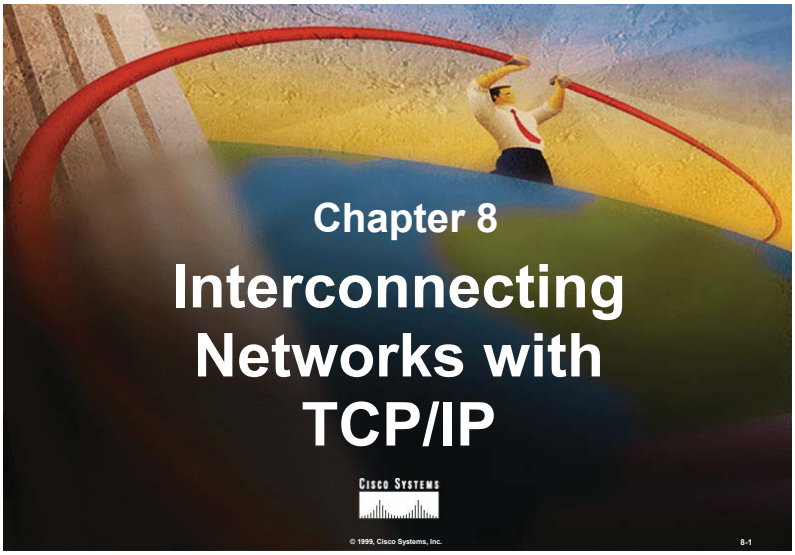
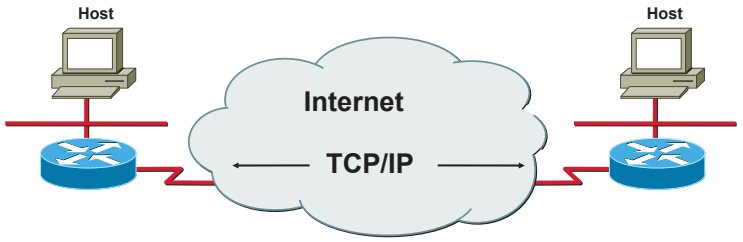



