Chapter 6

Delivery, Forwarding, and Routing of IP Packets

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.

Figure 6.1 *Direct delivery*

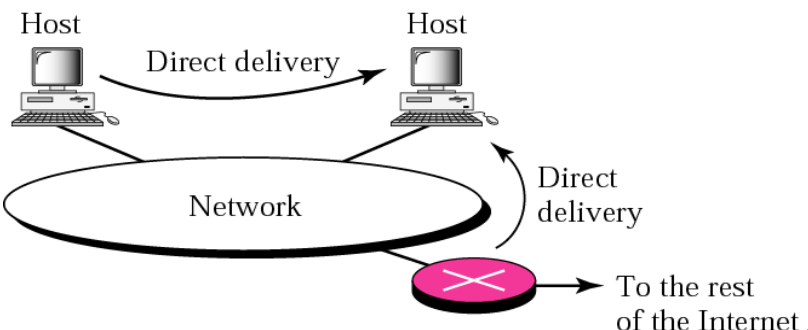
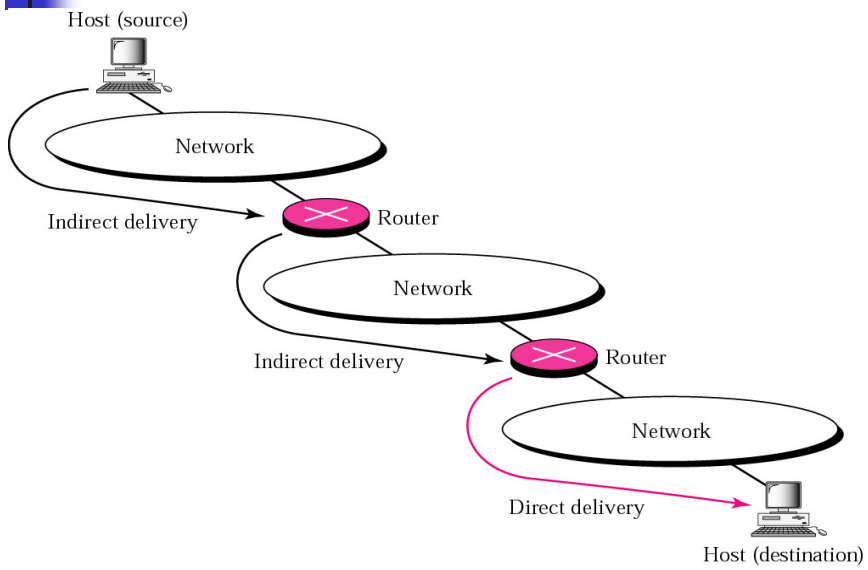


Figure 6.2 *Indirect delivery*



TCP/IP Protocol Suite 3

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. .

