Delivery and Forwarding of IP Packets

Objectives

Upon completion you will be able to:

- ***Understand the different types of delivery and the connection***
- ***Understand forwarding techniques in classful addressing***
- ***Understand forwarding techniques in classless addressing***
- ***Understand how a routing table works***
- ***Understand the structure of a router***

6.1 DELIVERY

The network layer supervises delivery, the handling of the packets by the underlying physical networks. Two important concepts are the type of connection and direct versus indirect delivery.

The topic discussed in this section include:

Direct Versus Indirect Delivery

Figure 6.1 ***Direct delivery***

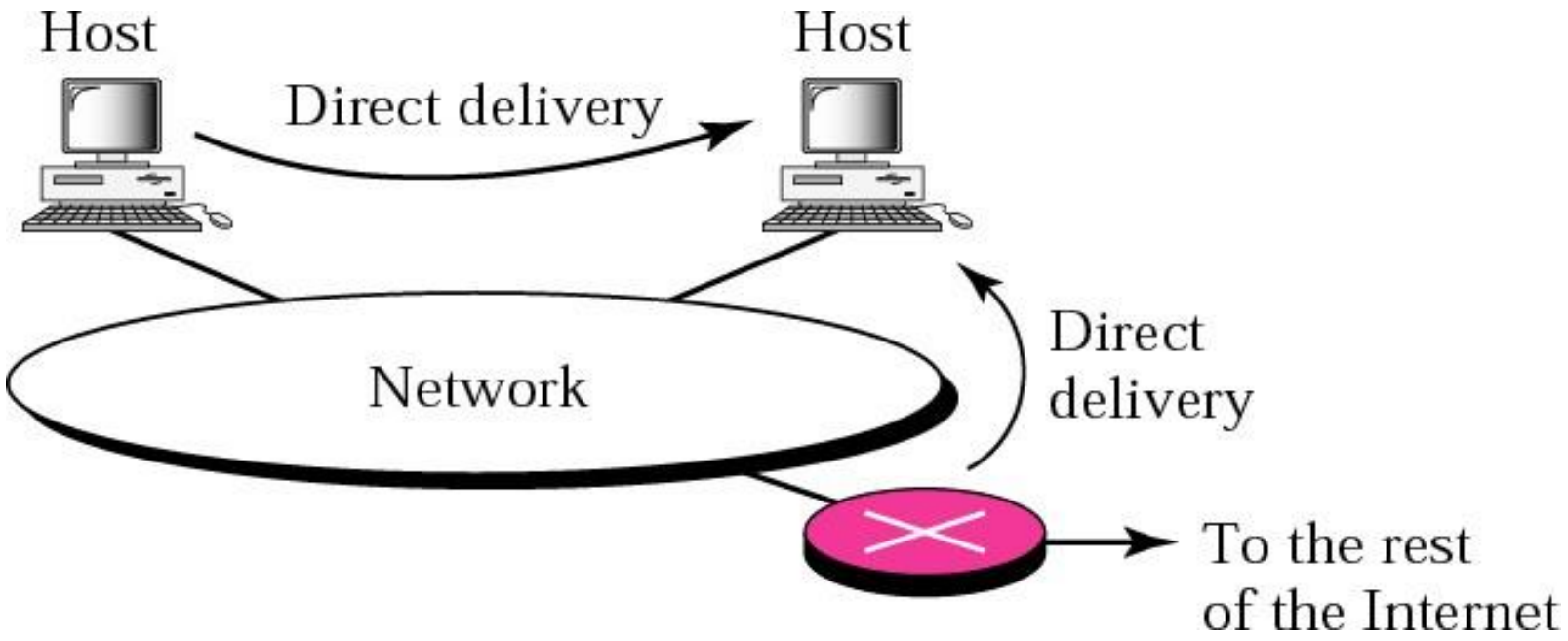
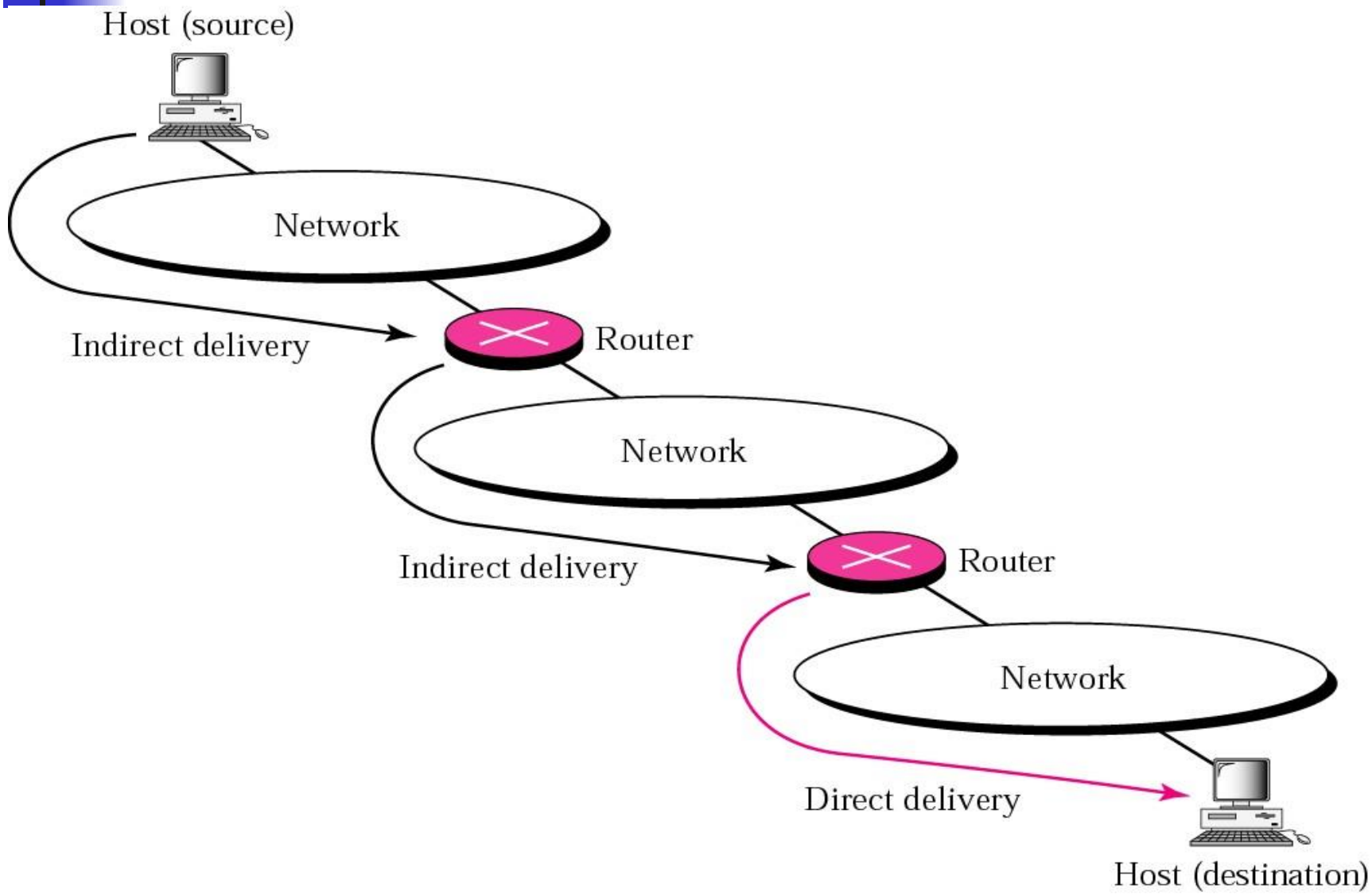


