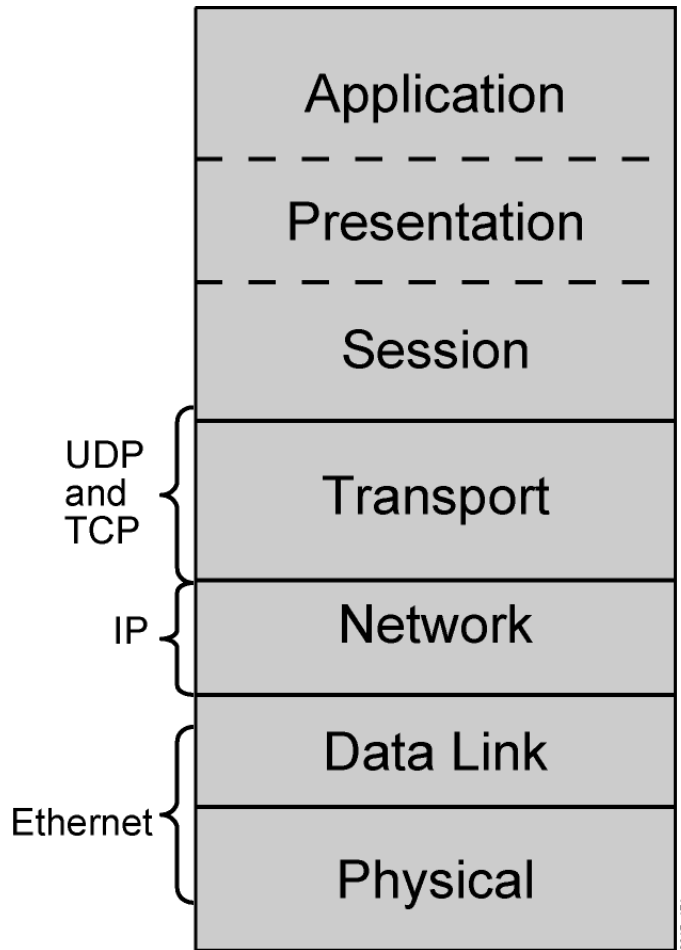




Transport Layer

Transport Layer



- Session multiplexing
- Segmentation
- Flow control (when required)
- Connection-oriented (when required)
- Reliability (when required)

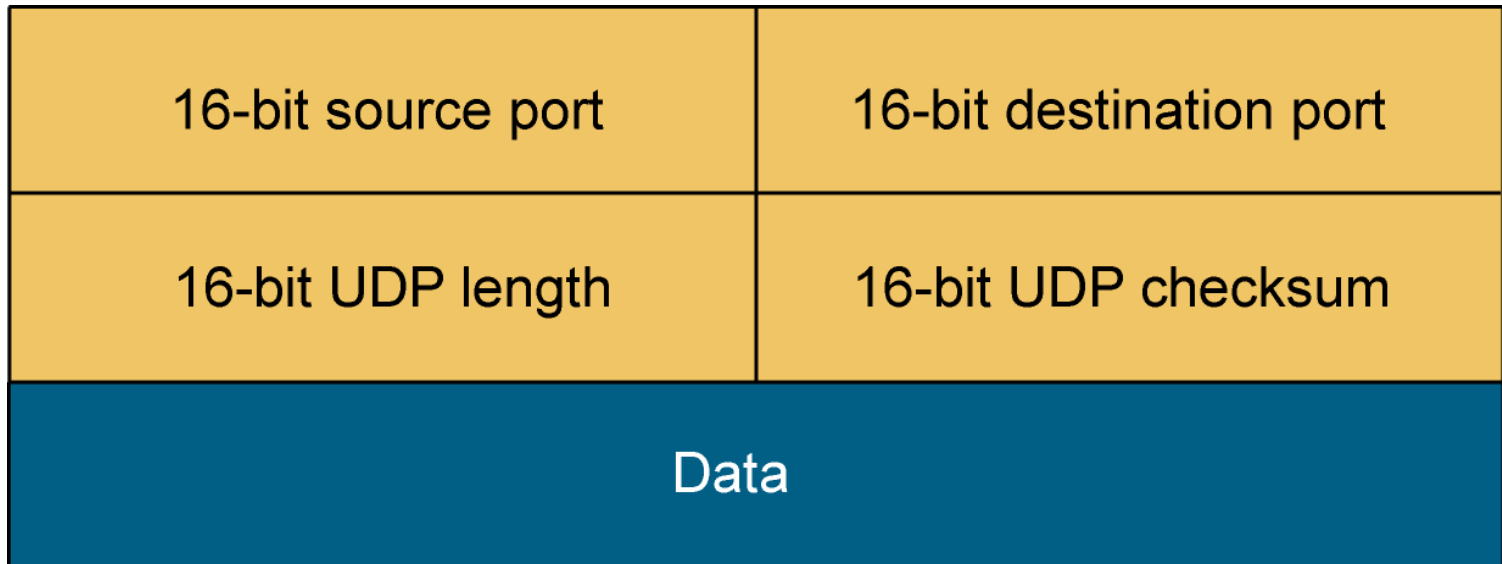
Reliable vs. Best-Effort Comparison

	Reliable	Best-Effort
Connection Type	Connection-oriented	Connectionless
Protocol	TCP	UDP
Sequencing	Yes	No
Uses	<ul style="list-style-type: none">▪ E-mail▪ File sharing▪ Downloading	<ul style="list-style-type: none">▪ Voice streaming▪ Video streaming

UDP Characteristics

- Operates at transport layer of OSI and TCP/IP models
- Provides applications with access to the network layer without the overhead of reliability mechanisms
- Is a connectionless protocol
- Provides best-effort delivery
- Provides limited error checking
- Has no data-recovery features

