Chapter 21

Multicast Routing

21-1 INTRODUCTION

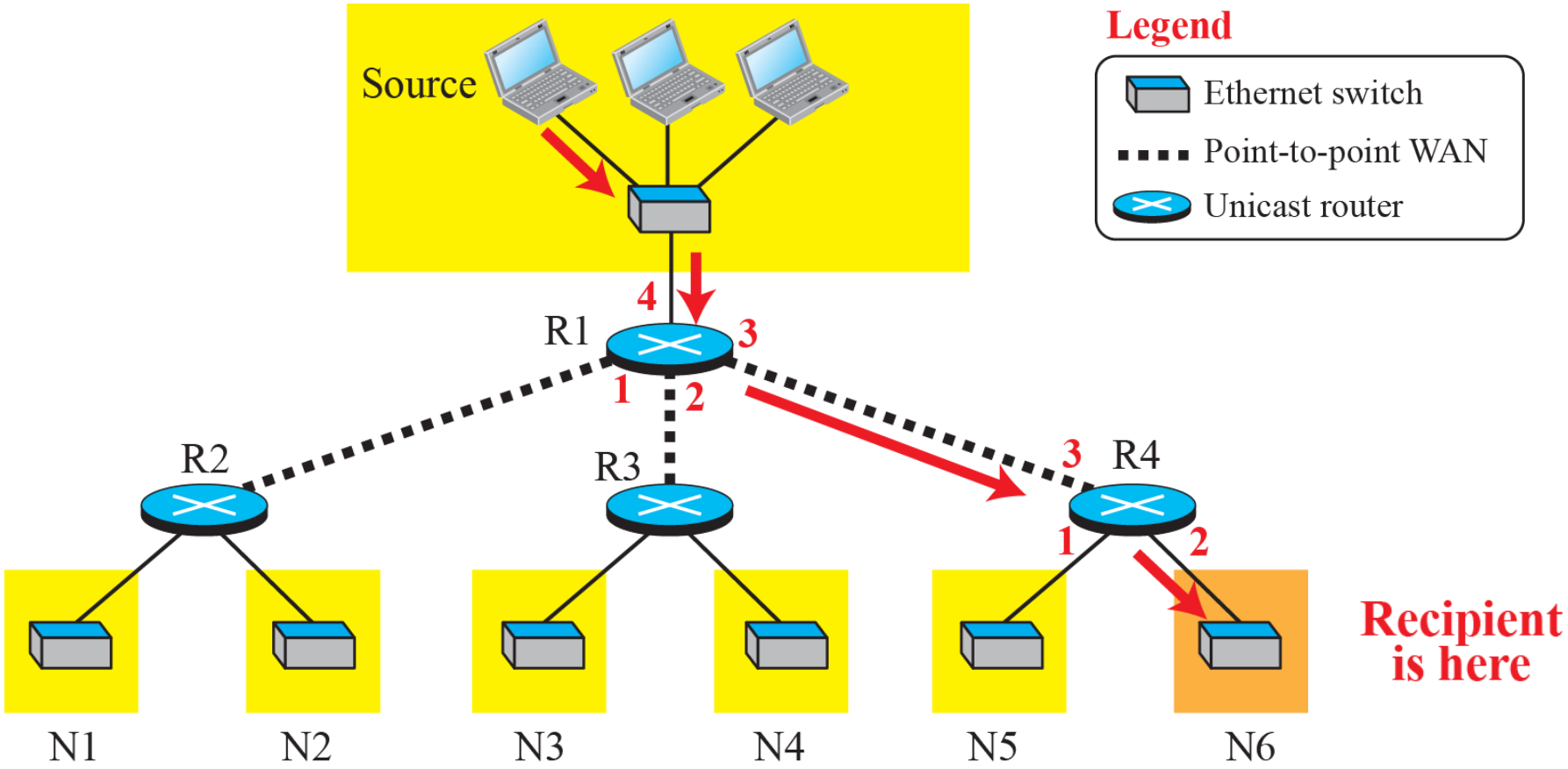
In this section, we first discuss,

- General ideas behind unicasting, multicasting, and broadcasting.
- Some basic issues in multicast routing.
- multicasting routing protocols in the Internet.
- IGMP

221.21.1 Unicasting

- In unicasting, there is one source and one destination network.
- The relationship between the source and the destination network is one to one.
- Each router in the path of the datagram tries to forward the packet to one and only one of its interfaces.

Figure 221.1: ***Unicasting***



20.21.2 Multicasting

- In multicasting, there is one source and a group of destinations. The relationship is one to many.

- In this type of communication, the source address is a unicast address, but the destination address is a group address, a group of one or more destination networks in which there is at least one member of the group that is interested in receiving the multicast datagram.

- The group address defines the members of the group.

Figure 221.2: ***Multicasting***

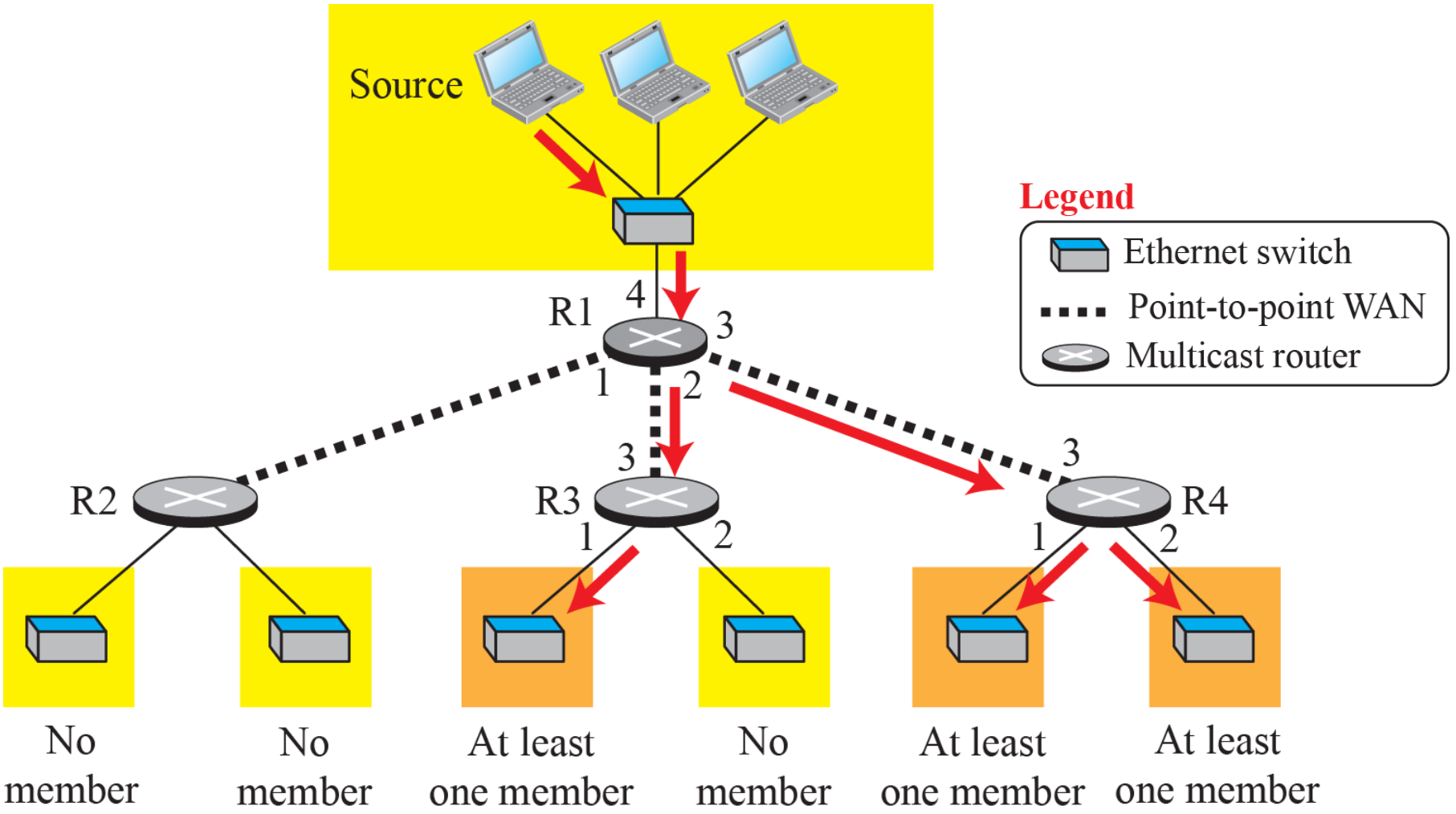
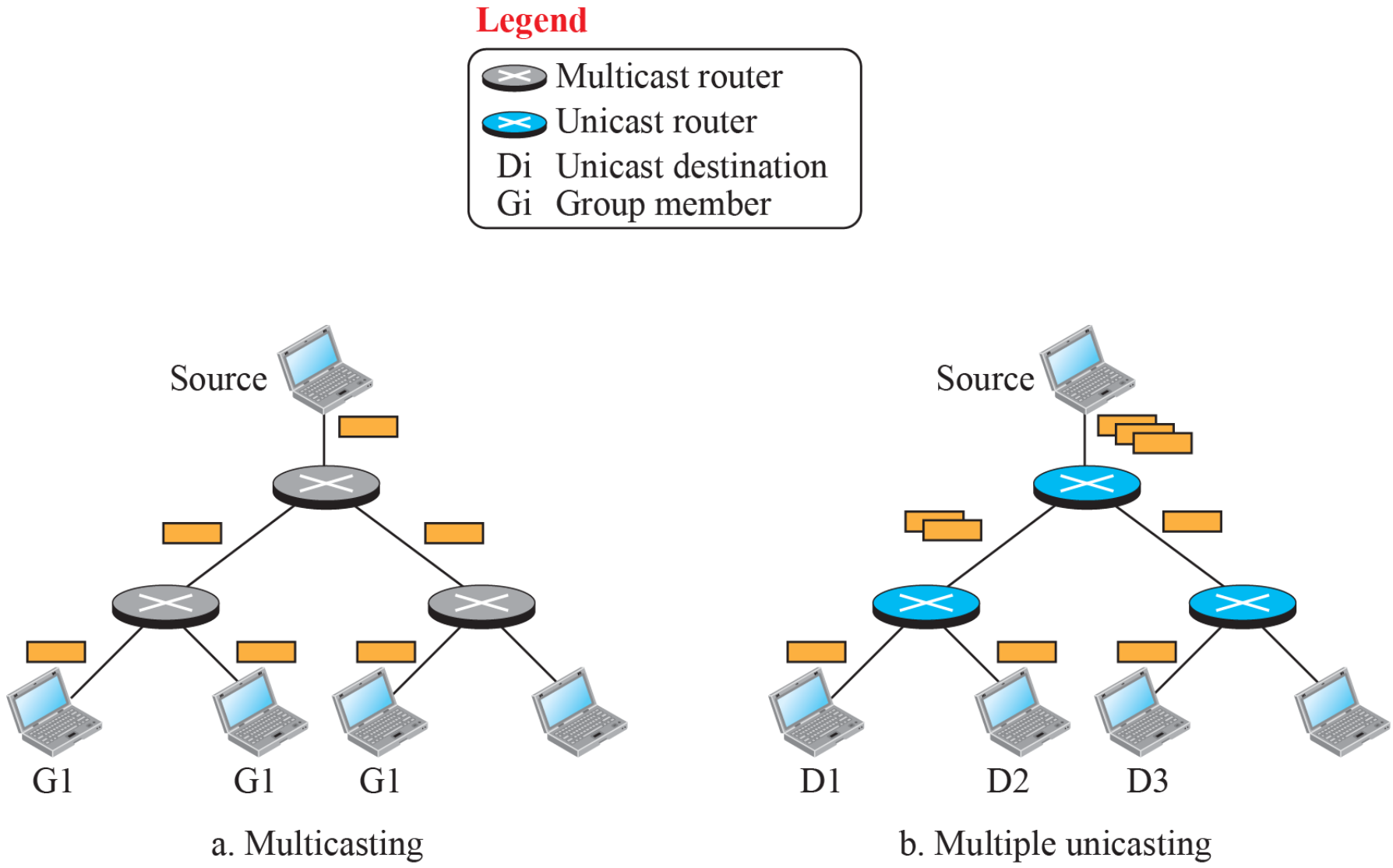


