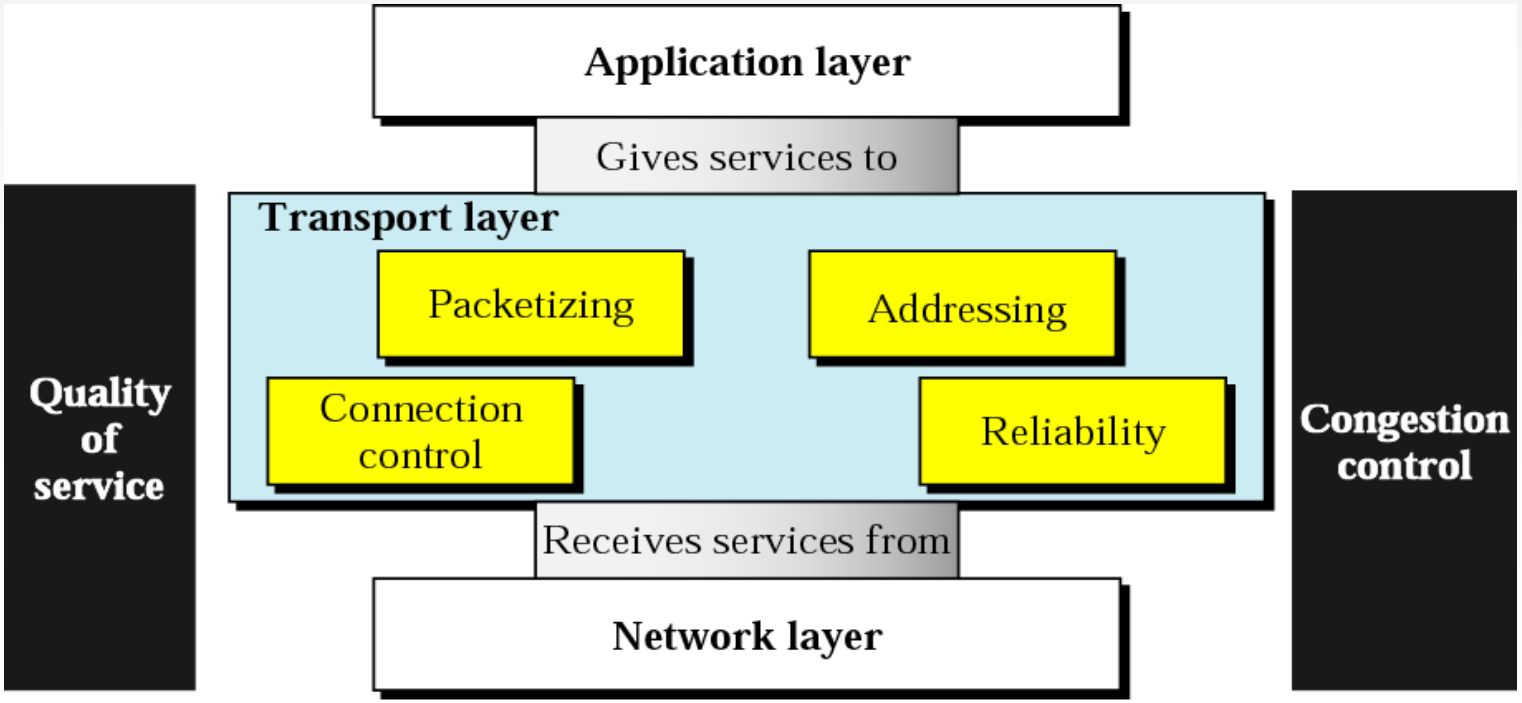
Transport Layer

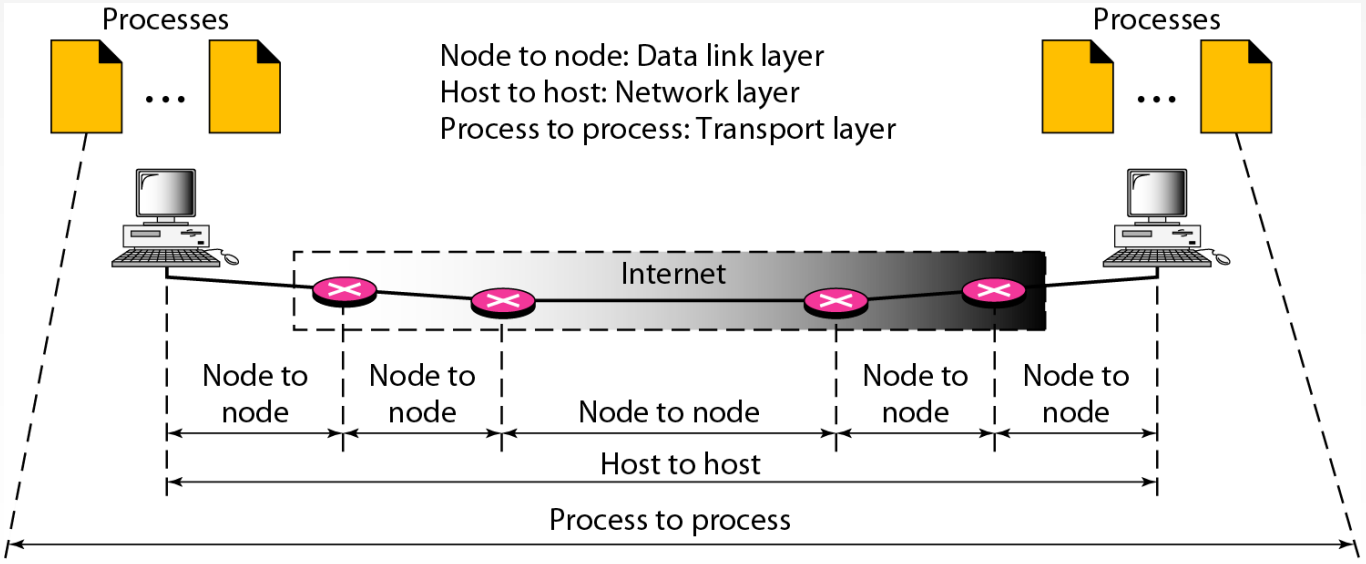
Position of Transport Layer

- Responsible for the delivery of a message from one process to another



Types of data deliveries

- The transport layer is responsible for process-to-process delivery.
