

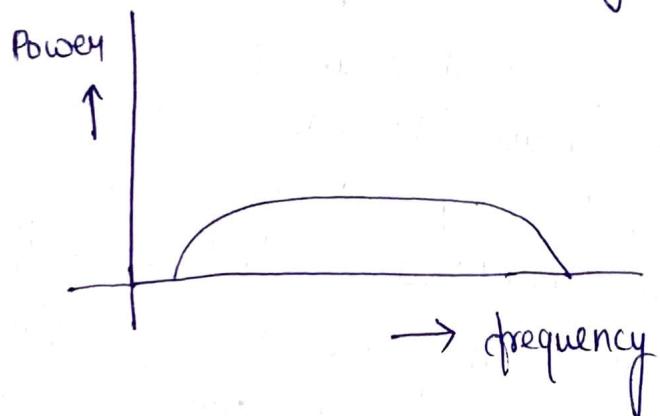
Spread spectrum: it is a technique used for transmitting radio or telecommunications signals. The term refers to the practice of spreading the transmitted signal to occupy the frequency spectrum available for transmission.

Advantage : - Noise reduction, security, and resistance to jamming

OR

In telecommunication and radio communication, spread-spectrum techniques are methods by which a signal (e.g. electrical, electromagnetic signal) generated with a particular bandwidth.

The spread spectrum signals have the signal strength distributed as shown in the following



features : -

- o Band of signals occupy a wide range of frequencies
- o Power density is low
- o Energy is wide spread.

These are of two types :

- ① frequency Hopped spread spectrum FHSS
- ② Direct sequence " DSSS

② FHSS :- This is frequency hopping technique, where the user are made to change the frequencies of user from one to another in a specified time interval, called frequency hopping.

Sender 1

f_i
allotted to S1
for time t_i
S1 hops for other
frequency

S2

S2 uses the
 f_i frequency this is
frequency reuse

The frequencies of the data are hopped from one to other in order to provide a secure transmission. The amount of time spent on each frequency hop is called as dwell time.

Direct sequence spread spectrum DSSS:-

Whenever a user wants to send data using this DSSS technique, each and every bit of the user data is multiplied by a secret code, called as chipping code. Chipping code is nothing but the spreading code which is multiplied with the original message and transmitted. The receiver uses the same code to receive the original message.

FHSS

- Multiple frequencies are used
- hard to find the user frequency at any instant of time
- frequency reuse is allowed
- Sender need not wait

DSSS | CDMA

- Single frequency is used
- User frequency when allotted is always the same.
- frequency reuse is not allowed
- Sender has to wait if the spectrum is busy.

well strength of signal is high
never affected by interference
it is cheaper

- low
- affected by interference
- it is expensive.

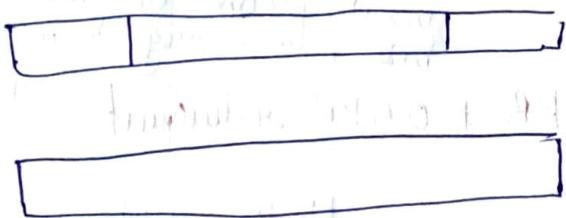
Error detection and correction.

Data can be corrupted during transmission. Some applications require that errors be detected and corrected.

Types of Errors: whenever bits flows from one point to another. They are subject to unpredictable changes because of interference.

Single bit error :- only 1 bit of given data unit such as byte, character, packet is changed from 1 to 0 or from 0 to 1.

Burst error :- two or more bit in data unit have changed. consists consecutive bit.
length of burst error.



ED

- 1) D+D Same.
- 2) Parity check.
- 3) CRC
- 4) Checksum.

Reducing errors :- The concept in detecting or correcting error is ".

to detect or correct errors, we need to send (extra) bits with data.

