

Chapter 3

Transport Layer

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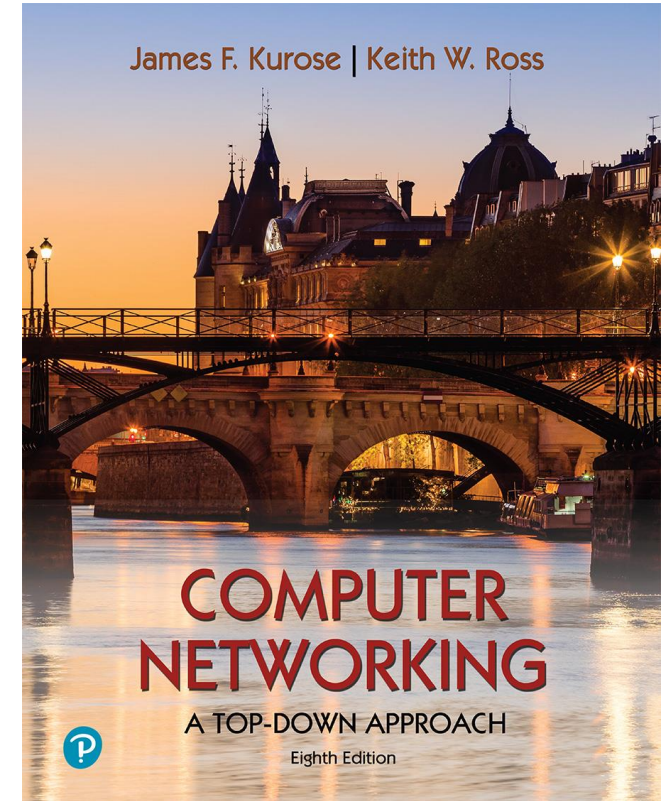
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*Computer Networking: A
Top-Down Approach*

8th edition

Jim Kurose, Keith Ross
Pearson, 2020

Transport layer: overview

Our goal:

- understand principles behind transport layer services:
 - multiplexing, 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

Transport layer: overview

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Network 2

Network 2

Transport layer: roadmap

- Transport-layer services
- Multiplexing and demultiplexing
- Connectionless transport: UDP
- Principles of reliable data transfer
- Connection-oriented transport: TCP
- Principles of congestion control
- TCP congestion control



Transport layer: roadmap

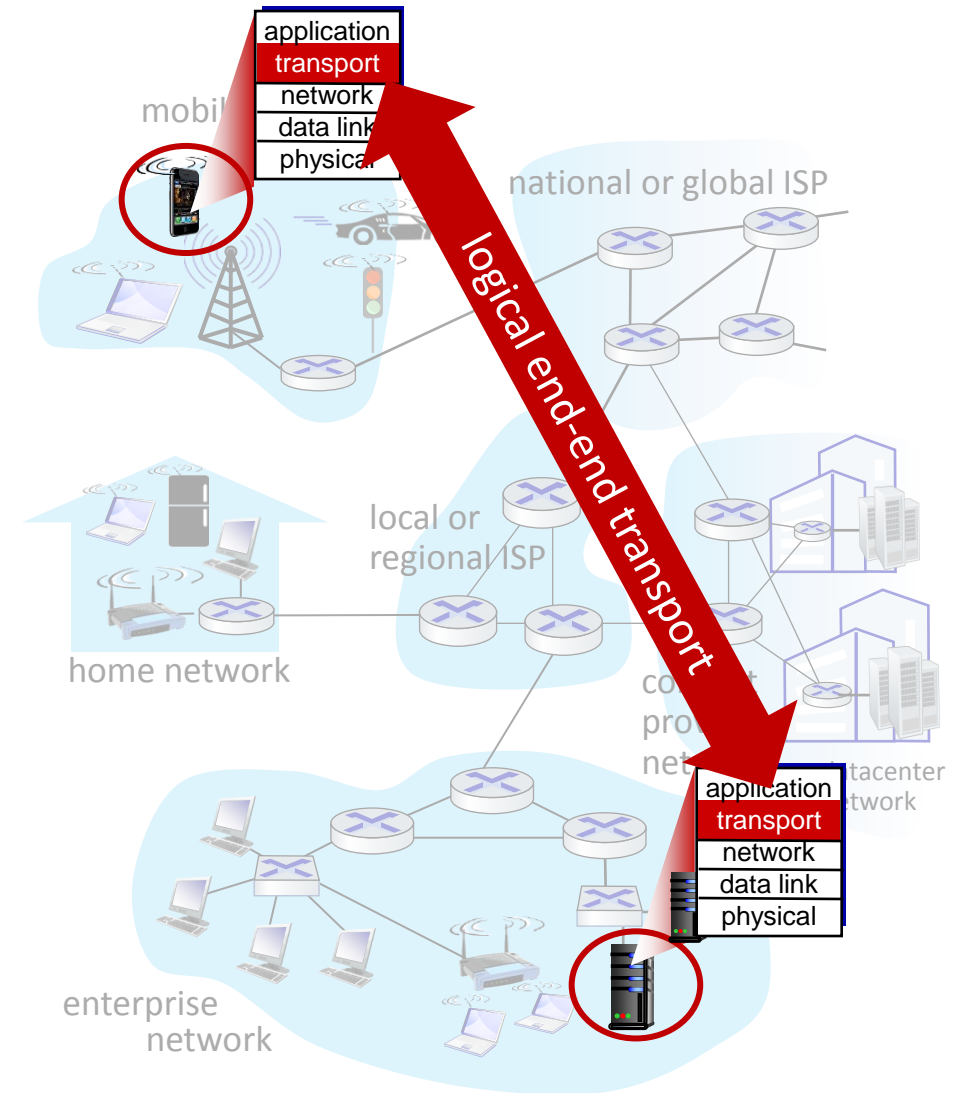
- Transport-layer services
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Network 2

Transport services and protocols

- provide *logical communication* between application processes running on different hosts
- transport protocols actions in end systems:
 - sender: breaks application messages into *segments*, passes to network layer
 - receiver: reassembles segments into messages, passes to application layer
- two transport protocols available to Internet applications
 - TCP, UDP



Transport vs. network layer services and protocols



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 vs. network layer services and protocols

