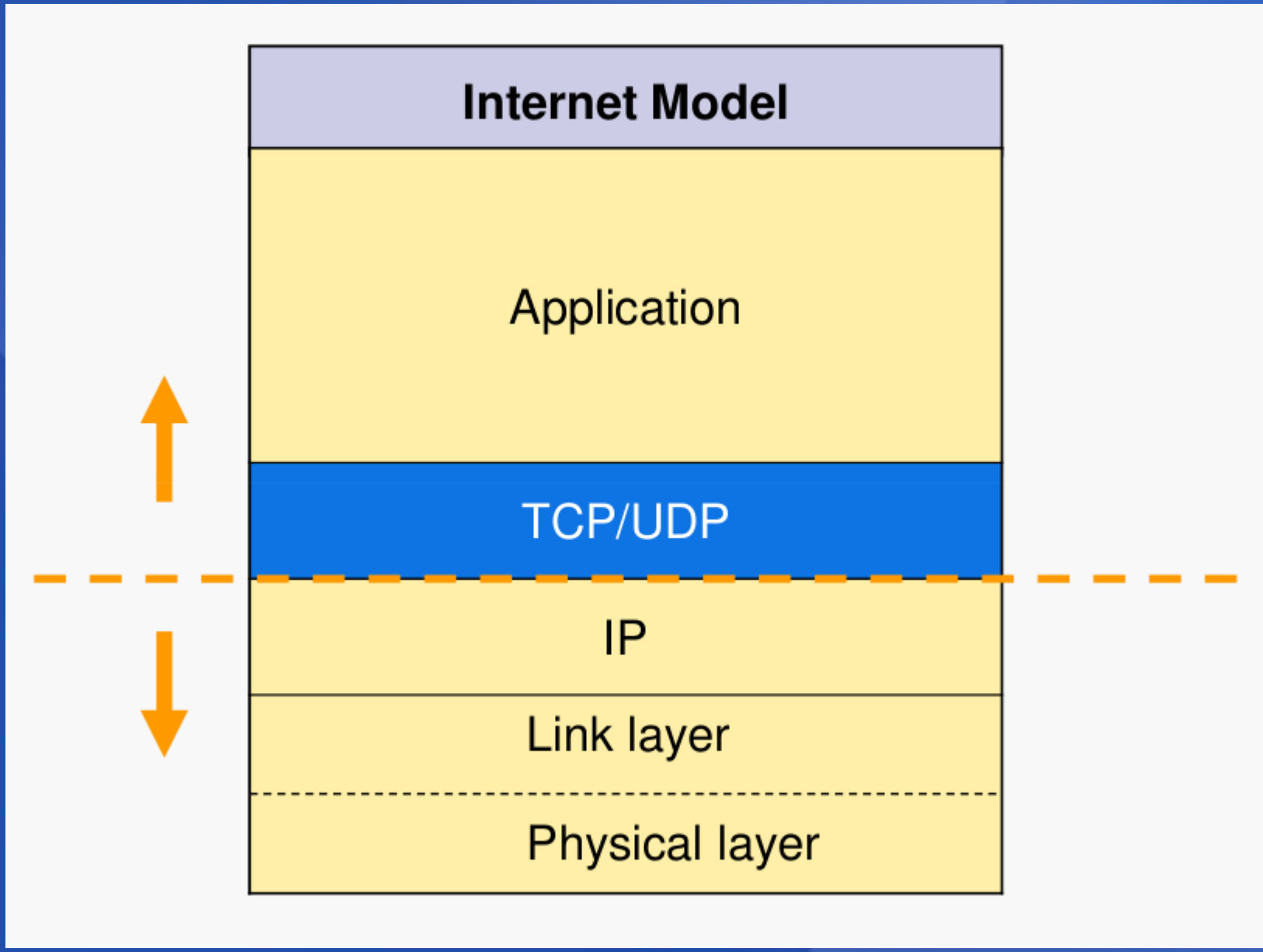
Transport Layer



Transport Service Overview

- Provide service to application layer by using the service provided by network layer
- Hide physical network
  - Hide processing complexity
  - Hide different network technologies and architectures
- Provide reliable, host-to-host transport

Transport layer design issues

- Addressing
- Connection Establishment
- Connection Release
- Flow Control
- Error Detection and Crash Recovery

