DFSC 1316: digital forensic and information assurance fundamentals I

5 IPv4 Addressing

*Reference book: *TCP/IP Protocol Suite* by Behrouz A. Forouzan.

Objectives

- To introduce the concept of an address space in general and the address space of IPv4 in particular.
- To discuss the classful architecture and the blocks of addresses available in each class.
- To discuss the idea of hierarchical addressing and how it has been implemented in classful addressing.
- To discuss classless addressing, that has been devised to solve the problems in classful addressing.
- To discuss NAT technology and show how it can be used to alleviate of address depletion.

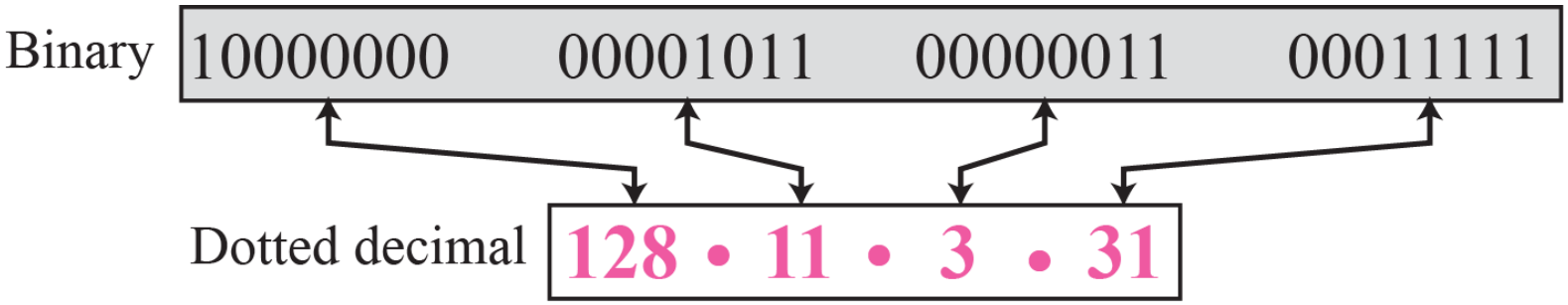
Introduction

- The identifier used in the IP layer of the TCP/IP protocol suite to identify each device connected to the Internet is called the Internet address or IP address.
- An IPv4 address is a 32-bit address that uniquely and universally defines the connection of a host or a router to the Internet.

Facts

- An IPv4 address is 32-bit long (4-bytes).
- The IPv4 addresses are unique and universal.
- The address space if IPv4 is 2^{32} or 4,294,967,296.

Dotted Decimal Notation



Exercise

- Find the error, if any, in the following IPv4 addresses:
  a. 111.56.045.78
  b. 221.34.7.8.20
  c. 75.45.301.14
  d. 11100010.23.14.67

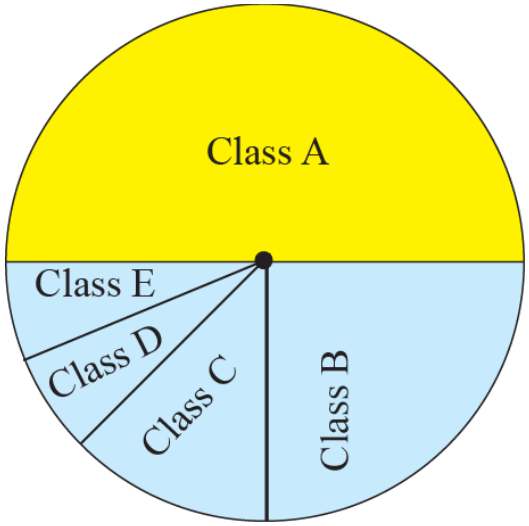
Exercise

- How many addresses exist between the range of the first address 146.102.29.0, and the last address 146.102.32.255?

Classful Addressing

- IP addresses used to use the concept of classes. This architecture is called *classful addressing*.
- *Classless addressing* was introduced in mid-90s and supersedes the original architecture.
- Both classful addressing and classless addressing will be discussed.

Class of IP Addresses



Class A: 2^{31} = 2,147,483,648 addresses, 50%

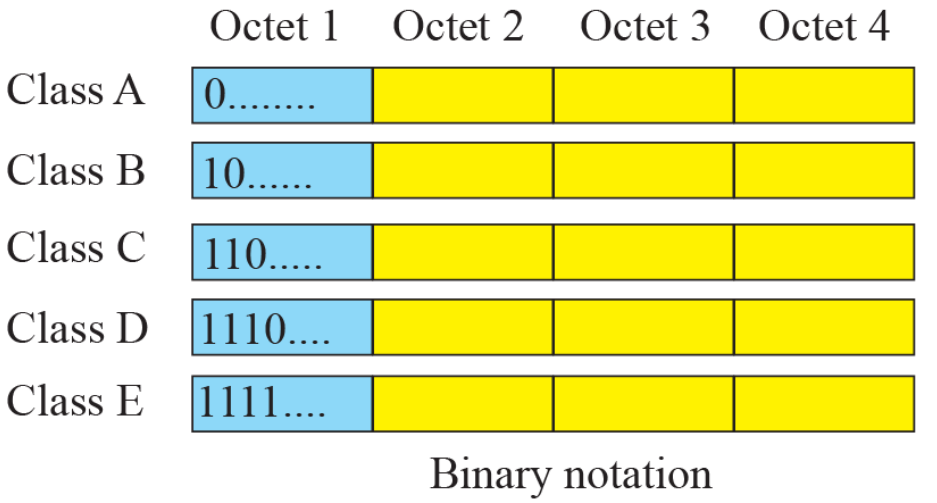
Class B: 2^{30} = 1,073,741,824 addresses, 25%

