

Transport Layer Overview

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Transport-layer Overview

- **Network layer:** host-to-host logical communication between *hosts*.
- **Transport layer:** logical communication between *applications*.
 - multiple comm. applications can reside in one host.
 - comm. applications can be a Web browser/server, an FTP client/server, etc.

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Multiplexing/demultiplexing

○ = comm. application = socket

P1 on host A is communicating with P3 on host B; while at the same time, P2 on host A is communicating with P4 on host B.

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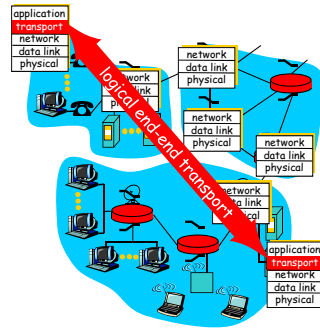
Transport-layer Service Model

- **Transport layer:** logical communication between *applications*.
 - multiplexing/demultiplexing
- Possible additional services:
 - **reliable data transfer** (guaranteed arrival, no error, in-order)
 - **flow control** (keep sender from overrunning receiver): good for myself
 - **congestion control** (keep sender from overrunning network): good for the community
 - **delay/bandwidth guarantee**
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Transport-layer in the Internet Architecture

- End-host only transport implementation
- Simple network layer, complex transport
- Benefits:
 - Flexible transport layer
 - Fast, stable network core
- Challenge:
 - Transport functions without router assistance



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Internet Transport-layer Protocols

- UDP: minimum service transport
 - multiplexing/demultiplexing
 - error detection
- TCP: full service transport
 - multiplexing/demultiplexing
 - error detection
 - reliable data transfer
 - flow control
 - congestion control
- Services not available:
 - delay guarantees
 - bandwidth guarantees
 - why?

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Connection-oriented / Connectionless Transport

- What is a *connection*?
 - logical grouping of data segments for a comm. session between the same pair of end-points
 - state maintained for such session
- Why is a connection useful?
 - conn. state-based reliable communication
 - track network performance using a history of performance measurement
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- UDP is connectionless
- TCP is connection-oriented

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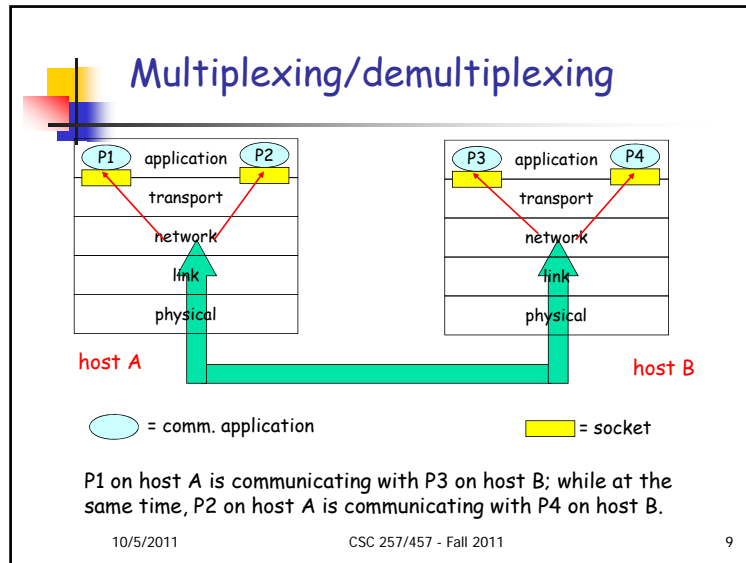
Outline

- Overview of transport-layer services/protocols
- Multiplexing and demultiplexing
- Connectionless transport: UDP
- Principles of reliable data transfer
- Connection-oriented transport: TCP
 - reliable data transfer
 - flow control
 - connection management
- Principles of congestion control
- Congestion control in TCP