Error detection :- any yes or No. EH ED EC (only looking see if any error has occurred)

Error correction :- we need to know the exact no. of bits that are corrupted and more importantly their location. If we need to correct 1 error in 8 bit then size of error is important for 2 errors in " 8 location 28 possibilities

④ Coding: Redundancy is achieved through various coding schemes.

sender $\xrightarrow{+}$ actual data \rightarrow receiver

redundant bit

checks the

relation b/w RB & data

two categories:

Block coding

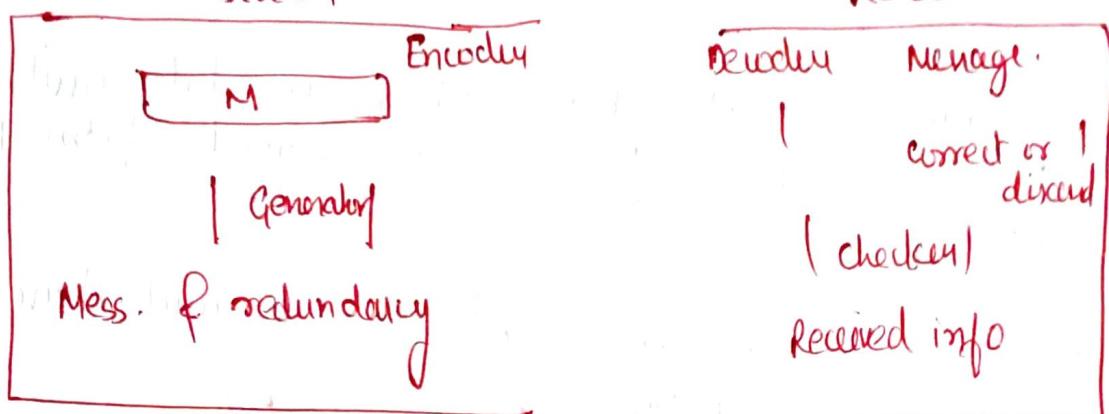
convolution coding - more complex

decoder.

structure of encoder &

Encoder

Receiver



Bit stuffing: \rightarrow is the mechanism of inserting one or more non-information bits into a msg to be transmitted, to break msg sequence, for syn.

i) Hamming code: $1KB + 0.5KB$ redundant

① Block coding: \div msg in blocks, each of K bits, called data words.

Add r redundant bits to each block to make

$$\text{length } n = K+r.$$

\Rightarrow n bit block called codewords.

$$\begin{matrix} K+r \\ \text{datawords} \\ \text{redundant} \end{matrix} = \begin{matrix} n \\ \text{codewords.} \end{matrix}$$

Have set of datawords \xrightarrow{n} codewords \xrightarrow{K} size. \xrightarrow{n} size.

we can create 2^K datawords, $\xrightarrow{n > K}$ 2^n codewords.

Since coding is one to one
Dataword if always encoded as codewords.
we have $2^n - 2^k$ codewords illegal.

Hamming Distance: The hamming distance b/w two words (of same size) is the no of differences b/w the corresponding bits. HD = b/w of 2 words.

$$\begin{array}{l} \text{000} \\ \text{011} \\ \text{101} \\ \text{110} \end{array} \quad d(x, y) = \begin{array}{l} c_1 = 1101 \\ c_2 = 1010 \\ = 0+1+1+1 \\ = 3 \end{array} \quad d_{c_1 c_2} = [c_1 \oplus c_2] = (0111) = 3$$

MHD

CRC

(000, 011) is 2 000 \oplus 011 is 011 two 1.

$$\begin{array}{l} \rightarrow c_1 1101 \\ \rightarrow c_2 1010 \\ \rightarrow c_3 1000 \end{array}$$

cyclic Redundancy check.

CRC Generator

EXOR
mod 2 sum

S

1101

R

1 + 1	0
1 + 0	1
0 + 1	1
0 + 0	0

1011011000

$$\begin{array}{r}
 & 11 \\
 & \downarrow \\
 \begin{array}{l} 1101 \\ \hline 1011011000 \end{array} & \boxed{000} \\
 & \hline
 & 1101 \\
 & \hline
 & 0110011000 \\
 & \hline
 & 1101 \\
 & \hline
 & 000111000 \\
 & \hline
 & 1101 \\
 & \hline
 & 1100 \\
 & \hline
 & 1101 \\
 & \hline
 & \boxed{0001}
 \end{array}$$

i) CRC Generator 4 bits its
in CRC is 3 bits

$$\begin{array}{r}
 R \\
 D \\
 \hline
 1011011001
 \end{array}$$

upper case 65 - 90
lower " 97 - 122
Digit 48 - 57

Special symbol 0 - 47, 58 - 64, 91, 96

123 - 127,

CN lecture 8/1/20

Participate

→ 140, 141, 143, 148, 150, 152, 701, 712, 719, 740

Absent

142, 144, 146, 149, 151, 54, 55, 56, 57, 60, 707, 08, 9, 10
11, 13, 14, 15, 18, 20, 22, 27, 29, 30, 31, 32, 41, 42

