Computer Networks(CS31006)
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IPV4 Addressing

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IPV4 Addresses

- 32-bit address.
- Uniquely and universally defines the connection of a device (for example, a computer or a router) to the Internet.
- The address space of IPv4 is 232 or 4,294,967,296.
- Packets used by the IP are called datagrams.
- A datagram is a variable-length packet consisting of two parts: header and payload (data).
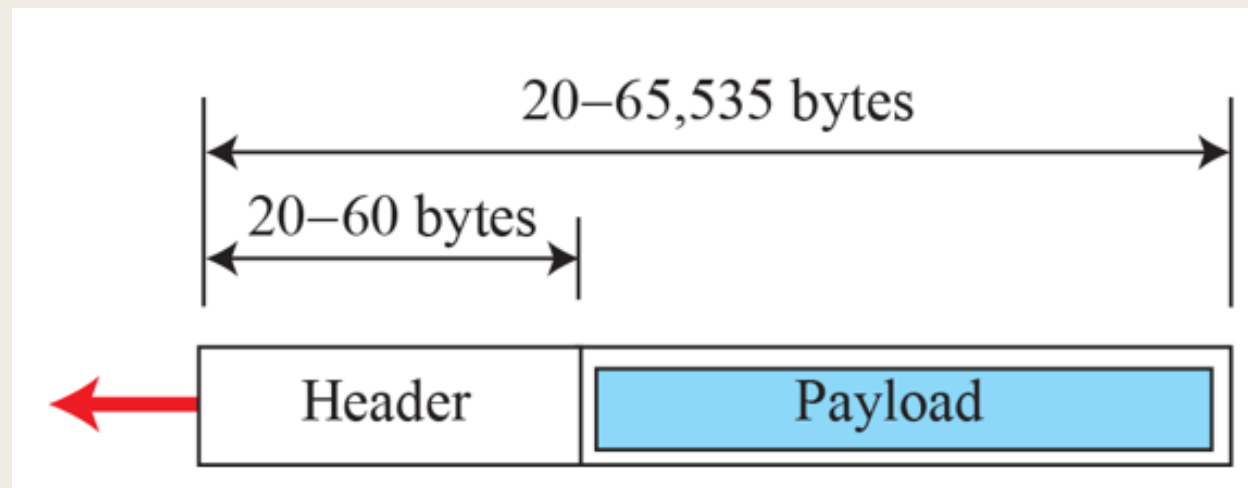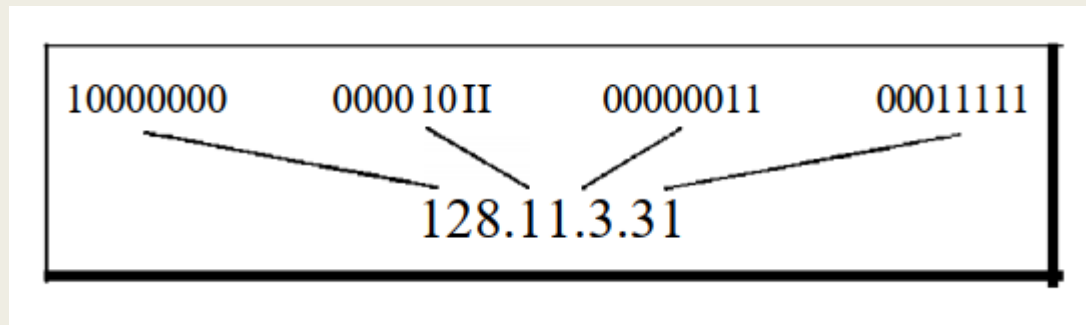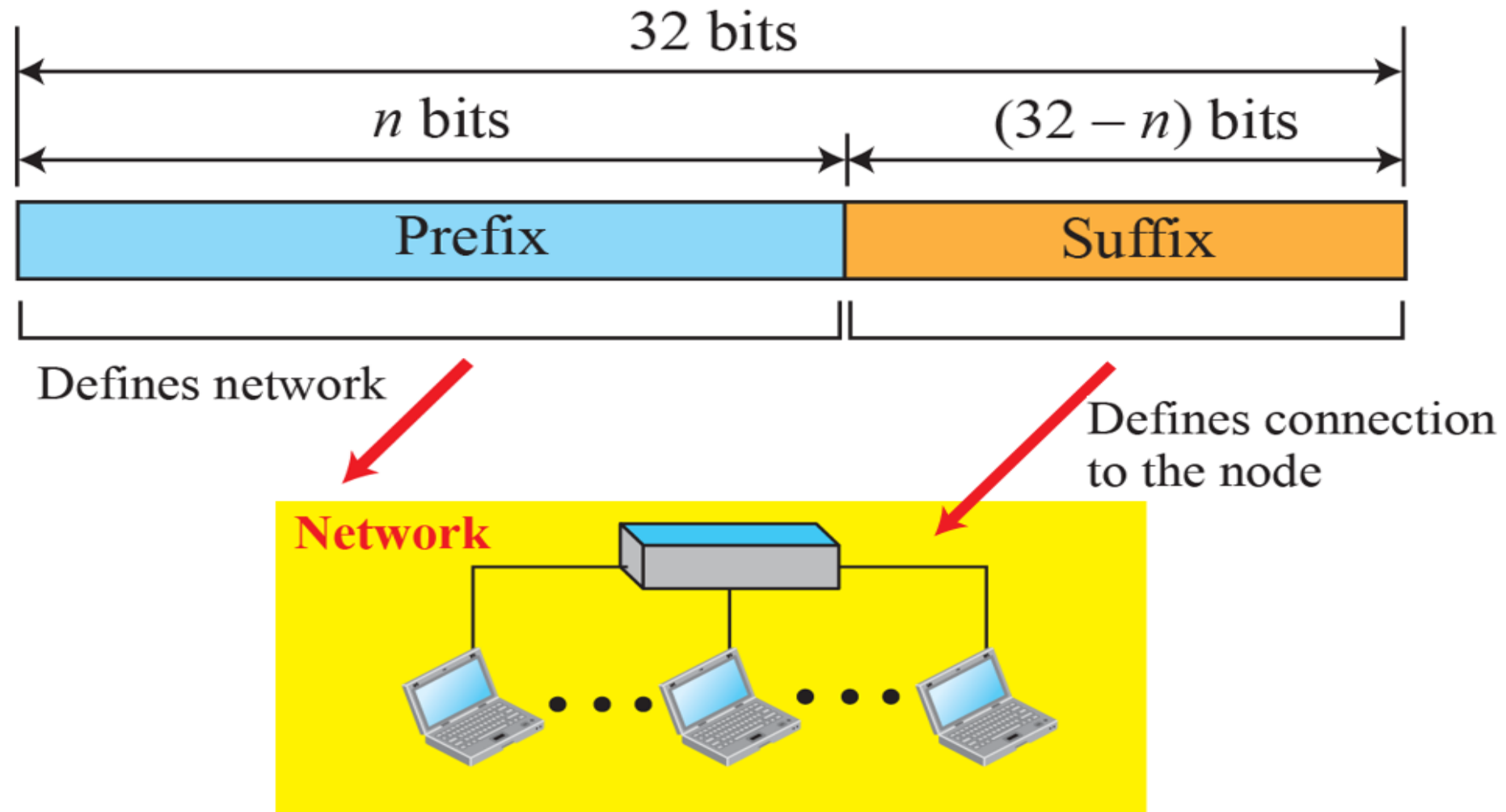- The header is 20 to 60 bytes in length and contains information essential to routing and delivery.