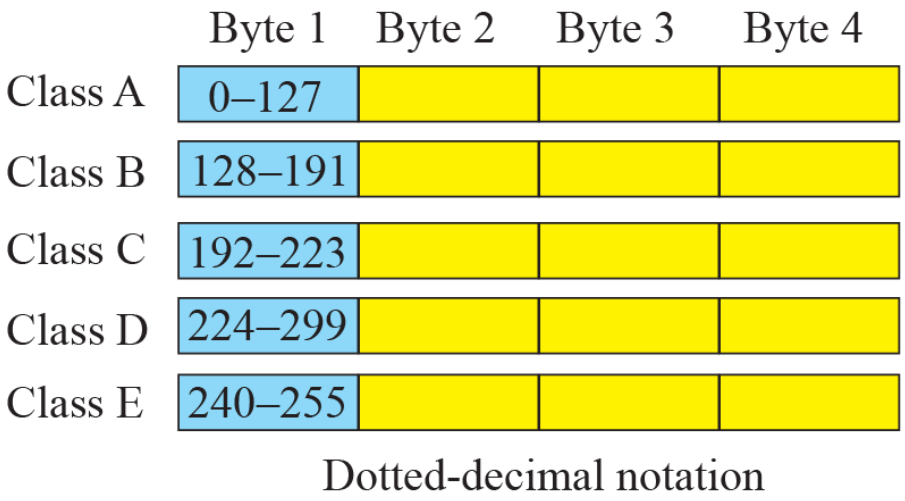
Class C: 2^{29} = 536,870,912 addresses, 12.5%

Class D: 2^{28} = 268,435,456 addresses, 6.25%

Class E: 2^{28} = 268,435,456 addresses, 6.25%

Class of IP Addresses





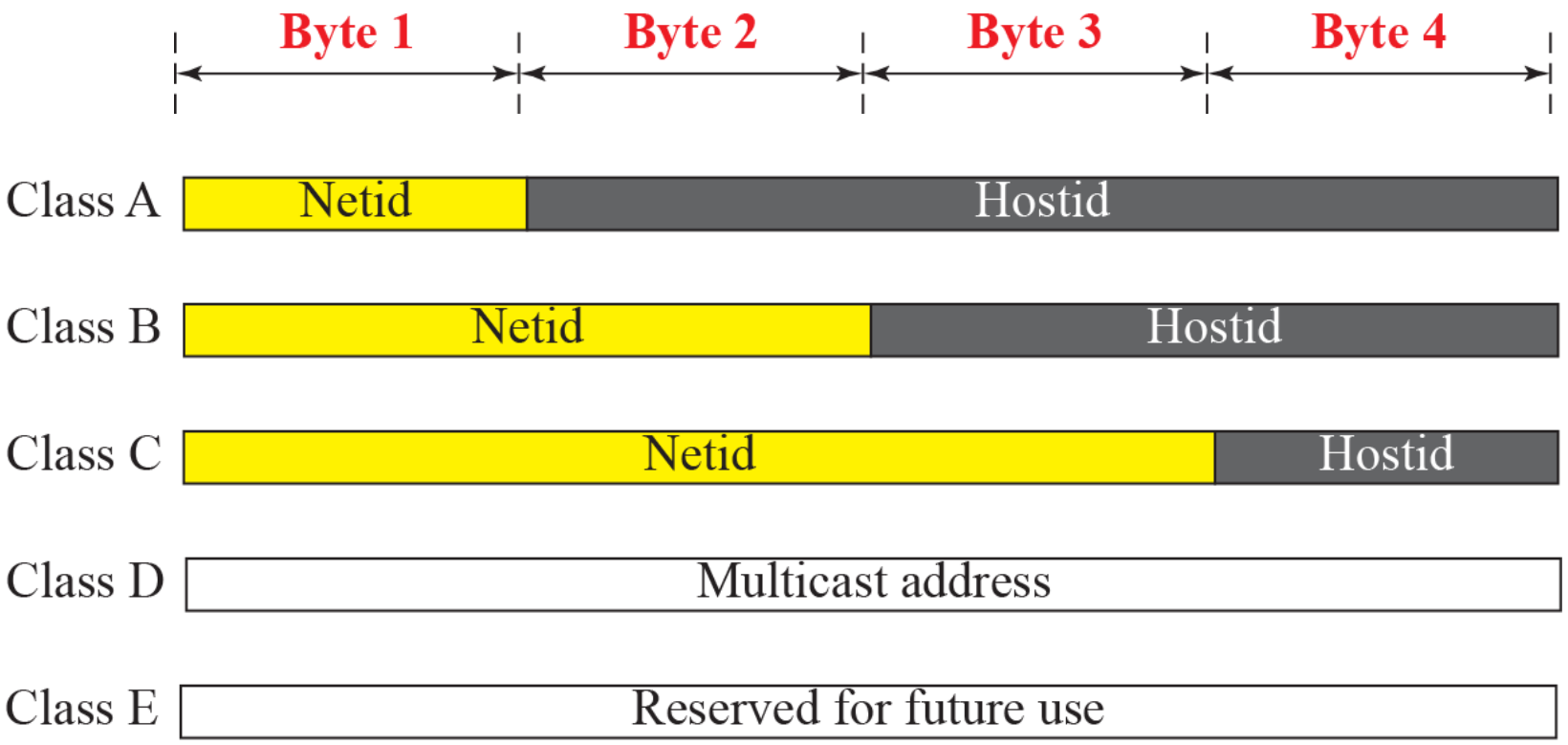
Exercise

- Find the class of each address:
  a. 00000001 00001011 00001011 11101111
  b. 11000001 10000011 00011011 11111111
  c. 10100111 11011011 10001011 01101111
  d. 11110011 10011011 11111011 00001111

