Wollo University
Kombolcha Institute of Technology
Department of Information System

Data Communication and Computer Networks

Chapter 07:

7.0 INTRODUCTION TO IP ADDRESSING AND SUBNETTING

7.1 Classful & Classless Addressing

Addressing the Network

- Assigning Addresses: Static or Dynamic
- IP addresses assigned either statically through an administrator or dynamically through DHCP
- **Static:** includes entering the host IP address, subnet mask, and default gateway
  - Advantages over dynamic addresses, useful for printers, servers, and other networking devices that need to be accessible to clients on the network
- However, it can be time-consuming to enter the information on each host
- When using static IP addressing, it is necessary to maintain an accurate list of the IP address assigned to each device, These are permanent addresses and are not normally reused.

Cont…

- **Dynamic**: DHCP enables the automatic assignment of addressing information
  - It reduces the burden on network support staff and virtually eliminates entry errors.
  - Dynamic address is not permanently assigned to a host but is only "leased" for a period of time.
  - If the host is powered down or taken off the network, the address is returned to the pool for reuse. This feature is especially helpful for mobile users that come and go on a network.

Cont…

Assigning Dynamic Addresses

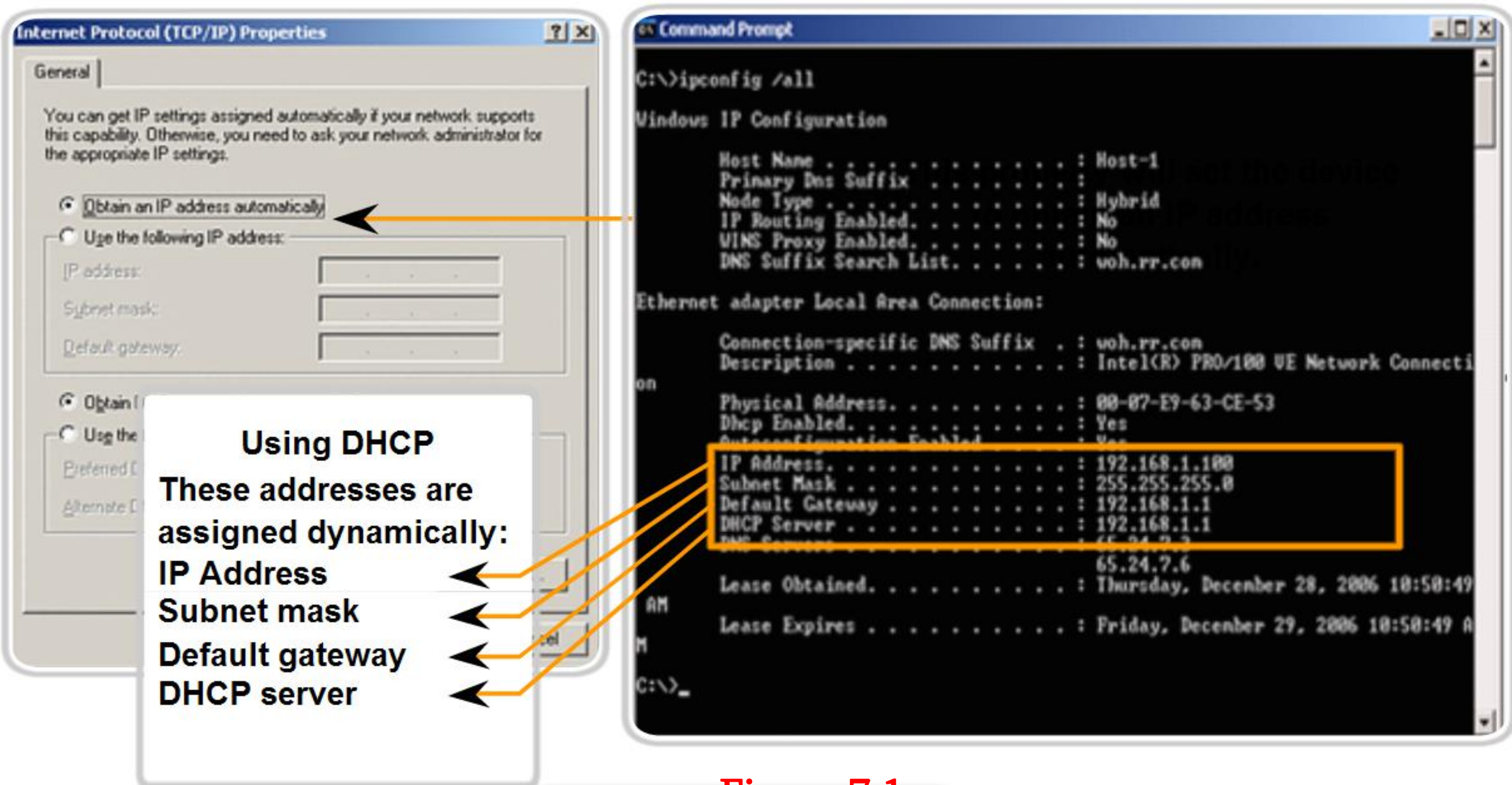


Figure 7.1

Cont…

- *Addresses for Servers and Peripherals:* are a concentration point for network traffic.
  - Should have a static/predictable addresses
- *Addresses for Hosts that are Accessible from Internet*
  - These devices are usually servers of some type
  - the addresses should be static & public space addresses
- *Addresses for Intermediary Devices:* concentration point for network traffic
  - Devices such as hubs, switches, and wireless access points do not require IPv4 addresses to operate as intermediary devices. However, if we need to access these devices as hosts to configure, monitor, or troubleshoot network operation, they need to have addresses.
  - they should have predictable addresses & should be in a different range within the network block than user device addresses

Cont…

- **Who assigns the different addresses:**(http://www.iana.net)
- Internet Assigned Numbers Authority(IANA): is the master holder of the IP addresses.
- The IP multicast addresses and the IPv6 addresses are obtained directly from IANA.
- Until the mid-1990s, all IPv4 address space was managed directly by the IANA.
- At that time, the remaining IPv4 address space was allocated to various other registries to manage for particular purposes or for regional areas.
- These registration companies are called Regional Internet Registries (RIRs):

Cont…

Entities that Oversee IP Address Allocation

Global	**IANA**				
Regional Internet Registries	**AfriNIC** Africa Region	**APNIC** Asia/ Pacific Region	**LACNIC** Latin America And Caribbean Region	**ARIN** North America Region	**RIPE NCC** Europe, Middle East, Central Asia Region

Cont…

Internet Service Provider/ISP's:

- An ISP will generally supply a small number of usable IPv4 addresses to their customers as a part of their services, loans or rents.
- To get access to the services of the Internet, we have to connect our data network to the **Internet using an Internet Service Provider (ISP).**
- Other services that an ISP generally provides to its customers are DNS services, e-mail services, and a website.
- Depending on the level of service required and available, customers use different tiers of an ISP.
- ISPs are designated by a hierarchy based on their level of connectivity to the Internet backbone. Each lower tier obtains connectivity to the backbone via a connection to a higher tier ISP

Cont…

- At the top of the ISP hierarchy are Tier 1 ISPs.
- These ISPs are large national or international ISPs that are directly connected to the Internet backbone.
- Their advantages are Speed & Reliability