Fig.: IP Datagram

Source: B. A. Forouzan, " Data Communications and Networking ,"
McGraw-Hill Forouzan Networking Series,5E.

Notations

- **Binary Notation**
- The IPv4 address is displayed as 32 bits.
- Each octet is often referred to as a byte.
- Example: 01110101 10010101 00011101 00000010

- **Decimal Notation**
- Internet addresses are written in decimal form with a decimal point (dot) separating the bytes.
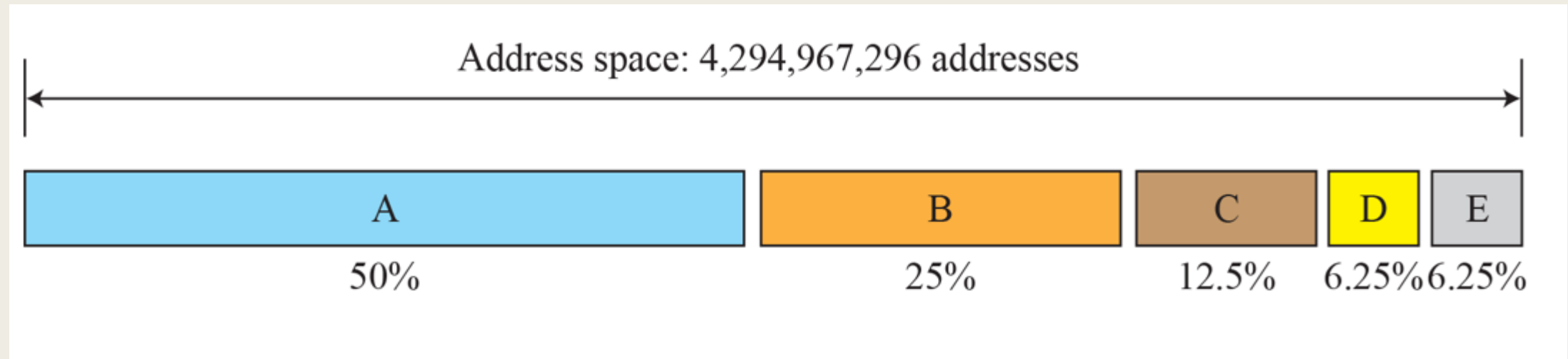- Example: 117.149.29.2

```
10000000      0000 10 II      00000011      00011111



              128.11.3.31
```

Hierarchy in addressing

Source: B. A. Forouzan, " Data Communications and Networking ,"
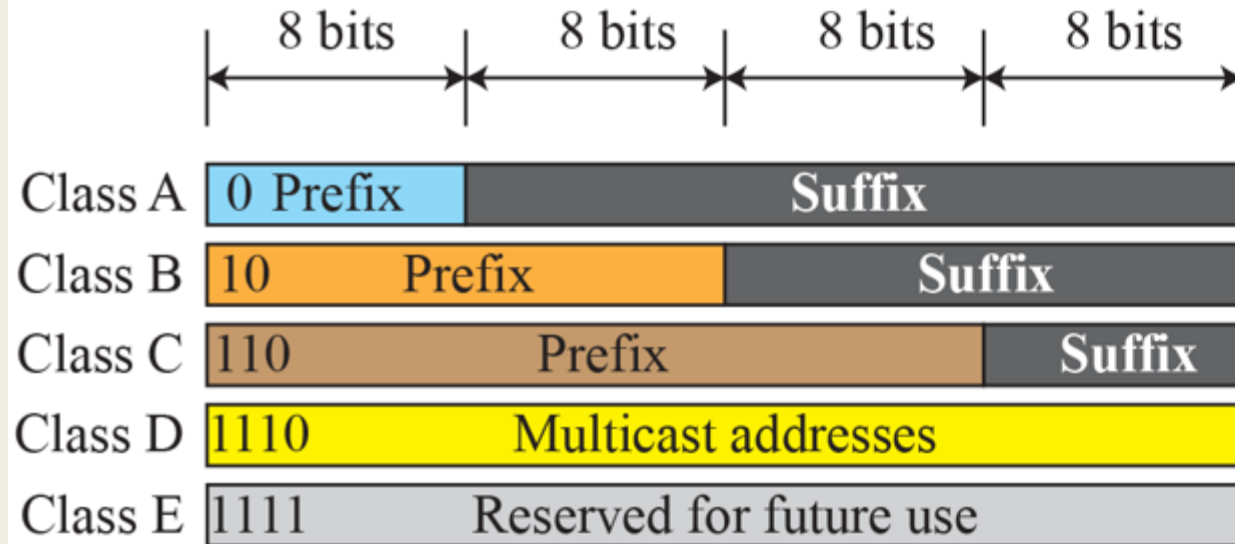*McGraw-Hill Forouzan Networking Series*,5E.

Classful Addressing

- Used the concept of classes.

- The address space is divided into five classes: A, B, C, D, and E.

- Each class occupies some part of the address space.

Address space: 4,294,967,296 addresses

A	B	C	D	E
50%	25%	12.5%	6.25%	6.25%

Cont...

