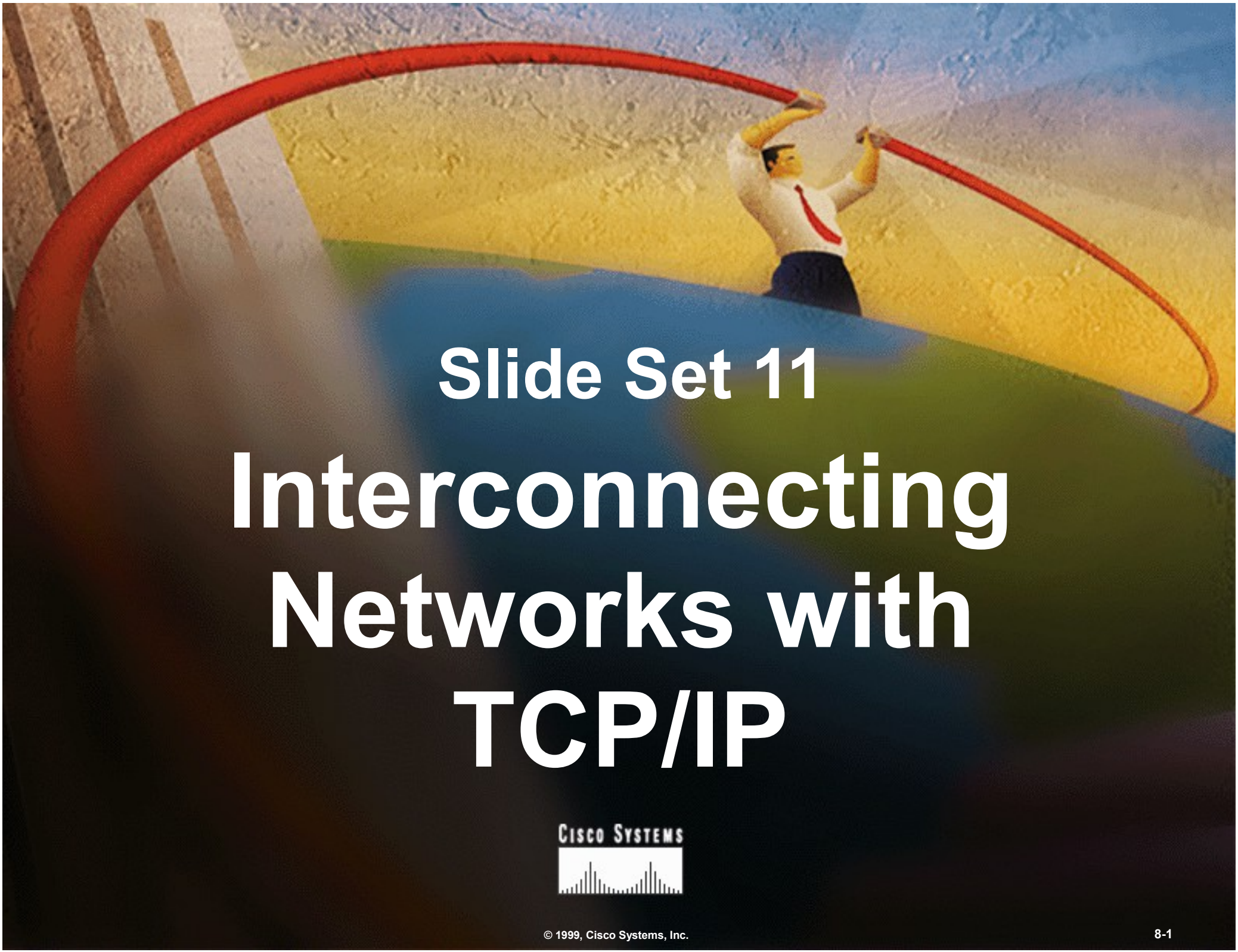
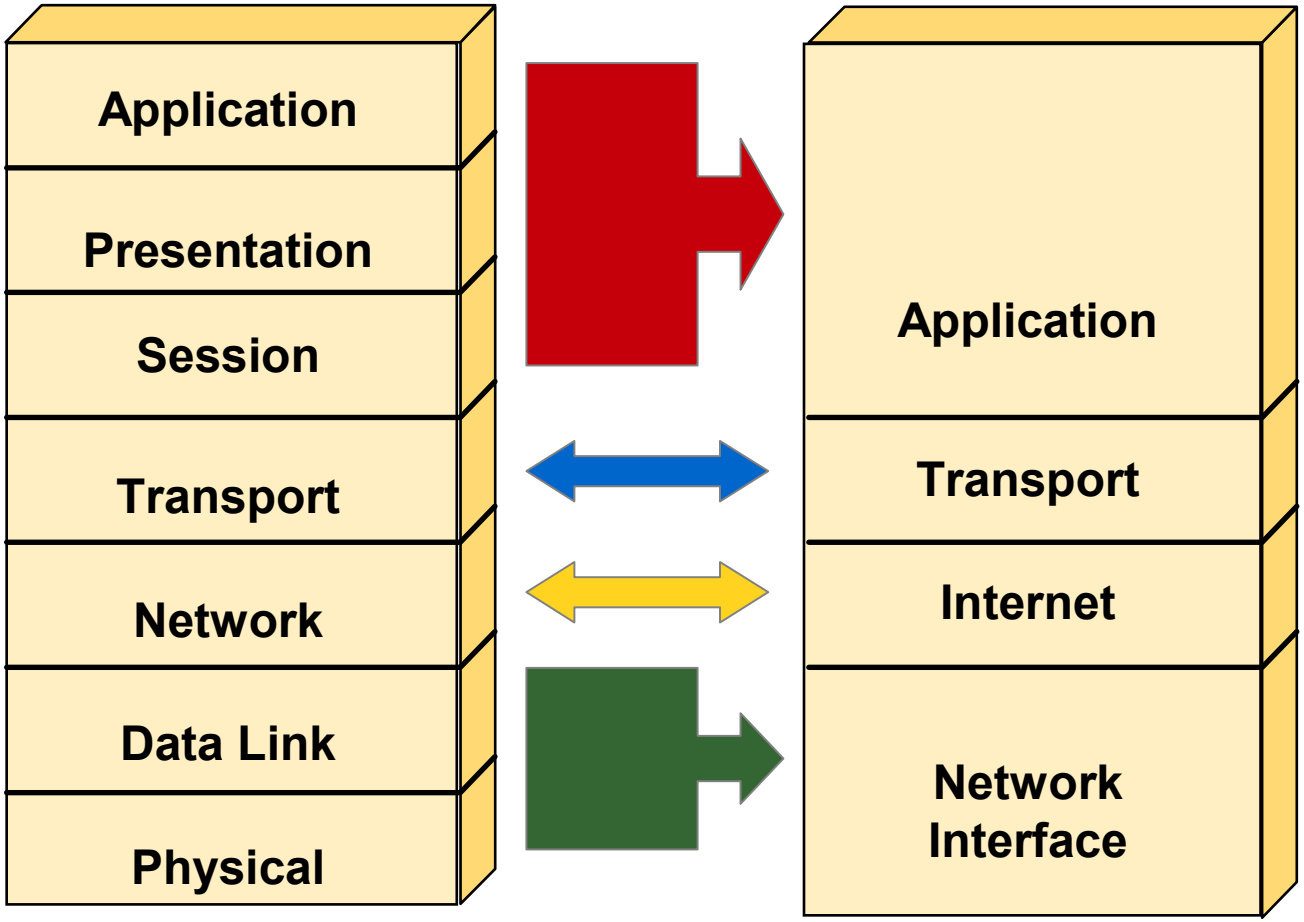