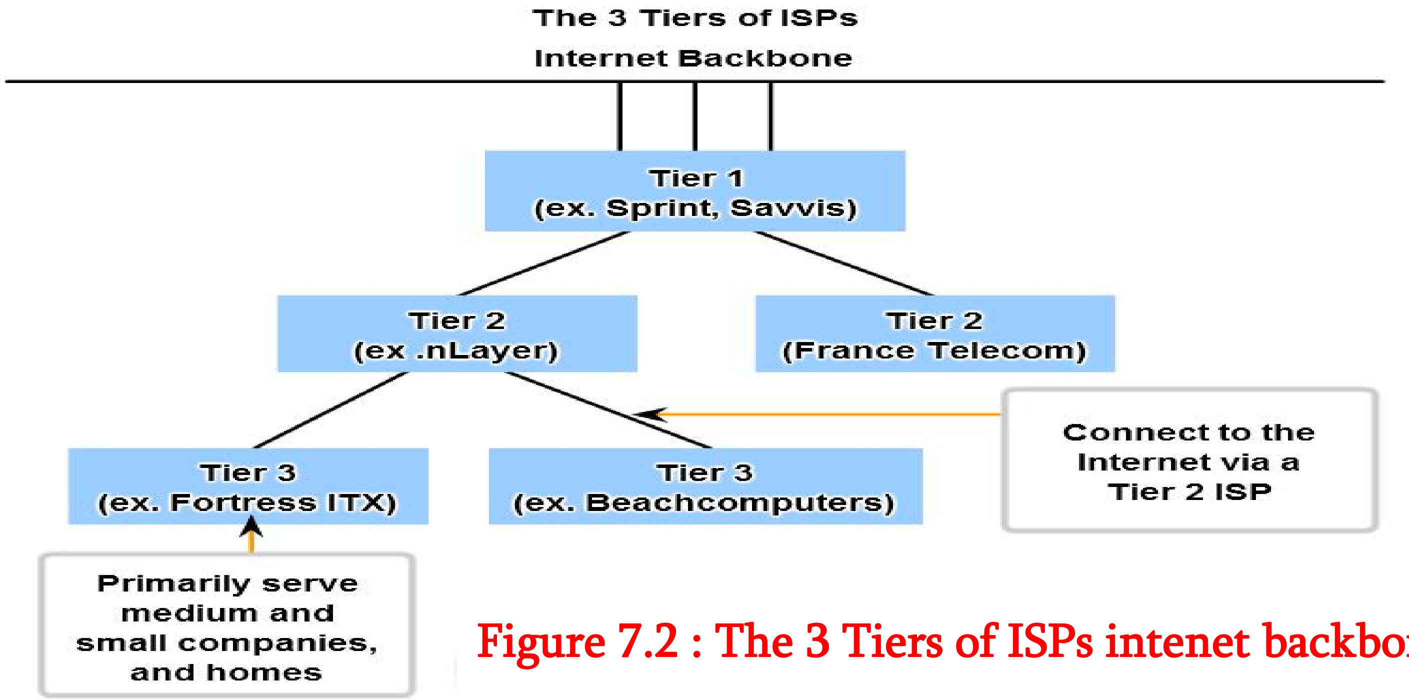


Figure 7.2 : The 3 Tiers of ISPs intenet backbon

IPV4 Addresses

Internet Scaling Problems

Over the past few years, the Internet has experienced two major scaling issues as it has struggled to provide continuous and uninterrupted growth:

- **The eventual exhaustion of IP version 4 (IPv4) address space**
  - It concerned with the eventual depletion of the IP address space.
  - IPv4 defines a 32-bit address which means that there are only 2^{32} (4,294,967,296) IPv4 addresses available. As the Internet continues to grow, this finite number of IP addresses will eventually be exhausted.
- **The need to route traffic between the ever increasing number of networks that comprise the Internet**
  - *It is caused by the rapid growth in the size of the Internet routing tables. Internet backbone routers are required to maintain complete routing information for the Internet*
  - *Unfortunately, the routing problem cannot be solved by simply installing more router memory and increasing the size of the routing tables.*

Cont…

- The long-term solution to these problems can be found in the widespread deployment of IP Next Generation (IPng or IPv6). Currently, IPv6 is being tested and implemented on the 6Bone network, which is an informal collaborative project covering North America, Europe, and Japan. 6Bone supports the routing of IPv6 packets, since that function has not yet been integrated into many production routers.

☛ *Please use these vocabulary terms in order to get your understanding better:*

- ✓ **Address** - The unique number ID assigned to one host or interface in a network.
- ✓ **Subnet** - A portion of a network that shares a particular subnet address.
- ✓ **Subnet mask** - A 32-bit combination used to describe which portion of an address refers to the subnet and which part refers to the host.
- ✓ **Interface** - A network connection

IP Address…

- **IP Address** is a unique identification given to Host, network device, server for data communication.
- IP Address stand for Internet Protocol address, it is an addressing scheme used to identify a system on a network.
- It is a unique address that certain electronic devices currently use to communicate with each other on a network using internet protocol.
- IPV4 is a 32 bit number represented in 4 decimal numbers, where each decimal number is of 8 bit (an octet), where each octet is separated by a dot in between. Thus the representation is known as Dotted Decimal Notation. An IPV4 address is divided into 2 parts with Network ID and Host ID. It allows 2^{32} addresses.

Cont…

- IPV4 has Unicast, Broadcast & Multicast addresses. Routing Protocols that supports IPV4 addressing are RIPV1, V2, IGRP, OSPF & EIGRP.
- Two device on the internet can never have the same address at the same time.
- A protocol such as IPv4 that defines address has an address space.
- An address space is the total number of addresses used by the protocol.
- If a protocol uses N bits to define an address space is 2^N Because each bit can have two different values (0 or 1) and N bits can have 2^N values
- IPv4 uses a 32 bit address, which means the address space is 2^{32} or **4,294,967,296.**

IP Addressing

There are four forms of IP addressing, each with its own unique properties.

1. **Unicast:** The most common concept of an IP address is in unicast addressing, available in both IPv4 and IPv6.

- It normally refers to a single sender or a single receiver, and can be used for both sending and receiving.
- Sending the same data to multiple unicast addresses requires the sender to send all the data many times over, once for each recipient

2. **Broadcast:** In IPv4 it is possible to send data to all possible destinations ("all-hosts broadcast"), which permits the sender to send the data only once, and all receivers receive a copy of it.

3. **Multicast:** A multicast address is associated with a group of interested receivers.

4. **Anycast:** Like broadcast and multicast, anycast is a one-to-many routing topology. However, the data stream is not transmitted to all receivers, just the one which the router decides is *logically closest in the network.*

IPv4 Classes

Classful IP Addressing

- In classful addressing, the address space is divided into five classes: A, B, C, D, and E.
- Each class occupies some part of the address space

We can find the class of an address

- ✓ When given the address in binary notation the first few bits can be immediately tell us the class of the address
- ✓ If the address is given in dotted decimal notation , the first byte describes the class

- Systems that have interfaces to more than one network require a unique IP address for each network interface.
- The first part of an Internet address identifies the *network on which the host resides*.
- The second part identifies the *particular host on the given network*.

