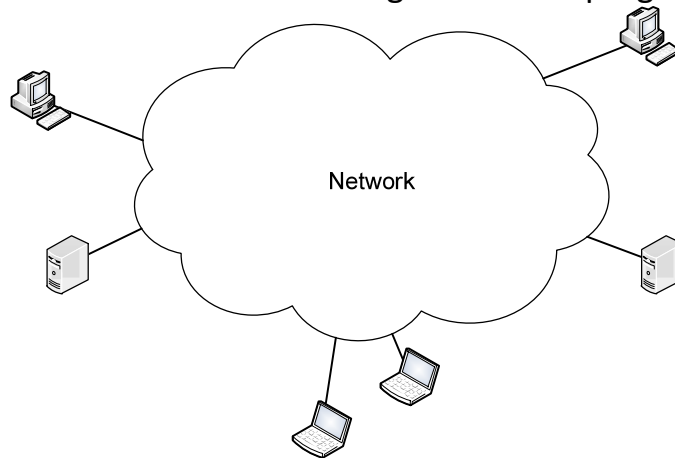


ECE 671 – Lectures 4 and 5

Review of Internet Protocols
Transport Layer

Process-to-process communication

- We have a network. How to get between programs?



Transport layer functionality

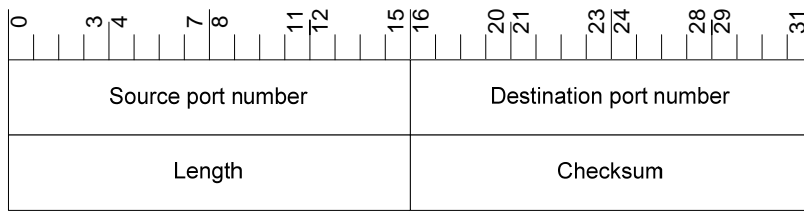
- What functions should transport layer implement?

Multiplexing/demultiplexing

- Multiple processes operate on one computer
 - Interface address alone is not sufficient to distinguish
- Need to (de)multiplex traffic from different processes
- 5-tuple used for unique identification of connection
 - IP source address
 - IP destination address
 - Transport layer source port
 - Transport layer destination port
 - Transport layer protocol

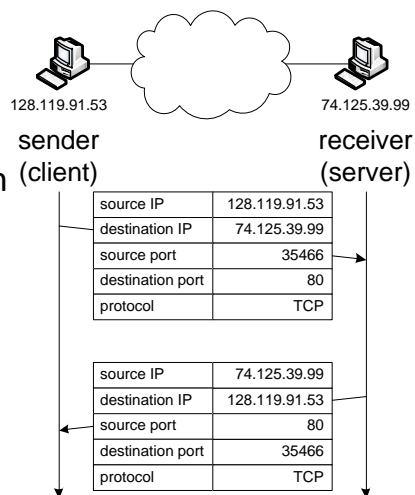
UDP: bare bones protocol

- Ports, length, checksum
 - Checksum is optional



5-tuple example

- 5-tuple is reversed for return communication
- Destination port is associated with application layer protocol (e.g., 80 for HTTP)
- Operating system picks source port randomly



What functionality does TCP provide?

What functionality does TCP provide?

- Reliability
 - Recovery from errors in the network layer
- Flow control
 - Limit transmission rate to not overwhelm receiver
- Congestion control
 - Limit transmission rate to not overwhelm network

Reliable data transfer

- How can reliability be achieved?

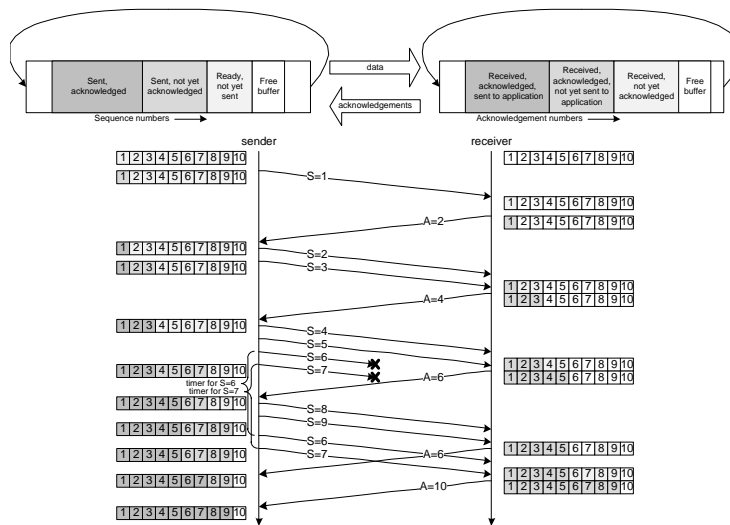
Reliable data transfer

- How can reliability be achieved?
 - Consider different assumptions for network layer
- Case 1: completely reliable network layer
 - Send segment
- Case 2: bit errors in network layer
 - Add error detection and ACK/NAK
 - Add sequence number to handle garbled ACK/NAK
- Case 3: bit errors and packet loss in network layer
 - Timer to trigger retransmission
 - “Stop-and-wait” protocol

Reliable data transfer

- Stop-and-wait has low performance
 - How can we increase throughput?
- Sliding window
 - Allow multiple segments “in-flight”

Sliding window example



TCP header

- Port numbers
- Sequence number
 - Position of data
- ACK number
 - Next expected data
- Checksum
- Flags for connection setup and teardown