8 bits	8 bits	8 bits	8 bits

Class A	0 Prefix	Suffix	
Class B	10 Prefix	Suffix	
Class C	110 Prefix	Suffix	
Class D	1110	Multicast addresses	
Class E	1111	Reserved for future use	

Class	Prefixes	First byte
A	$n = 8$ bits	0 to 127
B	$n = 16$ bits	128 to 191
C	$n = 24$ bits	192 to 223
D	Not applicable	224 to 239
E	Not applicable	240 to 255

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Classes and Blocks

Class	Number of Blocks	Block Size	Application
A	128	16,777,216	Unicast
B	16,384	65,536	Unicast
C	2,097,152	256	Unicast
D	1	268,435,456	Multicast
E	1	268,435,456	Reserved

Classes and Blocks

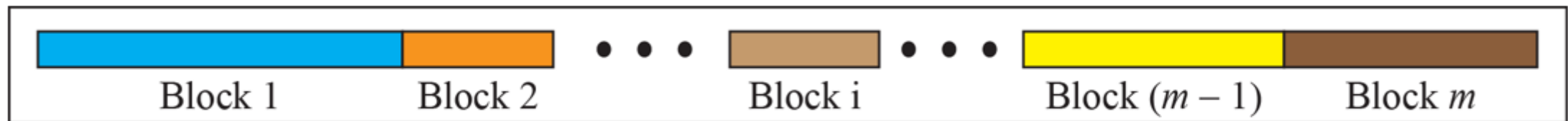| Class	Number of Blocks	Block Size	Application
A	128	16,777,216	Unicast
B	16,384	65,536	Unicast
C	2,097,152	256	Unicast
D	1	268,435,456	Multicast
E	1	268,435,456	Reserved

Mask

- An IP address in class A, B, or C is divided into netid and hostid.

- A 32-bit number made of contiguous 1s (netid) followed by contiguous 0s (hostid.)

- Mask helps us to find the netid and the hostid.

- For example, the mask for a class A address has eight 1s, which means the first 8 bits of any address in class A define the netid; the next 24 bits define the hostid.

Class	Binary	Dotted-Decimal	CIDR
A	11111111 00000000 00000000 00000000	255.0.0.0	18
B	11111111 11111111 00000000 00000000	255.255.0.0	116
C	11111111 11111111 11111111 00000000	255.255.255.0	124

Source: B. A. Forouzan, " Data Communications and Networking ,"
McGraw-Hill Forouzan Networking Series,5E.

Classless Addressing

- There are no classes

- The addresses are still granted in blocks.

- In classless addressing, when an entity, small or large, needs to be connected to the Internet, it is granted a block (range) of addresses.

- The size of the block (the number of addresses) varies based on the nature and size of the entity.

- For example, a household may be given only two addresses; a large organization may be given thousands of addresses.

Address space

Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Restrictions in Classless Addressing

- The addresses in a block must be contiguous, one after another.

- The number of addresses in a block must be a power of 2 (I, 2, 4, 8, ...).

- The first address must be evenly divisible by the number of addresses.

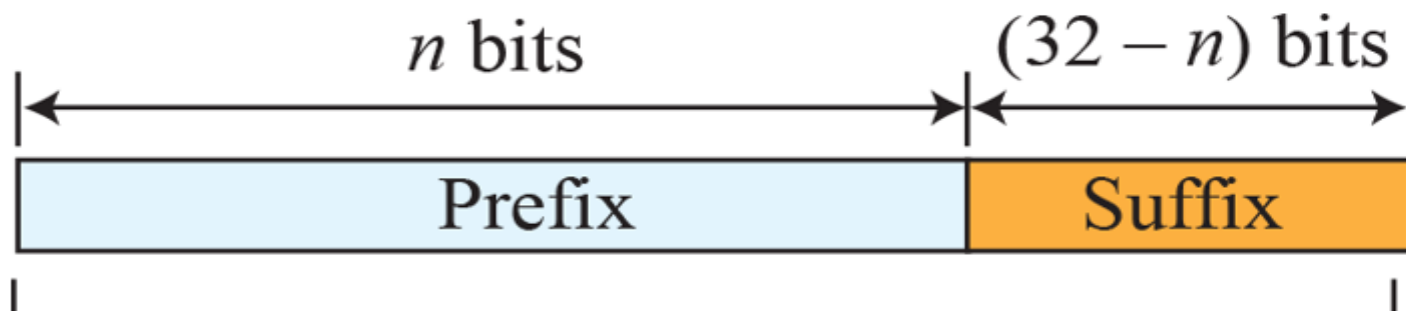
Examples:
12.24.76.8/**8**
23.14.67.92/**12**
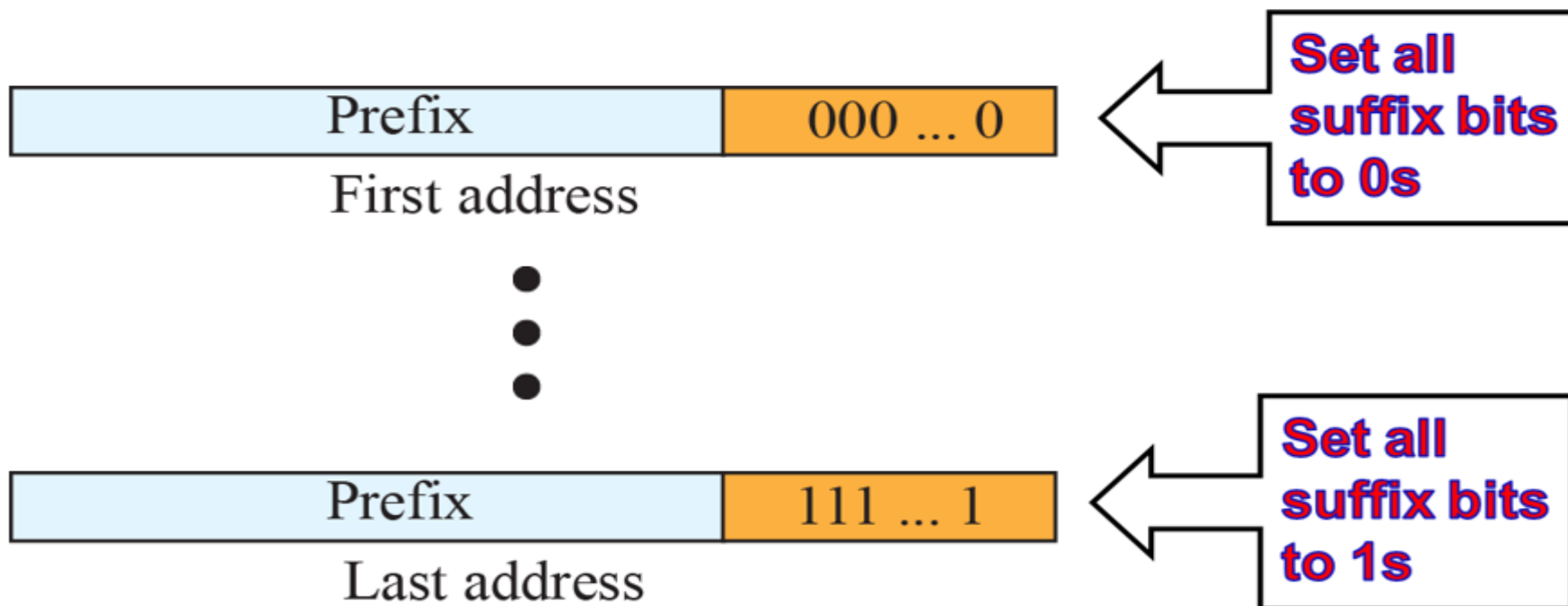220.8.24.255/**25**