Slide Set 11

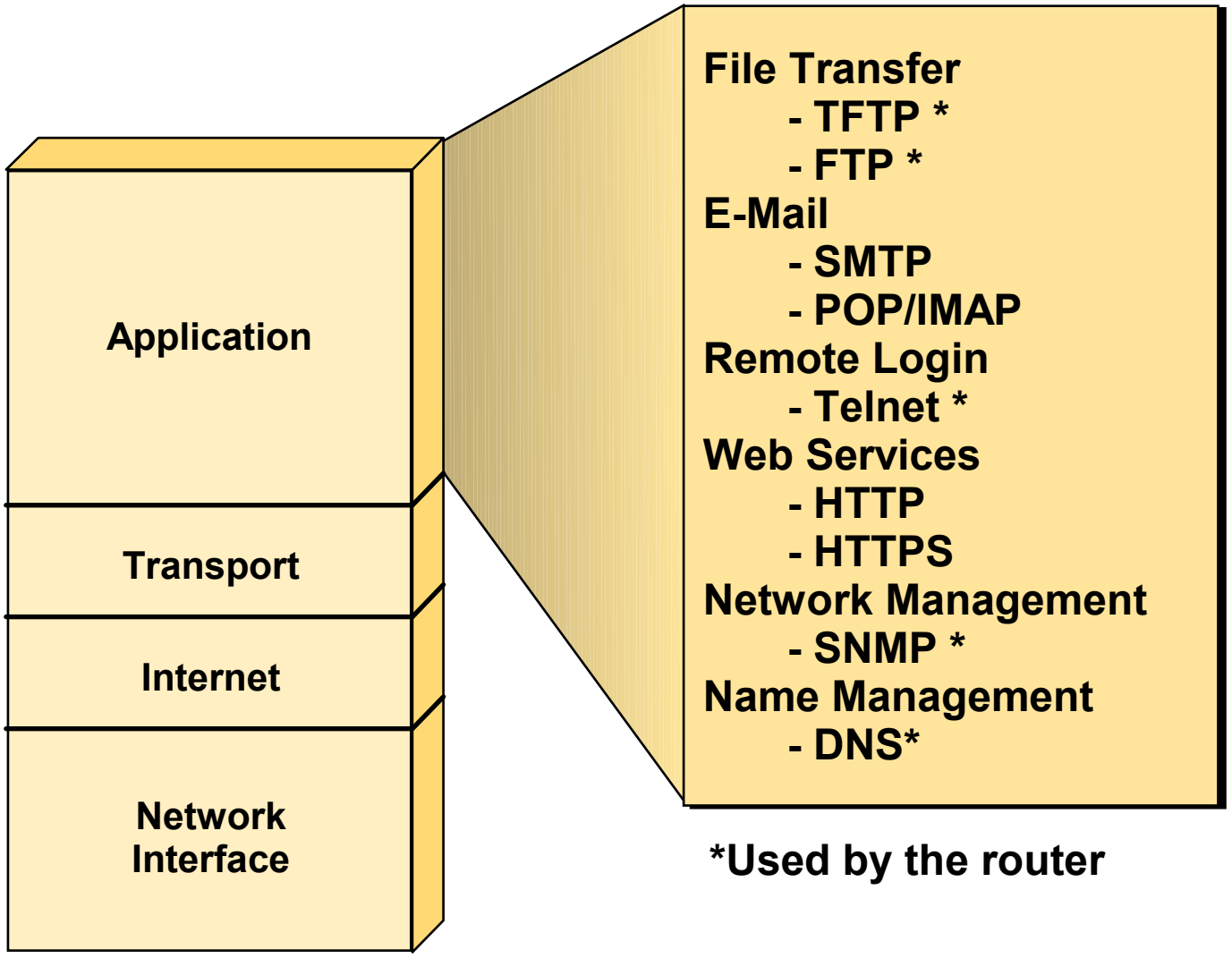
Interconnecting Networks with TCP/IP

Cisco Systems

ISO OSI Reference Model vs. TCP/IP Protocol Stack

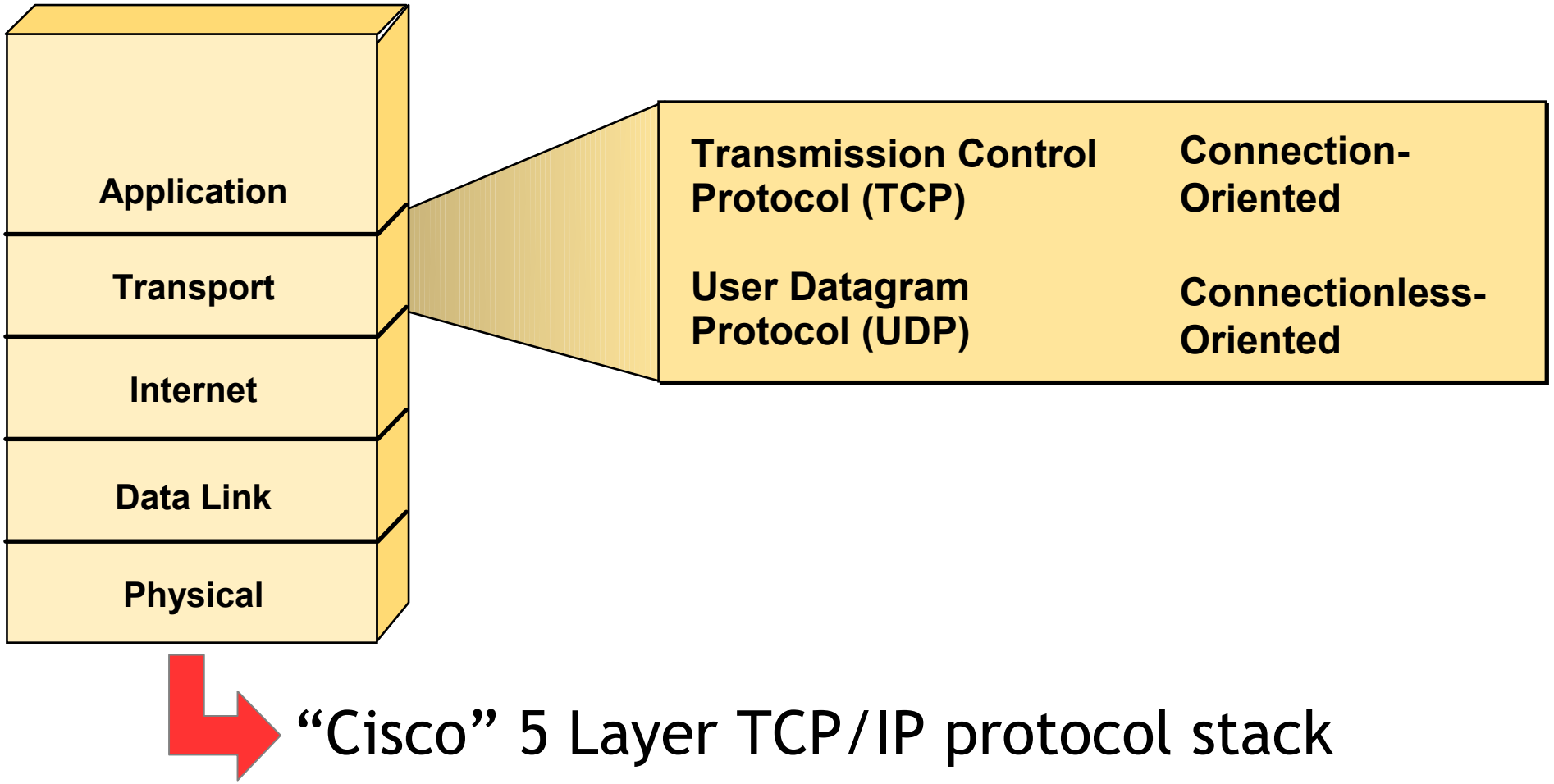


Application Layer Overview



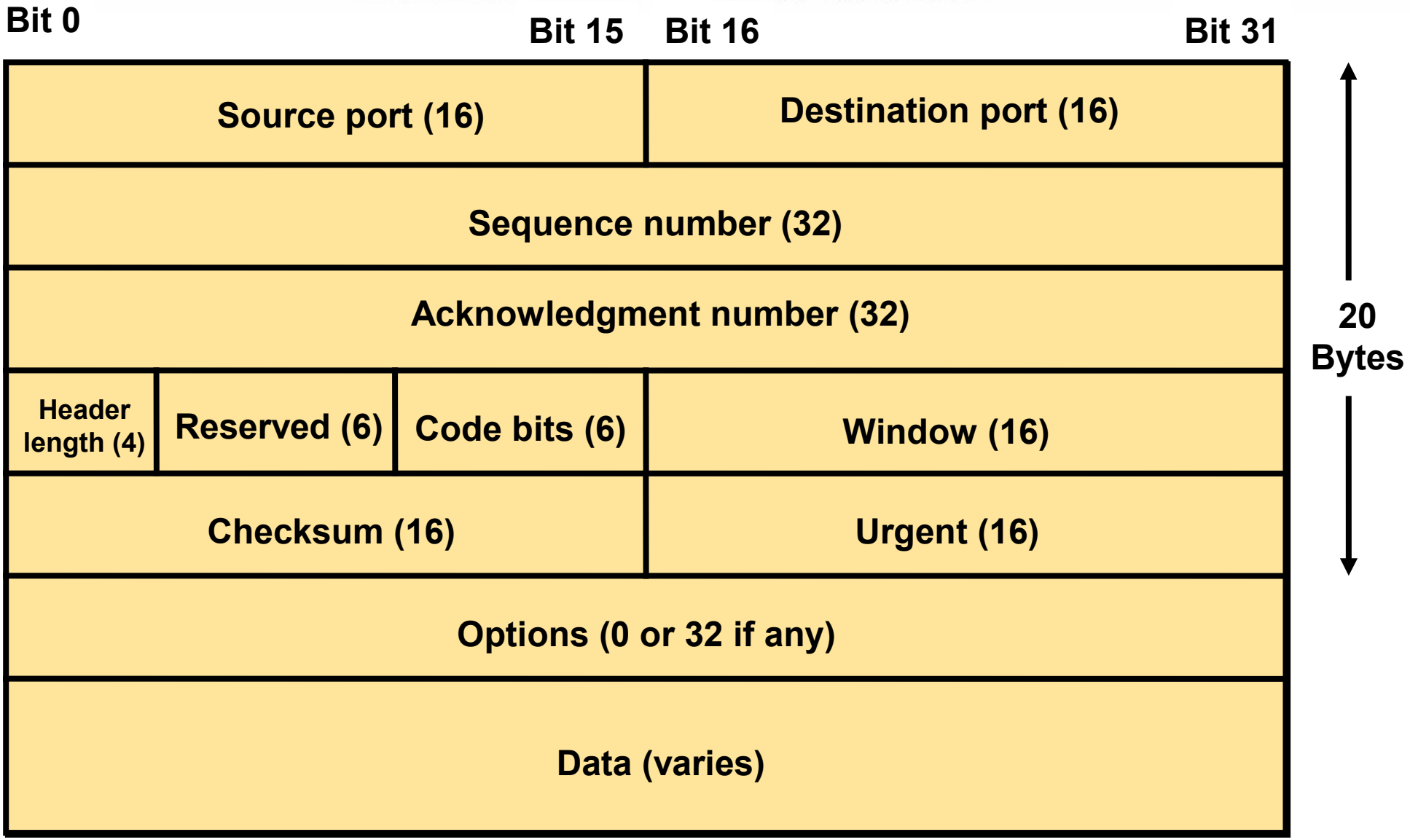
*Used by the router

Transport Layer Overview

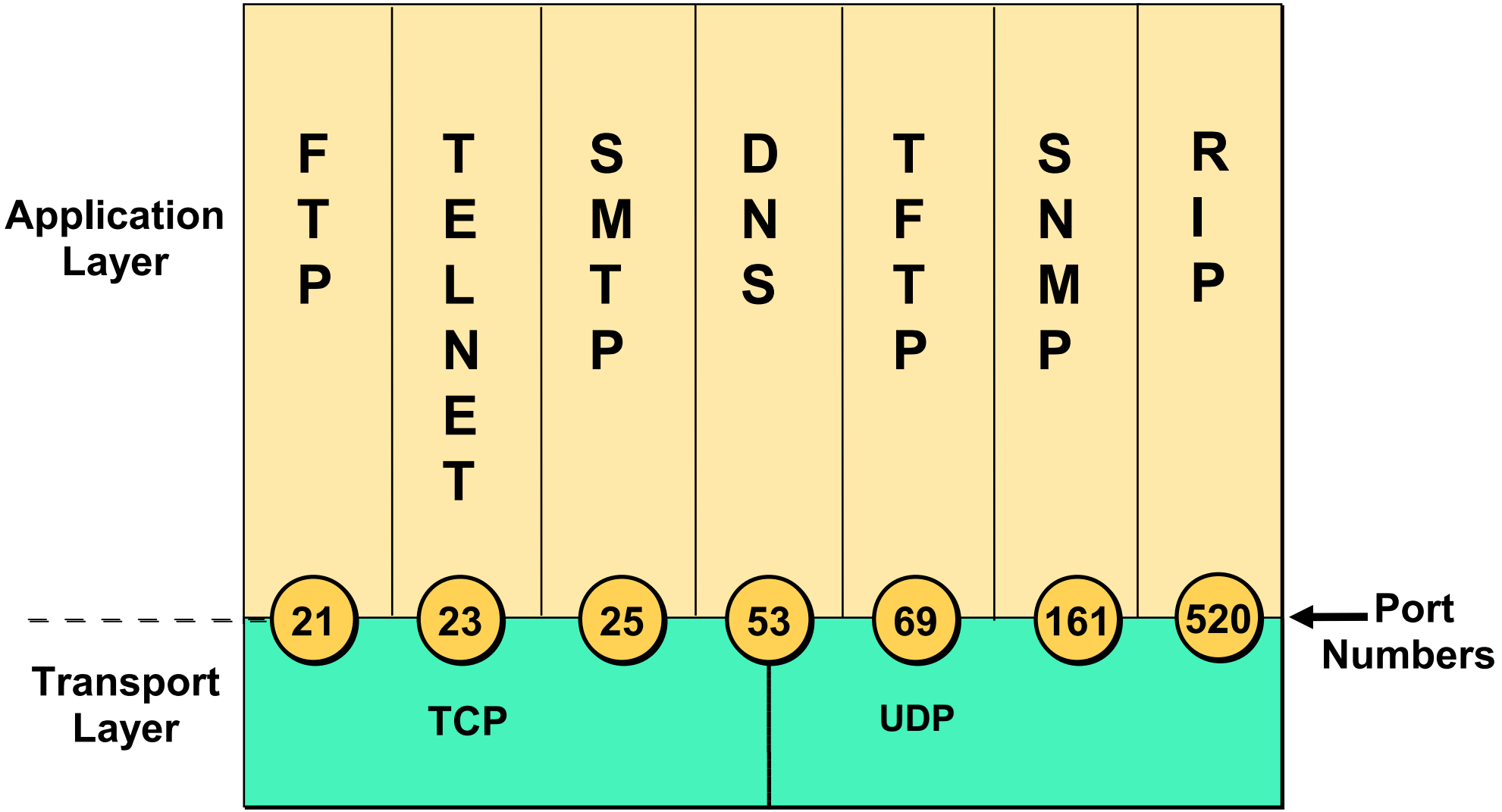


"Cisco" 5 Layer TCP/IP protocol stack

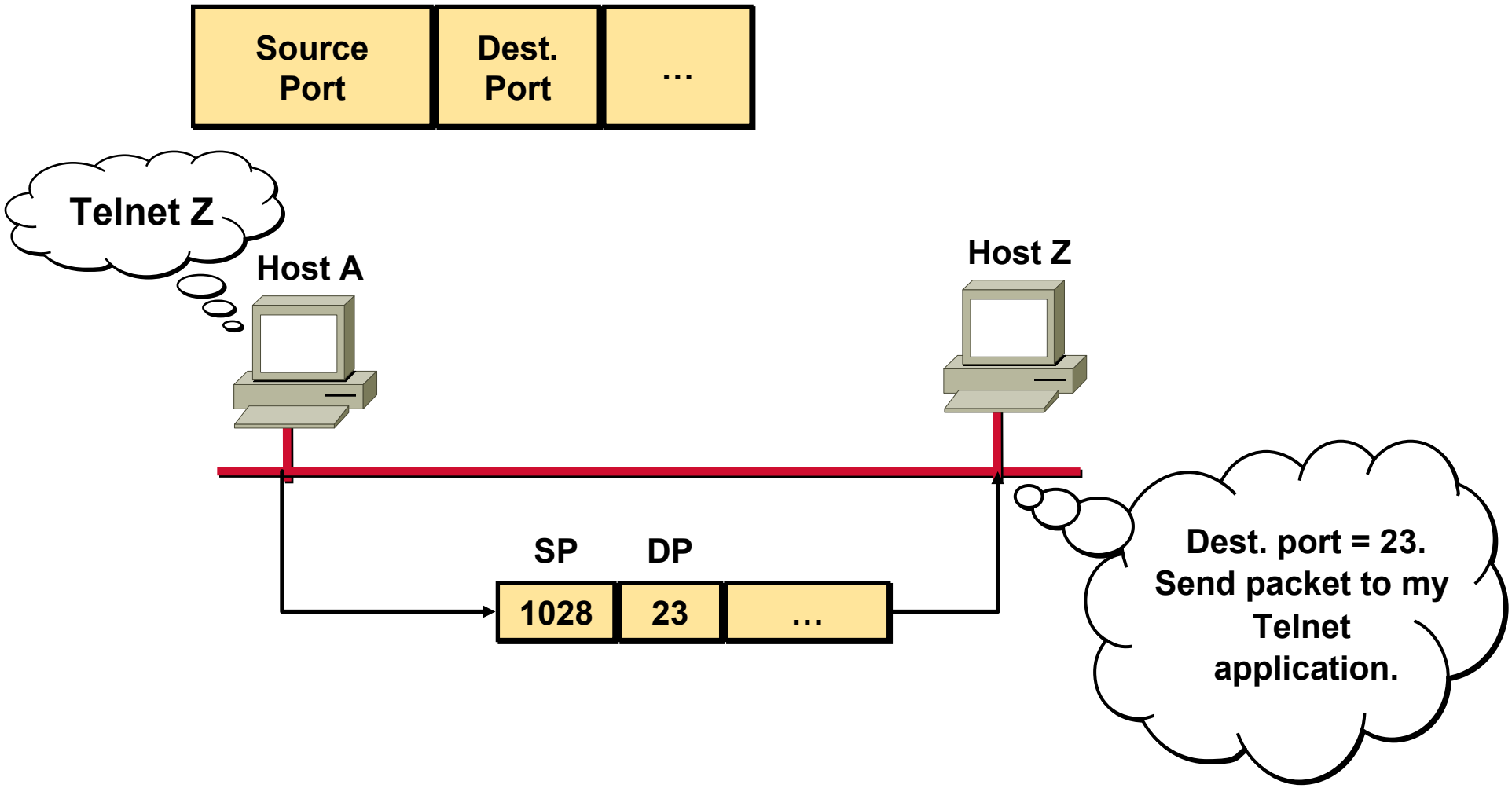
TCP Segment Structure
Transport Layer PDU



