



THE UNIVERSITY OF WINNIPEG

ACS-3911-050 Computer Network

Chapter 3 Transport Layer

ACS-3911-050 – Slides Used In The Course

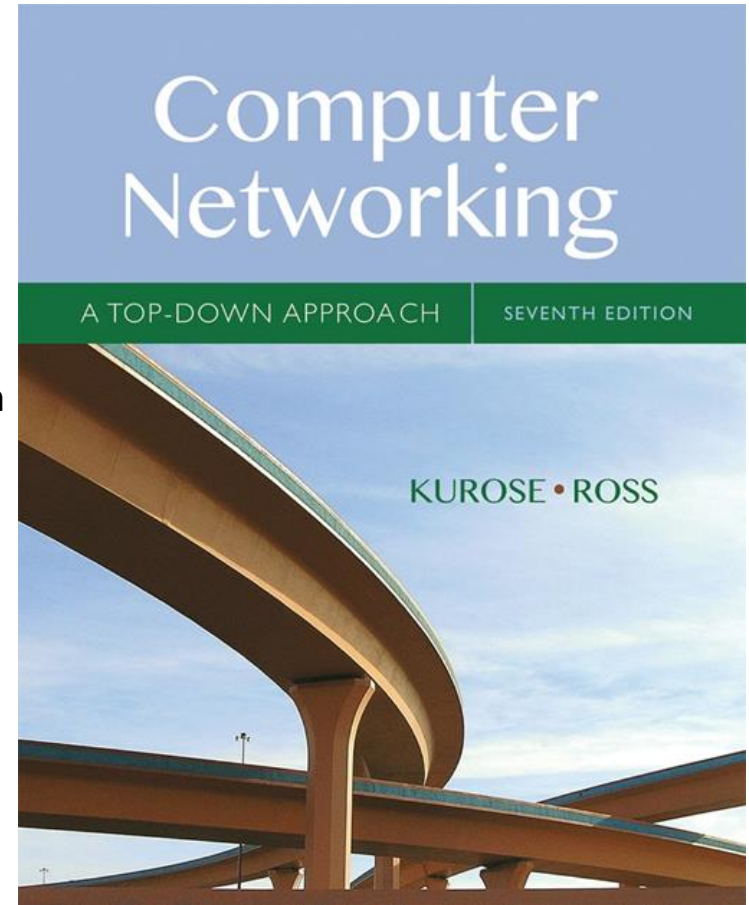
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our goals:

- understand principles behind transport layer services:
 - Multiplexing and demultiplexing
 - reliable data transfer
 - flow control
 - congestion control
- learn about Internet transport layer protocols:
 - UDP: connectionless transport
 - TCP: connection-oriented reliable transport
 - TCP congestion control

3.1 transport-layer services

3.2 multiplexing and demultiplexing

3.3 connectionless transport: UDP

3.4 principles of reliable data transfer

3.5 connection-oriented transport: TCP

- **segment structure**
- **reliable data transfer**
- **flow control**
- **connection management**

