

IPV4 Addressing

Computer Networks(CS31204)

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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 2^{32} 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.

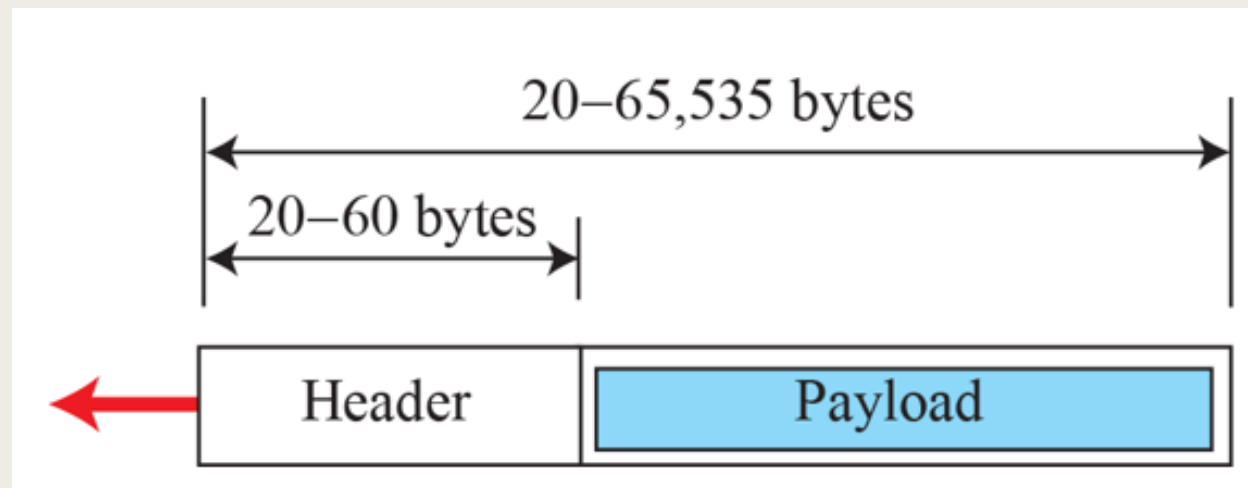
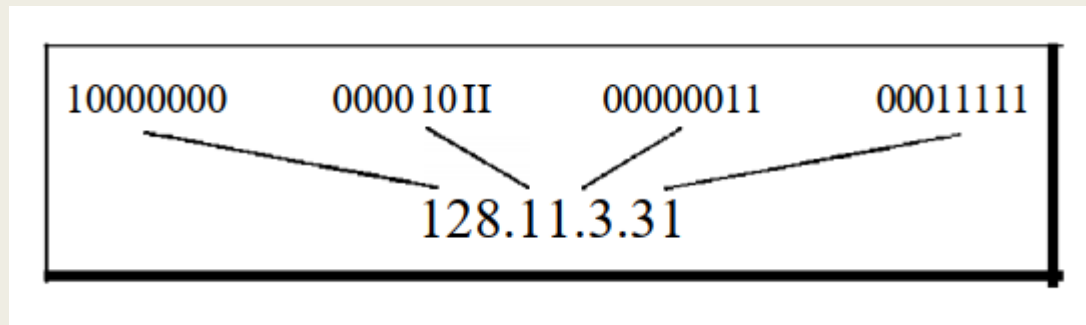


