Chapter 2: Getting Connected

1. **Explain Manchester Encoding.**
   - Manchester Encoding results in 0 being encoded as a low-to-high transmission and 1 being encoded as a high-to-low transmission.

2. **What are the types of errors occurring in a data transmission?**
   - Single-bit errors and burst errors.

3. **Define ARQ.**
   - Anytime an error is detected in exchange, a negative acknowledgement (NAK) is returned and the specified frames are retransmitted.

4. **How do you represent an Ethernet address?**
   - An Ethernet address is represented as a sequence of 6 numbers separated by colons. Each number corresponds to 1-byte of the 6-byte address and is given by a pair of hexadecimal digits, one for each of the 4-bit nibbles in the byte, leading 0s are dropped.
   
   Eg. 8:0:2b:e4:b1:2 is the human-readable representation of Ethernet address 00001000 00000000 00101011 11100100 10110001 00000010

5. **Explain NRZ encoding of a bit stream.**
   - 0 is mapped to low signal and 1 is mapped to high signal.

6. **Give the frame format of Clock-Based Framing.**
   - Overhead – Payload
7. **What are the three criteria necessary for an effective and efficient network?**

- The most important criteria are performance, reliability and security.
  - Performance of the network depends on number of users, type of transmission medium, the capabilities of the connected h/w and the efficiency of the s/w.
  - Reliability is measured by frequency of failure, the time it takes a link to recover from the failure and the network’s robustness in a catastrophe.
- Security issues include protecting data from unauthorized access and viruses.

8. **How does NRZ-L differ from NRZ-I?**

- In the NRZ-L sequence, positive and negative voltages have specific meanings: positive for 0 and negative for 1. In the NRZ-I sequence, the voltages are meaningless. Instead, the receiver looks for changes from one level to another as its basis for recognition of 1s.

9. **Explain byte oriented protocol.**

- It has its roots in terminals to mainframes.
- Each frame is viewed as a collection of byte rather than a collection of bits.
- Point-to-point protocol uses this approach recently and widely used.

 Sentinel based approach:

<table>
<thead>
<tr>
<th>SYN</th>
<th>SYN</th>
<th>SOH</th>
<th>Header</th>
<th>STX</th>
<th>Body</th>
<th>ETX</th>
<th>CRC</th>
</tr>
</thead>
</table>

Fig: BISYNC frame format

- BISYNC uses special characters known as sentential characters to indicate where frames start and end.
- The beginning of a frame is denoted by sending a special SYN character.
- SOH (Start of Header) field serves the same purpose as STX field.
- The frame format also includes a field labelled Cyclic Redundancy Check (CRC).
 Byte-counting approach:

- The number of bytes contained in a frame can be included as a field in the frame header.
- The DECNET’s DDCMP protocol uses this approach.
- COUNT Field specifies how many bytes are contained in the frames body.

Fig: DDCMP frame format

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10. **Explain stop-and-wait.**
- Simplest ARQ scheme.
- After transmitting one frame, the sender waits for an acknowledgement before transmitting the next frame.
- A time line is a common way to depict protocols behavior.
- The header for a stop-and-wait protocol includes a 1-bit sequence number.

11. **Explain sliding window protocol.**

- The sender maintains 3 variables:
  - Send window size gives the upper bound on the number of outstanding frames that the sender can transmit.
  - Last frame sent denotes the sequence number of LFS.
- Last acknowledgement received denotes the sequence number of The receiver maintains 3 variables:
  - Receive window size (RWS)-gives the upper bound on the number of out of order frames that the receiver is willing to accept.
  - Largest acceptable frame (LRT)-denotes the sequence number of largest acceptable frame.
  - Last frame received (LFR)-denotes the sequence number of LFR.
- Frame order and flow control:
  - Sliding window protocol is the best known algorithm in computer networking.
  - To reliably deliver frames across an unreliable link.
  - To prevent the order in which frames are transmitted.
  - To support flow control.
Concurrent logical channel:
- The data link protocol used in ARPANET, referred to as concurrent logical channel.
- ARPANET support 8 logical channels over each ground link and 16 over each satellite link.

