

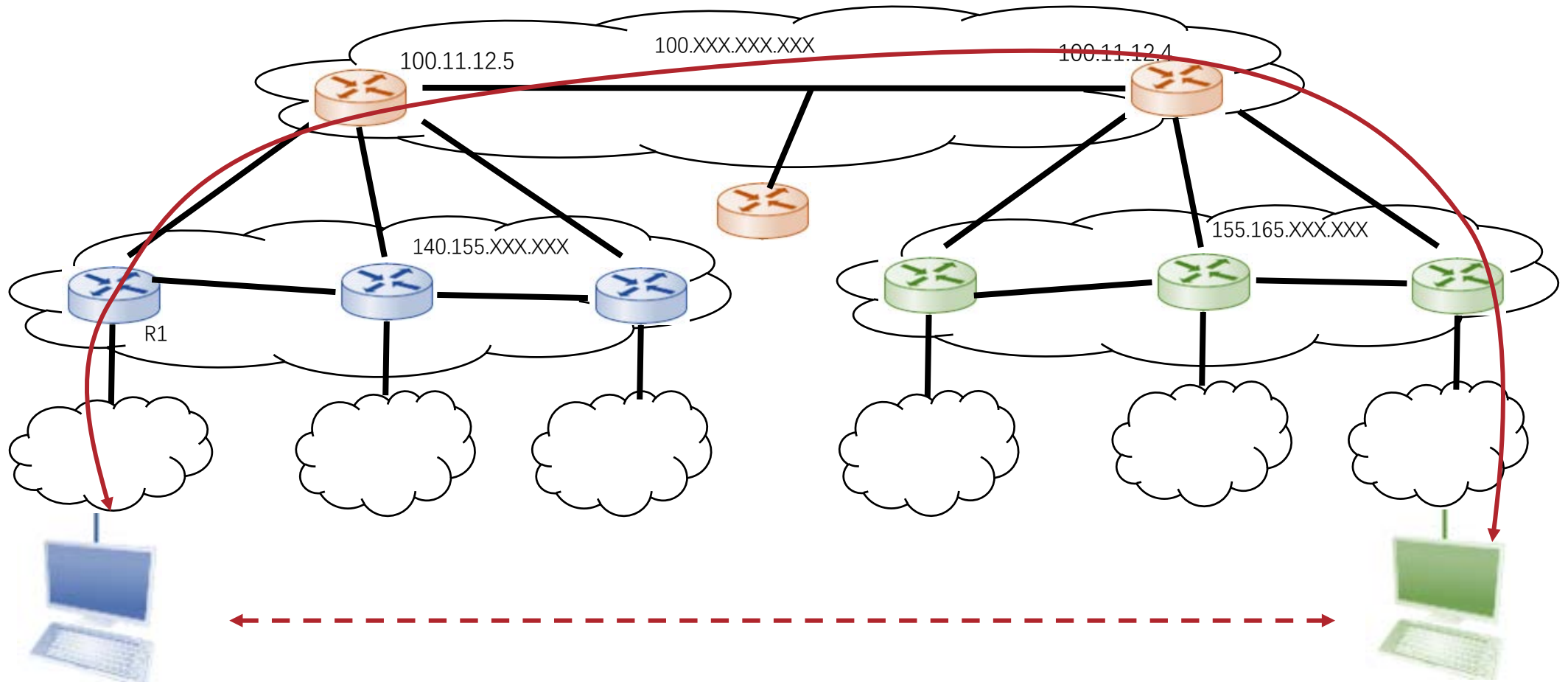


CS120: Computer Networks

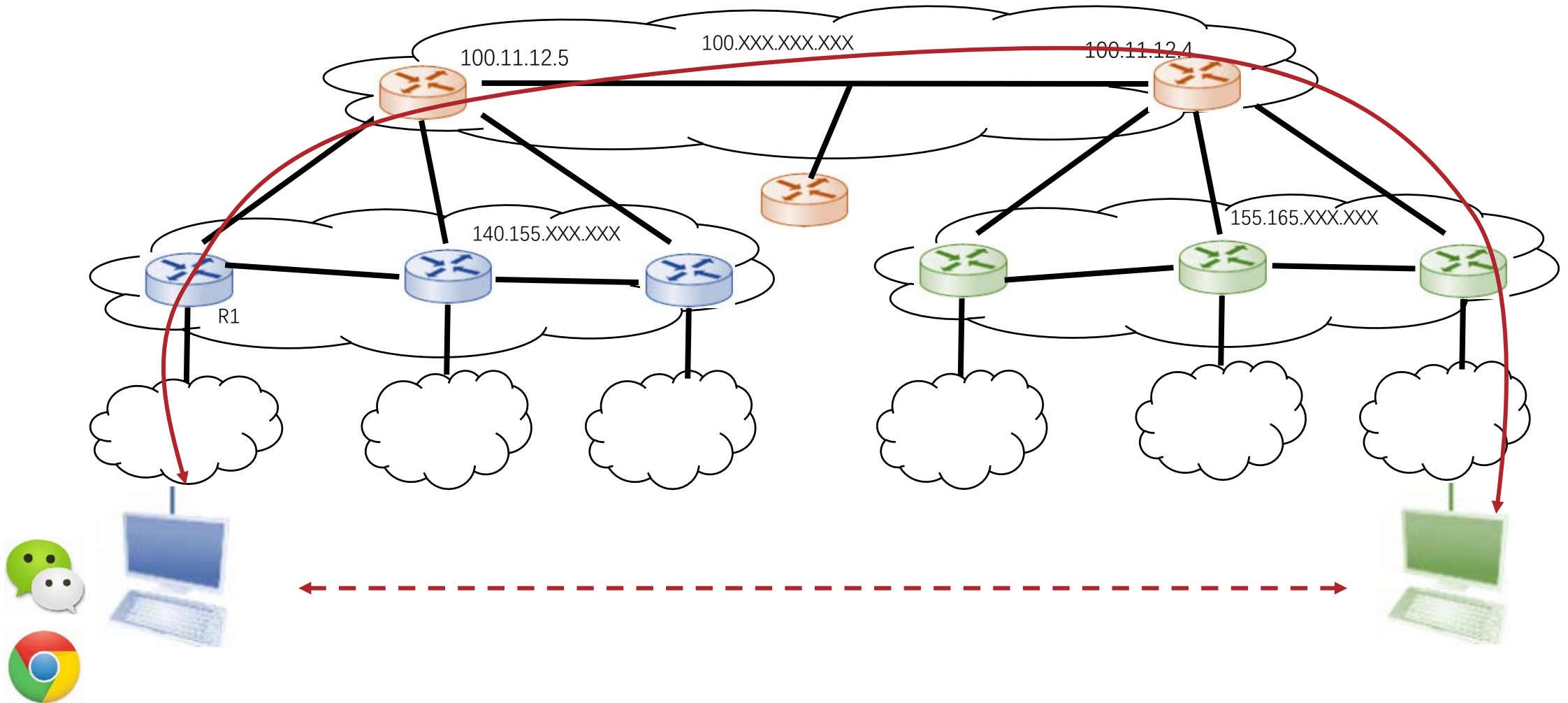
Lecture 15. TCP 1

Zhice Yang

IP: Host-to-host Protocol



Process-to-process Communication



Process-to-process Communication

- Problem: How to turn host-to-host packet delivery service into a process-to-process communication channel

Possible Application Level Requirements:

- Supports multiple application processes
- Reliable message delivery
- Messages are in order
- At most one copy
- Guaranteed delay
- Support arbitrarily large messages
- etc.



Support

IP Layer Provides:

- Host to host communication service

But:

- Messages may be dropped
- Messages may be reordered
- Messages may be duplicated
- Delivering delay is not guaranteed
- Message size is limited

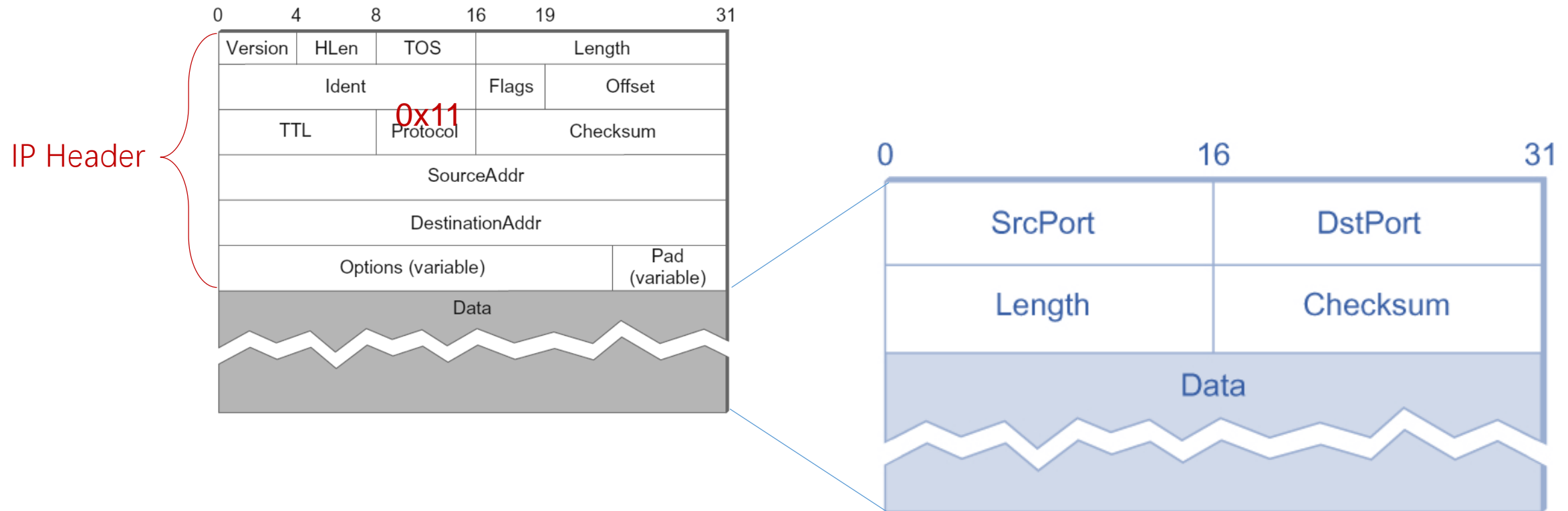
Outline

- Simple Demultiplexer (UDP)
- Reliable Byte Stream (TCP)

