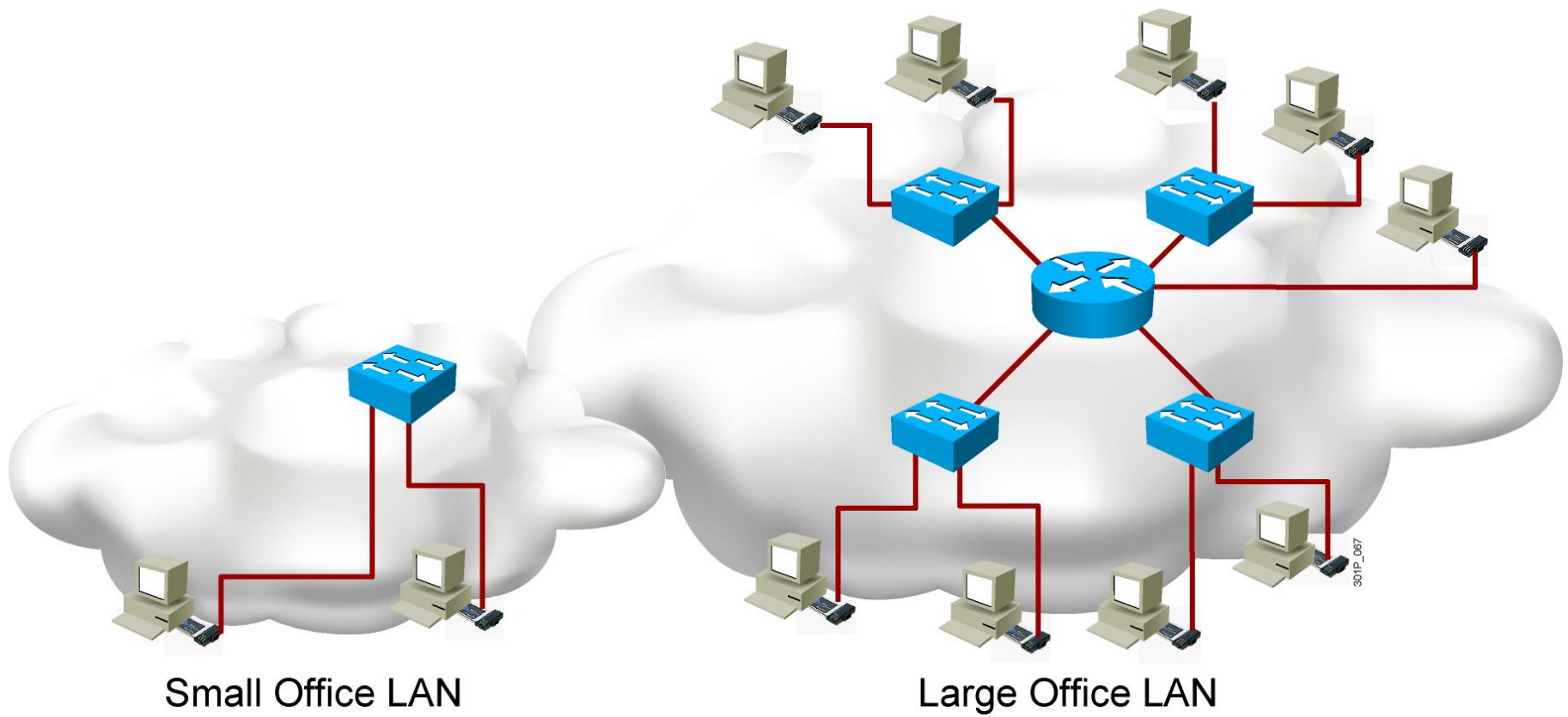




Understanding Ethernet

Local Area Network



LAN Components

- **Computers**

- PCs
- Servers

- **Interconnections**

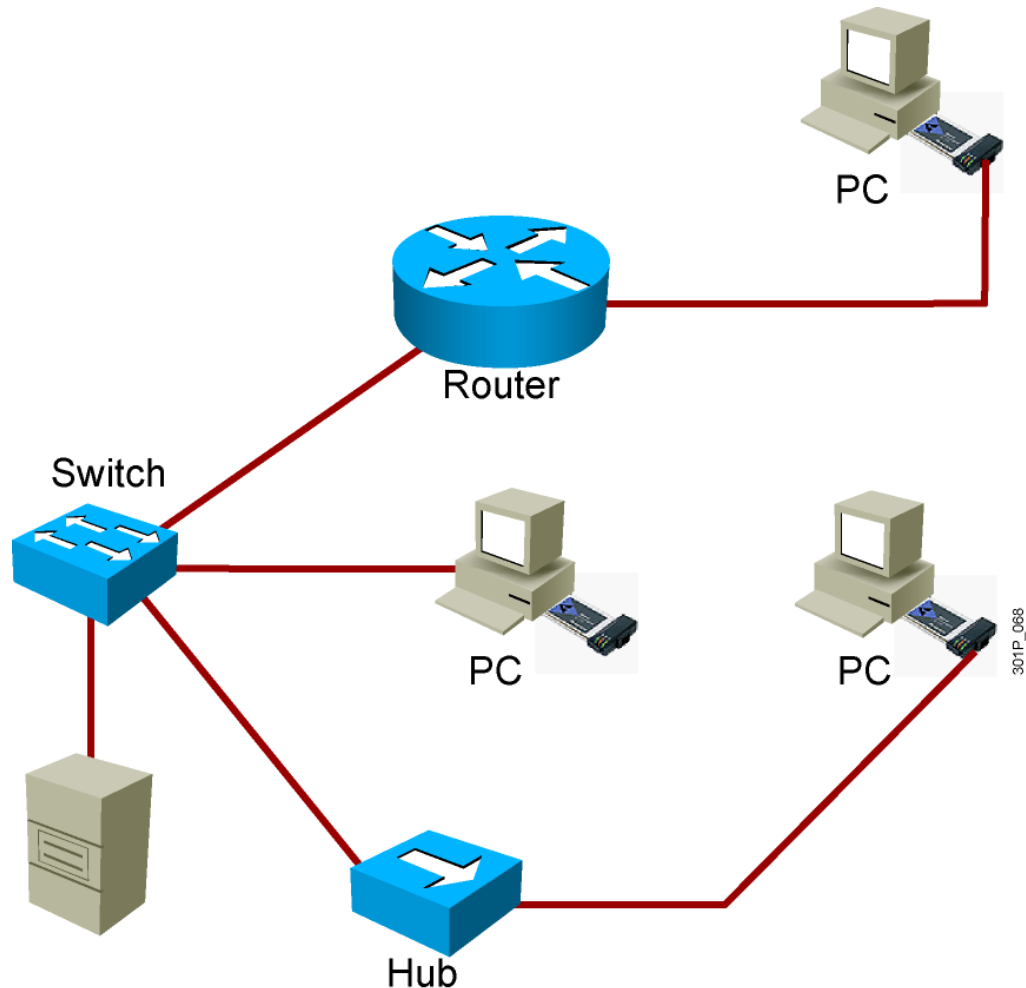
- NICs
- Media

- **Network devices**

- Hubs
- Switches
- Routers

- **Protocols**

- Ethernet
- IP
- ARP
- DHCP



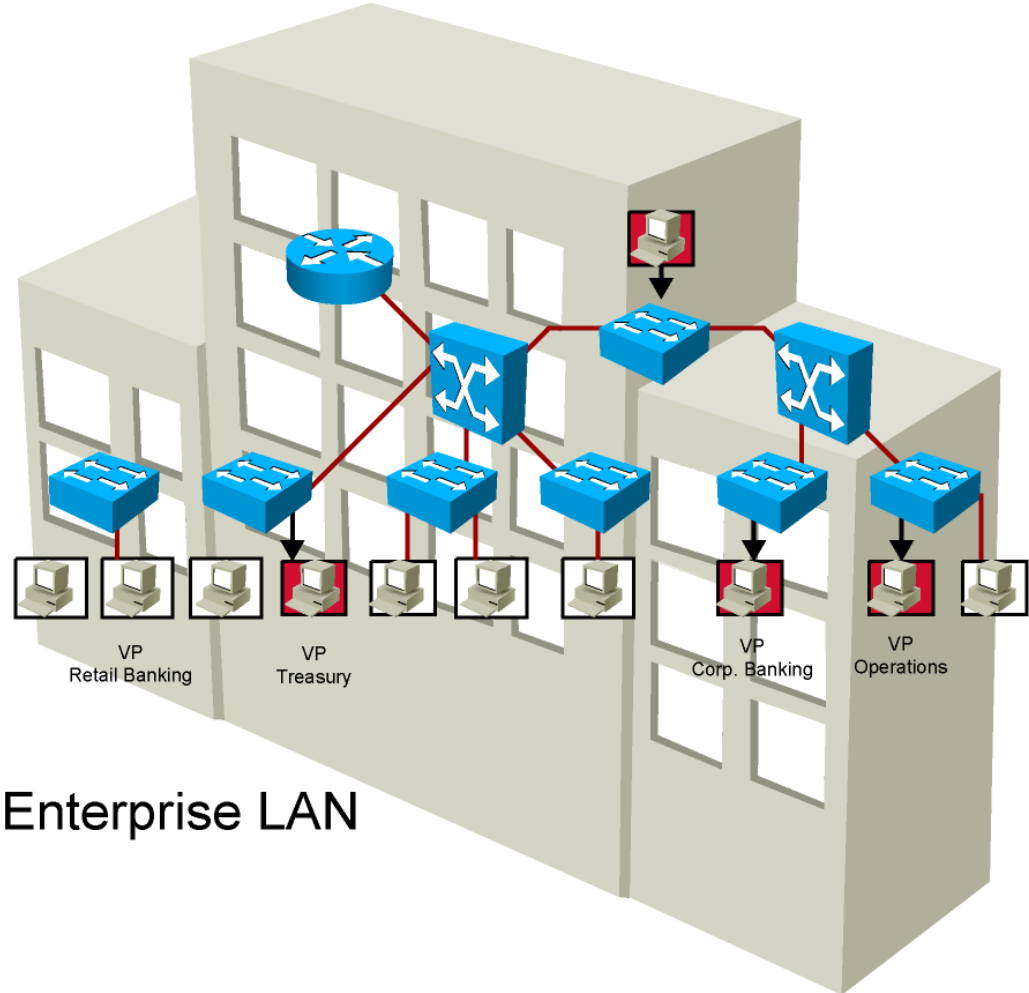
Functions of a LAN

- Data and applications
- Share resources
- Provide communication path to other networks

LAN Sizes



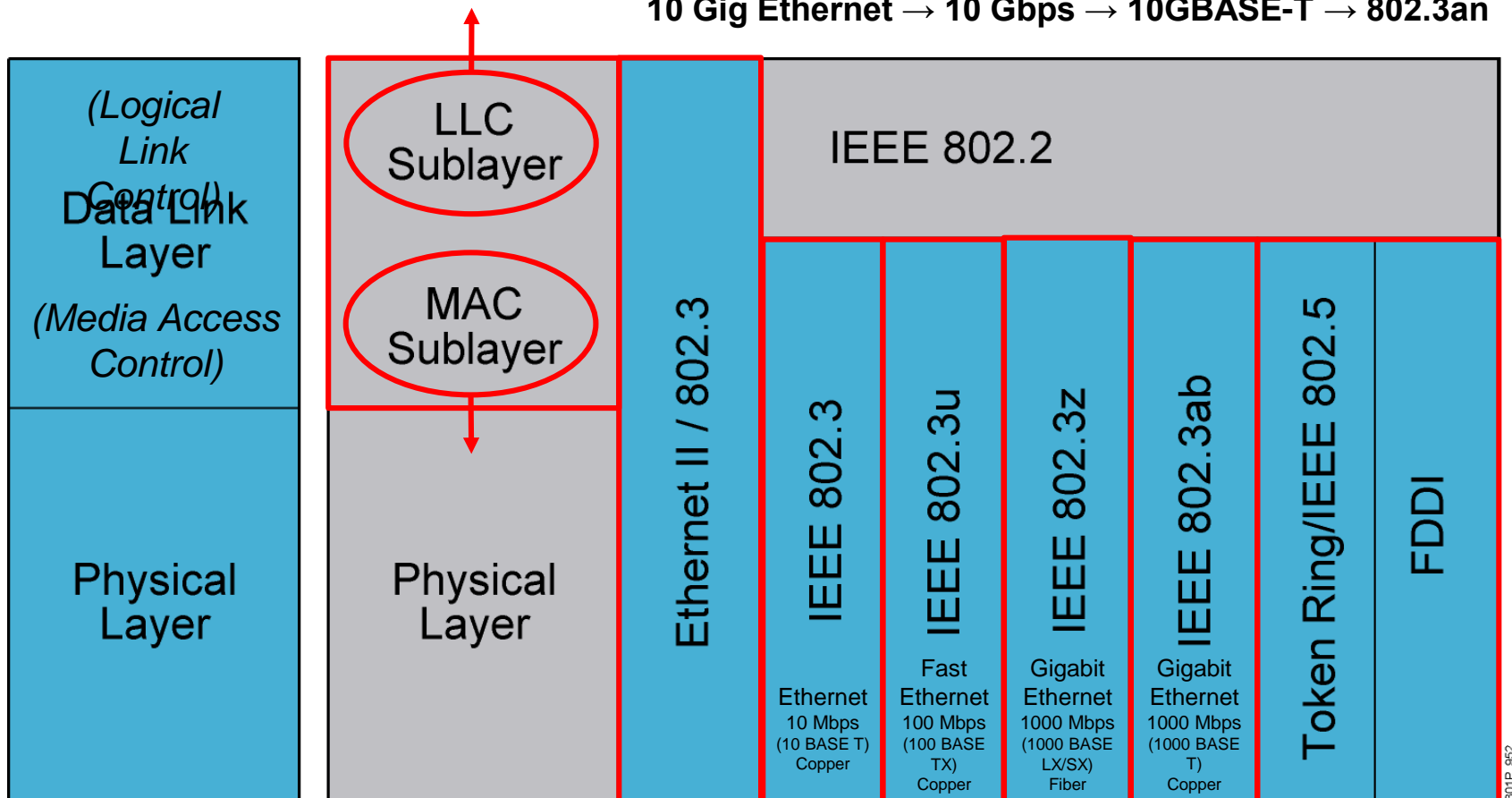
SOHO
LAN



Enterprise LAN

LAN Standards

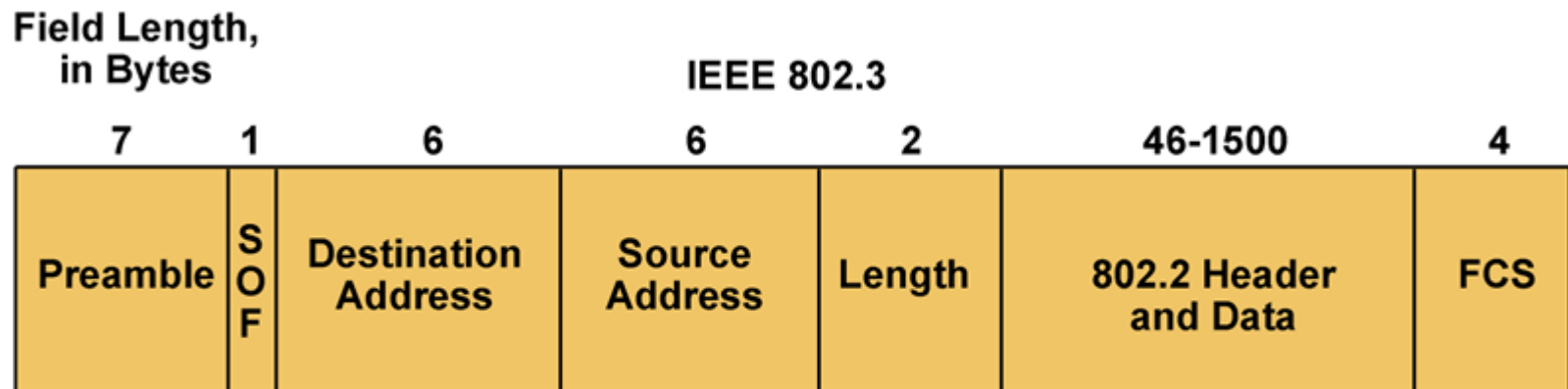
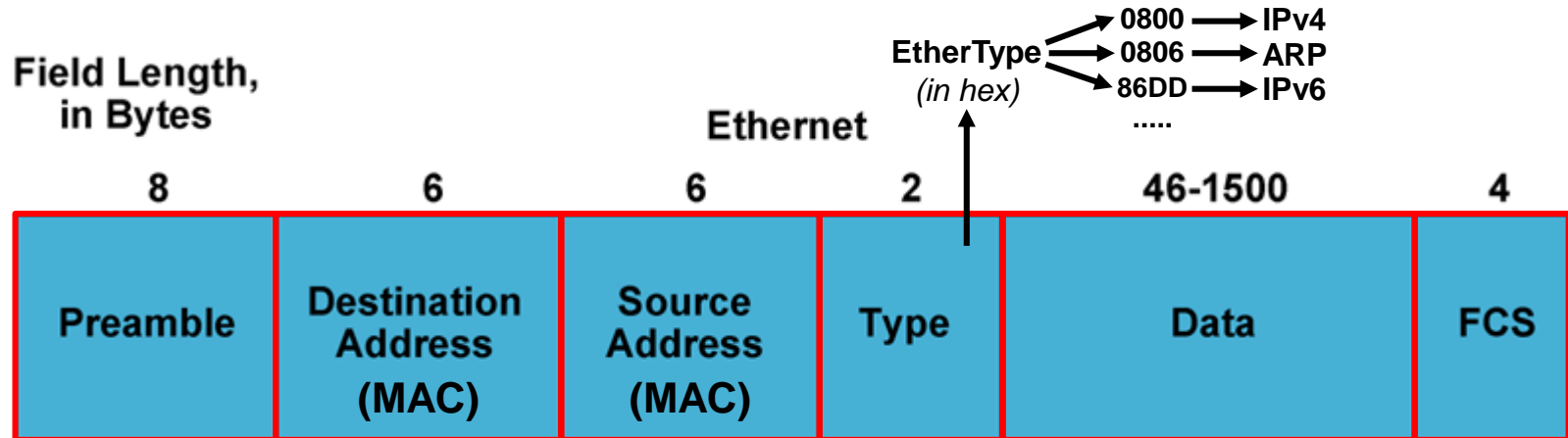
10 Gig Ethernet → 10 Gbps → 10GBASE-T → 802.3an



OSI Layers

LAN Specification
IEEE (Institute of Electrical and
Electronics Engineers)

