Data link control

It is necessary to impose a layer of control in each communicating device that provides functions such as flow control, error detection and control. This layer of control is known as a data link control protocol.

Requirements for effective data communication bet transmitting and receiving stations.

① Frame synchronization:

→ Data are sent in blocks called frame.

→ The begining and end of each frame must be recognizable.

→ It ~~reco~~ determines how much data will be transfered each time.

(ii) Flow control:

→ The sending station must not send frames at a rate faster than the receiving station can absorb them.

→ If rate is not same receiver maybe overflow.

(iii) Error control

→ Bit errors introduced by transmission system should be corrected.

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(iv) Addressing.

→ On multipoint line the identity of the two stations involved in a transmission must be specified.

(v) control and data on same link:

→ It is not desirable to have a physically seperate communications path for control information.

→ It receiver must be able to distinguish control information from the data being transmitted.

(vi) Link management

→ Link should be established when transmitter and receiver both are free.

Flow control

It is technique for speed matching of transmitter and Receiver.

2 types -

(i) stop-and-wait

(ii) sliding window

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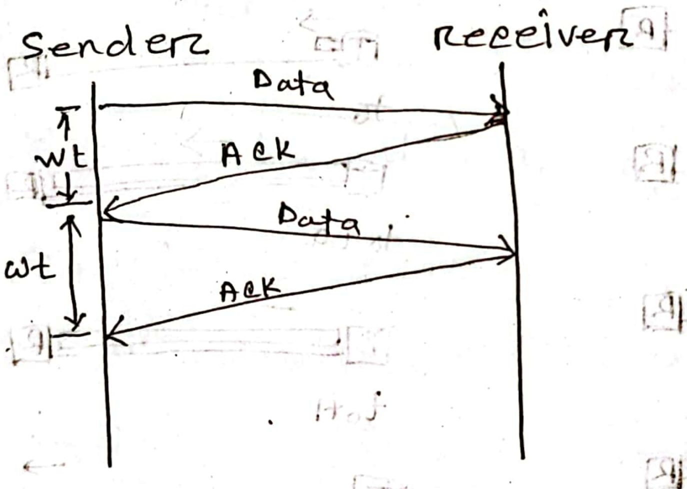
Stop-and-wait flow control

→ Simples form of flow control.

→ the receiver indicates its readiness to receive data for each frame.

→ the sender waits for an acknowledgement after every frame it sends.

→ Only when an acknowledgement has been received then the next fram is sent



→ If acknowledgment is not receive after certain time, sender resends datat.

→ when receiver gets same data it discard previous and replace with new one

→ Data shouldn't buffer size of the receiver

→ small frame = less error + transmission line can be used by multiple user.

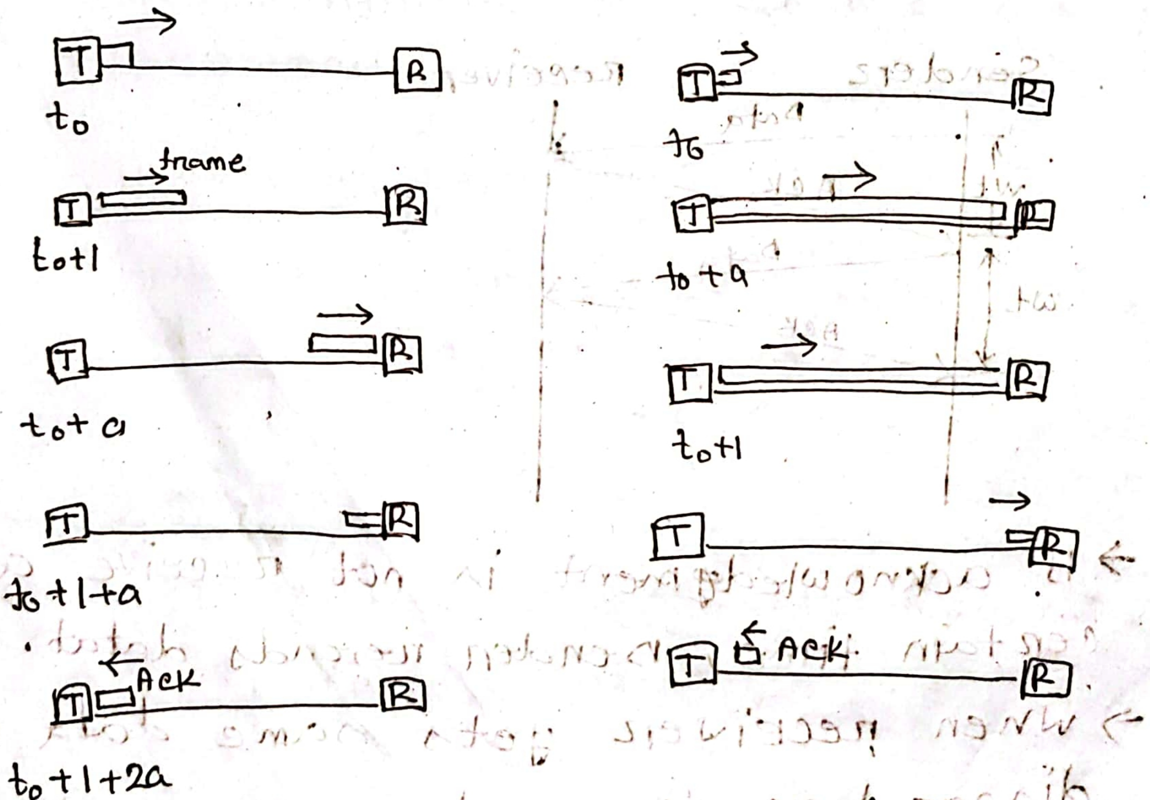
Link utilization

transmission time → time for moving one single frame from transmiter to medium

Propagation time → time for transfering one bit data from transmiter to receiver.

Let, a = propagation time

transmission time = 1



$a<1$

short distance

→ Receiver overflow

$a>1$

long distance

→ more line engage

Drawbacks of stop-and-wait flow control

(i) Only one frame can be in transmission at a time.

(ii) This leads to inefficiency if propagation delay is much longer than the transmission delay.

(iii) Inefficient for high data rates or long distance between sender and receiver.

