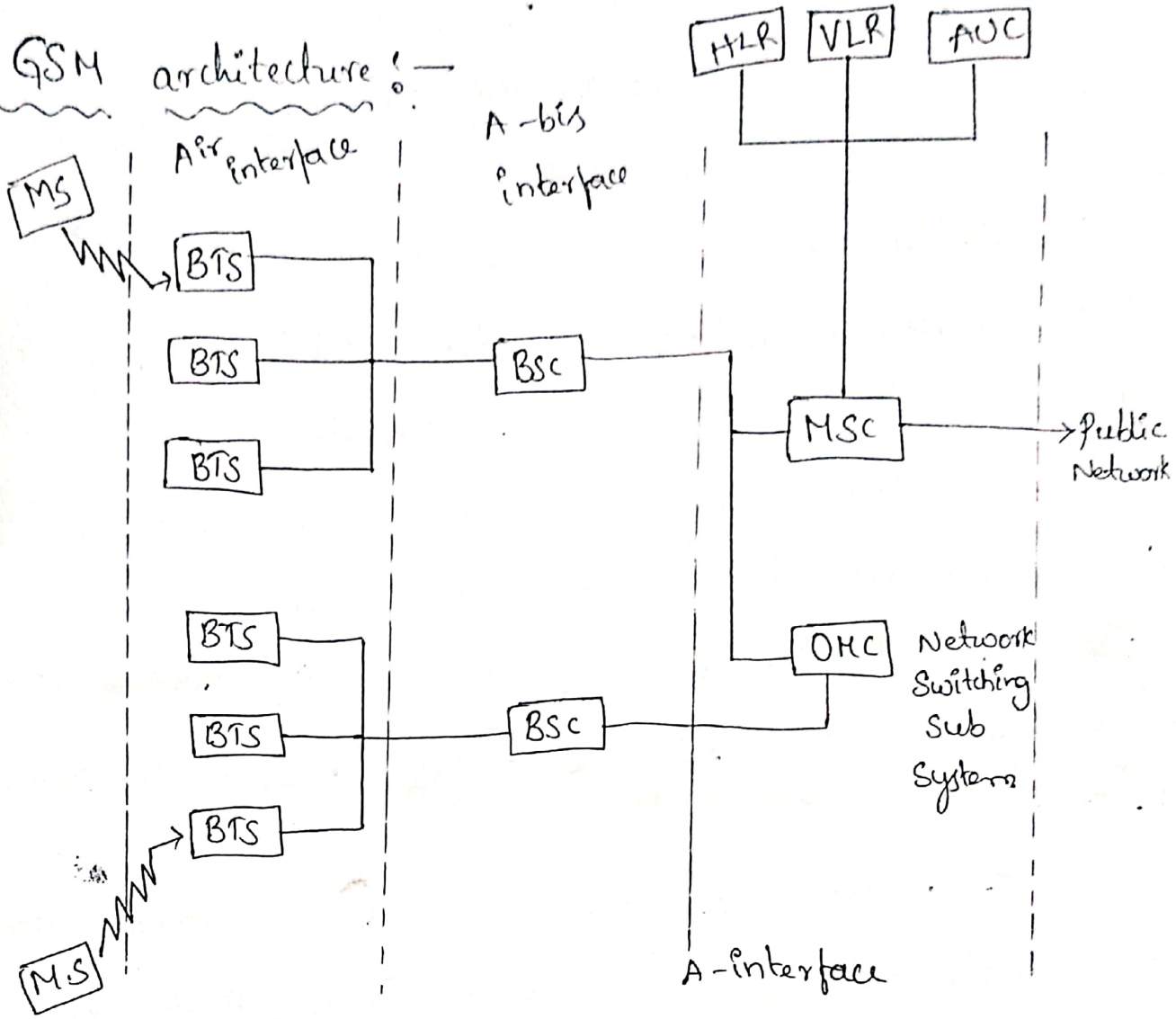
UNIT- VI

Digital Cellular Networks

GSM architecture :-



MS - Mobile station

BTS - Base Transceiver System

BSC - Base Station Controller

MSC - Mobile Switching center

OMC - operation & Maintainence Controller

HLR - Home location register

VLR - Visitor location register

AUC - Authentication Center

GSM- Global System for mobile Communications

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→ GSM consists of many sub systems, such as

1. Mobile station (MS)
2. Base station Sub system (BSS)
3. Network & Switching Sub System (NSS)
4. Operation Sub System (OSS)

1) Mobile Station (MS):—

→ Mobile Station includes mobile equipment (ME) and Subscriber Identity module (SIM).

→ Mobile equipment (ME) does not need to be personally assigned to one Subscriber.

→ Subscriber Identity module (SIM) is a subscriber module which stores all the subscriber related information.

→ when a subscribers SIM is inserted into the mobile equipment of a mobile station, that mobile station belongs to the subscriber and call is delievered to that mobile station.

→ The mobile equipment is not associated with a called number, it is linked to the SIM.

Base Station SubSystem:—

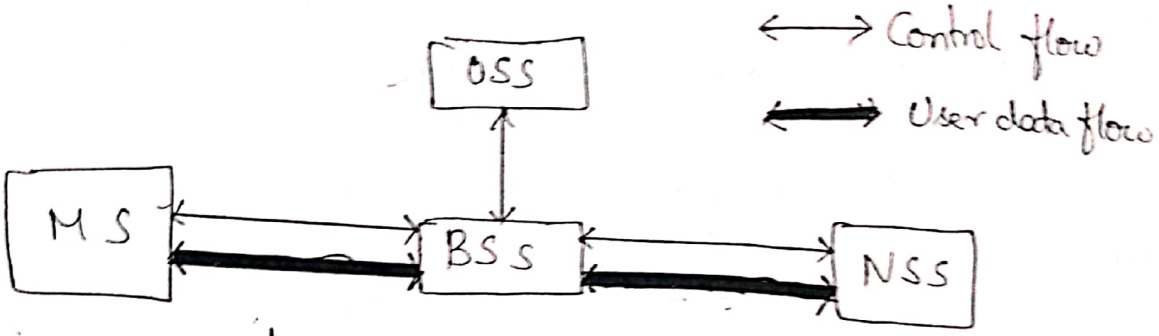
→ The Base Station Subsystem connects to the mobile station through a radio interface (or) air interface and also connects to the NSS.

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→ The BSS consists of a base transceiver station (BTS) located at the antenna site to the mobile equipment (ME) in an mobile station (MS).

→ A Transcoder rate adaption Unit (TRAU) carries out encoding and speech decoding and rate adaption for transmitting data.

→ As a subpart of the BTS, the TRAU may be sited away from the BTS, usually at the MSC.



External environment of BSS

→ Gsm uses the open System interConnection (OSI).

→ There are three common interfaces based on OSI

(i) Interface between MS & BTS is called "Air interface" (or) Radio interface

(ii) Interface between BTS & BSC is called "A-bis interface"

(iii) Interface between MSC & BSC is called "A-interface"

→ The difference between interface and protocal is interface represents the point of contact between two adjacent

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equipment and a protocal provides information through the interfaces

Network and Switching System :- (NSS)

→ Nss manages the common between GSM users and Telecommunication users.

→ Nss maragment consists of MSC.

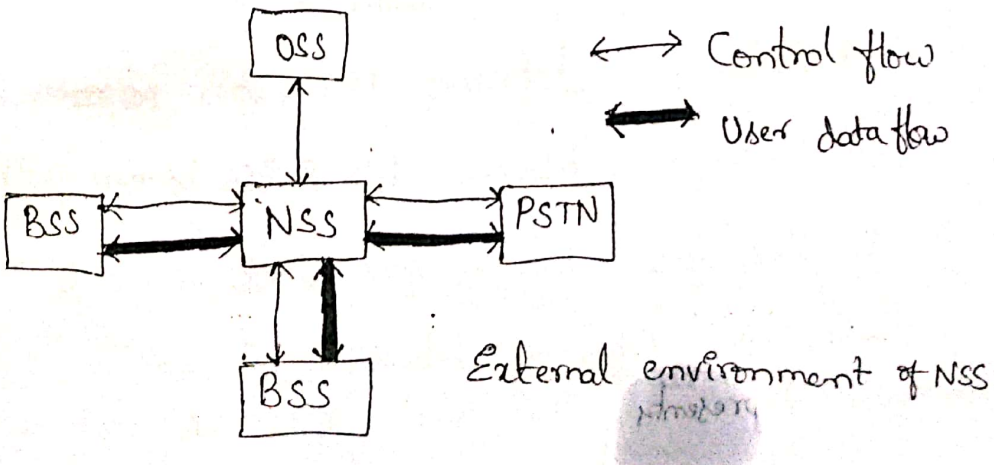
→ MSC which coordinates call setup to and from GSM users.

→ An MSC controls several BSC.

