



# **Principles of Reliable Data Transfer**

- Characteristics of unreliable channel will determine complexity of reliable data transfer protocol
  - e.g., delay in the channel is bounded in physical layer, not so for network layer
- Other services may interact with RDT protocol
  - e.g., flow control, congestion control
- Here we study widely applicable RDT principles
  - we don't make assumptions about the unreliable channel
  - we don't consider interaction with other services
- Later we see what RDT is like in practice
  - in a transport layer protocol TCP

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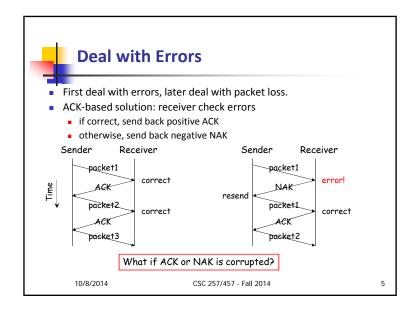


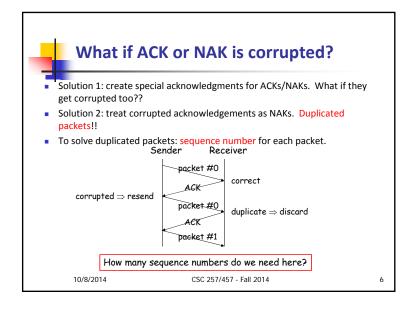
## **Outline**

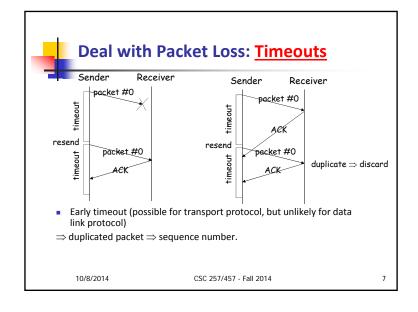
- Overview of reliable data transfer
- A <u>correct</u> protocol: stop-and-wait
  - one packet at a time
- An <u>efficient</u> protocol: sliding window
  - multiple packets simultaneously

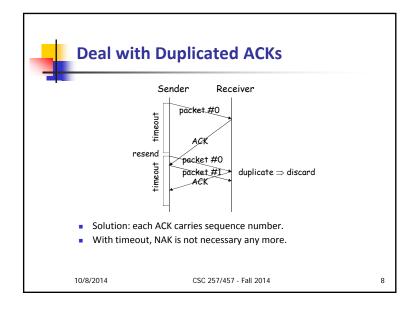
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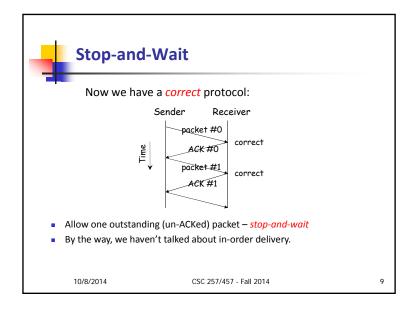
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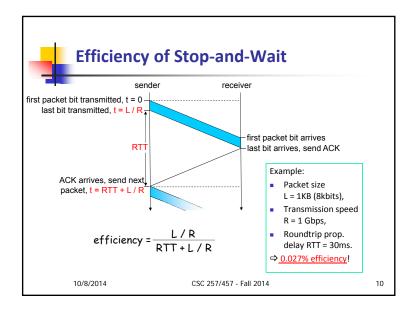