Fig.: Slash notation

Source: B. A. Forouzan, " Data Communications and Networking ,"
McGraw-Hill Forouzan Networking Series,5E.

Information Extraction

Any address

n bits | $(32 - n)$ bits

Number of addresses:
$$N = 2^{32 - n}$$

Prefix | Suffix

Prefix | 000 ... 0
First address

Set all suffix bits to 0s

Prefix | 111 ... 1
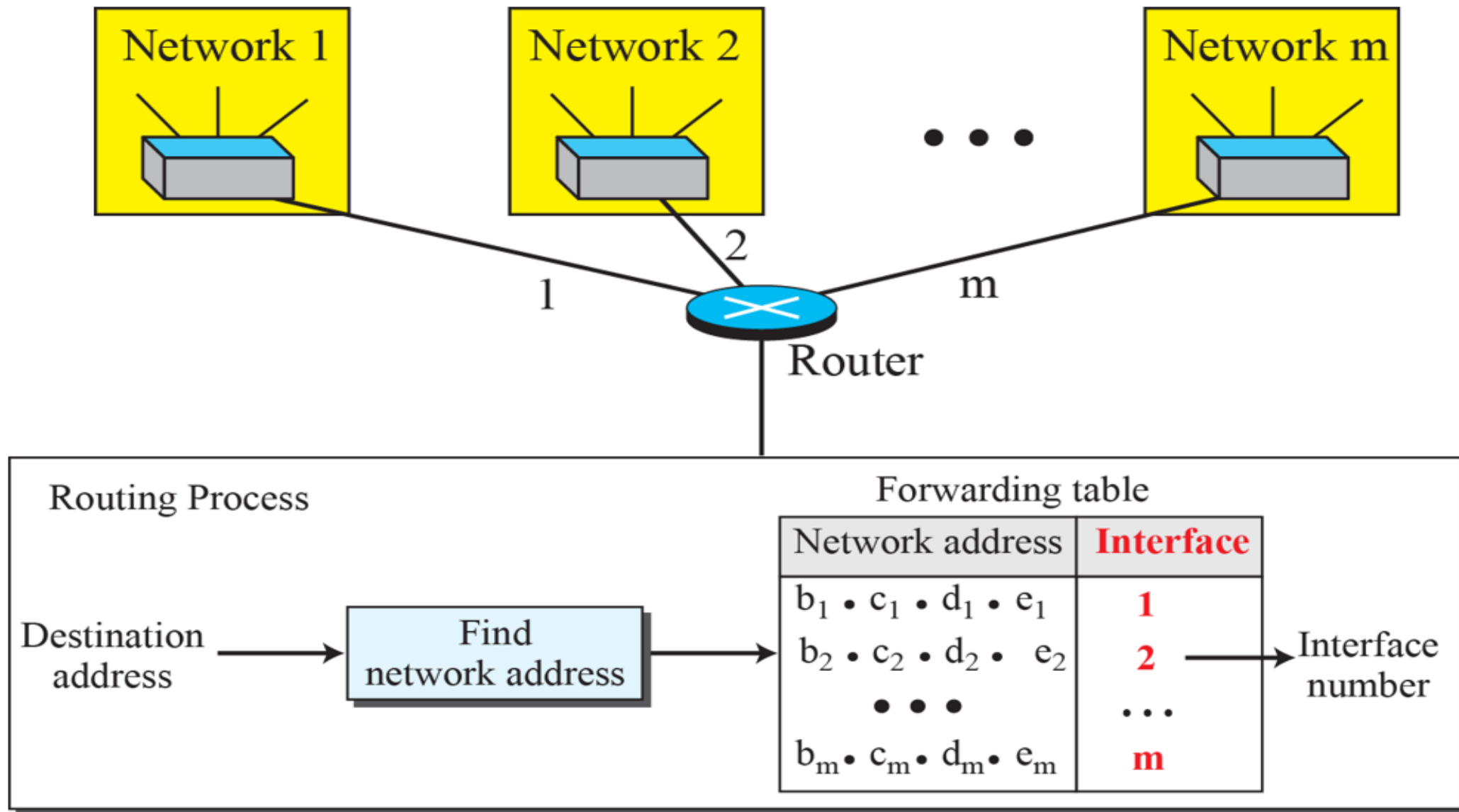Last address

Set all suffix bits to 1s

Information Extraction

- A classless address is given as 167.199.170.82/27.

- The number of addresses in the network is $2^{32-n} = 2^5 = 32$ addresses.

- The first address can be found by keeping the first 27 bits and changing the rest of the bits to 0s.

- The last address can be found by keeping the first 27 bits and changing the rest of the bits to 1s.

Address: 167.199.170.82/**27**	10100111	11000111	10101010	01010010
First address: 167.199.170.64/**27**	10100111	11000111	10101010	01000000

Address: 167.199.170.82/**27**	10100111	11000111	10101010	01011111
Last address: 167.199.170.95/**27**	10100111	11000111	10101010	01011111

Source: B. A. Forouzan, " Data Communications and Networking ,"
McGraw-Hill Forouzan Networking Series,5E.

