

# Chapter 3 outline

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

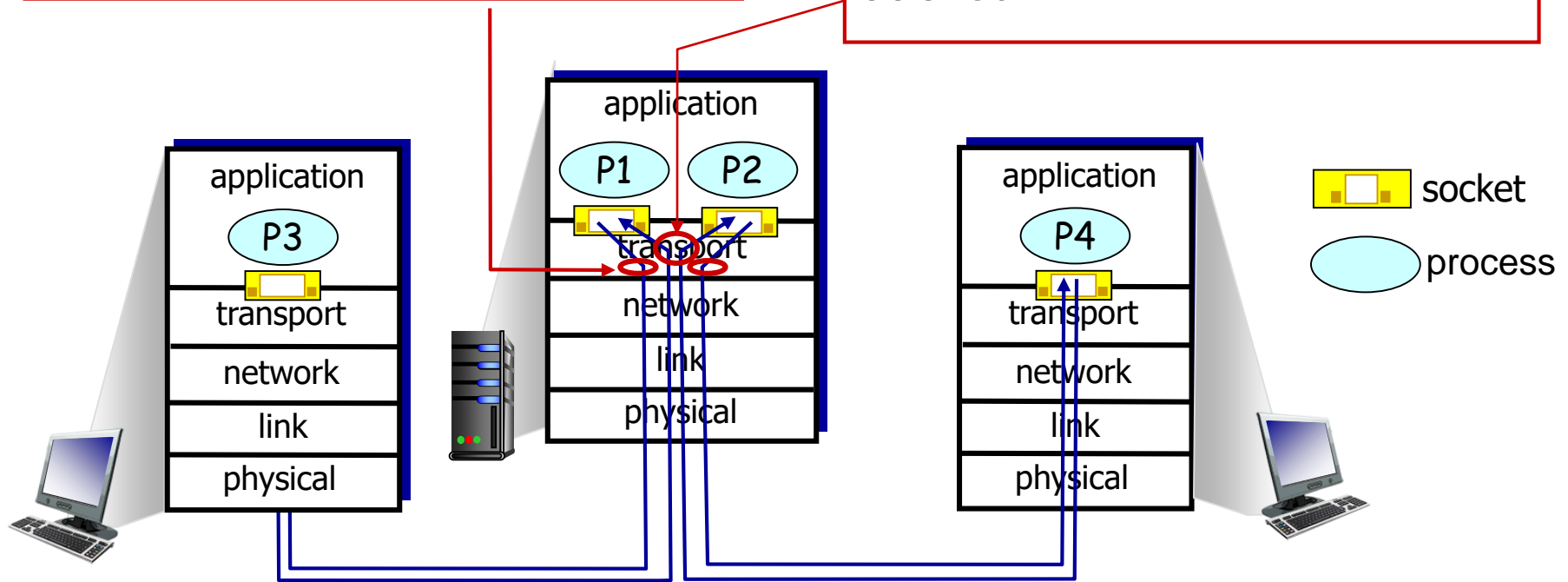
# Multiplexing/demultiplexing

## *multiplexing at sender:*

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

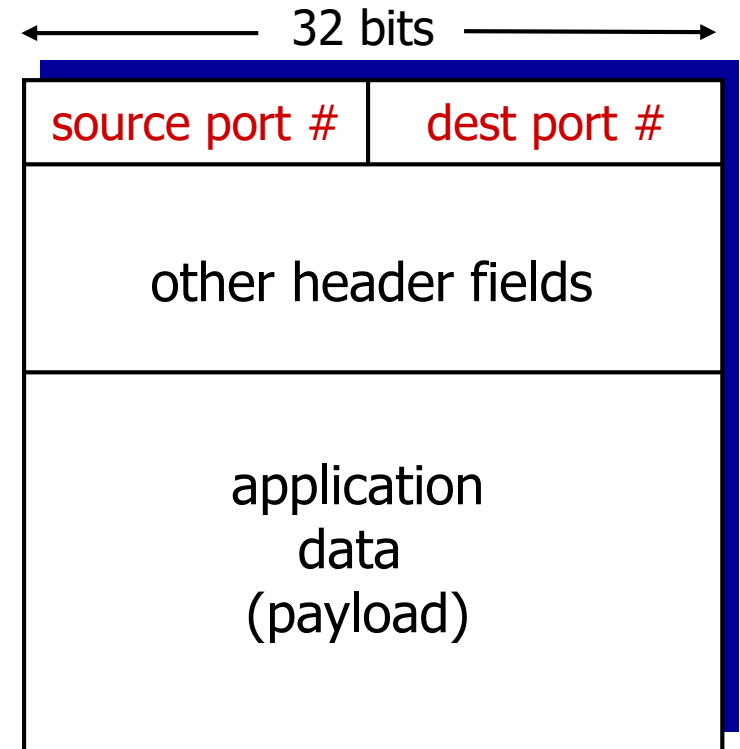