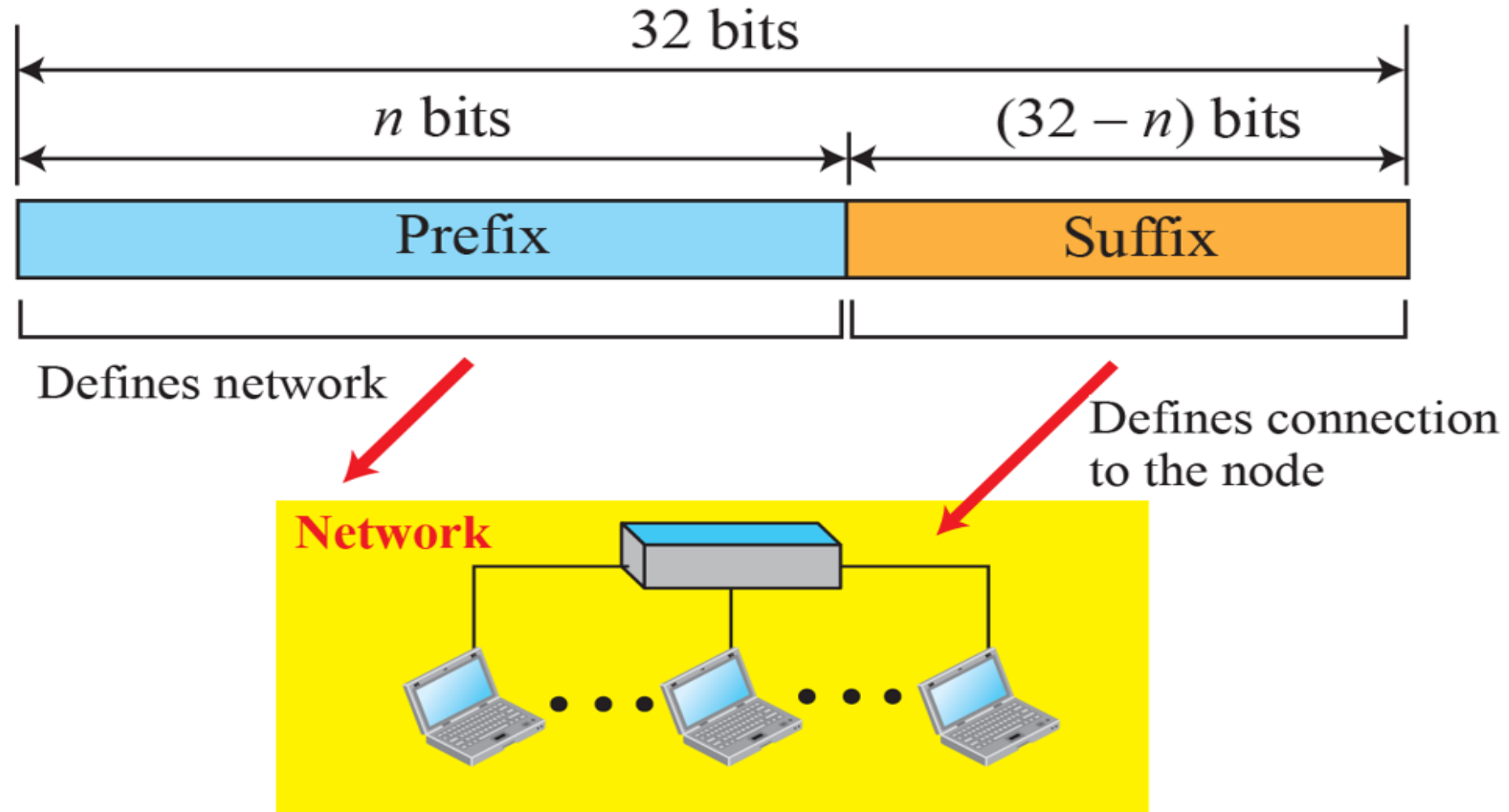
Fig.: IP Datagram

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



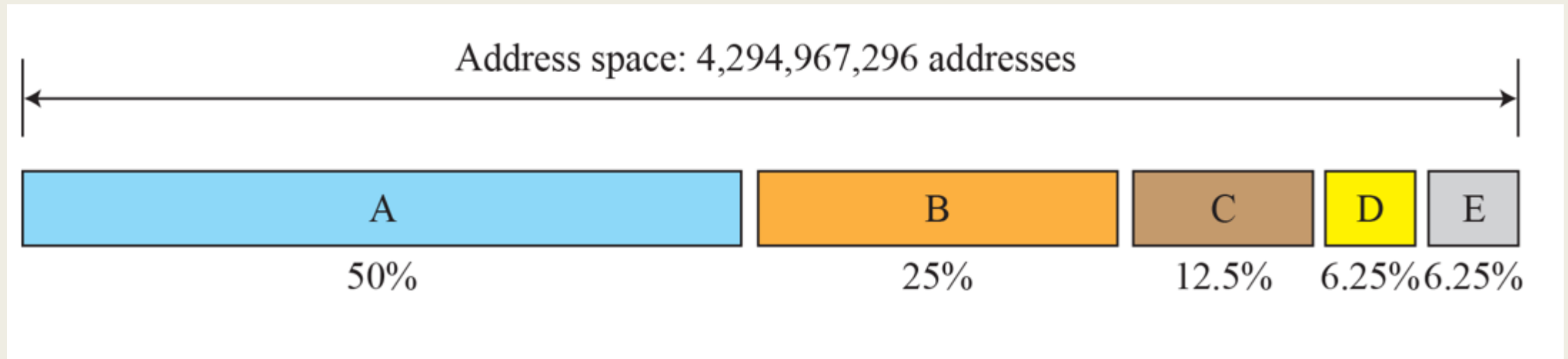
Hierarchy in addressing



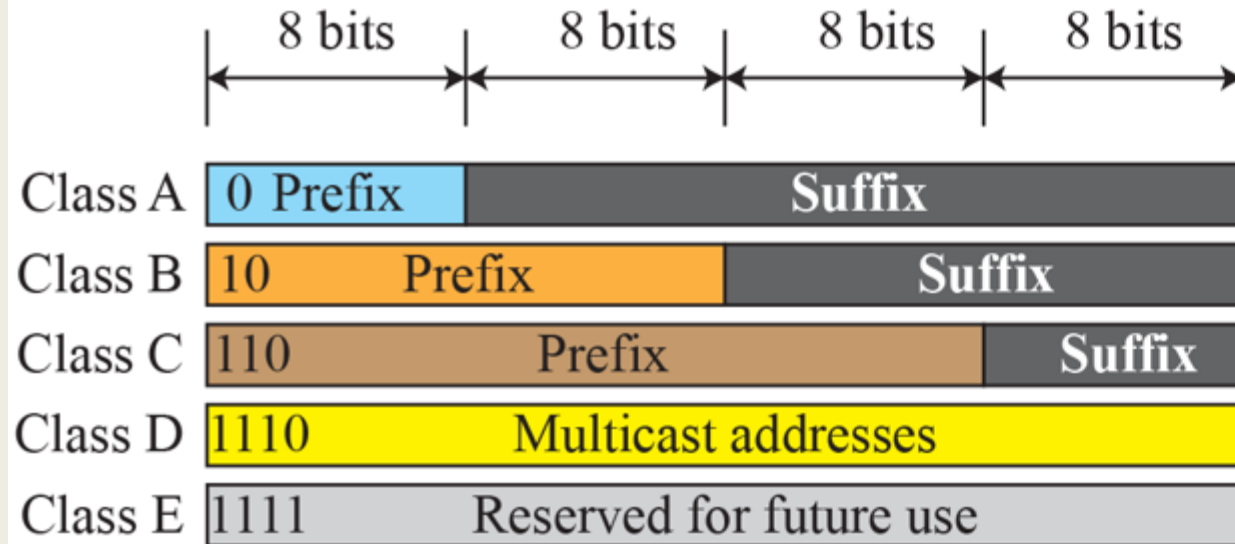


Classful Addressing

- 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.



Cont...



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

Classes and Blocks



<i>Class</i>	<i>Number of Blocks</i>	<i>Block Size</i>	<i>Application</i>
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

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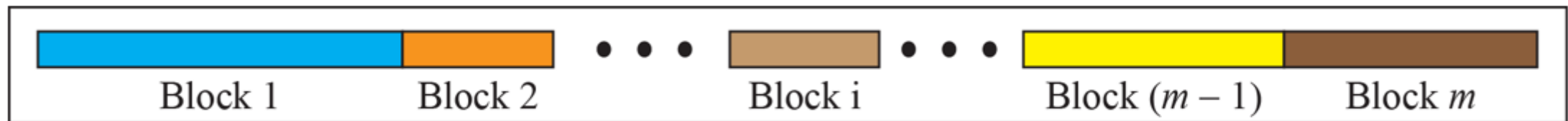
Mask

- 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 help 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.

<i>Class</i>	<i>Binary</i>	<i>Dotted-Decimal</i>	<i>CIDR</i>
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

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

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 (1, 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

