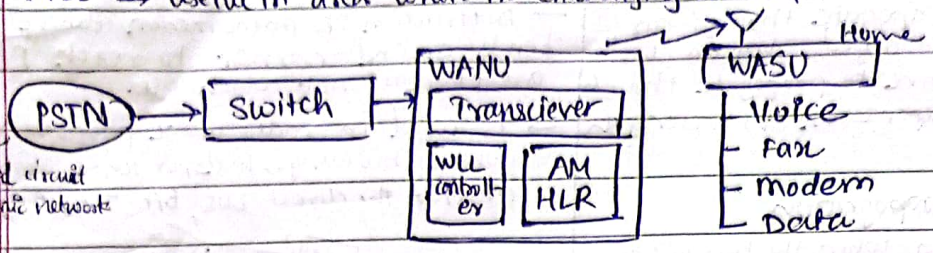
WIRELESS COMMUNICATION

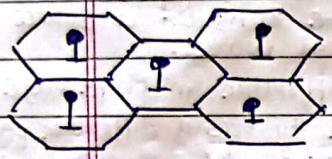
→ providing wireless connection stationary station within small service area.

WLL → connect subscriber to PSTN using wireless technology
→ useful in area where its challenging or costly to install traditional wired telephonic line



Cellular Mobile System → enable mobile comm over wide geographic area by dividing it into smaller cell.

provide voice and data services ↳ each cell is served by a BS which communicate with mobile device within coverage area.



consist of 3 parts
- Mobile unit
- BS
- MSC

→ adjacet cell assigned with diff. frequencies to avoid interference

Channel Assignment Strategy

↳ to allocate the available channel to the cell in the cellular system whenever a user want to make call request, then by using this strategy their request are fulfilled.

↳ designed in such a way to that their is efficient use of frequencies, time slot and band width.

↳ 3 types: Fixed, Dynamic, Hybrid

FCA	DCA
provided with limited no. of channel.	Channel are dynamically assigned based on network cond^n
User call is blocked when every channel is in use.	BS asks MSC for additional channel
simple algorithm are used	complex algorithm
less expensive	more expensive.
cell keeps the designated channel after call has ended.	The voice channel is returned to the MSC after the call is finished

Frequency reuse

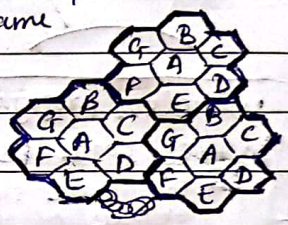
→ refers to practice of using the same radio frequency channel across diff. cells within a network.

→ Each cell is assigned set of frequencies for comm^n

→ cell with same letter uses same set of frequency

$$S = nN$$

S → Total no. of channel
N → no. of cells / size of cluster
n → no. of channel per cell.



→ The same set of channel can be reused in another cell if the cell is at distance 'D'. $D = \sqrt{3N}\,R$

R → Radius of cell. D → Reuse distance

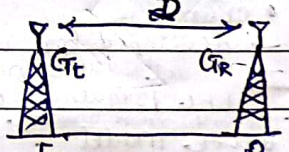
→ Distance b/t center of adjacent cell

$d = \sqrt{3}R$

Free Space Propogation model → used to predict the received signal strength with Tx and Rx have clear line of sight path

Power density of transmitted signal, if Tx radiate isotropically

$$PD = \frac{P_t}{4\pi D^2}$$



Then Received power is

$$P_r = \frac{P_t}{4\pi D^2} \cdot A_e$$

A_e → effective area of Rx antenna

$$A_e = \frac{\lambda^2}{4\pi} \cdot G_r$$

If Tx is not isotropic then,

$$P_r = \frac{P_t \cdot G_t}{4\pi D^2} \cdot \frac{\lambda^2}{4\pi} G_r$$

$$\boxed{P_r = \frac{P_t \cdot G_t \cdot G_r \cdot \lambda^2}{(4\pi D)^2}}$$ → friis free space path loss eqn

Path loss

$$P_L(dB) = 10 \log \left(P_t / P_r \right)$$

$$P_L(dB) = 10 \log \left(\frac{P_t \times (4\pi D)^2}{P_t \cdot G_t \cdot G_r \cdot \lambda^2} \right)$$

$$P_L(dB) = -10 \log \left[\frac{G_t \cdot G_r \lambda^2}{4\pi D^2} \right]$$

Interference → disruption or degradation of quality of comm^n signal due to various external and internal factor.

