Chapter 2 Getting Connected (cont’d)

Reliable transmission

- Frames are sometimes corrupted while in transit; corrupted frames must be discarded
- A link layer protocol that wants to deliver frames reliably must recover from discarded (lost) frames
- Two fundamental mechanisms for reliable delivery: acknowledgements (ACKs) and timeouts
  - The receiver sends back an ACK (i.e., a small control frame) when it correctly receives a frame
  - If the sender does not receive an ACK after a reasonable amount of time (i.e., the timeout period), it retransmits the original frame
- The Stop-and-Wait Algorithm
  - After transmitting one frame, the sender waits for an ACK before transmitting the next frame
  - If the ACK does not arrive after a certain period of time, the sender times out and retransmits the original frame
  - Use 1-bit seq no. to avoid delivering duplicate copies of a frame
    - When the receiver receives a duplicate frame, it discards the frame; it still sends an ACK in case the first ACK was lost
- Drawback of stop-and-wait
  - The sender has only one outstanding frame on the link at a time → Link capacity may not be fully utilized
- Consider a 1.5Mbps link with a 45ms RTT
- The link has a delay \times bandwidth product of 67.5 Kb or approximately 8 KB
- Assuming a frame size of 1 KB, maximum sending rate = 1024 \times 8/0.045 = 182 Kbps, about one-eighth of the link’s capacity
- To use the link fully, the sender should transmit up to 8 frames before having to wait for an ACK

- The Sliding Window Algorithm
  - Basic idea: allow multiple outstanding (un-ACKed) frames
  - Sender and receiver behavior (see slides)
  - When RWS = 1, the algorithm is called Go-Back-N
    - The receiver does not buffer out of order frames
  - Determining SWS and RWS
    - SWS = Bandwidth \times RTT/FrameSize (keeping the pipe full)
    - 1 \leq RWS \leq SWS, two common settings are RWS=1 and RWS=SWS
  - Finite sequence numbers
    - A frame’s seq no. is specified in a header field of some finite size \rightarrow sequence numbers wrap around
    - How to distinguish between different incarnations of the same sequence number?
      - Number of possible sequence numbers (denoted by MaxSeqNum) must be larger than the number of outstanding frames allowed, i.e., MaxSeqNum > SWS
• E.g., MaxSeqNum=2 and SWS=1 for Stop-and-Wait algorithm
  • Is MaxSeqNum ≥ SWS+ 1 sufficient?
    o If RWS=1, then MaxSeqNum ≥ SWS+ 1 is sufficient.
    o If RWS=SWS, then MaxSeqNum ≥ 2SWS is sufficient.

• The sliding window algorithm can be used to serve 3 roles
  • To reliably deliver frames across an unreliable link
  • To preserve frame order: the receiver does not pass a frame up to the higher layer until it has already passed up all frames with a smaller sequence number
  • To support flow control: the receiver can throttle the sender by informing the sender of how many frames it has room to receive