Unicast and Multicast Routing:

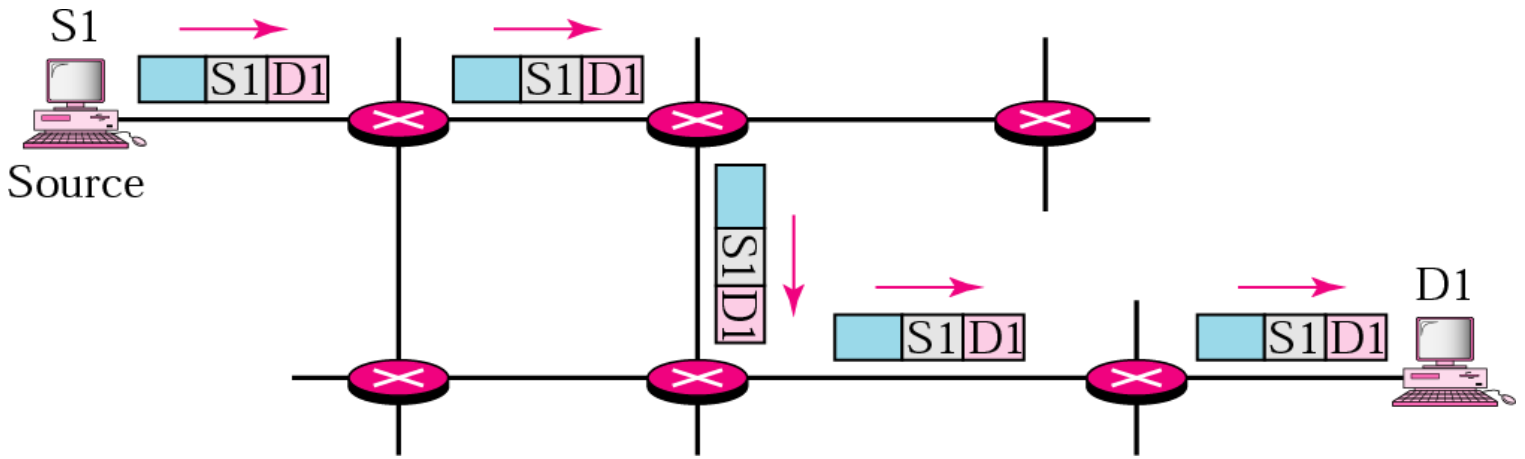
Routing Protocols

21.1 Unicast Routing

Metric

Interior and Exterior Routing

Figure 21.1 Unicasting



Note:

In unicast routing, the router forwards the received packet through only one of its ports.

21.2 Unicast Routing Protocols

RIP

OSPF

BGP

Figure 21.2 *Popular routing protocols*

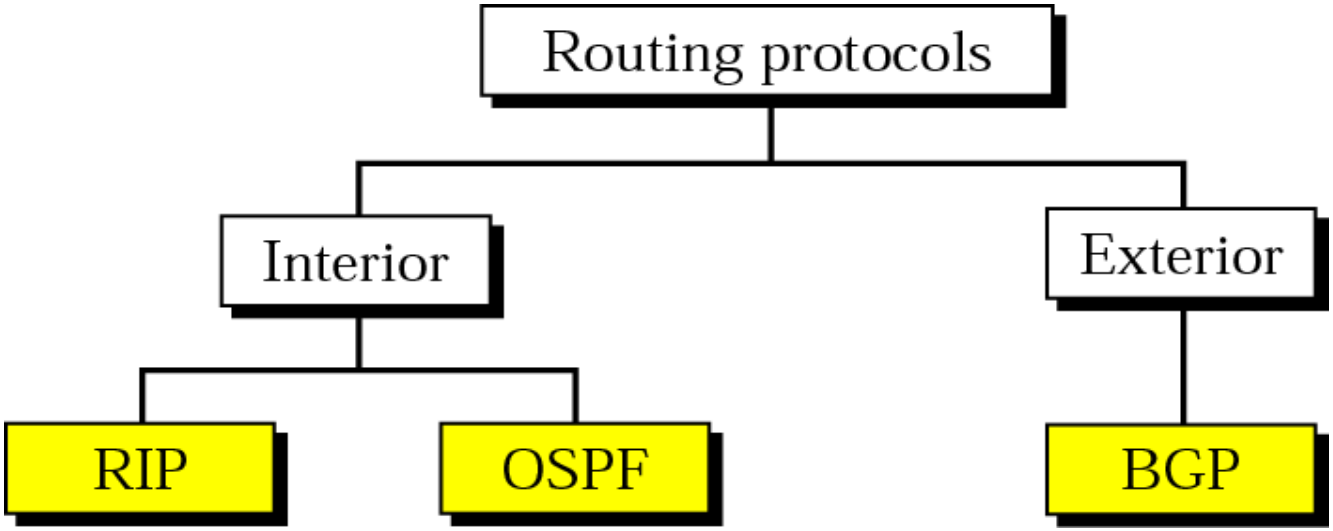


Figure 21.3 Autonomous systems

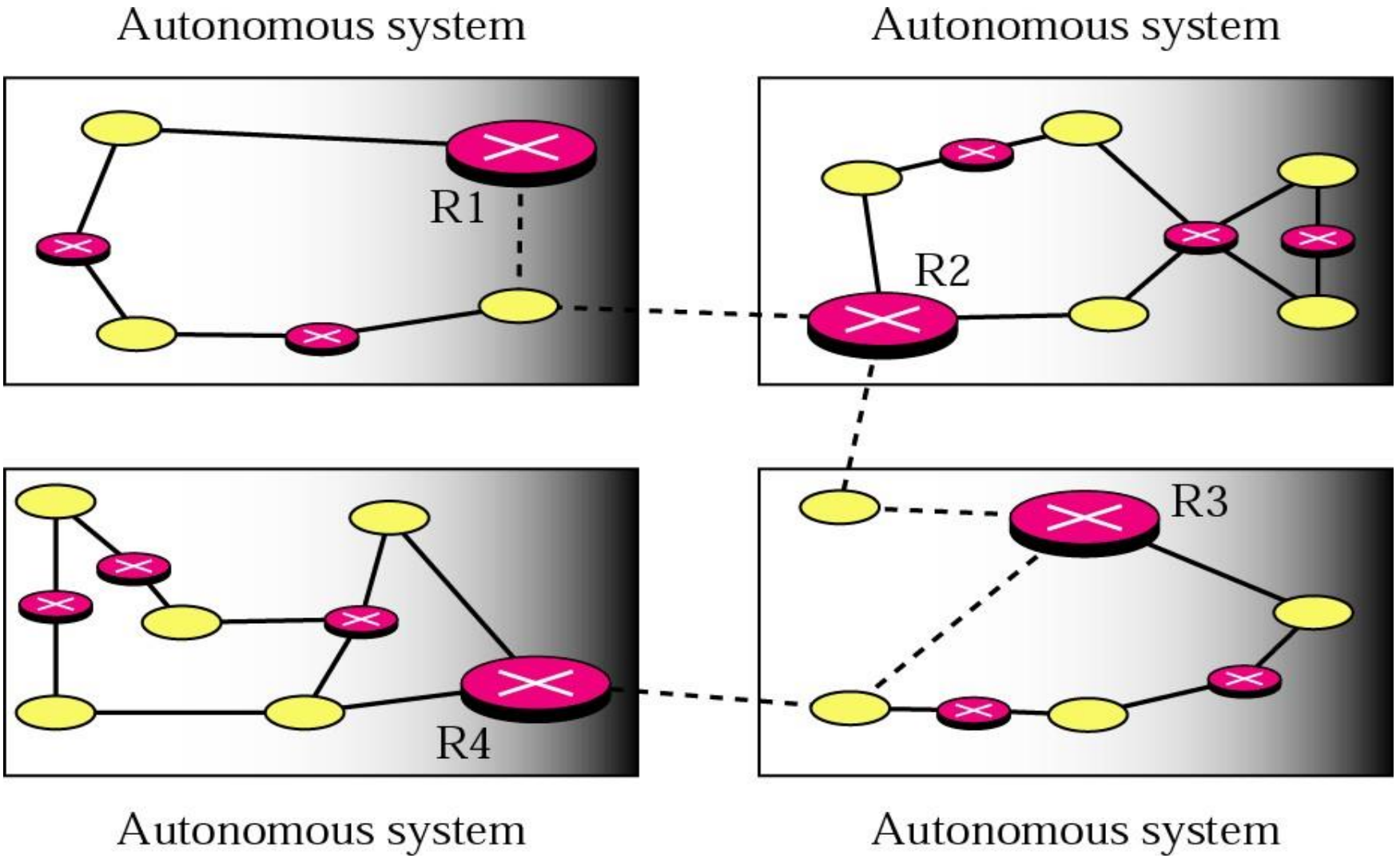


Table 21.1 A distance vector routing table

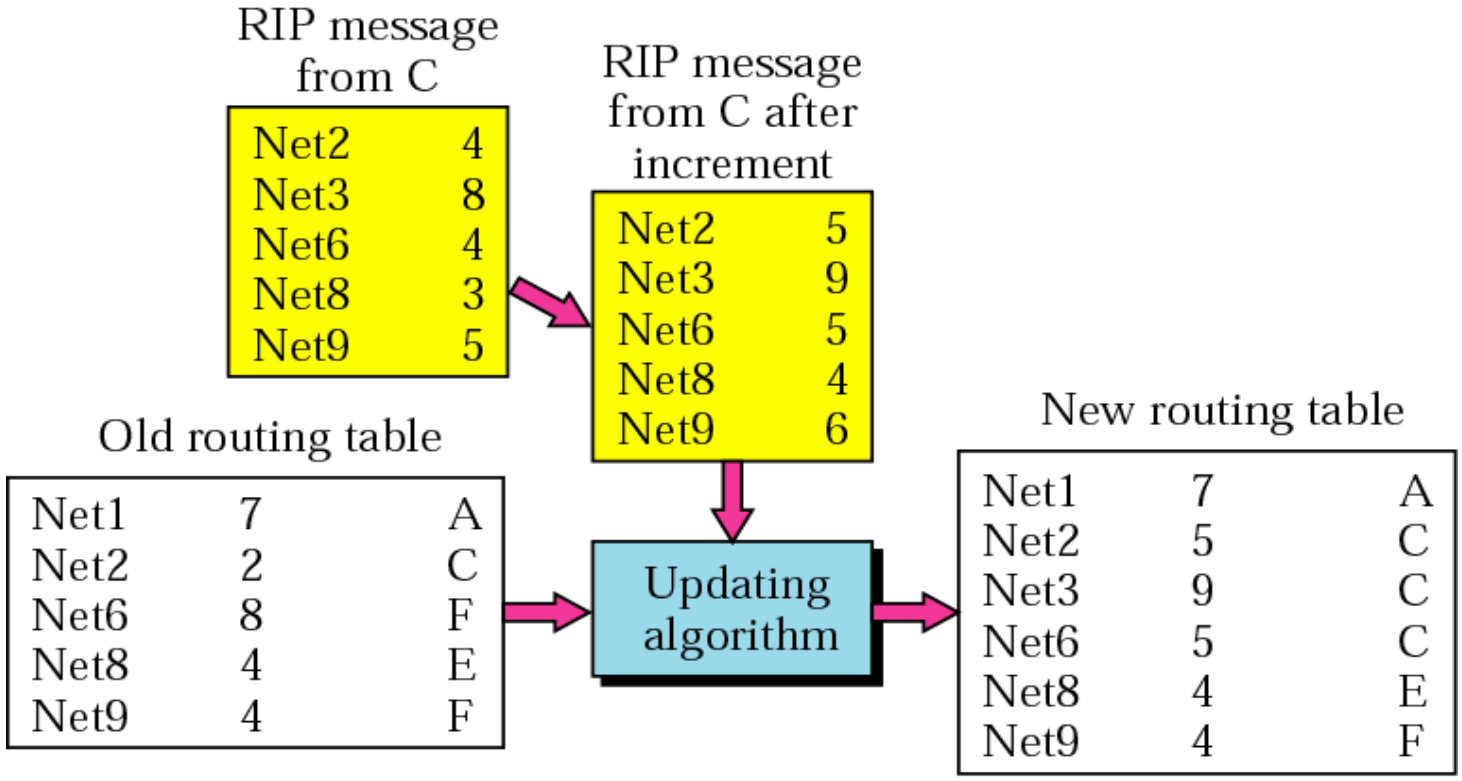
Destination	Hop Count	Next Router	Other information
163.5.0.0	7	172.6.23.4	
197.5.13.0	5	176.3.6.17	
189.45.0.0	4	200.5.1.6	
115.0.0.0	6	131.4.7.19	

RIP Updating Algorithm

Receive: a response RIP message

1. Add one hop to the hop count for each advertised destination.
2. Repeat the following steps for each advertised destination:
  1. If (destination not in the routing table)
    1. Add the advertised information to the table.
  2. Else
    1. If (next-hop field is the same)
      1. Replace entry in the table with the advertised one.
    2. Else
      1. If (advertised hop count smaller than one in the table)
        1. Replace entry in the routing table.
3. Return.

