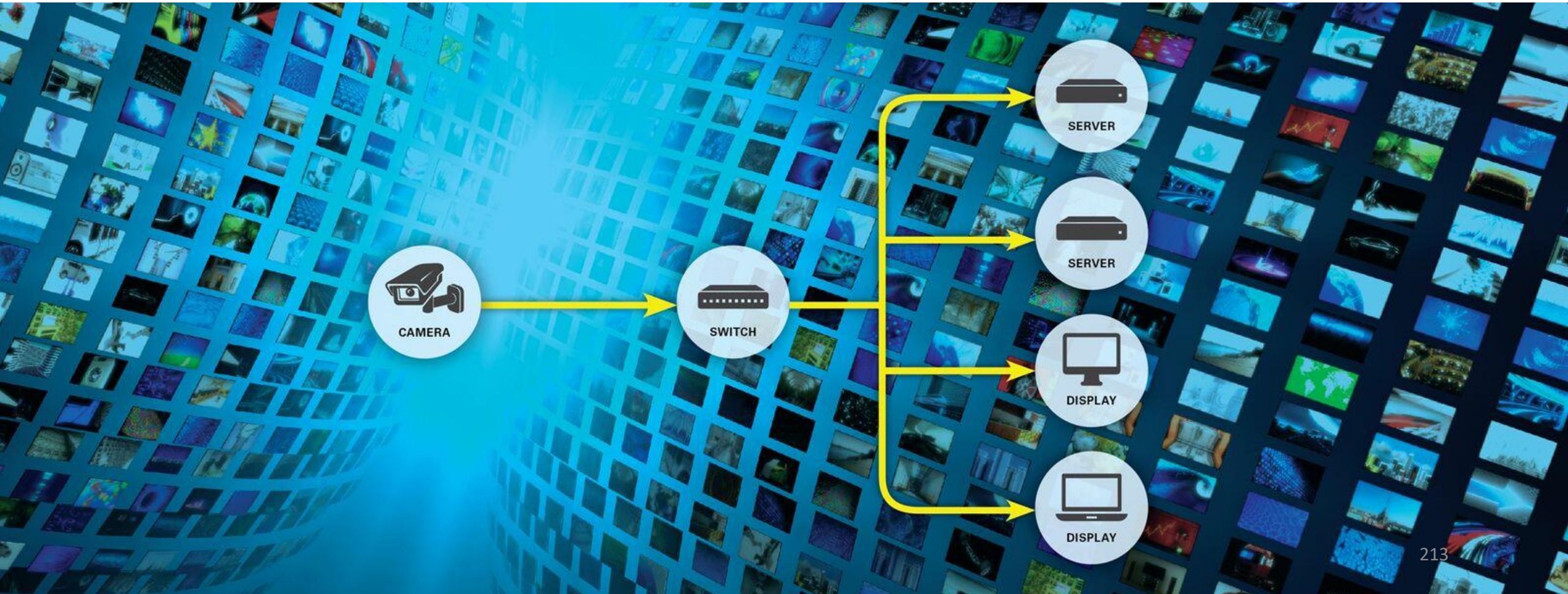
Multicast & Multicast Routing Protocols



Multicast & Multicast Routing Protocols

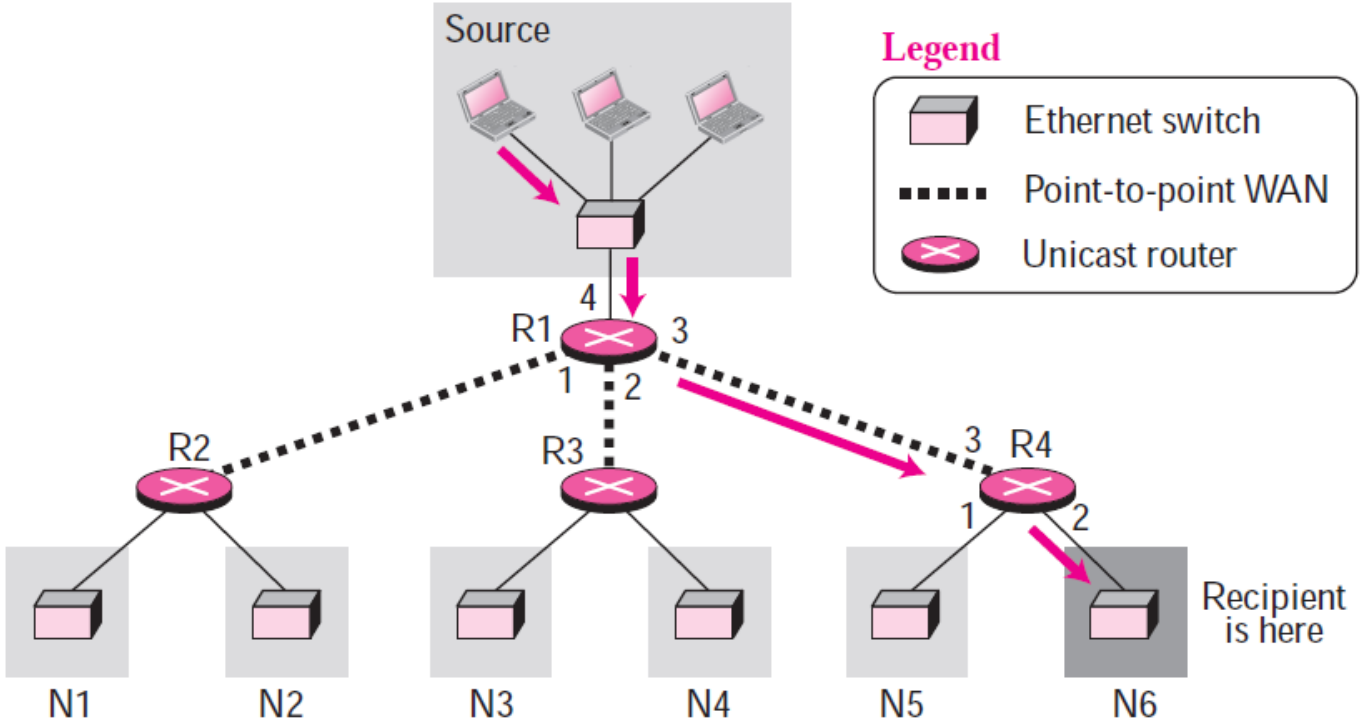
Introduction to Multicasting

a) Unicasting

- One Source and one Destination network
- Relationship between Source and Destination : One to One
- What is Unicasting?
  - Each router in the datagram path forwards packets to only one interface
- ***Example***
  - ***Problem:*** Delivery of packet from Source to Destination (N6)
  - ***Routers used:*** R1, R2 & R3
  - No of Ethernet Switches: 1

➢ *Solution*

- R1 forwards packets using interface 3
- R4 forwards packets using interface 2
- Delivery from Source to destination N6 is network's responsibility
- Mode of Delivery : Broadcast to all Hosts / Only to Destination (N6)



Unicasting – Example Scenario

Source: Behrouz A. Forouzan, "TCP IP Protocol Suite " 4th edition, 2010, McGraw-Hill ISBN: 0073376043