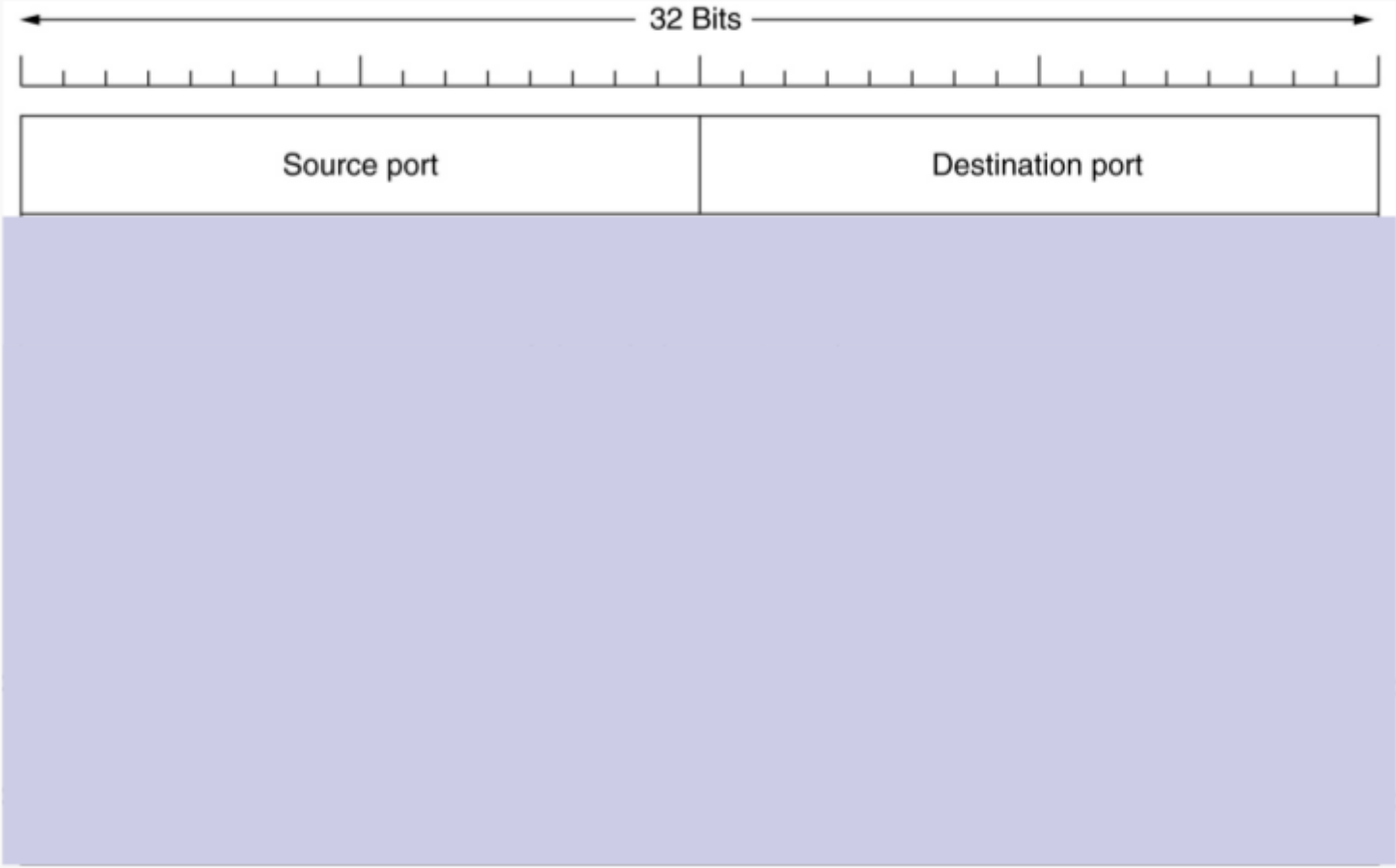
TCP -- Addressing

- There are many network applications running on a host. When a packet arrive at network layer, how to know which application to send to?
  - Port: there are 2^{16} = 65536 ports (0-65535) on one machine
  - One port is linked to only one application
  - One application may use many ports for different purposes

TCP -- Addressing

- How a client knows which service uses which port?
  - Permanent, well-known: often used service
    - 0-1023: well-known ports
    - 1024-49151: registered ports
    - 49152-65535: private ports
  - Process server proxy and create service on-the-fly: temporary service
  - Name server: for file service