User Datagram Protocol (UDP)

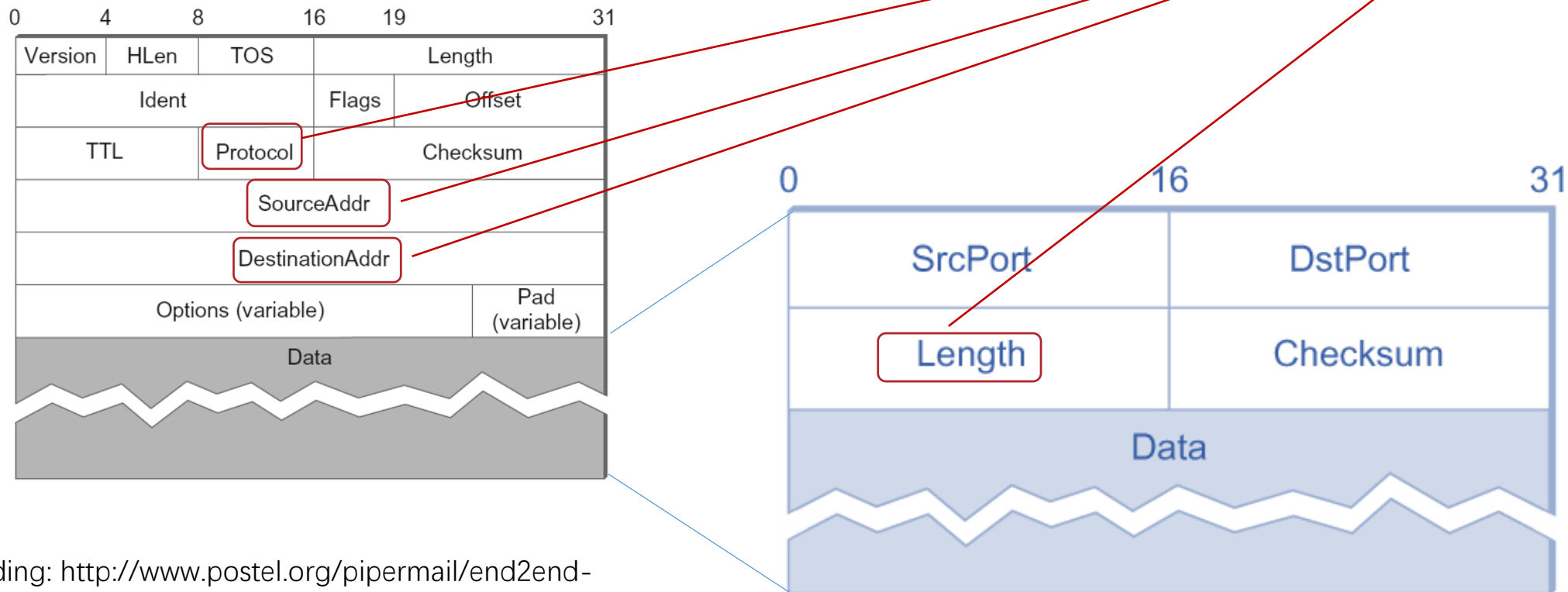
- RFC 768
- Direct Extension of IP
 - Best effort
 - Connectionless
 - No Guarantees
- Support Process Multiplexing

UDP Header



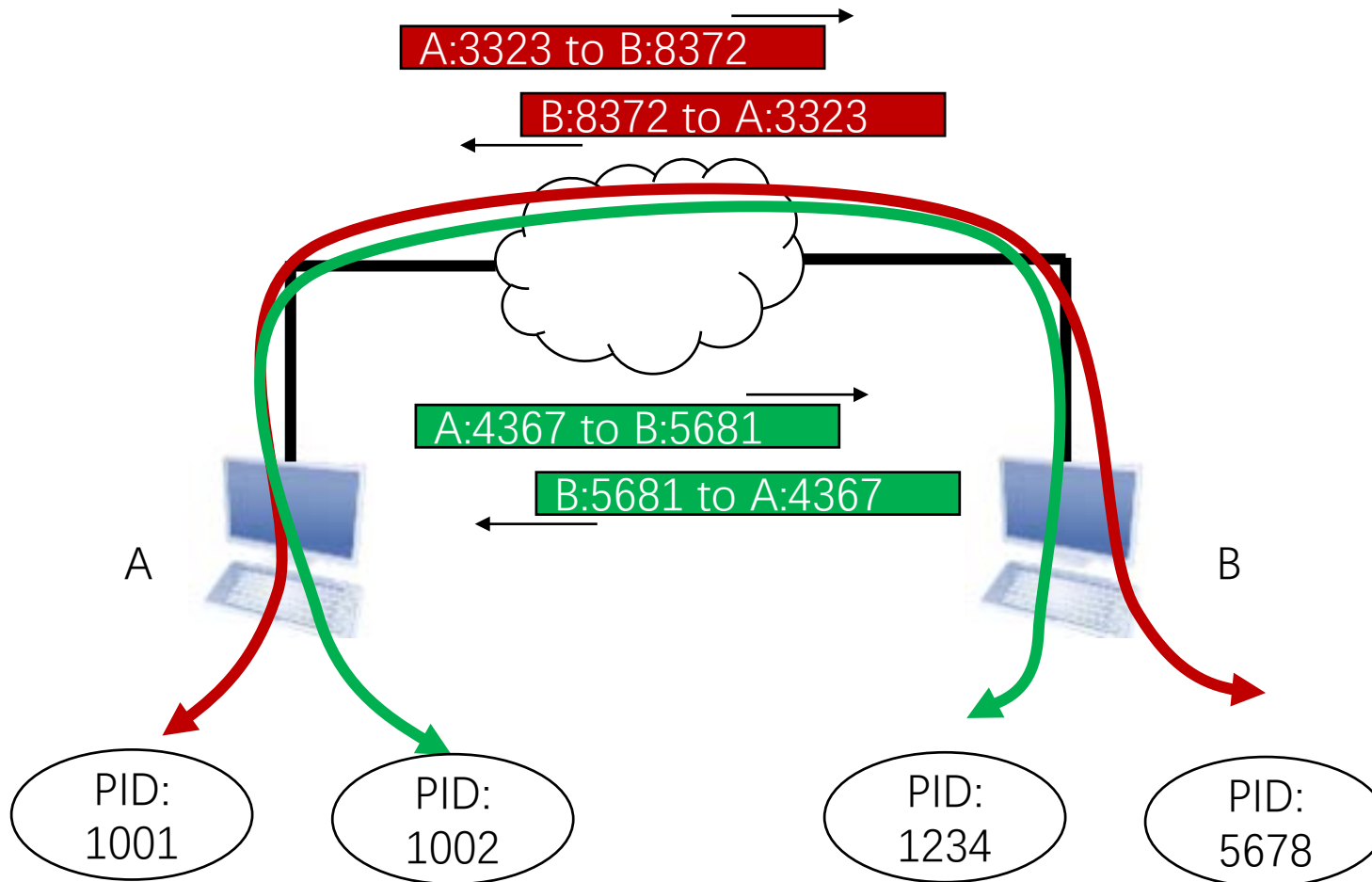
UDP Checksum

- UDP Checksum Range: UDP Header + UDP Data + Pseudoheader
 - Simple end-to-end integrity