Inter working function (IWF) :-

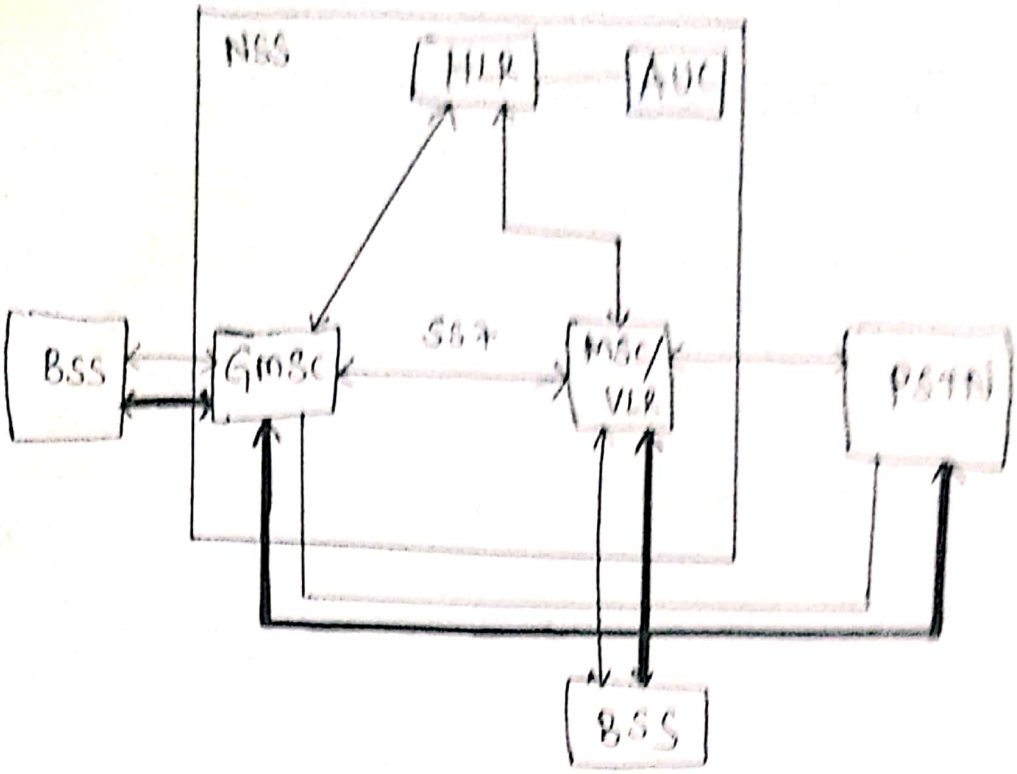
→ A gate way for MSC to interface with external Networks for communication with user outside GSM such as packet-Switched public data N/w (Network (PSPDN) or Circuit-Switched public data Network (CSPDN)

→ The role of the IWF depends on the type of user data and the N/w to which it interfaces.



External environment of NSS

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→ It consists of 3 parts

(i) HLR

(ii) VLR

(iii) AUC

Home Location register :-

→ It contains the subscriber information related to subscribers current location.

→ A subdivision of HLR is the authentication center.

Authentication center :-

It manages the security data for subscriber authentication. It contains Equipment Identify Register (EIR) which stores the data of mobile equipment (ME).

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Visitor location register :- (VLR)

→ It contains the information of roaming subscribers.

→ Here, the information is stored temporarily.

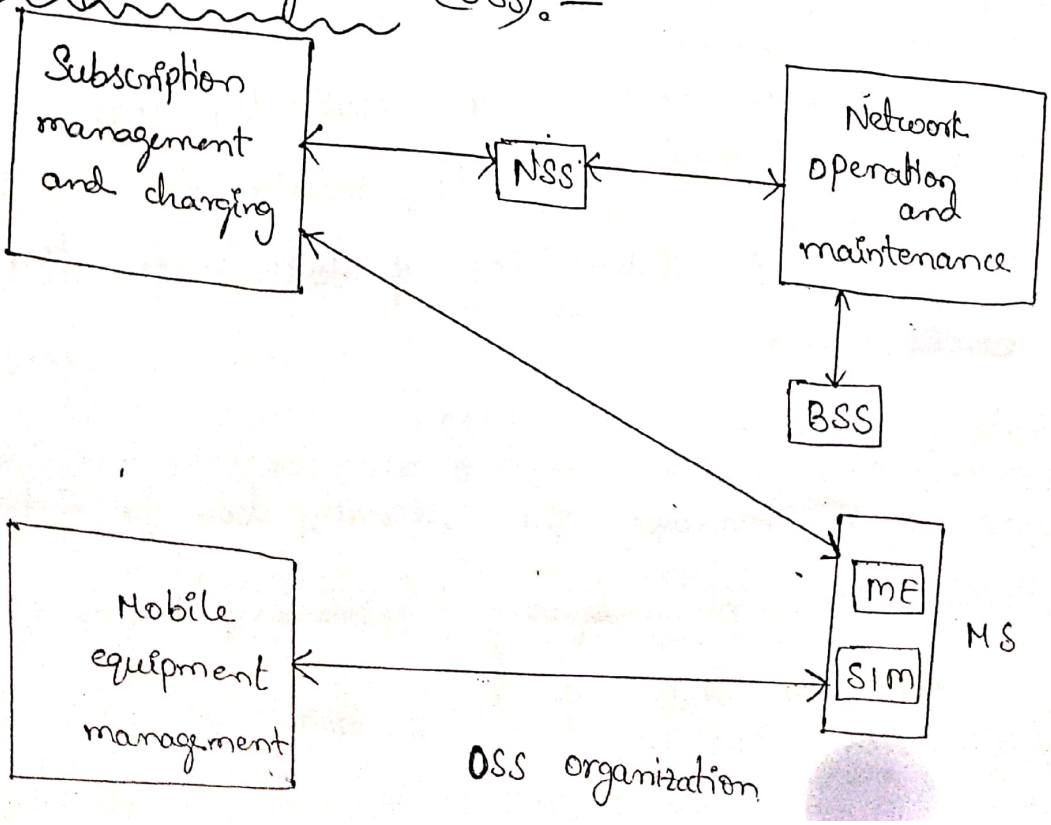
Signaling Transfer point (STP) :-

STP optimizes the cost of the signaling transport among MSC/VLR, GMSC and HLR.

Gateway mobile Switching center :- (GMSC)

The GMSC has an interface with the external network for gate waying, and the network also operates the full signaling system 7 (SS7) signaling between NSS machies.

Operating Sub System (OSS) :-



OSS organization

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→ There are 3 areas of OSS.

(i) Network operation and maintenance functions

(ii) Subscription management, including charging and billing

(iii) mobile equipment management

→ These tasks require interaction between some or all of the infrastructure equipment.

→ OSS is implemented in any existing network

Layer modeling (OSI model):—

The open System Interconnection (OSI) of GSM consists of five Layers

(i) Transmission

(ii) Radio resource management (RR)

(iii) Mobility Management (MM)

(iv) Communication Management (CM)

(v) Operation Administration and Maintenance (OAM)

→ The lower layers correspond to short-time-scale functions.

→ The Upper layers correspond to long-time scale functions.

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i) Transmission layer :-

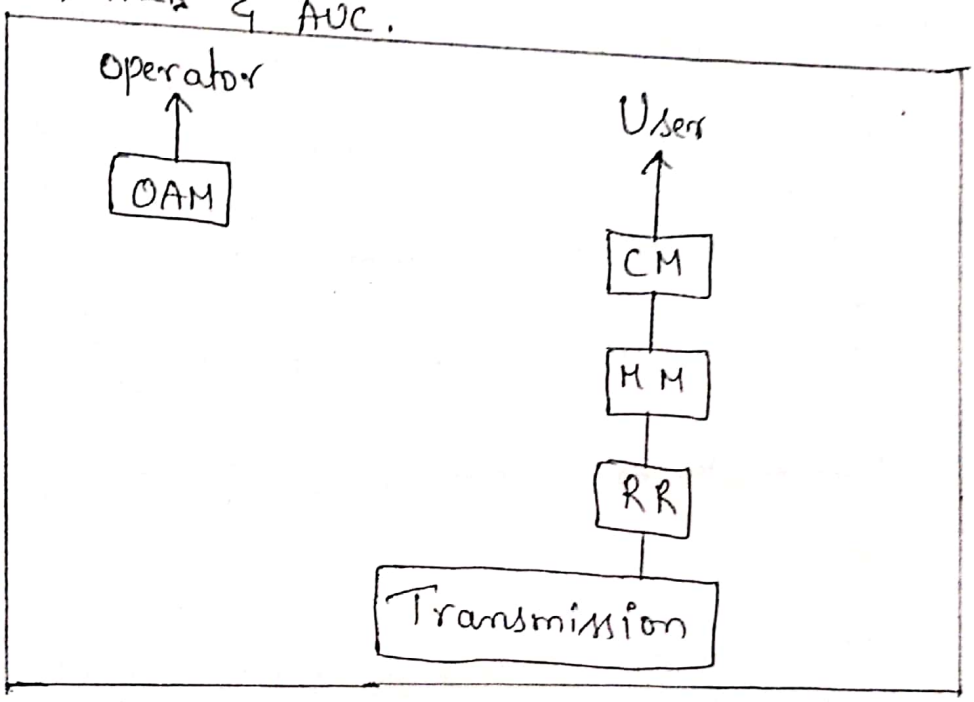
Transmission layer set up a connection between Mobile Station (MS) and Base Transceiver Station (BTS).

ii) RR Layer :-

It refers to the protocol for management of the transmission over the radio interface and provides a stable link between mobile station (MS) and Base station controller (BSC).

iii) MM layer :-

It manages the subscribers basis which includes location data & manages, authentication activities SIM, HLR & AUC.



