Wireless Communication

Unit - 1

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Wireless communication :

Wireless communication generally works through EM signals that are broadcast by an enabled device within the air, phy environment or atmosphere. The communication between two device occur when the destination or receiving devices captures these signals creating a wireless comm" bridge

It has various forms like

1. Satellite communication
2. mobile communicaton
3. Infrared communication
4. Bluetooth communication
5. Wireless N/w communication

We use wireless communication for

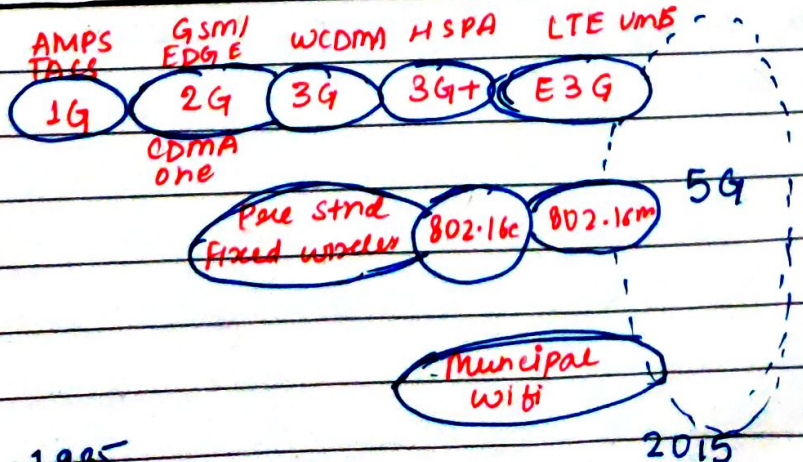
(i) Increased efficiency : High technology comm" systems leads to faster transfer of info

(ii) Rarely out of touch : No need to carry cables or adapters in order to access networks.

(iii) Greater flexibility : Can be networked without a sitting at dedicated PC's.

(iv) Reduced cost : cheaper to install and maintain.

(1) Evolution of Mobile communications :



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(i) 1934 : Police radio uses convention AM mobile comm systen
(ii) 1935 : Edwin Armstrong demonstrated FM
(iii) 1946 : First mobile telephone service – IMTS – full duplex
↳ (drawback was interruption while comm^n)
(iv) 1960 : IMTS (Improved) full duplexed
↳ (Bell lap introduce concept of cellur mobile systen)
(v) 1968 : AT&T propose concept of cellular mobu system to FCC.
(vi) 1976 : Bell mobu phone service, poor service due to cell blocking
(vii) 1983 : Advanced mobile protur system (AMPS), FDMA, FM use
(viii) 1991 : US Digital cellular (USDC) IS-54, TDMA, DQPSK
(ix) 1993 : IS-95, CDMA, QPSK, BPSK

Examples of wireless communication system
(i) Coordless phones
(ii) Remote controller (DVD player)
(iii) Walkie Talkie (certain Range)
(iv) Pagers (1990 to syn detailed msg)
(v) Telephones
(vi) WLAN

(2) Paging Systems:

(i) Conventional paging system sends brief message to subscribers.
(ii) Modern Paging system → News, headline, stock quotation fax may be sent.

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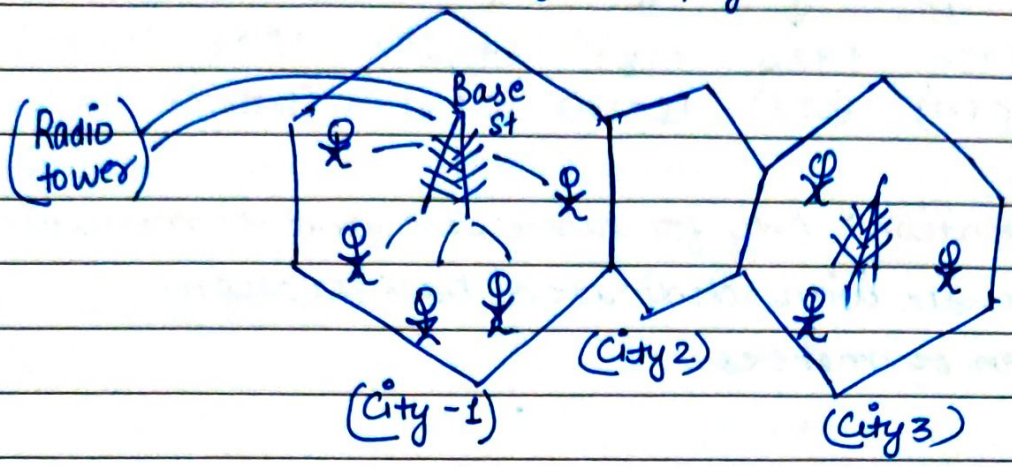
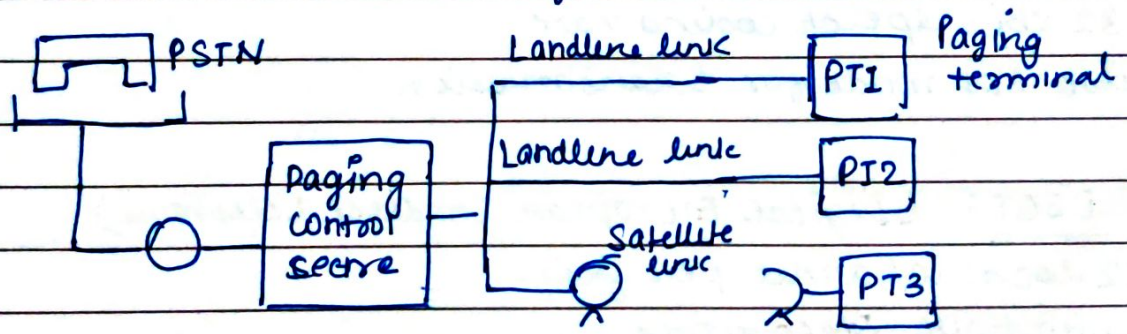
Message sent to paging subscriber by using paging system access no. Issued message → page.



(Radio tower → Base station → subscriber)

Simulcasting: Large radio towers that simultaneously broadcast a page from each base station.

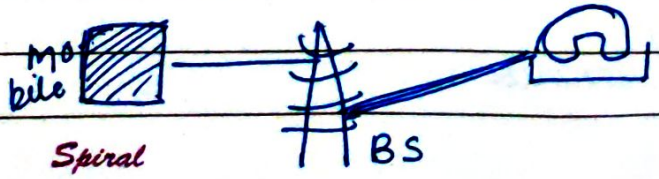
Paging system are designed to provide reliable comm^n to subscribe wherever they are.