- Process (Application Program)



Client-Server Paradigm

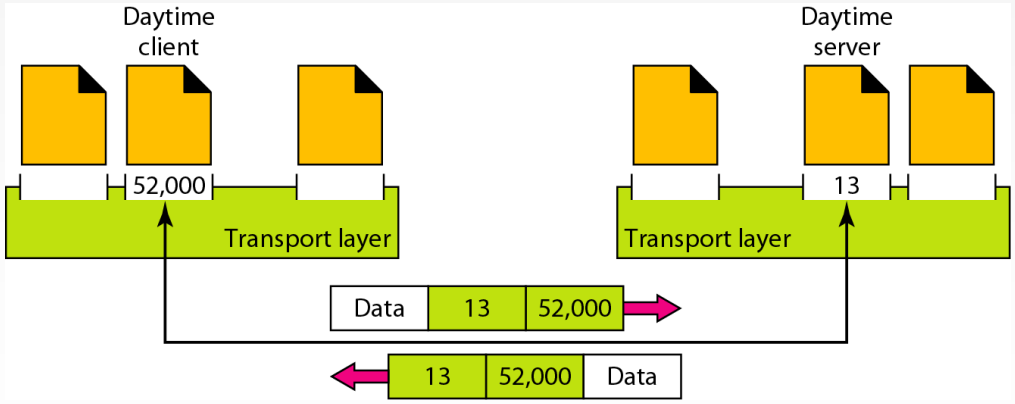
- Most common process-to-process communication is the client-server paradigm
- Operating systems support multiuser and multiprogramming environments.
- Local host, local process, remote host, remote process must be defined

