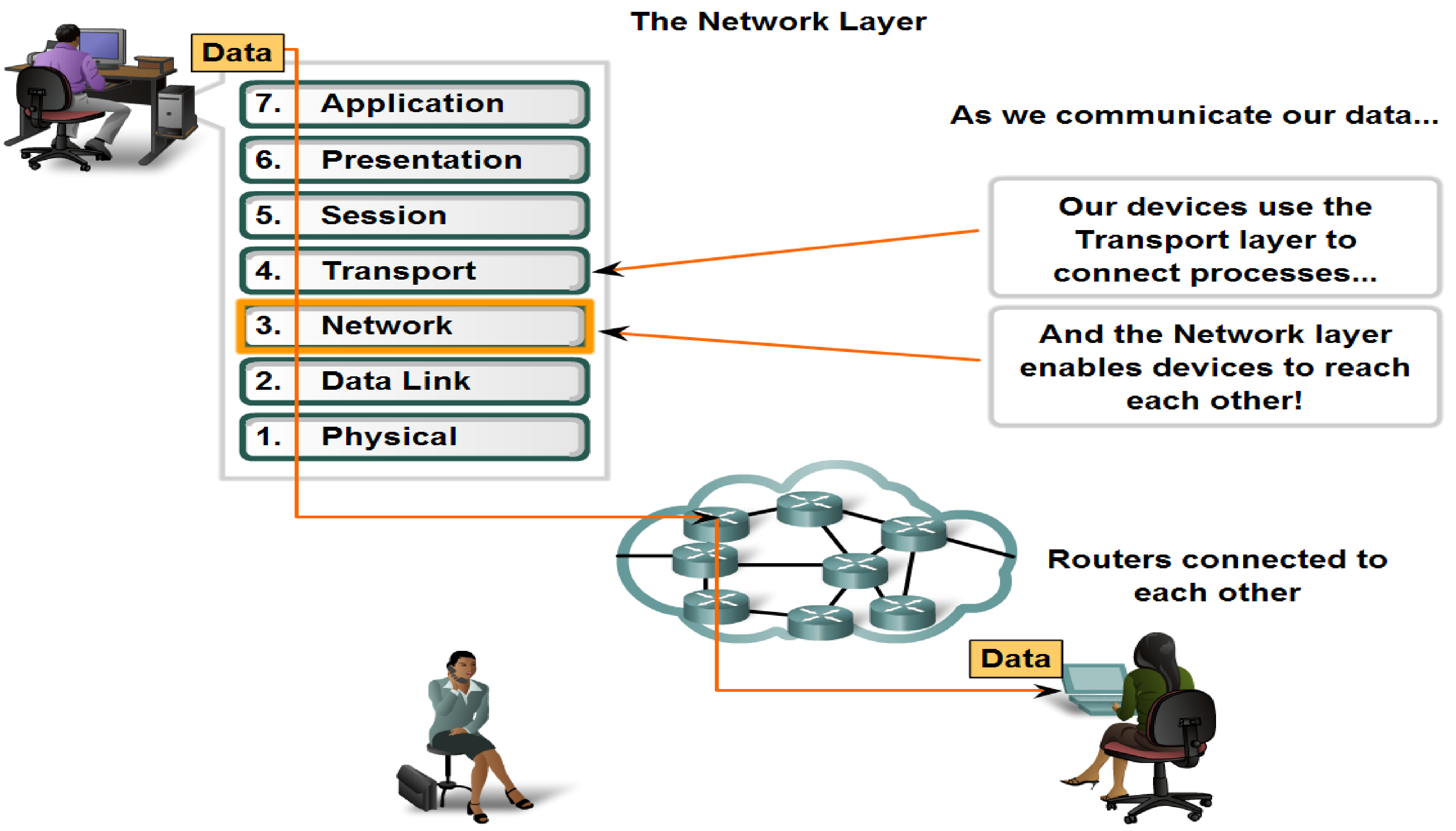
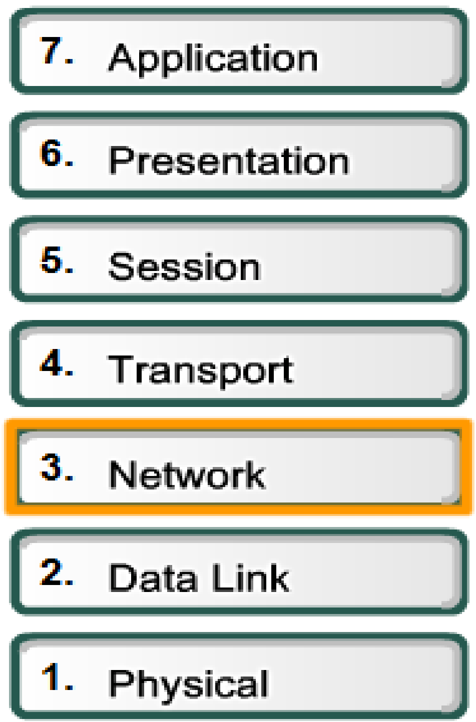
IPv4 Address

Network Layer Protocols



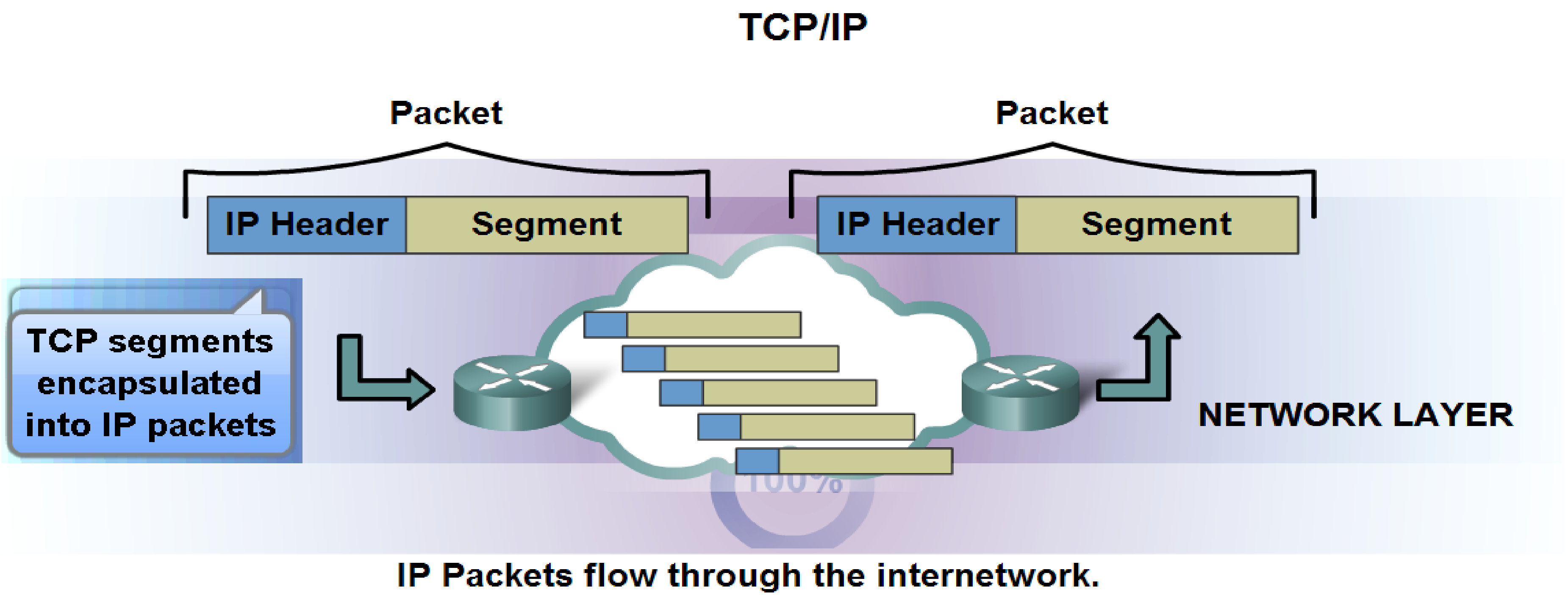
Network Layer Protocols

Network Layer Protocols



- Internet Protocol version 4 (IPv4)
- Internet Protocol version 6 (IPv6)
- Novell Internetwork Packet Exchange (IPX)
- AppleTalk
- Connectionless Network Service (CLNS/DECNet)

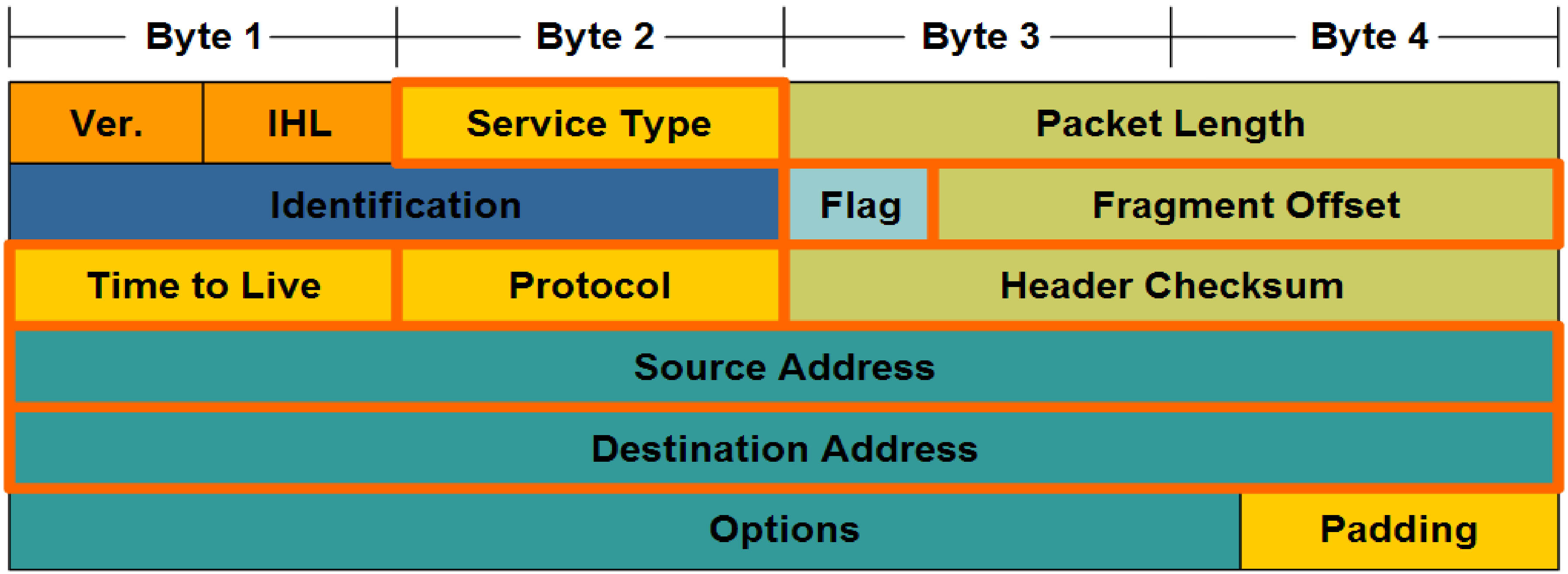
Network Layer Protocols and Internet Protocol (IP)



