B.Tech(ECE-7thsem) 1st Sessional Examination Sep 2015

Subject: Mobile Communication

Sub Code: ECE-419-F

Time: 1 Hr. 30 Min **MM: 30**

Note: Question number 1 is compulsory and attempt one question each from section B and Section C. Marks for each question are shown against each.

SECTION 'A'

1. Write short note on the followings

a) The basic propagation mechanisms of mobile radio propagation. **3**

Answer:

Reflection, Differeaction and Scattering are the three basic mechanism which impact the propagation in mobile communication system. These mechanisms are defined below:

i. Reflection: It occurs when a propagating electromagnetic wave impinges upon an object which has very low dimensions when compared to the wavelength of the propagating wave. Reflection occur from the surface of the earth and from buildings and walls.

ii. Differaction: It occurs when the radio path between the transmitter and receiver is obstructed by a surface that has sharp irregularities(edges). The secondary waves resulting from the obstructing surface are present throughout the space and even behind the obstacle, giving rise to a bending of waves around the obstacle, even when a LoS path does not exist between Tx and Rx. At high frequencies differaction like reflection, depends on the geometry of the object, as well as the amplitude, phase, and polarization of the incident waves at the point of differaction.

iii. Scattering: Scattering occurs when the medium through which the wave travels consist of objects with dimensions that are small compared to the wavelength, and where the number of obstacles per unit volume is large. Scattered waves are produced by rough surfaces, small objects, or by other irregularities in the channel. In practice, foliage, street signs, lamp posts induce scattering in mobile communication system.

b) Doppler Spread and Coherence Time. **3**

Answer

Doppler spread B_D is a measure of the spectral broadening caused by the time rate of change of mobile radio channel and is defined as the range of frequencies over which the received Doppler spectrum is essentially non-zero. When a pure sinusoidal tone of frequency fc is transmitted, the received signal spectrum, called Doppler spectrum, will have components in the range of fc – fd to fc + fd, where fd is the Doppler shift. The amount of spectral broadening depends on fd which is a function of relative velocity of the mobile, and the angle θ betweeen the direction of motion of the mobile and direction of arrival of scatter waves. If the baseband signal bandwidth is much greater than BD, the effect of Doppler spread are negligible at the receiver. In this case this is a slow fading channel.

Coherence Time: Coherence time Tc is the time dual of the Doppler Spread and is used to characterize the time varying nature of the frequency disperssiveness of the channel in time domain. The Doppler spread and Coherence time are inversely proportional to one another. That is :

$$Tc = 1/fm \qquad \text{--------(1)}$$

Coherence time is actually the a statistical measure of the time duration over which the channel impulse response is essentially invariant, and qualifies the similarity of the channel response at different times.

If the coherence time is defined as the time over which the time correlation function is above 0.5, then coherence time is approx:

$$Tc = \frac{9}{16\Pi fm} \qquad \text{----------(2)}$$

where fm is Doppler shift given by fm = v/λ

A popular rule of thumb for modern digital communication is to define the coherence time as the geometric mean eqn (1) and (2). That is:

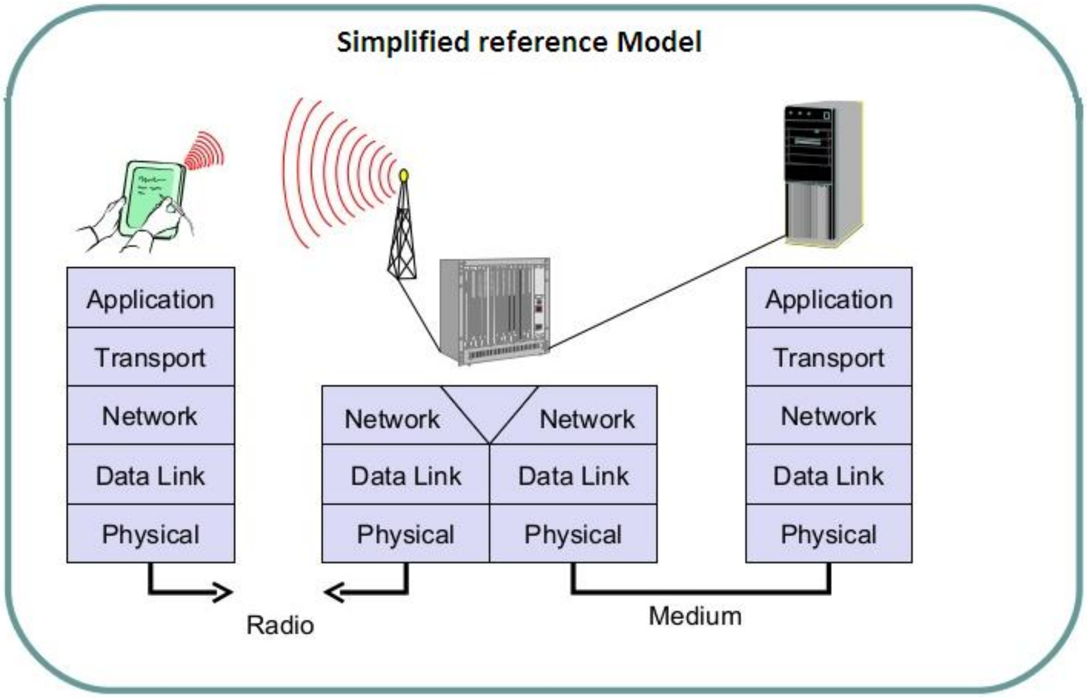
$$Tc = \sqrt{\frac{9}{16\Pi fm^2}} = \frac{0.423}{fm}$$

