❖ ERROR DETECTION AND CORRECTION IN DATA LINK LAYER

Data-link layer uses error control techniques to ensure that frames, i.e. bit streams of data, are transmitted from the source to the destination with a certain extent of accuracy.

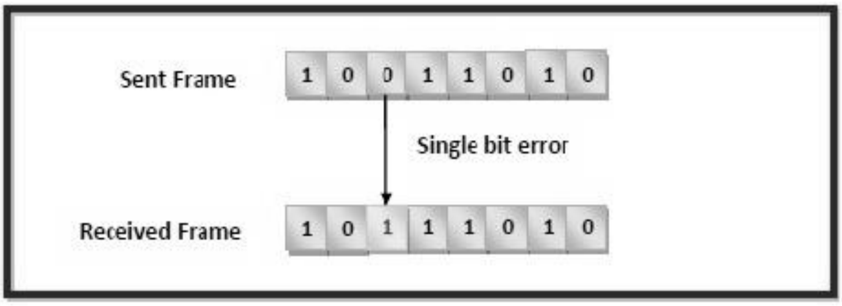
Errors

When bits are transmitted over the computer network, they are subject to get corrupted due to interference and network problems. The corrupted bits leads to spurious data being received by the destination and are called errors.

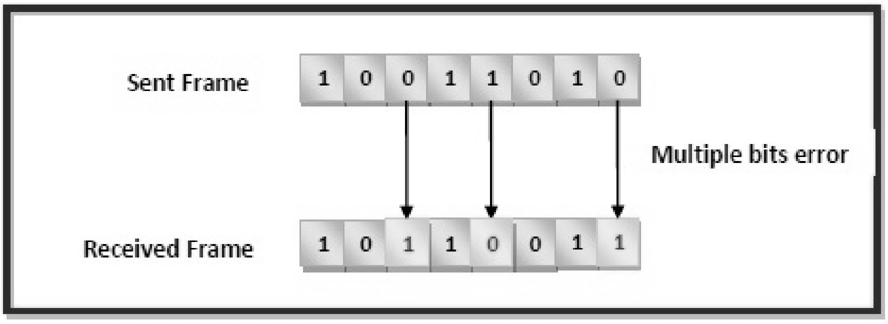
TYPES OF ERRORS

Errors can be of three types, namely single bit errors, multiple bit errors, and burst errors.

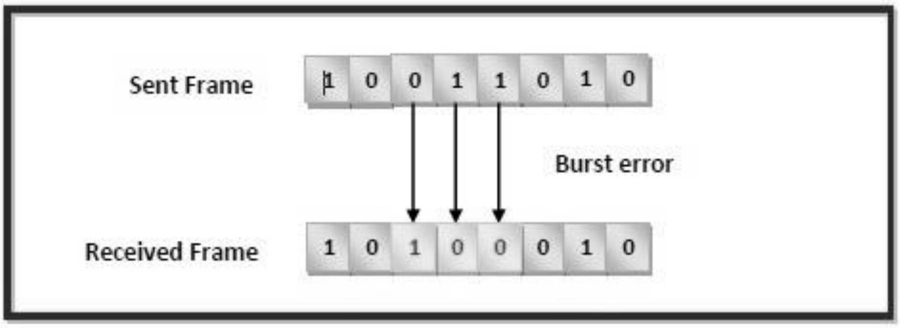
- **Single bit error** − In the received frame, only one bit has been corrupted, i.e. either changed from 0 to 1 or from 1 to 0.



- **Multiple bits error** − In the received frame, more than one bits are corrupted.



Burst error − In the received frame, more than one consecutive bits are corrupted.



ERROR CONTROL

Error control can be done in two ways

- **Error detection** − Error detection involves checking whether any error has occurred or not. The number of error bits and the type of error does not matter.

- **Error correction** − Error correction involves ascertaining the exact number of bits that has been corrupted and the location of the corrupted bits.

For both error detection and error correction, the sender needs to send some additional bits along with the data bits. The receiver performs necessary checks based upon the additional redundant bits. If it finds that the data is free from errors, it removes the redundant bits before passing the message to the upper layers.

Error Detection Techniques

There are three main techniques for detecting errors in frames: Parity Check, Checksum and Cyclic Redundancy Check (CRC).