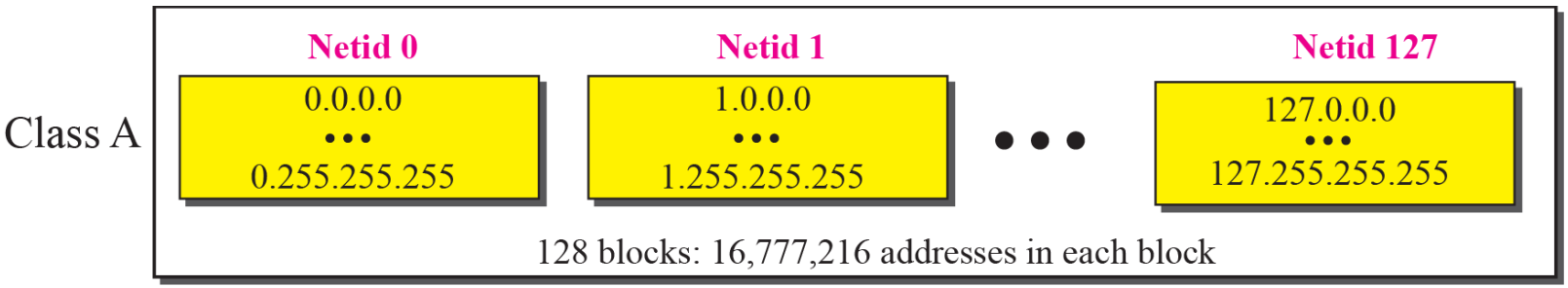
Exercise

- Find the class of each address:
  a. 227.12.14.87
  b. 193.14.56.22
  c. 14.23.120.8
  d. 252.5.15.111

Netid and Hostid

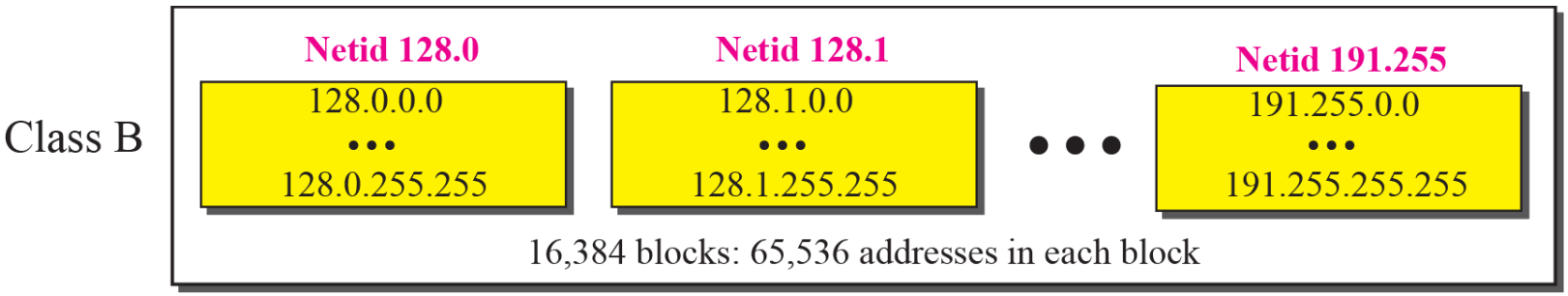


Blocks in Class A



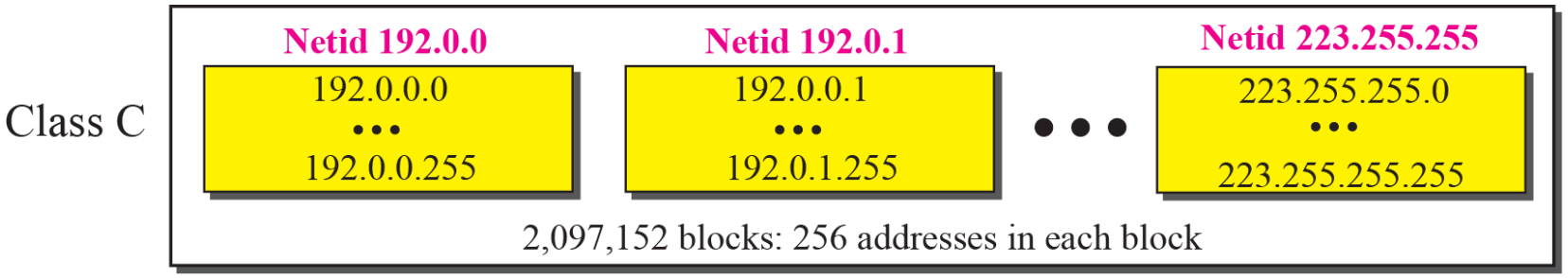
- Millions of class A addresses are wasted.

Blocks in Class B



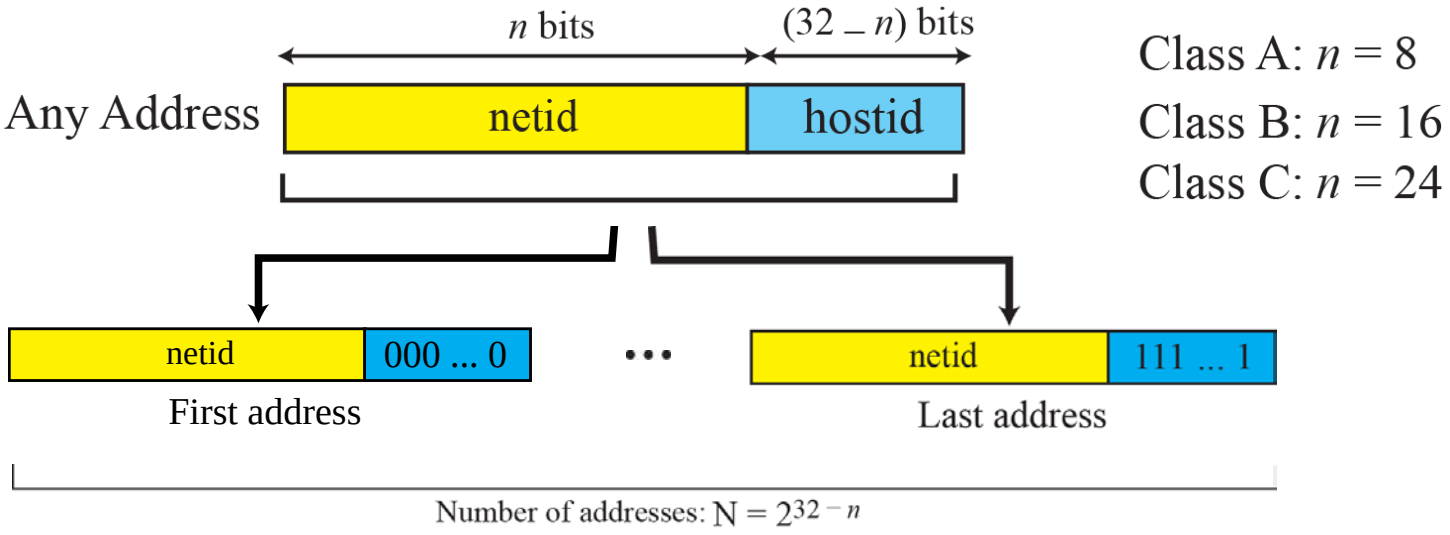
- Many class B addresses are wasted.