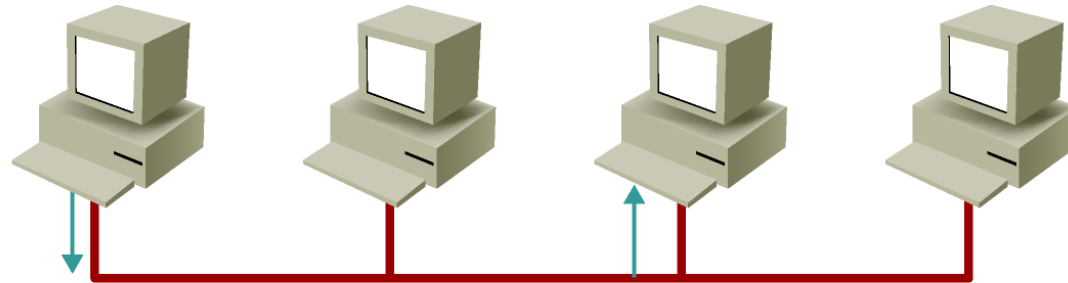
Ethernet Frame Structure



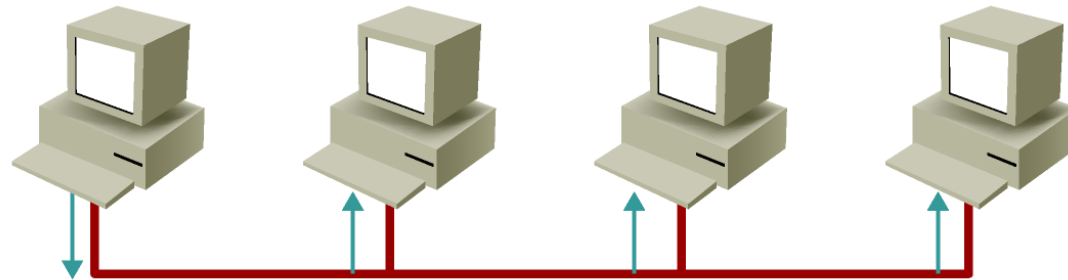
SOF = Start-of-Frame Delimiter
FCS = Frame Check Sequence

Communicating Within the LAN

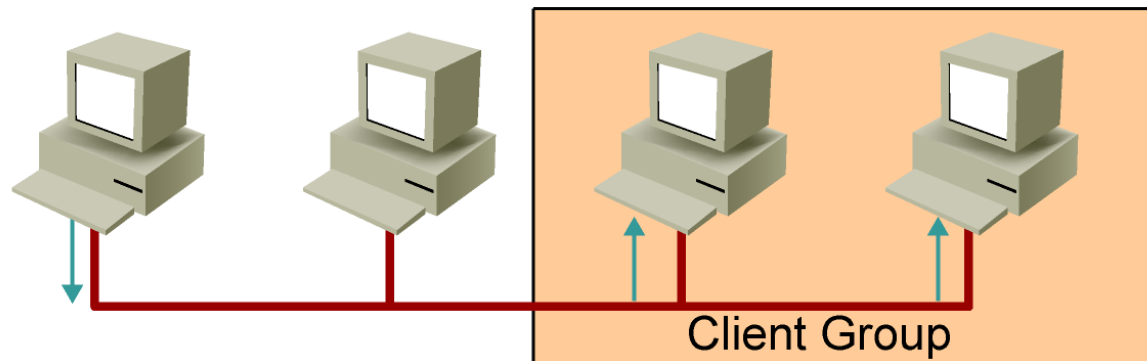
Unicast



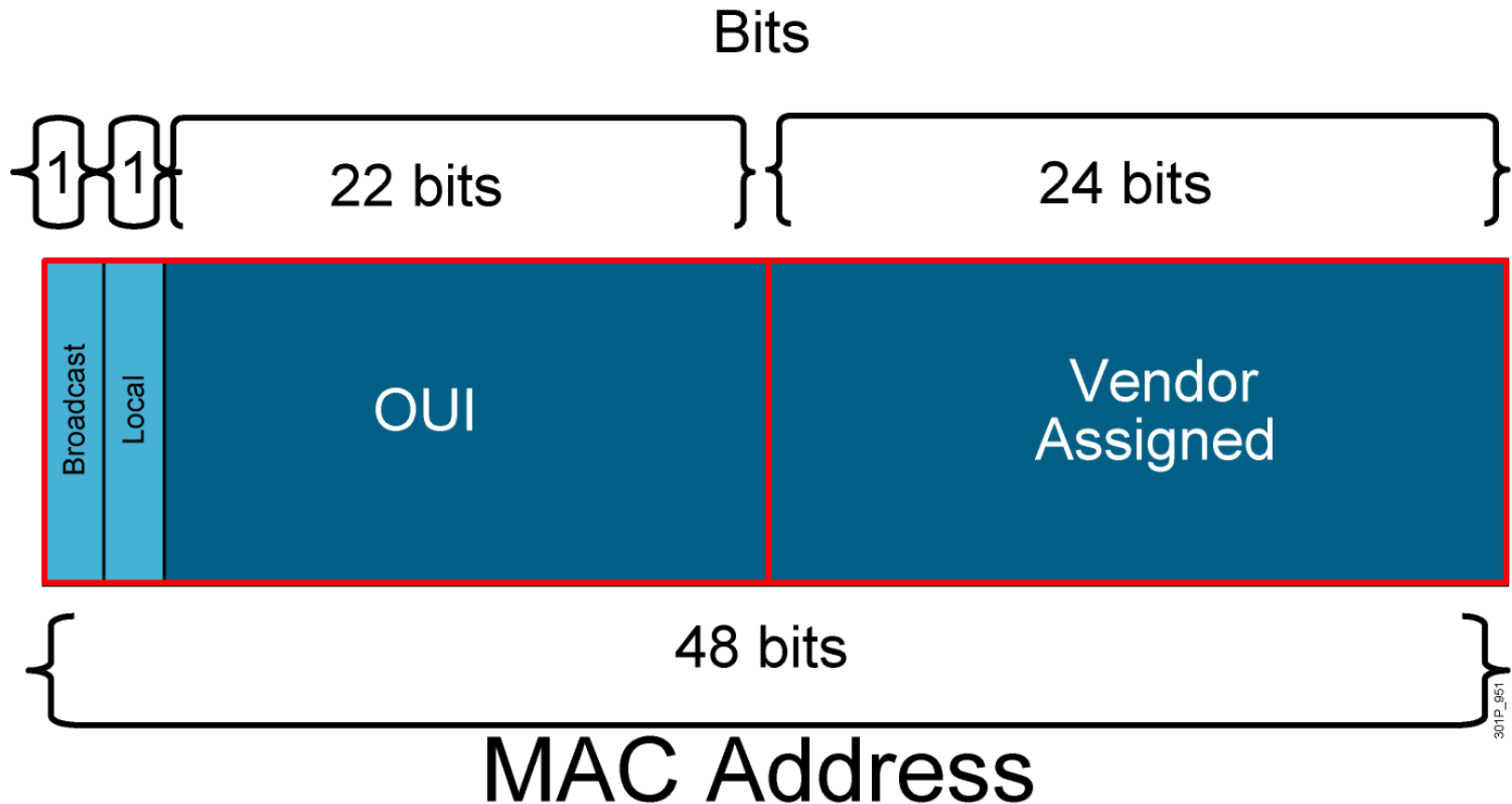
Broadcast



Multicast



MAC Address Components



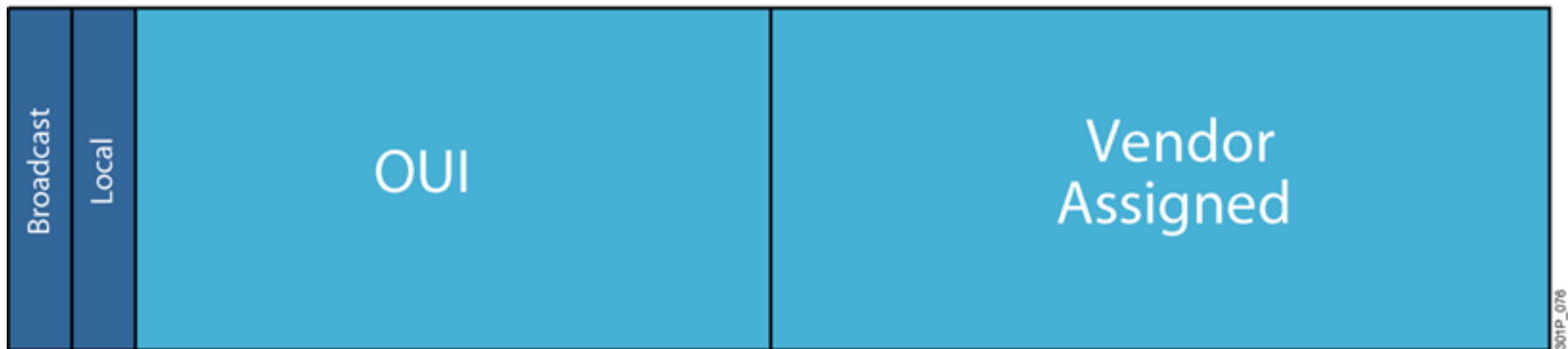
OUI: Organizational Unique Identifier

Decimal-Hexadecimal-Binary Conversion

Decimal (Base 10)	Hexadecimal (Base 16)	Binary (Base 2)
0	0	0 0 0 0
1	1	0 0 0 1
2	2	0 0 1 0
3	3	0 0 1 1
4	4	0 1 0 0
5	5	0 1 0 1
6	6	0 1 1 0
7	7	0 1 1 1
8	8	1 0 0 0
9	9	1 0 0 1
10	A	1 0 1 0
11	B	1 0 1 1
12	C	1 1 0 0
13	D	1 1 0 1
14	E	1 1 1 0
15	F	1 1 1 1

MAC Addresses

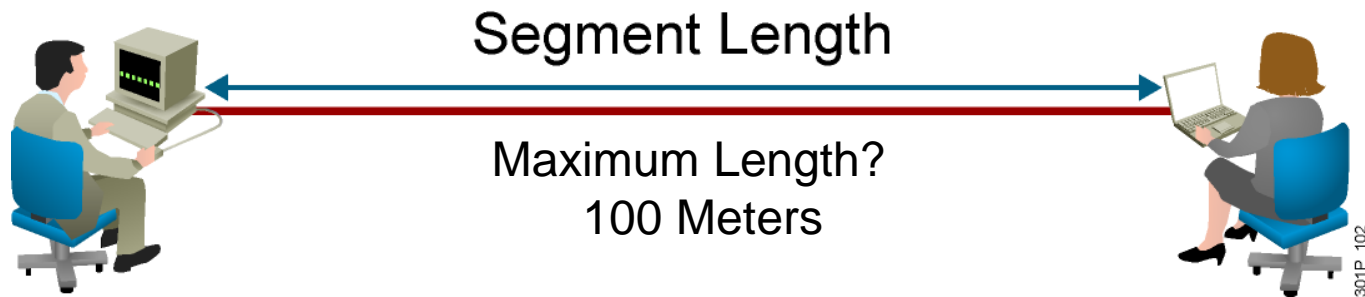
00:00:0c:43:2e:08



00-00-0c-43-2e-08 → Windows, ...

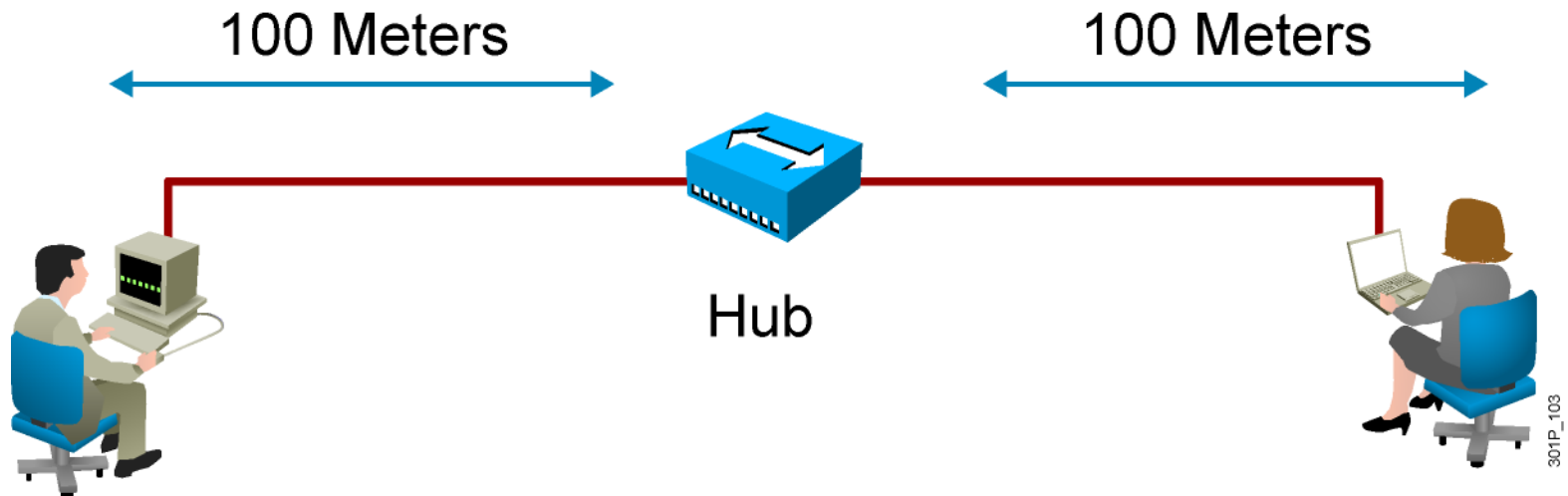
0000.0c43.2e08 → Cisco Devices, ...

LAN Segment Limitations



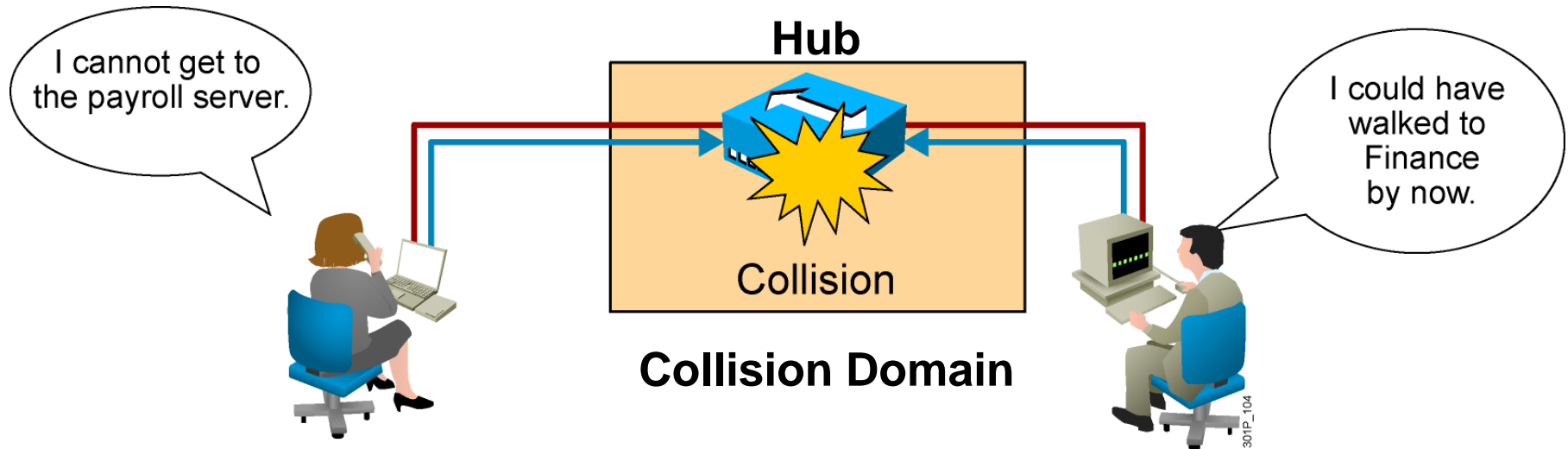
- Signals degrade with transmission distance.
- Each Ethernet type has a maximum segment length.