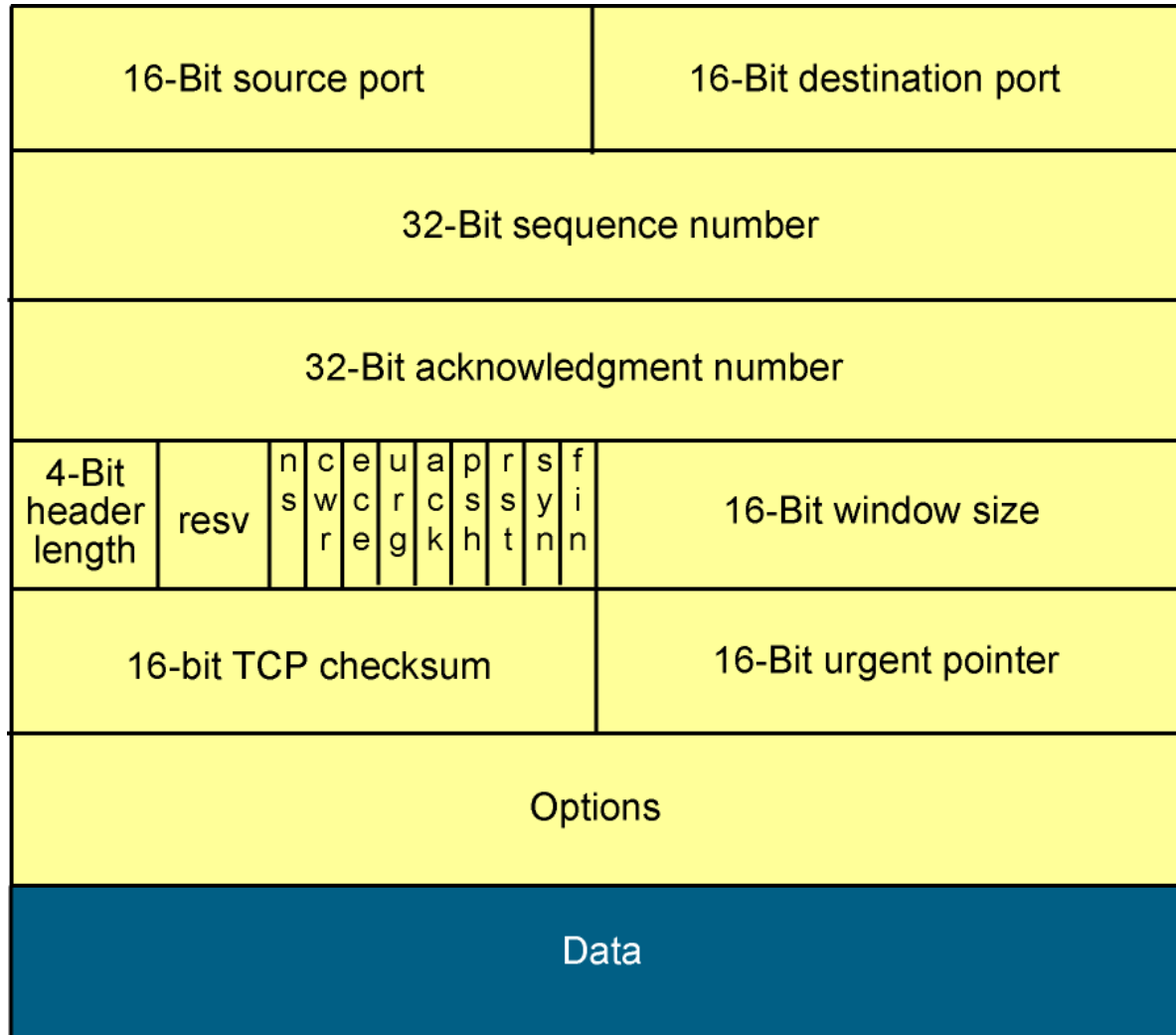
UDP Header



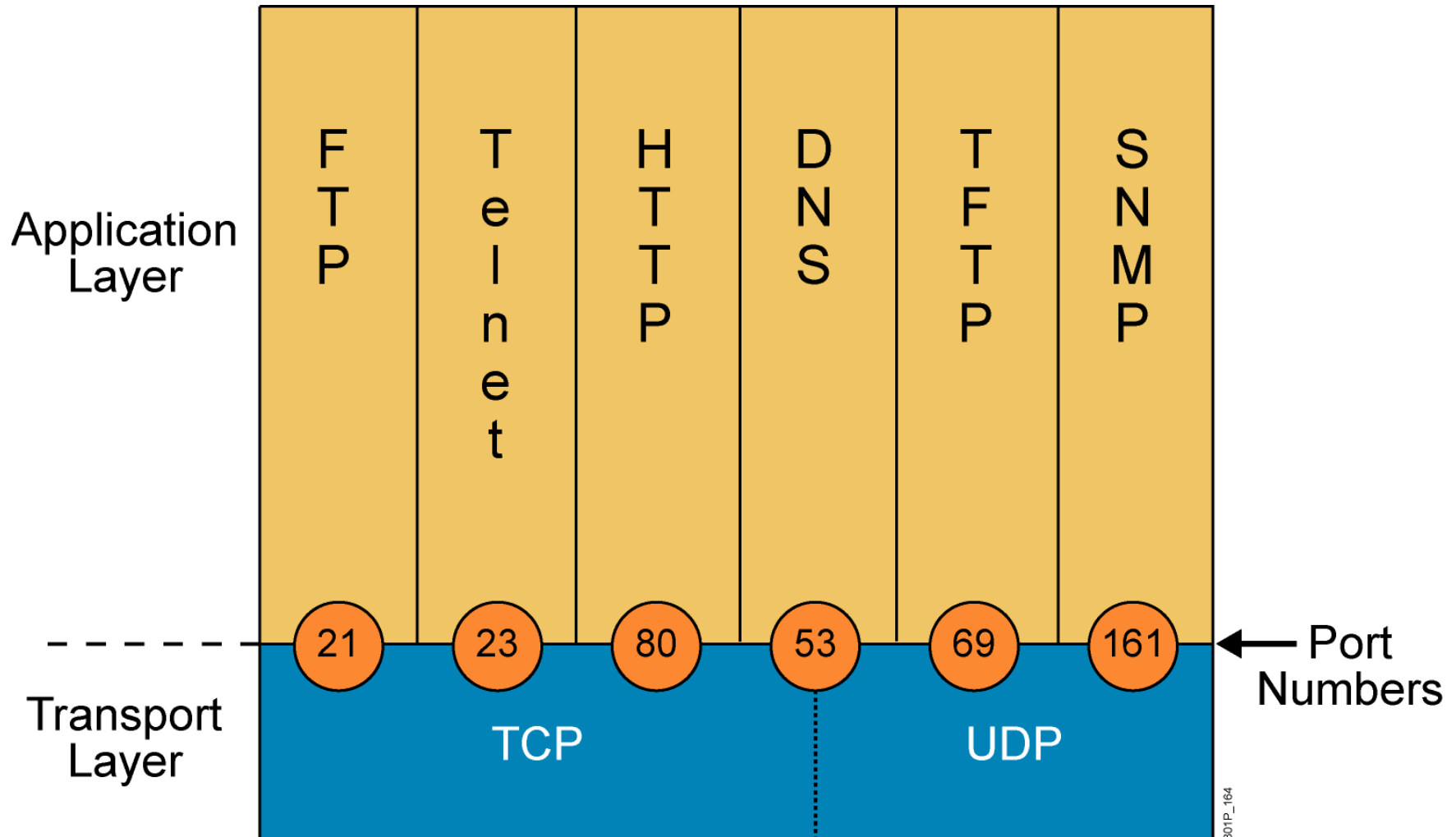
TCP Characteristics

- Transport layer of the TCP/IP stack
- Access to the network layer for applications
- Connection-oriented protocol
- Full-duplex mode operation
- Error checking
- Sequencing of data packets
- Acknowledgement of receipt
- Data-recovery features