Cont…

This creates the two-level addressing hierarchy that is illustrated below

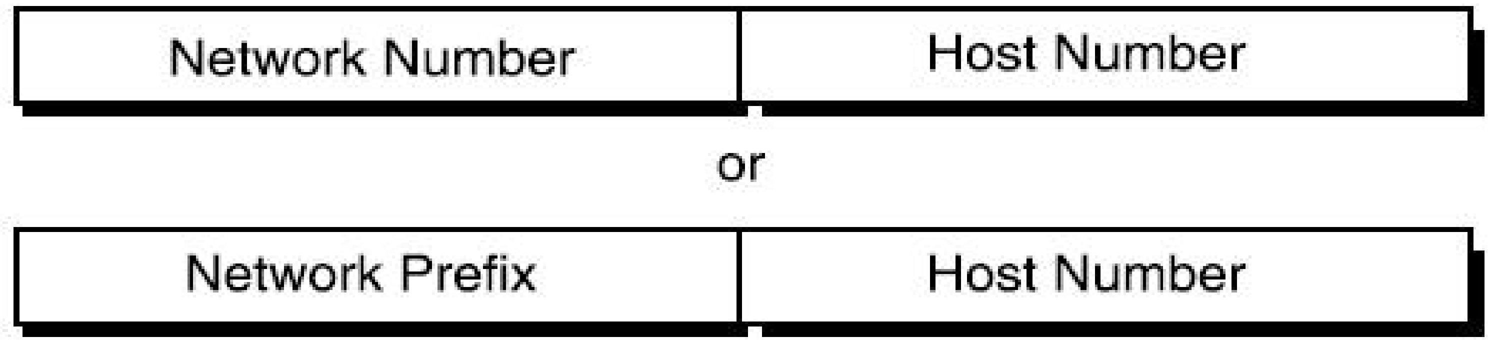
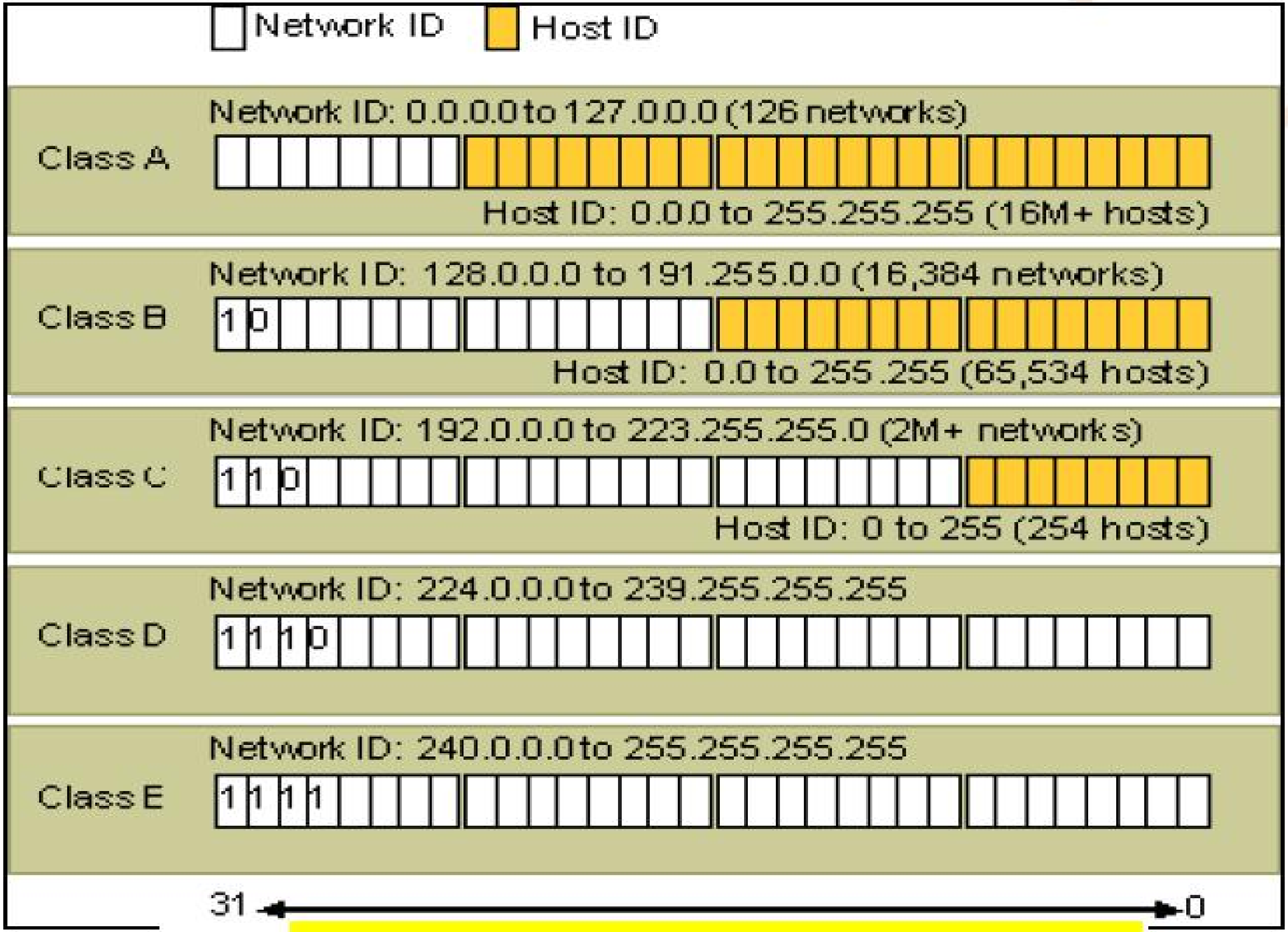


Figure 7.3*: Two-Level Internet Address Structure*

Cont.

Figure 7.4 :Available Network & Host Bit in IP Classes



Class A Networks(/8 Prefix)

- Each Class A network address has an 8-bit network prefix, with thehighest order bit set to 0 (zero) and a 7-bit network number, followed by a 24-bit host number.
- Today, Class A networks are referred to as"/8s" (pronounced "slash eight" or just "eights") since they have an 8- bit network prefix.
- A maximum of 126 (2^7-2) /8 networks can be defined.
- The calculation subtracts two because the /8 network 0.0.0.0 is reserved for use as the default route and the /8 network 127.0.0.0 (also written 127/8 or 127.0.0.0/8) is reserved for the "loopback" function.
- Each /8 supports a maximum of 2^{24} -2 (16,777,214) hosts per network. The host calculation subtracts two because the all-0s (all zeros or "this network") and all-1s (all ones or"broadcast") host numbers may not be assigned to individual hosts.
- Since the /8 address block contains 2^{31} (2,147,483,648) individual addresses and the IPv4 address space contains a maximum of 2^{32} (4,294,967,296) addresses, the /8 address space is 50 percent of the total IPv4 ***unicast*** address space.

Class B Networks (/16 Prefixes)

- Each Class B network address has a 16-bit network prefix, with the two highest order bits set to 1-0 and a 14-bit network number, followed by a 16-bit host number. Class B networks are now referred to as "/16s" since they have a 16-bit network prefix.
- A maximum of 16,384 (2^{14}) /16 networks can be defined with up to 65,534 (2^{16}-2) hosts per network. Since the entire /16 address block contains 2^{30} (1,073,741,824) addresses, it represents 25 percent of the total IPv4 unicast address space.

➢Class C Networks (/24 Prefixes)

- Each Class C network address has a 24-bit network prefix, with the three highest order bits set to 1-1-0 and a 21-bit network number, followed by an 8-bit host number. Class C networks are now referred to as "/24s" since they have a 24-bit network prefix.
- A maximum of 2,097,152 (2^{21}) /24 networks can be defined with up to 254 (2^{8}-2) hosts per network. Since the entire /24 address block contains 2^{29} (536,870,912) addresses, it represents 12.5 percent (or 1/18th) of the total IPv4 unicast address space.

Class D Networks

- Class D network addresses are not assigned to devices on a network.
- These addresses are used for special-purpose, multicast applications (such as video and audio-streaming applications).
- These addresses all need to be registered with IANA to be used globally.
- Addresses in this class have the first bits of the first octet set to 1110, yielding addresses in the first octet ranging from 11100000 to 11101111, or 224 to 239.
- These addresses are not defined by a normal subnet mask; instead, each address is used for a specific purpose. And because each address is individually used, it uses a 255.255.255.255 mask.