Extending LAN Segments



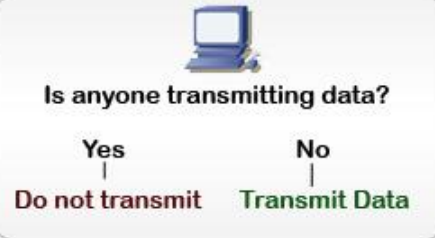
- Shares bandwidth
- Extends cable distances
- Repeats or amplifies signal
- Half-duplex

Collisions

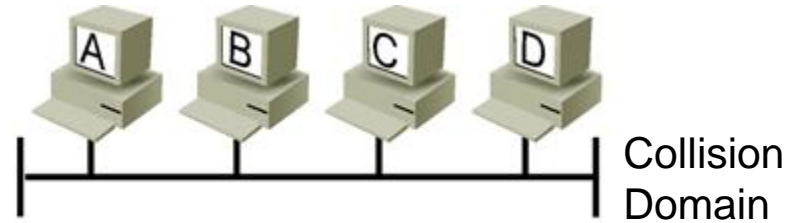


CSMA/CD

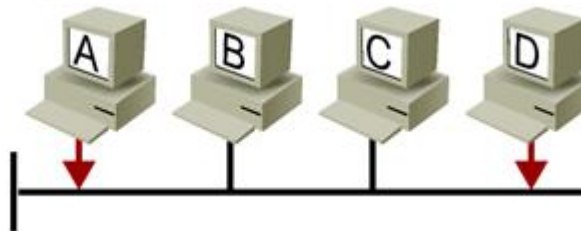
Carrier Sense



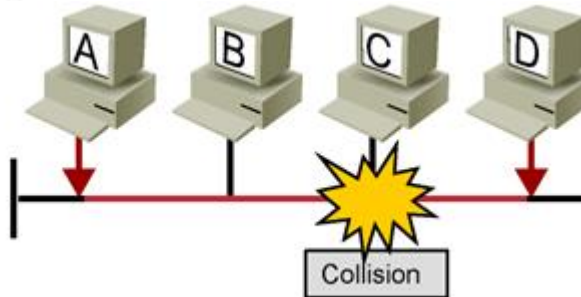
Carrier Sense



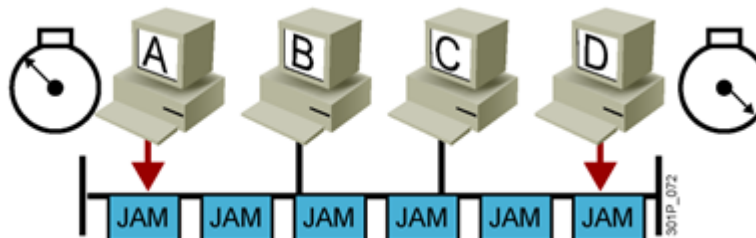
Multiple Access



Collision

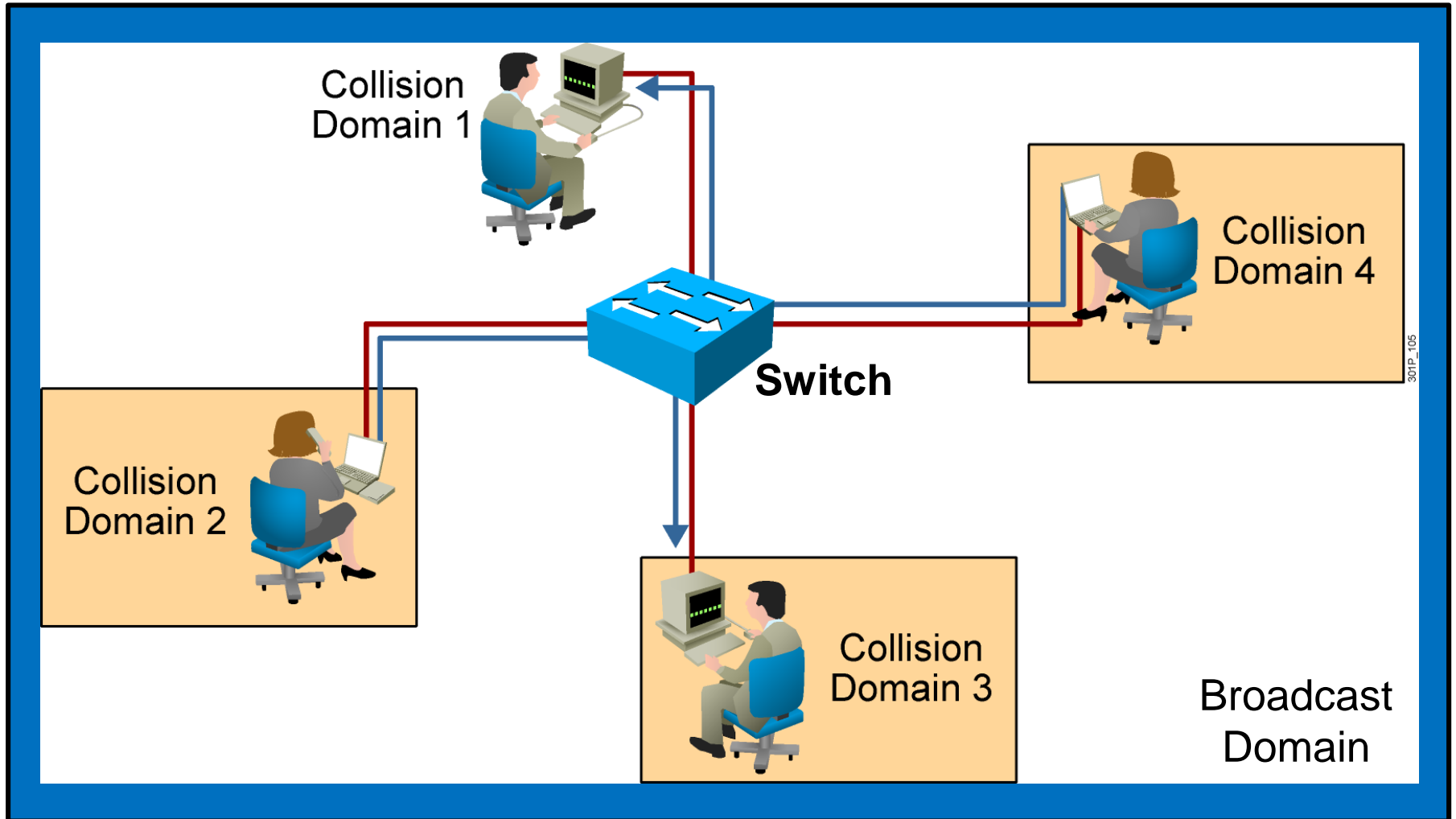


Collision Detection
(Backoff Algorithm)

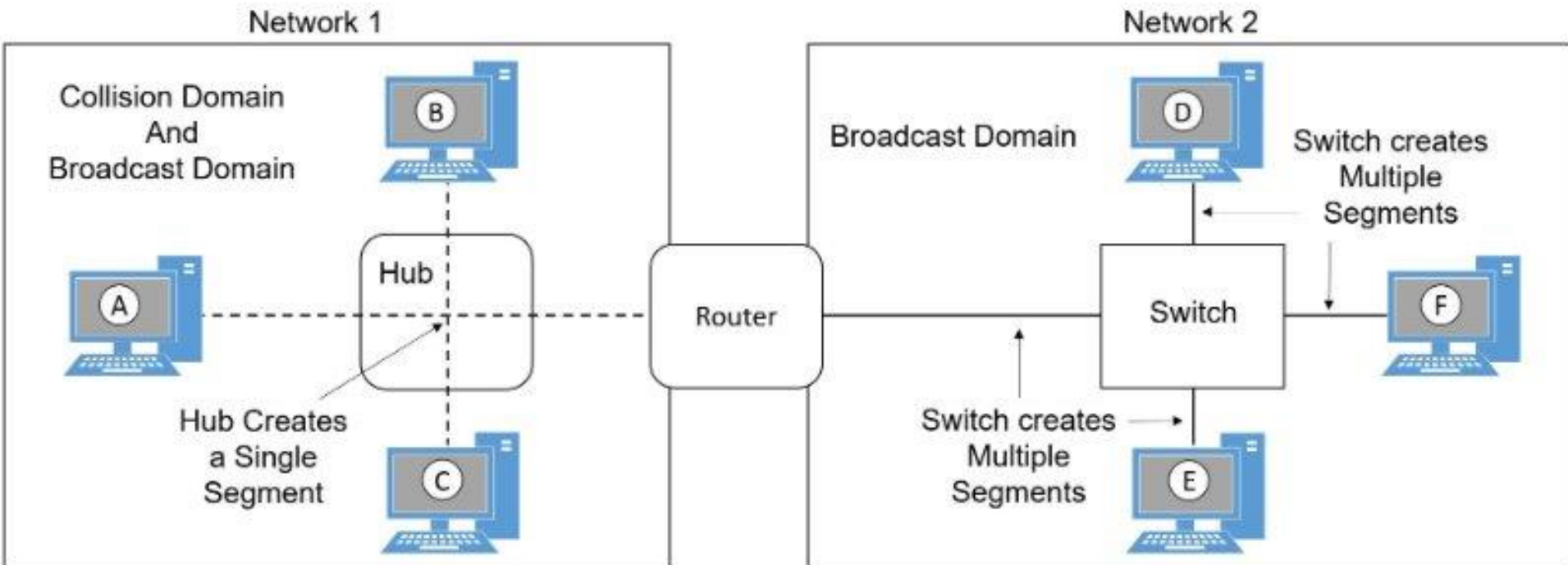


Carrier Sense Multiple Access Collision Detection (CSMA/CD)

Multiple Collision Domains



Collision & Broadcast Domains



- No. of **Broadcast domains** = No. of every active interface of the Routers
- No. of **Collision domains** = No. of every active interface of the Switches & Routers

Collision & Broadcast Domains (cont.)

This device:

- Continues **Collision Domains**
- Continues **Broadcast Domains**



Ethernet Hub

This device:

- Ends **Collision Domains**
- Continues **Broadcast Domains**



Ethernet Switch

These devices:

- End **Collision Domains**
- End **Broadcast Domains**

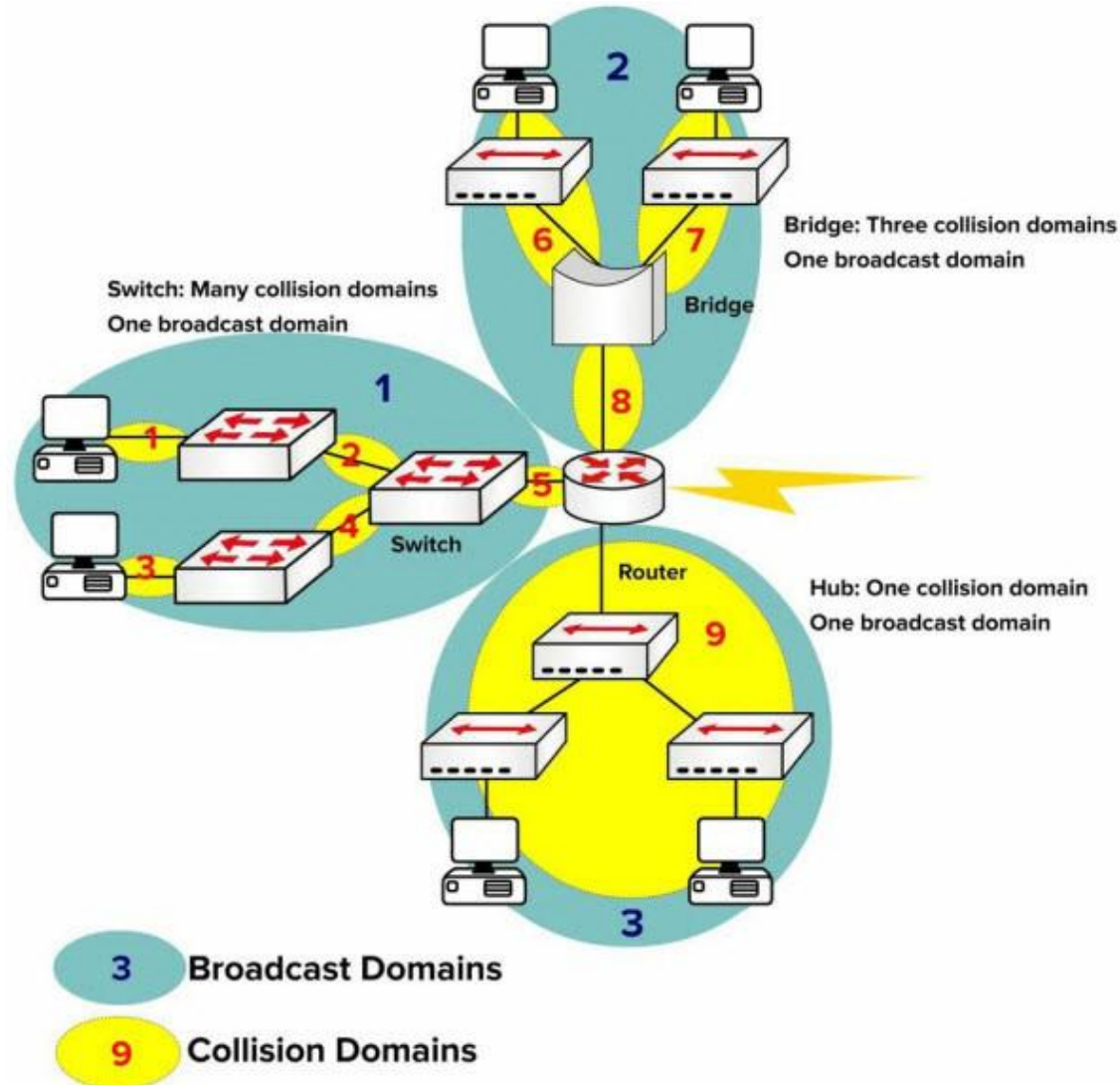


Router

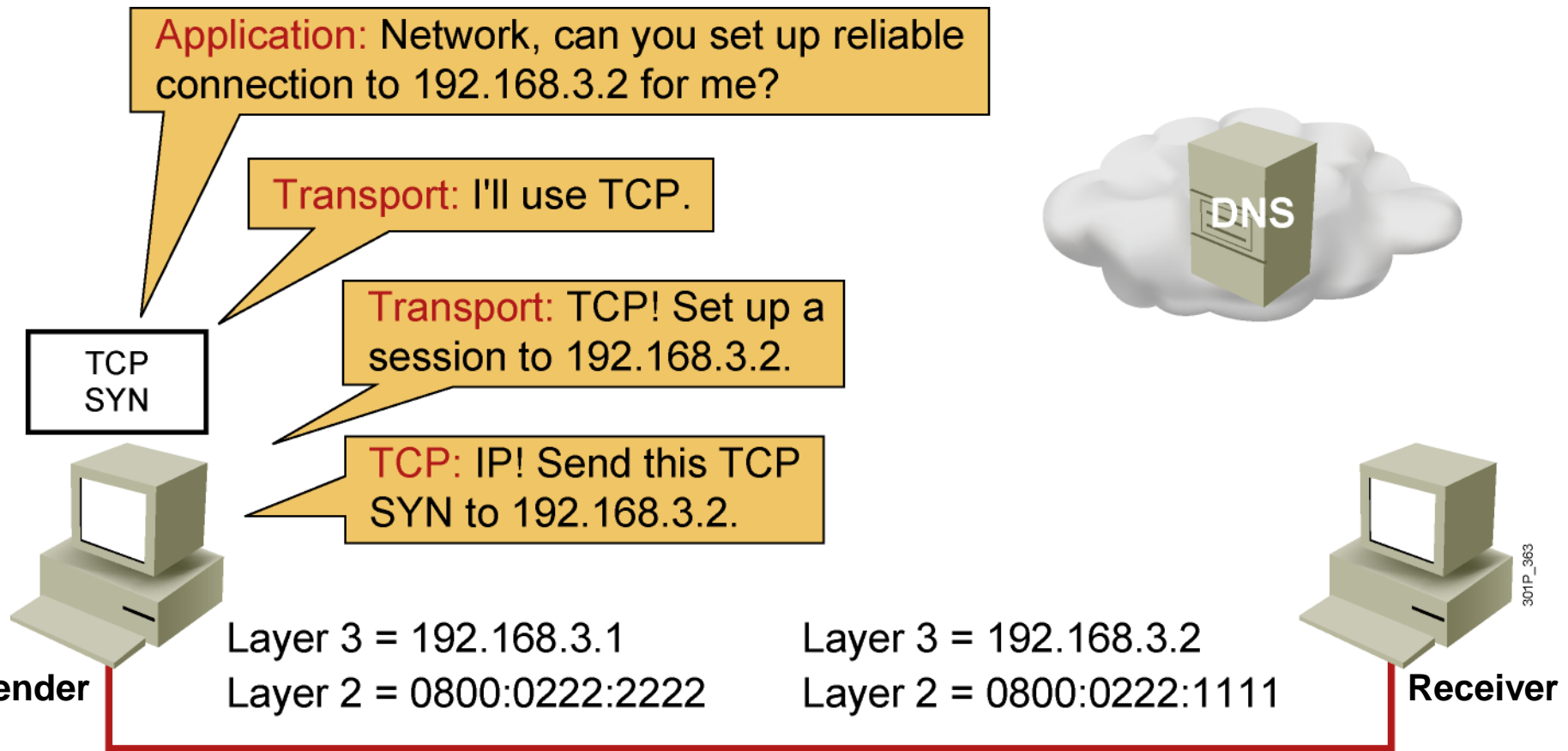


Firewall

Collision & Broadcast Domains Counting Example



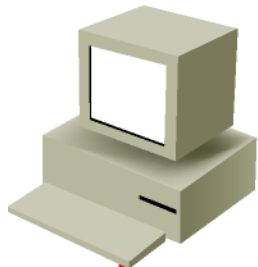
Host-to-Host Packet Delivery (1 of 22)



Host-to-Host Packet Delivery (2 of 22)

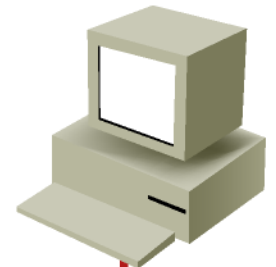
IP: Layer 2! Send this packet to 192.168.3.2 .

SRC IP 192.168.3.1	DST IP 192.168.3.2	TCP SYN
-----------------------	-----------------------	------------



Layer 3 = 192.168.3.1
Layer 2 = 0800:0222:2222

Sender



Layer 3 = 192.168.3.2
Layer 2 = 0800:0222:1111

Receiver

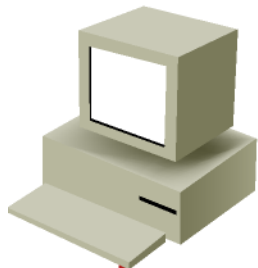
Host-to-Host Packet Delivery (3 of 22)

(Address Resolution Protocol)

Layer 2: ARP, do you have a mapping for 192.168.3.2?

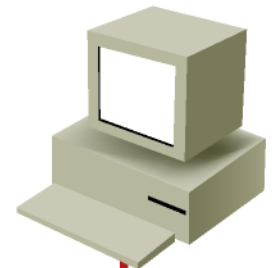
ARP: Is 192.168.3.2 in my ARP table? No, I guess Layer 2 will have to put the packet in the parking lot until I do an ARP.