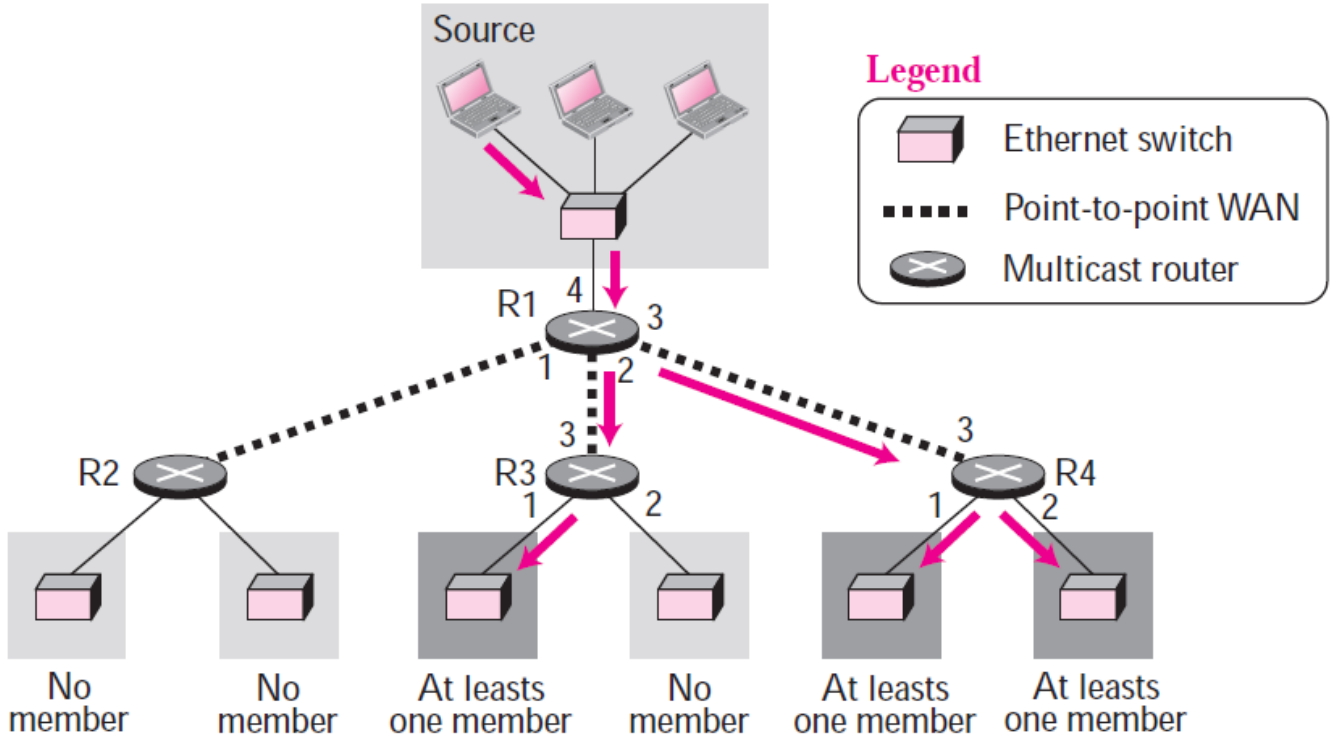
Multicast & Multicast Routing Protocols

Introduction to Multicasting Contd…

b) Multicasting

- One Source and one group of Destinations
- Relationship between Source and Destination : One to Many
- ***Source address:*** Unicast Address
- ***Destination address:*** Group of one / more Destination networks
  - At least one member interested in receiving the Multicast datagram
- Group address defines the group members
- ***Example***
  - Note: Unicast router replaced by Multicast router

- ***Routers used:*** R1, R2 & R3
- No of Ethernet Switches: 1
- ***Solution***
  - R1 forwards packets using interface 2 & 3
  - R4 forwards packets using interface 1 & 2
  - R3 forwards packet through interface 1



Multicasting – Example Scenario

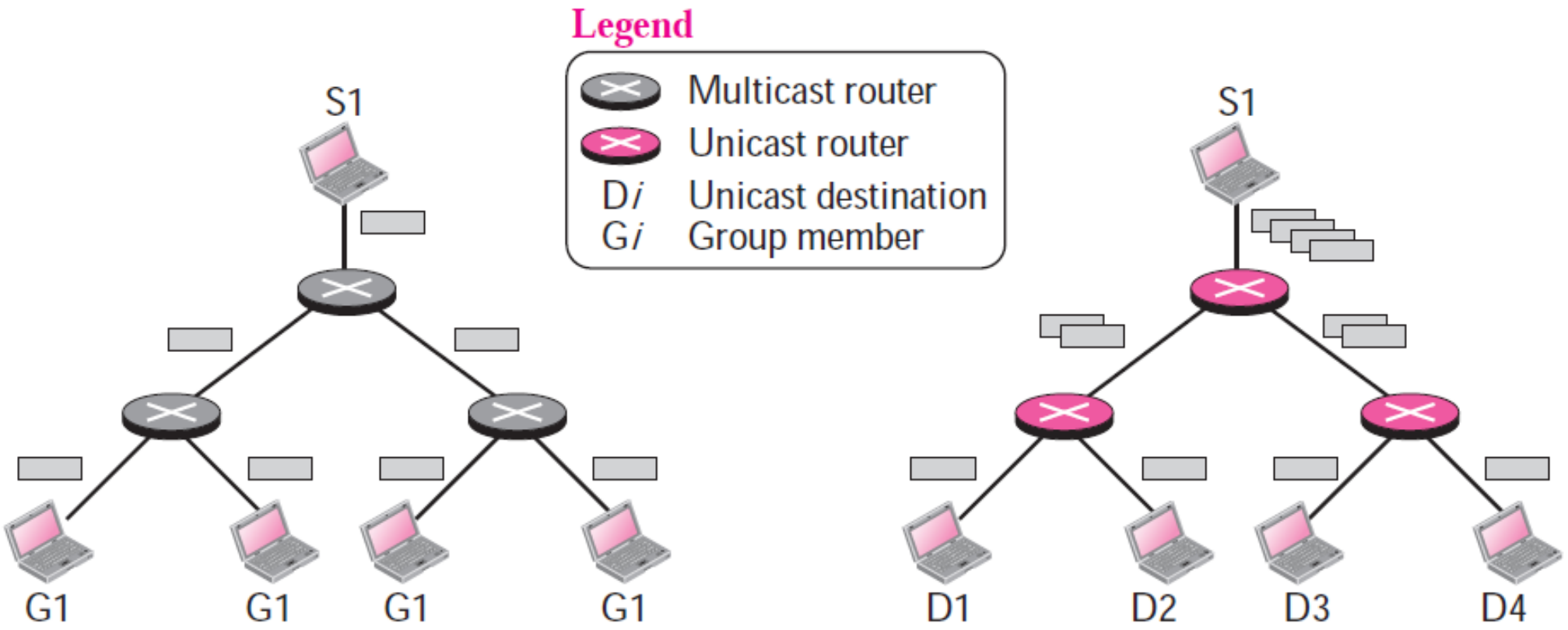
Source: Behrouz A. Forouzan, "TCP IP Protocol Suite " 4th edition, 2010, McGraw-Hill ISBN: 0073376043

Multicast & Multicast Routing Protocols

Introduction to Multicasting Contd…

c) Multicasting vs Multiple Unicasting

Multicasting	Multiple Unicasting
Single packet starts from the Source & duplicated by Routers	Multiple packets start from the Source and may have duplicates
Destination address in each packet remains the same for duplicates	Each packet has a different Unicast destination address
A single packet travels between two routers	There may be multiple copies between two routers
Example:	Example: Group E-mail



Multicasting ***Multiple Unicasting***

Multicasting vs Multiple Unicasting

Source: Behrouz A. Forouzan, "TCP IP Protocol Suite " 4th edition, 2010, McGraw-Hill ISBN: 0073376043

Introduction to Multicasting Contd…

d) Applications of Multicasting

i. Access to distributed databases

- ❑ Information stored in more than one location

ii. Information Dissemination

- ❑ Sending same information to multiple customer

iii. Dissemination of News

iv. Teleconferencing (Permanent or Temporary group)

v. Distance Learning

- ❑ Virtual Online classes

Multicast & Multicast Routing Protocols

Introduction to Multicasting Contd…

e) Why Multicasting cannot be emulated with Unicasting?