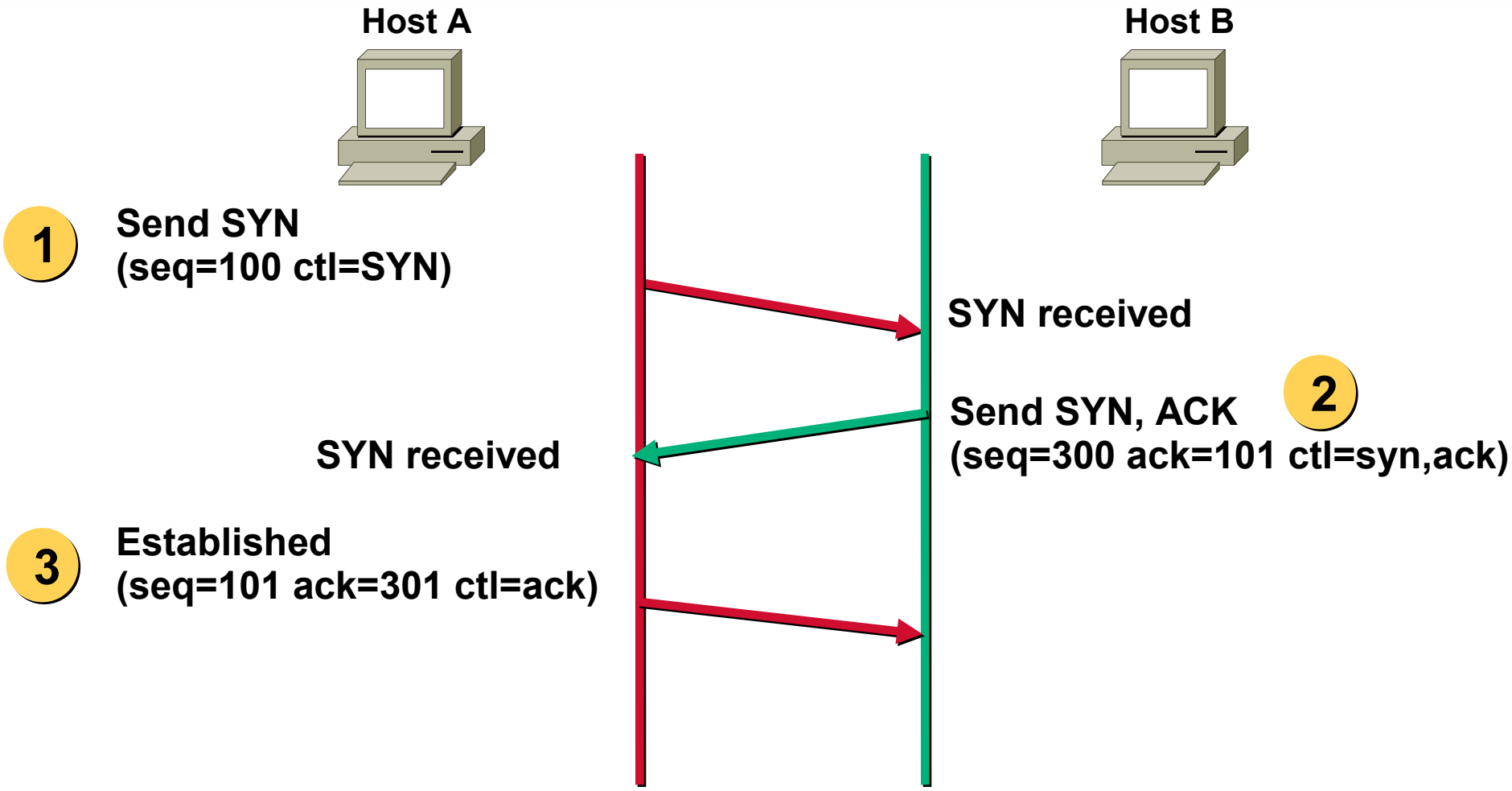
Port Numbers



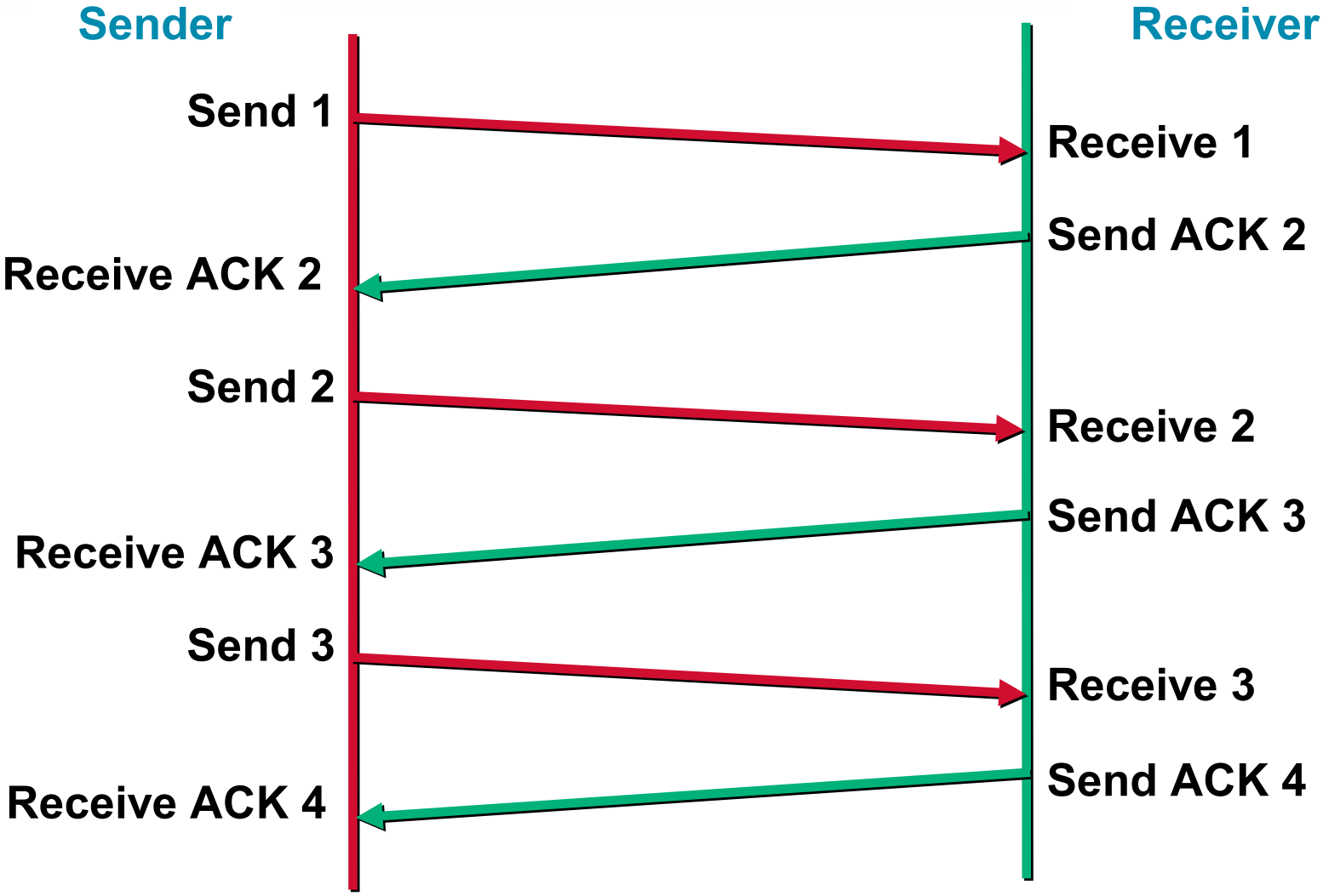
TCP Port Numbers



TCP Three Way Handshake/Open Connection



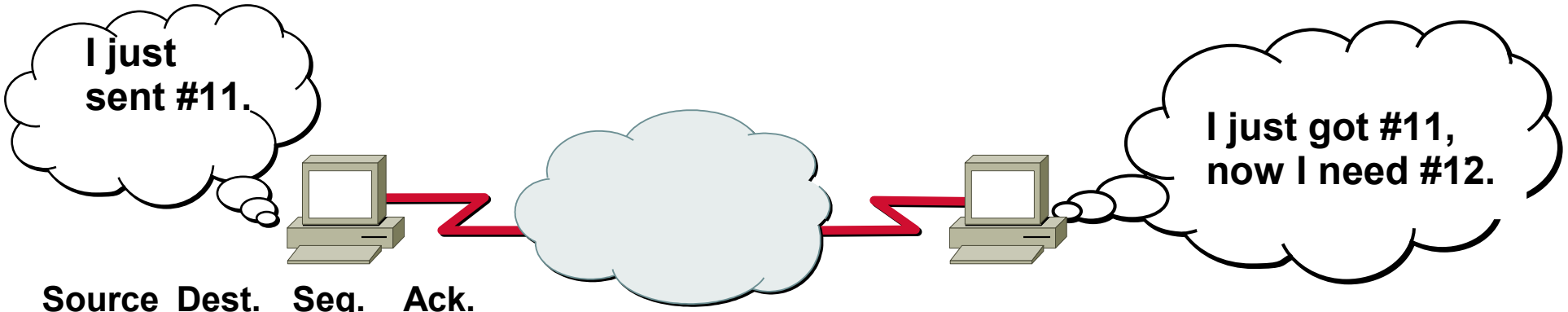
TCP Simple Acknowledgment



Window size = 1

TCP Sequence and Acknowledgment Numbers

Source Port	Dest. Port	Sequence #	Acknowledgement #	…



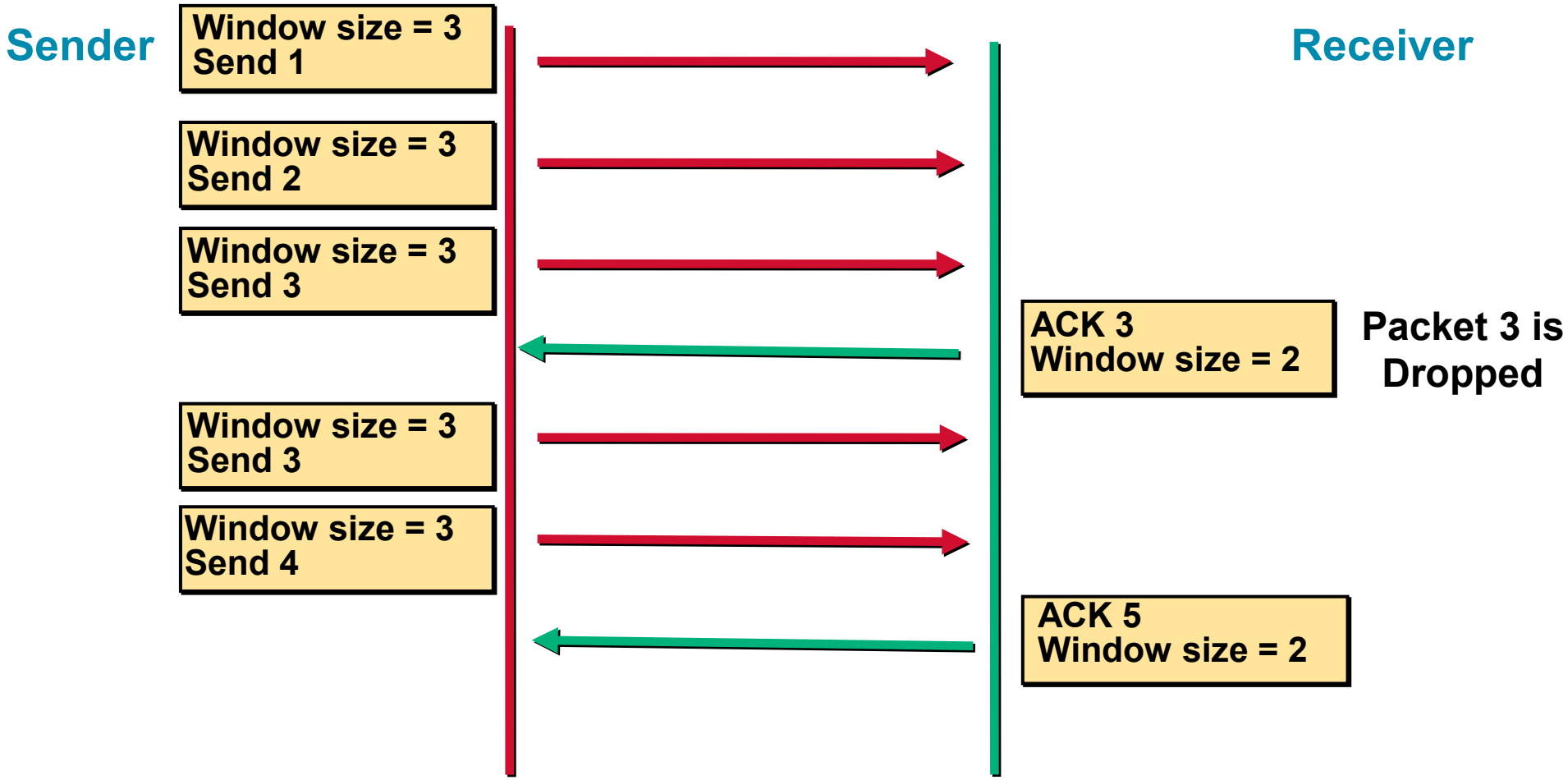
Source	Dest.	Seq.	Ack.
1028	23	10	1

Source	Dest.	Seq.	Ack.
23	1028	1	11

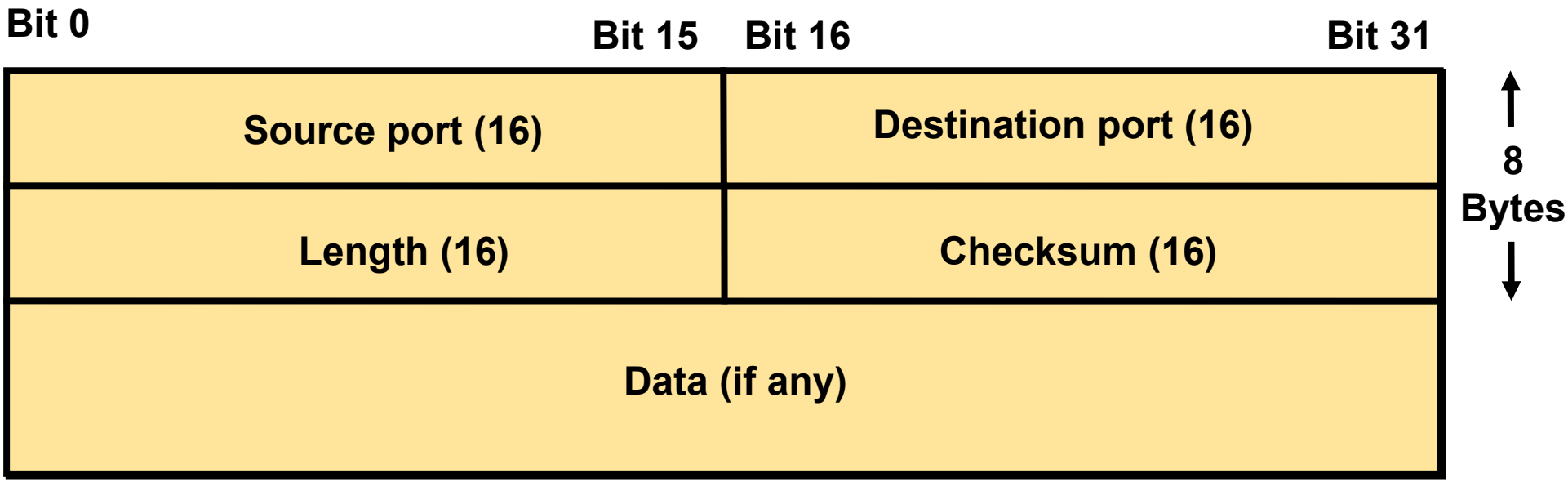
