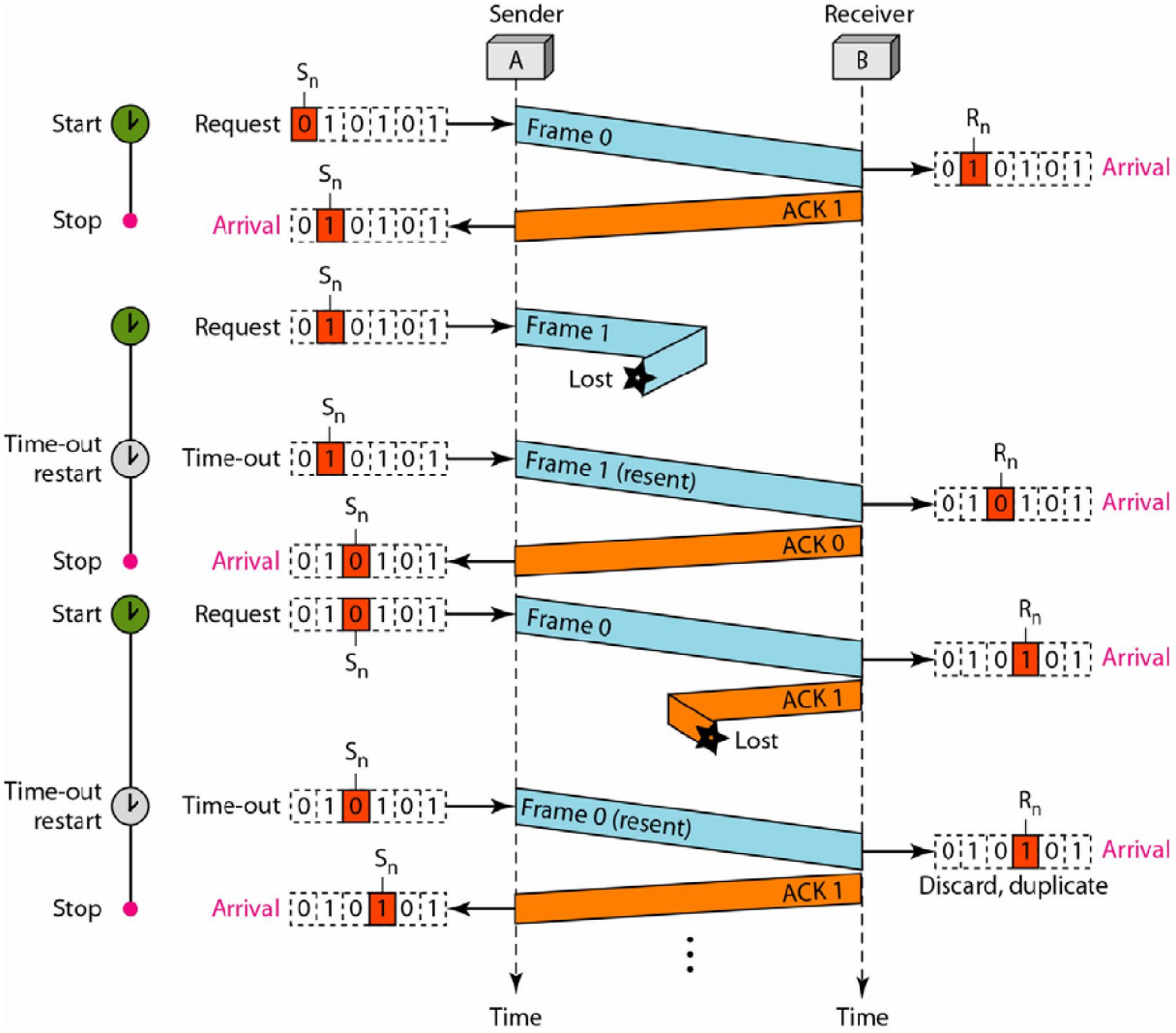
Stop-and-Wait ARQ (cont.)