- Multicasting is efficient than unicasting
- Requires less bandwidth than unicasting
- There is no delay in Multicasting

f) Broadcasting

- One Source and all hosts are Destinations
- Relationship between Source and Destination : One to All
- Internet does not support broadcasting explicitly
  - Due to Huge traffic & Bandwidth issues

Multicast Addresses

Multicast & Multicast Routing Protocols

Multicast Addresses in IPv4

- Destination address for a group of hosts that are part of a multicast group
- If there are no filtering mechanisms, all the recipients will receive the message broadcast through multicast
- ***Multicast Addresses in IPv4***
  - Block assigned for multicasting is 224.0.0.0/4
  - i.e., block has 2^{28} = 268,435,456 addresses
  - 224.0.0.0 to 239.255.255.255 is the address space for Multicast
  - CIDR need not be assigned to every designated range

Multicast & Multicast Routing Protocols

CIDR	*Range*	*Assignment*
224.0.0.0/24	224.0.0.0 → 224.0.0.255	Local Network Control Block
224.0.1.0/24	224.0.1.0 → 224.0.1.255	Internetwork Control Block
	224.0.2.0 → 224.0.255.255	AD HOC Block
224.1.0.0/16	224.1.0.0 → 224.1.255.255	ST Multicast Group Block
224.2.0.0/16	224.2.0.0 → 224.2.255.255	SDP/SAP Block
	224.3.0.0 → 231.255.255.255	Reserved
232.0.0.0/8	232.0.0.0 → 224.255.255.255	Source Specific Multicast (SSM)
233.0.0.0/8	233.0.0.0 → 233.255.255.255	GLOP Block
	234.0.0.0 → 238.255.255.255	Reserved
239.0.0.0/8	239.0.0.0 → 239.255.255.255	Administratively Scoped Block

Multicast Address Ranges

Source: Behrouz A. Forouzan, "TCP IP Protocol Suite " 4th edition, 2010, McGraw-Hill ISBN: 0073376043

Multicast & Multicast Routing Protocols

Multicast Addresses in IPv4 Contd...

a) Local Network Control Block (224.0.0.1/24)

- Used for Protocol control traffic & not used for general Multicast communication
- Multicast / Multicast related protocols use this block of address
- Routers are not allowed to forward IP packets with TTL set to 1
- Packet remains in the network

b) Internetwork Control Block (224.0.1/24)

- Used for Protocol control traffic
- IP packets within this address block can be forwarded over the internet
- ***Example:*** 224.0.1.1 is used by NTP protocol

Addresses in Network Control Block

Address	*Assignment*
224.0.0.0	Base address (reserved)
224.0.0.1	All systems (hosts or routers) on this network
224.0.0.2	All routers on this network
224.0.0.4	DMVRP routers
224.0.0.5	OSPF routers
224.0.0.7	ST (stream) routers
224.0.0.8	ST (stream) hosts
224.0.0.9	RIP2 routers
224.0.0.10	IGRP routers
224.0.0.11	Mobile Agents
224.0.0.12	DHCP servers
224.0.0.13	PIM routers
224.0.0.14	RSVP encapsulation
224.0.0.15	CBT routers
224.0.0.22	IGMPv3

Source: Behrouz A. Forouzan, "TCP IP Protocol Suite " 4th edition, 2010, McGraw-Hill ISBN: 0073376043

Multicast & Multicast Routing Protocols

Multicast Addresses in IPv4 Contd...

c) AD-HOC Block

- ***Range:*** 224.0.2.0 to 224.0.255.0
- Assigned to applications that does not fit in 1st or 2nd block

d) Stream Multicast Group Block

- 224.1.0.0/16
- Allocated for stream multimedia

e) SAP / SDP Block

- 224.2.0.0/16
- Used for Session Announcement protocol & Session Directory protocol

Multicast & Multicast Routing Protocols

Multicast Addresses in IPv4 Contd...

f) SSM Block

- 232.0.0.0/8
- Used for Source Specific Multicasting

g) GLOP Block

- 233..0.0.0/8
- Defines a range of globally assigned addresses
- Used inside an autonomous system (AS) and assigned to a 16 bit number
- AS number inserted as the 2-middle Octet in the block to create range of 256 multicast addresses

Multicast Addresses in IPv4 Contd...

h) Administratively Scoped Block

- 239.0.0.0/8
- Used in a particular area in internet
- Address in this block restricted to an organization

Internet Group Management Protocol (IGMP)

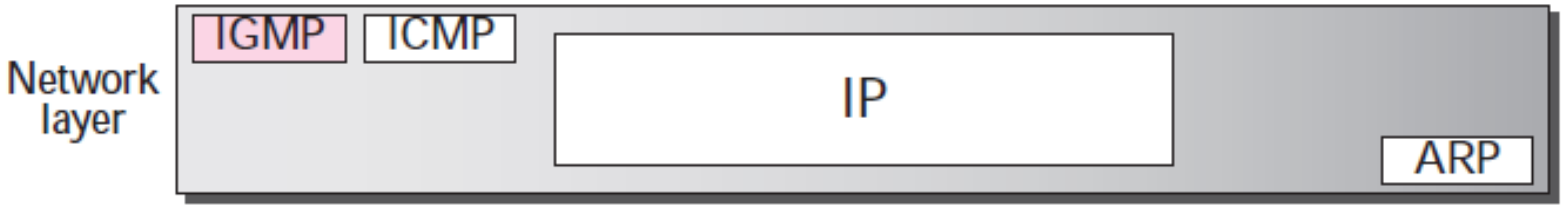
Multicast & Multicast Routing Protocols

Internet Group Management Protocol (IGMP)

- Multicast Communication: Message sent by sender to recipients of same group
  - One copy of message is copied and forwarded by multicast routers
- Multicast routers must know list of groups & minimum one loyal member related to each interface
- Information about members to be shared between multicast routers
- Information collected at two levels:
  - Locally (collected by IGMP)
  - Globally (propagated to other routers)

Multicast & Multicast Routing Protocols

Internet Group Management Protocol (IGMP) contd…



Position of IGMP in Network Layer

- IGMP collects & interprets information about group members in a network locally
- ***Note:*** IGMP is designed at the IP layer for the above said purpose

Source: Behrouz A. Forouzan, "TCP IP Protocol Suite " 4th edition, 2010, McGraw-Hill ISBN: 0073376043