SRC IP 192.168.3.1	DST IP 192.168.3.2	TCP SYN
-----------------------	-----------------------	------------



Layer 3 = 192.168.3.1
Layer 2 = 0800:0222:2222

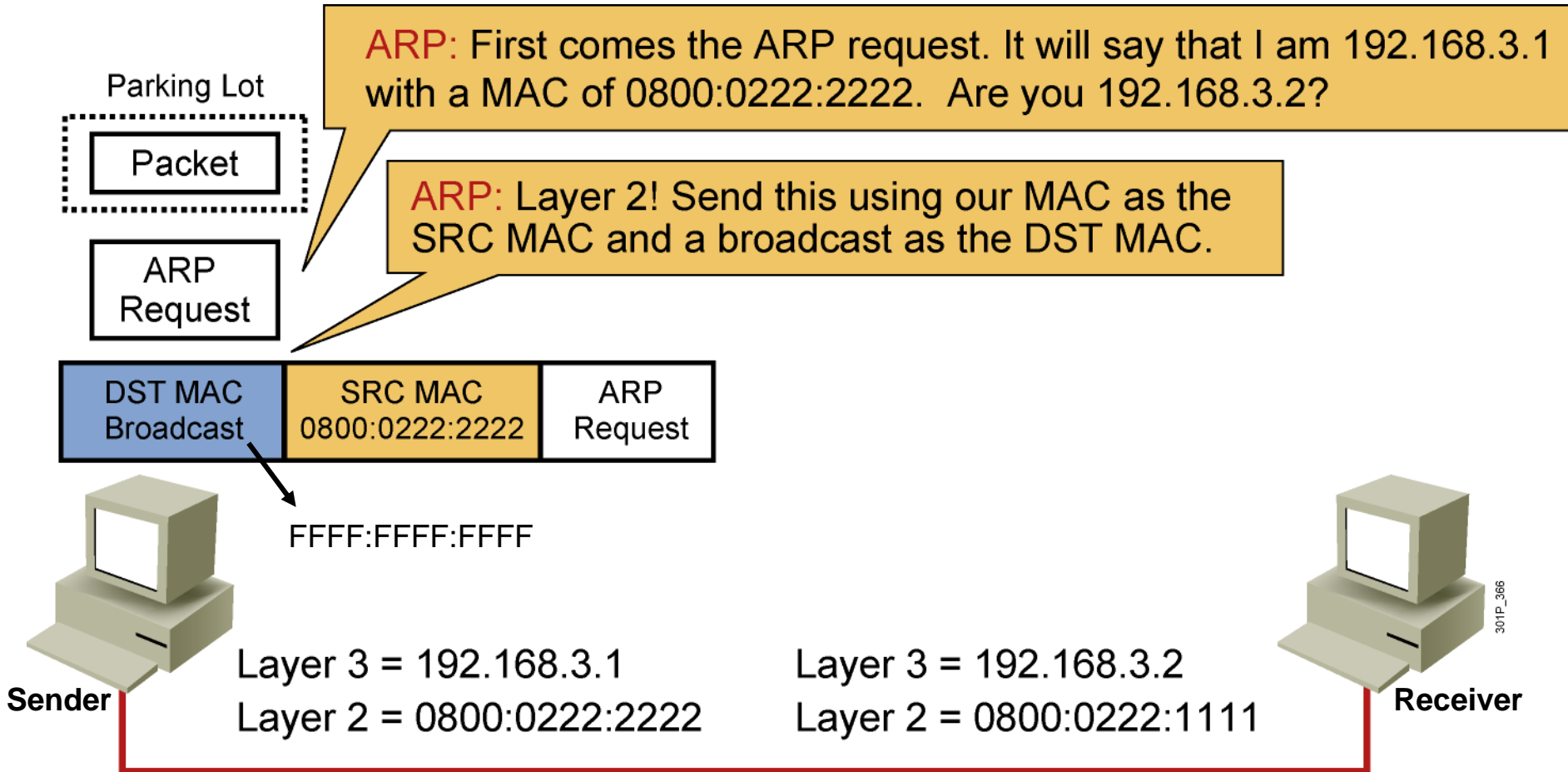
Sender



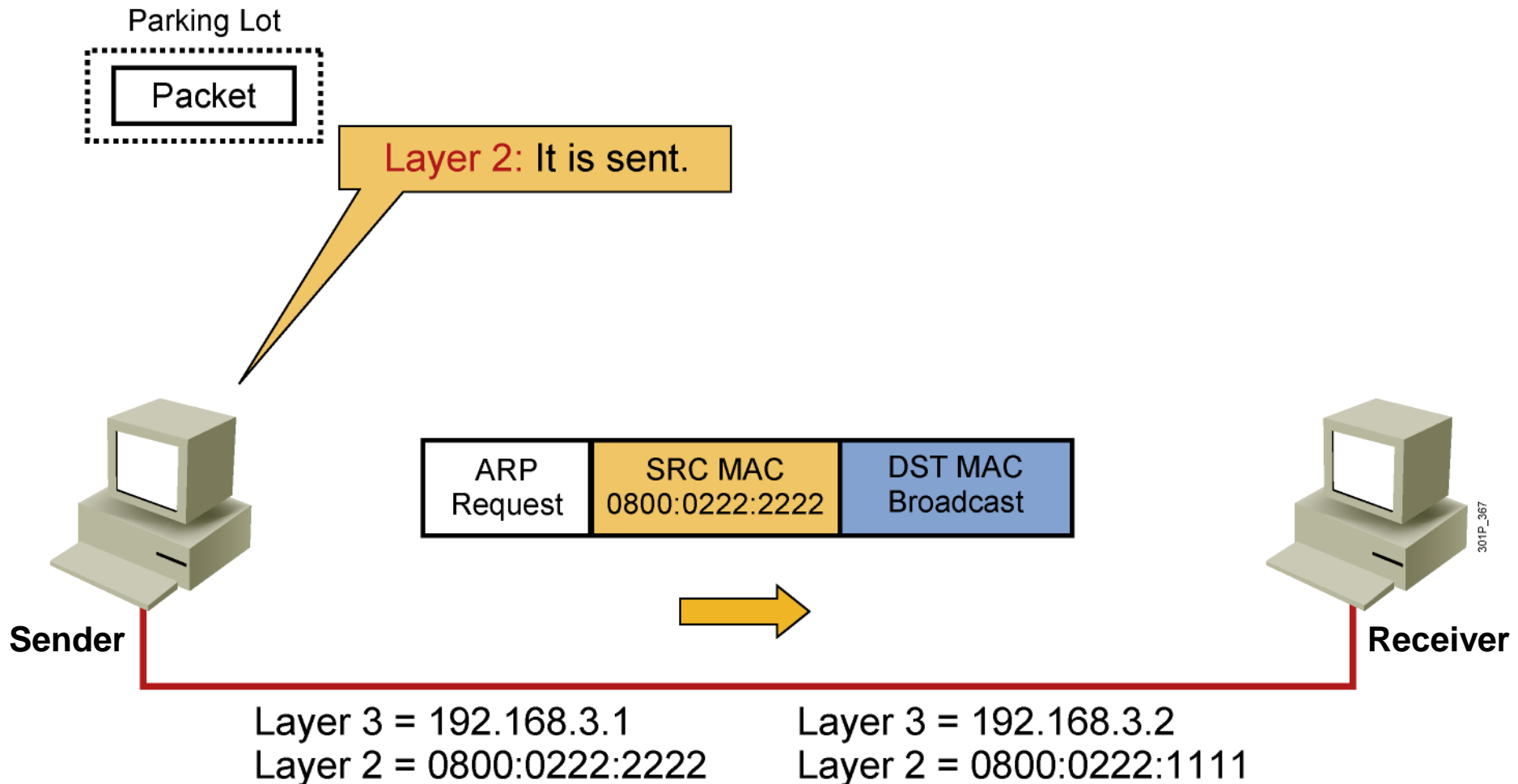
Layer 3 = 192.168.3.2
Layer 2 = 0800:0222:1111

Receiver

Host-to-Host Packet Delivery (4 of 22)



Host-to-Host Packet Delivery (5 of 22)

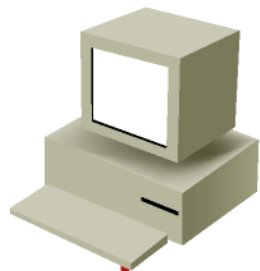
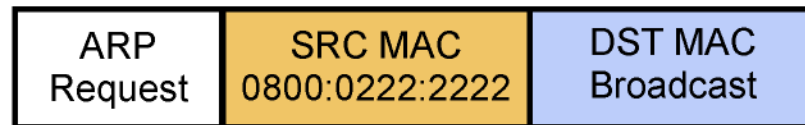


Host-to-Host Packet Delivery (6 of 22)

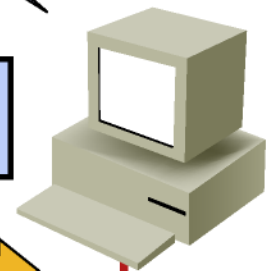
Parking Lot



Layer 2: I just got a frame with a broadcast MAC so I'll process it. The protocol ID indicates that it belongs to ARP. Let me strip the Layer 2 header and send it to ARP.



Sender

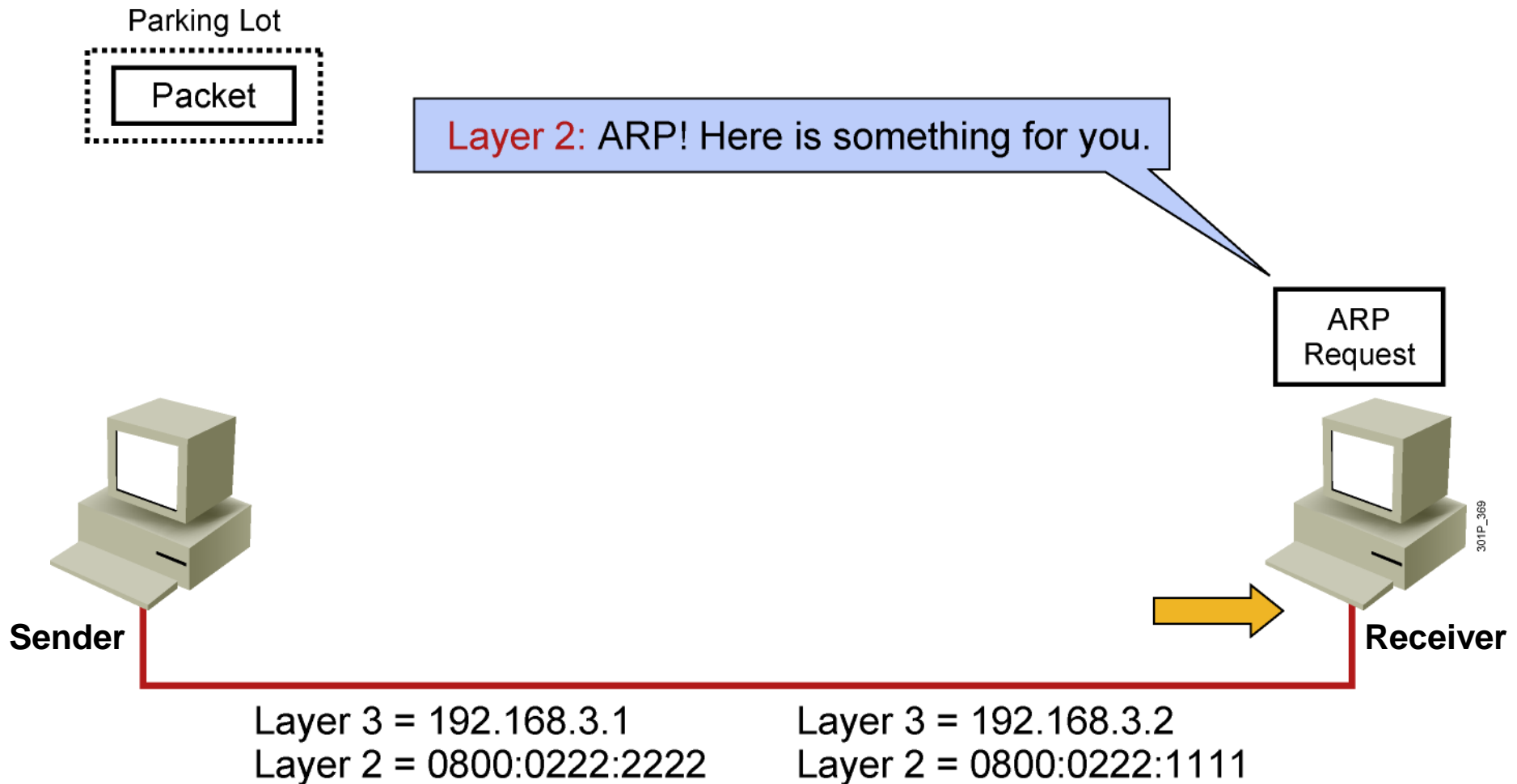


Receiver

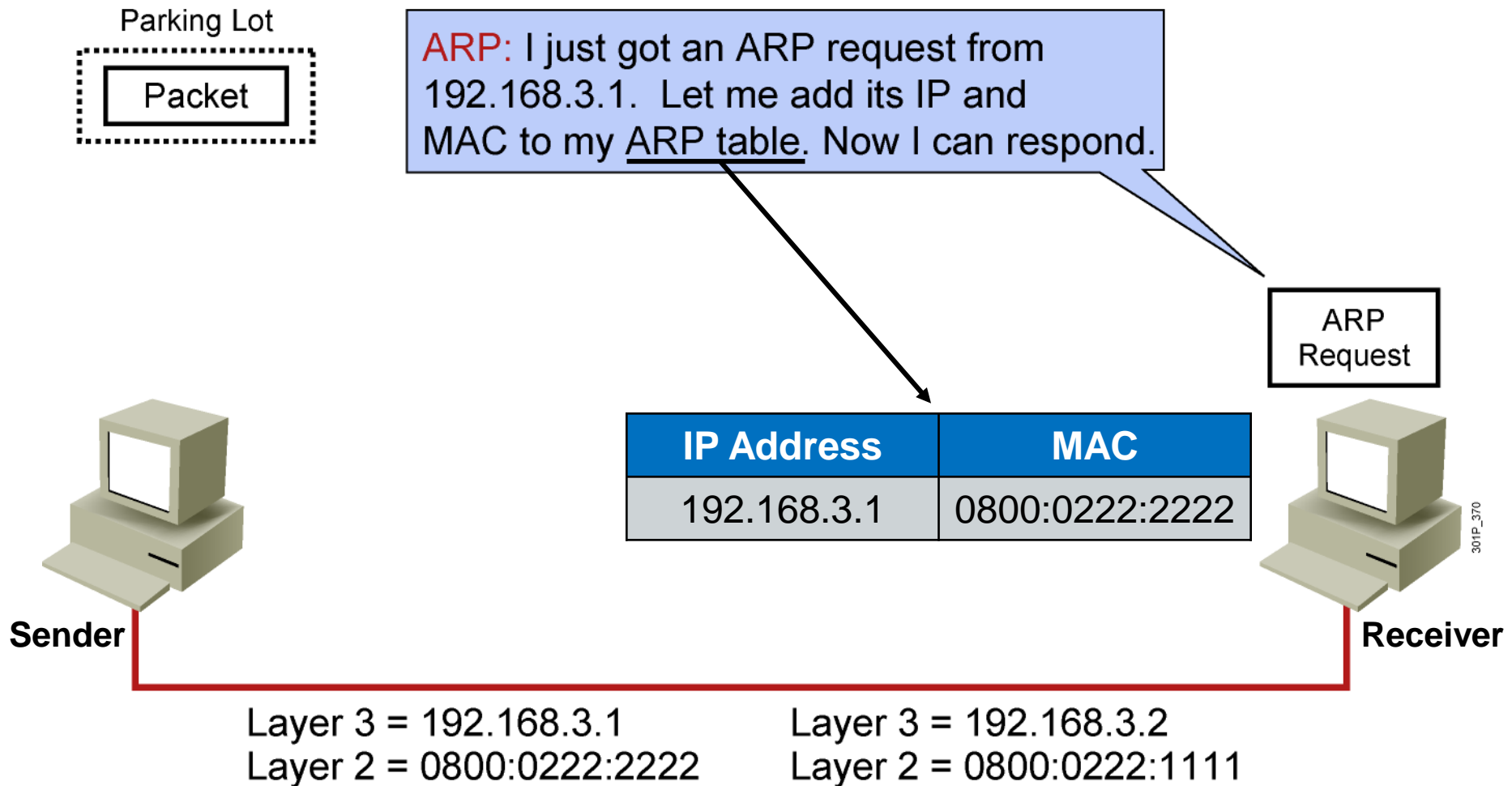
Layer 3 = 192.168.3.1
Layer 2 = 0800:0222:2222

Layer 3 = 192.168.3.2
Layer 2 = 0800:0222:1111

Host-to-Host Packet Delivery (7 of 22)



Host-to-Host Packet Delivery (8 of 22)



Host-to-Host Packet Delivery (9 of 22)

Parking Lot

Packet

ARP: The ARP reply will say that I am 192.168.3.2 with a MAC of 0800:0222:1111.

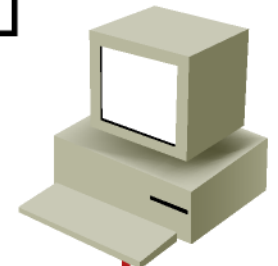
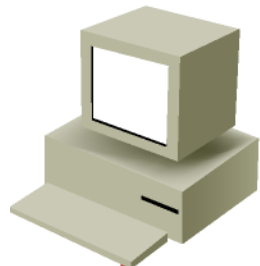
ARP: Layer 2, send this using our MAC as the SRC MAC and 0800:0222:222 as the DST MAC.

ARP Reply

DST MAC
0800:0222:2222

SRC MAC
0800:0222:1111

ARP Reply



301P_371

Sender

Receiver

Layer 3 = 192.168.3.1
Layer 2 = 0800:0222:2222

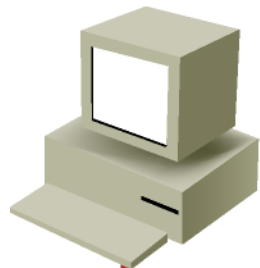
Layer 3 = 192.168.3.2
Layer 2 = 0800:0222:1111

Host-to-Host Packet Delivery (10 of 22)

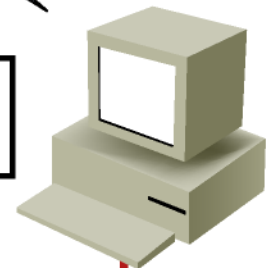
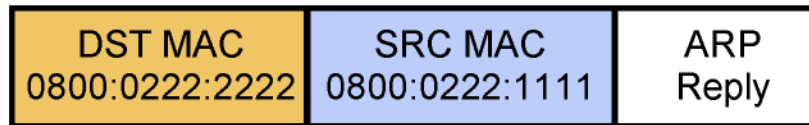
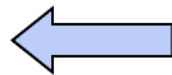
Parking Lot



Layer 2: It is sent.



Sender



Receiver

Layer 3 = 192.168.3.1
Layer 2 = 0800:0222:2222

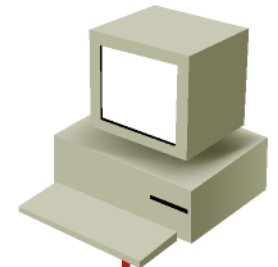
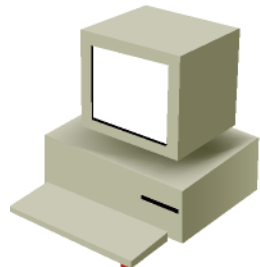
Layer 3 = 192.168.3.2
Layer 2 = 0800:0222:1111

Host-to-Host Packet Delivery (11 of 22)

Parking Lot



Layer 2: I just got a frame with my MAC so I'll process it. The protocol ID indicates that it belongs to ARP. Let me strip the Layer 2 header and send it to ARP.