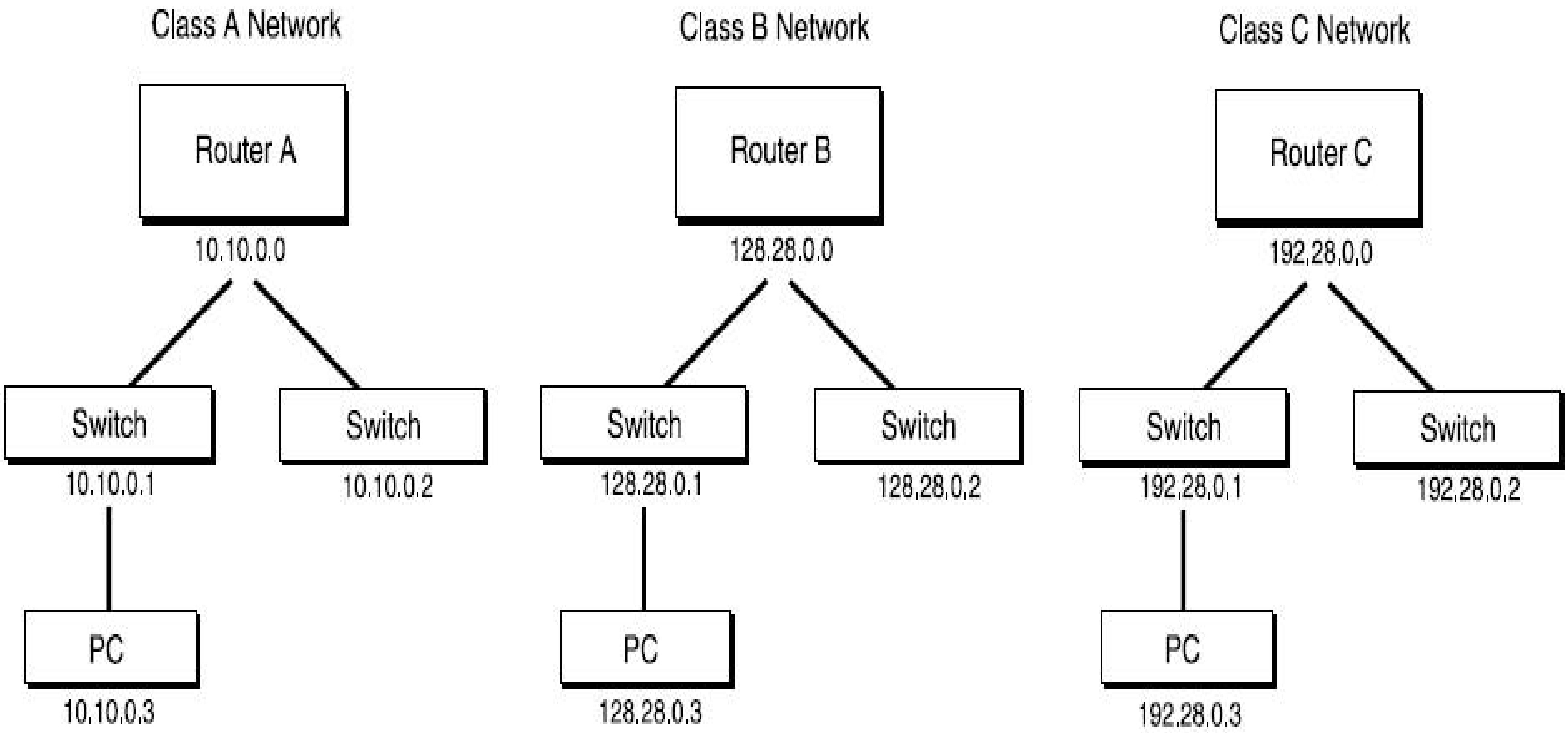
Class E Networks

- If Class D is special, Class E addresses are even more special.
- There is no defined use for this address class.
- Officially, it is listed as reserved for usage and testing by IANA and the Internet Research Task Force (IRTF). In fact, as of RFC3330 in 2002, Class E was updated to "**reserved for future use.**"
- Class E comprises absolutely all valid addresses with 240 or higher in the first octet.
- The first bits of the first octet is 1111, which yields addresses from 11110000 to 11111110 — or technically, 11111111 — which, in decimals, are 240 to 254 — or 255. Because this address class is not being used for address allocation, you cannot know what the network ID, which defines the valid addresses in a range. So the inclusion of 255 at the end of the range is moot because this address range is not available for you to use. All you need to know is that by definition Class E includes all valid addresses higher than Class D.

Short Summary for IP Address Classes

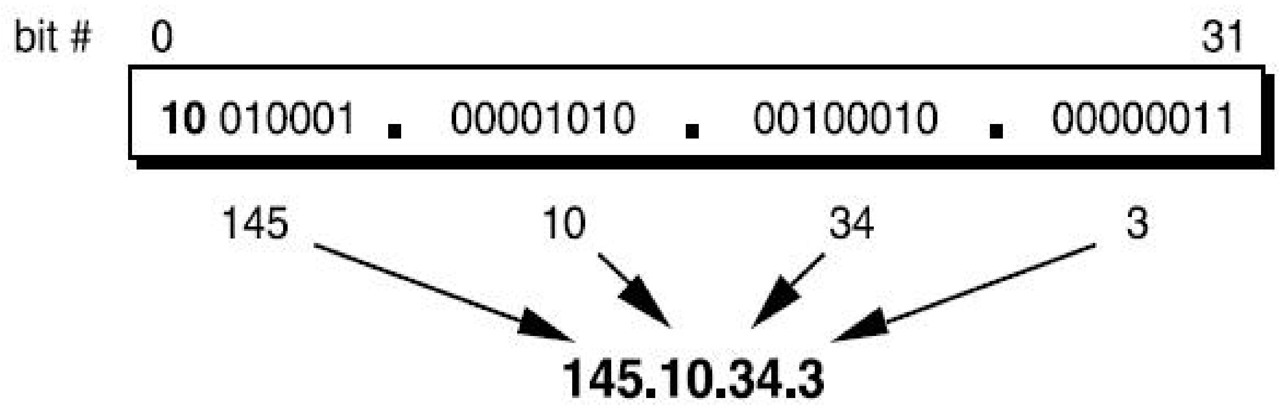
Class	1st Octet Decimal Range	1st Octet High Order Bits	Network/Host ID (N=Network, H=Host)	Default Subnet Mask	Number of Networks	Hosts per Network (Usable Addresses)
A	1 - 126*	0	N.H.H.H	255.0.0.0	126 (2^7 - 2)	16,777,214 (2^{24} - 2)
B	128 - 191	10	N.N.H.H	255.255.0.0	16,382 (2^{14} - 2)	65,534 (2^{16} - 2)
C	192 - 223	110	N.N.N.H	255.255.255.0	2,097,150 (2^{21} - 2)	254 (2^8 - 2)
D	224 - 239	1110	Reserved for Multicasting			
E	240 - 254	1111	Experimental; used for research			

Basic Class A, B, and C Networks



Dotted Decimal Notation

- To make Internet addresses easier for people to read and write, IP addresses are often expressed as four decimal numbers, each separated by a dot. This format is called "dotted-decimal notation."
- Dotted-decimal notation divides the 32-bit Internet address into four 8-bit fields and specifies the value of each field independently as a decimal number with the fields separated by dots.
- Example



The figure above shows how a typical /16 (Class B) Internet address can be expressed in dotted-decimal notation.

Cont…

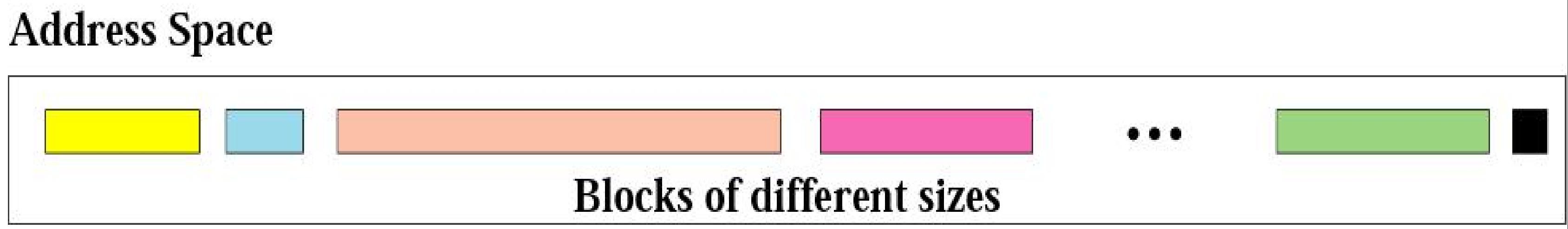
- The table below displays the range of dotted-decimal values that can be assigned to each of the three principle address classes. The "xxx" represents the host number field of the address that is assigned by the local network administrator.