Figure 6.2 ***Indirect delivery***



6.2 FORWARDING

Forwarding means to place the packet in its route to its destination. Forwarding requires a host or a router to have a routing table. .

The topics discussed in this section include:

* *Forwarding Techniques*
* *Forwarding with Classful Addressing*
* *Forwarding with Classless Addressing*

Figure 6.3

Routing table for host A

Destination	Route
Host B	R1, R2, Host B

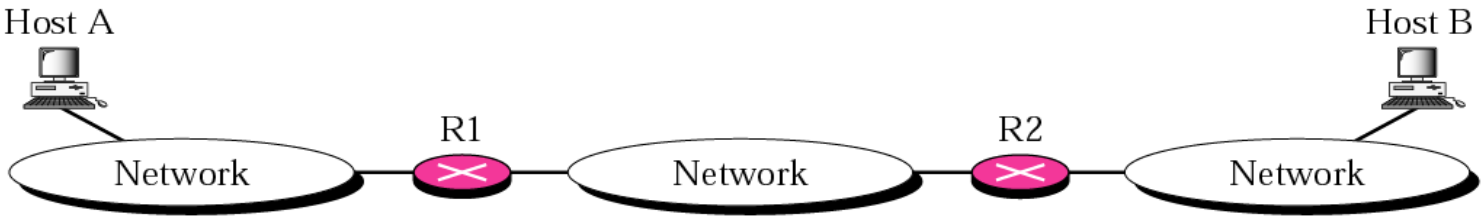
Routing table for R1

Destination	Route
Host B	R2, Host B

Routing table for R2

Destination	Route
Host B	Host B

a. Routing tables based on route



Routing table for host A

Destination	Next Hop
Host B	R1

Routing table for R1

Destination	Next Hop
Host B	R2

Routing table for R2

Destination	Next Hop
Host B	Ñ

b. Routing tables based on next hop

Figure 6.4

Routing table for host S based on host-specific method

Destination	Next Hop
A	R1
B	R1
C	R1
D	R1

Routing table for host S based on network-specific method

Destination	Next Hop
N2	R1

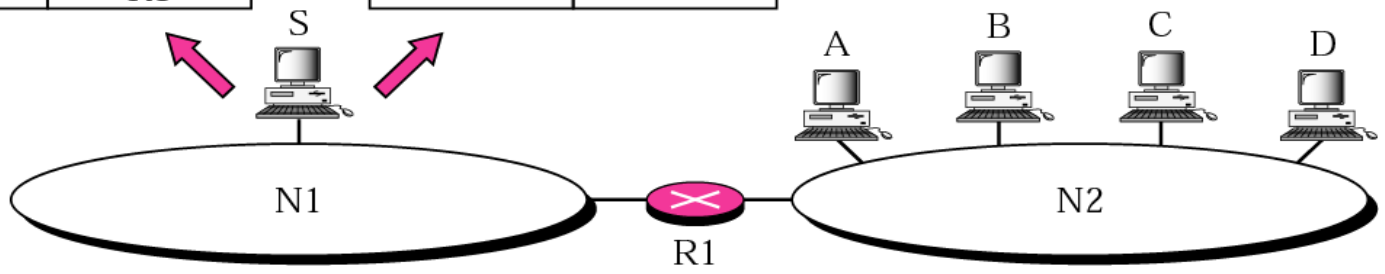


Figure 6.5

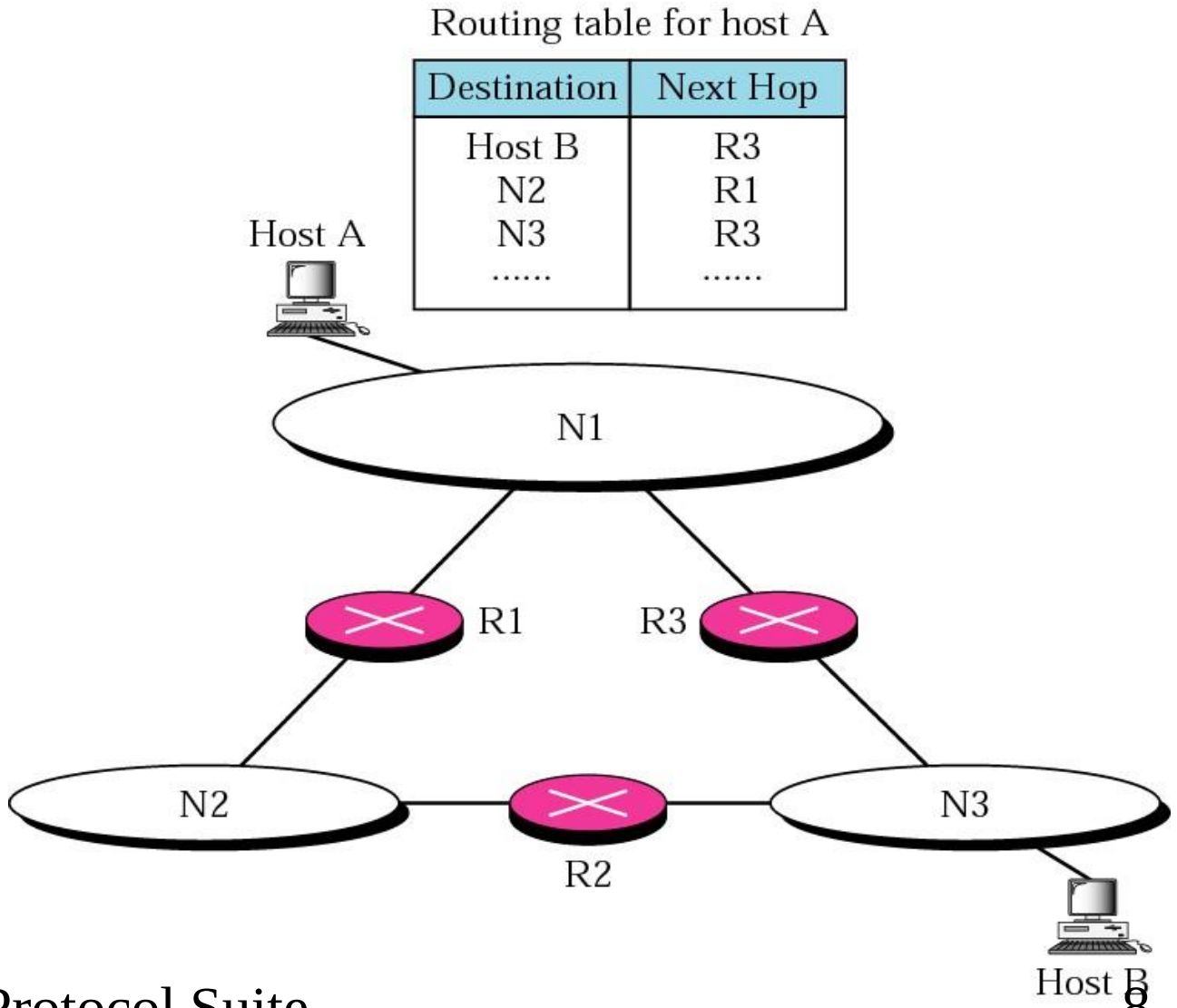

Routing table for host A
Destination
Next Hop
Host B
R3
N2
R1
N3
R3
.....
.....
Host A
N1
R1
R3
N2
R2
N3
Host B