Figure 21.4 Example of updating a routing table



Net1: No news, do not change
Net2: Same next hop, replace
Net3: A new router, add
Net6: Different next hop, new hop count smaller, replace
Net8: Different next hop, new hop count the same, do not change
Net9: Different next hop, new hop count larger, do not change

Figure 21.5 Initial routing tables in a small autonomous system

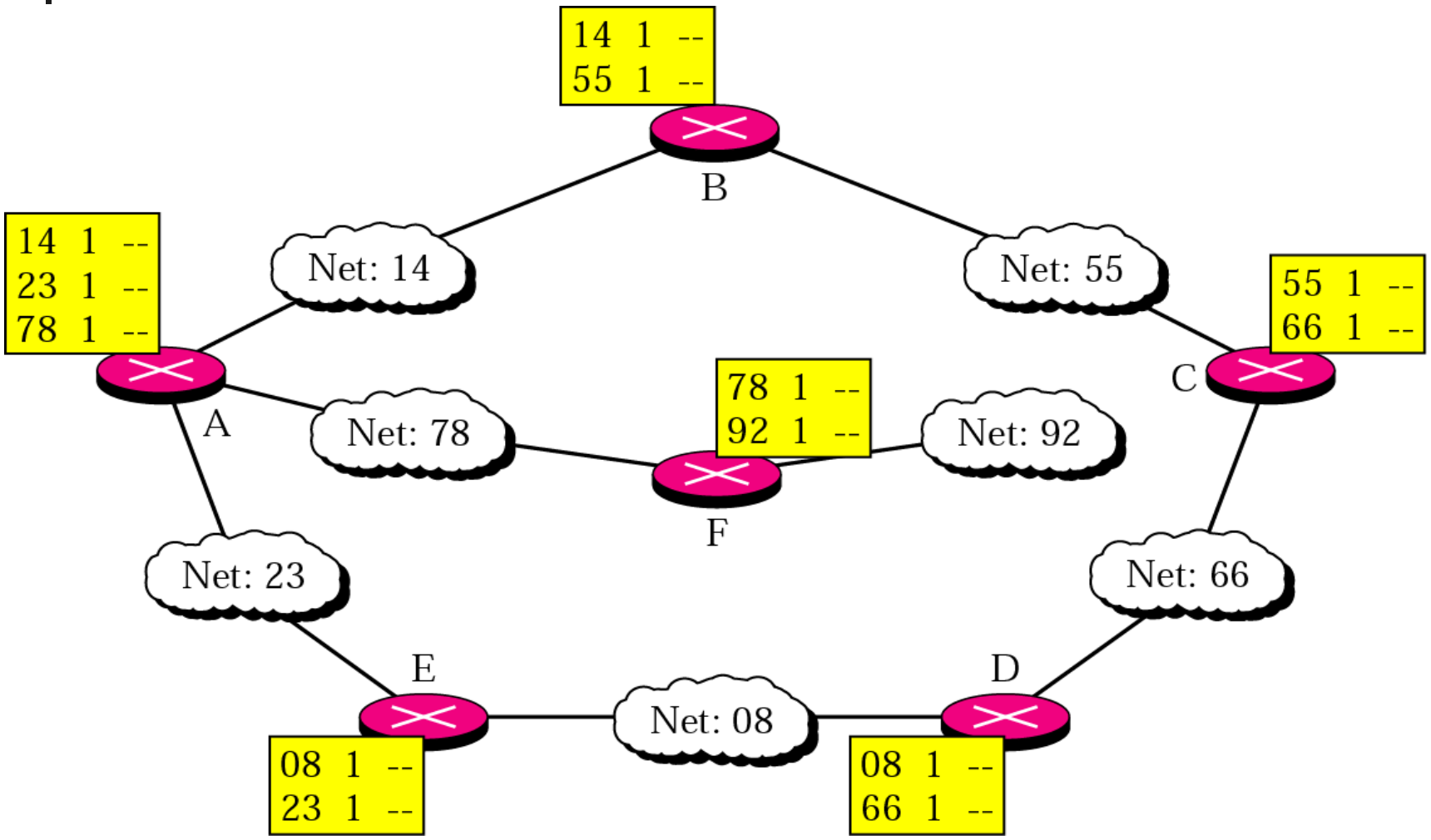


Figure 21.6 Final routing tables for Figure 21.5

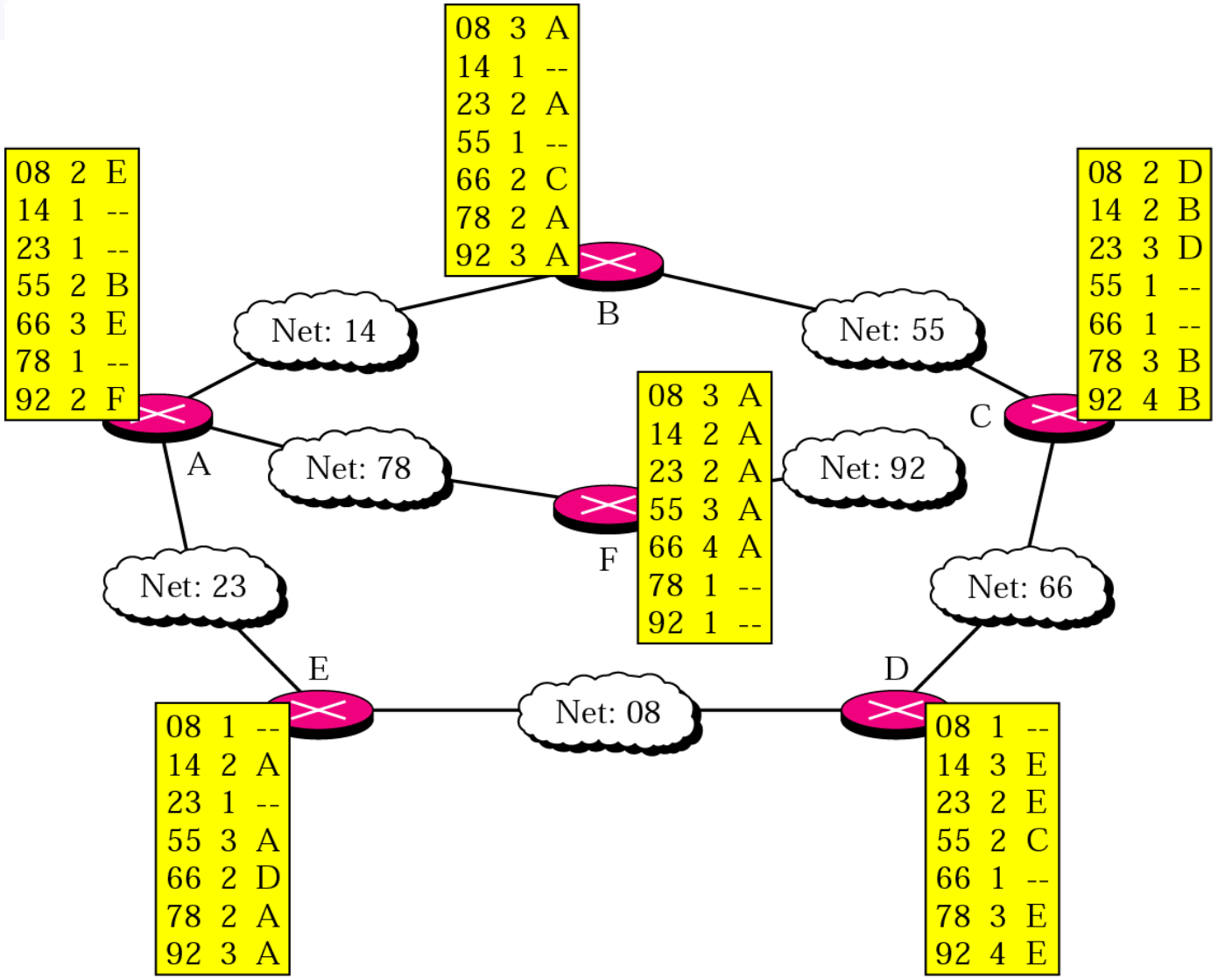


Figure 21.7 Areas in an autonomous system

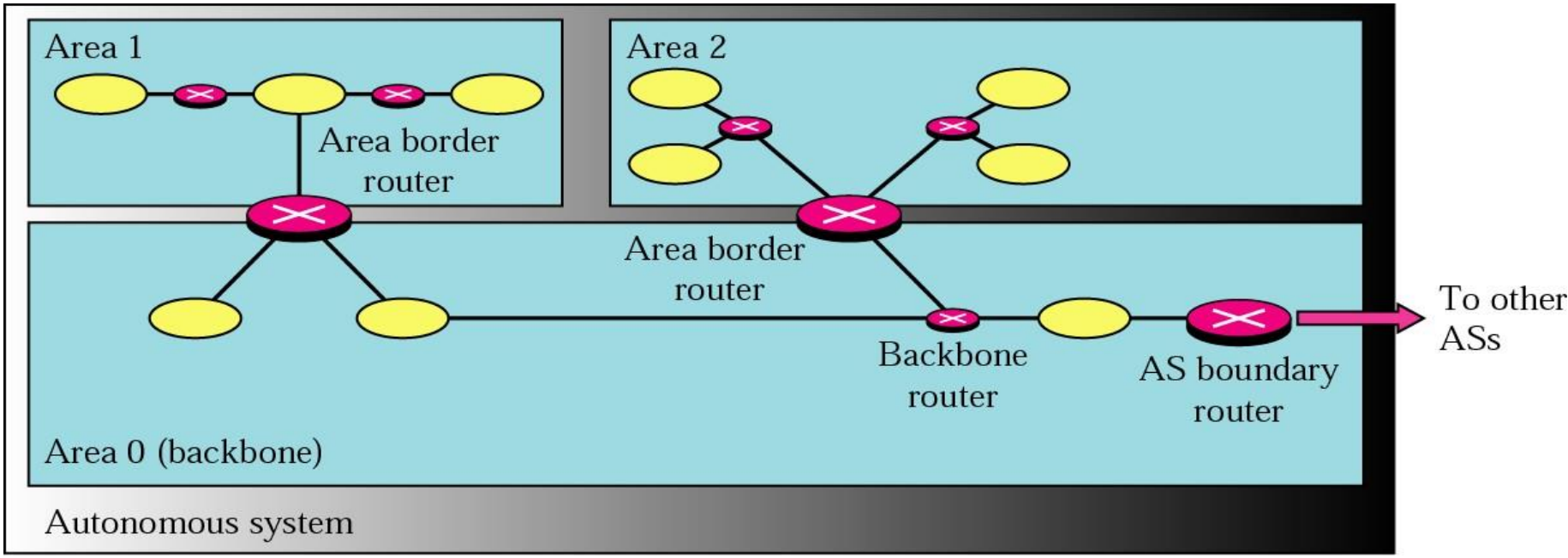


Figure 21.8 Types of links

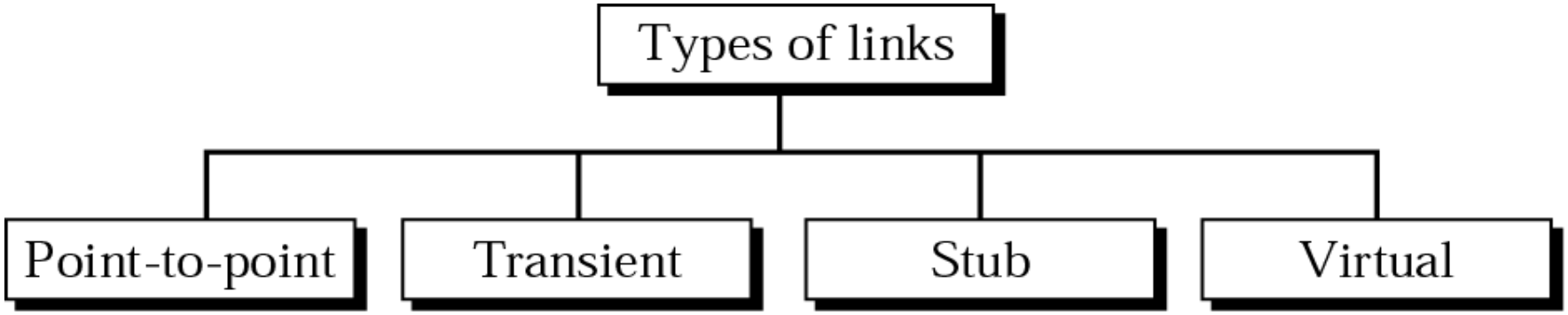


Figure 21.9 Point-to-point link

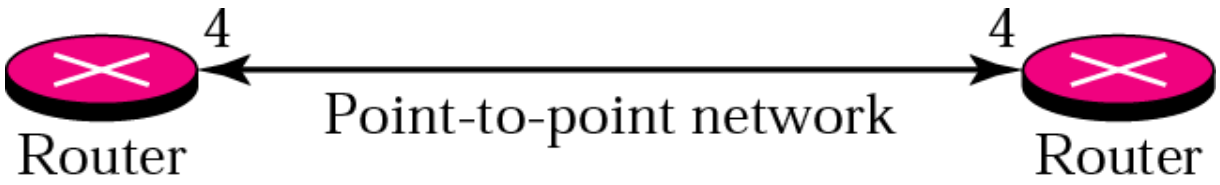
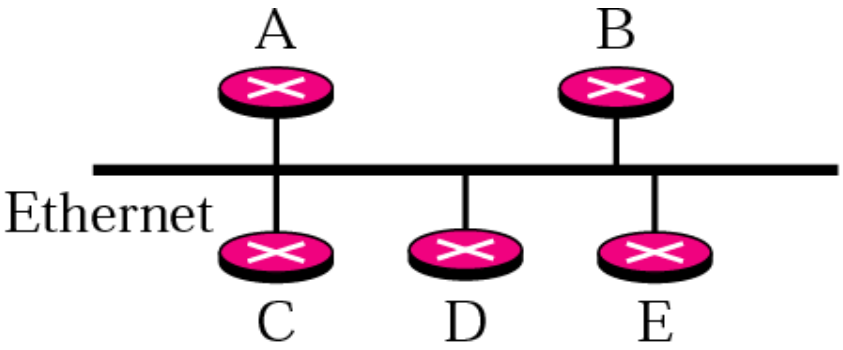
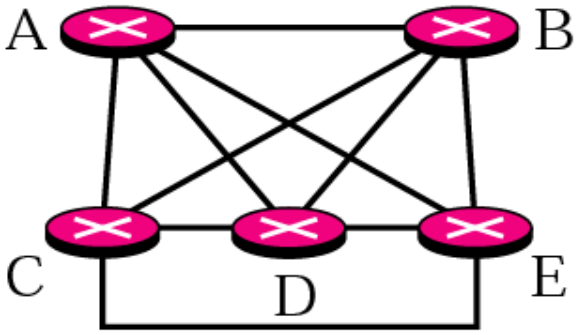