Source	Dest.	Seq.	Ack.
1028	23	11	2

Source	Dest.	Seq.	Ack.
23	1028	2	12

TCP Windowing

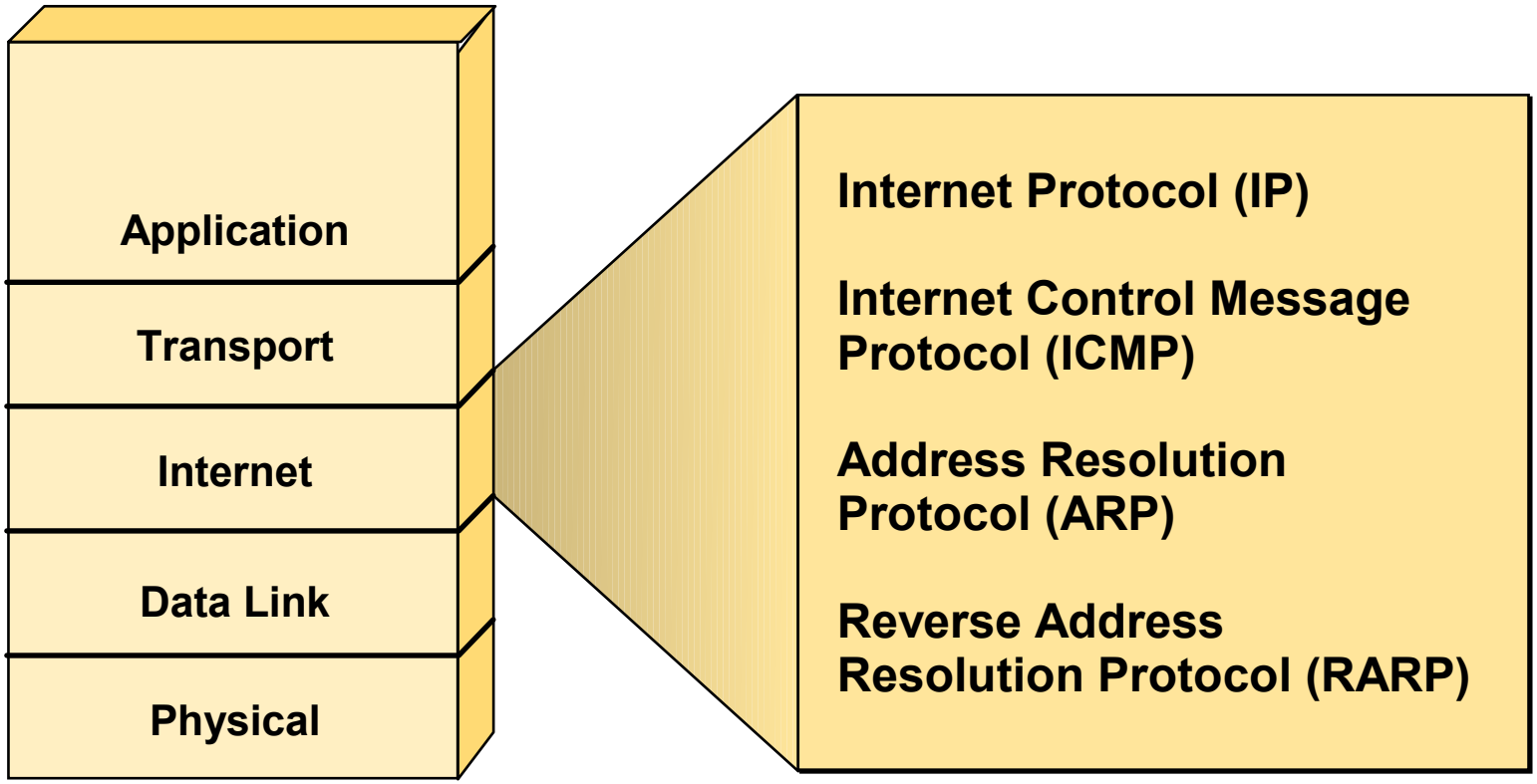


UDP Segment Structure Transport Layer PDU



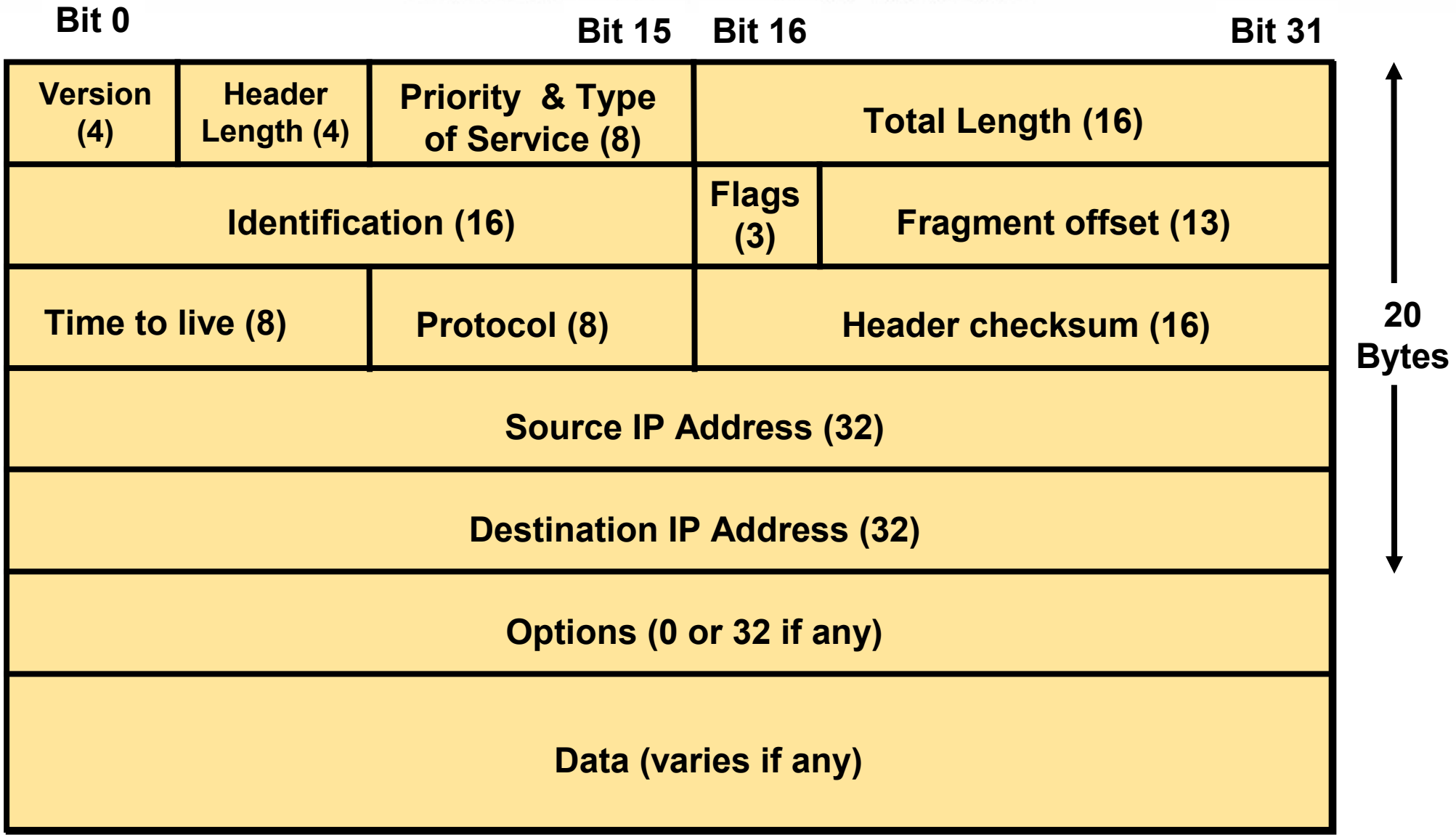
No sequence or acknowledgment fields

Internet Layer Overview

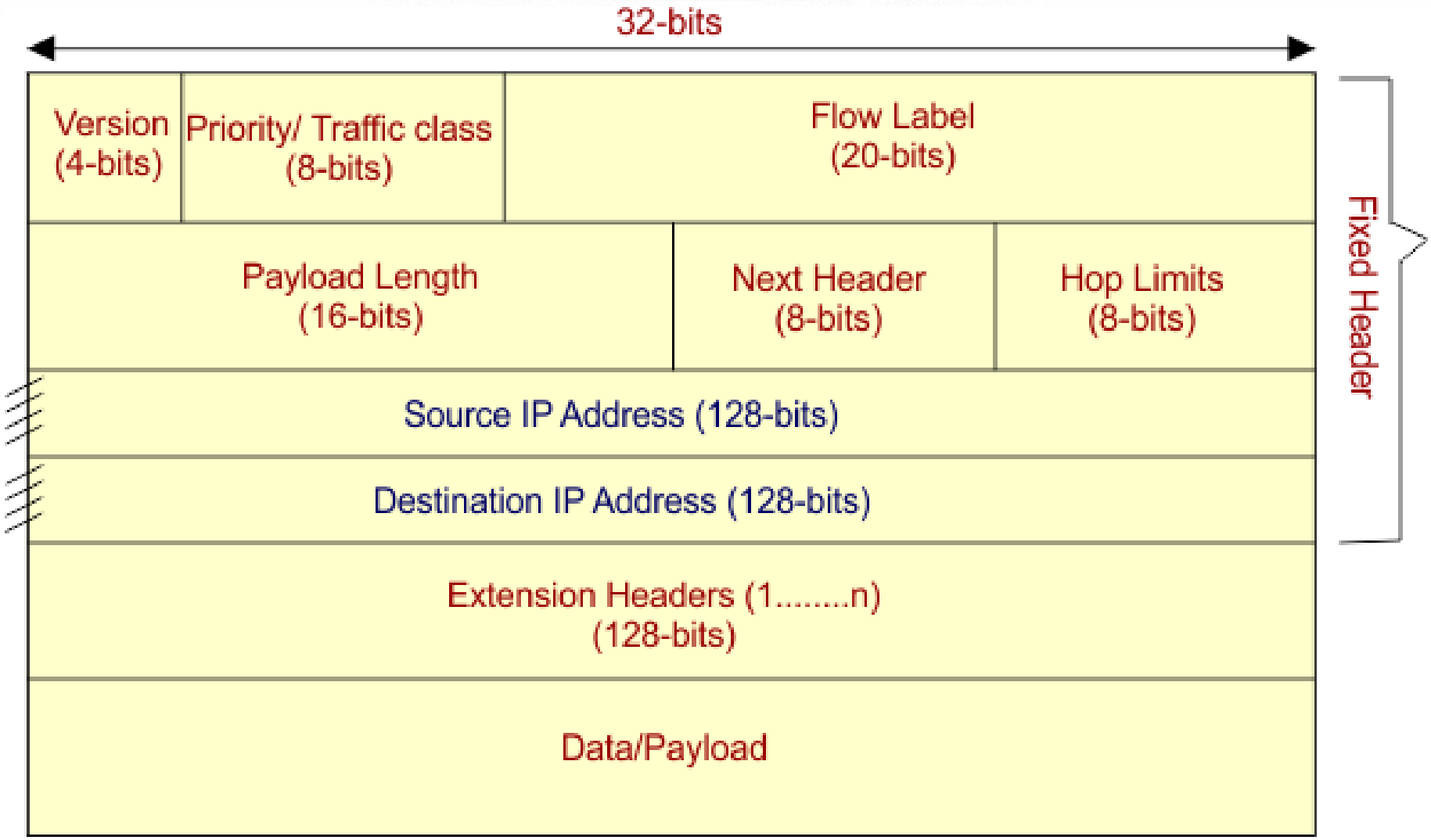


OSI network layer corresponds to the TCP/IP internet layer

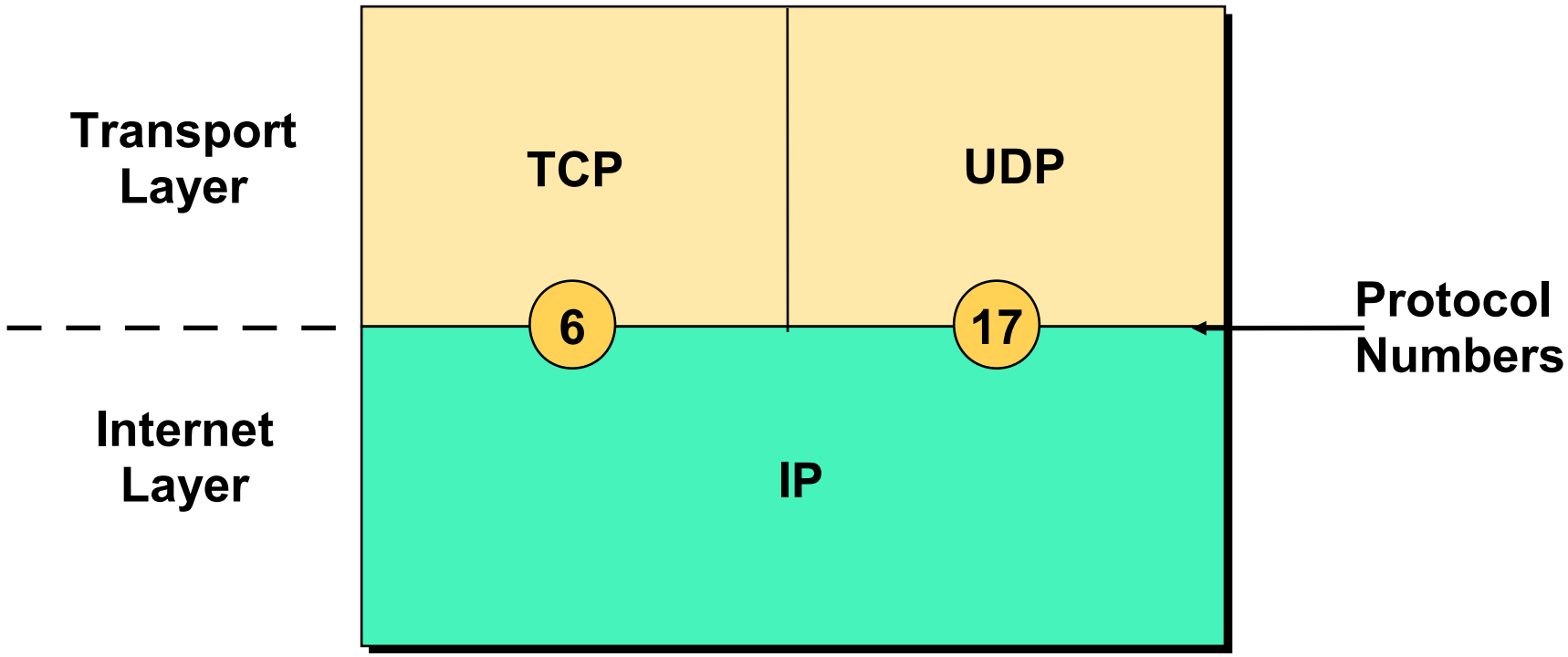
IPv4 Datagram Structure
Internet Layer PDU