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

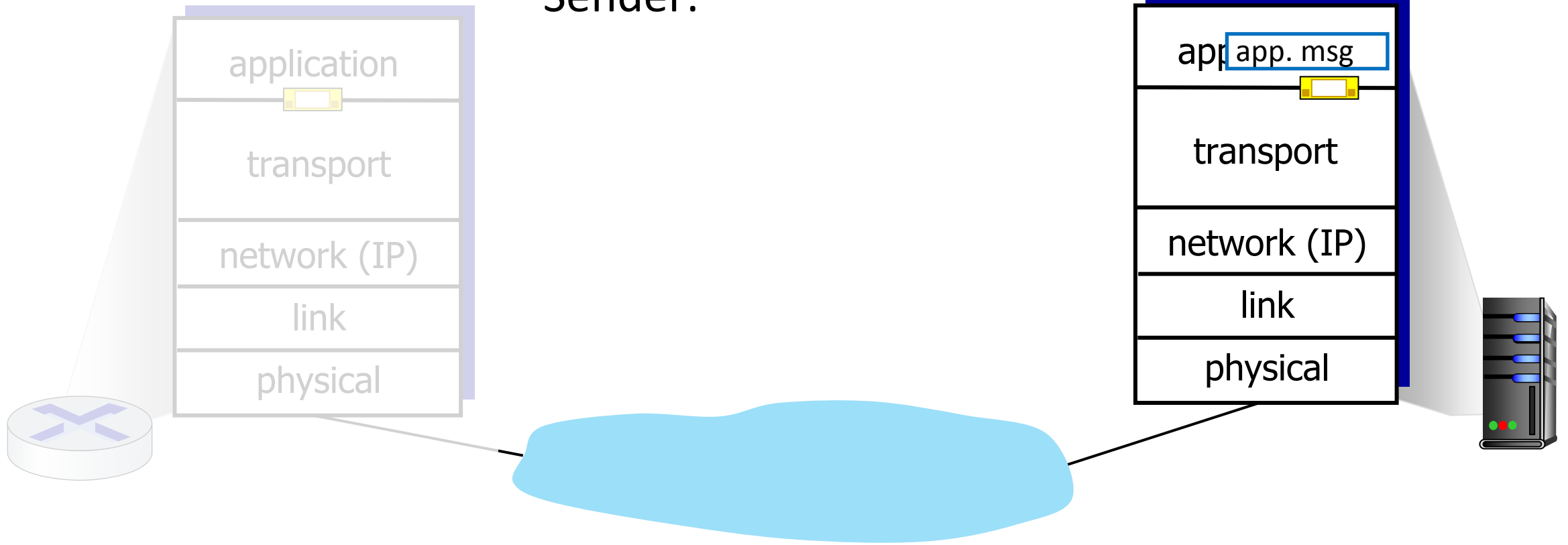
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Transport Layer Actions

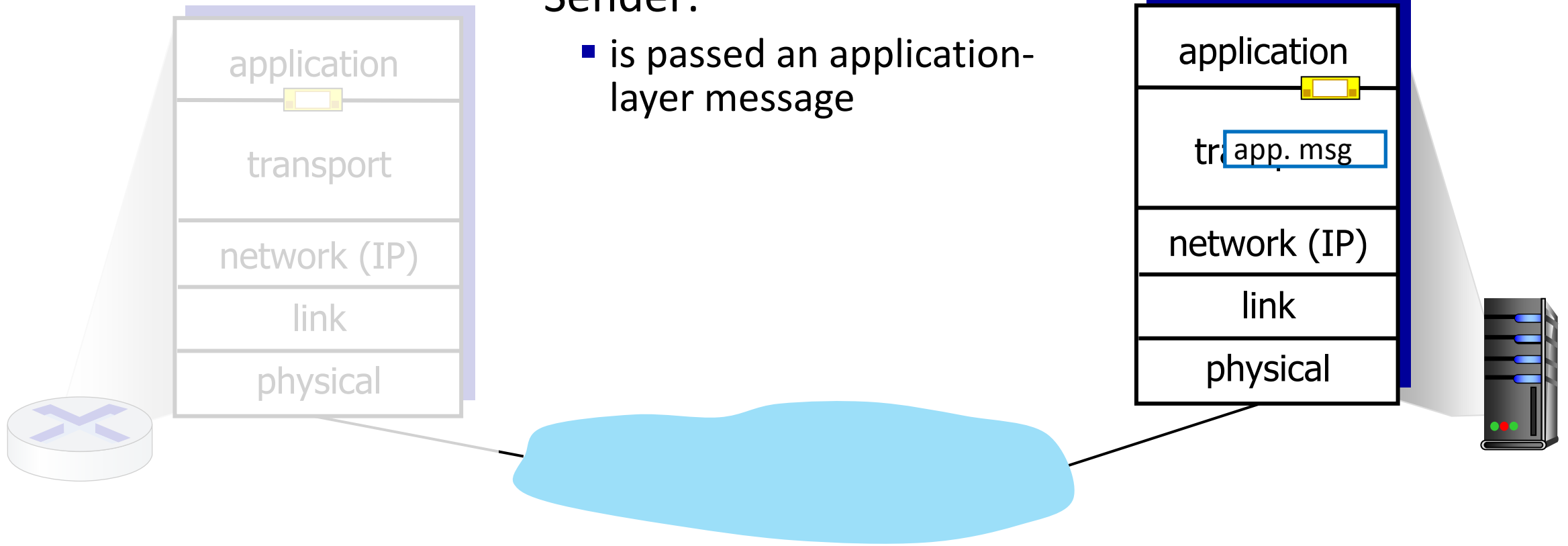
Sender:



Transport Layer Actions

Sender:

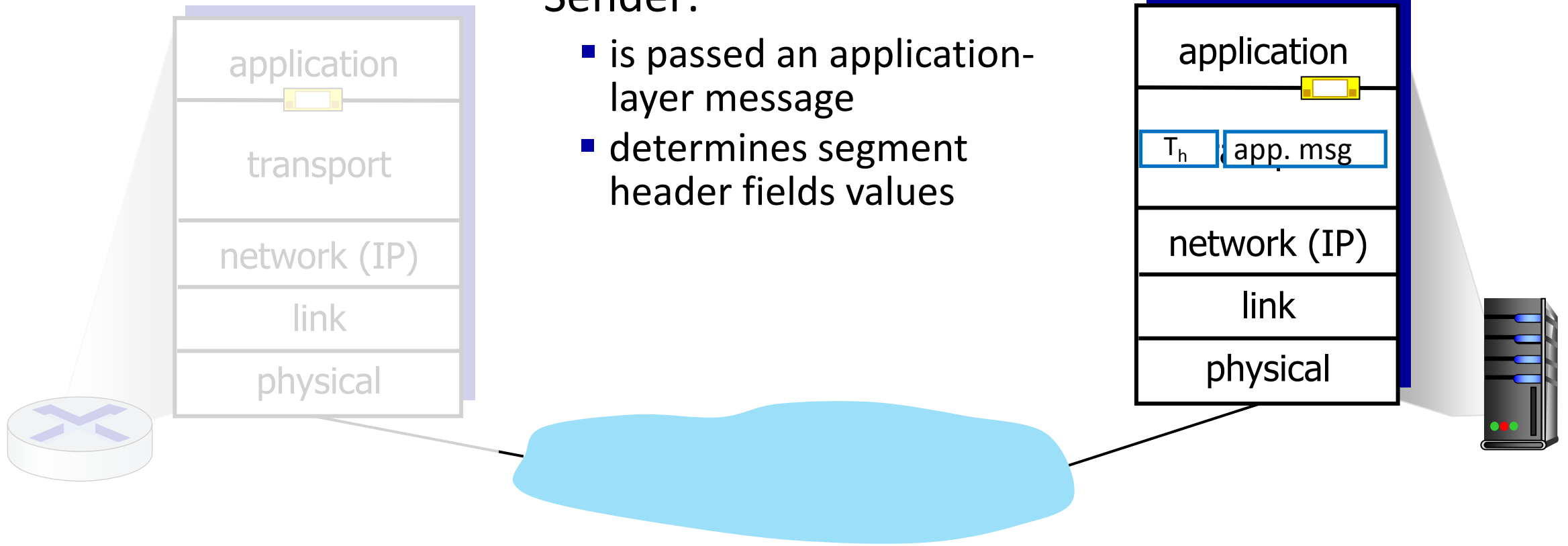
- is passed an application-layer message



