UNIT - 2

Date:_____ Page No:___

DATA LINK LAYER.

Data link layer: ~~Dis~~ Design issue / services / Functions

→ Services provided to Network layer

→ Frame Synchronization

→ Error control

→ Flow control

→ ~~Add~~ Addressing

→ Data and control on same link

→ link ~~Mgt~~ Management (connection establishment / use / termination)

→ Access ~~Mgt~~ Management. (MAC), (NIC)

↓

medium access control

Date:_____ Page No:____

*** SERVICES PROVIDED TO NETWORK LAYER:-

1. Unacknowledged Connectionless Services.
2. Acknowledged connectionless services.
3. Acknowledged connection oriented Services.

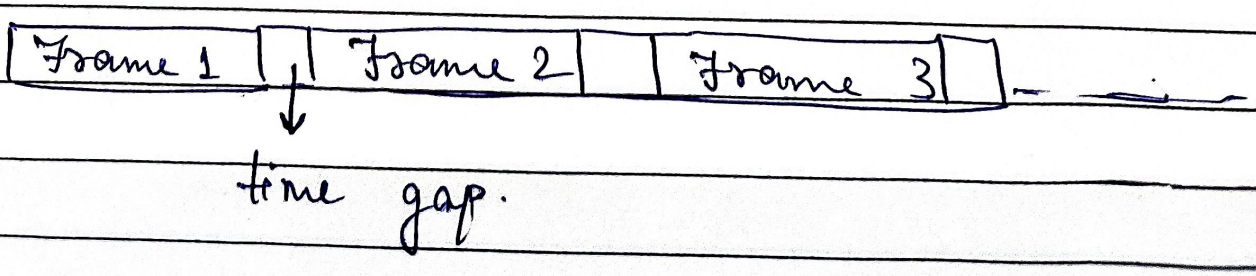
** FRAMING METHODS:-

1. Character Count
2. Starting and Ending Character with character stuffing.

Starting and ending Flag with Bit Stuffing.

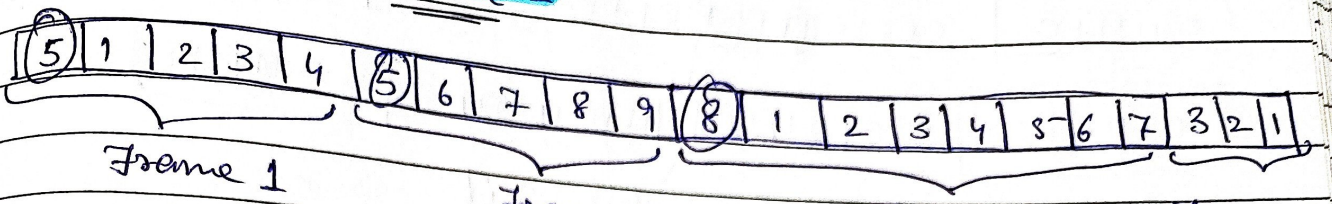
Physical layer coding violation.

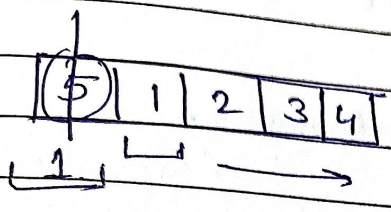
Time gap method failed. (it was not efficient).



Date:_____ Page No:____

(1) Character Count -

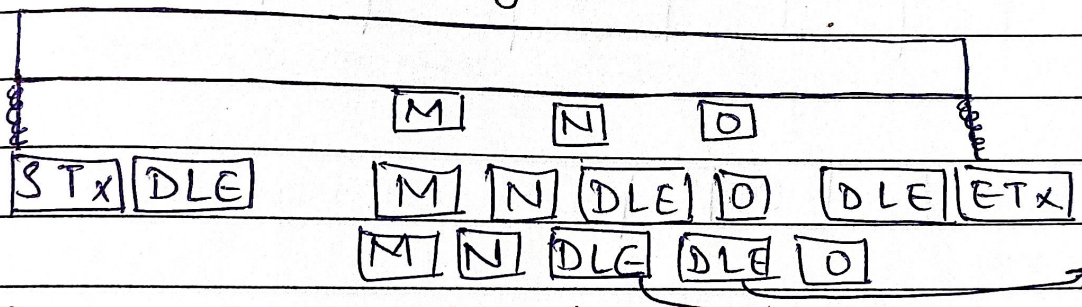




~~due~~ error due to noise.

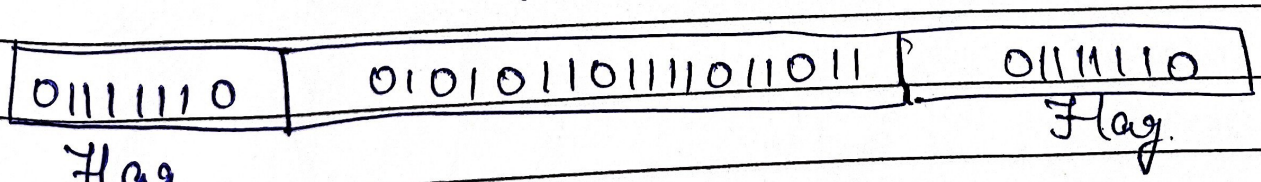
Here, Frames are ~~counted~~ defined by the first character.

(2) Starting and ending char. with char. stuffing -



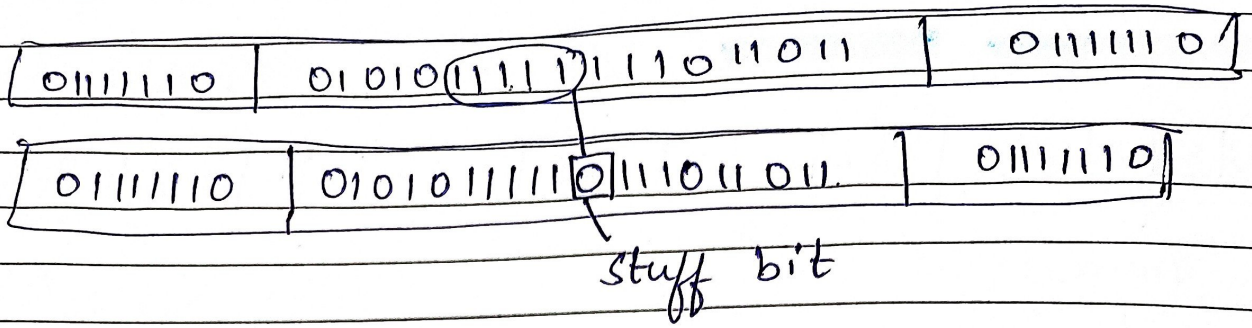
STx - Starting of text
DLE - Data link escape
ETx - Ending of text.