$T_f = \frac{L}{R}$ — time to sent bits into link

R = Link bandwidth (bps)
L = packet length (bits)

Link efficiency $U = \frac{T_f}{T_f + 2a}$

$a = \frac{d}{S}$ → propagation delay.

d = length of physical link
S = propogation speed

Sliding-window flow control

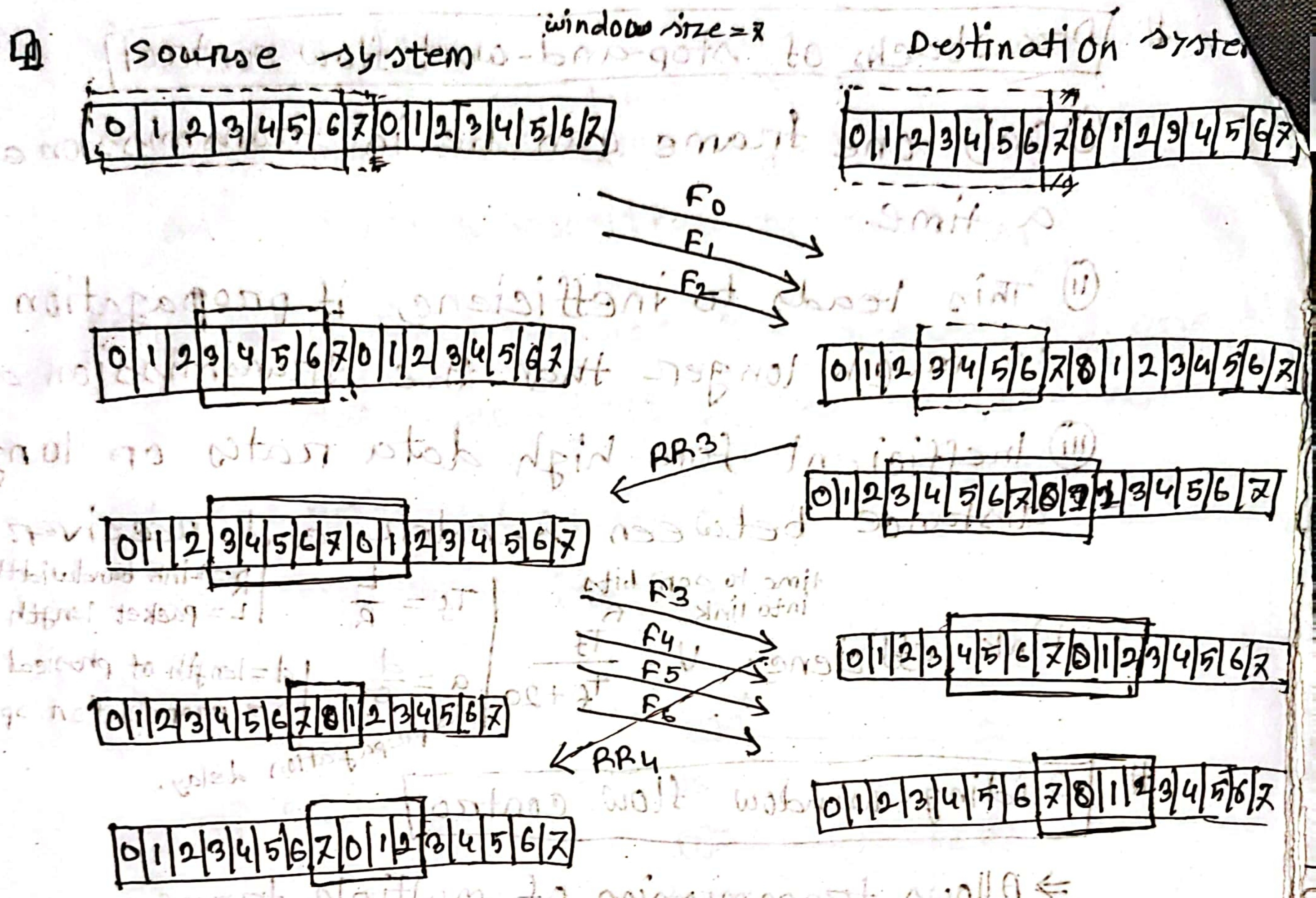
⇒ Allows transmission of multiple frames

⇒ Assigns each frame a k-bit sequence number.

⇒ Range of sequence number is $[0 \ldots 2^k-1]$ i.e

~~Ranges are counter modulo 2^k~~

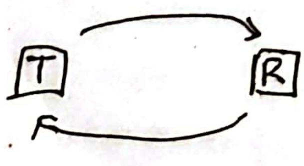
Frames are counted modulo 2^k



Piggybacking

If two stations exchange data, each needs to maintain two windows, one for transmit and one for receive and each side needs to send the data and acknowledgement to the other.

⇒ When receiver wants to send acknowledgement to sender, it waits until it has data to send back



Error control

2 types

(i) Lost frame: frame fails to arrive at the other side.

(ii) Damaged frame: recognizable frame arrives but some of the bits are in error.

techniques for error control

(i) Error detection

(ii) Positive acknowledgement

(iii) Retransmission after timeout

→ After predetermind amount of time, if receiver don't send any acknowledgement, the source retransmits a frame.

(iv) Negative acknowledgement and retransmission

These techniques refers to ARQ.