Types: ~~CCI (co-channel interference)~~
ACI (Adjacent channel interference)
IMI (Intermodulation interference
~~Noise interference~~
Propogation interference
Cell breathing

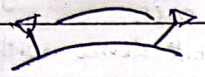
Radio Propogation model

→ radio wave can propogate through air, water various solid object, vacuum etc.

→ ability of radio wave to propogate through various medium depends on wavelength and frequency.

- **Ground wave propogation**

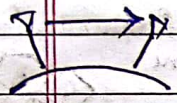
→ mode of propogation when the transmitting wave travel along the earth surface and are received at receiving antenna



→ used in medium range comm^n

- **Space wave propogation**

→ when transmitting wave travel directly to receiving antenna without any reflection, refraction or deflection



→ used in short range comm^n

Wireless propogation models

- **Free space loss model**

→ This assume simplest model and assume no obstacles or reflection

- **Two Ray Ground**

→ consider both direct path and a ground reflected propogated path b/t T and R.

- **Log Dist. Path loss**

→ consider factor like dist., frequency and environment.

→ assume logarithmic relationship b/t dist. and signal power, with path loss exponent that varies based on environment.

- **Okumura**

→ developed for urban environment

→ model takes into account factor like frequency, dist, and building density

→ provide more accurate prediction

- **Lee model**

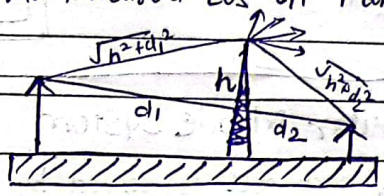
→ specifically developed for indoor enviornment

→ accounts for the effect of wall and other obstruction on signal propogation.

Knife edge diffraction model

→ Diffraction is phenomenon where em wave bends around corner to reach place which are otherwise not reachable.

→ is used in radio wave propogation analysis, where buildings, hills, or terrain irregularities obstruct the direct LOS b/t T and R.



→ It is based on Huygen principle which state that each point on a wavefront can be consider a source of secondary spherical waves.

→ Path loss due to diffraction in knife edge model is controlled by fresnel diffraction parameter which measure how deep the receiver is within the shadowed region.

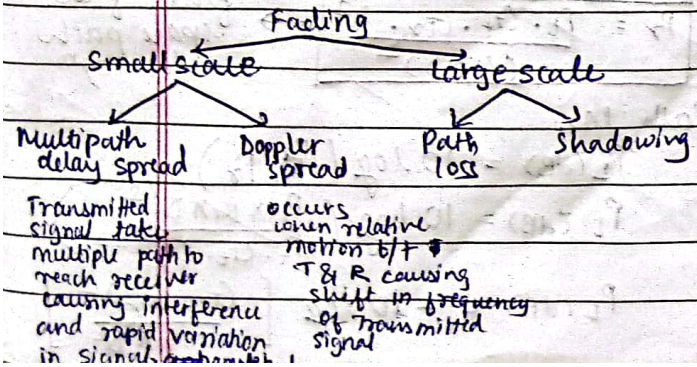
$$v = h\sqrt{\frac{2(d_1+d_2)}{\lambda d_1 d_2}}$$

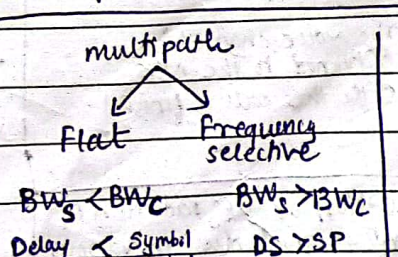
- $v \to -ve$ obstruction is below LOS. There is hardly any loss
- $v \to 0$ transmitter, receiver and tip of obstruction are all in line. and electric field strength is reduced by half.
- $v \to +ve$ means path loss is rapidly increasing

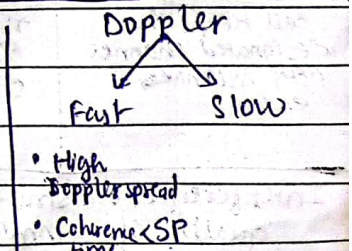
Factor influencing small scale fading

- multi path propogation :
- Distance : affect delay spread
- Higher frequency : experience more attenuation due to atmospheric absorption.
- Doppler effect : the frequency of received signal can be shifted due to doppler effect
- Obstructions : can block or reflect signal, causing fluctuation in signal strength.
- Atmospheric cond^n : affect signal propogation

Fading → refers to the variation in the strength or quality of a transmitted signal as it propogate through medius.







