Announcements

- Enrollment
  - No one is left on the wait list
- Reading
  - Today: Chapter 5 (5.1-5.2)
- Project #2
  - Handout is on the web
  - Due on Wed Sept 26th (10 AM)
  - Reminder, not credit for late work

ATM Datalink Protocol

- Cells (53 bytes)
  - 5 byte header (4 bytes address plus 1 byte crc)
  - 48 byte payload
- Header
  - use CRC over the 32 bits of the header
- How to find cell boundary?
  - use shift register to check for valid checksum
    - 1/256 chance of a random match
  - use HUNT mode to increase chances
    - after a good cell, skip to the next cell boundary
    - must receive δ cells with checksum matches
- Detecting loss of synchronization
  - one bad cell is probably an error
  - many bad cells is likely a slip (loss of sync)
  - if α bad cells are seen in a row, switch to hunt mode

Simple Link Protocols

- Stop-and-wait
  - Sender

```
while (1) {
        get frame from network layer;
        send frame;
        wait for ack;
}
```

  - Receiver:

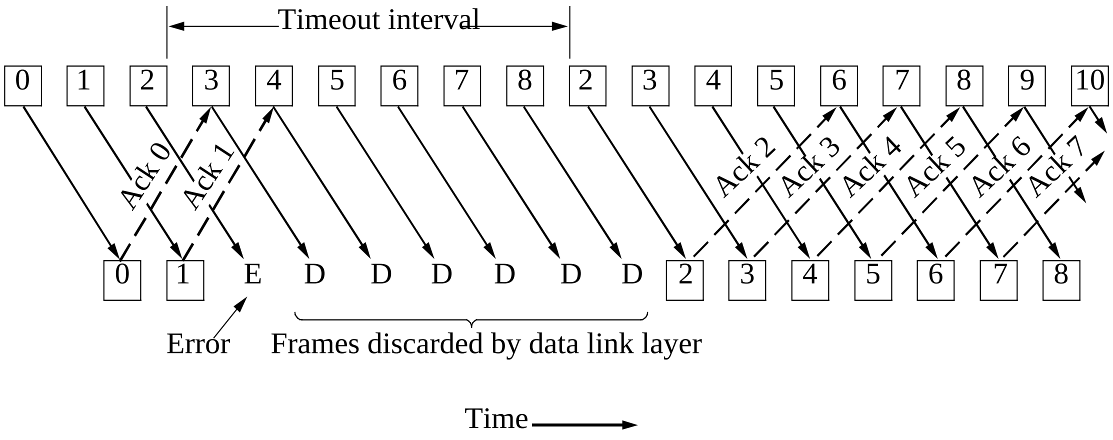
```
while (1) {
        recv frame;
        send frame to network layer;
        send ack;
}
```

  - Only one side active (sending) at once
  - Ensures rate matching

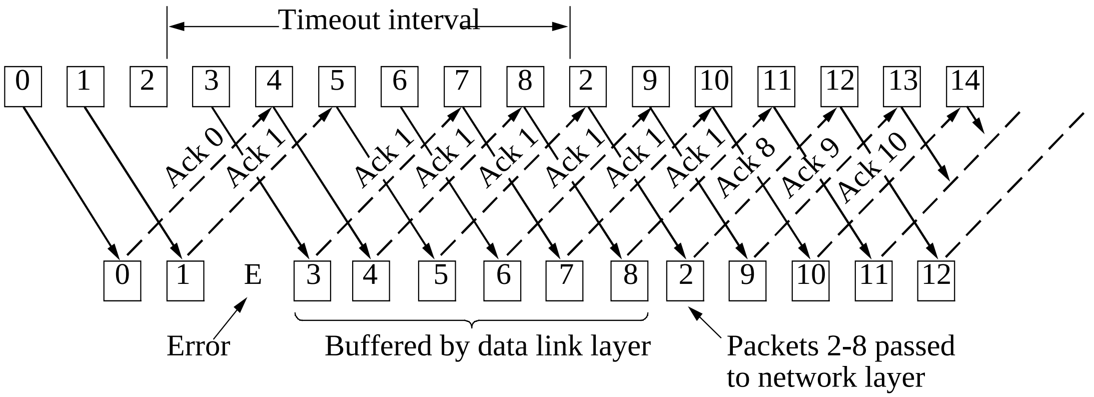
Sliding Window Protocol

- Need to
  - have multiple outstanding packets
  - limit total number of outstanding packets
  - permit re-transmissions to occur
- Sliding Window
  - permit at most N outstanding packets
  - when packet is ACK'd advance window to first non-ACK'd pkt
- Retransmission
  - Go-back N
    - when a packet is lost, restart from that packet
    - provides in-order delivery, but wastes bandwidth
  - Selective Retransmission
    - use timeout to re-sent lost packet
    - use NACK as a **hint** that something was lost

Sliding Window Example
Go-back N vs. Selective Retransmission



(a)



(b)

From: *Computer Networks*, 3rd Ed. by Andrew S. Tanenbaum, (c)1996 Prentice Hall.

Pthreads

- Allows multiple threads of control on a process
- Basic operations:
  - pthread_create(&threadId, attr, func, arg)
    - creates a new thread
    - threadid is the id of the new thread
    - attr are special attributes of the thread (pass NULL)
    - Func is a pointer to a function to run
    - arg is an argument to that function

  - first thread of control must not exit (will kill other threads)
    - pthread_join(threadid, status)
      - wait for a specific thread to terminate

Using Locks for the Critical Section

- Lock:
  - if no thread has the lock mark it locked and return
  - if another thread has the lock, wait
- Unlock:
  - release the lock
  - if other threads waiting, notify one **or** all of them
- Called mutexs in pthreads
  - pthread_mutex is the data type
  - pthread_mutex_init used to initialize it
  - pthread_mutex_lock locks it
  - pthread_mutex_unlock releases it
- Lock Grainularity
  - want to lock enough to protect accesses
  - don’t want to lock too much to slow down the program