301P_373

DST MAC	SRC MAC	ARP Reply
0800:0222:2222	0800:0222:1111	

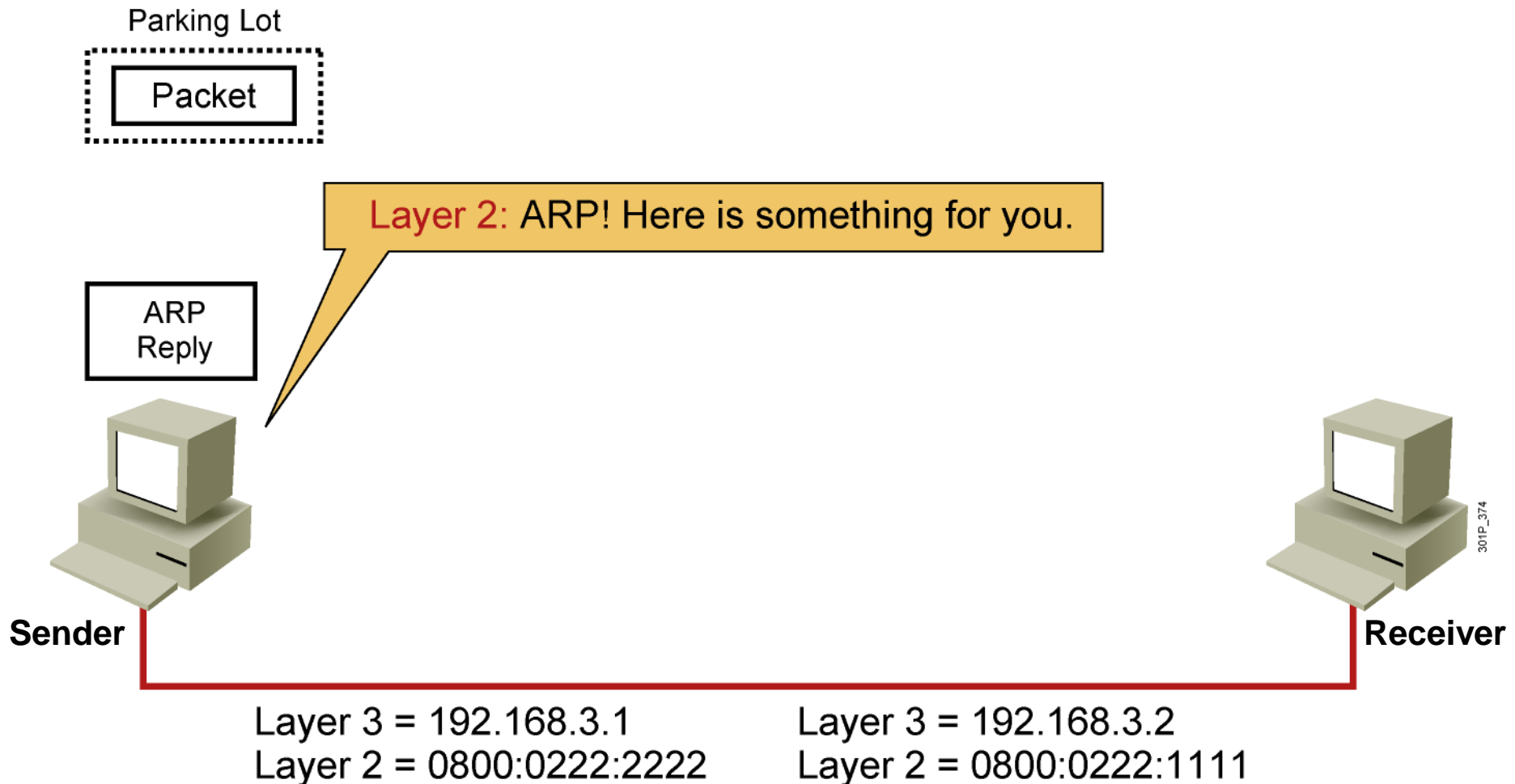
Sender

Receiver

Layer 3 = 192.168.3.1
Layer 2 = 0800:0222:2222

Layer 3 = 192.168.3.2
Layer 2 = 0800:0222:1111

Host-to-Host Packet Delivery (12 of 22)



Host-to-Host Packet Delivery (13 of 22)

Parking Lot

Packet

ARP: I just got an ARP reply from 192.168.3.2.
Let me add its IP and MAC to my ARP table.

ARP: Layer 2! I have 192.168.3.2
mapped to 0800:0222:1111.

IP Address	MAC
192.168.3.2	0800:0222:1111

ARP
Request

301P_375

Sender

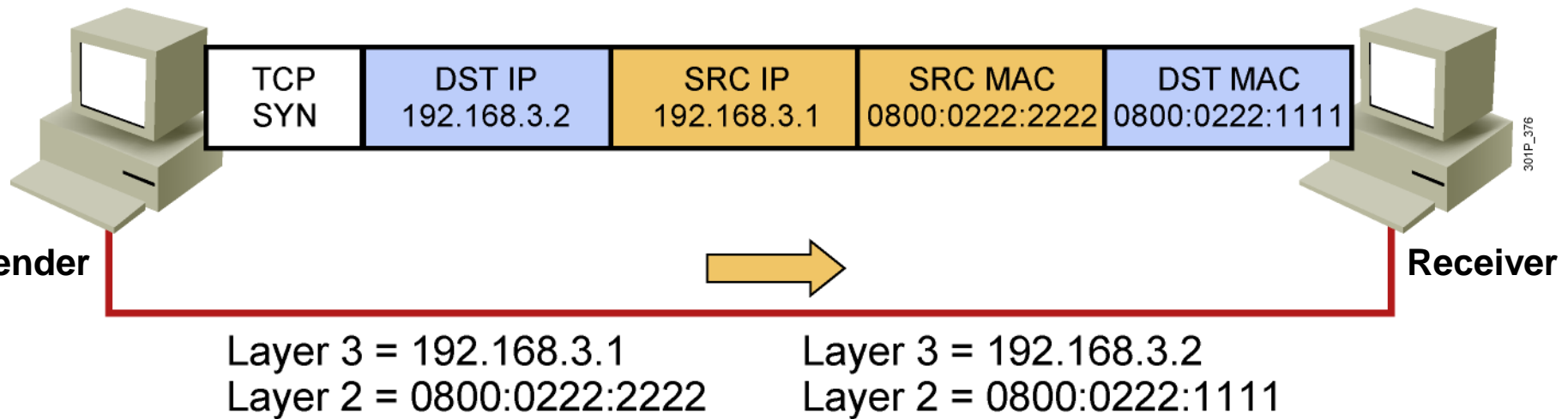
Receiver

Layer 3 = 192.168.3.1
Layer 2 = 0800:0222:2222

Layer 3 = 192.168.3.2
Layer 2 = 0800:0222:1111

Host-to-Host Packet Delivery (14 of 22)

Layer 2: I can send out that pending packet.



Host-to-Host Packet Delivery (15 of 22)

TCP: I need to send a SYN ACK to the TCP SYN that I received.

TCP
SYN

SRC IP
192.168.3.1

DST IP
192.168.3.2

TCP
SYN

DST MAC
0800:0222:1111

SRC MAC
0800:0222:2222

SRC IP
192.168.3.1

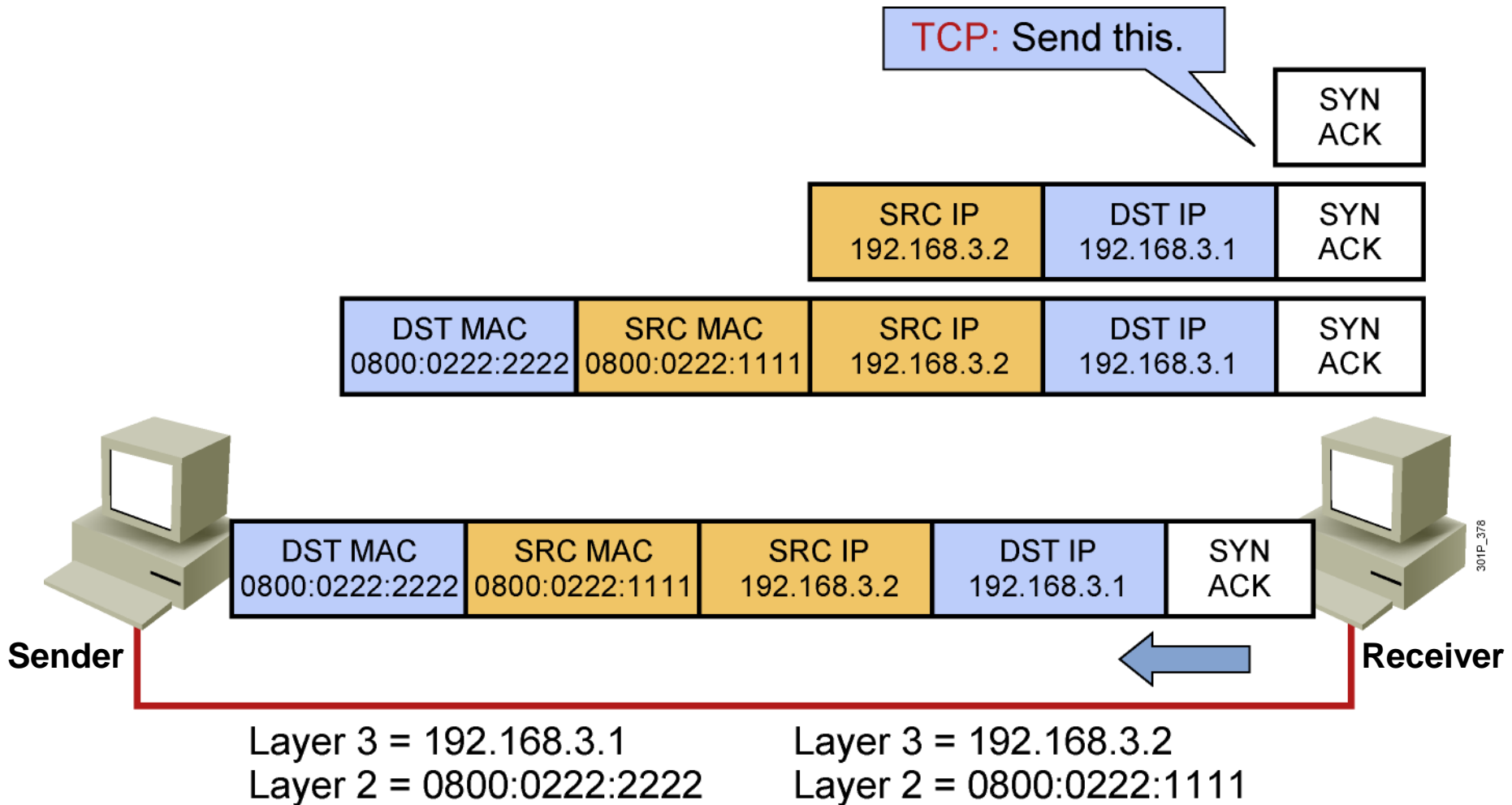
DST IP
192.168.3.2

TCP
SYN

Layer 3 = 192.168.3.1
Layer 2 = 0800:0222:2222

Layer 3 = 192.168.3.2
Layer 2 = 0800:0222:1111

Host-to-Host Packet Delivery (16 of 22)



Host-to-Host Packet Delivery (17 of 22)

TCP: Got the ACK.

SYN
ACK

SRC IP
192.168.3.2

DST IP
192.168.3.1

SYN
ACK

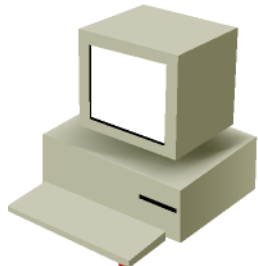
DST MAC
0800:0222:2222

SRC MAC
0800:0222:1111

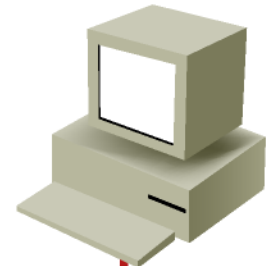
SRC IP
192.168.3.2

DST IP
192.168.3.1

SYN
ACK



Sender



Receiver

Layer 3 = 192.168.3.1
Layer 2 = 0800:0222:2222

Layer 3 = 192.168.3.2
Layer 2 = 0800:0222:1111

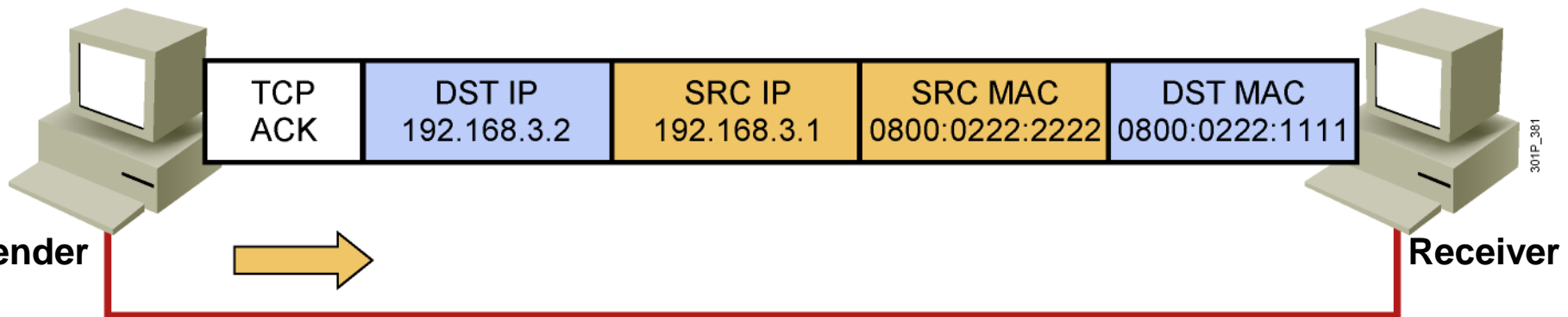
Host-to-Host Packet Delivery (18 of 22)

TCP: I need to let the other end know I got the SYN ACK to complete the session establishment.

TCP
ACK

SRC IP 192.168.3.1	DST IP 192.168.3.2	TCP ACK
-----------------------	-----------------------	------------

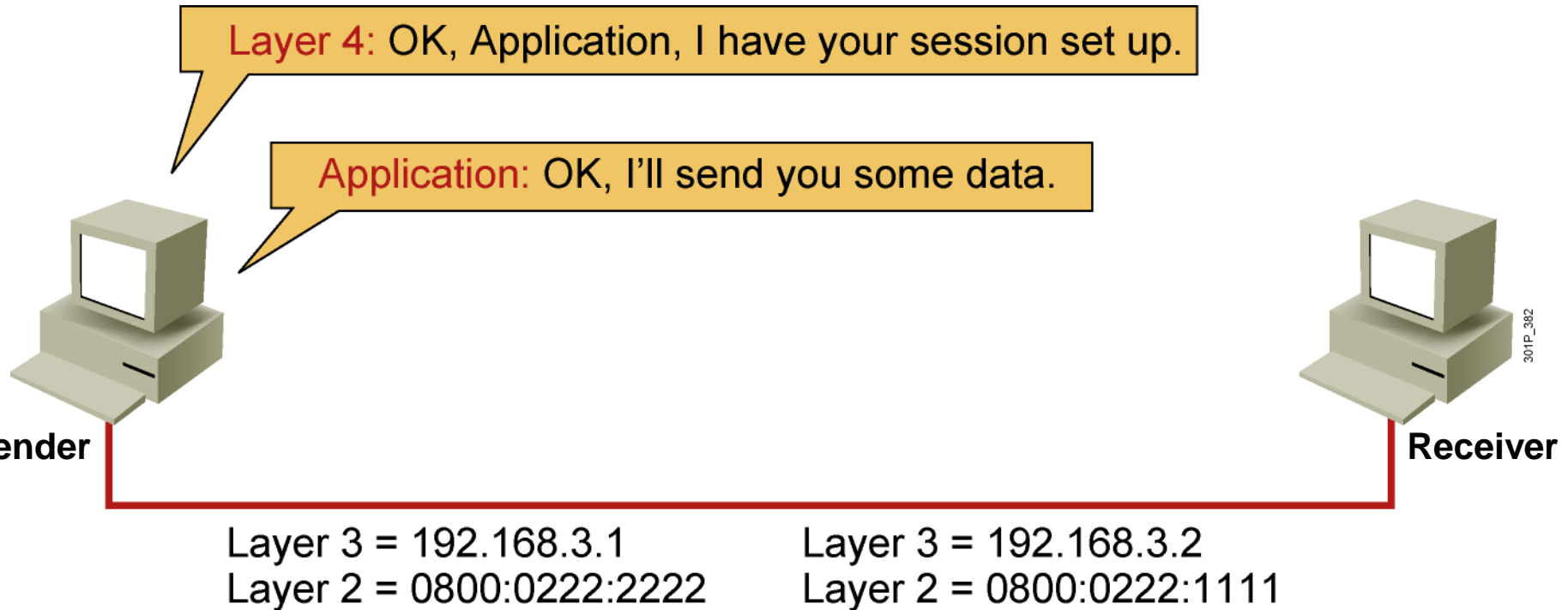
DST MAC 0800:0222:1111	SRC MAC 0800:0222:2222	SRC IP 192.168.3.1	DST IP 192.168.3.2	TCP ACK
---------------------------	---------------------------	-----------------------	-----------------------	------------



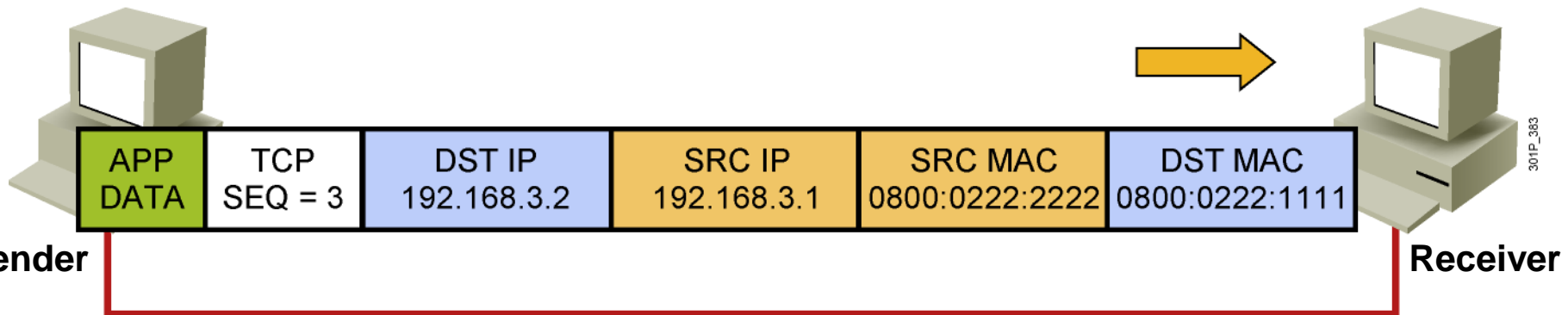
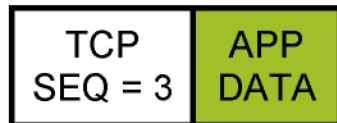
Layer 3 = 192.168.3.1
Layer 2 = 0800:0222:2222

Layer 3 = 192.168.3.2
Layer 2 = 0800:0222:1111

Host-to-Host Packet Delivery (19 of 22)



Host-to-Host Packet Delivery (20 of 22)



Layer 3 = 192.168.3.1
Layer 2 = 0800:0222:2222

Layer 3 = 192.168.3.2
Layer 2 = 0800:0222:1111

Host-to-Host Packet Delivery (21 of 22)

TCP: Application! Here is some data.