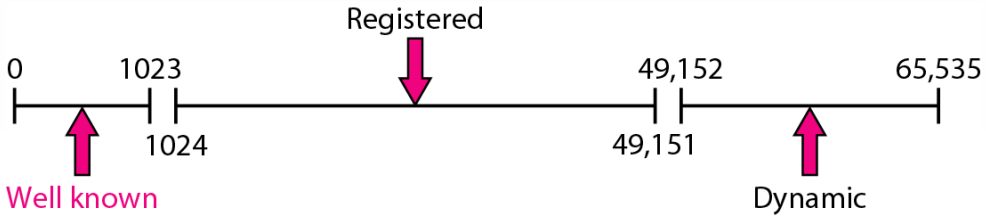
Addressing

- Address required for delivery
- Transport layer address: Port Number

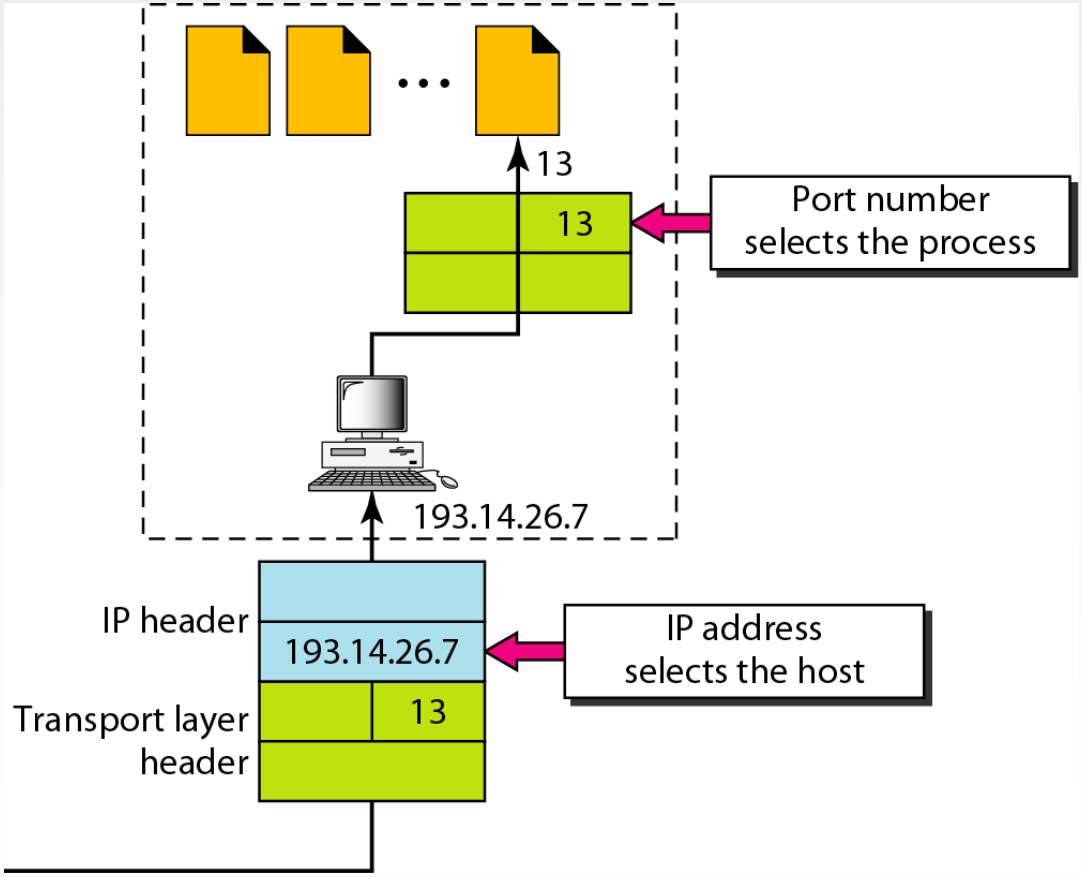
Port Numbers

- 16 bits between 0 and 65553
- Ephemeral port number
- IANA (Internet Assigned Number Authority) range: well-known ports, registered ports, dynamic ports