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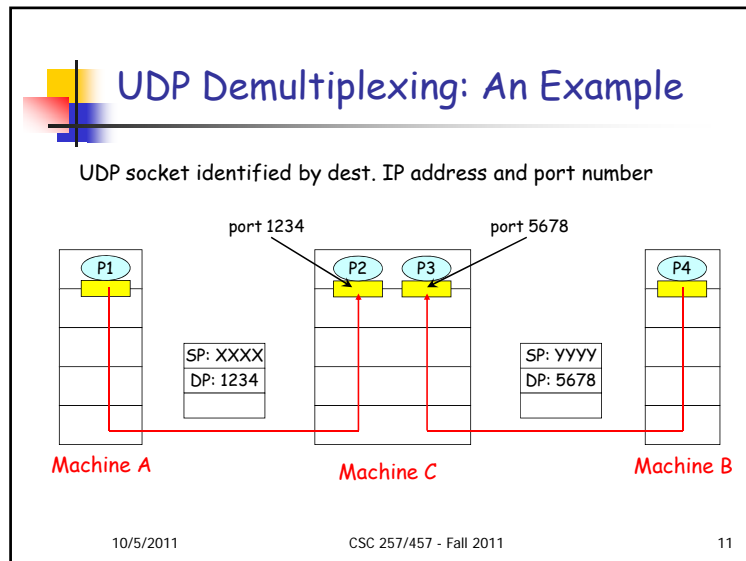
How multiplexing/demultiplexing works?

| | | |
|-----------|----------------|------------------|
| IP header | TCP/UDP header | application data |
|-----------|----------------|------------------|

IP packet format

- **using port numbers**
 - each IP packet has source IP address, destination IP address
 - each IP packet carries a transport-layer segment
 - each segment has source, destination port number
- **dest. IP address** for routing to the host; **IP addresses and port numbers** for going to appropriate socket in the dest. host.