Routing table for host A

Destination	Route
Host B	R1, R2, Host B

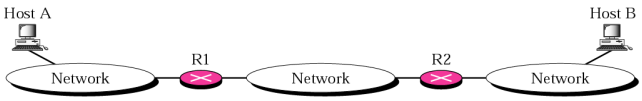
Routing table for R1

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 6.3 *Next-hop method*

TCP/IP Protocol Suite 4

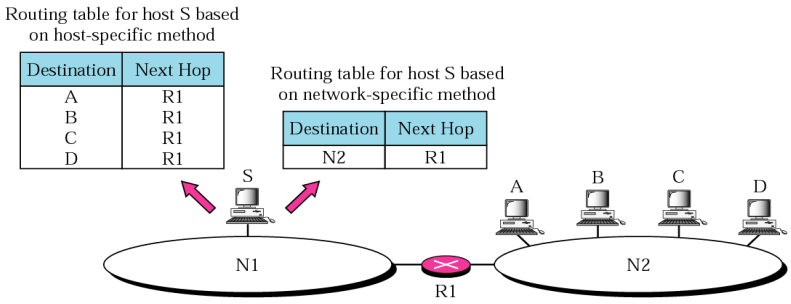


Figure 6.4 *Network-specific method*

Figure 6.5 *Host-specific routing*

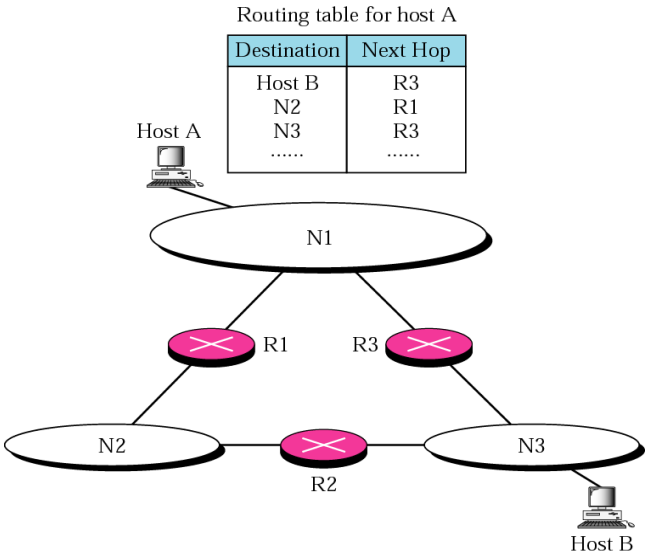


Figure 6.6 *Default routing*

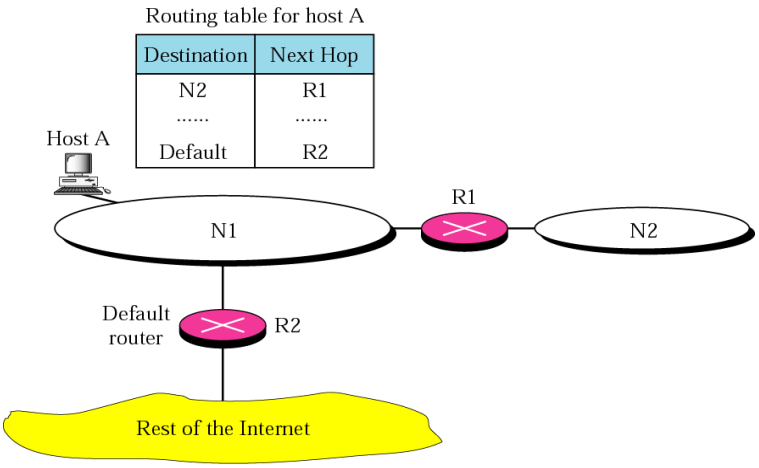


Figure 6.7 *Simplified forwarding in classful address without subnetting*

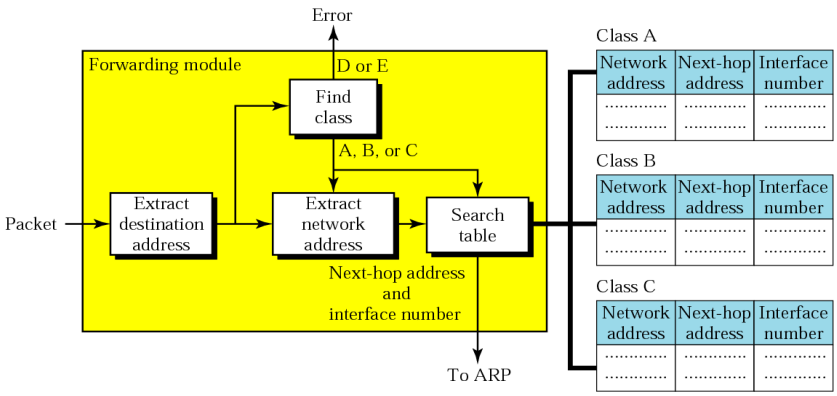


Figure 6.8 *Example 1*

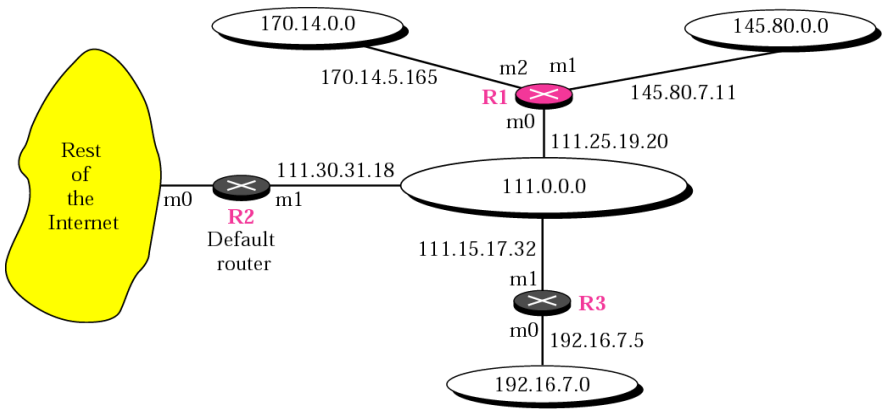


Figure 6.9 *Tables for Example 1*