3.6 principles of congestion control

3.7 TCP congestion control

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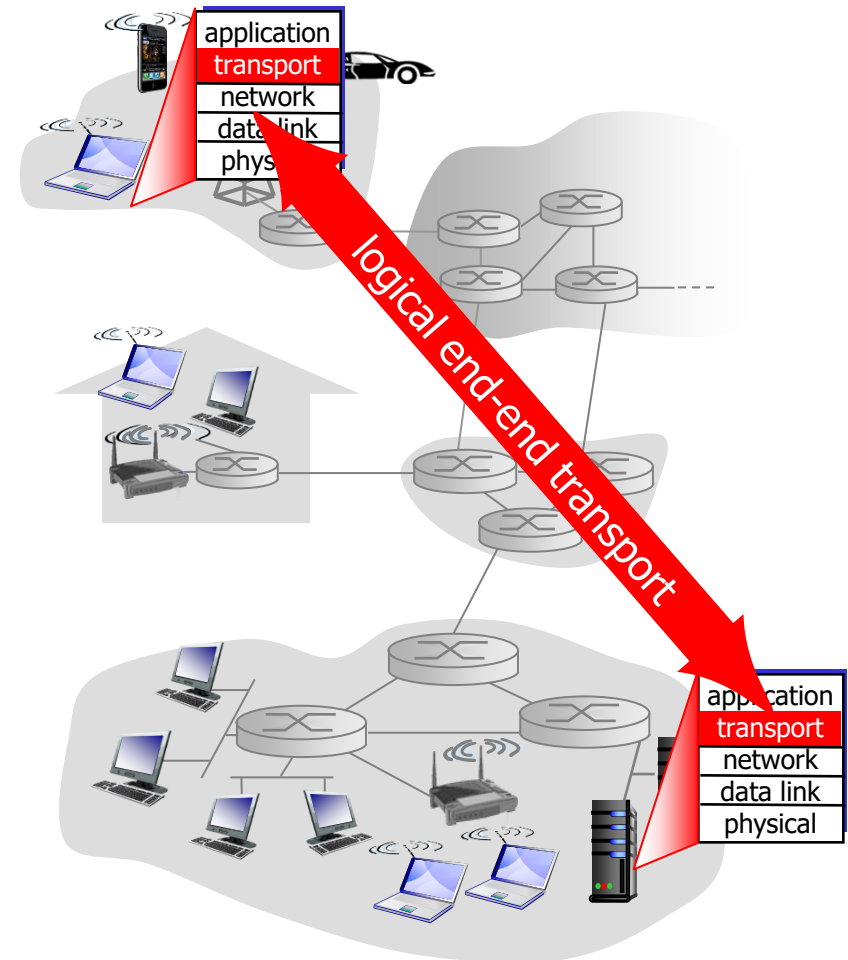
- segment structure
- reliable data transfer
- flow control
- connection management

3.6 principles of congestion control

3.7 TCP congestion control

Transport Services and Protocols

- provide *logical communication* between app processes running on different hosts
- transport protocols run in end systems
 - send side: breaks app messages into *segments*, passes to network layer
 - rcv side: reassembles segments into messages, passes to app layer
- more than one transport protocol available to apps
 - Internet: TCP and UDP



Transport vs. network layer

- *network layer*: logical communication between hosts
- *transport layer*: logical communication between processes
 - relies on, enhances, network layer services

household analogy:

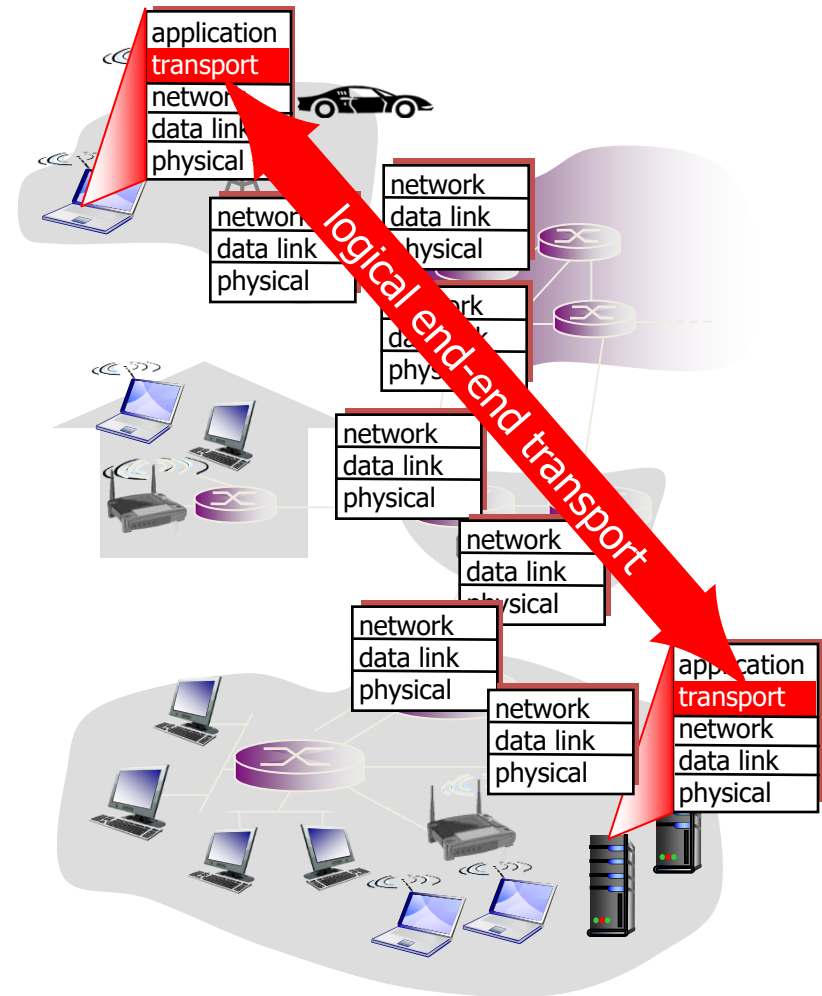
12 kids in Ann's house sending letters to 12 kids in Bill's house:

- hosts = houses
- processes = kids
- app messages = letters in envelopes
- transport protocol = Ann and Bill who demux to in-house siblings
- network-layer protocol = postal service

Internet Transport Layer Protocols



- reliable, in-order delivery (TCP)
 - congestion control
 - flow control
 - connection setup
- unreliable, unordered delivery: UDP
 - no-frills extension of “best-effort” IP
- services not available:
 - delay guarantees
 - bandwidth guarantees



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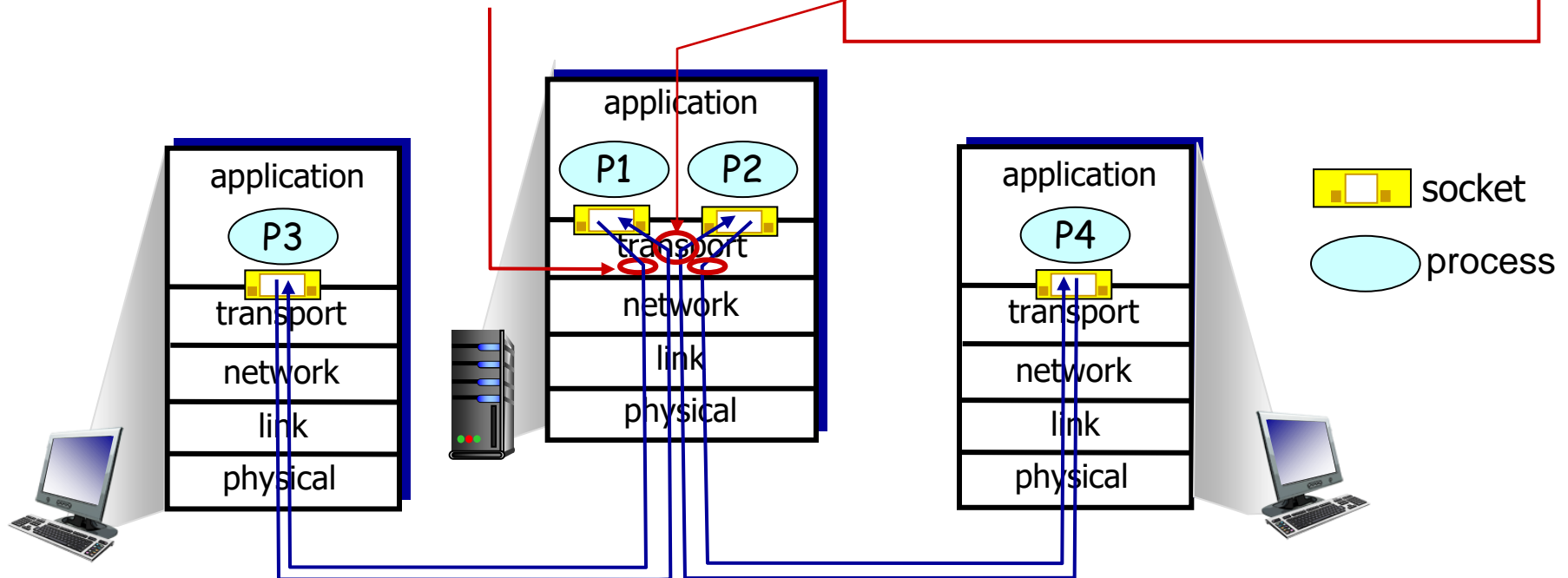
Multiplexing and Demultiplexing

