Data Link Layer (Part 3)

References:
Section 7.3 Stallings
Section 11.5 Forouzan
Section 7 Study Guide

Review of Lecture 6

- Question - Why would you expect a CRC to detect more errors than a parity bit?

Review of Lecture 6

- Question - Why would you expect a CRC to detect more errors than a parity bit?
- Answer - The CRC has more bits and therefore provides more redundancy. That is, it provides more information that can be used to detect errors.

Review of Lecture 6

- Question - Is it possible to to design an ECC that will correct some double bit errors but not all double bit errors? Why or why not?

Review of Lecture 6

- Question - Is it possible to to design an ECC that will correct some double bit errors but not all double bit errors? Why or why not?
- Answer - It is possible. You could design a code in which all codewords are at least a distance of 3 from all other codewords, allowing all single-bit errors to be corrected. Suppose that some but not all codewords in this code are at least a distance of 5 from all other codewords. Then for those particular codewords, but not the others, a double- bit error could be corrected.

Review of Lecture 6

- Question - Describe stop-and-wait flow control.

Review of Lecture 6

- Question - Describe stop-and-wait flow control.
- Answer - A flow control protocol in which the sender transmits a block of data and then awaits an acknowledgement before transmitting the next block.

Review of Lecture 6

- Question - What are reasons for breaking a long data transmission up into a number of frames?

Review of Lecture 6

- Question - What are reasons for breaking a long data transmission up into a number of frames?
- Answer - (1) The buffer size of the receiver may be limited. (2) The longer the transmission, the more likely that there will be an error, necessitating retransmission of the entire frame. With smaller frames, errors are detected sooner, and a smaller amount of data needs to be retransmitted. (3) On a shared medium, such as a LAN, it is usually desirable not to permit one station to occupy the medium for an extended period, thus causing long delays at the other sending stations.

Review of Lecture 6

- Question - Describe sliding-window flow control.

Review of Lecture 6

- Question - Describe sliding-window flow control.
- Answer - A method of flow control in which a transmitting station may send numbered packets within a window of numbers. The window changes dynamically to allow additional packets to be sent.

Review of Lecture 6

- Question - Describe ARQ.

Review of Lecture 6

- Question - Describe ARQ.
- Answer - A feature that automatically initiates a request for transmission when an error in transmission is detected.
- Stop-and-wait, Go-back-N ARQ and Selective-reject ARQ

Learning Objectives

- Understand the reasons for having flow control;
- describe the types of flow control;
- understand the reasons for having error control; and
- describe the types of error control

Data Link Control Protocol

- To achieve error-free exchange of data, a layer of logic is added above physical interfacing, referred as ***data link control protocol***

Data Link Control Protocol

Data link control protocols governs:

- ***Frame synchronization*** - identifies the start/ end of frames
- ***Flow control*** - controls the flow so that sender must not send frames faster than receiver can absorb
- ***Error control*** - identifies and corrects any bit error introduced by transmission systems
- ***Addressing*** - identify the identity of stations in multipoint connection
- ***Differentiating control and data*** - provides mean of differentiating control and data signals
- ***Link management*** - coordinates the initiation, maintenance and termination of a sustained data exchange

HDLC- High Level Data Link Control

- A protocol defined by ISO for use on both point-to-point and multipoint WAN data links
- Basic Characteristics:
  - **Station types** – 3 types:
    - **Primary station**
      - Controls operation of link
      - Frames issued are called commands
      - Maintains separate logical link to each secondary station
    - **Secondary station**
      - Under control of primary station
      - Frames issued are called responses
    - **Combined station**
      - May issue commands and responses

HLDC-Basic Characteristics

- **Link configurations**
  - **Unbalanced**
    - One primary and one or more secondary stations
    - Supports full duplex and half duplex
  - **Balanced**
    - Two combined stations
    - Supports full duplex and half duplex
- **Data transfer modes**
  - **Normal Response Mode (NRM)**
    - Unbalanced configuration
    - Primary initiates transfer to secondary
    - Secondary may only transmit data in response to command from primary
    - Host computer as primary, Terminals as secondary