ARQ → Automatic Repeat Request

3 types of ARQ

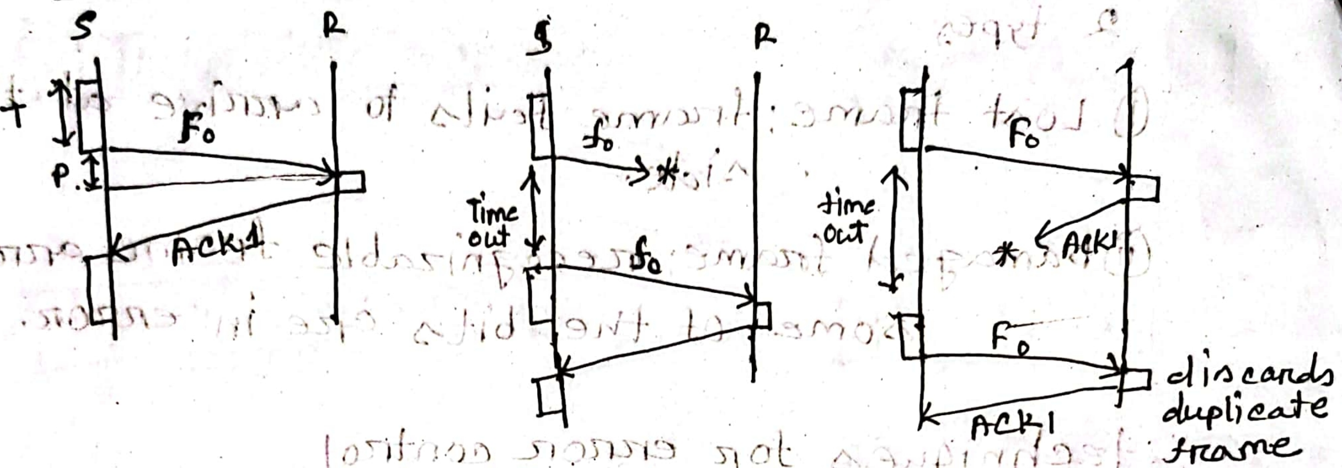
(i) stop-and-wait ARQ

(ii) Go-back-N ARQ

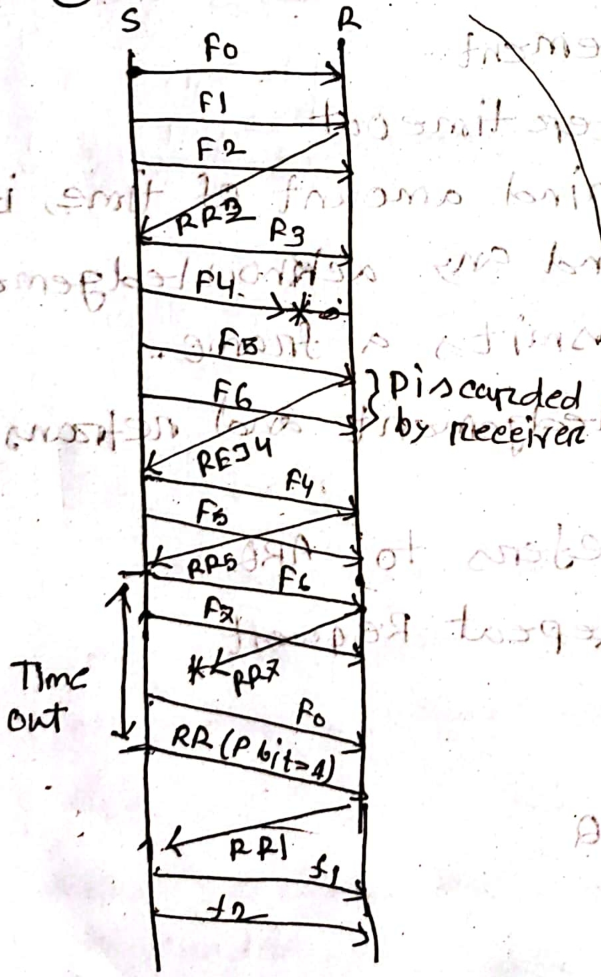
(iii) Selective reject ARQ

(i) stop-and-wait ARQ

transmission time = T
propagation " = P



(ii) Go-Back-N ARQ



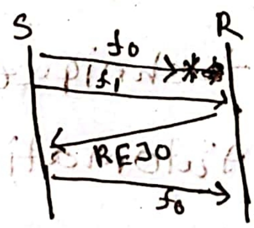
(iii) Selective-reject ARQ

যেই fram নষ্ট হবে শুধু ঐ frame পাঠাবে।

bt, sequence break হয়ে যায়।

3 contigencies:

(i) Damaged frame



→ R receives frame (i+1) out of order

→ R sends REJ i.

(ii) Damaged RR

(iii) Damaged REJ

HDLC

→ High-Level Data Link control

3 types of station

① Primary station
→ control the operation of the link
→ Frames issued by it is called command

ⓘⓘ secondary station
→ operates under the control of primary station
→ frames are called responses.

ⓘⓘⓘ combined station
→ Primary + secondary

2 link configuration

① Unbalanced configuration
→ one primary + one or more secondary station
→ supports half + full - duplex transmission

ⓘⓘ Balanced configuration
→ two combined station
→ half + full duplex

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3 data transfer modes

① NRM → Normal Response Mode

→ Unbalanced configuration.

→ Primary initiate data transfer to secondary

→ secondary only transmit data in response to a command from the primary.

(ii) Asynchronous balance mode (ABM)

→ balanced configuration

→ ~~secondary~~ either combined station may initiate transmission without receiving permission from other combined station

(iii) Asynchronous response mode (ARM)

→ Unbalanced configuration

→ secondary may initiate transmission

Frame structure

Header — trailer

Flag	Address	control	information	FCS	Flag
←8→	← 8 → extendable	←8 or 16→	←Variable→	←16 or 32→	← 8 →

Fag → 01111110

Bit stuffing

→ While receiving a frame a station continues to hunt for flag sequence to determine the end of the frame

→ But '0111110' this sequence may be contained in the information part.

→ This may destroy the synchronization.

→ To solve this problem transmiter insert an extra '0' whenever it find 5 consecutive ones.

→ The receiver removes that extra '0' after receiving.

→ This process is known as bit stuffing.

e.g. original pattern → 111111001111101

After bit shifting → 11111010011111001

Address field

→ identifies the secondary station

→ usually 8-bit but can be extended

→ To determine last octant left most bit is '1'.

0	0	1
8bit	8 bit	8 bit

→ last octant of address field

→ single octant address of 11111111 is used to allow the primary to broadcast a frame for reception by all secondaries.

control field

3 types of frames:

(i) I: Information → carry the data to be transmitted
→ flow and error control data are piggybacked.

1	2 3 4	5	6 7 8
0	N(S)	P/F	N(R)

(ii) S: supervisory → Provide ARQ machanism when piggybacking is not used.

1	2	3 4	5	6 7 8
1	0	S	P/F	N(R)

(iii) U: Unnumbered → Provide supplement link control function

1	2	3 4	5	6 7 8
1	1	M	P/F	M

N(S) → send sequence number
N(R) → Receive sequence "
S → supervisory function bits
M → Unnumbered function bits
P/F → poll / final bit

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1

Why is break up of large block of data into smaller blocks necessary in stop and wait flow control?

Ans.

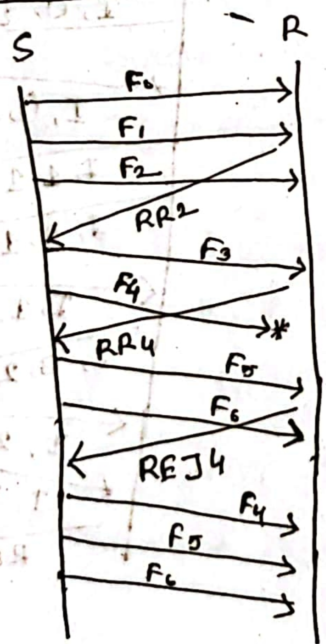
(i) Buffer size of the receiver may be limited.

(ii) The longer the transmission ~~of~~ the more likely that there will be an error.
with smaller frame errors are detected sooner.

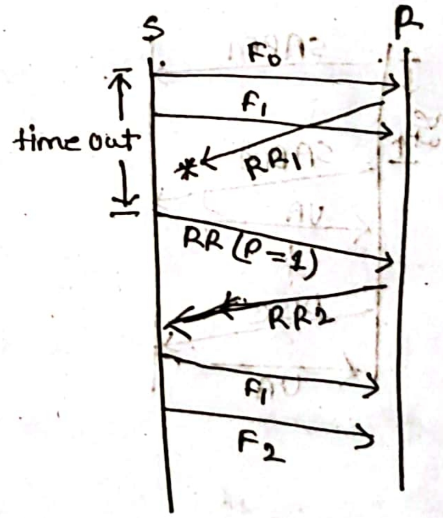
(iii) Long frame occupies medium for long time.