(3) Coordless Telephone system:

(i) Designed to provide low cost wireless communicaton to PSTN.

(ii) Fully duplex comm^n that can wirelessly connect a portable handset to dedicare base st which is connected to dedicated telephone levels.



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They are upgraded in 5 phases

1980	1984	1987	1989	1991
(CTO)	(CT1)	(CT1+)	(CT2)	(DECT)

First generation: Only for home use and communication only possible with dedicated base stations.

(ii) few ten of meters.

Second generation: Can be used in out door as well

(ii) combined with paging systems

(iii) few hundred of meters.

→ **CT2:**

(i) Developed in Europe (1989)

(ii) 40 FDMA channel

(iii) 32 Kbps speech coding rate

(iv) Use TDD mode for transmission

→ **DECT:** (Digital European Coordless telephone)

(i) 12 local channel per freq.

(ii) Also have sleep mode

(iii) It conversation from one time slot to another (time slot transfer)

(iv) support seamless handoff

(v) compatible with GSM and allow mobility

→ **DHS:** (Personal handy phone system)

(i) Developed in Japan

(ii) Also have sleep mode

(iii) TDMA / TDD

(iv) BW partition → 77 channels

(v) 32 Kbps coding rate

(vi) support handoff.

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→ **PACS: (Personal access control system)**

(i) designed using WLL (Wireless local loop)

(ii) 32 Kbps speech coding rate

(iii) Use TDMA / FDD

(iv) supports roaming management

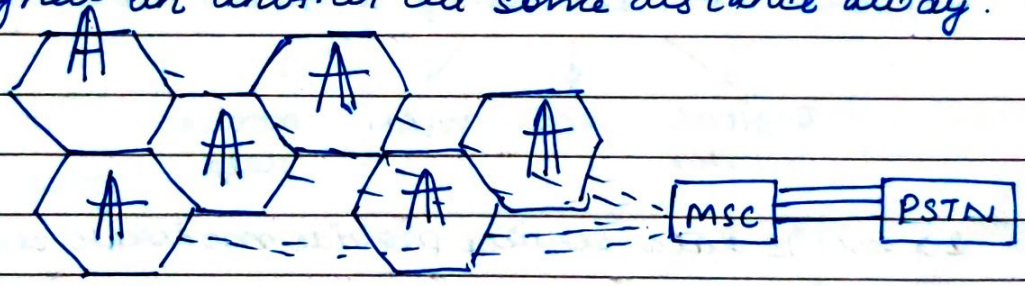
(4) Cellular telephone system:

(i) It is also known as PCS

(ii) Provide two way comm^n at high speed with regional in national coverage.

(iii) Main principle → to reuse frequency

→ The coverage area of cellular system is divided into non overlapping cells where some set of channel is assigned to each cell. This same channel is also assigned in another cell some distance away.



→ The operation within a cell is controlled by BS which consist of Tx and Rx.

(ii) This is connected to high speed dedicated comm^n link to MSC which coordinate the activities of all the B.S in limited region to provide connection to other fixed N/W such as PSTN.

e.g (GSM, AMPS, D-AMPS, IS-95)

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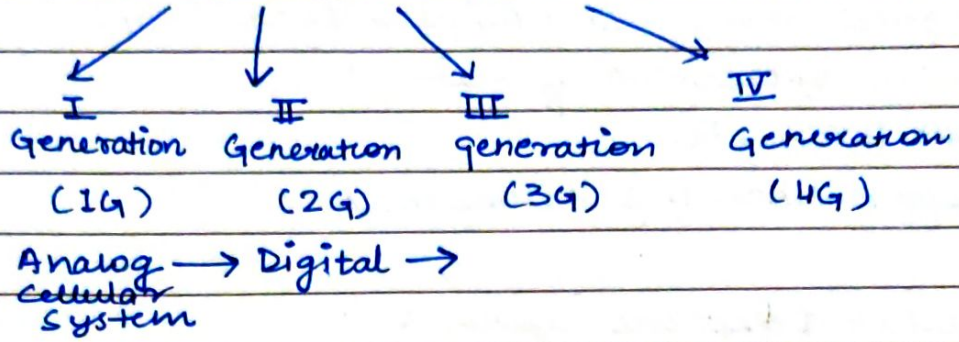
(5) Generation of cellular System:

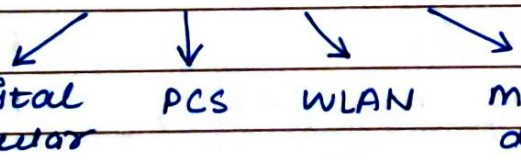


(i) First generation (1G):

(i) uses FDD schemes
(ii) typical allotted bandwidth each direction is 25 MHz.
(iii) uses analog cellular system
e.g AMPS, NMT

→ Second generation (2G):

(i) shift from analog to digital system
(ii) supports all 4 sectors of wireless industry.



(iii) 2G mobile data service provide moderate data rate and wide coverage area access to packet switch N/W
(iv) 2G WLAN provides high data rate.

→ Third generation (Internet system):

(i) It offers better capacity, high speed wireless intern (upto 2Mbps), wireless multimedia services
(ii) Enable person to communicate with anyone at anytime and anyplace.
(iii) provide more reliable service feature

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→ Fourth generation (4G and Beyond):

(i) In this user has freedom and flexibility to select any desired service with reasonable QoS.

(ii) High usability.

(iii) Support multimedia service at low transmission cost

(6) Comparison b/w wireless systems:

Parameter	Coordless	Paging	Cellular
Description	They are telephone with wireless handset that comm^n using radio waves with B.S	Gives indications like musical alert, name calling etc to particular indi. whom system want at telephone	Radio N/W distributed over areas called cells each served by atleast one Tx known as Base station.
Standards	CT2, DECT, PACS, GSM	POCSAG, FEEX, GSC	AMPS, NAMPS, USDC, IS-95
multiple access	FDMA, TDMA	Simplex	FDMA, CDMA, TDMA
Used for	Short distance	Country to country	Within N/W.
Mobile St.	MS coverage area is low	MS coverage area is high.	MS coverage area is high
Infra	Few infrastructure	High infra.	High infra
complexity	moderate complexity	Low complexity	High complexity
	H/W cost is low	H/W cost low	H/W cost moder

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Carrier frequency	1 GHZ	<1GHZ	1-3 GHZ
Functionality	Transciver	Reciever	Transreciver
Coverage range	Low coverage.	High coverage	Low coverage

→ **Personal communication service:**

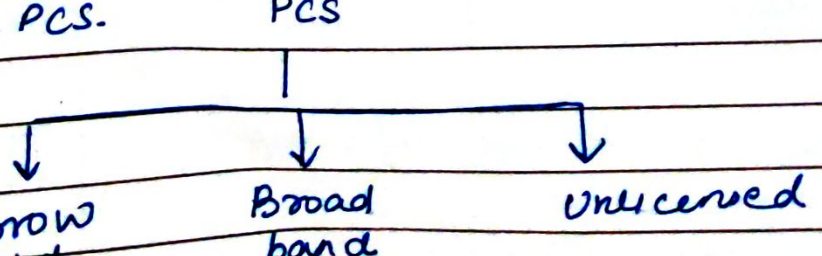
(i) It is a type of wireless mobile service with advanced coverage and that delivers services at a personal level. It generally refers to a modern mobile communication that boosts the capabilities of conventional cellular N/W and fixed line telephony N/W as well.