Transport Layer Actions

Sender:

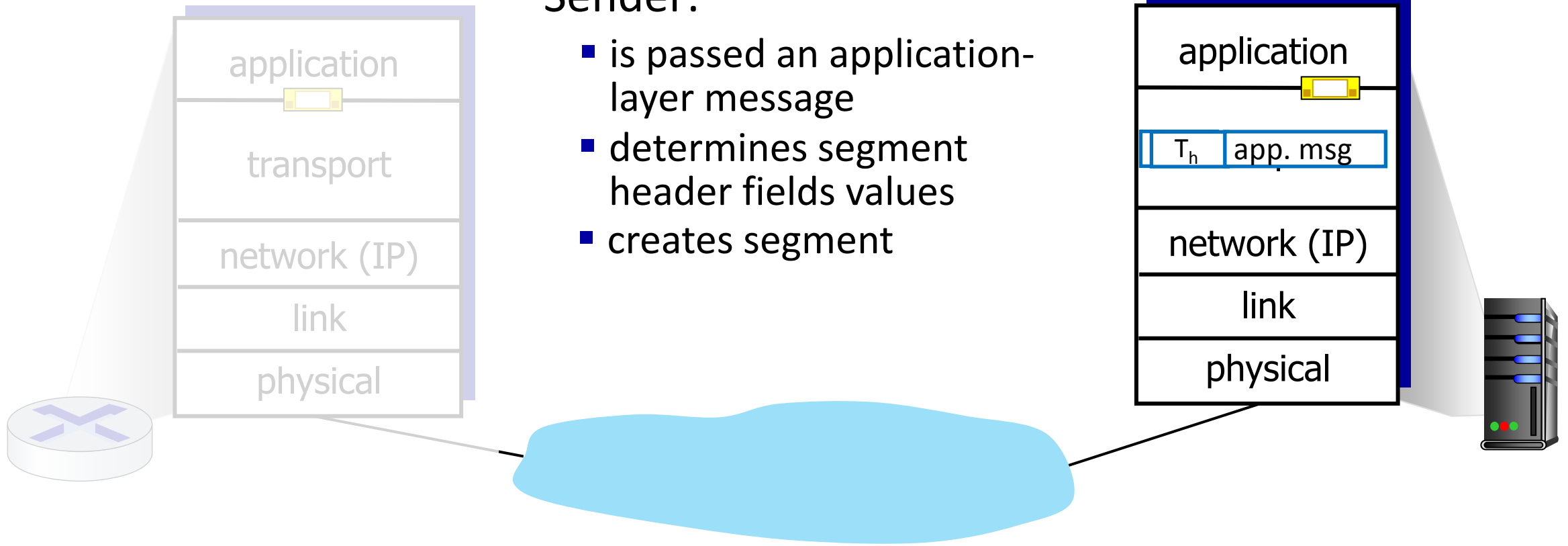
- is passed an application-layer message
- determines segment header fields values



Transport Layer Actions

Sender:

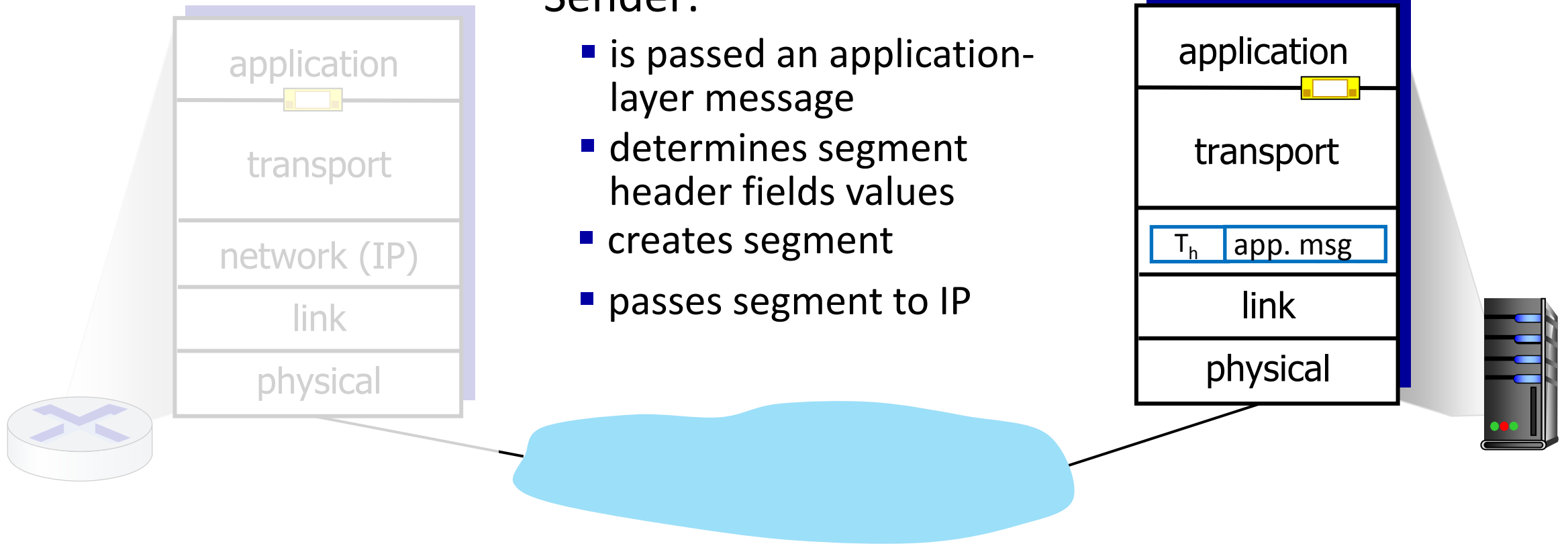
- is passed an application-layer message
- determines segment header fields values
- creates segment