The functional planes of GSM

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CM layer :-

The following functions are parts of the CM layer.

a) Call control
b) Supplementary Services Management
c) Short message service (SMS)

a) Call control :-

The CM Layer setup calls, maintains calls, and releases calls.

The CM layer interacts among the MSC/VLR, GMSC, IWF, and HLR for managing circuit-oriented service, including speech and circuit data.

b) Supplementary services management :-

It allows users to have some control of their calls in the network, and has specific variations from the basic service.

c) Short message service (SMS) :-

→ It is related to point-to-point SMS.

→ A SMS service center (SMS-SC) may connect to several GSM networks.

→ Short message transmission requires setting up

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a signaling connection between the mobile station (MS) and mobile switching center (MSC).

→ The two functions of SMS are

(i) Mobile-originating short message

(ii) Mobile-terminating short message

5) OAM layer:-

→ OSS is an integral part of the OAM layer.

→ All the subsystems, such as BSS and NSS, contribute to the OAM operation and maintenance functions.

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GSM channels :—

GSM channels are of

(i) physical channels
(ii) Logical channels
(iii) Signalling channels

(i) physical channels :—

There are three kinds of physical channels, which are also called as "TRAFFIC CHANNEL" (TCH).

These carry digitally encoded user speech or user data & have identical functions and both the forward & reverse link.

TCH's may be either full rate or half rate.

when transmitted as full-rate, user data is contained within one transmission per frame.

when transmitted as half-rate, user data is mapped onto the same time slot, but is sent in alternate frames.

a) Full rate TCH (or) TCH/F :—

① Full-rate Speech channel (TCH/FS):—

The full rate Speech channel carries user Speech which is digitized at a raw data rate of 13 kbps.

The full rate Speech channel carries 22.8 kbps

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② Full - rate data channel for 9600 bps (TCH/F9.6):—

The full rate traffic data channel carries raw user data which is sent 9600 bps, additional forward error correction coding applied by the GSM standard, the 9600 bps data is sent at 22.8 kbps.

③ Full rate data channel for 4800 bps (TCH/F4.8):—

This carries user data is sent at 4800bps additional forward error correction coding applied by the GSM standard, the 4800bps is sent at 22.8 kbps.

④ Full rate data channel for 2400bps (TCH/F2.4):—

This carriers user data which is sent at 2400 bps additional forward error correction coding applied by the GSM standard, the 2400 bps is sent at 22.8 kbps.

Half Rate TCH:—

① Half rate Speech channel (TCH/HS):—

The half rate speech channel has been designed to carry digitized speech which is sampled at a rate half, that of the full rate channel, the half-rate speech channel will carry 11.4 kbps.

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Half rate data channel for 4800bps (TCH/H4.8): ④

The H4.8 data channel carries 4800bps, additional forward error correction coding applied by the GSM standard, the 4800bps data is sent at 11.4 kbps.

③ Half rate data channel for 2400bps (TCH/H2.4):-

It carries raw user data, which is sent at 2400 bps, with additional forward error correction coding applied by GSM standard, the 2400 bps data is sent at 11.4 kbps

ii. Logical channels:—

→ These are divided into 3 channels.

→ They are

a) Broadcast channel (BCH)

b) Common Control channel (CCCH)

c) Dedicated Control channel (DCCH)

a) Broad cast channel (BCH):—

The broad cast channel operates on the forward link, and transmits data only first time slot (TS0).

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→ Unlike RF's which are duplex, BCH, the forward link.

→ BCH provides synchronization for all within the cell is occasionally monitored by mobile neighbouring cells.

→ BCH's are of three types, namely

① Broadcast control channel (BCCH)

② Frequency correction channel (FCCH)

③ Synchronization channel (SCH)

① Broadcast Control channel (BCCH):—

It is a forward control channel.

It is used to broadcast information such as cell and network identity and operating characteristics of the cell.

This is also broadcasts the list of channels that are currently in use within the cell.

② Frequency correction channel (FCCH):—

The FCCH allows each subscriber unit to synchronize its internal freq standard to the exact frequency of the base station.

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Synchronization channel (SCH):—

It is used to identify the serving base station while allowing each mobile to frame synchronize with the base station.

(b) Common Control Channels (CCCH's):—

CCH consists of three different channels, they are

① Paging channel (PCH) [Forward link channel]

② Random Access channel (RACH) [Reverse link channel]

③ Access Grant channel (AGCH) [Forward link channel]

① Paging channel (PCH):—

∴ The paging channel provides paging signals from the base station to all mobiles in the cell. The PCH may be used to provide cell broadcast ASCII text messages to all subscribers.

② Access Grant channel (AGCH):—

The AGCH is used by the base station to provide forward link communication to the mobile, and carries data which instructs the mobile to operate in a particular physical channel with

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a particular dedicated control channel.

3) Random Access channel (RACH):—

This is a reverse link channel used by a subscriber unit to acknowledge page from the base and is also used by mobiles to originate a call.

4) Dedicated Control channels (DCCHs):—

In this there are three types of dedicated control channels which are bidirectional & have the same format & function on both forward & reverse link.

The three types are

① Stand-alone dedicated Control channel (SDCCHs)

② Slow Associated control channel (SACCH)

③ Fast Associated Control channel (FACCH)

① Stand-alone Dedicated Control channel (SDCCHs):—

This carries signalling data following the connection of the mobile with the base station, and just before a TCH assignment is issued by the base station.

The SDCCH ensures that the mobile station and base station remain connected while the base station & MSC verify the subscriber unit & allocate resources for the mobile. This is used to send authentication

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nd alert messages.

Slow - Associated control channel (SACCH):-

This is always associated with a traffic channel or a SDCCH & maps onto the same physical channel. It is used to send slow but regularly changing control information to the mobile, such as transmit power level instructions, & specific timing advance instructions for each user.

③ Fast - Associated control channels (FACCH):-

The FACCH carries urgent messages and contains essentially the same type of information as the SDCCH.

A FACCH is assigned whenever a SDCCH has not been dedicated for a particular user & there is an urgent message such as a hand off request.

ii) Signalling channels:-

All the signaling channels have chosen one of the physical channels, and the logical channels names are based on their logical functions.

———— o ————

Multiple Access Scheme:—

→ Generally GSM is a combination of FDMA and TDMA.

→ The total number of channels in FDMA is 124, and each channel is 200kHz.

→ Both the 935 - 960 MHz uplink and 890 - 915 MHz downlink have been allocated 25MHz for a total 50 MHz

→ If the TDMA is used within 200kHz channel, 8 time slots are required to form a frame.

→ Frame duration is 4.615 ms & the time slot duration burst period is 0.577 ms

→ The downlink is 1805 - 1880 MHz & the uplink is 1700 - 1785 MHz

→ The numbering of the uplink slots is derived from the downlink slots by a delay of 3 time slots.

→ This allows the slots of one channel to bear the same time slot number in both directions.

Frequency Hopping:—

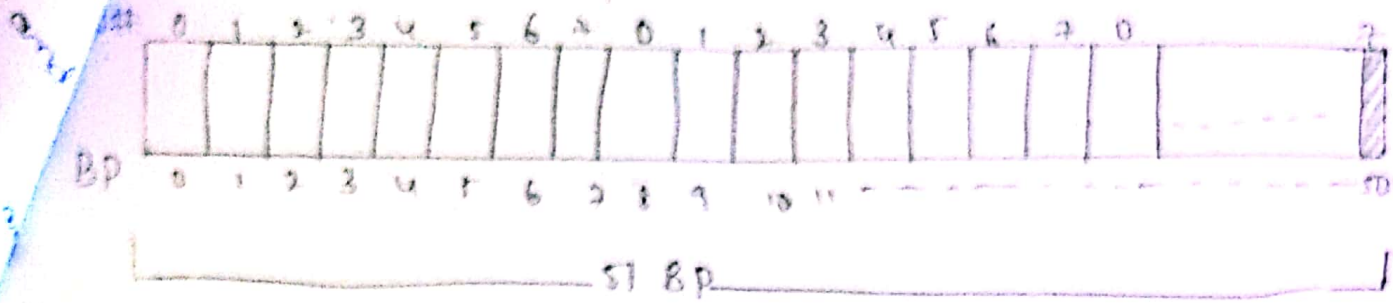
→ GSM has a slow frequency hoping radio interface. The slow hopping is defined in bits per hop.

→ The slow hopping is 217 hops/second.

Different types of time slots:—

→ Each cell provides a reference clock from which the time slots are defined. Each time slot is given a number (TN) which is known by the base station and the mobile station.

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Bursts & training Sequences:-

→ In TDMA, the signaling transmits in bursts. The time interval of the burst brings the amplitude of a transmitted signal up from a starting value of 0 to its normal value.