(3) Starting and ending Flag with Bit Stuffing -

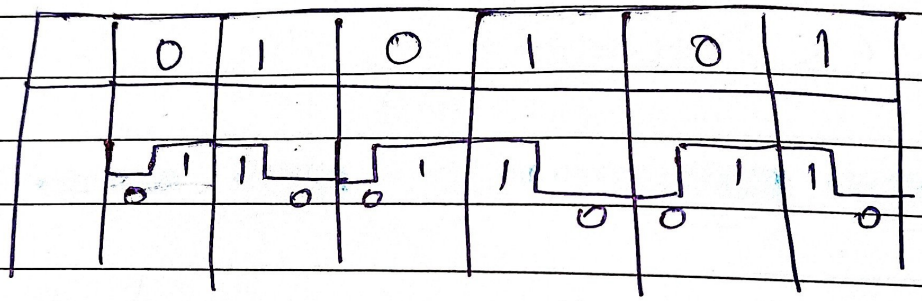


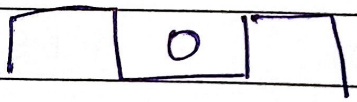
6 consicutive 1 → Flag.
5 consicutive 1 → we will stuff 0
↳ stuff

Date:_____ Page No:____



(4) Physical Layer Code Violations — (Manchester)





** ERROR CONTROL

Date: _____ Page No: _____

ERROR CONTROL

1. Single Bit Error
2. Burst error.

eg.,

original 1 0 0 1 0 1

1 0 0 0 0 1 → error.

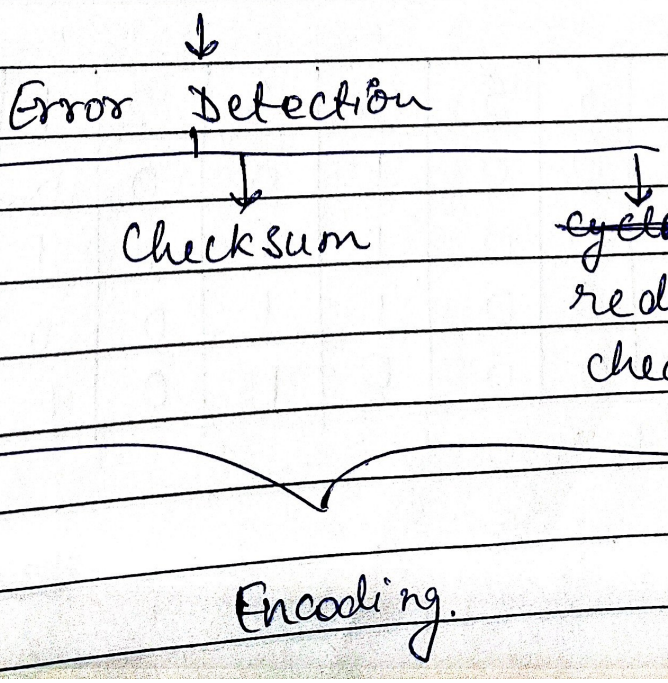
1 0 1 0 0 1 → error.

Acknowledgement can be +ve or -ve.

→ Error detection

→ Timer.

* Flowchart:



Encoding.

Date: _____ Page No: ____

** PARITY BIT

(1,0)

P	0	1	0	0	1	1	0

← 7 bit →

if no. of 1 in the data is even then P = 1.

if no. of 1 in the data is odd then P = 0.

Can only identify 1 bit error.

~~Pari~~

Priority Method (even / odd)

- LRC — Horizontal/longitudinal redundancy check.
- VRC — vertical redundancy check

	P	7	6	5	4	3	2	1
H	0	1	0	0	1	0	0	0
O	1	1	0	0	1	1	1	1
L	1	1	0	0	1	1	0	0
E	0	1	0	0	0	1	0	1

even bit parity

Date: _____ Page No: ____

LRC / VRC -

(Two dimension priority check)

	C	O	M	P	U	T	E	R	LRC priority bit
b_1	1	1	1	0	1	0	1	0	1
b_2	1	1	0	0	0	0	0	1	0
b_3	0	1	1	0	1	1	1	0	0
b_4	0	1	1	0	0	0	0	0	1
b_5	0	0	0	1	1	1	0	1	1
b_6	0	0	0	0	0	0	0	0	1
b_7	1	1	1	1	1	1	1	1	1
VRC bit (even parity)	0	0	1	1	1	0	0	0	0

- Codeword = original data + check sum.

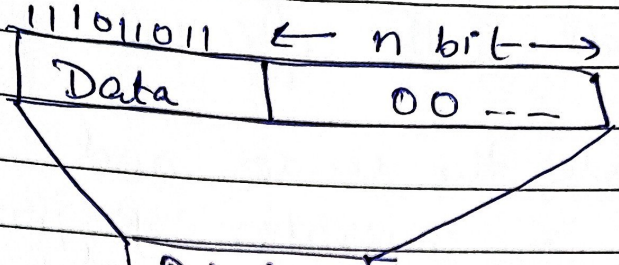
CHECKSUM -

Codeword = Original Data + Checksum.