Multicast & Multicast Routing Protocols

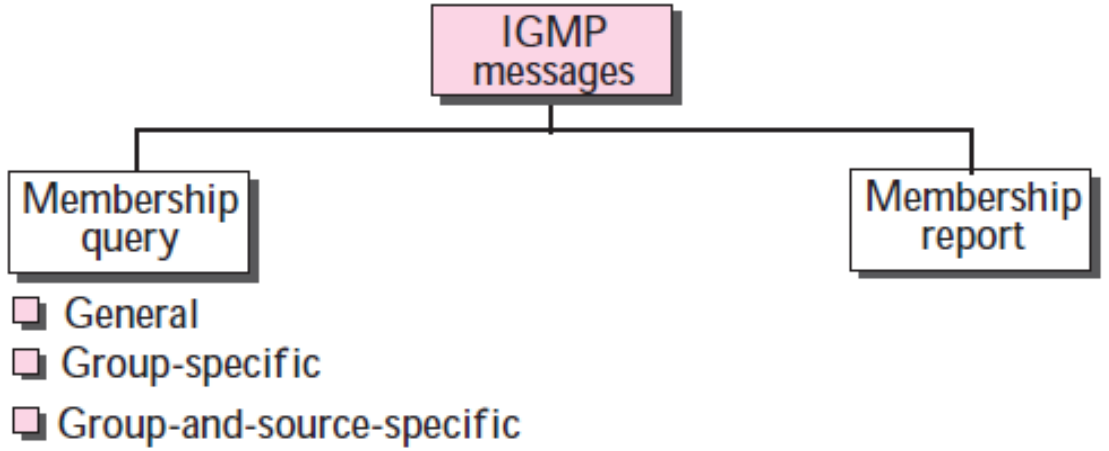
Internet Group Management Protocol (IGMP)

- ***Group Management***
- IGMP manages group membership
  - Provides information to the multicast routers about membership status of routers connected to a network
  - Maintains a list of groups in the network which has at least one loyal member
  - Without IGMP, traffic increases & more bandwidth is consumed
- ***Versions of IGMP:*** 1,2 & 3
  - Version 1 & 2 provides Any Source Multicast (ASM)
  - Version 3 provides Source Specific Multicast (SSM)

Multicast & Multicast Routing Protocols

Internet Group Management Protocol (IGMP)

- ***IGMPv3 Messages***
- Two types of messages
  a) Membership Query message
     i. General
     ii. Group Specific
     iii. Group and Source Specific
  b) Membership Report Message



IGMP Messages

Source: Behrouz A. Forouzan, "TCP IP Protocol Suite " 4th edition, 2010, McGraw-Hill ISBN: 0073376043

Multicast & Multicast Routing Protocols

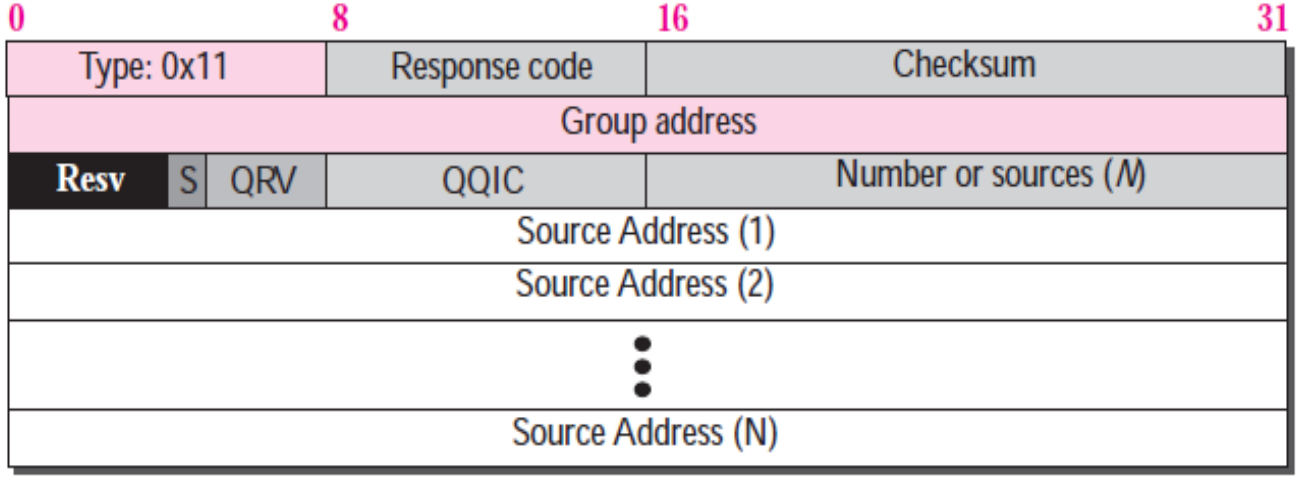
Internet Group Management Protocol (IGMP)

- ***IGMPv3 Messages Contd…***

a) Membership Query message

i. General Query Message

- Router probes each neighbor to report the whole group membership list



Membership Query Message Format

ii. Group Specific Query Message

- Router probes each neighbor to report if it is still interested in a specific group
- ***Multicast group address*** defined as *x.y.z.t* in group address field

Internet Group Management Protocol (IGMP)

- ***IGMPv3 Messages Contd…***

iii. Group and Source Specific Query message

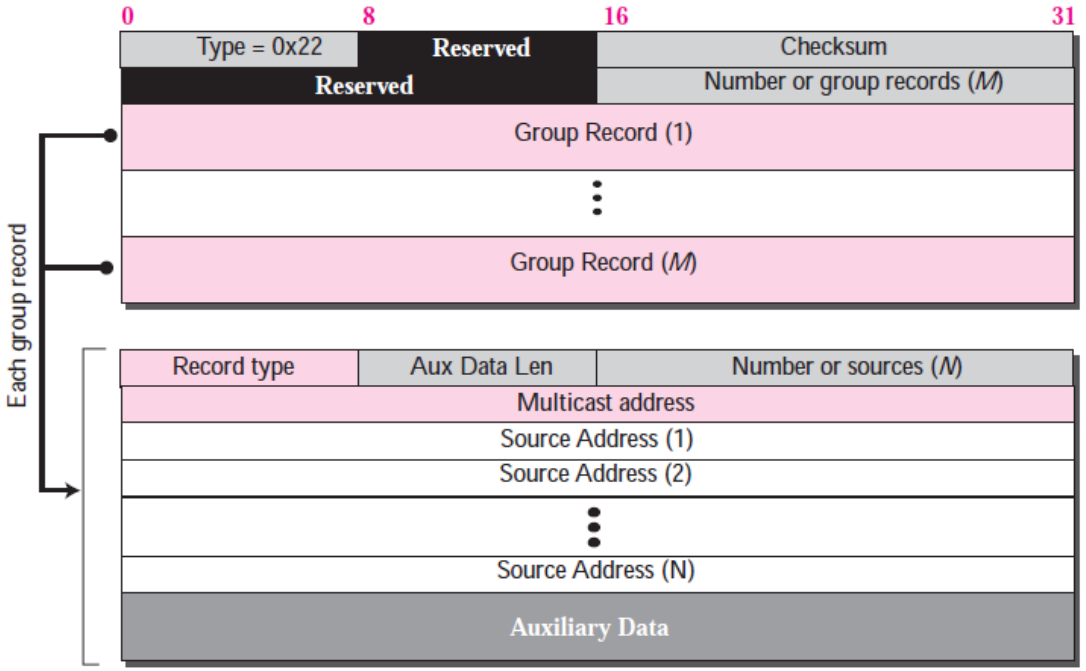
- Router probes each neighbor to report it is still in a specific multicast group

b) Membership Query message format

- Important fields
  - Checksum
  - Number of Sources
  - Aux data
  - Aux Data Len