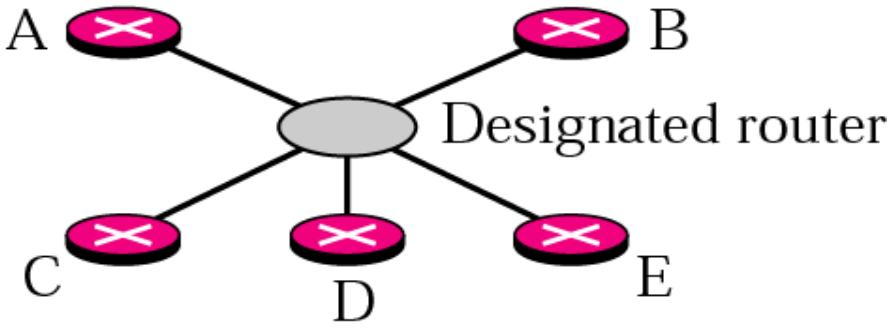
Figure 21.10 Transient link



a. Transient network

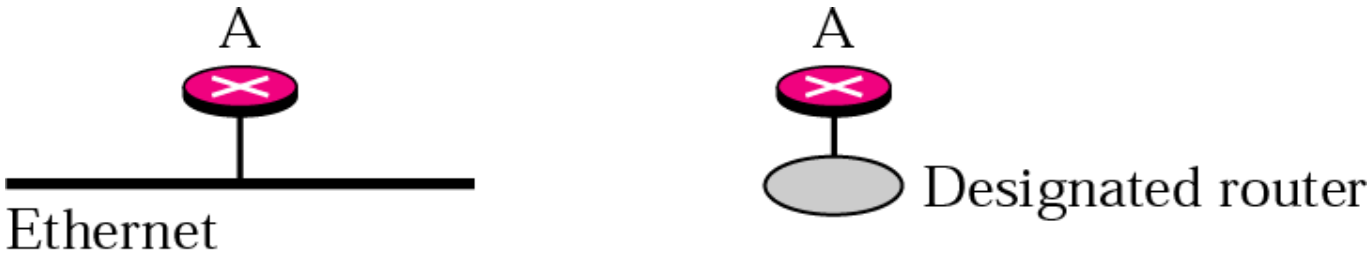


b. Unrealistic representation



c. Realistic representation

Figure 21.11 Stub link



a. Stub network b. Representation

Figure 21.12 Example of an internet

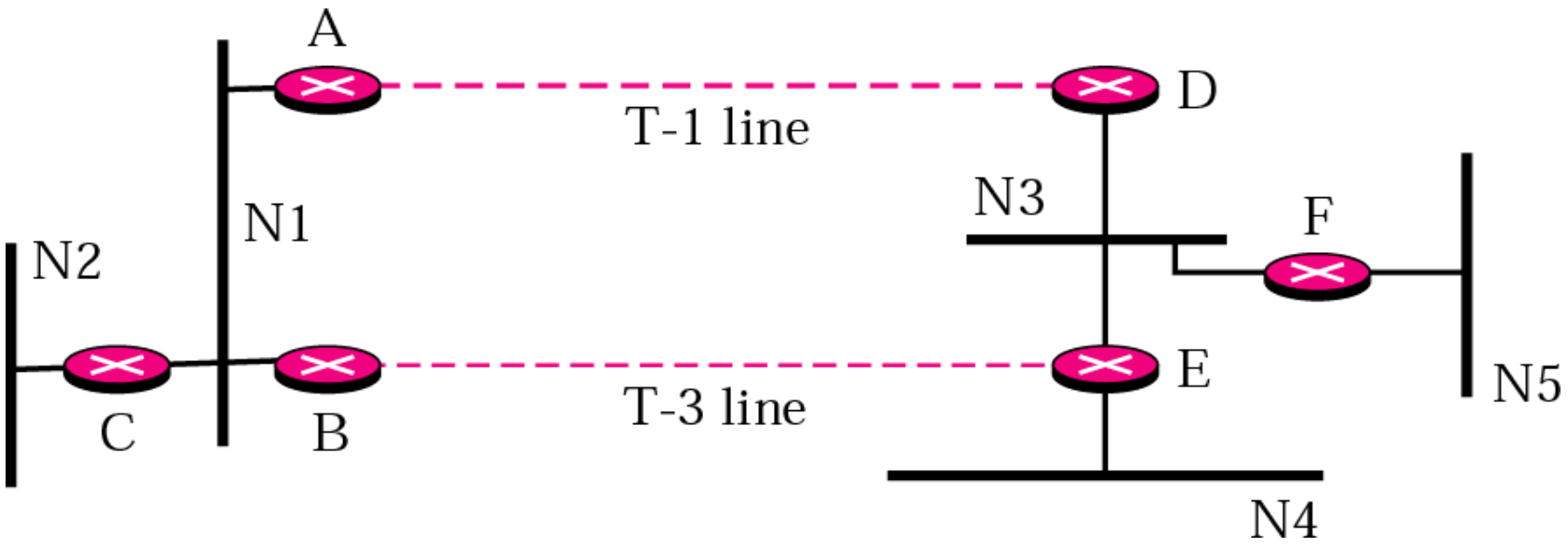


Figure 21.13 Graphical representation of an internet

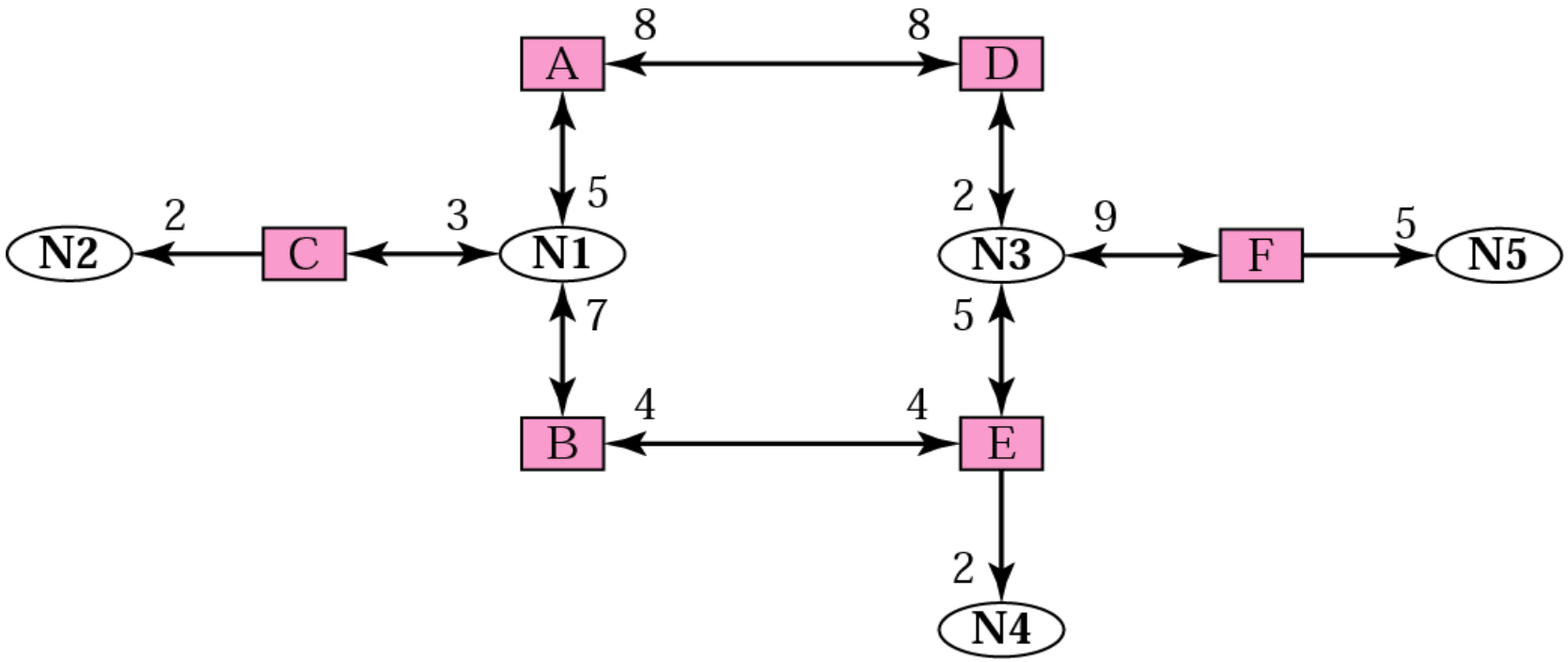


Figure 21.14 Types of LSAs

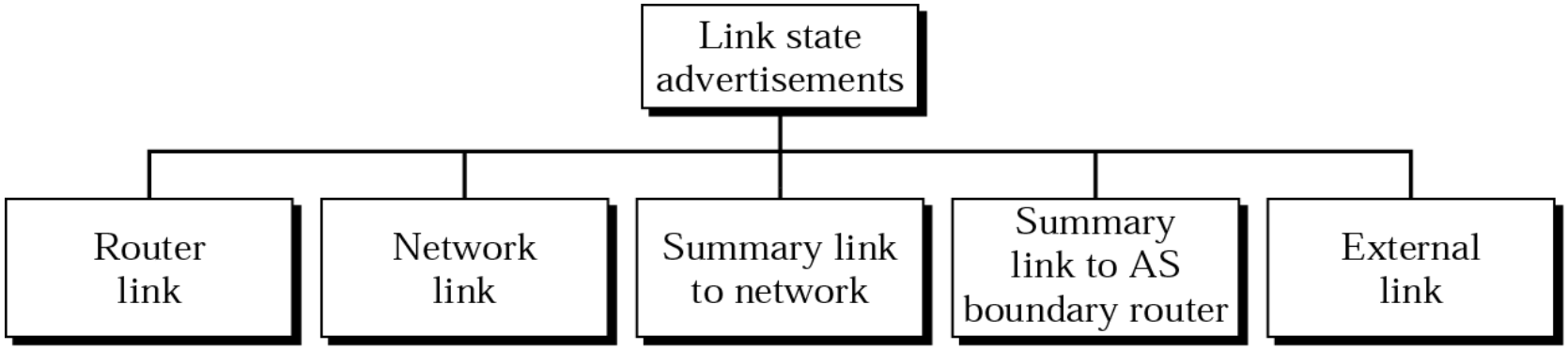


Figure 21.15 Router link

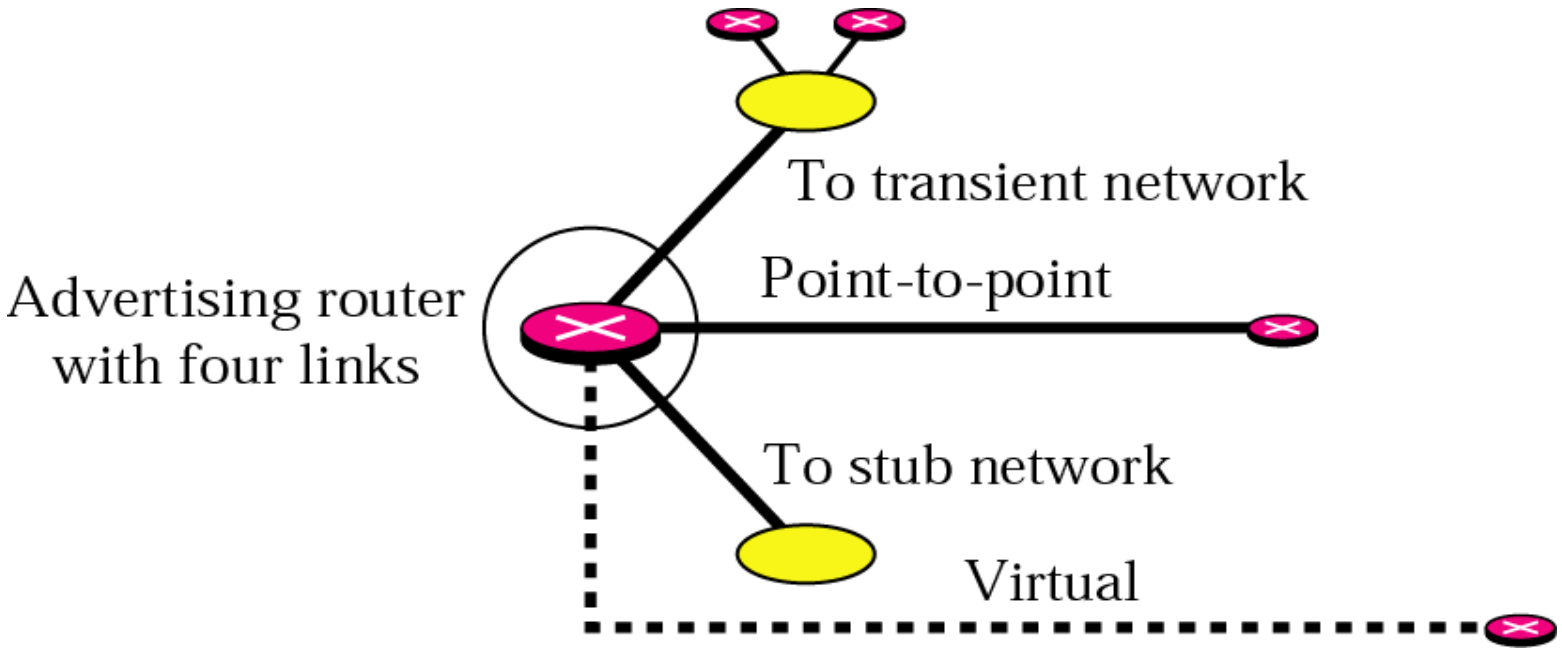


Figure 21.16 Network link

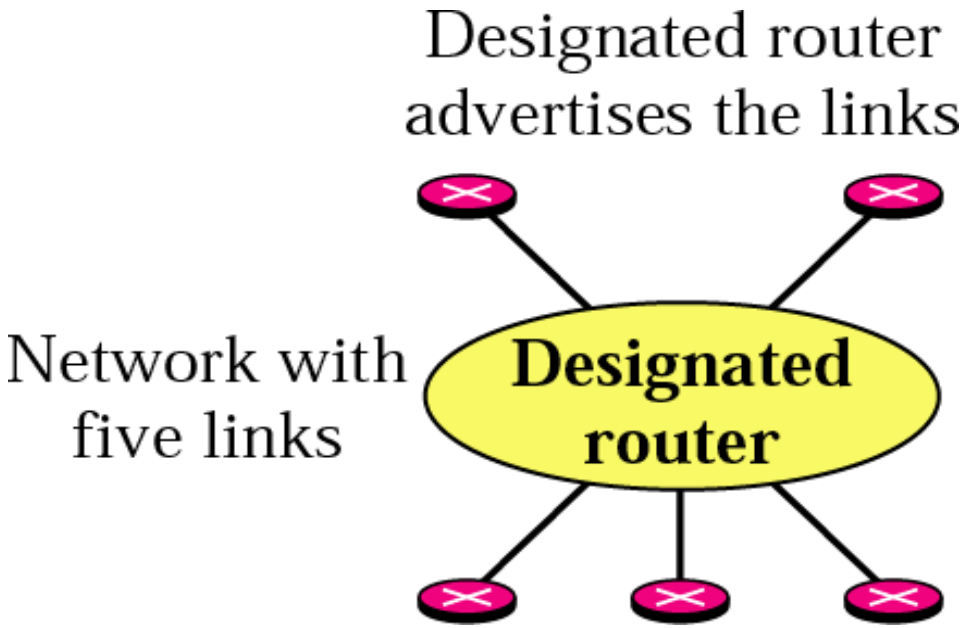


Figure 21.17 Summary link to network

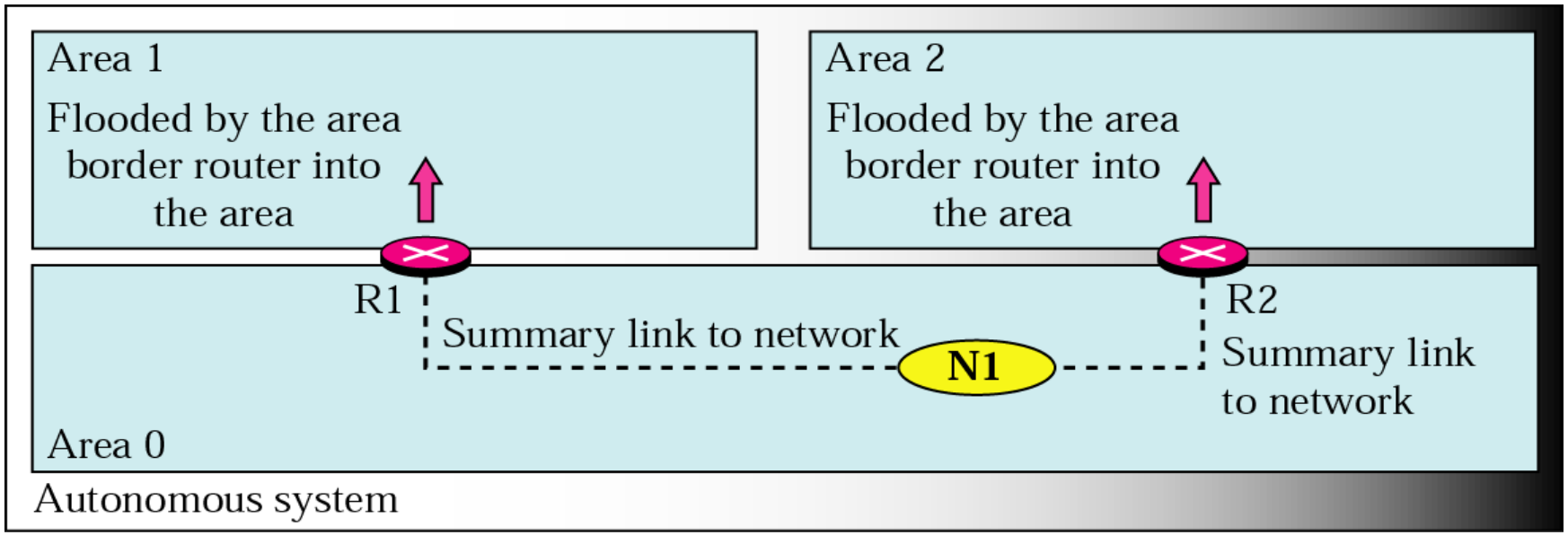


Figure 21.18 Summary link to AS boundary router

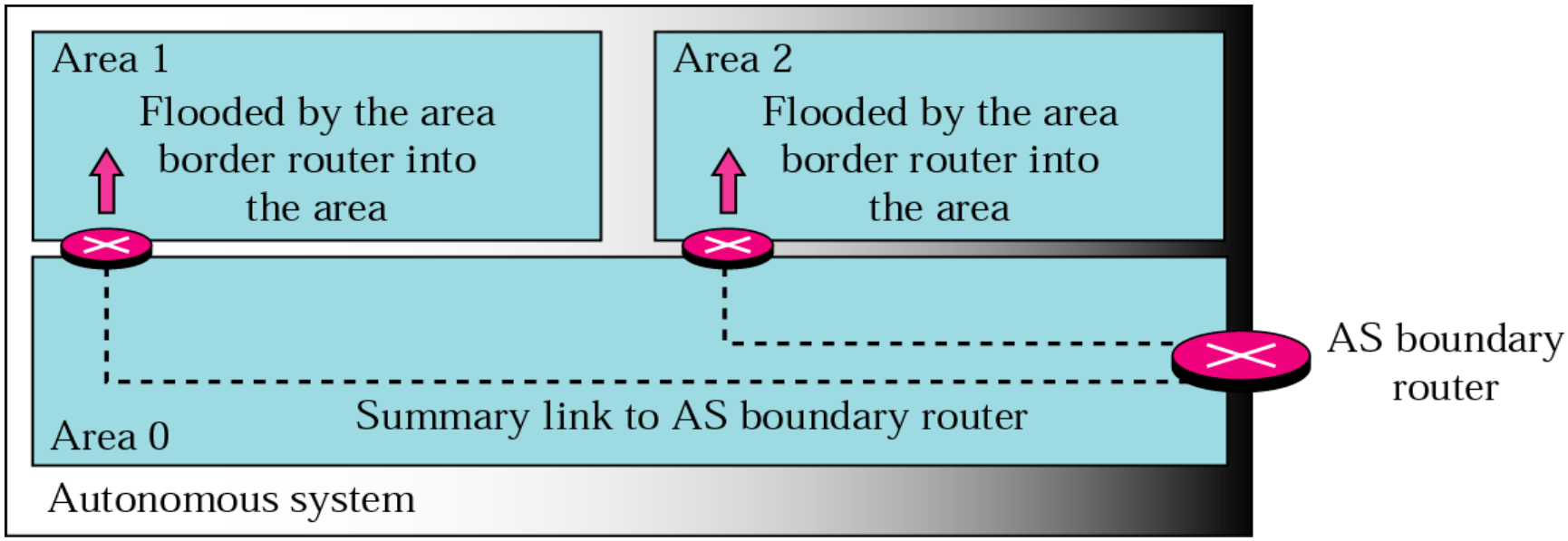
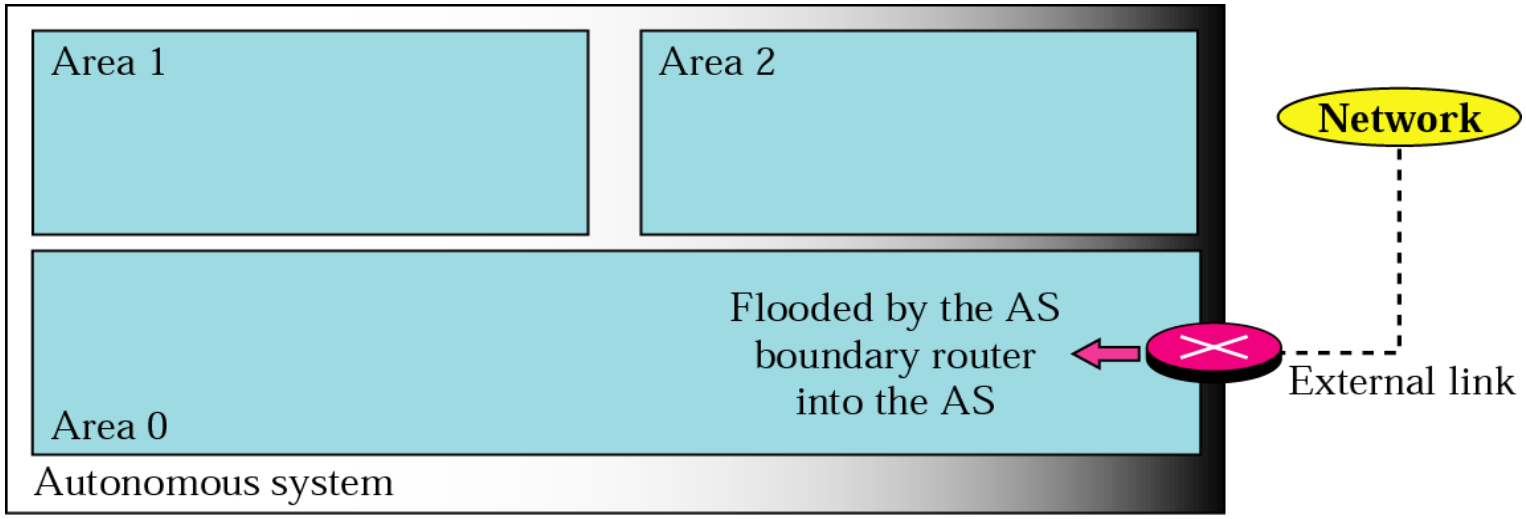


Figure 21.19 External link



In OSPF, all routers have the same link state database.

Dijkstra Algorithm

1. Start with the local node (router): the root of the tree.