Blocks in Class C



- One class C block may be too small for many organizations.

Two-Level Addresses in Classful Addressing



Exercise

- An address in a block is given as 73.22.17.25. Find the Netid, Hostid, and number of addresses in the block.

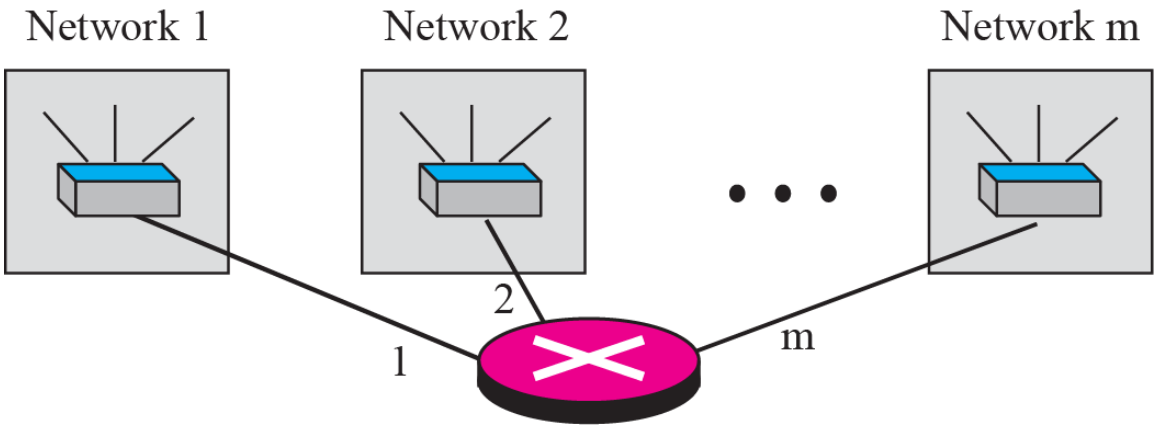
- Solution:
  1. Class A.
  2. Netid: first byte, 73.0.0.0.
  3. Hostid: last 3 bytes, 0.22.17.25.
  4. Number of addresses: $2^{(32-8)}$

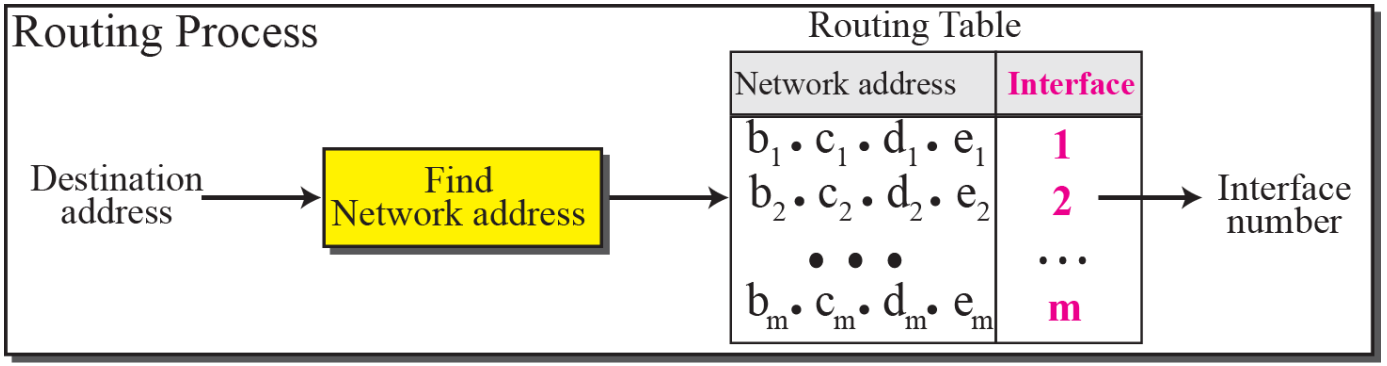
Exercise

- An address in a block is given as 180.8.17.9. Find the Netid, Hostid, and number of addresses in the block.