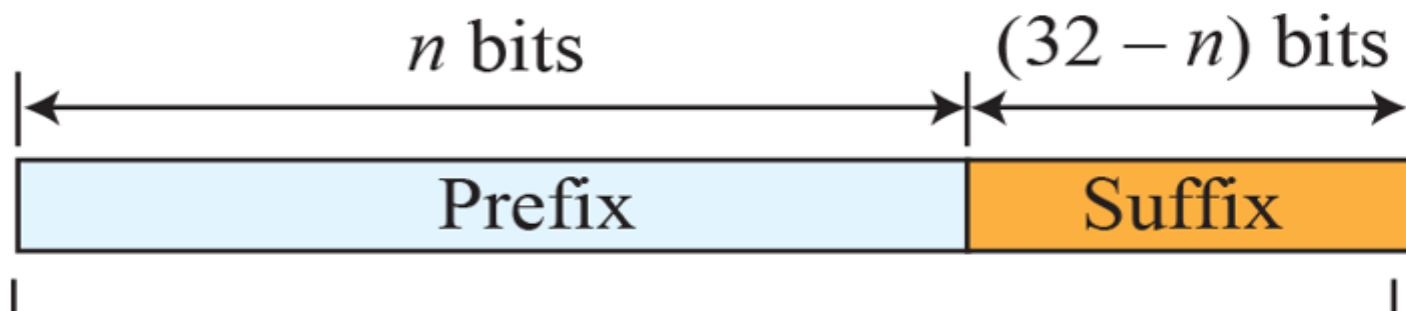
220.8.24.255/25

Fig.: Slash notation

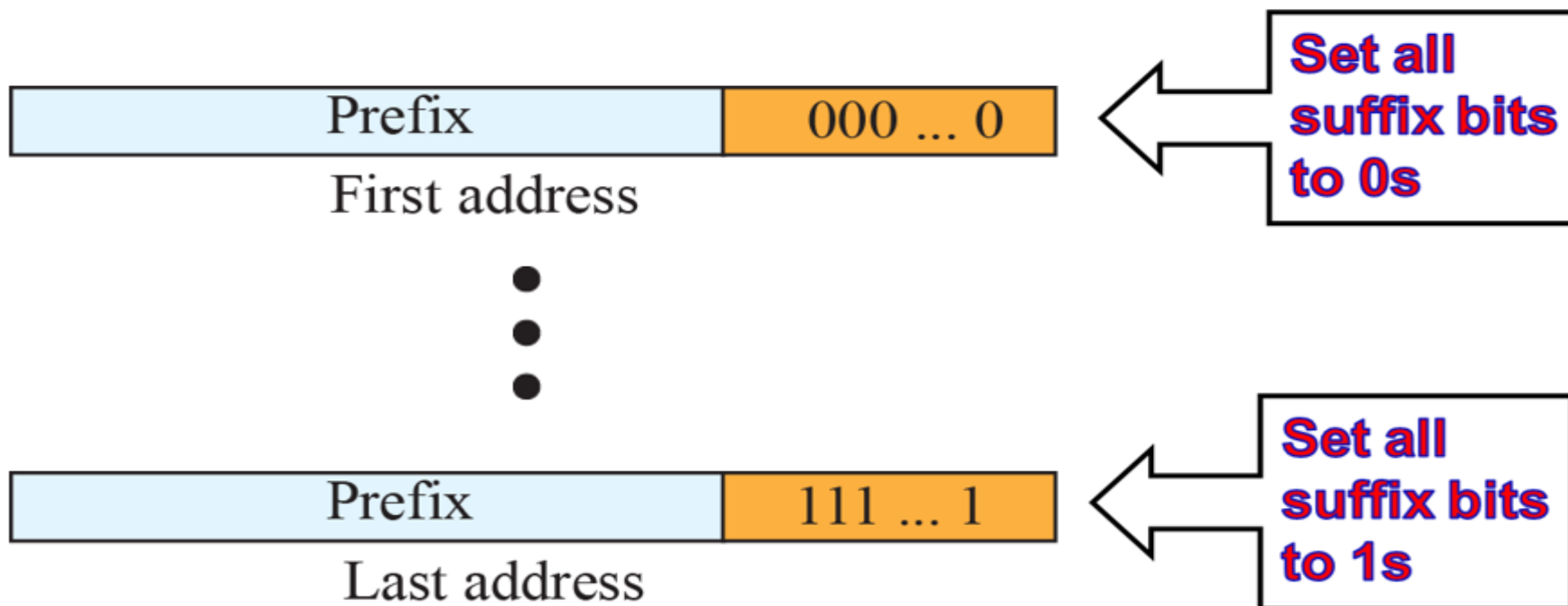
Information Extraction



Any address



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





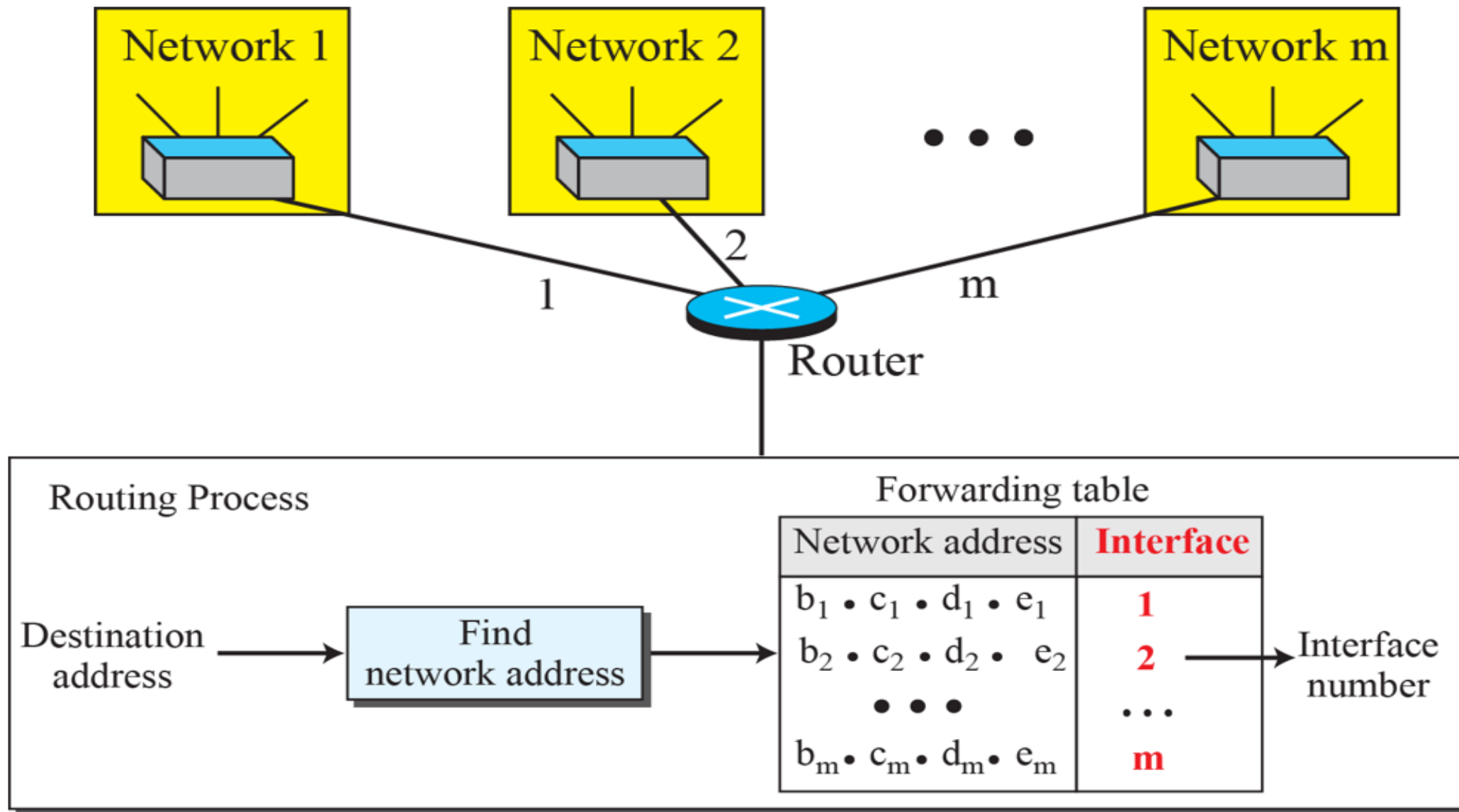
Information Extraction

- 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

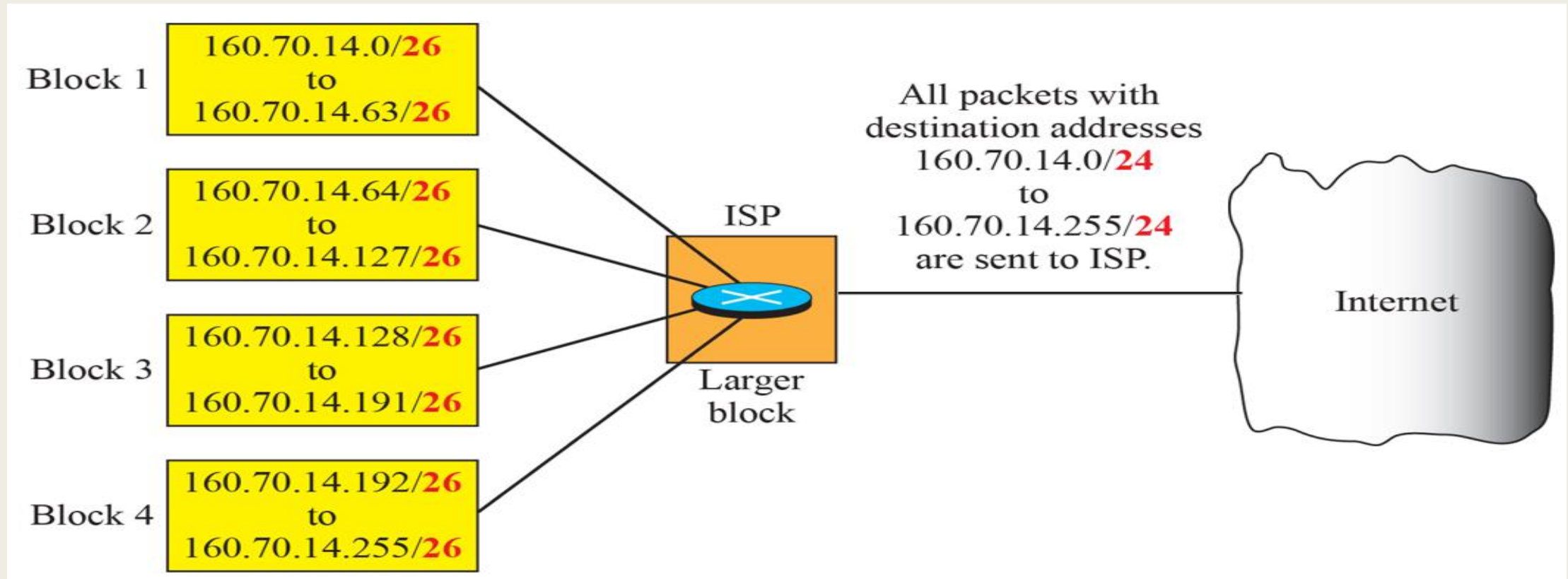
Network Address