APP
DATA

TCP
SEQ = 3

APP
DATA

SRC IP
192.168.3.1

DST IP
192.168.3.2

TCP
SEQ = 3

APP
DATA

DST MAC
0800:0222:1111

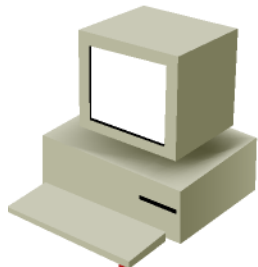
SRC MAC
0800:0222:2222

SRC IP
192.168.3.1

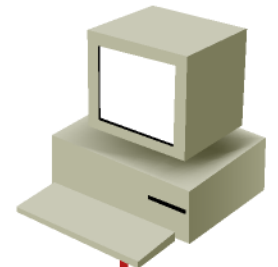
DST IP
192.168.3.2

TCP
SEQ = 3

APP
DATA



Sender



Receiver

Layer 2 = 0800:0222:2222
Layer 3 = 192.168.3.1

Layer 2 = 0800:0222:1111
Layer 3 = 192.168.3.2

Host-to-Host Packet Delivery (22 of 22)

I need to send an ACK to the data that I received.

ACK = 4
SEQ = 3

SRC IP
192.168.3.2

DST IP
192.168.3.1

ACK = 4
SEQ = 3

DST MAC
0800:0222:2222

SRC MAC
0800:0222:1111

SRC IP
192.168.3.2

DST IP
192.168.3.1

ACK = 4
SEQ = 3

DST MAC
0800:0222:2222

SRC MAC
0800:0222:1111

SRC IP
192.168.3.2

DST IP
192.168.3.1

ACK = 4
SEQ = 3

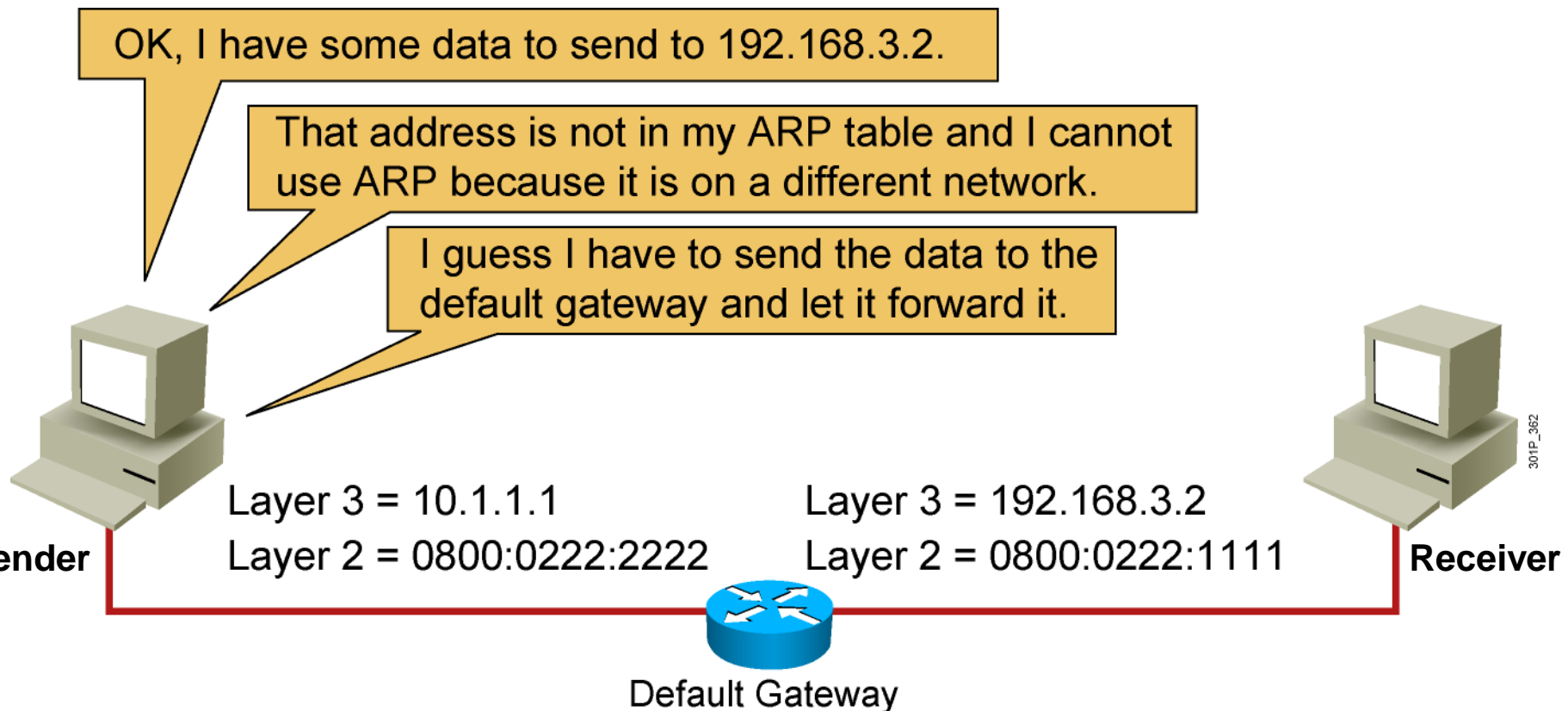
Sender

Receiver

Layer 3 = 192.168.3.1
Layer 2 = 0800:0222:2222

Layer 3 = 192.168.3.2
Layer 2 = 0800:0222:1111

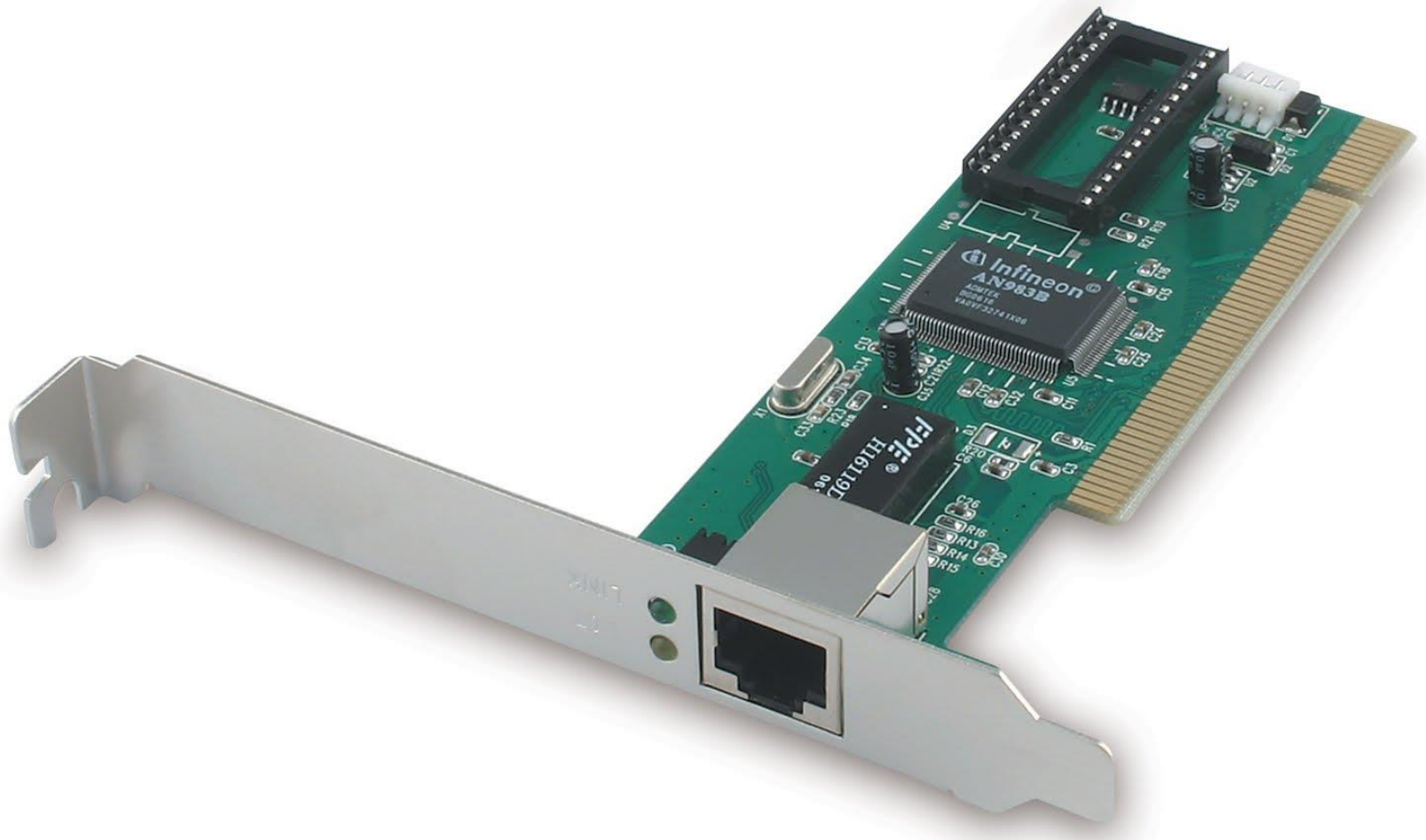
Default Gateway





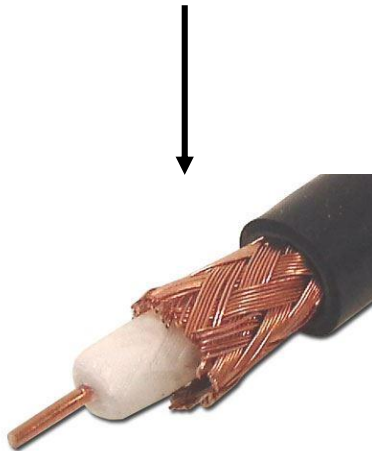
Cabling in Internetwork

Network Interface Card



Common Network Cable Types - Copper

Coaxial



Twisted Pair

UTP

(Unshield Twisted Pair)



STP

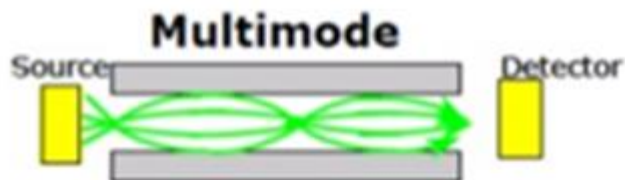
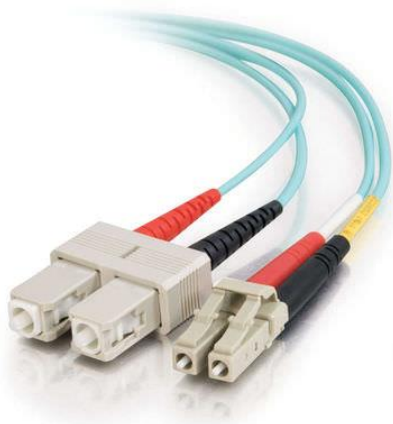
(Shield Twisted Pair)



- More susceptible to noise and crosstalk
- Cheaper
- Easily installed as cables are smaller, lighter, and flexible

- Less susceptible to noise and crosstalk
- Moderately expensive
- Installation of cables is difficult comparatively

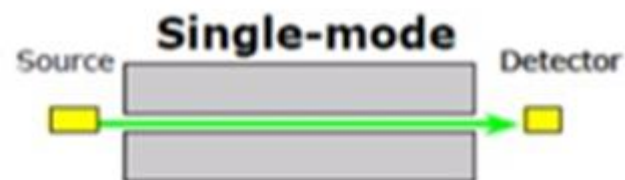
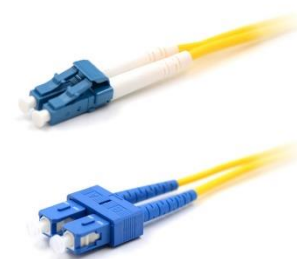
Common Network Cable Types - Fiber Optic



- + Low cost sources
 - + 850 nm and 1310 nm LEDs
 - + 850 nm lasers at 1 & 10 Gb/s
 - + Low precision packaging
- + Low cost connectors
- + Lower installation cost
- Higher fiber cost
- + Lower system cost
- Higher loss, lower bandwidth
- Distance up to 2 km

Best for:

- LAN, SAN, Data Center, CO



- High cost sources
 - 1310+ nm lasers 1 and 10 Gb/s
 - 1 Gb/s + w/ DWDM
 - High precision packaging
- Higher cost connectors
- Higher installation cost
- + Lower fiber cost
- Higher system cost
- + Lower loss, higher bandwidth
- + Distance to 60 km+

Best for:

- WAN, MAN, Access, Campus

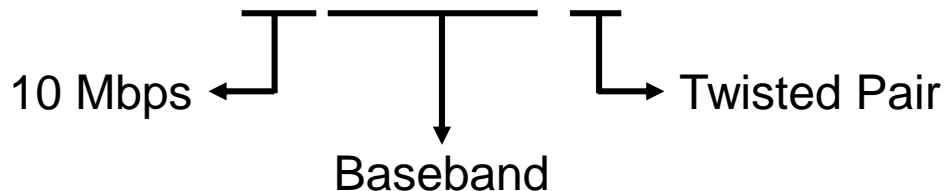
UTP Category

UTP Category	Data Rate	Max. Length	Application
CAT1	Up to 1 Mbps	-	Old Telephone Cable
CAT2	Up to 4 Mbps	-	Token Ring Networks
CAT3	Up to 10 Mbps	100m	Token Ring & 10BASE-T Ethernet
CAT4	Up to 16 Mbps	100m	Token Ring Networks
CAT5	Up to 100 Mbps	100m	Ethernet, Fast Ethernet, Token Ring
CAT5e	Up to 1 Gbps	100m	Ethernet, Fast Ethernet, Gigabit Ethernet
CAT6	Up to 10 Gbps	100m	Gigabit Ethernet, 10G Ethernet (55 meters)
CAT6a	Up to 10 Gbps	100m	Gigabit Ethernet, 10G Ethernet (55 meters)
CAT7	Up to 10 Gbps	100m	Gigabit Ethernet, 10G Ethernet (100 meters)

Comparing Ethernet Media Requirements

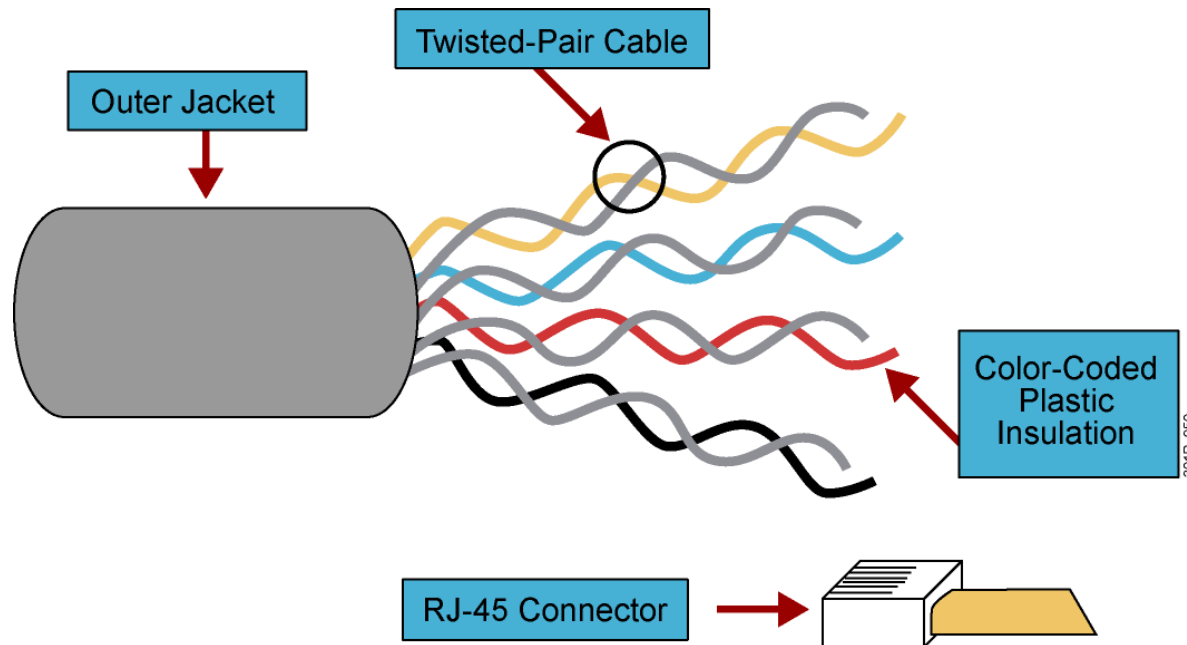
Requirement	10 BASE-T	100 BASE-TX	100 BASE-FX	1000 BASE-CX	1000 BASE-T	1000 BASE-SX	1000 BASE-LX
Media	EIA/TIA Category 3, 4, 5 UTP 2 pair	EIA/TIA Category 5 UTP 2 pair	62.5/125 micron multimode fiber	STP	EIA/TIA Category 5 UTP 4 pair	62.5/50 micron multimode fiber	9 micron single-mode fiber
Maximum Segment Length	100 m (328 ft)	100 m (328 ft)	400 m (1312.3 ft)	25 m (82 ft)	100 m (328 ft)	275 m (62.5 micron) 550 m (50 micron)	3-10 km (1.86-6.2 miles)
Connector	ISO 8877 (RJ-45)	ISO 8877 (RJ-45)	Duplex media interface connector (MIC) ST	ISO 8877 (RJ-45)	ISO 8877 (RJ-45)	—	—

10BASE-T



Baseband: commonly used for digital transmission.
 Broadband: commonly used for analog transmission.
 The broadband systems can cover a bigger area than baseband systems.