## *demultiplexing at receiver:*

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 #



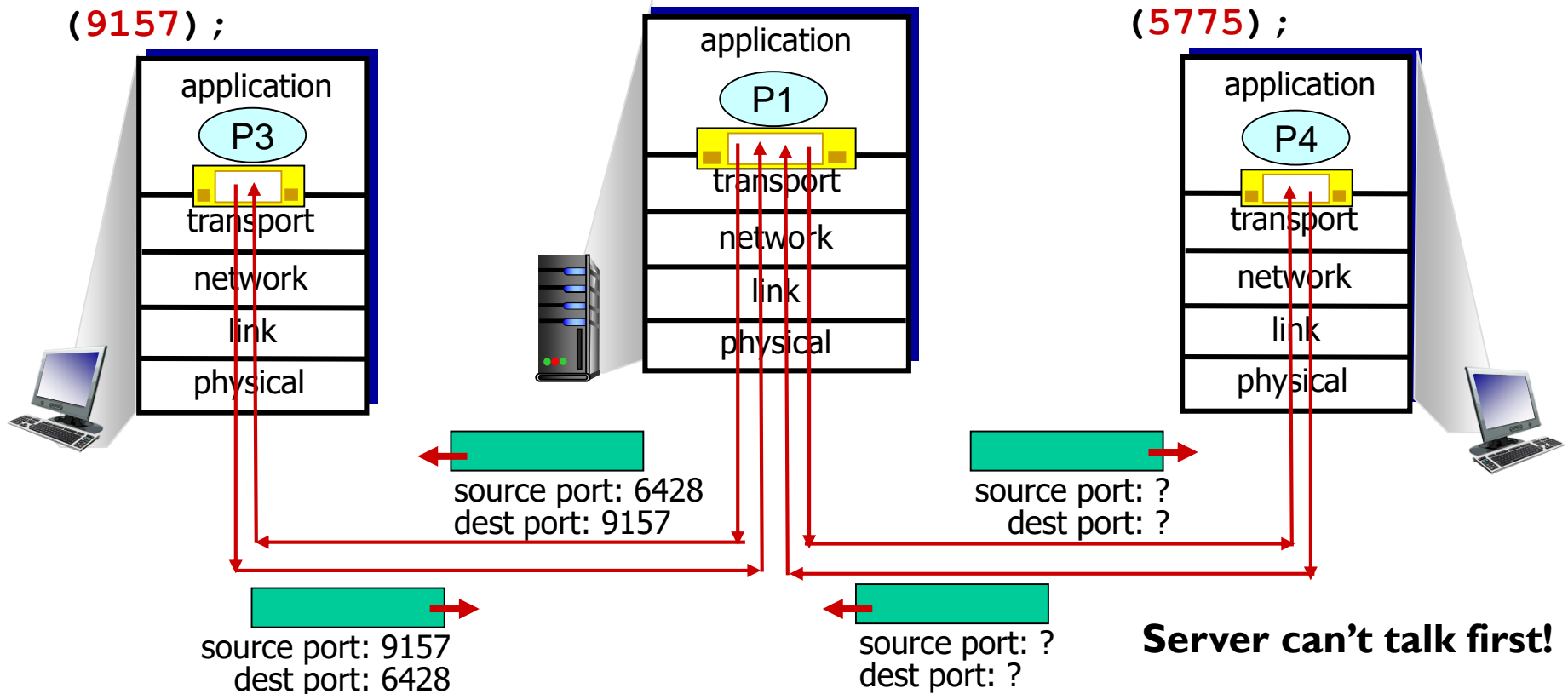
IP datagrams with *same dest. port #*, but different source IP addresses and/or source port numbers will be directed to *same socket* at dest