(ii) Also known as digital cellular

(iii) It works similar to cellular N/W in basic operations but requires more service provider infrastructure to cover a wider geographical area.

(iv) PCS generally includes:
a) Wireless comm^n (data, voice & video)
b) Mobile PBX
c) Paging and Texting
d) Wireless radio

(v) TDMA, CDMA, GSM, 2G, 3G, 4G are common tech used to deliver a PCS.



PSTN → Public switched telephone N/W

MSN → Mobile switching N/W.

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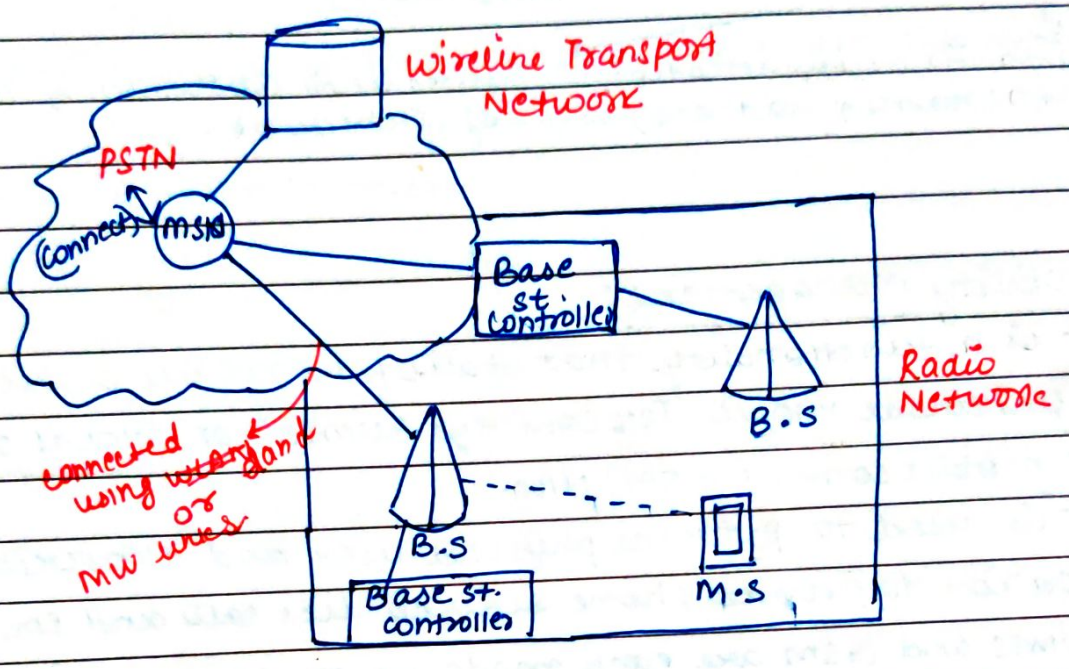
→ PCS architecture :

PCS architecture basically compress of two parts

a) Radio Network

b) Wireline Transport Network



Radio N/W → PCS users carry mobile st. to comm. with a BS in a PCS N/W. MS The radio coverage of a base st. is called cell. In GSM each cell is controlled by BSC which are connected to MSN through BS.

M.S
(handsets through which comm" happens)

B.S
(Base st provides signal and faulty for MS all time)

B.S.C
(Base station controller controls the connection b/w MS and nearest BS acc to range)

(checks security, data rate, functions

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b) Wireline Transport N/w → An MSC is a telephone exchange configured specially for mobile app^{n}. It interfaces MS with PSTN. MSC are also connected to mobility database to track the location of MS and roaming management. (HLR and VLR are those databases)

HLR → contains authentication info (names, addr etc)

VLR → (gives info about loc of area of subscriber)

→ **Mobility management:**

(i) It is a functionality that facilitates mobile device opr in Universal Mobile Telecom sys (UMTS) or Global system for mobile comm (GSM) N/w.

(ii) It is used to p·trace physical user and subscriber location to provides phone services like calls and SMS.

(iii) UMTS and GSM are each made up of seperate cells (B.S) that cover specific geographical area.

(iv) The loc. update procedure allows a mobile device to notify when shifting between areas. When a mobile device recognizes that an area code differs from previous update it executes a loc update by sending loc. req. to its N/W, prior loc & specific temp. mobile subscriber Id.

(v) Roaming is among the basic procedures of mobility management. It enables subscribers to use mobile services when moving outside geo. area of a specific N/w.

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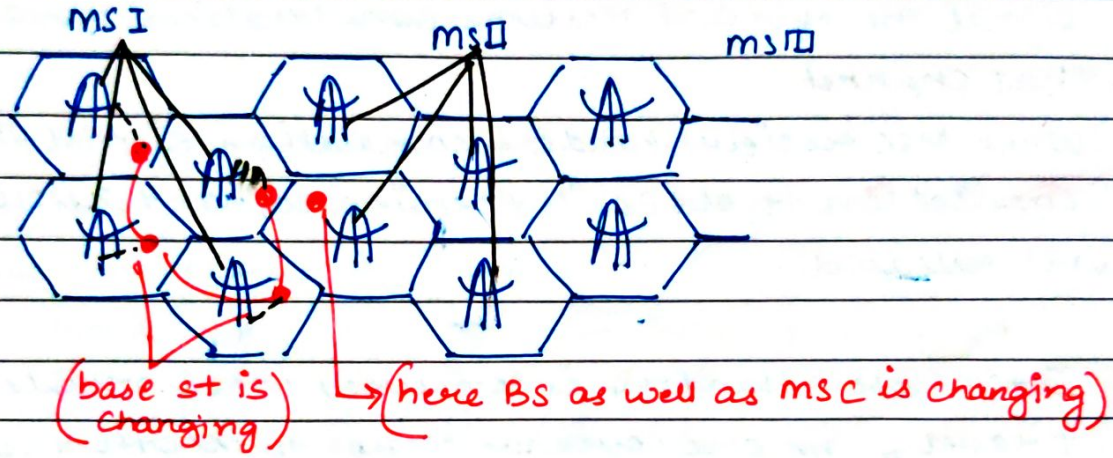
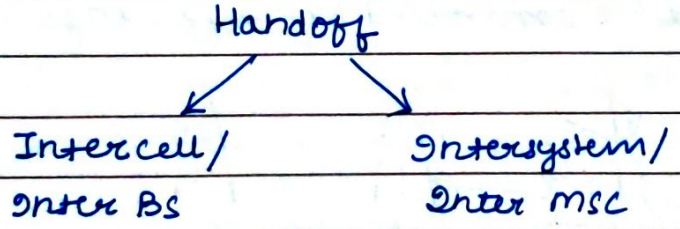
It refers to the way the N/w manages the movement of mobile subscribers which significantly affect peformance of the PCS N/w.