Figure 6.6

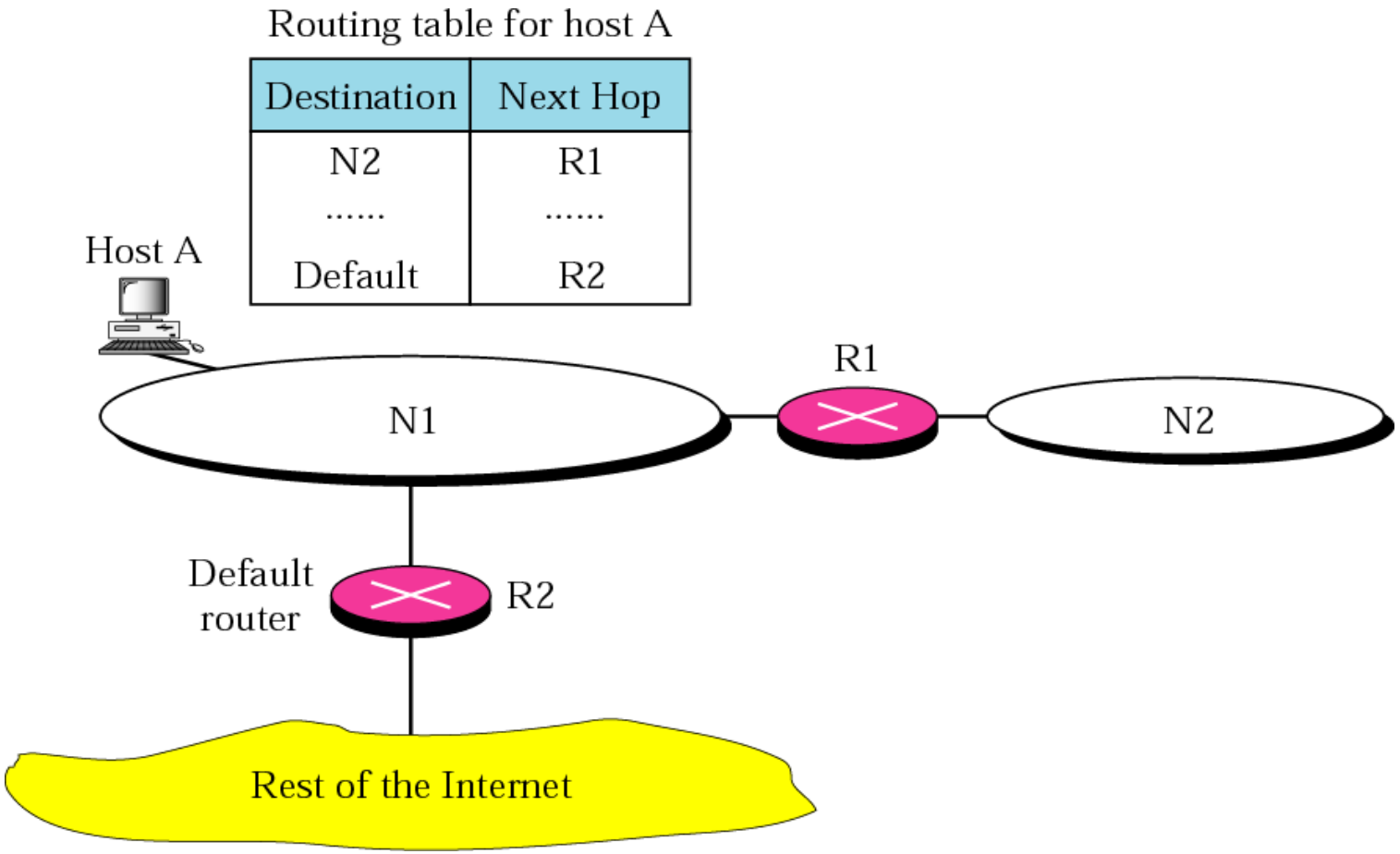
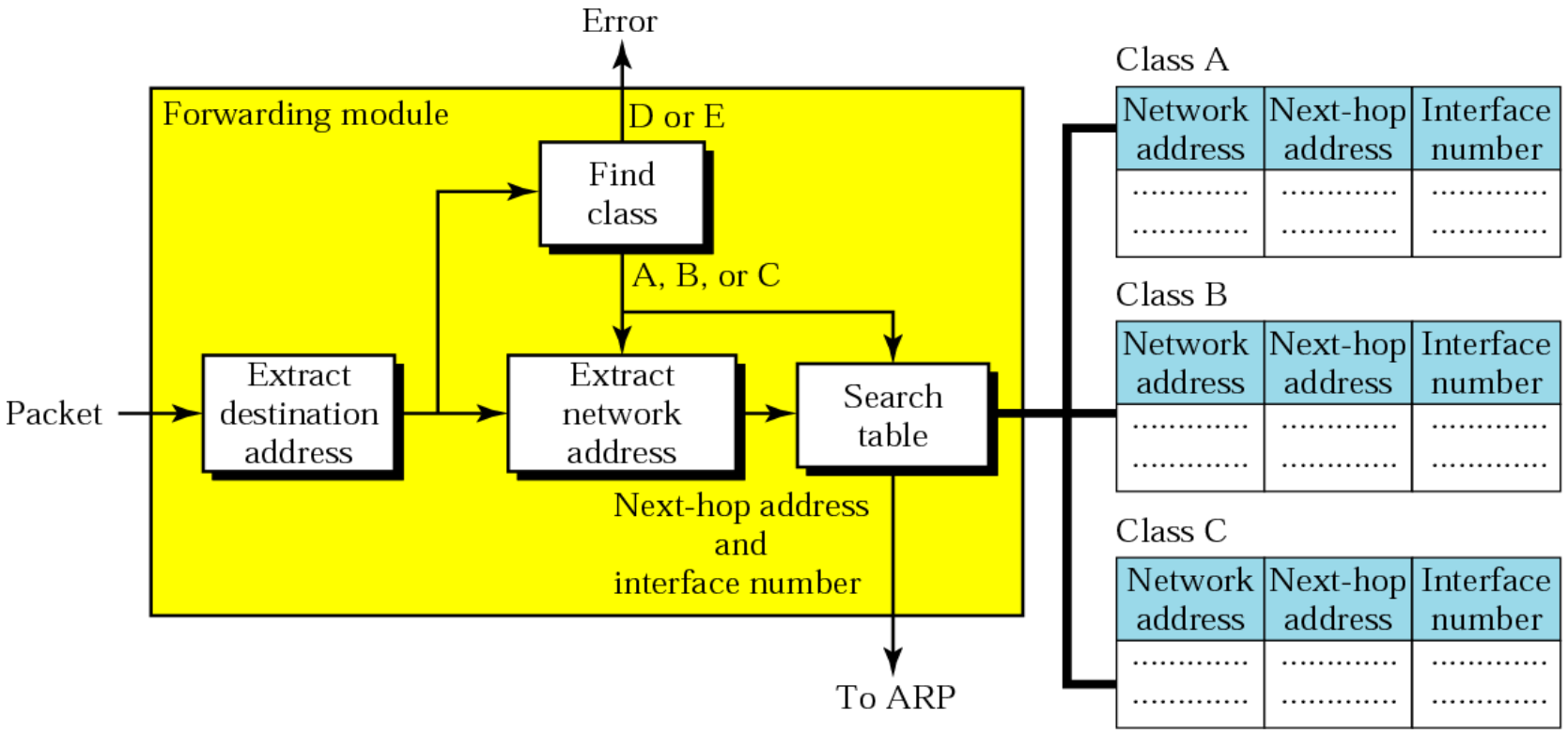