# Connectionless demux: example

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

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

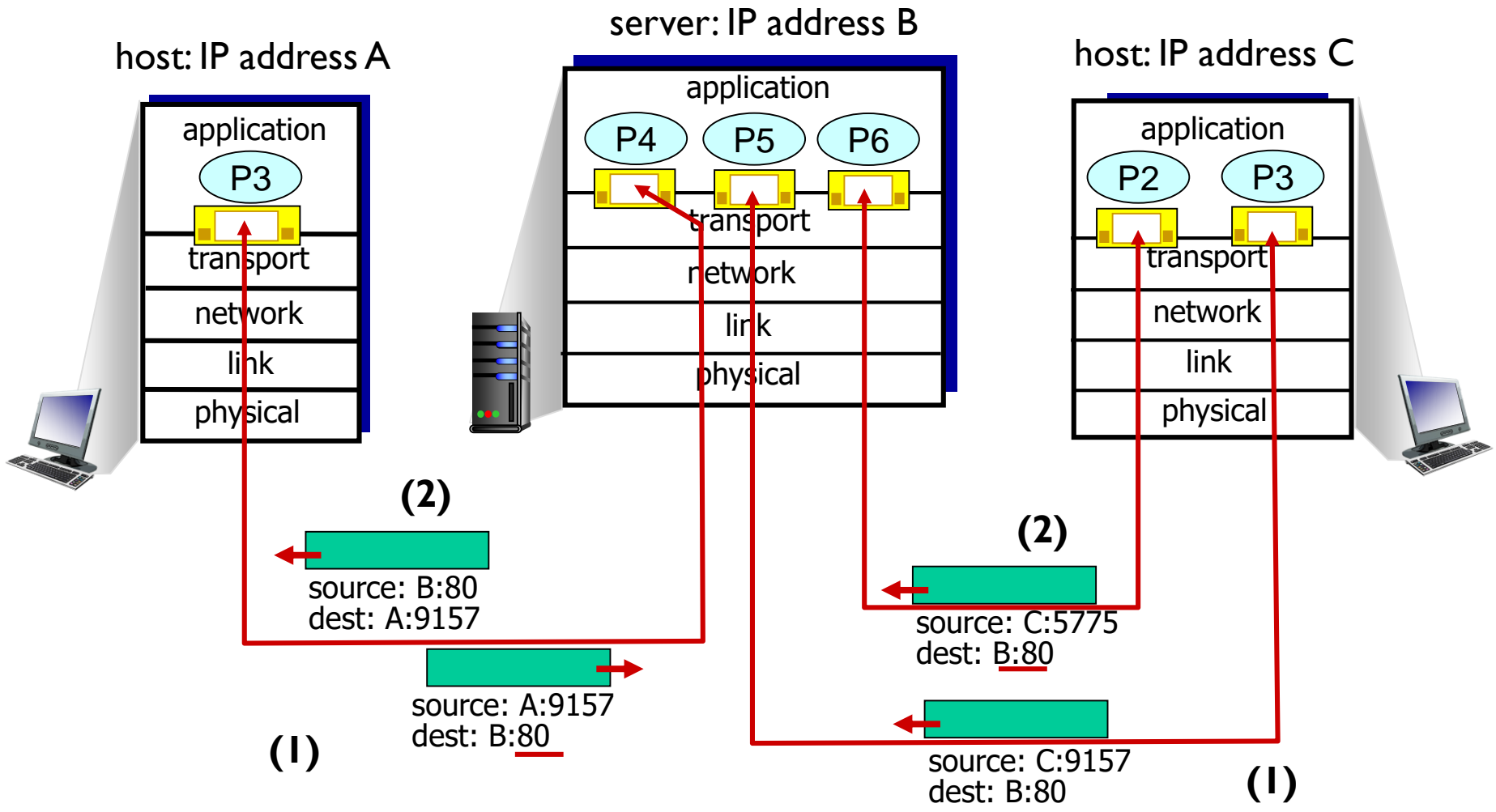
```
DatagramSocket  
mySocket1 = new  
DatagramSocket  
(5775);
```