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.



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.

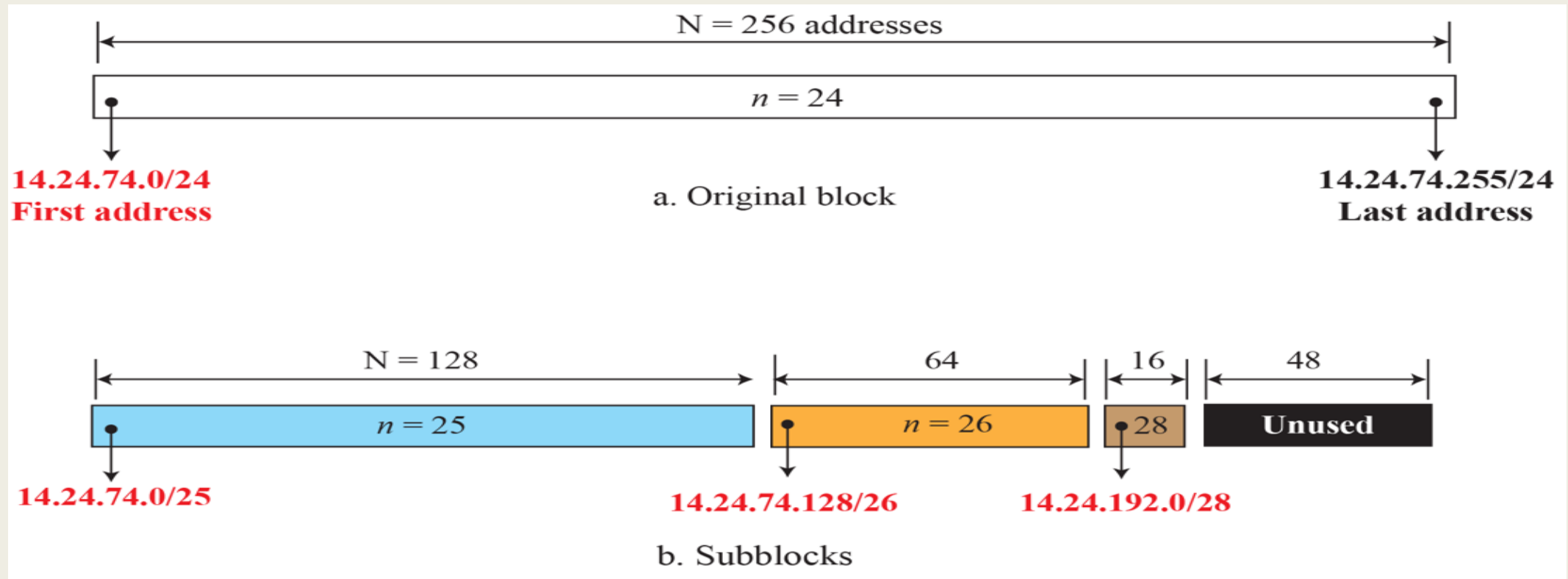
The number of addresses in the largest subblock, which requires 120 addresses, is not a power of 2. We allocate 128 addresses. The subnet mask for this subnet can be found as $n_1 = 32 - \log_2 128 = 25$. The first address in this block is 14.24.74.0/25; the last address is 14.24.74.127/25.