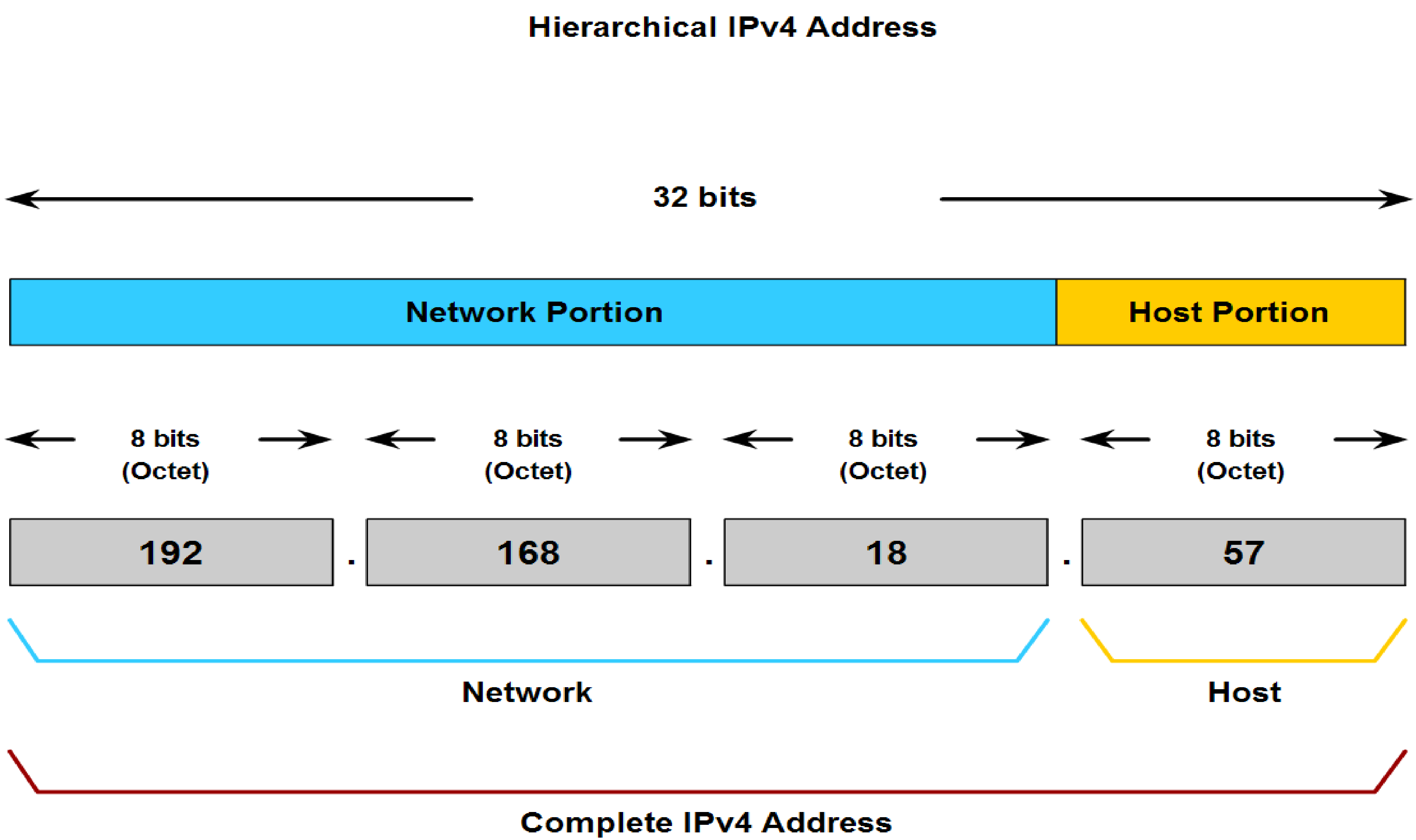
- Connectionless - No connection is established before sending data packets.
- Best Effort (unreliable) - No overhead is used to guarantee packet delivery.
- Media Independent - Operates independently of the medium carrying the data.

Network Layer Protocols and Internet Protocol (IP)

IPv4 Packet Header Fields



Grouping Devices into Networks and Hierarchical Addressing



Binary & Decimal Numbering System

Binary To Decimal Conversion

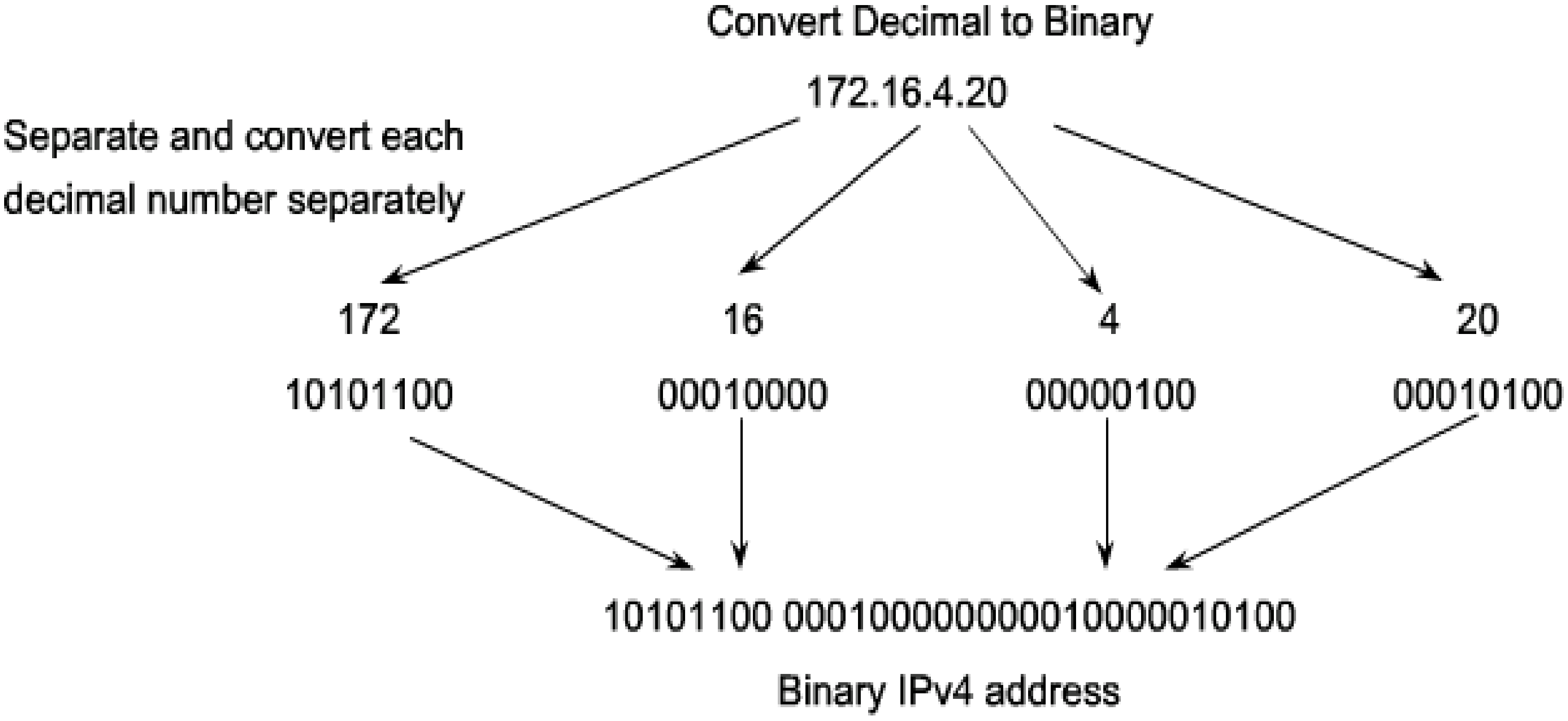
Exponent	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Position	128	64	32	16	8	4	2	1
Bits	1	1	1	1	0	1	0	1
	1 BYTE / 1 Octet							
Add these numbers together	128 +	64 +	32 +	16 +	0 +	4 +	0 +	1
Decimal	245							

A 1 in this position means 64 is added to the total.

A 0 in any position means that 0 is added to the total.