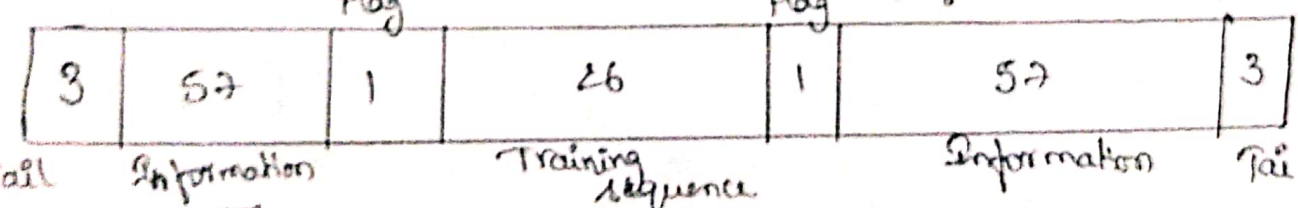
→ There are tail bits and training sequence bits within a burst.

→ The tail bits are three 0 bits added at the beginning and at the end of each burst which provide the guard time.

→ The training sequence bits are inserted in the middle of time slot sometimes called a midamble,

→ There are several kinds of bursts

1. The normal burst used in TCH:



The 1-bit binary information indicating data or signalling is called "Stealing flag"

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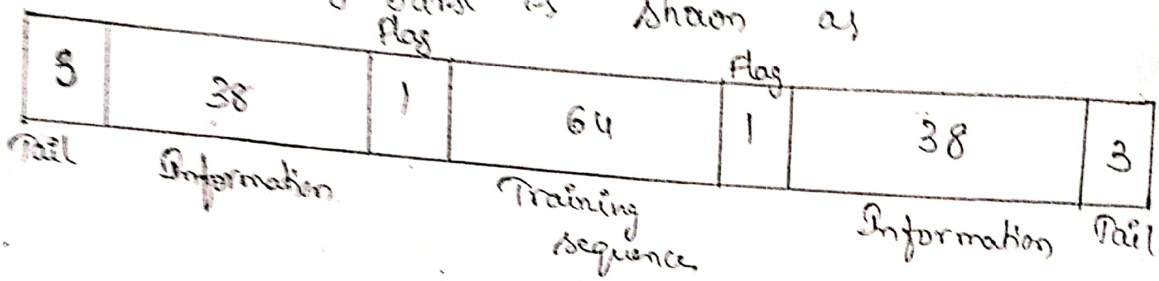
(Random Access channel)

4) the access burst used on the RACH in the Uplink direction flag



5) The F & S bursts. The F burst is used on the frequency correction channel. FCCH & has the simplest format. All of the 148 bits are zero, producing a pure sinewave. Five S bursts in each 51 X 8 BP cycle are used on the SCH.

→ One S burst is shown as



GSM's strengths:— GSM is the first to apply the TDMA scheme developed for mobile radio system. It has several distinguishing features

1. Roaming in European countries
2. Connection to ISDN through RA box
3. Use of SIM cards
4. Control of transmission layer
5. Frequency hoping
6. Discontinuous transmission
7. Mobile - Assisted handover.

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Time division Multiple Access (TDMA):-

(or)

North American TDMA :- TDMA architecture

→ The NA-TDMA architecture is similar to GSM architecture

→ The only difference is that in NA-TDMA, there is only one common interface., which is the radio interface.

→ The NA-TDMA uses the intelligent network.

→ All the components such as HLR, VLR, AUC and EIR are the same as used in GSM.

→ In developing the NA-TDMA system, there were two phases.

First phase :-

TD commonly share the 21 setup channels, which are used for the analog system. The first-phase system is only for voice transmission.

Both modes, AMPS and digital, are built in the same unit.

The handoff procedure has to take care of the following features

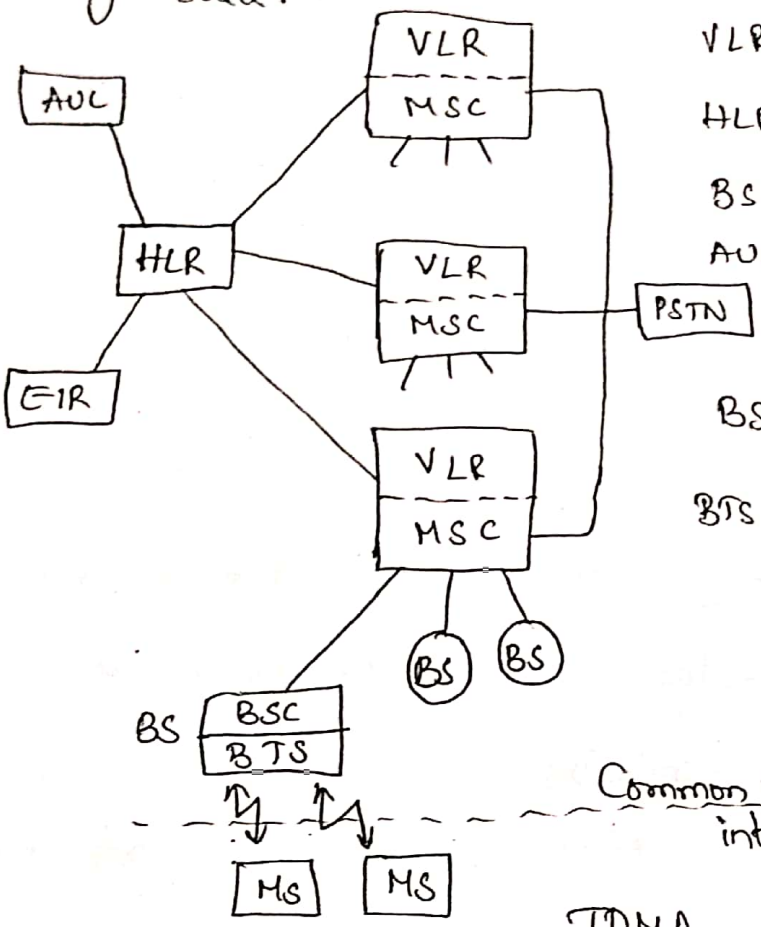
1. AMPS cell to AMPS cell
2. TDMA cell to TDMA cell
3. AMPS cell to TDMA cell
4. TDMA cell to AMPS cell.

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Second phase :-

→ Generate new digital set-up channels (i.e were in the voice band) to access to TDMA voice channels so that a digital stand-alone unit can be provided.

→ Specify a data-service signal protocol for transmitting data.

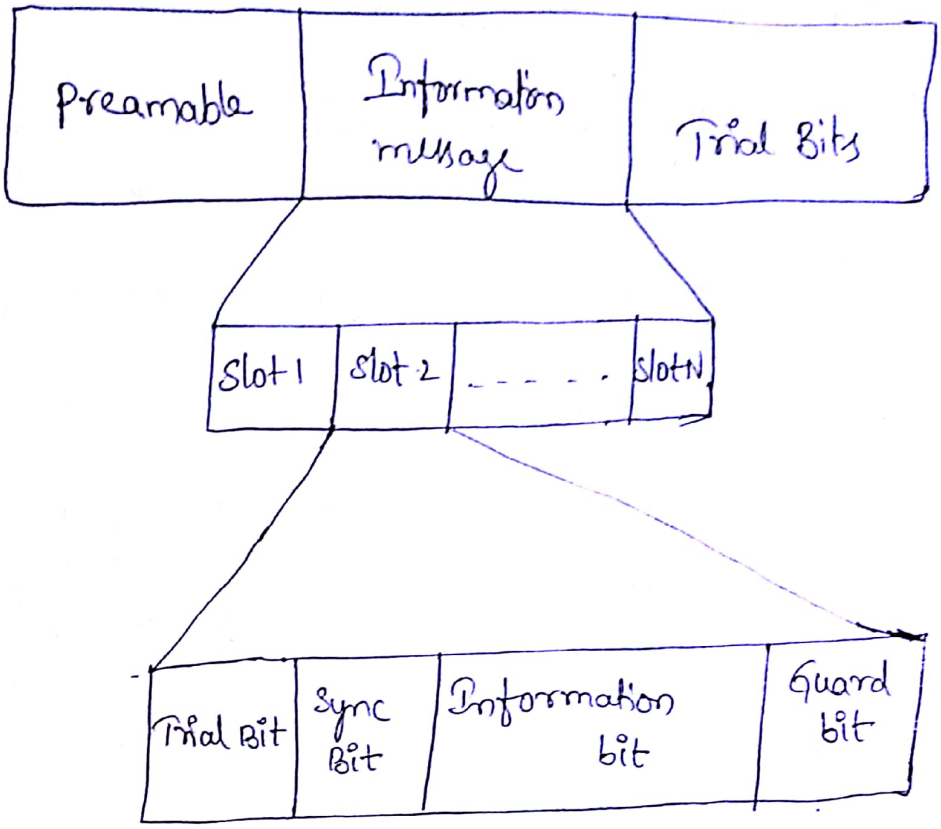


VLR – Visitor location registration
HLR – Home location registration
BS – Base station
AUC – Authentication center
EIR – Equipment Identity registe
BSC – Base station Controller
BTS – Base transceiver Station

TDMA architecture

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TDMA Structure :—



TDMA frame Structure

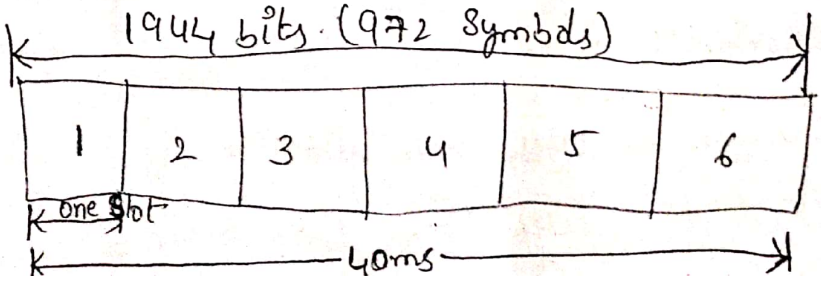
→ In NA-TDMA, the set-up channels are analog channels shared with the AMPS system.