UDP Multiplexing

- UDP Port: the Identifier for Processes



UDP Multiplexing

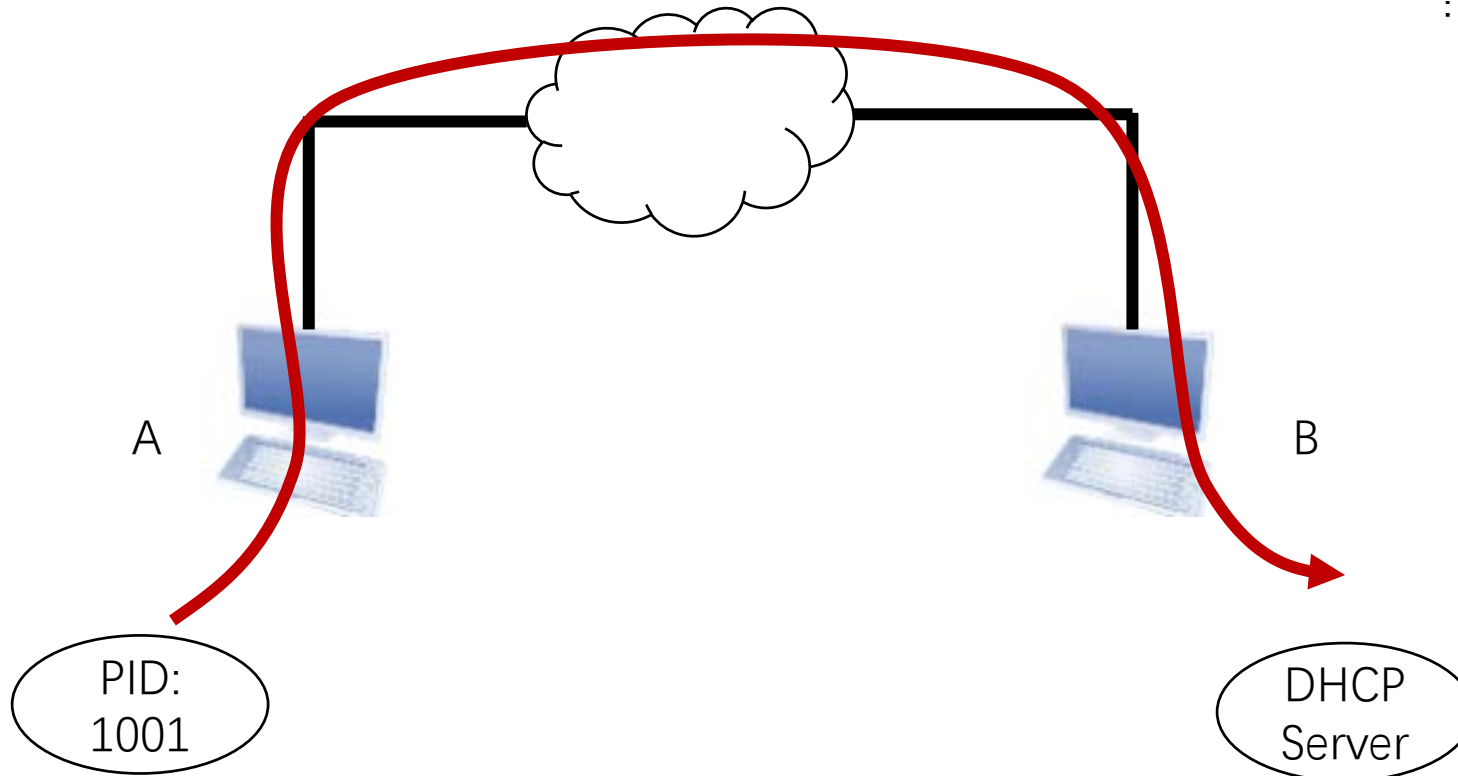
- Initiate Connection: Default Port

- stored in /etc/services

A:3323 to B:67

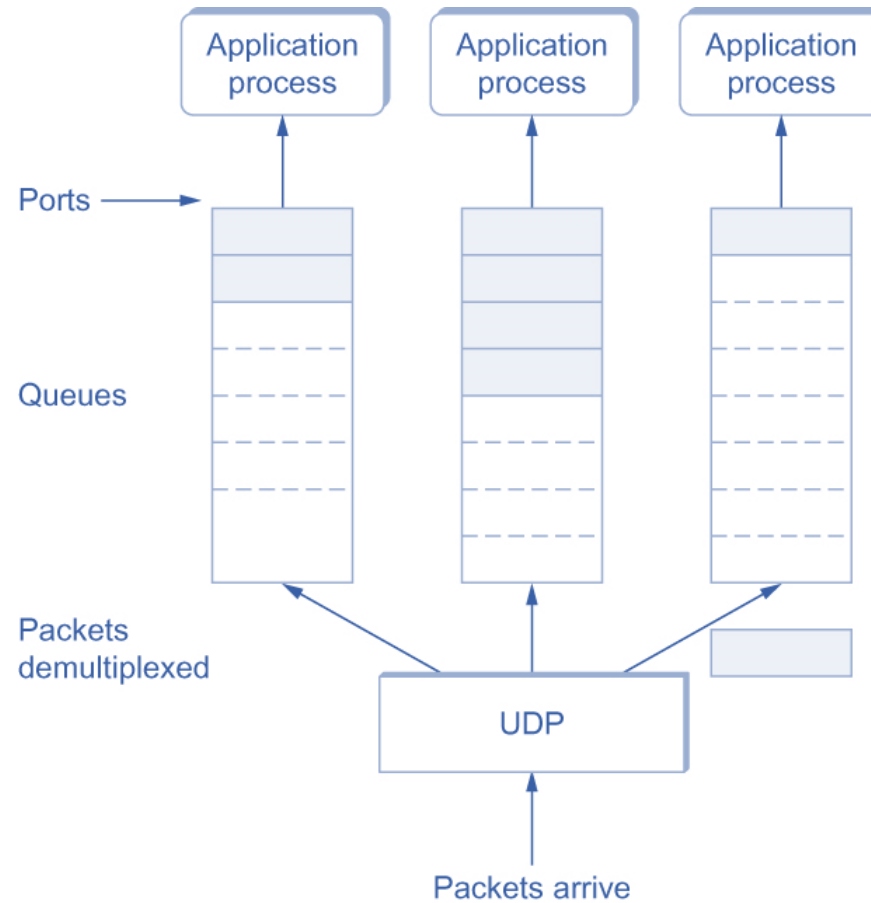
Port Number	Protocol	Function
21	TCP	FTP (File Transfer Protocol)
22	TCP/UDP	SSH (ssh,scp copy or sftp)
23	TCP/UDP	Telnet
25	TCP/UDP	SMTP (for sending outgoing emails)
43	TCP	WHOIS function
53	TCP/UDP	DNS Server (Domain name service for DNS requests)
67	UDP	DHCP Server
68	TCP	DHCP Client
70	TCP	Gopher Protocol
79	TCP	Finger protocol
110	TCP	POP3 (for receiving email)
119	TCP	NNTP (Network News Transfer Protocol)
143	TCP/UDP	IMAP4 Protocol (for email service)

⋮



UDP Multiplexing

- Ports in OS



Demo

- netstat

User Datagram Protocol (UDP)

- RFC 768
- Direct Extension of IP
 - Best effort
 - Connectionless
 - No Guarantees
- Support Process Multiplexing
- UDP Use:
 - Loss tolerant, Rate sensitive
 - Video Stream
 - No Connection Setup delay, “One Time” Transfer
 - DNS
 - DHCP
 - Reliable Transfer over UDP
 - Add reliability at application layer, e.g., QUIC

Process-to-process Communication

- Problem: How to turn host-to-host packet delivery service into a process-to-process communication channel

Possible Application Level Requirements:

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- Reliable message delivery
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- At most one copy
- Guaranteed delay
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Support

IP Layer Provides:

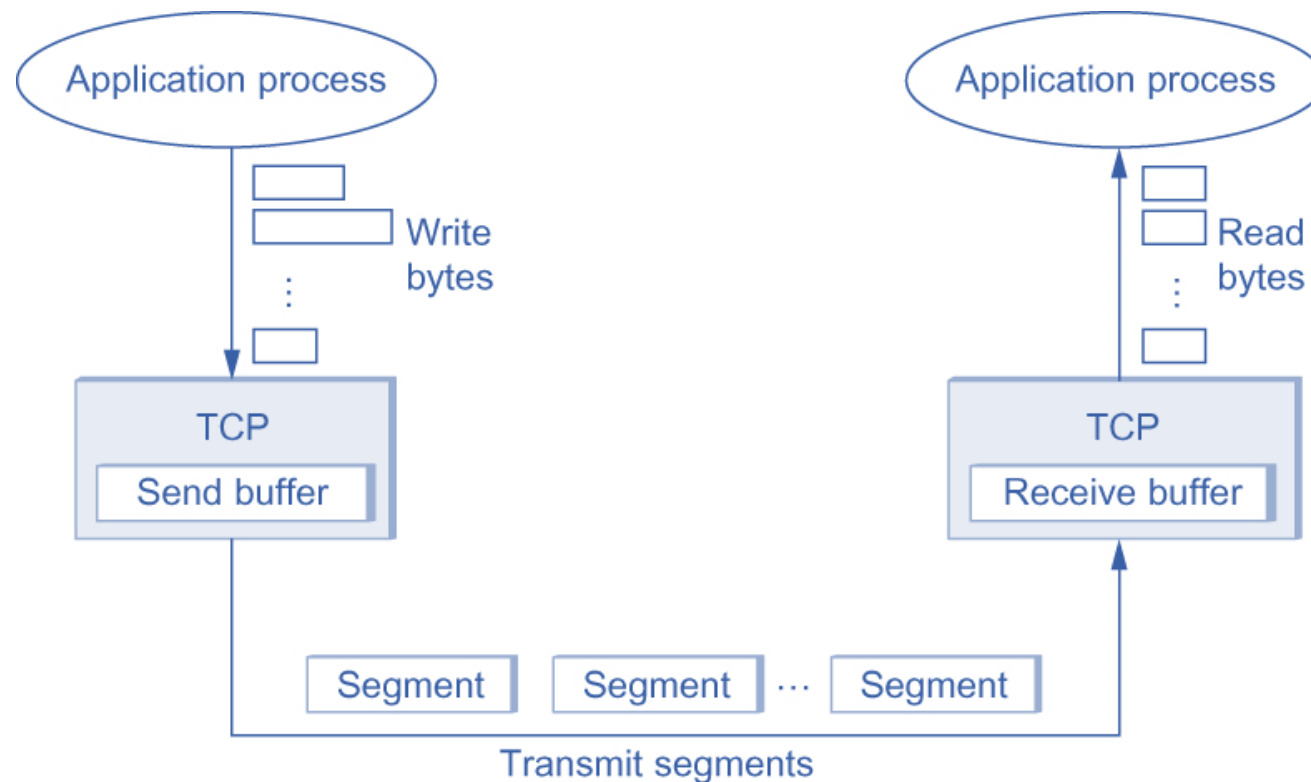
- Host to host communication service

But:

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TCP: Communicate Model

- TCP Peers Communicate through Segments



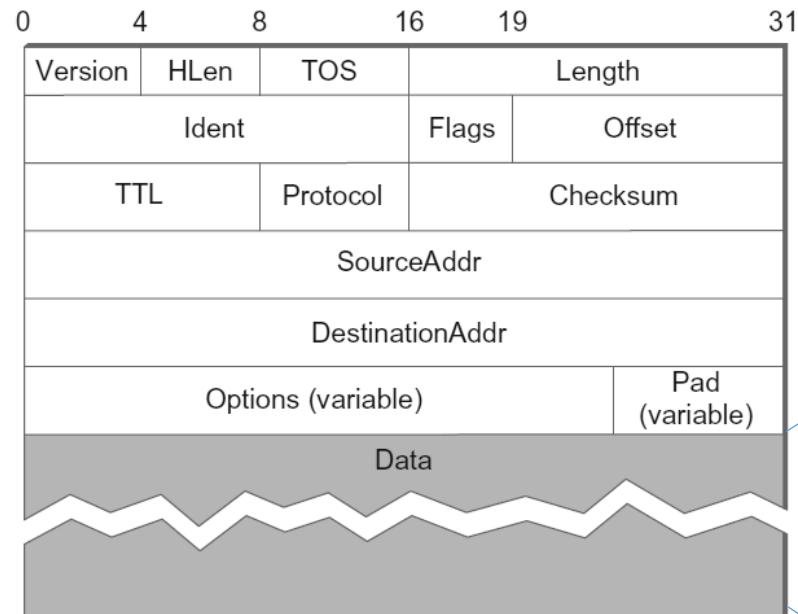
Transmission Control Protocol (TCP)

- RFC: 793, 1122, 1323, 2018, 2581
- Goal: Reliable, In-order Delivery
 - Connection oriented
 - Reliable message delivery
 - Messages are in order
 - At most one copy
 - Flow control
 - Congestion control
- Core Algorithm: Sliding Window

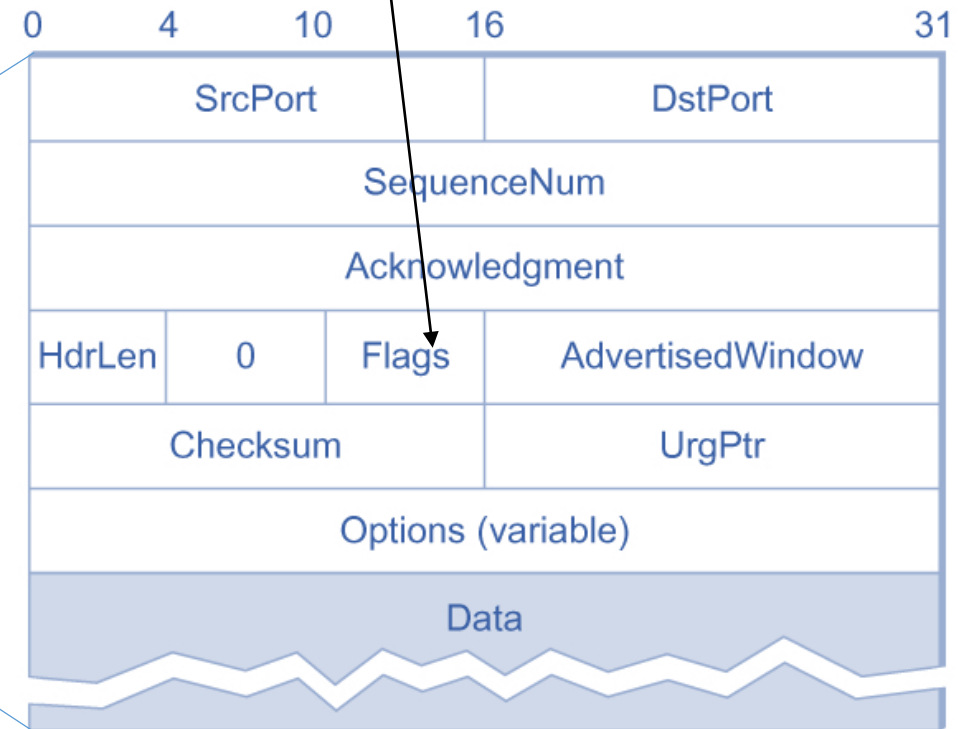
Extensions to Simple Sliding Window

- Connection Establishment
 - Need to share connection parameters
- Adaptive Timeout
 - Need to handle dynamic RTT in IP network
- Timeout Packet
 - Need to distinguish old packets
- Flow Control
 - Need to know the receiver's capability
- Congestion Control
 - Need to estimate the network capacity

TCP: Header



URG|ACK|PUSH|RESET|SYN|FIN

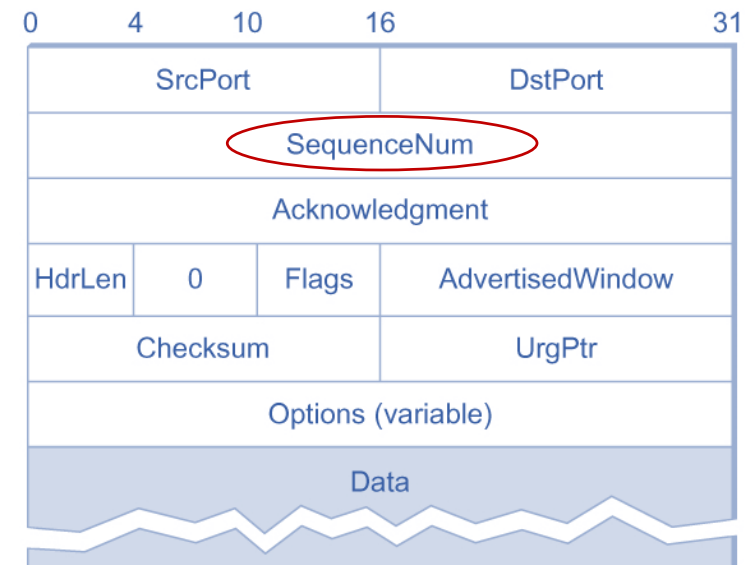


Connection Establishment

- Why?
 - Reserve Connection Resource (buffer, etc.)
 - Negotiate Sequence Number
 - Reject Out-of-time Connection Request

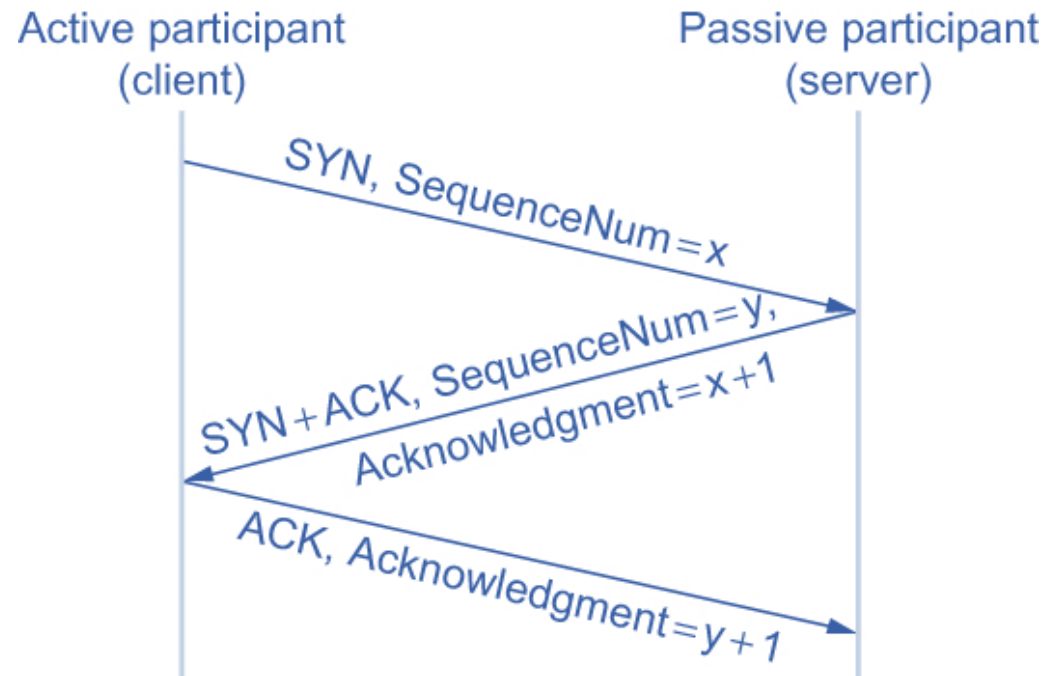
Connection Establishment

- Sequence Number
 - The pointer of the data byte in the segment
 - Initial sequence number is exchanged in connection establishment
 - Initial sequence number is a random number (32bits):
 - To avoid confusions causing by segments with same sequence number from dead connections
 - Security concern
 - Sequence number prediction attack
- Acknowledgement
 - Expected next sequence number