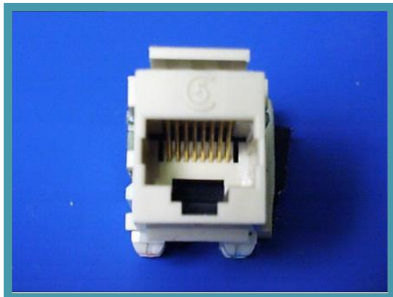
Unshielded Twisted-Pair Cable



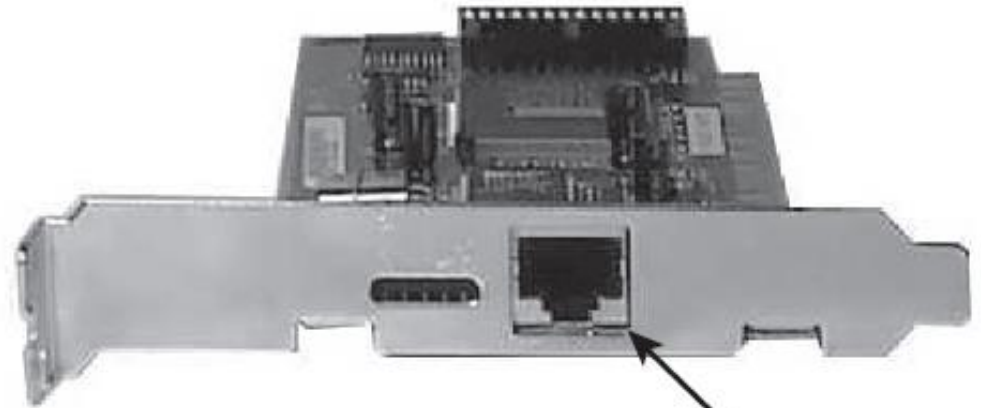
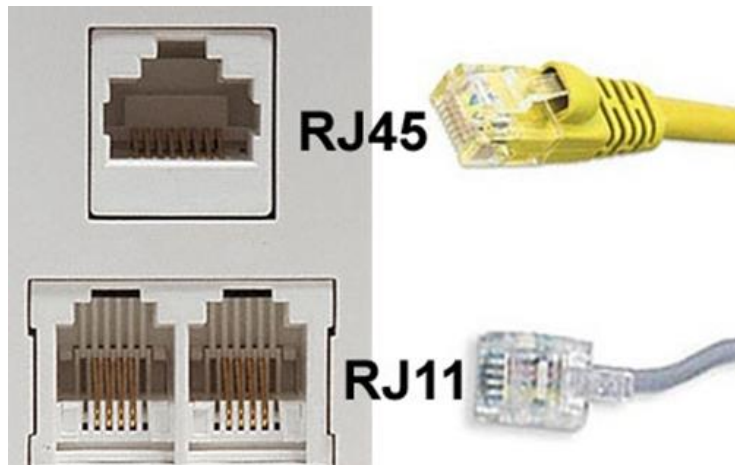
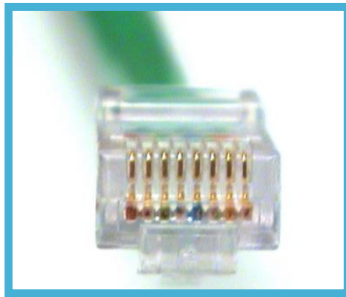
- Speed and throughput: 10 to 1000 Mb/s
- Average cost per node: Least expensive
- Media and connector size: Small
- Maximum cable length: Varies

RJ45 Connector & RJ45 Jack

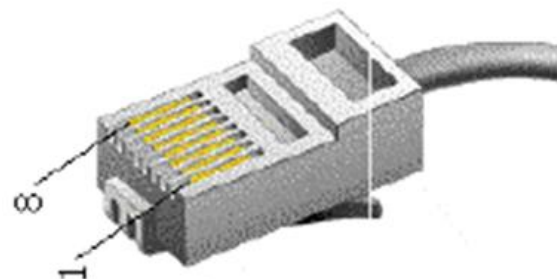
**RJ45 Jack
(Female)**



















**RJ45 Connector
(Male)**

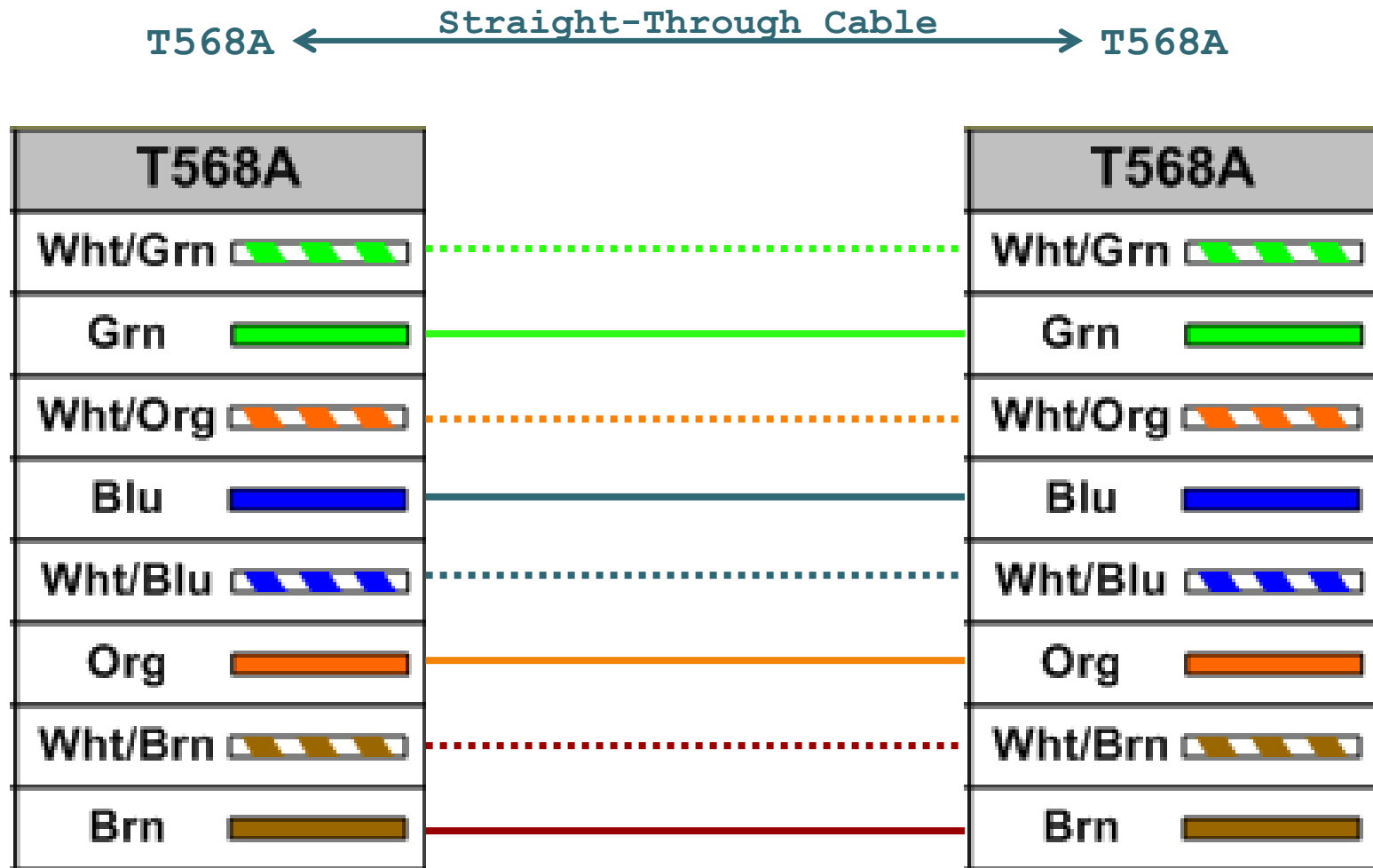


EIA/TIA T568A & T568B



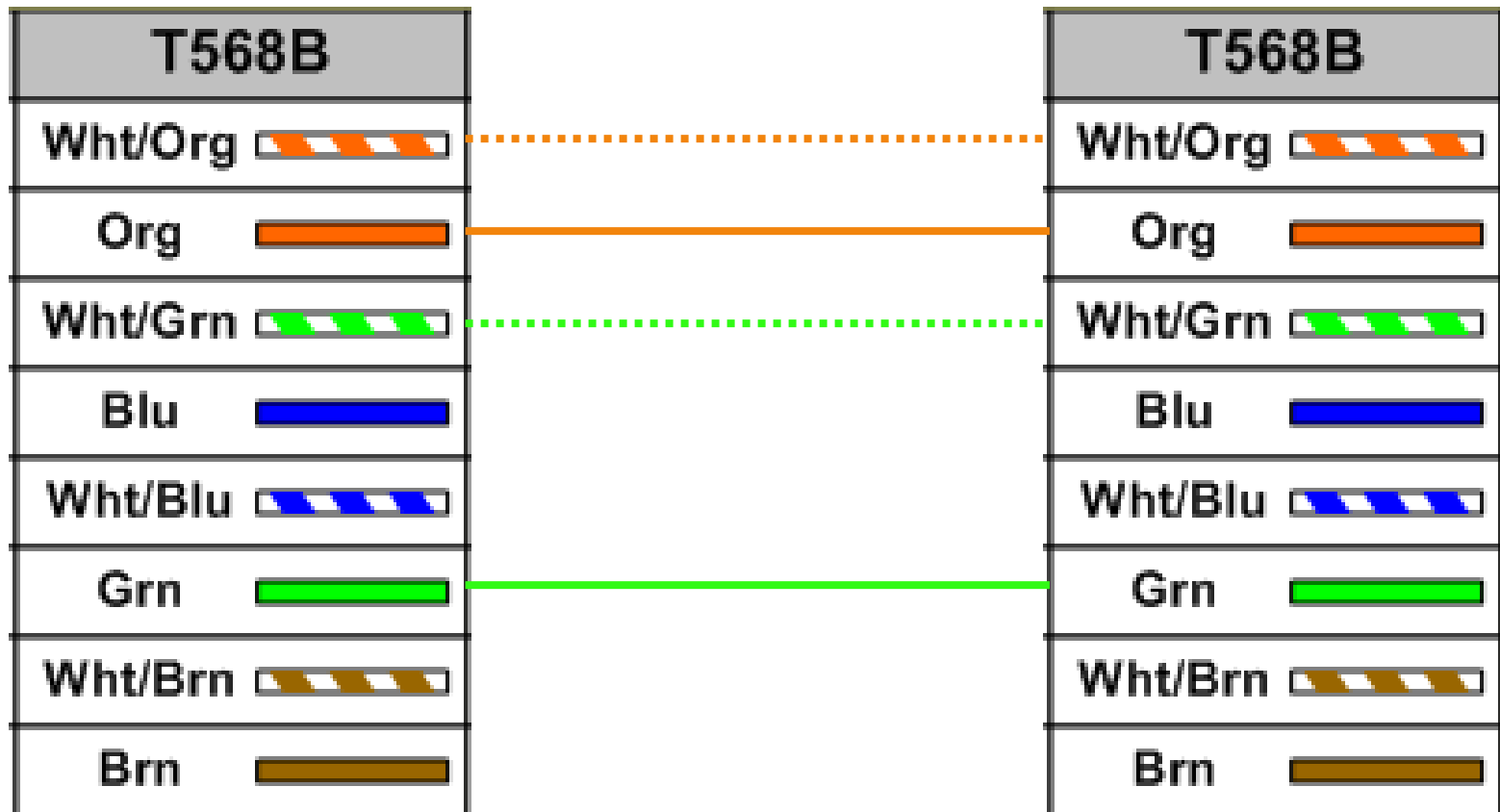
Pin	T568A	T568B	Signal 10/100BaseTx
1	Wht/Grn 	Wht/Org 	Tx+
2	Grn 	Org 	Tx-
3	Wht/Org 	Wht/Grn 	Rx+
4	Blu 	Blu 	Unused
5	Wht/Blu 	Wht/Blu 	Unused
6	Org 	Grn 	Rx-
7	Wht/Brn 	Wht/Brn 	Unused
8	Brn 	Brn 	Unused

UTP Implementation (Straight-Through)

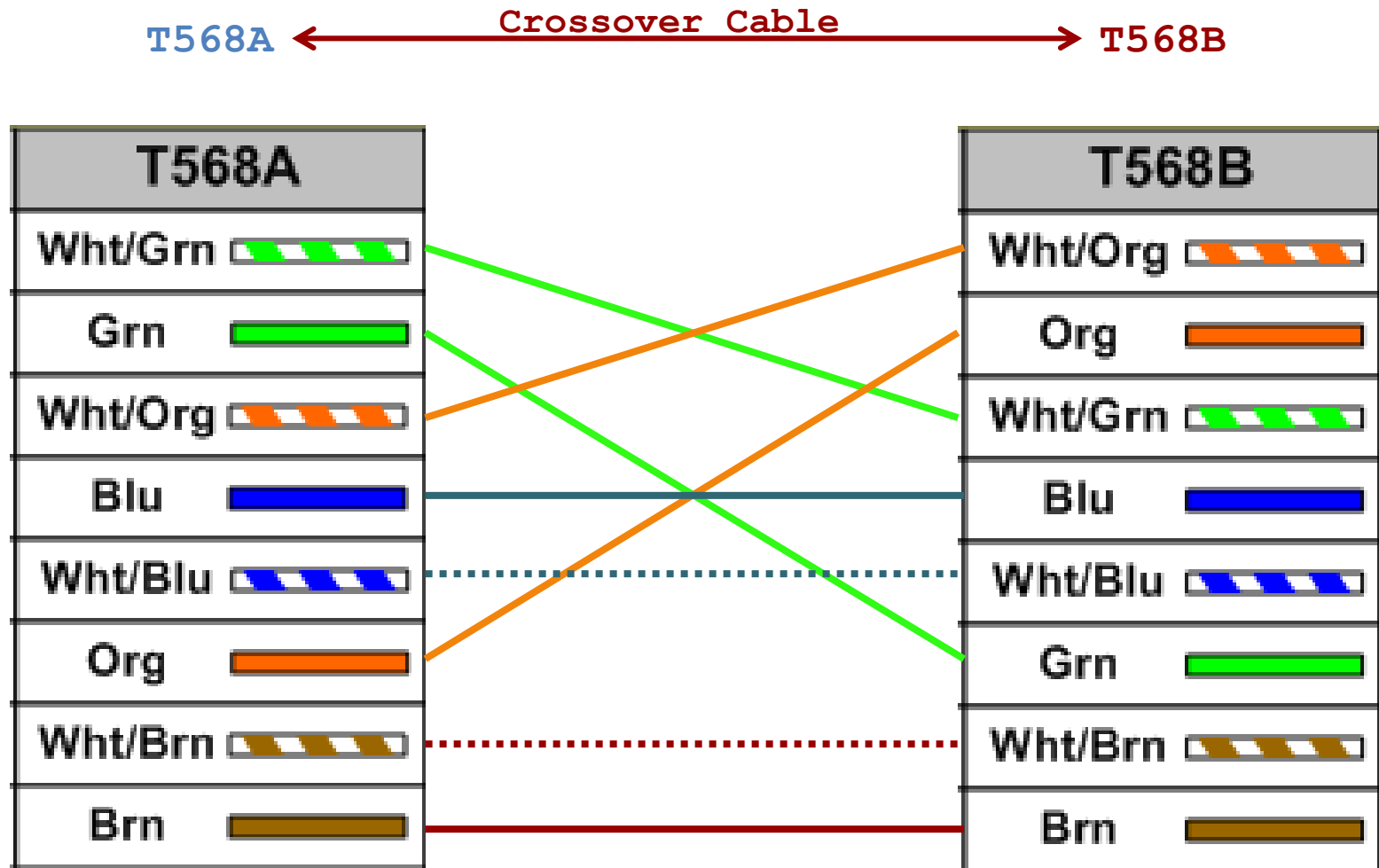


UTP Implementation (Straight-Through)

T568B ← Straight-Through Cable → **T568B**

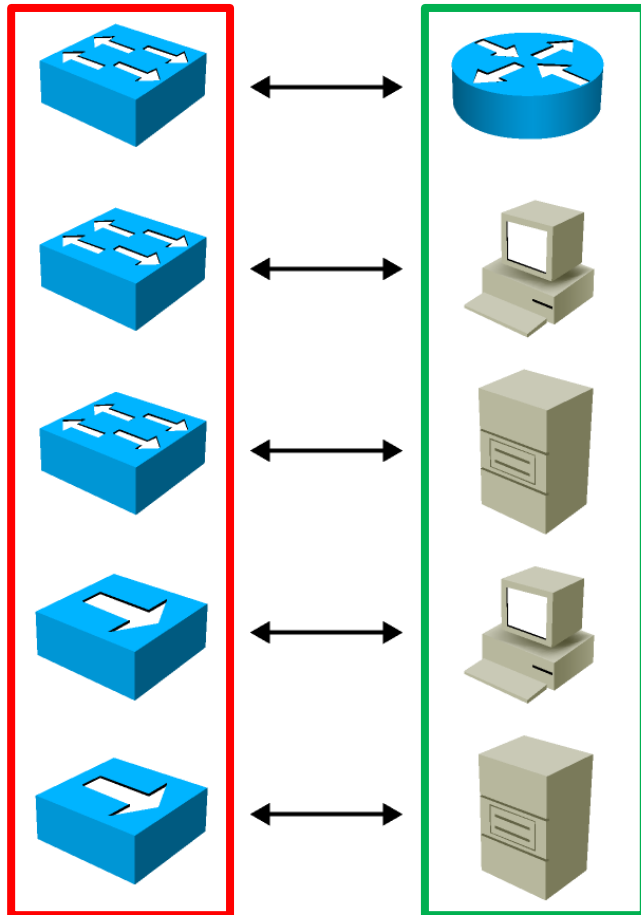


UTP Implementation (Crossover)