Parity Check

The parity check is done by adding an extra bit, called parity bit to the data to make a number of 1s either even in case of even parity or odd in case of odd parity.

While creating a frame, the sender counts the number of 1s in it and adds the parity bit in the following way

- In case of even parity: If a number of 1s is even then parity bit value is 0. If the number of 1s is odd then parity bit value is 1.
- In case of odd parity: If a number of 1s is odd then parity bit value is 0. If a number of 1s is even then parity bit value is 1.
- On receiving a frame, the receiver counts the number of 1s in it. In case of even parity check, if the count of 1s is even, the frame is accepted, otherwise, it is rejected. A similar rule is adopted for odd parity check.
- The parity check is suitable for single bit error detection only.

Checksum

In this error detection scheme, the following procedure is applied

- Data is divided into fixed sized frames or segments.
- The sender adds the segments using 1's complement arithmetic to get the sum. It then complements the sum to get the checksum and sends it along with the data frames.

- The receiver adds the incoming segments along with the checksum using 1's complement arithmetic to get the sum and then complements it.
- If the result is zero, the received frames are accepted; otherwise, they are discarded.

Cyclic Redundancy Check (CRC)

Cyclic Redundancy Check (CRC) involves binary division of the data bits being sent by a predetermined divisor agreed upon by the communicating system. The divisor is generated using polynomials.

- Here, the sender performs binary division of the data segment by the divisor. It then appends the remainder called CRC bits to the end of the data segment. This makes the resulting data unit exactly divisible by the divisor.
- The receiver divides the incoming data unit by the divisor. If there is no remainder, the data unit is assumed to be correct and is accepted. Otherwise, it is understood that the data is corrupted and is therefore rejected.

Error Correction Techniques

Error correction techniques find out the exact number of bits that have been corrupted and as well as their locations. There are two principle ways

- **Backward Error Correction (Retransmission)** − If the receiver detects an error in the incoming frame, it requests the sender to retransmit the frame. It is a relatively simple technique. But it can be efficiently used only where retransmitting is not expensive as in fiber optics and the time for retransmission is low relative to the requirements of the application.
- **Forward Error Correction** − If the receiver detects some error in the incoming frame, it executes error-correcting code that generates the actual frame. This saves bandwidth required for retransmission. It is inevitable in real-time systems. However, if there are too many errors, the frames need to be retransmitted.

❖ DATA LINK CONTROL

Data Link Control is that the service provided by the Link Layer to supply reliable data transfer over the physical medium. For instance, within the half-duplex transmission mode, one device can only transmit the info at a time.

If both the devices at the top of the links transmit the info simultaneously, they're going to collide and results in the loss of knowledge. The info link layer provides the coordination among the devices in order that no collision occurs.

- **Line discipline.**
- **Flow control.**
- **Error control.**

i).LINE DISCIPLINE

In-Line Discipline is a functionality of the Data link layer that provides coordination among the link systems. It determines which device can send, and when it can send the data. There are also some categories of line discipline.

Categories of Line Discipline

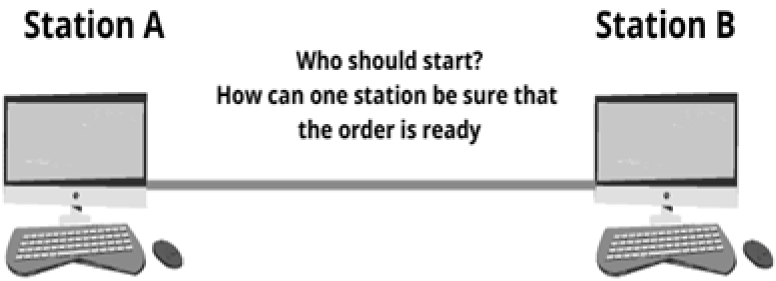
- **Enquiry/Acknowledgment (ENQ/ACK)**
- **Poll / Select**

The first method is employed in peer to see communication; the second method is employed in primary secondary communication.

Enquiry/Acknowledgment (ENQ/ACK)

Is employed primarily during a system where there's no doubt of the incorrect receiver getting the transmission, that is, when there's a fanatical link between two devices in order that the sole device capable of receiving the transmission is that the intended one.

ENQ/ACK coordinates which device may start transmission and whether or not.



