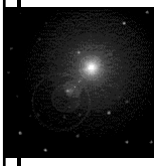
CS 4/54201 Computer

Communication Network

Kent State University

Dept. of Computer Science

www.cs.kent.edu/~javed/class-NET06F/

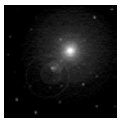


A Course on Networking and

Computer Communication

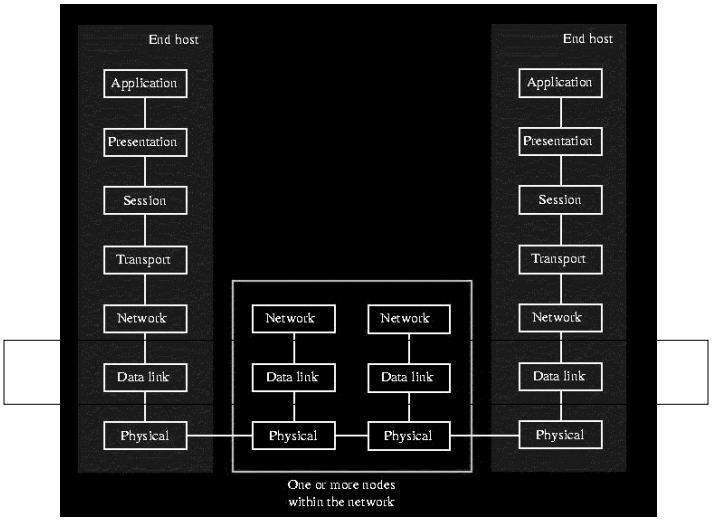
POINT-TO-POINT FLOW CONTROL

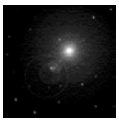
Today's class will be very useful for doing the simulation assignment.
In fact, I will describe all the algorithms that you will need to know to do the first assignment.



COMPUTER COMMUNICATION NETWORK

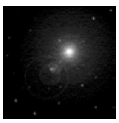
A Simple Data Link Layer Protocol



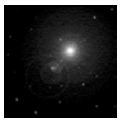


Sender Layer

```
typedef enum {frame_arrival} event_type;
#include "protocol.h"

void sender1(void)
{
  frame s;                    /* buffer for an outbound frame */
  packet buffer;              /* buffer for an outbound packet */

  while (true) {
      from_network_layer(&buffer);        /* go get something to send */
      s.info = buffer;            /* copy it into s for transmission */
      to_physical_layer(&s);      /* send it on its way */
  }                               /* Tomorrow, and tomorrow, and tomorrow,
                                     Creeps in this petty pace from day to day
                                     To the last syllable of recorded time
                                          - Macbeth, V, v */
}
```



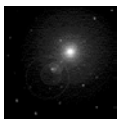
Receiver Layer



COMPUTER COMMUNICATION NETWORK

```
void receiver1(void)
{
  frame r;
  event_type event;              /* filled in by wait, but not used here */

  while (true) {
       wait_for_event(&event); /* only possibility is frame_arrival */
       from_physical_layer(&r);/* go get the inbound frame */
       to_network_layer(&r.info);            /* pass the data to the network la
  }
}
```


Characteristics of Protocol-1



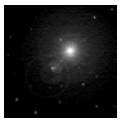
COMPUTER COMMUNICATION NETWORK

- A very simple data link layer protocol.
- Features:
  - One directional communication only.
  - Assumes that the communication channel is error free.
  - Assumes that receiver can process all the input infinitely fast.

Protocol-2 with Limited Buffer

- Stop-and-go: After receiving each frame the receiver sends a dummy ACK frame. Sender cannot flood the receiver.

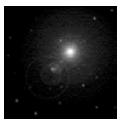
```
typedef enum {frame_arrival} event_type;
#include "protocol.h"

void sender2(void)
{
  frame s;                    /* buffer for an outbound frame */
  packet buffer;              /* buffer for an outbound packet */
  event_type event;           /* frame_arrival is the only possibility */

  while (true) {
      from_network_layer(&buffer);                  /* go get something to send */
      s.info = buffer;        /* copy it into s for transmission */
      to_physical_layer(&s);  /* bye bye little frame */
      wait_for_event(&event); /* do not proceed until given the go ahead */
  }
}
```



Protocol-2 with Limited Buffer

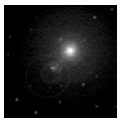
```
void receiver2(void)
{
  frame r, s;                 /* buffers for frames */
  event_type event;           /* frame_arrival is the only possibility */
  while (true) {
      wait_for_event(&event);  /* only possibility is frame_arrival */
      from_physical_layer(&r); /* go get the inbound frame */
      to_network_layer(&r.info);/* pass the data to the network layer */
      to_physical_layer(&s);   /* send a dummy frame to awaken sender */
  }
}
```

- But still, the transmission is not reliable.
- What if there is a timer?
- What if the ACK is lost?