multiplexing at sender:

handle data from multiple sockets, add transport header (later used for demultiplexing)

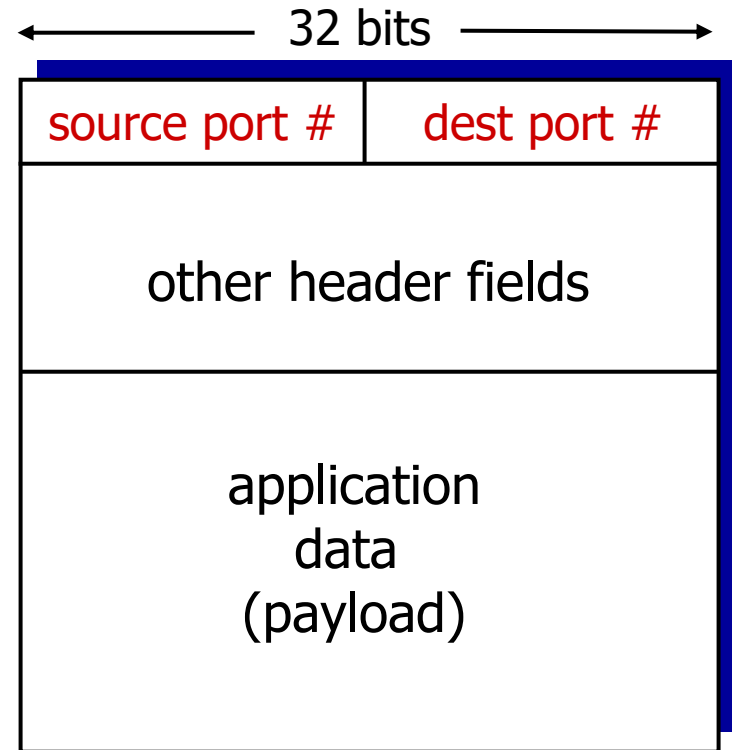
demultiplexing at receiver:

use header info to deliver received segments to correct socket



How Demultiplexing Works

- host receives IP datagrams
 - each datagram has source IP address, destination IP address
 - each datagram carries one transport-layer segment
 - each segment has source, destination port number
- host uses *IP addresses & port numbers* to direct segment to appropriate socket



TCP/UDP segment format

Connectionless Demultiplexing

- *recall*: created socket has host-local port #:

```
DatagramSocket mySocket1  
= new DatagramSocket(12534) ;
```

- *recall*: when creating datagram to send into UDP socket, must specify

- destination IP address
- destination port #

- when host receives UDP segment:

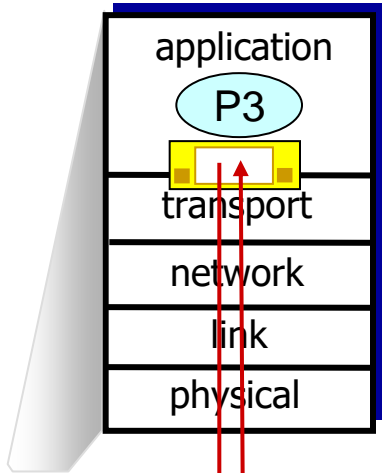
- checks destination port # in segment
- directs UDP segment to socket with that port #