Working Of ENQ/ACK

The initiator first transmits a frame called an inquiry (ENQ) asking if the receiver is out there to receive data. The receiver must answer either with an acknowledgment (ACK) frame if it is ready to receive or with a negative acknowledge (NAK) frame if it is not.

ii).FLOW CONTROL

- Ensuring the sending entity doesn't overwhelm the receiving entity
  —Preventing buffer overflow
- Transmission time
  —Time is taken to emit all bits into the medium at the sender's side
  —Determined by the data rate

- Propagation time

  —Time for a touch to traverse the link and reach the destination

  —Determined by the transmission distance

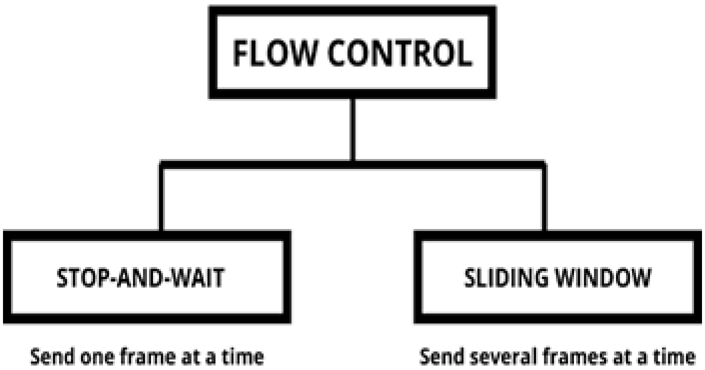
- We first assume error-free transmission.

Flow control -For speed mismatch (sender faster than receiver), finite receiver buffer, or occasional unavailability of the receiver feedback mechanism is usually required.

CATEGORIES OF FLOW CONTROL

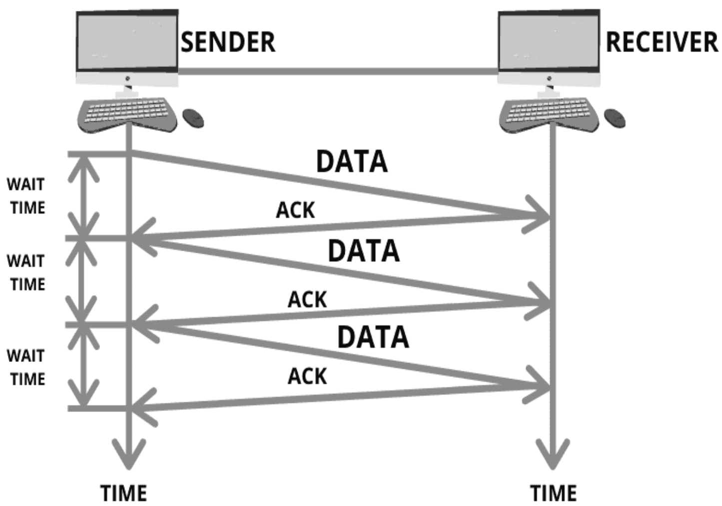
We are going to talk about categories of Flow control.

- **Stop-and-wait**
- **Sliding window**



STOP-AND-WAIT

- The source transmits a frame.
- The destination receives the frame and replies with a small frame called acknowledgment (ACK).
- The source waits for the ACK before sending the next frame.
  —This is the core of the protocol!



- The destination can stop the flow by not sending an ACK (e.g., if the destination is busy …).
- Performance of Stop-and-Wait
- STOP-AND-WAIT Flow control is not efficient for the end of the day transmission and high-speed transmission. Another sort of protocol called “sliding-window” is meant for this situation.

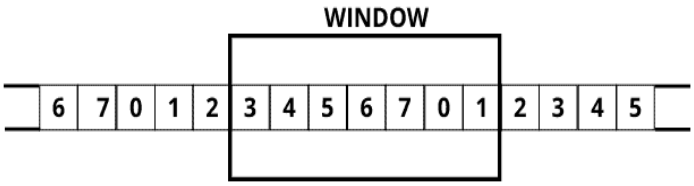
SLIDING WINDOW

Sliding window flow control-

- Idea: allow multiple frames to transmit

  —The receiver has a buffer of W frames

  —The transmitter can send up to W frames without receiving the ACK
- Each frame must be numbered: sequence number is included within the frame header
- ACK includes the sequence number of the subsequent expected frame by the receiver