11110101 in Binary = Decimal Number 245

Binary & Decimal Numbering System



Addressing the Network – IPv4

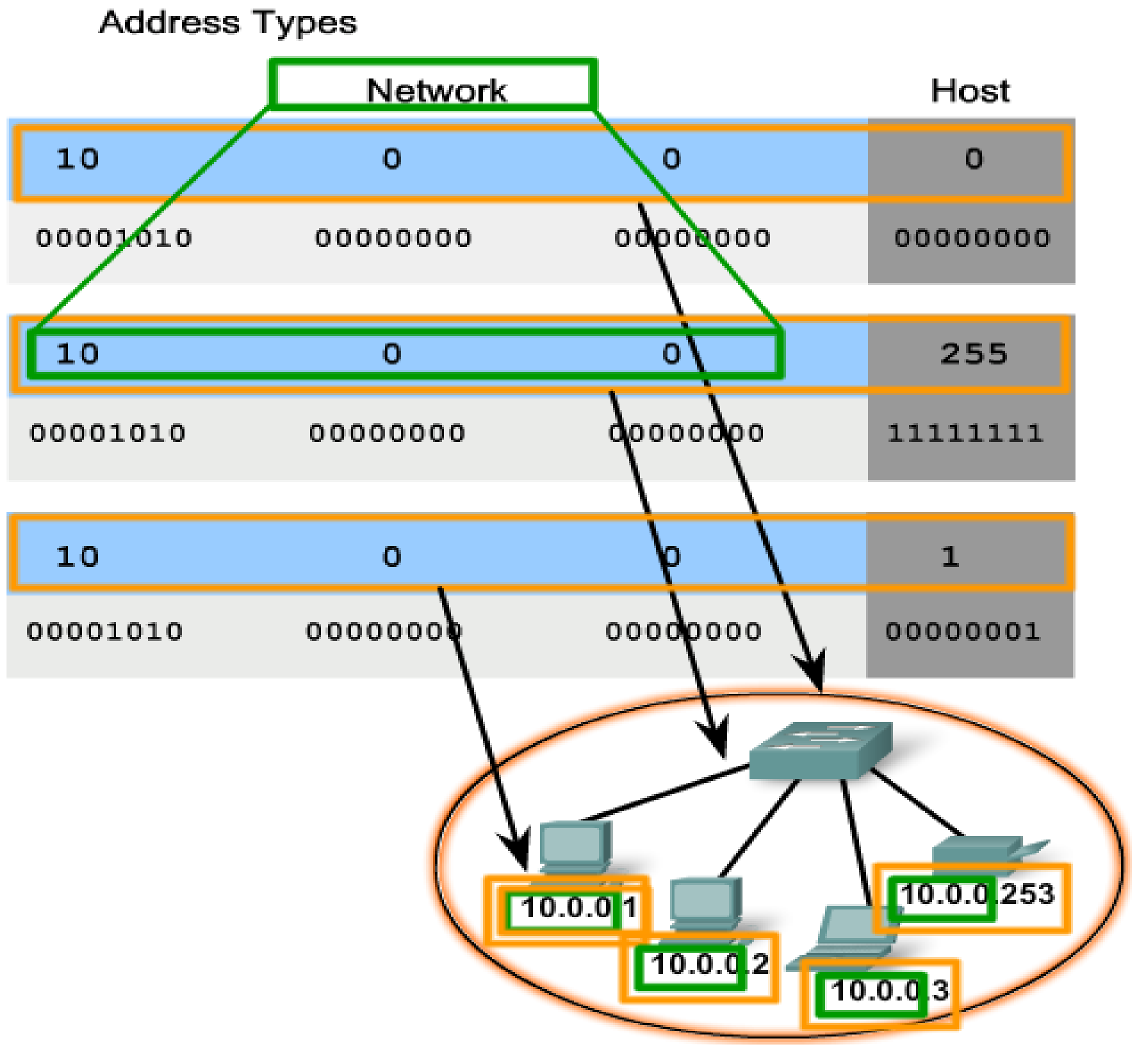
Classify and Define IPv4 Addresses

Network Address

Broadcast Address

Host Address

Roll over to learn more.



IP address Classes

IP Address Classes

Address Class	1st octet range (decimal)	1st octet bits (green bits do not change)	Network(N) and Host(H) parts of address	Default subnet mask (decimal and binary)	Number of possible networks and hosts per network
A	1-127**	00000000-01111111	N.H.H.H	255.0.0.0	128 nets (2^7) 16,777,214 hosts per net (2^24-2)
B	128-191	10000000-10111111	N.N.H.H	255.255.0.0	16,384 nets (2^14) 65,534 hosts per net (2^16-2)
C	192-223	11000000-11011111	N.N.N.H	255.255.255.0	2,097,150 nets (2^21) 254 hosts per net (2^8-2)
D	224-239	11100000-11101111	NA (multicast)		
E	240-255	11110000-11111111	NA (experimental)		

** All zeros (0) and all ones (1) are invalid hosts addresses.

Subnet mask

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	255	0	0
	11111111	11111111	00000000	00000000
Network Address	11000000	00000000	00000000	00000000
Network	192 .	0 .	0 .	0

Private Addresses

- These private IP addresses are for intra-network use only and can not be routed across the Internet.
- These private addresses are
  - •Class A → 10.0.0.0/8 to 10.255.255.255/8
  - •Class B → 172.16.0.0/16 to 172.31.255.255/16
  - •Class C → 192.168.0.0/24 to 192.168.255.255/24

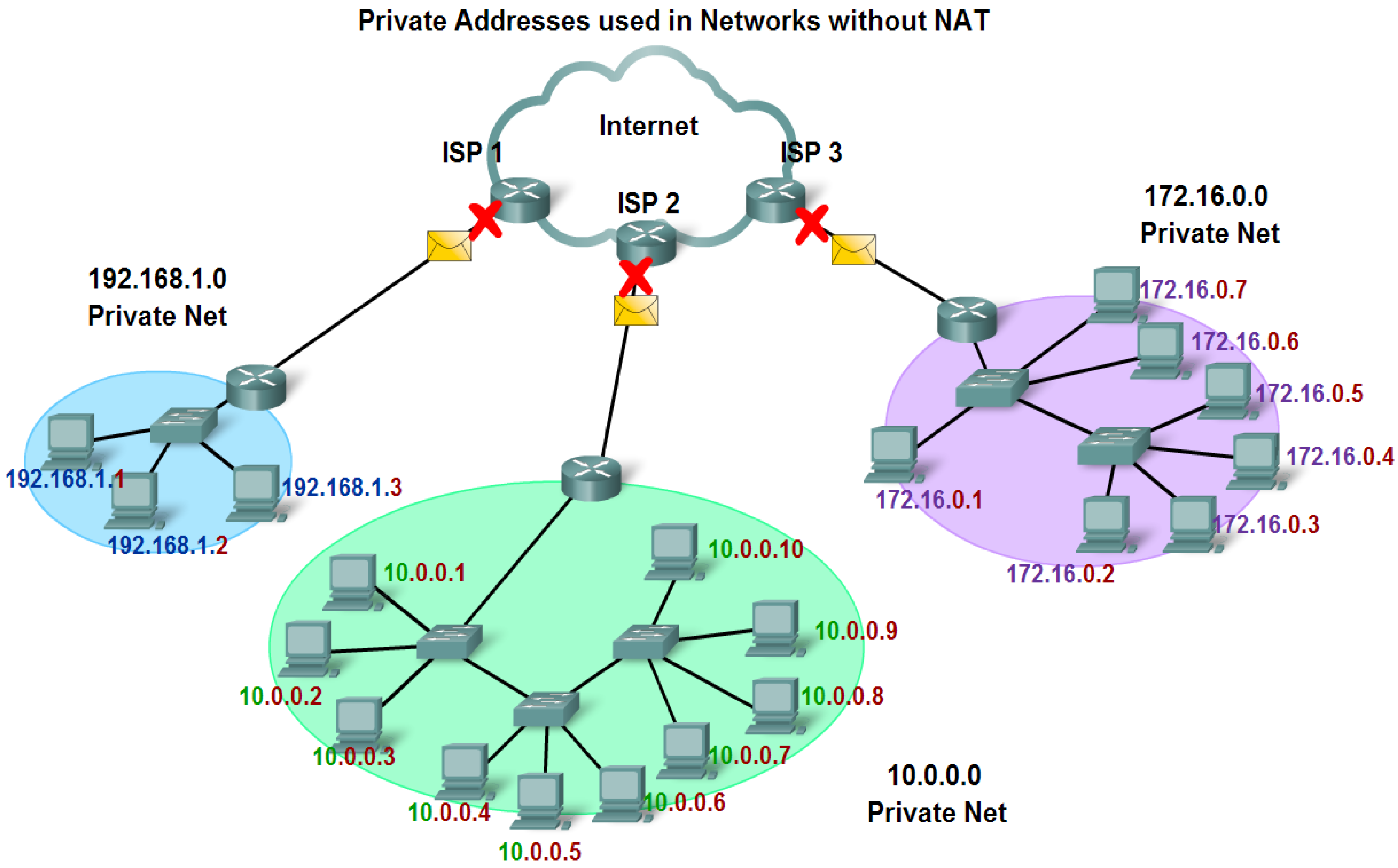
Private IP Addresses

Private IP addresses are another solution to the problem of the impending exhaustion of public IP addresses.As mentioned, public networks require hosts to have unique IP addresses.

However, private networks that are not connected to the Internet may use any host addresses, as long as each host within the private network is unique.

Class	RFC 1918 internal address range
A	10.0.0.0 to 10.255.255.255
B	172.16.0.0 to 172.31.255.255
C	192.168.0.0 to 192.168.255.255

