Wireless and mobile communication (REC-085, 1st sessional examination 2019-20)

Section-A

Ans1a. Base Station :A fixed station in a mobile radio system used for radio communication with mobile stations. Base stations are located at the center or on the edge of a coverage region and consist of radio channels and transmitter and receiver antennas mounted on a tower.

Ans1b. Full Duplex :Communication systems which allow simultaneous two-way communication systems. Transmission and reception is typically on two different channels (FDD) although new cordless PCS systems are using TDD.

Ans1c. 824-849MHz(UL /869-894MHz(DL)

Ans1d. P(dBm) = $10\log_{10}$ (P(10,000mW))=40dBm

Ans.1e. $G = 4\pi A/\lambda^2$

$A = \lambda^2/4\pi$ as Isotropic antenna gain is unity.

$\lambda = 3x10^8/ 900x\ 10^6 = 1/3 = 0.33m$

$A = (0.33)^2/4x3.14 = 0.0086m^2$

Section-B

Ans2a.

Given:

Transmitter power, P_t = 50 W.

Carrier frequency, f_c = 900 MHz

Using equation (3.9),

(a) Transmitter power,

$$P_t(\text{dBm}) = 10\log[P_t(\text{mW})/(1\ \text{mW})]$$
$$= 10\log[50\times10^3] = 47.0\ \text{dBm}.$$

(b) Transmitter power,

$$P_t(\text{dBW}) = 10\log[P_t(\text{W})/(1\ \text{W})]$$
$$= 10\log[50] = 17.0\ \text{dBW}.$$

The received power can be determined using equation (3.1).

$$P_r = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 d^2 L} = \frac{50\,(1)\,(1)\,(1/3)^2}{(4\pi)^2\,(100)^2\,(1)} = 3.5\times10^{-6}\ \text{W} = 3.5\times10^{-3}\ \text{mW}$$

$$P_r(\text{dBm}) = 10\log P_r(\text{mW}) = 10\log\left(3.5\times10^{-3}\ \text{mW}\right) = -24.5\ \text{dBm}.$$

The received power at 10 km can be expressed in terms of dBm using equation (3.9), where d_0 = 100 m and d = 10 km

$$P_r(10\ \text{km}) = P_r(100) + 20\log\left[\frac{100}{10000}\right] = -24.5\ \text{dBm} - 40\ \text{dB}$$
$$= -64.5\ \text{dBm}.$$

Ans2b.

2G: Digital Networks

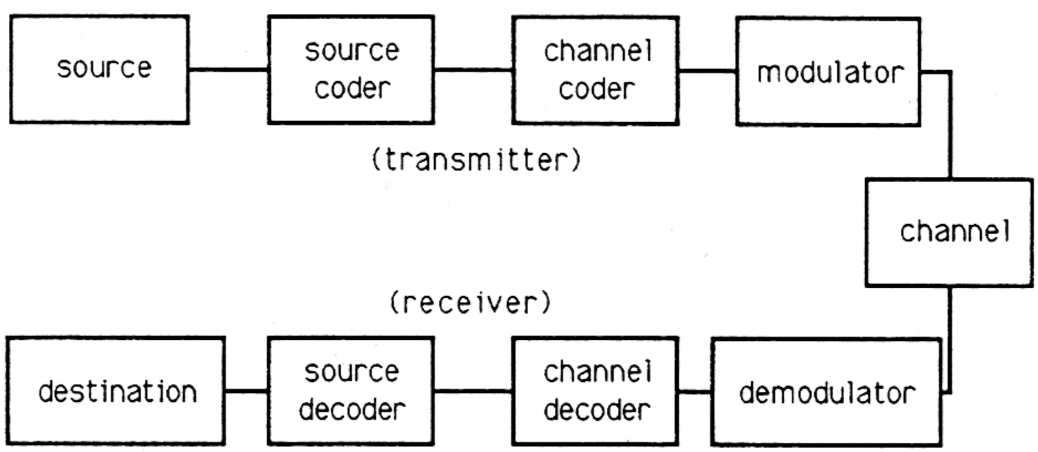
In higher data transfer speeds and capacity.the 1990s, the 'second generation' (2G) mobile phone systems emerged, primarily using the GSM standard. These 2G phone systems differ from the previous generation in their use of digital transmission instead of analog transmission, and also by the introduction of advanced and fast phone-to-network signaling.

The second generation introduced-- SMS text messaging on GSM networks and eventually on all digital networks.

Some benefits of 2G were Digital signals require consume less battery power, so it helps mobile batteries to last long. Digital encryption has provided secrecy and safety to the data and voice calls.
“**2.5G**” using GPRS (General Packet Radio Service) technology is a cellular wireless technology developed in between its predecessor, 2G, and its successor, 3G. GPRS could provide data rates from 56 kbit/s up to 115 kbit/s. It can be used for services such as Wireless Application Protocol (WAP) access, Multimedia Messaging Service (MMS), and for Internet communication services such as email and World Wide Web access.
2.75 – EDGE is an abbreviation for Enhanced Data rates for GSM Evolution. EDGE technology is an extended version of GSM. It allows the clear and fast transmission of data and information up to 384kbit/s speed.