Address Class	Dotted-Decimal Notation Ranges
A (/8 prefixes)	1.xxx.xxx.xxx through 126.xxx.xxx.xxx
B (/16 prefixes)	128.0.xxx.xxx through 191.255.xxx.xxx
C (/24 prefixes)	192.0.0.xxx through 223.255.255.xxx

Table: Dotted Decimal Ranges for Each Address Class

CLASSLESS ADDRESSING

- During the 1990s, ISP(Internet Service Provider)s came into prominence.
- An ISP is an organization that provides Internet access for individuals, small business, and mid-size organization
- An ISP can be granted several class B or class C blocks and then subdivide the range of addresses(in groups of 2,4,8, or 16 addresses)
- The customers are connected via a dial-up modem, DSL, or capable modem to the ISP
- To facilitate this evolution, in 1996, the Internet authorities announced a new architecture called classless addressing that would eventually render classful addressing obsolete.



Classless Addressing

- To simplify the handling of addresses, the internet authorities impose three restriction on classless address blocks
  - The address in a block must be contiguous, one after another
  - The number of addresses in a block must be a power of 2(1,2,4,8,16…)
  - The first address must be evenly divisible
- Example: A classless IP address assigned to a small organization with only 16 IP Addresses

205.16.37.32

205.16.37.33

.

.

.

205.16.37.47

Classless Addressing …

- A better way to define a block of address in classless addressing is to select any address in the block and mask it.
- A mask is a 32bit number in which the n left most bits are 1s and the 32-n rightmost bits are 0s.
- The mask can take a value from 0 to 32
- IN IPV4 classless addressing a block of addresses can be defined as x.y.z.t/n in which x.y.z.t defines one of the addresses and the /n defines the mask
- The address and /n notation completely define the whole block (the first address, the last address , and the number of addresses).
- The first address in the block can be found by setting the 32-n right most bits in the binary notation of the address 0.
- The last address in the block can be found by setting the rightmost 32-n bits to 1s.

Classless Addressing

- The number of address in the block can be found by using the formula 2^{32-n}
- Example: Find the first address, the last address and the number of addresses in the following classless block 205.16.37.39/28

Solution

Step 1: Convert the dotted decimal representation into binary representation 11001101.00010000.00100101.00100111

Step 2: To find the first address in the block convert the 32-28 right most bits to 0. 11001101.00010000.00100101.00100000=205.16.37.32.

Step 3: To find the last address in the block convert the 32-28 right most bits to 1. 11001101.00010000.00100101.00101111=205.16.37.47.

Step 4: The number of address is 2^{32-28} is 16.

Network Masks

- A network mask helps you know which portion of the address identifies the network and which portion of the address identifies the node. Class A, B, and C networks have default masks, also known as natural masks, as shown here:
  - Class A: 255.0.0.0
  - Class B: 255.255.0.0
  - Class C: 255.255.255.0
- An IP address on a Class A network that has not been subnetted would have an address/mask pair similar to: 8.20.15.1 255.0.0.0.
- In order to see how the mask helps you identify the network and node parts of the address, convert the address and mask to binary numbers.

8.20.15.1 = 00001000.00010100.00001111.00000001

255.0.0.0 = 11111111.00000000.00000000.00000000

Cont…

- Once you have the address and the mask represented in binary, then identification of the network and host ID is easier.

1. Any address bits which have corresponding mask bits set to 1 represent the network ID.
2. Any address bits that have corresponding mask bits set to 0 represent the node ID(Host ID).

8.20.15.1 = 00001000.00010100.00001111.00000001

255.0.0.0 = 11111111.00000000.00000000.00000000

----

net id | host id

netid = 00001000 = 8

hostid = 00010100.00001111.00000001 = 20.15.1

Cont…

- The Network Address
- When an IPv4 packet is created or forwarded, the destination network address must be extracted from the destination address.
- This is done by a logic called AND
- The IPv4 host address is logically ANDed with its subnet mask to determine the *network address* to which the host is associated
  - When this ANDing between the address and the subnet mask is performed, the result yields the network address

<u>Anding operation</u>:

1 AND 1 = 1

1 AND 0 = 0

0 AND 1 = 0

0 AND 0 = 0

Applying the Subnet Mask

A device with address 192.0.0.1 belongs to network 192.0.0.0

	High order bits Prefix /16		Low order bits	
	192 .	0 .	0 .	1
Host Address	11000000	00000000	00000000	00000001
Subnet Mask	255 11111111	255 11111111	0 00000000	0 00000000
Network Address	11000000	00000000	00000000	00000000
Network	192 .	0 .	0 .	0

Cont…

Using the subnet mask to determine the network address for the host 172.16.132.70/20

Convert binary network address to decimal

Host Address	172	16	132	70
Binary Host Address	10101100	00010000	10000100	01000110
Binary Subnet Mask	11111111	11111111	11110000	00000000
Binary Network Address	10101100	00010000	10000000	00000000
Network Address	172	16	128	0

Figure 7.5: Network address Determination

7.2 Subnetting and Variable Length Subnet Masking(VLSM)

7.2.1 Subnetting

- Subnetting allows you to create multiple logical networks that exist within a single Class A, B, or C network.
- If you do not subnet, you are only able to use one network from your Class A, B, or C network, which is unrealistic.

But what are the implications of dividing networks for the network planners?

- ✓ **Dividing the Network into right size:**
- Every network within the internetwork of a corporation or organization is designed to accommodate a finite number of hosts.
- Some networks, such as point-to-point WAN links, only require a maximum of two hosts.

Cont…

- Other networks, such as a user LAN in a large building or department, may need to accommodate hundreds of hosts.
- Network administrators need to devise the internetwork addressing scheme to accommodate the maximum number of hosts for each network

- **Network Administrators must Consider the following points:**

- *Determine the Total Number of Hosts*

  This includes end user devices, servers, intermediate devices, and router interfaces

- *Determine the Number and Size of the Nets based on common groupings of hosts*

  We subnet our network to overcome issues with location, size, and control.

  - Grouping based on common geographic location
  - Grouping hosts used for specific purposes
  - Grouping based on ownership

How to create subnet

In order to subnet a network, *extend the natural mask with some of the bits from the host ID portion of the address* in order to create a subnetwork ID.

- *For each bit borrowed, we double the number of sub networks available.*
- *For example, if we borrow 1 bit, we can define 2 subnets, If we borrow 2 bits, we can have 4 subnets.*

- Example: if we borrow one bit
  - √ **11111111.11111111.11111111.00000000 – Subnet 1**
  - √ **11111111.11111111.11111111.10000000 -- Subnet 2**
- If we borrow two bit
  - √ **11111111.11111111.11111111.00000000 – Subnet 1**
  - √ **11111111.11111111.11111111.01000000 -- Subnet 2**
  - √ **11111111.11111111.11111111.10000000 – Subnet 3**
  - √ **11111111.11111111.11111111.11000000 -- Subnet4**

- *However, with each bit we borrow, fewer host addresses are available per subnet*

Subnet Design Considerations

The deployment of an addressing plan requires careful thought.

Four key questions that must be answered before any design should be undertaken are:

1. How many total subnets does the organization need today?
2. How many total subnets will the organization need in the future?
3. How many hosts are on the organization's largest subnet today?
4. How many hosts will there be on the organization's largest subnet in the future?

Example1:RouterA in the figure has two interfaces to interconnect two networks. Given an address block of 192.168.1.0 /24, we need to create two subnets?