Classify and Define IPv4 Addresses

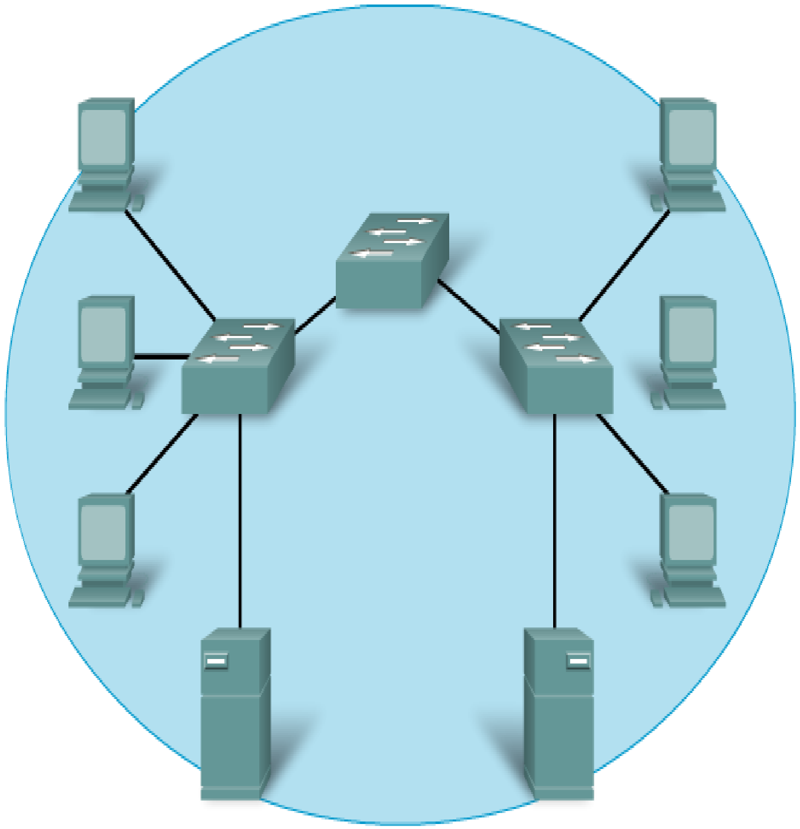


IPv4 Subnetting

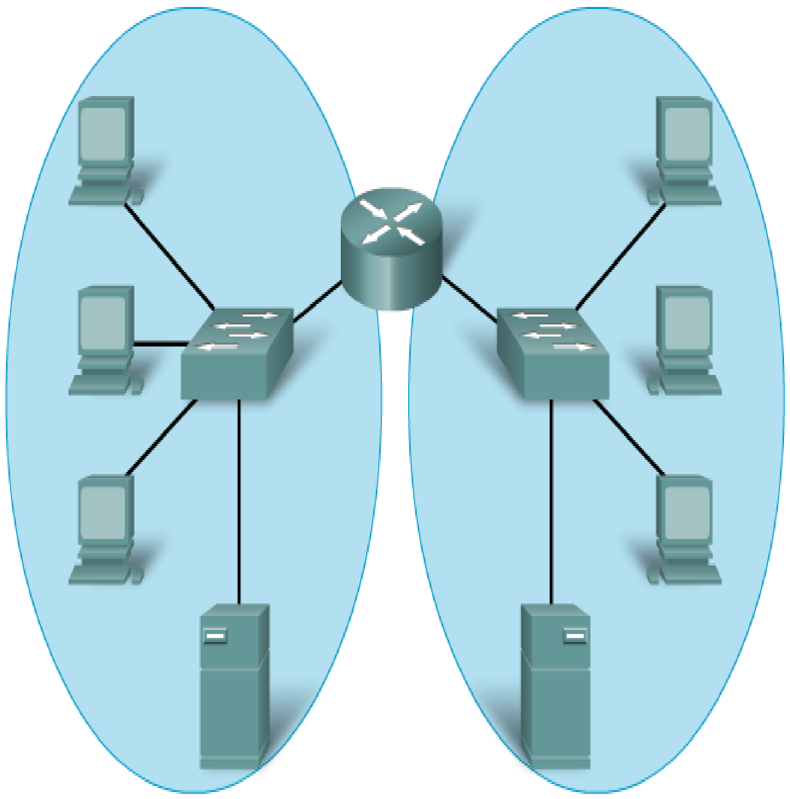
Segmentation of networks

- Purpose of network segmentation are:-
  - Increase Network performance
  - Increase Network Security
  - Increase Network Management

Increase Network performance

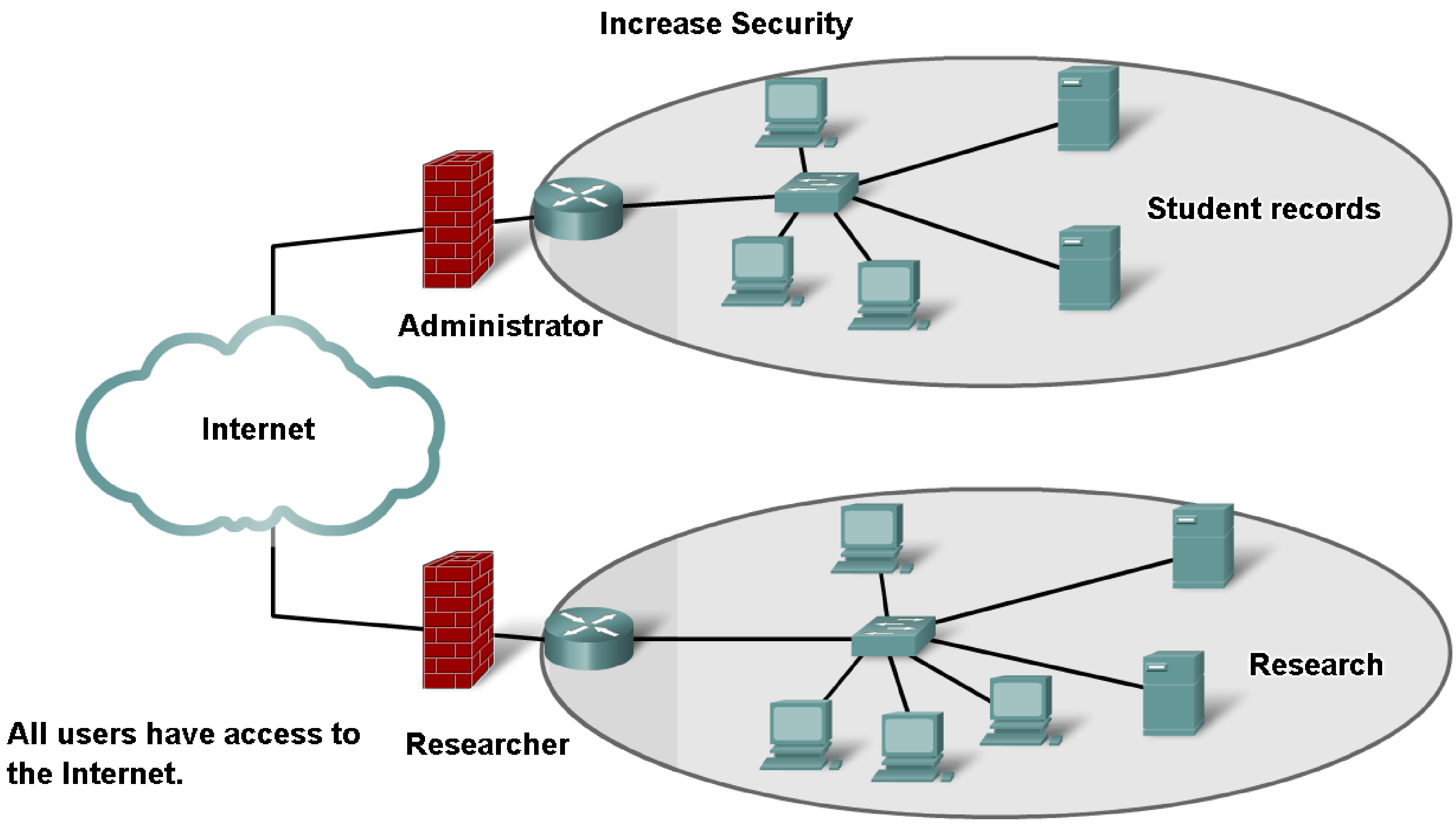


All devices in this network are connected in one broadcast domain when the switch is set to the factory default settings. Since switches forward broadcasts by default, broadcasts are processed by all devices in this network.

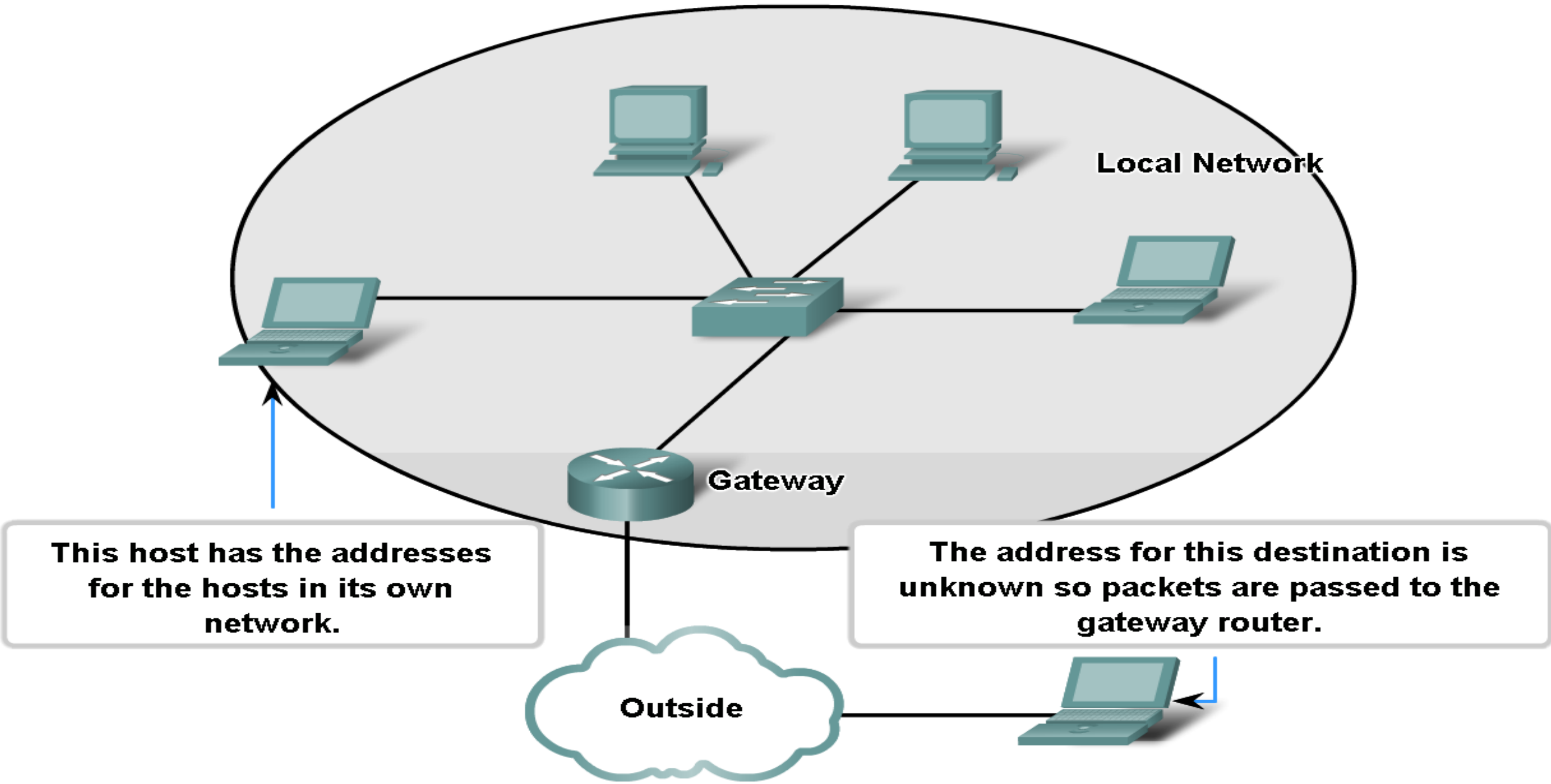


Replacing the middle switch with a router creates 2 IP subnets, hence, 2 distinct broadcast domains. All devices are connected but local broadcasts are contained.