## Introduction to TCP/IP

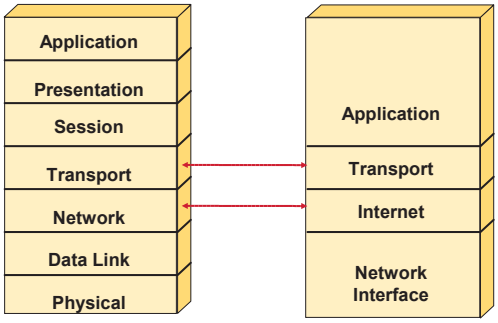



Early protocol suite

Universal

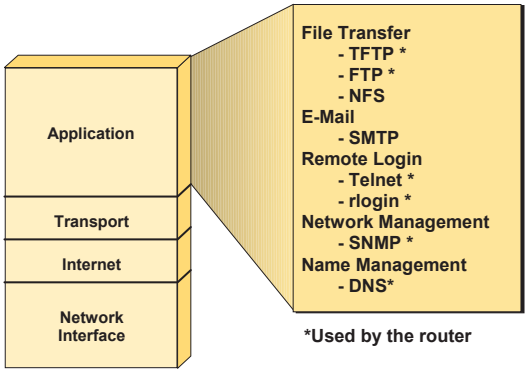


## TCP/IP Protocol Stack





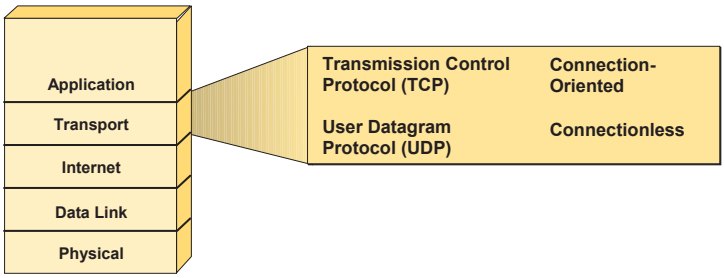

## Application Layer Overview




*Used by the router

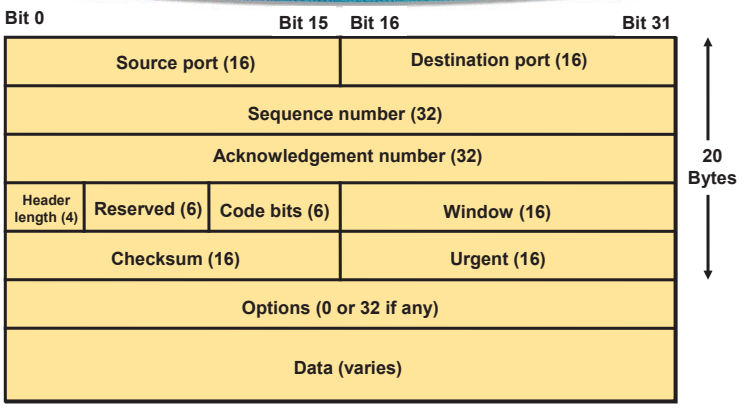


## Transport Layer Overview

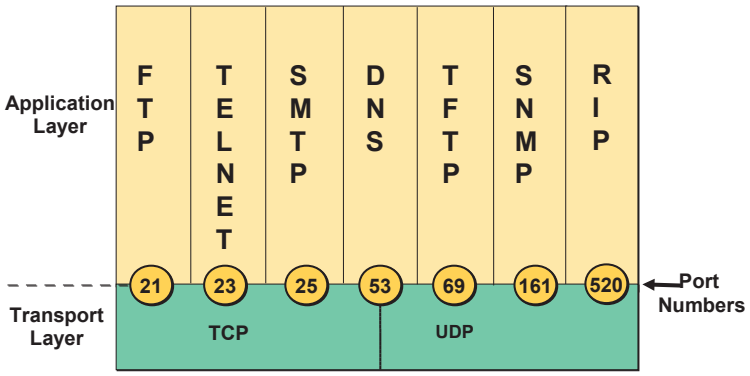





## TCP Segment Format

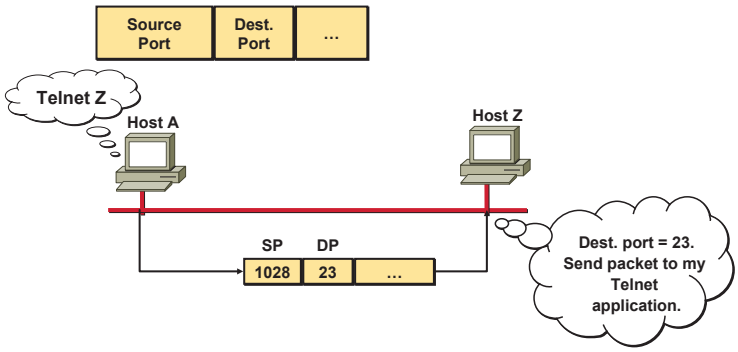


