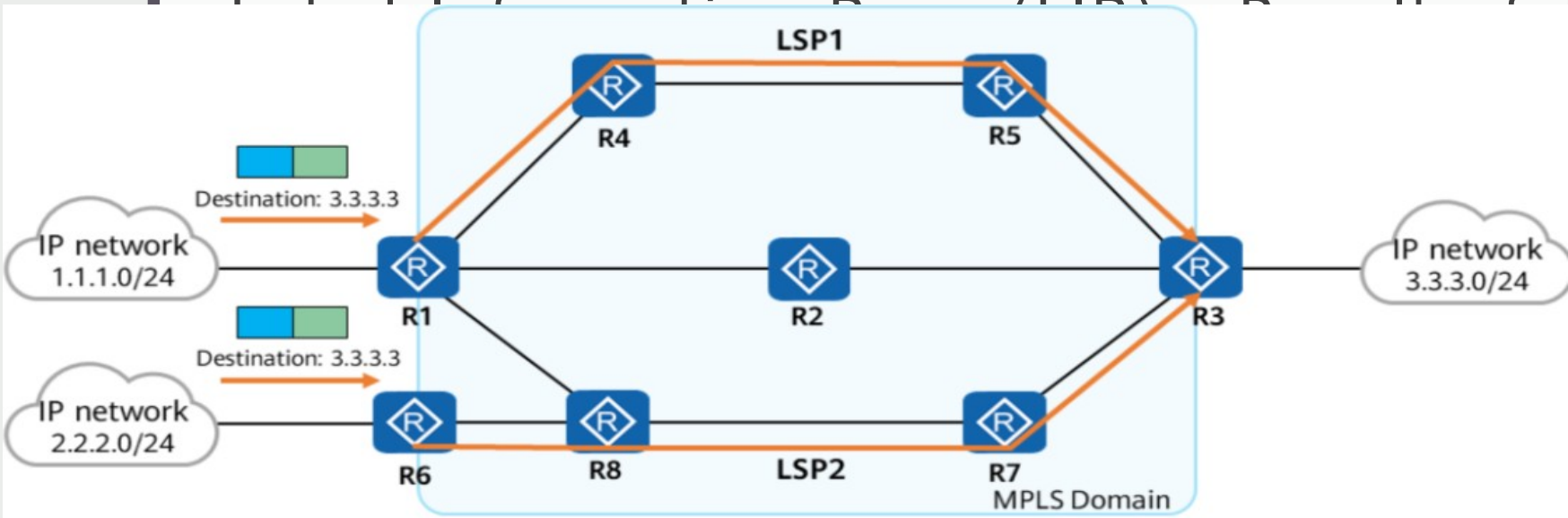
Forwarding Equivalence Class FEC

- Is a representation of a group of packets that share the same requirements for their transport like destination IP address, network masks, type of service, etc.
- The assignment of a particular packet to a particular FEC is done just once (when the packet enters the network)



Label-Switched Paths - LSPs

- A path is established before the data transmission starts. A path is a representation of a FEC.
- LSPs are generated and maintained in a distributed fashion.
- Each LSR negotiates a label for each Forwarding Equivalence Class (FEC) with its upstream and downstream neighbours using a distribution method.



MPLS Operations

- The following steps must be taken for a data packet to travel through an MPLS domain.

❖ label creation and distribution

❖ table creation at each router

❖ label-switched path creation

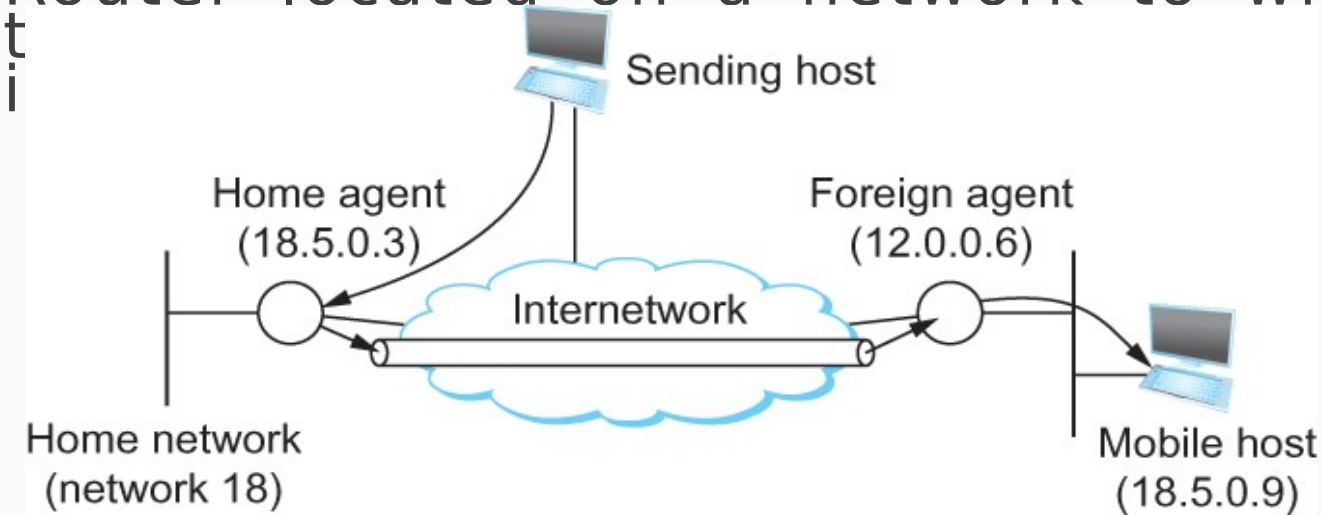
❖ label insertion/table lookup

❖ packet forwarding

Mobile IP

Routing in Mobile Devices

- home agent
- Router located on the home network of the mobile hosts
- home address
- The permanent IP address of the mobile host.
- Has a network number equal to that of the home network and thus of the home agent
- foreign agent
- Router located on a network to which t n it i



Routing in Mobile Devices

Problem of delivering a packet to the mobile node

- How does the home agent intercept a packet that is destined for the mobile node?

❖ Proxy ARP

- How does the home agent then deliver the packet to the foreign agent?

❖ IP tunnel

❖ Care-of-address

- How does the foreign agent deliver the packet to the mobile node?

"Triangle routing" Problem

- The Correspondent Host (CH) has to send packets to the Mobile Host (MH) via the Home Agent (HA), while the MH sends packets directly to the CH. As the communication in the two directions follows different routes, the problem of "triangle routing" arises, which leads to low efficiency especially when the MH is far away from the HA and the CH is near to the MH.

Handoff Problem

- It means that the HA sends the IP packets of the MH to the original foreign network via the tunnel because it doesn’t know the latest Care of Address (CoA) of the MH. As a result, these dropped IP packets have an

Problem of Intra-Domain Movement Routing in Mobile Devices

- The frequent intra-domain movement of the MH within a small area will lead to frequent handoff. Consequently, a great amount of registered messages are generated in the network and the network performance is greatly affected.

QoS Problem

- In the mobile environment, it is hard to provide QoS over Mobile IP due to dynamically varying wireless network topologies, limited network resources,

Next Chapter IV

Transport