2. Assign a cost of 0 to this node and make it the first permanent node.
3. Examine each neighbor node of the node that was the last permanent node.
4. Assign a cumulative cost to each node and make it tentative.
5. Among the list of tentative nodes
    1. Find the node with the smallest cumulative cost and make it permanent.
    2. If a node can be reached from more than one direction
        1. Select the direction with the shortest cumulative cost.
6. Repeat steps 3 to 5 until every node becomes permanent.

Figure 21.20 Shortest-path calculation

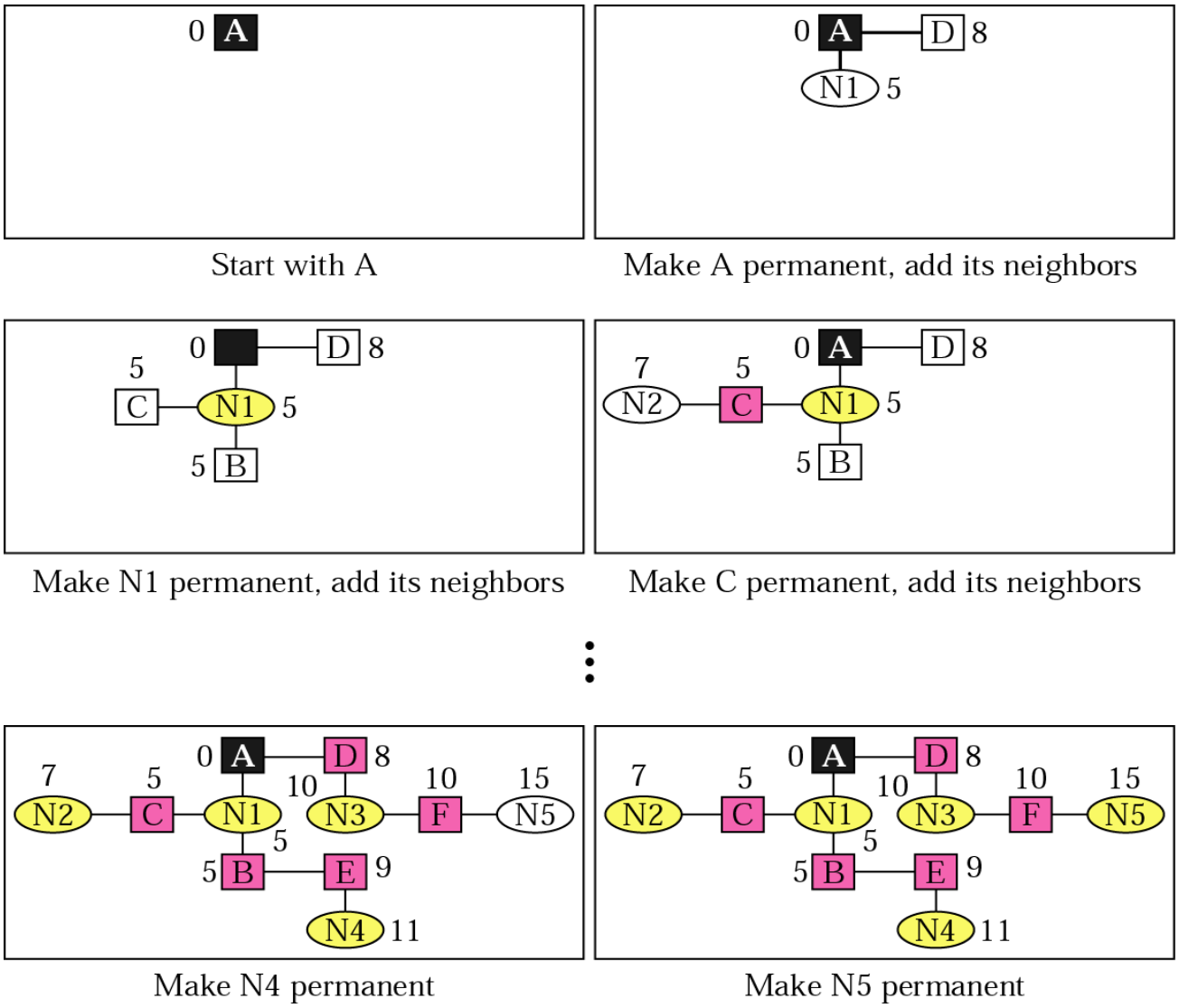


Table 21.2 Link state routing table for router A

Network	Cost	Next Router	Other Information
N1	5	C	
N2	7	D	
N3	10	B	
N4	11	D	
N5	15	C	

Table 21.3 Path vector routing table

Network	Next Router	Path
N01	R01	AS14, AS23, AS67
N02	R05	AS22, AS67, AS05, AS89
N03	R06	AS67, AS89, AS09, AS34
N04	R12	AS62, AS02, AS09

Figure 21.21 Path vector messages

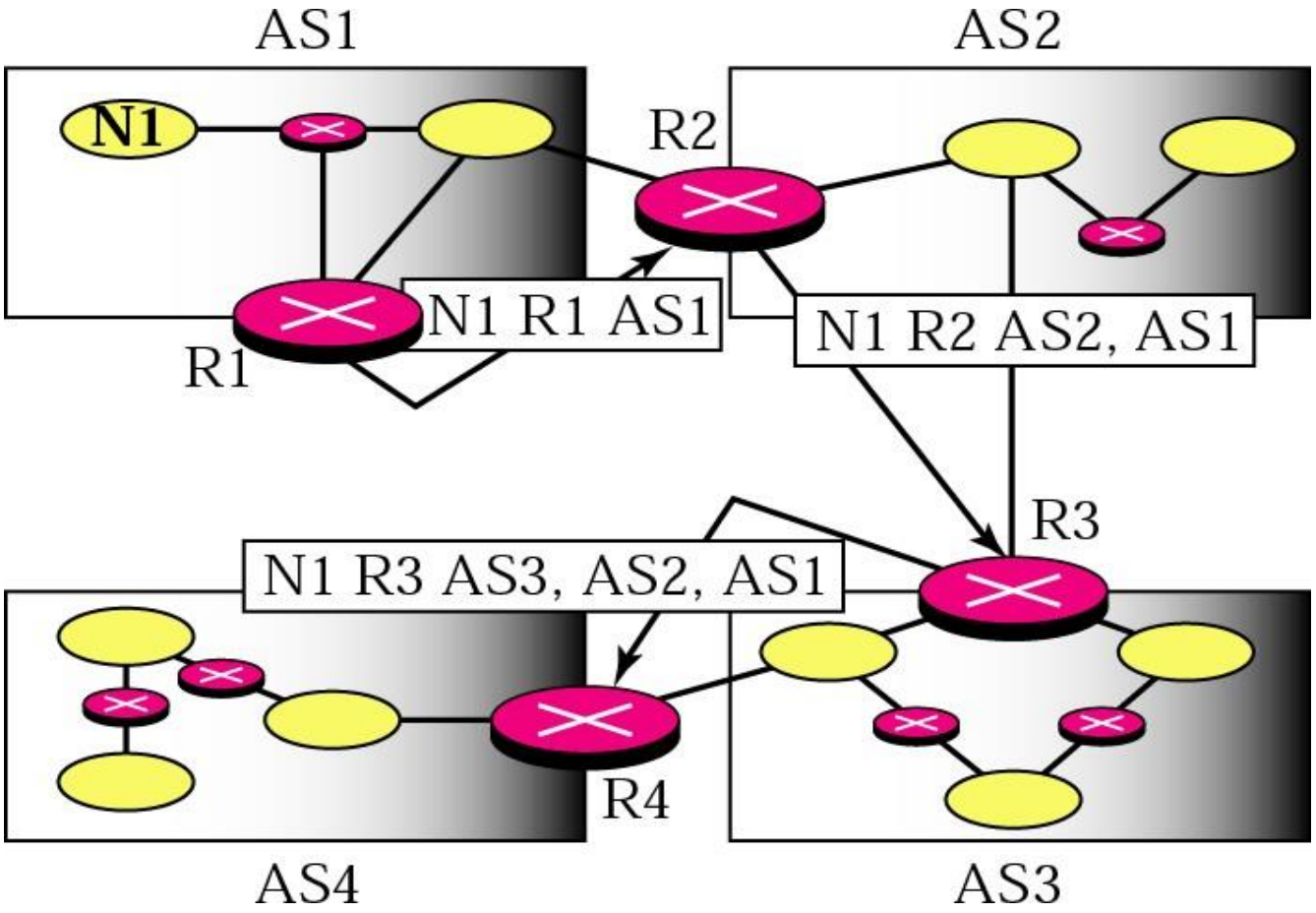
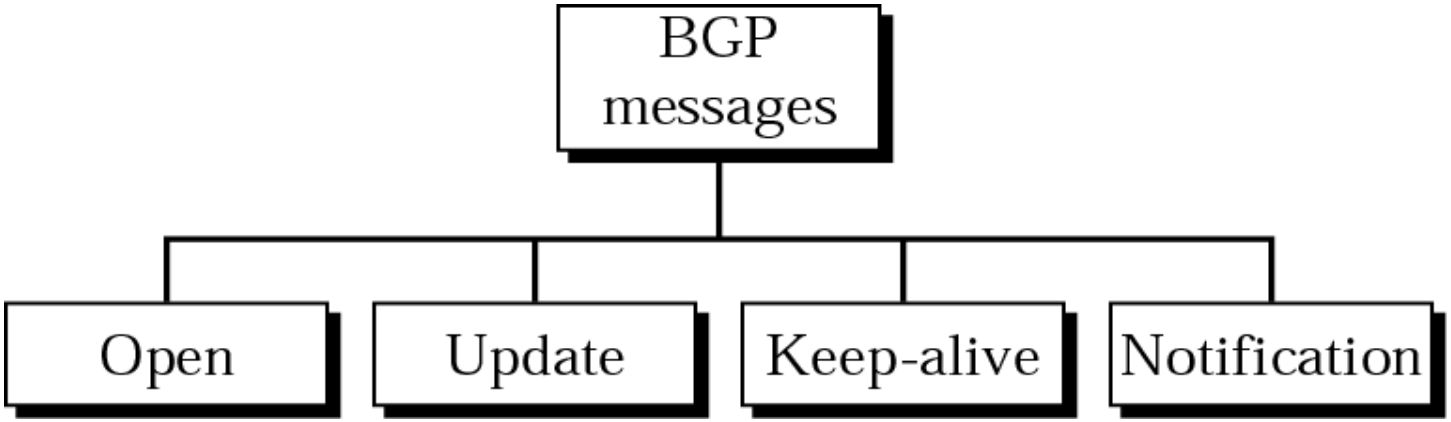