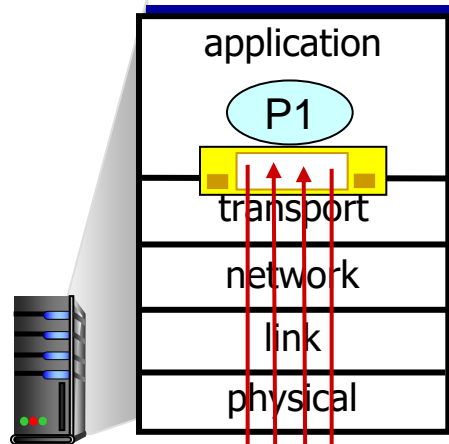
IP datagrams with *same dest. port #*, but different source IP addresses and/or source port numbers will be directed to *same socket* at dest

Connectionless Demux: Example

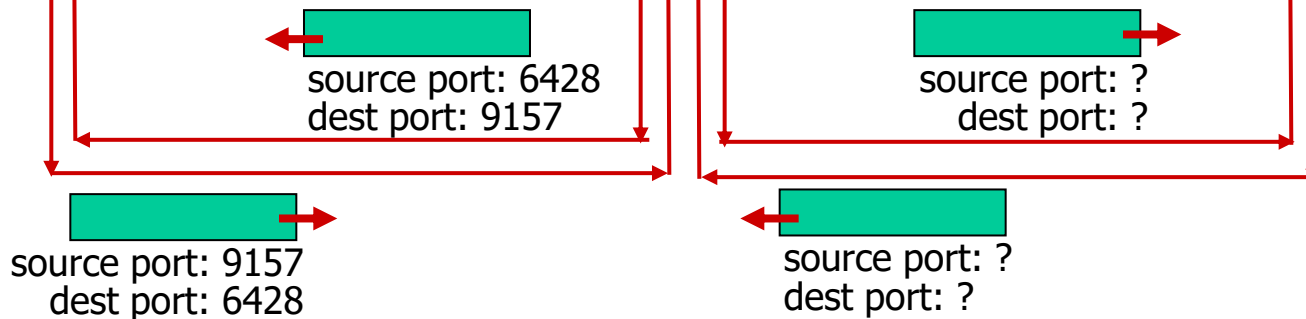
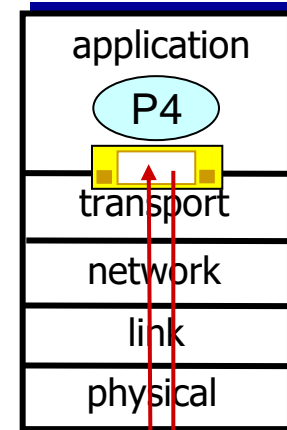
```
DatagramSocket
mySocket2 = new
DatagramSocket
(9157);
```



```
DatagramSocket
serverSocket = new
DatagramSocket
(6428);
```