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

More examples in the book

Notes

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

in classless addressing, we need at least four columns (including mask)

Figure 6.12 *Simplified forwarding module in classless address*

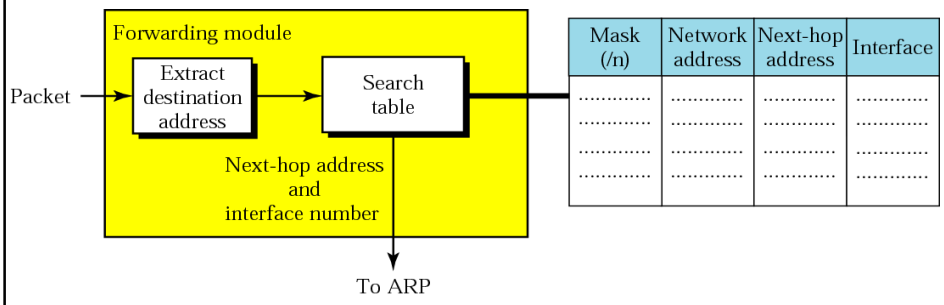


Figure 6.13 *Example 7*

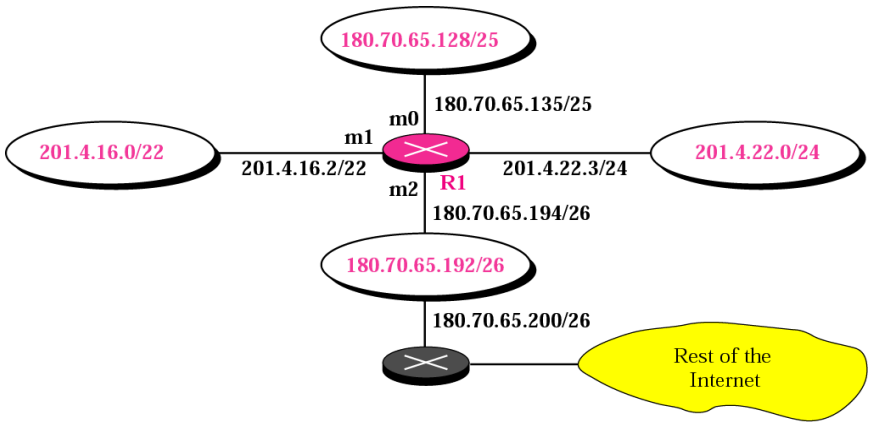


Table 6.1 Routing table for router R1 in Figure 6.13

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 (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

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.

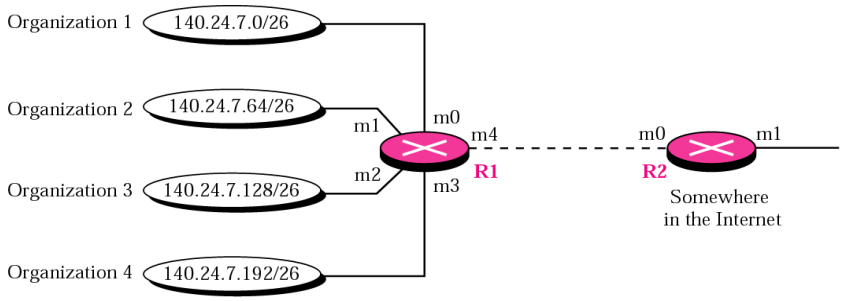
Solution

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 (default router)