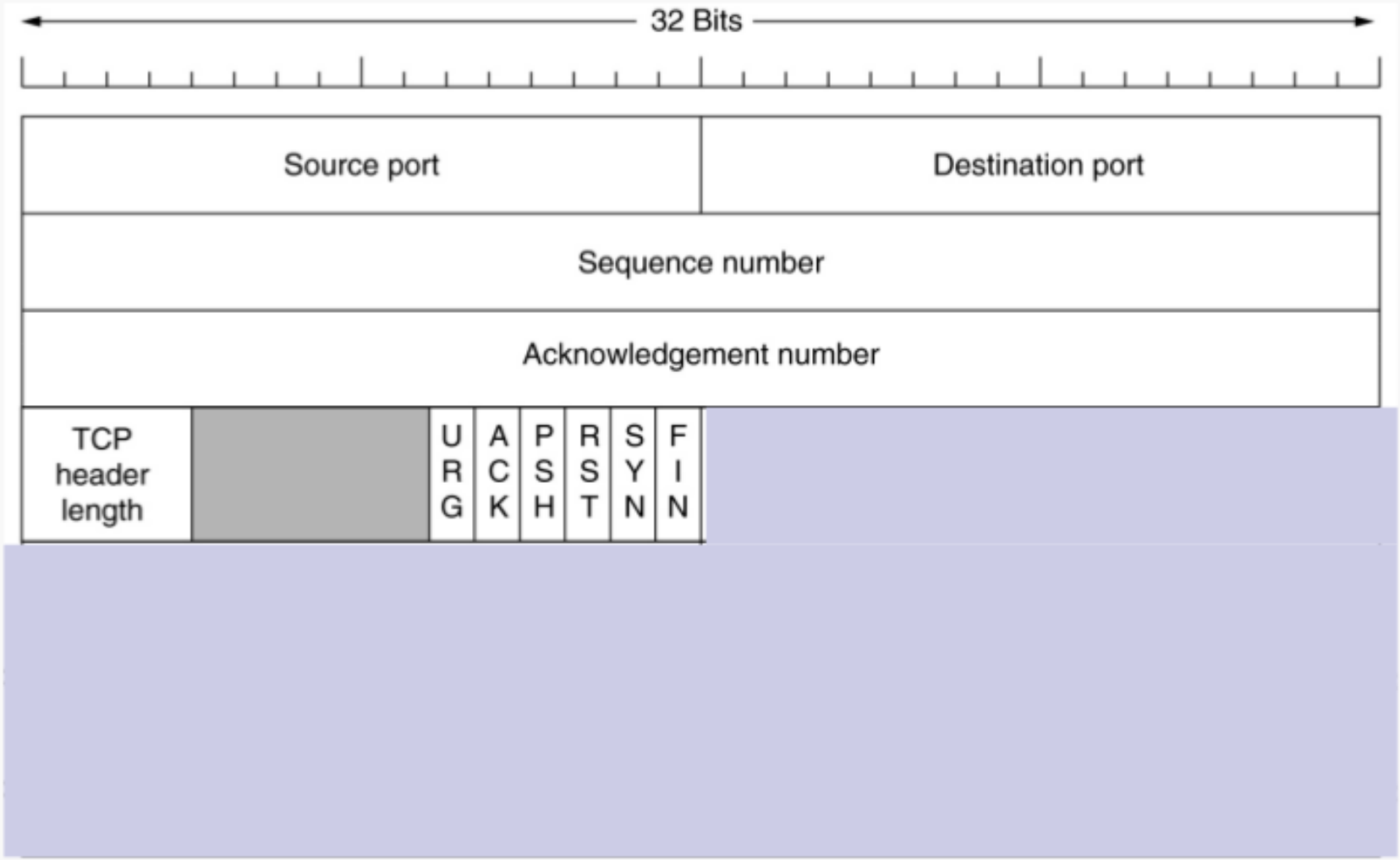
TCP Addressing Header Fields



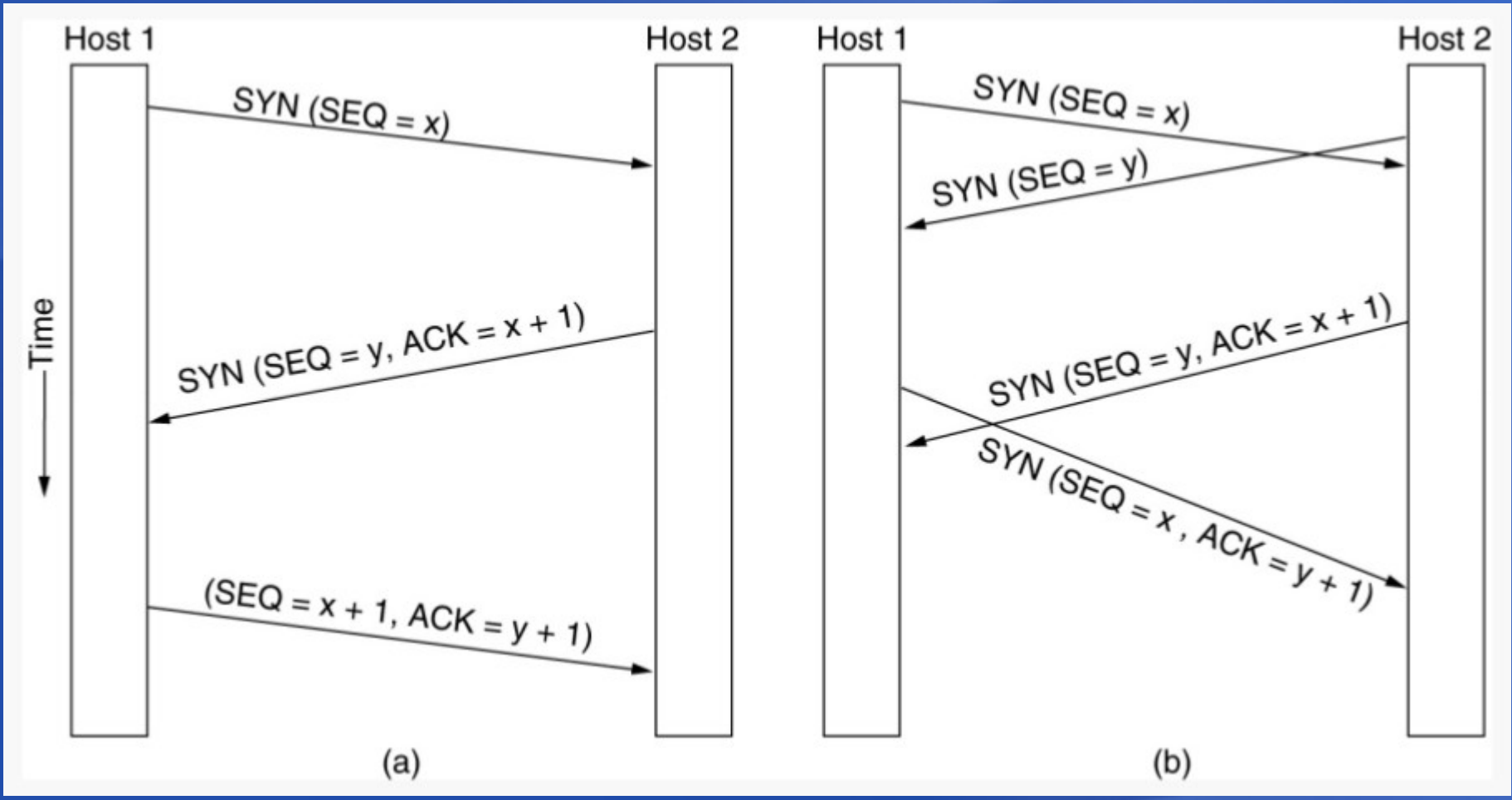
Transpor TCP Connection Establishment – design issue

- Connection establishment becomes tricky when the network lose, delay and duplicate packets
  - Bank example
- How to differentiate a new packet from a delayed, duplicated packet
  - Sequence number
    - Sequence number increase for each packet
    - Sequence number space issue:
      - Sequence number wrap back
        - A packet should avoid using a sequence number that another packet is using
- A duplicated or delayed packet should die after a while
  - IP layer already handles this issue by ‘Time To Live’ header field