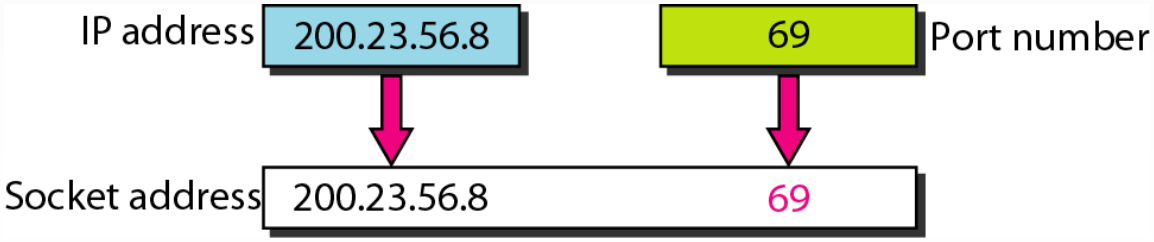


IP Addresses vs Port Numbers



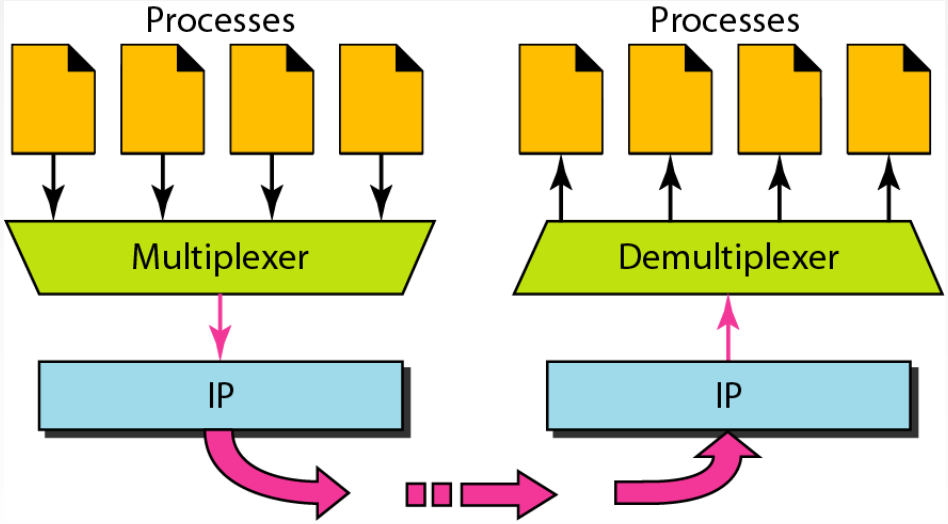
Socket address

- Process-to-process delivery needs two identifiers, IP address and the port number
- Socket address is the combination of an IP address and a port number
- A transport-layer protocol needs a pair of socket addresses; the client and server socket address



Multiplexing and demultiplexing

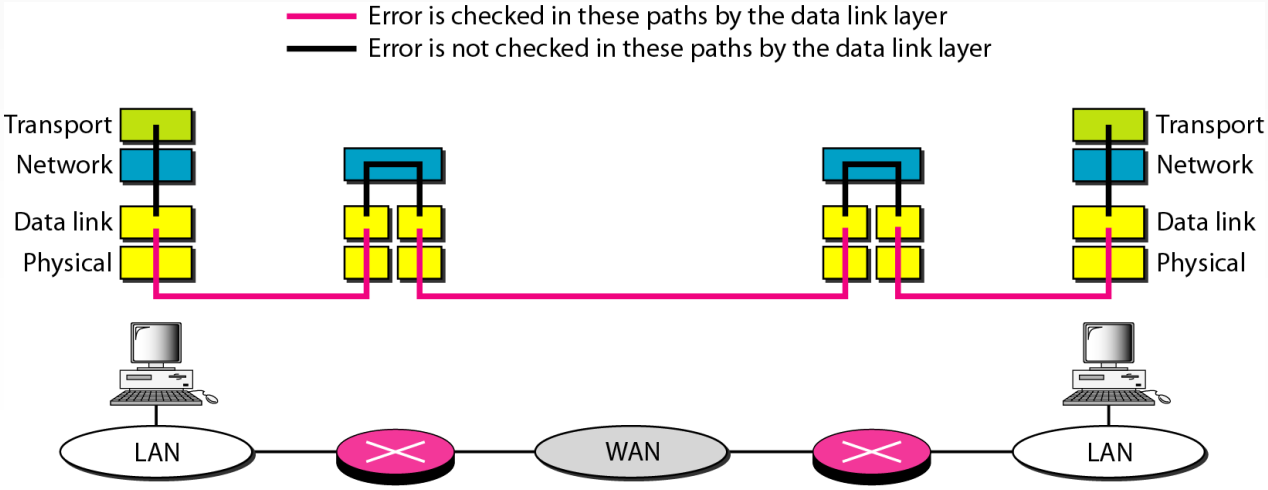
- Addressing mechanism allows multiplexing and demultiplexing by the transport layer