Go-back-N ARQ

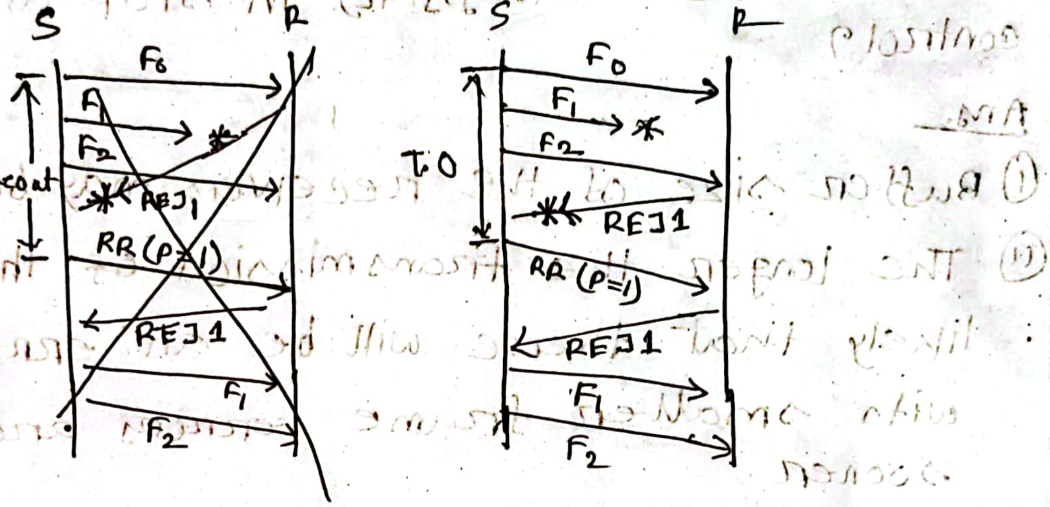
(i) Damaged Frame



(ii) Damaged RR



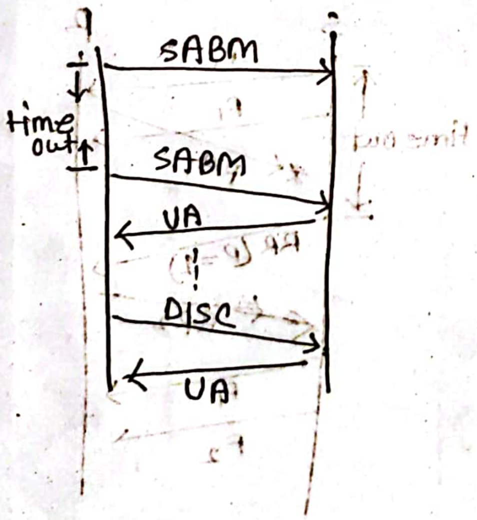
(iii) Damaged Rej



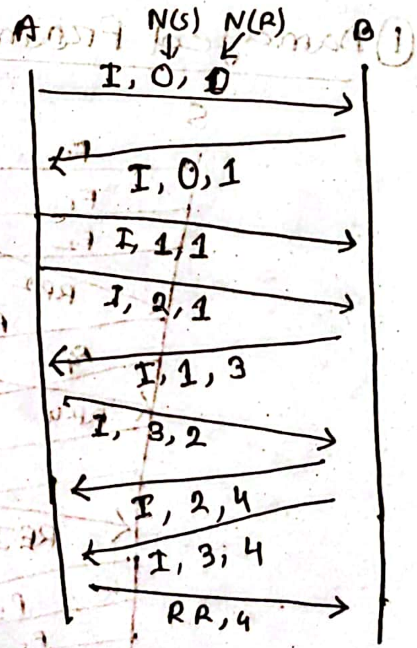
HDLC operation

(i) initialization (ii) Data transfer (iii) Disconnect

a) Link setup and disconnect



b) Two way data exchange



Cyclic Redundancy check (CRC)

→ most powerful error detecting code

→ K-bit block of message. $\boxed{M}$ k bit

→ transmiter generates (n-k) bits sequence, known as fram check sequence (FCS)

→ Resulting frame consists of n bits, is exactly divisible by some predetermined number.

→ The receiver divides the incoming frame by that number.

→ If there is no ~~error~~ remainder, there is no error.

modulo 2 arithmetic

→ It uses binary addition with no carries. i.e. XOR operation.

say, T = n bit frame to be transmitted.

M = k bit block of data, first k bit of T

F = (n-k) bit FCS. last (n-k) bit of T

P = pattern of n-k+1 bit, this is predetermined divisor.

We would like T/P to have no remainder.

$$T = 2^{n-k} M + F$$

By multiplying M by 2^{n-k}, it is left shifted by n-k bits. Adding F yields the concatenation of M and F.

Now, $\dfrac{2^{n-k} M}{P} = Q + \dfrac{R}{P}$

As division is modulo 2, the remainder is always at least one bit shorter than the divisor.	$P \; 5 \overline{)\,11\,}\, 2 \to Q$ 10 $1 \to R$ $11 = 5 \times 2 + 1$ $\Rightarrow \dfrac{11}{5} = 2 + \dfrac{1}{5}$ $= Q + \dfrac{R}{P}$

$\therefore T = 2^{n-k} M + R$ | R = FCS Now

Now, $\dfrac{T}{P} = \dfrac{2^{n-k} M + R}{P}$

$$= \frac{2^{n-k} M}{P} + \frac{R}{P}$$

$$= Q + \frac{R}{P} + \frac{R}{P}$$

$= Q + 0$ [any binary number added to itself modulo 2 yields 0]

$= Q$

B

Given, message $M = 1010001101$ (10 bits)

$P = 110101$ (6 bit)

FCS $R = ?$

Here $k = 10$ bits, $n-k+1 = 6$ bits. $\therefore n = 15$ bits

$\therefore n-k = 5$ bits

Now, $2^{n-k} \cdot M = 2^5 M = 101000110100000$

```
                 1101010110      ← Q
110101 ) 101000110100000         ← 2^(n-k) M
         110101
         ------
          111011
          110101
          ------
            111010
            110101
            ------
              111110
              110101
              ------
               101100
               110101
               ------
                110010
                110101
                ------
                  1110           ← R
```

$T = 2^{n-k} M + R = 10100011010\,1110$. it will be transmitted.

at the receiver side,

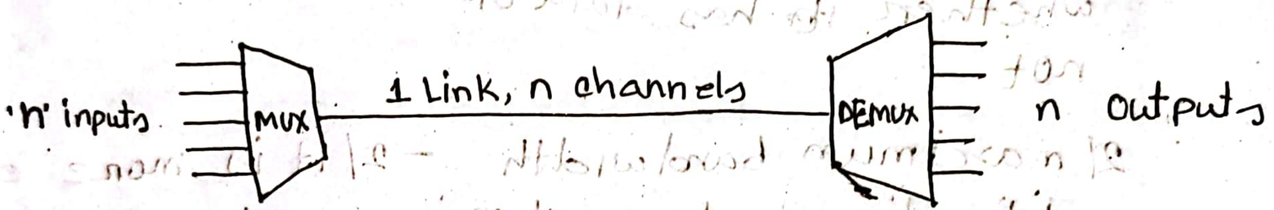
```
                1101010110      ← Q
110101 / 101000110101110        ← T
         110101
         ------
          111011
          110101
          ------
           111010
           110101
           ------
            111110
            110101
            ------
             101111
             110101
             ------
              110101
              110101
              ------
                   0            ← R
```

No remainder, so, no error.

