Getting Connected
(Chapter 2 Part 3)

Networking
CS 3470, Section 1
Sarah Diesburg
Last Lectures

- Encoding/decoding
- Framing
- Error Detection
Today

- Error Correction (through *reliability* mechanisms)
- Media Access
Reliability

Three sample problems

- A frame has corrupt (and non-recoverable) data. What do you do?
- Your store-and-forward switch is being flooded by connections and your input buffer is full. What do you do?
- You are a transmitting process that requires a guaranteed delivery. How long do you “hold out” before assuming a packet was lost?
Reliability

- Usually accomplished through combination of two fundamental mechanisms
  - *Acknowledgments* (ACKs)
  - *Timeouts*
General strategy of using ACKs and timeouts to implement reliable delivery is called *automatic repeat request (ARQ)*

- Stop-and-wait
- Sliding window
Stop-and-Wait

- Simplest algorithm
  - After transmitting one frame, sender waits for ACK before transmitting next frame
  - If ACK does not arrive in time, sender times out and retransmits original frame

- 4 basic scenarios
  - What are they?
Stop-and-Wait

- Timeline diagram
- The ACK is received before the timer expires
Stop-and-Wait

- The original frame is lost
Stop-and-Wait

- The ACK is lost
Stop-and-Wait

- ACK not delivered before timeout
  - How to fix??
Stop-and-Wait

- Suppose sender ends up sending duplicate frames and receiver got both frames
  - E.g., if ACK from receiver was lost or timed out

- Q: How does receiver know that it shouldn’t use both frames?
Stop-and-Wait

Timeline for stop-and-wait with 1-bit sequence number

Is 1 bit enough?
Delay x Bandwidth Again…

- Represents the amount of data that *could* be in transit
- Would like to be able to send this much data without waiting for the first acknowledgment
- “Keeping the pipe full”
Stop-and-Wait

- Does not “keep the pipe full”
- Consider a 1.5 Mbps link with a 45 ms RTT and a 1KB frame size
- To use the link fully, then sender should transmit up to eight frames before having to wait for an acknowledgement
  - How???
Stop-and-Wait

- The link has a delay × bandwidth product of 67.5 Kb or approximately 8 KB.
- Since the sender can send only one frame per RTT and assuming a frame size of 1 KB.
- Maximum Sending rate is about 1/8 of link’s capacity.
Sliding window time transition

time

1 RTT

Sender

ACK

Receiver
The sliding window requires a more elaborate sequence number:

- Send window size: SWS
- Last frame sent: LFS
- Last frame ACK'd: LAR (last ACK rec'd)

\[ SWS \geq LFS - LAR \]

- After a while, you can't send any more frames until ACKs start coming back.
- Note: Packets may be delivered out of sequence!
Sliding Window

- After a while, the sender can't send any more frames until ACKs start coming back
  - Window is “full”

- Note: Packets may be delivered out of sequence!
Sliding Window

Pkt0 sent
0 1 2 3 4 5 6

Pkt1 sent
0 1 2 3 4 5 6

Pkt2 sent, window full
0 1 2 3 4 5 6

Ack0 rcvd, Pkt3 sent
0 1 2 3 4 5 6

Pkt1 timeout, Pkt1 resent
0 1 2 3 4 5 6

Pkt0 rcvd, Ack0 sent
0 1 2 3 4 5 6

Pkt2 rcvd, buffered
0 1 2 3 4 5 6

Pkt3 rcvd, buffered
0 1 2 3 4 5 6

Pkt1 rcvd, Ack3 sent
0 1 2 3 4 5 6

...
Sliding Window Quiz

- What is the SWS? (Send Window Size)
- Last frame sent: LFS?
- Last frame ACK'd: LAR?
Sliding Window Quiz

- Pkt 8 rcvd, Ack 8 sent
- 0 1 2 3 4 5 6 7 8 9 10

- Receive window size: RWS?
- Last frame received: LFR?
- Largest acceptable frame: LAF?
There are “issues” with the sliding window protocol with regard to the window size and the sequence number.

- Suppose window size is one less than total sequence numbers and ACKs are dropped

In the end:
\[ SWS < \frac{(\text{MaxSeqNum}+1)}{2} \]

- Alternates between two halves of the sequence number space
Sliding Window Benefits

- Reliable delivery of frames
- Preservation of order at the receiver end
- Flow control
  - “Throttles the sender”
- Reliable delivery of frames important at the link layer (remember, ISO/OSI model)
  - The other two are sometimes better implemented at higher layers
Core Ethernet

- Ethernet standard is 802.3
- Legacy multiple-access network
  - Set of nodes sends and receives frames over shared link
  - Kind of like a bus
Core Ethernet

- Ethernet is CSMA/CD, which stands for “Carrier Sense, Multiple Access with Collision Detection.”
  - **Carrier sense**: all nodes can distinguish between idle and busy link
  - **Collision detection**: node listens as it transmits can tell if it collides with another frame
By standard, Ethernet is implemented using Coax, on segments limited to 500m.

Hosts joined by “tapping into” segment

Multiple Ethernet segments joined together by repeaters

What do you think a repeater does?

No more than four repeaters allowed.
Core Ethernet

- Total reach: 2500m
- All physical limitations considered, an Ethernet is limited to 1024 hosts maximum.
- Any signal emitted by a host on the ethernet is broadcast over the *entire* network
- Terminators attached to the end absorb the signal and prevent bounce-back.
Ethernet Technologies: 10Base2

- **10**: 10Mbps; **2**: under 200 meters max cable length
- thin coaxial cable in a bus topology

- Repeaters used to connect up to 5 multiple segments
- Repeater repeats bits it hears on one interface to its other interfaces: physical layer device only!
- Has become a legacy technology
Core Ethernet

- **Cable Types:**
  - **10Base2**
    - 10Mbps peak, Baseband, with 200m limit
  - **10Base5**
    - 10Mbps peak, Baseband, with 500m limit
  - **10BaseT**
    - 10Mbps peak, Baseband, Twisted-Pair cable, 100m limit
Core Ethernet

- Encoding schemes
  - Original specification used Manchester encoding
  - Higher-speed Ethernet uses 4B/5B or the similar 8B/10B encoding
Shared Access

- Everyone speaks at the same time
- Competition for the same link, speaking at the same time produces the notion of a collision domain.
Ethernet Frame Structure

- Sending adapter encapsulates IP datagram (or other network layer protocol packet) in **Ethernet frame**

- **Preamble**:  
  - 7 bytes with pattern 10101010 followed by one byte with pattern 10101011  
  - used to synchronize receiver, sender clock rates
Ethernet Frame Structure (more)

- **Addresses**: 6 bytes
  - if adapter receives frame with matching destination address, or with broadcast address, it passes data in frame to net-layer protocol
  - otherwise, adapter discards frame
- **Type**: indicates the higher layer protocol, mostly IP but others may be supported such as Novell IPX and AppleTalk
- **CRC**: checked at receiver, if error is detected, the frame is simply dropped