→ One digital channel contains 25 frames per second.

→ Each frame is 40-ms long and has 6 time slots.

→ Each time slot is 6.66 ms long.

→ One frame contains 1944 bits (972 symbols).



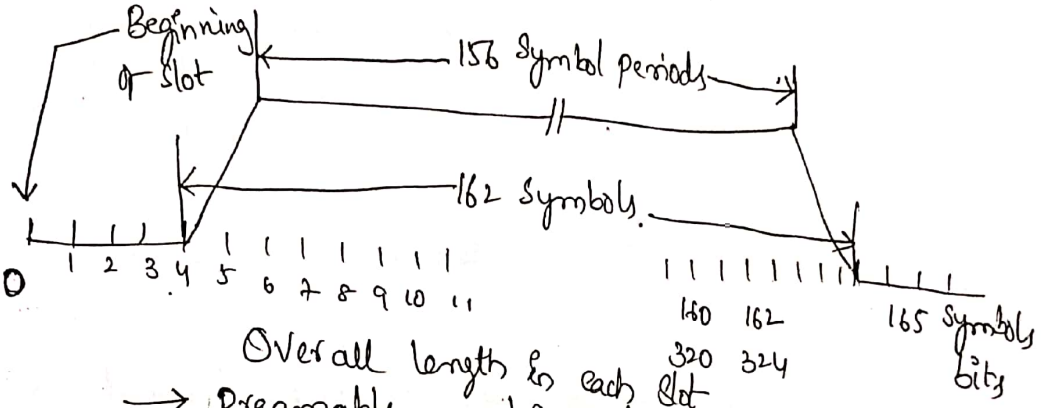
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→ Each slot contains 324 bits (162 symbols) and the duration between bits is 20.57 μs.

→ One radio channel is transmitted at 48.6 kbps but only 24,000 symbols per second over the radio path.

→ Each frame consists of 6 time slots.

→ The maximum effect on the signal for a forward time slot is one-half full symbol period and for a reverse time slot is 6 symbol periods.



Overall length in each slot

→ Preamable contains the address & Synchronization information that both base station and Subscriber use to identify each other.

Frame length:—

→ There are two frame lengths, fullrate and halfrate. Each full rate traffic channel shall use two equally spaced time slots of the frame. The overall length in each slot.

Channel 1 uses time slots 1 and 4.

Channel 2 uses time slots 2 and 5.

Channel 3 uses time slots 3 and 6.

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→ Each half rate traffic channel shall use one time slot of the frame.

Channel 1 uses time slot 1

Channel 2 uses time slot 2

Channel 3 uses time slot 3

Channel 4 uses time slot 4

Channel 5 uses time slot 5

Channel 6 uses time slot 6

Frame offset :-

→ At the mobile station, the offset between the reverse and forward frame timing is

Forward frame = reverse frame + (1 time slot + 44 symbols)

= reverse frame + 206 symbols.

→ The time slot (TS) 1 of frame N (in forward link) occurs 206 symbol periods after TS 1 of frame N in the reverse link.

Modulation Timing :-

Modulation Timing with in a forward time slot :-

The first modulated symbol used by the mobile unit shall have maximum effect on the signal (156 symbols) transmitted from the base antenna, one-half symbol (1 bit) period after beginning the time slot.

Modulation Timing with in a reverse time slot :-

The first modulated symbol has a maximum effect

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on the signal transmitted at the mobile unit symbol periods after the beginning of the reverse-time

NA-TDMA Channels:—

In NA-TDMA there are no common channels such as those used in GSM. The digital call set-up uses the 21- setup channels which are shared with the analog system.

Fast associated Control channel:— (FACCH)

FACCH is a blank and burst channel equivalent to a signaling channel for the transmission of control and supervision messages between the base station and the mobile station. It consists of 260 bits. Mostly FACCH is used for handoff messages.

Slot associated Control channel (SACCH):—

SACCH is a signaling channel including twelve code bits present in every time slot transmitted over the traffic channel whether these contain voice (or) FACCH information.

Mobile-assisted handoff:—

The mobile station performs signal quality measurements on two types of channels:

1) Measure the RSSI (Received Signal Strength Indicator) and the BER (Bit error rate) information

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of the current forward traffic channel during a call.

2). Measures the RSSI of any RF channel which is identified from the measurement order message from the base station.

→ MAHO consists of three messages

(i) Start Measurement Order

(ii) Stop Measurement order

(iii) Channel quality message.

Signalling format and Message structure in TDMA :-

Signalling format in different channels :-

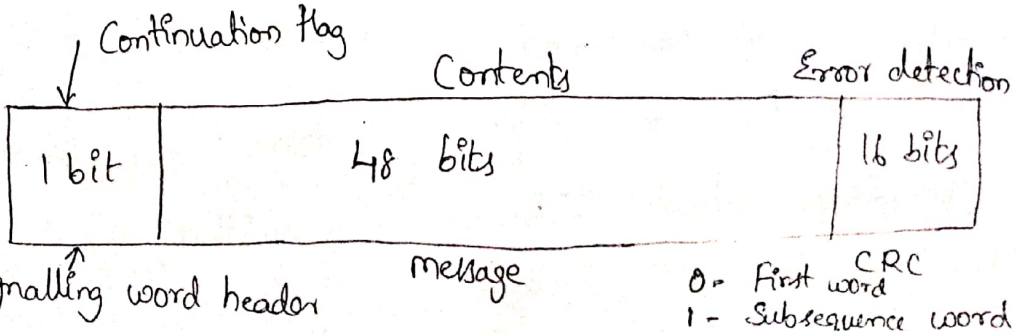
A reverse digital traffic channel (RDTC) is used to transport user information and signalling.

A forward digital traffic channel (FDTC) has same format as the RTDC (reverse digital traffic channel).

Two control channels are used : the FACCH is a blank and borst channel, the SACCH is a continuous channel, and interleaving is on the SACCH.

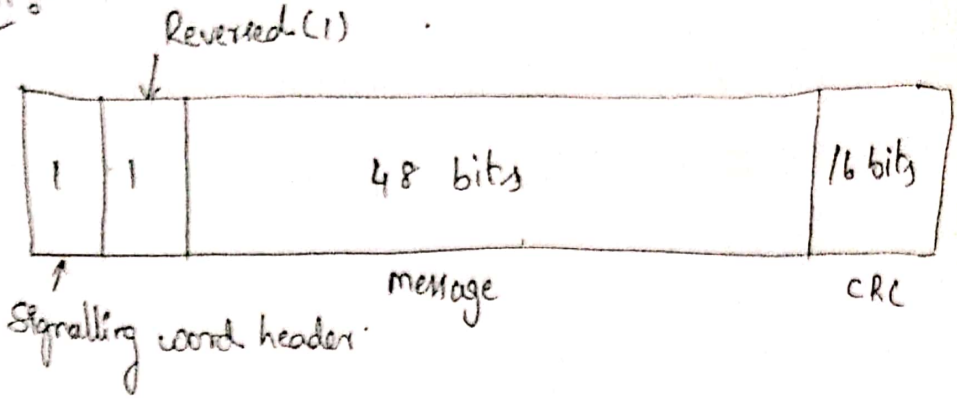
The signalling formats of these two channels are shown below.

FACCH :-



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SACCH :-



Signalling formats of FACCH & SACCH

Message structure :-

All messages contain

1. An application message header
2. Mandatory fixed parameters
3. Mandatory Variable parameters
4. Remaining length
5. Optional Variable parameters

Purpose ↓ ; ↓ which protocal

Message type (8 bits)	Protocal Discriminator (2 bits)	Mandatory fixed parameters	Mandatory Variable parameters	Remaining length 6 bits	Optimum Variable parameters

Handoff action :-

When a handoff order is received, the mobile Station is at high state and stays at that state.

Hand off to a digital traffic channel is described as follows :

① Turn on signaling tone for 50 ms, turn off signaling tone, turn off transmitter which was operating on the old frequency.