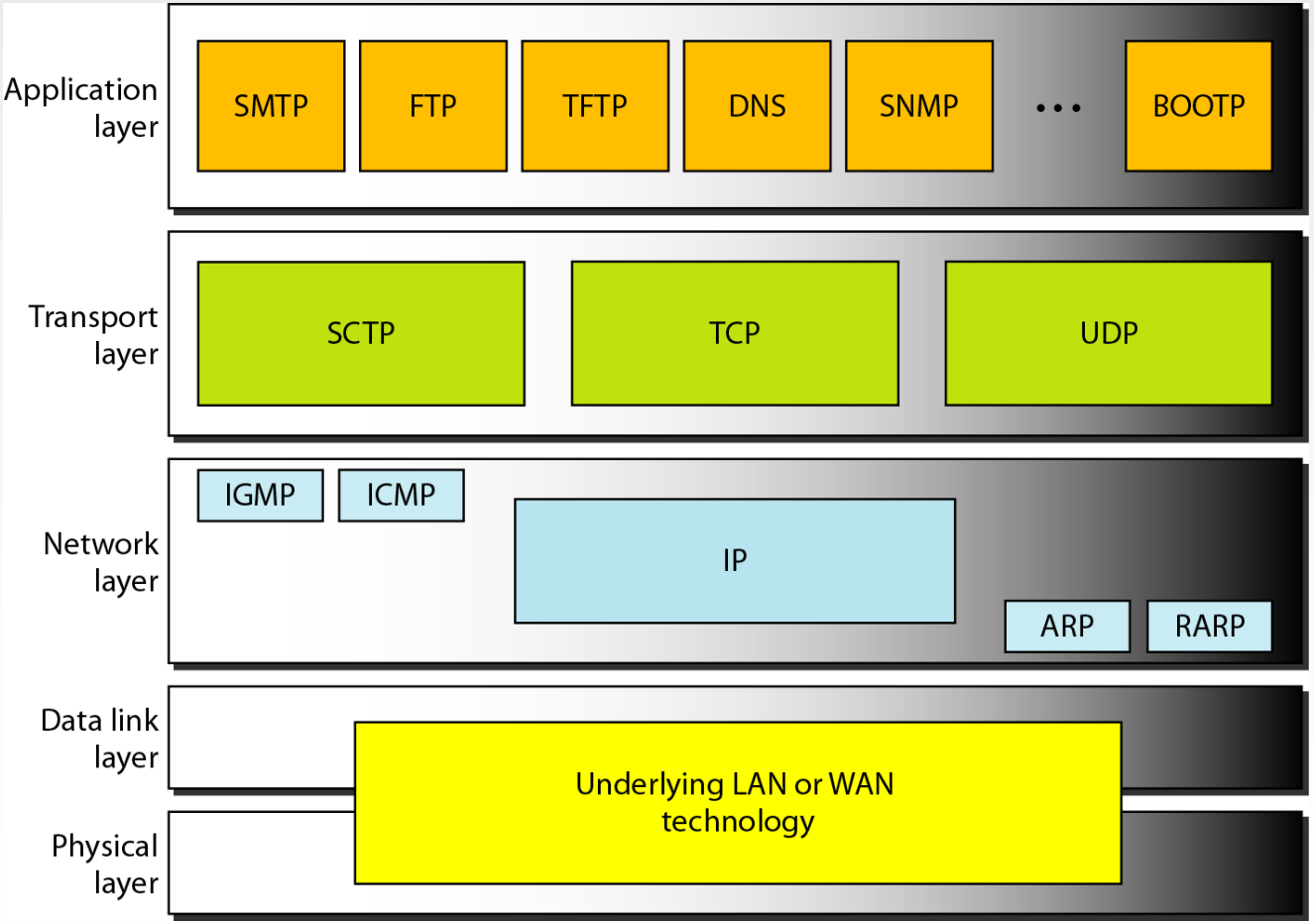
Connectionless Versus Connection-oriented

- Connection-oriented: connection established, data transferred, connection released
- TCP and SCTP
- Connectionless: UDP

Reliable vs. Unreliable

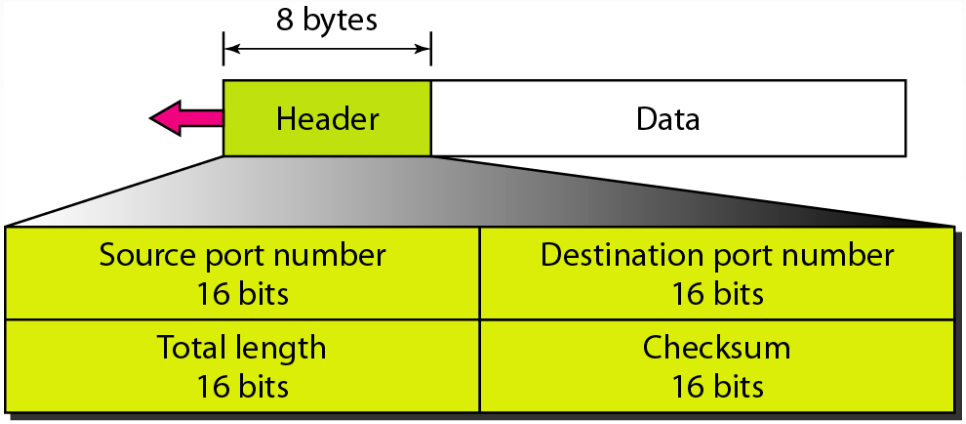


Position of UDP, TCP, and SCTP



UDP

- A connectionless, unreliable transport protocol
- Does not add anything to the services of IP except to provide process-to-process communication instead of host-to-host communication
- No Flow Control/ Error Control
- Very Simple, less overhead
- The calculation of checksum and its inclusion in the user datagram are optional