COMPUTER COMMUNICATION NETWORK

Characteristics of Protocol-1



COMPUTER COMMUNICATION NETWORK

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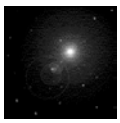
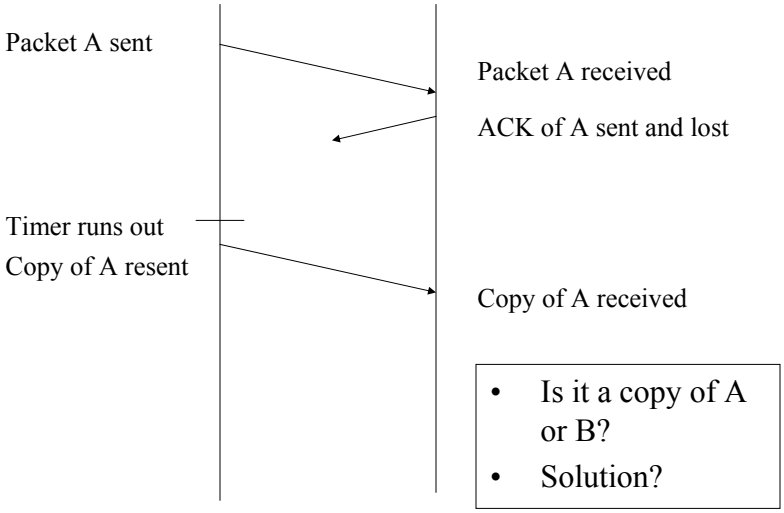
The problem of Missing ACK



COMPUTER COMMUNICATION NETWORK



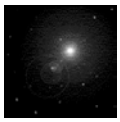
- Is it a copy of A or B?
- Solution?

Protocol-3 with Sequence Number

```
#define MAX_SEQ 1                       /* must be 1 for protocol 3 */
typedef enum {frame_arrival, cksum_err, timeout} event_type;
#include "protocol.h"

void sender3(void)
{
  seq_nr next_frame_to_send;            /* seq number of next outgoing frame */
  frame s;                              /* scratch variable */
  packet buffer;                        /* buffer for an outbound packet */
  event_type event;

  next_frame_to_send = 0;               /* initialize outbound sequence numbe
  from_network_layer(&buffer);          /* fetch first packet */
  while (true) {
      s.info = buffer;                  /* construct a frame for transmission */
      s.seq = next_frame_to_send;       /* insert sequence number in frame */
      to_physical_layer(&s);            /* send it on its way */
      start_timer(s.seq);               /* if (answer takes too long, time out */
      wait_for_event(&event);           /* frame_arrival, cksum_err, timeout */
      if (event == frame_arrival) {
          from_physical_layer(&s);      /* get the acknowledgement */
          if (s.ack == next_frame_to_send) {
              from_network_layer(&buffer); /* get the next one to send */
              inc(next_frame_to_send); /* invert next_frame_to_send */
          }
```

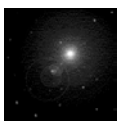


COMPUTER COMMUNICATION NETWORK

Protocol-3 with Sequence Number

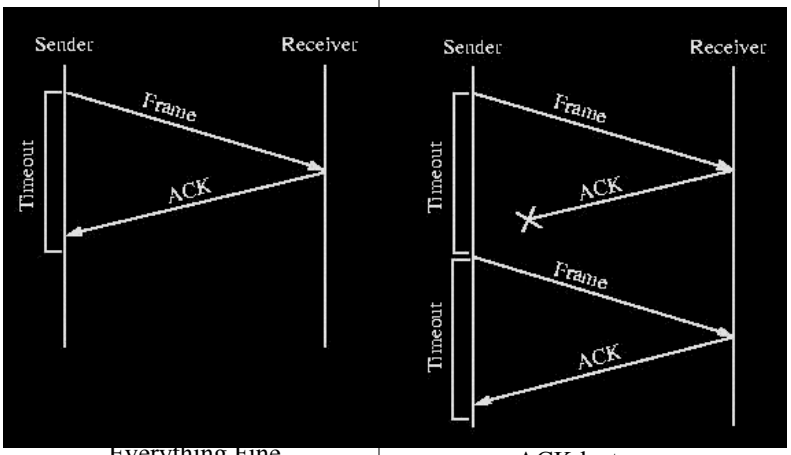
```
void receiver3(void)
{
  seq_nr frame_expected;
  frame r, s;
  event_type event;

  frame_expected = 0;
  while (true) {
      wait_for_event(&event);           /* possibilities: frame_arrival, cksum_err */
      if (event == frame_arrival) {     /* a valid frame has arrived. */
          from_physical_layer(&r);      /* go get the newly arrived frame */
          if (r.seq == frame_expected) { /* this is what we have been waiting for. */
              to_network_layer(&r.info); /* pass the data to the network layer */
              inc(frame_expected);      /* next time expect the other sequence nr */
          }
          s.ack = 1 - frame_expected;   /* tell which frame is being acked */
          to_physical_layer(&s);        /* none of the fields are used */
      }
  }
}
```