IPv6 Datagram Structure
Internet Layer PDU

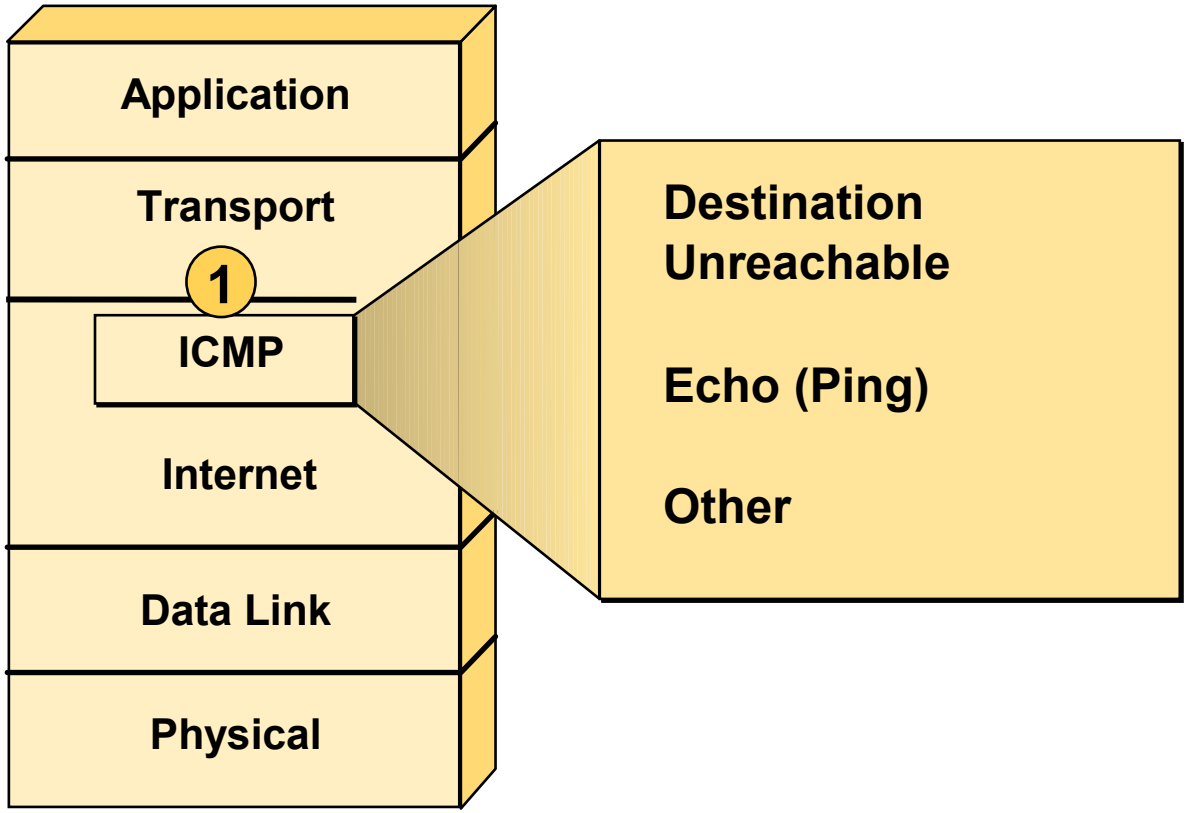


Protocol Field

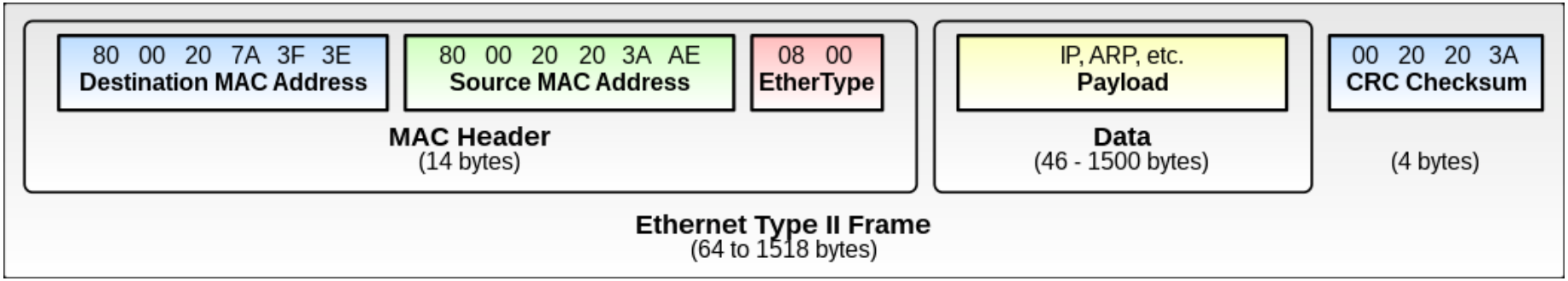


Determines destination upper-layer protocol

Internet Control Message Protocol

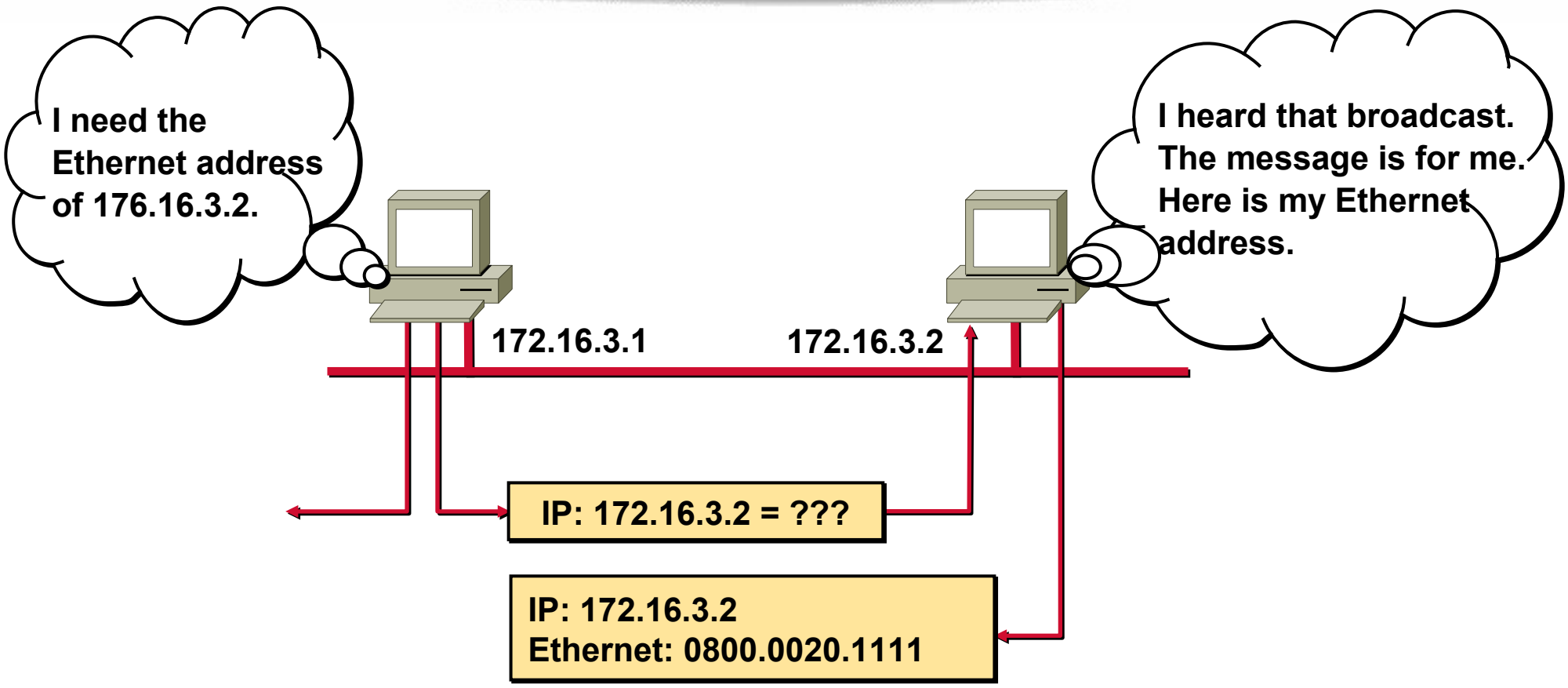


Ethernet Frame Structure Data Link Layer PDU



- The Destination MAC address field comes first to help in cut-through switching.
- The EtherType field is most of the time 0800 meaning that payload contains and Ipv4 or Ipv6 datagram but it could be different for other type of payloads e.g. ARP, RARP, etc...
- The payload data size must be a minimum of 46 bytes. If there is no payload content (e.g. HTTP request), 46 bytes of zeroes are padded into it.

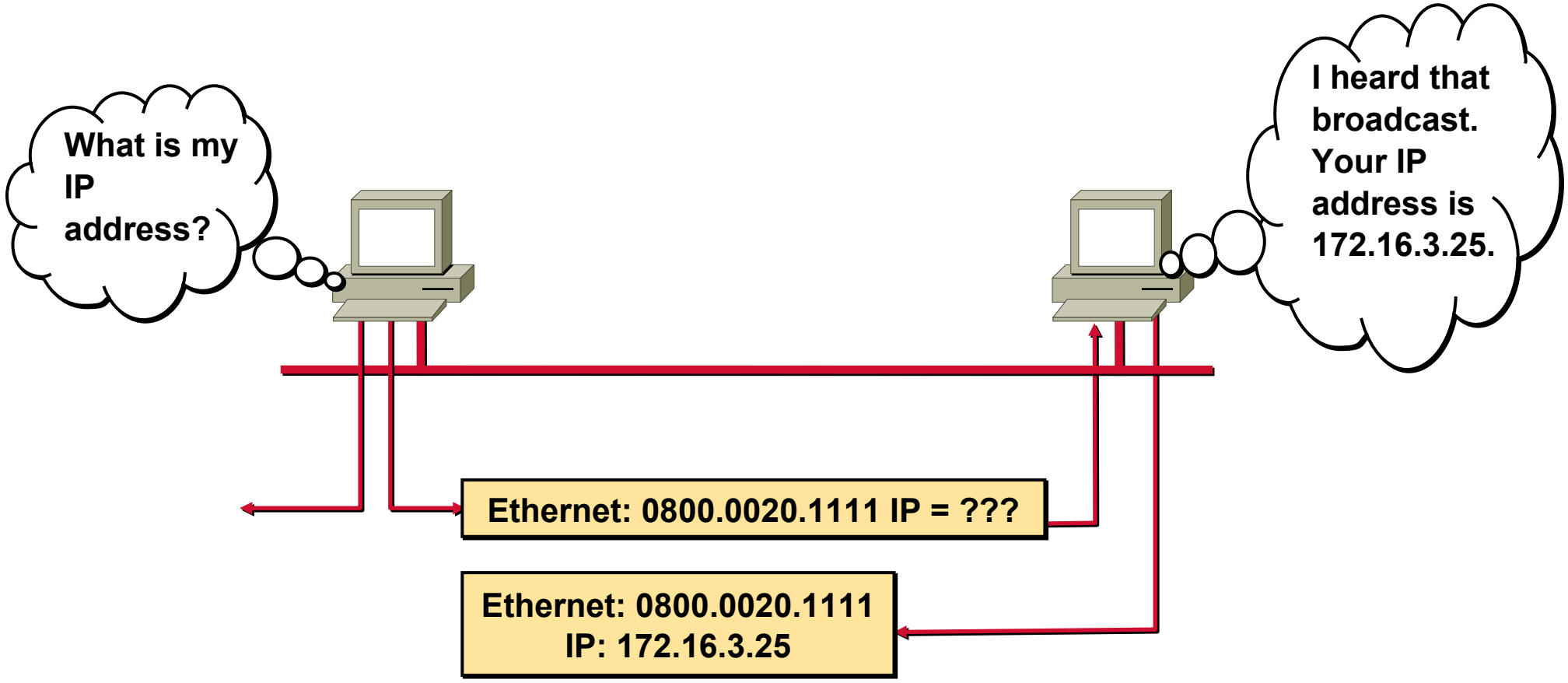
Address Resolution Protocol



Map IP → Ethernet

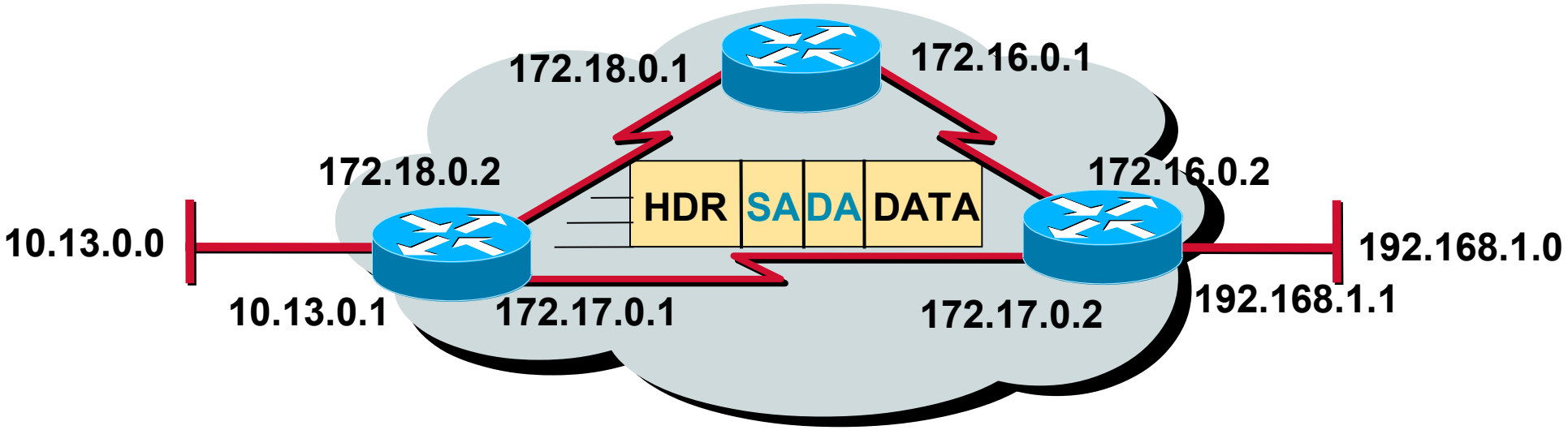
Local ARP

Reverse ARP



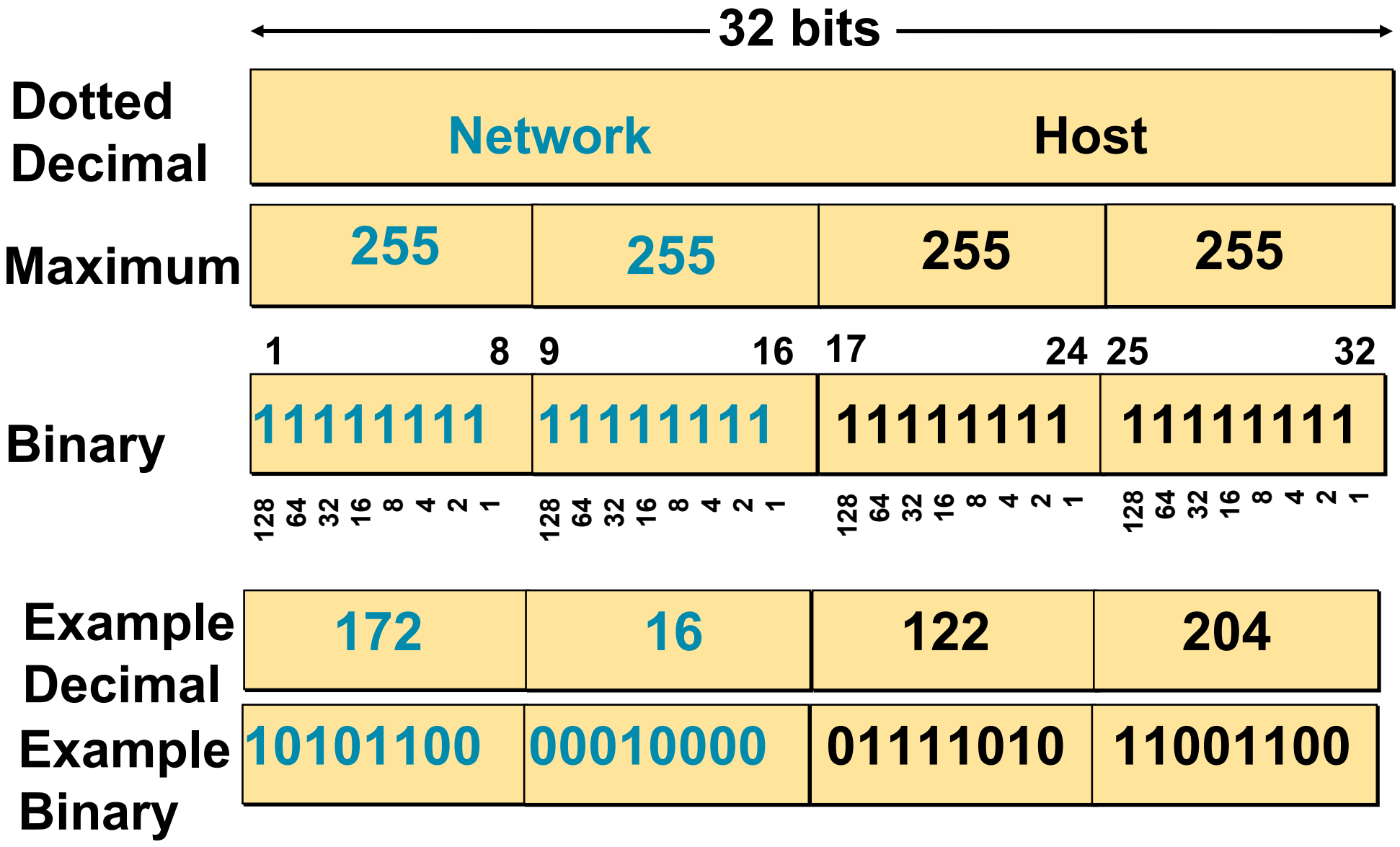
Map Ethernet → IP

Introduction to TCP/IP Addresses

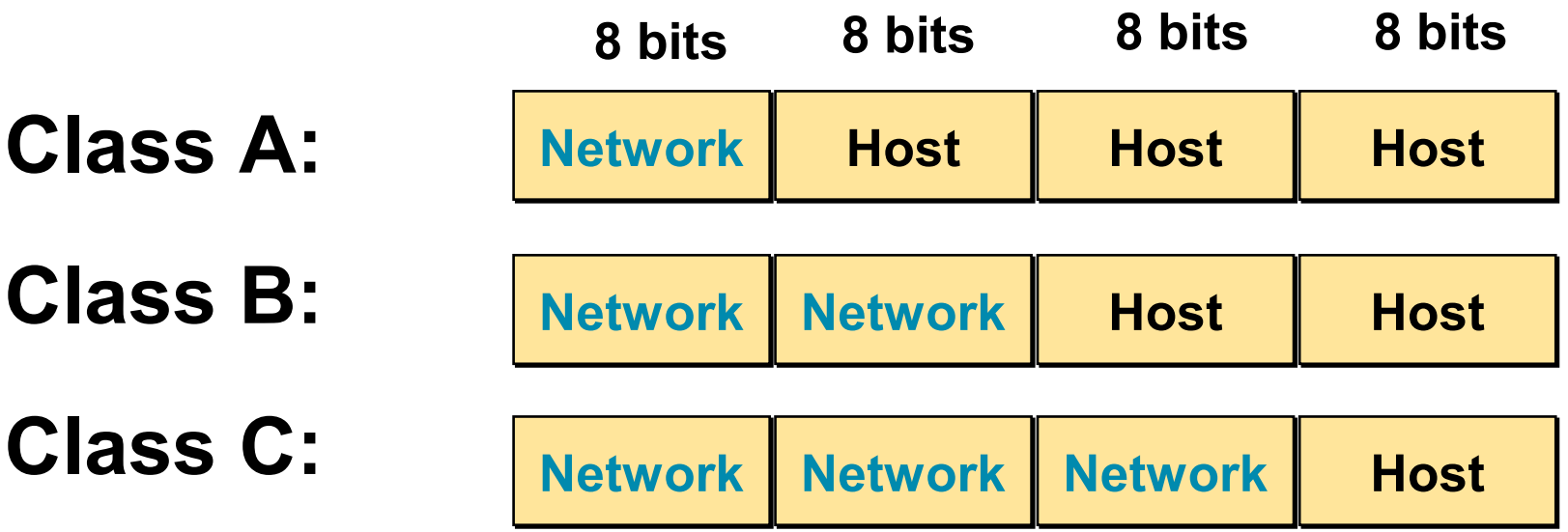


- Unique addressing allows communication between end stations
- Path choice is based on location