This means two signals arriving with a time separation greater than Tc are affected differently by the channel

c) Reference model of a mobile communication **2**

Answer:

The reference model is used to structure communication system. Figure below shows the simplified reference model of the wireless communication system. In the figure a personal digital assistant (PDA) communicates with the base station shown in the middle. The base station consists of a radio transceiver and an internetworking unit connecting the wireless link with the fixed link. The communication partner of the PDA, a conventional computer, is shown on the right of picture. Also shown below each unit (PDA, base station and computer) are the protocol stack implemented in the system according to the reference model, such as the PDA and computer need full protocol stack. Applications on the end systems communicate with each other using the lower services. Intermediate systems, such as internetworking units, do not necessarily need all layers. During communication, as only the entities at the same level communicate with each other, end system applications do not notice the intermediate systems directly in this scenario.



d) Time dispersion parameters. **2**

Answer:

In order to compare different multipath channels and to develop some general design guidelines for wireless systems, parameters which quantify the multipath channel are used. The mean excess delay, rms delay spread, and excessive delay spread(X dB) are multipath channel parameters that can be determined from a power delay profile. The time dispersive properties of wide band multipath channels are most commonly quantified by their mean excess delay(τ) and rms delay spread(σ_τ)

i. The mean excess delay is defined to be:

$$\overline{\tau} = \frac{\sum_k a_k^2 \ \tau_k}{a_k^2} = \frac{\sum_k p(\tau_k) \ \tau_k}{\sum_k p(\tau_k)}$$

ii. The rms delay spread is the square root of the second central moment of power delay profile and is defined to be:

$$\sigma_\tau = \sqrt{\bar{\tau}^2 - (\tau)^2}$$

$$\text{Where } \bar{\tau}^2 == \frac{\sum_k a_k^2 \, \tau_k^2}{a_k^2} = \frac{\sum_k p(\tau_k) \, \tau_k^2}{\sum_k p(\tau_k)}$$

iii. The maximum excess delay (X dB) of the power delay profile is defined to be the time delay during which the multipath energy falls to X dB below the maximum. In other words, the maximum excess delay is defined as $(\tau_x - \tau_0), where\ \tau_0$ is the first arriving signal and $\tau_x\ is\ the\ maximum\ delay$ at which a multipath component is within X dB of the strongest arriving multipath signal

SECTION 'B'

2. **a). Level Crossing in mobile communication system.** **5**

Answer:

Rice computed joint statistics which provided simple expression for computing the average number of level crossings and the duration of the fades. The level crossing rate (LCR) and average fading duration are the two statistics which are useful for designing error control codes and diversity scheme to be used in mobile communication system, since it becomes easy to relate the time rate of change of received signal to the signal level and velocity of mobile.

Level crossing rate(LCR) is defined as the expected rate at which the Rayleigh fading envelop, normalized to the local rms signal level, crosses a specified level in a positive going direction. The number of level-crossings per seconds is given by:

N_R = $\int_0^{\infty} \dot{r} p(R, \dot{r}) d\dot{r}$ = $\sqrt{2\pi} f m \rho e^{-\rho^2}$ where

$\dot{r}$ is the time derivative of r(t) i.e. the slope

$p(R, \dot{r})$ is the joint density function of r and $\dot{r}$ at r = R

Fm is the maximum Doppler frequency

ρ = R / Rrms is the value of the specific level R, normalized to local rms amplitude of the fading envelop

The level crossing rate is the function of the mobile speed. There are certain level crossings at both high and low levels, with a maximum rate occurring at $\rho = \frac{1}{\sqrt{2}}$

b). For a Rayleigh Fading signal, find (a) number of zero level crossings and (b) the average fade duration for the threshold levels, ρ=0.1 and ρ=1, when the Doppler frequency is given as 20 Hz. **5**

