

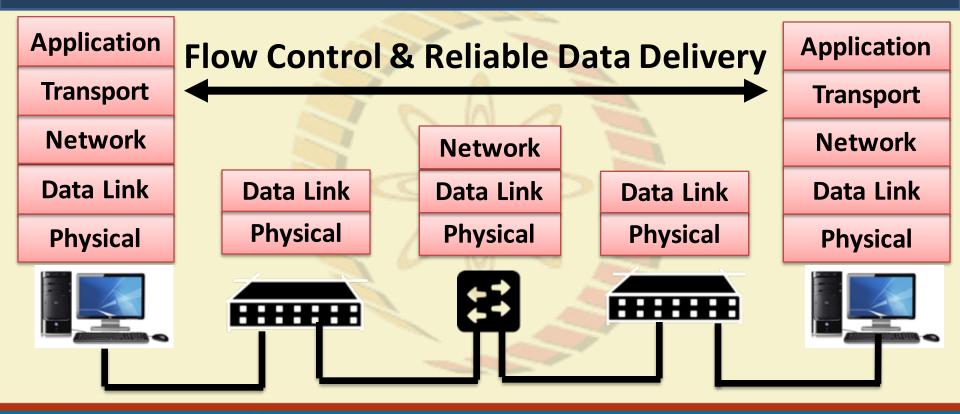


# COMPUTER NETWORKS AND INTERNET PROTOCOLS

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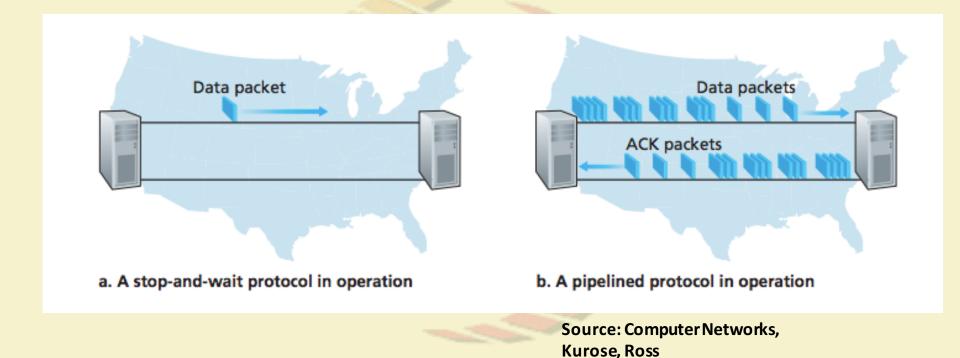
## **Transport Layer - V (Sliding Window Protocols)**







# Stop and Wait versus Sliding Window (Pipelined)







## **Sliding Window Protocols**

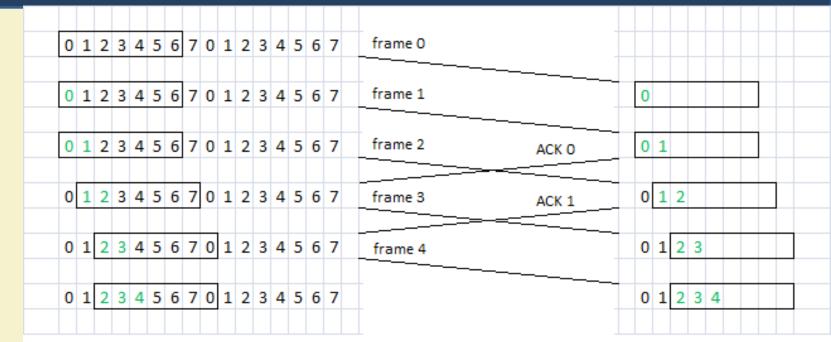
• Each outbound segment contains a sequence number – from 0 to some maximum (2<sup>n</sup>-1 for a n bit sequence number)

 The sender maintains a set of sequence numbers corresponding to frames it is permitted to send (sending window)

The receiver maintains a set of frames it is permitted to accept (receiving window)



### Sliding Window Protocols – Sending Window and Receiving Window



Source:

http://ironbark.xtelco.com.au/subjects/DC/

lectures/13/

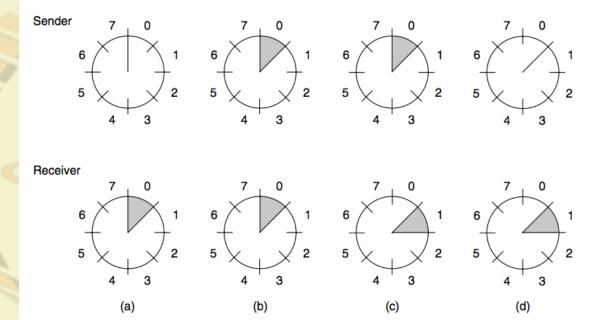
Sliding window Protocol





## Sliding Window for a 3 bit Sequence Number

Source: Computer Networks (5<sup>th</sup> Edition) by Tanenbaum, Wetherell



**Figure 3-15.** A sliding window of size 1, with a 3-bit sequence number. (a) Initially. (b) After the first frame has been sent. (c) After the first frame has been received. (d) After the first acknowledgement has been received.