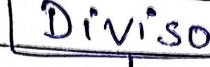
- If m bit checksum is used, the data unit to be transmitted is divided into segments of m bits.
- All the m bit segments are added.
- The result of the sum is then complemented using 1's complement arithmetic.
- The value so obtained is called as checksum

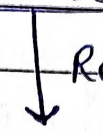
kkk **CYCLE REDUNDANCY CHECK ∞ (CRC)**

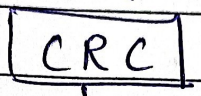
~~Recei~~ Sender:

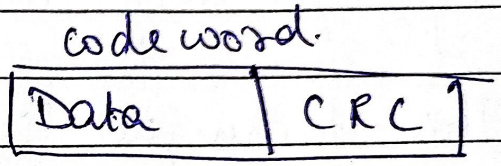


(10101)



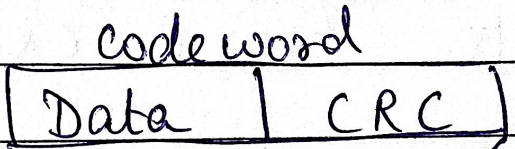


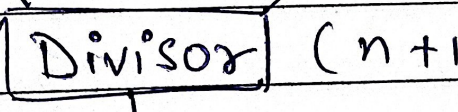


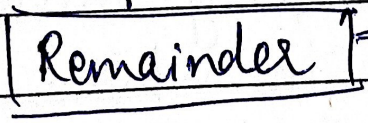


[CRC - generator]

Receiver:







= 0 (no error)

≠ 0 (error)

[CRC - checker]

Polynomial generator

CRC 12, CRC 16

Date: Page No:

* CRC is a type of polynomial code in which a bit string is represented in the form of ~~poly~~ polynomial with coefficient of 0 and 1 only.

* For CRC code, the sender and receiver should agree upon a generator polynomial ~~g(x)~~ G(x).

* A codeword can be generated for a given dataword (message) polynomial M(x) with the help of long division.

* This technique is more powerful than the parity check and checksum error detection.

* CRC is based on binary division, a sequence of redundant bits called CRC.

* CRC remainder is appended at the end of a data unit.

* The resulting data unit after adding CRC remainder becomes exactly divisible by another predetermined binary number.

* At the receiver this data unit is divided by the same binary number. There is no error if this division does not yield ~~and~~ any remainder

Date: _____ Page No: ____

~~1) PRO~~

procedure ~~to obtain~~ CRC

Procedure to obtain CRC -

- The redundancy bits used by CRC are derieved by following the procedure given be
  a) divide the data unit by predetermined divi
  b) obtain the remainder. It is the CRC

Requirement of CRC -

- A CRC will be valid if and only if it satisfies the following requirements -

a) It should have exactly 1 less bit tha divisor.

b) Appending the CRC to the end of data uni should result in the bit sequence which is exactly divisible by the divisor.

Date:_____ Page No:___

** CRC Generator -

a) Append a string of n zeros to the data unit where n is one less than the ~~data unit~~ no. of bits in the pre-decided divisor (n+1 bits long)

b) Divide the newly generated data unit in Step 1 by the divisor. This is a binary division.

c) The remainder obtained after the division in Step 2 is the end bit CRC.

) This CRC will replace the n zeroes appended to the data unit in Step 1, to get the codeword to be transmitted as figure (sender)

t CRC checker -

The codeword received at the receiver consist of data and CRC. The receiver treats it as 1 unit and divides it by the same n+1 bit division which was used at the transmitter. The remainder of this division is then checked. If the remainder is 0, then the received codeword is error free and hence should be accepted. But a non zero remainder indicates presence of error, hence the corresponding codeword should be rejected.

1 ± 1 = 0
0 ± 0 = 0
1 ± 0 = 1
0 ± 1 = 1

} Sub/Add in modulo-2-division.

Date:________ Page No:______

* A CRC checker functions exactly like a generator after receiving the data appending with CRC it does the same modulo-2-division.

Binary Division in a CRC generator

```
                   111101        ← Quotient
                   data
Divisor — 1101 ) 100100 000        Divident
                 1101
                 01000
                  1101
                  01010
                   1101
                   01110
                    1101
                    001100
                      1101
                      0001
```

data = 100100

Q = 111101
R = 001

| 100100 001 | → data + R.

P.T.O.