Routing table for host A
Destination
Next Hop
N2
R1
.....
.....
Default
R2
Host A
R1
N1
N2
Default
router
R2
Rest of the Internet

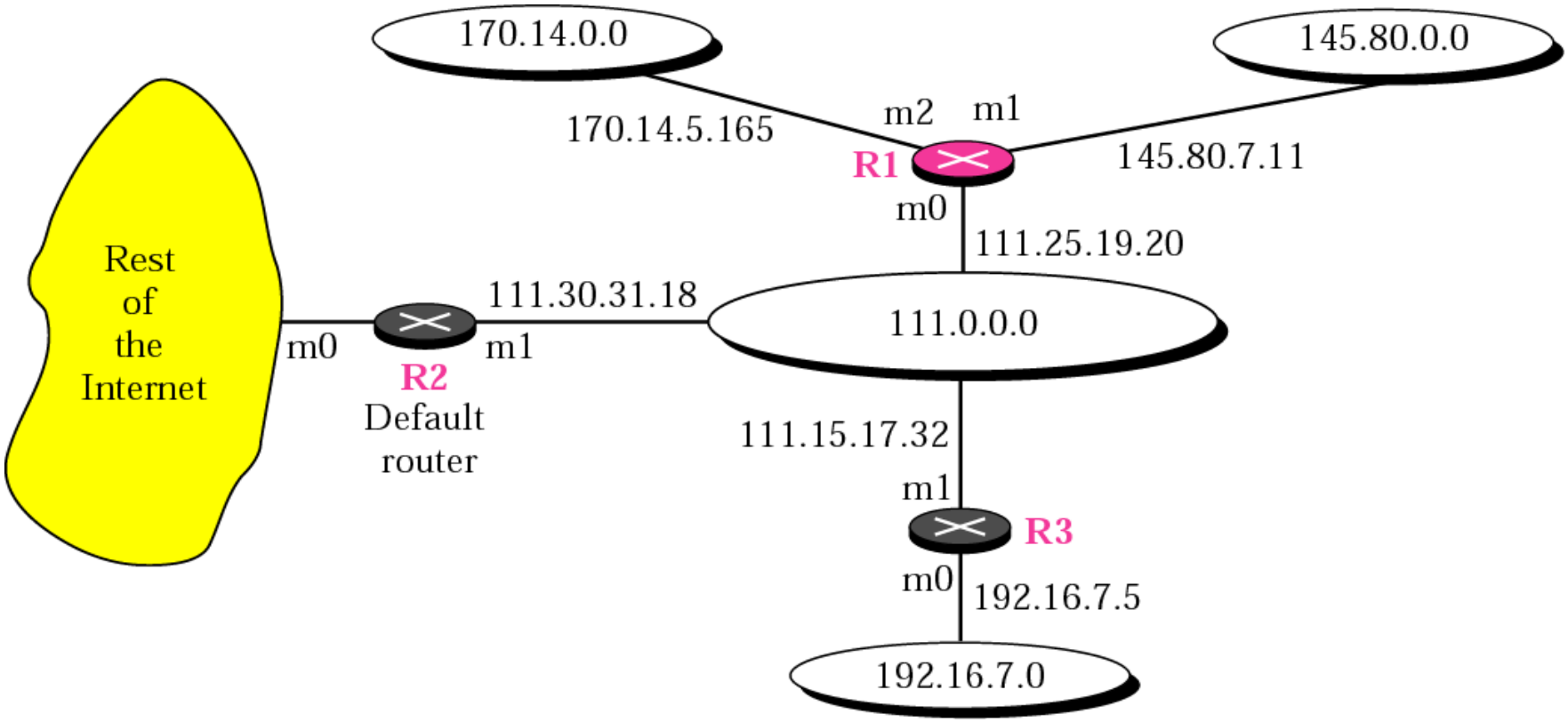
Figure 6.7 *Simplified forwarding module in classful address without subnetting*