Network Address

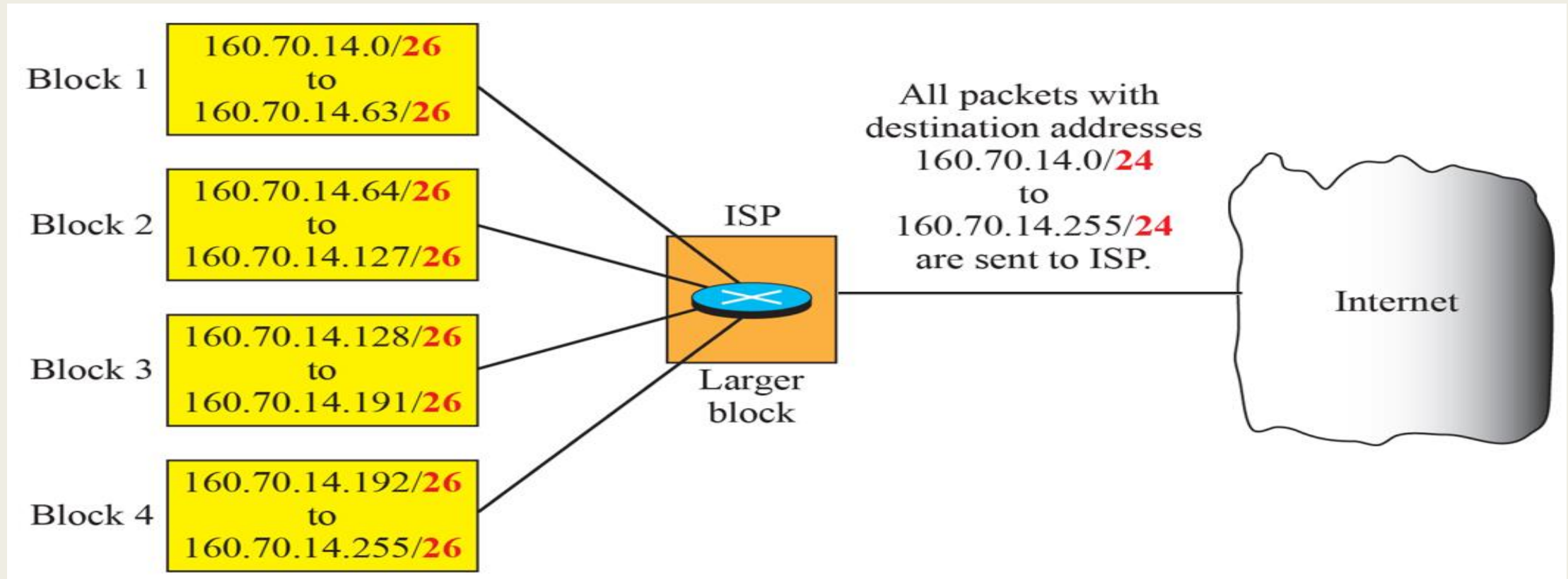Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Subnetting

- Bigger network is divided into smaller networks, in order to maintain security, then that is known as Subnetting.
- The maintenance is easier for smaller networks.
- All messages are sent to the router address that connects the organization to the rest of the Internet the router routes the message to the appropriate subnets.

Source: B. A. Forouzan, " Data Communications and Networking ,"
McGraw-Hill Forouzan Networking Series,5E.

Example

An organization is granted a block of addresses with the beginning address 14.24.74.0/24. The organization needs to have 3 subblocks of addresses to use in its three subnets: one subblock of 10 addresses, one subblock of 60 addresses, and one subblock of 120 addresses. Design the subblocks.

Solution

There are $2^{32-24} = 256$ addresses in this block. The first address is 14.24.74.0/24; the last address is 14.24.74.255/24.

To satisfy the third requirement, we assign addresses to subblocks, starting with the largest and ending with the smallest one.
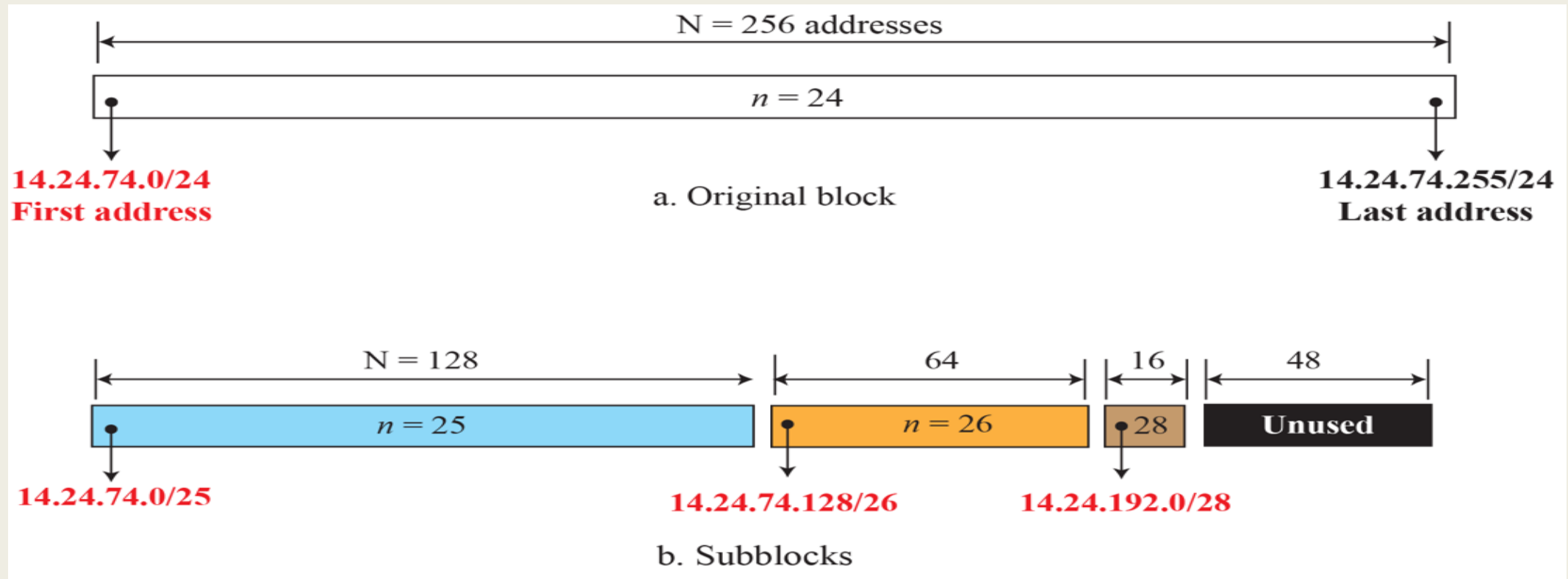
The number of addresses in the largest subblock, which requires 120 addresses, is not a power of 2. We allocate 128 addresses. The subnet mask for this subnet can be found as $n_1 = 32 - \log_2 128 = 25$. The first address in this block is 14.24.74.0/25; the last address is 14.24.74.127/25.