→ **Network signalling:**

Handoff:

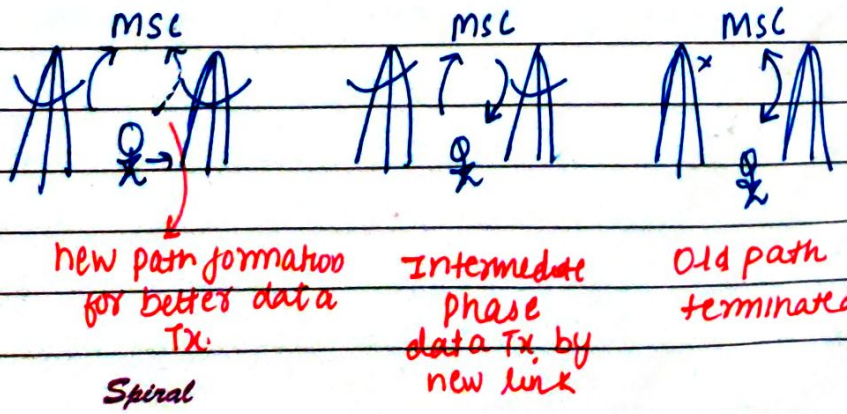
It is the process which Enable call to proceed uninterupted when moved user moves from one cell to another or one system to another.





(1) The inter BS Handoff req. when mobile unit travel from one BS to another BS while old n New connected to same MSC.

Steps for connection:



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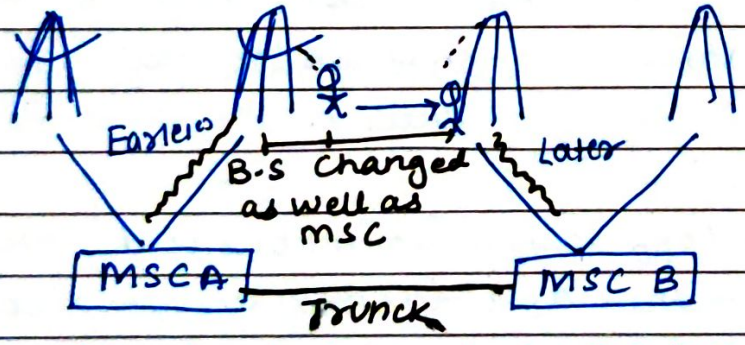
(i) When the signal recieved from the current BS is not strong enough the MS momentarily suspend convo and initiate the handoff procedure by signalling on an idle channel in the new BS. Then convo on old BS is resumed

(ii) When MSC rx the signal it transfers the info to the selected idle channel of the new BS and new conv path is setup.

(iii) After the MS has been transfer to the new BS, it signal the N/w and resume conversation through that channel.

(iv) When MSC recieves handoff completion signal the connection to old BS is terminated and resource are released

(2) Intersystem Handoff is required when mobile unit travel from one coverage region to another while new and old BS controlled by diff. MSC



[after trunk → req. from one msc to another
after this only another msc will send data via it]

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→ **Handoff detection techniques:**

(i) **MCHO:** (Mobile controlled Handoff)

a) In this scheme the MS determine the handoff requirement and control handoff process.

b) In this method

* MS continuously monitors the signal quality from the current BS and several candidate BS for handoff.
* When handoff criteria is met, MS choose the best BS with best signal strength.

(ii) **NCHO:** (Network controlled handoff)

a) In this scheme the BS determine the handoff req and control handoff process.

b) In this BS cont. monitors the signal quality from MS when handoff criteria is met BS inform the MS to arrange the handoff to another BS.

c) The N/w ask all nearby BS to monitor the signal from MS and based on this info BS N/w chooses BS with best signal strength and connection transfered to new BS.

(iii) **MAHO:** (Mobile Assisted handoff)

a) In this handoff procedure is controlled by N/w with help of MS.

b) In this N/w asks MS to measure signal from (each BS) surrounding BS, MS sends info to old BS using which the N/w checks the handoff req.

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→ Channel Assignment strategies:

(i) FCA: (Fixed channel assign)

a) In this each cell is allocated pr determined set of voice channel.

b) If any user calls within a cell only available unused channel may be used

c) If all channel is occupied call is blocked & service denied

(ii) BCA: (Borrowing channel assignment)

a) In this strategy a cell can borrow channel from neighbouring cell when all its own channels are occupied

b) The MSC supervise this borrowing process and ensure borrowing channel does not interfere any call in progress

(iii) DCA: (Dynamic channel assignment)

a) Instead of allocating voice channel to diff cell permanently the serving BS has to req. a channel from MSC whenever call req. is made.

b) MSC follow algo and then allocate channel to req. cell

c) Thus DCA reduces likelihood of blocking.

→ Prioritising Handoffs:

(i) NPS: (Non priority scheme)

In this handoff calls or New call both are handle by BS in same manner, i.e hand off call is blocked. ~~this~~ if no channel is available