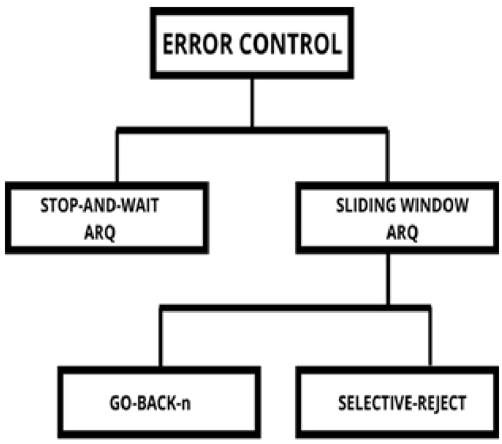


iii).ERROR CONTROL

- Error control: detection and correction of errors
- We consider two types of errors:

  —Lost frames
- The receiver cannot recognize that this is often a frame.

  —**Damaged frames**
- The receiver can recognize the frame, but some bits are in error.



STOP-AND-WAIT ARQ

- Based on stop-and-wait flow control
- The source station is equipped with a timer.
- The source transmits a single frame and waits for an ACK
- If the frame is lost…

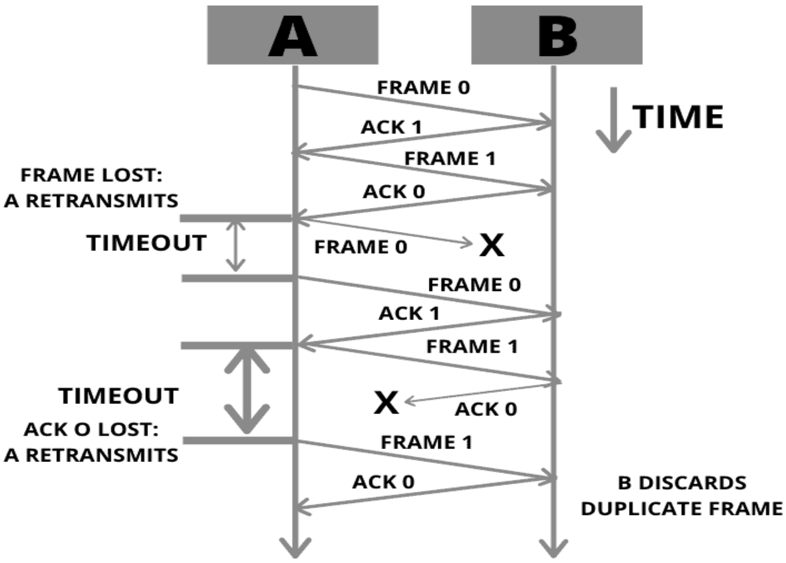
  —the timer eventually fires, and therefore the source retransmits the frame.
- If the receiver receives a damaged frame, discard it

  —the timer eventually fires, and therefore the source retransmits the frame.
- If everything goes right, but the ACK is broken or lost, the source won't recognize it

  —the timer eventually fires, the source will retransmit the frame

  —the receiver gets two copies of an equivalent frame!

  —Solution: use sequence numbers, 1 bit is enough, i.e., frame0 and frame1, ACK0 and ACK1



GO-BACK-n ARQ

- Based on sliding-window flow control
- Use window size to regulate the number of unacknowledged frames outstanding
- If no error, the destination will send ACK as usual with the next frame expected (positive ACK, RR: receive ready)
- If error, the destination will reply with rejection (negative ACK, REJ: reject)

  — the receiver discards that frame and all future frames until the erroneous frame is received correctly.

  —The source must go back and retransmit that frame and all succeeding frames that were transmitted in the interim.