WiMax	Wifi
provide high speed internet access over long dist.	enable local wireless networking within limited range.
Cover larger area suitable for WAN deployment	smaller area LAN deployment
Provide better QoS compared to wifi	QoS degrades over longer distance
Require specialized infrastructure and equipment	can deployed using standard equipment such as router and access point
operates on licensed spectrum band and unlicensed frequency	unlicensed spectrum

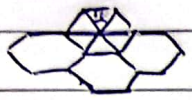
Cell splitting

- Divide larger cell into smaller cell to ↑es capacity
- ↑es capacity by reducing cell size
- cell radius ↓es co-channel reuse factor unchanged

- additional antennas deployed in new smaller cells

Cell sectoring

- into sector to ↑es capacity and coverage
- by focusing on antenna radiation in specific direction.
- co channel reuse factor ↑es, cell radius remain unchanged



- Antenna focused in specific direction with the original cell.

ZigBee → is WC standard designed

For low power, low data rate and short range wireless networking.

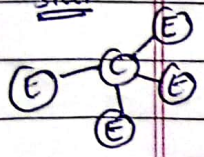
→ It is based on IEEE 802.15.4 standard that define the physical and MAC layer

→ ZigBee Network component

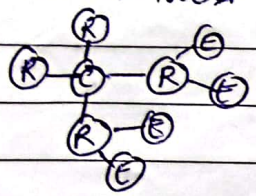
- ZigBee coordinator device
  - ↳ ZigBee network have exactly 1 ZC
  - ↳ store info. about network
- ZigBee Router
  - ↳ transmitting data from other devices
  - ↳ need less memory than ZC
- ZigBee End Device
  - ↳ it communicate with ZR

→ ZigBee support a wide range of network topologies

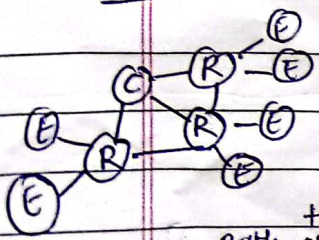
Star



Cluster tree

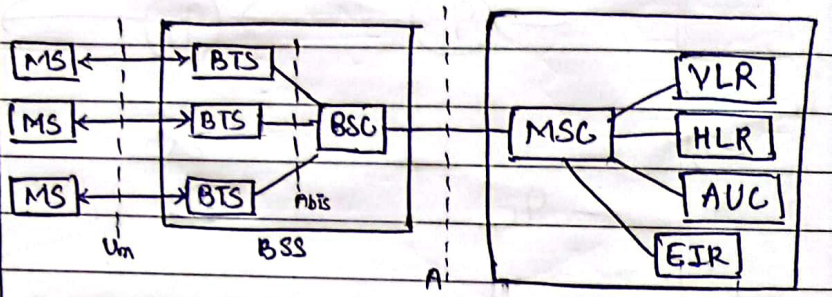


mesh

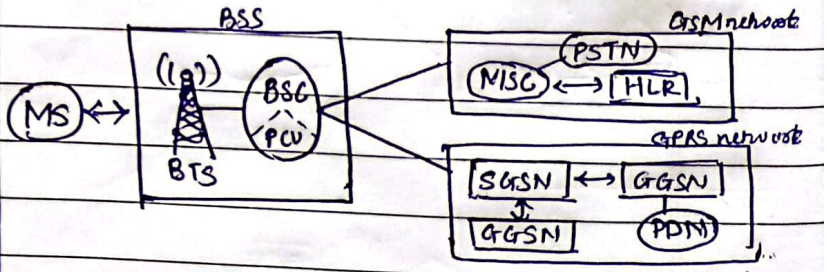


mesh topology allow network to self heal by rerouting data through alternate path if a node fail or become unreachable

GSM → responsible for managing radio comm^n b/t MS and BSS.



GPRS → consist of various network element that facilitate the delivery of packet switched data over mobile network.