Increase Network Security



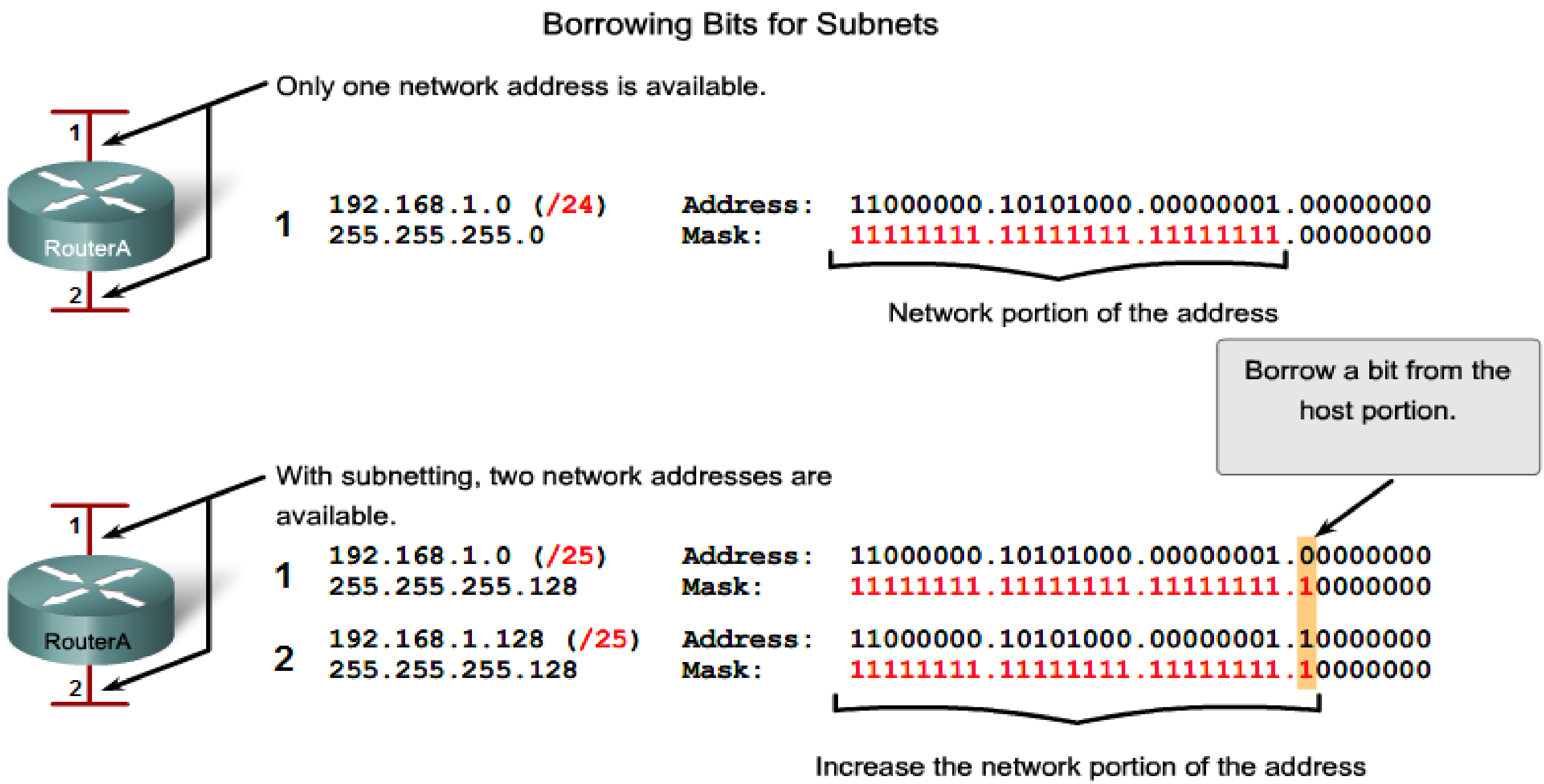
Increase Network manageability



Hosts do not know how to deliver data to devices in a remote network - this is the role of the gateway.

Because the fast deployment of internet, the IP addresses become not enough

Subnetting


Borrowing Bits for Subnets
Only one network address is available.
RouterA
1
2
1
192.168.1.0 (/24)
255.255.255.0
Address: 11000000.10101000.00000001.00000000
Mask: 11111111.11111111.11111111.00000000
Network portion of the address
Borrow a bit from the host portion.
With subnetting, two network addresses are available.
RouterA
1
2
1
192.168.1.0 (/25)
255.255.255.128
Address: 11000000.10101000.00000001.00000000
Mask: 11111111.11111111.11111111.10000000
2
192.168.1.128 (/25)
255.255.255.128
Address: 11000000.10101000.00000001.10000000
Mask: 11111111.11111111.11111111.10000000
Increase the network portion of the address

Subnetting

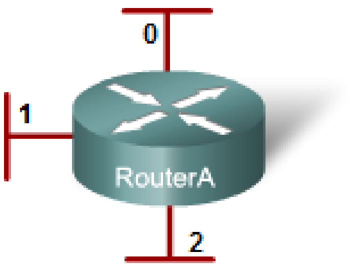
Borrowing Bits for Subnets

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

Subnetting

Borrowing Bits for Subnets



-	192.168.1.0 (/24)	Address:	11000000.10101000.00000001.00000000
	255.255.255.0	Mask:	11111111.11111111.11111111.00000000
0	192.168.1.0 (/26)	Address:	11000000.10101000.00000001.00000000
	255.255.255.192	Mask:	11111111.11111111.11111111.11000000
1	192.168.1.64 (/26)	Address:	11000000.10101000.00000001.01000000
	255.255.255.192	Mask:	11111111.11111111.11111111.11000000
2	192.168.1.128 (/26)	Address:	11000000.10101000.00000001.10000000
	255.255.255.192	Mask:	11111111.11111111.11111111.11000000
3	192.168.1.192 (/26)	Address:	11000000.10101000.00000001.11000000
	255.255.255.192	Mask:	11111111.11111111.11111111.11000000

Two bits are borrowed to provide four subnets.

Unused address in this example.

A 1 in these positions in the mask means that these values are part of the network address.

More subnets are available, but fewer addresses are available per subnet.

Subnetting

Borrowing Bits for Subnets

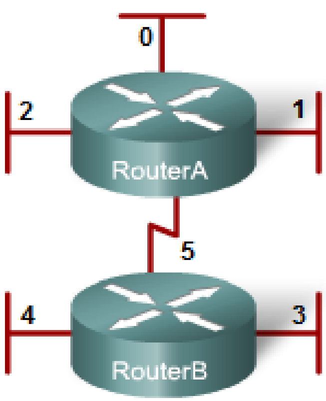
Addressing Scheme: Example of 4 networks

Subnet	Network address	Host range	Broadcast address
0	192.168.1.0/26	192.168.1.1 - 192.168.1.62	192.168.1.63
1	192.168.1.64/26	192.168.1.65 - 192.168.1.126	192.168.1.127
2	192.168.1.128/26	192.168.1.129 - 192.168.1.190	192.168.1.191
3	192.168.1.192/26	192.168.1.193 - 192.168.1.254	192.168.1.255

Subnetting

Borrowing Bits for Subnets

Start with this address	-	192.168.1.0 (/24)	Address:	11000000.10101000.00000001.00000000
		255.255.255.0	Mask:	11111111.11111111.11111111.00000000
Make 8 subnets	0	192.168.1.0 (/27)	Address:	11000000.10101000.00000001.00000000
		255.255.255.224	Mask:	11111111.11111111.11111111.11100000
	1	192.168.1.32 (/27)	Address:	11000000.10101000.00000001.00100000
		255.255.255.224	Mask:	11111111.11111111.11111111.11100000
	2	192.168.1.64 (/27)	Address:	11000000.10101000.00000001.01000000
		255.255.255.224	Mask:	11111111.11111111.11111111.11100000
	3	192.168.1.96 (/27)	Address:	11000000.10101000.00000001.01100000
		255.255.255.224	Mask:	11111111.11111111.11111111.11100000
	4	192.168.1.128 (/27)	Address:	11000000.10101000.00000001.10000000
		255.255.255.224	Mask:	11111111.11111111.11111111.11100000
	5	192.168.1.160 (/27)	Address:	11000000.10101000.00000001.10100000
		255.255.255.224	Mask:	11111111.11111111.11111111.11100000
	6	192.168.1.192 (/27)	Address:	11000000.10101000.00000001.11000000
		255.255.255.224	Mask:	11111111.11111111.11111111.11100000
	7	192.168.1.224 (/27)	Address:	11000000.10101000.00000001.11100000
		255.255.255.224	Mask:	11111111.11111111.11111111.11100000



Three bits are borrowed to provide eight subnets.

Subnetting

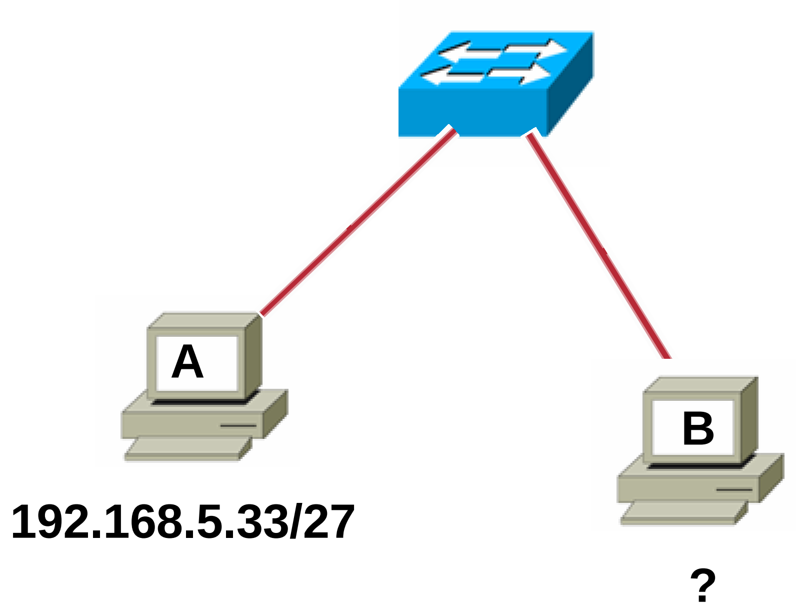
Borrowing Bits for Subnets

Addressing Scheme: Example of 6 networks

Subnet	Network address	Host range	Broadcast address
0	192.168.1.0/27	192.168.1.1 - 192.168.1.30	192.168.1.31
1	192.168.1.32/27	192.168.1.33 - 192.168.1.62	192.168.1.63
2	192.168.1.64/27	192.168.1.65 - 192.168.1.94	192.168.1.95
3	192.168.1.96/27	192.168.1.97 - 192.168.1.126	192.168.1.127
4	192.168.1.128/27	192.168.1.129 - 192.168.1.158	192.168.1.159
5	192.168.1.160/27	192.168.1.161 - 192.168.1.190	192.168.1.191
6	192.168.1.192/27	192.168.1.193 - 192.168.1.222	192.168.1.223
7	192.168.1.224/27	192.168.1.225 - 192.168.1.254	192.168.1.255

Subnetting Example

- Which IP address should be assigned to PC B ?