00 000
01 011
10 101
11 110

147 left
153

236

9/1/20 → 4(A) L1 214

214 20, 23, ~~25~~, 35, 37

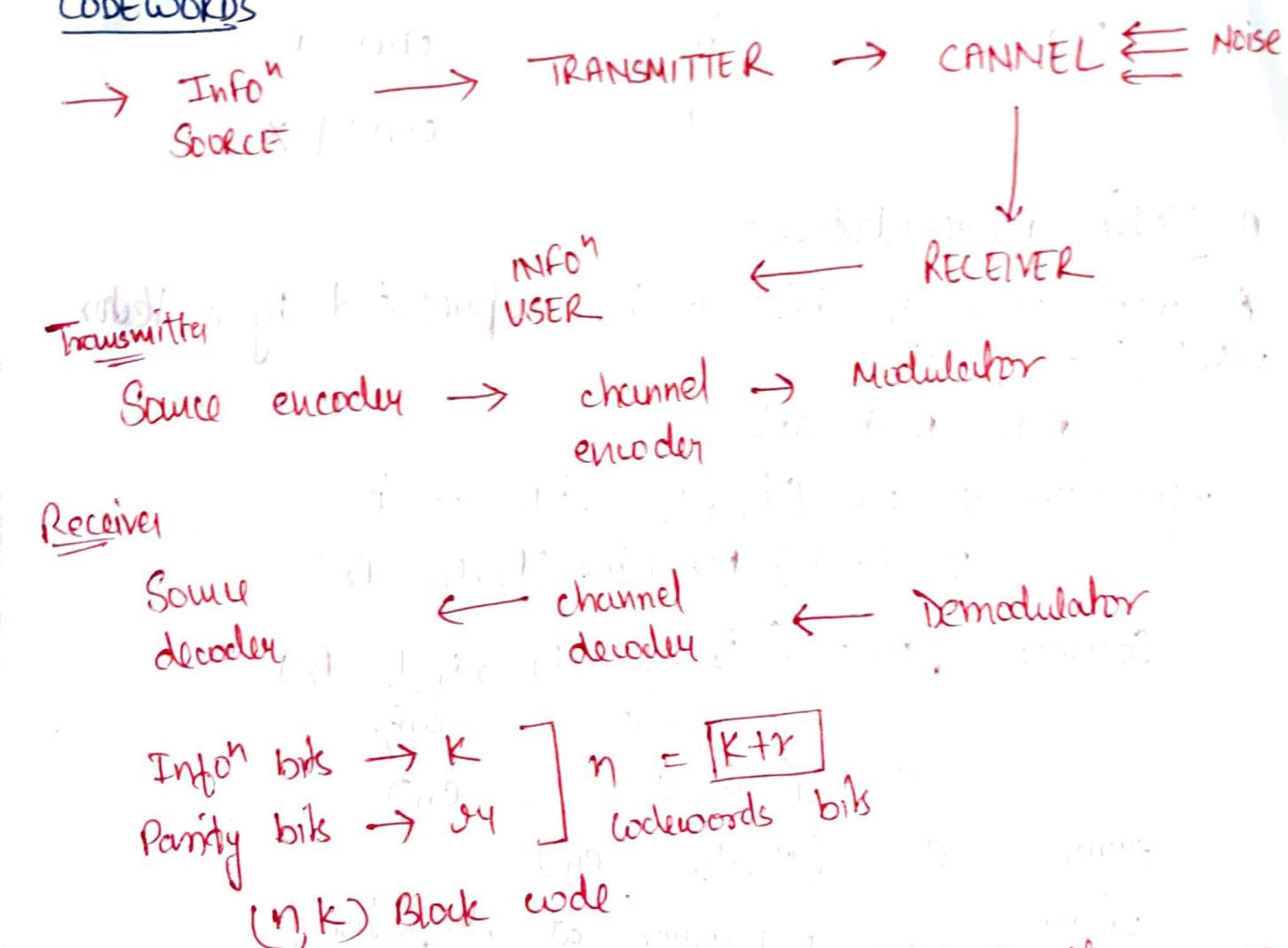
217

214	*	32	*	193 - A
215	*	33	*	95 - A
216	*	34	**	
218	**	36	*	
219	—	38	**	214 - A
21	*			22M
22	*			
24	*			
25	*			
26	*			
28	*			
29	*			
30	**			
31	**			

error coding: Block codes

every channel has an upper limit on the rate at which information can be transmitted reliably through the channel. This limitation on the capacity of a channel to transmit info is referred to as the CHANNEL CAPACITY.