Figure 221.3: Multicasting versus multiple unicasting



21-1 MULTICAST BASICS

Before discussing multicast routing protocols in the Internet, we need to discuss some multicasting basics: multicast addressing, collecting information about multicast groups, and multicast optimal trees.

221.2.1 Multicast Addresses

In multicast communication, the sender is only one, but the receiver is many, sometimes thousands or millions spread all over the world. It should be clear that we cannot include the addresses of all recipients in the packet.

The destination address of a packet, as described in the Internet Protocol (IP) should be only one. For this reason, we need multicast addresses.

A multicast address defines a group of recipients, not a single one. In other words, a multicast address is an identifier for a group.

Figure 221.4: Needs for multicast addresses

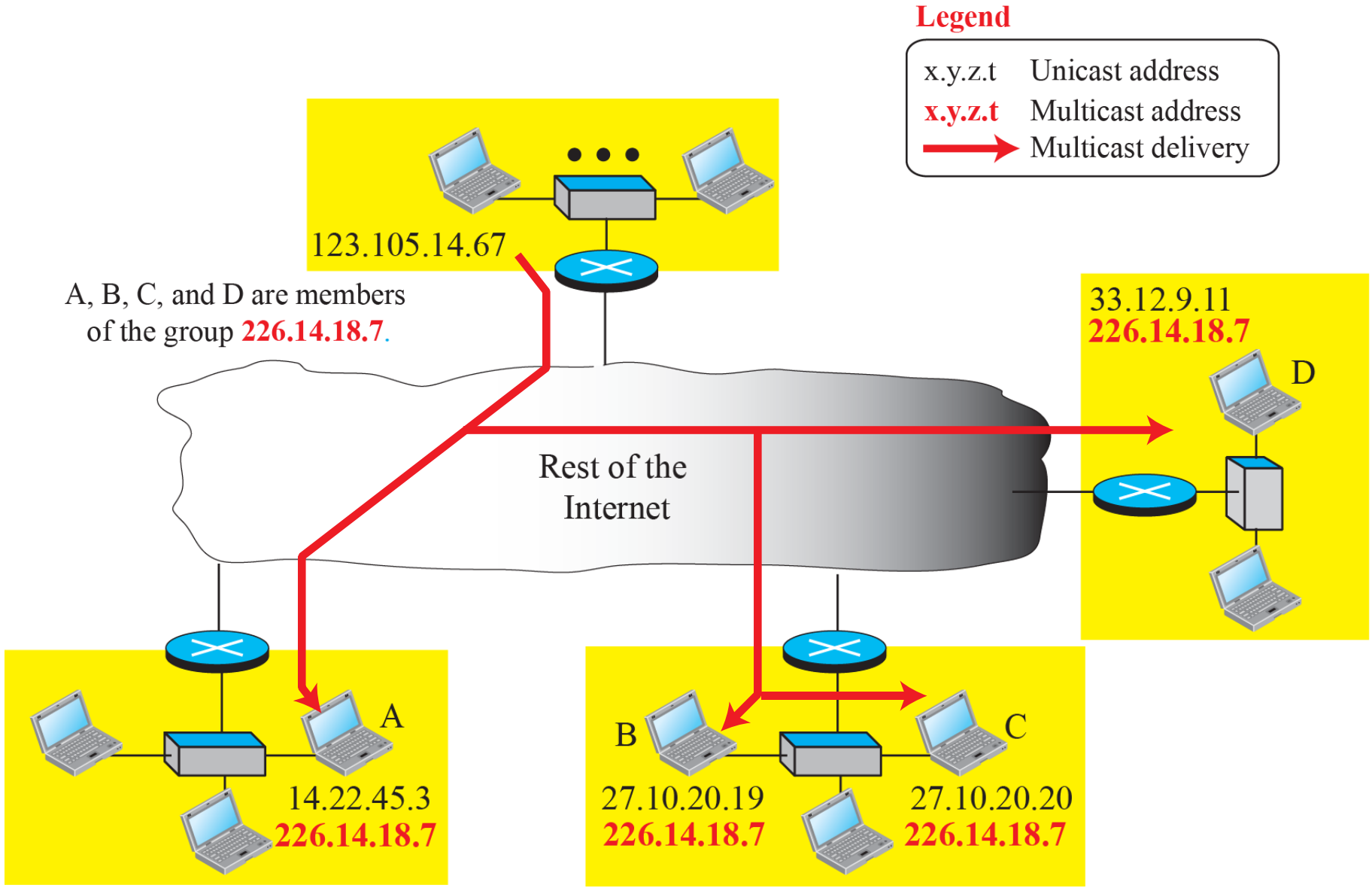
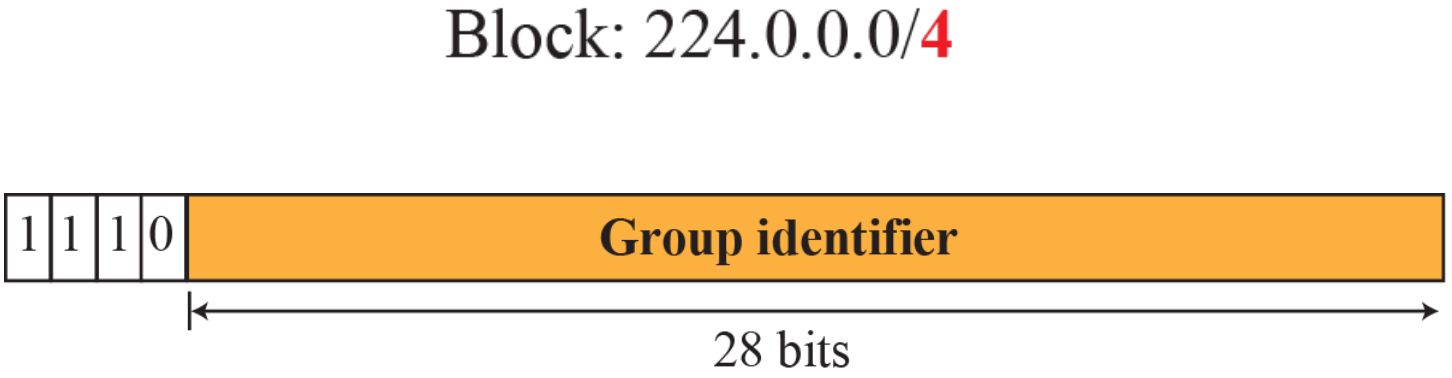