TCP Connection Related Header Fields

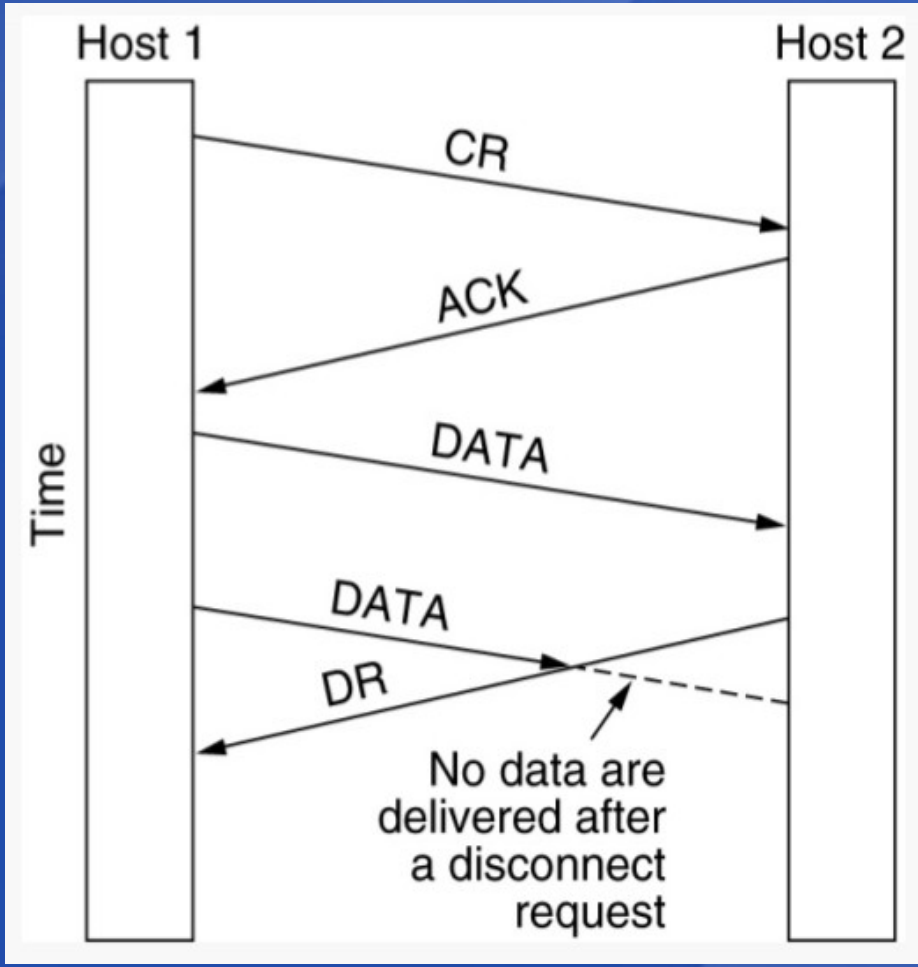


TCP Connection Establishment – three way handshake

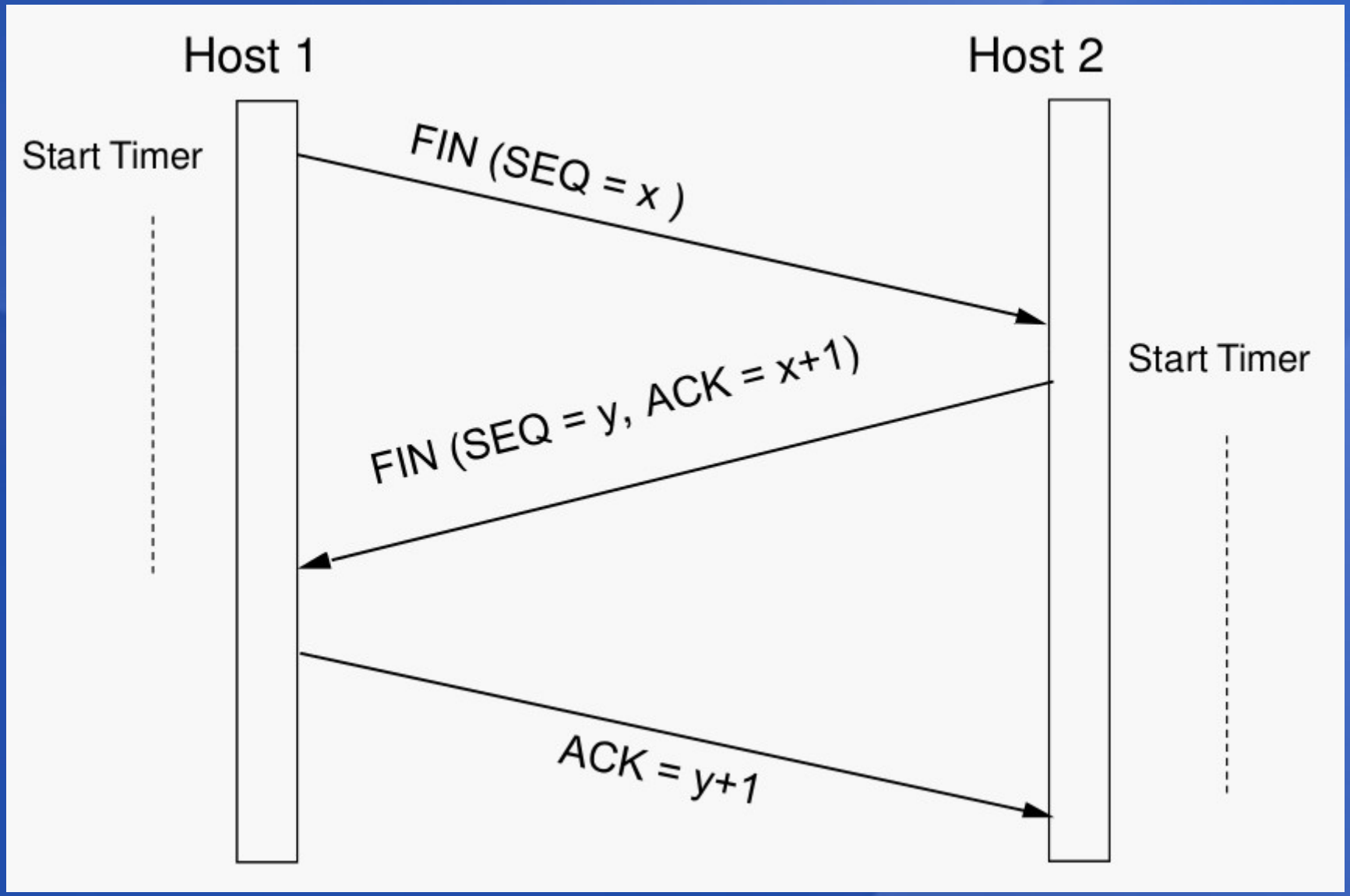


TCP Connection Release

- Two release method: asymmetric and symmetric
- Asymmetric release issue: possibility of losing data