Answer:

a) for ρ=1, the number of zero level crossing,

NR= $\sqrt{2\pi} f m \rho e^{-\rho^2}$ = $\sqrt{2\pi}\ X\ 20(1)e^{-1^2}$

$= 18.44\ crossings/sec$

Average fade duration,

T=$\left[e^{1^2} - 1\right]/(1)(20)(\sqrt{2\pi})$

= 1.71/50.1

= 34.1 ms

b) For ρ=0.1, the number of zero level crossing,

NR= $\sqrt{2\pi} f m \rho e^{-\rho^2}$ = $\sqrt{2\pi}\ X\ 20(1)e^{-0.1^2}$

$= 45.25\ crossings/sec$

Average fade duration,

T= $\left[e^{0.1^2} - 1\right]/(0.1)(20)(\sqrt{2\pi})$

= 0.002ms = 2 microseconds

3. (a) Explain the factors influencing the small scale fading. 5

Answer:

There are many physical factors in the radio propagation channel that influence the small-scale fading. These are explained below:

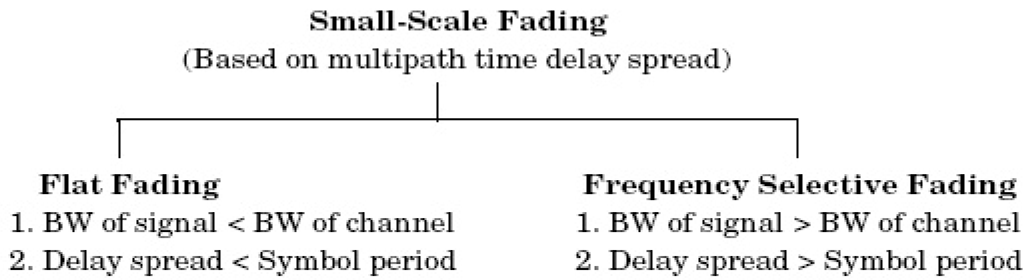
a. Multipath Propagation: The presence of reflecting objects and scatterers in the channel creates a constantly changing environment that dissipate the signal energy in amplitude, phase and frequency. These effects t results in radio signals reaching the receiving antenna by two or more paths. The effects of multipath include constructive and destructive interference, and phase shifting of the signal.
b. Speed of the Mobile: The relative motion between the base station and the mobile results in random frequency modulation due to different Doppler shifts on each of the ,ultipath components. Doppler shift will be positive or negative depending on whether the mobile receiver is moving towards or away from the base station.
c. Speed of the surrounding objects: If the objects in the radio channel are in motion, they induce a time varying Doppler shift on multipath components. If the surrounding objects move at a greater rate than the mobile, then this effect dominates the small-scale fading. Otherwise, the motion of the surrounding objects may be ignored, and only the speed of the mobile need be considered.
d. Transmission Bandwidth of the signal: If the transmitted radio signal bandwidth is greater than the bandwidth of the multipath channel, the received signal will be distorted, but the received signal strength will not fade much over a local area. If the transmitted signal has a narrow bandwidth compared to the channel, the amplitude of the signal will change rapidly, but the signal will not be distorted in time.

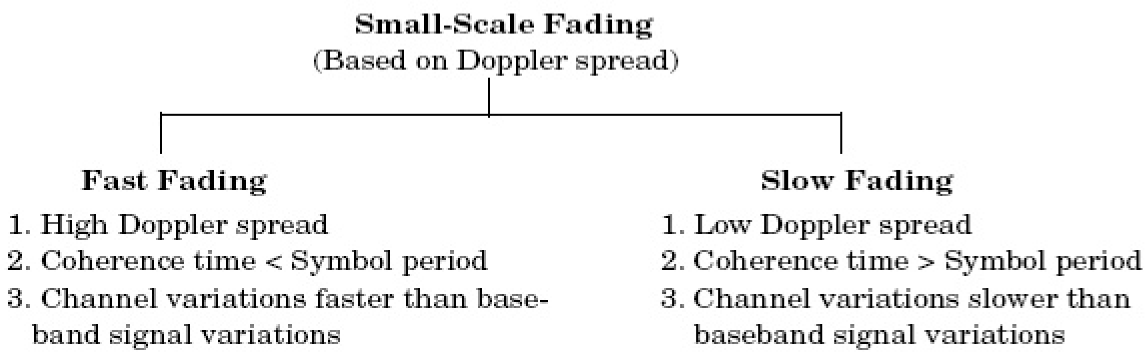
(b) What do you understand by small-scale fading? Explain the types of the small scale fading in mobile radio communication. 5

Answer:

Small-Scale Fading: Small-scale fading, or simply fading is used to describe the rapid fluctuations of the amplitude, phase or multipath delays of radio signal over a short period of time or travel distance, so that large-scale path loss effects may be ignored. Fading is caused by interference between two or more versions of the transmitted signal which arrive at the receiver at slightly different times. As a mobile moves over very small distances, the instantaneous received signal strength may fluctuate rapidly giving rise to small-scale fading.