# Connection-oriented demux

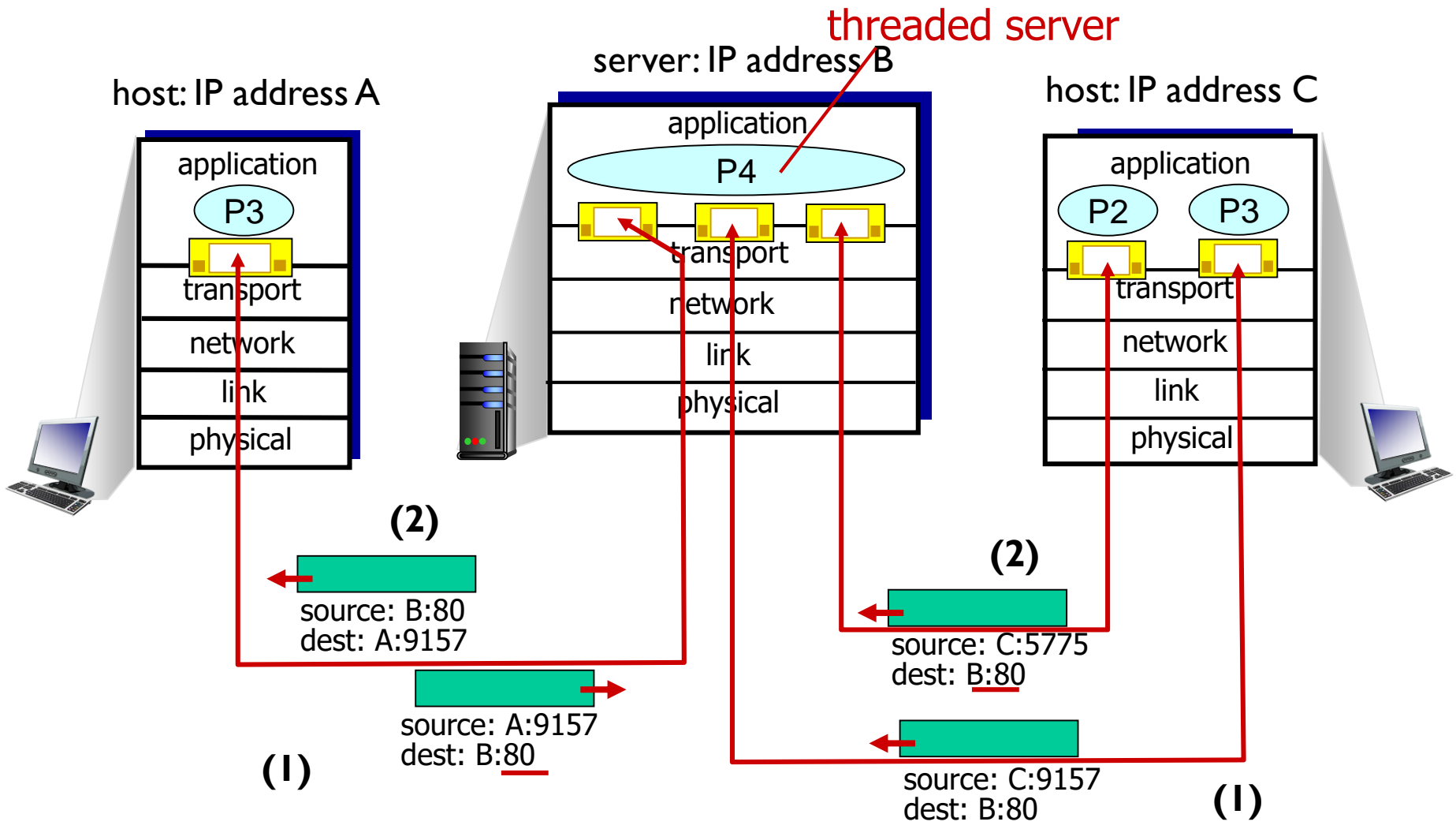
- ❖ TCP socket identified by 4-tuple:
  - source IP address
  - source port number
  - dest IP address
  - dest port number
- ❖ demux: receiver uses all four values to direct segment to appropriate socket
- ❖ server host may support many simultaneous TCP sockets:
  - each socket identified by its own 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