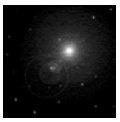


COMPUTER COMMUNICATION NETWORK

Protocol-3: Various Scenarios

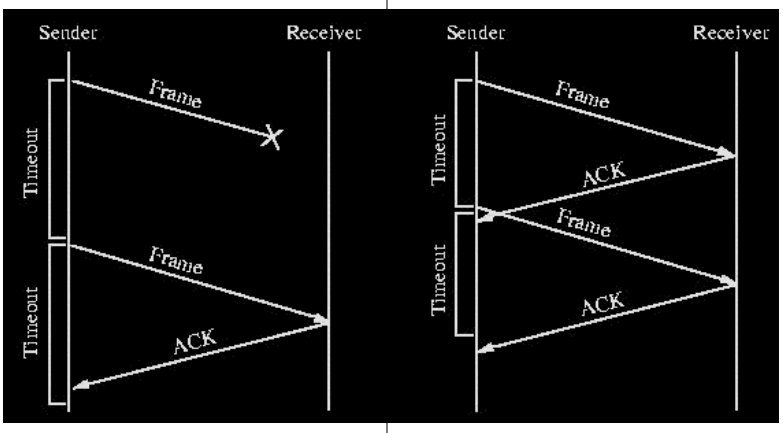


Everything Fine | ACK lost

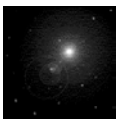


COMPUTER COMMUNICATION NETWORK

Protocol-3: Various Scenarios

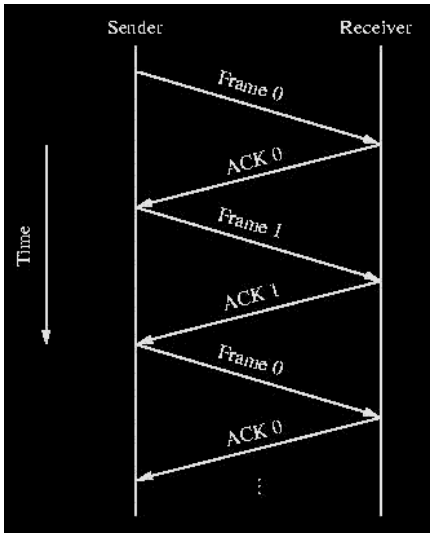


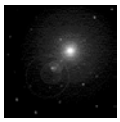
Frame Lost | Low time out value



COMPUTER COMMUNICATION NETWORK

Protocol-3: Transmission Sequence



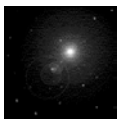


COMPUTER COMMUNICATION NETWORK

- Quiz:
  - How many bits are needed in the sequence number field?

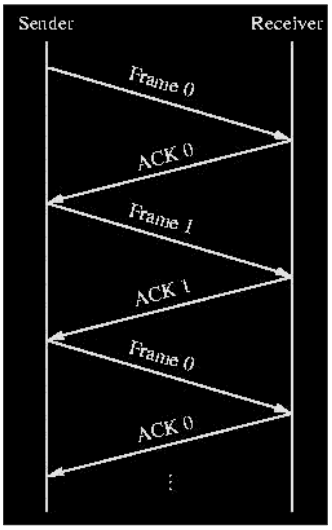
Protocol-4 : Full-duplex Communication

- In full-duplex communication instead of sending separate ACK frames, both sides have a sender and a receiver.
- Each side use the outgoing frames to **piggyback** the ACK of the incoming channel.
- Each frame now has a ACK field. It is only few bits. This overhead is much better than sending a series of extra frames (fewer frame arrived interrupt, fewer checksum check, etc.)
- If there is no, outgoing frame, only then it sends a distinct ACK only frame. Waiting too long can trigger sender to retransmit.