Cont…

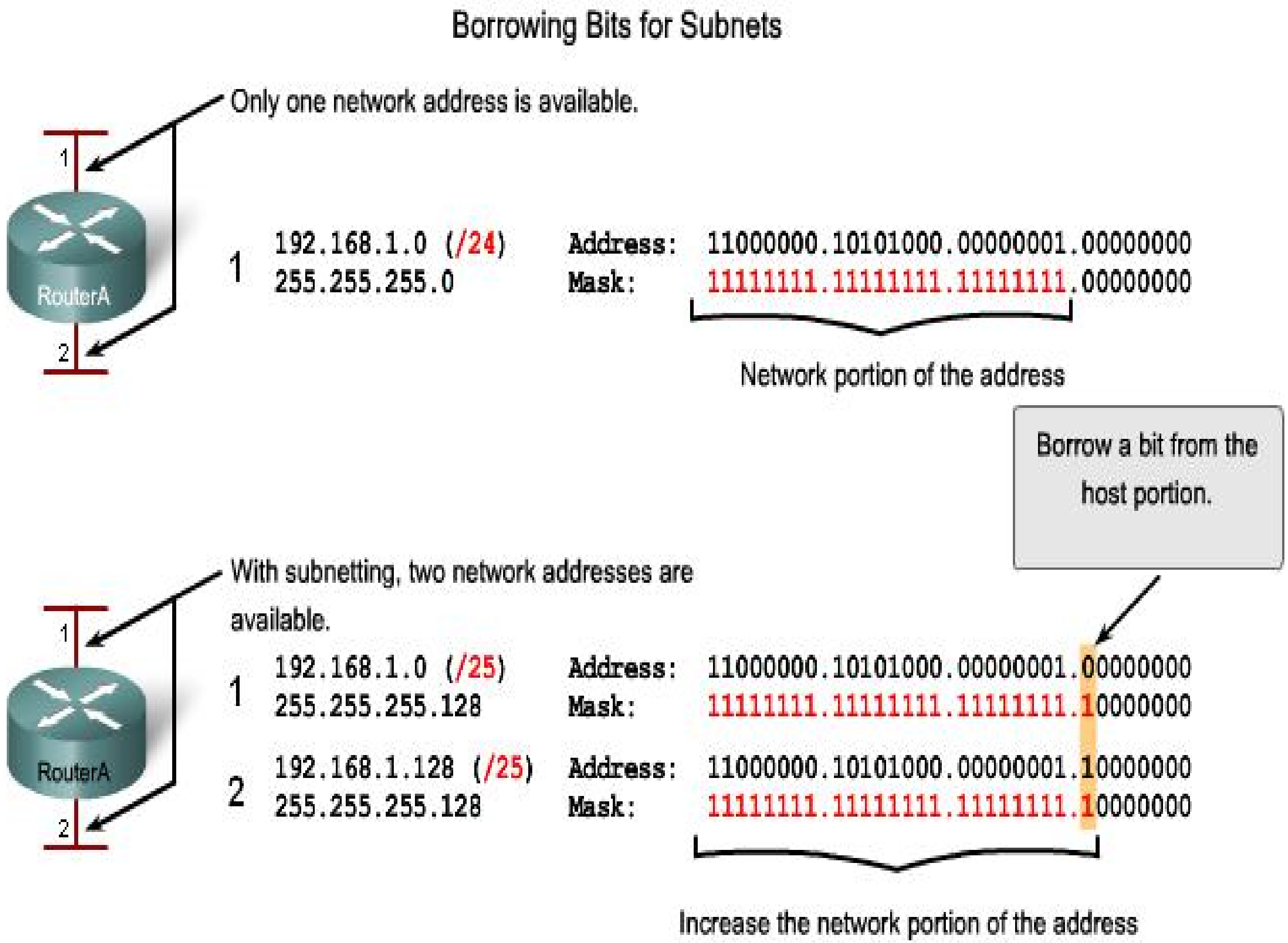


Figure 7.6:Subnetting Example 1

Calculating Addresses

- **Example#1**: Router A in the figure above has two interfaces to interconnect two networks. Given an address block of 192.168.1.0 /24, we need to create two subnets.
  - We borrow one bit from the host portion by using a subnet mask of 255.255.255.128, instead of the original 255.255.255.0 mask.
  - The most significant bit in the last octet is used to distinguish between the two subnets.
  - For one of the subnets, this bit is a "0" and for the other subnet this bit is a "1".

Formula for calculating subnets we can create by borrowing bits of host address

- √ 2^n where n = the number of bits borrowed

In this example, the calculation looks like this:

- √ $2^1 = 2$ subnets

Cont…

Formula for calculating the number of *hosts in the subnet*

- $2^n - 2$ where n = the number of bits left for hosts
- Applying this formula, ($2^7 - 2 = 126$) shows that each of these subnets can have 126 hosts.
- For each subnet, examine the last octet in binary. The values in these octets for the two networks are:
  - ✓ Subnet 1: 00000000 = 0
  - ✓ Subnet 2: 10000000 = 128

See the figure for the addressing scheme for these networks

Addressing Scheme: Example of 2 networks

Subnet	Network address	Host range	Broadcast address
0	192.168.1.0/25	192.168.1.1 - 192.168.1.126	192.168.1.127
1	192.168.1.128/25	192.168.1.129 - 192.168.1.254	192.168.1.255

Defining the Subnet Numbers

Subnet Example #2

Given: An organization is assigned the network number 193.1.1.0/24 and it needs to define six subnets. The largest subnet is required to support 25 hosts.

- Since a network address can only be subnetted along binary boundaries, subnets must be created in blocks of powers of two [2 (2^1), 4 (2^2), 8 (2^3), 16 (2^4), and so on]. Thus, it is impossible to define an IP address block such that it contains exactly six subnets.
- For this example, the network administrator must define a block of 8 (2^3) and have two unused subnets that can be reserved for future growth.
- In this example, the organization is subnetting a /24 so it will need three more bits, or a /27, as the extended network prefix.
- A 27-bit extended network prefix mask can be expressed in dotted-decimal notation as 255.255.255.224.

Cont…

- A 27-bit extended network prefix leaves 5 bits to define host addresses on each subnet. This means that each subnetwork with a 27-bit prefix represents a contiguous block of 2^5 (32) individual IP addresses.
- However, since the all-0s and all-1s host addresses cannot be allocated, there are 30 (2^5-2) assignable host addresses on each subnet.
- The eight subnet numbers for this example are listed in the following code sample. The **underlined portion of each address** identifies the extended network prefix, while the **bold digits** identify the 3 bits representing the subnet number field:

Base Net: 11000001.00000001.00000001 .00000000 = 193.1.1.0/24

1. Subnet #0: 11000001.00000001.00000001.**000** 00000 = 193.1.1.0/27
2. Subnet #1: 11000001.00000001.00000001.**001** 00000 = 193.1.1.32/27
3. Subnet #2: 11000001.00000001.00000001.**010** 00000 = 193.1.1.64/27
4. Subnet #3: 11000001.00000001.00000001.**011** 00000 = 193.1.1.96/27
5. Subnet #4: 11000001.00000001.00000001.**100** 00000 = 193.1.1.128/27
6. Subnet #5: 11000001.00000001.00000001.**101** 00000 = 193.1.1.160/27
7. Subnet #6: 11000001.00000001.00000001.**110** 00000 = 193.1.1.192/27
8. Subnet #7: 11000001.00000001.00000001.**111** 00000 = 193.1.1.224/27

Defining Host Addresses for Each Subnet

- According to Internet practices, the host number field of an IP address cannot contain all 0-bits or all 1-bits.
- The all-0s host number identifies the base network (or subnetwork) number, while the all-1s host number represents the broadcast address for the network (or subnetwork).
- In our current example, there are 5 bits in the host number field of each subnet address. This means that each subnet represents a block of 30 host addresses (2^5 -2 = 30, note that the 2 is subtracted because the all-0s and the all-1s host addresses cannot be used). The hosts on each subnet are numbered 1 through 30.