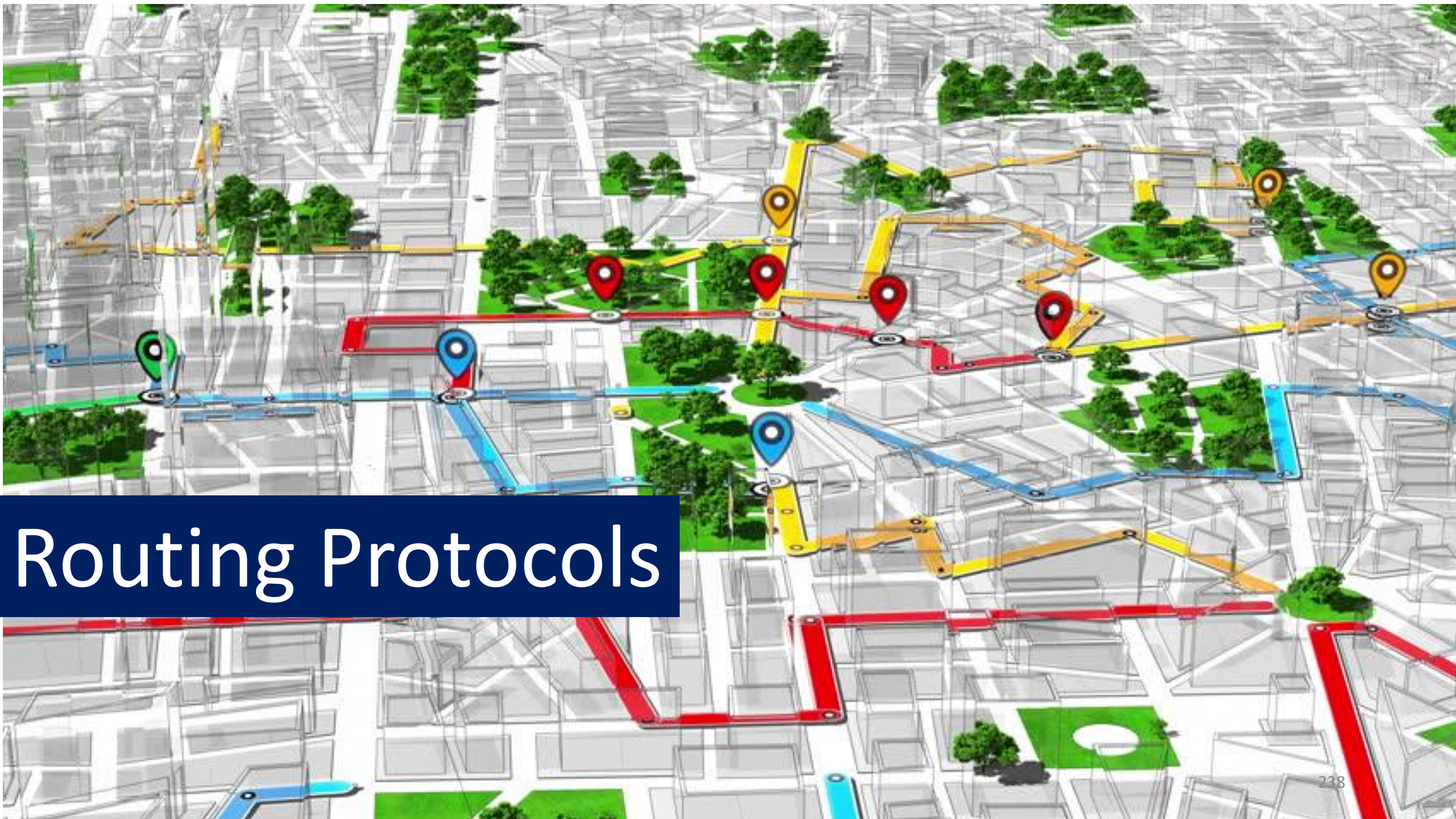
Internet Group Management Protocol (IGMP)

➢ IGMPv3 Messages Contd...



Membership Report Message Format

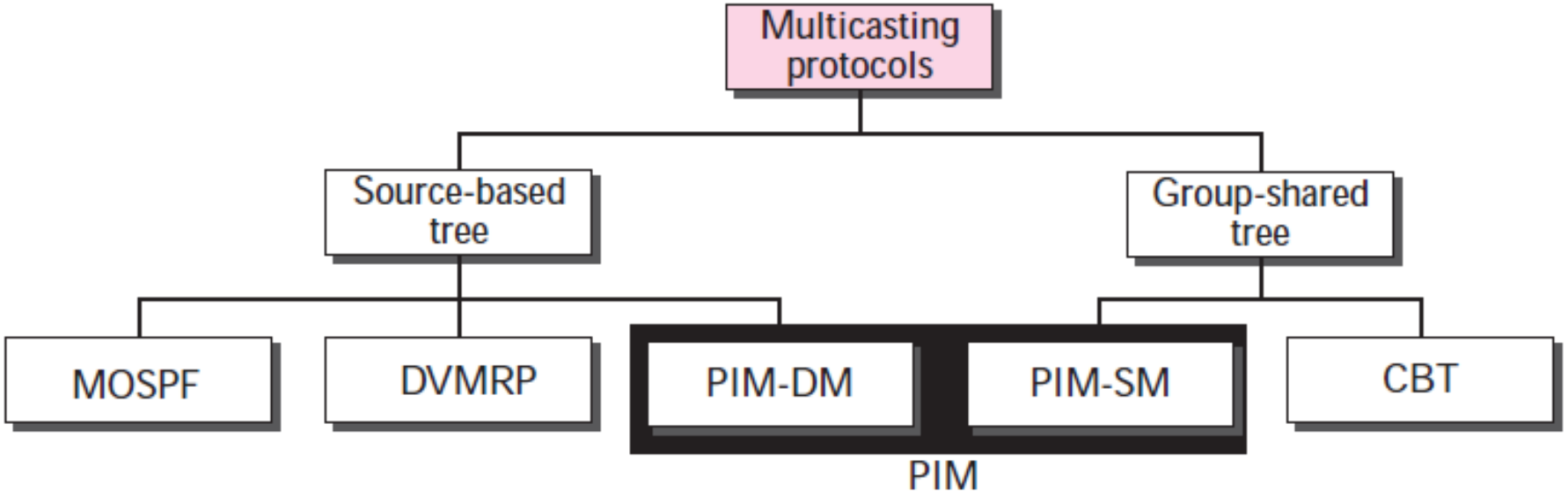
Source: Behrouz A. Forouzan, "TCP IP Protocol Suite " 4th edition, 2010, McGraw-Hill ISBN: 0073376043



Routing Protocols

Multicast & Multicast Routing Protocols

Routing Protocols



Taxonomy of Common Multicast Protocols

Source: Behrouz A. Forouzan, "TCP IP Protocol Suite " 4th edition, 2010, McGraw-Hill ISBN: 0073376043

Multicast & Multicast Routing Protocols

Routing Protocols Contd…

Multicast Link state routing

- Extension of unicast routing
- Uses source based tree approach
- Node advertises every group that has any loyal member on the link
- Group information comes form IGMP
- Router creates ‘n’ groups based on Link state Packets (LSP’s)
- Note: Each router has a routing table that has ‘n’ shortest path trees
- Disadvantage: More Time & Space needed to create & Store shortest path trees

