Data link layer. Error Detection & Correction

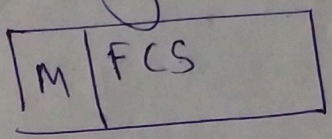
Longer the frame size higher the probability of single bit error.

Single bit error.

Transmitted - 10110010
Received - 10100010

Burst error: In case of serial transmission.

Solution: Using Redundancy.



FCS: Frame check sequence

$$FCS = F(M)$$

1. Simple Pairity check.
2. Two dimensional pairity check.
3. check sum.
4. Cyclic Redundancy check.

1. Pairity check:

In case of even pairity FCS ensures no' of 1's is even.

SPC performance - Fool proof against single bit error.

In case of burst error, only odd bit error.

2. Two dimensional Pairity check

Block of bits are arranged in a table.

Simple Pairity check for each row & column.

original data 10110001 | 00101100

10110001	0
00101100	1
10011101	1

Check Sum

Original data is divided into K segments each of n bits
Segments are added using One's complement.
(carry is added in the end)
Final sum is complemented to obtain check sum

ex: Segment size = 4, No. of segments = 2.

1010 ; 1100

```
 1010
 1100
------
 0110
    1
------
 0111
```

complement: 1000 ← check sum.

check sum is added to data segment

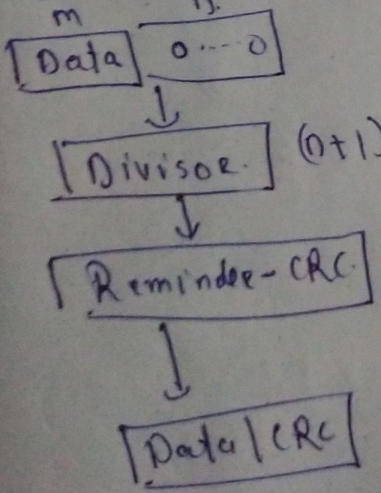
Receiver Side: check sum is performed for Recieved data
If result is all 0, then no error.

checks all odd error bits, almost all errors can be detected
Overhead is less than two dimensional parity check.

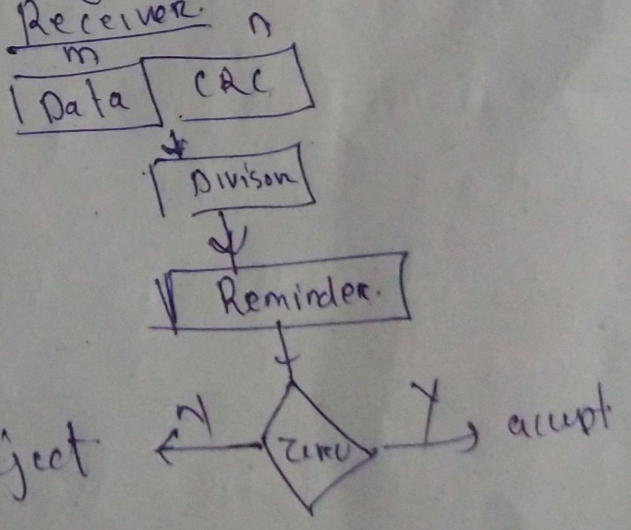
CRC.

Data size - M, FCS - N bits.
M+N should be divisible by a predetermined number

Sender.



Receiver.



Division is modulo 2.

eg: Data: 1010 – Padded with 3 zeros

Divisor: 1011

```
        1 1
      ------
1011 | 1110 000
       1011
      ------
        1010
        1011
      ------
        0010
```

Reminder of 3 bits.

CRC using Polynomial:

P: 11001 = $x^4 + x^3 + 1$.

$M(x) \times x^3 / P(x) = R(x)$

CRC-16: $x^{16} + x^{15} + x^2 + 1$

CRC - should not be divisible by x but by (x+1)

CRC is implemented using: LFSR

Can: Single bit errors

All double bit " (3 1's)

Any odd " (divisible by x+1)

All burst errors less than degree polynomial.

Error Correction:

Backward Error Correction: ARQ (Automatic Repeat Request)

Forward Error Correction:

Forward E.C (Use redundant bits in transmitted data)

Minimum distance btw two valid codewords must be atleast 2.
↳ For detection.

→ For correction > 2 (minimum distance)

If K is the additional bits $2^K \geq m+K+1$

Say $m = 16$, then $K > 4$.

Step-1 $\boxed{M+P}$ → (m+K) bit codes.

Step-2 Location of each (m+K) bit ← Decimal value.

Step-3 Parity bits are placed in $2^0, 2^1 \ldots 2^2 \ldots 2^{K-1}$ location.