Example 1

Figure 6.8 shows an imaginary part of the Internet. Show the routing tables for router R1.

Figure 6.8 *Configuration for routing, Example 1*



ExamplE 1 (ContinuEd)

Solution

Figure 6.9 shows the three tables used by router R1. Note that some entries in the next-hop address column are empty because in these cases, the destination is in the same network to which the router is connected (direct delivery). In these cases, the next-hop address used by ARP is simply the destination address of the packet as we will see in Chapter 7.

Figure 6.9 *Tables for Example 1*

Class A

Network address	Next-hop address	Interface
111.0.0.0	----------	m0

Class B

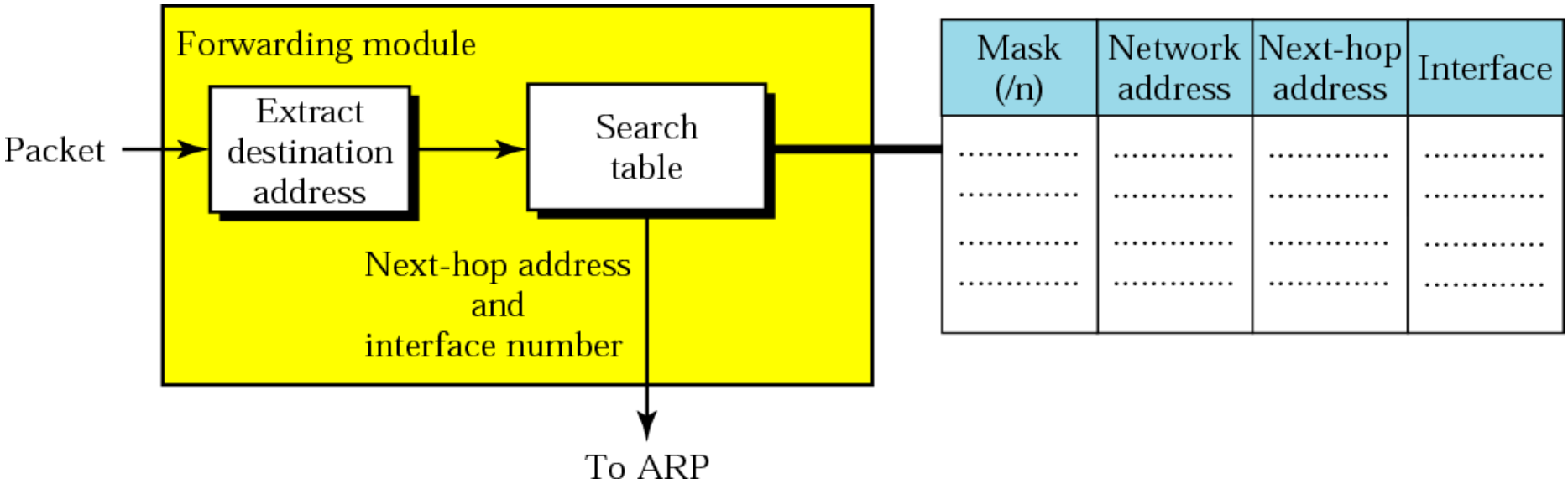
Network address	Next-hop address	Interface
145.80.0.0	----------	m1
170.14.0.0	----------	m2

Class C

Network address	Next-hop address	Interface
192.16.7.0	111.15.17.32	m0

Default: 111.30.31.18, m0

Figure 6.12 *Simplified forwarding module in classless address*



Note:

In classful addressing we can have a routing table with three columns;

in classless addressing, we need at least four columns.

Example 7

Make a routing table for router R1 using the configuration in Figure 6.13.

Solution

Table 6.1 shows the corresponding table.