Cont…

- In general, to define the address assigned to Host #N of a particular subnet, the network administrator places the binary representation of N into the subnet's host number field. For example, to define the address assigned to Host #15 on Subnet #2, the network administrator simply places the binary representation of 15 (01111_2) into the 5-bits of Subnet #2's host number field.
- The valid host addresses for Subnet #2 in this example are listed in the following sample code. The underlined portion of each address identifies the extended network prefix, while the bold digits identify the 5-bit host number field:

Subnet #2: <u>11000001.00000001.00000001.010</u> **00000** = 193.1.1.64/27

- Host #1: <u>11000001.00000001.00000001.010</u> **00001** = 193.1.1.65/27
- Host #2: <u>11000001.00000001.00000001.010</u> **00010** = 193.1.1.66/27

Cont…

Host #3: 11000001.00000001.00000001.010 **00011** = 193.1.1.67/27

Host #4: 11000001.00000001.00000001.010 **00100** = 193.1.1.68/27

Host #5: 11000001.00000001.00000001.010 **00101** = 193.1.1.69/27

.

.

Host #15: 11000001.00000001.00000001.010 **01111** = 193.1.1.79/27

Host #16: 11000001.00000001.00000001.010 **10000** = 193.1.1.80/27

.

.

Host #27: 11000001.00000001.00000001.010 **11011** = 193.1.1.91/27

Host #28: 11000001.00000001.00000001.010 **11100** = 193.1.1.92/27

Host #29: 11000001.00000001.00000001.010 **11101** = 193.1.1.93/27

Host #30: 11000001.00000001.00000001.010 **11110** = 193.1.1.94/27

Cont…

Note: The All-0s Subnet and All-1s Subnet

- *When subnetting was first defined in RFC 950, it prohibited the use of the all-0s and the all-1s subnets. The reason for this restriction was to eliminate situations that could potentially confuse a classful router.*
- *Some devices would not allow the use of these subnets. Cisco Systems devices allow the use of these subnets when the* ***ip subnet zero*** *command is configured.*
- *Today a router can be both classless and classful at the same time-it could be running RIP-1 (classful protocol) and BGP-4 (Border Gateway Protocol Version 4-a classless protocol) at the same time.*

Cont…

Subnet Example #3

Given the Class C network of 204.15.5.0/24, subnet the network in order to create the network in Figure below with the host requirements shown.

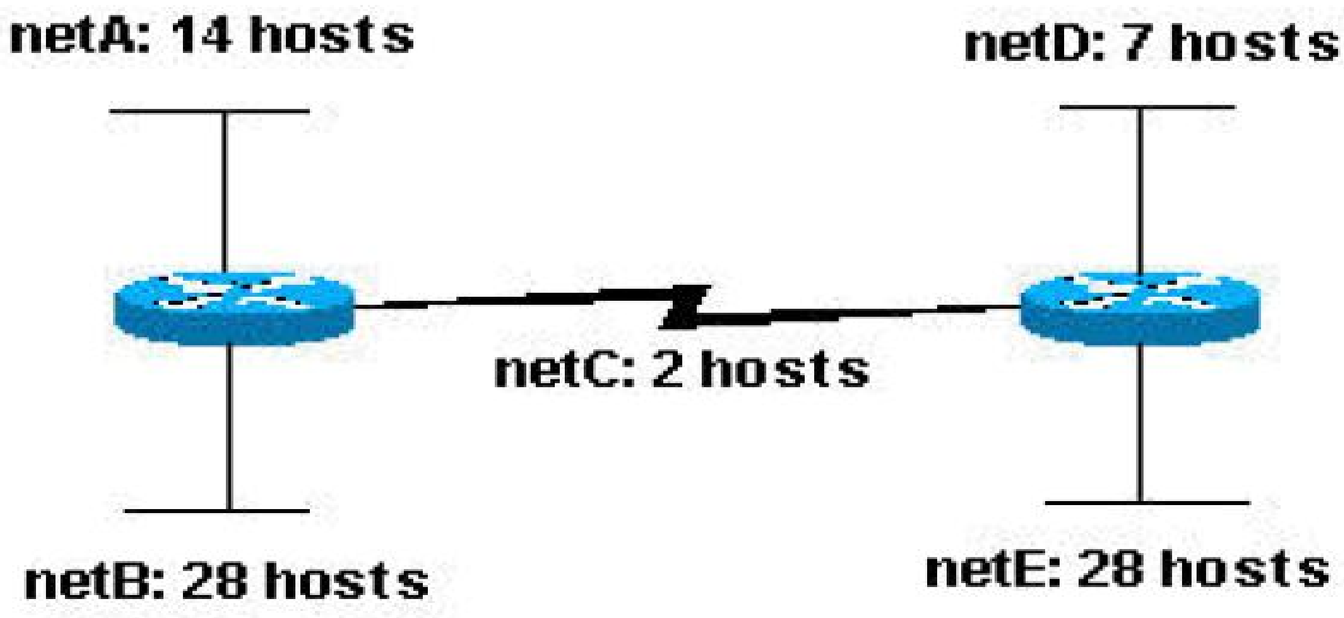


Figure 7.6: Subnetting Example 3

Cont…

- Looking at the network shown in Figure above, you can see that you are required to create five subnets. The largest subnet must support 28 host addresses. Is this possible with a Class C network? and if so, then how?
- You can start by looking at the subnet requirement. In order to create the five needed subnets you would need to use three bits from the Class C host bits.
- Two bits would only allow you four subnets (2^2).
- Since you need three subnet bits, that leaves you with five bits for the host portion of the address.
- How many hosts does this support? $2^5 = 32$ (30 usable). This meets the requirement.

Cont…

- Therefore you have determined that it is possible to create this network with a Class C network.

An example of how you might assign the subnetworks is:

1. netA: 204.15.5.0/27 host address range 1 to 30
2. netB: 204.15.5.32/27 host address range 33 to 62
3. netC: 204.15.5.64/27 host address range 65 to 94
4. netD: 204.15.5.96/27 host address range 97 to 126
5. netE: 204.15.5.128/27 host address range 129 to 158

7.2.2 Variable Length Subnet Masking(VLSM)

- *VLSM is a technique that network administrators* employ in order to use their IP subnet(s) in a more effective manner.
- By using VLSM, a long mask can be used on a network that has a few hosts and a short net mask on subnets that have a large number of hosts.
- To use VLSM, however, a routing protocol that supports it has to be used. Cisco routers support the concept with the following protocols: Integrated IS-IS (Integrated Intermediate System to Intermediate System), EIGRP (Enhanced Interior Gateway Routing Protocol), RIPv2, Open Shortest Path First (OSPF), and static routing.
- VLSM allows networks to have different subnet masks if the routing protocol on the network on which it is employed supports it.
- *VLSM also allows more than one subnet mask within the same network address space, which is also referred to as "subnetting a subnet."*