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(2) Adjust power, tune to new channel, set stored vcc field of the received message.

(3) Set the transmitter and receiver to digital mode set the transmit and receive rate based on the message type field

(4) Set time slot based on the message-type field

(5) Set the time alignment offset to the value based on the field.

(6) Once the transmitter is synchronized, enter the conversion task to the digital traffic channel.

Features of TDMA :-

→ TDMA shares a single carrier frequency with several users, where each other makes use of non-overlapping time slots.

→ The number of time slots per frame depends on several factors like modulation techniques, available Bandwidth etc.

→ Data transmission for TDMA system is not continuous, but occurs in bursts.

→ This results in ~~low~~ low battery consumption, since subscriber transmitter can be turned off when not in use.

→ TDMA uses different time slots for transmission and reception, thus duplexes are not required.

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→ Adaptive equalization is usually necessary in TDMA systems, since the transmission rates are generally very high as compared to FDMA channels.

→ In TDMA, guard time should be minimised

→ High synchronization overhead is required in TDMA systems because of burst transmissions.

→ TDMA transmissions are slotted, and this requires the receivers to be synchronized for each data burst.

→ TDMA has an advantage in that it is possible to allocate different numbers of time slots per frame to different users.

→ Thus Bandwidth can be supplied on demand to different users by concatenating or reassigning time slots based on priority.

Efficiency of TDMA:—

→ It is a measure of the percentage of transmitted data that contains information as opposed to providing overhead for the access scheme.

→ The frame efficiency "η_f" is the percentage of bits per frame which contain transmitted data.

→ The transmitted data may include source and channel coding bits, so the raw end-user efficiency of a system is generally less than "η_f".

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→ The frame efficiency can be calculated as follows

$$B_{OH} = N_r b_r + N_t b_p + N_t b_g + N_r b_g$$

where,

N_r = no. of reference bursts per frame

N_t = no. of traffic bursts per frame

b_r = no. of overhead bits per reference burst

b_p = no. of overhead bits per preamble in each slot

b_g = no. of equivalent bits in each guard time interval

→ The total no. of bits per frame

$$b_T = T_f R \quad (b_T = T_f R)$$

T_f = frame duration

R = Channel bit rate

→ The frame efficiency η_f is

$$\eta_f = \left(1 - \frac{b_{OH}}{b_T}\right) \times 100\%$$

Number of channels in TDMA System:-

→ The number of TDMA channel slots =

No. of TDMA slots / channel × No. of channel available

i.e., $$N = \frac{m(B_{tot} - 2B_{guard})}{R}$$

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where,

m = maximum no of TDMA users supported on a radio channel

Examples:-

① Consider Global system for mobile, which is a TDMA FDD system that uses 25MHz for the forward link, which is broken into radio channels of 200kHz. If 8 speech channels are supported on a single radio channel, and if no guardband is assumed, find the number of simultaneous users that can be accomodated in GSM?

∴ The number of simultaneous users that can be accomodated in GSM is given as

$$N = \frac{25MHz}{(200kHz)/8} = 1000$$

Thus GSM can accomodate 1000 simultaneous users.

Example ② If GSM uses a frame structure where each frame consists of eight time slots, and each time slot contains 156.25 bits, and data is transmitted at 270.833 Kbps in the channel, find

a) The time duration of a bit

b) The time duration of a slot

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c) The time duration of a frame

d) how long must a user occupying a single time slot wait between two successive transmissions.

Sol

a) The time duration of a bit,

$$T_b = \frac{1}{270.833 \text{ kbps}} = 3.692 \text{ usec}$$

b) The time duration of a slot,

$$T_{slot} = 156.25 \times T_b$$

$$= 156.25 \times 3.692 \text{ usec} = 0.577 \text{ ms}$$

c) The time duration of a frame,

$$T_f = 8 \times T_{slot}$$

$$= 8 \times 0.577 \text{ ms}$$

$$T_f = 4.615 \text{ ms}$$

d) A user has to wait 4.615 ms, the arrival time of a new frame, for its next transmission.

Example ③ If a normal GSM time slot consists of six trailing bits 8.25 guard bits, 26 training bits, and two traffic burst of 58 bits of data, find the frame Efficiency.

Sol^n → A time slot has

$$6 + 8.25 + 26 + 2(58) = 156.25 \text{ bits}$$

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→ A frame has, $8 \times 156.25 = 1250$ bits / frame.

→ The number of overhead bits per frame is given by,

$$b_{OH} = 8(6) + 8(8.25) + 8(26)$$

$$= 322$$

$$b_{OH} = 322 \text{ bits}$$

→ Thus, the frame efficiency,

$$\eta_f = \left[1 - \frac{322}{1250}\right] \times 100$$

$$\boxed{\eta_f = 74.24\%}$$

TDMA advantages & Disadvantages:—

Advantages:—

① Better suited for digital
② Gets higher capacity

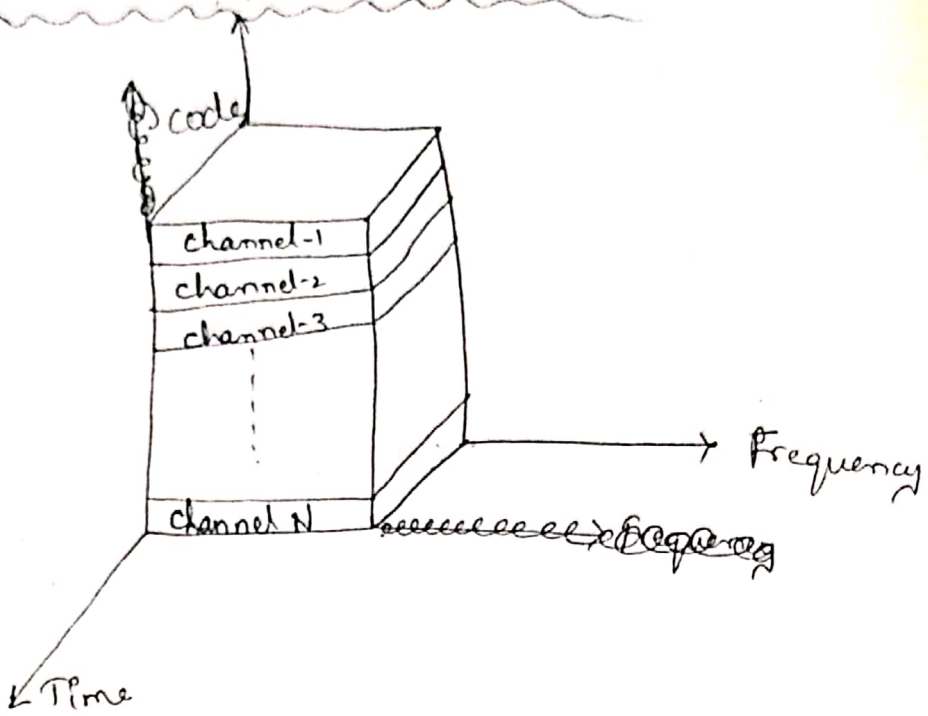
Disadvantage:—

Strict synchronization & Guard time needed

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Code Division Multiple Access (CDMA):-



→ In CDMA System, the narrowband message signal is multiplied by a very large signal called spreading signal.

→ The spreading signal is a pseudo noise code sequence that has a orders of magnitudes greater than the data rate of the message.

→ All users in a CDMA System, use the same carrier frequency and may transmitt simultaneously

→ For detection of message signal it is essential that receiver must know the code word used by the Transmitter.

→ Each user operates independently without the knowledge of other users.

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→ CDMA gives good protection against interferrence.

→ CDMA receiver has to know the background noise composed of other signals due to which designing of receiver is complex.