4

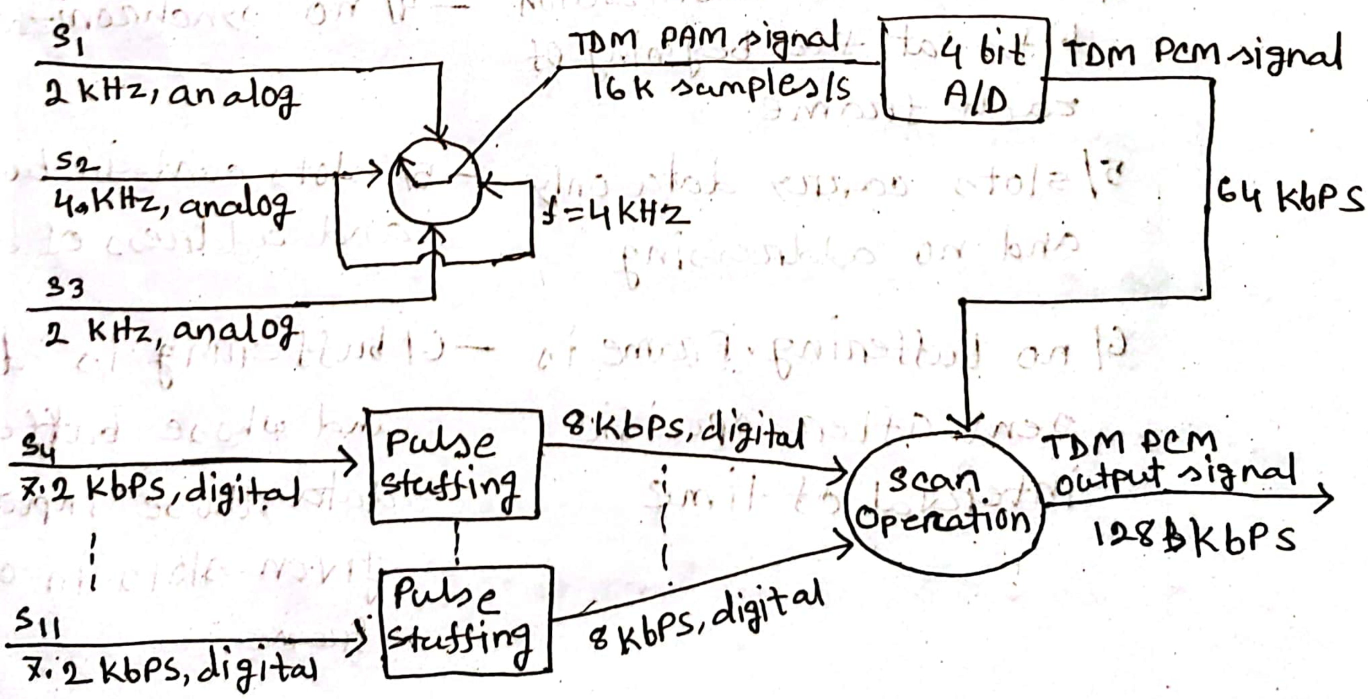
Multiplexing

It is a way of sending multiple signals over a communication link at the same time in the form of single signal.



☐ S_1, S_3 : Analog, 2 KHz bandwidth
S_2 : " , 4 KHz "
S_{4-11} : Digital 7200 bPS

Design and draw TDM system.



Synchronous TDM vs statistical TDM

Synchronous	Statistical
1/ Time slots are allocated to each input device whether it has data or not	1/ Time slots are allocated dynamically.
2/ maximum bandwidth utilization is done when all inputs have data to send	2/ It is more effective as it allocates time slot on demand.
3/ number of slots in each frame are equal to number of input lines.	3/ number of slots in each frame are less than the number of input line
4/ It uses synchronization bits at the begining of each frame	4/ no synchronization bits
5/ slots carry data only and no addressing	5/ slots contain both data and address of destination.
6/ no buffering. Frame is sent after specific interval of time	6/ buffering is done. and whose buffer contains data, those inputs are given slots in output frame.

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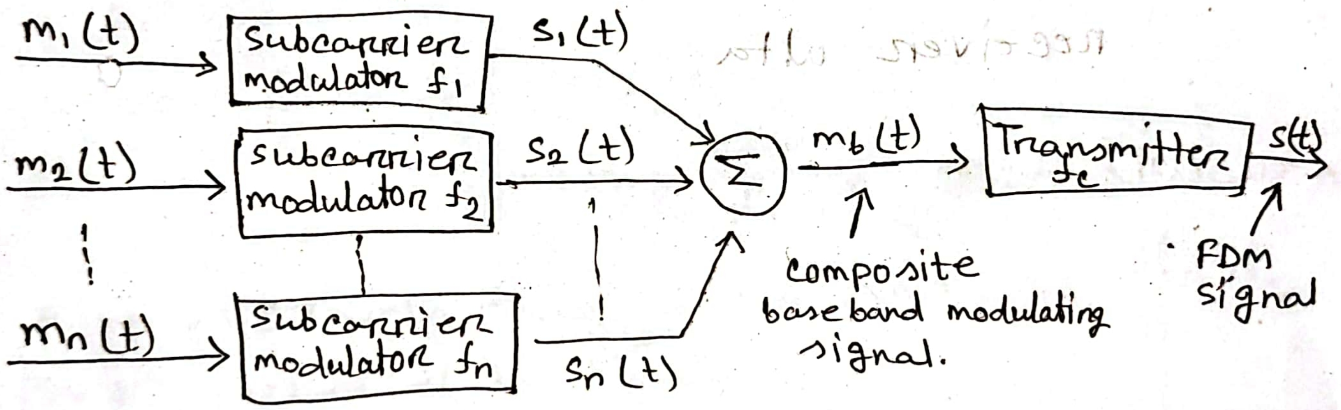
Synchronous TDM is called synchronous if

⇒ Time slots are preassigned to sources and fixed.