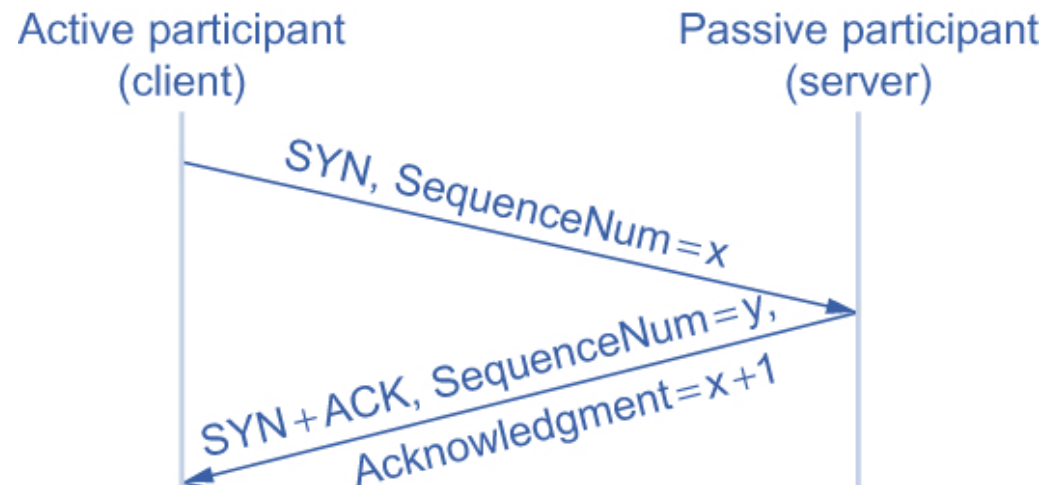
Connection Establishment

- Three-way Handshake
 - To share sequence number
 - To reserve resource



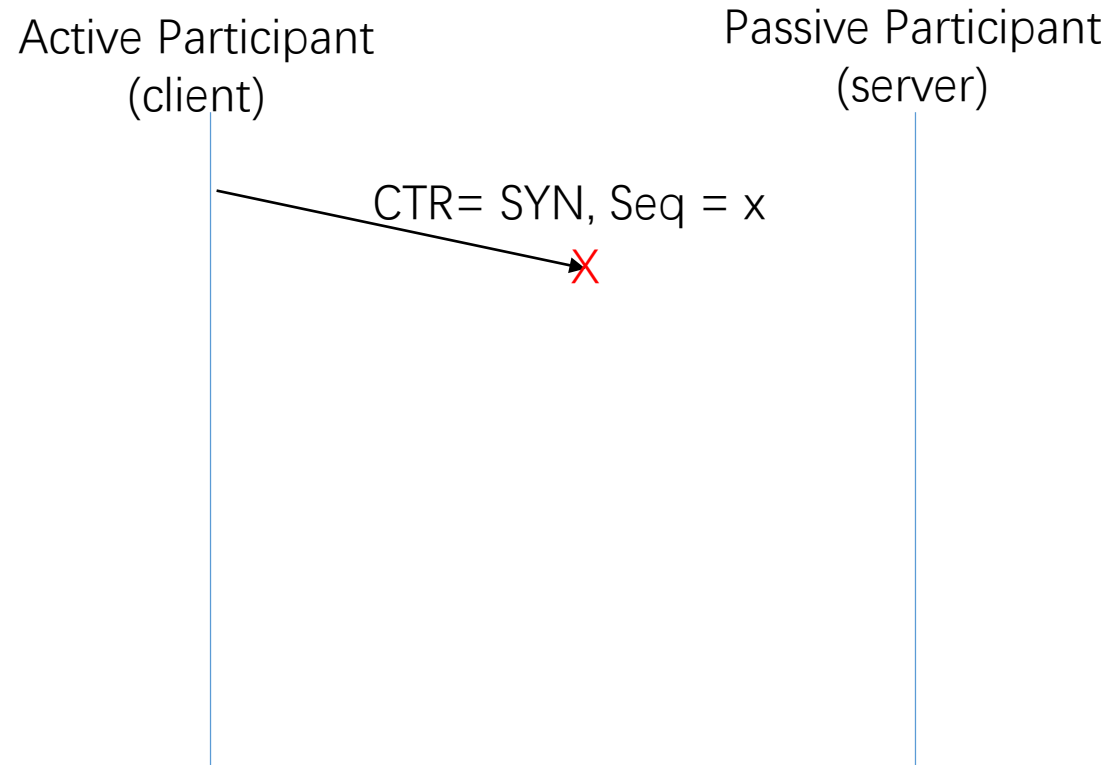
Connection Establishment

- Why two-way handshake is not enough ?
 - To eliminate out-of-order connection request
 - Three-way: client will not respond to the SYN+ACK if the connection request is old
 - To confirm that the client knows the server is ready
 - In case SYN+ACK loss



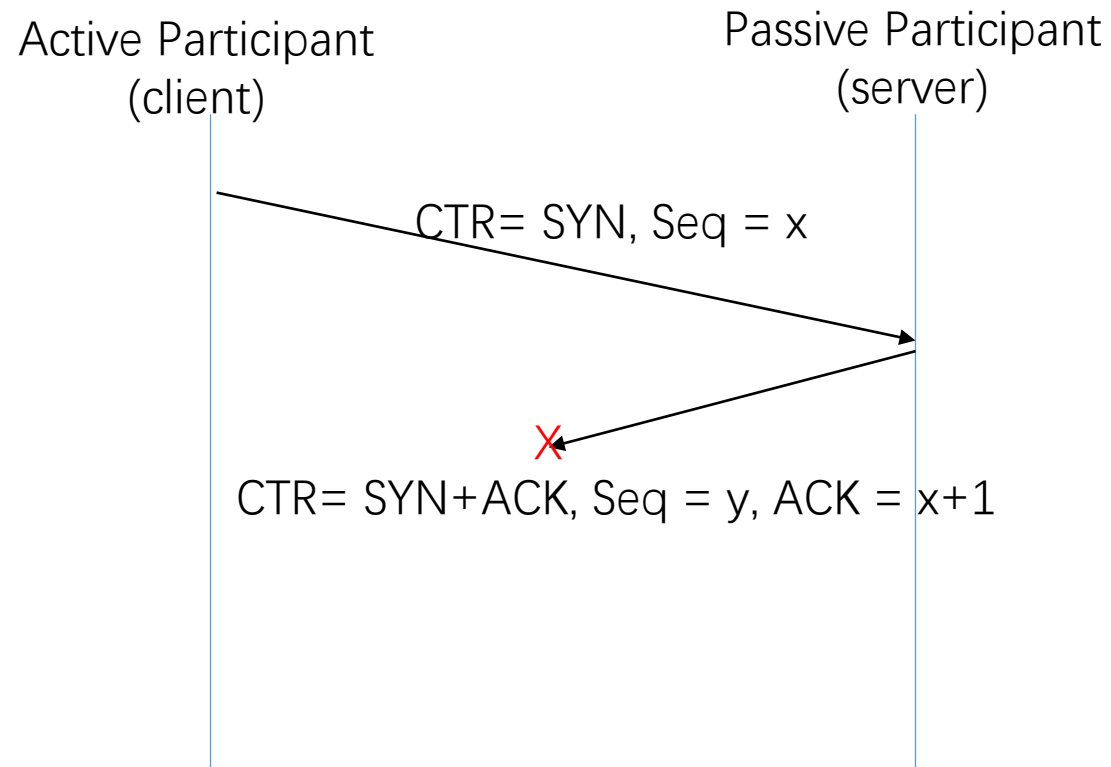
Connection Establishment

- Three-way Handshake
 - SYN loss
 - Client retransmits, until receives SYN+ACK from server



Connection Establishment

- Three-way Handshake
 - SYN+ACK loss
 - Server retransmits, until receive ACK from client