Transport Layer Actions

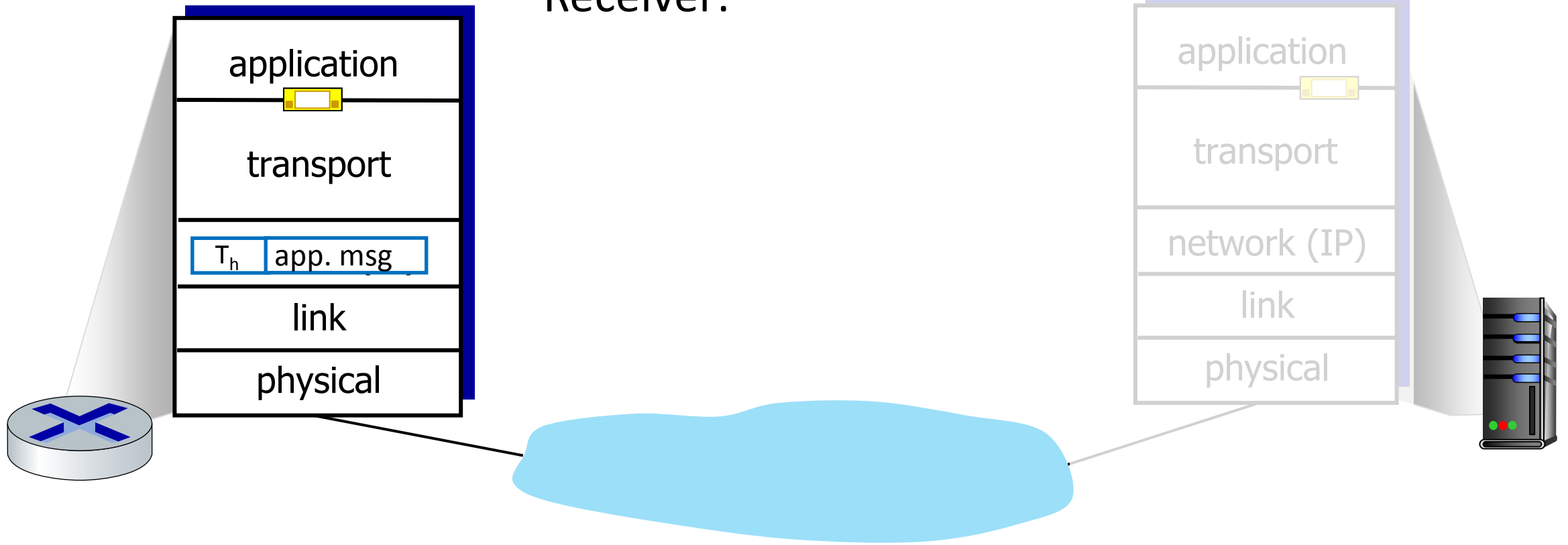
Sender:

- is passed an application-layer message
- determines segment header fields values
- creates segment
- passes segment to IP



Transport Layer Actions

Receiver:



Transport Layer Actions

Receiver:

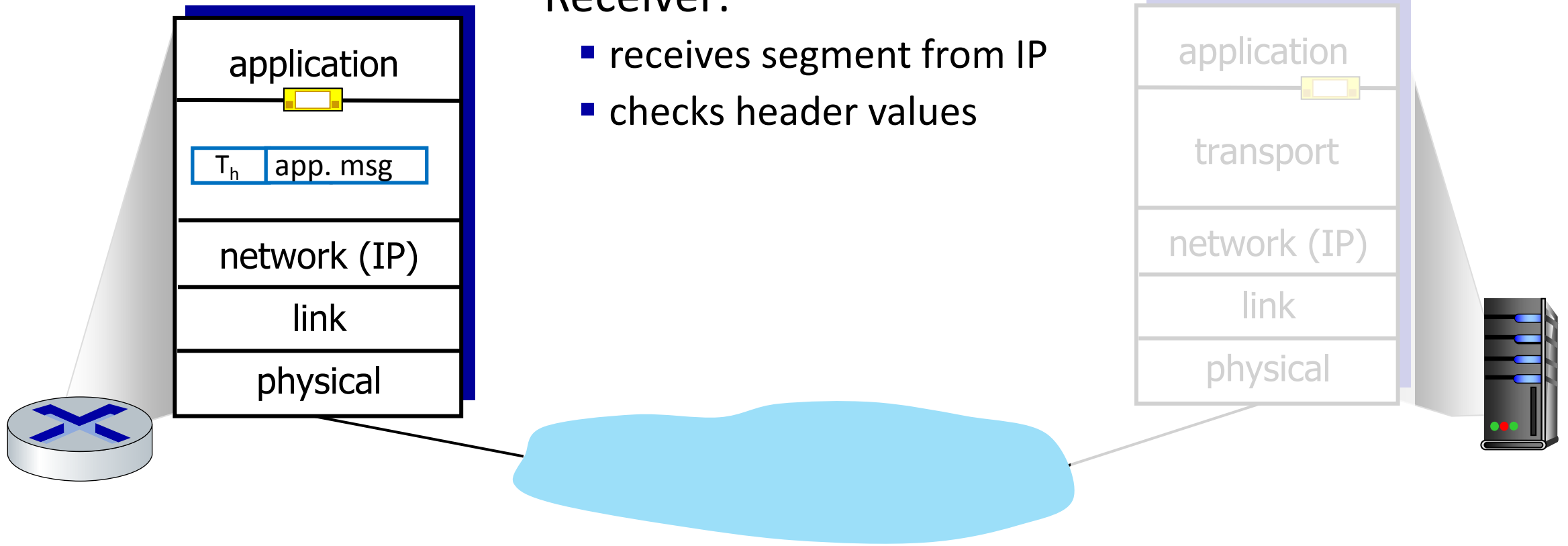
- receives segment from IP



Transport Layer Actions

Receiver:

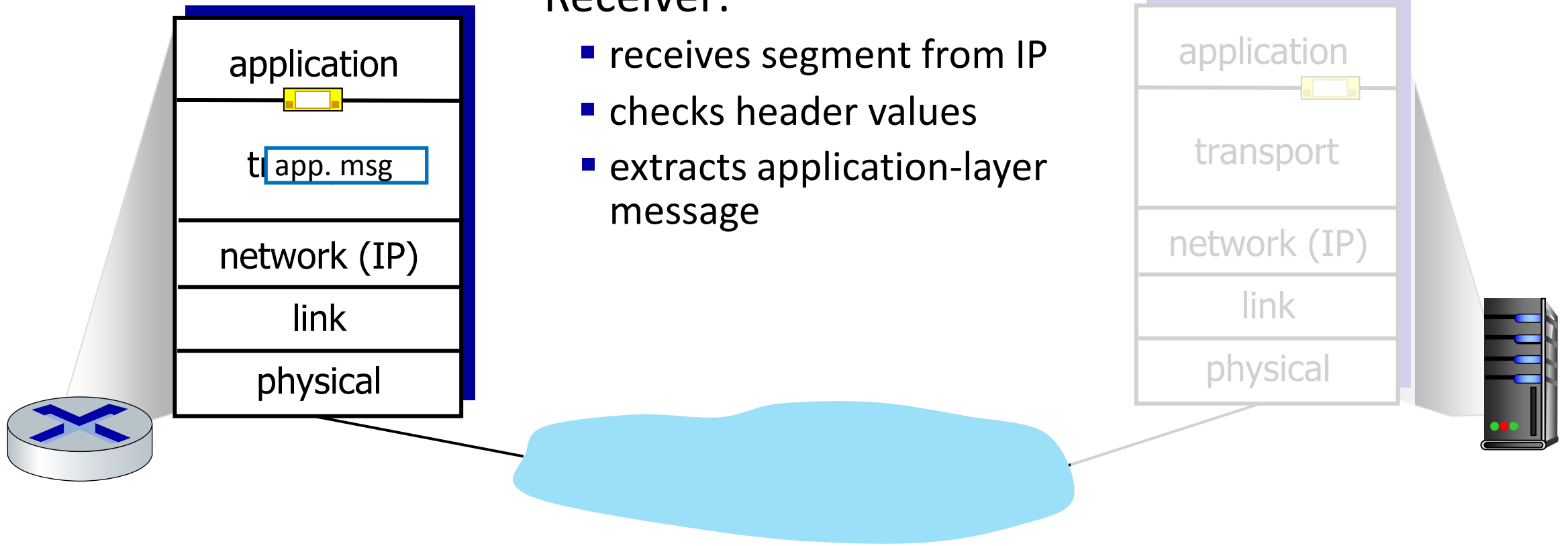
- receives segment from IP
- checks header values



Transport Layer Actions

Receiver:

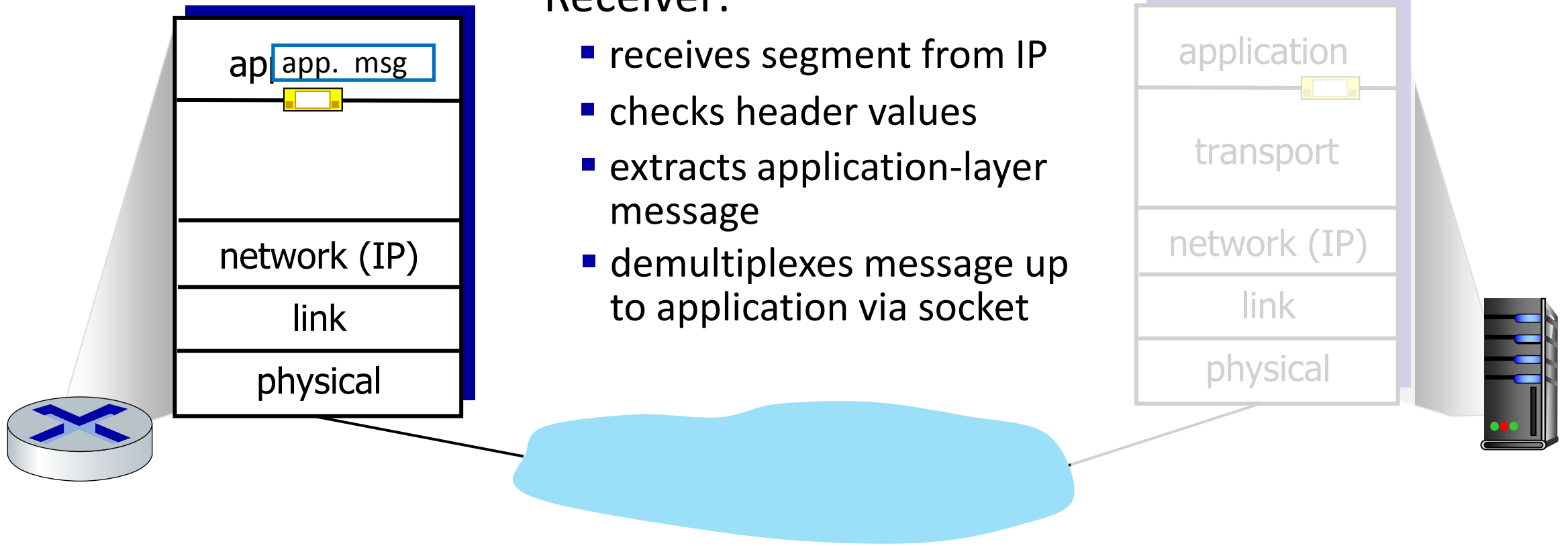
- receives segment from IP
- checks header values
- extracts application-layer message



Transport Layer Actions

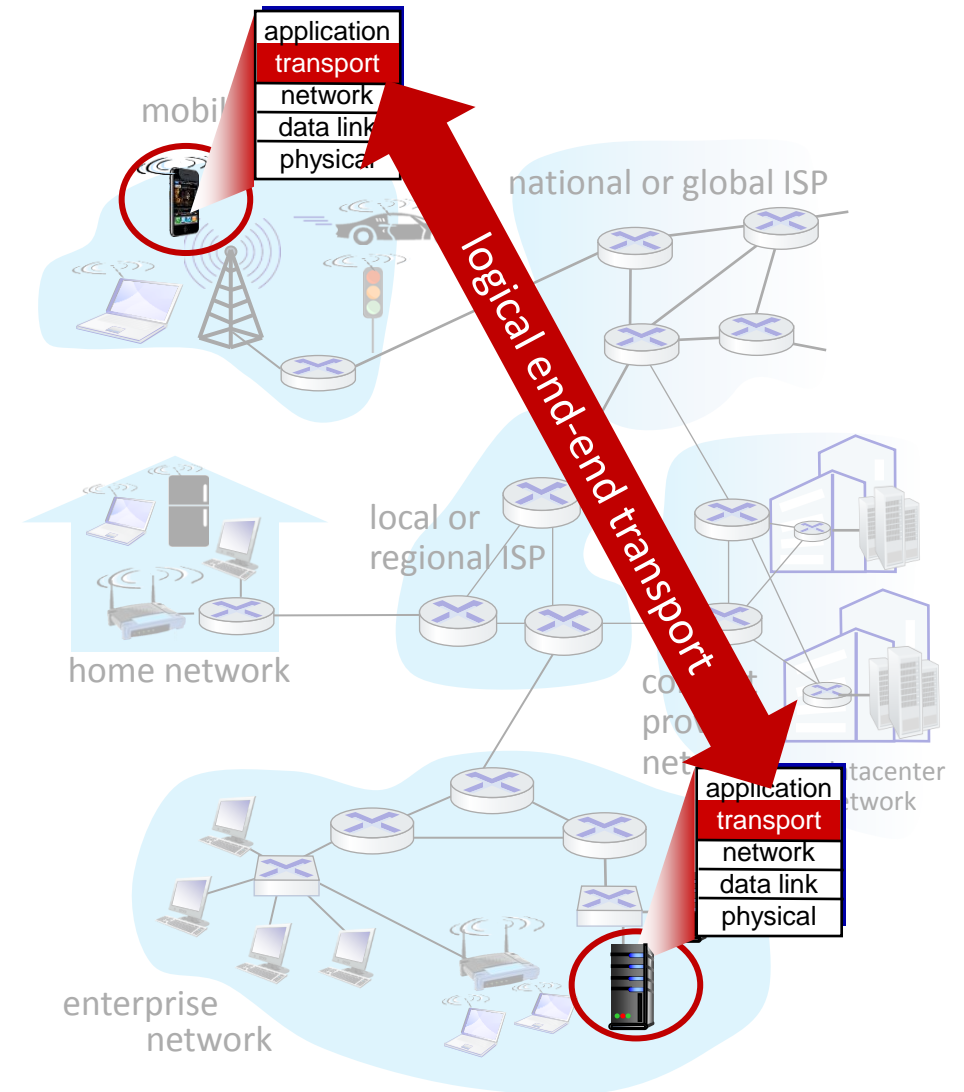
Receiver:

- receives segment from IP
- checks header values
- extracts application-layer message
- demultiplexes message up to application via socket



Two principal Internet transport protocols

- **TCP:** Transmission Control Protocol
 - reliable, in-order delivery
 - congestion control
 - flow control
 - connection setup
- **UDP:** User Datagram Protocol
 - unreliable, unordered delivery
 - no-frills extension of “best-effort” IP
- services not available:
 - delay guarantees
 - bandwidth guarantees

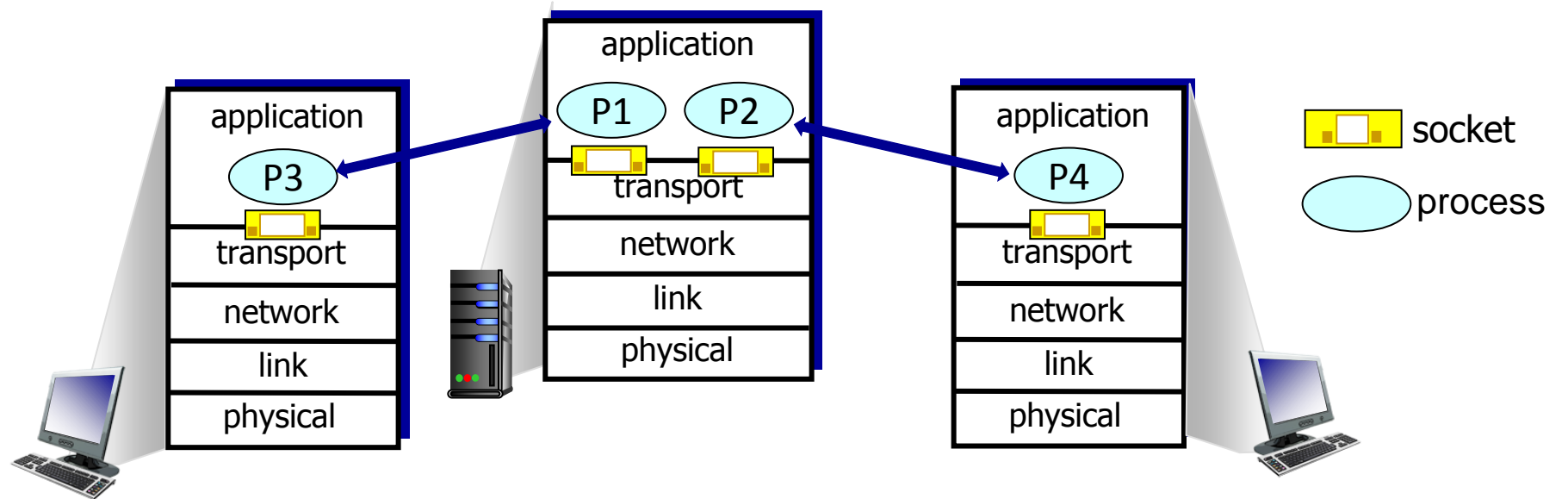


Chapter 3: roadmap

- Transport-layer services
- **Multiplexing and demultiplexing**
- Connectionless transport: UDP
- Principles of reliable data transfer
- Connection-oriented transport: TCP
- Principles of congestion control
- TCP congestion control
- Evolution of transport-layer functionality



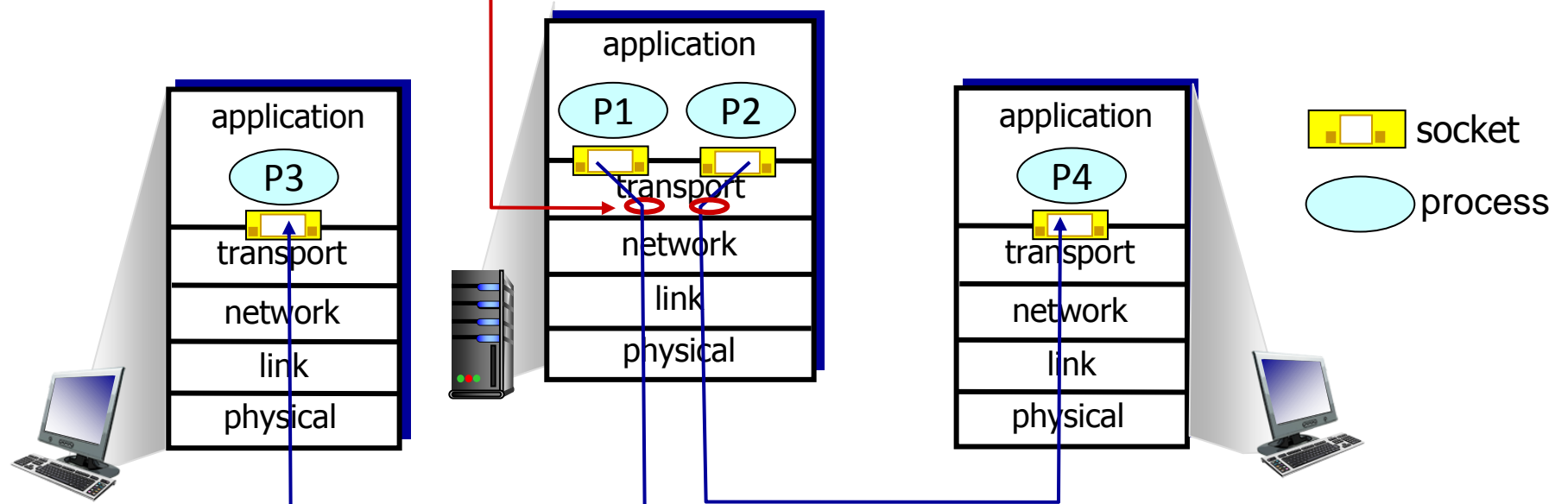
Multiplexing/demultiplexing



Multiplexing/demultiplexing

multiplexing at sender:

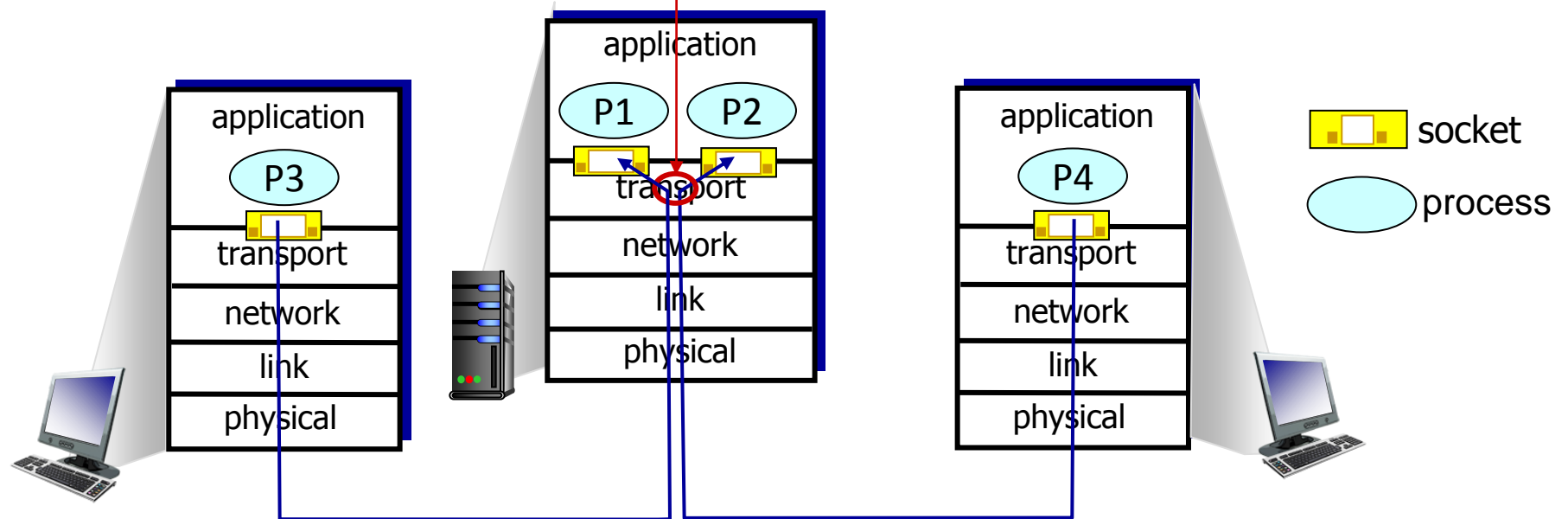
handle data from multiple sockets, add transport header (later used for demultiplexing)



Multiplexing/demultiplexing

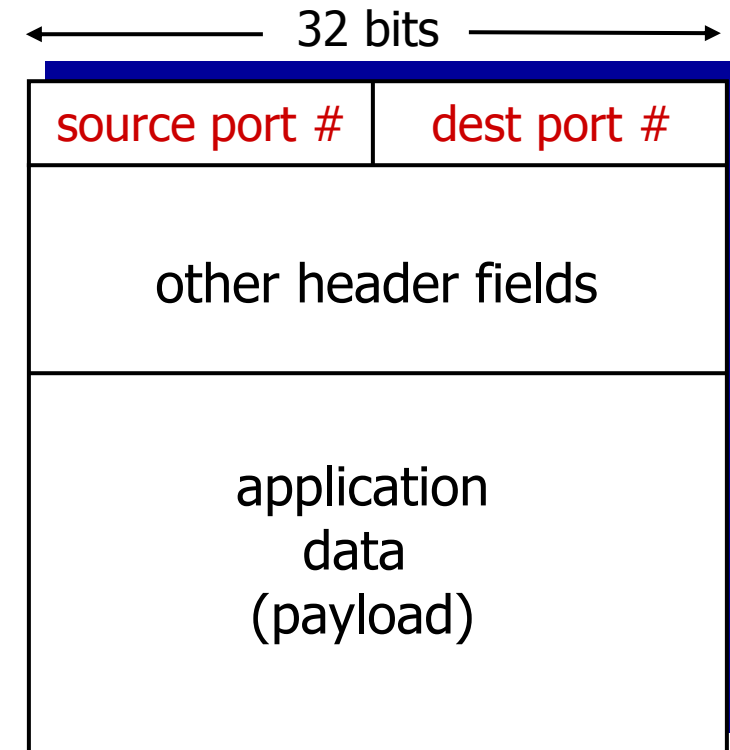
demultiplexing at receiver:

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:

- when creating socket, must specify *host-local* port #:

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

- when creating datagram to send into UDP socket, must specify
 - destination IP address
 - destination port #

when receiving host receives *UDP* segment:

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



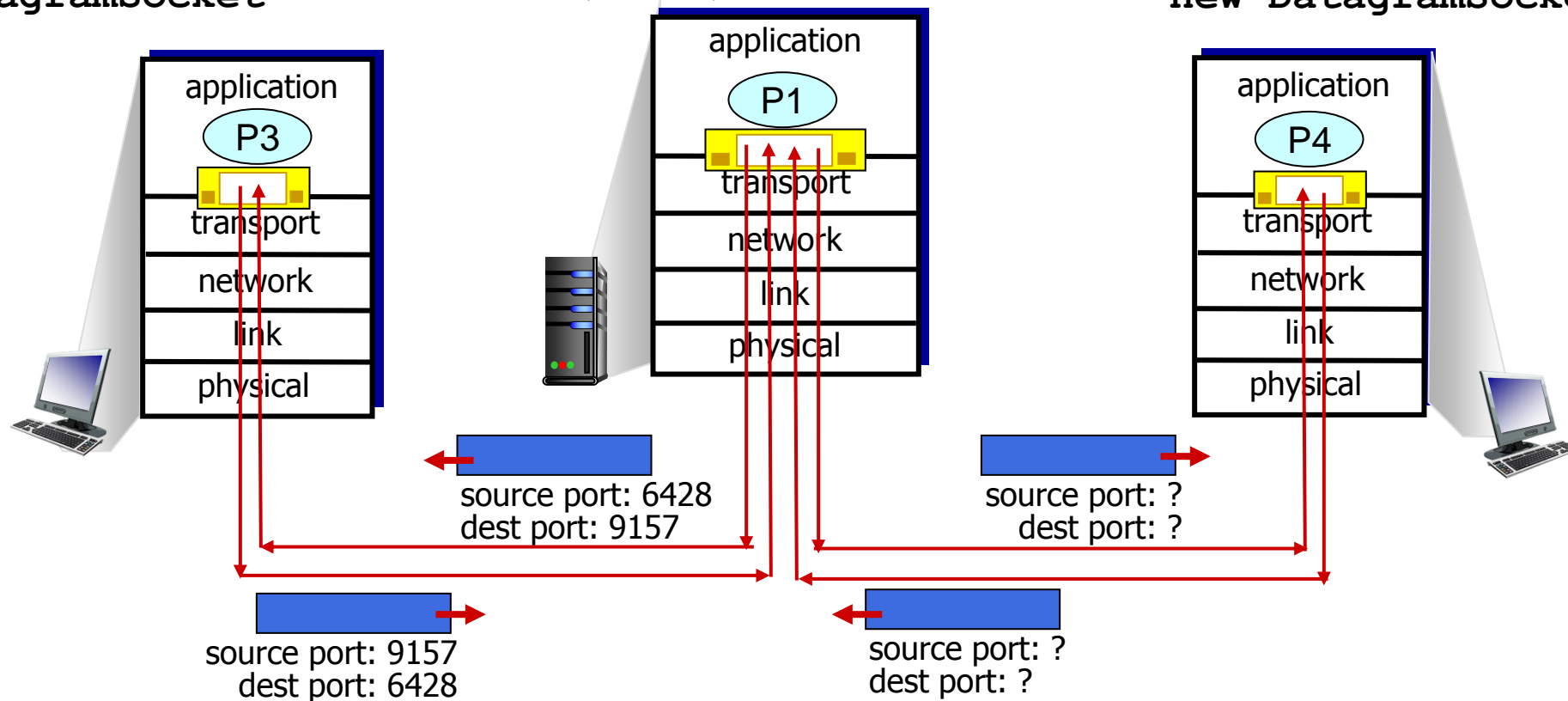
UDP segments with *same dest. IP address and port #*, but different source IP addresses and/or source port numbers will be directed to *same socket* at receiving host