Def "Block Codes": A Block Code is a set of words that has well defined mathematical property structure, and where each word is a sequence of a fixed no. of bits. The words belonging to a block code are called as CODEWORDS.



A codeword whose infoⁿ bits are kept together so that they are easily identifiable are called as SYSTEMATIC, otherwise as NON-SYSTEMATIC.

For (n, k) Block code :-

→ (i) 2^k Codewords have seq. structure

→ (ii) $2^n - 2^k$ redundant words

→ (iii) Code Rate, $R = \frac{k}{n}$, ($0 \leq R \leq 1$)

what is redundant words.

K (info bits) \times r (Parity bits)

$n = K+r$ bits

(4,3) even parity Block code : (n, k) , $r = n-k = 1$

8 bits info Parity bits codeword

0000	0	0000 ✓
0001	1	0001 ✗

An Vector Representation:

A word with 'n' bits can be represented by a vector with 'n' components

(n, k) Block code

info word $\Rightarrow i = (i_1, i_2, \dots, i_k) \rightarrow$

$r = (n-k)$ Parity bits (P_1, P_2, \dots, P_r)

Codeword $c = (\underbrace{i_1, i_2, \dots, i_k}_{\text{info}}, \underbrace{P_1, P_2, \dots, P_r}_{\text{Parity}})$

$c = (c_1, c_2, \dots, c_n)$

Error $e = (e_1, e_2, \dots, e_n)$

where

$e_j = 1$ [error at j th position]

$= 0$ [error free]

$v = c + e$

$v = (c_1 + e_1, c_2 + e_2, \dots, c_n + e_n)$

$= v_1, v_2, \dots, v_n$

All addition are
modulo-2 addition.

Cyclic Redundancy Check (CRC)

- Based on binary division.
- total bits ($m+r$)
- Polynomial should not be divisible by x also not with ($n+1$)
- can detect all odd errors, single bit, burst error of length equal to polynomial degree.

$$n^4 + n^3 + 1$$

append 4 0's

11001

$$\begin{array}{r} 1010101010 \underline{\quad 0000} \\ 11001 | \\ 011000 \\ \hline 11001 \\ \hline 000011010 \\ 11001 \\ \hline 11000 \\ 1100 \\ \hline 0010 \end{array}$$



1010101010 0010 valid

m

14 bits in send.

$$G(n) = n^4 + n^3 + 1 \quad \text{and} \quad n^4 + n^3 + n^2 + n^1 + 1 \quad \text{is polynomial}$$

$$M(x) = 110101111$$

now calculate sum of $M(x) \cdot G(x)$ & divide by $G(x)$ to get remainder

11/120 28em 12(6) Absent
193, 95, 96, 216,

20 + 23 total,

III.1-20
CN lab \rightarrow Div 3

*Present No.

180 303 108 159

158

163

142

144

144

150

154

149

146

140, 143, 147, 148, 149, 150, 151, 152,
153, 154, 155, 2
701, 2, 4, 5, 6, 7, 8, 10, 11, 12, 15, 18, 19, 20, 21, 22, 25, 26, 27, 28, 29
30, 31, 32, 33, 36, 37, 39

Absent

15413

05051994

4(3)
20
6

Cyclic code : In a cyclic code, if co

1011001

0110011

CRC Cyclic code is using so cyclic Redundancy check

Redundancy \rightarrow cyclic redundancy check is we are going to use some redundant bits

check \rightarrow The receiver is going to use whatever you have sent.



Flow control

5 is discarded.

↑ Buffer is full

5 4 3 2 1

(S)

(R)