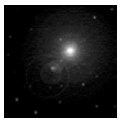
COMPUTER COMMUNICATION NETWORK

Transmission Efficiency of Stop-and-go



- Consider a 1.5Mbps link with 45-ms round trip time (RTT)
  - If the packet size is 1 KB, it can send only one frame per 45 ms.
  - This is 1024x8/ .045 = 182 Kbps
  - Only 1/8th of the link capacity is utilized for simplex
  - Only 1/4the for the duplex version.

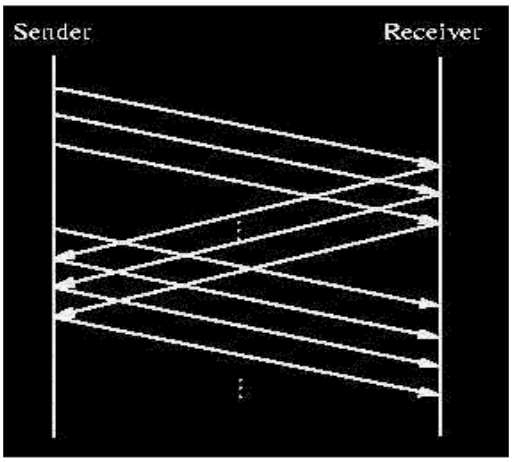
- Quiz:
  - How to increase channel utilization?



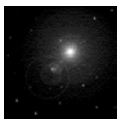
For satellite channel RTT is 520ms

Protocol-5: Sliding Window

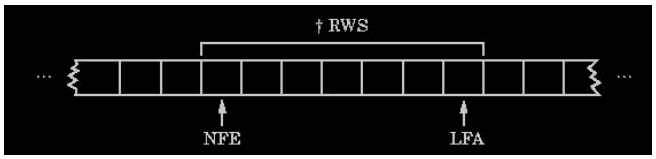
- Solution: Do not wait for ACK for each Frame. Allowed to send N frames without ACK

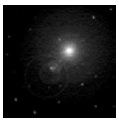


- Sender and receiver both must have buffer of size N.
- Why?

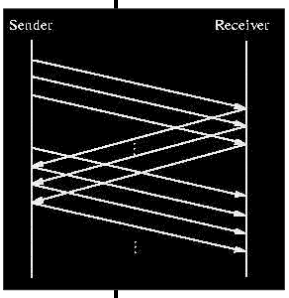


Sliding Window Management





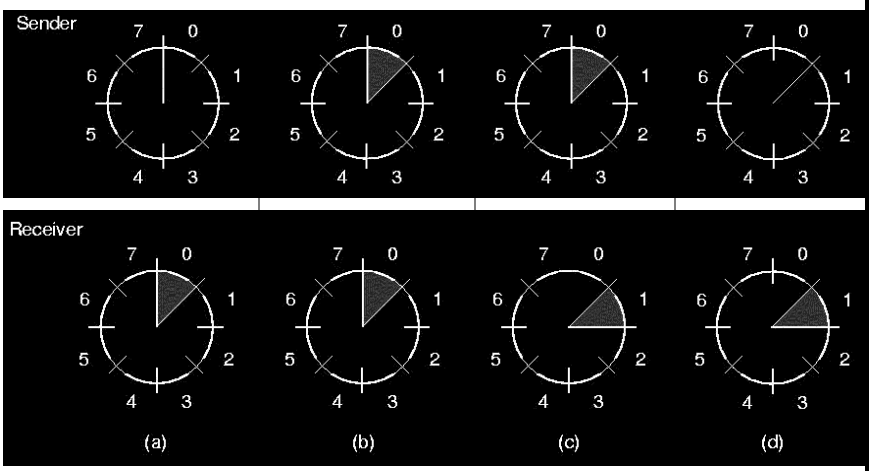
COMPUTER COMMUNICATION NETWORK

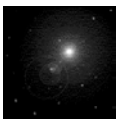


- SWS=Senders Window Size, RWS=Receivers Window Size
- LFS=Last Frame Sent, LAR=Last ACK Received
- LFA=Last Frame Acceptable, NFE=Next Frame Expected

- Quiz:
  - How many bits are needed in the sequence number field?

