Classless Addressing

Summary of Classful Addressing

Class A	
Total Networks:	128
Total Hosts/Net:	16,777,214

Class B	
Total Networks:	16,384
Total Hosts/Net:	65,534

Class C	
Total Networks:	2,097,152
Total Hosts/Net:	254

Class D & E 12.5%
Class C 12.5%
Class B 25%
Class A 50%

- Classful Addressing wasted addresses and exhausted the availability of IPv4 addresses.

- Classless Addressing Introduced in the 1990s

  - Classless Inter-Domain Routing (CIDR, pronounced "cider")

  - Allowed service providers to allocate IPv4 addresses on any address bit boundary (prefix length) instead of only by a class A, B, or C.

Introduction

- Prior to 1981, IP addresses used only the first 8 bits to specify the network portion of the address

- In 1981, RFC 791 modified the IPv4 32-bit address to allow for three different classes

  - Class A addresses used 8 bits for the network portion of the address,

  - Class B used 16 bits,

  - Class C used 24 bits.

  – This format became known as classful IP addressing.

- IP address space was depleting rapidly

- the Internet Engineering Task Force (IETF) introduced Classless Inter-Domain Routing (CIDR)

  – CIDR uses Variable Length Subnet Masking (VLSM) to help conserve address space.

  - -VLSM is simply subnetting a subnet

Classful and Classless IP Addressing

- Classful IP addressing
  - When the ARPANET was commissioned in 1969, no one anticipated that the Internet would explode.
  - 1989, ARPANET transformed into what we now call the Internet.
  - As of January 2007, there are over 433 million hosts on internet
- Initiatives to conserve IPv4 address space include:

  -VLSM & CIDR notation (1993, RFC 1519)

  -Network Address Translation (1994, RFC 1631)

  -Private Addressing (1996, RFC 1918)

Exponential growth of hosts on the Internet

Number of Internet Hosts

Source: ISC

Year
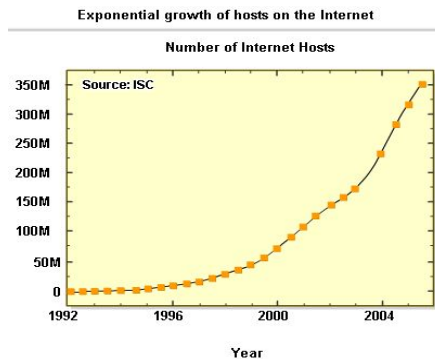
Classful and Classless IP Addressing

▪ The IPv4 Classful Addressing Structure (RFC 790)

An IP address has 2 parts:

-The **network** portion

Found on the **left** side of an IP address

-The **host** portion

Subnet Mask based on Class

	1st Octet	2st Octet	3st Octet	4st Octet	Subnet Mask
Class A	Network	Host	Host	Host	255.0.0.0 or /8
Class B	Network	Network	Host	Host	255.255.0.0 or /16
Class C	Network	Network	Network	Host	255.255.255.0 or /24

Number of Networks and Hosts per Network for Each Class

Address class	First Octet Range	Number of Possible Networks	Number of Host per Networks
Class A	0 to 127	128 (2 are reserved)	16,777,214
Class B	128 to 191	16,384	65,534
Class C	192 to 223	2,097,152	254

Classful and Classless IP Addressing

▪ As shown in the figure, class A networks used the first octet for network assignment, which translated to a 255.0.0.0 classful subnet mask.

– Because only 7 bits were left in the first octet (remember, the first bit is always 0), this made 2 to the 7th power or 128 networks.

– With 24 bits in the host portion, each class A address had the potential for over 16 million individual host addresses.

Subnet Mask based on Class

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Classful and Classless IP Addressing

▪ With 24 bits in the host portion, each class A address had the potential for over 16 million individual host addresses.

▪ What was one organization going to do with 16 million addresses?

▪ Now you can understand the tremendous waste of address space that occurred in the beginning days of the Internet, when companies received class A addresses.

▪ Some companies and governmental organizations still have class A addresses.

  – General Electric owns 3.0.0.0/8,

  – Apple Computer owns 17.0.0.0/8,

  – U.S. Postal Service owns 56.0.0.0/8.

Classful and Classless IP Addressing

- Class B: RFC 790 specified the first two octets as network.

  - With the first two bits already established as 1 and 0, 14 bits remained in the first two octets for assigning networks, which resulted in 16,384 class B network addresses.

  - Because each class B network address contained 16 bits in the host portion, it controlled 65,534 addresses. (Remember, 2 addresses were reserved for the network and broadcast addresses.)