Figure 221.5: A multicast address in binary



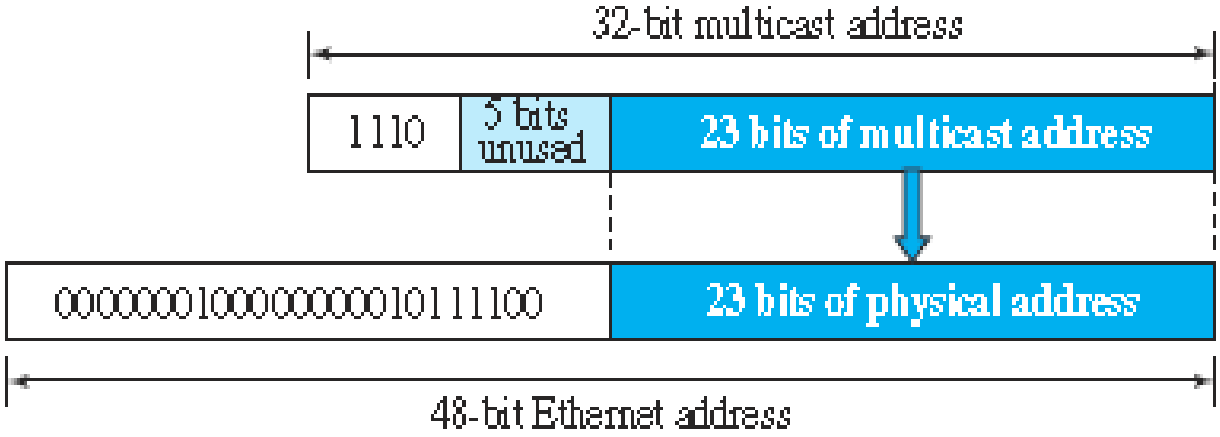
Delivery at Data Link Layer

- Corresponding ARP protocol cannot find corresponding multicast MAC Address to forward a multicast packet at data link layer.

- It depends on underlying data link layer supports physical multicast addresses.

Network with Multicast Support

Figure 21.6 *Mapping class D to Ethernet physical address*

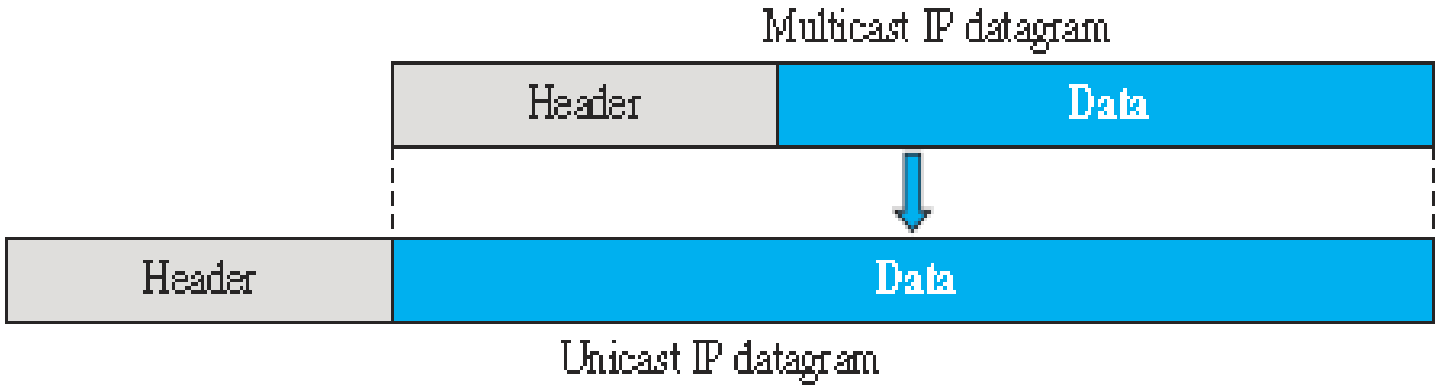


An Ethernet multicast physical address is in the range

01:00:5E:00:00:00 to 01:00:5E:7F:FF:FF

Network with No multicast Support

Figure 21.7 *Tunneling*



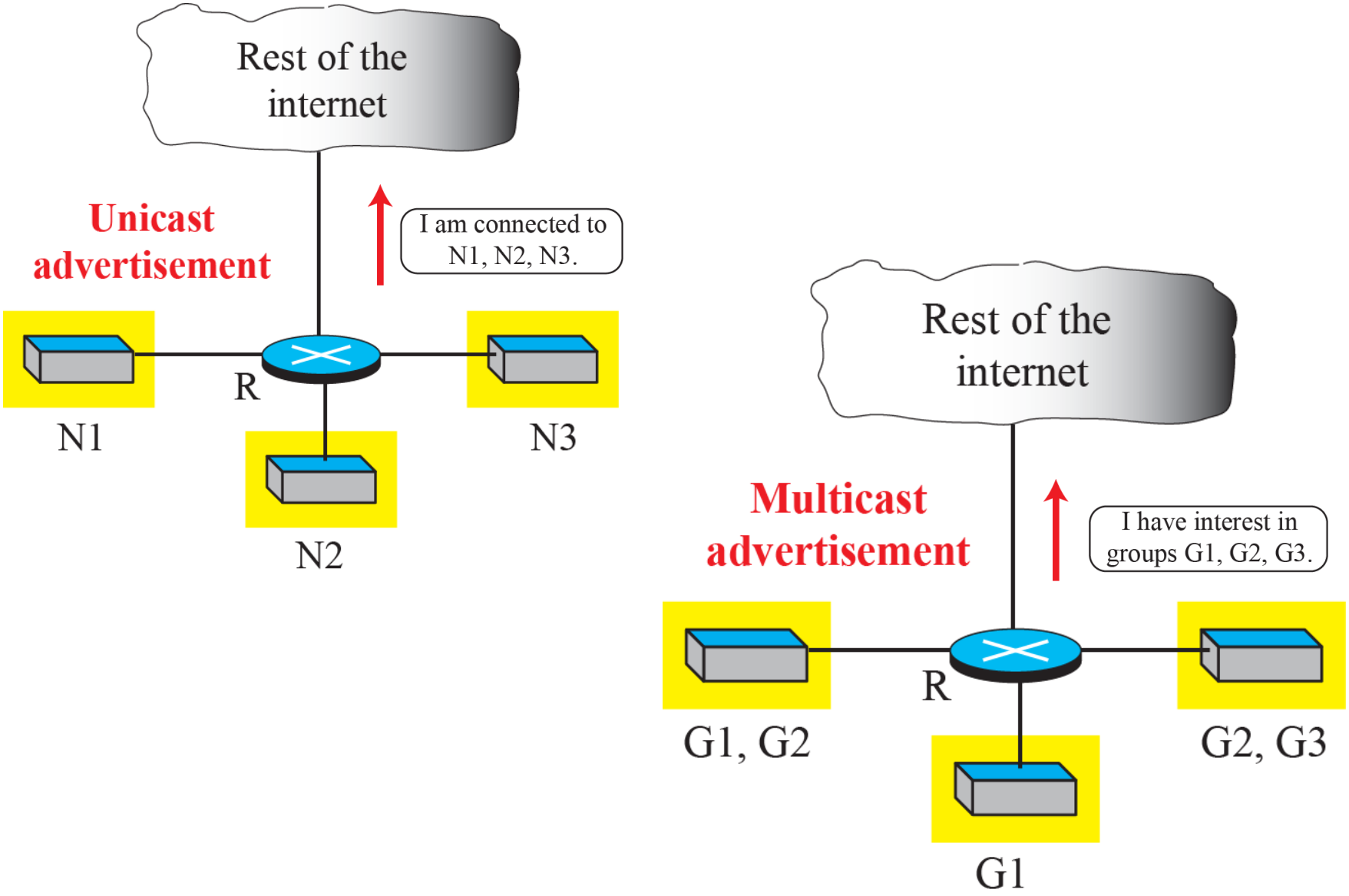
221.2.3 Collecting Information

Creation of forwarding tables in both unicast and 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 so that each router knows to which destination each other router is connected.