HLDC-Basic Characteristics

- Data transfer modes …
  - **Asynchronous Balanced Mode (ABM)**
    - Balanced configuration
    - Either station may initiate transmission without receiving permission
    - Most widely used
    - No polling overhead
  - **Asynchronous Response Mode (ARM)**
    - Unbalanced configuration
    - Secondary may initiate transmission without permission form primary
    - Primary responsible for line
    - rarely used

Frame Structure

- HDLC uses synchronous transmission
- A single frame format is used for all types of data and control exchanges

Frame Format

Flag Fields

- Delimit frame at both ends by **01111110**
- Same flag may close one frame and open another
- Receiver continuously hunts for flag sequence to synchronize frames
- **Bit stuffing** used to avoid confusion with data containing **01111110**
  - Extra 0 is inserted after every sequence of five 1s
  - If receiver detects five 1s it checks next bit
  - If 0, it is deleted
  - If 1 and seventh bit is 0, accept as flag
  - If sixth and seventh bits 1, sender is indicating abort

Bit Stuffing Example

- Original pattern:
  - **111111111011111111**
- After bit stuffing
  - **1111101111011111110111**

Address Field

- Identify the secondary station that sent or will receive frame
- Usually 8 bits long, may be extended to multiples of 8 bits
- 7 bits contains the actual address, the extra bit is located at the least significant bit of each octet. The value of this extra bit may be:
  - 1 if the block is the last block of the address field
  - 0 if the block is NOT the last block of the address field
- All ones (11111111) is broadcast

Control Field

- HDLC defines three type of frames, each with a different control field format.
- Frame types:
  - **Information (I-frames)**
    - carry data to be transmitted for the user
    - If piggybacking is used by ARQ, flow and error control data are piggybacked on an information frame
  - **Supervisory (S-frames)**
    - provides ARQ mechanism when piggybacking is not used
  - **Unnumbered (U-frames)**
    - provides supplemental link control functions
- First one or two bits of control filed identify frame type

Information Field

- Only in information (I-frame) and some unnumbered frames (U-frame)
- Must contain integral number of octets
- Variable length

Frame Check Sequence (FCS)

- Error detection code calculated as the remainder of CRC calculation
- 16-bit CRC CCITT standard is usually used

HDLC Operation

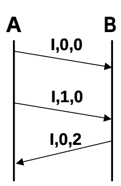
- Exchange of information, supervisory and unnumbered frames
- Three phases of operation
  - **Initialization**
    - signals the other side that initialization is requested
    - Specifies which of the three modes (NRM,ABM,ARM) is requested
    - Specifies whether 3 or 7-bit sequence numbers are to be used

    The other side can response with:
    - Unnumbered Acknowledged Frame (UA) to accept
    - Disconnect Mode (DM) frame to reject

HDLC Operation

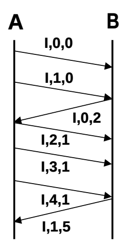
- **Data Transfer**
  - When initialization is accepted, a logical connection is established
  - Both sides may begin to send data
- **Disconnect**
  - Either side can initiate a disconnect
  - Request to disconnect can be generated because of:
    - fault during communication
    - request from high-layer user
  - Issues a disconnect (DISC) frame and other side replies by sending UA frame

Information Frame



- All the examples we have shown so far in ARQ assume the data is flow in one- direction
- To allow bi- directional data exchange as adopted by HDLC, each frame now have to contains both the id of the frame sent , ***N(s),*** and the acknowledgement to the frame sent by the other party, ***N(r)***
- The ACK is piggybacked in the information frame

Information Frame



- **A sends f0, and does not acknowledge any frame from B, N(s)= 0, N(r)= 0**
- **A sends f1, does not acknowledge any frame from B, N(s)= 1, N(r)= 0**
- **B sends f0 and acknowledges f0 and f1 sent by A, N(s)= 0, N(r)= 2**
- **N(r) = 2 is the same as saying RR2 in ARQ. Note: RR frame in HDLC is a supervisory frame**
- **A sends f2, and acknowledged f0 sent by B, N(s)= 2, N(r)= 1**
- **A sends f3, and there is no more frame arrived from B to be acknowledged, N(s)= 3, N(r) = 1**
- **A sends f4, N(s)= 4, N(r)= 1**
- **B sends f1 and acknowledged all frames sent by A up to f4, N(s)= 1, N(r)= 5**