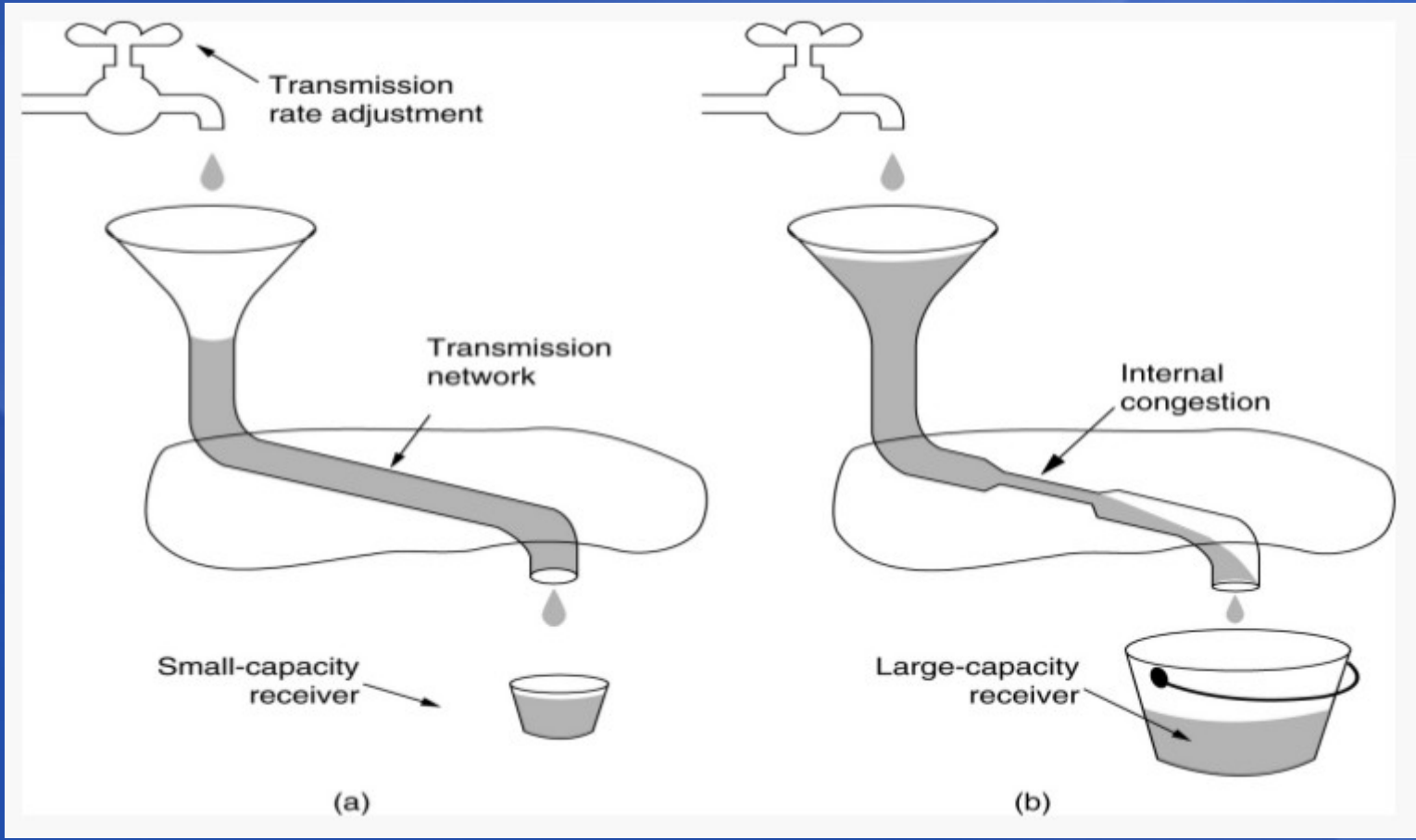
TCP Connection Release – solution
Three way handshake + timeout