Figure 21.22 Types of BGP messages



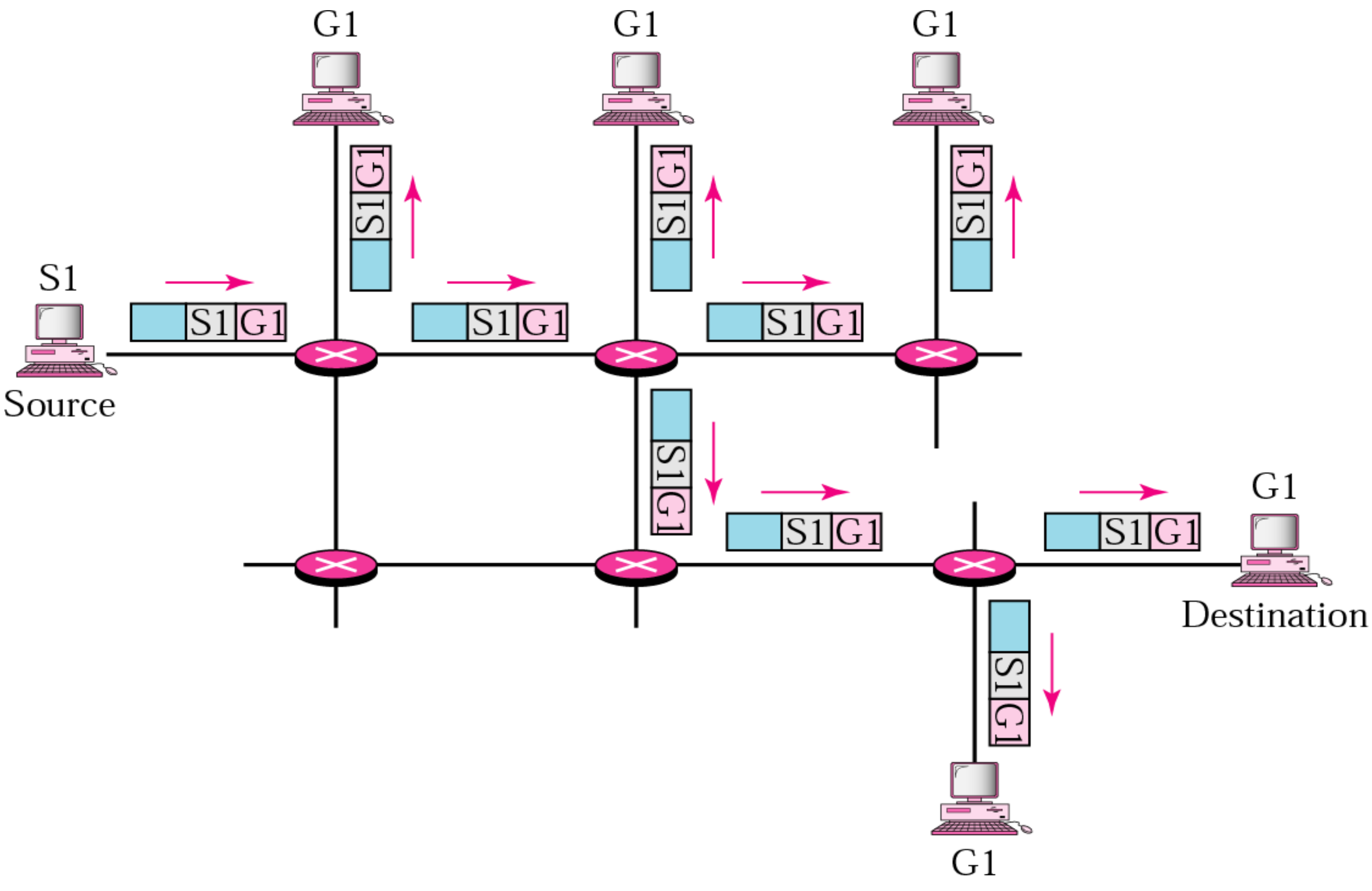
Multicast Routing

IGMP

Multicast Trees

MBONE

Figure 21.23 Multicasting



Note:

In multicast routing, the router may forward the received packet through several of its ports.

Note:

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

Figure 21.24 IGMP message types

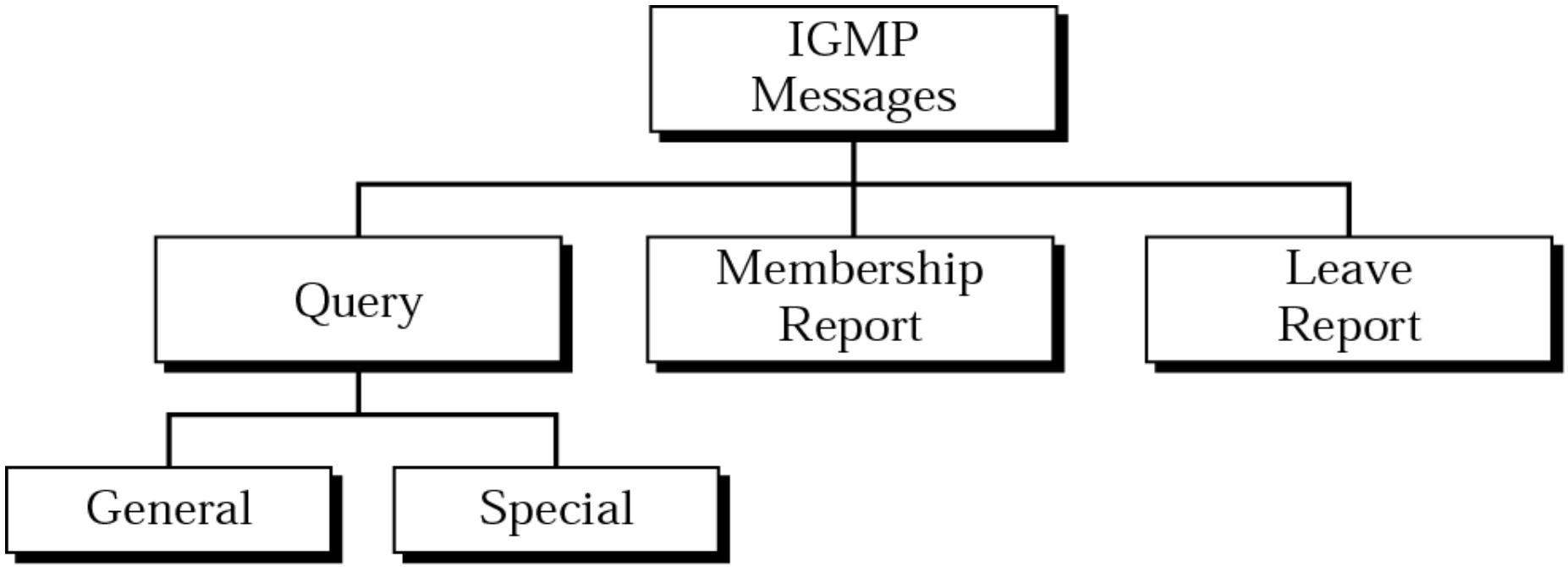


Figure 21.25 IGMP message format

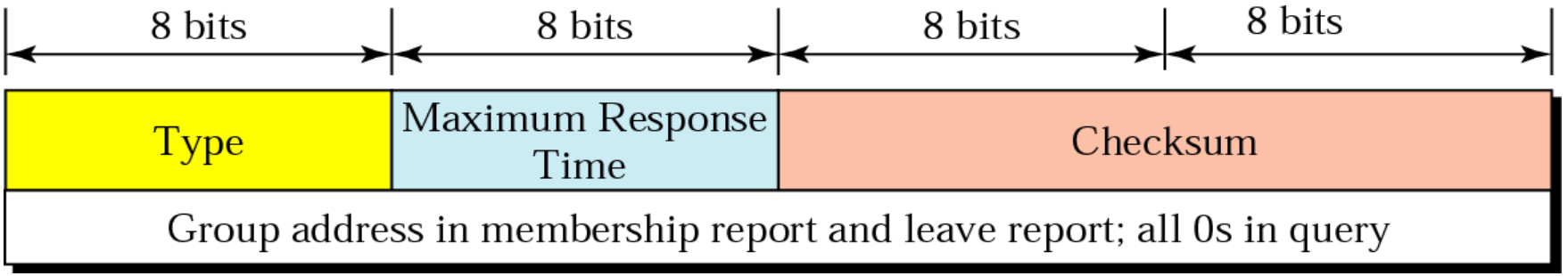


Table 21.4 IGMP type field

Type	Value
General or special query	0x11 or 00010001
Membership report	0x16 or 00010110
Leave report	0x17 or 00010111

Figure 21.26 IGMP operation

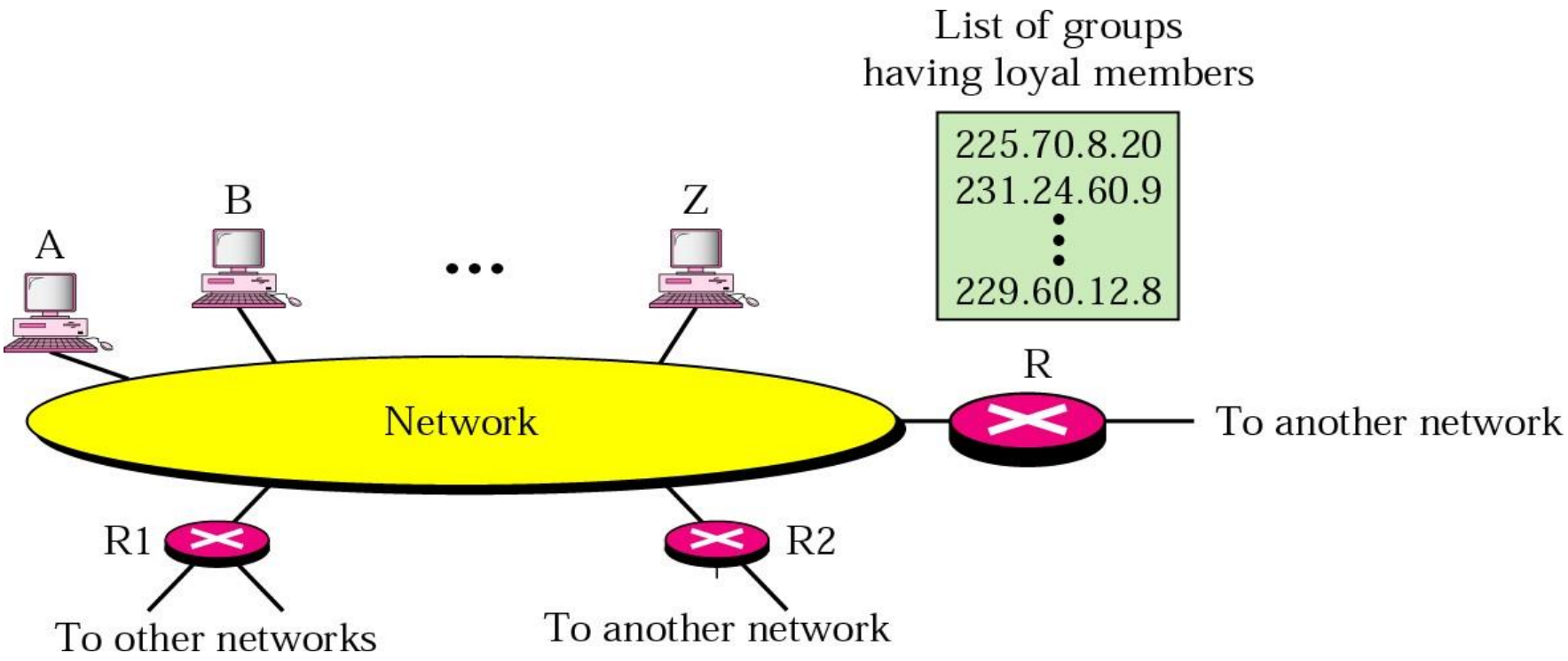
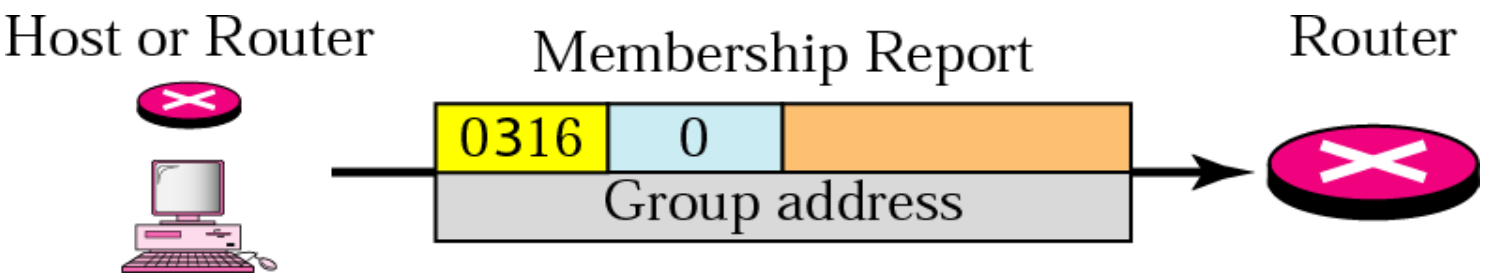