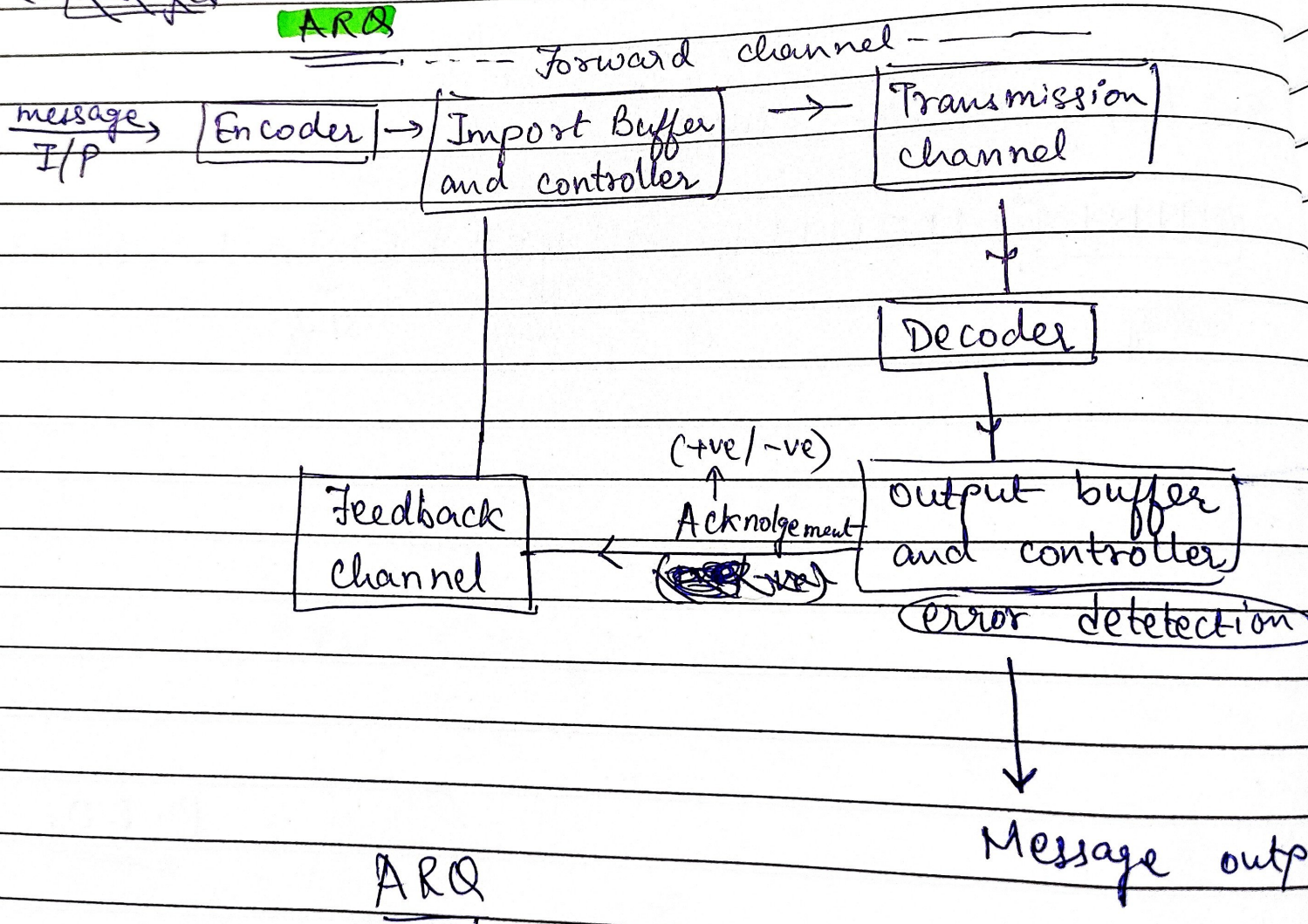
Date: _____ Page No: ____

Error Correction

- ARQ
  - Automatic Request for Retransmission
- FFT / FET
  - Feed Forward Technique / Forward error correction

⇒ message

ARQ



Message outp

ARQ

Date: _____ Page No: _____

ARQ

- Stop and wait ARQ
- Go back n ARQ
- Selective Repeat ARQ.

*** ARQ (Automatic Request for Retransmission)

Q. The code word is received as 1100100101011. Check whether there are errors in the received code word if the divisor is 10101.

```
          11111 10001
      ____________________
10101 ) 1100100101011
        10101
        -----
        011000
         10101
         -----
         011010
          10101
          -----
          011111
           10101
           -----
           010100
            10101
            -----
            000011011
                10101
                -----
                01110
```

Since R ≠ 0, error is there

Date:_____ Page No:____

*** ARQ -

~~*** AN ELEMENTARY DATA LINK~~

* There are 2 basis systems for error detection and correction. The first on being the forward error correction system (FEC) and second one is the ARQ (automatic repeat request)

* In the ARQ system of error control, when an error is detected, a request is made for the retransmission of that signal. Therefore a feedback channel is required for sending the request for retransmission.

* The ARQ system differ from the FEC system in 3 important respects. They are as under -

(i) In ARQ system, less no. of checkbits (parity bits) are required to be sent. This will increase (K/N ratio) for an (n, k) block code if transmitted using the ARQ system.

(ii) A ~~written~~ return transmission path an additional hardware in order to implement repeat transmission of codeword will be required.

(iii) The bitrate of forward transmission must make allow for the backward repeat transmission

Working system operation of ARQ system-

The encoder produces codewords for each message signal as its input. Each codeword at the encoder output is stored temporarily and transmitted over the forward transmissi channel. At the destination, a decoder will decode the codewords and look for errors. A decoder will output a +ve acknowlegement if no errors are detected and it will output a -ve acknowledgement if error is detected. On receiving a -ve acknowledg signal via the return transmission path, The controller will transmit the approp word from the words stored by the inpu buffer. A particular word may be retransmitted only once, or it may be retransmitted twice or more no. of times. The output controller and buffer on the receiver side assemble the output bit stre from the codewords accepted by the dec