TCP Flow Control – design issue

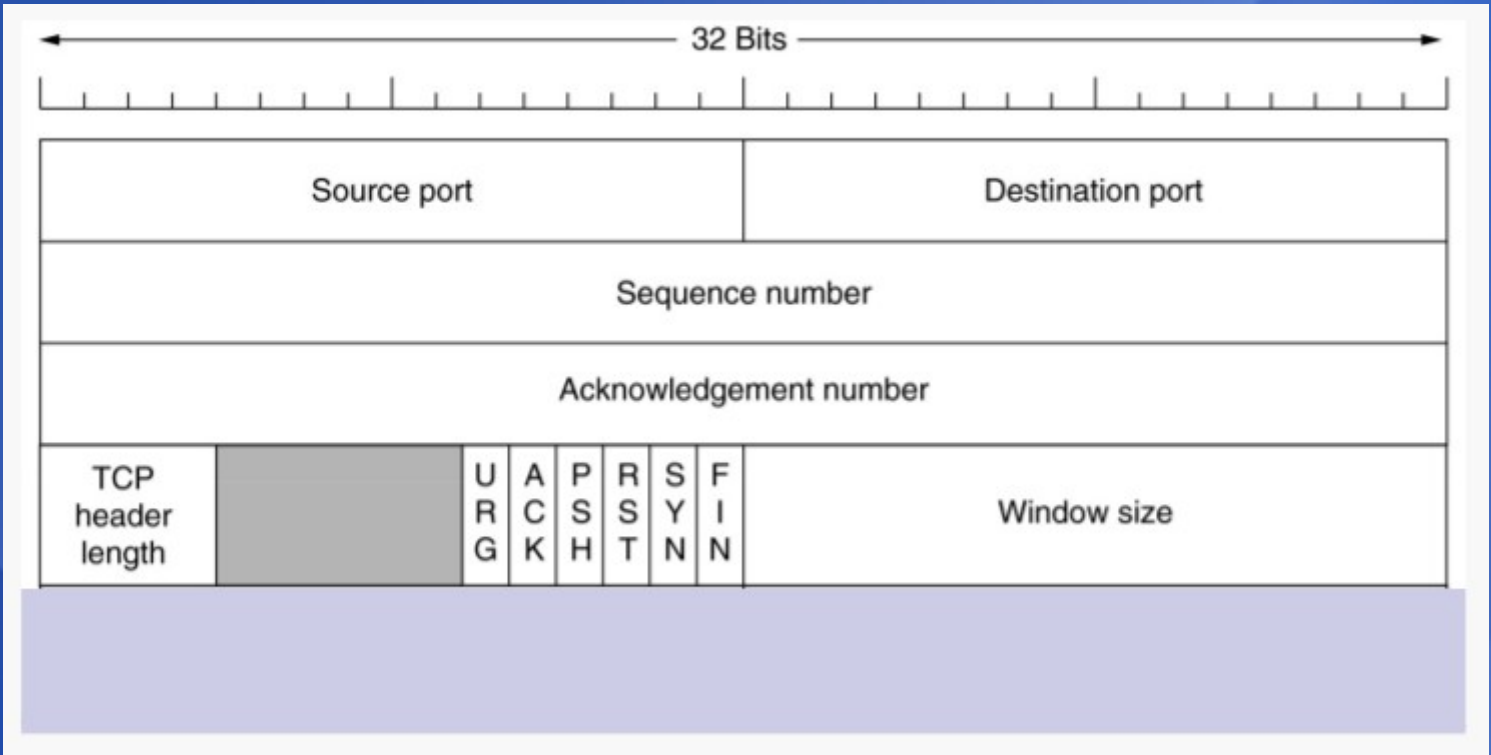
- Speed of data sending is critical
  - Too fast:
    - network congestion or
    - receiving side overload
  - Too slow – type example
    - waste of network resource
    - or receiving memory

Transport Layer



Transport Layer

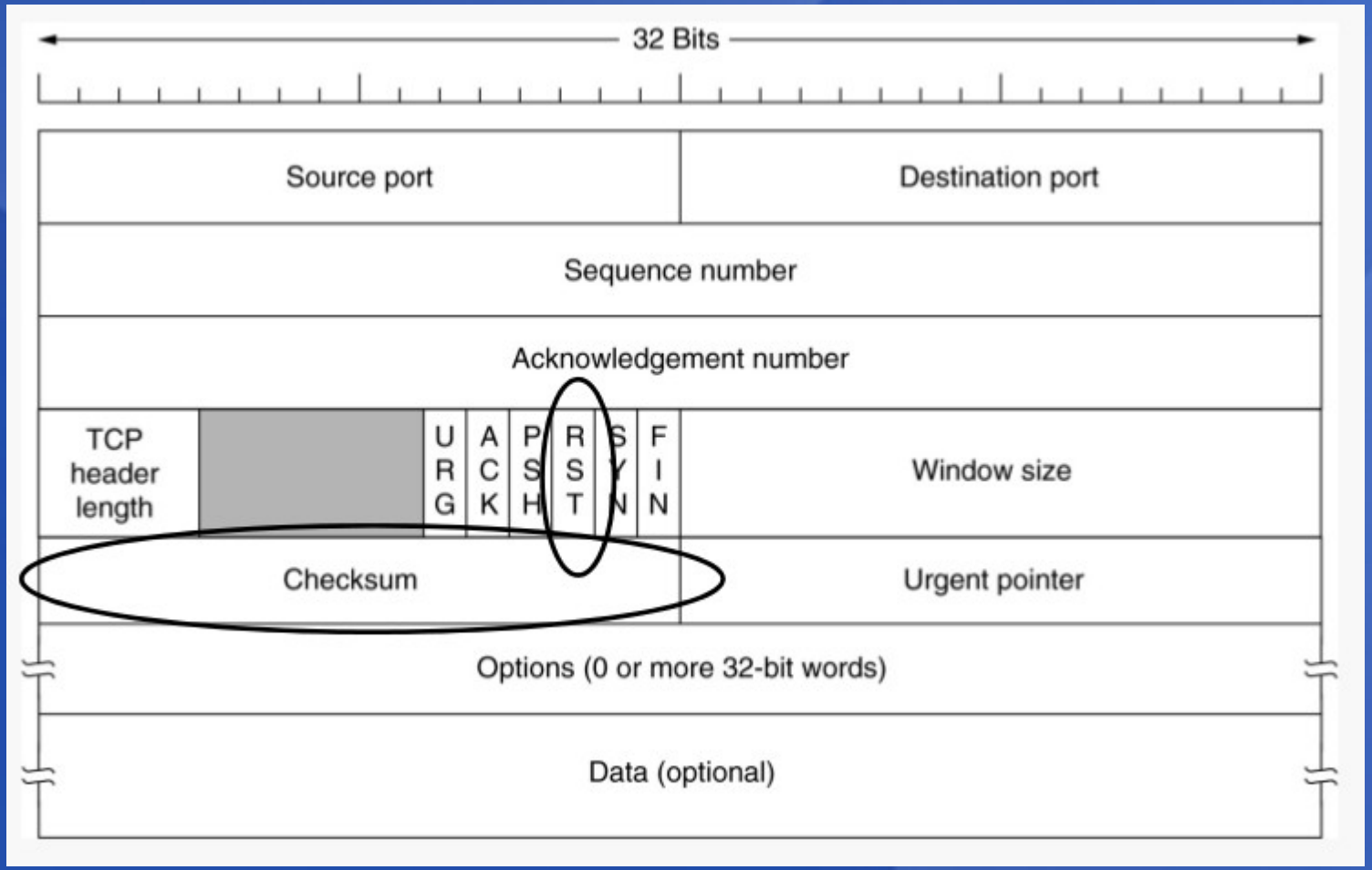
TCP Flow Control – solution (1)