# Port Numbers



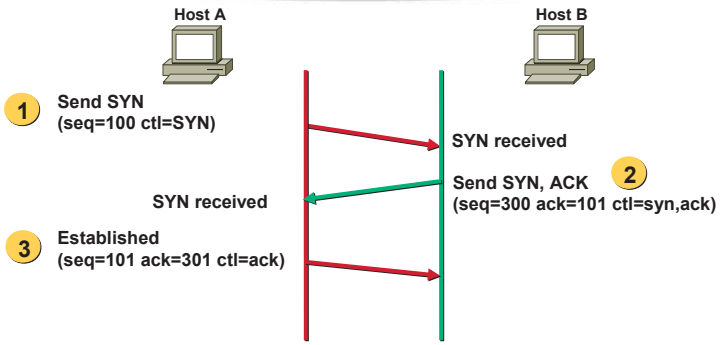



# TCP Port Numbers



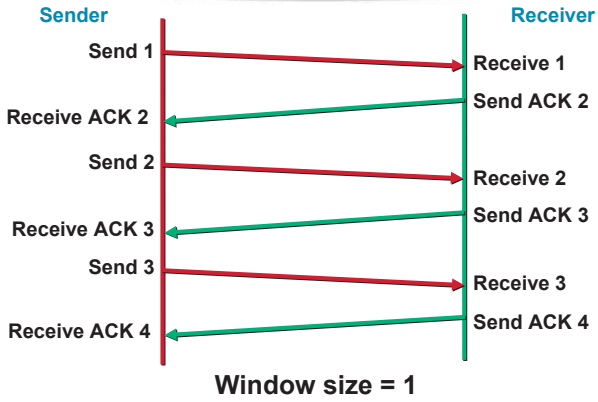



# TCP Three Way Handshake/Open Connection



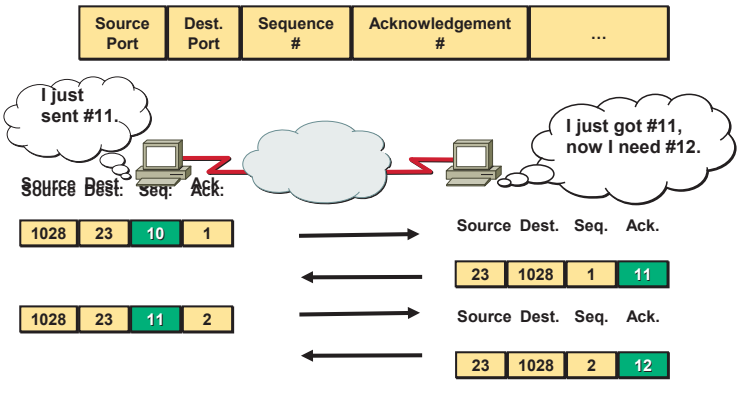



# TCP Simple Acknowledgment



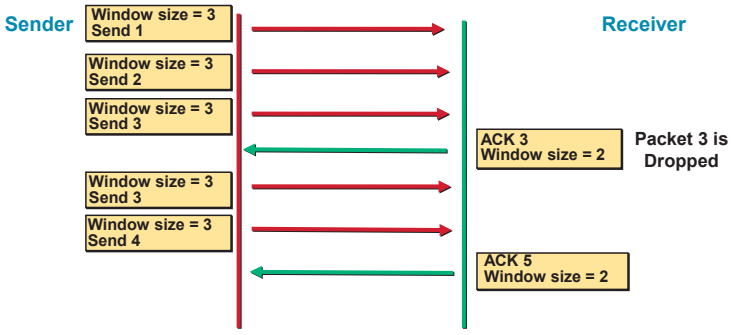



# TCP Sequence and Acknowledgment Numbers

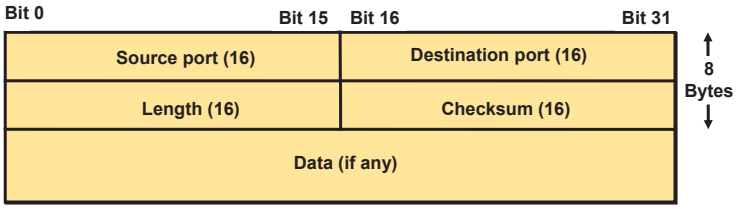





# TCP Windowing



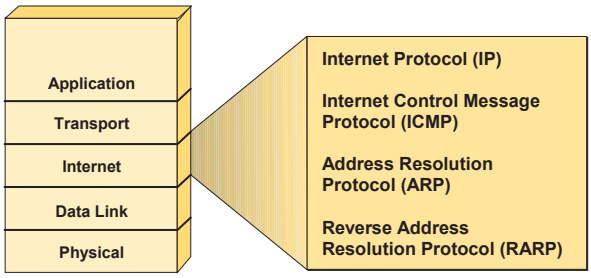