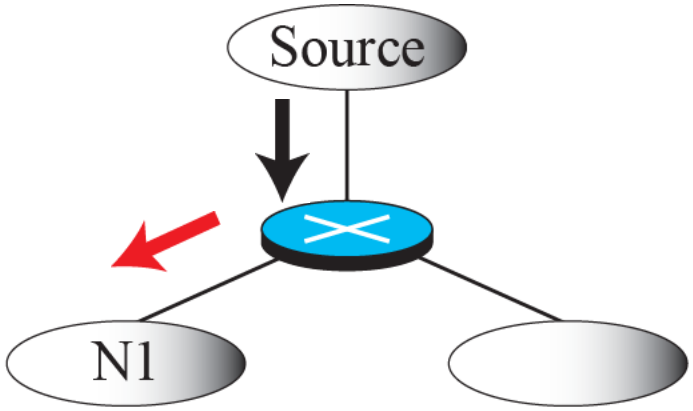
Figure 221.8: Unicast versus multicast advertisement



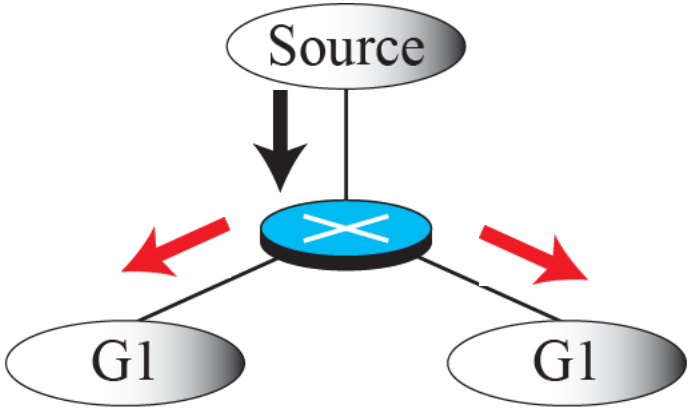
221.2.4 Multicast Forwarding

Another important issue in multicasting is the decision a router needs to make to forward a multicast packet. Forwarding in unicast and multicast communication is different.

