Introduction to the Transport Layer

CSC 249 Feb 13, 2018

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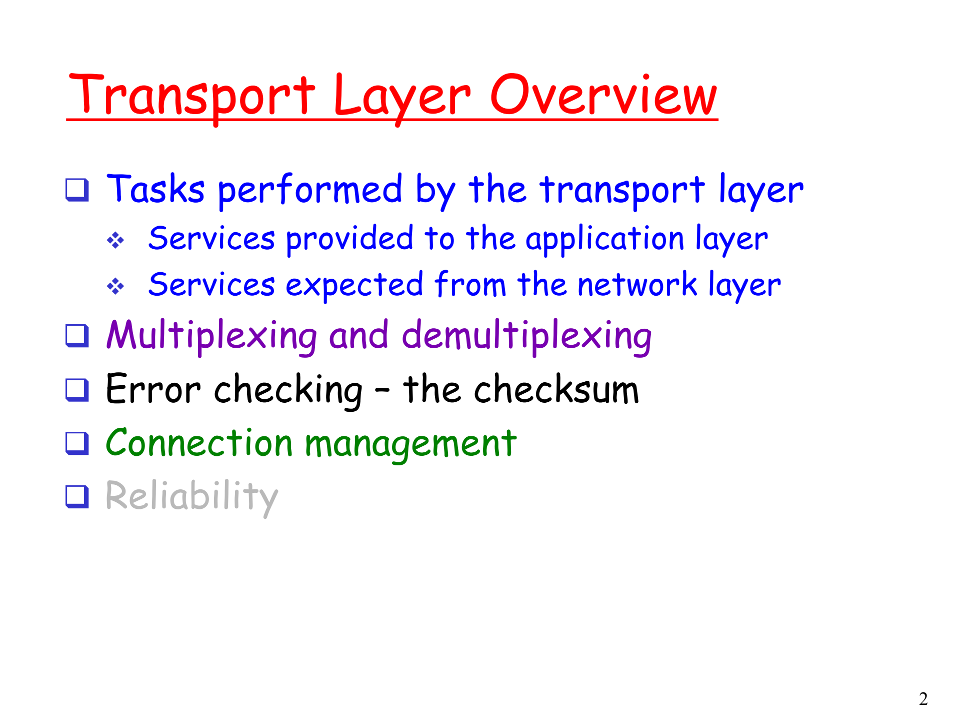

Transport Layer Overview

- ❑ Tasks performed by the transport layer
  - ❖ Services provided to the application layer
  - ❖ Services expected from the network layer
- ❑ Multiplexing and demultiplexing
- ❑ Error checking – the checksum
- ❑ Connection management
- ❑ Reliability

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Transport Layer Tasks

- The transport layer (TCP) provides reliability over an unreliable network
- What can go wrong?
  - Bit errors
    - original data as well as ACKs
  - Lossy channel (with bit errors)
    - Stop-and-wait v. pipelining
  - Out-of-order packets
  - Noticeable delay

The Actual Transport Layer

- Basic transport layer services:
  - Connection management
  - Reliable data transfer
  - Multiplexing/demultiplexing
  - Some error checking
  - Flow control & Congestion control
- Services not available:
  - delay guarantees
  - bandwidth guarantees
  - security
- Internet transport protocols:
  - UDP: Connectionless transport
  - TCP: Connection-oriented transport & Reliability

Multiplexing/demultiplexing

- ❑ Multiplexer
  - Selects input from one of many input lines (processes) and directs the information to a single output line
  - Many sockets to one network connection
- ❑ Demultiplexer
  - Direct a single input to one of many possible processes that are running
  - Single network connection to many sockets (processes)