CDMA forwards channels :-

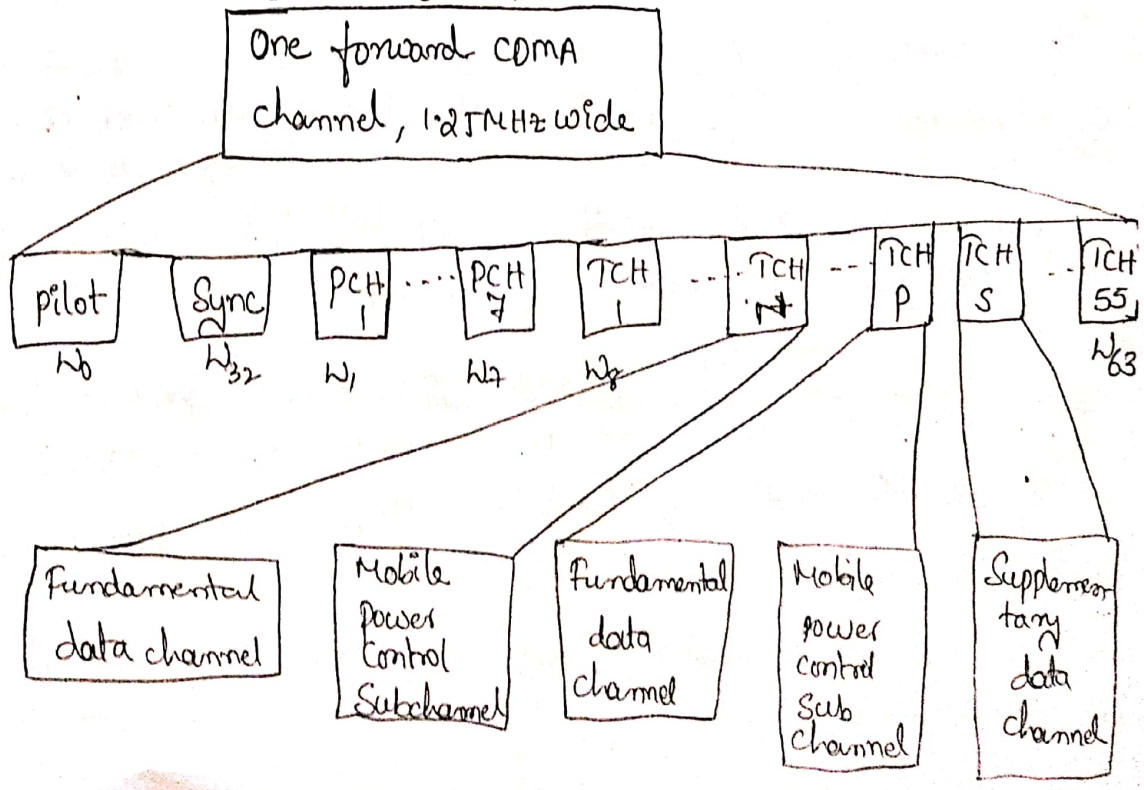
CDMA forward channels have 4 types of logical channels. They are

1) pilot channel
2) Synchronization channel
3) Paging channel
4) Forward traffic channel

→ Every forward channel carrier consists of a pilot channel, Synchronization channel, seven paging channels and several forward traffic channel.

→ The Structure of CDMA forwarad channel is below,

Forward channel Structure



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→ From the figure, it can be observed that the channels are separated from each other using different Spreading codes.

→ Based on the picture of signaling and data traffic a channel carries, it is named as fundamental data channel, supplementary data channel or mobile power control sub channel.

Pilot channel :-

→ It is a reference channel used by Base station (BS) in downlink for synchronizing and tracking all the MSS (Mobile Station SubSytems).

→ This channel compares signal strengths of all the channels in sytem and locks channels having (RF) Radio frequency carrier.

→ It is the stronger channel with combined power transmitted from base station & capable of supporting Soft handover and coherent deflection.

Synchronization channel :-

→ This channel use the walsh code i.e., W_0 containing all zeros.

→ It performs all the synchronizing functions and configures information to the mobile phones.

→ The Synchronization channel present in CDMA forward channel helps mobile users in decoding the other logical channels by providing them with precise timing information.

→ Walsh code W_{32} is assigned to Synchronization channel.

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Paging channel :—

→ The control information and paging message are sent to mobile users in a system using paging channel.

→ There are seven paging channels in forward channel that are used to sent short message like, broad cast messages, registration procedure details, traffic channel information, response to access requests, list of parameters of neighbouring cell sites etc.

→ The walsh code w_1 to w_7 are assigned to seven paging channels.

Forward traffic channel :—

→ It primarily carries data an establish link between cell site and mobile users to enable communication, that is data transfer.

→ In CDMA forward channel out of 64 channels 55 channels are used for traffic channel which are assigned with walsh codes from w_8 to w_{31} and w_{33}.

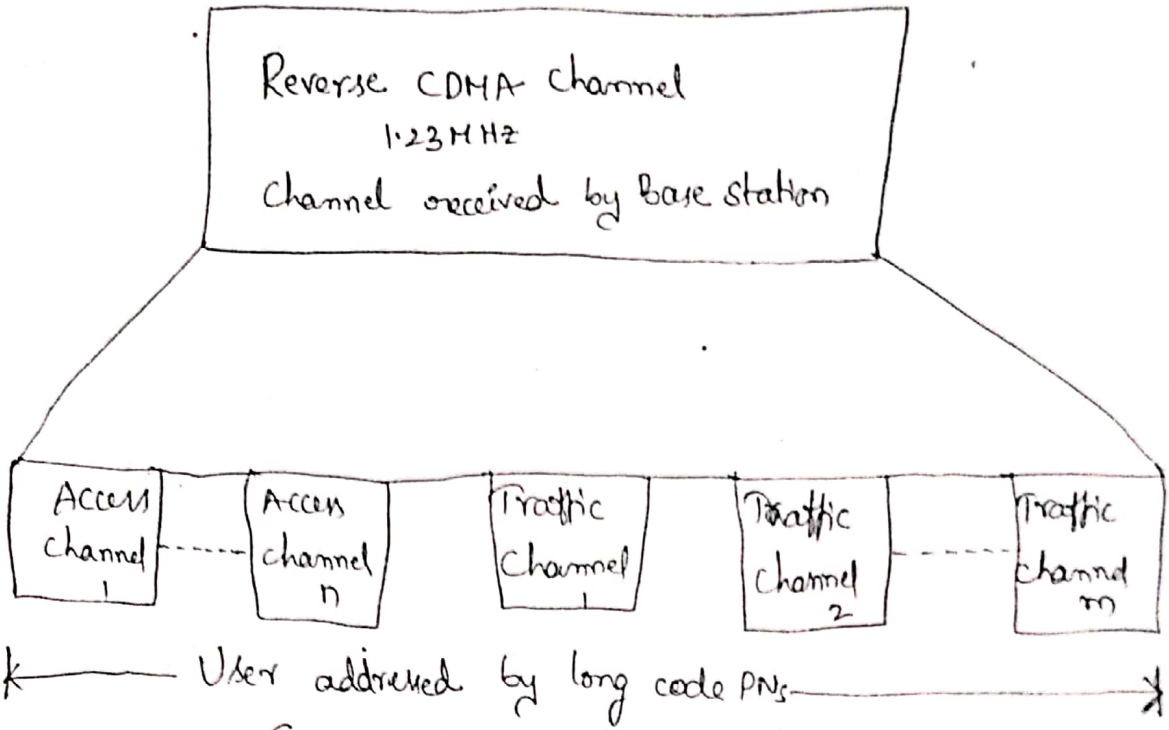
→ In case when huge data traffic arrives which can't be handled using the default traffic channel then some extra supplementary traffic channels are dynamically added to meet the desired data rates.

CDMA Reverse channel :—

→ All the mobiles in coverage area of a cell use reverse CDMA channel for sending signals to the base station.

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→ The structure of CDMA reverse channel is below



CDMA Reverse channel Structure

→ At any given point of time, there is always a possibility of 'X' mobiles busy in call & 'Y' mobiles trying to access the system.

→ In order to access to as many mobiles as possible.

→ CDMA reverse channel uses 62 distinct traffic channels & 32 distinct access channels in system.

→ There are two types of reverse channels in CDMA. They are

1) Access channels

2) Reverse Traffic channels

1) Access channels:—

It allows a mobile to communicate with the system for registration, call origination & sending

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response signals to receiving on a paging channel.

→ It configurable one (or) two access channels are generally configured for 1 paging channel with data rate of 4.8 kbps.

2) Reverse Traffic channel :—

→ The voice (or) data traffic from a mobile to the Base station is transmitted using reverse traffic channel that are paired with their respective forward traffic channels.

→ During call signaling, information is transfered again using blank & burst by dim & burst mode.

-DMA

Advantages :—

→ CDMA technique enables the users to Communicat in a secured network environment.

→ It provides secured communication

→ It allows the use of small antennas with no interference problem.

→ It strongly rejects the noise and other unwanted signals.

→ CDMA technique permits individual stations to access the complete bandwidth irrespective of time limit.

→ It eliminates the time Synchronization activity of cell stations.

→ It is highly resistant to interference and Jamming.

→ It provides user privacy by employing random code...

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→ CDMA provides an improved call quality by cross talk, interference noise etc.

→ It supports soft hand-offs due to the presence of multiple diversities.

→ It provides higher coverage quality with fewer cells.

→ It increases the talk-time & battery life for mobile phones.

CDMA disadvantages :-

→ CDMA technique has low through put efficiency.

→ As the number of subscribers increases, the total performance of the system decreases to a low level.

→ CDMA is a bit complex system.

→ It suffers from self-Jamming & near-far problems.

→ The backward compatibility techniques used in CDMA are not economical

→ The cost of the equipment is high.

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Difference between TDMA, FDMA, CDMA?