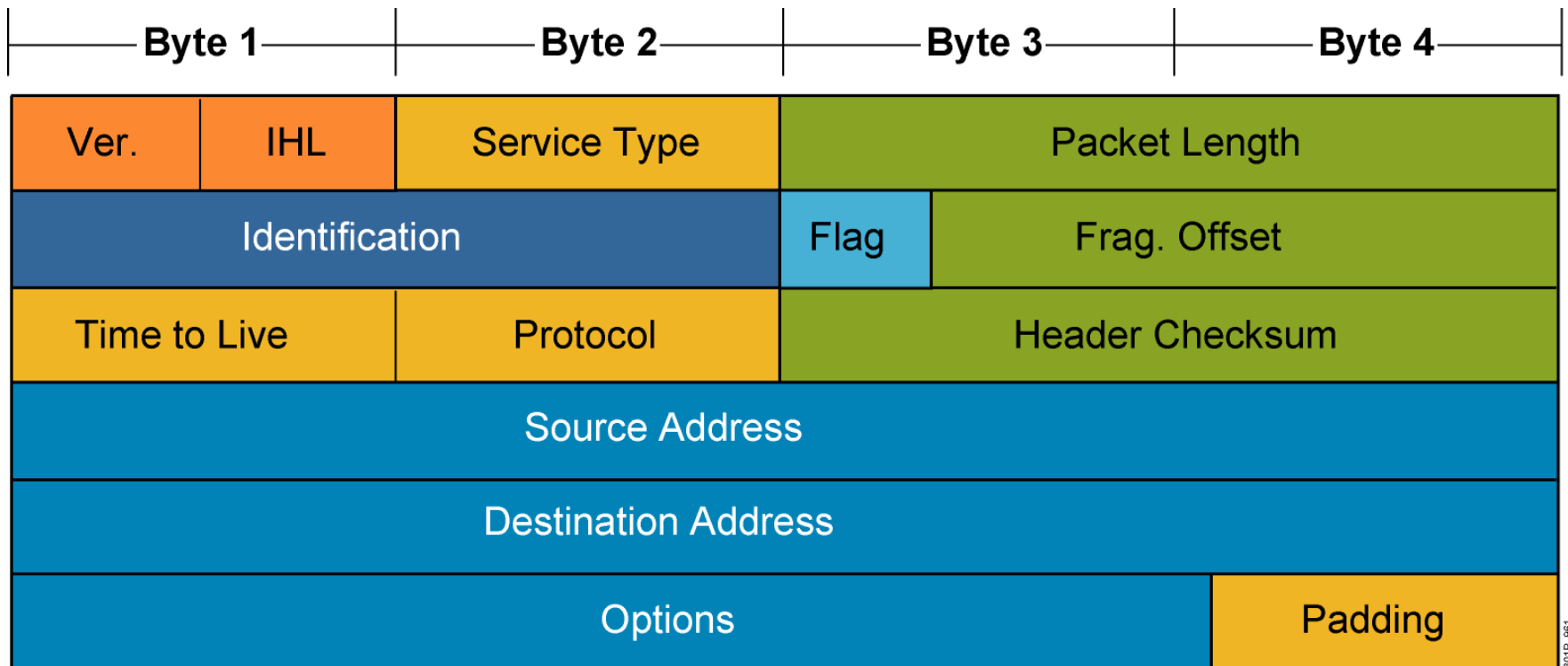
TCP Header



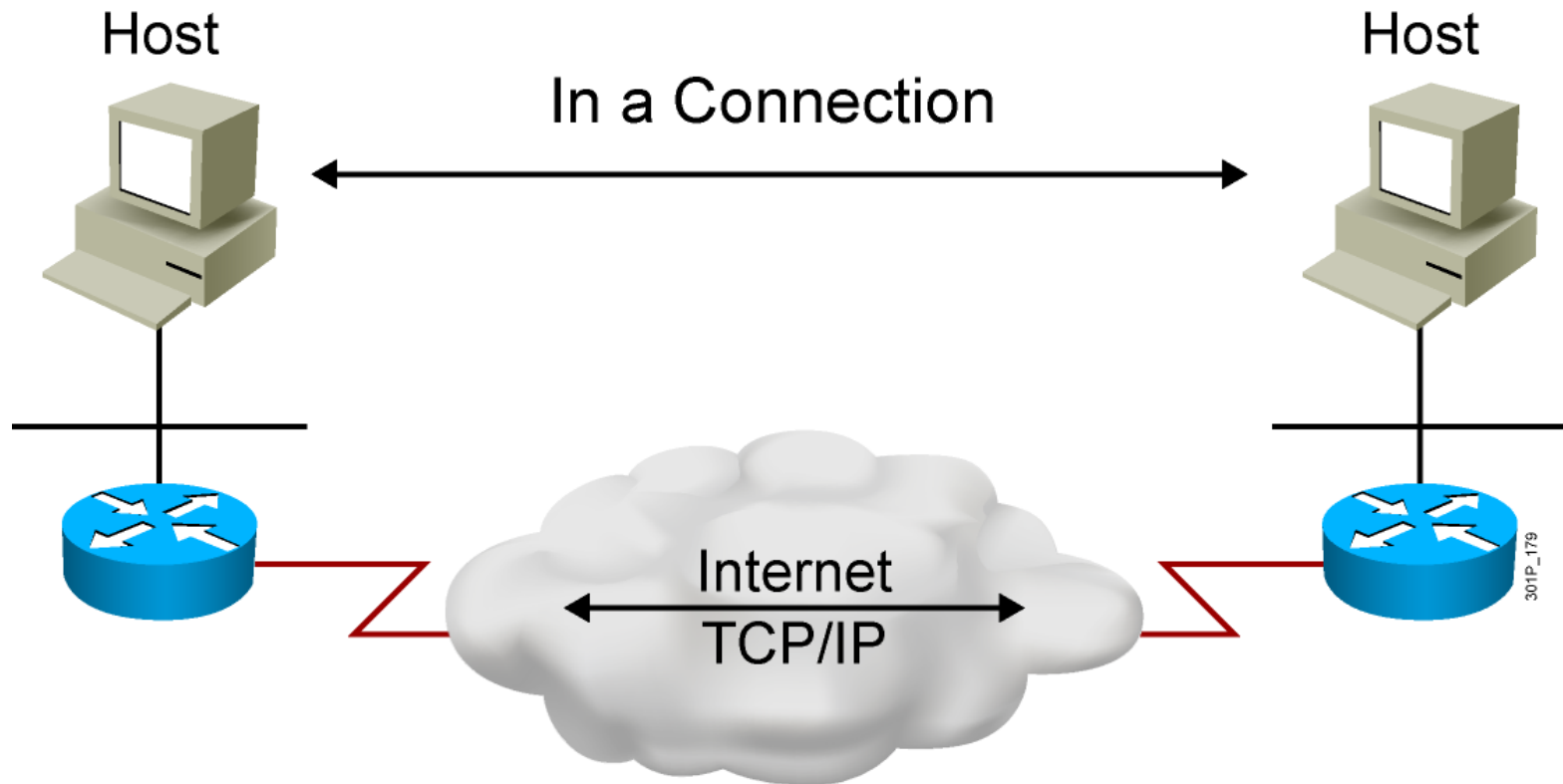
Mapping Layer 4 to Applications



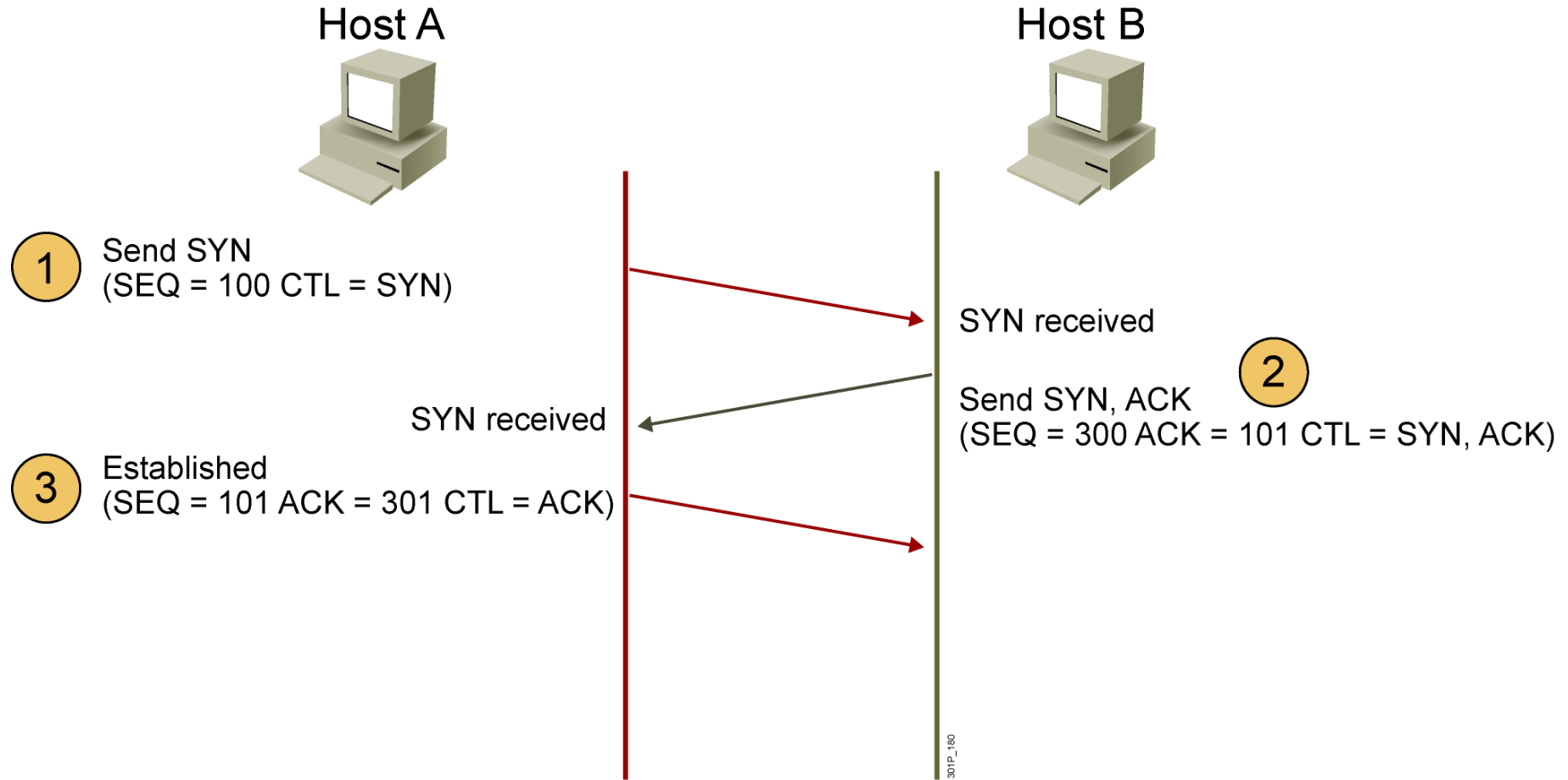
Mapping Layer 3 to Layer 4



Establishing a Connection