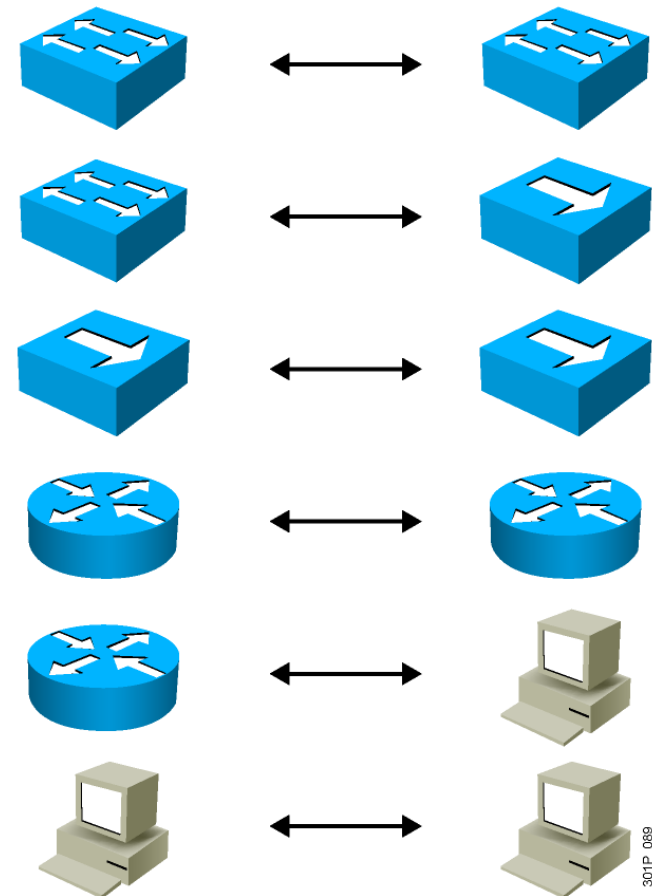


UTP Implementation: Straight-Through vs. Crossover

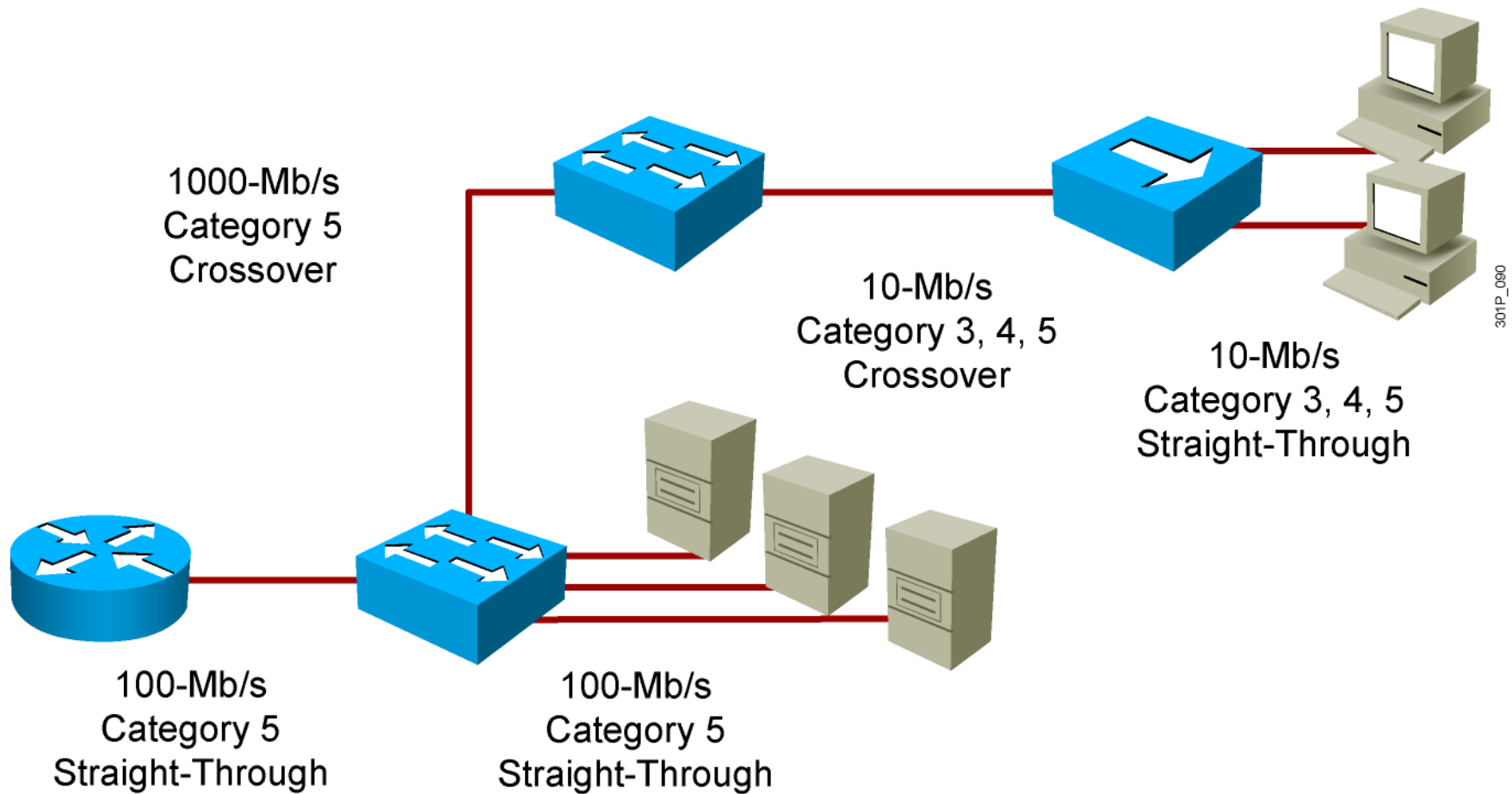
Straight-Through Cable



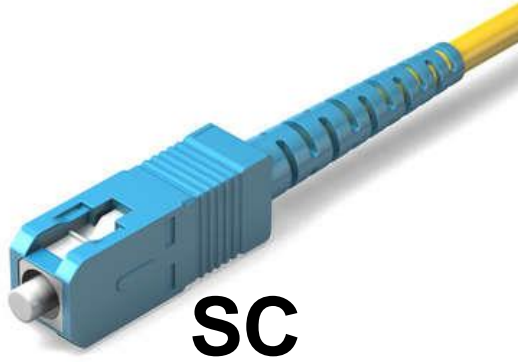
Crossover Cable



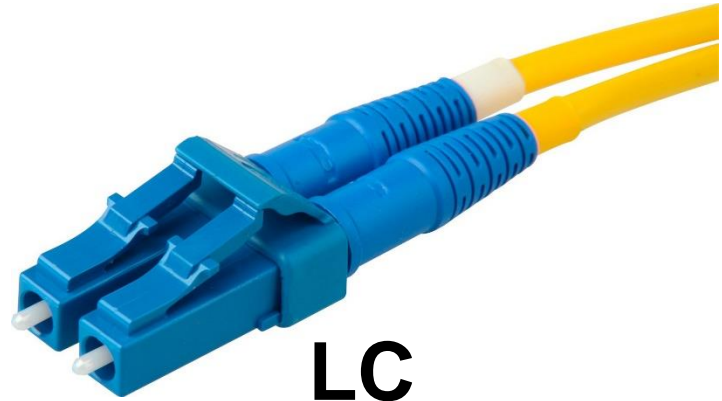
Using Varieties of UTP



Fiber Optic Connectors



SC



LC

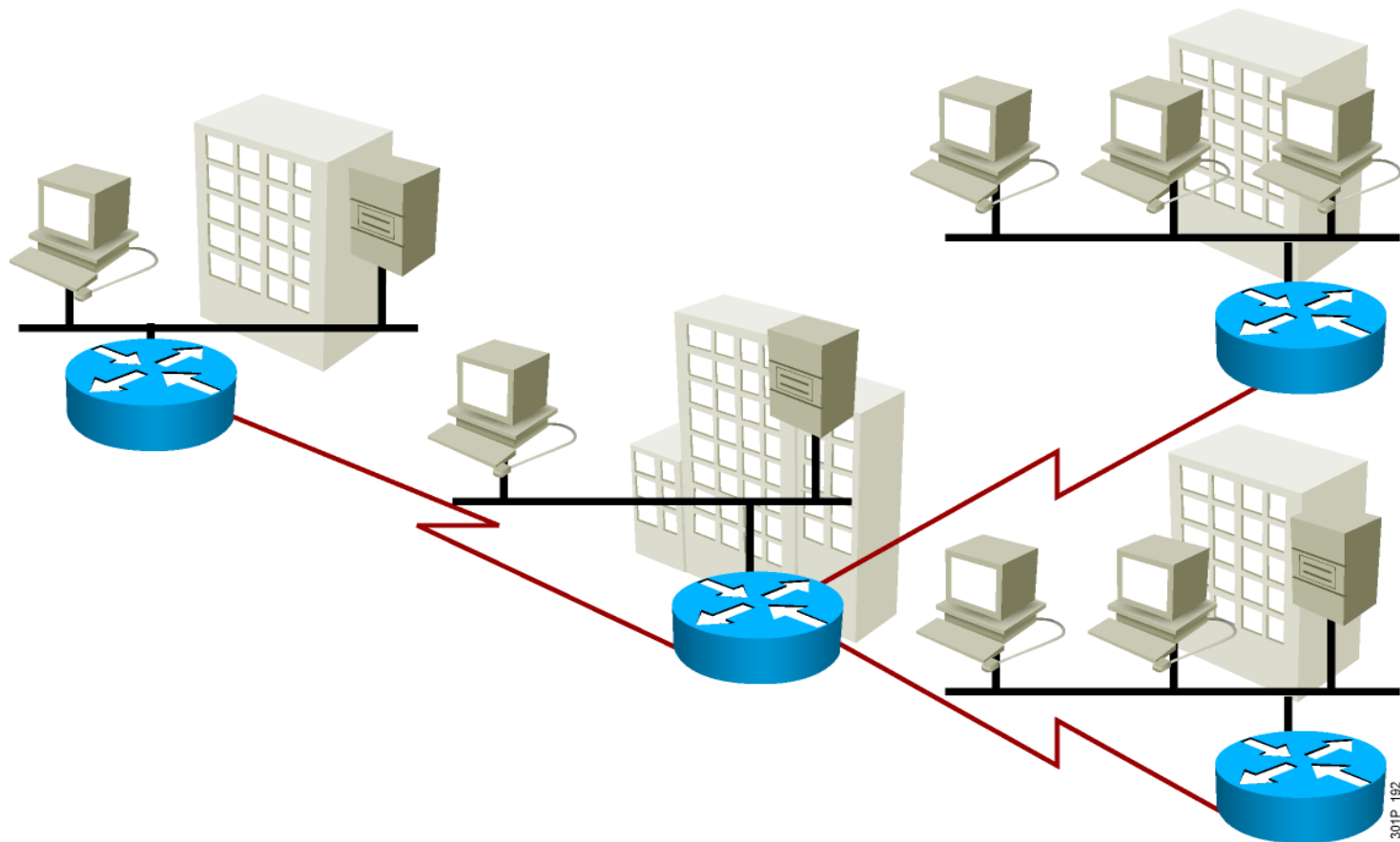


FC

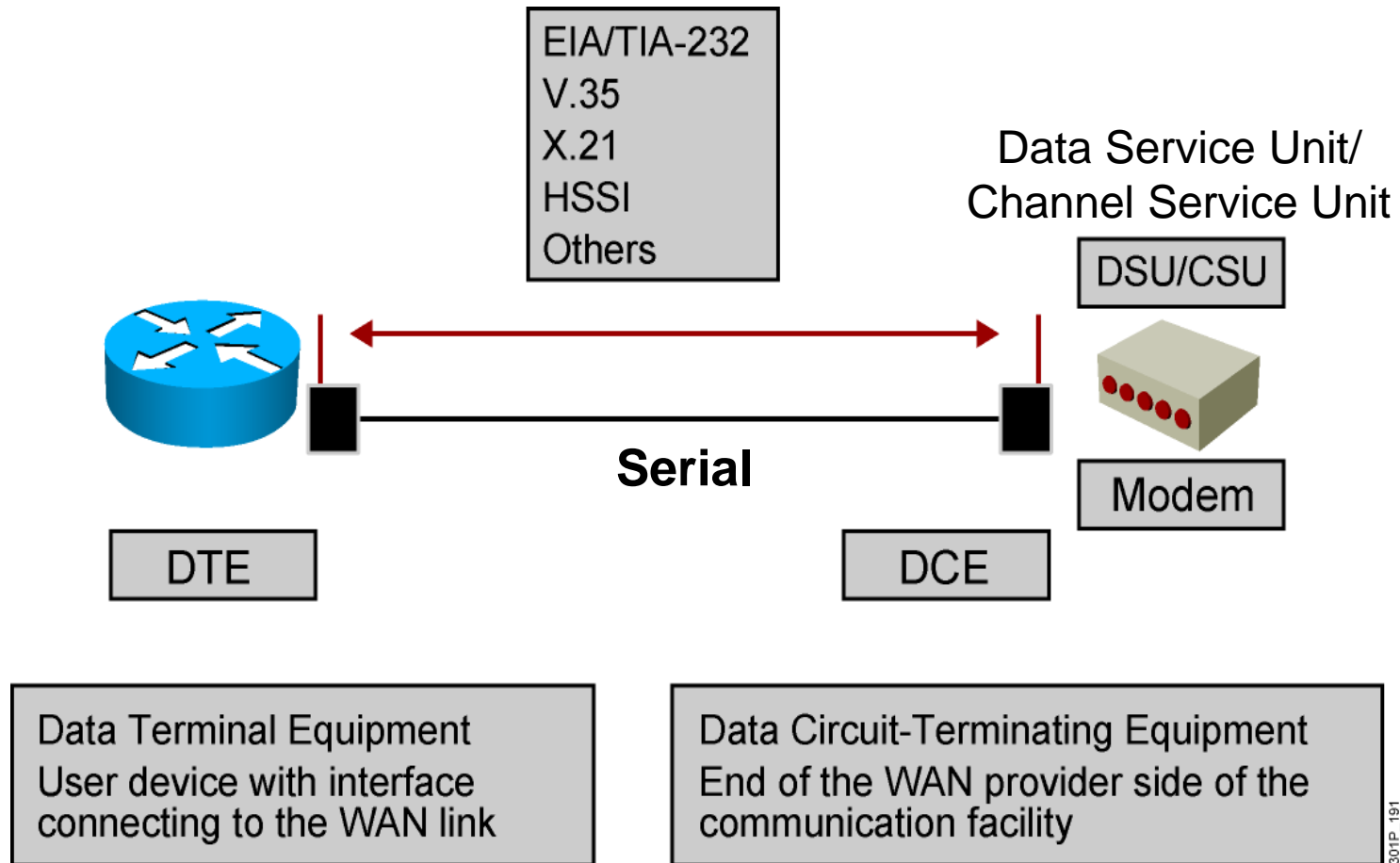


ST

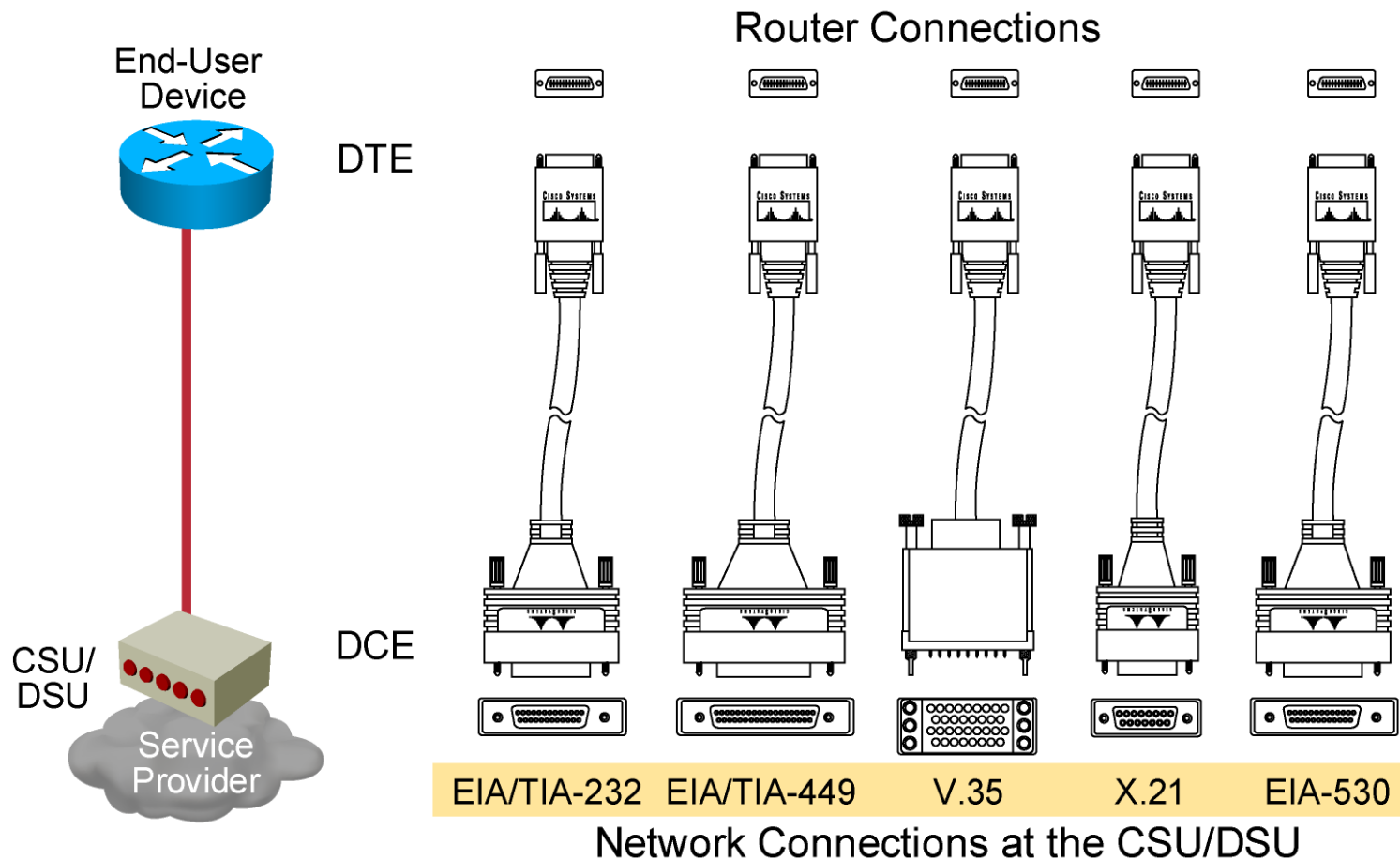
WAN—Multiple LANs



Physical Layer: WANs



Serial Point-to-Point Connections



WAN Devices

WAN Connections



LAN Connections

Management Port Connections

To T1
circuit



To router



Setting up a Console Connection

Console
Rollover
Null-modem

HyperTerminal
SecureCRT
Putty



COM
RS232



RJ-45
CONSOLE



Start → Program → Accessories → Communication → Hyper Terminal