Figure 221.9: *Destination in unicasting and multicasting*

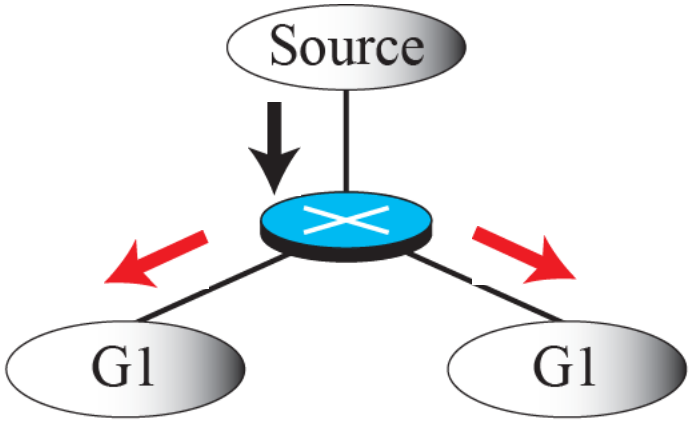


a. Destination in unicasting is one

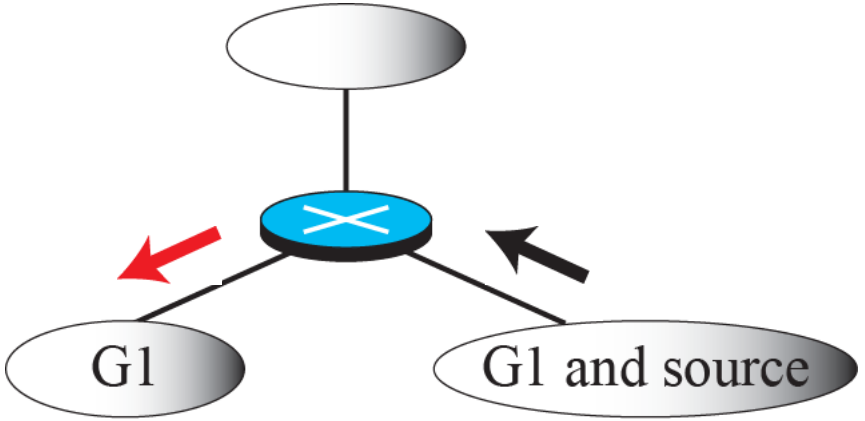


b. Destination in mulicasting is more than one

Figure 221.10: ***Forwarding depends on the destination and the source***



a. Packet sent out of two interfaces



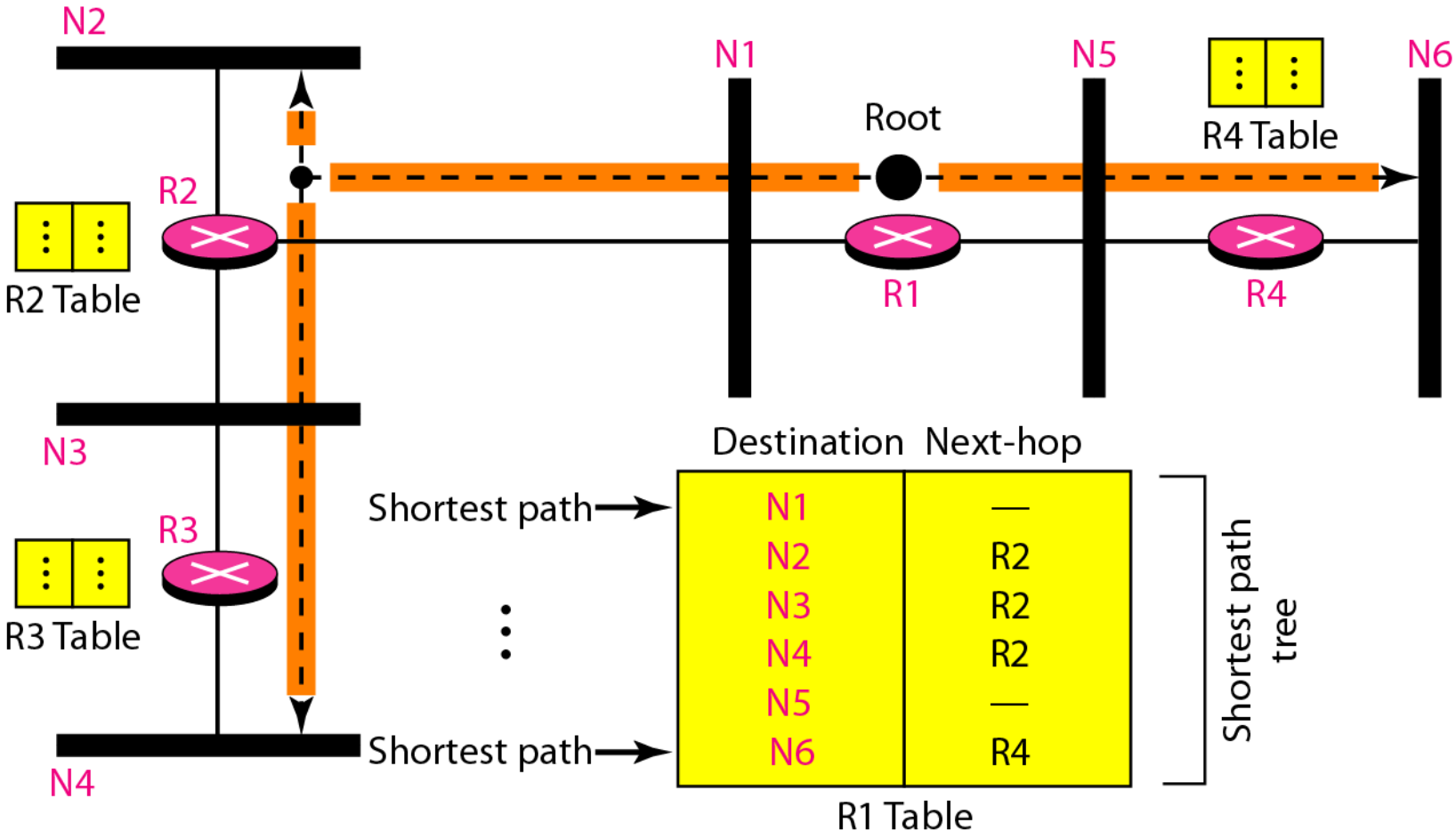
b. Packet sent out of one interface

221.2.5 Two Approaches to Multicasting

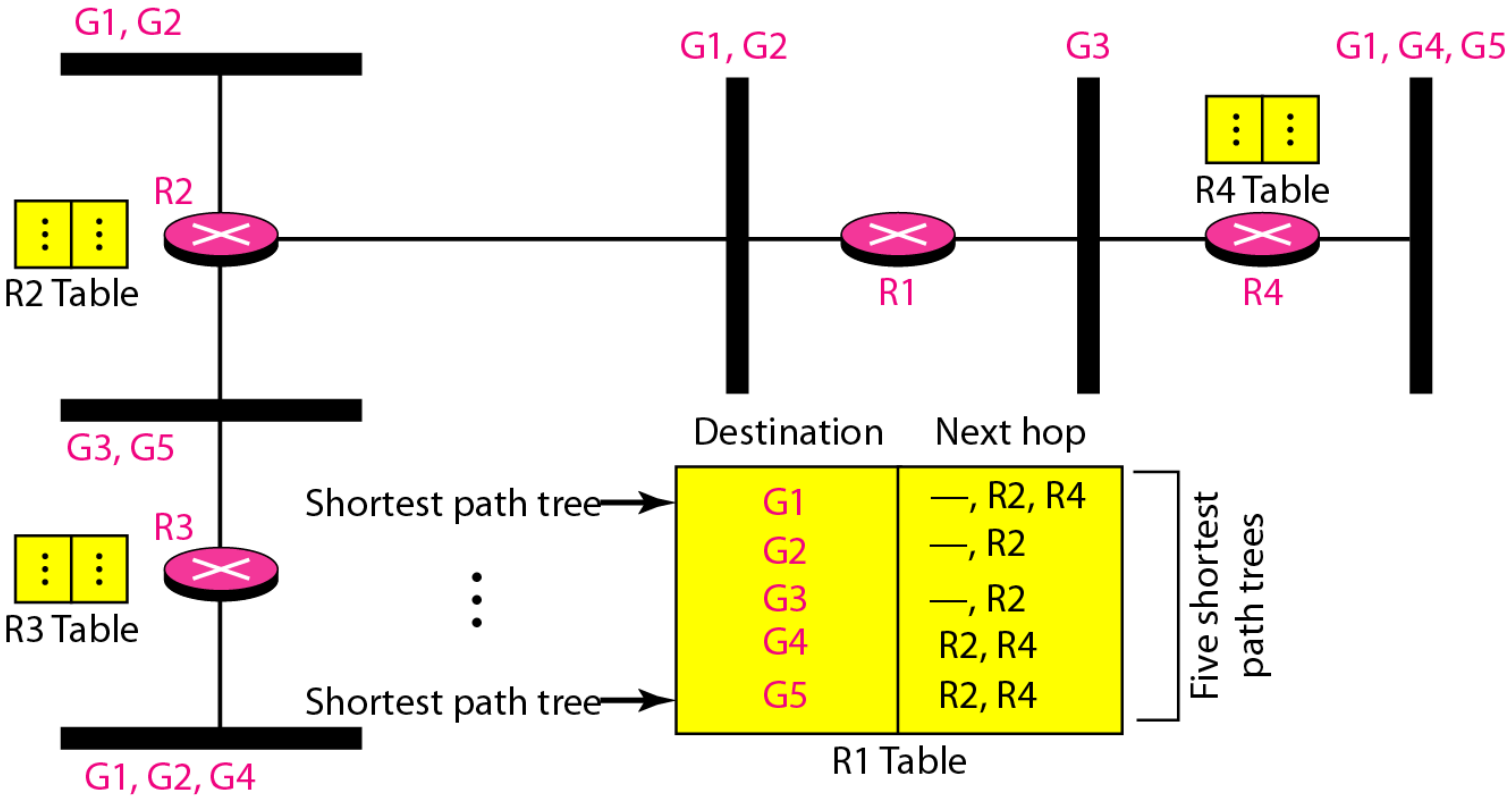
In multicast routing, as in unicast routing, we need to create routing trees to optimally route the packets from their source to their destination. However, as we discussed before, the multicast routing decision at each router depends not only on the destination of the packet, but also on the source of the packet. The involvement of the source in the routing process makes multicast routing much more difficult than unicast routing.

For this reason, two different approaches in multicast routing have been developed: routing using source-based trees and routing using group-shared trees.

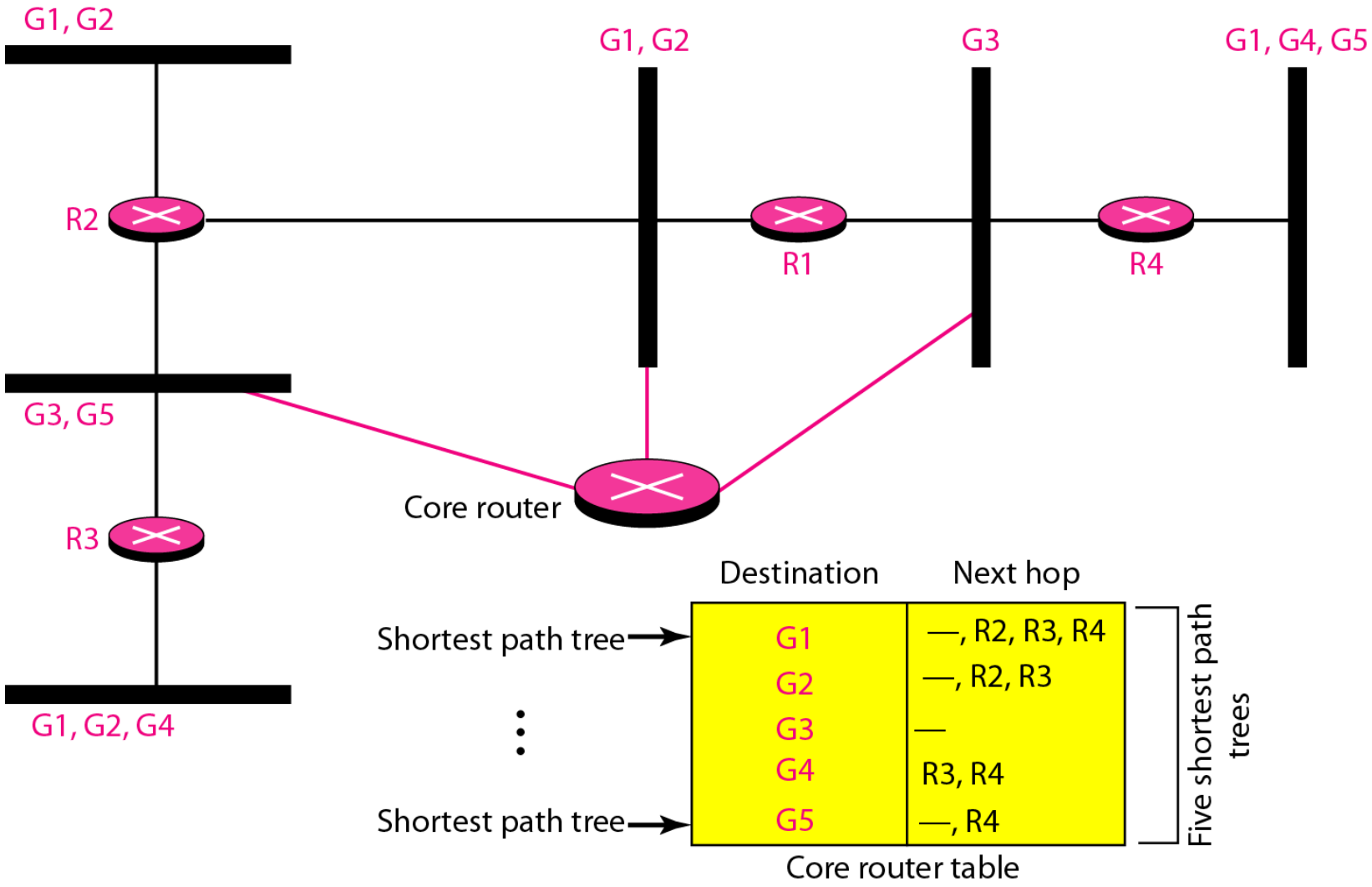
Shortest path tree in unicast routing



Source-based tree approach



Group-shared tree approach



21-3 INTRADOMAIN PROTOCOLS

During the last few decades, several intradomain multicast routing protocols have emerged. In this section, we discuss three of these protocols. Two are extensions of unicast routing protocols (RIP and OSPF), using the source-based tree approach; the third is an independent protocol which is becoming more and more popular.