- Solution:
  1. Class B.
  2. Netid: first 2 bytes, 180.8.
  3. Hostid: last 2 bytes, 17.9.
  4. Number of addresses: $2^{(32-16)}$

Routing According to Network Addresses

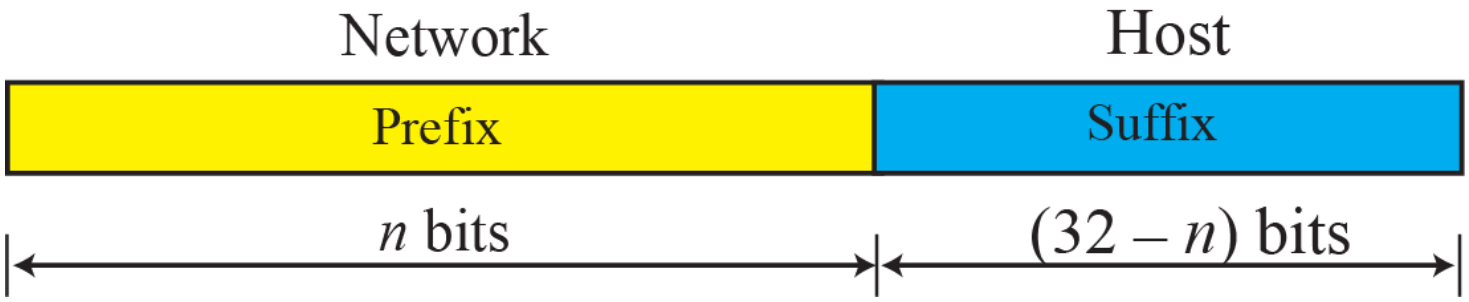




Classless Addressing

- With the growth of the Internet, it was clear that a larger address space was needed as a long-term solution.
- Although the long-range solution has already been devised and is called IPv6, a short-term solution was also devised to use the same address space but to change the distribution of addresses to provide a fair share to each organization.
- The short-term solution still uses IPv4 addresses, but it is called *classless addressing*.

Prefix and Suffix in Classless Addressing



- In classless addressing, the prefix defines the network and the suffix defines the host.
- The prefix length in classless addressing can be 1 to 32.

Exercise

- What is the prefix length and suffix length if the whole Internet is considered as one single block with 4,294,967,296 addresses?

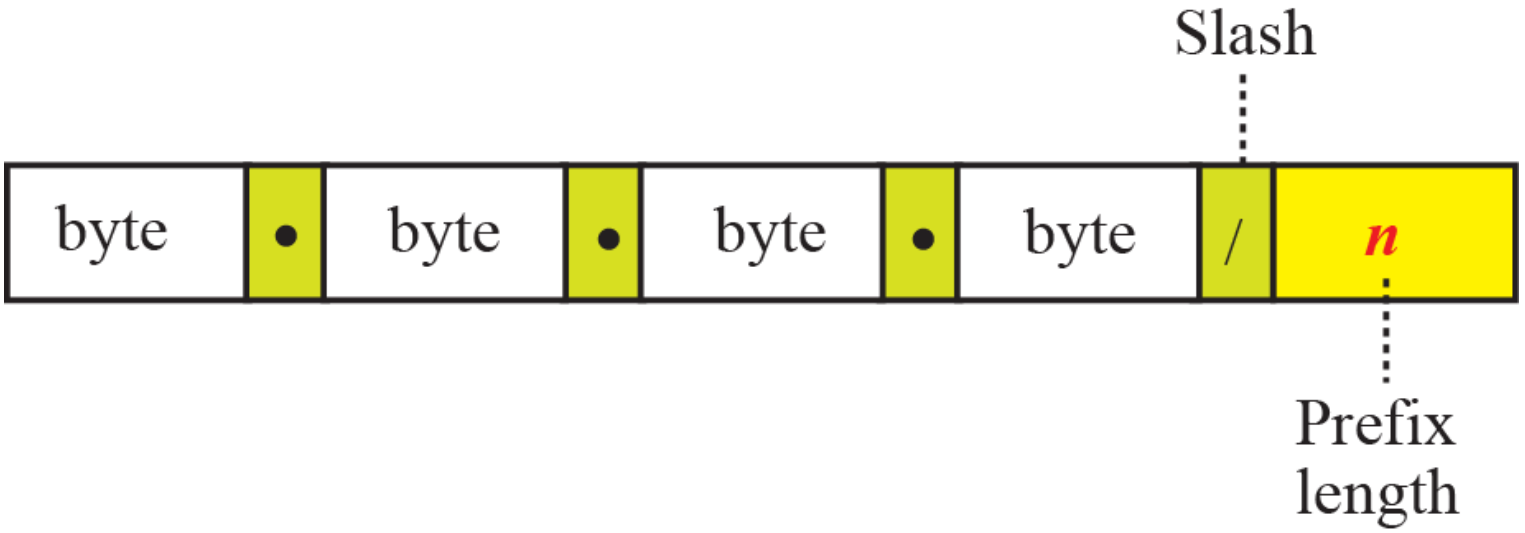
- Solution
  In this case, the prefix length is 0 and the suffix length is 32. All 32 bits vary to define 232 = 4,294,967,296 hosts in this single block.

Exercise

- What is the prefix length and suffix length if the Internet is divided into 4,294,967,296 blocks and each block has one single address?

- Solution
  In this case, the prefix length for each block is 32 and the suffix length is 0. All 32 bits are needed to define 232 = 4,294,967,296 blocks. The only address in each block is defined by the block itself.

Slash Notation in Classless Addressing



- The number of addresses in a block is inversely related to the value of the prefix length, n.
- In classless addressing, we need to know one of the addresses in the block and the prefix length to define the block.

Example

- In classless addressing, an address cannot per se define the block the address belongs to. For example, the address 230.8.24.56 can belong to many blocks some of them are shown below with the value of the prefix associated with that block:

Prefix length:16	→	Block:	230.8.0.0	to	230.8.255.255
Prefix length:20	→	Block:	230.8.16.0	to	230.8.31.255
Prefix length:26	→	Block:	230.8.24.0	to	230.8.24.63
Prefix length:27	→	Block:	230.8.24.32	to	230.8.24.63
Prefix length:29	→	Block:	230.8.24.56	to	230.8.24.63
Prefix length:31	→	Block:	230.8.24.56	to	230.8.24.57

Example

230 . 8 . 24 . 56

Convert to binary

11100110. 00001000. 00110000. 00111000

Example

11100110. 00001000. 00110000. 00111000

Mask = 20 (230.8.24.56/20)

11100110. 00001000. 00110000. 00111000

Example

11100110. 00001000. 0011 0000. 00111000

Netid:

11100110. 00001000. 0011 0000. 00000000

Hostid:

00000000. 00000000. 0000 0000. 00111000

Example

Netid:

11100110. 00001000. 0011 0000. 00000000

230 . 8 . 48 . 0

Hostid:

00000000. 00000000. 0000 0000. 00111000

0 . 0 . 0 . 56

Example

- The following addresses are defined using slash notations.
  a. In the address 12.23.24.78/8, the network mask is 255.0.0.0. The mask has eight 1s and twenty-four 0s. The prefix length is 8; the suffix length is 24.
  b. In the address 130.11.232.156/16, the network mask is 255.255.0.0. The mask has sixteen 1s and sixteen 0s.The prefix length is 16; the suffix length is 16.
  c. In the address 167.199.170.82/27, the network mask is 255.255.255.224. The mask has twenty-seven 1s and five 0s. The prefix length is 27; the suffix length is 5.

Exercise

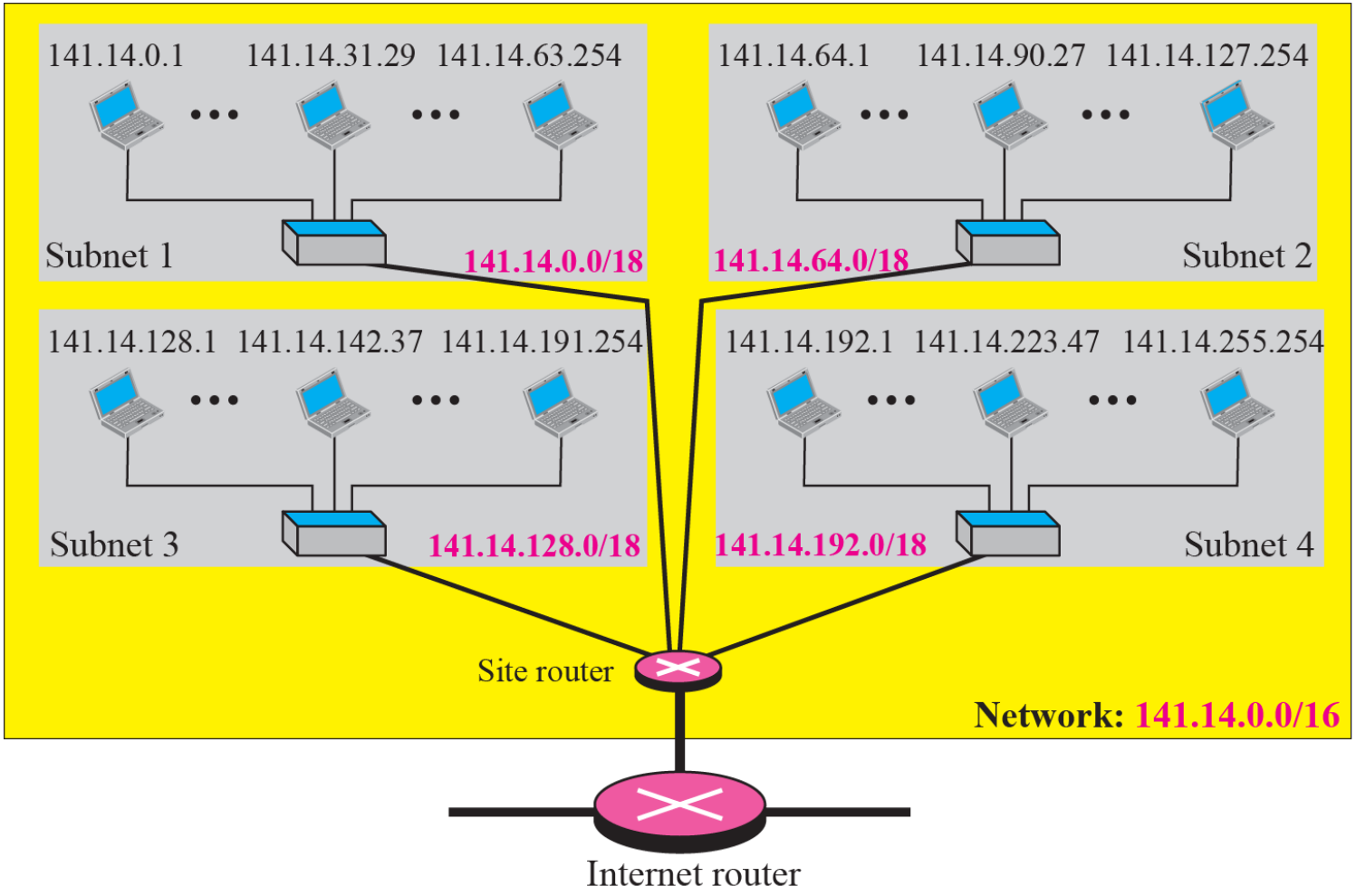
- One of the addresses in a block is 110.23.120.14/20. Find the Netid, Hostid, and number of addresses in the block.

- Solution
  1. The network mask is 255.255.240.0.
  2. The Netid is 110.23.112.0
  3. The Hostid is 0.0.8.14

Example

- An ISP has requested a block of 1000 addresses. The following block is granted.
  a. Since 1000 is not a power of 2, 1024 addresses are granted (1024 = 210).
  b. The prefix length for the block is calculated as n = 32 − $\log_2 1024$ = 22.
  c. The beginning address is chosen as 18.14.12.0.
- The granted block is 18.14.12.0/22. The first address is 18.14.12.0/22 and the last address is 18.14.15.255/22.