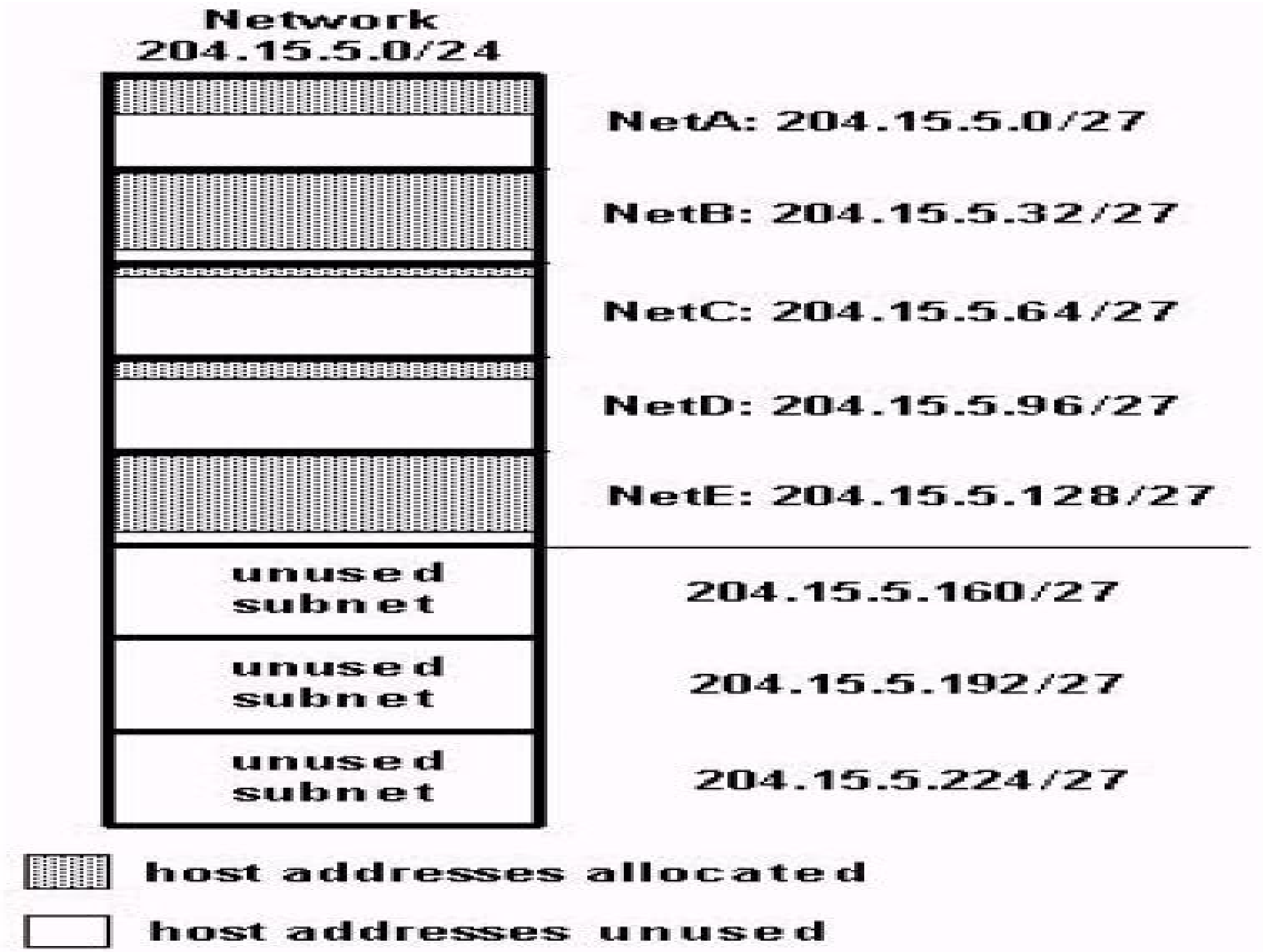
(VLSM)…

VLSM Example

- In all of the previous examples of Subnetting, notice that the same subnet mask was applied for all the subnets. This means that each subnet has the same number of available host addresses.
- You can need this in some cases, but, in most cases, having the same subnet mask for all subnets ends up wasting address space.
- For example, in the ***Subnet Example #3*** section, a class C network was split into eight equal-size subnets; however, each subnet did not utilize all available host addresses, which results in wasted address space. Figure 7.7 illustrates this wasted address space.

(VLSM)…

Figure 7.8: the subnets that are being used, NetA, NetC, and NetD have a lot of unused host address space.



(VLSM)…

- √ VLSM allows you to use different masks for each subnet, thereby using address space efficiently.

Given the same network and requirements as in **Subnet Example #3** develop a subnetting scheme with the use of VLSM, given:

1. netA: must support 14 hosts
2. netB: must support 28 hosts
3. netC: must support 2 hosts
4. netD: must support 7 hosts
5. netE: must support 28 host.

Determine what mask allows the required number of hosts.

1. netA: requires a /28 (255.255.255.240) mask to support 14 hosts
2. netB: requires a /27 (255.255.255.224) mask to support 28 hosts
3. netC: requires a /30 (255.255.255.252) mask to support 2 hosts
4. netD*: requires a /28 (255.255.255.240) mask to support 7 hosts
5. netE: requires a /27 (255.255.255.224) mask to support 28 hosts

* a /29 (255.255.255.248) would only allow 6 usable host addresses therefore netD requires a /28 mask.

(VLSM)…

- The easiest way to assign the subnets is to assign the largest first.

For example, you can assign in this manner:

1. netB: 204.15.5.0/27 host address range 1 to 30
2. netE: 204.15.5.32/27 host address range 33 to 62
3. netA: 204.15.5.64/28 host address range 65 to 78
4. netD: 204.15.5.80/28 host address range 81 to 94
5. netC: 204.15.5.96/30 host address range 97 to 98

(VLSM)…

This can be graphically represented as shown in Figure 7.9

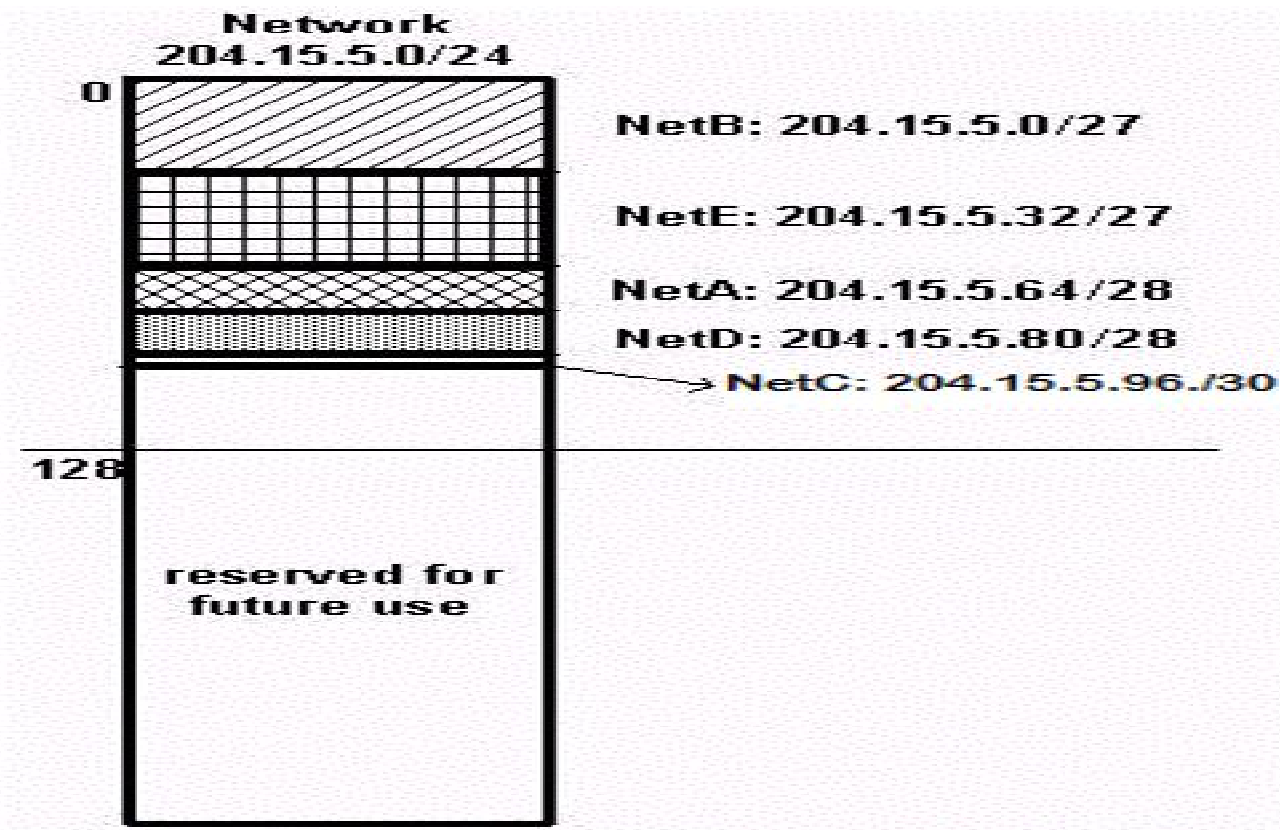


Figure 7. ddress space.

Chapter End

???