Sliding Window and Stop-and-go

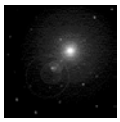




COMPUTER COMMUNICATION NETWORK

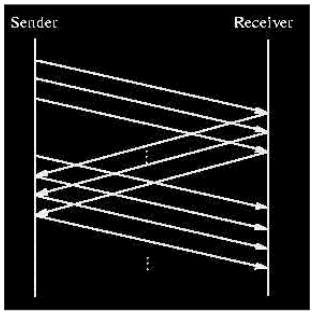
- Sliding window of size 1, with 3-bit sequence number. (a) initially, (b) after first frame has been sent. © after the first frame has been received, (d) after the first ACK has been received.

Efficiency of Sliding Window



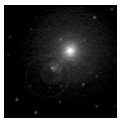
COMPUTER COMMUNICATION NETWORK

- If window size n x time to send one packet is larger than RTT then it has the potential of fully utilizing the channel capacity.



- Quiz:
  - what if one of the frame in the middle of a long stream is lost?

Error in a Sequence



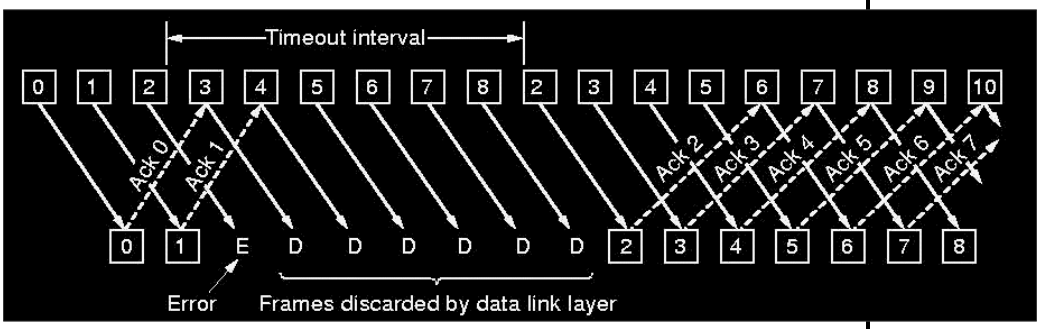
COMPUTER COMMUNICATION NETWORK

- If a frame in the middle of a long stream is lost or damages, large number of succeeding frames will arrive at the receiver, before the sender even finds out that anything is wrong!
- When a damaged frame arrives at the receiver. It is discarded.

- But, what to do with the correct frames following it?
  - Strategy-1: Go Back-n (protocol-5)
  - Strategy-2: Selective repeat. (protocol-6)

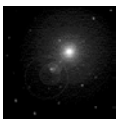
Go-Back-N (Protocol-5)

COMPUTER COMMUNICATION NETWORK



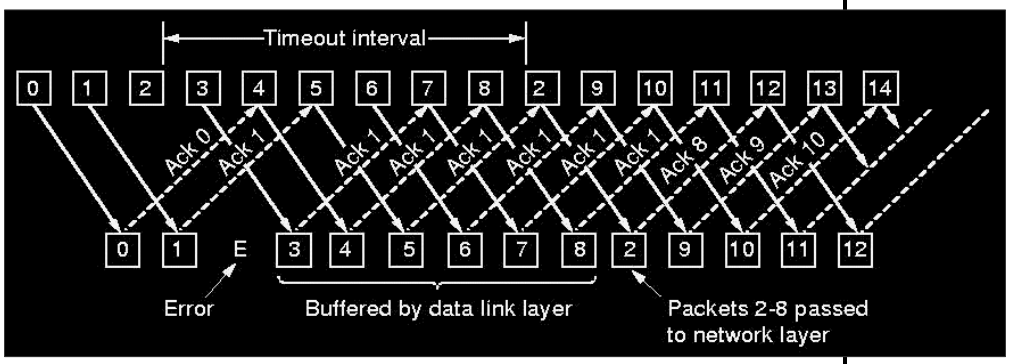
- Large number of frames lost!

Selective Repeat



COMPUTER COMMUNICATION NETWORK

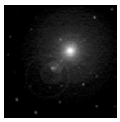
- Receiver stores all the correct frames following bad one. When the sender finally notices the that something is wrong, it just retransmits the bad one. Not all its successors.



- Receiver, waits until all the preceding ones have been passed to the network layer.

Conclusions

- In a noisy channel Selective Time out is more efficient. But it needs more buffer, and separate clock timer for every frame.
- The sliding-window protocol is a many in one. It performed:
  - Reliability by retransmission
  - Ordering of frames
  - Flow control/ buffer management.
- It is possible to design communication model which can separate this three functions and perform them at separate layers.



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