# UDP Segment Format




**No sequence or acknowledgment fields**



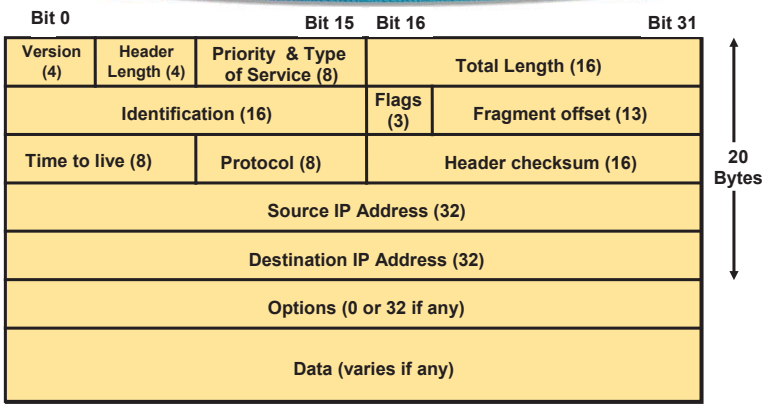
# Internet Layer Overview




**OSI network layer corresponds to the TCP/IP internet layer**

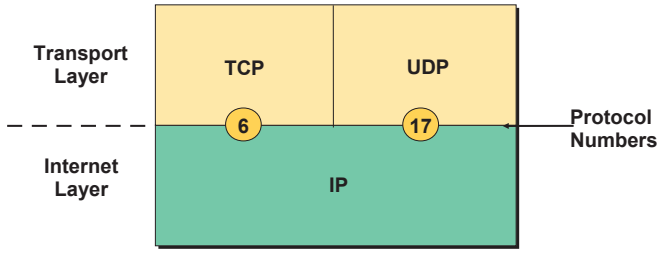


# IP Datagram





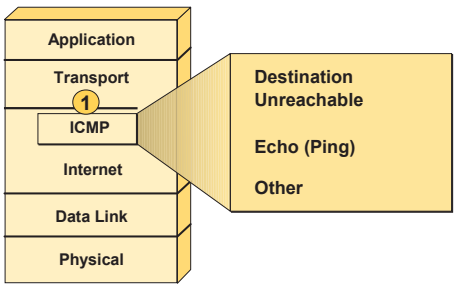

# Protocol Field




**Determines destination upper-layer protocol**

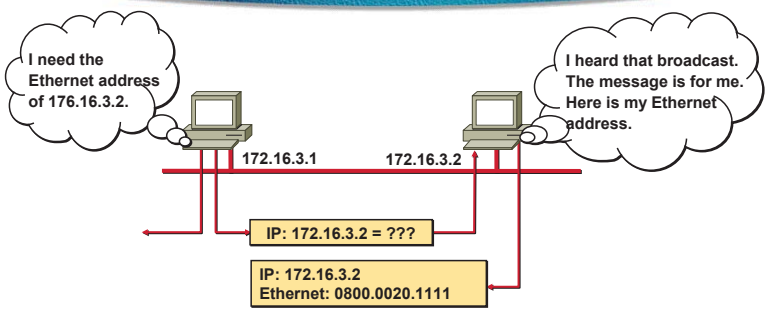