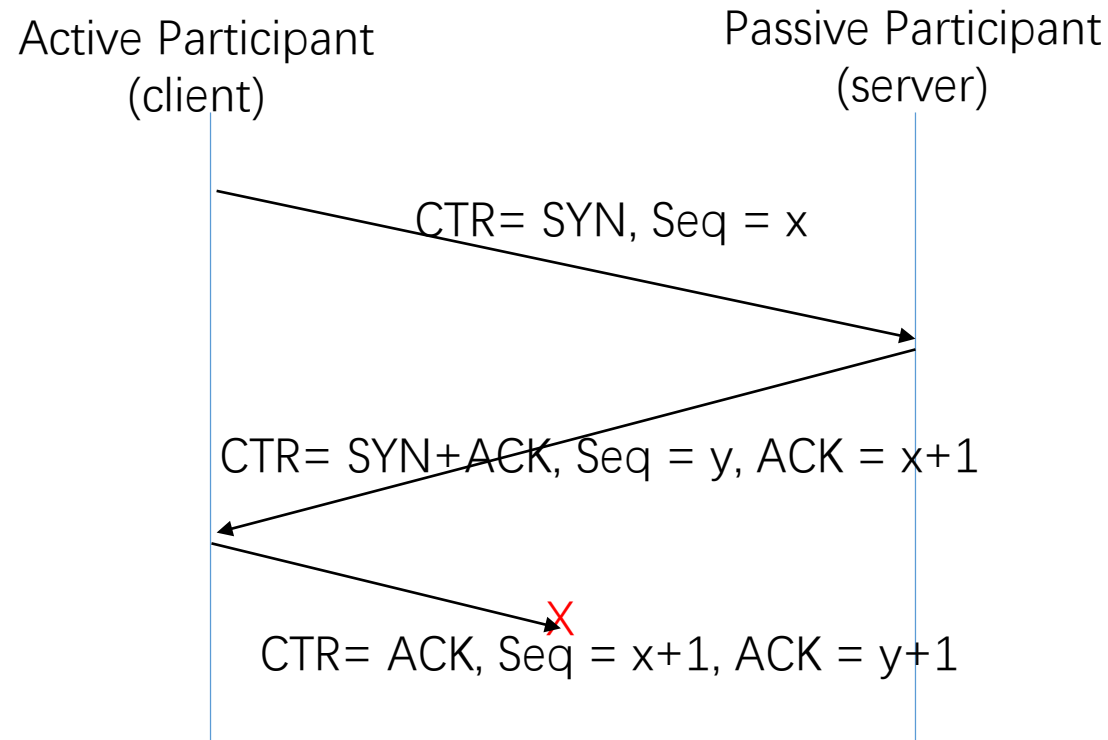


Connection Establishment

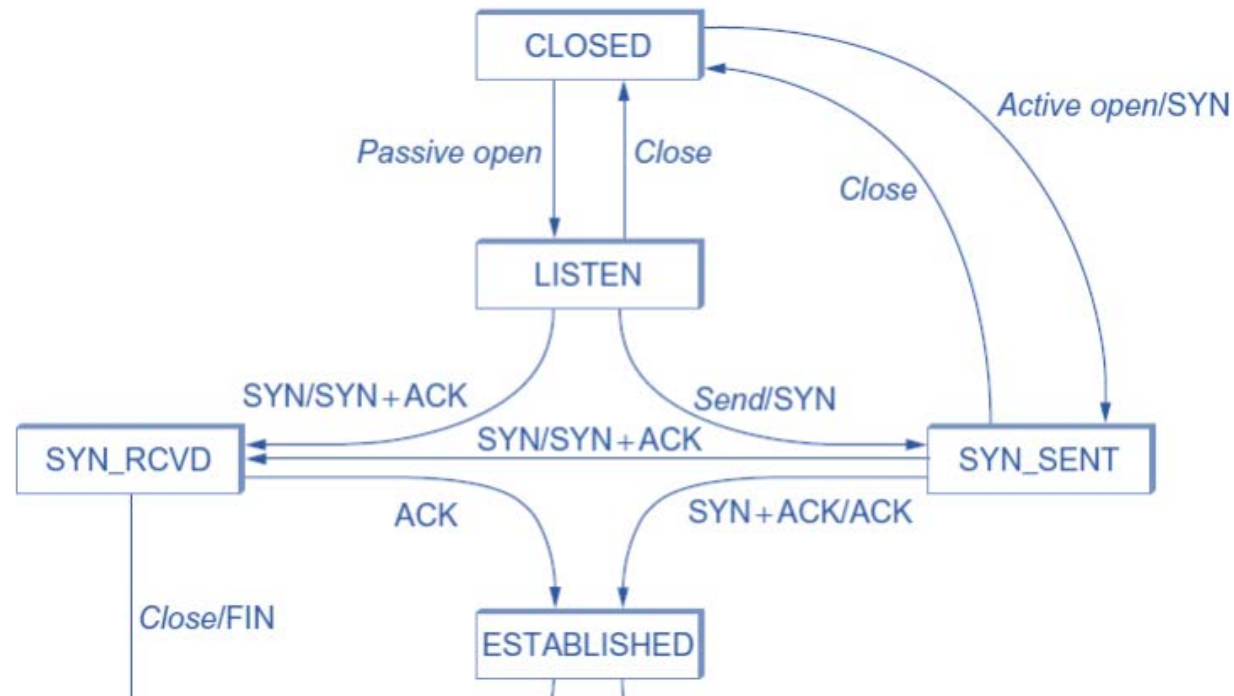
- Three-way Handshake

- Client ACK loss

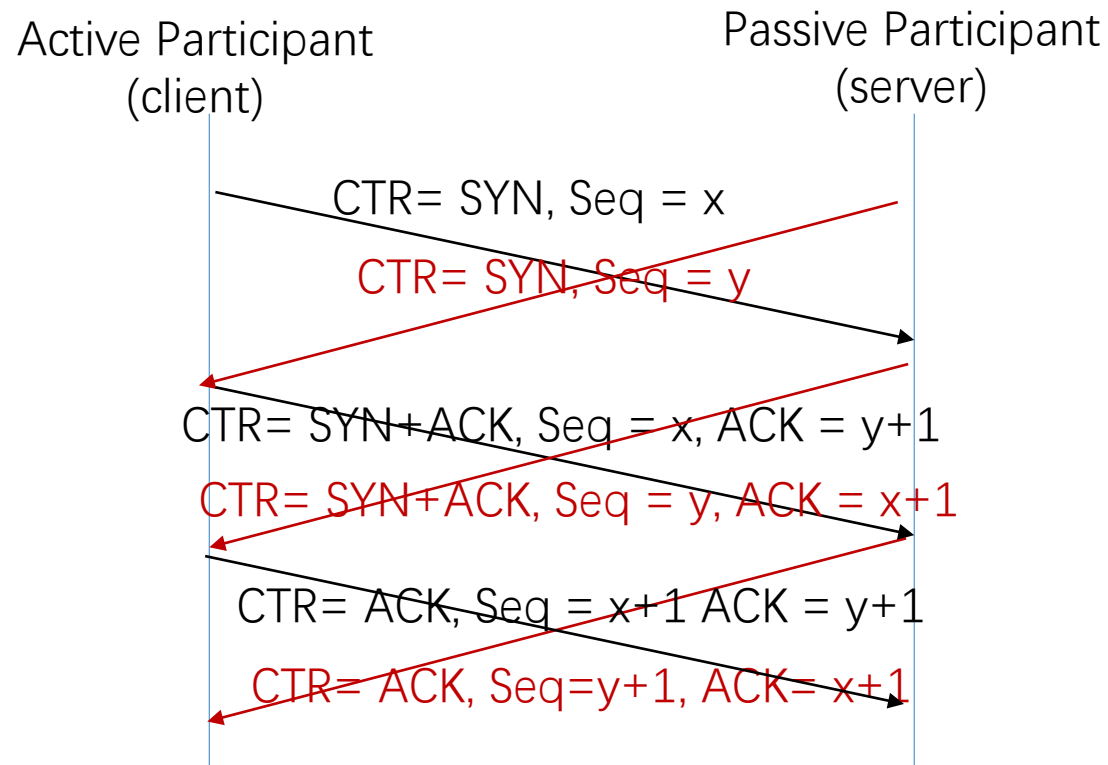
- Server retransmits SYN+ACK, until receive ACK from client
 - or Client transmits DATA+ACK, server treats it as ACK



TCP State-transition Diagram



TCP State-transition Diagram



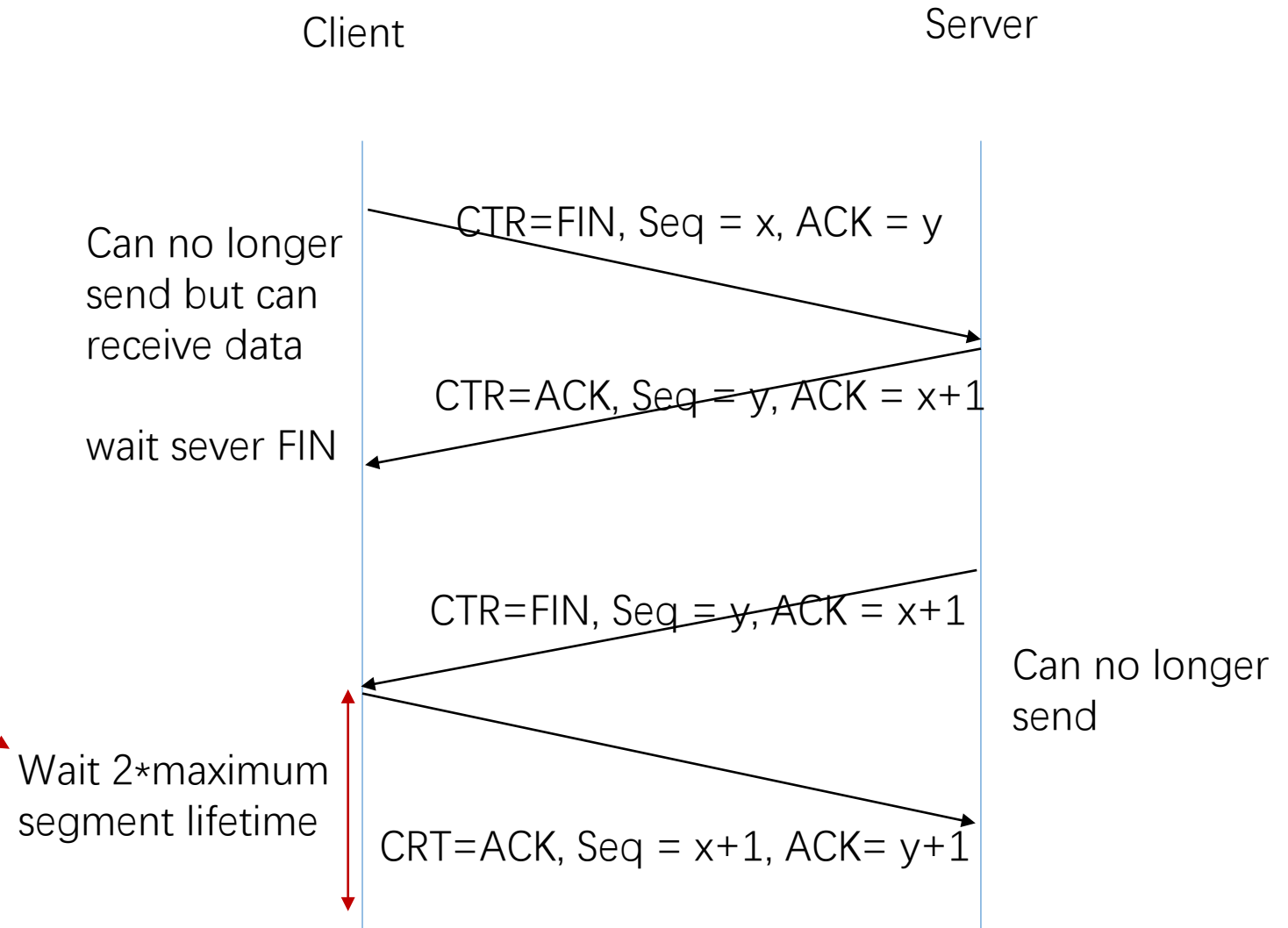
Connection Termination

- Four-way Handshake
 - To release resource
 - Can be asymmetric
 - e.g.: server is transmitting to client; client has nothing to transmit, it closes the connection, releases transmission queue

Connection Termination

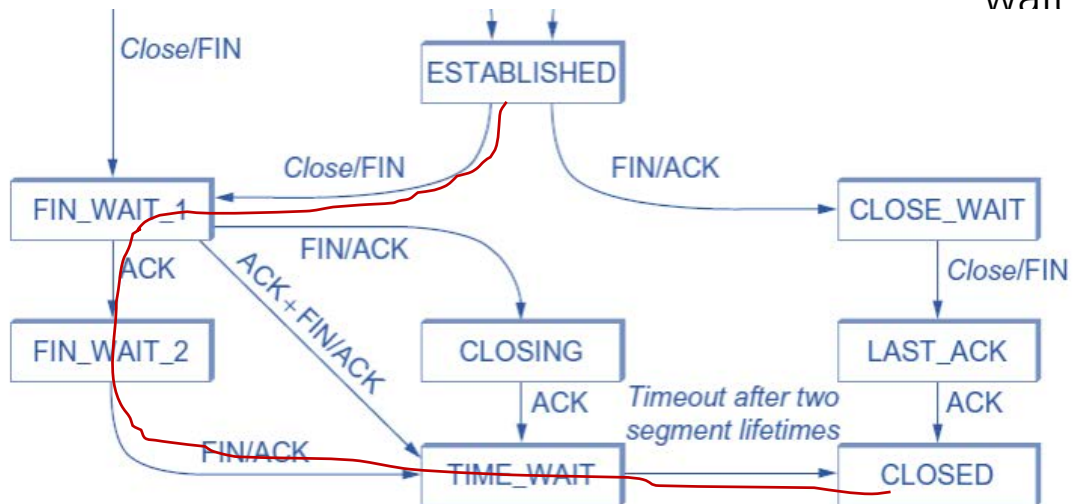
- Four-way Handshake

Use to prevent
retransmitted FIN (due to
ACK loss) from terminating
new connections