S.No	Parameters	TDMA	FDMA	CDMA
1.	Modulation (Process of encoding information to be transmitted)	QPSK (Quadrature phase shift keying)	QPSK	QPSK and OQPSK
2.	FEC coding	In this, redundancy offered by FEC coding requires higher transmission rate & greater bandwidth	In this also FEC coding requires higher transmission rate & greater bandwidth	In this also FEC coding requires higher transmission rate & greater bandwidth.
3.	Diversity	Multiple receivers are necessary to achieve diversity	Multiple receivers are necessary to achieve diversity.	It supports soft handoffs due to the presence of multiple diversity

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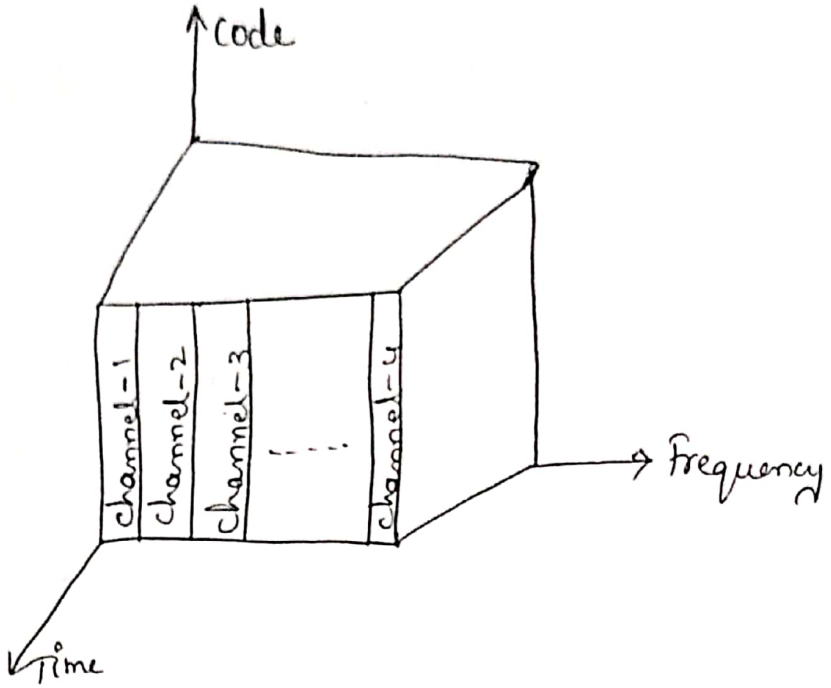
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System Complexity	In order to share the available time slots, mobile subscribers must improve their level of co-operation	In FDMA, the number of mobile users is not dependent	CDMA system may suffers with a limitation referred to as self Jamming that occurs when non-orthogonal PN sequences are allocated to the CDMA subscriber
5. Multiple Access Interference (MAI)	Interference effect is reduced by the fixed assignment of frequency groups to specific cells	Interference effect is reduced by the fixed assignment of frequency groups to specific cells	A CDMA System suffers from other elimination reference to as near-far problem that occurs when a single channel is being shared by different subscribers

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quency Division Multiple Accn (FDMA):—

→ FDMA assigns individual channels to individu users.



→ These channels are assigned to on demand to users request service

→ During the period of the call, no other user can share the same channel.

→ In FDD (Frequency division duplexing) systems, the users are assigned a channel as a pairs of frequencies, one frequency for forward channel while the other for the reverse channel

Features of FDMA:—

→ FDMA channel carries only one phone circuit at a time.

→ If an FDMA channel is not in use, then it sits idle and cannot be used by other users to increase capacity.

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→ After the assignment of a voice channel, the Base Station and the mobile transmit simultaneously and continuously.

→ The bandwidths of FDMA channels are relatively narrow (30 kHz in AMPS) as each channel supports only one circuit per carrier.

→ FDMA is usually implemented in narrow band systems.

→ The symbol time of a narrow band signal is large as compared to the average delay spread.

→ No equization is required in FDMA narrow band systems.

→ The complexity of FDMA mobile systems is lower when compared to TDMA systems.

→ FDMA systems have higher cell site system cost compared to TDMA.

→ The FDMA mobile unit uses duplexer since both the transmitter and receiver operate at the same time.

→ FDMA requires tight RF filtering to minimize adjacent channel reference.

Example of FDMA:—

AMPS (Advanced Mobile phone System)

→ It is based on FDMA/FDD.

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→ A single user occupies a single channel while the call is in progress, and the single channel is actually two simplex channels, which are frequency duplexed with a 45Hz split.

→ Multiple users are accomodated in AMPS by giving each user a unique channel.

→ Voice signals are sent on the forward channel from the Base station to mobile unit, on the reverse channel from the mobile unit to the Base Station

→ In AMPS, analog narrow band frequency modulation (NBFM) is used to modulate the carriers.

→ The number of channels that can be simultaneously supported in a FDMA system is given by,

$$N = \frac{B_t - 2B_{guard}}{B_c}$$

where,

B_t = total spectrum allocation

B_{guard} = guard band allocated at the edge of the allocated spectrum band

B_c = channel Bandwidth

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Example

In US AMPS ; 416 channels are allocated to various cellular operators. The channel between them is 30kHz with the guard band of 10kHz Calculate the spectrum allocation to each other.

Sol

Given that,

Number of channels (N) = 416

Guard band (B_{guard}) = 10kHz

Channel bandwidth (B_c) = 30 kHz

We know that, total spectrum allocation (B_t) = ?

$$N = \frac{B_t - 2B_{guard}}{B_c}$$

$$NB_c = B_t - 2B_{guard}$$

$$NB_c + 2B_{guard} = B_t$$

$$B_t = NB_c + 2B_{guard}$$

$$B_t = 416 \times 30\times10^3 + 2(10\times10^3)$$

$$B_t = 12.5 \text{ MHz}$$

So, 12.5 MHz is allocated for each simplex band

o

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Orthogonal Frequency Division Multiple Access (OFDMA):-

(Or)

Orthogonal frequency Division multiplexing (OFDM):-

→ OFDM is similar to frequency division multiplexing (FDM)

→ In OFDM the sub carriers signal has orthogonal relation ship.

→ Orthogonality allows the OFDM subcarrier to overlap each other with out interference

→ In the OFDM the input information sequence is first converted into parallel data sequence and each serial / parallel converter output is multiplied with spreading code.

→ Data from all subcarriers is modulated by FSK modulation and passes through ~~fast~~ Inverse Fast Fourier Transform (IFFT), which convert frequency domain to time domain and converted back to serial data.

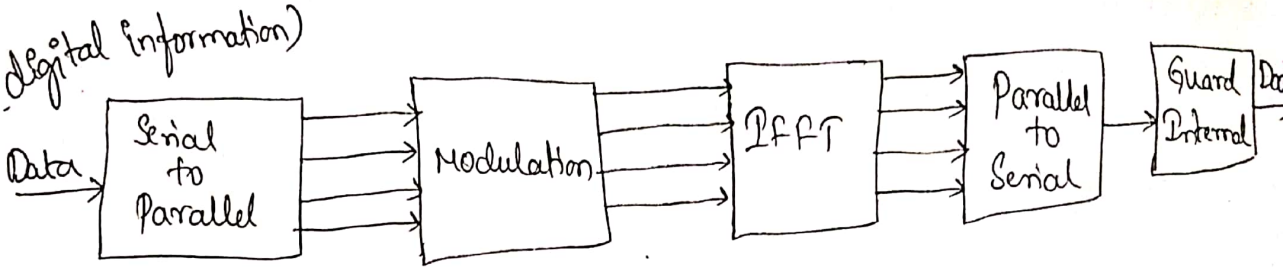
→ The guard interval is inserted between symbols to avoid FSI by multipath fading. (Floor space Index)

→ At receiver (Rx) the subscriber comparing and corresponding to the received data is first coherently detected with FFT and frequency domain converted to time domain.

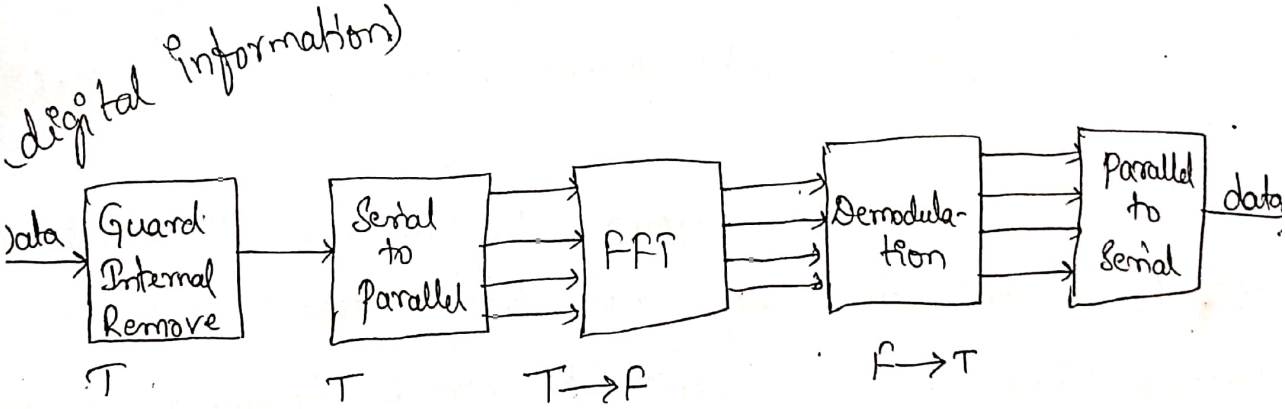
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→ Then demodulation is done and converted back to serial data.

OFDM Transmitter



OFDM Receiver



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