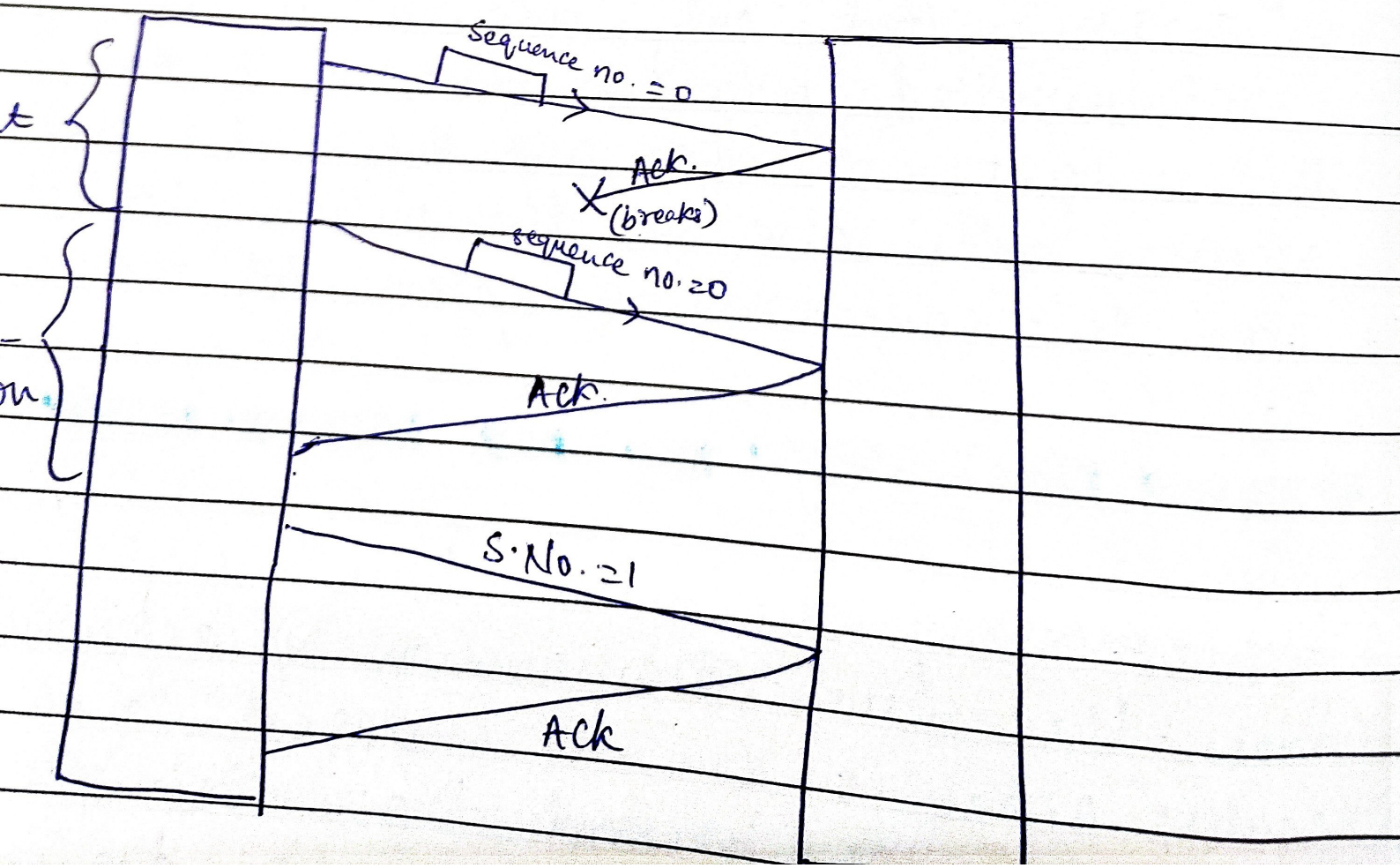
Error Probability on the return path-

The bitrate of the return transmission whi involves the return transmission of acknowle negative ack. is low as compared to the bitrate of the forward transmission. The the error probability of the return transmi

is negligibly small.

AN ELEMENTARY DATA LINK LAYER PROTOCOL

1. An unrestricted simple protocol
2. Simplex Stop and wait protocal
3. A ~~stop~~ simplex protocol for noisy channel
4. Piggy backy concept.



PIGGY BACKY

Date:_____ Page No:____

* The transmission of data needs to be bi-directional. This is called full duplex transmission.

* One way of achieving full duplex transmission is to have 2 seperate channels, one for forward data transfer and other for reverse data transfer but this will waste the bandwith of the reverse channel almost entirely. A better solution would be to use each channel (forward and reverse) to transmit frames both ways, ~~The receiver waits~~ with both channels having the same capacity.

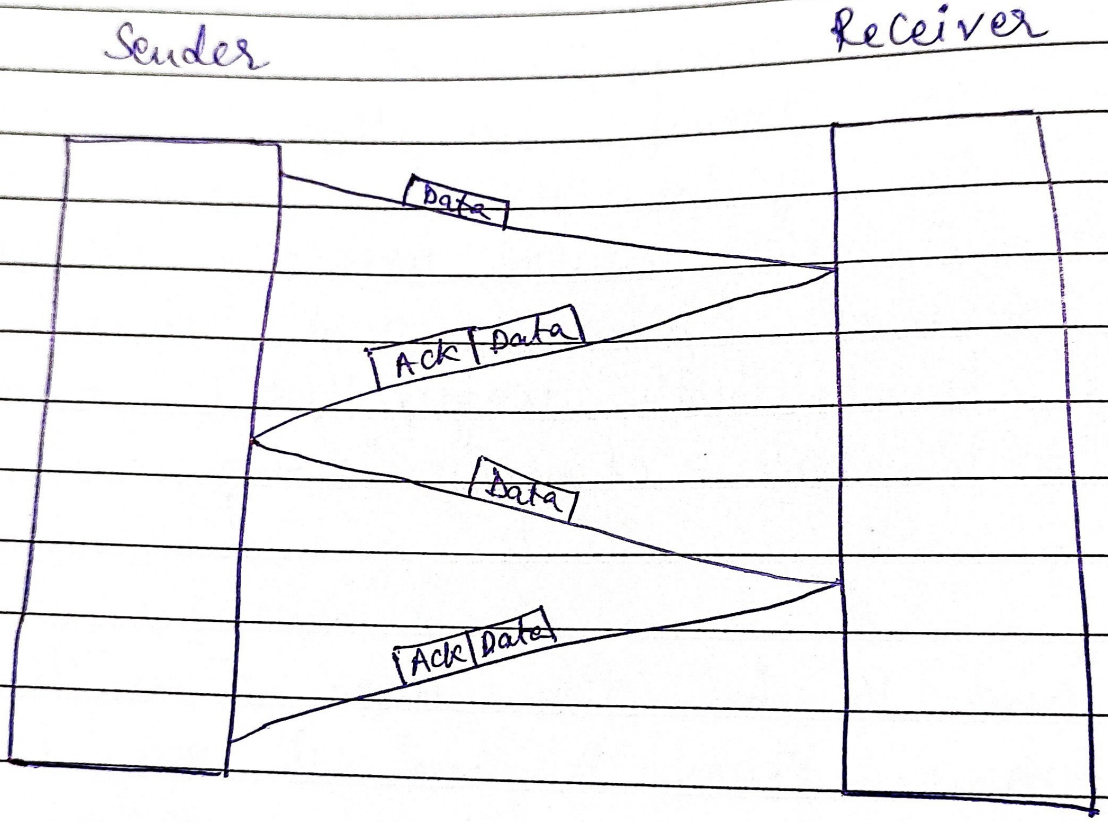
* Let A and B be the user then the data frames from A and B are intermixed with the acknowledgements from A to B, one more improvement can be made when the data frames arrives, the receiver waits, does not send a control frame (acknowledgement) back immediately. The receiver waits until its network layer ~~process~~ passes in the next data packet. The ack. is then attached to this outgoing data frame. This technique in which the outgoing acknowledgement is ~~attached~~

Date:

delayed temporarily is called piggy backy.