# Internet Control Message Protocol





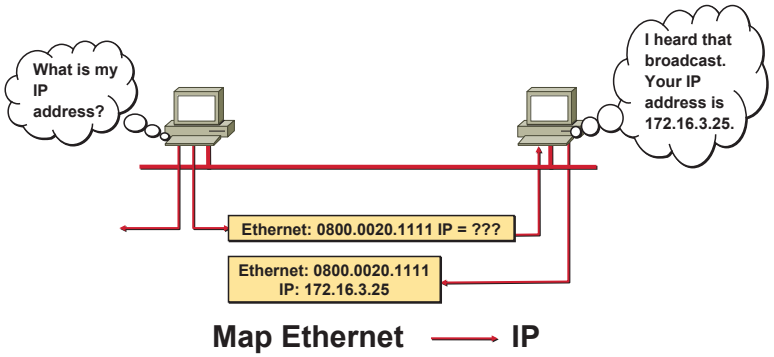

# Address Resolution Protocol




**Map IP → Ethernet**

**Local ARP**

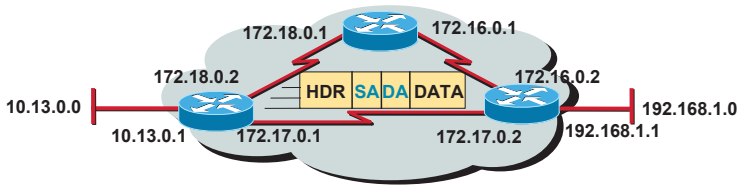
# Reverse ARP




**Map Ethernet → IP**



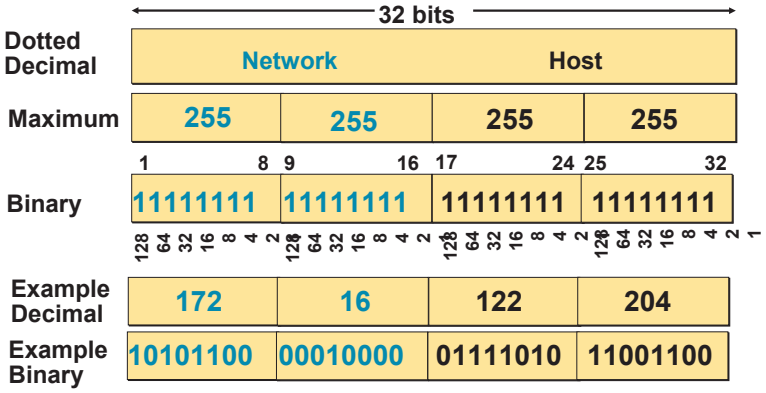

# Introduction to TCP/IP Addresses




- Unique addressing allows communication between end stations
- Path choice is based on location