12. **Explain clock based framing (SONET).**
- SONET (synchronous optical network) is the dominant standard for long distance transmission of data over optical networks.
- It defines a hierarchy of signaling levels called synchronous transport signals (STS).
- The physical links defined to carry each level of STS are called optical carriers (OC).
- SONET frame is a matrix of 9 rows of 90 octets.
- First 3 column of the frame are used for section and line overhead.
- Upper 3 rows of the first 3 column are used for section overhead.
- Lower 6 are line overhead.
- The rest of the frame is synchronous payload envelope (SPE)
- The overhead bytes of a SONET frame are encoded using NRZ where 1s are high and 0s are low.
- SONET supports multiplexing of multiple low-speed links.

13. **Explain Bluetooth.**
- Bluetooth fills the niche of very short-range communication between mobile phones, PDAs, notebook, and other personal or peripheral devices.
- Bluetooth operates in the licence-exempt band at 2.45 GHz. It has a range of only about 10 m.
- Version 2.0 provides speed up to 2.1 Mbps.
- IEEE 802.15.1 standard is based on Bluetooth but excludes the application protocols.
- The basic Bluetooth network configuration, called a piconet.
- It uses frequency hopping with 79 channels, using each for 625 um at a time.

14. **Explain access protocol.**
- It also called Ethernet’s media access control.
- It is implemented in hardware on the network adaptor.
Frame format:

| Preamble | dest addr | src addr | type | Body |

Fig: Ethernet frame format

- 64 bit preamble allows the receiver to synchronize with the signal;
- It is a sequence of alternating 0s and 1s.
- It includes a 32-bit CRC.
- It is a bit-oriented framing protocol.

Addresses:

- Each host on an Ethernet has a unique Ethernet address.
- Ethernet addresses are in the form of a sequence of six numbers separated by colons.
- (Eg): 8:0:2b:e4:b1:2 is the human readable representation of Ethernet address
  00001000 00000000 00101011 11100100 10110001 00000010

15. Explain token ring media access control.

- Token ring contains a receiver and transmitter.
- Token holding time (THT).
- The priority of the token changes over time due to the use of 3 reservation bits in the frame header.
- When it copies the frame into its adaptor it sets the c-bit.
- When the sending node release the token.
- Early release-sender can insert the token back on to the ring immediately following its frame.
- Delayed release-after the frame it transmit has gone all the way around the ring and been removed.

16. Explain about Reliable Transmission.

- Using a combination of two fundamental mechanisms.
  - Acknowledgement
  - Timeouts
The general strategy used to implement reliable delivery is called automatic repeat request.

**Stop and Wait**
- Flow and error control mechanism
- Straightforward
- After transmitting one frame, the sender waits for an acknowledgement before transmitting the next frame. If the acknowledgement does not arrive after a certain period of time, the sender time out and retransmits the original frame.
- Operations
  - Normal Operation
  - Lost or damaged frame
  - Lost Acknowledgement
  - Delayed Acknowledgement

**Sliding Window**
- The window slides to include new unsent frames when the correct acknowledgements are received. This window is a sliding window.

**Sender sliding Window**
- Assign a sequence number to each frame.
- Sender maintain three variables
  - Send window size
  - Last acknowledgement received
  - Last frame sent

**Receiver sliding window**
- It maintains three variables
  - Receive window size
  - Largest acceptable frame
  - Last frame received
- Finite sequence numbers and sliding window
- Frame order and Flow control
  - Used to serve 3 roles
    a. To reliably deliver frames across an unreliable link.
    b. To preserve the order in which frames are transmitted
    c. To support flow control
Concurrent logical channels

17. **Explain about 802.11**
   - It is designed for use in a limited area, and its primary challenge is to mediate access to a shared communication medium.
   - Physical properties
     - Run over three physical media
       - Two based on spread spectrum
       - One based on diffused infrared
     - Frequency hopping
     - Direct sequence
     - Infrared signal
   - Collision Avoidance
   - It address two problems
     - Hidden node problem
     - Exposed node problem
   - Multiple access with collision avoidance
   - Request to send
   - Clear to send
   - Distribution system
   - Frame format
     - Contains source and destination node addresses
     - Control field contain three subfields

18. **Give a brief notes on Byte oriented Protocol.**
   - To view each frame as a collection of bytes rather than a collection of bits.
   - 2 different framing techniques.
     - Sentinel approach
     - Byte counting approach
   - Sentinel Approach
     - Frame format
   - Byte- Counting Approach
     - Frame format
Show the NRZ, Manchester, and NRZI encodings for the bit pattern shown in the figure below. Assume that the NRZI signal starts out low.