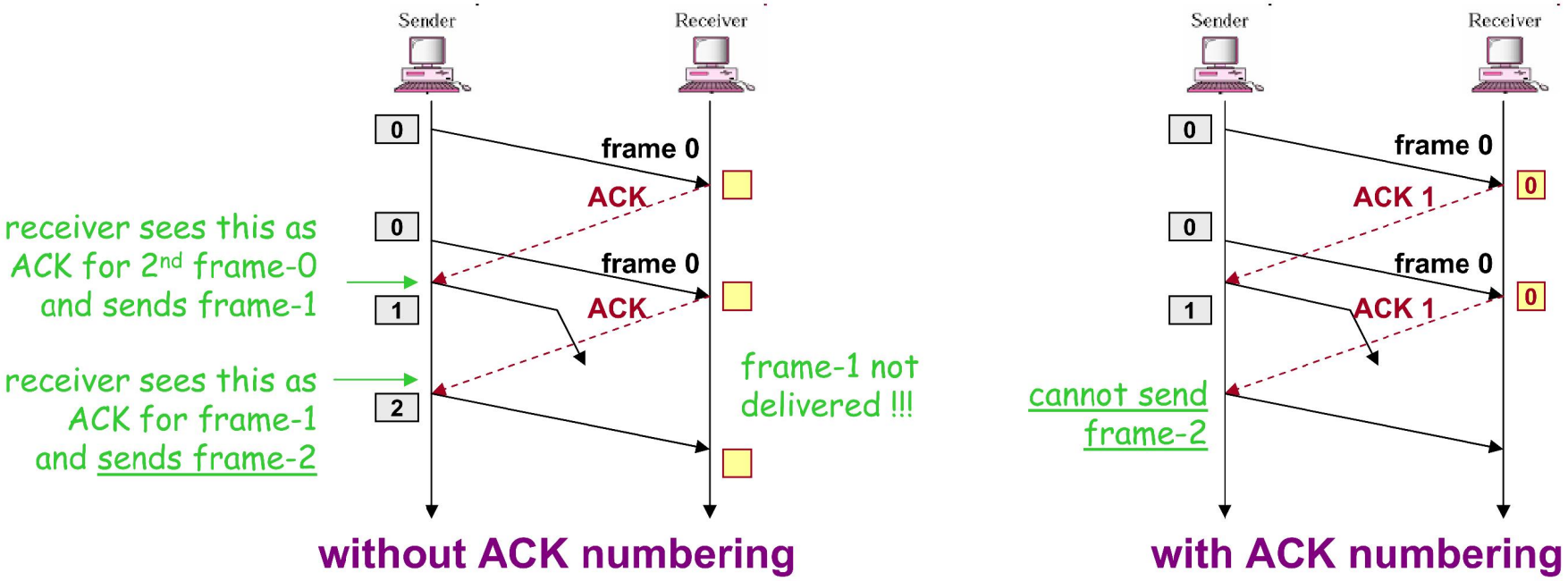


http://www.net-seal.net/animations.php?aid=37

Stop-and-Wait ARQ (cont.)

Delayed Acknowledgment (Premature Timeout)

- ACKs can be delayed due to problems with links or network congestion
  - time-out expires early, sender resends frame
  - when delayed ACK arrives, sender assumes that given ACK is for the last frame sent
- **ACKs must be numbered** to prevent gaps in delivered packet sequence

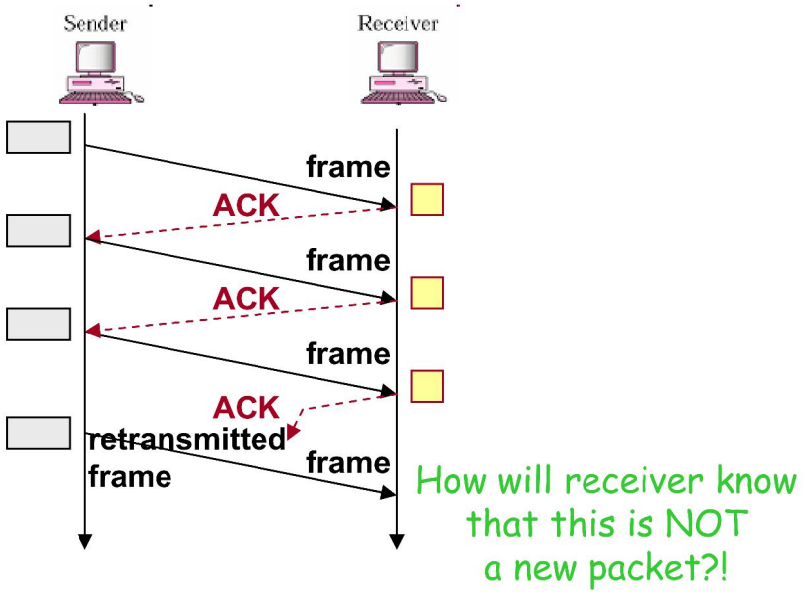


How large should the packet / ACK sequence be? Only 1-bit long !!!