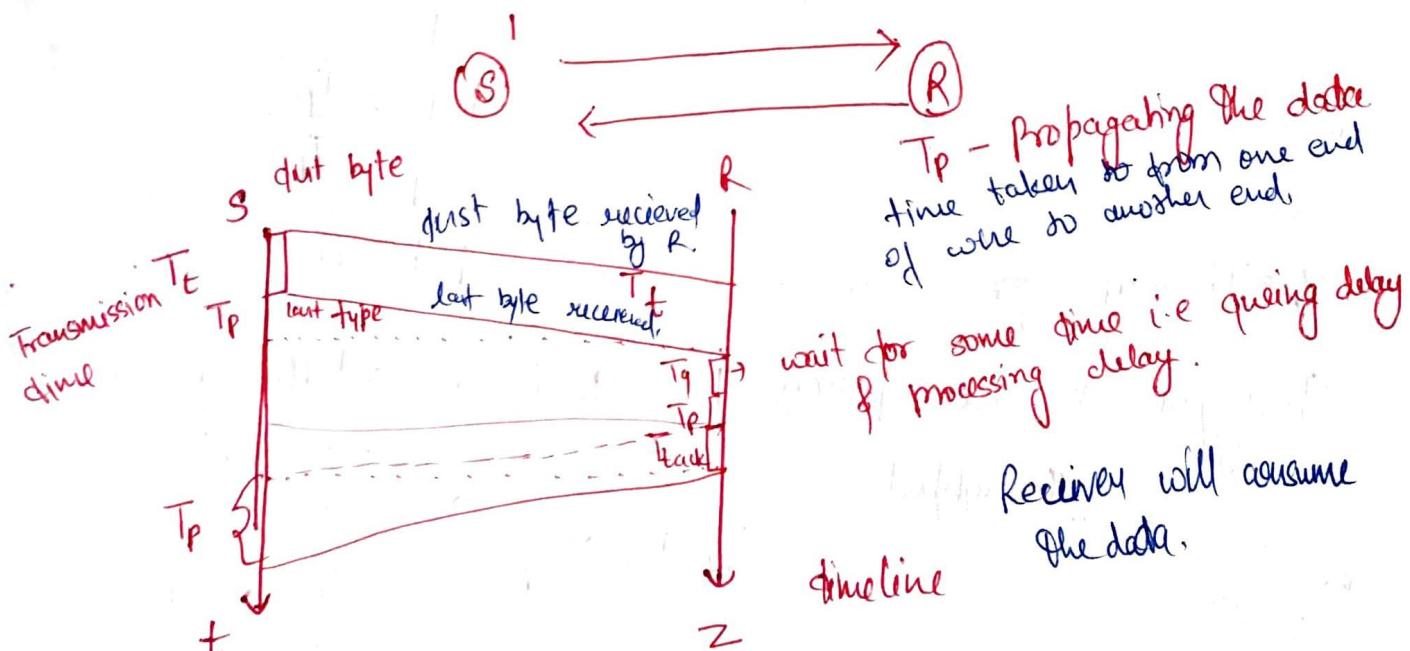
If there is S f R sender keep on sending packet.
The receiver will not be able to keep process the data
at the rate the sender is producing it.

You should always send the packet in such a way
that receiver will receive them and process them.

Flow control method allows the sender will always
follow the receiver. i.e. S will send packet in the only in
position the receiver will receive it.

Stop & wait:- S send packet 1 & R packet 1 is
received by R. Receiver ask for packet 2. Then send packet
2.

Send one packet then stop & wait until the receiver
said that I am done and send next packet.

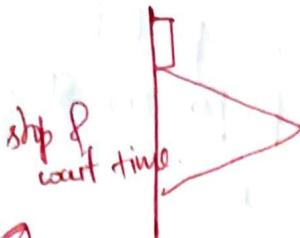


Total time for only one packet

②

Total time to send one packet is.

$$\text{Total} = L T_{t\text{ data}} + T_p + T_q + T_{\text{process}} + T_{\text{ack}} + T_p$$



$$\begin{aligned} \text{Total} &= L T_{t\text{ data}} + 2 * T_p + T_{\text{ack}} \\ &= L T_{t\text{ data}} + 2 T_p = 1 + 4 = 5 \end{aligned}$$

if $T_{t\text{ data}}$ is in second then T_{ack} is in microsecond.

transmit the packet and then stop & wait for ack. The end time is SFW.