GSM	GPRS
→ lower Bandwidth	→ Higher Bandwidth
→ involve circuit switching	→ It uses packet switching
→ Based on system TDMA	→ Based on GSM
→ 1 time slot allocated to 1MS	→ Multiple time slot are allocated to 1 MS
→ Billing is based on call duration	→ Billing is based on data volume consumed
→ does not allow direct connection to internet	→ direct connection to internet

FDMA (frequency division access)

→ 1st generation technique

→ is a technique used in tele-communication that allows multiple user to access shared communication channel by dividing available frequency spectrum into smaller frequency bands, each allocated to a different user or communication channel

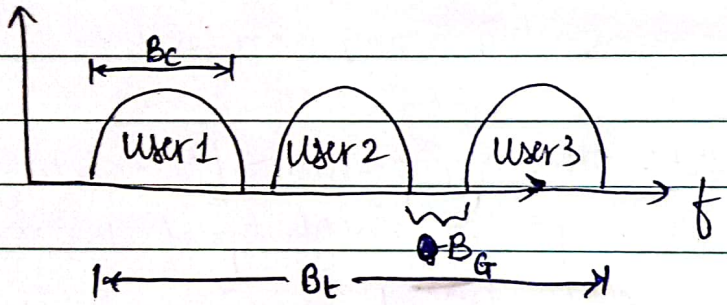
→ This allocation is done in such a way that the frequency band do not overlap, ensuring that each user ~~frequency~~ signal remains distinct and can be seperated at the receiver

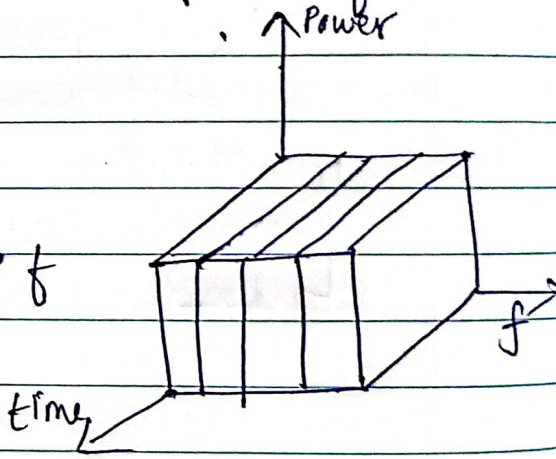
→ Guard band is used to avoid ISI (inter symbol interference)

→ User communicate simultaneously over their respective frequency band.

No. of channels,

$$N = \frac{B_t - 2B_G}{B_c}$$





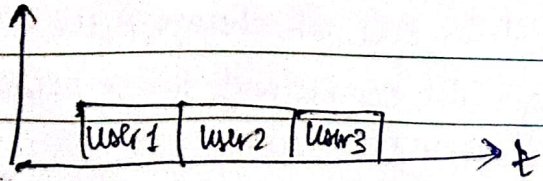
TDMA (Time Division access)

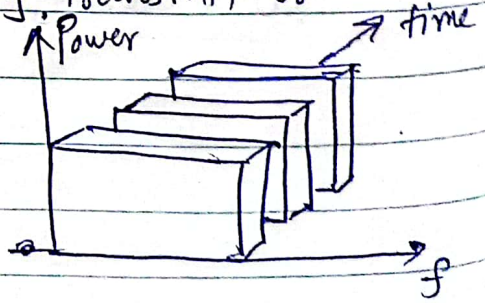
→ It is used in 2nd generation technique such as GSM

→ is a technique used in telecommunicaton to allow multiple user to share the same transmission medium by dividing it into time slots.

→ Each user is allocated one or more time slots within a predifined time frame, during which they transmit or receive data.

$$N = \left(\frac{B_t - 2B_G}{B_c}\right) \cdot m$$





apsara

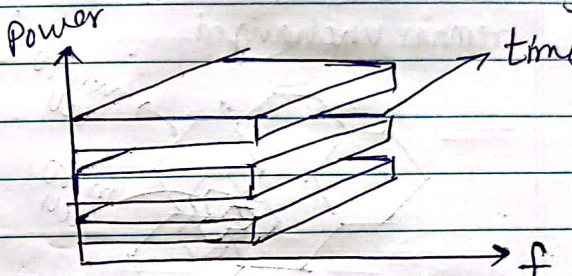
Date:

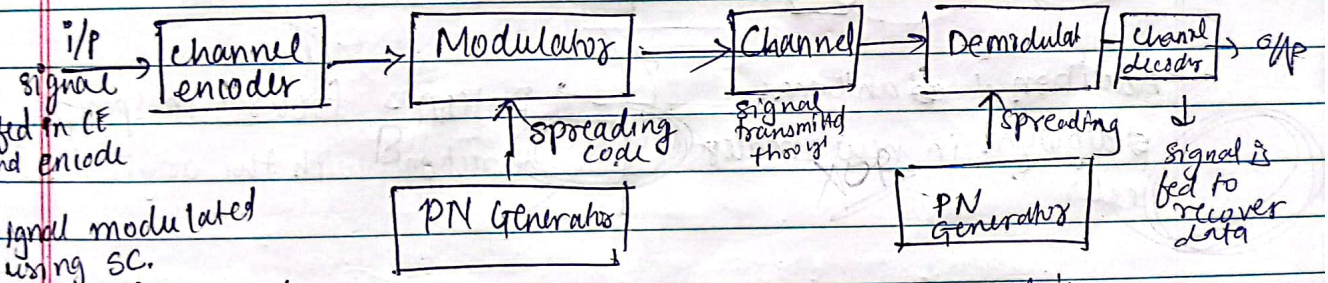
CDMA (Code division access)

→ is a digital cellular communication technology that allows multiple user to share same frequency band but assigning unique code to each ~~other~~ user.

→ CDMA seperates users by using unique spreading code

Bez → each user data is encoded with a unique code, CDMA offers inherent privacy and security, a unauthorized user would require the corred code to decode the transmitted signals.





signal modulated using SC.
result in ~~freq~~ of signal
to be transmitted

same code is use to ~~decode~~ demodulate spreaded ~~code~~ signal.
despreading of signal is by XORing it with same PN code.

FDMA	TDMA	CDMA
- Allocate seperat frequency band for each user	divides time into slots, each user occupies a different time slot.	use unique code for each user.
- Allocat specific frequency band	Allocate specific time slot	Share entire bandwidth
- Synchronization is not required	is required	not required
- It uses continuously signal for data transmission	It uses signal in bursts for data transmission	uses digital signal
- low data rate	medium data rate	High data rate
- It require guard band	It require guard time of the adjacent time slot	Both.
- b/t adjacent band	Restricted cell capacity	NO capacity restriction
Limited cell capacity		

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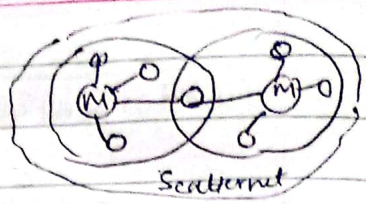
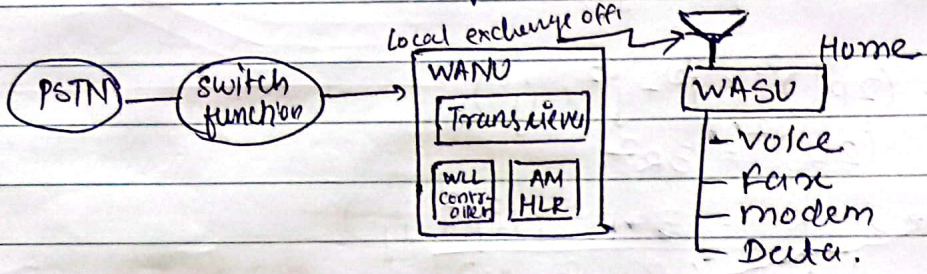
Bluetooth



→ Short range data exchange b/t electronic devices
→ it operates in the 2.4 GHz frequency band
→ Architecture of bluetooth define 2 type of network
- Piconet → 1 master node, 7 slave node } 8 active node.
- Scatternet → formed using various piconet

WLL (wireless local loop)

↳ is a telephonic system that connect subscriber to local telephonic network using wireless technology
↳ useful in area where its challenging or costly to install traditional wired telephonic line.



PSTN (Public switched telephonic network) → collection of world circuit switched telephonic network (interconnected)
WANU (Wireless access network unit) → present at LXO. All WASU are connect to it.
- Transciever : transmit/receive data
- WLL controller : control WLL component with WASU
- AM : responsible for Authentication
- HLR (Home location register) : stores details of all local WASU.