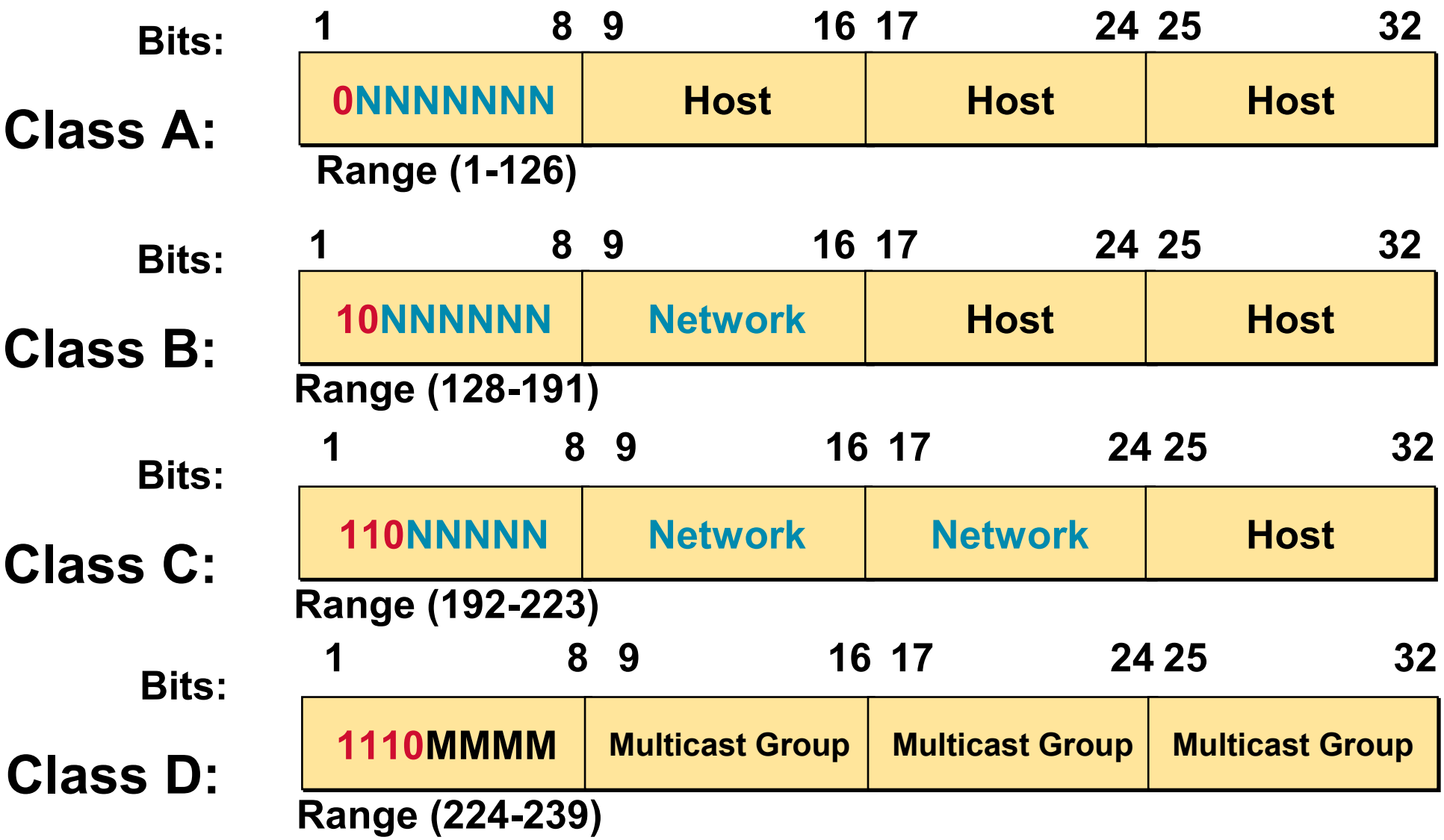
IP Addressing



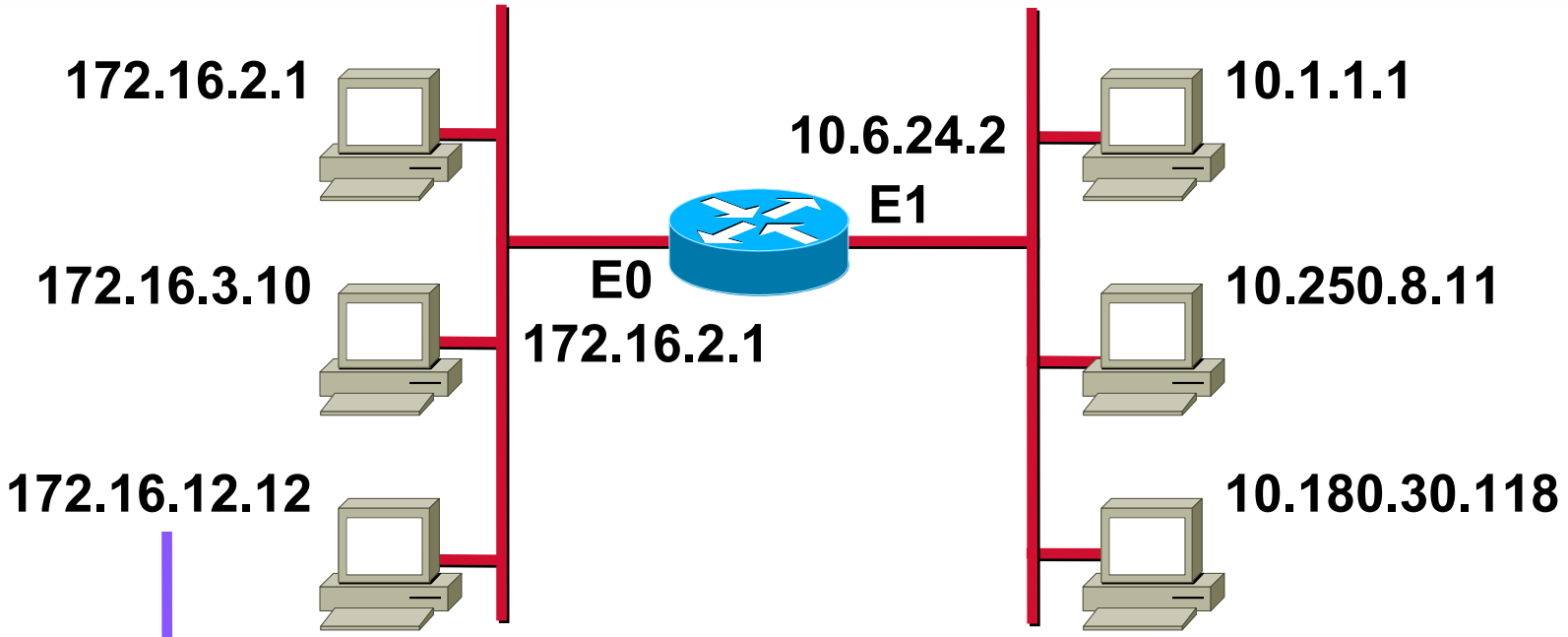
IP Address Classes



IP Address Classes



Host Addresses



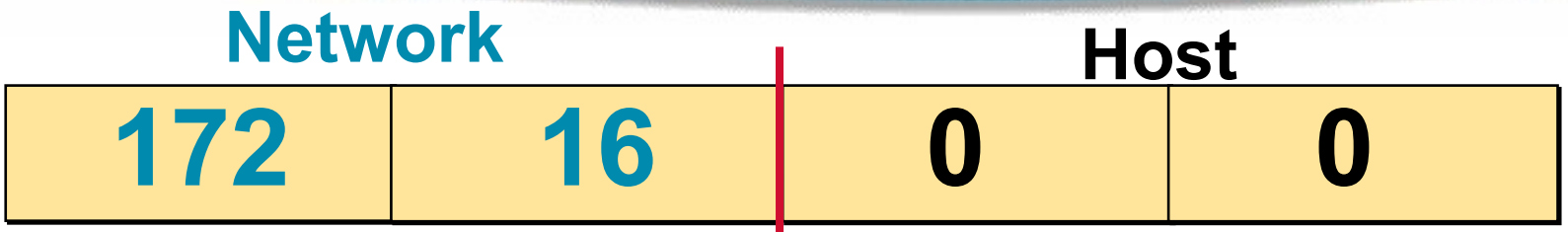
172.16 . 12 . 12

Network Host

Routing Table

Network	Interface
172.16.0.0	E0
10.0.0.0	E1

Determining Available Host Addresses



		16 15 14 13 12 11 10 9	8 7 6 5 4 3 2 1	N
10101100	00010000	00000000	00000000	1
		00000000	00000001	2
		00000000	00000010	3
		⋮	⋮	⋮
		11111111	11111101	65534
		11111111	11111110	65535
		11111111	11111111	65536

$$2^N-2 = 2^{16}- 2 = 65534$$

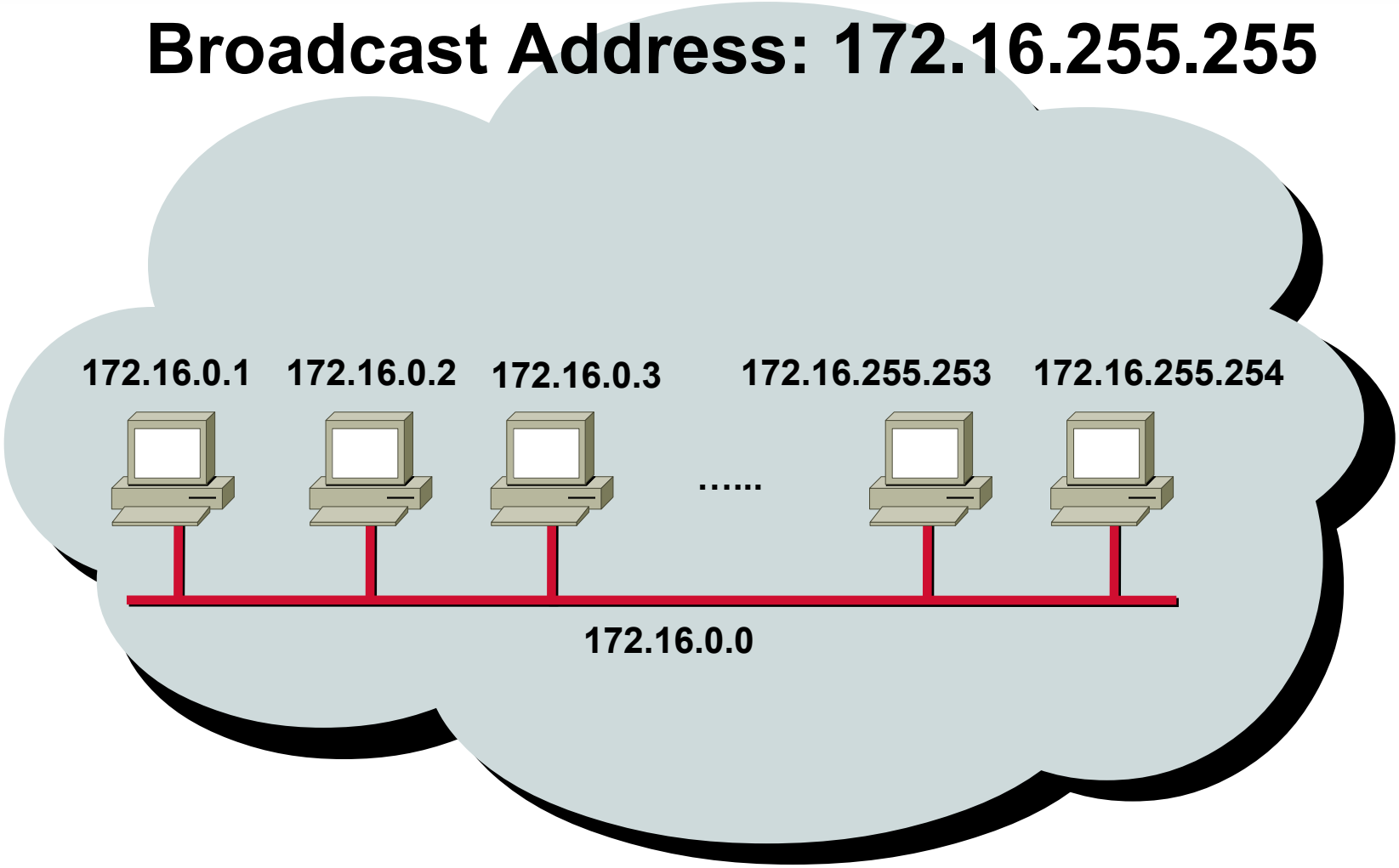
$$\begin{array}{r} 65536 \\ -\quad 2 \\ \hline 65534 \end{array}$$

IP Address Classes Exercise

Address	Class	Network	Host
10.2.1.1			
128.63.2.100			
201.222.5.64			
192.6.141.2			
130.113.64.16			
141.201.257.10			