Ans 2c.

general model of wireless communication link is shown in following figure. source coding such as Huffmann coding,Shannon feno coding etc to the message signal applied from source are carried out by source coder. The channel coding such as Turbo code and LDPC codes are applied onth source coded information. The suitable modulation technique for digital transmission is applied and the modulated signal is transmitted over the medium. At the receiver , the reverse process is carried out.The signal is demodulated by the appropriate method ,the message from channel is decoded , and the source decoder decodes the message. And the message is routed to the user at receiving end.



Ans2d. Interference is the sum of all signal contributions that are neither noise not the wanted signal.
Types of Interference :
There are two types of system generated interference :1. Co-channel interference 2. Adjacent channel interference

1. **Co-Channel Interference** : Co-channel interference occurs the because of frequency reuse, i.e. several cells use the same set of frequency. These cells are called co-channel cells. Co-channel interference cannot be combated by increasing the power of the transmitter. This is because an increment in carrier transmit power increases the interference to neighboring co-channel cells. To reduce the co-channel interference, the cells must be separated by a minimum distance to provide sufficient isolation due to propagation or reduce the footprint of the cell. Some factors other than reuse distance that influence co-channel interference are antenna type, directionality, height, site position etc.

2. **Adjacent channel interference:** Interference concluding from the signals which are adjacent in frequency to the desired signal is called adjacent channel interference. Adjacent channel interference results from imperfect receiver filters which allow nearby frequencies to leak into the pass band. Adjacent channel interference can be minimized through channel assignments and careful filtering. By keeping the frequency separation between each channel in a given cell as large as possible, the adjacent interference may be reduced considerably.

Section –C

Ans3a. Hexagonal shapes are preferred than square or circle in cellular architecture because it covers an entire area without overlapping. ... It is because it requires fewer cells to represent a hexagon than triangle or square. Other advantages of hexagonal cellular system: The frequency reuse become possible using this shape.

While designing a network, two things are kept in mind:
1) a tower in a cell should provide equal signal in that cell
2) no blackspots. Blackspots are those areas where you wont get any signals
Now, answering this question, lets see pros n cons if we use square, circle or hexagon
Square: wont create black spots. But distance from its centre to a corner is higher than distance to any side. This will create issues in providing equal level of signals at every point
Circle: since distance from centre to any point in the circle would be same so there wont be any issue in providing equal level of signals at every point. But, when we arrange circles together, many areas would be created which wont be covered by any circle. These areas are called the blackspots, where signals from no nearby circle could be received.
Hexagon: hexagon or the beehive structure overcome all the above said issues. Its distance from centre to any point it the same and they can be arranged in such a way that no blackspots are created.

Ans3b. Urban environment

The Hata model for urban environments is the basic formulation since it was based on Okumura's measurements made in the built-up areas of Tokyo. It is formulated as following:

$$L_U = 69.55 + 26.16 \log_{10} f - 13.82 \log_{10} h_B - C_H + [44.9 - 6.55 \log_{10} h_B] \log_{10} d$$

For small or medium-sized city,

$$C_H = 0.8 + (1.1 \log_{10} f - 0.7) h_M - 1.56 \log_{10} f$$

and for large cities,

$$C_H = \begin{cases} 8.29 (\log_{10}(1.54 h_M))^2 - 1.1 \text{ , if } 150 \le f \le 200 \\ 3.2 (\log_{10}(11.75 h_M))^2 - 4.97 \text{ , if } 200 < f \le 1500 \end{cases}$$

where

- L_U = Path loss in urban areas. Unit: decibel (dB)
- h_B = Height of base station antenna. Unit: meter (m)
- h_M = Height of mobile station antenna. Unit: meter (m)
- f = Frequency of transmission. Unit: Megahertz (MHz)
- C_H = Antenna height correction factor
- d = Distance between the base and mobile stations. Unit: kilometer (km).

suburban environment

The Hata model for suburban environments is applicable to the transmissions just out of the cities and on rural areas where man-made structures are there but not so high and dense as in the cities. To be more precise, this model is suitable where buildings exist, but the mobile station does not have a significant variation of its height. It is formulated as:

$$L_{SU} = L_U - 2\left(\log_{10}\frac{f}{28}\right)^2 - 5.4$$

where

L_{SU} = Path loss in suburban areas. Unit: decibel (dB)

L_U = Path loss from the small city version of the model (above). Unit: decibel (dB)

f = Frequency of transmission. Unit: Megahertz (MHz).

Open environments [edit]

The Hata model for rural environments is applicable to the transmissions in open areas where no obstructions block the transmission link. It is formulated as:

$$L_O = L_U - 4.78\left(\log_{10} f\right)^2 + 18.33\left(\log_{10} f\right) - 40.94$$

where

L_O = Path loss in open areas. Unit: decibel (dB)

L_U = Average path loss from the small city version of the model (above). Unit: decibel (dB)

f = Frequency of transmission. Unit: megahertz (MHz).

Ans.4a. In wireless communications, fading is variation of the attenuation of a signal with various variables. These variables include time, geographical position, and radio frequency. Fading is often modeled as a random process.