Figure 6.13 *Configuration for Example 7*

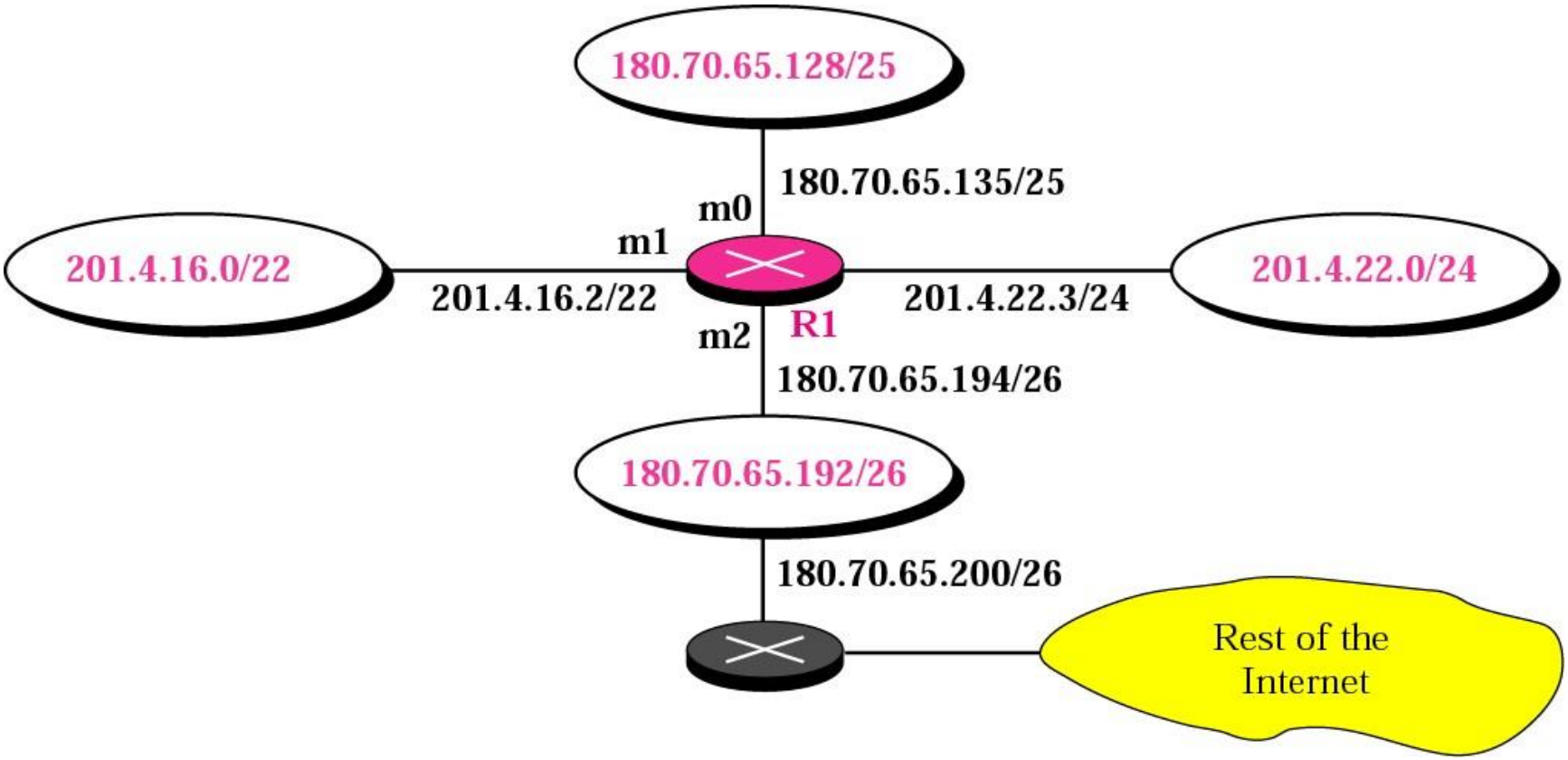


Table 6.1 Routing table for router R1 in Figure 6.13

Mask	*Network Address*	*Next Hop*	*Interface*
/26	180.70.65.192	-	m2
/25	180.70.65.128	-	m0
/24	201.4.22.0	-	m3
/22	201.4.16.0	....	m1
Default	Default	180.70.65.200	m2

Example 8

Show the forwarding process if a packet arrives at R1 in Figure 6.13 with the destination address 180.70.65.140.

Solution

The router performs the following steps:

1. ***The first mask (/26) is applied to the destination address. The result is 180.70.65.128, which does not match the corresponding network address.***

Example 8 (Continued)

2. The second mask (/25) is applied to the destination address. The result is 180.70.65.128, which matches the corresponding network address. The next-hop address (the destination address of the packet in this case) and the interface number m0 are passed to ARP for further processing.

Example 9

Show the forwarding process if a packet arrives at R1 in Figure 6.13 with the destination address 201.4.22.35.

Solution

The router performs the following steps:

ExamplE 9 (ContinuEd)

1. The first mask (/26) is applied to the destination address. The result is 201.4.22.0, which does not match the corresponding network address (row 1).

2. The second mask (/25) is applied to the destination address. The result is 201.4.22.0, which does not match the corresponding network address (row 2).

3. The third mask (/24) is applied to the destination address. The result is 201.4.22.0, which matches the corresponding network address. The destination address of the package and the interface number m3 are passed to ARP.

ExamplE 10

Show the forwarding process if a packet arrives at R1 in Figure 6.13 with the destination address 18.24.32.78.

Solution

This time all masks are applied to the destination address, but no matching network address is found. When it reaches the end of the table, the module gives the next-hop address 180.70.65.200 and interface number m2 to ARP. This is probably an outgoing package that needs to be sent, via the default router, to some place else in the Internet.