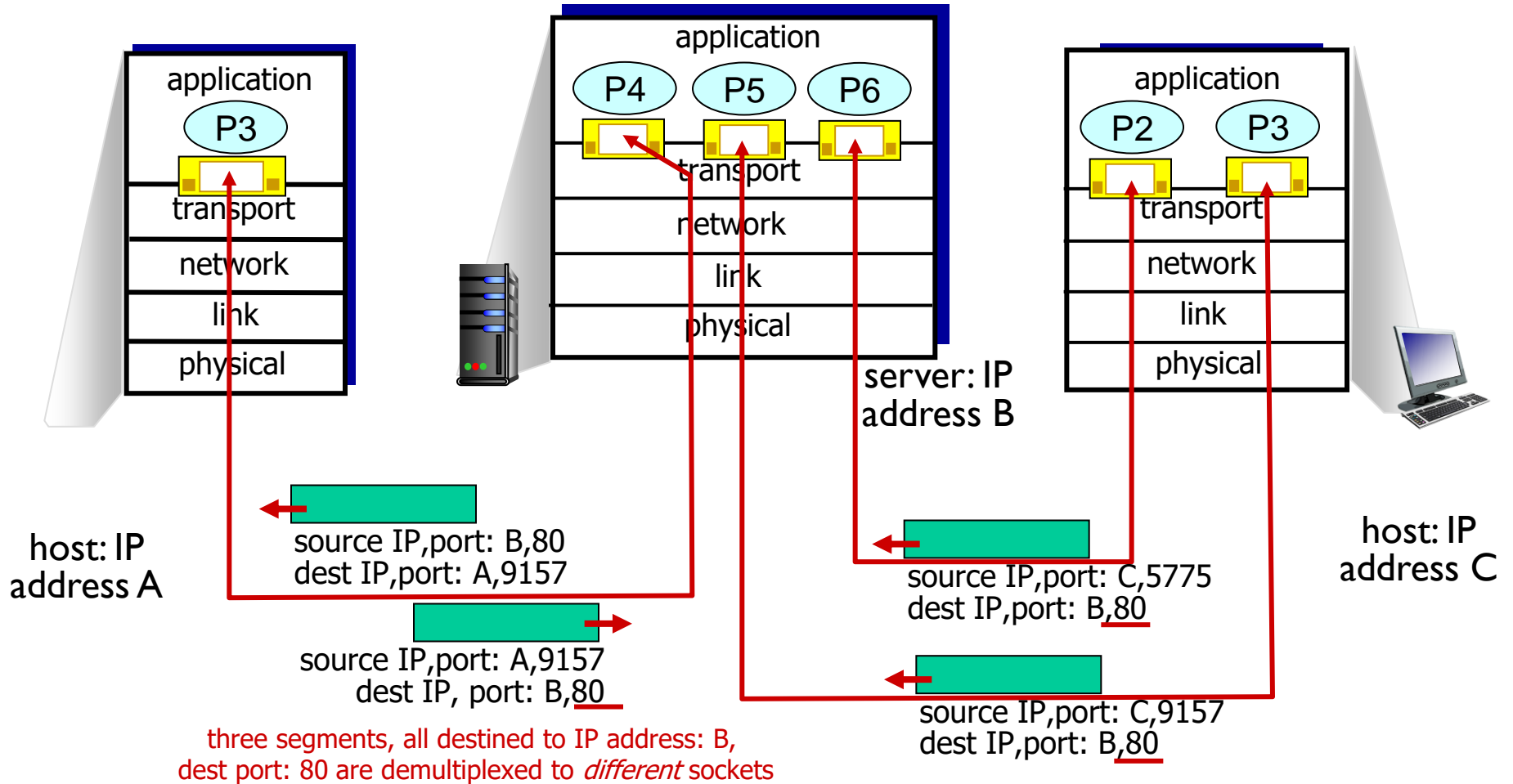
```
DatagramSocket
mySocket1 = new
DatagramSocket
(5775);
```