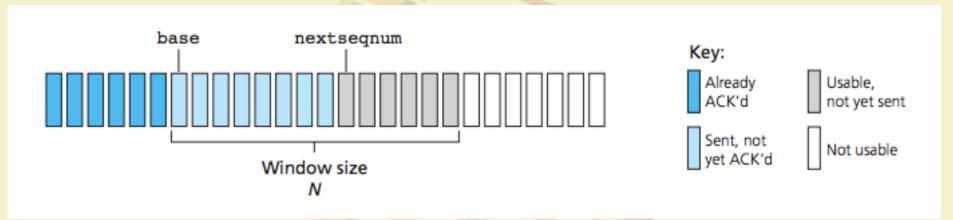
## **Sliding Window Protocols in Noisy Channels**

- A timeout occurs if a segment (or the acknowledgment) gets lost
- How does the flow and error control protocol handle a timeout?
- Go Back N ARQ: If segment N is lost, all the segments from segment 0 (start of the sliding window) to segment N are retransmitted
- Selective Repeat (SR) ARQ: Only the lost packets are selectively retransmitted
  - Negative Acknowledgement (NAK) or Selective Acknowledgements (SACK): Informs the sender about which packets need to be retransmitted (not received by the receiver)





#### Go Back N ARQ – Sender Window Control



Source: Computer Networks,

Kurose, Ross





#### Go Back N ARQ







#### Go Back N ARQ - Sender

rdt\_send(data) if(nextsegnum<base+N){ sndpkt[nextseqnum]=make pkt(nextseqnum,data,checksum) udt send(sndpkt[nextseqnum]) if(base==nextsegnum) start timer nextsegnum++ base=1 else nextsegnum=1 refuse data(data) timeout start timer udt send(sndpkt[base]) Wait udt send(sndpkt[base+1]) rdt\_rcv(rcvpkt) && corrupt(rcvpkt) udt send(sndpkt[nextseqnum-1]) Λ rdt rcv(rcvpkt) && notcorrupt(rcvpkt) base=getacknum(rcvpkt)+1 If(base==nextseqnum) stop timer else start\_timer

Source: Computer Networks, Kurose, Ross





#### Go Back N ARQ - Receiver

```
rdt_rcv(rcvpkt)
                 && notcorrupt(rcvpkt)
                 && hasseqnum(rcvpkt,expectedsegnum)
               extract(rcvpkt,data)
               deliver data(data)
               sndpkt=make_pkt(expectedseqnum,ACK,checksum)
               udt send(sndpkt)
               expectedsegnum++
                                         default
                           Wait
                                         udt_send(sndpkt)
       Λ
expectedsegnum=1
sndpkt=make_pkt(0,ACK,checksum)
```

Source: Computer Networks, Kurose, Ross



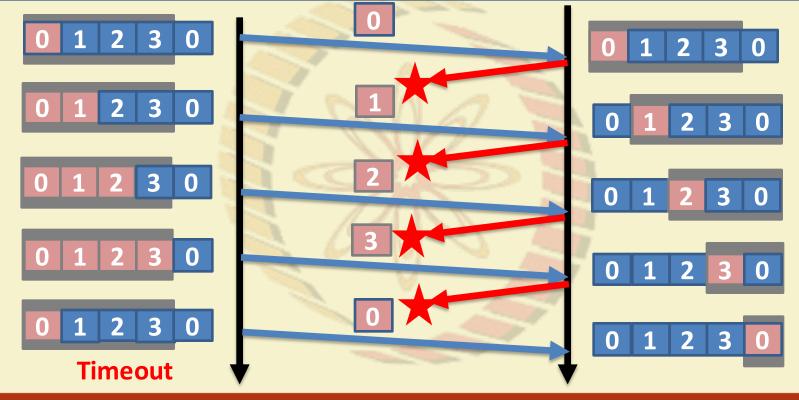


#### Go Back N ARQ – A Bound on Window Size

- Outstanding Frames Frames that have been transmitted, but not yet acknowledged
- Maximum Sequence Number (MAX\_SEQ): MAX\_SEQ+1 distinct sequence numbers are there
  - 0,1,...,MAX\_SEQ
- Maximum Number of Outstanding Frames (=Window Size): MAX\_SEQ
- **Example:** Sequence Numbers (0,1,2,...,7) 3 bit sequence numbers, number of outstanding frames = 7 (Not 8)