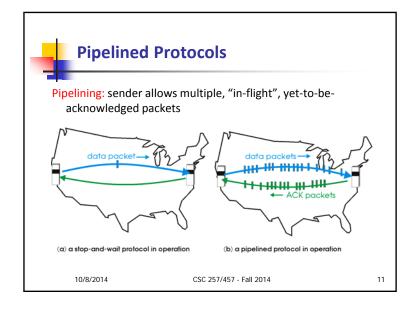


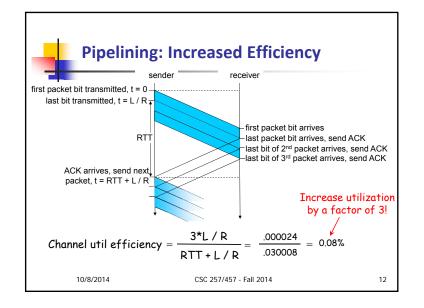


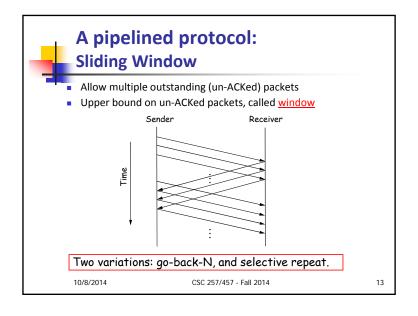


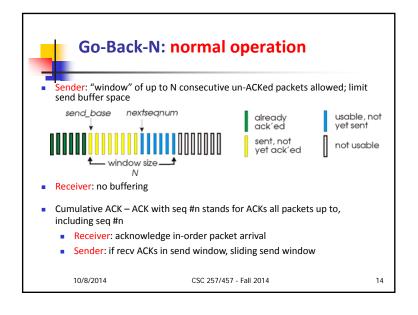


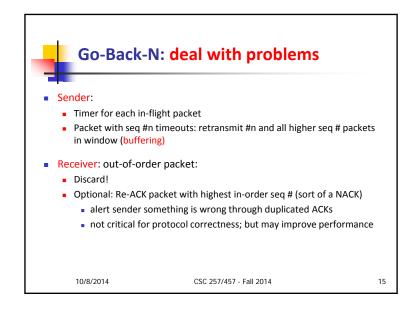


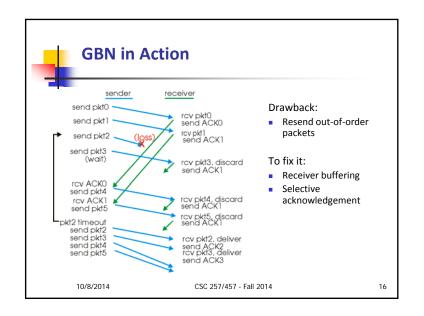


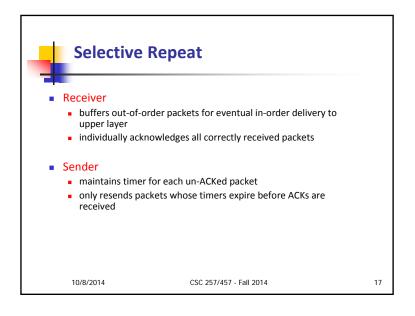


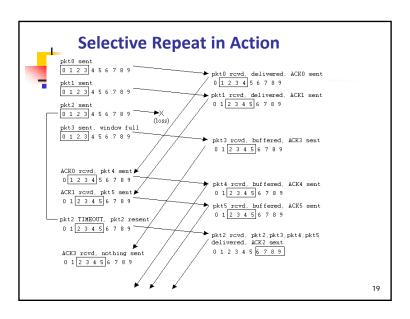


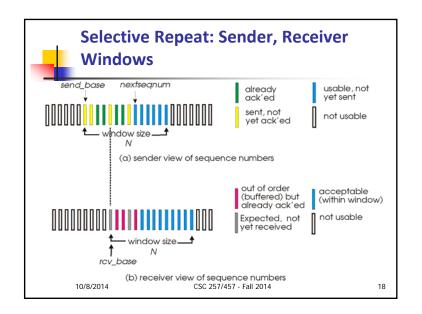


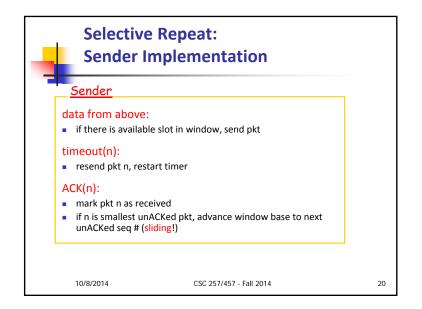














# Selective Repeat: Sequence Numbers at Receiver

- rcvbase is the first expected packet.
- Is it possible to see an arriving packet with sequence number of rcvbase+N or greater?
  - No since rcvbase is still in send window which can't go beyond rcvbase+N-1.
- Is it possible to see an arriving packet with sequence number smaller than rcvbase?
  - Yes. For instance, due to lost acknowledgement.
- What is the smallest seg number receiver can possibly see?
  - All the way down to the first packet since a packet can hang inside the network for unbounded time.
- What is the smallest seg number that may still be in send window?
  - rcvbase-N.

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# Selective Repeat: Receiver Implementation

#### Receiver

pkt n in [rcvbase, rcvbase+N-1]

- send ACK(n)
- in-order: deliver (also deliver buffered, in-order pkts), advance window to next not-yet-received pkt (sliding!)
- out-of-order: buffer

pkt n in [rcvbase-N, rcvbase-1]

ACK(n)

#### otherwise:

ignore

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## **Sequence Numbers**

- Bounding of the currently relevant sequence number space?
  - We bound it at the first step of stop-and-wait when there is no packet loss and every packet is accounted for before the protocol moves on.
  - Cannot be bounded in practice when earlier sent packet (assumed lost by the protocol) may hang around in the network for a long time and then arrives suddenly.
- External (beyond the current communication session) reasons for arbitrary sequence numbers:
  - Packets belonging to earlier sessions between the same communication hosts
  - Malicious attacker injects packets

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