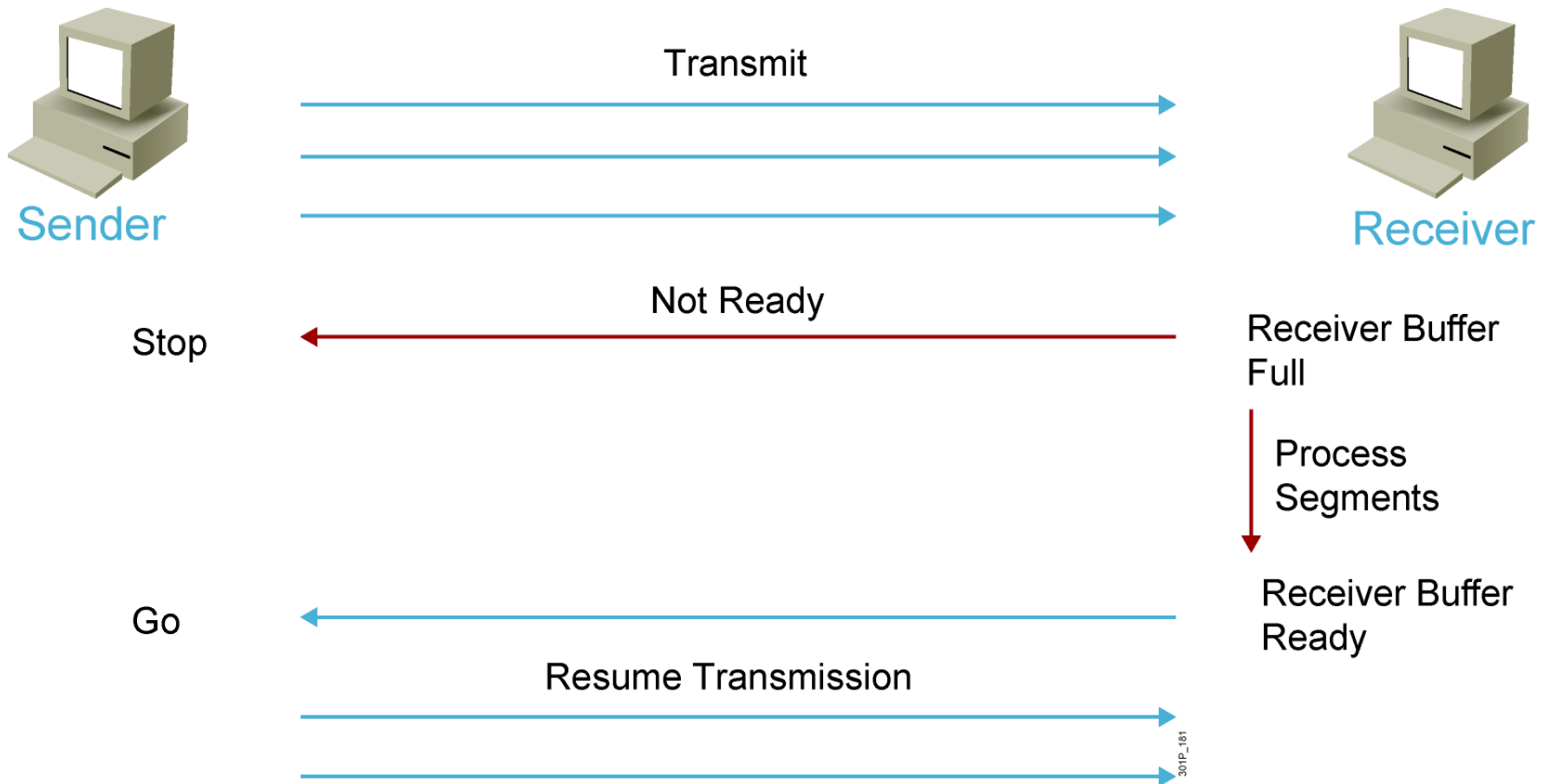


Three-Way Handshake

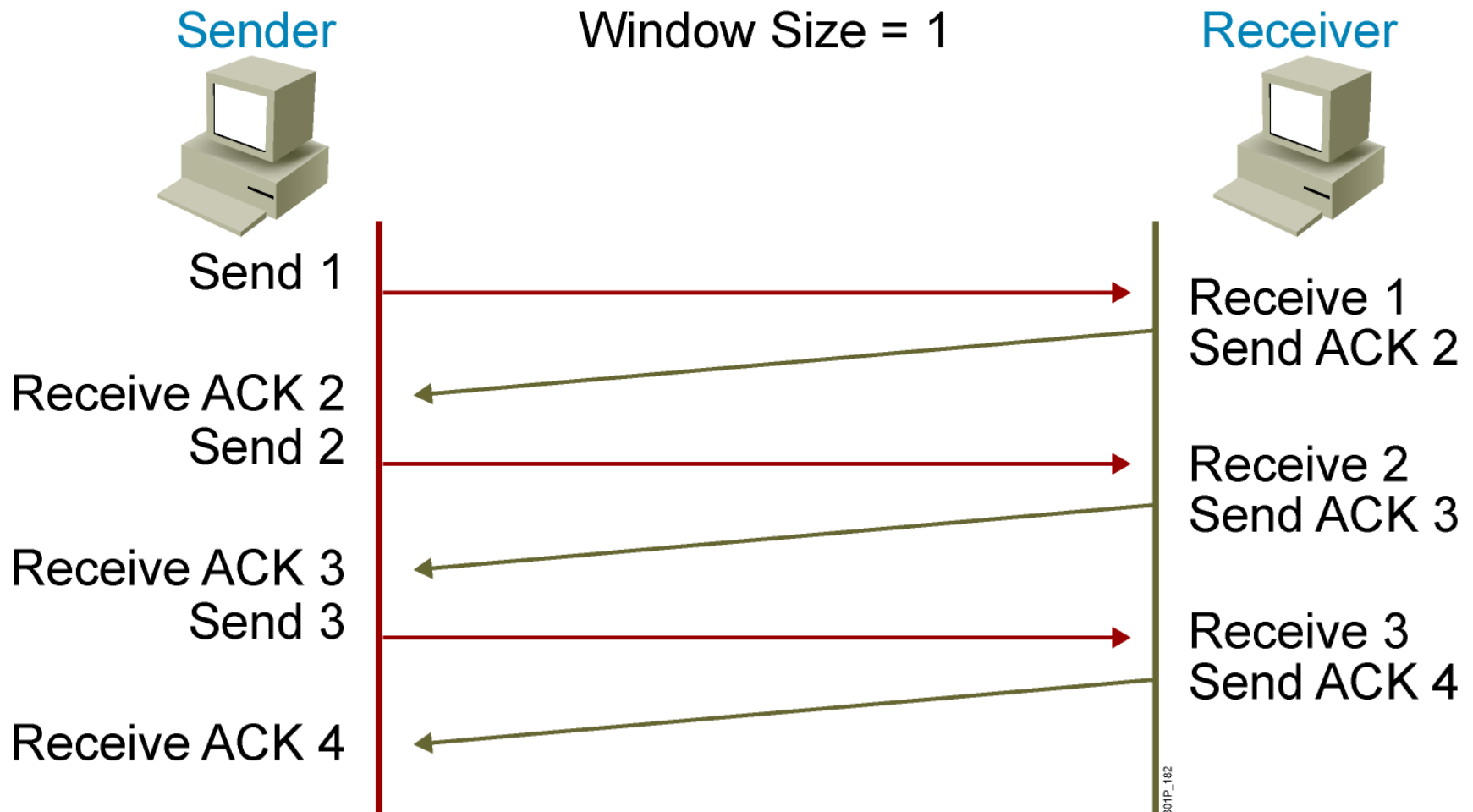


CTL = Which control bits in the TCP header are set to 1

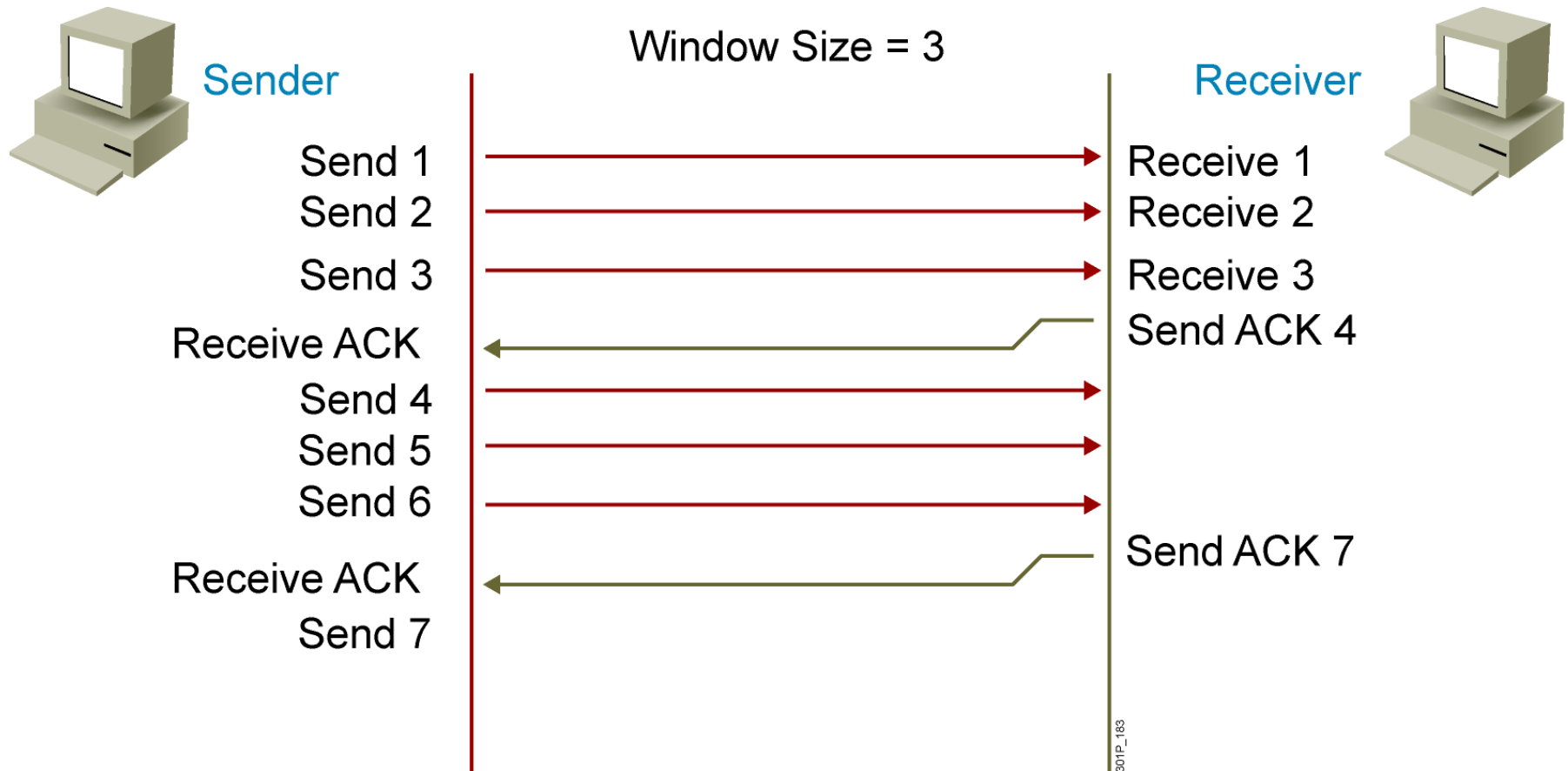