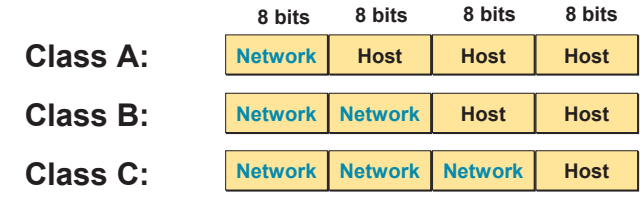

# IP Addressing







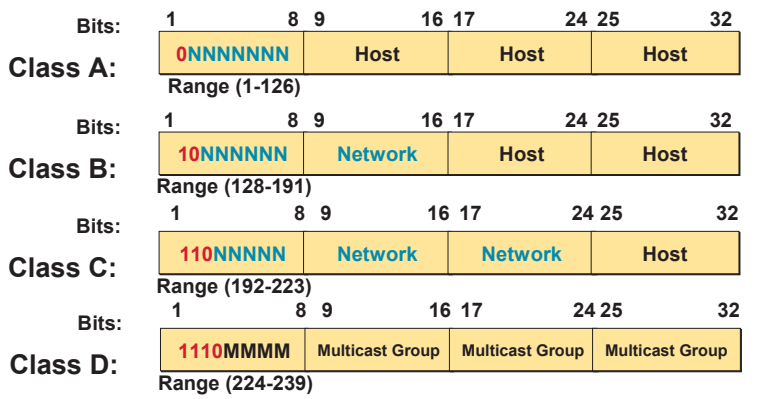
# IP Address Classes







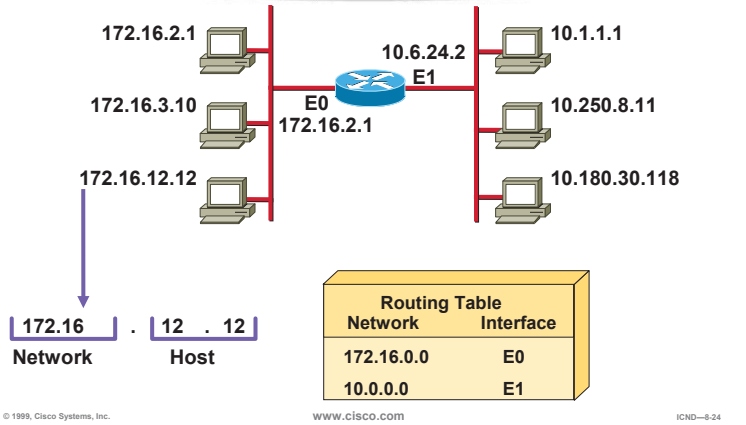
# IP Address Classes



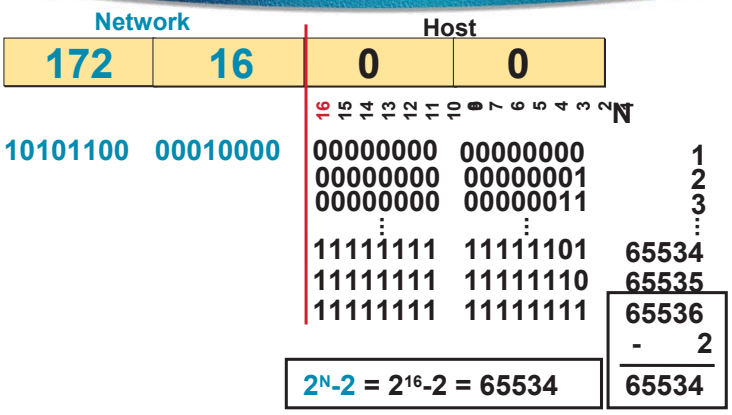




# Host Addresses



# Determining Available Host Addresses



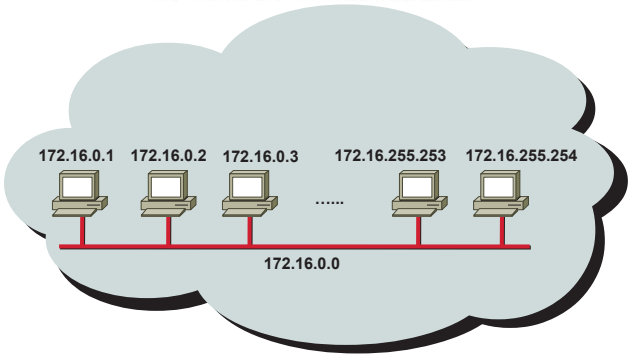



# IP Address Classes Exercise Answers

| Address | Class | Network | Host |
|---|---|---|---|
| 10.2.1.1 | | | |
| 128.63.2.100 | | | |
| 201.222.5.64 | | | |
| 192.6.141.2 | | | |
| 130.113.64.16 | | | |
| 241.256.201.10 | | | |