Multicast & Multicast Routing Protocols

Routing Protocols Contd…

a) Multicast Open Shortest path first : MOSPF

- Data driven protocol & Extension of OSPF
- Uses multicast link state routing to create source based trees
- Group membership LSA includes hosts in the tree that's belongs to a group
- When MOSPF router encounters a datagram with a given source and group address
  - Router constructs the Dijkstra shortest path tree

Routing Protocols Contd…

b) Multicast Distance Vector Routing Protocol

- Uses source-based trees but router does not make a routing table
- Router receives multicast packet and forwards
- After forwarding the packet the table is destroyed
- MDV uses a process based on 4 decision making strategies
  i. Flooding
  ii. Reverse path forwarding (RPF)
  iii. Reverse Path Broadcasting (RPB)
  iv. Reverse path Multicasting (RPM)

Multicast & Multicast Routing Protocols

Routing Protocols Contd…

b) Multicast Distance Vector Routing Protocol Contd…

i. Flooding

- Router forwards received packets and sends to every interface except itself
- Destination group address is not checked
- Every network with active members receives the packet
- Networks without active members also receive the packet
- Flooding supports broadcast not unicast
- ***Disadvantage:*** Creation of loops
  - Overcome by Reverse Path Forwarding (RPF)

Multicast & Multicast Routing Protocols

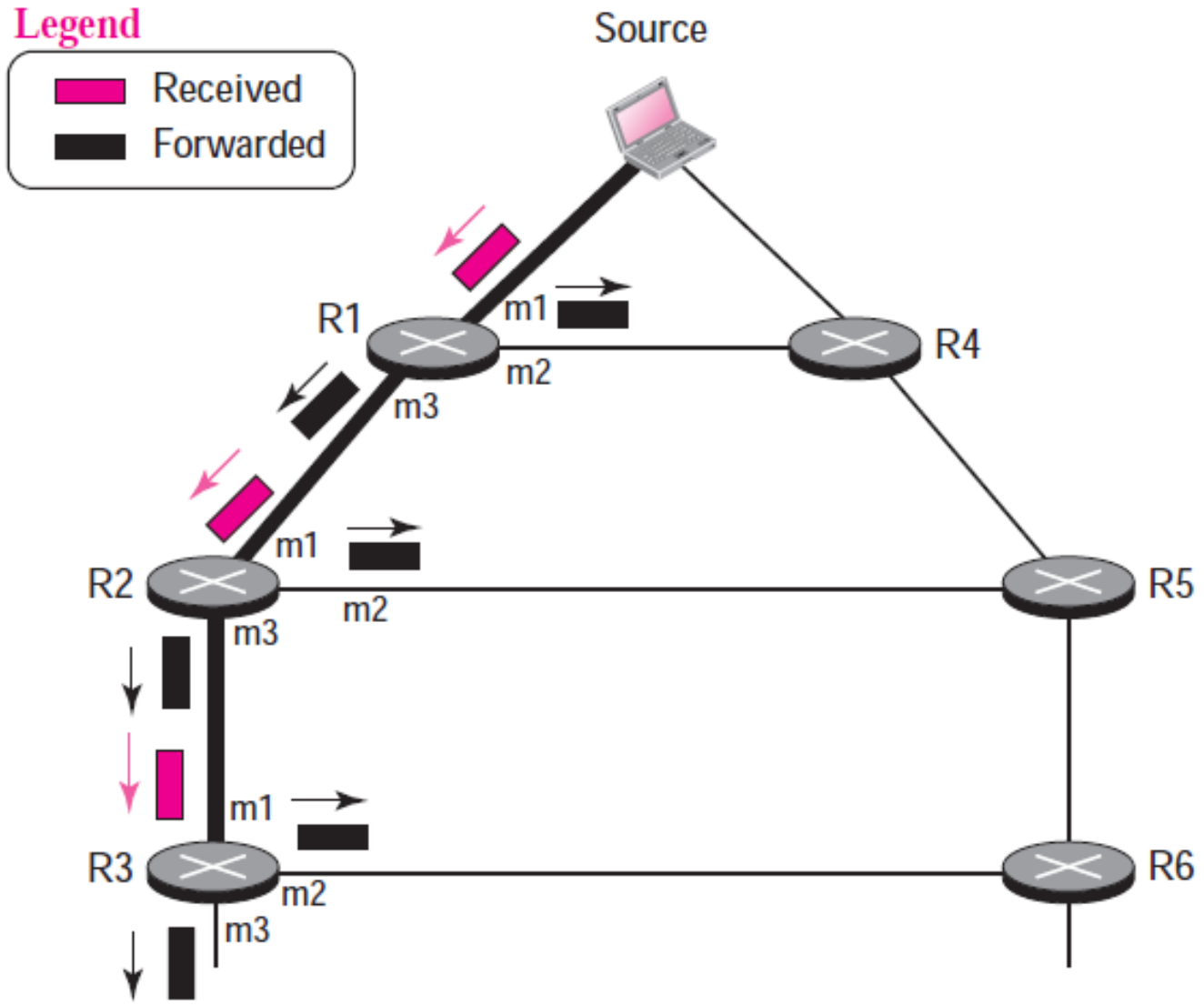
Routing Protocols Contd…

b) Multicast Distance Vector Routing Protocol Contd…

ii. Reverse Path Forwarding (RPF)

- Modified flooding strategy: Only one copy is forwarded to avoid flooding
  - Router forwards the copy that has travelled the shortest path from Source to router
- RPF uses Unicast routing table to find this packet
- Looping is prevented, since there is only one shortest path from Source to Router
- ***Disadvantage:*** No guarantee that each network receives only one copy; Network may receive multiple copies

- Routers: R1, R2, R3, R4, R5 & R6
- Shortest Path : R1, R2 & R2
- R1 receives packet from source through interface m1
  - Packet forwarded
- Packet forwarded to R2 and R3 similarly
- Note: Upstream routers towards source always discards packet not gone through the shortest path



Reverse Path Forwarding (RPF)

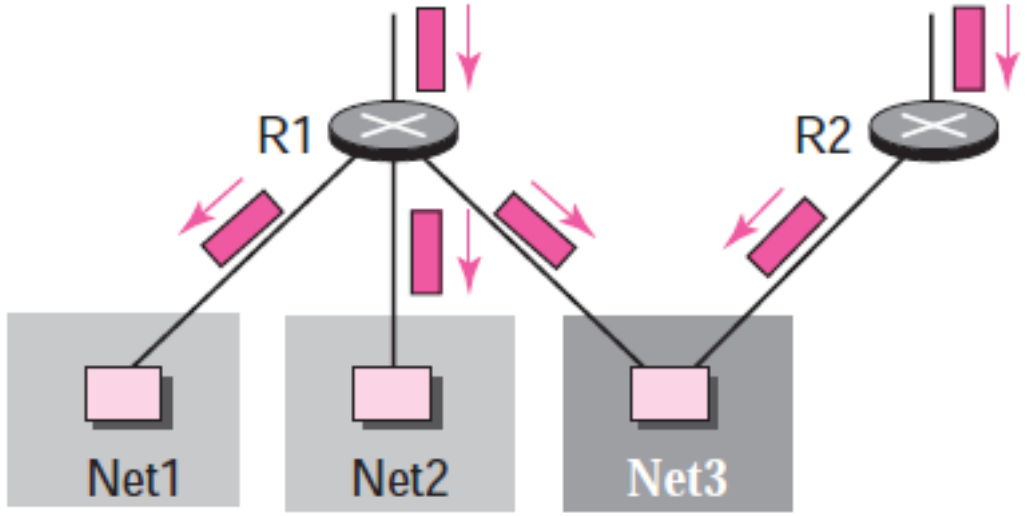
Source: Behrouz A. Forouzan, "TCP IP Protocol Suite " 4th edition, 2010, McGraw-Hill ISBN: 0073376043