The number of addresses in the second largest subblock, which requires 60 addresses, is not a power of 2 either. We allocate 64 addresses. The subnet mask for this subnet can be found as $n_2 = 32 - \log_2 64 = 26$. The first address in this block is 14.24.74.128/26; the last address is 14.24.74.191/26.

Cont...

The number of addresses in the largest subblock, which requires 120 addresses, is not a power of 2. We allocate 128 addresses. The subnet mask for this subnet can be found as $n_1 = 32 - \log_2 128 = 25$. The first address in this block is 14.24.74.0/25; the last address is 14.24.74.127/25.

N = 256 addresses

n = 24

14.24.74.0/24
First address

14.24.74.255/24
Last address

a. Original block

N = 128   64   16   48

n = 25   n = 26   28   Unused

14.24.74.0/25   14.24.74.128/26   14.24.192.0/28
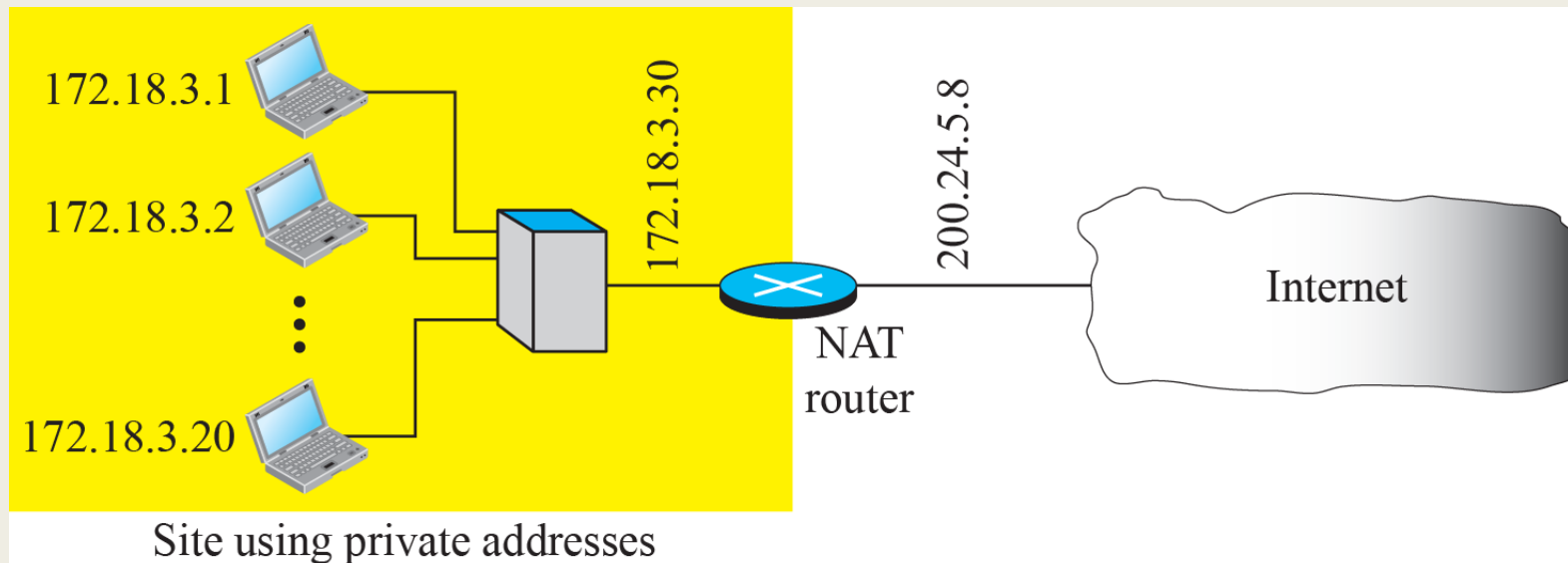
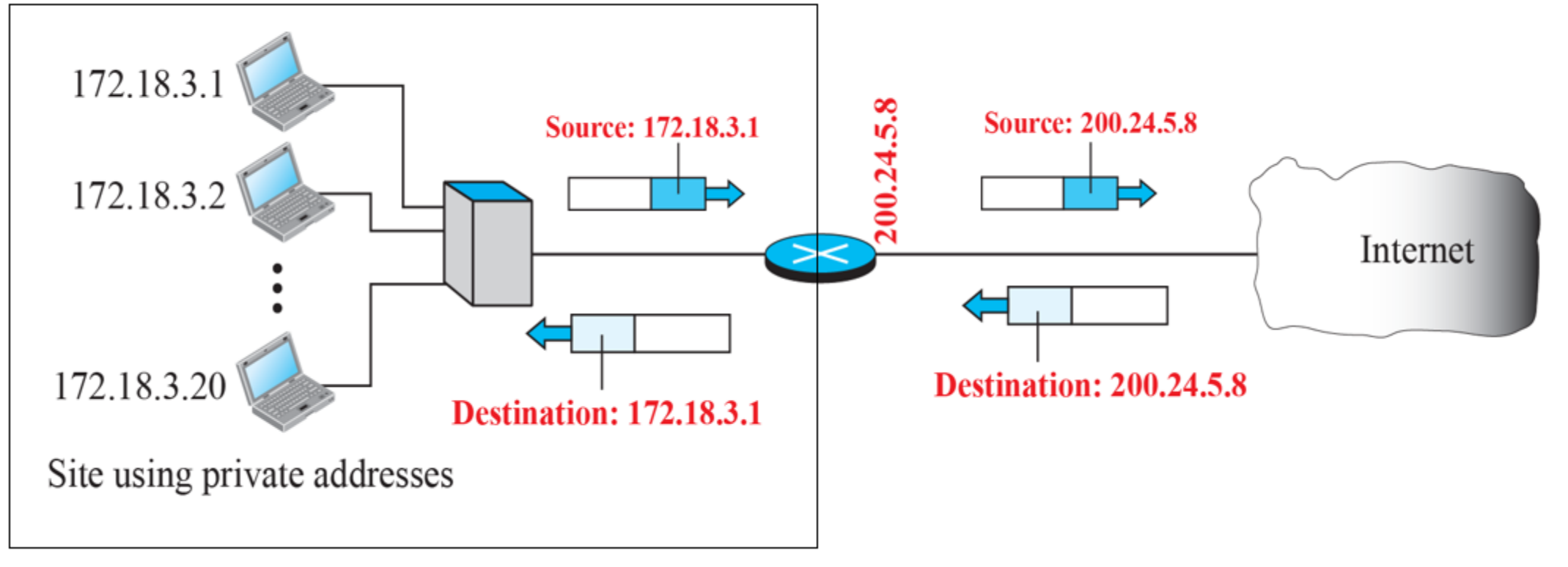b. Subblocks

Network Address Translation

In most situations, only a portion of computers in a small network need access to the Internet simultaneously.