Subnet Mask based on Class

	1st Octet	2st Octet	3st Octet	4st Octet	Subnet Mask
Class A	Network	Host	Host	Host	255.0.0.0 or /8
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Classful and Classless IP Addressing

- class C: RFC 790 specified the first three octets as network.

    – With the first three bits established as 1 and 1 and 0, 21 bits remained for assigning networks for over 2 million class C networks.

    – But, each class C network only had 8 bits in the host portion, or 254 possible host addresses.

Subnet Mask based on Class

	1st Octet	2st Octet	3st Octet	4st Octet	Subnet Mask
Class A	Network	Host	Host	Host	255.0.0.0 or /8
Class B	Network	Network	Host	Host	255.255.0.0 or /16
Class C	Network	Network	Network	Host	255.255.255.0 or /24

Number of Networks and Hosts per Network for Each Class

Address class	First Octet Range	Number of Possible Networks	Number of Host per Networks
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Classful and Classless IP Addressing

- ## Classless Inter-domain Routing (CIDR – RFC 1517)

  - Requires subnet mask to be included in routing update because address class is meaningless

    - The network portion of the address is determined by the network subnet mask, also known as the network prefix, or prefix length (/8, /19, etc.).

    - The network address is no longer determined by the class of the address

    - Blocks of IP addresses could be assigned to a network based on the requirements of the customer, ranging from a few hosts to hundreds or thousands of hosts.

- ## CIDR – use arbitrary prefix length of Network ID

 - E.g. 205.100.0.0/22 means that network ID length is 22 bits, i.e. netmask is 255.255.252.0

Classless Inter-Domain Routing

- Do not use classes to determine network ID

- Assign any range of addresses to network
  - Use common part of address as network number
  - E.g., addresses 192.4.16 - 192.4.31 have the first 20 bits in common. Thus, we use these 20 bits as the network number
  - netmask is /20, /xx is valid for almost any xx

- Enables more efficient usage of address space (and router tables)

CIDR Example

- Network provide is allocated 8 class C chunks, 201.10.0.0 to 201.10.7.255
  - Allocation uses 3 bits of class C space
  - Remaining 21 bits are network number, written as 201.10.0.0/21
- Replaces 8 class C routing entries with 1 combined entry
  - Routing protocols carry prefix with destination network address
  - Longest prefix match for forwarding

CIDR Illustration

Provider is given 201.10.0.0/21

Provider

201.10.0.0/22   201.10.4.0/24   201.10.5.0/24   201.10.6.0/23
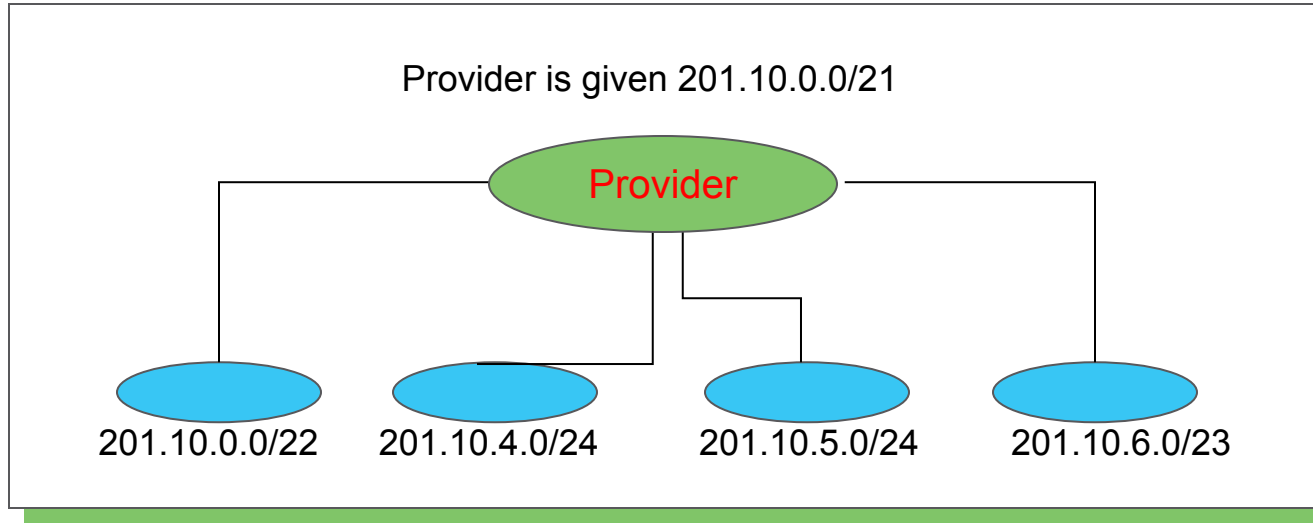
Classless Inter-Domain Routing (CIDR)