Subnet


141.14.0.1
141.14.31.29
141.14.63.254
Subnet 1
141.14.0.0/18
141.14.64.1
141.14.90.27
141.14.127.254
141.14.64.0/18
Subnet 2
141.14.128.1
141.14.142.37
141.14.191.254
Subnet 3
141.14.128.0/18
141.14.192.1
141.14.223.47
141.14.255.254
141.14.192.0/18
Subnet 4
Site router
Network: 141.14.0.0/16
Internet router

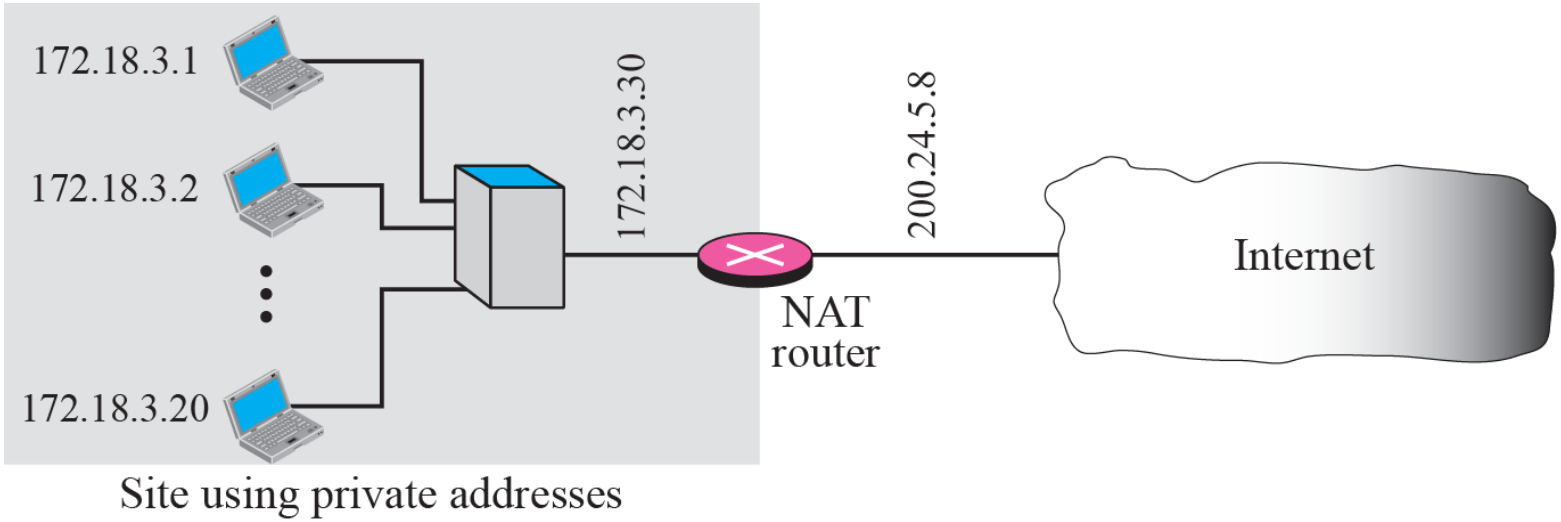
Special Addresses

- In classful addressing some addresses were reserved for special purposes. The classless addressing scheme inherits some of these special addresses from classful addressing.

Network Address Translation

- If a business grows or the household needs a larger range, the ISP may not be able to grant the demand because the addresses before and after the range may have already been allocated to other networks.
- In most situations, however, only a portion of computers in a small network need access to the Internet simultaneously.
- A technology that can help in this cases is network address translation (NAT).