A . 192.168.5.5

B . 192.168.5.32

C . 192.168.5.40

D . 192.168.5.63

E . 192.168.5.75

Answer : C

Subnetting Example

- Given the choices below, which address represents a unicast address?

A . 224.1.5.2
B . FFFF. FFFF. FFFF.
C . 192.168.24.59/30
D . 255.255.255.255
E . 172.31.128.255/18

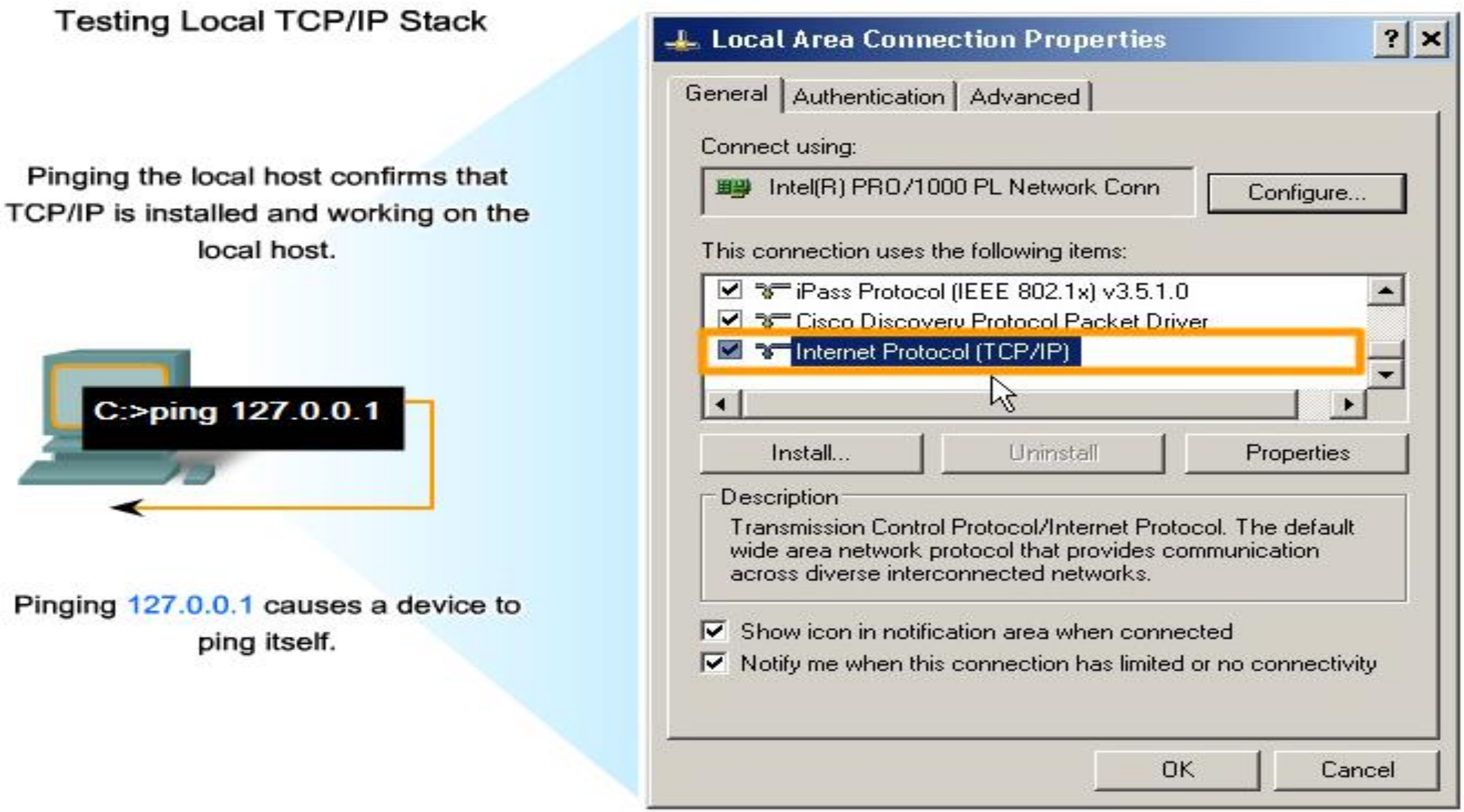
Answer : E

Test a connectivity

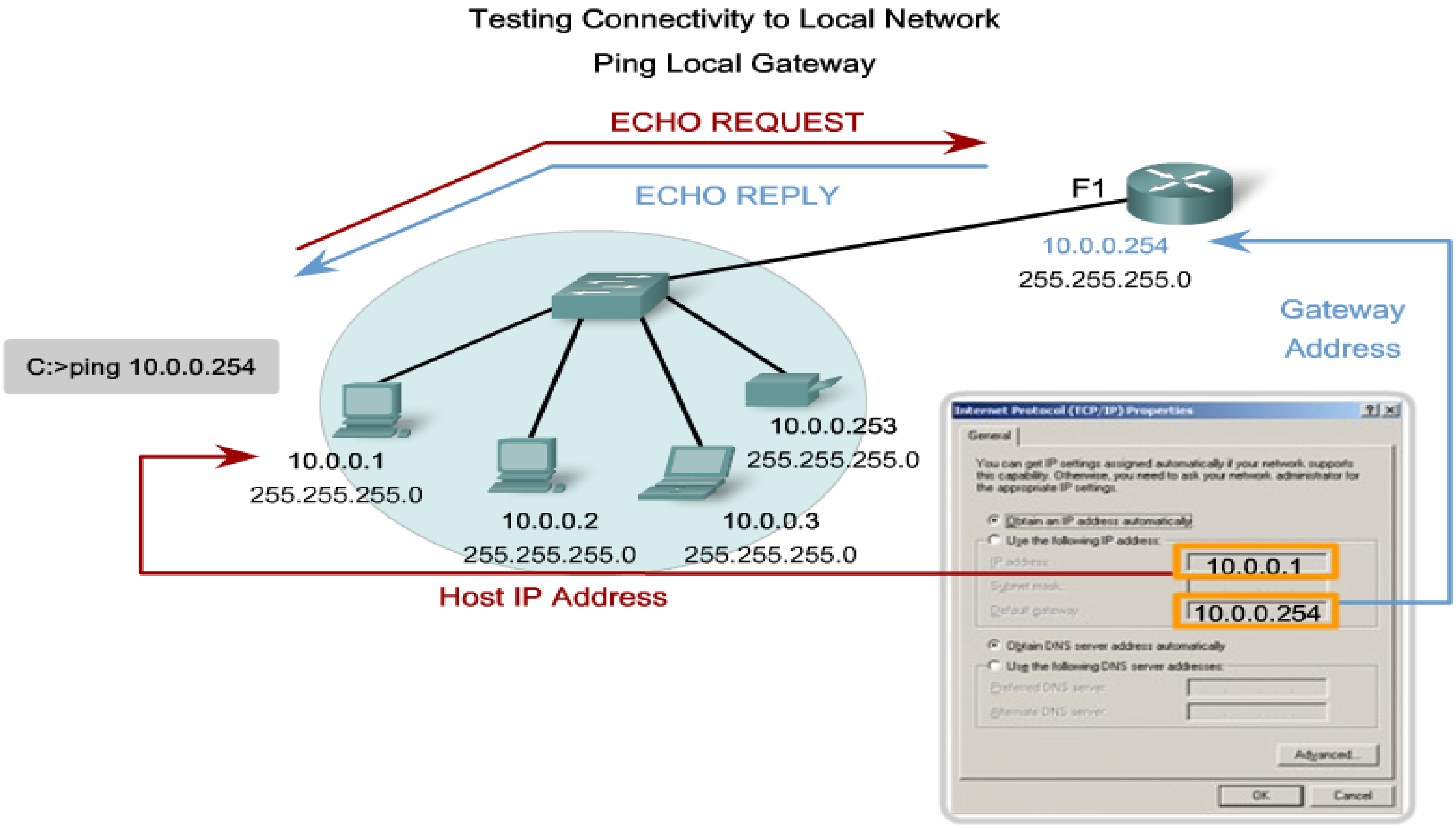
- Ping is a utility for testing IP connectivity between hosts. Ping sends out requests for responses from a specified host address. Ping uses a Layer 3 protocol that is a part on the TCP/IP suite called Internet Control Message Protocol (ICMP). Ping uses an ICMP Echo Request datagram.

- If the host at the specified address receives the Echo request, it responds with an ICMP Echo Reply datagram. For each packet sent, ping measures the time required for the reply.