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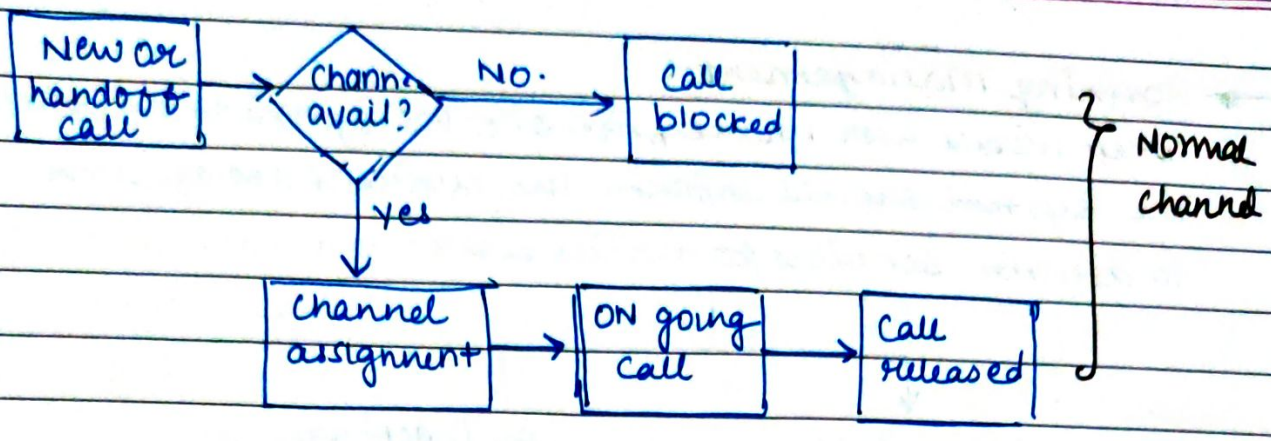
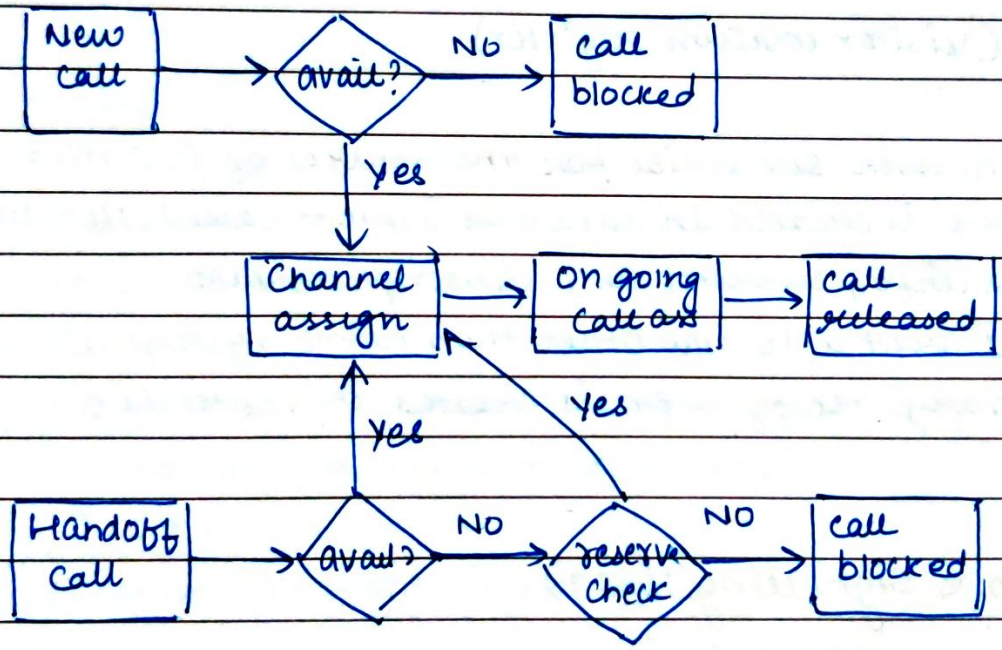


(ii) RCS : (Reserved channel scheme)

In this channel is divided into 2 parts

(i) Normal channel → (for both)

(ii) Reserved channel → (can use hand off call)



(iii) SRS: (Subrating scheme)

(i) When free channel avail work similar NPS

(ii) When handoff req. come and a free channel is not ava SRS creates a new channel by subrating (breaking) in 1/2 existing calls. One will be used for existing calls another for handoff req.

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→ Roaming Management :

When mobile user moves from one PCS system to another the system should inform the current loc of user to deliver services to mobile user.

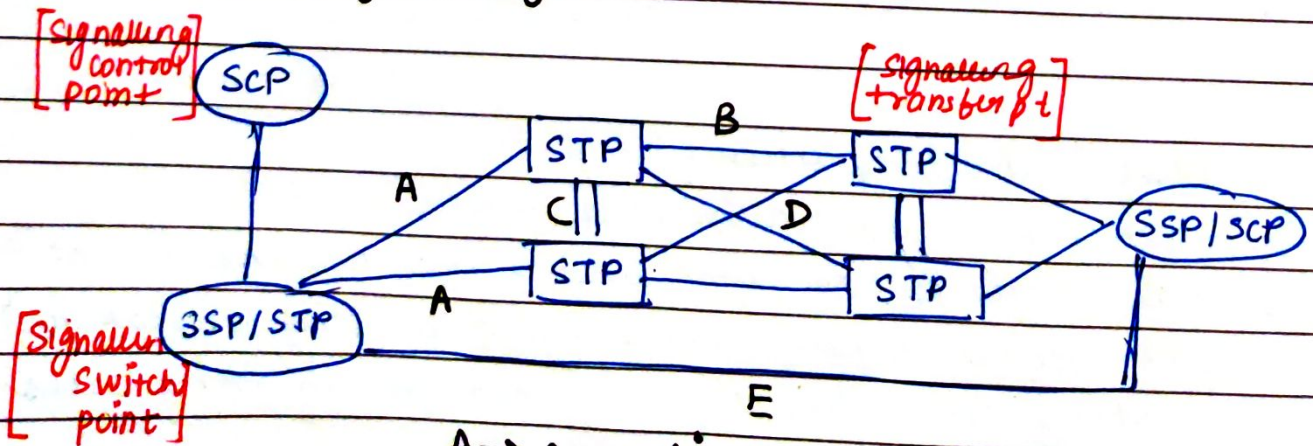
- Loc. update (The process where MS inform system of its location)
- Loc. Tracking (The process where systems locate MS location)

For updating loc. 2 database are there

(i) HLR (Home location register) → (stores data of user)
(ii) VLR (Visitor location register)

(i) When a user subscribe for the service of PCS N/W a record is created in database system called HLR like profile info, current loc, subscription info.
(ii) If MS visit a PC N/W other than home systems a temporary rec of user is created in visitor loc.

→ Network Signalling: (SS7)



A → Access link
B → Bridge link
C → Cross link
D → Diagonal
E → Extended
F → Fully associate

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(i) SSP:

a) It is an interface to telephone N/W
b) It converts voice signal to SST signal link
c) Local exchange to subscriber

(ii) SCP:

a) It is an interface with database
b) Handles database queries and subscribers info.

(iii) STP:

a) It is basically a network node
b) Works as a router

→ A link:

Connects SCP/STP to SSP and provides info of subscriber

→ B link:

Connects STP to STP

→ C link:

Connects STP to STP only and works for route failure and in that case provide another part

→ D link:

Connects STP – STP diagonally.