WASU (Wireless access subscriber unit) → present at house of subscribers connect subscriber to WANU.
→ power supply is provided locally

WLAN

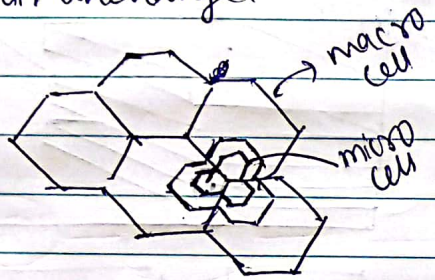
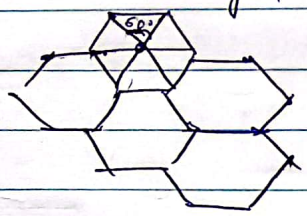
→ WLAN uses radio comm^n to provide mobility to the network user while maintaining the connectivity to wired network.
→ Performance of WLAN is high compared to wired
→ is a type of network allow devices to connect to internet and communicate with each other wirelessly typically using radio waves.

Advantage : Scalable → easily accomodate change in network no. of user by adding or removing access point.
Reduced cost
using encryption, authentication, firewall technology provide secure network access

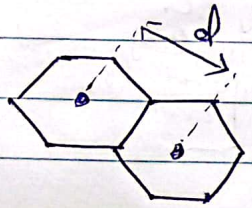
Date:

↑es capacity of system by reducing cell size

↑es capacity by using directional antenna

Cell splitting	Cell sectoring
→ Divides a large cell into smaller cells to ↑es capacity.	→ Divides a cell into sector to ↑es capacity and coverage
→ ↑es capacity by ~~red~~ ↓ing cell size	→ ↑es capacity and coverage by focusing on antenna radiation in specific direction
→ The cell radius ↓es while the co-channel reuse ratio remain unchanged	→ The co-channel reuse ratio is ↓es, while the cell radius remain unchanged
	
→ Additional antennas deployed in new smaller cells	→ Antennas focused in specific direction with the original cell.

Derivation to select no. of cell in cluster :-



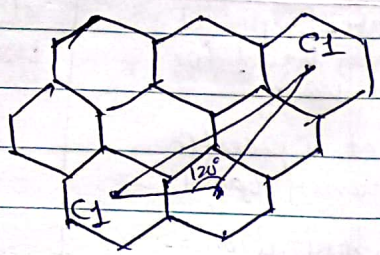
N = Frequency Reuse factor

R = Radius of cell

d = Distance b/t centres of adjacent cell

D_{min} = min. dist. b/t centre of cell that uses same frequency

S = Total no. of channel allocated.



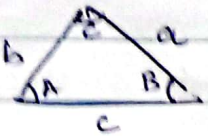
N=7.

For hexagonal cell pattern

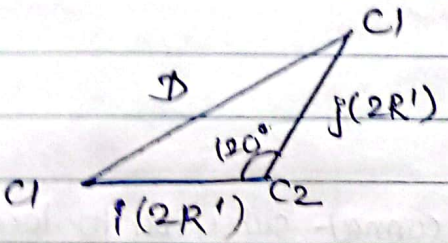
$d = \sqrt{3}R$

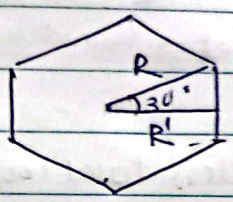
$\therefore D_{min} = \sqrt{3N} * R$

fundamental geometric rule.



$c^2 = a^2 + b^2 - 2ab\cos C.$





$\frac{R'}{R} = \cos 30°$

$R' = R \times \cos 30°$

$R' = \frac{\sqrt{3}}{2} R$

$2R' = \sqrt{3} R$

$(2R')^2 = 3R^2$

Reuse distance.

$D^2 = (i(2R'))^2 + (j(2R'))^2 - 2i(2R')j(2R')\cos 120°$

$= (i^2 + j^2)(2R')^2 + ij(2R')^2$

$= (2R')^2 (i^2 + j^2 + ij)$

$3N * R^2 = (2R')^2 (i^2 + j^2 + ij)$

$(2R')^2 = 3R^2$

$N * 3 * R^2 = 3 * R^2 (i^2 + j^2 + ij)$

To select the no. of cell in the cluster $\Rightarrow$ $N = (i^2 + j^2 + ij)$

Wireless Communication :-

WC → medium of transmission of info. from one device to another

Advantages	Disadvantage
• Fast efficiency.	• security
• Cost saving	• Limited Bandwidth → can only support certain no. of user at a time
• Scalability.	• Limited coverage area → user can only connect to the network
• Flexibility in Installation.	• Transmission speed → slower.
• wires bind you to single location wireless allow you to move around	