Connectionless demultiplexing: an example

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

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

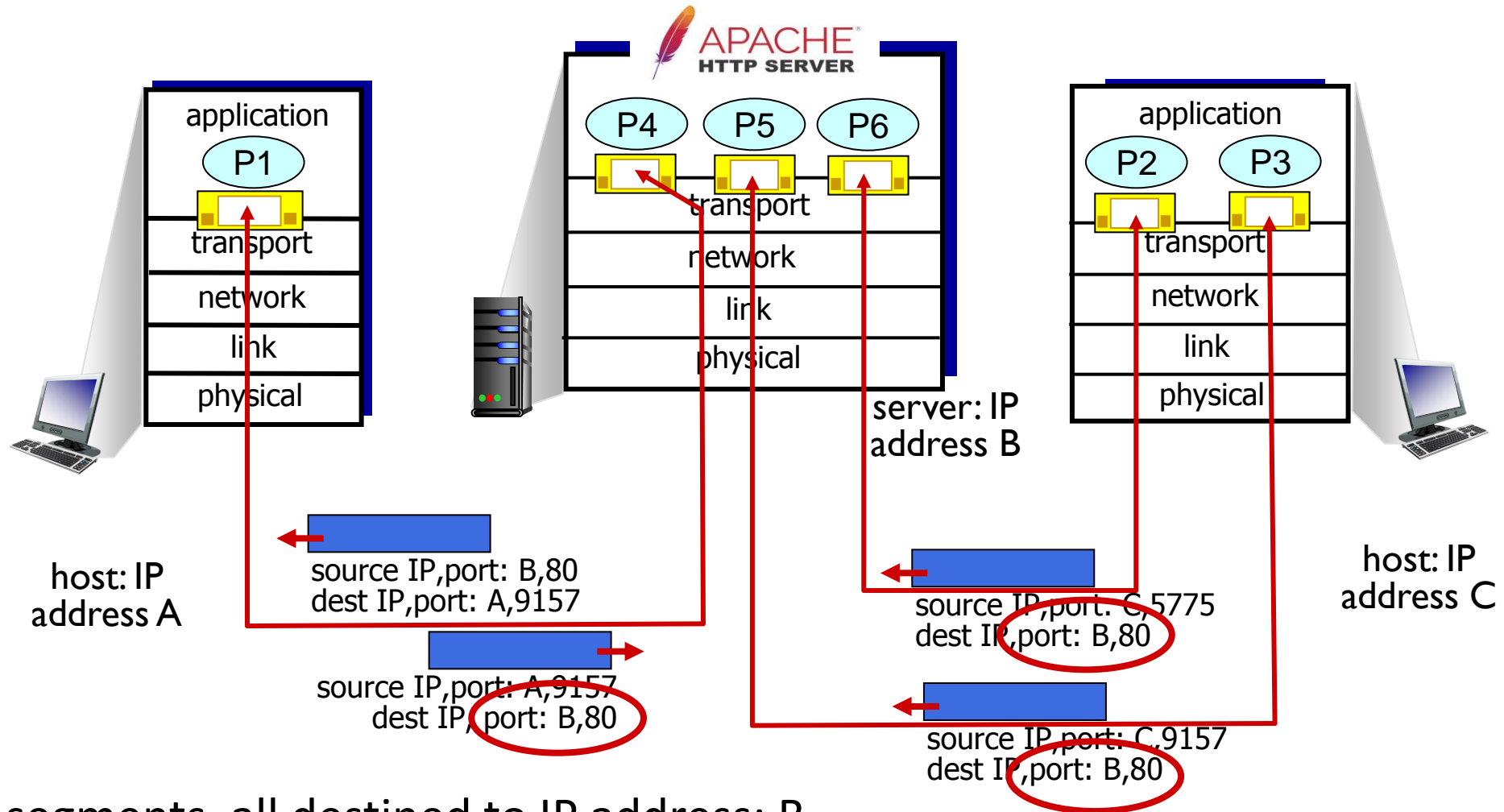
```
DatagramSocket mySocket1 =  
new DatagramSocket (5775) ;
```



Connection-oriented demultiplexing

- TCP socket identified by 4-tuple:
 - source IP address
 - source port number
 - dest IP address
 - dest port number
- demux: receiver uses *all four values (4-tuple)* to direct segment to appropriate socket
- server may support many simultaneous TCP sockets:
 - each socket identified by its own 4-tuple
 - each socket associated with a different connecting client

Connection-oriented demultiplexing: example



Three segments, all destined to IP address: B,
dest port: 80 are demultiplexed to *different* sockets

Summary

- Multiplexing, demultiplexing: based on segment, datagram header field values
- **UDP:** demultiplexing using destination IP address and port number
- **TCP:** demultiplexing using 4-tuple: source and destination IP addresses, and port numbers
- Multiplexing/demultiplexing happen at *all* layers

Summary

- Multiplexing, demultiplexing: based on segment, datagram header field values
- **UDP:** demultiplexing using destination IP address and port number
- **TCP:** demultiplexing using 4-tuple: source and destination IP addresses, and port numbers
- Multiplexing/demultiplexing happen at *all* layers

DQ: Can two different processes in the same host have the same port number? explain