221.3.1 DVMRP

The Distance Vector Multicast Routing Protocol (DVMRP) is the extension of the Routing Information Protocol (RIP) which is used in unicast routing. It uses the source-based tree approach to multicasting. It is worth mentioning that each router in this protocol that receives a multicast packet to be forwarded implicitly creates a source-based multicast tree in three steps:

- *Flooding*
- *RPF*
- *RPB*
- *RPM*

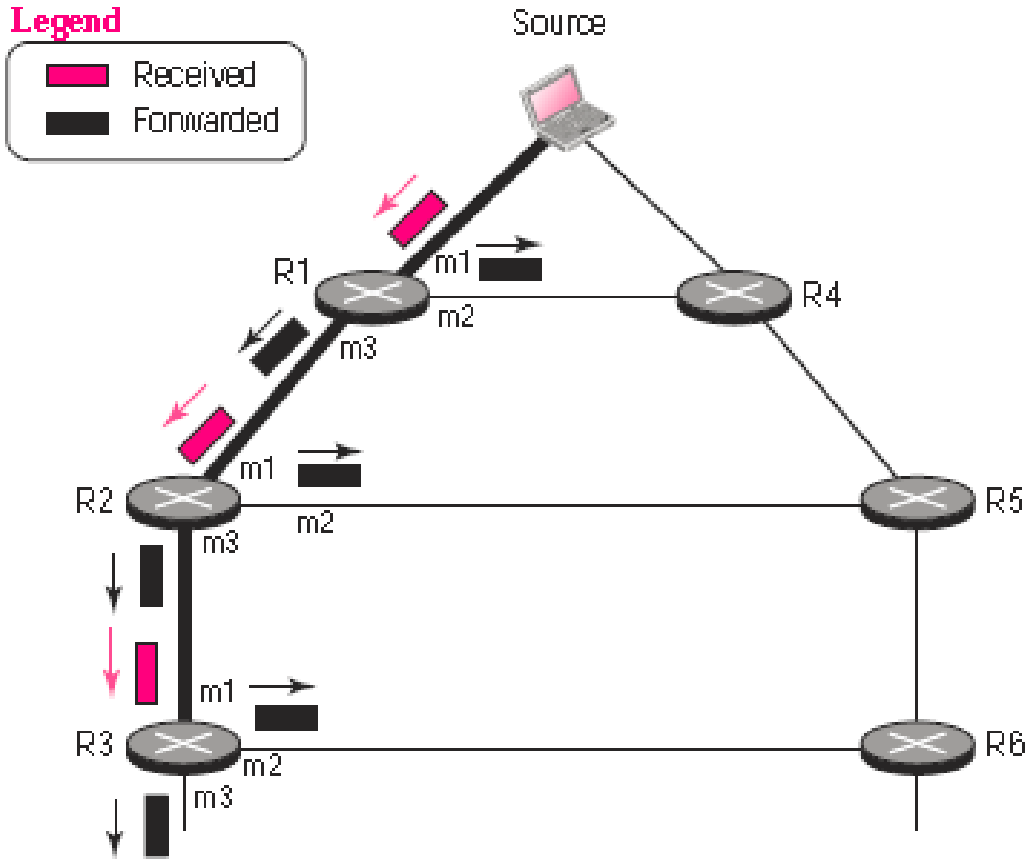
Flooding

- router receives a packet and without even looking at the destination group address, sends it out from every interface except the one from which it was received.

- **Flooding** accomplishes the first goal of multicasting: every network with active members receives the packet.
- a broadcast, not a multicast
- it creates loops

Reverse Path Forwarding

Figure 12.22 *RPF*



Reverse Path Broadcasting

Figure 12.23 *Problem with RPF*

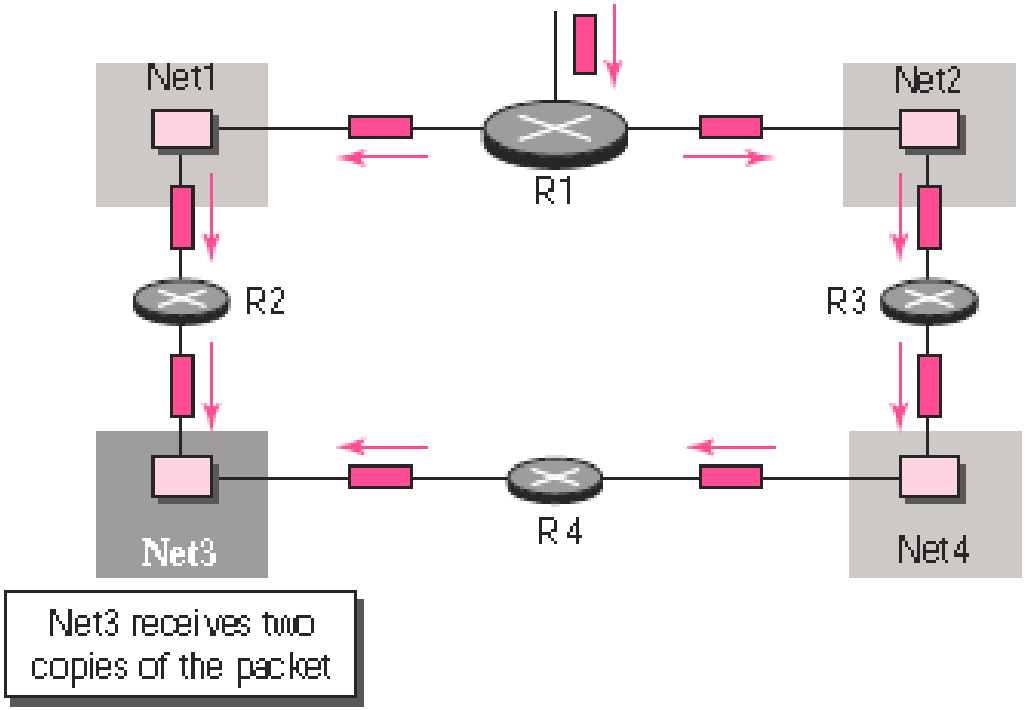
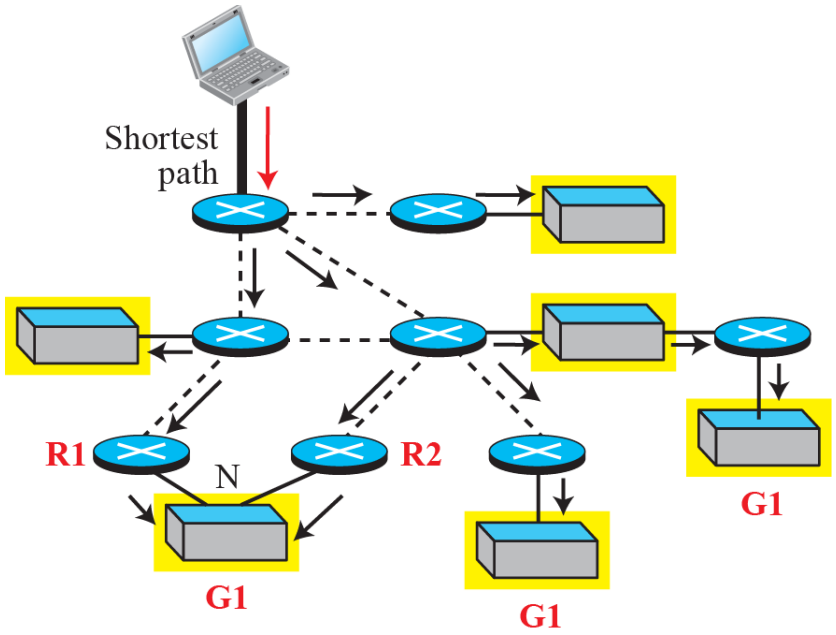
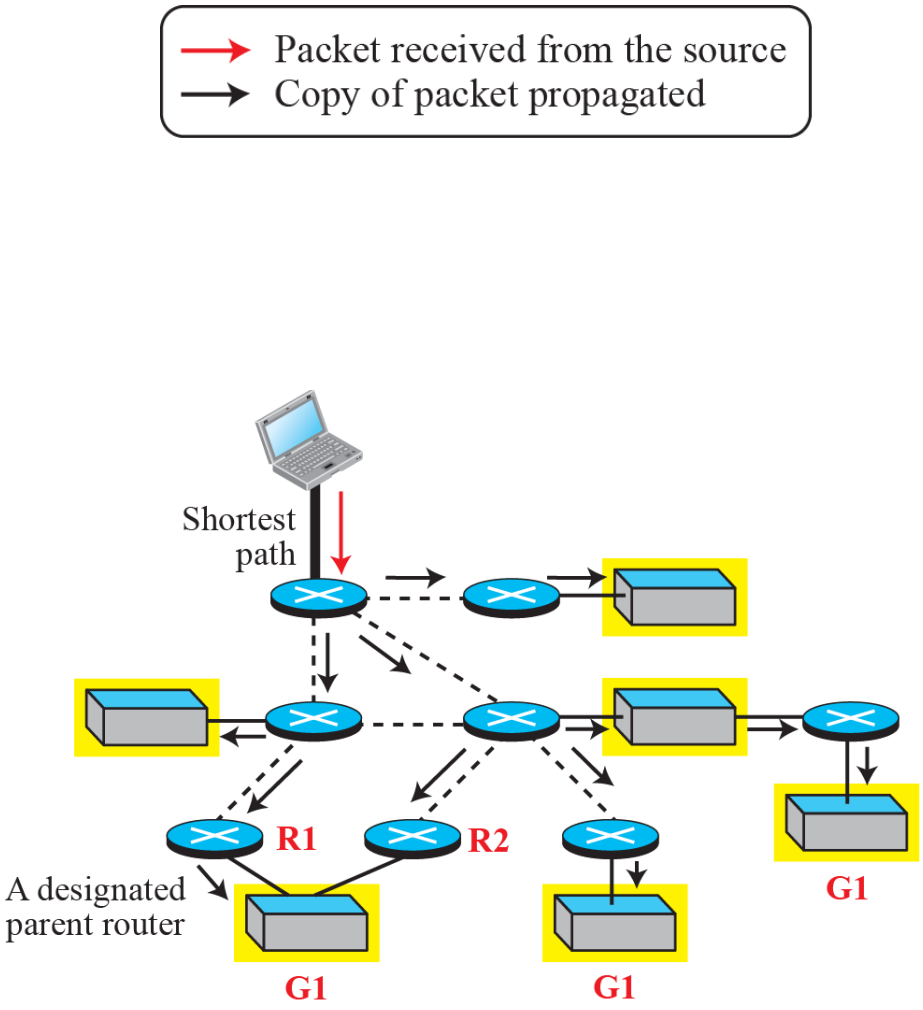