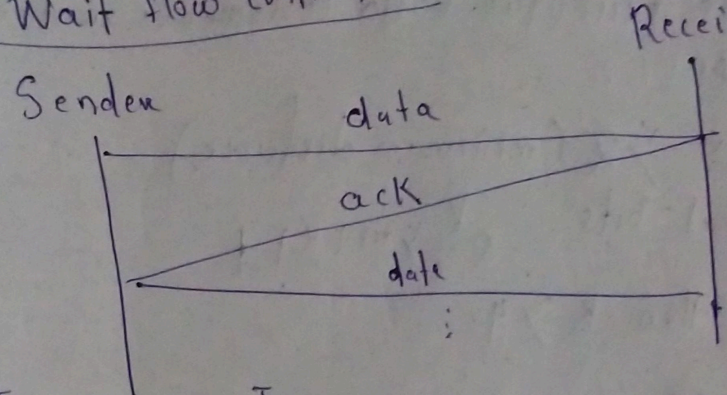
Example Data - 1010, Parity bits - 3, position 1, 2 4

7	6	5	4	3	2	1
d_4	d_3	d_2	P_3	d_1	P_2	P_1
1	0	1		0		

Flow Control & Error Control:

Flow control :-
purpose: Receiver should not be overwhelmed

Stop & Wait flow control



$$a = \frac{\text{Transmission Time}}{\text{propagation Delay}}$$

If $a < 1$: First bit arrives before transmission of frame is complete

If $a > 1$: Transmission gets completed before the first bit arrives

$$U = 1/(1+2a)$$

Drawback: At a time only one frame is in transmission.

If $a > 1$, Stop & Wait is inefficient.

Sliding window:

Frames are assigned sequential numbers.

If K bits are used for Seq. no., size of Sender window is at max $2^K - 1$.

Sender side buffer size = Window size

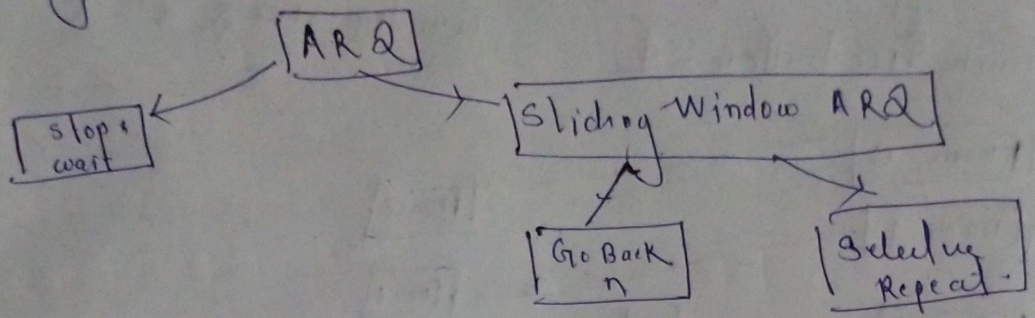
Receiver " " " = 1

If Receiver receives frame0, it sends Ack 1.

piggybacking :- | Seq no | Ack no |

Backward Error Control

1. Error Detection
2. Positive ACK.
3. Retransmission after Time out.
4. Negative ACK & Retransmission.



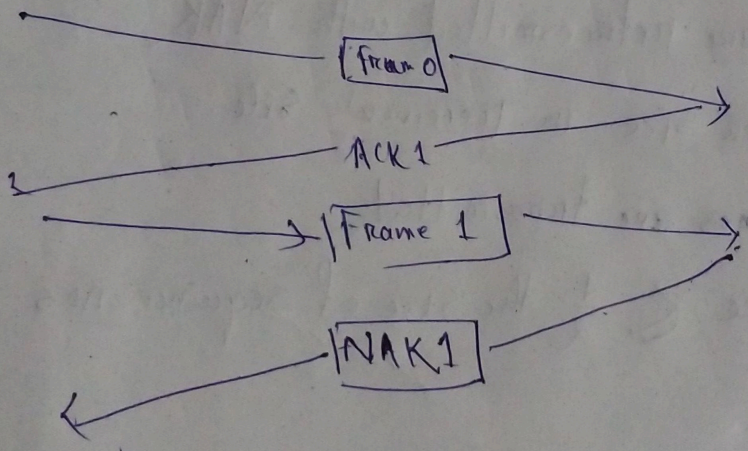
Stop & wait

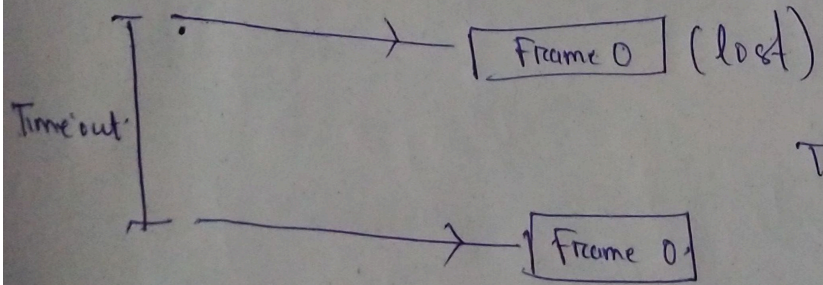
After each frame is sent, sender waits for proper ACK for a waiting period.