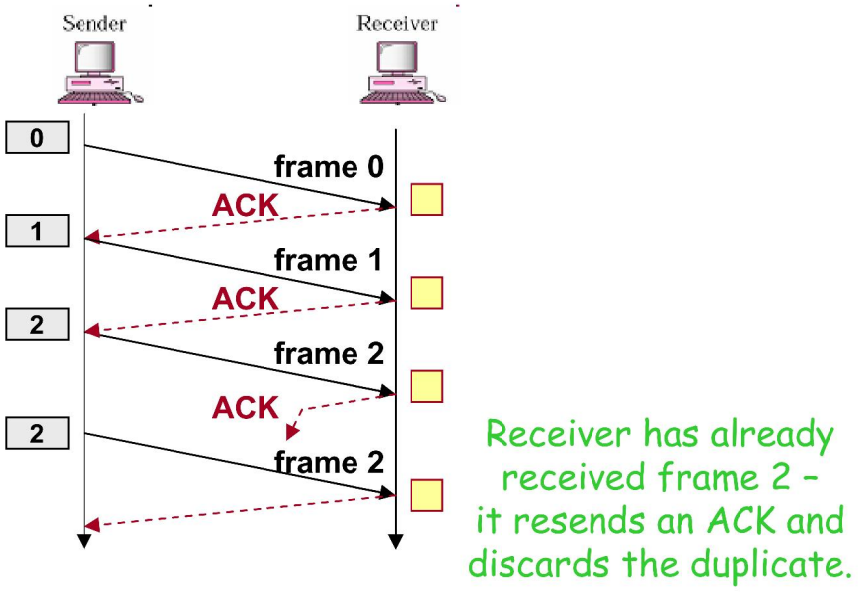
Stop-and-Wait ARQ (cont.)

Lost Acknowledgment

- frame received correctly, but ACK undergoes errors / loss
  - after time-out period, sender resends frame
  - receiver receives the same frame twice
- frames must be numbered so that receiver can recognize and discard duplicate frames
  - sequence # are included in packet header



without packet numbering

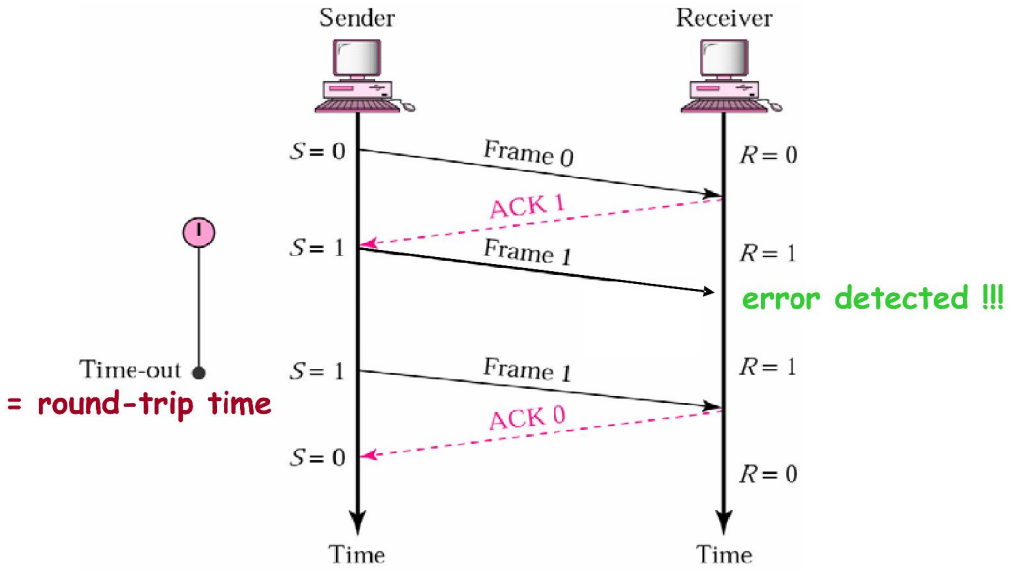


with packet numbering

Stop-and-Wait ARQ

Stop-and-Wait ARQ – simplest flow and error control mechanism

- sender sends an information frame to receiver
- sender, then, stops and waits for an ACK
- if no ACK arrives within time-out, sender will resend the frame, and again stop and wait
  - time-out period > roundtrip time
- abnormalities (and how to fix them)
  - lost acknowledgment
  - delayed acknowledgment



(1) Stop-and-Wait ARQ

Error and Flow Control

Flow Control – set of procedures used to restrict the amount of data that sender can send while waiting for acknowledgment

- two main strategies
  - (1) **Stop-and-Wait**: sender waits until it receives ACK before sending next frame
  - (2) **Sliding Window**: sender can send W frames before waiting for ACKs

Error + Flow Control Techniques

(1) Stop-and-Wait ARQ
(2) Go-Back-N ARQ
(3) Selective Repeat ARQ

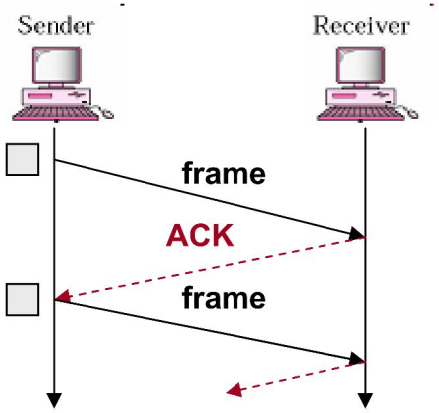
Error Detection + ARQ (error detection with retransmissions)
must be combined with methods that intelligently limit the number of 'outstanding' (unACKed) frames.