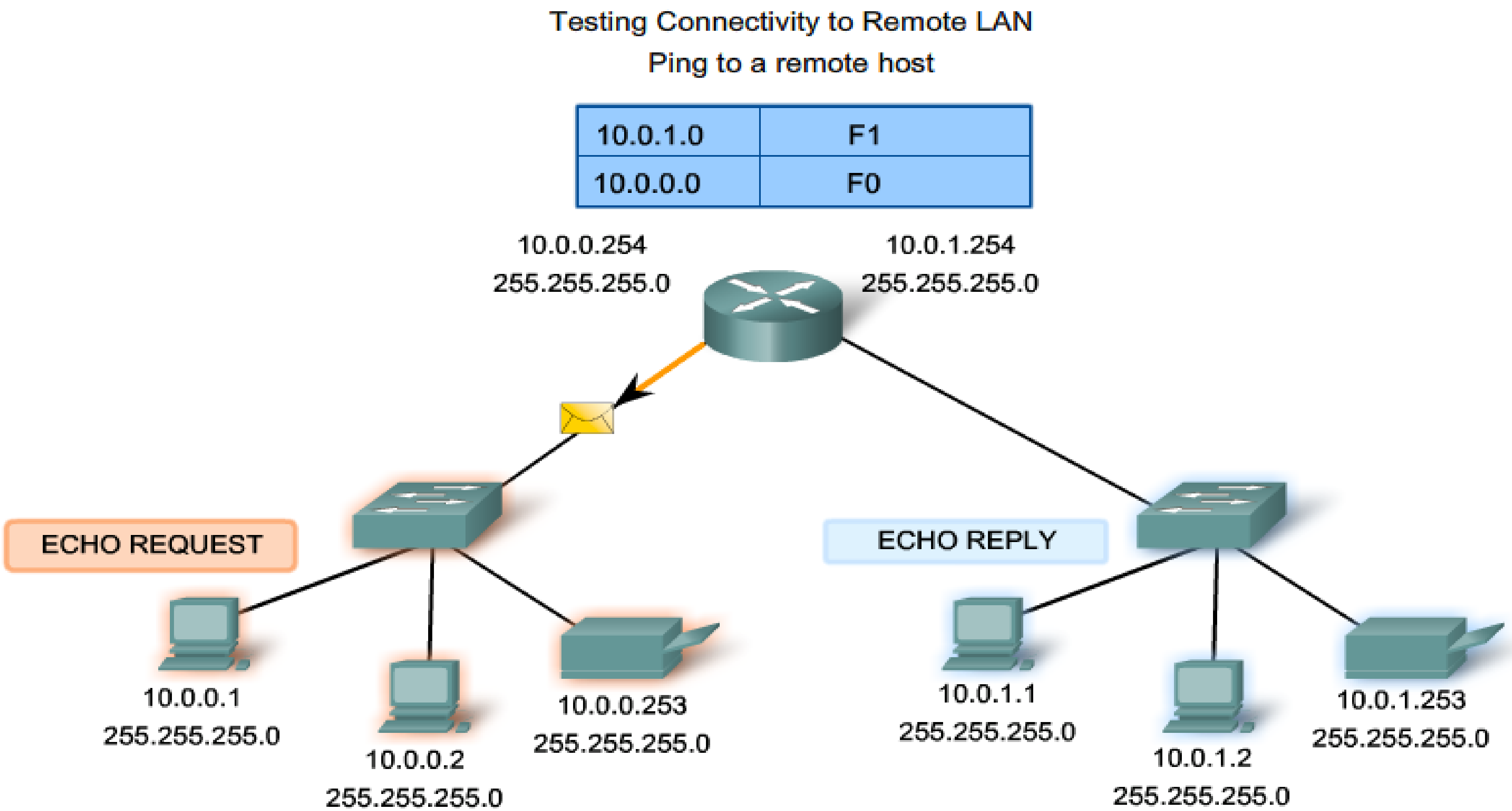
Test a connectivity



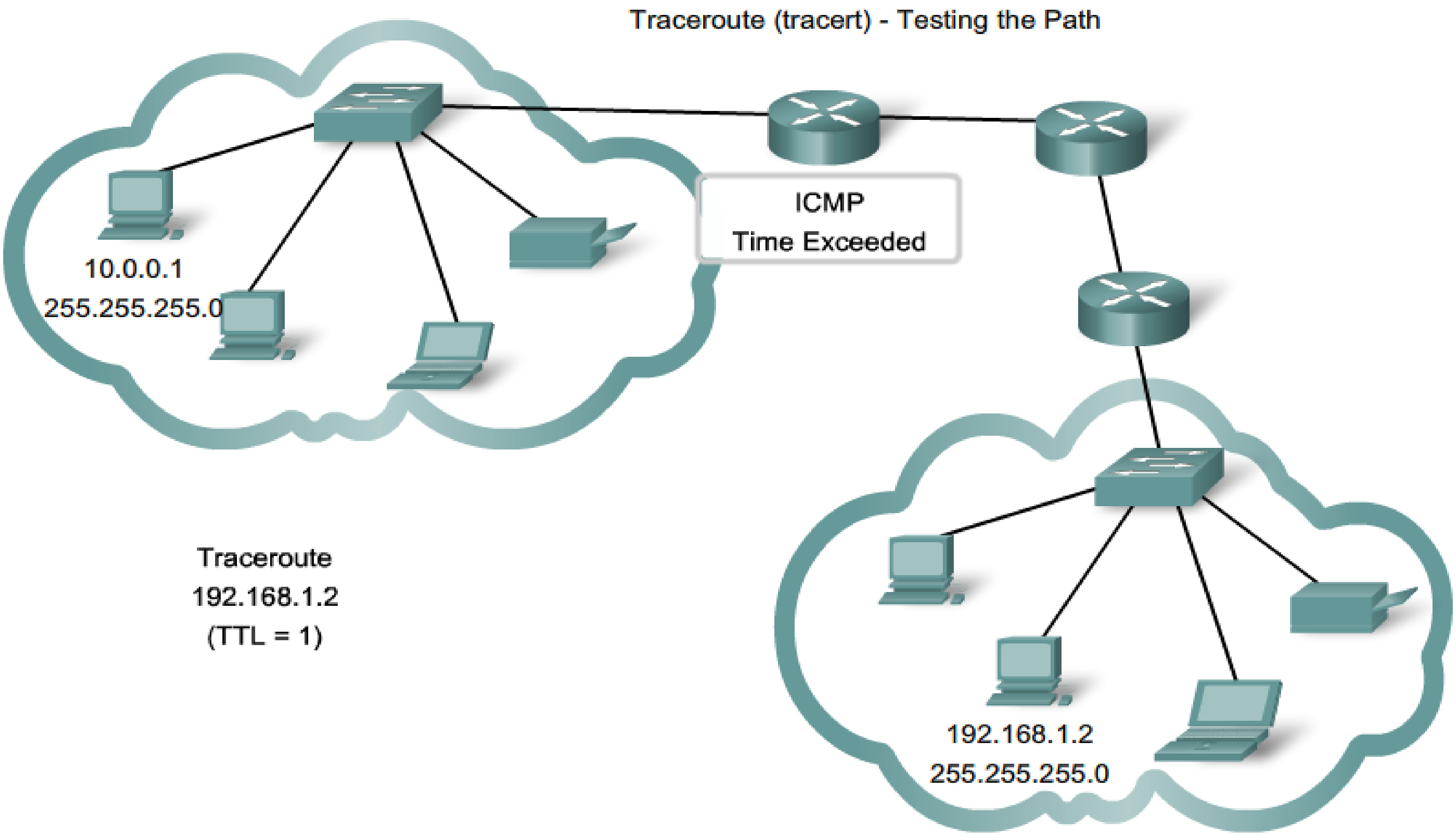
Test a connectivity



Test a connectivity



Test a connectivity



Summary

In this chapter, you learned to:

- Explain the structure IP addressing and demonstrate the ability to convert between 8-bit binary and decimal numbers.
- Given an IPv4 address, classify by type and describe how it is used in the network.
- Explain how addresses are assigned to networks by ISPs and within networks by administrators.
- Determine the network portion of the host address and explain the role of the subnet mask in dividing networks.
- Given IPv4 addressing information and design criteria, calculate the appropriate addressing components.
- Use common testing utilities to verify and test network connectivity and operational status of the IP protocol stack on a host.

VLSM and CIDR

Objectives

- Compare and contrast classful and classless IP addressing.
- Review VLSM and explain the benefits of classless IP addressing.
- Describe the role of the Classless Inter-Domain Routing (CIDR) standard in making efficient use of scarce IPv4 addresses

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
- 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

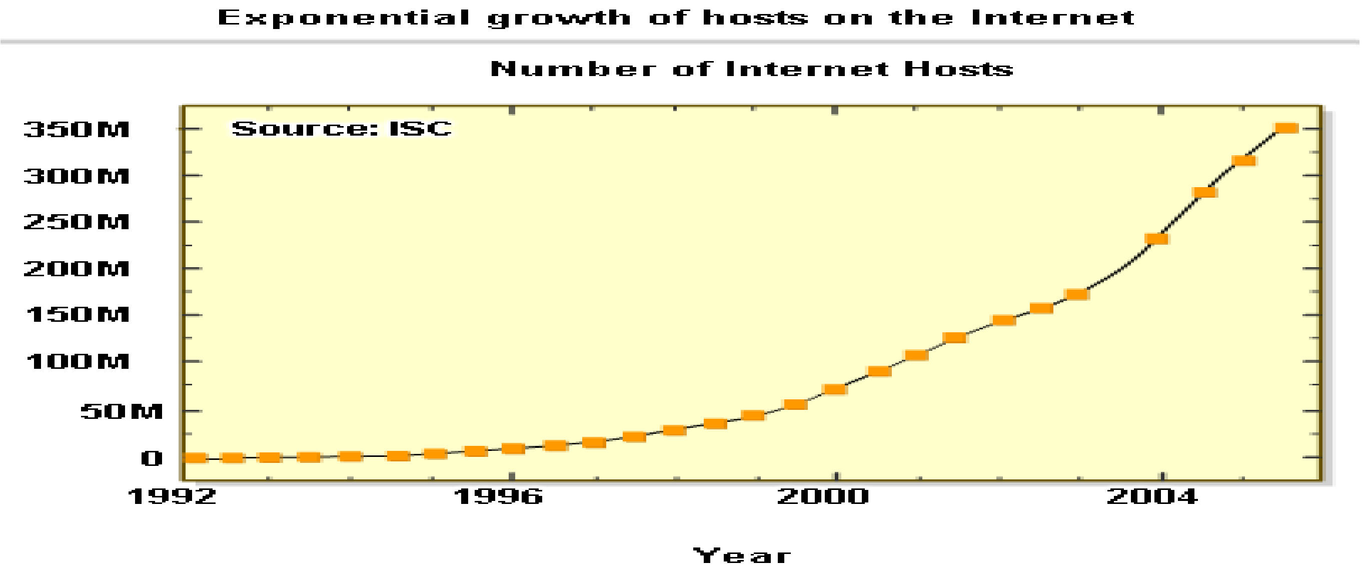
Classful and Classless IP Addressing

- Classful IP addressing
- 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)