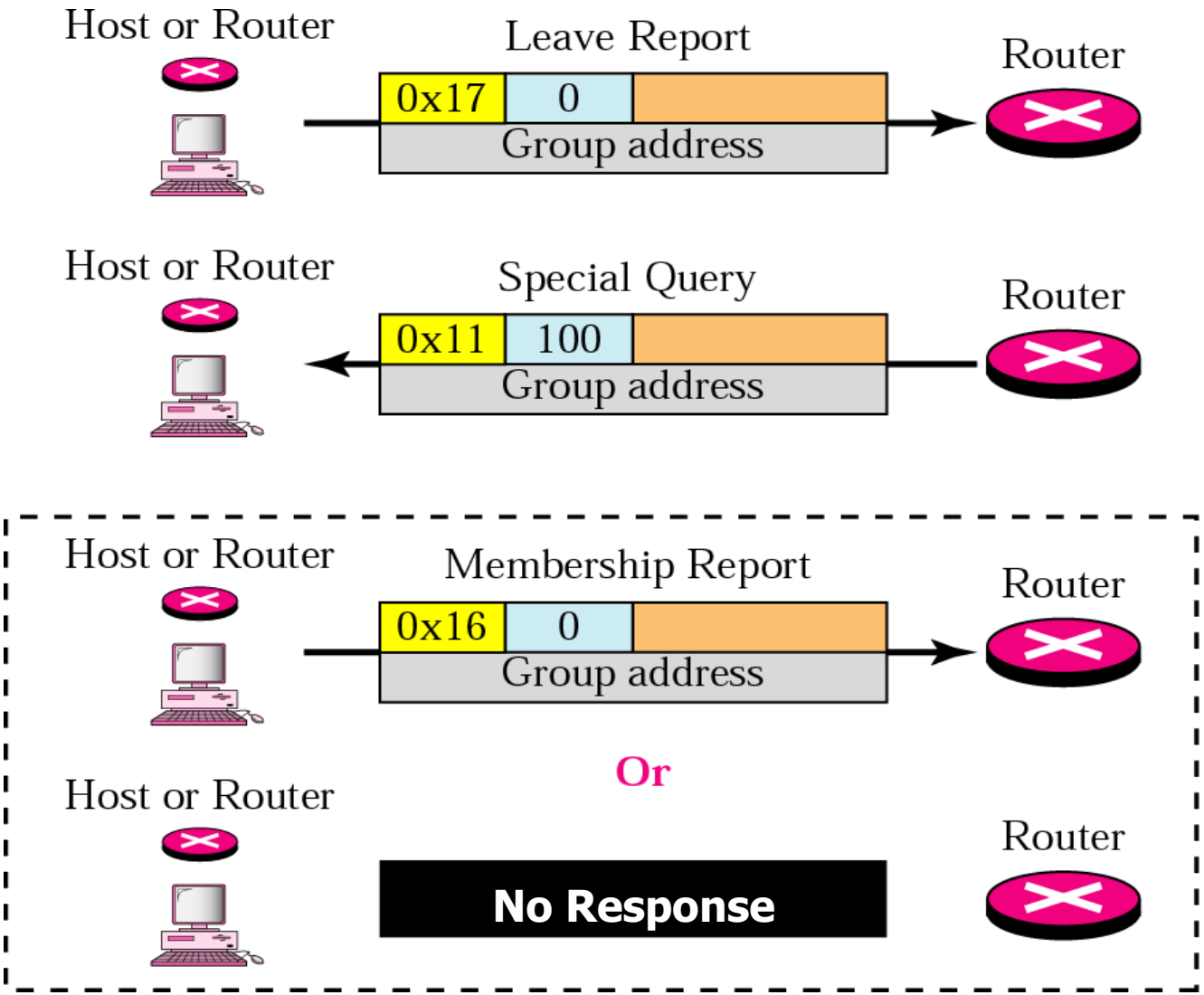
Figure 21.27 Membership report



Note:

In IGMP, a membership report is sent twice, one after the other.

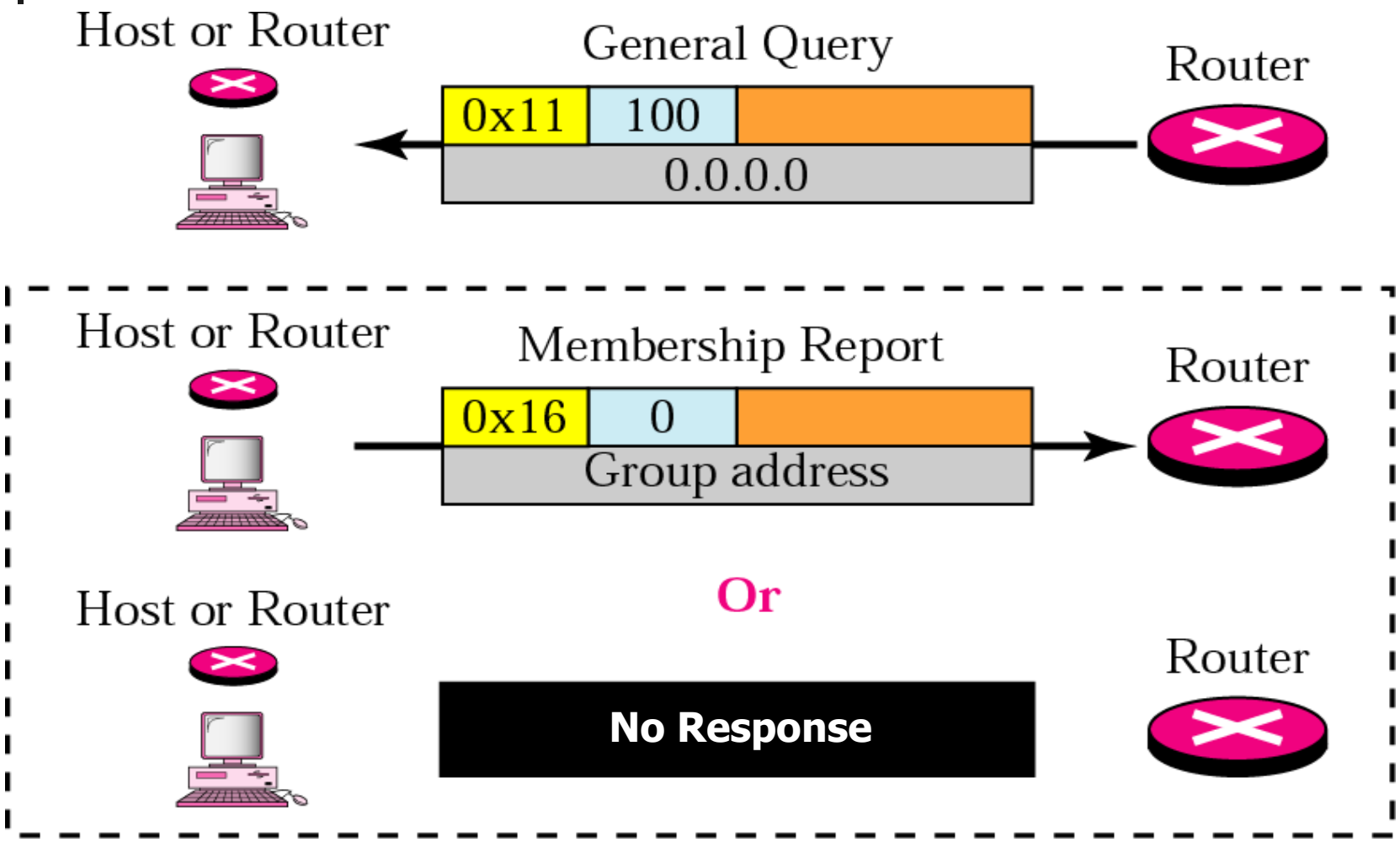
Figure 21.28 Leave report



Note:

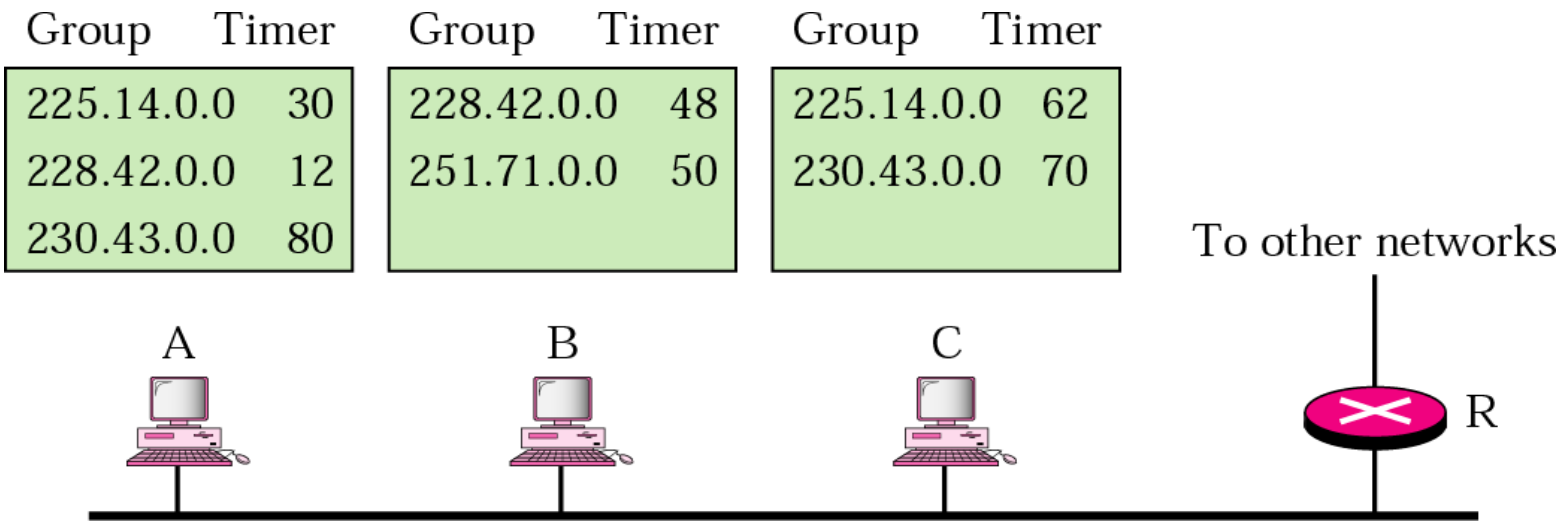
The general query message does not define a particular group.

Figure 21.29 General query message



Example 1

Imagine there are three hosts in a network, as shown in Figure 21.30 (below). A query message was received at time 0; the random delay time (in tenths of seconds) for each group is shown next to the group address. Show the sequence of report messages.



Solution

The events occur in this sequence:

1. Time 12. The timer for 228.42.0.0 in host A expires and a membership report is sent, which is received by the router and every host including host B which cancels its timer for 228.42.0.0.
2. Time 30. The timer for 225.14.0.0 in host A expires and a membership report is sent, which is received by the router and every host including host C which cancels its timer for 225.14.0.0.
3. Time 50. The timer for 251.71.0.0 in host B expires and a membership report is sent, which is received by the router and every host.
4. Time 70. The timer for 230.43.0.0 in host C expires and a membership report is sent, which is received by the router and every host including host A which cancels its timer for 230.43.0.0.

Note:

In a source-based tree approach, the combination of source and group determines the tree.

Note:

In the group-shared tree approach, the group determines the tree.