The general form of CIDR notation is: **ddd.ddd.ddd.ddd/m**

- **ddd** is the decimal value for an octet of the address
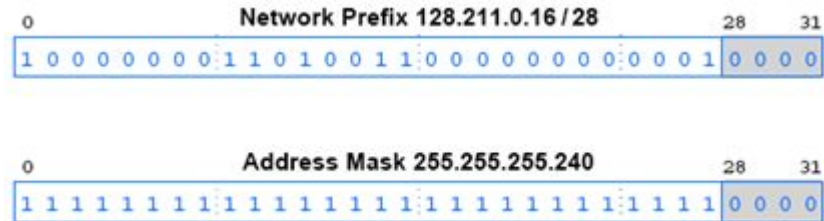- **m** is the number of one bits in the mask

Consider the mask needed for a network with 28 bits of prefix:
- It has 28-bits of 1s followed by 4-bits of 0s
- In dotted decimal, the mask is: **255.255.255.240**

In CIDR notation,
the mask is written:
128.211.0.16/28
which specifies
a mask with 28 bits
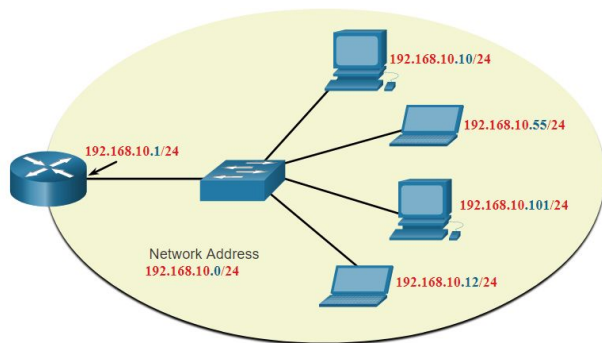of prefix and 4 bits
of suffix.

Network Prefix 128.211.0.16 / 28

0																											28	31

`1 0 0 0 0 0 0 0 1 1 0 1 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0 1 | 0 0 0 0`

Address Mask 255.255.255.240

`1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | 0 0 0 0`

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Network, Host, and Broadcast Addresses

Within each network are three types of IP addresses:

- Network address
- Host addresses
- Broadcast address

Network Address
192.168.10.0/24

|	Network Portion			Host Portion	Host Bits
Subnet mask **255.255.255.0 or /24**	255 11111111	255 11111111	255 11111111	0 00000000	
Network address **192.168.10.0 or /24**	192 11000000	168 10100000	10 00001010	0 00000000	All 0s
First address **192.168.10.1 or /24**	192 11000000	168 10100000	10 00001010	1 00000001	All 0s and a 1
Last address **192.168.10.254 or /24**	192 11000000	168 10100000	10 00001010	254 11111110	All 1s and a 0
Broadcast address **192.168.10.255 or /24**	192 11000000	168 10100000	10 00001010	255 11111111	All 1s