Because of SFW there is an efficiency means.

for \rightarrow T_t packet is transmitted efficiently & waiting

for $2 * T_p$ time completely.

$$\eta = \frac{\text{useful time}}{\text{total cycle time.}} = \frac{T_t}{T_t + 2 T_p}$$

$$= \frac{1}{1 + 2 \frac{T_p}{T_t}}$$

$$= \frac{1}{1 + 2 \alpha}$$

How many bits
i am able to
send/s

$$\frac{L}{B} = \frac{T_t}{T_p}$$

efficiency for SFW is

Throughput \rightarrow no process bits that we actually sending/s.

effective
bandwidth
or
bandwidth
utilization.

$$\text{throughput} = \frac{L}{T_t + 2 * T_p} = \frac{\left(\frac{L}{B}\right) * B}{T_t * 2 T_p}$$

$$= \frac{T_t}{T_t + 2 * T_p} * B$$

$$= \left(\frac{1}{1+2a} \right) B = n * B$$

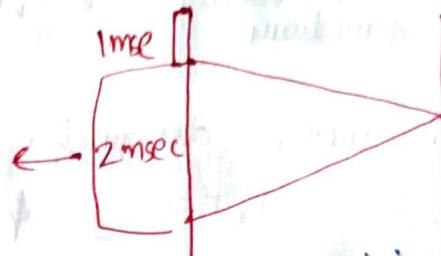
$$T_t = \frac{L}{B} \quad \begin{matrix} \text{- length of packet} \\ \text{Bandwidth} \end{matrix} \quad D T_t = 1 \text{ msec} \quad T_p = 1 \text{ msec}$$

$$T_p = \frac{d}{v} \quad \begin{matrix} \text{distance} \\ \text{velocity} \end{matrix} \quad n = ?$$

$$n = \frac{1}{1+2a} = \frac{1}{1+2*\frac{1}{3}} = \frac{1}{\frac{5}{3}} = \frac{3}{5}$$

Round trip time.

$$= 2 * T_p$$



②

$$T_t = 2 \text{ msec}$$

$$T_p = 1 \text{ msec}$$

③ If $M \geq 0.5$

$$n = \frac{1}{1+2\frac{1}{2}} = \frac{1}{\frac{5}{2}} = 50\% \quad \text{what is relationship b/w } n$$

$$\frac{T_t}{T_t + 2 * T_p} \geq \frac{1}{2}$$

To increase the transmission time

we have to increase the packet size.

$$L/B \geq 2 * T_p$$

$$L \geq 2 * T_p * B$$

$$2 T_t \geq T_t + 2 * T_p$$

$$T_t \geq 2 * T_p$$

8. B is 4 mbps, $T_p = 1 \text{ msec}$, $L = ?$ when $n \geq 0.5$

$$L \geq 2 * 10^{-3} * 4 * 10^6$$

$$1 \text{ mb} = 10^6 \text{ bits}$$

$$\geq 8 * 10^3 \text{ bits}$$

effective bandwidth $\Rightarrow T_h = n * B$

$$n = \frac{1}{2}$$

$$B = 4 \text{ mbps}$$

$$M = \frac{1}{2} * 4$$

$= 2 \text{ mbps}$ half of time we are waiting and half time for sending

②

factor effecting bandwidth.

$$\eta = \frac{1}{1+2a}$$

whenever we buy a link
Bandwidth is constant

$$\eta = \frac{1}{1+2 \times \frac{d}{v} + \frac{B}{L}}$$

fixed by link Bandwidth u
fixed.

we can't inc. the velocity
inside of medium. \leftarrow velocity is fixed

- If distance increase denominator increases $\downarrow \ln \eta$, $d \uparrow \eta \downarrow$
stop f wait is better to apply on LAN.
- If length of packet increase η increase.
stop f wait good for big packet.

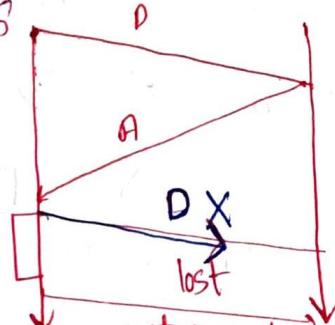
stop f wait should be used in LAN with big packet.

Problems in stop f wait: \rightarrow Data packet lost.

R. D S

Time out timer To timer

autransmit the data



according to sender receiver is busy. sending is wait Receiver wait. Both go in deadlock

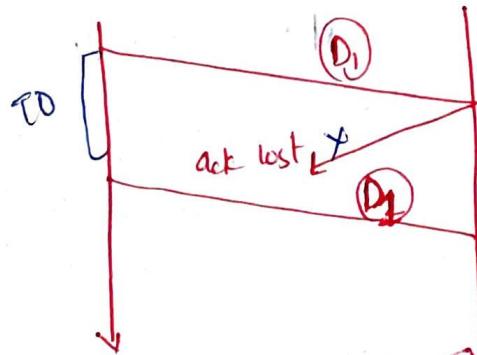
$$SFw + T0 = i.e. SFw . ARQ$$

Automatic repeat request

Problem is called data packet lost

③ Ack lost

ARQTC



Duplicate packet problem.
 \rightarrow add sequence no's to the data
 $SFw + T0 + Seq.$