Figure 21.31 Logical tunneling

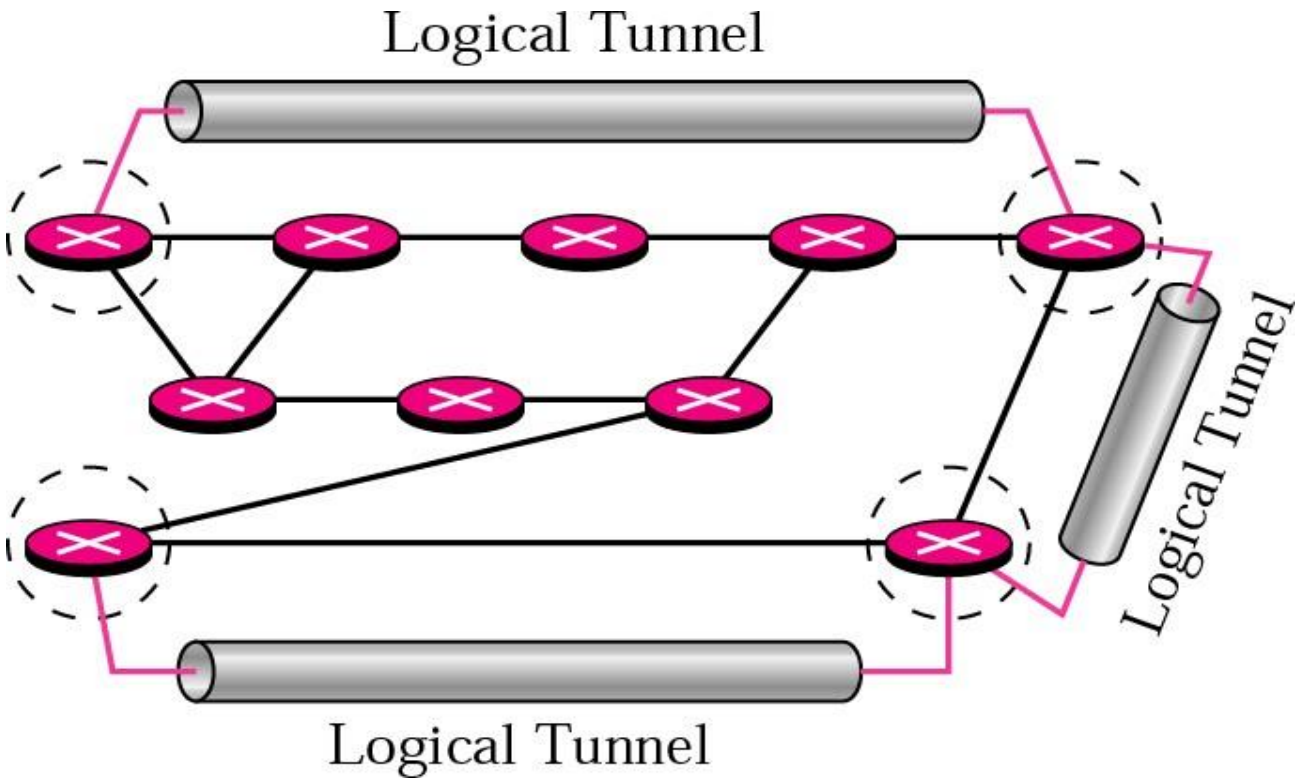
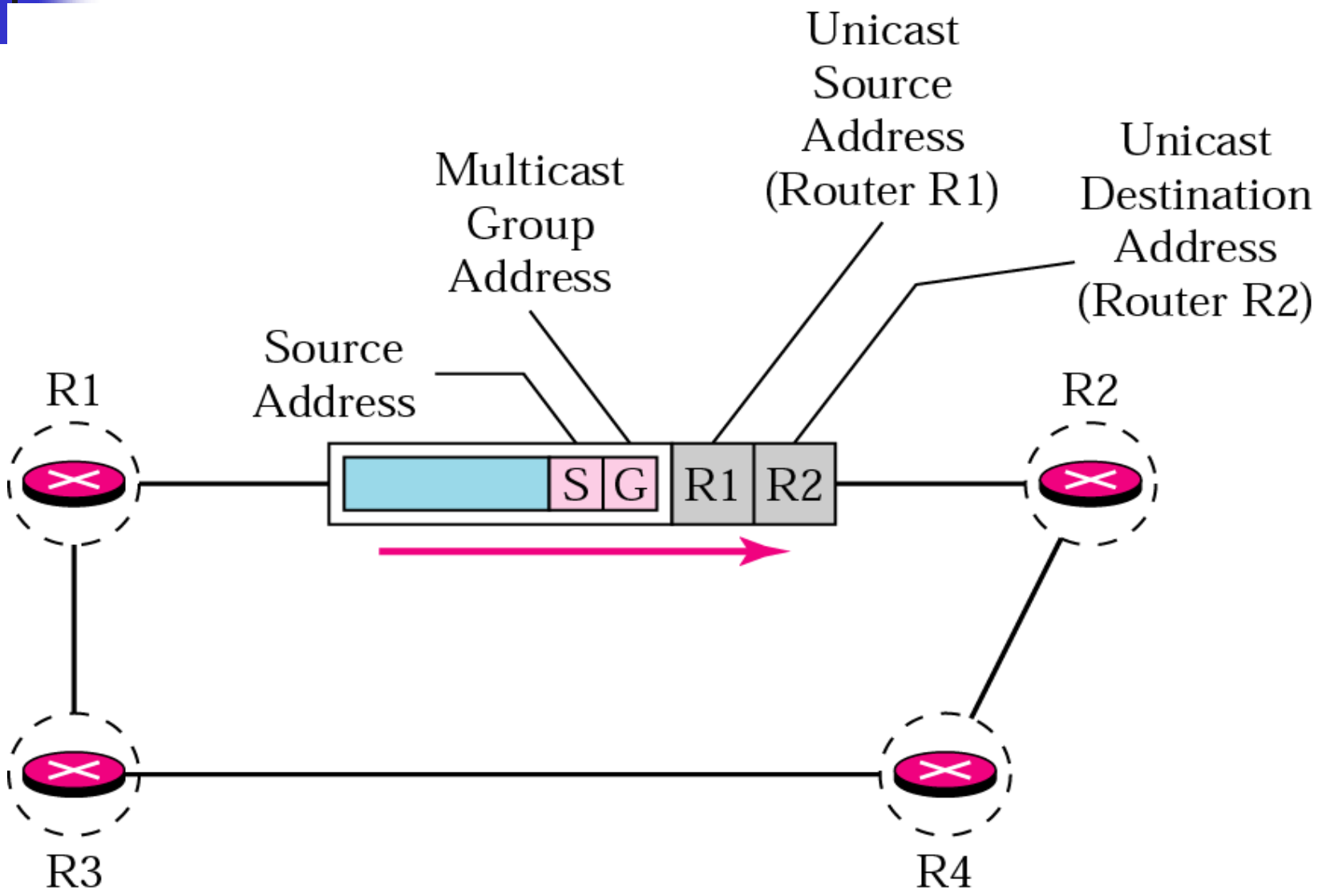


Figure 21.32 MBONE



Multicast Routing Protocols

DVMRP

MOSPF

CBT

PIM

Figure 21.33 Multicast routing protocols

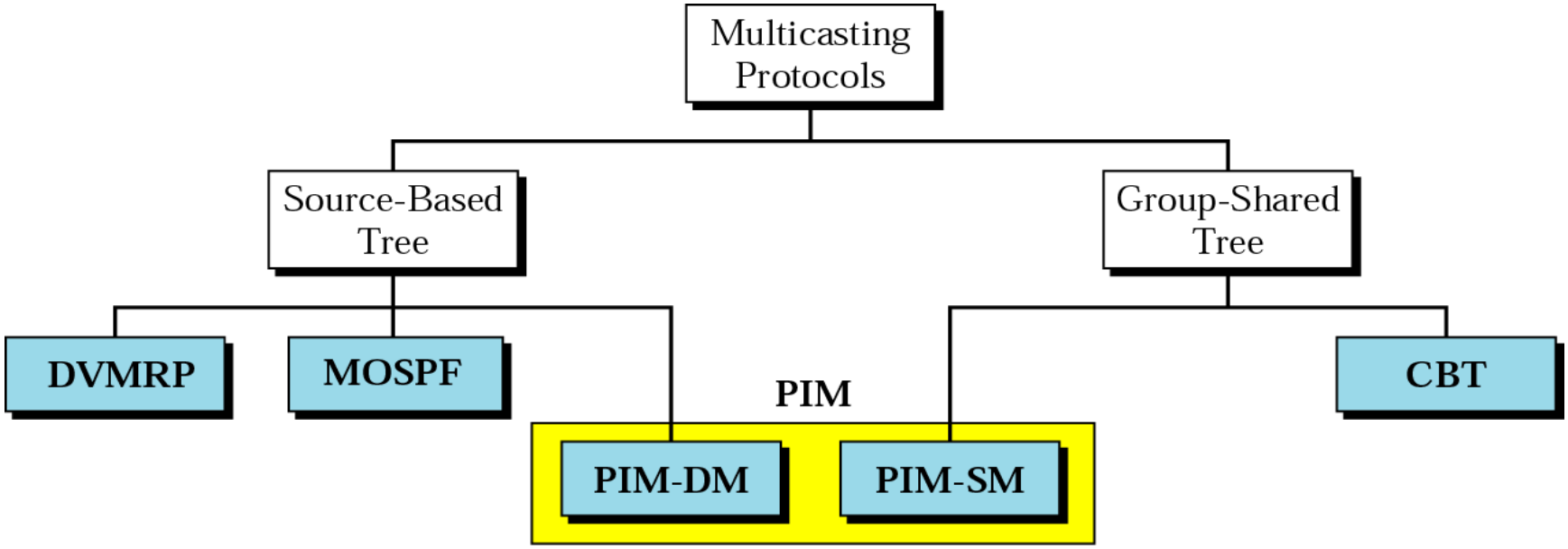
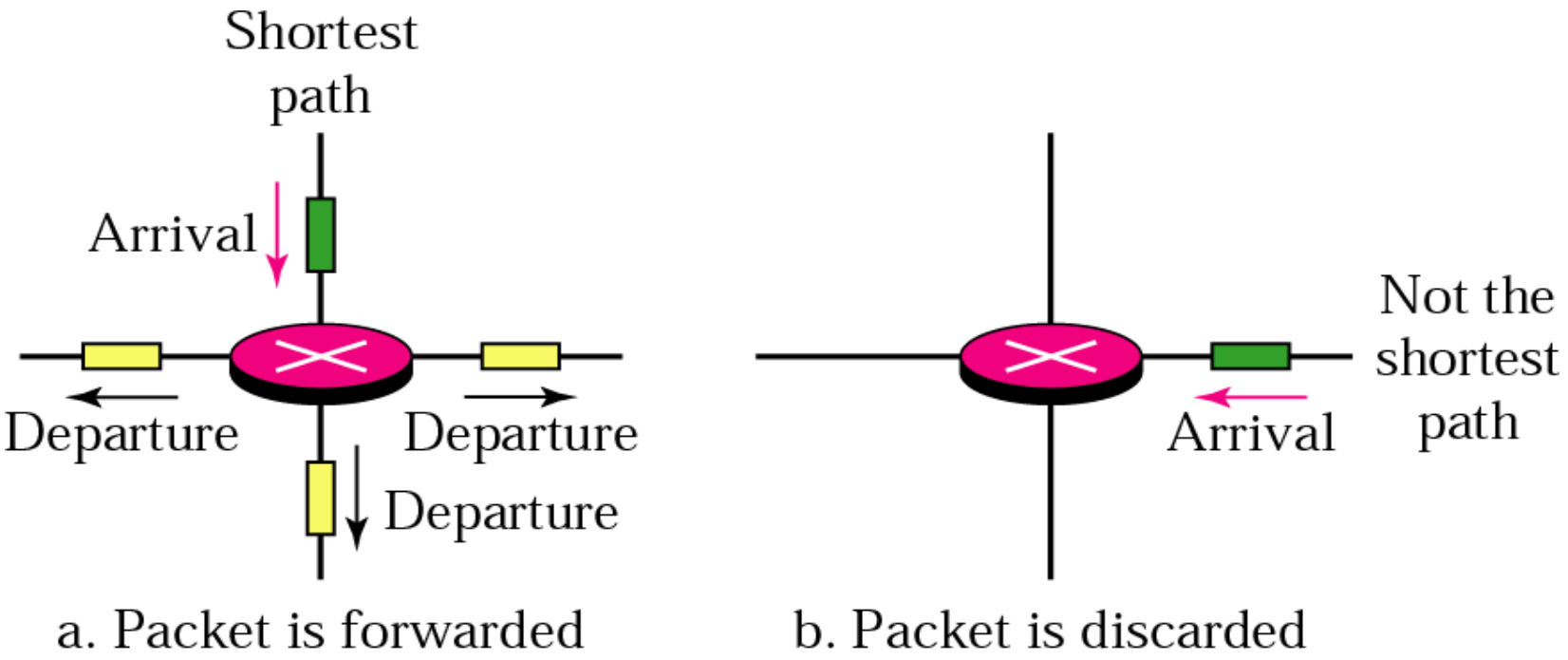


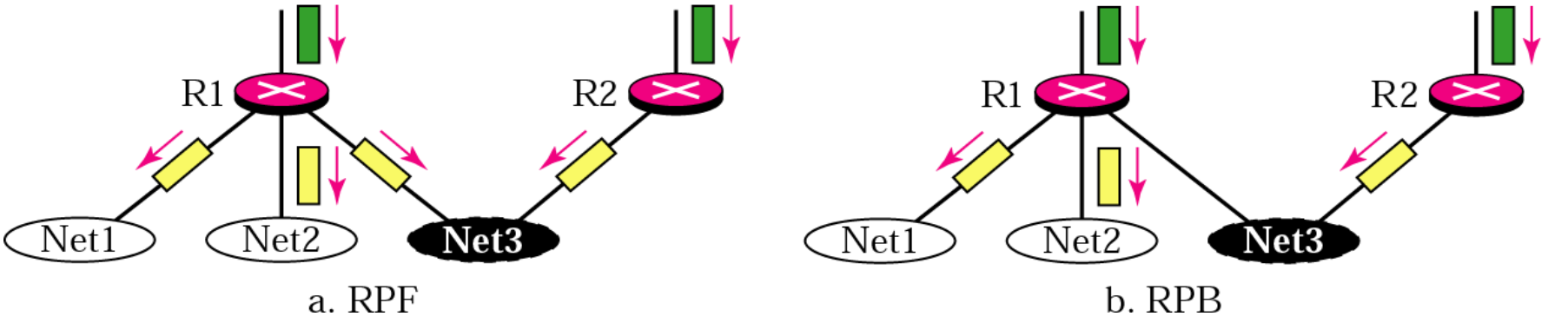
Figure 21.34 Reverse path forwarding



Note:

In reverse path forwarding, the router forwards only the packets that have traveled the shortest path from the source to the router; all other copies are discarded. RPF prevents the formation of loops.

Figure 21.35 RPF versus RPB

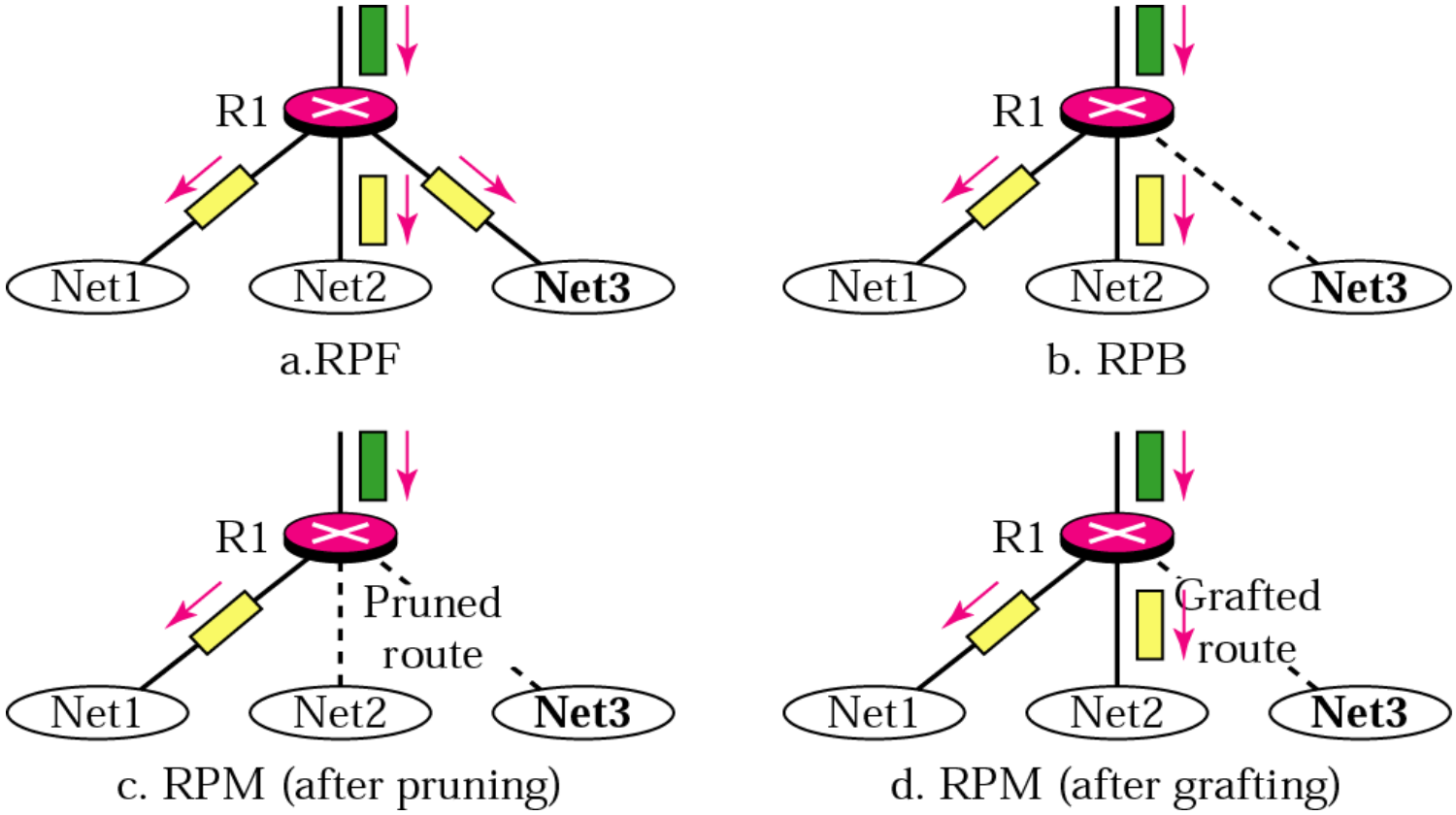


Note:

RPB creates a shortest-path broadcast tree from the source to each destination.