A technology that can provide the mapping between the private and universal addresses, and at the same time support virtual private is Network Address Translation (NAT).

The technology allows a site to use a set of private addresses for internal communication and a set of global Internet addresses (at least one) for communication with the rest of the world.

Site using private addresses

Source: B. A. Forouzan, " Data Communications and Networking ,"
*McGraw-Hill Forouzan Networking Series,*5E.

Address Translation

Site using private addresses

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McGraw-Hill Forouzan Networking Series,5E.

Cont...

Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.
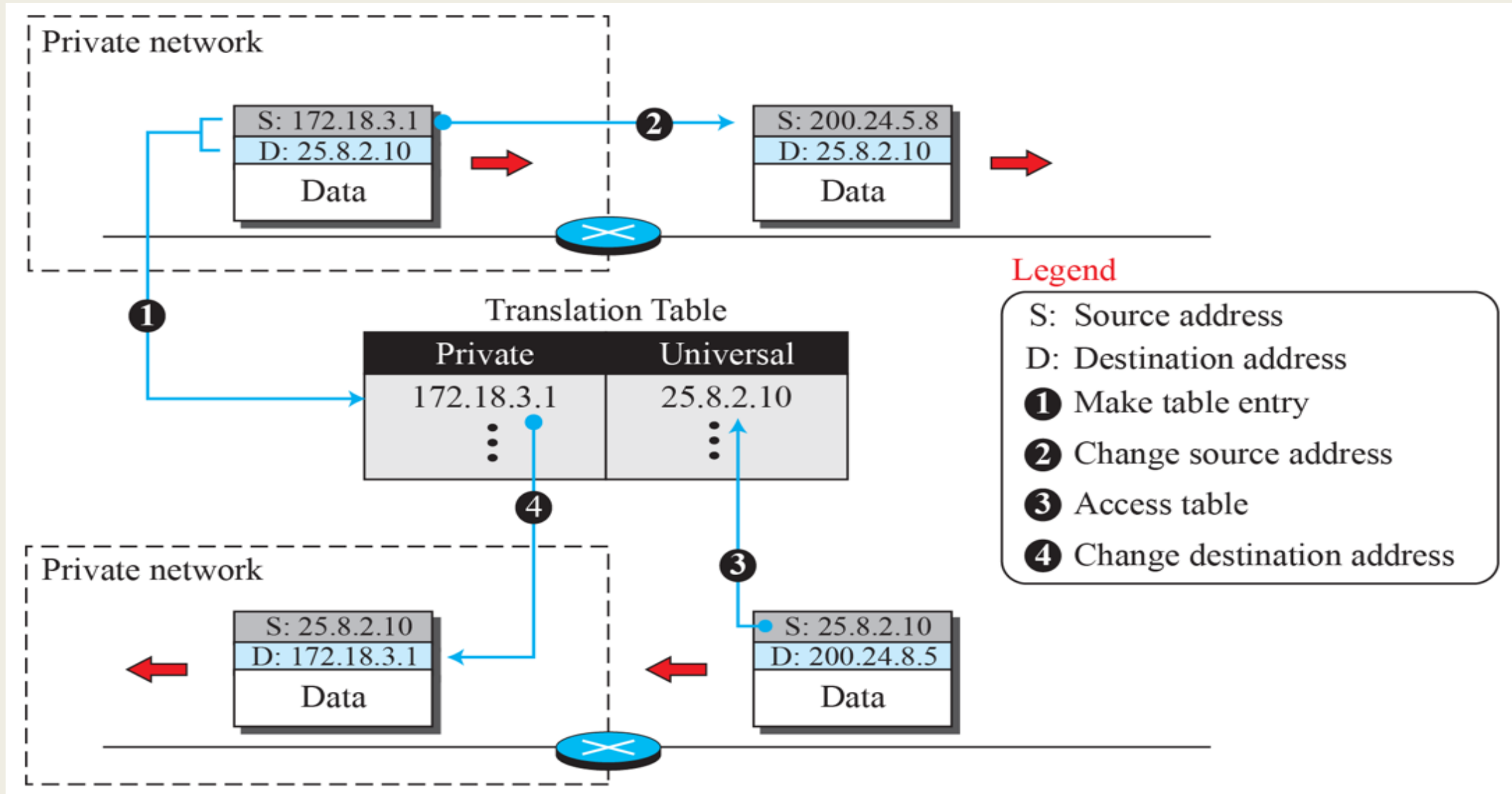
Translation Table

Private address	Private port	External address	External port	Transport protocol
172.18.3.1	1400	25.8.3.2	80	TCP
172.18.3.2	1401	25.8.3.2	80	TCP
⋮	⋮	⋮	⋮	⋮

Source: B. A. Forouzan, " Data Communications and Networking ,"
McGraw-Hill Forouzan Networking Series,5E.

Example

Make a forwarding table for router R1 using the configuration in Figure. Show the forwarding process if a packet arrives at R1 in Figure with the destination address 180.70.65.140.