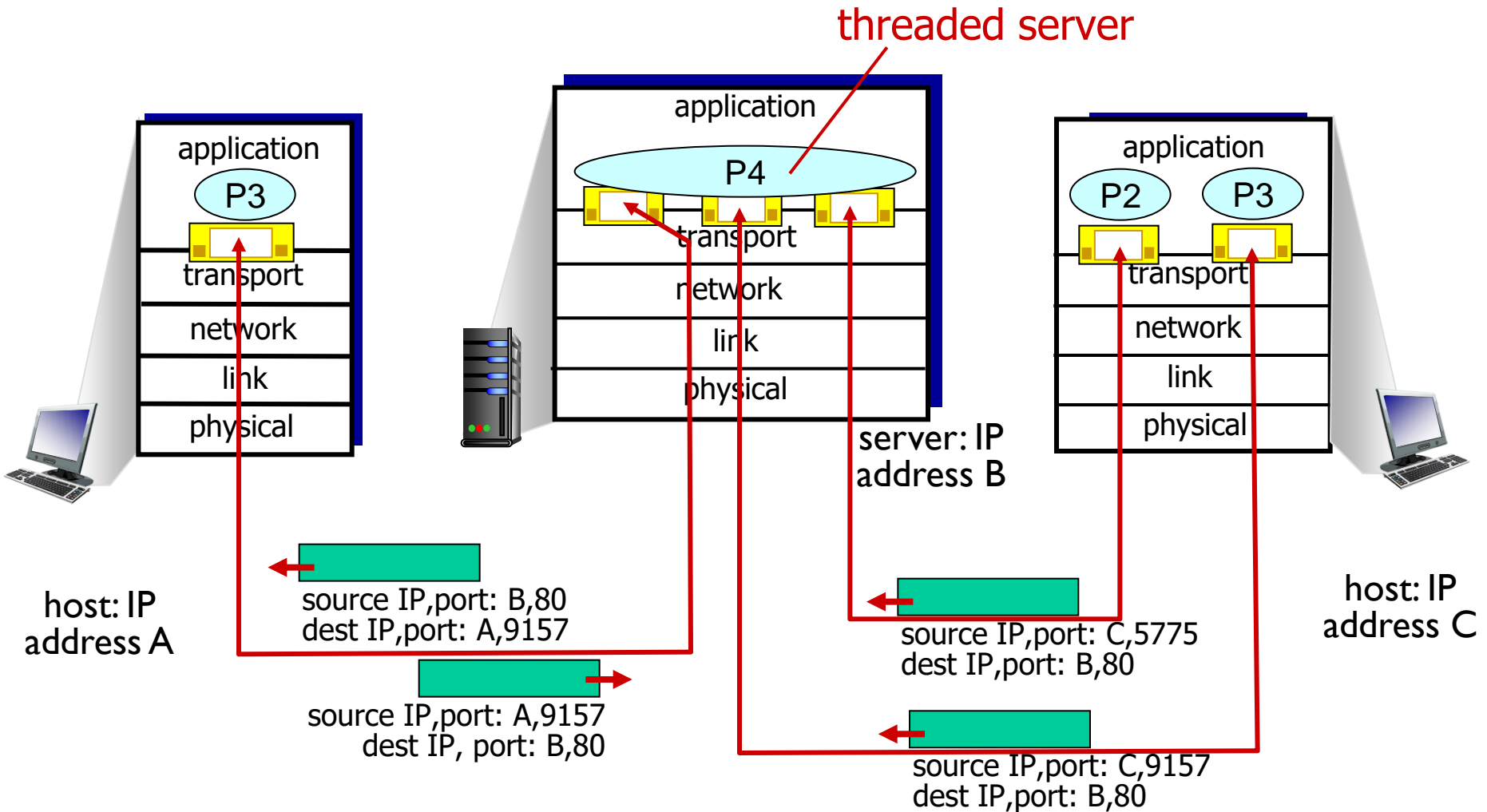
Connection-Oriented Demux

- TCP socket identified by 4-tuple:
 - source IP address
 - source port number
 - dest IP address
 - dest port number
- demux: receiver uses all four values to direct segment to appropriate socket
- server host may support many simultaneous TCP sockets:
 - each socket identified by its own 4-tuple
- web servers have different sockets for each connecting client
 - non-persistent HTTP will have different socket for each request

Connection-Oriented Demux: Example 1



Connection-Oriented Demux: Example 2



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- segment structure
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- flow control
- connection management