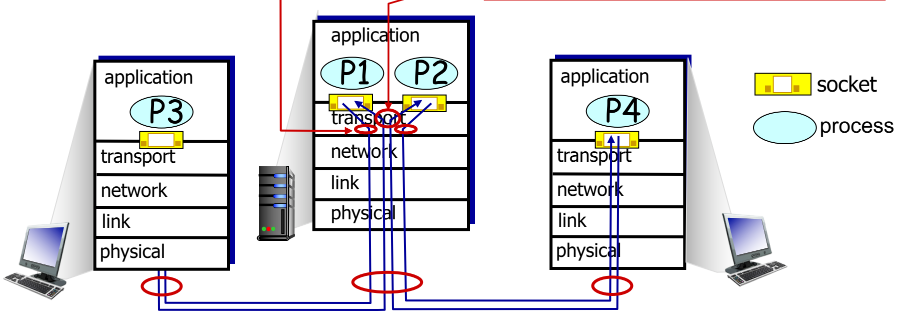
Multiplexing/demultiplexing

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

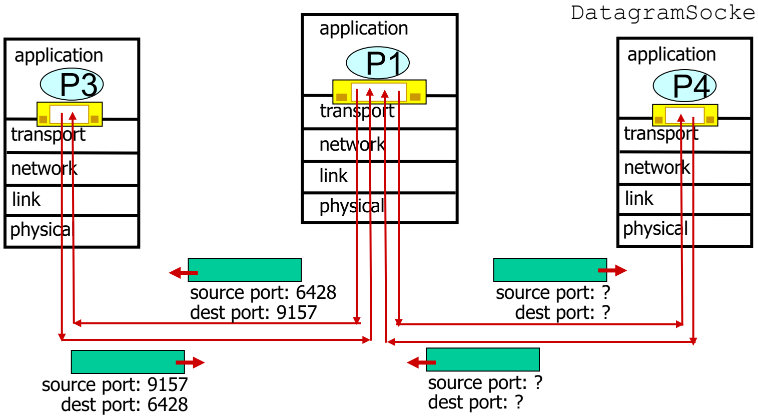


Connectionless demultiplexing

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

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

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



Connectionless demultiplexing

- ❑ *UDP* socket is bound to the local host port #
- ❑ *recall:* when creating datagram to send into a UDP socket, the socket must specify
  - ❖ destination IP address
  - ❖ destination port #

- ❑ when host receives UDP segment:
  1) check destination port # in segment header
  2) direct 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 destination

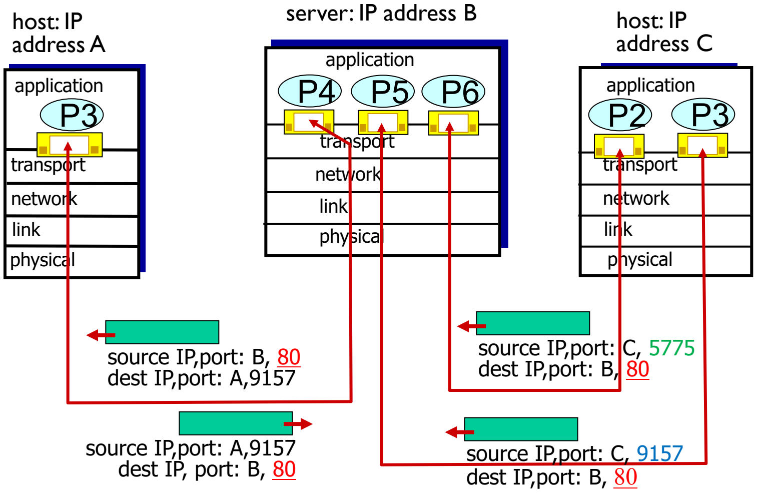
UDP: User Datagram Protocol

- UDP is a "best effort" service. Segments may be:
  - lost
  - delivered out of order

SO why is there a UDP?

- Better control over what is sent and when
- Simple: no connection state at sender, receiver
- Fast(er):
  - no connection establishment (can add delay)
  - small segment header
  - no congestion control: UDP can blast away as fast as desired

Connection-oriented demux: example



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

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

TCP Socket & Segment

- TCP: Server host has simultaneous TCP sockets, one for each connection:
  - each socket identified by its own 4-tuple
- TCP segment includes data, and source & destination port and IP addresses (+ length & checksum)

Error Checking: Checksum

* Practice in HW * – straightforward calculation

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

Sender:

- treat segment contents as sequence of 16-bit integers
- checksum: 1's complement of the sum of (16-bit) segment contents
- sender puts checksum value into UDP checksum field

Receiver:

- compute checksum of received segment – including the sender's checksum 16-bit word in the sum
- If receiver's sum is all '1's then there were no errors (probably)
  - If a bit is 0 then the packet has errors

Internet Checksum Example

- Note
  - When adding numbers, a carryout from the most significant bit needs to be added to the result, for 1's complement
- 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	1	1

Summary

- Transport layer services
  - Desired services
  - Actual protocol services
  - What can go wrong?
- Multiplexing and demultiplexing
- Connection Management
- Error checking – checksum
  - Transport layer provides end-to-end error checking v. link layer single link error checking