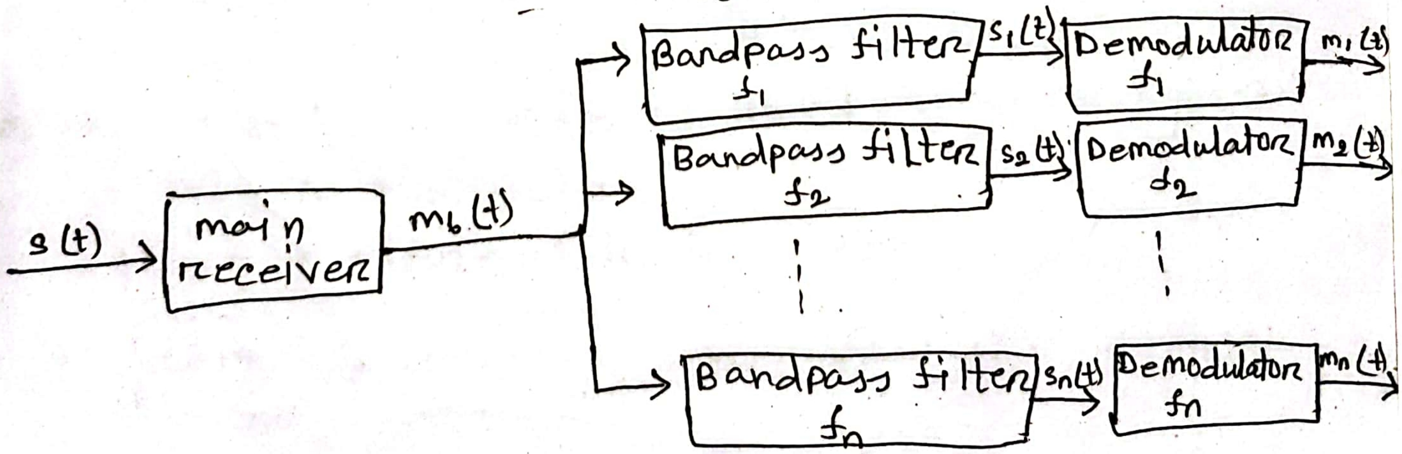
⇒ Time slots for each source are transmitted whether or not the source has data to send.

⇒ Therefore, synchronous transmission is used.

$\boxed{\text{FDM}}$



Transmitter



Receiver

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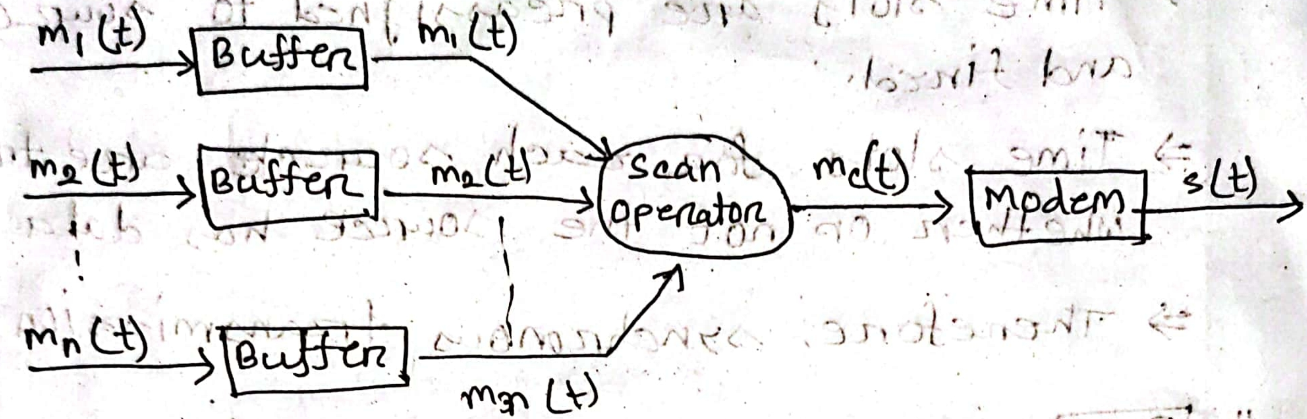
$\boxed{\text{TDM}}$



Transmitter

receiver ulta

ADSL

→ Asymmetric Digital Subscriber Line

→ provides more capacity downstream than upstream.

→ It uses FDM.

→ high speed data transmission over ordinary telephone wire.

There are 3 elements of ADSL —

(i) Reserve lowest 25 kHz for voice, known as POTS (Plain Old Telephone service).

→ The voice is carried only 0-4 kHz band.

→ additional bandwidth is to prevent crosstalk bet^n voice and data channels.

(ii) Use either echo cancellation or FDM to allocate two bands.

→ smaller upstream band and larger downstream band.

(iii) Use FDM withing upstream and downstream band.

→ a single bit stream is split into multiple parallel bit streams.

→ each portion carried in a separate frequency band.

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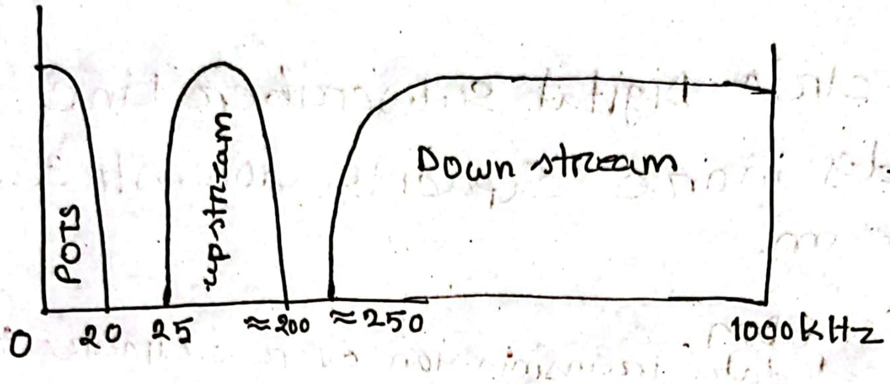
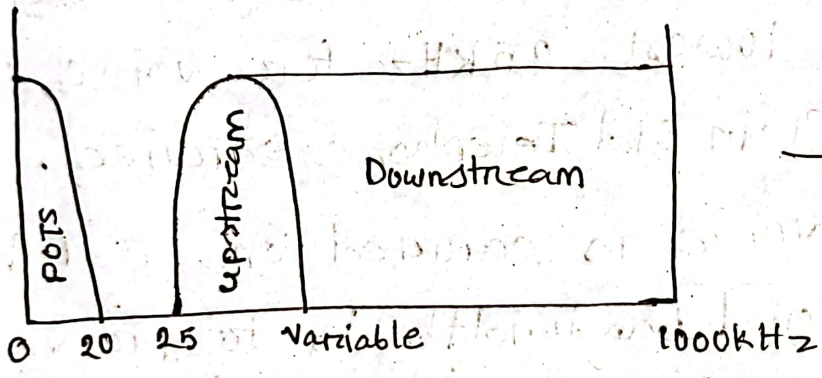


→ FDM



→ echo cancellation

when echo cancellation is used, the entire frequency band for upstream overlaps the lower portion of the downstreame channel. It has 2 advantages.