Addressing without Subnets

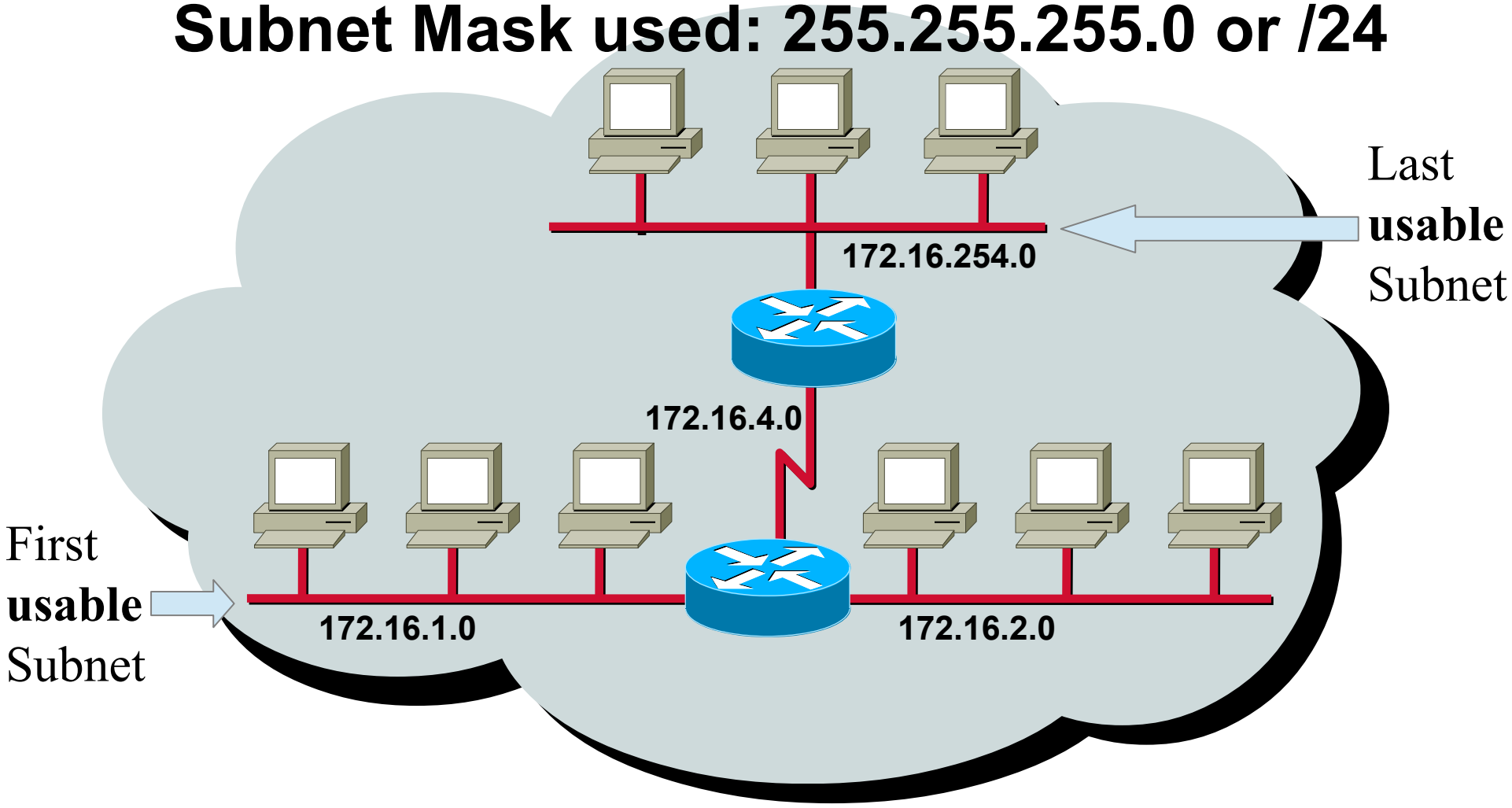
Broadcast Address: 172.16.255.255



Network Address: 172.16.0.0

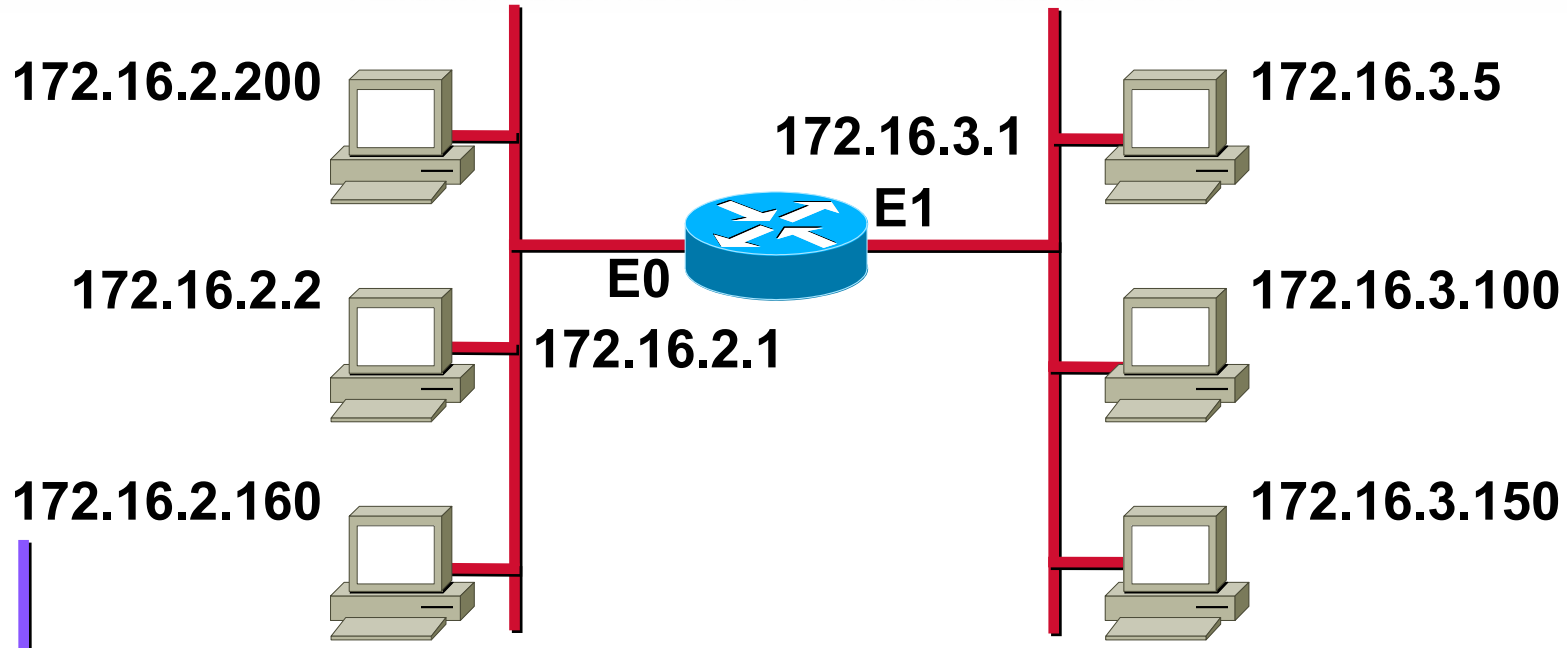
Addressing with Subnets

Subnet Mask used: 255.255.255.0 or /24



Network 172.16.0.0

Subnet Addressing if using SM = 255.255.255.0

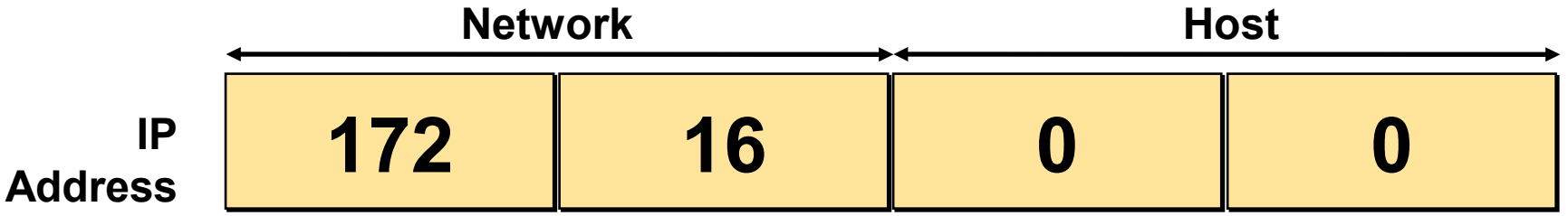


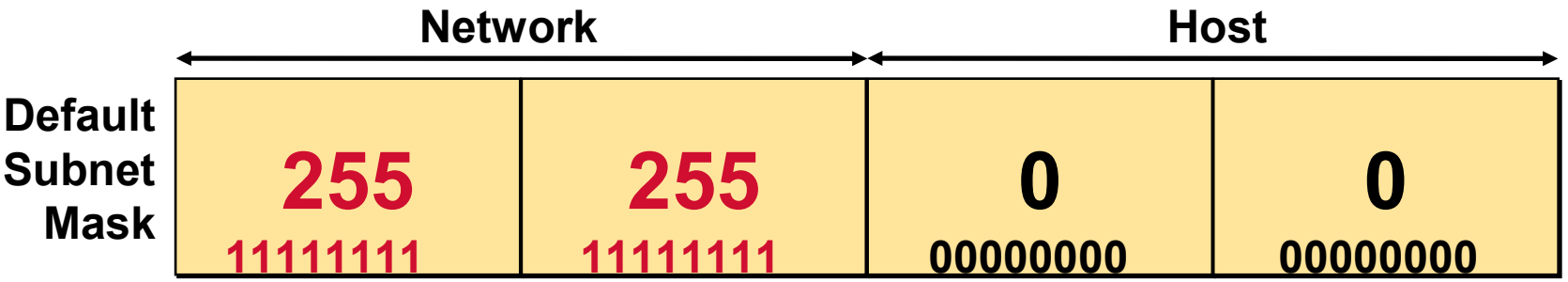
172.16 . 2 . 160

Network Subnet Host

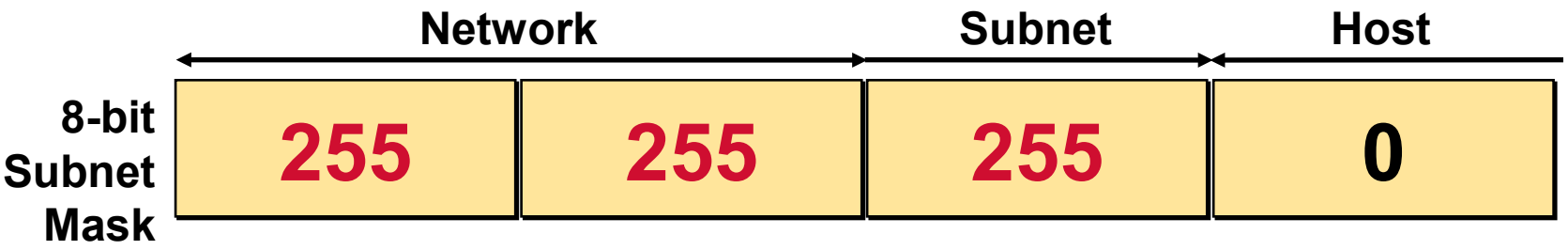
New Routing Table	
Network	Interface
172.16.2.0	E0
172.16.3.0	E1

Subnet Mask



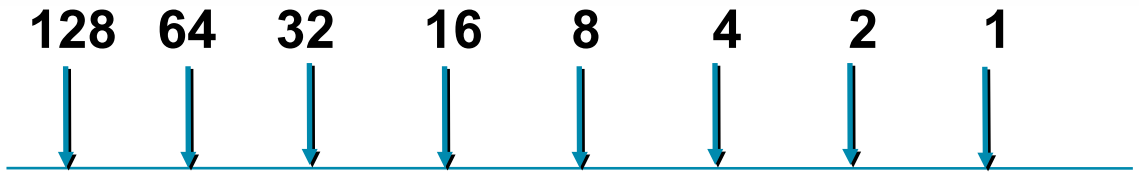


Also written as "/16" where 16 represents the number of 1s in the mask.



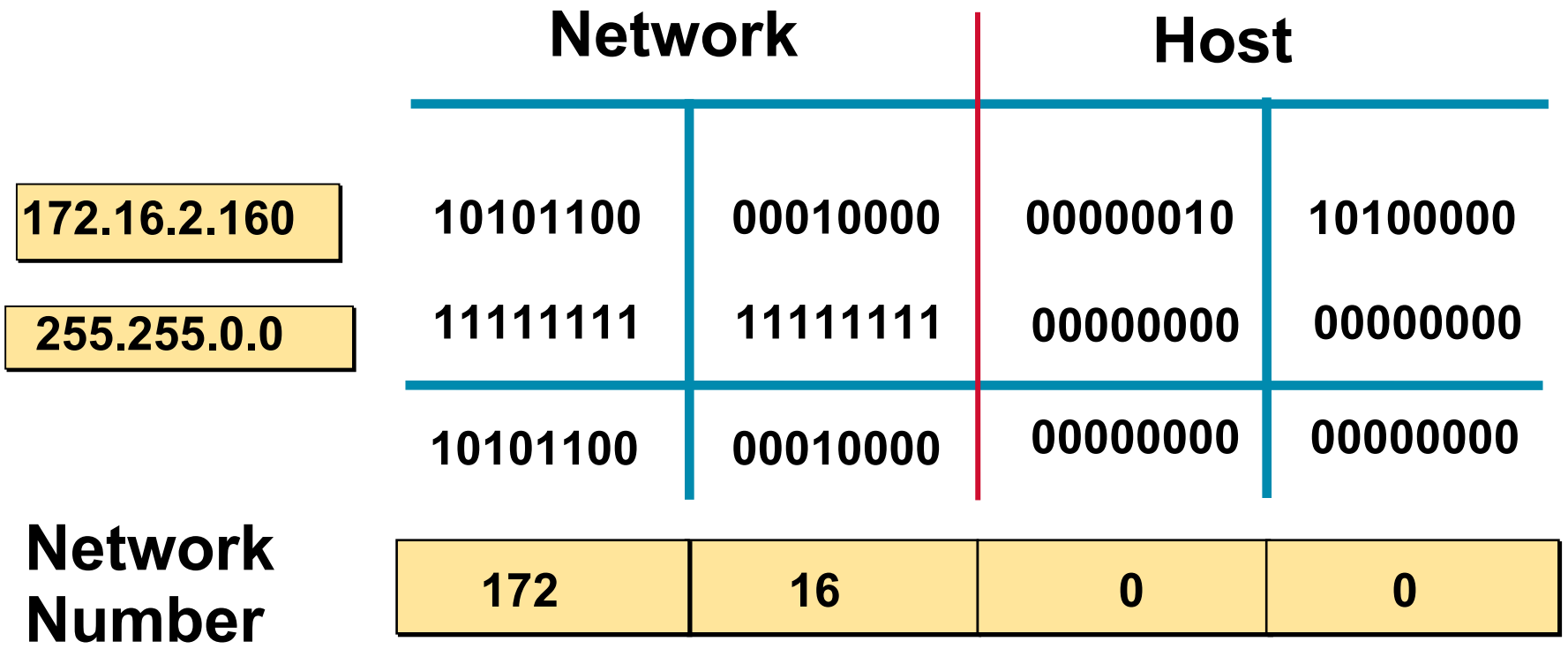
Also written as "/24" where 24 represents the number of 1s in the mask.