Figure 221.11: RPF versus RPB

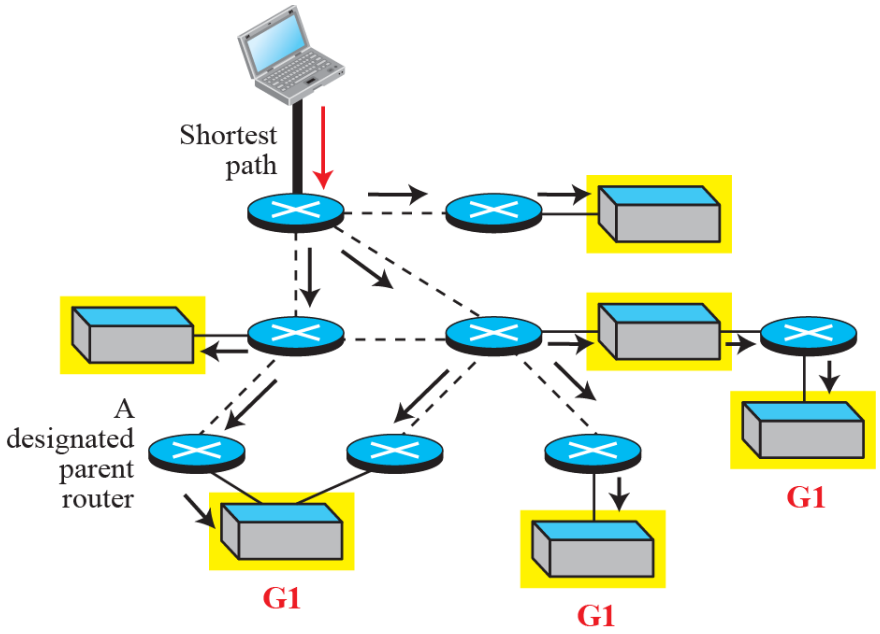


a. Using RPF, N receives two copies.

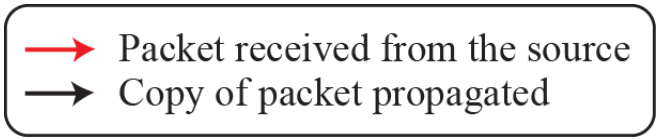


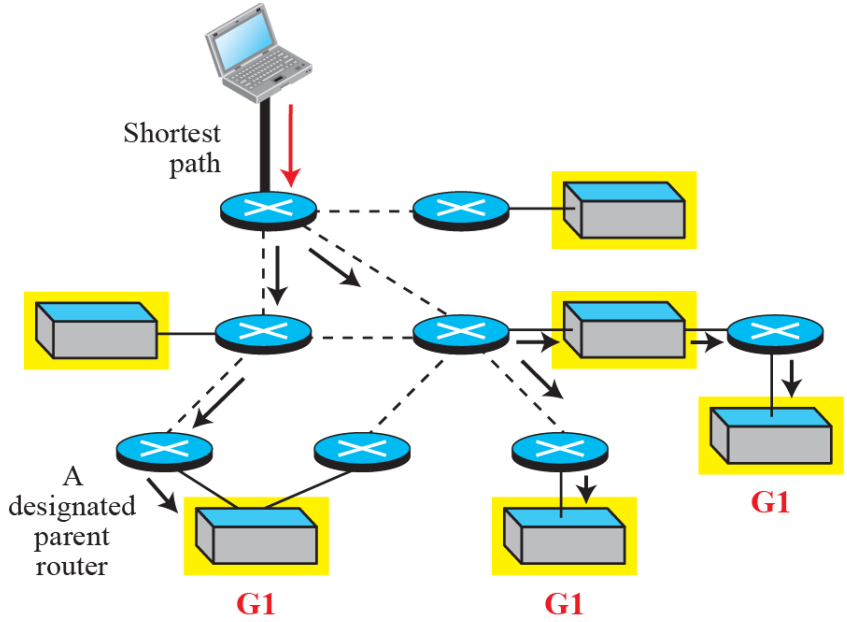
b. Using RPB, N receives only one copy.

Figure 221.12: RPB versus RPM



a. Using RPB, all networks receive a copy.

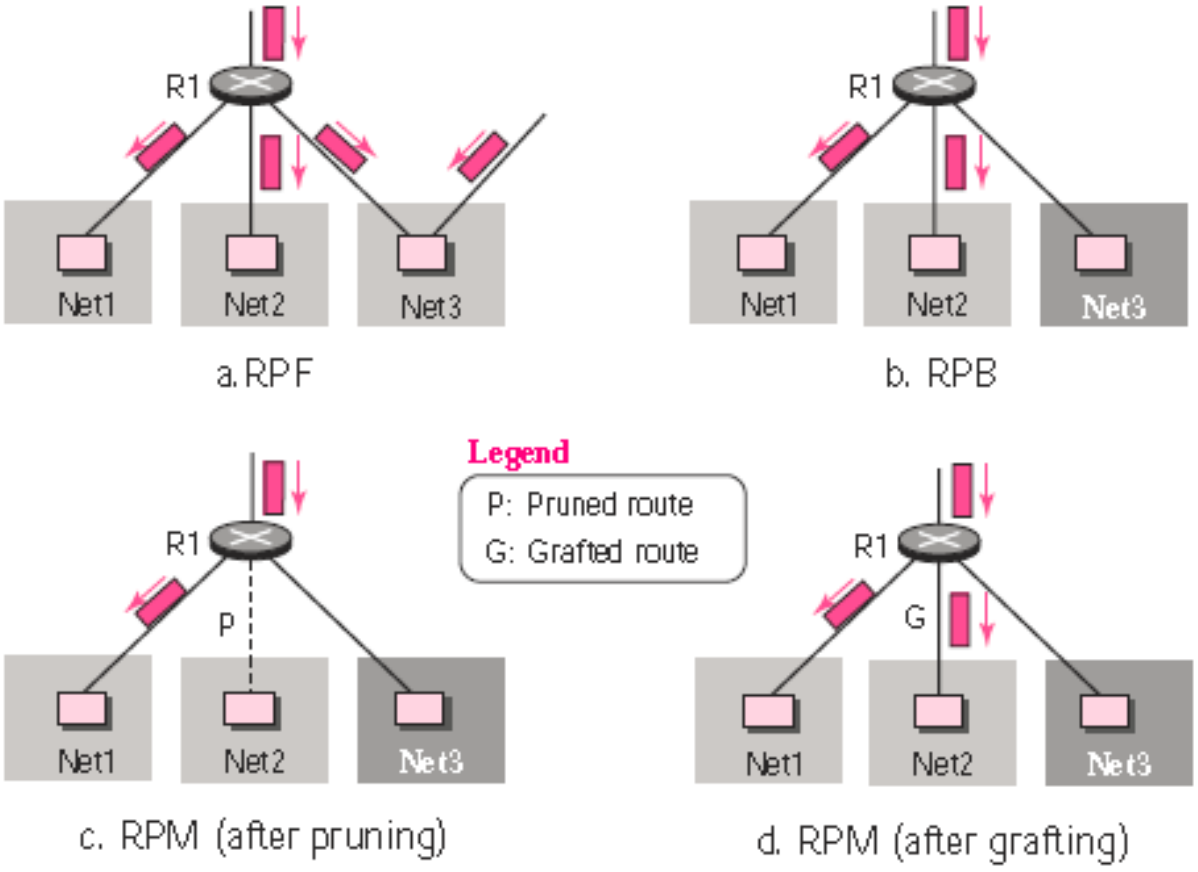




b. Using RPM, only members receive a copy.