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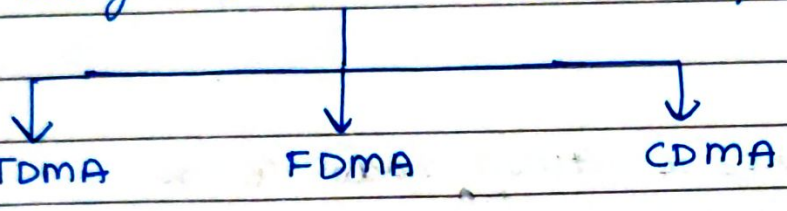
→ Multiple access techniques:

In wireless comm systems it is often desirable to allow the subscriber to send information simultaneously from the MS to BS while receiving info from BS to MS Hence a cellular system divides any given area into cells where a mobile unit in each cell comm with BS.

Main aim : To able to inc the capacity of channel as possible in given BW with sufficient quality of service



(i) TDMA (Time division multiple access):

In the cases where cont. Tx is not req. there TDMA

a) is used. It divides a single channel into time slots where each user makes use of non overlapping slots.

b) TDMA is not continuous but occur in bursts hence handsoff is simple.

c) Duplexers are not req as Tx and Rx occur at diff slots

d) BW can be supplied or demand to diff users by concatenating or reassigning slots based on priority.

In this division of calls happens on time basis. System first digitizes calls then combines convo in unified digital stream on single radio channel. Then it divides each channel into time slots and is assigned to each call during convo.

(Digital technique)

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(ii) FDMA: (Freq. Division multiple access)

It is basic technology for advanced mobile phone services.

a) It allots diff sub band freq to each diff user to access N/w
b) If FDMA is not in use, channel is left idle instead of alloting to others
c) Implemented in Narrow band system (Analog technique)
d) Less complex than TDMA.
e) Filtering is done to reduce interferance
d) BS and MS rx and tx data continuously

(iii) CDMA: (Code Division multiple access)

It is an example where several transmitters use a single channel to send info simultaneously.

a) every user use full avail. spectrum
b) recomended for voice and data comm
c) while multiple codes occupy same channel, users having same code can comm with each other.
d) Handsoff is very well handled.

In this every bit of a convo is tagged with specific and unique code. Now the data is split into small parts and is tagged with unique code. Now this data in small pieces is sent over discrete freq avail at any time in the range.

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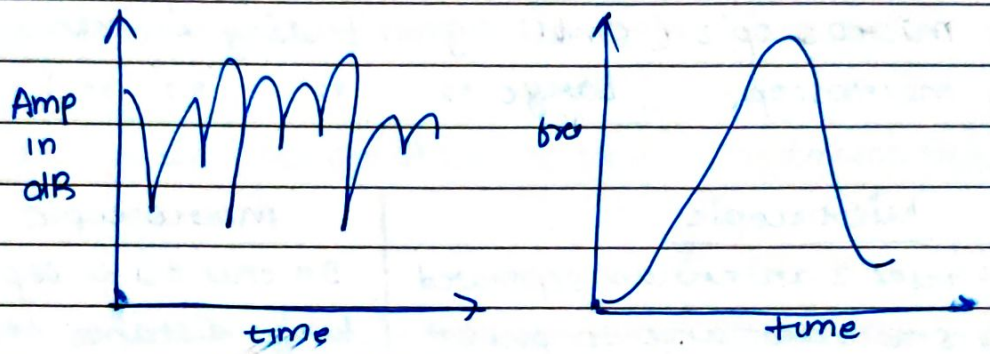
→ Rayleigh fading:

(i) It is assumed that variation in signal passed through Rayleigh fading channel would follow rayleigh distribution

(ii) This model assumes that the mag of signal passed through a Tx medium will vary randomly or fade acc to Rayleigh distribution – the radial comp of sum of 2 uncorrected gausian random variable

(iii) It is caused by multipath reception (reflected and scattered waves)



It is commonly used to describe statistical time varying nature of rx ~~signal of~~ flat fading signal and can be given as bellow:

$$s(r) = \begin{cases} \frac{r}{\sigma^2} \exp\left(\frac{-r^2}{2\sigma^2}\right) & 0 \le r \le \infty \\ 0 & r < 0 \end{cases}$$

→ BER performance in Fading Channel: (Bit error rate)

(i) BER is a function of E_b/N_0 and is plotted for various fading channel.

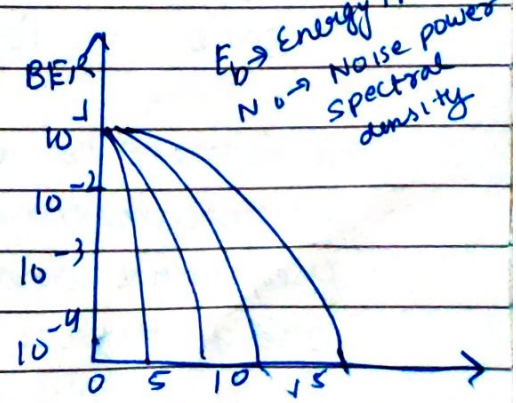
(ii) As BER ↓ E_b/N_0 ↑

(iii) AWGN exhibit good perform (conc)

(iv) Rician Good performance

(v) Rayligh Poor performance

(vi) Flat fading Poor performance



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→ Diversity modelling :

(i) This was introduced to compare and overcome deep fading.

(ii) As in deep fading if we have a single channel the connection will get interrupted or link will degrade due to fading. Hence to remove this problem

(iii) multiple links is applied b/w Tx and Rx which will affect comm. even after fading.

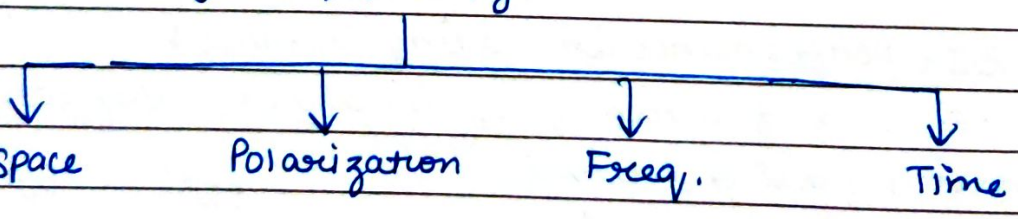
(iv) Diversity modelling is divided into 2 parts

a) Microscopic (small signal fading is men)

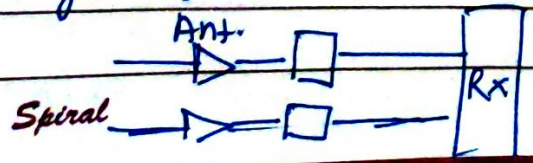
b) Macroscopic (Large " " " ")

Microscopic	Macroscopic
(i) It uses 2 antennas seperated by small distance to prvent small scale fading	In this BS is seperated by large distance that is not shadowed hence mobiles can acquire better SNR. Such contracting reduces large scale fading.
(ii) By selecting strong signal at all time a rx can mitigate small scale fading	

Types of Diversity



(i) This is most conventional method in which we have several antennas which are seperated by diff freq. band and they reach to reciever. Even if one got degrade rest will reach to rx



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There are 4 types of subdivision:

a) selection diversity
b) Feedback diversity
c) maximum ratio diversity
d) Equal gain diversity

(ii) This is used where signal is transmitted using pair of polarized antenna and rx by another pair of antenna. when fading channel can be rx hence this diversity is used
→ Circular and linear diversity antenna is used

(iii) In this info is sent on carriers from transmitter end to receiver end.