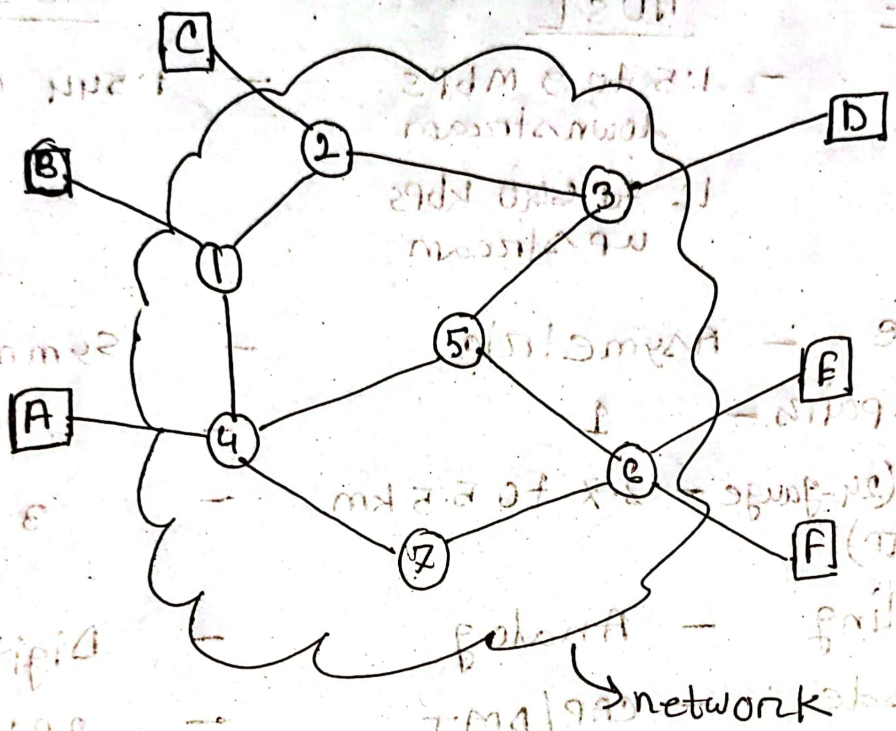
(i) more of the downstream bandwidth is in the good part of the spectrum.

(ii) The upstream channel can be extended upward without running into the downstream, area of overlap is extended.

ADSL vs HDSL

topic		ADSL		HDSL
bps	–	1.5 to 9 Mbps downstream 16 to 640 kbps up stream	–	1.544 or 2.048 Mbps
Mode	–	Asymetric	–	Symmetric
copper pairs	–	1	–	2
Range (24-gauge UTP)	–	3.7 to 5.5 km	–	3.7 km
Signaling	–	Analog	–	Digital
Line code	–	CAP/DMT	–	2B1Q
Frequency	–	1 to 5 MHz	–	196 kHz
Bits/cycle	–	Varies	–	4

Circuit switching



3 phases.

① Circuit establishment:

suppose we want to send data from A to E. A sends request to 4. say, based on availability and cost node 4 requests to node 5. Now, 5 requests to 6 and 6 is directly connected with E. so, path is $A \to 4 \to 5 \to 6 \to E$

Once circuit is established other user can't use that line until connection is terminated.

(ii) **Data transfer** : Transferring data through that path.

(iii) circuit disconnected : can be terminated from any station. signals must be propagated to connected nodes to deallocate the dedicated resources.

⇒ Inefficient, because whether one transfers data or not, once conn. circuit is established no other can use it.

A public telecommunications network can be described using 4 generic architectural components—

(i) subscriber → The devices that attach to the network.

(ii) Subscriber line → The link bet^n subscriber and the network.
→ also reffered to as subscriber loop or local loop

(iii) Exchanges → switching centers in the network
→ The switching center that directly support subscriber is known as end office.

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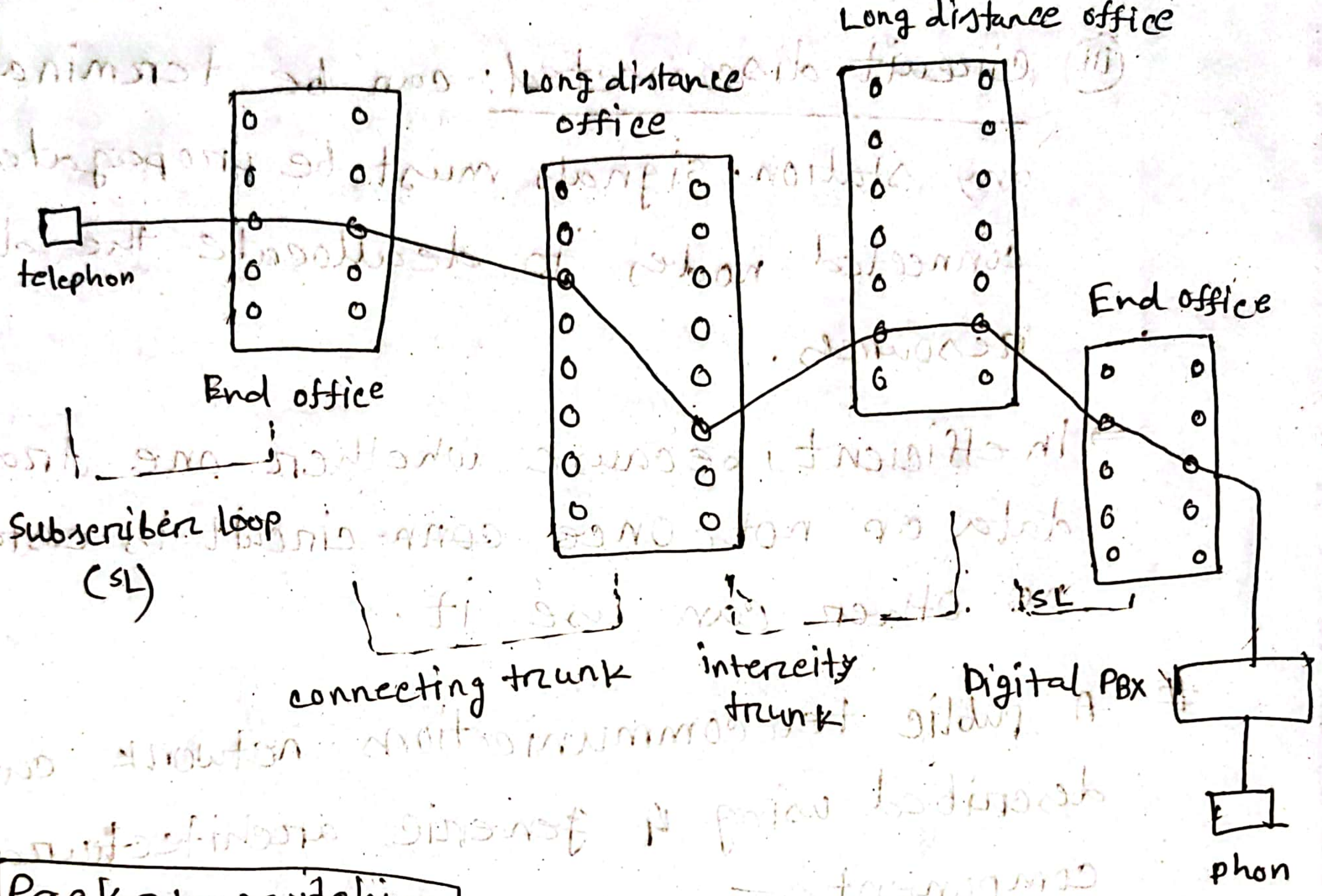
④ Trunks → The branches betn exchanges.