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.



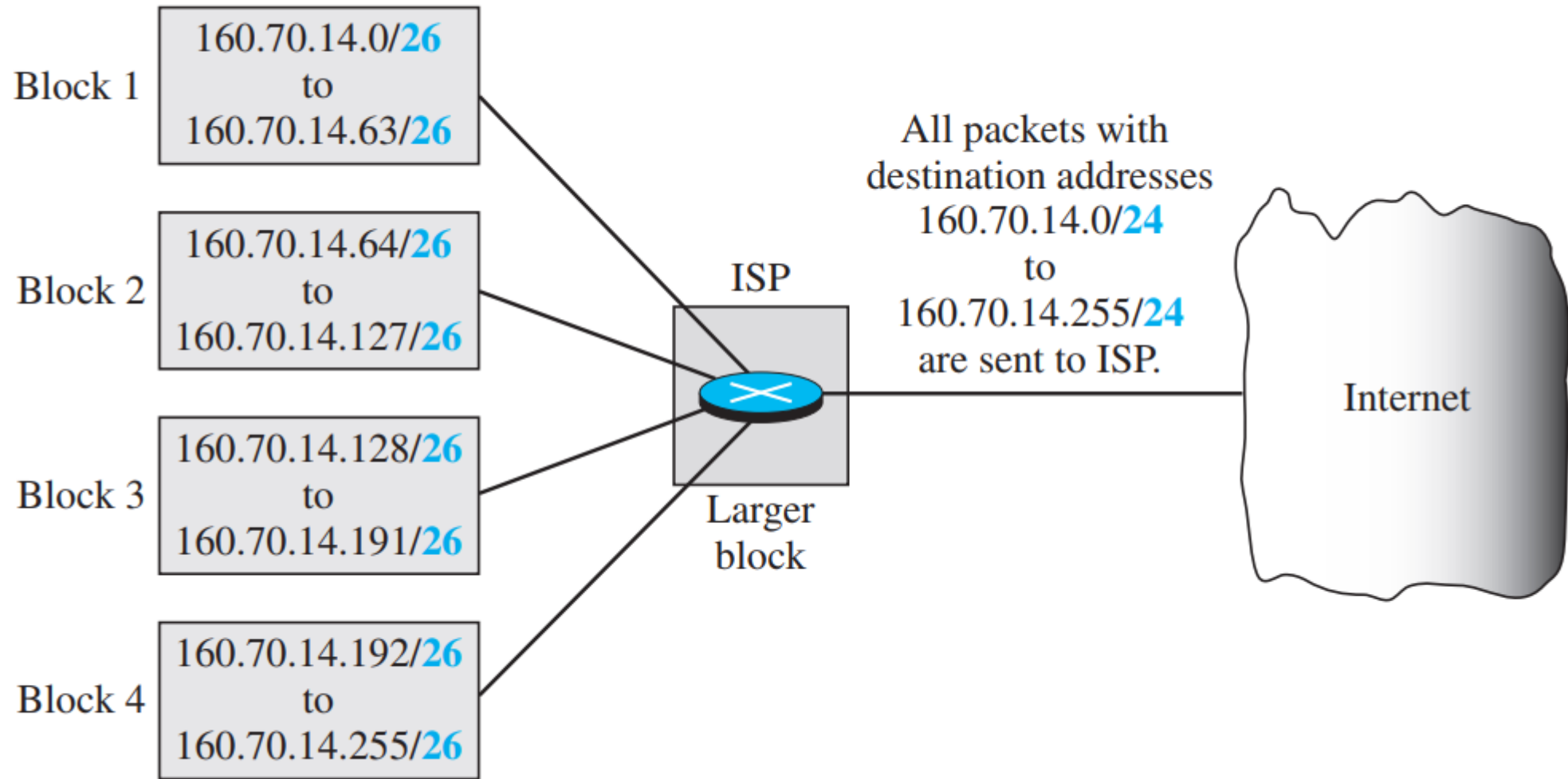
- Allocate IPs in contiguous blocks using classless addressing
- Combine contiguous networks into a larger network for the purpose
- Saves IP space and reduces routing table size
- Also called [Supernetting](#) or [Route Aggregation](#)

Supernetting



- When blocks of addresses are combined to create a larger block, routing can be done based on the prefix of the larger block.
- ICANN assigns a large block of addresses to an ISP.
- Each ISP in turn divides its assigned block into smaller subblocks and grants the subblocks to its customers.

Supernetting





Advantages of Supernetting

- More efficient use of IP addresses
- Reduced routing table size
- Simplified network management
- Improved scalability
- Reduced broadcasting



Disadvantages of Supernetting

- Complexity
- Security risks
- Limited flexibility
- Reduced scalability
- Lack of compatibility

Packet Forwarding



- ❑ **Packet forwarding** is the basic method for sharing information across systems on a network.
- ❑ Packets are transferred between a source interface and a destination interface, usually on two different systems.
- ❑ When you issue a command or send a message to a nonlocal interface, your system forwards those packets onto the local network.
- ❑ The interface with the destination IP address that is specified in the packet headers then retrieves the packets from the local network.
- ❑ If the destination address is not on the local network, the packets are then forwarded to the next adjacent network, or **hop**.

Packet Processing



- ❑ Routers use IP prefix for processing IP packets.
- ❑ A network prefix is an aggregation of IP addresses.
- ❑ For example, 192.50.128.0/17 defines the first 17 bits of the IP address to identify the address aggregation. The remaining 15 bits may be either sub-aggregated or assigned to devices within the network that owns the prefix.
- ❑ Routers look at the destination address's IP prefix, searches the forwarding table for a match, and forward the packet to the corresponding next hop in the forwarding table.
- ❑ An incoming IP's prefix may match multiple IP entries in a table.
- ❑ In the table, addresses from 192.24.12.0 to 192.24.15.255 overlap, i.e., match with both entries of the table.
- ❑ To handle this situation we utilize longest prefix matching.