Network, Host, and Broadcast Addresses
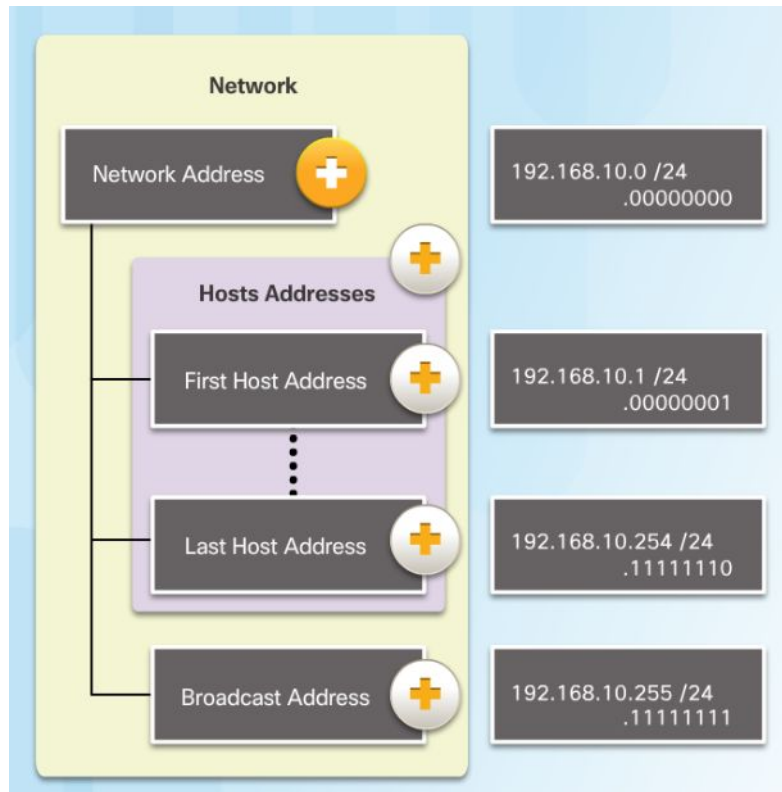
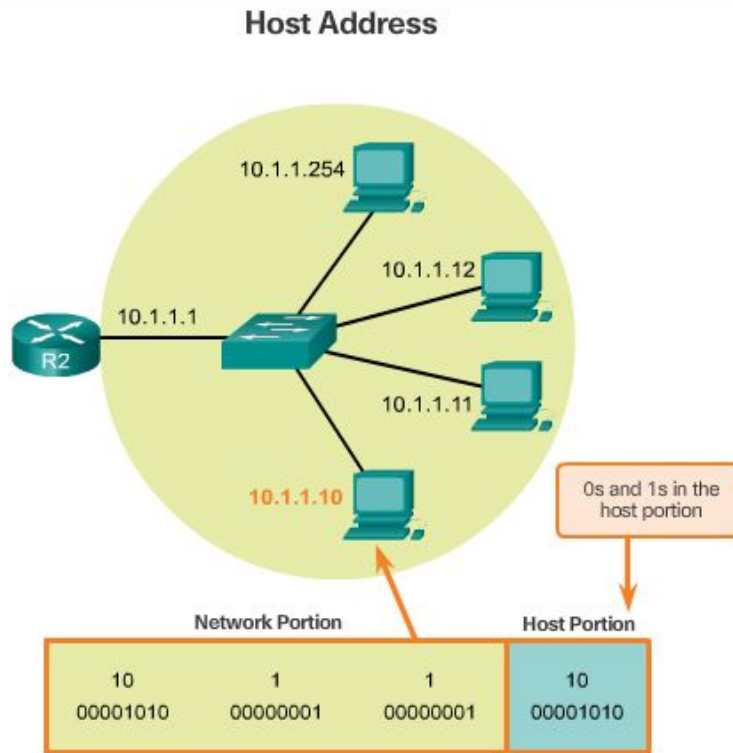- Types of Addresses in Network 192.168.10.0/24

  - Network Address - host portion is all 0s (.00000000)

  - First Host address - host portion is all 0s and ends with a 1 (.00000001)

  - Last Host address - host portion is all 1s and ends with a 0 (.11111110)

  - Broadcast Address - host portion is all 1s (.11111111)