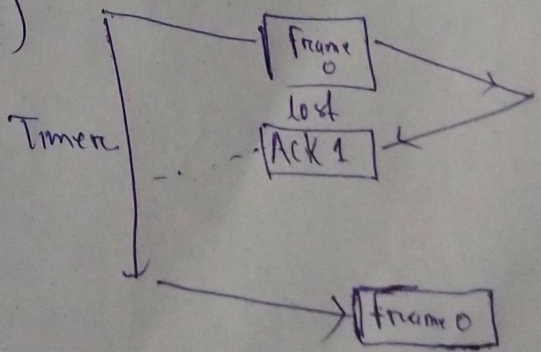
If ACK does not arrive, or improper ACK arrives, sender retransmits.

Frame 0 | Frame 1 | Frame 0 | ...

ACK 0 | ACK 1 | ...





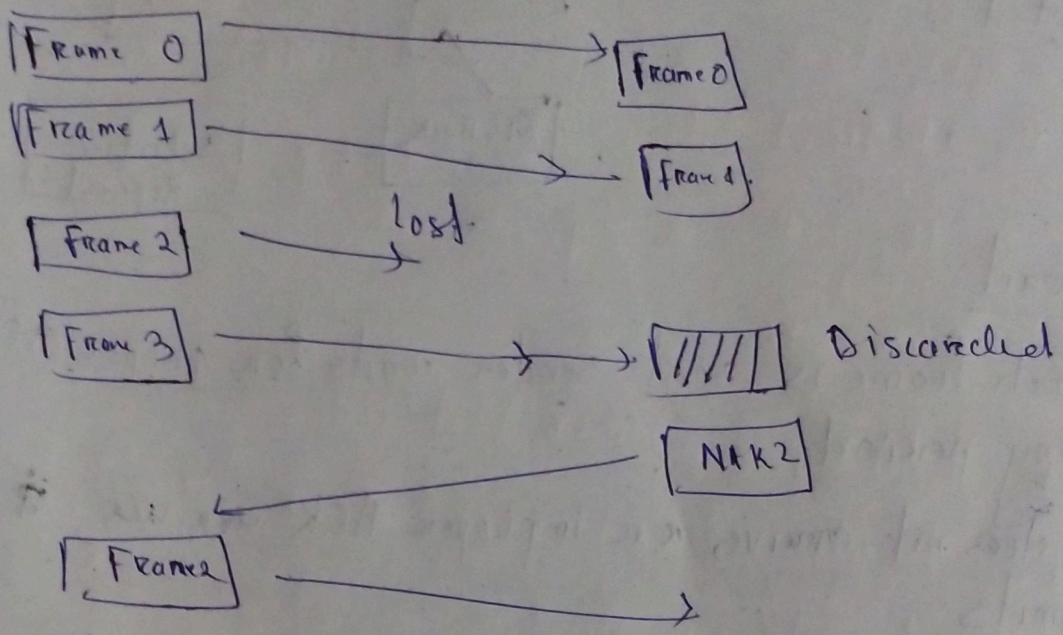


Go Back N ARQ

If Destination detects error or out of order frame, it sends NAK. Destination rejects all future frames until the frame in error is correctly received.

Sender window size $\leq 2^K - 1$

Receiver Size buffer = 1



Selective Repeat - ARQ.

- Only those frames are retransmitted with NAK.
- Requires more buffer size in receiver's side.
- → Selective frames are transmitted.

Window size $\leq \frac{1}{2}$ the size of sequence nos.

Data link Control

Transmission Medium + Data link Control = Data link

Data link Control features:-

1. Frame Synchronisation (Beginning & end of frame should be distinguished)
2. Flow control
3. Error Control
4. Control & Data on same link
5. Link management

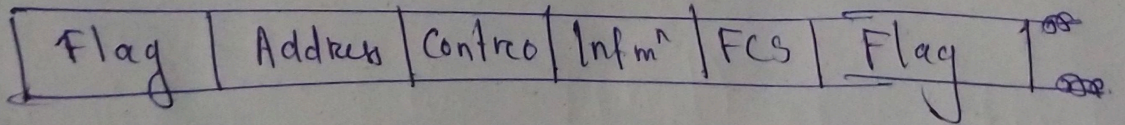
Asynchronous Transmission:-
Character level synchronisation
Based on character oriented file transfer

Synchronous Transmission:-
Block of bits are streammed without using start or stop bits.

Bit oriented- Every block begins with preamble bit pattern & ends with a postamble bit pattern.

HDLC (High-level Data link Control)
HDLC is a bit oriented Protocol.

Stations
- Primary
- Secondary
- Combined



Flag - 01111110

Control bit → Seq. number
→ ACK number