Packet-switching

→ message is broken up into a series of packets

→ each packet contains a portion of data + control information.

→ each route receives packet, stores briefly and passed on to next node.

2 types:

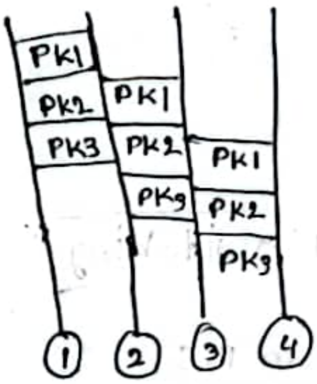
① Datagram approach

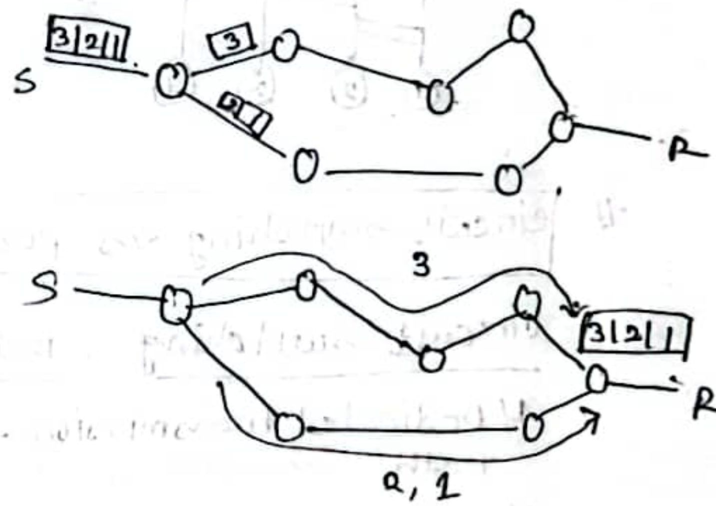
② virtual approach

Datagram approach

→ each packet is treated independently
→ choose next node on a packet's path based on information received from neighbouring nodes, line failures and so on.
→ Packets each with same destination address do not follow the same route.
→ They may arrive out of sequence at the exit point.

→





Virtual approach

→ Preplanned route is established before sending any packets
→ all the packets follow the same route
→ duration of logical connection, is similar to a circuit switching network.
→ each packet contains virtual circuit indentifier and data.

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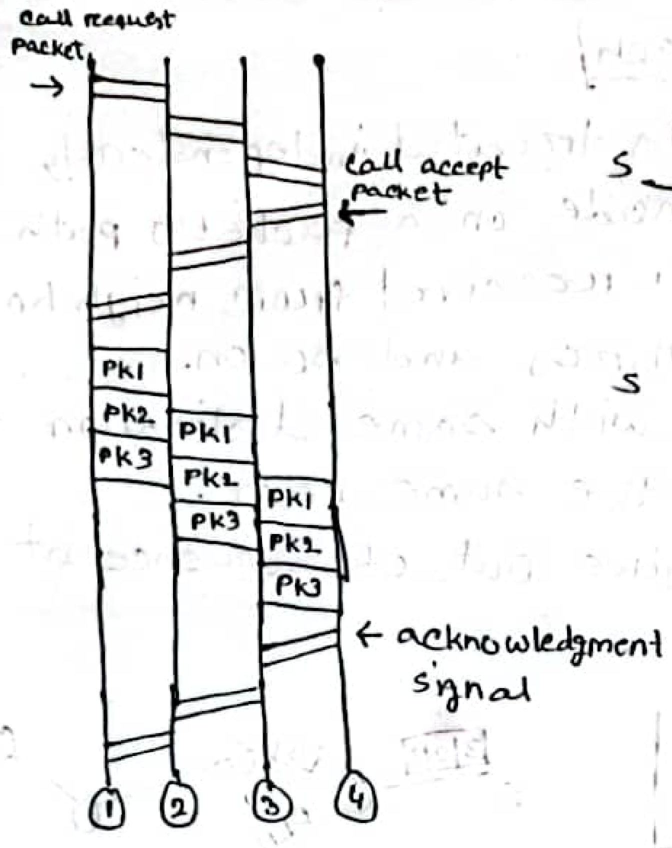

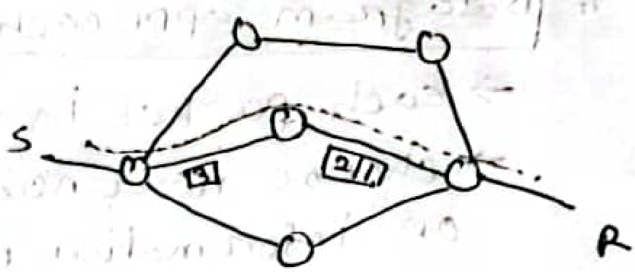

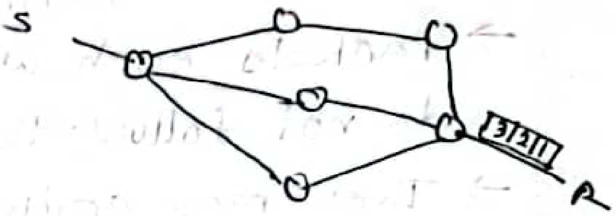

circuit switching vs packet switching

circuit switching	Datagram P.S.	virtual P.S
1/ Dedicated transmission path	1/ not	1/ not
2/ continuous transmission of data	2/ Transmission of packets	2/ transmission of packets
3/ messages not stored	3/ may be stored until delivered	3/ stored untill delivered.
4/ path is established for entire conversation	4/ route is established for each packet	4/ route is established for entire packet

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5/ call set delay. negligible transmission delay	5/ Packet transmission delay	5/ call set setup delay. transmission delay.
6/ Overload may block call set up; no delay for established calls	6/ overload increases packet delay	6/ over load may block call set up; increases packet delay.
7/ Fixed bandwidth	7/ Dynamic use of bandwidth	7/ Dynamic use of bandwidth

Key features of X.25

(i) call control packets, used for setting up and clearing virtual circuits, are carried on the same channel and same virtual circuit as data packets.

(ii) multiplexing of virtual circuits takes place at layer 3.

(iii) Both layer 2 and layer 3 include flow control and error control mechanisms.

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Advantages of frame relay over X.25

(i) High speed: Frame relay doesn't perform error detection. ~~that~~ This allows frame relay to acheivee higher speed than X.25.

(ii) simplicity

(iii) Higher data rates: up ~~a~~ to several Mbps.

(iv) Less overhead: because it doesn't perform error correction and flow control.

(v) support for bursty traffic

(vi) Lower cost.

Disadvantages

(i) No flow control and error detection

(ii) create varying delays for different user

(iii) variable lantency: The time its take to travel from one point to another can vary.

(iv) It doesn't have built in congestion control mechanism. This can lead to congestion and packet loss if the network is overloaded.

(v) Not suitable for delay sensitive data like real time voice or video.

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