ExamplE 11

Now let us give a different type of example. Can we find the configuration of a router, if we know only its routing table? The routing table for router R1 is given in Table 6.2. Can we draw its topology?

Table 6.2 Routing table for Example 11

Mask	*Network Address*	*Next-Hop Address*	*Interface Number*
/26	140.6.12.64	180.14.2.5	m2
/24	130.4.8.0	190.17.6.2.0	m1
/16	110.70.0.0	----------	m0
/16	180.14.0.0	----------	m2
/16	190.17.0.0	----------	m1
Default	Default	110.70.4.6	m0

ExamplE 11 (ContinuEd)

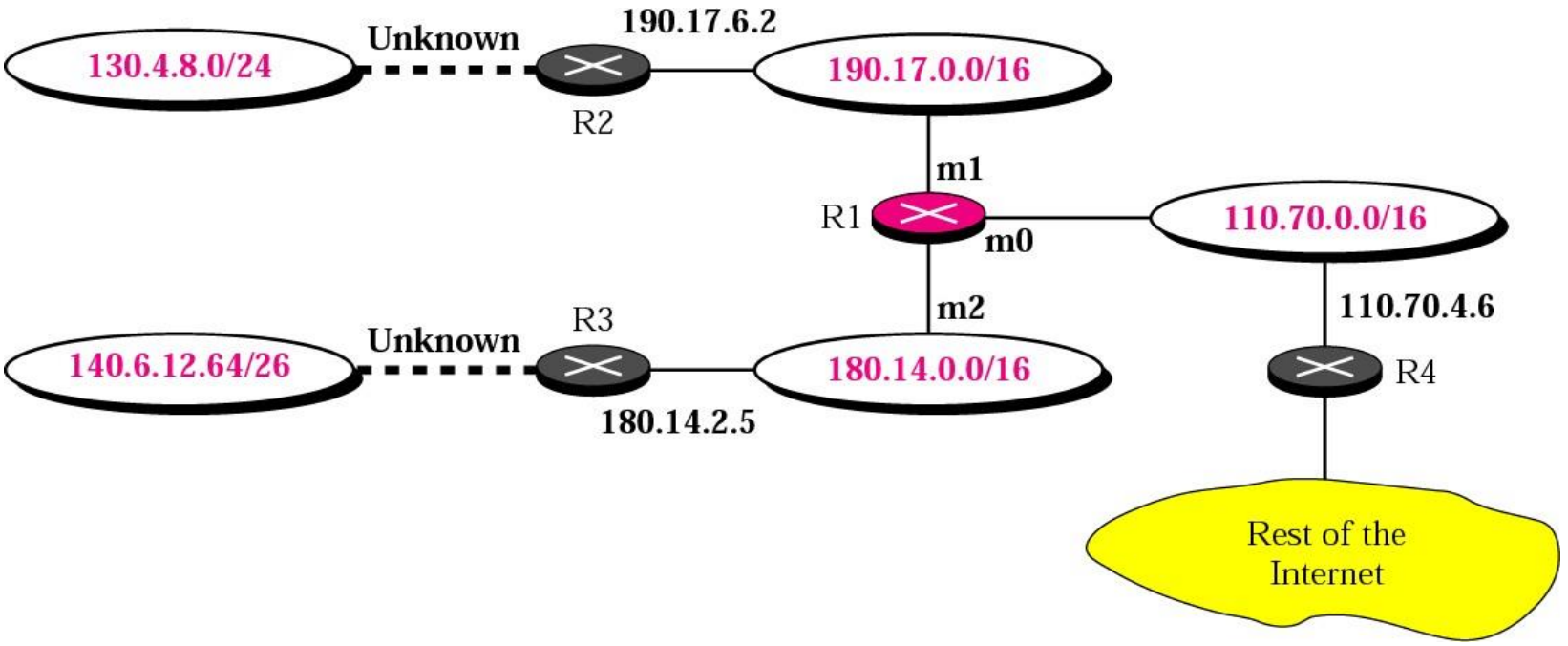
Solution

We know some facts but we don't have all for a definite topology. We know that router R1 has three interfaces: m0, m1, and m2. We know that there are three networks directly connected to router R1. We know that there are two networks indirectly connected to R1. There must be at least three other routers involved (see next-hop column). We know to which networks these routers are connected by looking at their IP addresses. So we can put them at their appropriate place.

Example 11 (Continued)

We know that one router, the default router, is connected to the rest of the Internet. But there is some missing information. We do not know if network 130.4.8.0 is directly connected to router R2 or through a point-to-point network (WAN) and another router. We do not know if network140.6.12.64 is connected to router R3 directly or through a point-to-point network (WAN) and another router. Point-to-point networks normally do not have an entry in the routing table because no hosts are connected to them. Figure 6.14 shows our guessed topology.

Figure 6.14 *Guessed topology for Example 6*



Lectures main notes

- Two types of delivery (Direct & Indirect)
- Four types of forwarding techniques (
- 3 main columns in the routing table for the classful addressing, while 4 main columns in the routing table for the classless addressing.