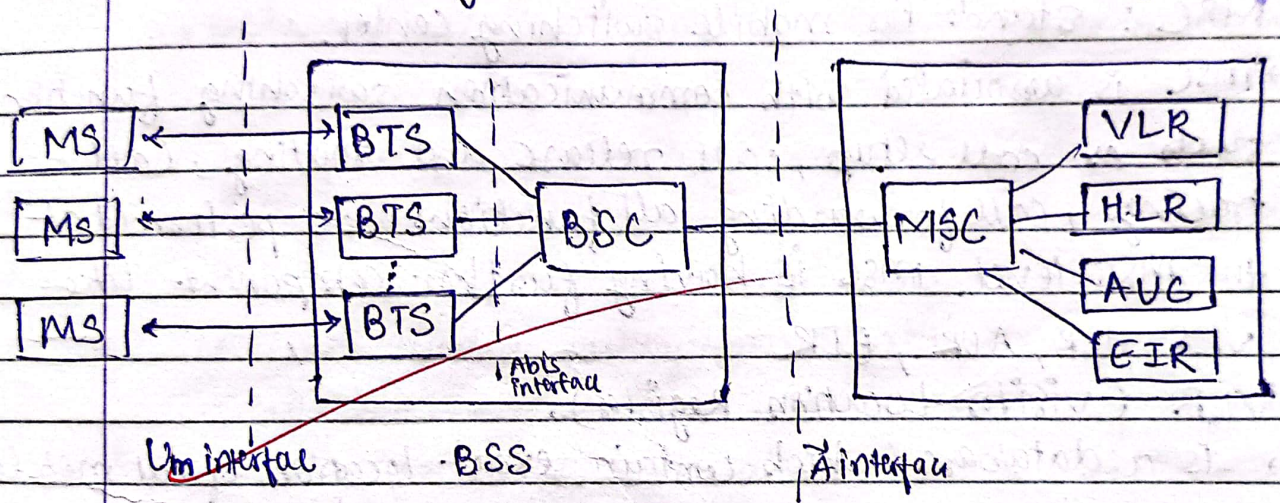
WiMax

→ wireless broadband technology that provides high speed internet access over long distances.
→ wimax cover large area compared to wifi
→ It offers high data transfer rate and better quality of service (QoS) compared to ~~wifi~~ traditional wireless technologies like wifi
→ wiMax network require specialized infrastructure and ~~equivalent~~ equipment and they are often deployed by service providers.

WiMAX	Wifi
→ provide high speed internet access over long distance	→ Enable local wireless networking within limited range.
→ covers larger area suitable for WAN deployment	→ cover smaller area suitable for LAN deployment
→ Provides better QoS ~~compered~~ compared to Wifi	→ QoS ~~da~~ may degrade over longer distance or in environment with interference
→ Require specialized infrastructure and equipment include Base station, subscriber units etc.	→ can be dployed using standard ~~off the shelf~~ equipment such as routers and access points
→ Operates on licensed spectrum bands and unlicensed frequencies	→ unlicensed spectrum band

Q1. Explain the GSM Architecture in details?
~~How does GSM radio subsystem works?~~

Ans The GSM (Global system for Mobile communication) radio system is a fundamental component of GSM networks responsible for managing radio communication between mobile device (MS - mobile station) and the base station system (BSS - Base station subsystem). ~~These~~



- MS : stands for mobile system. MS comprises user equipment and software needed for communication a mobile network

  MS = mobile equipment (ME) + Subscriber Identity Modu (SIM)

Now this MS are connected to tower and that tower connected ~~to~~ with BTS through TRX. TRX is a ~~transce~~ transceiver which comprises transmitter and receiver

- BTS : BTS stand for Base Transceiver station which facilitates wireless communication between user equipment and a network Every tower has BTS.

- BSC : stand for Base station controller. BSC has multiple BTS. You can consider the BSC as a local exchange of your area which has multiple towers and multiple tower have BTS. It handles tasks such as handover management, frequency allocation, power control, and call setup and teardown.

- MSC : stands for mobile switching center.
→ MSC is associated with communication switching function such as call setup, call release and routing. Call tracing, call forwarding all functions are performed at the MSC level. MSC is having further component like VLR, HLR, AUR, EIR

⇒ VLR (Visitor Location Register).
↳ is a database which contain exact location of all mobile subscribers currently present in the service area of MSC. If you are going from one state to another state then your entry is marked into the database of VLR.

⇒ HLR (Home location Register)
↳ is a database containing pertinent data regarding subscribers authorized to use GSM network. If you purchase SIM card from in the HLR. HLR is like a home which contain all data like your ID proof, which plan you are taking, which caller tune you are using etc.

