

## About the second lecturer

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- Transport layer and application layer protocols
- Building mobile applications and Web Services
- Multimedia streaming and P2P (optional)

Transport layer protocols


## Transport layer port numbers

- How can ensure it is delivered to the right application on that machine?
- We need to be able to address the applications on a machine, just like we had to address the machines themselves.
- We use port numbers.



## Layer 4 - the Transport Layer.

- The network layer performs machine to machine delivery of datagrams
- The transport layer performs application to application delivery.
- Ports are ( 16 bit) numbers (like house numbers) that form the address space of a protocol.
- i.e. you can have tcp/53 and udp/53
- A socket is a software structure associated with a port.
- An application must 'bind' (associate) a socket to a port before it can be used.
- The Socket API is the interface for applications to gain access to the network.


## Simple Example

- Client is assigned some random unused port $\times$ by its host.
- The SMTP server runs on well known port 25.
- Reply is to destination
port $\times$, with src port 25



## Socket API

- Client/server paradigm
- Two levels of service in the socket API:
- User Datagram Protocol (UDP)

Best effort protocol, transmits datagrams.

- Transmission Control Protocol (TCP)
reliable, byte stream-oriented, with capacity control, transmits segments.


## Delivery Without Guarantees

- Remember, IP Datagrams may be:
- Duplicated,
- Delivered out of order,
- Lost/Discarded
- Corrupted
- By the network layer.
- The TCP protocol will need to resolve these, while the UDP protocol ignores them.



## Pipelined Protocols

Pipelining: sender allows multiple, "in-flight", yet-to-beacknowledged packets.

(a) a stop-and-wait protocol in operation

(b) a pipelined protococol in operation

- Two generic forms of pipelined protocols: go-Back-N, selective repeat


## How do we manage all these inflight packets?

- We can use a software construct called a sliding window.

We have a fixed size window (i.e. n packets)
This means we can have up to $n$ packets on the 'wire'
When we successfully send a packet (i.e. its been ack'd by the receiver), we can move the window on by 1 .
We need buffering at sender and/or receiver


## Quick exercise

- When using the sliding-window protocol, will the utilization be improved because of the following?
- A. Reduce propagation delay
- B. Reduce sliding window size
- C. Increase sliding window size
- D. Reduce packet size


## Protocol summary

- The important features of a sliding window protocol are:
- Sequence number assignment
- The resend protocol
- Window management
- We're going to look at GoBackN followed by Selective repeat.


## Go Back N



- Very simple receiver, only accepts packets that arrive inorder and discards others.
- Send each packet in window in turn, window moves on when first packet in window is acknowledged.
- Timeout on first packet, then all UNACKNOWLEDGED packets resent


## Go Back N (Cumulative ACK)


$\square$ ack'ed $\quad \square$ sent $\quad \square$ available $\quad \square$ Not available

- Should a later packet be ACKed, consider all prior packets in the window to also be ACKed, so in other words:
ACK is cumulative, so an ACK for a later sequence number effectively
ACKs all preceding packets.
- Lost ACK(6) and ACK(7)
- Get ACK(8)


## Quick exercise

- In a Go-Back-N protocol, if the window size is 63 , what is the minimum range of sequence numbers?
- A. 0-62
- B. 0-63
- C. 0.64
- D. I-63


## Go Back $N$ in action



## Selective Repeat



- Can send fewer packets at the cost of making the protocol more complicated.
- Packets are individually acknowledged.
- Only one packet resent on timer expiry.


## Selective Repeat in Action



## Quick exercise

- In Selective Repeat, if 5 is the number of bits for the sequence number, then the maximum size of the sliding window must be $\qquad$
- A. 15
-B. 16
-C. 31
- D. I