(iv) In time diversity info is transmitted repeatedly after a specific time. It leads to repetion of signal also.

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→ **Wireless channels and fading:**

Wireless comm is prone to noise, interference and other channel obstruction which change over time unpredictably resulting degradation of signal.

Losses in signal arises both in Tx of signal in short distances as well as long distances.

Long distances

Here loss is due to path loss and shadowing.

Path loss → degradation of signal due to dissipation in path because of propogation effects

Shadowing → caused by obstacles that absorbs power.

small scale fading

short distances

Here loss is caused due to multipath delay and dopplers spreading.

multipath spreading → addn of constructive & deconstructive signal components while prop

Doppler's spread → change in freq of EM due to relative motion of rx wrt Tx. & velocity and direction of motion of rx wrt arrival of wave.

(1) **Small scale Fading:**

(i) Describes rapid fluctuations of amplitude of RF signal over a short period of time and distance.

(ii) Fading is the phenomenon caused due to interference b/w two or more versions of Tx signal which arrives at the rx at slightly diff times.

These are delayed versions of Tx signal caused due to mov and called multipath waves.

Signal

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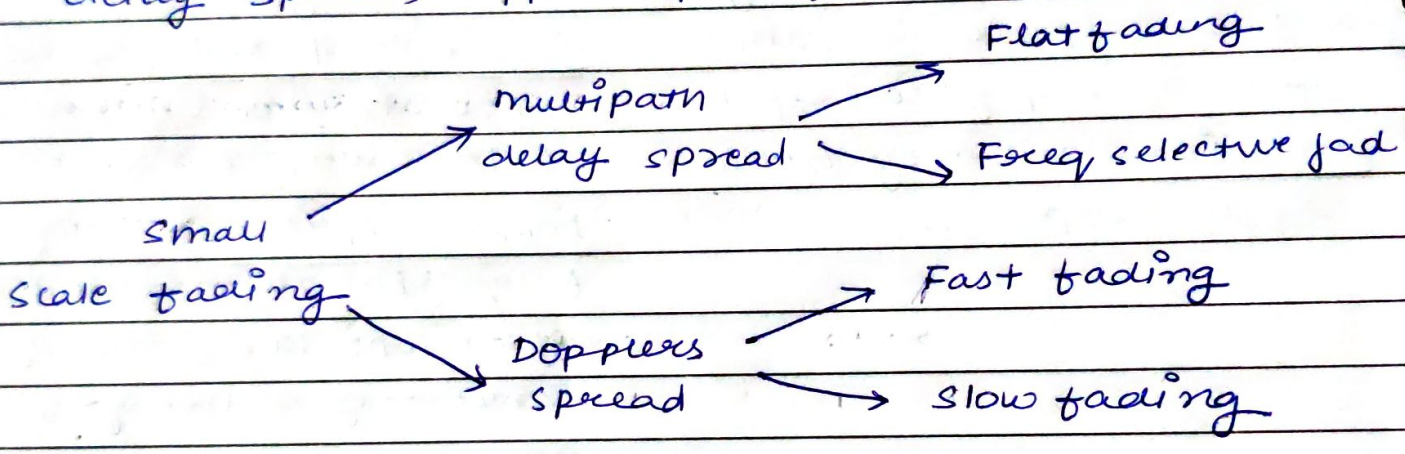
Reasons of small scale fading

(i) Rapid change in signal strength over small distance
(ii) Random freq mod. effects due to doppler shifts
(iii) Time dispersion due to multipath delays.

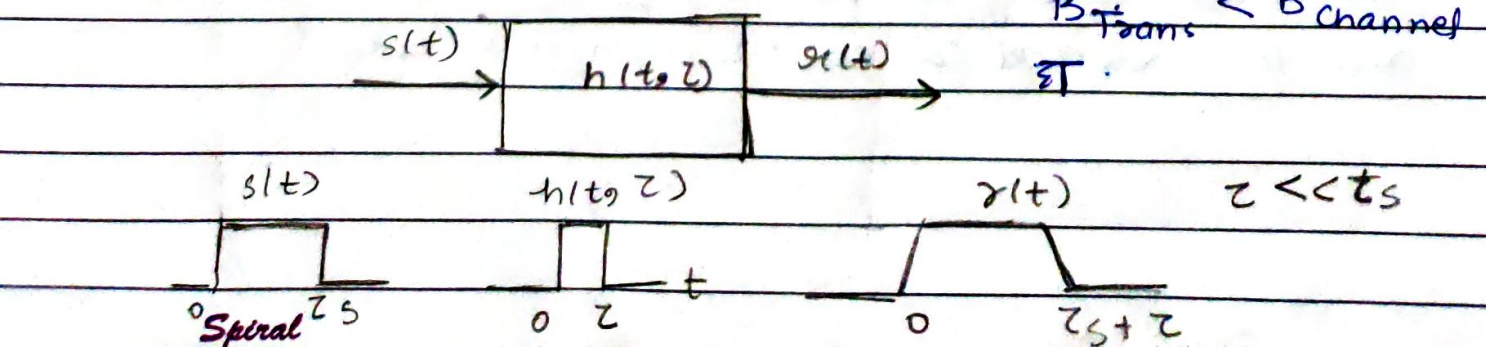
Types of Small Scale Fading:

Type of fading experienced by Tx signal depends on the nature of Tx signal wrt characteristics of channel. i.e (depends on relation b/w signal parameters i.e BW, symbol period etc and channel parameters i.e delay spread, doppler spread).



(i) Flat fading channel →

→ caused by time dispersion due to multipath compone
→ occurs in rx signal if channel has const gain and linear phase response over BW > BW transmitted signa
→ most common type of fading
→ In this spectral charac. of Tx signal is preserved in rx signal while strength changes with time



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Conditions for flat fading

(i) $B_{transmitted\ signal} < B_{channel}$

(ii) ~~$T_{signal} > T_{channel}$~~ (Rate of change of ~~channel~~ ~~slowed~~ ~~be faster than signal~~)

(iii) Delay spread < symbol period

(ii) Freq. selective fading channel :

→ caused due to time dispersion due to delayed multipath components.