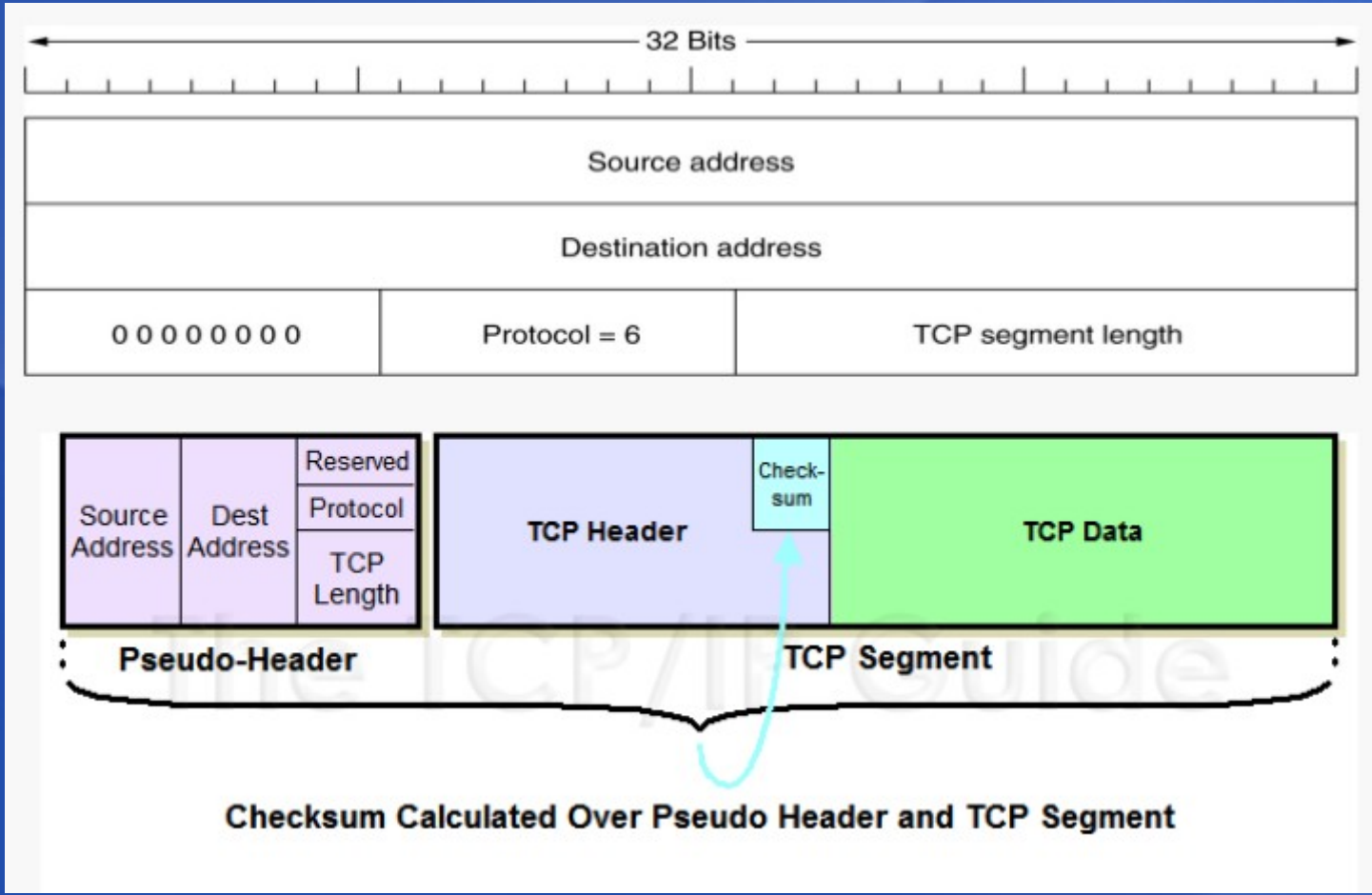
- Windows maintained by both sending and receiving hosts
- Receiving side window size is decided by the available capability of receiving host's
- Sender maintains two windows
  - receiver window (got from receiving host), congestion window (to calculate)