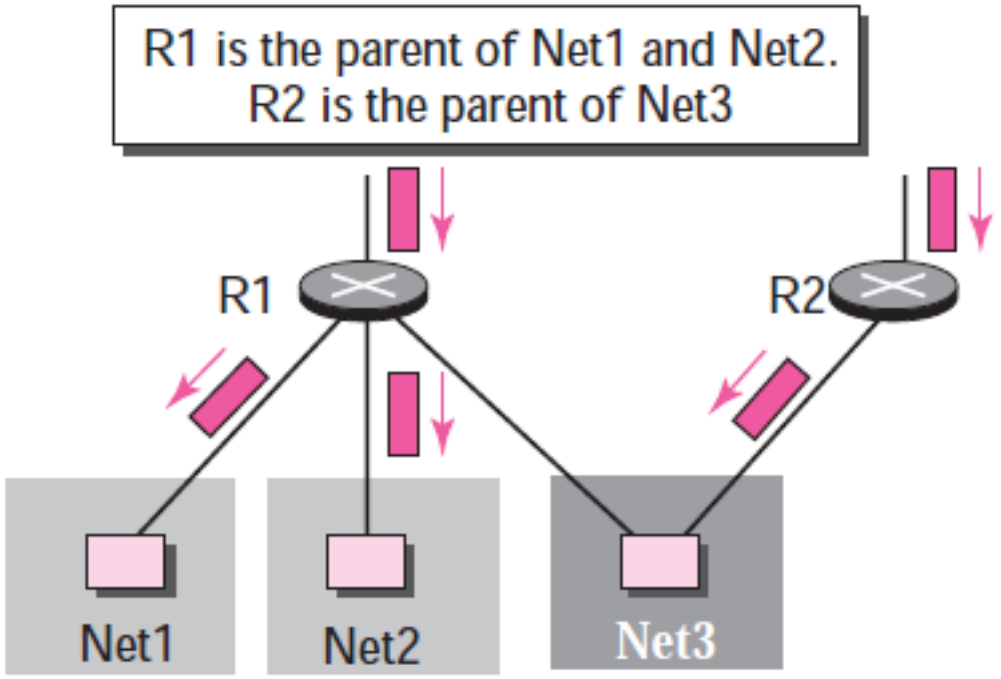
Routing Protocols Contd…

b) Multicast Distance Vector Routing Protocol Contd…

iii. Reverse Path Broadcasting (RPB)

- Problem in RPF is overcome by eliminating duplication
- Restriction used in RPB: Only one parent router defined for each network
- Policy: For each source, router sends packet only out of interfaces which is the designated parent
- RPB guarantees the elimination of duplicate copies
- ***Designated Parent:*** Router with the shortest path to the source
- ***Disadvantage:*** RPB broadcasts, not multicasts





Reverse Path Forwarding (RPF)

Reverse Path Broadcasting (RPB)

Difference between RPF and RPB

Source: Behrouz A. Forouzan, "TCP IP Protocol Suite " 4th edition, 2010, McGraw-Hill ISBN: 0073376043

Multicast & Multicast Routing Protocols

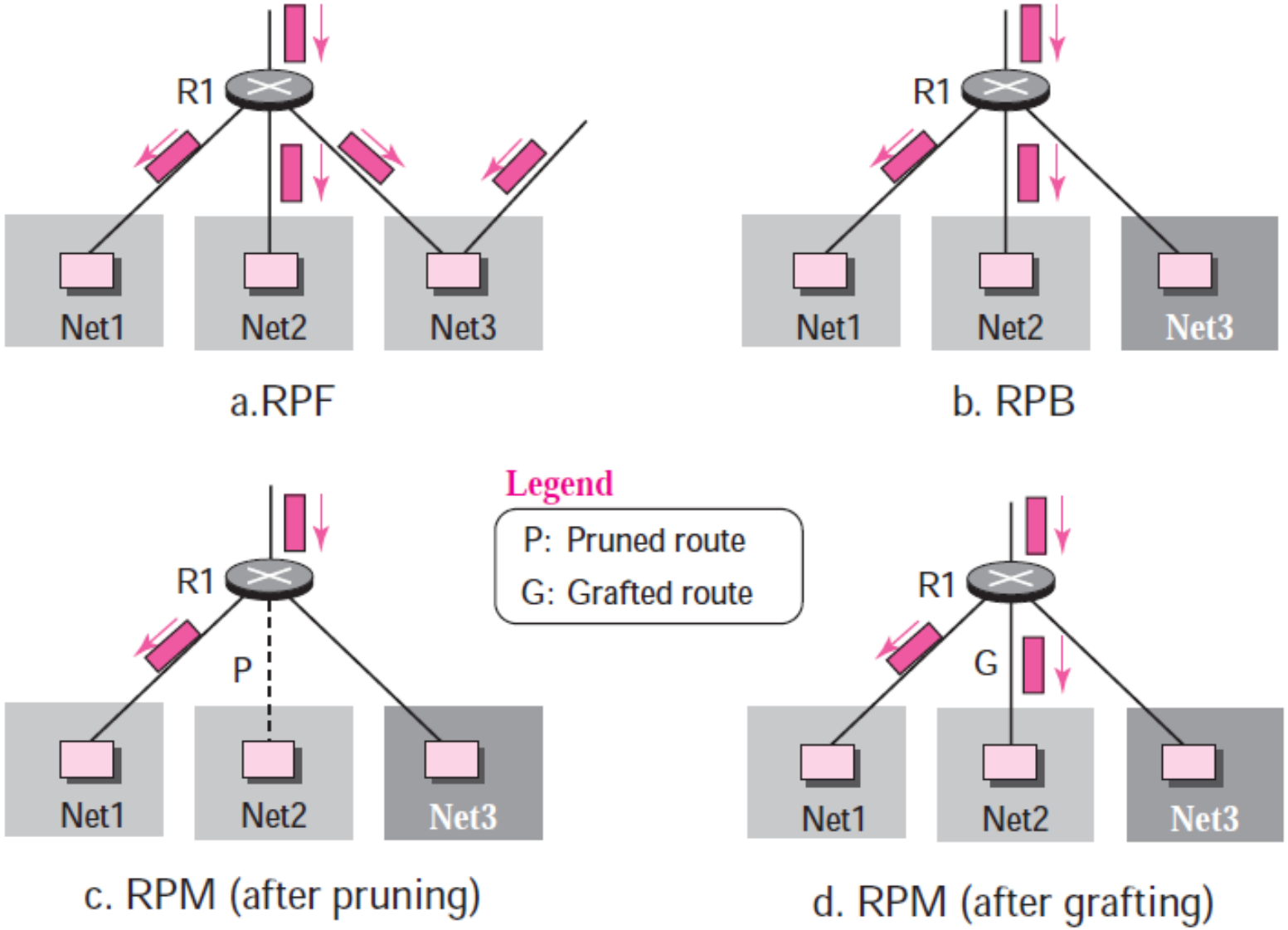
Routing Protocols Contd…

b) Multicast Distance Vector Routing Protocol Contd…

iv. Reverse Path Multicasting (RPM)