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

Figure 6.15 *Address aggregation*



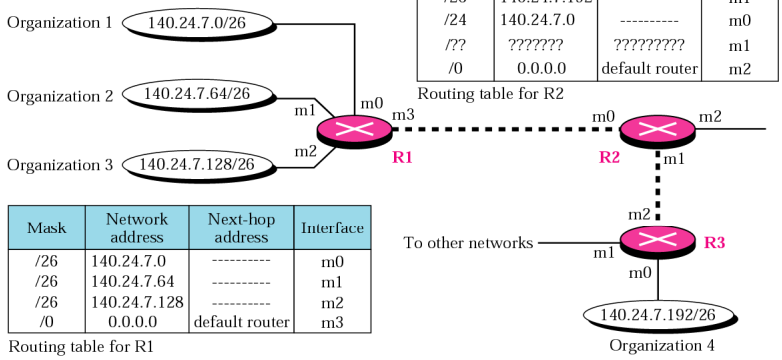
Mask	Network address	Next-hop address	Interface
/26	140.24.7.0	----------	m0
/26	140.24.7.64	----------	m1
/26	140.24.7.128	----------	m2
/26	140.24.7.192	----------	m3
/0	0.0.0.0	default router	m4

Routing table for R1

Mask	Network address	Next-hop address	Interface
/24	140.24.7.0	----------	m0
/0	0.0.0.0	default router	m1

Routing table for R2

Figure 6.16 *Longest mask matching*



Mask	Network address	Next-hop address	Interface
/26	140.24.7.192	----------	m1
/24	140.24.7.0	----------	m0
/??	???????	?????????	m1
/0	0.0.0.0	default router	m2

Routing table for R2

Mask	Network address	Next-hop address	Interface
/26	140.24.7.0	----------	m0
/26	140.24.7.64	----------	m1
/26	140.24.7.128	----------	m2
/0	0.0.0.0	default router	m3

Routing table for R1

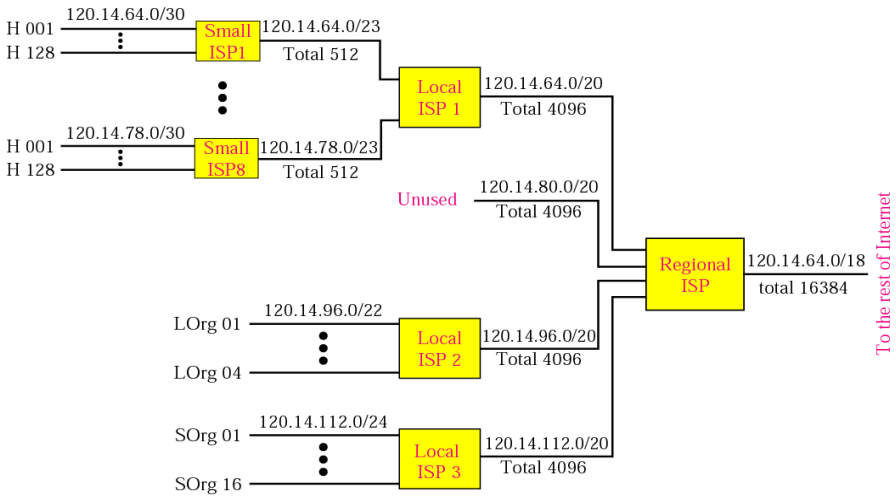
Mask	Network address	Next-hop address	Interface
/26	140.24.7.192	----------	m0
/??	???????	?????????	m1
/0	0.0.0.0	default router	m2

Routing table for R3

EXAMPLE 12

As an example of hierarchical routing, let us consider Figure 6.17. A regional ISP is granted 16384 addresses starting from 120.14.64.0. The regional ISP has decided to divide this block into four subblocks, each with 4096 addresses. Three of these subblocks are assigned to three local ISPs, the second subblock is reserved for future use. Note that the mask for each block is /20 because the original block with mask /18 is divided into 4 blocks.