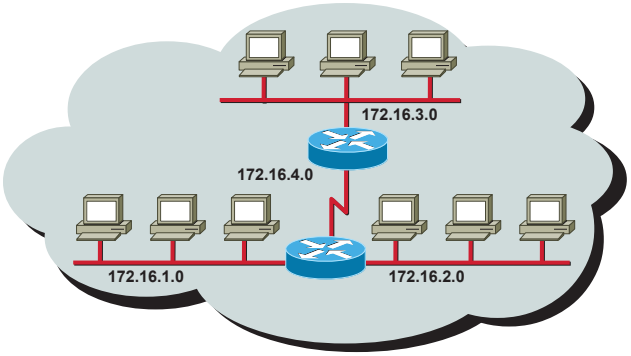
# Addressing without Subnets




Network 172.16.0.0



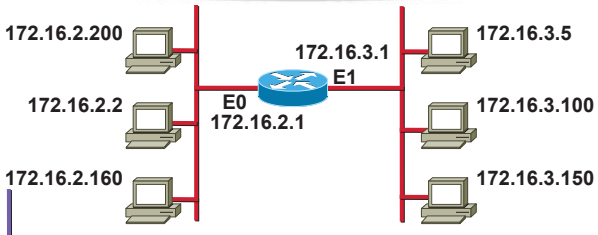
# Addressing with Subnets




Network 172.16.0.0



# Subnet Addressing

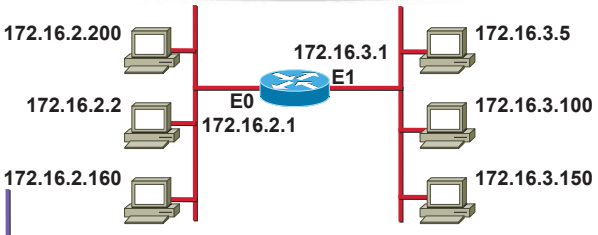



172.16 . 2 . 160
Network Host

| New Routing Table Network | Interface |
|---|---|
| 172.16.0.0 | E0 |
| 172.16.0.0 | E1 |



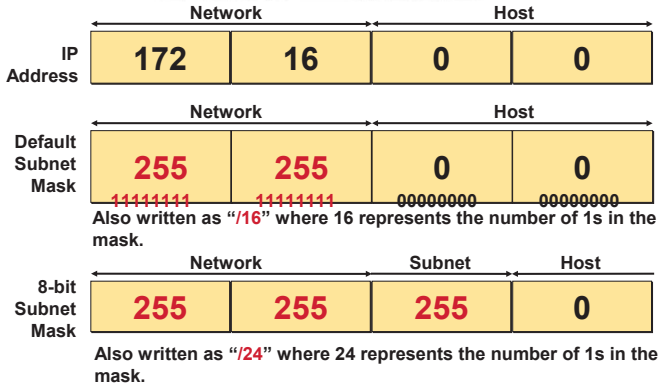
# Subnet Addressing




172.16 . 2 . 160
Network Subnet Host

| New Routing Table Network | Interface |
|---|---|
| 172.16.2.0 | E0 |
| 172.16.3.0 | E1 |

# Subnet Mask




Also written as "/16" where 16 represents the number of 1s in the mask.




Also written as "/24" where 24 represents the number of 1s in the mask.



# Decimal Equivalents of Bit Patterns

| 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | = | 128 |
| 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | = | 192 |
| 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | = | 224 |
| 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | = | 240 |
| 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | = | 248 |
| 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | = | 252 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | = | 254 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | = | 255 |



# Subnet Mask without Subnets

| | Network | | Host | |
|---|---|---|---|---|
| 172.16.2.160 | 10101100 | 00010000 | 00000010 | 10100000 |
| 255.255.0.0 | 11111111 | 11111111 | 00000000 | 00000000 |
| | 10101100 | 00010000 | 00000000 | 00000000 |
| Network Number | 172 | 16 | 0 | 0 |

Subnets not in use—the default



# Subnet Mask with Subnets

| | Network | | Subnet | Host |
|---|---|---|---|---|
| 172.16.2.160 | 10101100 | 00010000 | 00000010 | 10100000 |
| 255.255.255.0 | 11111111 | 11111111 | 11111111 | 00000000 |
| | 10101100 | 00010000 | 00000010 | 00000000 |
| Network Number | 172 | 16 | 2 | 0 |

Network number extended by eight bits



# Subnet Mask with Subnets (cont.)

| | Network | | Subnet | Host |
|---|---|---|---|---|
| 172.16.2.160 | 10101100 | 00010000 | 00000010 | 10100000 |
| 255.255.255.192 | 11111111 | 11111111 | 11111111 | 11000000 |
| | 10101100 | 00010000 | 00000010 | 10000000 |
| Network Number | 172 | 16 | 2 | 128 |

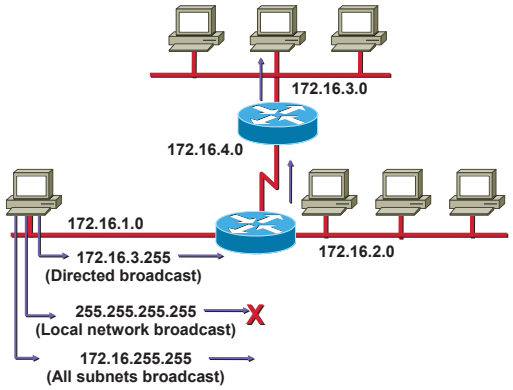
Network number extended by ten bits



# Subnet Mask Exercise Answers

| Address | Subnet Mask | Class | Subnet |
|---|---|---|---|
| 172.16.2.10 | 255.255.255.0 | | |
| 10.6.24.20 | 255.255.240.0 | | |
| 192.168.6.2 | 255.255.255.0 | | |