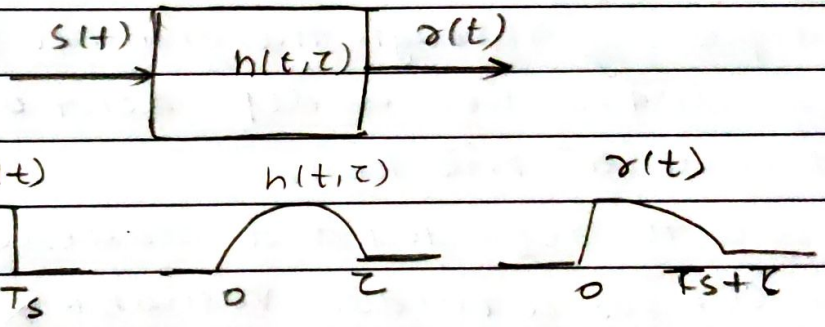
→ occurs in rx signal if channel has constant gain and linear phase response over BW channel < BW signal.

Condition for selective fading

(i) BW signal > B channel

(ii) ~~$T_{channel} > T_{signal}$~~ Delay spread > symbol period

→ Received signal includes faded and delayed signal tor hence signal is distorted and Intersymbol Interference is induced.



(iii) Fast fading channel :

→ caused due to freq dispersion due to doppler spread

→ Rate of change of channel is faster than rate of change of Tx signal.

→ Doppler spread is greater than Tx signal.

(i) $T_{signal} > T_{channel}$ (T_s → symbol period)

(ii) $B_{signal} < B_{doppler\ spread}$

(iv) Slow fading channels :

→ Caused due to freq dispersion due to doppler spread
→ Rate of change of channel is slower than Tx signal
→ Impulse response is static
→ Doppler spread is smaller than Tx signal
(i) $T_s << T_c$ (T_c → coherence time)
(ii) $B_{signal} >> B_{doppler}$ (T_s → symbol period)

(2) Rayleigh and Rician fading channels :

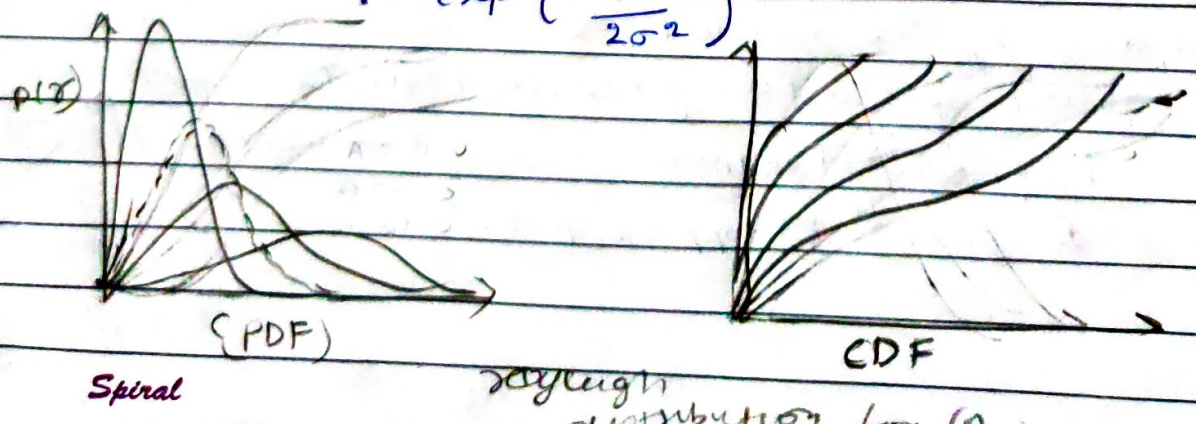
These fadings occur to a signal as a result of effect of propogation channel.

(i) Rayleigh fading channel :

→ Based on Rayleigh distribution which is used to describe statistical time varying nature of rx waveform of a flat fading signal
→ signal passing through this channel follows rayleigh distn
→ Rayleigh distribution is dependent on Gaussian and Normal distribution.
→ Caused due to reflected and scattered waves
→ PDF and CDF for a random variable x following Rayleigh distribution is given as

$$p(r) = \begin{cases} \frac{r}{\sigma^2} \exp\left(\frac{-r^2}{2\sigma^2}\right) & 0 \le r \le \infty \\ 0 & r > 0 \end{cases}$$

$$P(r) = 1 - \exp\left(\frac{-R^2}{2\sigma^2}\right)$$



Spiral

Rayleigh distribution for (A)

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(ii) Rician fading channels:

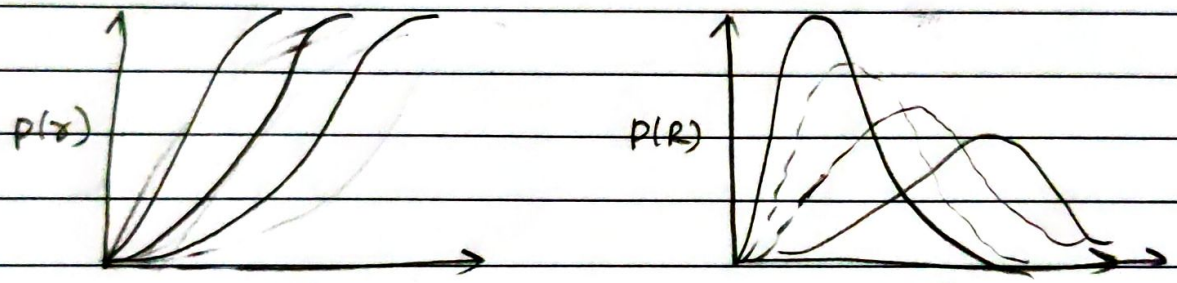
→ A wireless channel modelled when there exists non-fading signal, LOS propagation path, radion multipath components and these are superimposed on a non-fading signal.

→ At the receiver the o/p signal having effect of all these components resulting weaker signal following Ricean distribution.

→ PDF and CDF are given as

$$p_r = \frac{r}{\sigma^2} e^{\frac{(r^2+A^2)}{2\sigma^2}} I_0\left(\frac{Ar}{\sigma^2}\right) \quad A>0 \; r>0$$

$$P(R) = 1 - Q\left(\frac{A}{\sigma}, \frac{r}{\sigma}\right)$$



(Ricean distribution)

(3) BER performance in fading channels:

(i) BER stands for bit error rate per bit transfered.

(ii) It is a function of E_b/N_0 plotted for various channel

(iii) BER ↓, E_b/N_0 ↑

(iv) In Rician fading the chan