Figure 6.17 *Hierarchical routing with ISPs*



EXAMPLE 12 (CONTINUED)

The first local ISP has divided its assigned subblock into 8 smaller blocks and assigned each to a small ISP. Each small ISP provides services to 128 households (H001 to H128), each using four addresses. Mask is /23, then subdivided into mask /30

The second local ISP has divided its block into 4 blocks and has assigned the addresses to 4 large organizations (LOrg01 to LOrg04). Note that each large organization has 1024 addresses and the mask is /22.

The third local ISP has divided its block into 16 blocks and assigned each block to a small organization (SOrg01 to SOrg15). Each small organization has 256 addresses and the mask is /24.

EXAMPLE 13

$ netstat -rn

Kernel IP routing table

Destination	*Gateway*	*Mask*	*Flags*	*Iface*
153.18.16.0	0.0.0.0	255.255.240.0	U	eth0
127.0.0.0	0.0.0.0	255.0.0.0	U	lo
0.0.0.0	153.18.31.	254 0.0.0.0	UG	eth0.

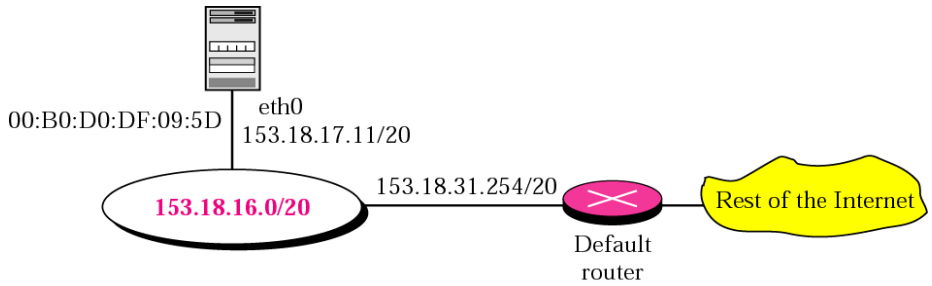
EXAMPLE 13 (CONTINUED)

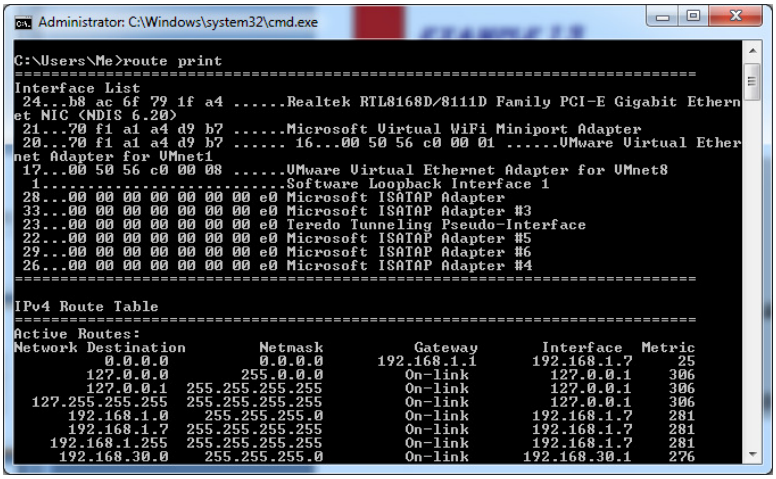
More information about the IP address and physical address of the server can be found using the ifconfig command on the given interface (eth0).

```
$ ifconfig eth0
eth0 Link   encap:Ethernet   HWaddr 00:B0:D0:DF:09:5D
inet addr:153.18.17.11       Bcast:153.18.31.255      Mask:255.255.240.0
....
```

From the above information, we can deduce the configuration of the server

Figure 6.19 *Configuration of the server for Example 13*





6.4 STRUCTURE OF A ROUTER

We represent a router as a black box that accepts incoming packets from one of the input ports (interfaces), uses a routing table to find the departing output port, and sends the packet from this output port.