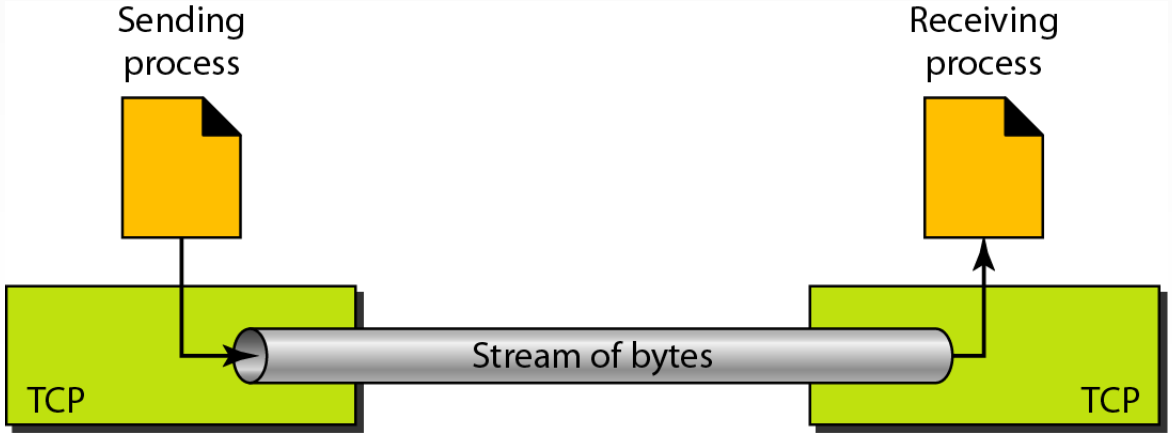


Use of UDP

- Suitable for a process that requires simple request-response communication with little concern for flow and error control
- Suitable for a process with internal flow and error control mechanisms such as TFTP
- Suitable for multicasting
- Used for management processes such as SNMP
- Used for some route updating protocols such as RIP

TCP

- Transmission Control Protocol
- Connection-oriented, reliable transport protocol
- It adds connection-oriented and reliability features to the services of IP
- Like UDP, TCP uses port numbers as transport-layer addresses
- Unlike UDP, TCP is a stream-oriented protocol