# Broadcast Addresses






# Addressing Summary Example

| | 172 | 16 | 2 | 160 | |
|---|---|---|---|---|---|
| 172.16.2.160 | 10101100 | 00010000 | 00000010 | 10 100000 | Host 1 |
| 255.255.255.192 | 11111111 | 11111111 | 11111111 | 11 000000 | Mask 2 |
| 172.16.2.128 8 | 10101100 | 00010000 | 00000010 | 10 000000 | Subnet 4 |
| 172.16.2.191 9 | 10101100 | 00010000 | 00000010 | 10 111111 | Broadcast 5 |
| 172.16.2.129 | 10101100 | 00010000 | 00000010 | 10 000001 | First 6 |
| 172.16.2.190 | 10101100 | 00010000 | 00000010 | 10 111110 | Last 7 |

3



# Class B Subnet Example

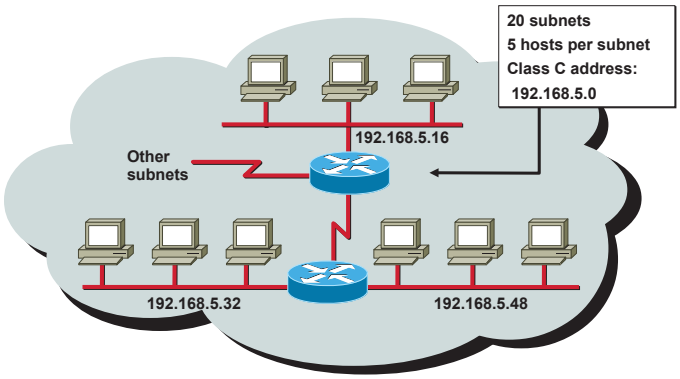
IP Host Address: 172.16.2.121
Subnet Mask: 255.255.255.0

| | Network | Network | Subnet | Host |
|---|---|---|---|---|
| 172.16.2.121: | 10101100 | 00010000 | 00000010 | 01111001 |
| 255.255.255.0: | 11111111 | 11111111 | 11111111 | 00000000 |
| Subnet: | 10101100 | 00010000 | 00000010 | 00000000 |
| Broadcast: | 10101100 | 00010000 | 00000010 | 11111111 |

Subnet Address = 172.16.2.0
Host Addresses = 172.16.2.1–172.16.2.254
Broadcast Address = 172.16.2.255
Eight bits of subnetting



# Subnet Planning






# Class C Subnet Planning Example

IP Host Address: 192.168.5.121
Subnet Mask: 255.255.255.248

| | Network | Network | Network | Subnet | Host |
|---|---|---|---|---|---|
| 192.168.5.121: | 11000000 | 10101000 | 00000101 | 01111001 | |
| 255.255.255.248: | 11111111 | 11111111 | 11111111 | 11111000 | |
| Subnet: | 11000000 | 10101000 | 00000101 | 01111000 | |
| Broadcast: | 11000000 | 10101000 | 00000101 | 01111111 | |

Subnet Address = 192.168.5.120
Host Addresses = 192.168.5.121–192.168.5.126
Broadcast Address = 192.168.5.127
Five Bits of Subnetting



# Broadcast Addresses Exercise Answers

| Host Address | Subnet Mask | Class | Subnet Network Address | Subnet Broadcast Address |
|---|---|---|---|---|
| 201.222.10.60 | 255.255.255.248 | | | |
| 15.16.193.6 | 255.255.248.0 | | | |
| 128.16.32.13 | 255.255.255.252 | | | |
| 153.50.6.27 | 255.255.255.128 | | | |