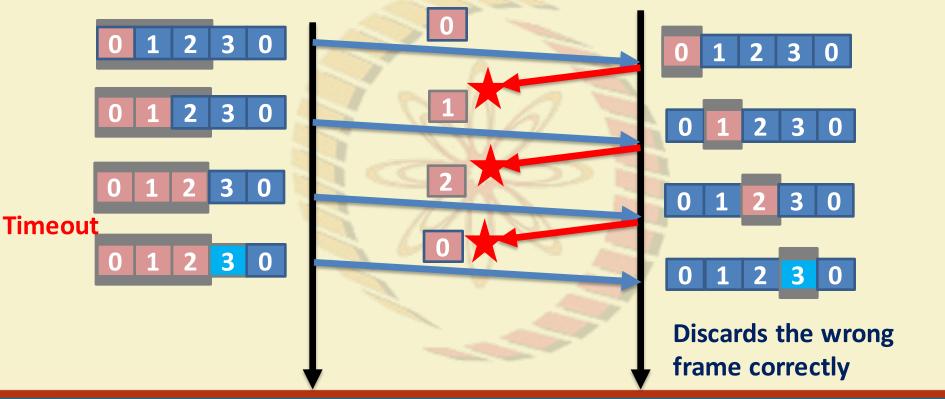
# Go Back N ARQ (MAX\_SEQ = 3, Window Size = 4)







# Go Back N ARQ (MAX\_SEQ = 3, Window Size = 3)







## Selective Repeat (SR) – Window Control

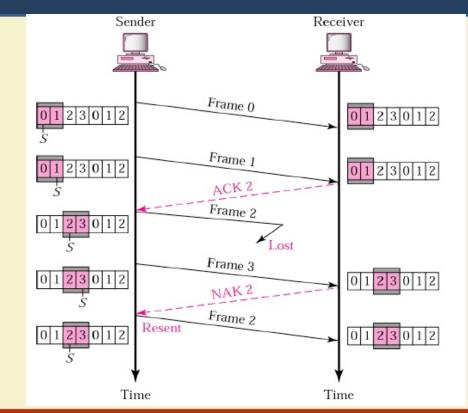
send base nextseqnum Key: Already Usable. ACK'd not yet sent Sent, not Not usable yet ACK'd Window size a. Sender view of sequence numbers rcv base Key: Out of order Acceptable (buffered) but (within already ACK'd window) Expected, not Not usable Window size yet received N b. Receiver view of sequence numbers

Source: Computer Networks, Kurose, Ross





# Selective Repeat ARQ



Source: Computer Networks, Tanenbaum





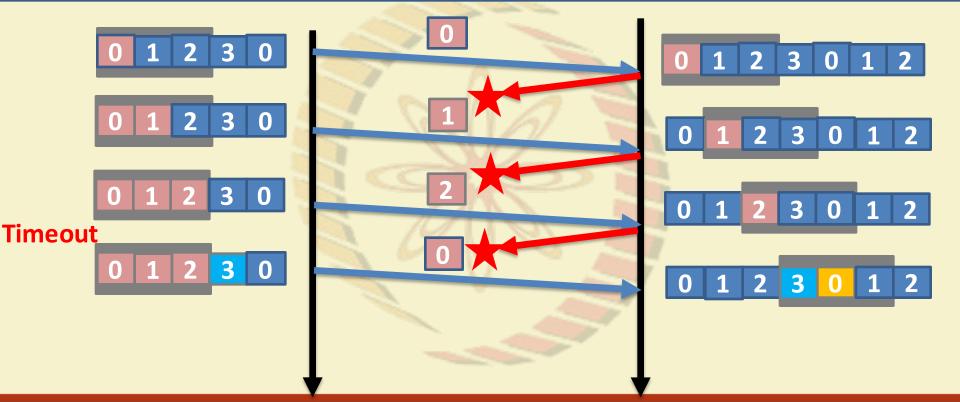
## **Selective Repeat – A Bound on Window Size**

- Maximum Sequence Number (MAX\_SEQ): MAX\_SEQ+1 distinct sequence numbers are there
  - 0,1,...,MAX\_SEQ

- Maximum Number of Outstanding Frames (=Window Size): (MAX\_SEQ+1)/2
- **Example:** Sequence Numbers (0,1,2,...,7) 3 bit sequence numbers, number of outstanding frames (window size) = 4



# Selective Repeat (MAX\_SEQ = 3, Window Size = 3)







## **Selective Repeat (MAX\_SEQ = 3, Window Size = 3)**