Connection Termination

- Four-way Handshake



Client

Server

Can no longer
send but can
receive data

wait sever FIN

ximum
fetime

FIN

ACK

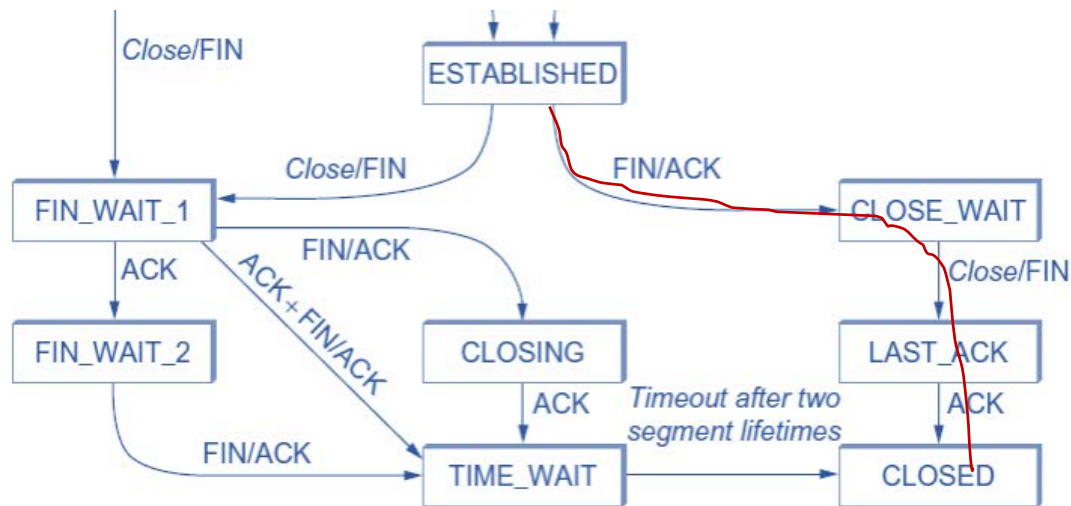
FIN

ACK

Can no longer
send

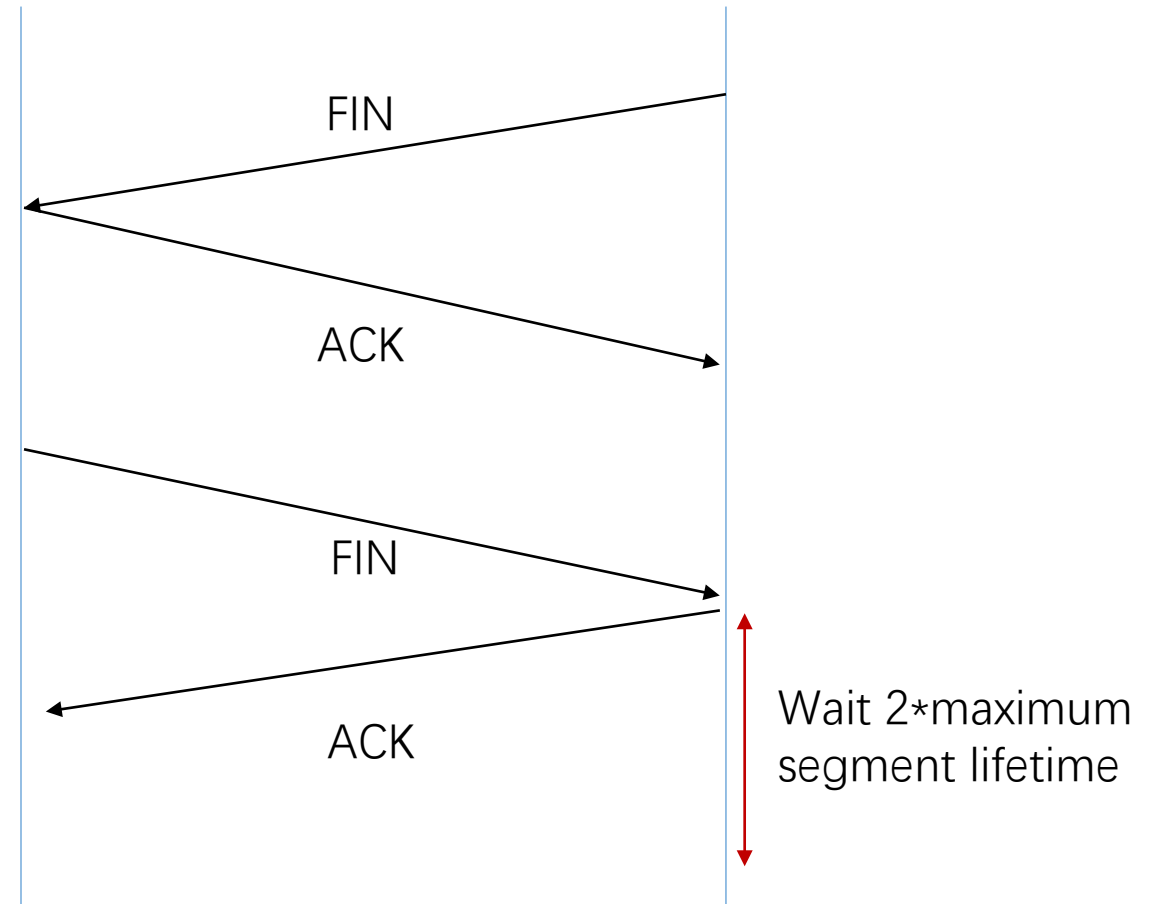
Connection Termination

- Case 2:



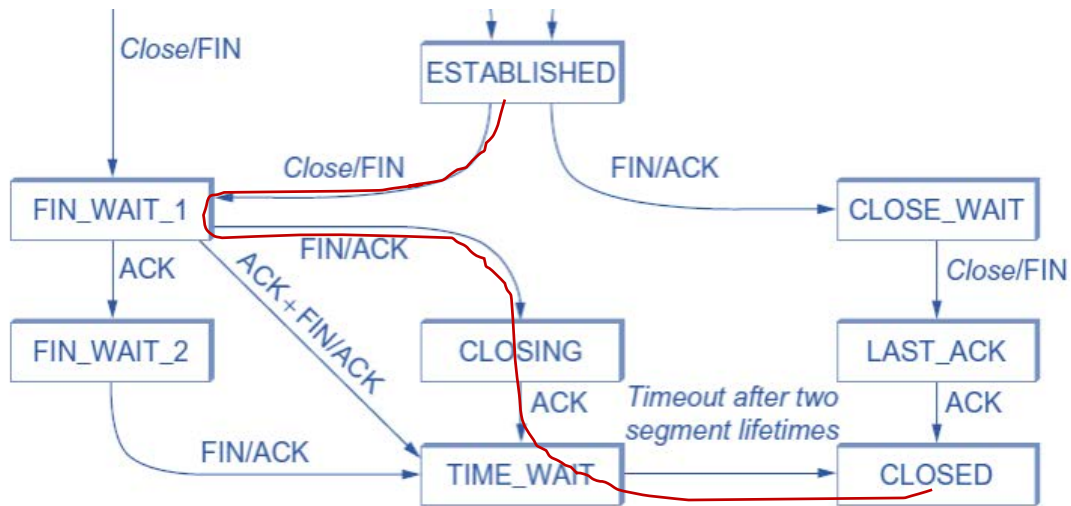
Client

Server



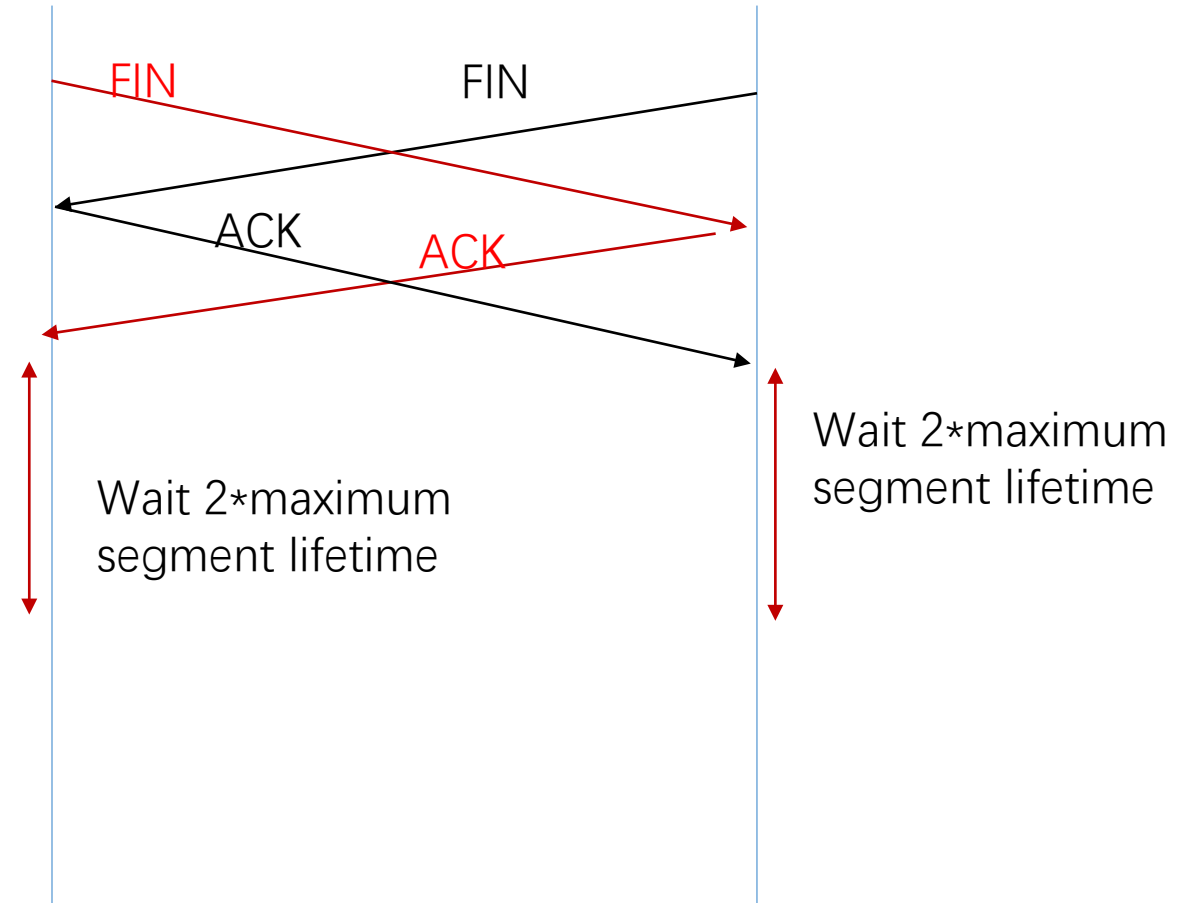
Connection Termination

- Case 3:



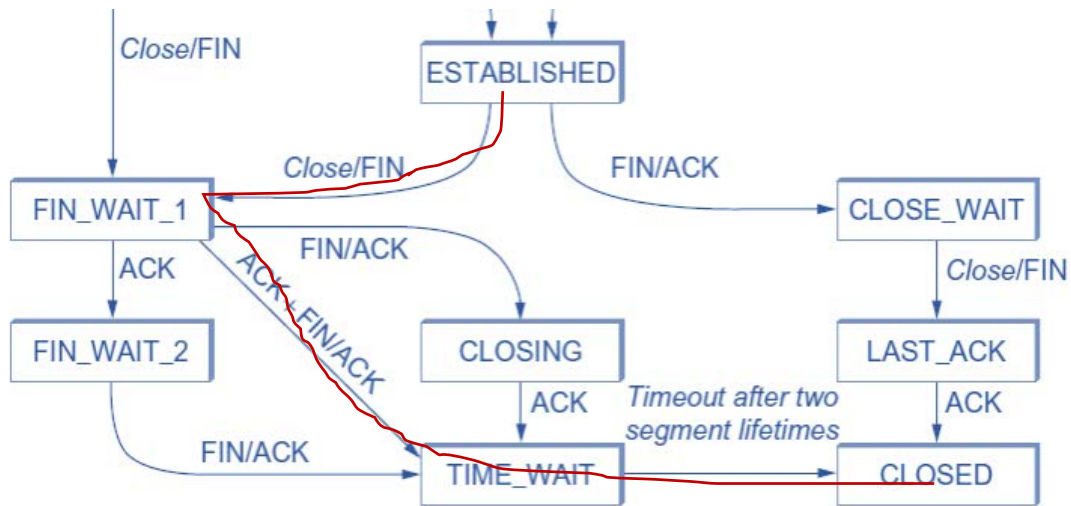
Client

Server



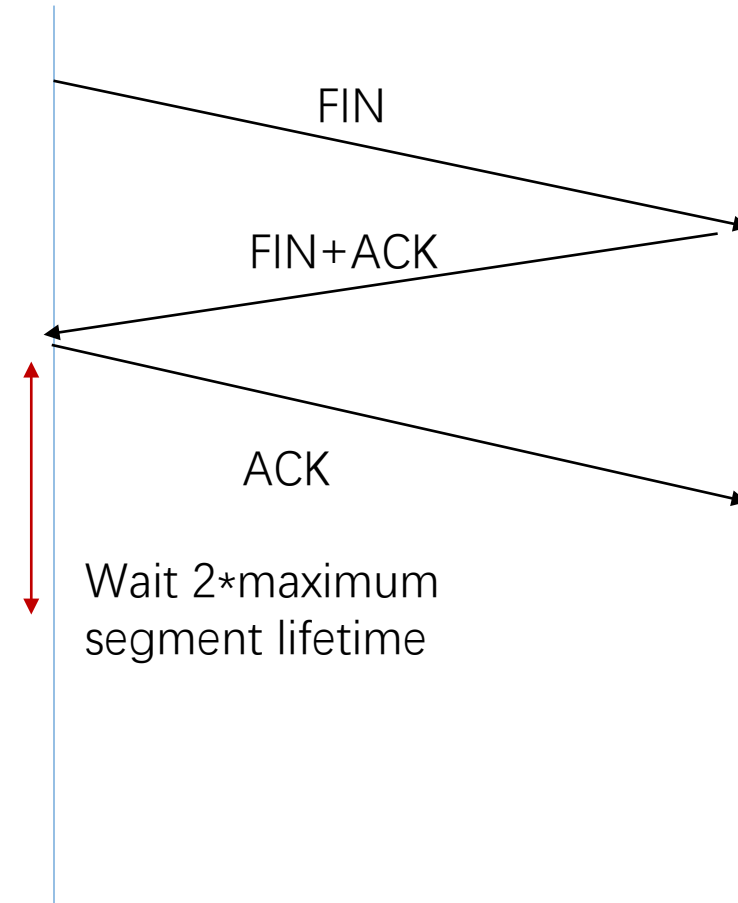
Connection Termination

- Case 4:

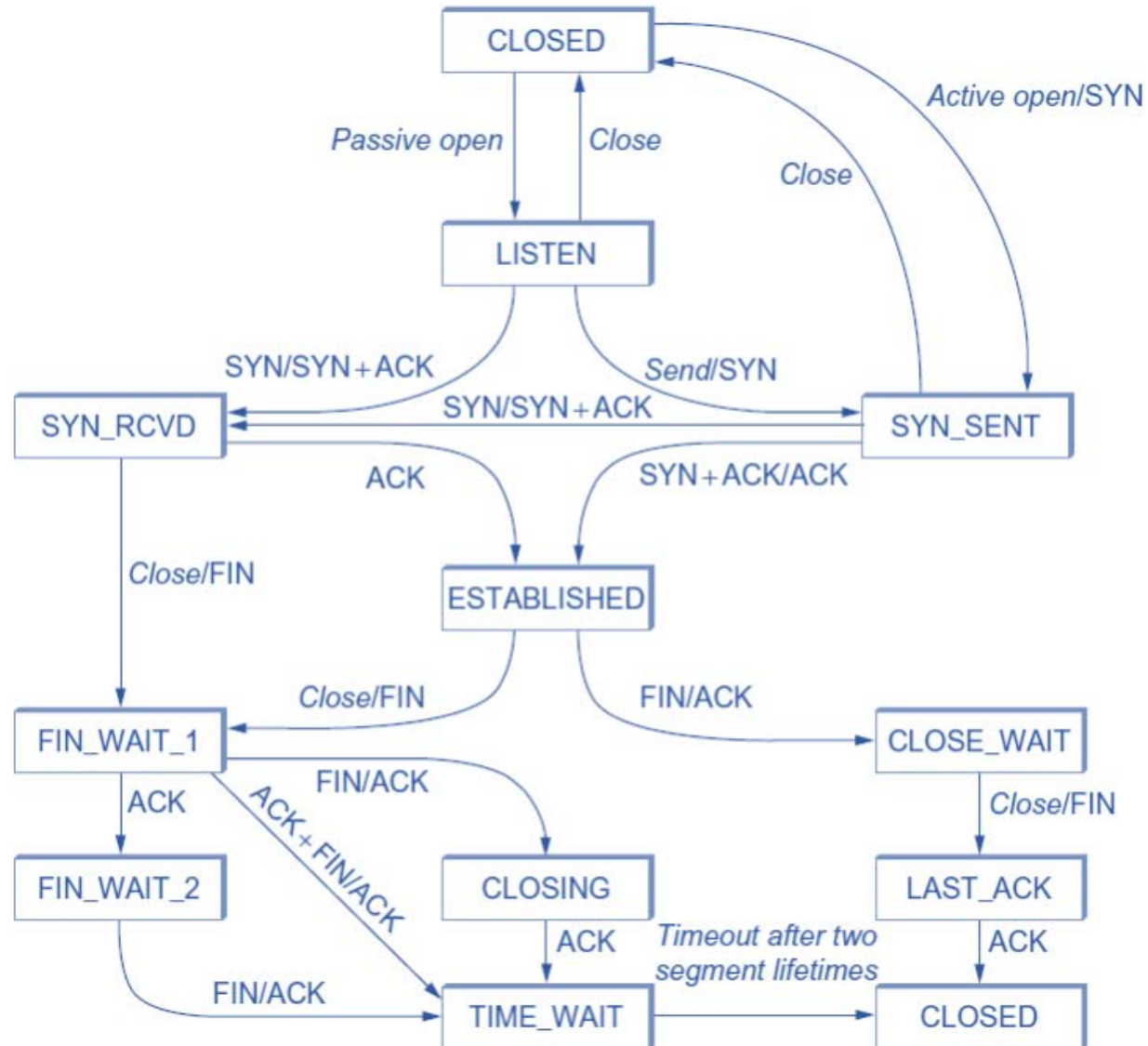


Client

Server



TCP State-transition Diagram



Reference

- Textbook 5.1 5.2