Flow Control



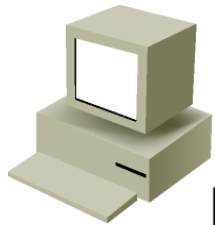
TCP Acknowledgment



Fixed Windowing



TCP Sliding Windowing



Sender

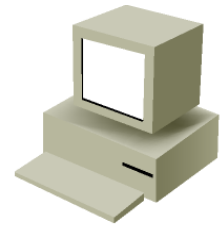
Window Size = 3
Send 1

Window Size = 3
Send 2

Window Size = 3
Send 3

Window Size = 3
Send 3

Window Size = 3
Send 4



Receiver

ACK 3
Window Size = 2

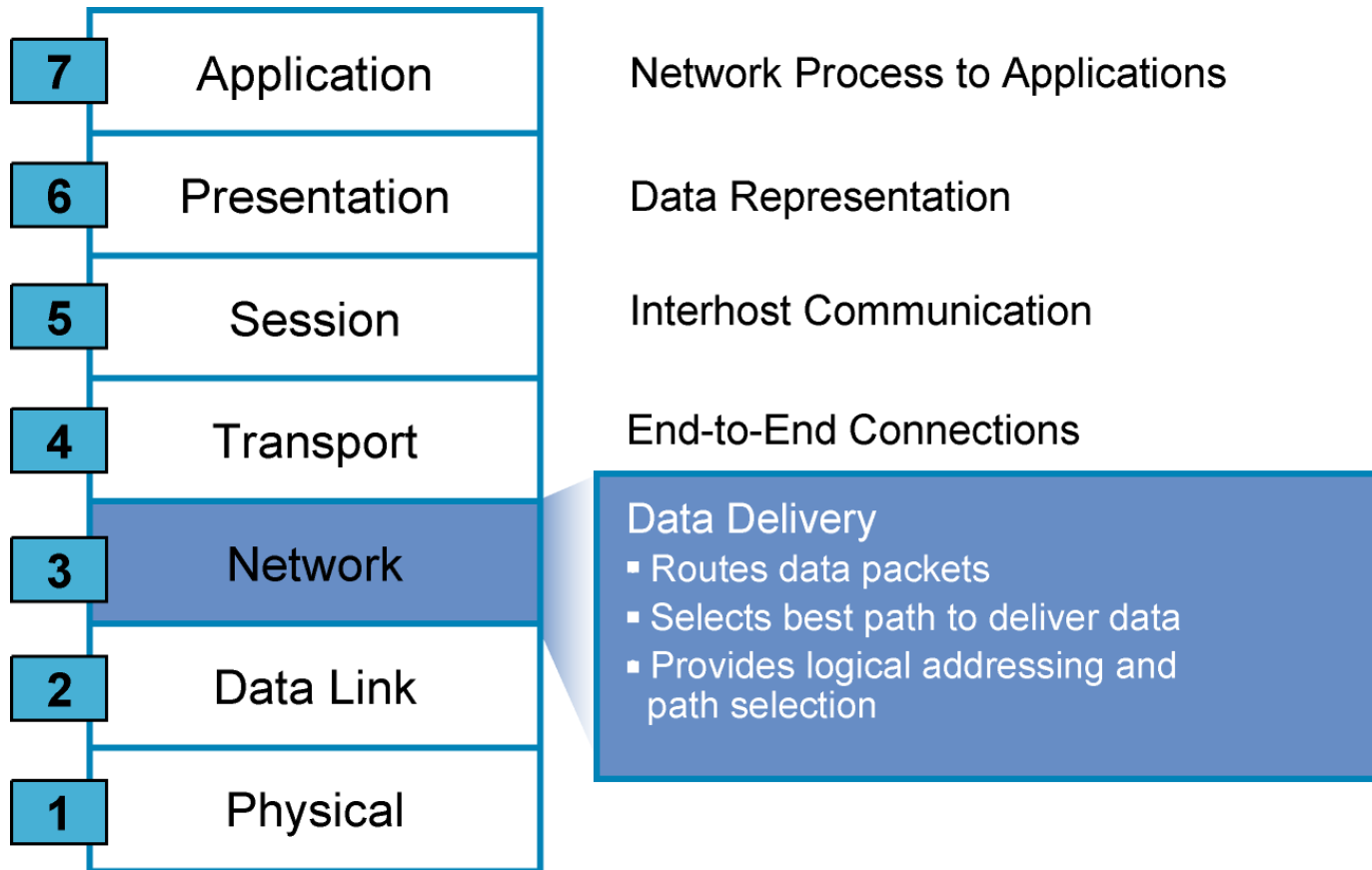
Segment 3 is lost because of the congestion of the receiver.