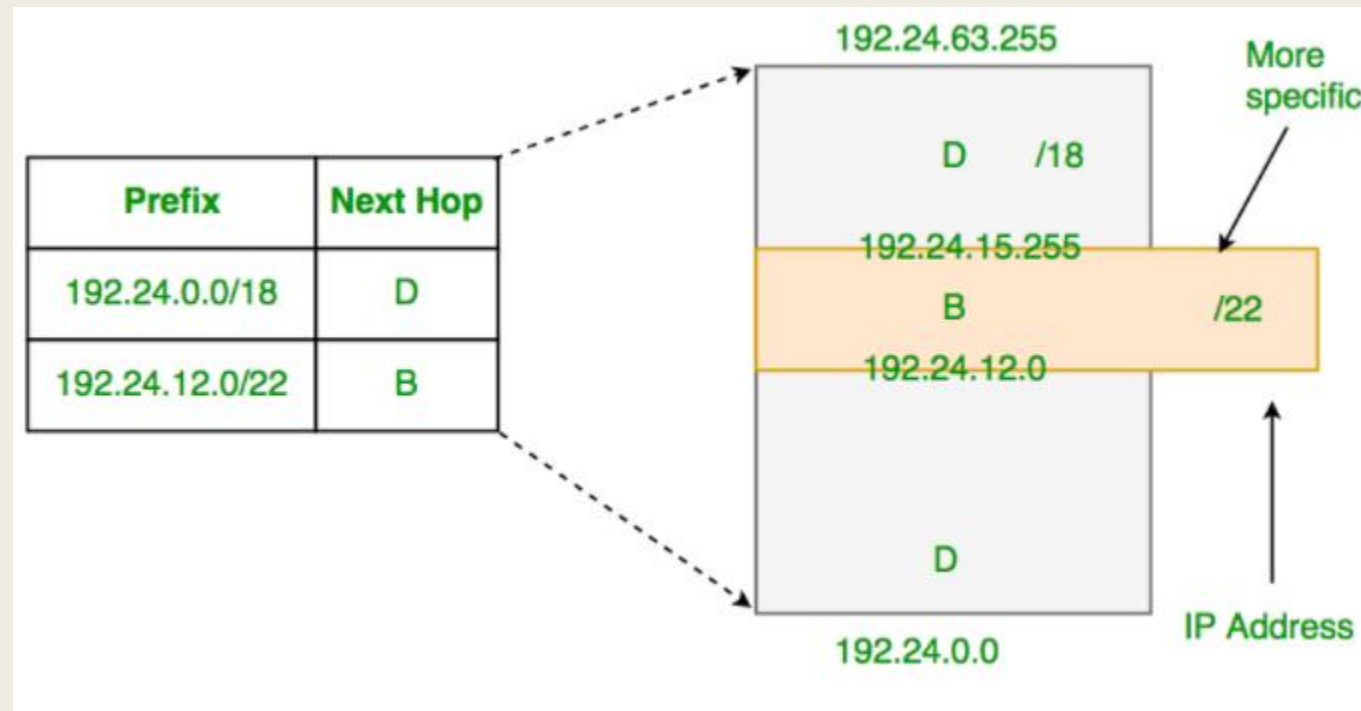
Prefix	Next Hop
192.24.0.0/18	D
192.24.12.0/22	B

Source: [Online], Available: <https://www.geeksforgeeks.org/longest-prefix-matching-in-routers/>

Longest Prefix Matching



- ❑ The entry in a table which has the longest prefix matching with the incoming packet's destination IP and forward the packet to the corresponding next hop.
- ❑ In the example, all packets in overlapping range (192.24.12.0 to 192.24.15.255) are forwarded to next hop B as B has a longer prefix (22 bits).



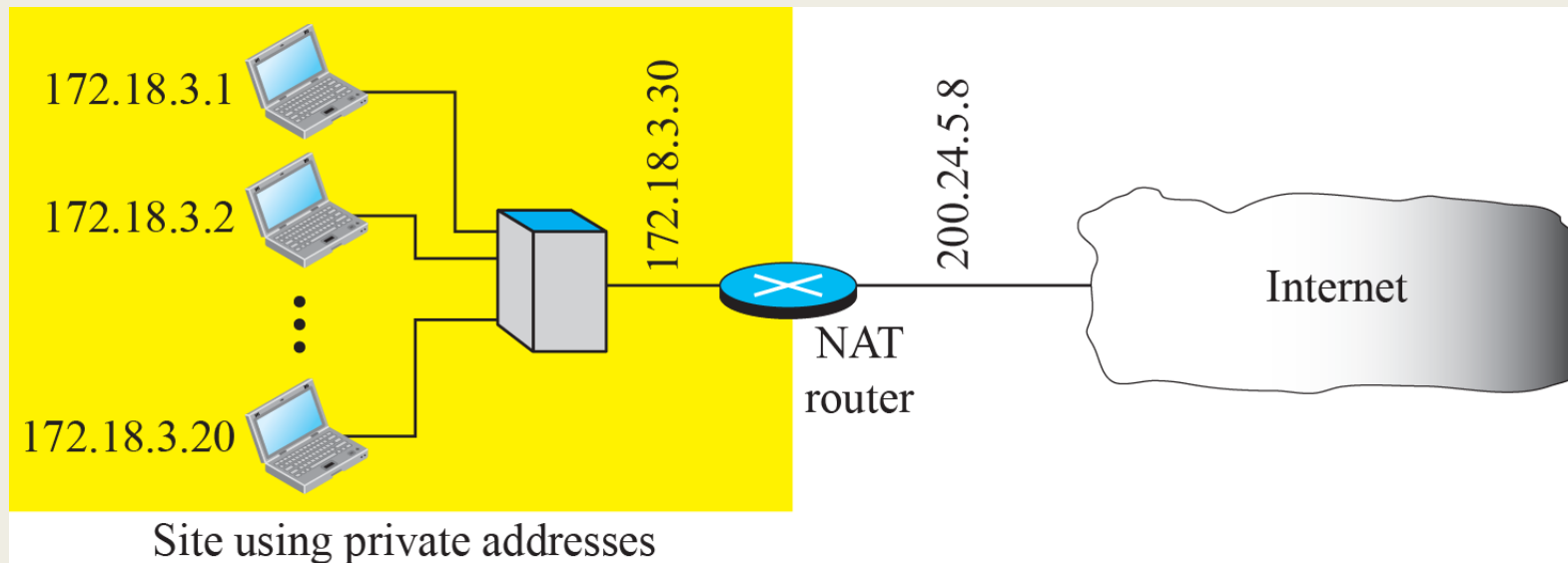
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Network Address Translation