Q. Bit stream = 10011101 is transmitted using CRC 9 generator.

Generator polynomial = $n^3 + 1$

- (i) what is the actual bit string transmitted?
 (ii) Suppose 3rd bit from left is inverted during transmission. How will receiver detect this error?

$$Q(n) = n^3 + 1 \rightarrow 1001 \quad [4 \text{ bits}]$$

Binary Division :- $\begin{array}{r} 1001 \sqrt{10011101000} \\ \underline{-1001} \end{array}$ CRC

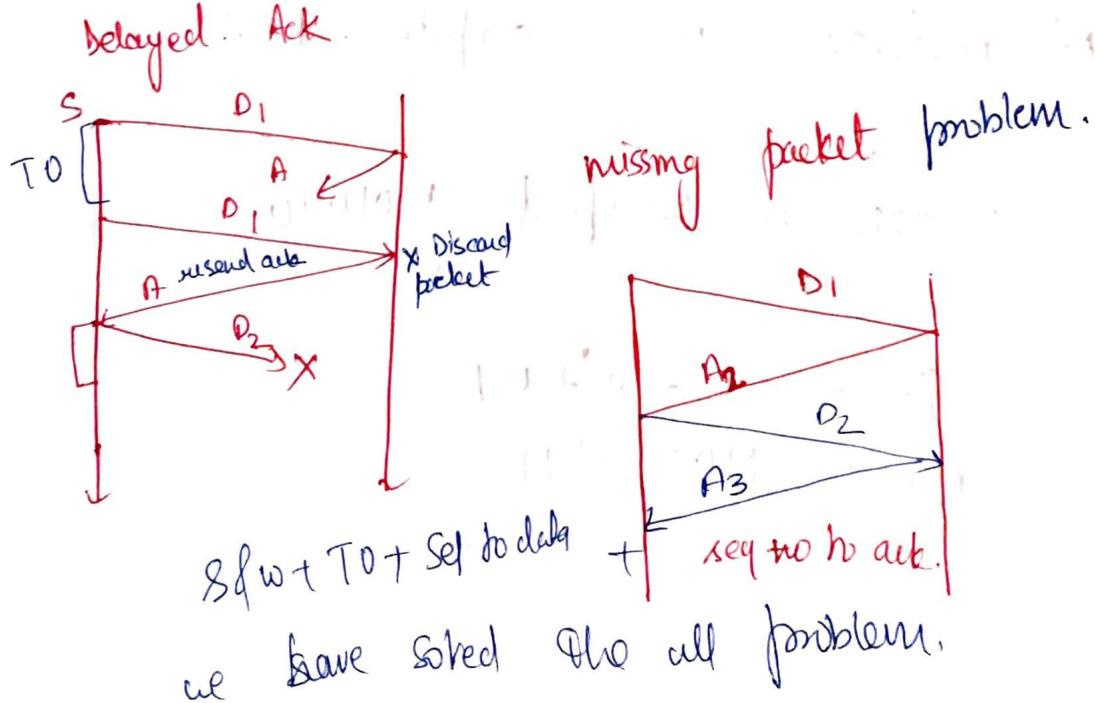
Now show 3rd bit is inverted.

Q. If bit sequence 1010001101 is transmitted with CRC. What is the divisor polynomial? GATE 2005 :-

$$\text{Divisor poly } n^5 + n^4 + n^2 + 1$$

$$\begin{array}{r} 110101 \sqrt{1010001101} \\ \underline{-110101} \end{array}$$

③



Ques is sender Other Reciever.

S

1101

R

in practice we have 1KB P MSB of data

1011011

Both sender & R will know a common no i.e. CRC generator.

from Sender side it will compute the CRC using CRC Generator

If CRC q is 4 bit it append 3 0's if we are going to apply X-OR also called mod 2 Sum.

$\frac{n^3+n+1}{n^3+n+1}$ - Degree of CRC q polynomial is 3
we append

① At Sender D : 11010
crc qp $n^3+n+1 = 1011$

At Receiver again compute CRC.

Assume data is corrupted 1101010

② $Q(u) = u^4 + u^3 + u^1$
 $M(u) = 110101111$