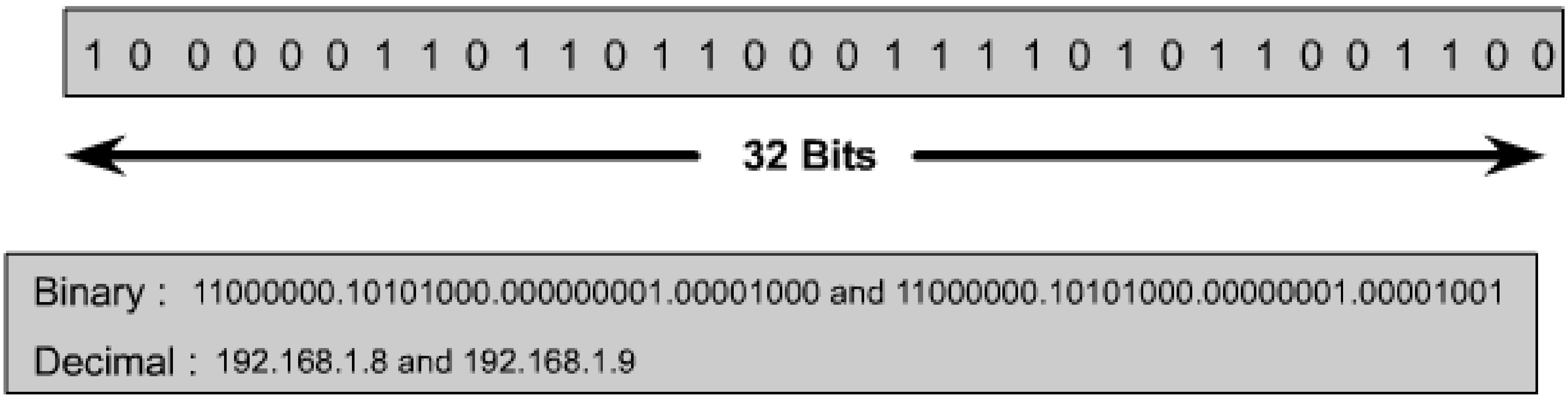
  -Private Addressing (1996, RFC 1918)



Classful and Classless IP Addressing

- The High Order Bits

  These are the leftmost bits in a 32 bit address



Classful and Classless IP Addressing

- Classes of IP addresses are identified by the decimal number of the 1st octet

Class A address begin with a **0** bit

Range of class A addresses = 0.0.0.0 to 127.255.255.255

Class B address begin with a **1** bit and a **0** bit

Range of class B addresses = 128.0.0.0 to 191.255.255.255

Class C addresses begin with **two 1** bits & a **0** bit

Range of class C addresses = 192.0.0.0 to 223.255.255.255.

High Order Bits

Class	High Order Bits	Start	End
Class A	0	0.0.0.0	127.255.255.255
Class B	10	128.0.0.0	191.255.255.255
Class C	110	192.0.0.0	223.255.255.255
Multicast	1110	224.0.0.0	239.255.255.255
Experimental	1111	240.0.0.0	255.255.255.255

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

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

Classful and Classless IP Addressing

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	16,348	65,534
Class C	192 to 223	2,097,152	254

Classful and Classless IP Addressing

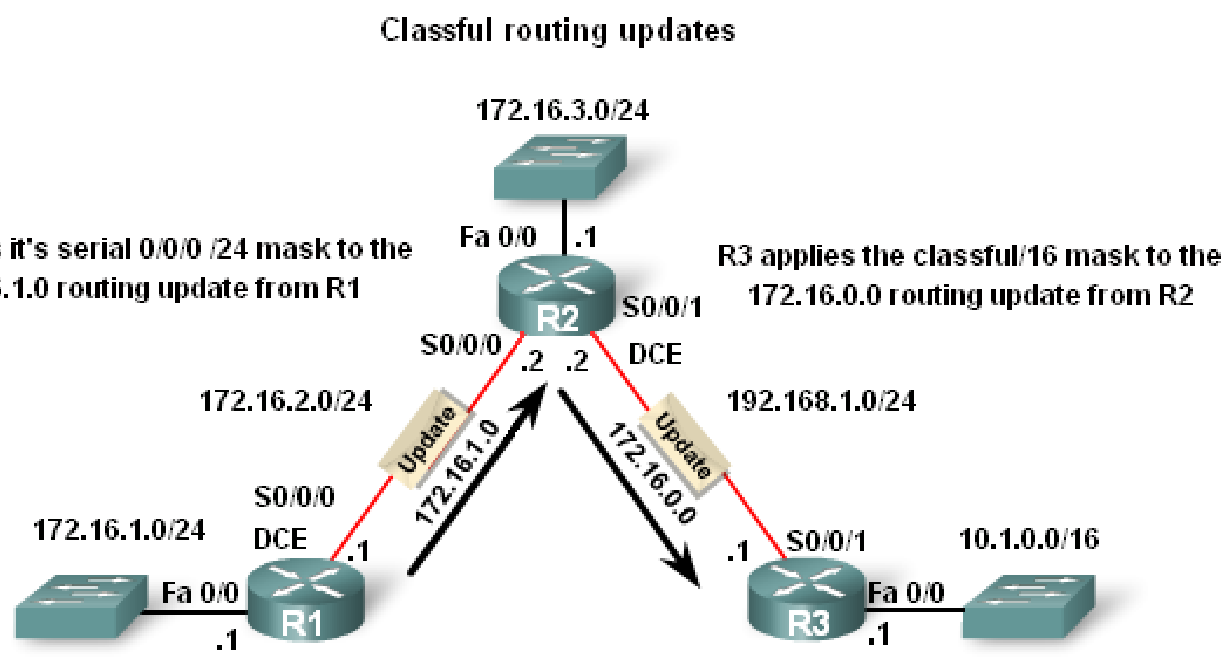
- **Purpose of a subnet mask**

  It is used to determine the network portion of an IP address

Classful and Classless IP Addressing

- Classful Routing Updates

-Recall that classful routing protocols (i.e. RIPv1) do not send subnet masks in their routing updates The reason is that the Subnet mask is directly related to the network address



Classful and Classless IP Addressing

- Classless Inter-domain Routing (CIDR – RFC 1517)
  - Advantage of CIDR :

    -More efficient use of IPv4 address space

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

    Recall purpose of a subnet mask:

    -To determine the network and host portion of an IP address

Classful and Classless IP Addressing

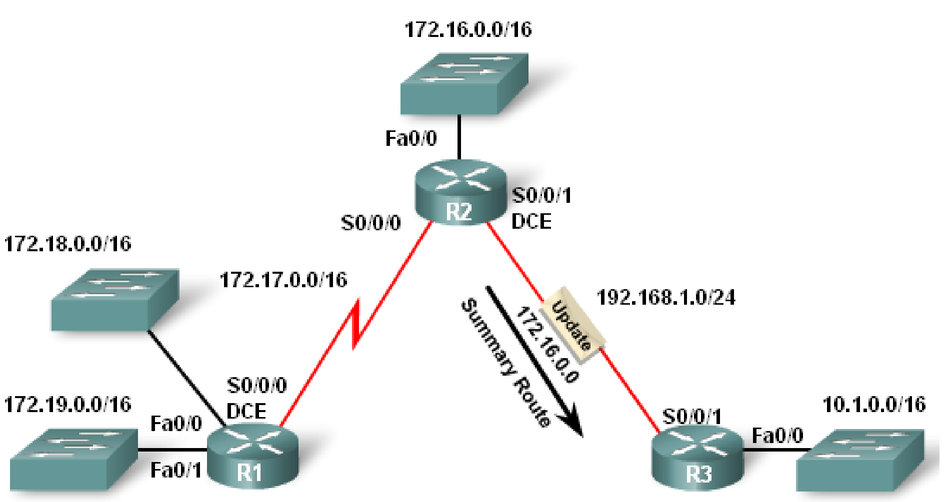
- Classless Routing Protocol
- Characteristics of classless routing protocols:

  -Routing updates include the subnet mask

  -Supports VLSM

  Supports Route Summarization

Classless Routing



Classful and Classless IP Addressing

- Classless Routing Protocol

Routing Protocol	Routing updates Include subnet Mask	Supports VLSM	Ability to send Supernet routes
Classful	No	No	No
Classless	Yes	Yes	Yes

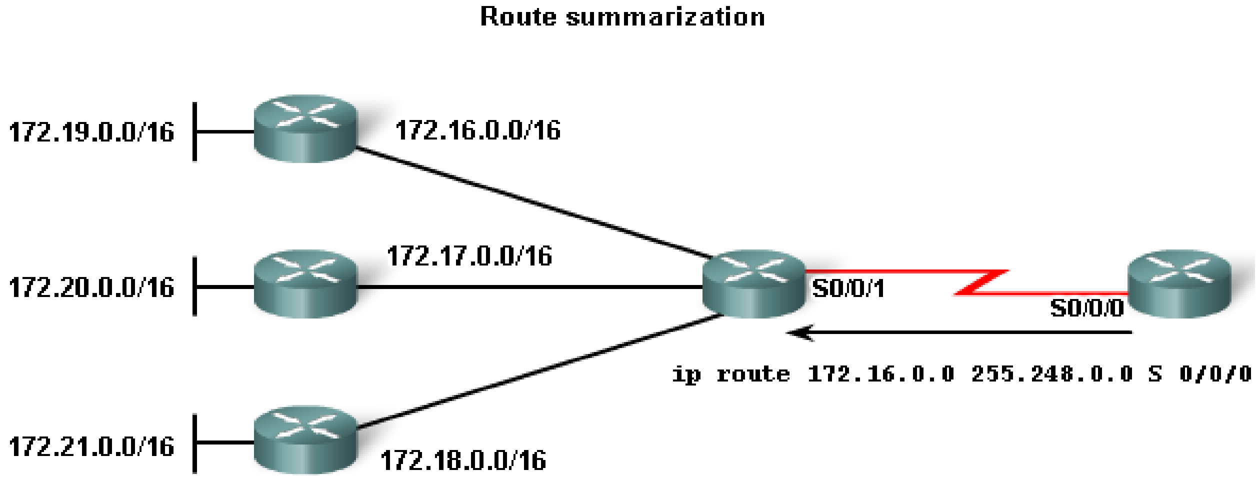
Classless Inter-Domain Routing (CIDR)

- Route summarization done by CIDR

  -Routes are summarized with masks that are less than that of the default classful mask

  -Example:

  172.16.0.0 / **13** is the summarized route for the 172.16.0.0 / **16** to 172.23.0.0 / **16** classful networks



Classless Inter-Domain Routing (CIDR)

- Steps to calculate a route summary
  - -List networks in binary format
  - -Count number of left most matching bits to determine summary route's mask
  - -Copy the matching bits and add zero bits to determine the summarized network address