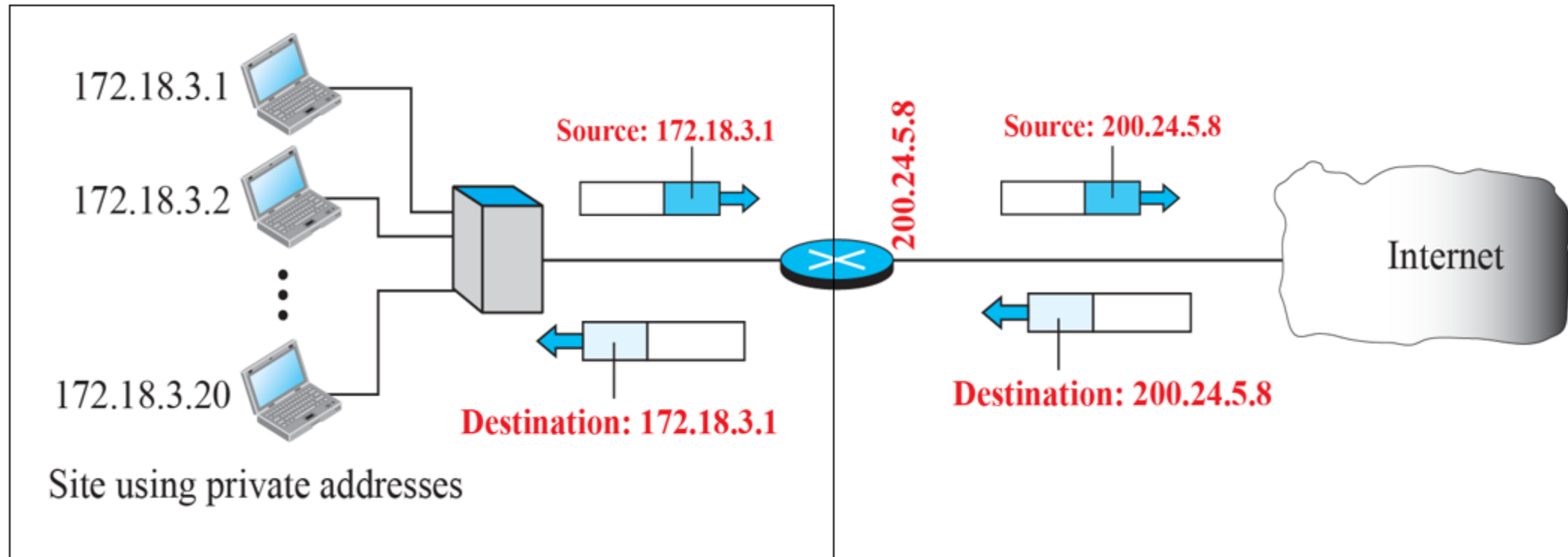
In most situations, only a portion of computers in a small network need access to the Internet simultaneously.

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).

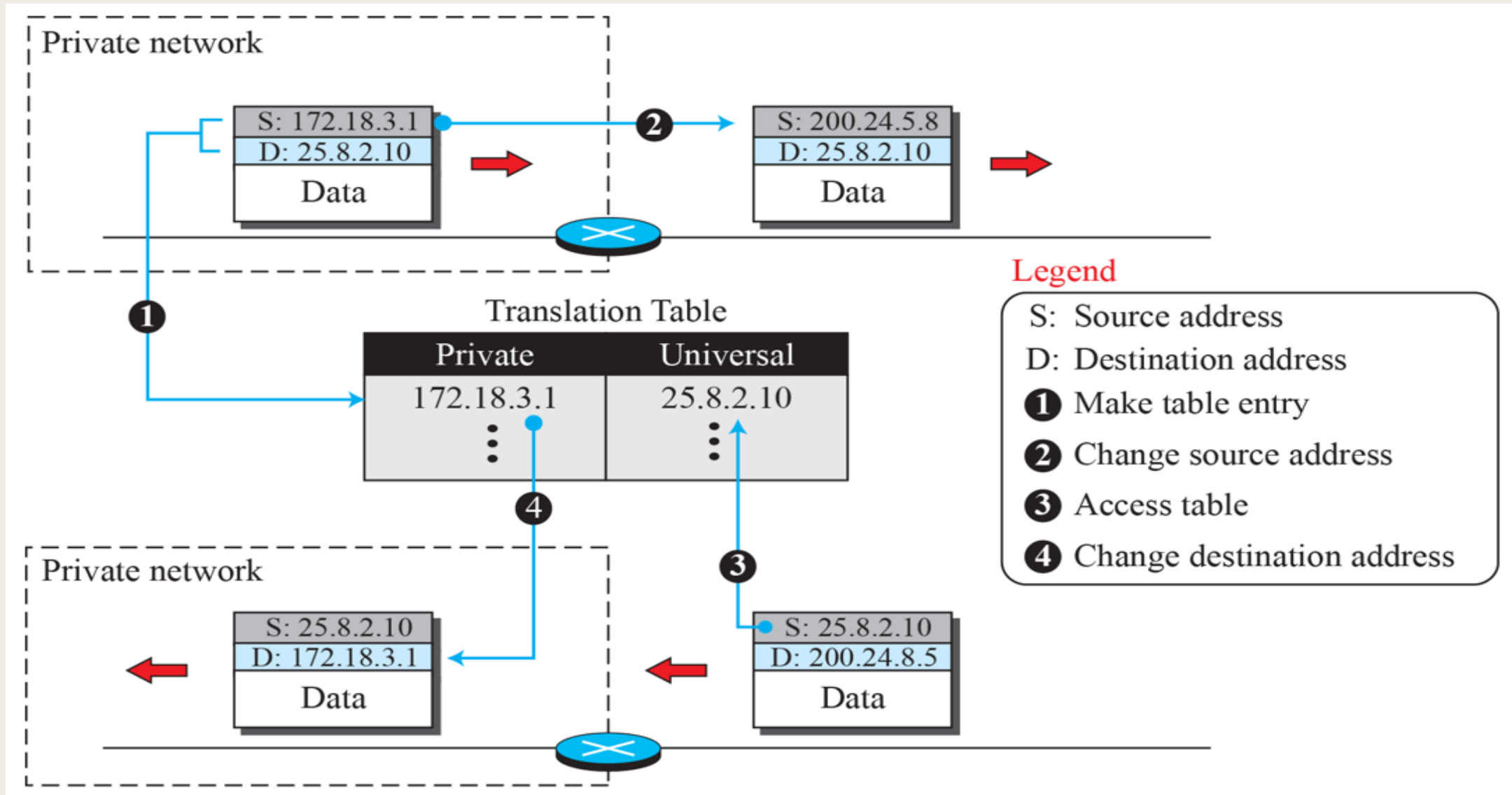
The technology allows a site to use a set of private addresses for internal communication and a set of global Internet addresses (at least one) for communication with the rest of the world.