For each of these sub-parts, identify whether the encoding can have problems with:

A. Long strings of 0s
B. Long strings of 1s
C. Both long strings of 1s or long strings of 0s
D. None of the above

(a) Manchester encoding
(b) NRZ
(c) NRZI

Solution:
(a) Manchester encoding: (D) Non-of the above. Manchester encoding will provide a signal change on every bit of data transferred, but has the down-side of making the data-rate only have the baud rate (i.e., rate at which the signal can change on the wire).
(b) NRZ: (C) For non-return to zero, the signal only changes when the data on the wire changes. Thus, it can lose clock synchronization with a sequence of either 1's or 0's.
(c) NRZI: (A) Non-return to zero inverted signals a 1 by making a transition, but signals a 0 by staying at the same signal. Thus, it has problems with long sequences of zeros.
Consider the data bit sequence 0000 0011 1110 0111 1111 1110 0001 0000 0001 1111.

a) Frame the bits using bit stuffing as defined by the HDLC protocol. You need to show only the (stuffed) data bits and the sentinel bits.

<table>
<thead>
<tr>
<th>Flag</th>
<th>Body</th>
<th>Flag</th>
</tr>
</thead>
<tbody>
<tr>
<td>01111110</td>
<td>0000 0011 1110 0111 1111 1110 0001 0000 0001 1110</td>
<td>01111110</td>
</tr>
</tbody>
</table>

**Question-C**

You are working for a company that delivers digital pictures to users over different types of networks. You are developing a new product that will use a network link that has a bandwidth of 1MHz. Your boss asks two of your colleagues, Bob and Jane, to estimate how long it will take to transfer 1 MByte images over the channel.

(a) Jane took a networking course and vaguely remembers something about Nyquist. She uses the Nyquist limit - what answer does she get?

(b) Bob took the same course but was more impressed by the slide on Shannon. He applies the Shannon formula. He assumes that the signal-to-noise-ratio is 30 dB (that is after all, what was on the slide in class). What answer does he get?

(c) Your boss is unhappy. He did not expect to get two different answers and he calls you in to explain the difference. What do you say?

**Solution:**

(a) \( 2 \times 1\text{MHz} = 2\text{Mbps} \)

(b) \( 30 \text{ dB} = 10 \times \log(S/N) \); \( S/N = 1000 \).

\[
C = 1 \text{ MHz} \times \log_2(1 + 1000) = 9.967 \text{ Mbps}
\]

(c) The Nyquist limit assumes a binary amplitude encoding. Shannon’s theorem allows for more agressive encodings. This explains why that formula results in a higher bandwidth. Shannon’s theorem also takes noise into consideration.
Draw a time line diagram for the sliding window algorithm with SWS = RWS = 3 frames, for the following two situations. Use a timeout interval of about $2 \times RTT$ and assume that two frames must be sent at least $1/2 \ RTT$ apart. Sequence numbers can grow arbitrarily large.

(a) The first transmission of frame 4 is lost. Use the version of SWS that does not use redundant ACKs, and show the protocol until frame 7 is transmitted

![Time line diagram for the sliding window algorithm with SWS = RWS = 3 frames. The diagram shows the protocol until frame 7 is transmitted, with the first transmission of frame 4 being lost.](Image)
b) The first ACKs for frames 2, 3, and 4 are lost. Use the version of SWS that does use redundant ACKs, and show the protocol until frame 5 is transmitted.

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**Question-E**

Suppose the following sequence of bits arrives over a link:

0110101111101010011111101100111110

Show the resulting frame after any stuffed bits have been removed. Indicate any errors that might have been introduced into the frame.

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Let * mark each position where a stuffed 0 bit was removed. There was one error where the several consecutive 1’s are detected (err) At the end of the bit sequence; the end of frame was detected (sof).

0111011111*1010011111111111111111110 110011111101110