⇒ AUC (Authentication center)
↳ authenticate the mobile subscriber that wants to connect in the networks.

⇒ EIR : EIR stands for Equipment Identity Register
↳ is a database that keeps the record of all allowed or banned in the network. If you are banned in the network then you can't enter the network and you can't make a call.

HLR	VLR
→ Stores permanent subscriber data and location.	→ Stores temporary subscriber data and location
→ Centralized database	→ Distributed database
→ manages subscriber registration, authentication, and mobility information.	→ manage temporary subscriber data for subscriber currently within its coverage area
→ Database size is large	→ Database size is relatively smaller
→ Not directly connected to MSC	→ Directly connected to MSC.

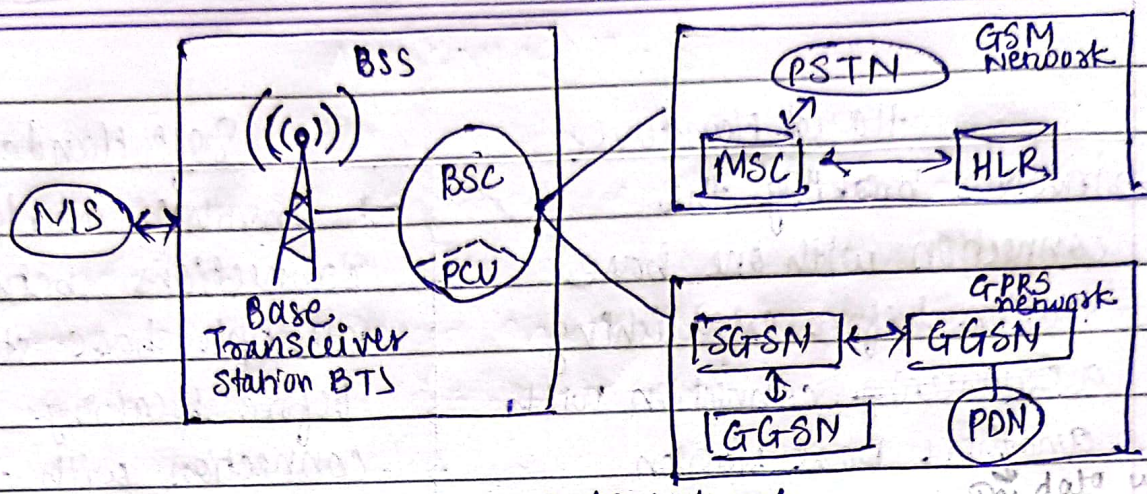
Hard Handover	Soft Handover
→ involves breaking the connection with one base station before establishing a ~~connecting~~ connection with another Base station	→ Involves overlapping connections between multiple base station before breaking the connection with the old base station.
→ Momentary interruption during the handover process	→ Seamless transition with no noticeable interruption during handover.
→ Typically simpler to implement and manage	→ More complex due to the need for coordination b/t ~~mul~~ ~~mBS~~ multiple base station
→ more efficient for system with low mobility or when the distance between base station is significant	→ more efficient for system ~~for~~ ~~w~~ with high mobility or when the distance between base station is ~~relati~~ relatively small

Q5. Explain GPRS Architecture in details

Ans GPRS (General Packet Radio service) architecture consists of various network element that facilitate the delivery of packet switched data over mobile networks.

→ GPRS offers end - to end packet switched data transfer services.

Voice Network.



Key components:-

① Mobile Station: The user mobile device equipped with GPRS - enabled terminal.

② GPRS support node:

↳ SGSN: manage the mobility of the mobile station within its service area.

- Keep track of the location of mobile devices and perform security function
- Routes and forward data packet to the appropriate B
- processes registration of new mobile subscribers and keep record of their location inside a given service area.

↳ GGSN: Act as an interface between the GPRS network and external packet switched network.

- Assign IP address to mobile device
- Handles encapsulation and decapsulation of user data packets.

③ BSS:

↳ BTS: manages the radio communication with the mobile devices. It convert digital data into radio signals.

↳ BSC: manage multiple BTS.

- handle the handover process between cells

↳ PCU : (packet control unit)

- responsible for managing packet switched data transmission within the GPRS network, including handling packet routing, error correction, and resource allocation. It plays a crucial role in ensuring efficient data transfer over the mobile network.