Address Translation



Cont...



Translation Table

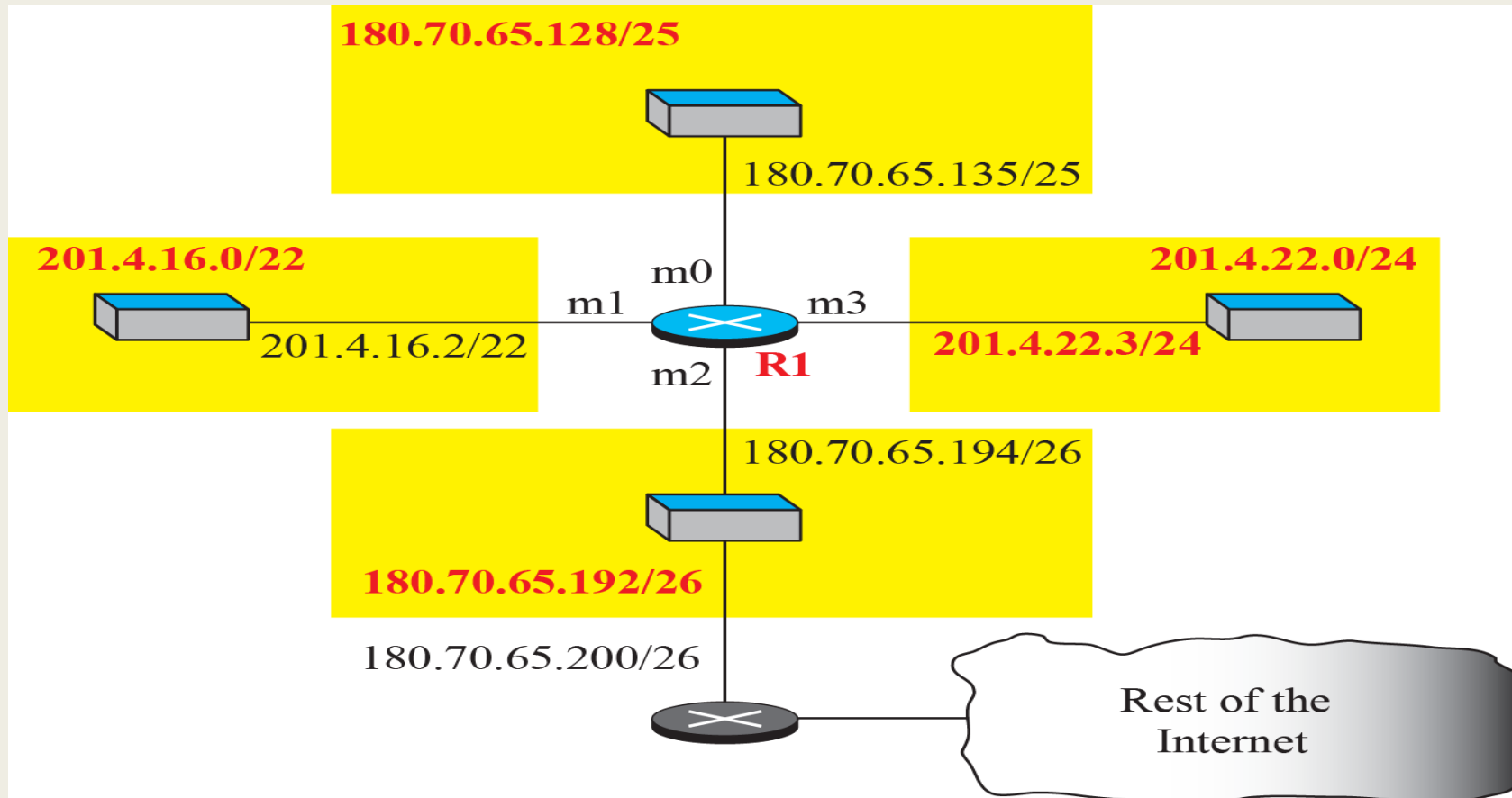


<i>Private address</i>	<i>Private port</i>	<i>External address</i>	<i>External port</i>	<i>Transport protocol</i>
172.18.3.1	1400	25.8.3.2	80	TCP
172.18.3.2	1401	25.8.3.2	80	TCP
⋮	⋮	⋮	⋮	⋮

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.



Solution



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

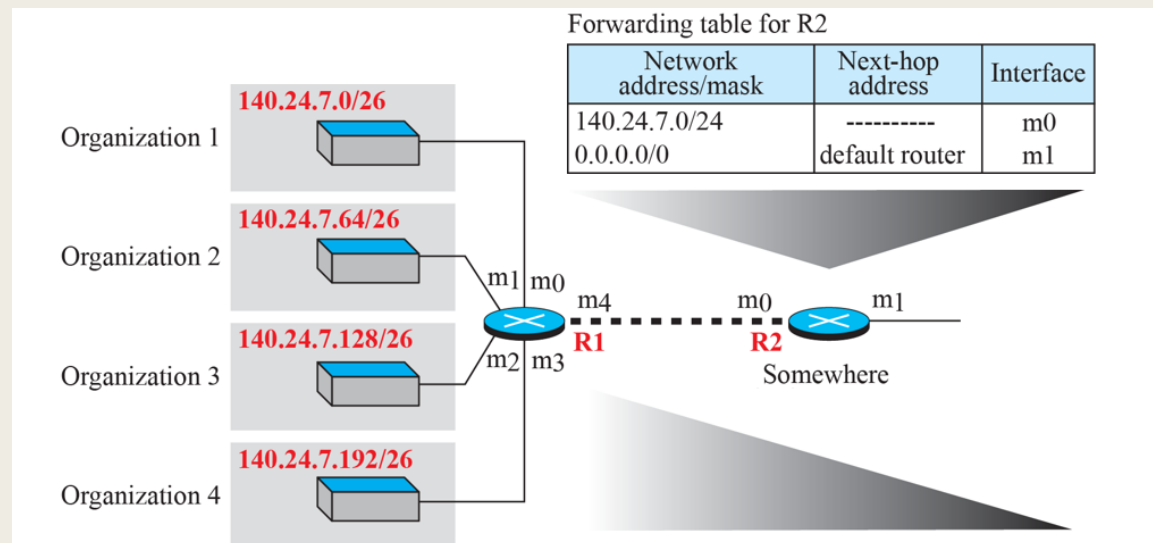
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The router performs the following steps:

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 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

Thank You!!!