ACK 5
Window Size = 2



Network Layer

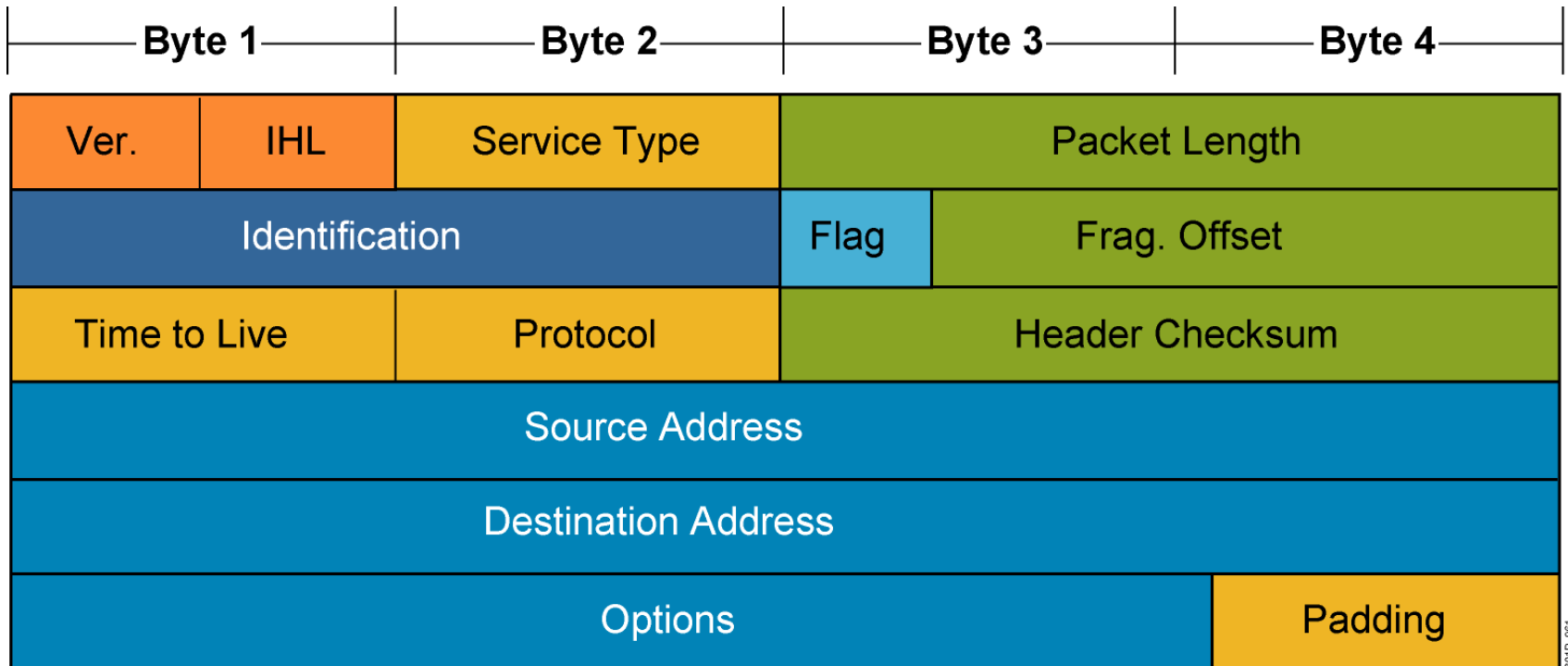
Network Layer



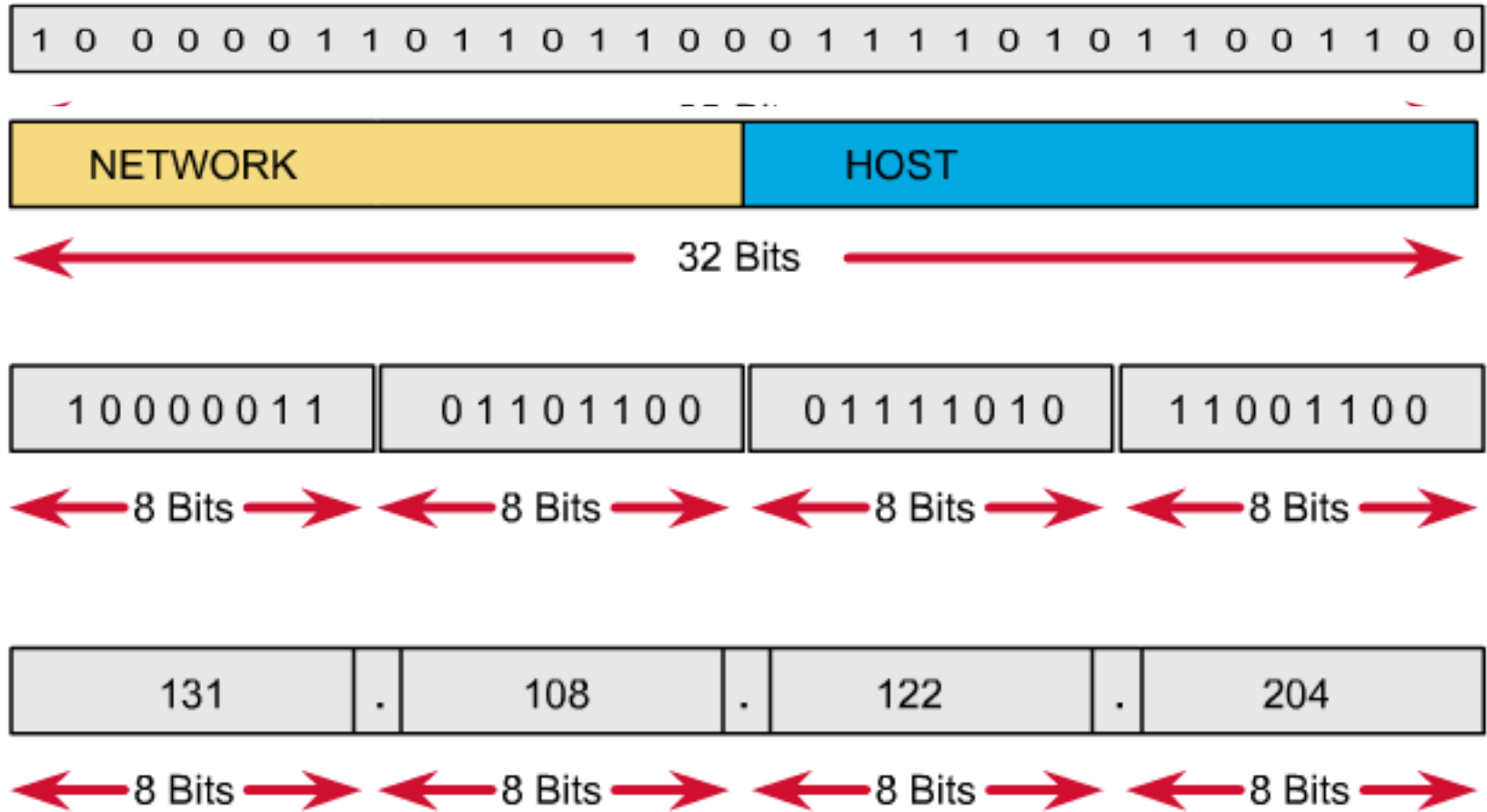
Internet Protocol Characteristics

- Operates at network layer of OSI
- Connectionless protocol
- Packets treated independently
- Hierarchical addressing
- Best-effort delivery
- No data-recovery features