TCP Error Handling

- Host crash and recovery
- Data error during transmission



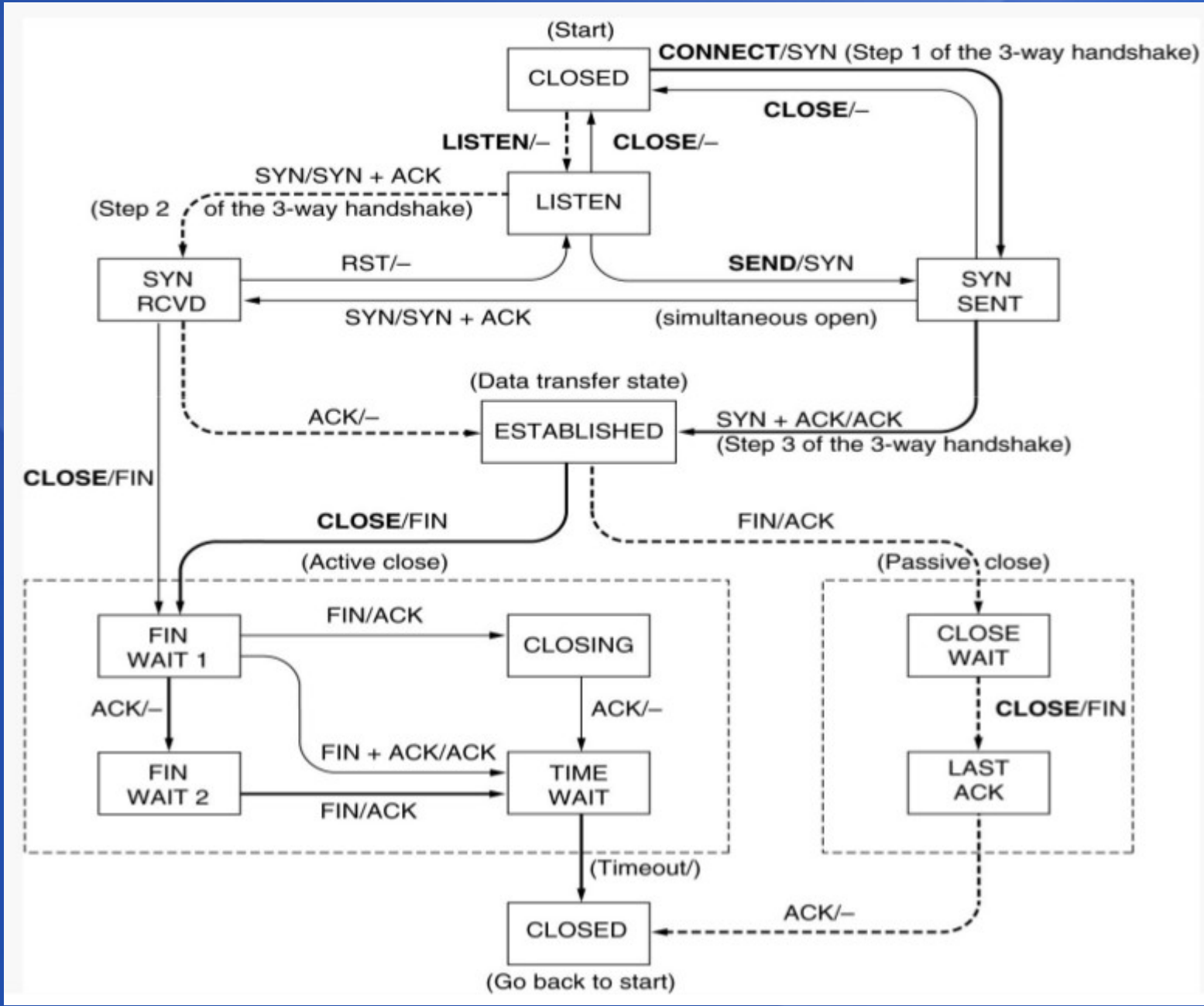
TCP Error Handling – TCP checksum



Transport Layer

Primitive	Meaning
SOCKET	Create a new communication end point
BIND	Attach a local address to a socket
LISTEN	Announce willingness to accept connections; give queue size
ACCEPT	Block the caller until a connection attempt arrives
CONNECT	Actively attempt to establish a connection
SEND	Send some data over the connection
RECEIVE	Receive some data from the connection
CLOSE	Release the connection

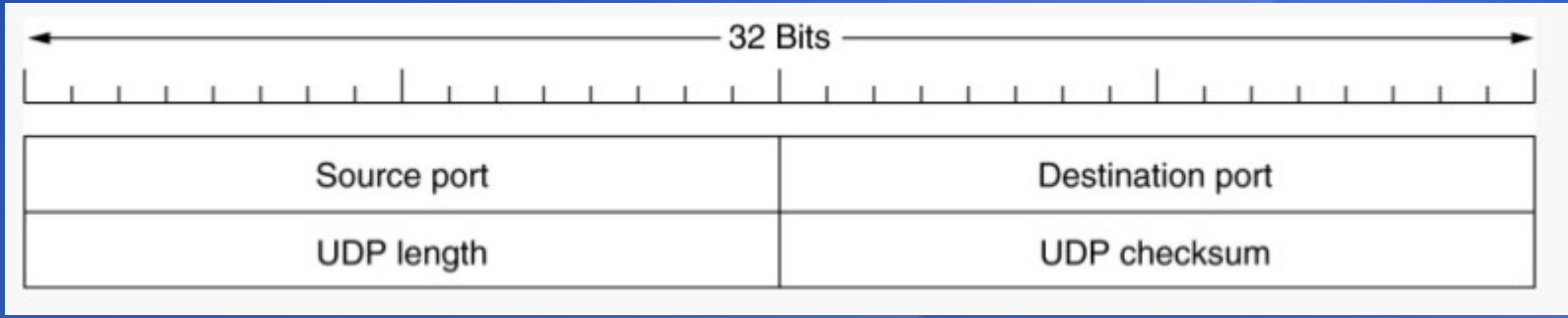
TCP Finite State Machine



TCP application examples

- When to use TCP:
  - When an application need a reliable transport
- Examples
  - File Transfer Protocol : FTP (21)
  - Secure Shell: SSH (22)
  - Teletype Network: TELNET (23)
  - Simple Mail Transfer Protocol: SMTP (25)
  - Hypertext Transfer Protocol: HTTP (80)

UDP Header



- UDP Destination Port: identifies destination process
- UDP Source Port: optional – identifies source process for replies, or zero
- Message Length: length of datagram in bytes, including header and data
- Checksum: optional -- 16-bit checksum over header and data, or zero

UDP Properties

- UDP provides an unreliable datagram service
  - Packets may be lost or delivered out of order
  - Message split into datagrams, user sends datagrams as packets on network layer
  - No buffer at either sending or receiving side
  - Unreliable but fast
  - Full duplex
  - Application must deal with lost packets

UDP Application Examples

- When to use UDP
  - Reduce the requirement of computer resources
  - The checking scheme has provided completely by the application program
  - When using the Multicast or Broadcast to transfer
  - The transmission of Real-time packets

UDP Properties

- Examples
  - Trivial File Transfer Protocol,TFTP
  - Simple Network Management Protocol,SNMP
  - Dynamic Host Configuration Protocol,DHCP
  - Domain Name System,DNS
  - Routing Information Protocol,RIP
  - Real-Time Transport Protocol,RTP

FINISH