+ Advantages:
Better use of available channel bandwith

+ Disadvantages:
Increase overall system complexity



Link management

HDLC (High Level Data Link Control Protocol) –

* Developed by ISO.
* It is the most widely accepted data link protocol.
* It offers a high level of flexibility, adaptability, liability and efficiency of operation.
* HDLC is a bit oriented data link protocol and it satisfies a variety of data control requirements.
* To make HDLC protocol applicable to various possible network configurations, 3 types of stations have been defined –

(a) Primary stations
(b) Secondary stations
(c) Combined stations

A primary station looks after the data link management. In the event of communication b/w the primary and secondary station. The primary station has a responsibility of connecting and disconnecting to data link. The frames sent by the

point to point config. → 1 sender — 1 receiver
point to multipoint config → 1 sender — many receiver

Date: _____ Page No: ____

primary station are commands.

* **Secondary station** - Secondary station operates under the control of a primary station. The frames sent by secondary stations are called responses.

* **Combined Stations** - It can act both as a primary as well as secondary station therefore it can issue both command and responses.

** OPERATING MODES FOR DATA TRANSFER -

* In HDLC both synchronous and asynchronous modes of communications are permitted. Following modes of operation are responsible for data transfer -

(i) Normal Response Mode (NRM) } unbalanced
(ii) Asynchronous Response Mode (ARM) } type.
(iii) Asynchronous Balance Mode (ABM)

~~ASYNCHRONOUS RESPONSE MODE~~ (NRM) - NRM -

This mode is suitable for point to point and point to multipoint configuration. Here the primary station will control the overall data link management. It is a synchron

mode of communication

Date: Page No:

ARM

* In ARM, the secondary station can transmit the response (in form of frame) without taking permission from the primary station. This is not allowed in NRM. Therefore NRM is a more deciplined mode than ARM. The responsibility of link management system still lies with the primary station.

ABM

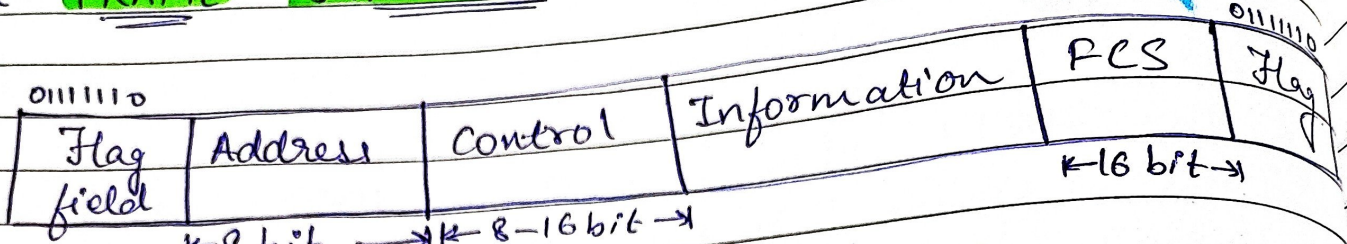
* This mode is applicable to the point to point communication b/w 2 combined station. As both these station are combined station, they are capable of link management functions. As the communication is asynchronous, one station can transmit a frame without permission from the other station, in this mode information frames can be transmitted in full duplex manner.

P.T.O.

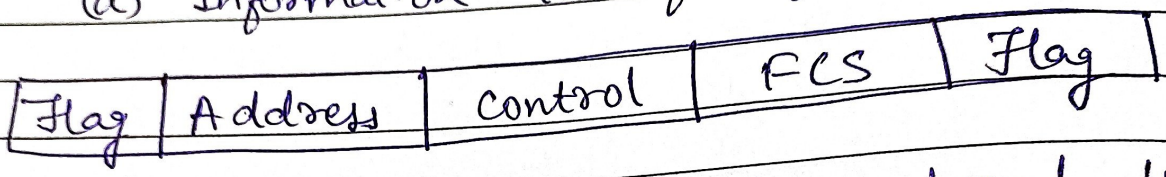
HDLC → High level data link control

Date:_____ Page No:___

*** FRAME STRUCTURE IN HDLC -



(a) Information transfer frame



(b) Supervision and Unnumbered frame

** FLAG FIELD -

* The flag is a unique 8 bit word pattern (01111110). It is used to identify the start and end of each frame.

** ADDRESS FIELD -

* It consists of the address of secondary station respective of whether a frame is being transmitted by primary or secondary station. It consists of 8 bits hence it is capable of addressing 256 addressing.

Date: Page No:

CONTROL FIELD

It usually consists of 8 bit but the no. of bits can be extended to 16. It carries the sequence no. of the frame, acknowledgement, request for transmission and other control commands and responses.

INFORMATION FIELD

This is a 16 The field size of this field is variable and it can consists of any no. of bits. It consists of the user's data bit and it is completely transparent

FRAME CHECKSUM (FCS)

This is a 16 bit field which is used for detection of errors in the address, contsol an information field. It is nothing else but a 16 bit CRC code for error detection.

P.T.O.

P/F = Poll / Final bit
N(S) = Sequence no. of frame sent.
N(R) = Sequence no. of next frame expected.

Page No:
Date:

*** FRAME TYPES IN HDLC

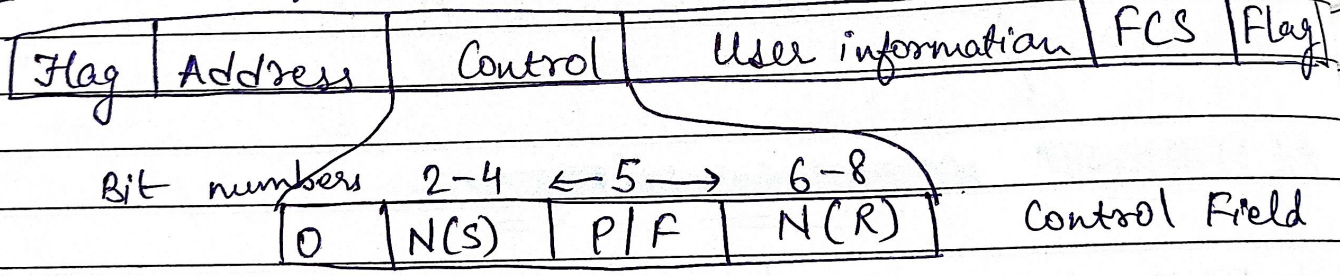
* There are 3 types of frames defined under HDLC. They are -