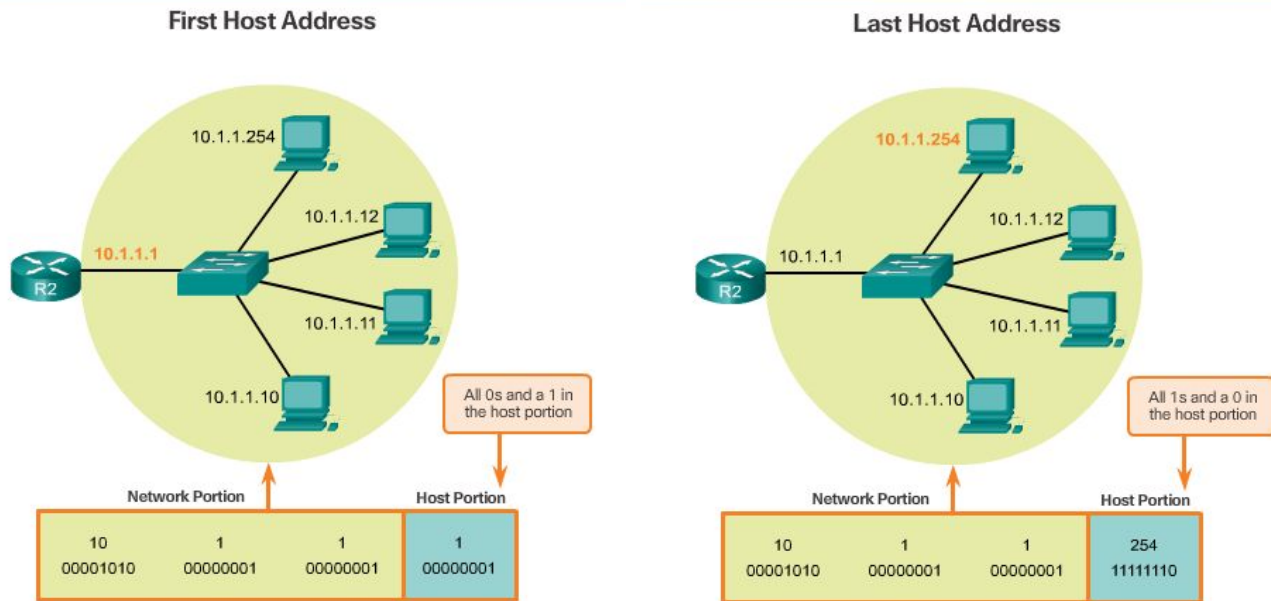# Network, Host, and Broadcast Addresses (cont.)
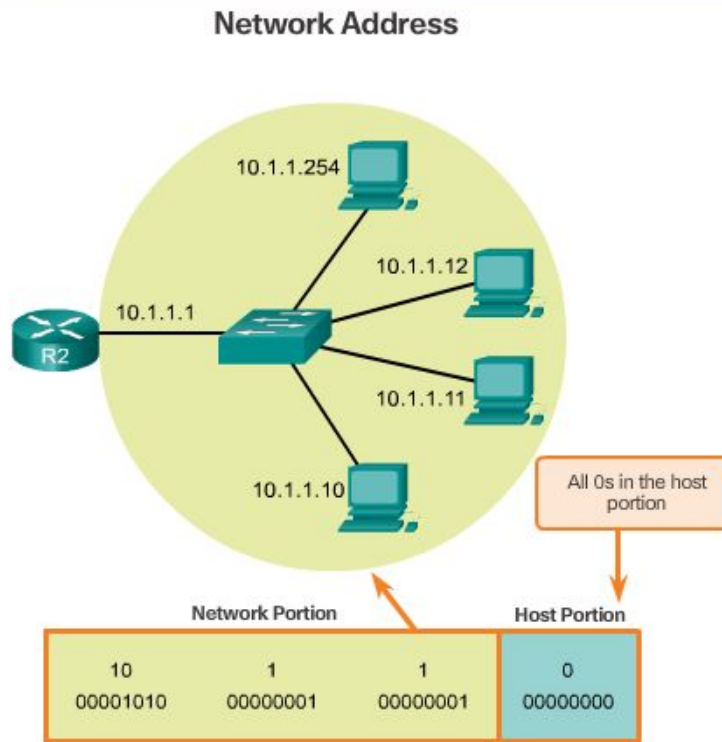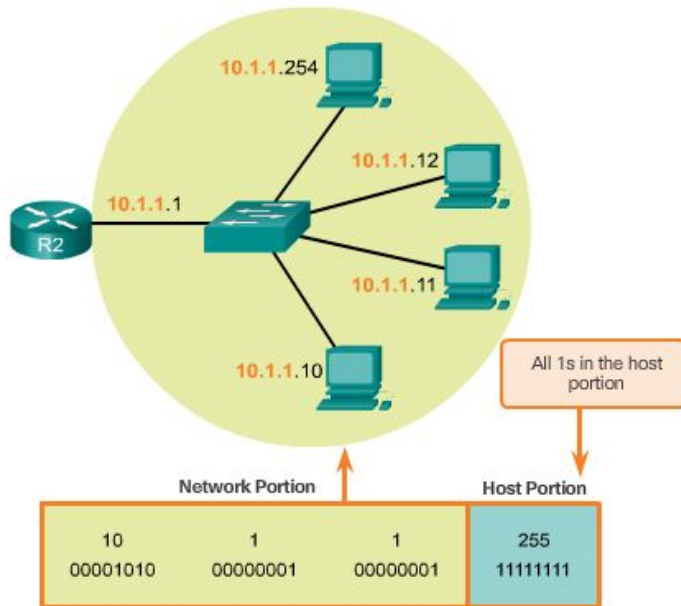
Network, Host, and Broadcast Addresses (cont.)

Network, Host, and Broadcast Addresses (cont.)

Network, Host, and Broadcast Addresses (cont.)

Broadcast Address

Practice test 2 task description

Analyze the table shown below and identify the network portion and host portion of the given IPv4 addresses.

The first two rows show examples of how the table should be completed.

Key for table:

N = all 8 bits for an octet are in the network portion of the address

n = a bit in the network portion of the address

H = all 8 bits for an octet are in the host portion of the address

h = a bit in the host portion of the address

IP Address/Prefix	Network/Host N,n = Network, H,h = Host	Subnet Mask	Network Address
192.168.10.10/24	N.N.N.H	255.255.255.0	192.168.10.0
10.101.99.17/23	N.N.nnnnnnnh.H	255.255.254.0	10.101.98.0

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