180.70.65.128/25

180.70.65.135/25

201.4.16.0/22

201.4.22.0/24

m0

m1   m3

201.4.16.2/22

201.4.22.3/24

m2   **R1**

180.70.65.194/26

180.70.65.192/26

180.70.65.200/26

Rest of the Internet

Source: B. A. Forouzan, " Data Communications and Networking ,"
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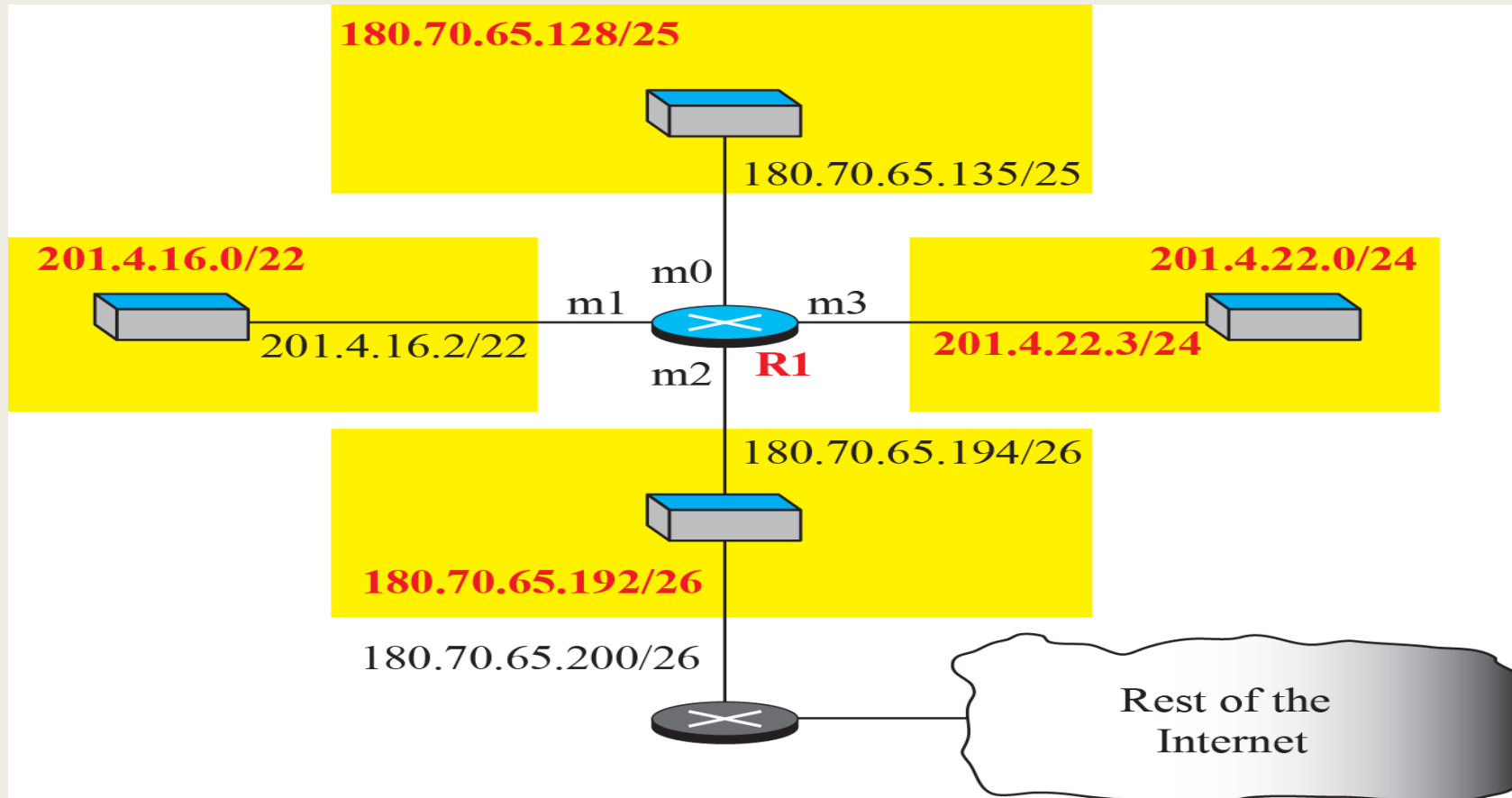
Solution

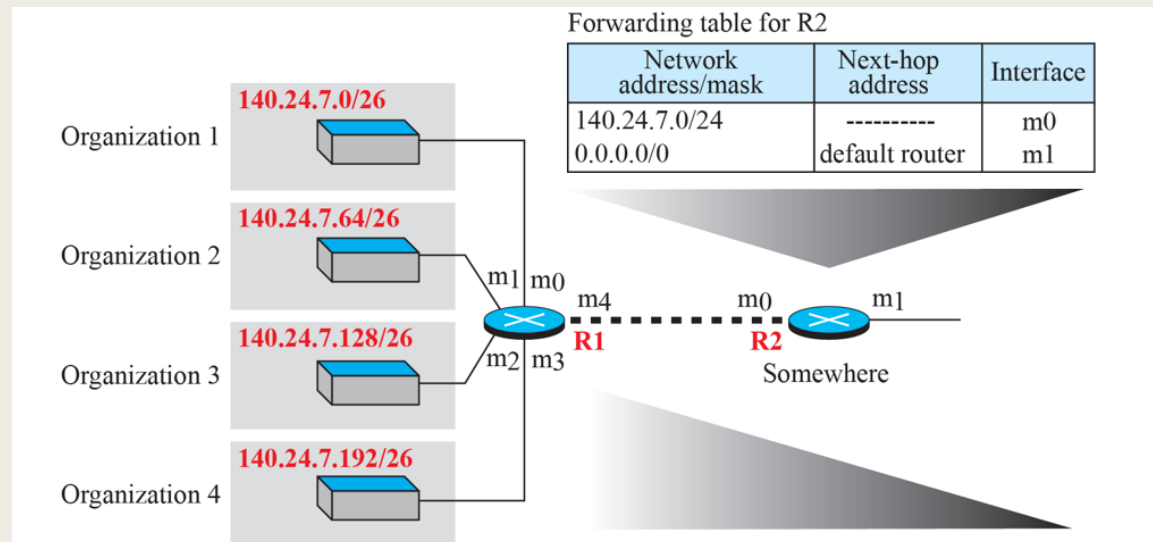| Leftmost bits in the destination address	Next hop	Interface
10110100 01000110 01000001 11	—	m2
10110100 01000110 01000001 1	—	m0
11001001 00000100 00011100	—	m3
11001001 00000100 000100	—	m1
Default	180.70.65.200	m2

Cont...

The router performs the following steps:
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.

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 and the interface number m0 are extracted for forwarding the packet.

Forwarding table for R2

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

Forwarding table for R1

Network address/mask	Next-hop address	Interface
140.24.7.0/26	----------	m0
140.24.7.64/26	----------	m1
140.24.7.128/26	----------	m2
140.24.7.192/26	----------	m3
0.0.0.0/0	address of R2	m4

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Thank You!!!