① The I frame or Information frame (data)

② The S frame or Supervisory frame (control)

③ The U frame or Unnumbered frame (control)

① The I frame



I - frame
8 bit

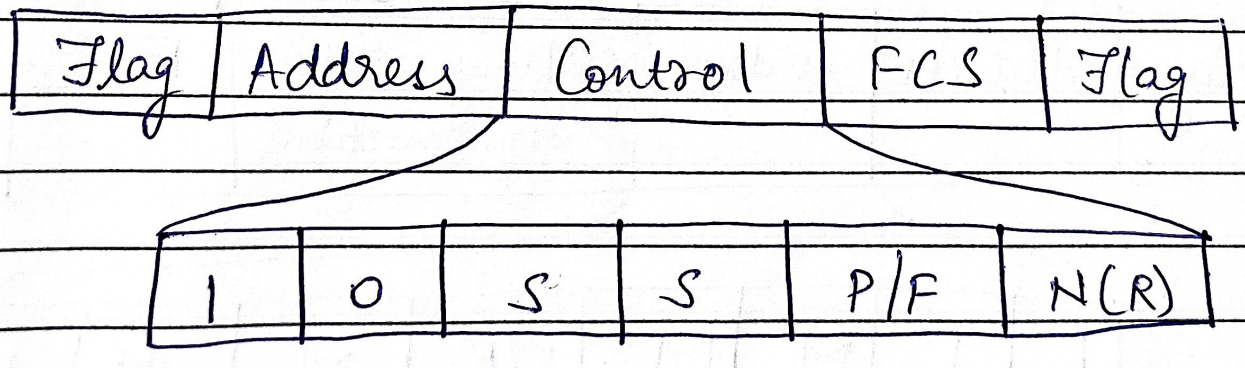
It is supposed to carry the user data from the network layer. It is also possible to include the flow and error control information which is also called piggy backing.

It is the first bit in the control field

Date: Page No:

is zero it is defined as an information frame. The next ~~three~~ three bits 2-4 are called N(S) and they are used to define the sequence no. of the frame. The next bit 5 is Pole / final. It can have two value 0 & 1 out of which it has meaning only when P/F = 1, it means pole when a frame is sent by primary station to secondary and if P/F = 0, it means frame is sent by the secondary station to primary station. When P/F = 1 it store address of secondary station and vice-versa. The last 3 bit 6-8 define the N(R) field. It is usually for piggy backing. The three bits in N(R) field correspond to the acknowledgement when piggy backing is used.

(2) **The S frame** –



The S frame does not contain any information field. These frames are use for flow and error control. When piggybackin

Date:_____ Page No:____

is not possible, First two bits (0,1) of the control fields identify it as supervisory frame the next two bits define the code field marked SS.
There are 4 types of supervisory frames corresponding to the 4 - possible value of the S bits in the control field.

1) SS 00 ⇒ Corresponds to receive ready RR frames which are used to acknowledge frames when no I - frame are available to piggyback the acknowledgement.
2) SS 01 ⇒ Corresponds to reject (REJ) frames which are used by the receiver to send a (NAK) when error has occured.
3) SS 10 ⇒ Correspond to receive not ready (RNR) frame and it is used for flow control
4) SS 11 ⇒ Corresponds to selective repeat frame which indicates to transmitter that it should retransmit the frames indicated in the N(R) sub field.

(3) The U Frame –

Flag	Address	Control	Management Information	FCS	Flag

1	1	M	M	P/F	M	M	M

→ 32 - Function
→ Initialization
→ Status reporting
→ Resetting

→ Management information is main function

DATA LINK LAYER IN THE INTERNET

1. SLIP — Serial line Internet Protocol (1984)
2. PPP — Point to point

Flag	Address	Control	Protocol	Data and padding	FCS	Flag
8 bit	8 bit	8 bit	1 to 2 Byte	8 to 16	2 or 4 bytes	1 byte

PPP

* One of the most common protocol is PPP is used by millions of internet users to connect their home computers to the server of an internet service provider. Most of these users have a traditional model and they are connected to the internet through a telephone line or a TV cable. The PPP is used for controlling and managing the data transfer.