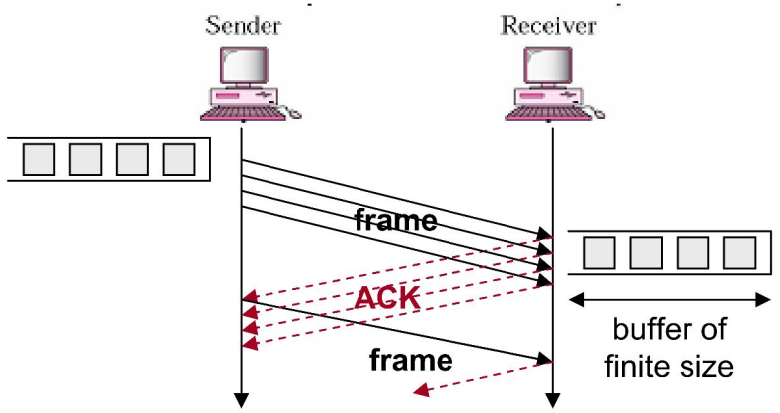
Fewer unACKed frames ⇒ fewer packets buffered at sender and receiver.

Error Control (cont.)

Challenges of ARQ-based Error Control

- **send one frame at the time, wait for ACK**
  - **easy to implement, but inefficient in terms of channel usage**
- **send multiple frames at once**
  - **better channel usage, but more complex to implement - sender must keep (all) sent but unACKed frame(s) in a buffer, as such frame(s) may have to be retransmitted**





How many frames should be sent at any point in time?

How should frames be released from the sending buffer?

Error Control

Error Control Approaches

(1) **Forward Error Correction (FEC)**

(2) **Error Detection + Automatic Retrans. Req. (ARQ)**

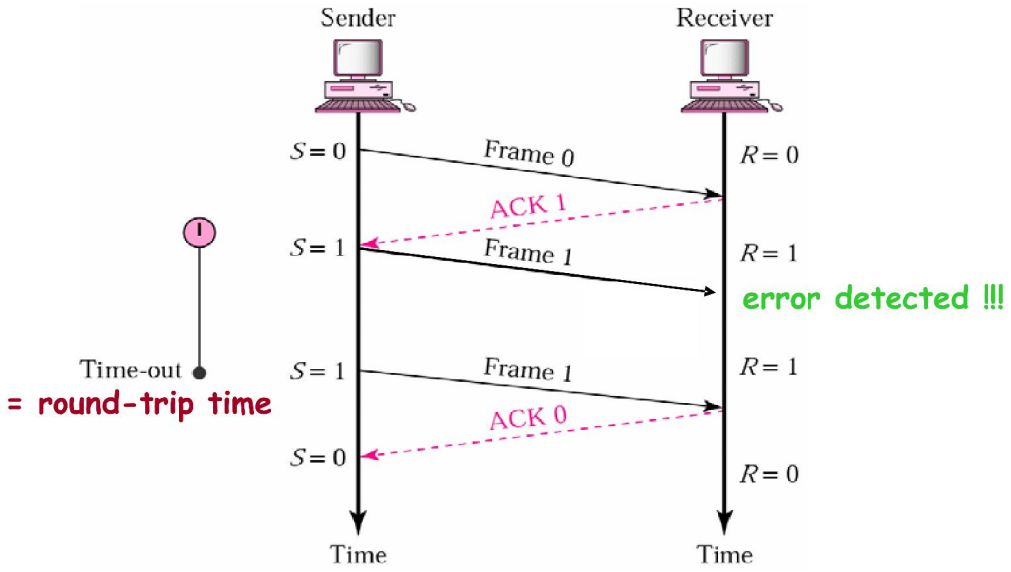
- not enough redundant info to enable error correction

case (a) receiver detects no errors

- an ACK packet is sent back to sender

case (b) receiver detects errors

- no ACK sent back to sender
- sender retransmits frame after a 'time-out'



Error and Flow Control

Required reading:
Garcia 5.2

CSE 3213, Fall 2010
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