Decimal Equivalents of Bit Patterns



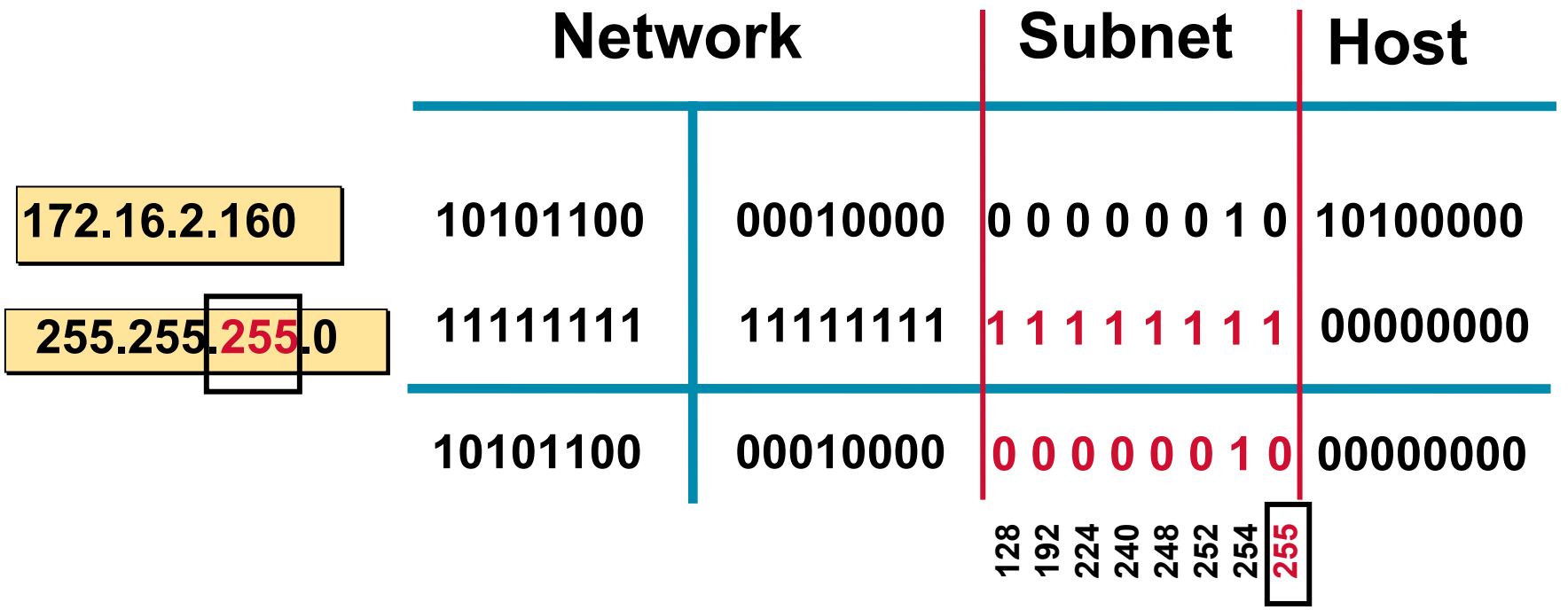
1	0	0	0	0	0	0	0	=	128
1	1	0	0	0	0	0	0	=	192
1	1	1	0	0	0	0	0	=	224
1	1	1	1	0	0	0	0	=	240
1	1	1	1	1	0	0	0	=	248
1	1	1	1	1	1	0	0	=	252
1	1	1	1	1	1	1	0	=	254
1	1	1	1	1	1	1	1	=	255

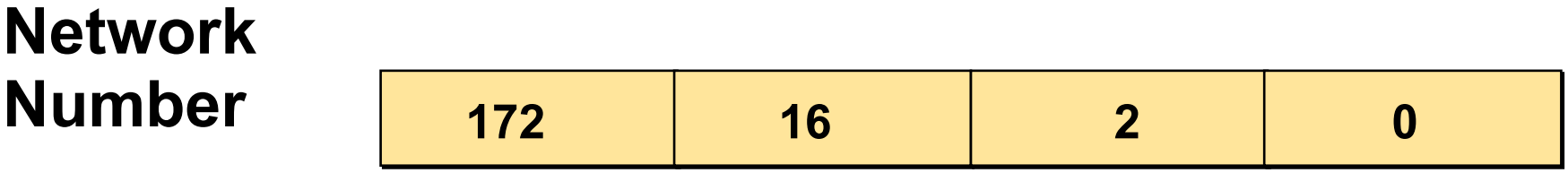
Subnet Mask without Subnets



Subnets not in use—the default

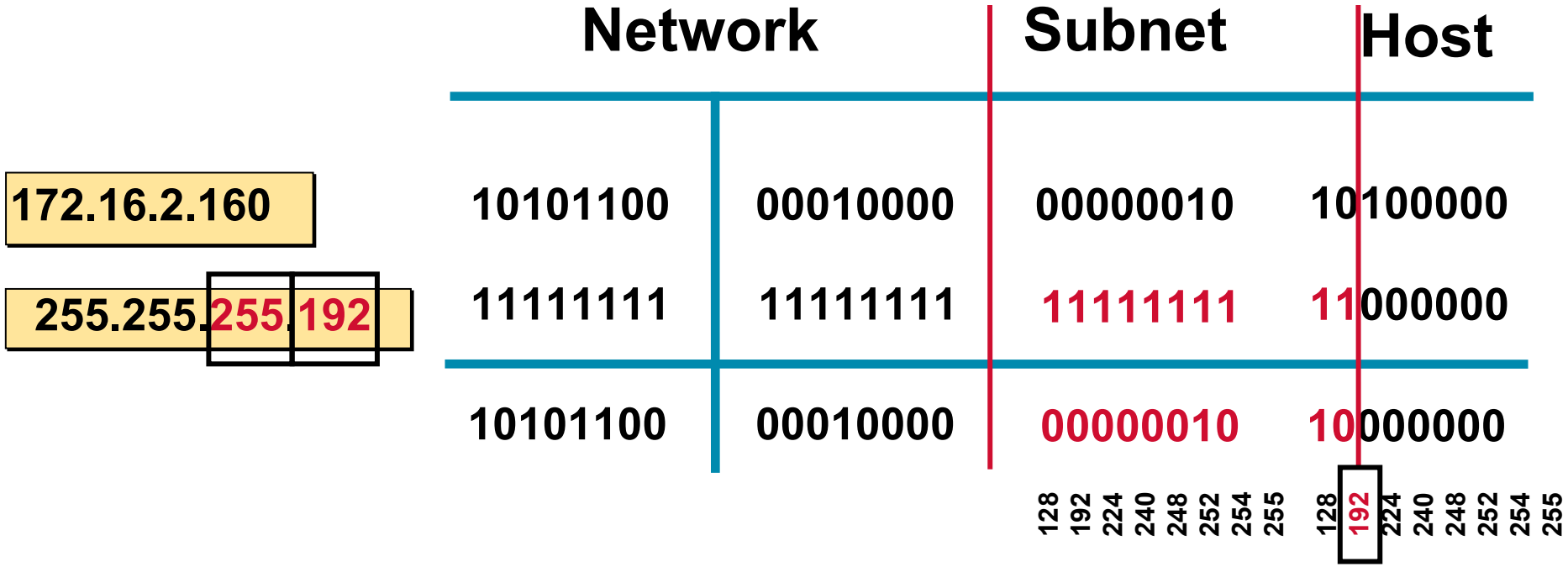
Subnet Mask with Subnets

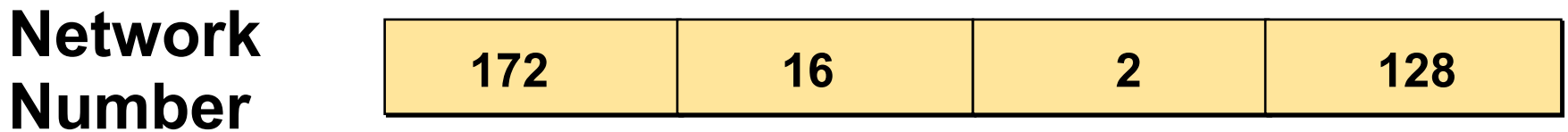




Network number extended by eight bits

Subnet Mask with Subnets (cont.)





Network number extended by ten bits

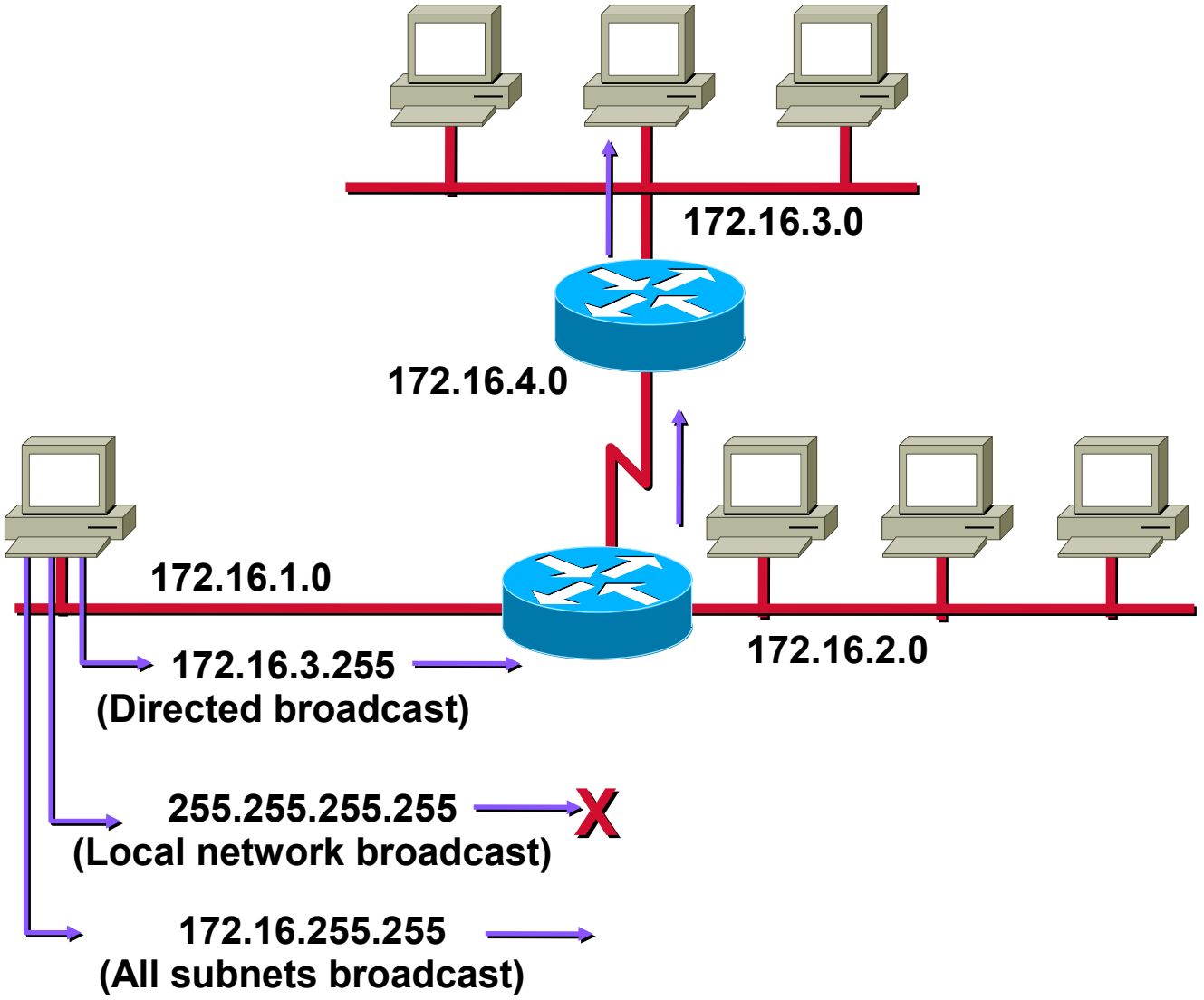
Subnet Mask Exercise Answers

Address	Subnet Mask	Class	Subnet
172.16.2.10			
10.6.24.20			
10.30.36.12			

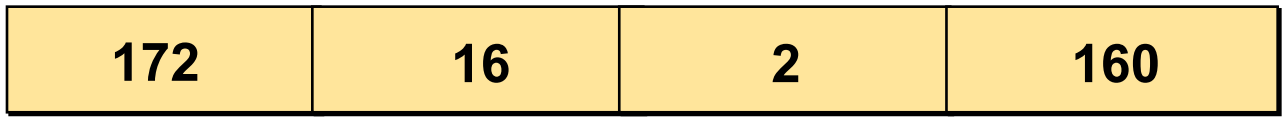
```
10.6.24.20          00001010.00000110.00011000.00010100
255.255.240.0       11111111.11111111.11110000.00000000

Subnet id           00001010.00000110.00010000.00000000
```

Broadcast Addresses



Addressing Summary Example



How many usable subnets = 2^10 – 2 = 1022 subnets

	172.16.2.160	10101100	00010000	00000010	10000000	Host 1
	255.255.255.192	11111111	11111111	11111111	11000000	Mask 2
8	172.16.2.128	10101100	00010000	00000010	10000000	Subnet 4
9	172.16.2.191	10101100	00010000	00000010	10111111	Broadcast 5
	172.16.2.129	10101100	00010000	00000010	10000001	First 6
	172.16.2.190	10101100	00010000	00000010	10111110	Last 7

3

How many hosts per subnet = 2^6 – 2 = 62 hosts per subnet

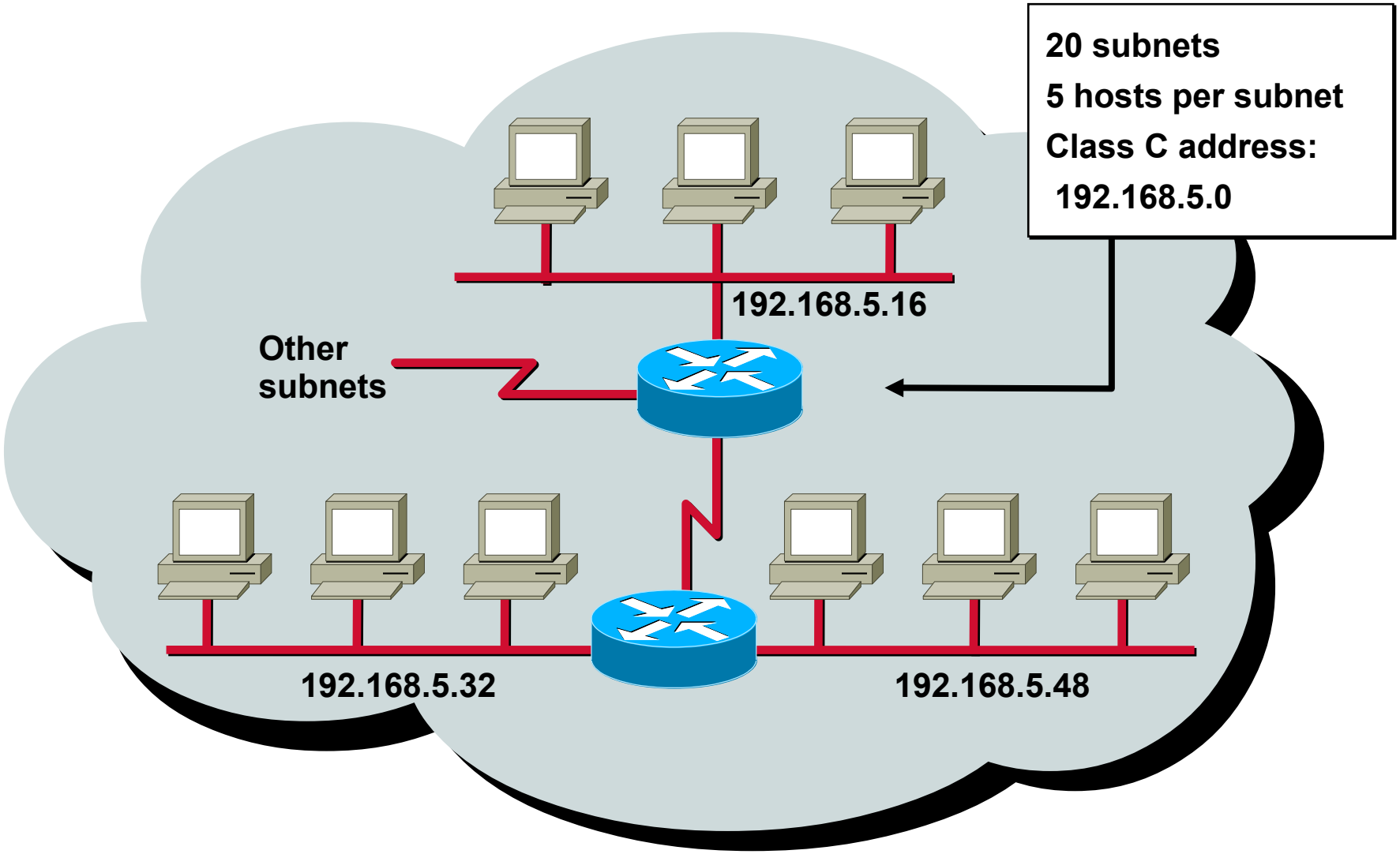
Class B Subnet Example

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
Subnet Broadcast:	10101100	00010000	00000010	11111111

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

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

IP Address	Subnet Mask	Class	Subnet Add	Broadcast Add
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			