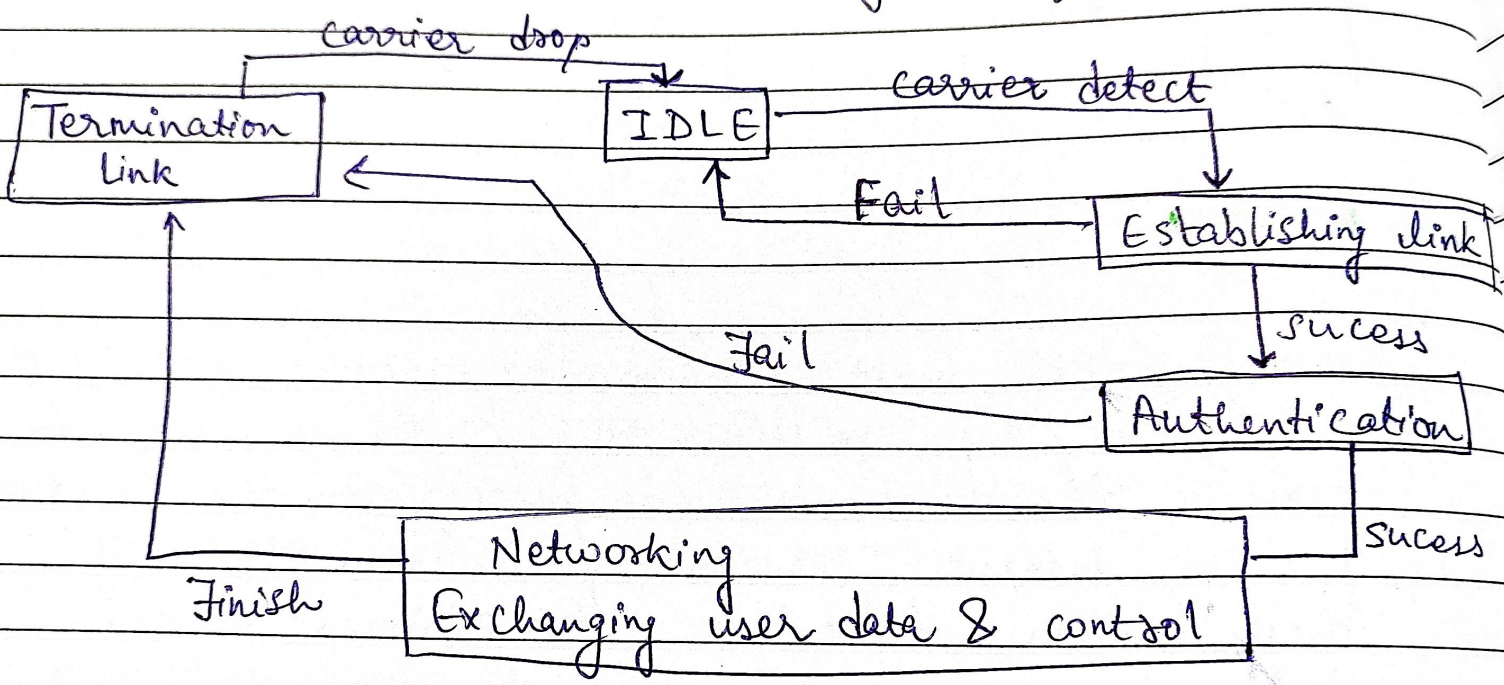
Service provided by PPP

1) defines the format of the frames
2) It defines how the link b/w 2 devices is to be established and how the data exchange should take place.

Date:_____ Page No:____

3) it decides the encapsulation of network layer data into the data link frame.
4) it defines the way in which the two devices can authenticate each other.

Transition State Diagram of PPP



* FDMA – Frequency division multiple access.
* TDMA – Time division multiplex access.
* CDMA – Code division multiple access.

Date: Page No:

DDL

Sublayer-1
LLC
Sublayer-2
MAC

Logical link control

Medium access control

① Static channel Allocation
② Dynamic channel Allocation.

have dedicated communication path

→ Frequency division multiplexing (FDM)
→ Time division multiplexing (TDM)
→ Code division multiplexing
→ Wave division multiplexing (WDM)

static

ttt FDMA –

(10 – 200 freq. for this eg.).

[Freq. = 100, Time = 2

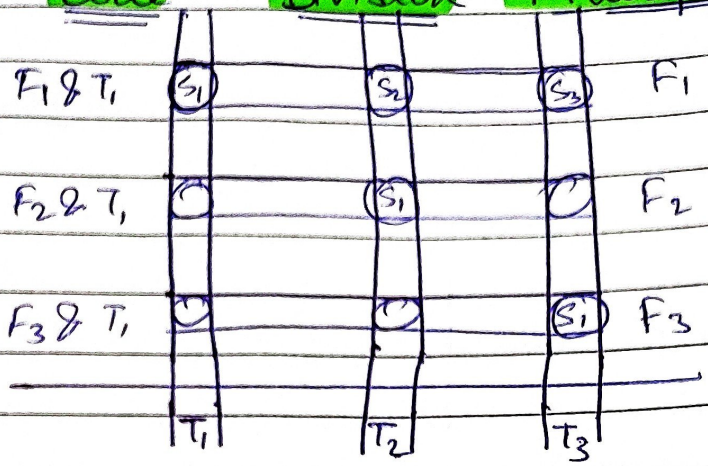
Freq.
15

In FDMA, we have 100% Time.

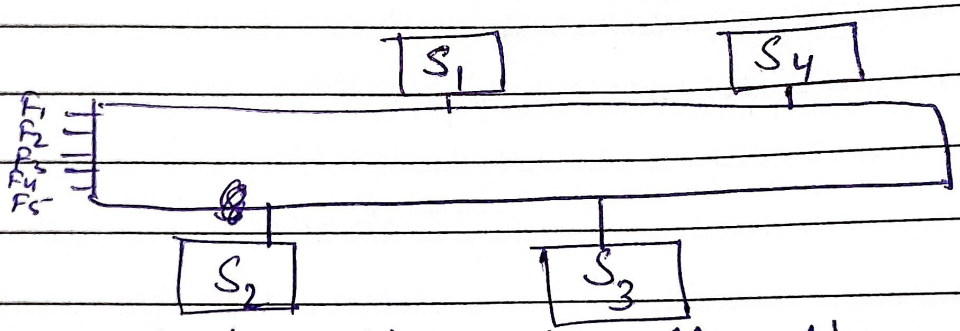
Date:_____ Page No:____

*** TDMA ... (we have 100% Frequency but limited time)

*** Code Division Multiplexing



*** CODE DIVISION MULTIPLEXING



Static Channel allocation.

S_1 use F_1 line

S_2 use F_2 line & so on - - -

imited
ne)

Imp

Date:_____ Page No:____

Multiple Access Method

Control access

- Random Access
  - PURE Aloha
  - SLOTTED Aloha
  - CSMA (carrier sense multiple access)
  - CSMA/CD (collision detection)
  - CSMA/CA (collision avoidance)
  - Collision Free Protocol (Bit Map protocol).

[performance
- 18%
- 36%]

- Token passing
- polling

Chanelizat
- FDMA
- TDM
- CDM

PURE ALOHA

Frames are transmitted at arbitory time.

Through put (S) = $G \times e^{-2G}$

The max utilization is about 18.4%.

Global time is not required.

SLOTTED ALOHA

Time is divided up into discreate slots, the frame is sent at start of slot.

Through put (S) = $G \times e^{-G}$

The max utilization is about 36.8%.

It requires Global

CSMA (Carrier Sense Multiple Access)

→ Non-Persistent

→ 1-Persistent

→ P-Persistent

PURE ALOHA	SLOTTED ALOHA
	time for synchronization as it is divided up into discreate slot.
* Simple to implement.	Implementation is comple due to synchronizatio of all node on statio
* Cannot use for satellite due to very slow utilization.	It is used in broadcast satellite.