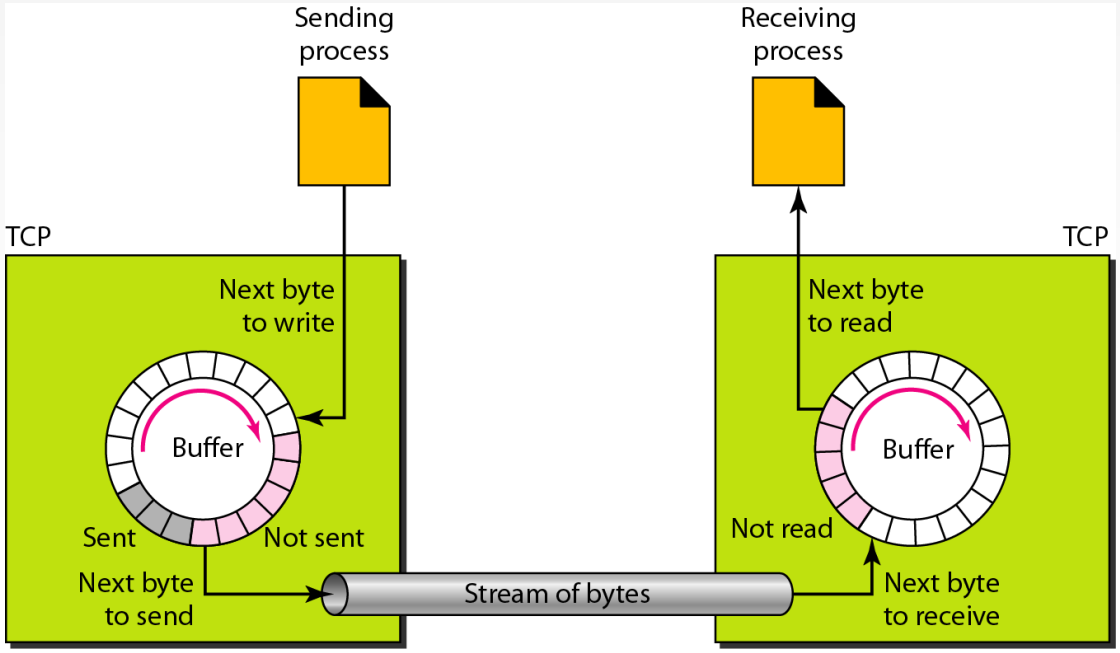


Well-known Ports for TCP

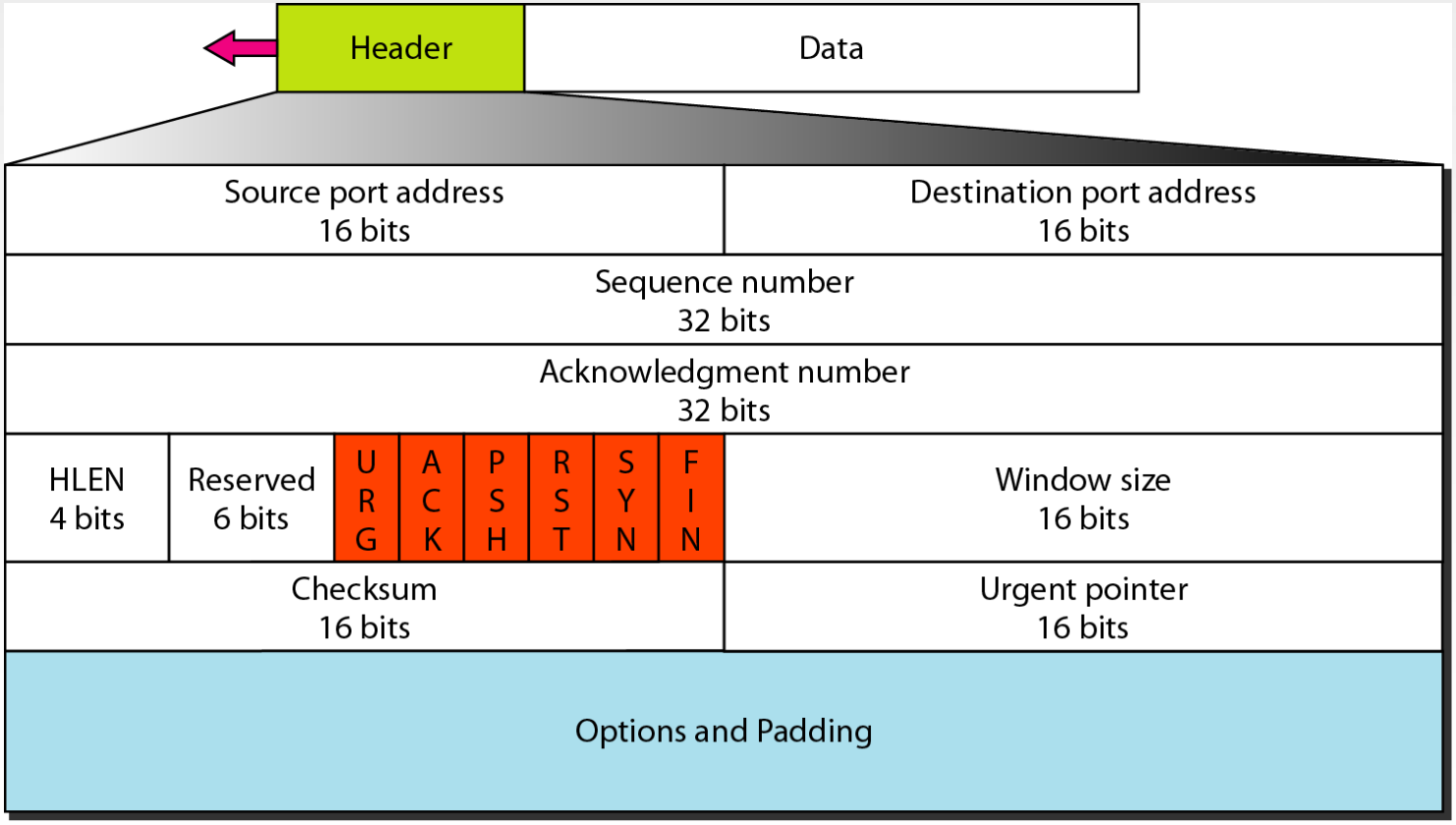
Port	*Protocol*	*Description*
7	Echo	Echoes a received datagram back to the sender
9	Discard	Discards any datagram that is received
11	Users	Active users
13	Daytime	Returns the date and the time
17	Quote	Returns a quote of the day
19	Chargen	Returns a string of characters
20	FTP, Data	File Transfer Protocol (data connection)
21	FTP, Control	File Transfer Protocol (control connection)
23	TELNET	Terminal Network
25	SMTP	Simple Mail Transfer Protocol
53	DNS	Domain Name Server
67	BOOTP	Bootstrap Protocol
79	Finger	Finger
80	HTTP	Hypertext Transfer Protocol
111	RPC	Remote Procedure Call