three segments, all destined to B:80  
are demultiplexed to *different* sockets

# Connection-oriented demux: example



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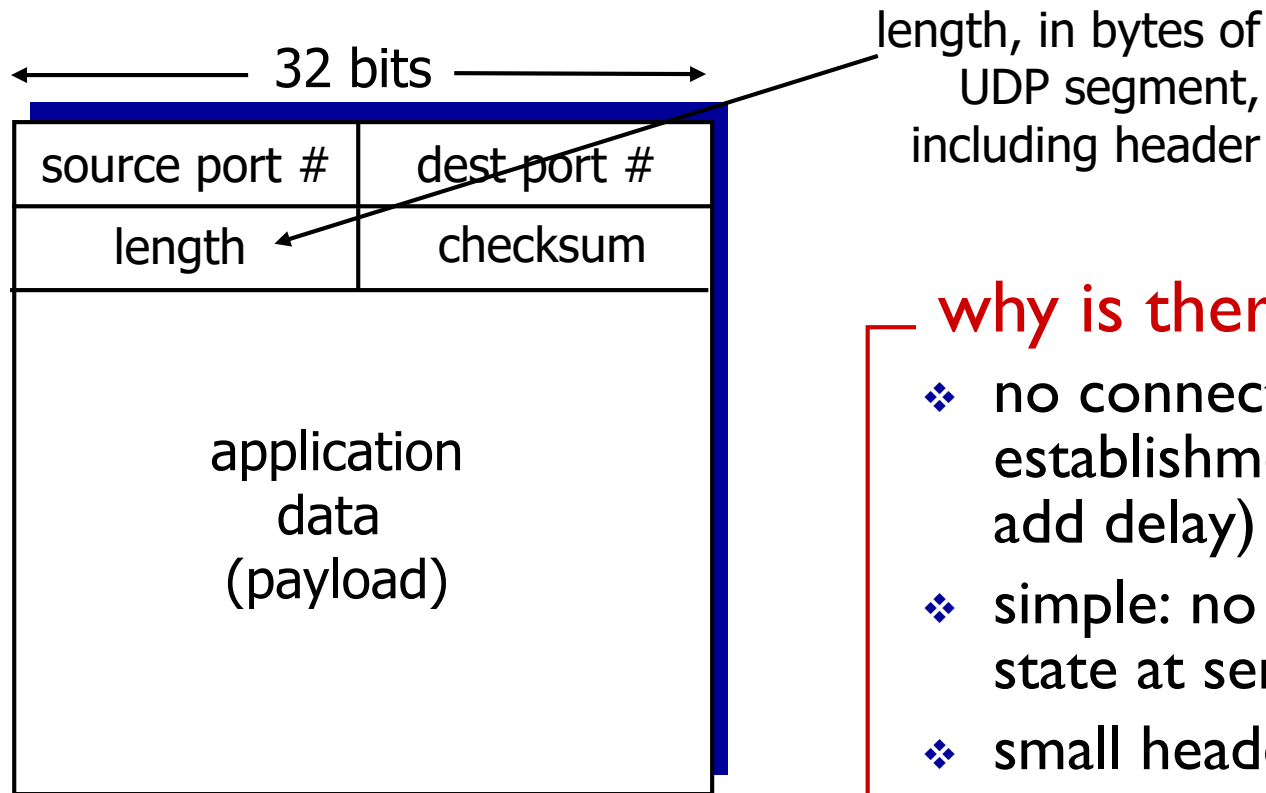
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# UDP: User Datagram Protocol [RFC 768]

- ❖ “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

# UDP checksum

*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
<hr/>																
wraparound	1	1	0	1	1	1	0	1	1	1	0	1	1	1	0	1
<hr/>																
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	1	1

*Then, see if the sum added to the checksum is all 1's*

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