It guarantees that each destination receives one and only one copy of the packet.

Figure 21.36 RPF, RPB, and RPM



Note:

RPM adds pruning and grafting to RPB to create a multicast shortest-path tree that supports dynamic membership changes.

Figure 21.35 RPF versus RPB

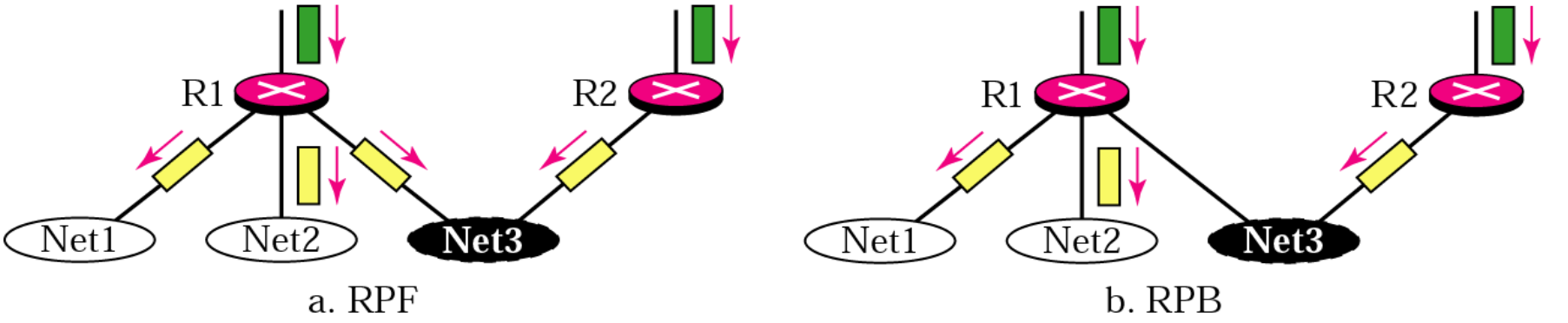
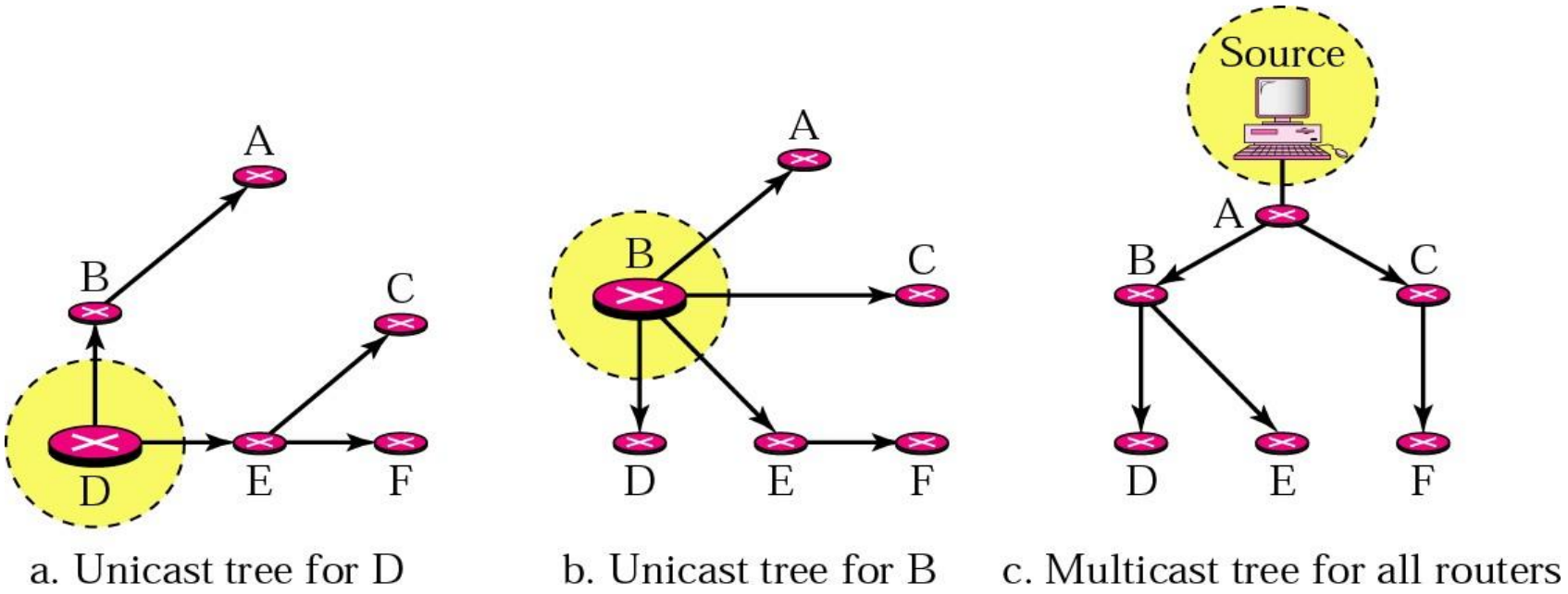


Figure 21.37 Unicast tree and multicast tree



a. Unicast tree for D

b. Unicast tree for B

c. Multicast tree for all routers

Figure 21.38 Shared-group tree with rendezvous router

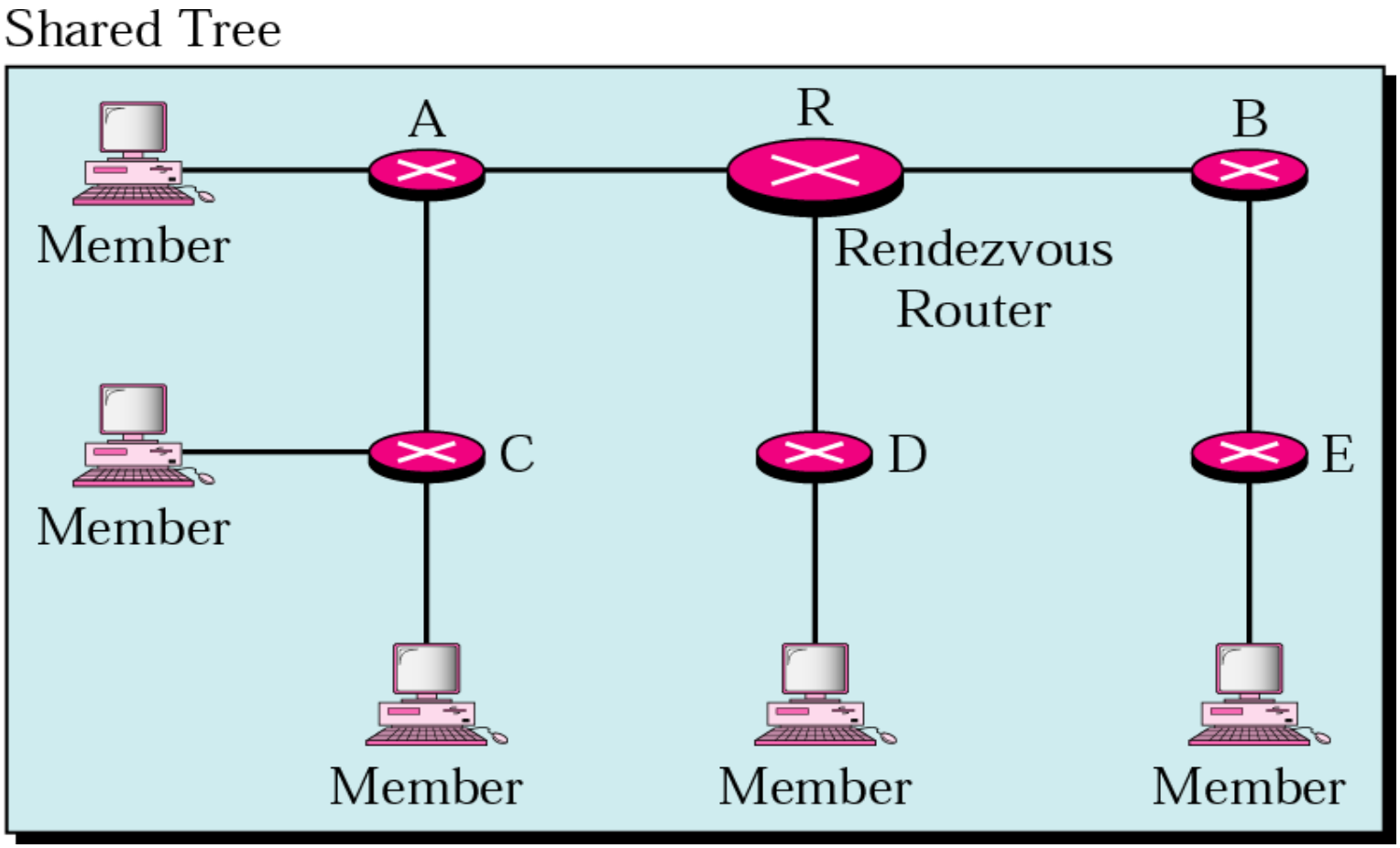
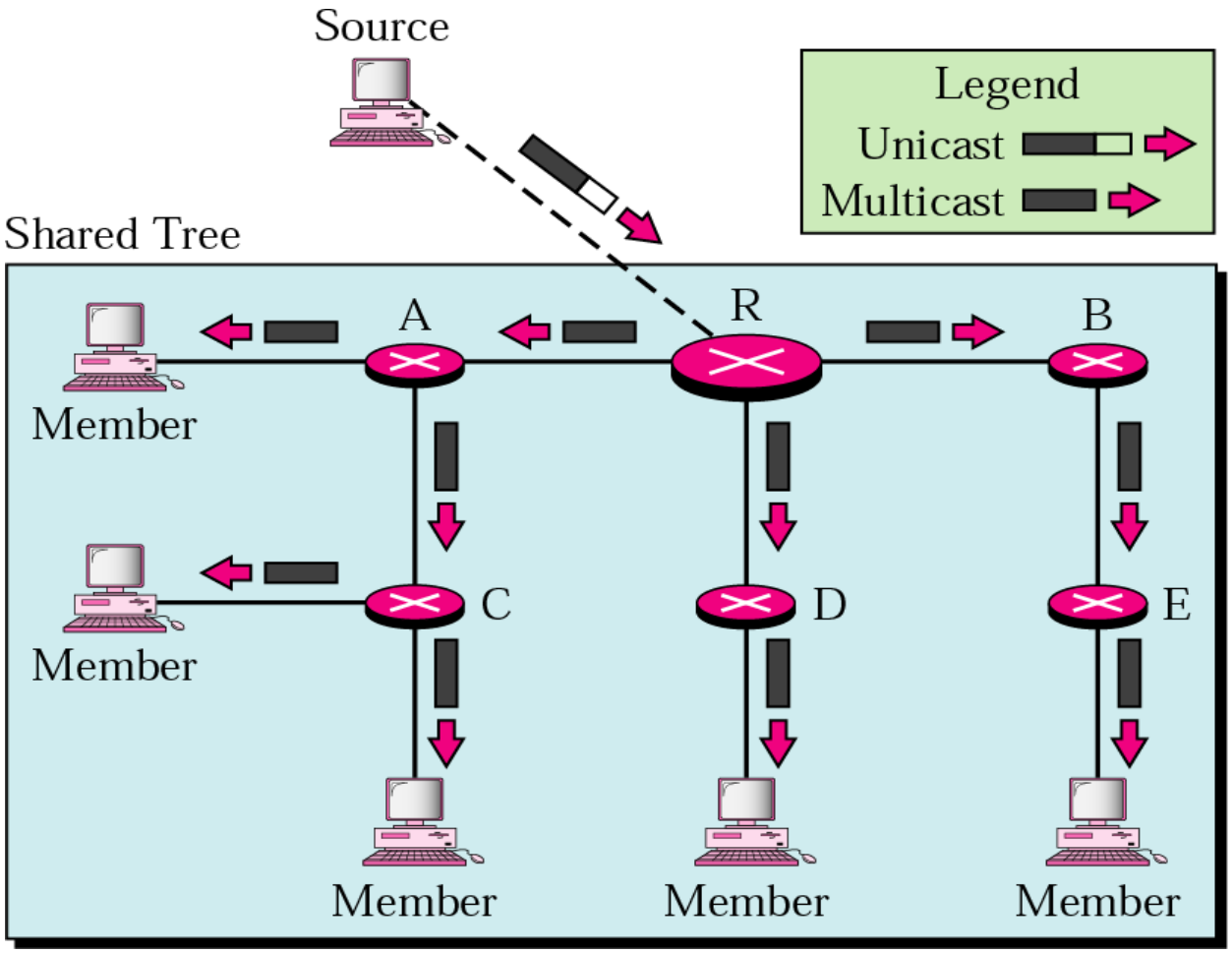


Figure 21.39 Sending a multicast packet to the rendezvous router



Note:

In CBT, the source sends the multicast packet to the core router. The core router decapsulates the packet and forwards it to all interested hosts.

Note:

PIM-DM uses RPF and pruning and grafting strategies to handle multicasting. However, it is independent of the underlying unicast protocol.

Note:

PIM-SM is similar to CBT but uses a simpler procedure.