In wireless systems, fading may either be due to multipath propagation, referred to as multipath-induced fading, weather (particularly rain), or shadowing from obstacles affecting the wave propagation, sometimes referred to as shadow fading.

The terms *slow* and *fast* fading refer to the rate at which the magnitude and phase change imposed by the channel on the signal changes. The coherence time is a measure of the minimum time required for the magnitude change or phase change of the channel to become uncorrelated from its previous value.

Slow fading arises when the coherence time of the channel is large relative to the delay requirement of the application.

Fast fading occurs when the coherence time of the channel is small relative to the delay requirement of the application.

Block fading is where the fading process is approximately constant for a number of symbol intervals.

Selective fading or **frequency selective fading** is a radio propagation anomaly caused by partial cancellation of a radio signal by itself the signal arrives at the receiver by two different paths, and at least one of the paths is changing (lengthening or shortening).

As the carrier frequency of a signal is varied, the magnitude of the change in amplitude will vary. The coherence bandwidth measures the separation in frequency after which two signals will experience uncorrelated fading.

- In **flat fading**, the coherence bandwidth of the channel is larger than the bandwidth of the signal. Therefore, all frequency components of the signal will experience the same magnitude of fading.

In **frequency-selective fading**, the coherence bandwidth of the channel is smaller than the bandwidth of the signal. Different frequency components of the signal therefore experience uncorrelated fading.

Ans.4b. To describe microcellular propagation, the Rayleigh model lacked the effect of a dominant line-of-sight component, and Rician model appeared to be more appropriate. For analytical and numerical evaluation of system performance, the expressions for Rician fading are less convenient, mainly due to the occurrence of a Bessel function in the Rician probability density function of received signal amplitude. Approximations by a Nakagami distribution, with simpler mathematical expressions have become popular rror rates can differ by orders of magnitude.

The Nakagami fading model was initially proposed because it matched empirical results for short wave ionospheric propagation. In current wireless communication, the main role of the Nakagami model can be summarized as follows

It describes the amplitude of received signal after maximum ratio diversity combining.

The sum of multiple independent and identically distributed (i.i.d.) Rayleigh-fading signals have a Nakagami distributed signal amplitude. This is particularly relevant to model interference from multiple sources.

The Nakagami distribution matches some empirical data better than other models.

The Rician and the Nakagami model behave approximately equivalently near their mean value. This observation has been used in many recent papers to advocate the Nakagami model as an approximation for situations where a Rician model would be more appropriate.

Ans5a.

Simplex:

In simplex transmission mode, the communication between sender and receiver occurs in only one direction. The sender can only send the data, and the receiver can only receive the data. The receiver cannot reply to the sender.

Simplex transmission can be thought of as a one-way road in which the traffic travels only in one direction—no vehicle coming from the opposite direction is allowed to drive through.To take a keyboard / monitor relationship as an example, the keyboard can only send the input to the monitor, and the monitor can only receive the input and display it on the screen. The monitor cannot reply, or send any feedback, to the keyboard.

Half Duplex:

The communication between sender and receiver occurs in both directions in half duplex transmission, but only one at a time. The sender and receiver can both send and receive the information, but only one is allowed to send at any given time. Half duplex is still considered a one-way road, in which a vehicle traveling in the opposite direction of the traffic has to wait till the road is empty before it can pass through.

For example, in walkie-talkies, the speakers at both ends can speak, but they have to speak one by one. They cannot speak simultaneously.

Full Duplex:

In full duplex transmission mode, the communication between sender and receiver can occur simultaneously. The sender and receiver can both transmit and receive at the same time. Full duplex transmission mode is like a two-way road, in which traffic can flow in both directions at the same time.

For example, in a telephone conversation, two people communicate, and both are free to speak and listen at the same time.

Ans5b. Cell splitting is a method of subdividing cell into the smaller sized cell. The parent cell that was originally congested is called as macro cells and the smaller cell called as microcells. Cell sectoring is another method to increase capacity. It keeps the radius of the cell constant and decreases the co-channel reuse ratio D/R to reduce the cluster size N.
Let we check the difference between cell splitting and cell sectoring :

Cell splitting :

- Cell splitting is a method of subdividing cell into the smaller sized cell. The parent cell that was originally congested is called as macro cells and the smaller cell called as microcells.
- The cell is divided into a smaller cell.
- In cell splitting the transmit power must be reduced to maintain the S/I ratio.
- The radius of the cell is decreased and the co-channel reuse ratio D/R is kept constant to improve the capacity.
- In cell splitting large macro-cell are dedicated to high-speed traffic. The reason for a number of handoffs will be less and call progress can be smoothly done.

Cell sectoring :

- Cell sectoring is a method of decreasing the co-channel interference and enhancing system performance by using a directional antenna.
- The cell is divided into 120^{0} and 60^{0} sectors.
- Cell sectoring improves the S/I ratio using a directional antenna.
- The radius of the cell is kept constant and the co-channel reuse ratio D/R is decreased to improve the capacity.
- Cell sectoring decreases the coverage area of a group of channels and increases the number of handoffs.