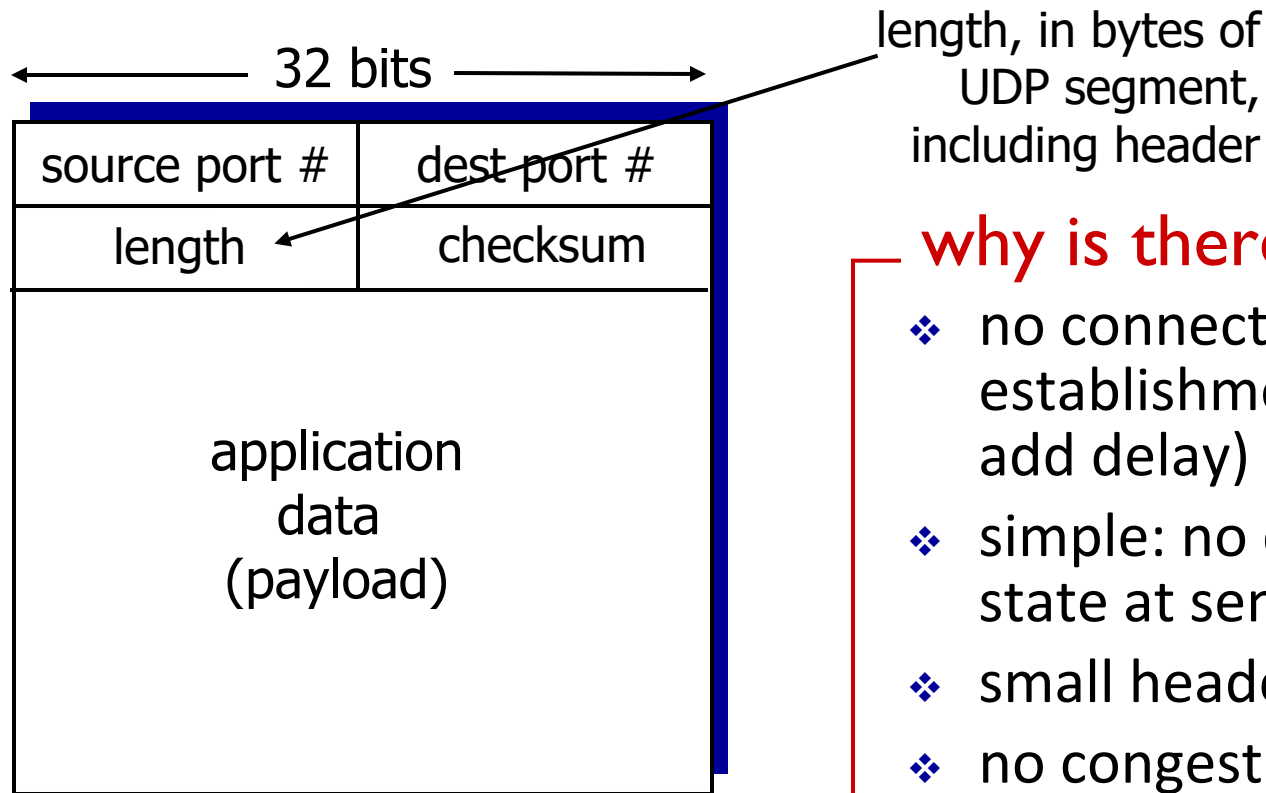
3.6 principles of congestion control

3.7 TCP congestion control

UDP: User Datagram Protocol [RFC 768]

- “no frills,” “bare bones”
Internet transport protocol
- “best effort” service, UDP segments may be:
 - lost
 - delivered out-of-order to app
- *connectionless*:
 - no handshaking between UDP sender, receiver
 - each UDP segment handled independently of others
- UDP use:
 - streaming multimedia apps (loss tolerant, rate sensitive)
 - DNS
 - SNMP
- reliable transfer over UDP:
 - add reliability at application layer
 - application-specific error recovery!

UDP: Segment Header



UDP segment format

why is there a UDP?

- ❖ no connection establishment (which can add delay)
- ❖ simple: no connection state at sender, receiver
- ❖ small header size
- ❖ no congestion control: UDP can blast away as fast as desired

Goal: detect “errors” (e.g., flipped bits) in transmitted segment

sender:

- treat segment contents, including header fields, as sequence of 16-bit integers
- checksum: addition (one’s complement sum) of segment contents
- sender puts checksum value into UDP checksum field

receiver:

- compute checksum of received segment
- check if computed checksum equals checksum field value:
 - NO - error detected
 - YES - no error detected.
But maybe errors nonetheless? More later
....

Internet Checksum: Example

example: add two 16-bit integers

	1	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	
	1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	
wraparound	1	1	0	1	1	1	0	1	1	1	0	1	1	1	0	1	1
sum	1	0	1	1	1	0	1	1	1	0	1	1	1	1	0	0	
checksum	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	1	1

Note: when adding numbers, a carryout from the most significant bit needs to be added to the result

Questions?

QUESTIONS

now