Sending and Receiving Buffers

- Buffering handles the disparity between the speed of the producing and consuming processes
- One example: to use a circular array of 1-byte locations

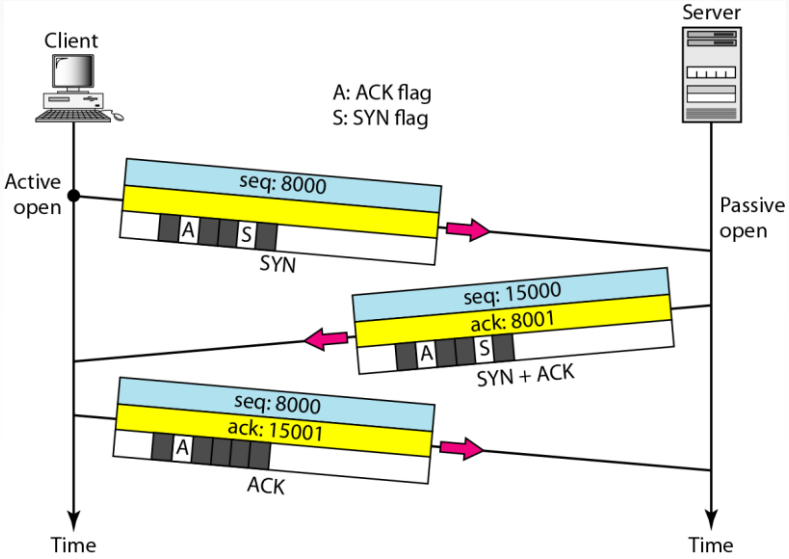


TCP Segment Format



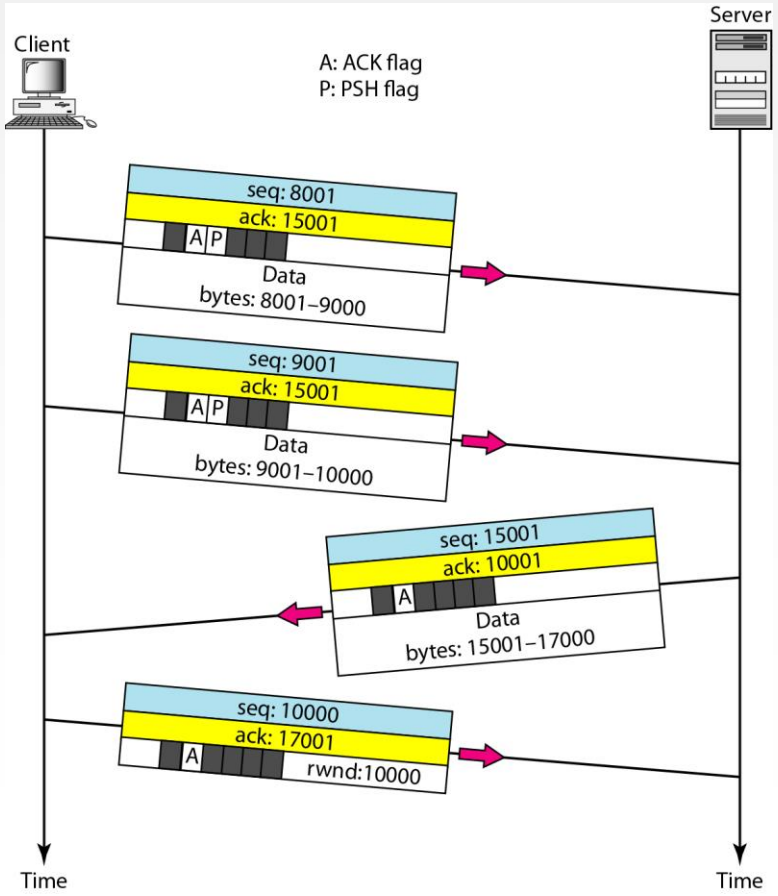
TCP Connection: Establishment

- Connection establishment: Three-way handshaking
- A SYN segment cannot carry data, but it consumes one sequence number
- A SYN + ACK segment cannot carry data, but does consume one sequence number
- An ACK segment, if carrying no data, consumes no sequence number
- Simultaneous open
- SYN flooding attack (denial-of service attack, cookie)



TCP Connection: Data Transfer

- After connection is established, bidirectional data transfer can take place
- Pushing data and urgent data



TCP Connection: Connection Termination

- Three-way handshaking