  — This makes the receiver simple but decreases the efficiency

GO-BACK-n: DAMAGED FRAME

- Suppose A is sending frames to B. After each transmission, A sets a timer for the frame.
- n Go-Back-N ARQ, if the receiver detects an error in frame i

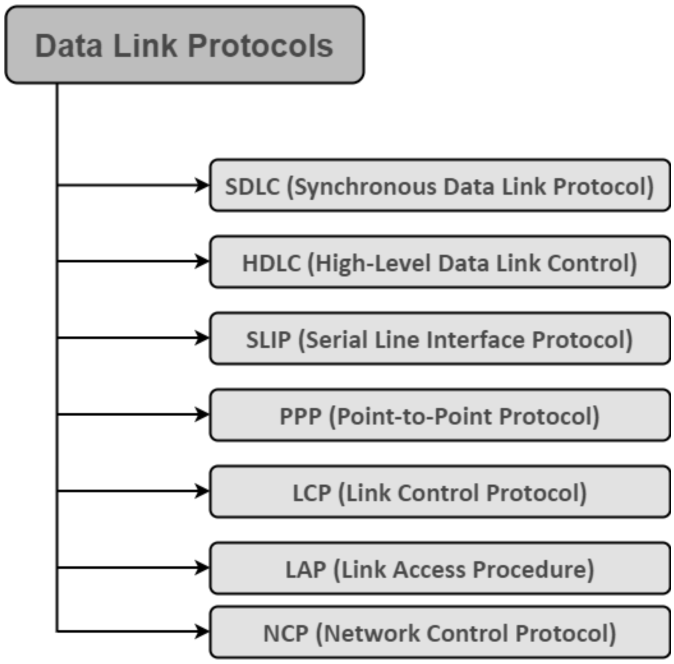
  — The receiver discards the frame and sends REJ-i

  — Source gets REJ-i

  — Source retransmits frame I and all subsequent frames

❖ DATA LINK LAYER PROTOCOLS

There are various data link protocols that are required for Wide Area Network (WAN) and modem connections. Logical Link Control (LLC) is a data link protocol of Local Area Network (LAN). Some of data link protocols are given below:



1. **Synchronous Data Link Protocol (SDLC)**

   SDLC is basically a communication protocol of computer. It usually supports multipoint links even error recovery or error correction also. It is usually used to carry SNA (Systems Network Architecture) traffic and is present precursor to HDLC. It is also designed and developed by IBM in 1975. It is also used to connect all of the remote devices to mainframe computers at central locations may be in point-to-point (one-to-one) or point-to-multipoint (one-to-many) connections.

2. **High-Level Data Link Protocol (HDLC)**

   HDLC is basically a protocol that is now assumed to be an umbrella under which many Wide Area protocols sit. It is also adopted as a part of X.25 network. It was originally created and developed by ISO in 1979. This protocol is generally based on SDLC. It also provides best-effort unreliable service and also reliable service. HDLC is a bit-oriented protocol that is applicable for point-to-point and multipoint communications both.

3. **Serial Line Interface Protocol (SLIP)**

   SLIP is generally an older protocol that is just used to add a framing byte at end of IP packet. It is basically a data link control facility that is required for transferring IP packets usually among Internet Service Providers (ISP) and a home user over a dial-up link. It is an encapsulation of the TCP/IP especially designed to work with over serial ports and several router connections simply for communication.

4. **Point to Point Protocol (PPP)**

   PPP is a protocol that is basically used to provide same functionality as SLIP. It is most robust protocol that is used to transport other types of packets also along with IP Packets. It can also be required for dial-up and leased router-router lines. It basically provides framing method to describe frames. It is a character-oriented protocol that is also used for error detection.

5. **Link Control Protocol (LCP)**

   It was originally developed and created by IEEE 802.2. It is also used to provide HDLC style services on LAN (Local Area Network). LCP is basically a PPP protocol that is used for establishing, configuring, testing, maintenance, and ending or terminating links for transmission of data frames.

6. **Link Access Procedure (LAP)**

   LAP protocols are basically a data link layer protocols that are required for framing and transferring data across point-to-point links. It also includes some reliability service features. There are basically three types of LAP i.e. LAPB (Link Access Procedure Balanced), LAPD (Link Access Procedure D-Channel), and LAPF (Link Access Procedure Frame-Mode Bearer Services). It is actually originated from IBM SDLC, which is being submitted by IBM to the ISP simply for standardization.

7. **Network Control Protocol (NCP)**

   NCP was also an older protocol that was implemented by ARPANET. It basically allows users to have access to use computers and some of the devices at remote locations and also to transfer files among two or more computers. It is generally a set of protocols that is forming a part of PPP. NCP is always available for each and every higher-layer protocol that is supported by PPP. NCP was replaced by TCP/IP in the 1980s.

~~~~~ The End: Unit-II ~~~~~