RPF vs RPB vs RPM

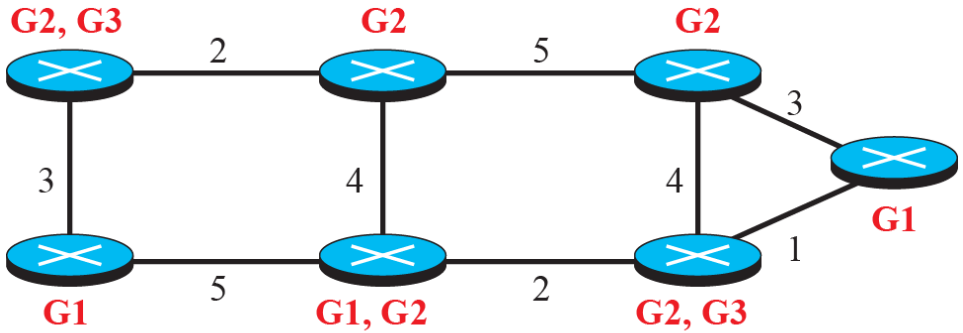
Figure 12.25 *RPF, RPB, and RPM*



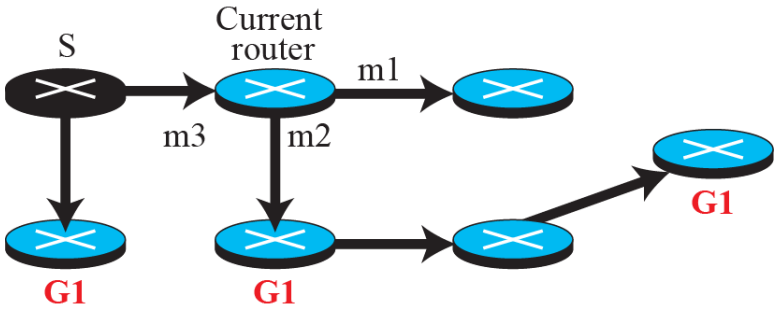
221.3.2 Multicast Link State (MOSPF)

Multicast Open Shortest Path First (MOSPF) is the extension of the Open Shortest Path First (OSPF) protocol, which is used in unicast routing. It also uses the source-based tree approach to multicasting. If the internet is running a unicast link-state routing algorithm, the idea can be extended to provide a multicast link-state routing algorithm. To extend unicasting to multicasting, each router needs to have another database, as with the case of unicast distance-vector routing, to show which interface has an active member in a particular group.

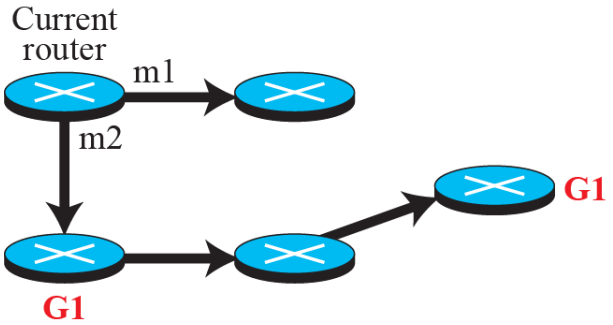
Figure 221.13: Example of tree formation in MOSPF



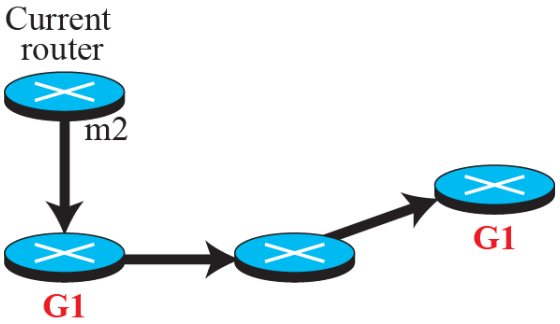
a. An internet with some active groups



b. S-G1 shortest-path tree



c. S-G1 subtree seen by current router



d. S-G1 pruned subtree

Forwarding table for current router

Group-Source	Interface
S, G1	m2
...	...

Internet Group Management Protocol

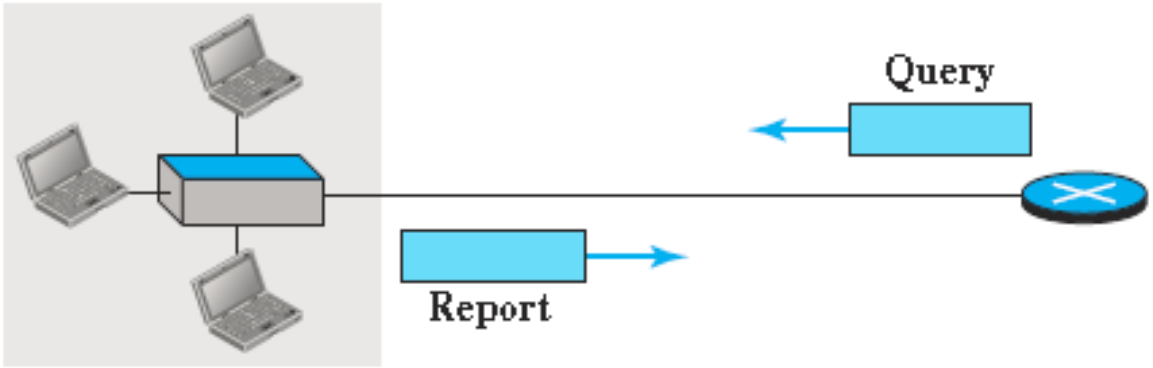
- Multicast communication means that a sender sends a message to a group of recipients that are members of the same group.
- each multicast router needs to know the list of groups that have at least one loyal member related to each interface.
- multicast routers need to collect information about members and share it with other multicast routers.

Position of IGMP

Figure 12.6 *Position of IGMP in the network layer*

IGMP is a group management protocol. It helps a multicast router create and update a list of loyal members related to each router interface.

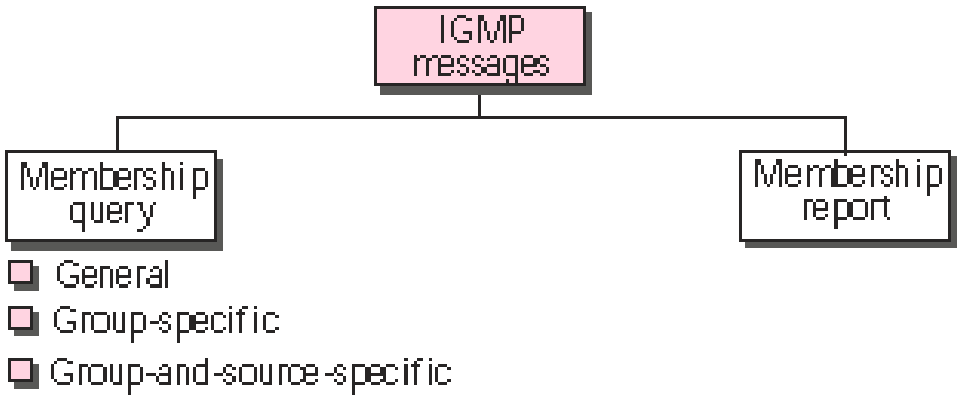
IGMP Operation



- A query message is periodically sent by a router to all hosts attached to it to ask them to report their interests about membership in groups.
- A report message is sent by a host as a response to a query message.

IGMP Messages

Figure 12.7 *IGMP messages*



Membership Query messages

- In a *general query message*, the querier router probes each neighbor to report the whole list of its group membership (interest in any multicast group).
- In a *group-specific query message*, the querier router probes each neighbor to report if it is still interested in a specific multicast group.
- In a *group-and-source-specific query message*, the querier router probes each neighbor to report if it is still in a specific multicast group, *x.y.z.t*, coming from any of the *N* sources whose unicast addresses are defined in this packet.

Membership Report Message

- sent by a host as a response to a query message.
- The report message contains list of records which contains:
  - identifier of the corresponding group (multicast address)
  - addresses of all sources that the host is interested in receiving messages.
  - the source addresses from which the host does not desire to receive a group message (exclusion).

Encapsulation

- The IGMP message is encapsulated in an IP datagram with the value of the protocol field set to 2 and the TTL field set to 1.
- The destination IP address of the datagram, however, depends on the type of message

Message Type	*IP Address*
General Query	224.0.0.1
Other Queries	Group address
Report	224.0.0.22