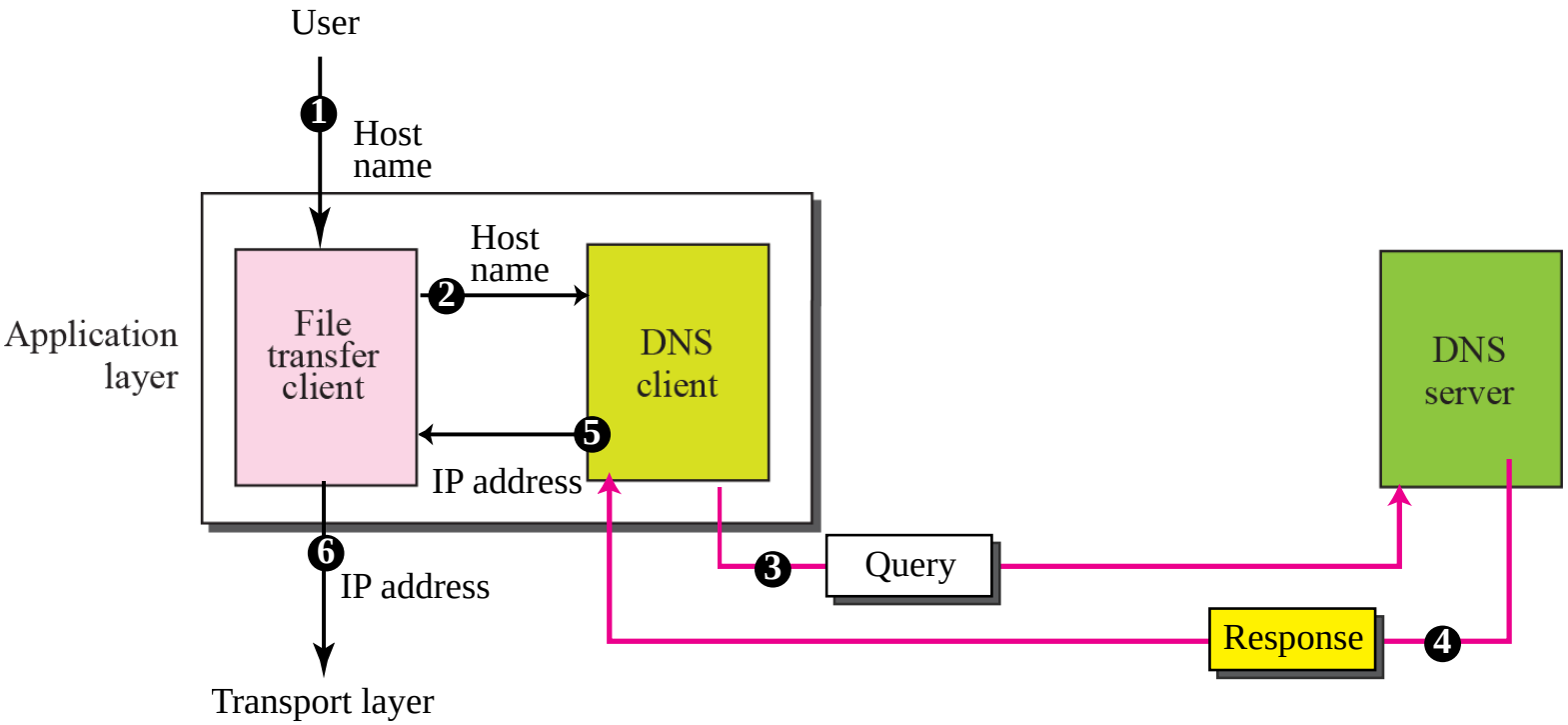
NAT


172.18.3.1
172.18.3.2
172.18.3.20
172.18.3.30
200.24.5.8
NAT
router
Internet
Site using private addresses

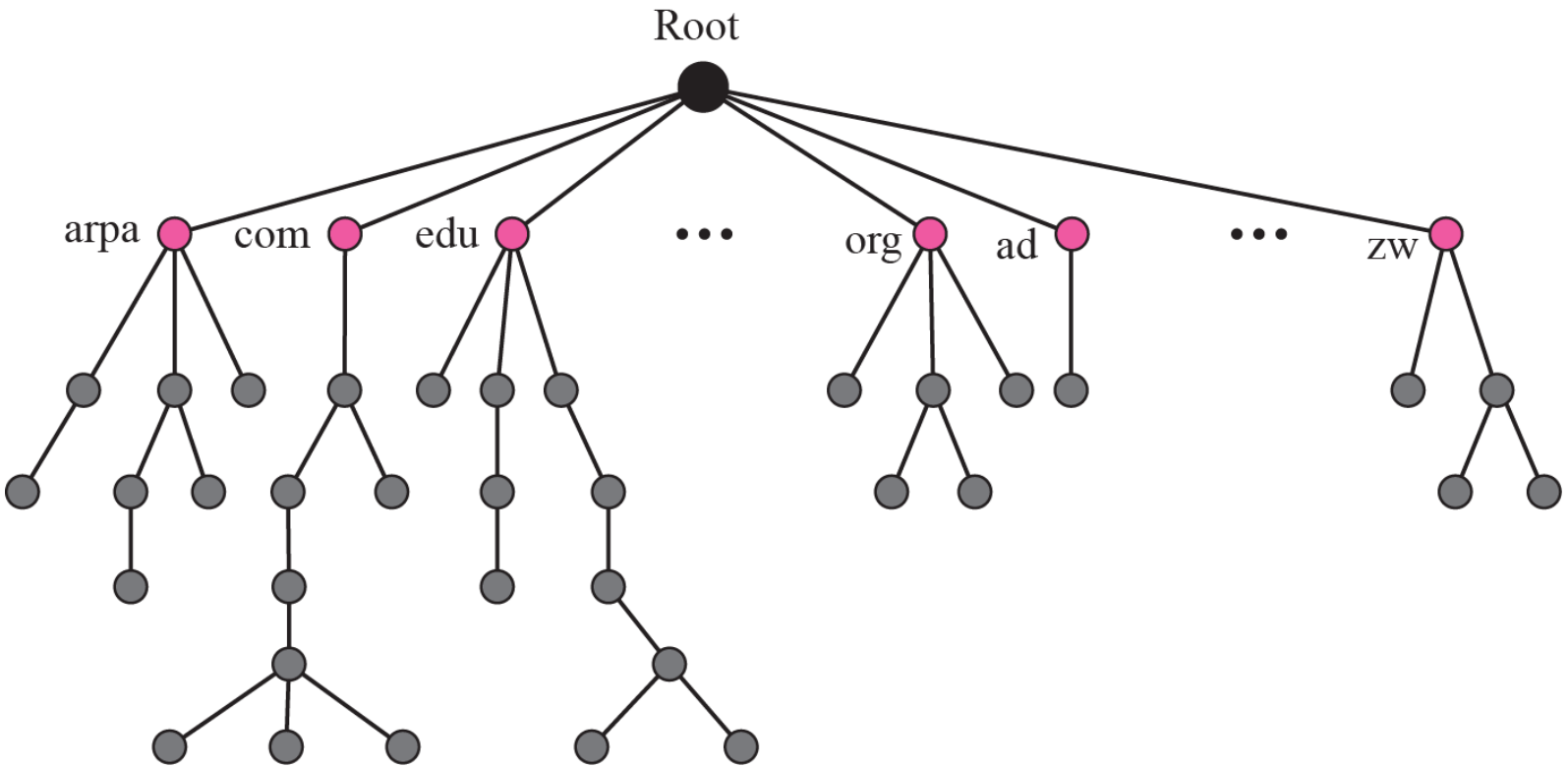
Domain Name System (DNS)

- To identify an entity, TCP/IP protocols use the IP address, which uniquely identifies the connection of a host to the Internet.
- However, people prefer to use names instead of numeric addresses.
- Therefore, we need a system that can map a name to an address or an address to a name.

DNS


User
1
Host name
Application layer
File transfer client
Host name
2
DNS client
5
IP address
6
IP address
Transport layer
3
Query
DNS server
Response
4

Domain Name Space



Misc

- Static IP address and dynamic IP address
  - Static IP: preset and will not change.
  - Dynamic: IP address lease from DHCP server, can expire and is dynamically assigned.

- Inspecting/setting/changing IP address on your computer.

Summary

- IP address is unique and universal, which is composed with 4 bytes (32 bits) binary digits.
- Classful addresses: A – E.
- Classless addresses: prefix and suffix.
- NAT and DNS