- Multicast packet must reach networks with active members for the particular group only
- To convert broadcast to multicast: use Pruning & Grafting
- ***Pruning:*** Prune message sent to upstream router to prune corresponding interface
- ***Grafting:*** Graft message forces upstream router to resume sending multicast images

RPF, RPB & RPM



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Multicast & Multicast Routing Protocols

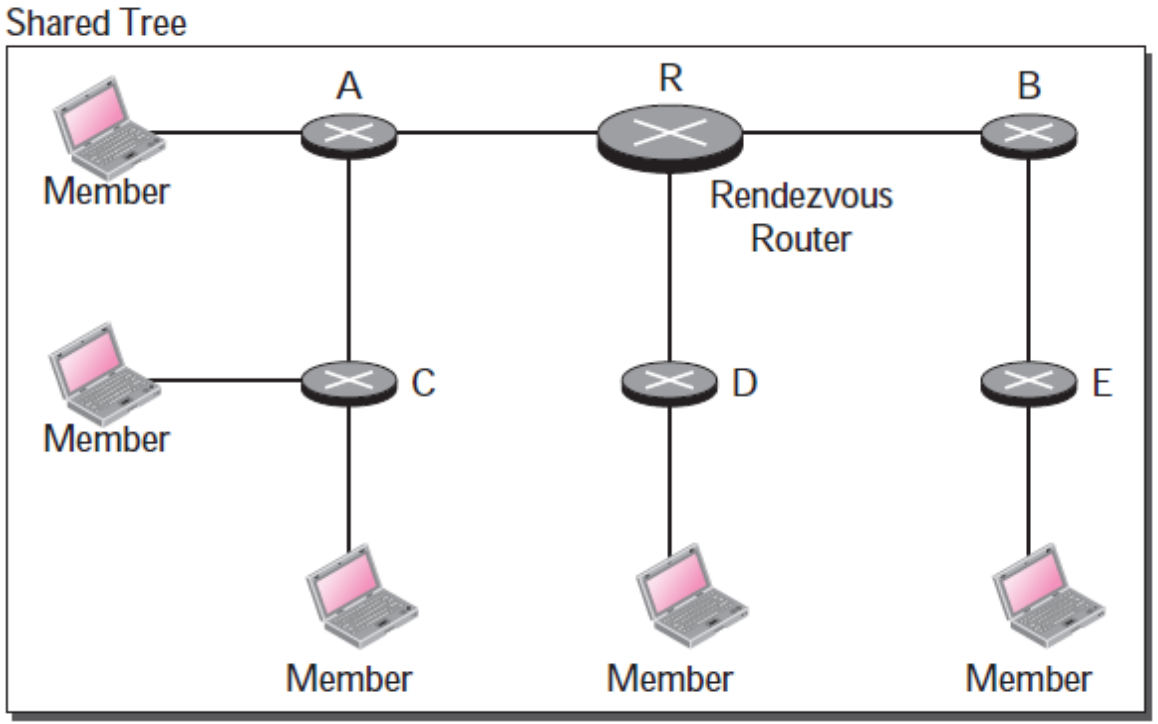
Routing Protocols Contd…

c) Core-Based Tree Protocol

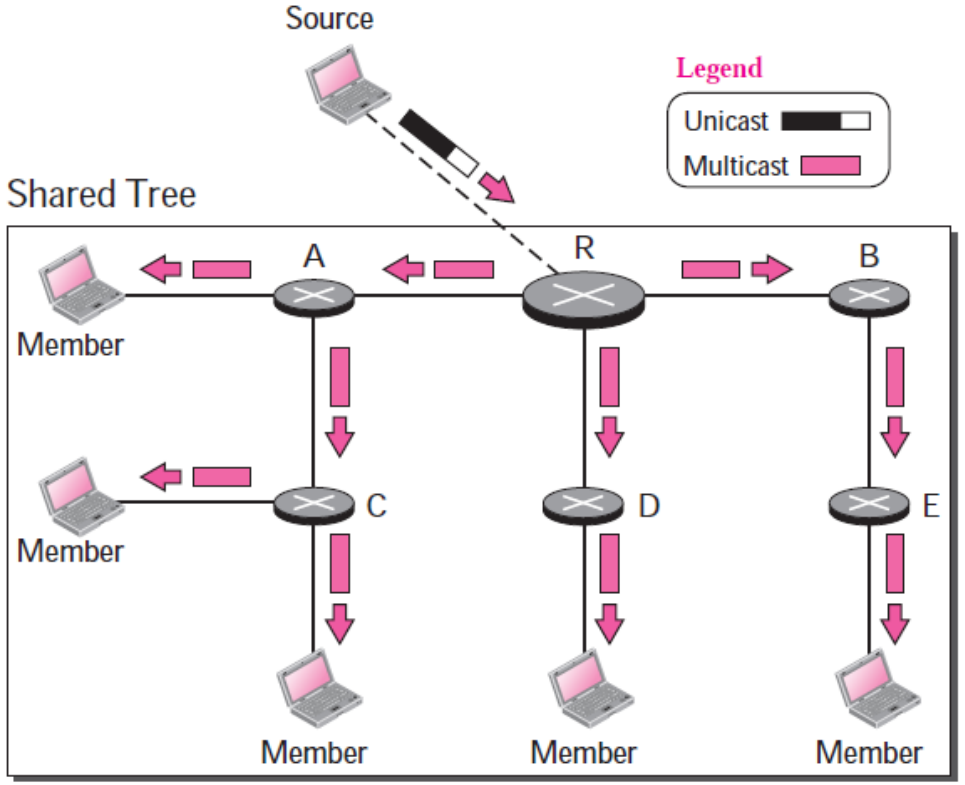
- Group-shared tree, center-based protocol; Uses one tree per group
- One of the routers in the tree is called the core
- ***Procedure for sending Packet from Source to Group members:***

1) Source encapsulates the multicast packet inside a unicast packet with the unicast destination address of the core and sends it to the core
   - This part of delivery is done using a unicast address
   - The only recipient is the core router
2) Core decapsulates the unicast packet and forwards it to all interested interfaces

3) Each router that receives the multicast packet, in turn, forwards it to all interested interfaces



Group-shared Tree with Rendezvous Router



Sending a Multicast Packet to the Router

Source: Behrouz A. Forouzan, "TCP IP Protocol Suite " 4th edition, 2010, McGraw-Hill ISBN: 0073376043

Multicast & Multicast Routing Protocols

Routing Protocols Contd…

d) Protocol Independent Multicast (PIM)

- Consists of two protocols

i. Protocol Independent Multicast, Dense Mode (PIM-DM)

- Source-based tree routing protocol
  - Uses RPF & Pruning / Grafting strategies for Multicasting
- Used when each router in involved in Multicasting
- Used in dense environment : LAN
- PIM-DM can be either be a Distance Vector Protocol (RIP) (or) Link State Protocol (OSPF)

Multicast & Multicast Routing Protocols

Routing Protocols Contd…

d) Protocol Independent Multicast (PIM) Contd…

ii. Protocol Independent Multicast, Sparse Mode (PIM-SM)

- Group-shared tree routing protocol; Similar to CBT
- Simple to implement
- Rendezvous point at the Source of Tree
- No Acknowledgement required from a join message
- ***Characteristic:*** Can switch between Group shared (or) Source based Strategy