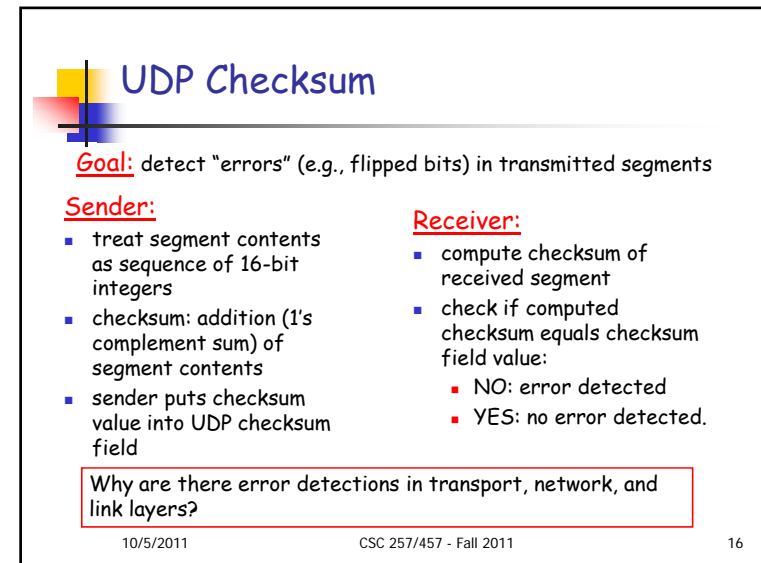
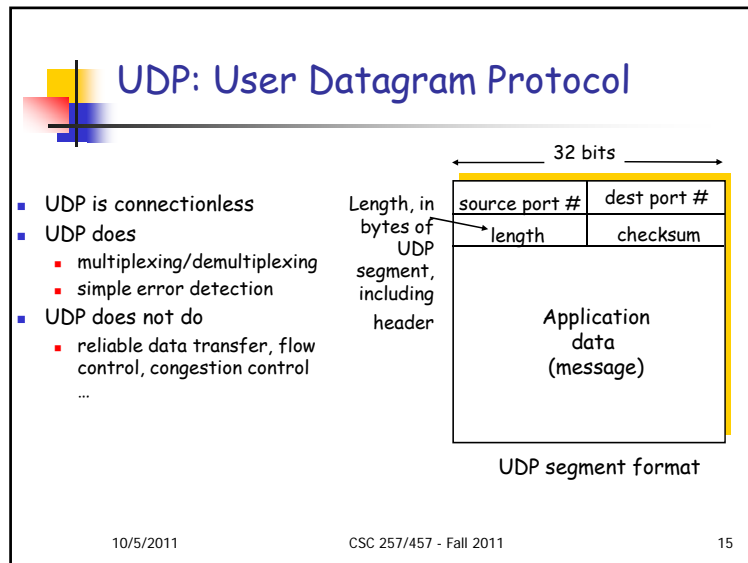
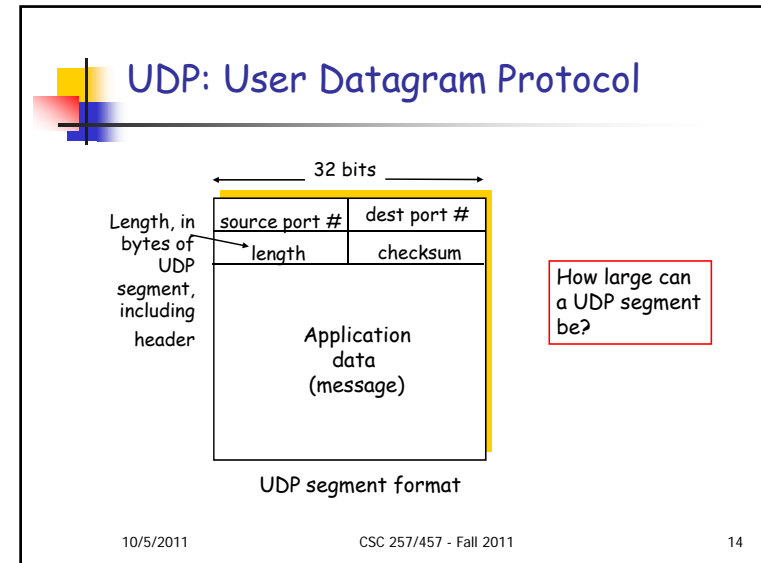
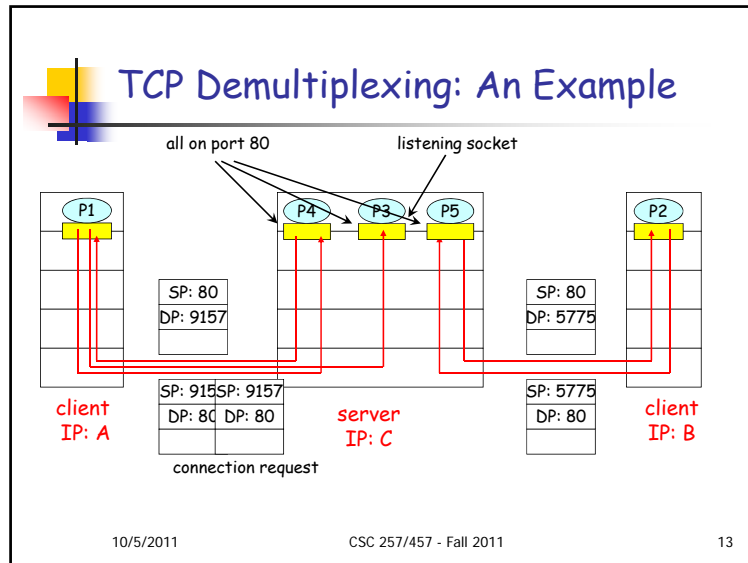
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TCP Demultiplexing (Connection-oriented)

- Multiple TCP connections may simultaneously share a single port:
 - **Example:** web server (on default port 80) has multiple connections, one for each client
- TCP socket identified by 4-tuple:
 - (source IP address, source port number, dest IP address, dest port number)
 - rcv host uses all four values to direct segment to appropriate socket

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What is good about UDP?

- Less overhead:
 - no running cost for connection management
 - no space cost for connection state
 - small segment header
- Flexibility in doing things your own way
 - no congestion control: UDP can blast away as fast as desired (may not be good for others, but not bad for my own connection ☺)
- Simple ⇒ more robust, less security vulnerability
 - less susceptible to denial-of-service attacks

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UDP In Practice

- When to use UDP?
 - TCP services are not useful, or even hurtful
 - TCP services are useful, but not worth the cost
 - TCP services are useful, but in customized ways
- Used for:
 - routing exchanges between routers
 - network performance measurements
 - streaming multimedia apps
 - loss tolerant, rate sensitive
 - flow control and loss recovery sometimes implemented at the application level

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