IP PDU Header



IP Address Format



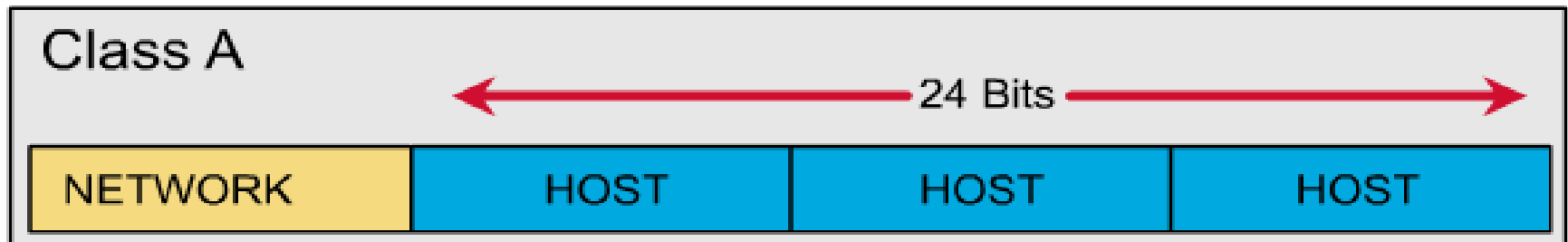
IP Address Format

- All network part bits cannot be set to all binary 0.
- If all host part bits is set to all binary 0, we have a network address.
- If all host part bits is set to all binary 1, we have a broadcast address.

IP Address Classes

	1 Byte 8 Bits	1 Byte 8 Bits	1 Byte 8 Bits	1 Byte 8 Bits
Class A:	N	H	H	H
Class B:	N	N	H	H
Class C:	N	N	N	H

Class A



# Bits	1	7	24
--------	---	---	----

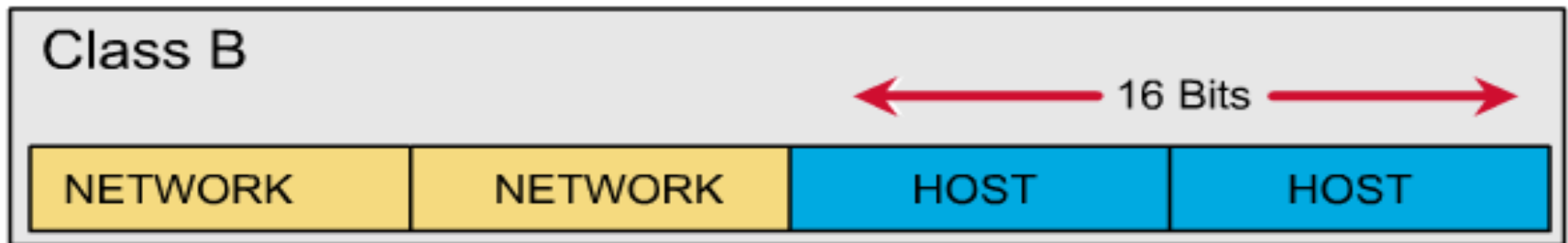
Class A:

0	NETWORK#	HOST#
---	----------	-------

Class A

- Network address:
1.0.0.0 -> 127.0.0.0
- Network 127.0.0.0 : loopback network
⇒ Usable network address: 1.0.0.0 -> 126.0.0.0
(126 network).
- Host part: 24 bits => Every class A network
have $2^{24} - 2$ hosts.

Class B



# Bits	1	1	14	16
--------	---	---	----	----

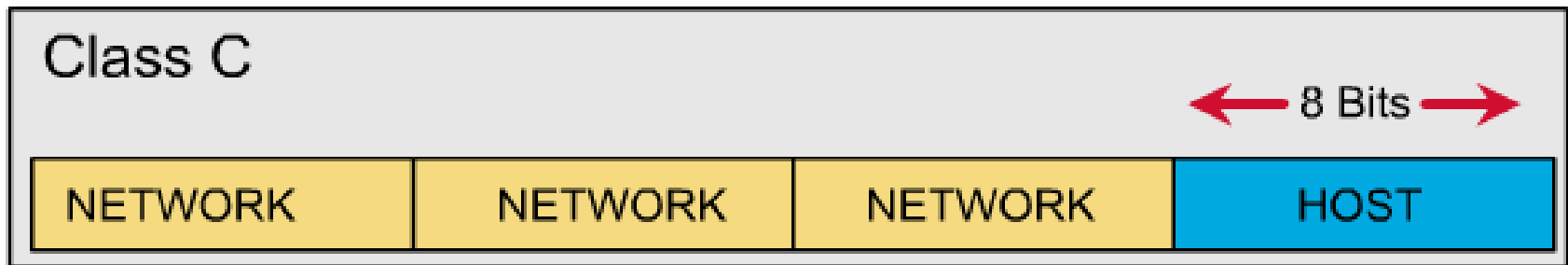
Class B:

1	0	NETWORK#	HOST#
---	---	----------	-------

Class B

- Network address :
128.0.0.0 -> 191.255.0.0
There are all 2^{14} networks in class B network.
- Host part : 16 bits
Every class B network have $2^{16} - 2$ hosts.

Class C



# Bits	1	1	1	21	8
--------	---	---	---	----	---

Class C:

1	1	0	NETWORK#	HOST#
---	---	---	----------	-------

Class C

- Network address:
192.0.0.0 -> 223.255.255.0
There are all 2^{21} networks in class C network.
- Host part: 8 bit
Every class C network have $2^8 - 2 = 254$ hosts.

Class D

- Network:
224.0.0.0 -> 239.255.255.255
- Multicast address.
- Example: 224.0.0.5 is used for OSPF
224.0.0.9 is used for RIPv2

Class E

- From 240.0.0.0 to the end.
- Reserved.

Broadcast

- Direct broadcast
Example: 192.168.1.255
- Local broadcast
255.255.255.255

Private and Public

- In LAN: Private.
- In Internet: Public.
- IP private range (RFC 1918):
 - Class A: 10.x.x.x
 - Class B: 172.16.x.x -> 172.31.x.x
 - Class C: 192.168.x.x
- NAT: Translate private <-> public.
- IP Private address help conserve IP public address.

Subnet mask and Prefix-length

- Subnet mask

Class A: 255.0.0.0

Class B: 255.255.0.0

Class C: 255.255.255.0

- Prefix-length

Class A: /8

Class B: /16

Class C: /24