Type of Small-Scale Fading: Fadings are classified depending on multipath time delay spread or based on Doppler Spread and are given below:





SECTION 'C'

4. (a) What do you understand by free space path loss. **3**

Answer:

In free space radio waves travel as light does, it follows a LoS communication between the sender and receiver. Even if no matter exists between the communicating stations, the signal still experiences a free space path loss. Thus in telecommunication, free space path loss is the loss in signal strength that would result if all absorbing, differacting, obstructing, refracting, scattering, and reflecting influences were sufficiently removed having no effectnon its propagation. It does not take into account any path gain of antenna. The free space loss (FSL) is proportional to square of distance and is given as:

$$FSL = \frac{(4\Pi d)^2}{\lambda} = \frac{(4\Pi df)^2}{c}$$

The free space power received by a receiving antenna which is separated from the radiating antenna by a distance d, is given by Friis free space equations as:

$$Pr(d) = \frac{PtGtGr\,\lambda^2}{(4\pi d)^2 L}$$ where

Pt is transmitted power, Gt, Gr are gain of radiating and receiving antenna, L is system loss other than environment, λ is wavelength, d is separation

(b) Find the Fraunhofer distance for an antenna with maximum dimension of 1 meter and operating frequency of 900 MHz. If the antenna have a unity gain, calculate the path loss. 7

Answer:

Since the operating frequency f = 900 Mhz,

the wavelength $\lambda = \frac{3 \times 10^8}{900\ X 10^6}$ = 0.33m .

Thus, with the largest dimension of the antenna, D=1m,

the far field distance is $d_f = 2D^2 / \lambda = 2(1)^2 / 0.33 = 6m$

Path Loss PL(dB) = $-10\log\left(\frac{\lambda^2}{(4\Pi)^2 d^2}\right)$

= $-10\log\left(\frac{0.33^2}{(4x3.14)^2 X 6^2}\right)$

= 47 dB

5. **(a) What is the purpose of the propagation model. Explain the Okumara's Propagation Model and also write the advantages of this model. 10**

Answer:

Propagation model have focused on predicting the average received signal strength at a given distance from the transmitter, as well as the variability of the signal strength in close spatial proximity to a particular location. Propagation model that predict the mean signal strength for an arbitrary T-R separation distance are useful in estimating the radio coverage area of a transmitter and are called large-scale propagation model. On the other hand, propagation model that characterize the rapid fluctuations of the received signal strength over very short travel distances are called small-scale propagation model.

Okumra's Model: Okumara model for urban areas is a radio propagation model that was built using the data collected in city of Tokyo, japan. The model is ideal for using in cities with many tall blocking buildings. The model is applicable for frequencies in the range of 150 MHz to 1950 MHz and distance of 1Km to 100 Km. it can be used for base station antenna heights ranging from 30m to 1000mtr.

Okumara developed a set of curves giving the median attenuations relative to free space (Amu), in the urban area over a quassi smooth terrain with base station affective antenna height (hte) of 200 m and mobile antenna height (hre) of3m. These curves were developed from experimental data using vertical omnidirectional antenna at both sender and receiver end and are plotted as a function of frequencies in the range of 100Mhz to 1920MHz and as a function of distance from the base station in the range of 1 Km to 100 Km.

To determine the path loss using Okumara model, the free space path loss is first determined between points of interest, and then the values of Amu(f,d) is added to it along with correction factor to account for the type of terrain. The model can be expressed as:

$$L_{50}(dB) = L_F + A_{mu}(f,d) - G(hte) - G(hre) - G_{AREA}$$

Where

L_{50} is the 50 percentile(i.e. median) value of propagation path loss.

L_F is the free space path loss

A_{mu} is the median attenuation relative to free space

G(hte), G(hre) are the base station and mobile antenna height

G_{AREA} is the gain due to type of environment.

Furthermore Okumara found that G(hte) varies at the rate of 20dB/decade and G(hre) varies at a rate of 10dB/decade for heights less than 3 m.

$$G(hte) = 20 \log \left(\frac{hte}{200}\right) \qquad 1000m > hte > 30m$$

$$G(hre) = 10 \log \left(\frac{hre}{3}\right) \qquad hre \le 3m$$

$$G(hre) = 20 \log \left(\frac{hre}{3}\right) \qquad 10\ m > hre > 3m$$

Advantages:

Okumara's model is wholly based on measured data and does not provide any any analytical explanations.

This model is considered to be the simplest model

This model is best in terms of accuracy in path loss prediction for mature cellular and land mobile radio system in clustered environment

This model is very practical and has become a standard for systems planning in modern land mobile radio system in Japan

This model is very good for urban area.

Disadvantages:

Slow Response to rapid changes in terrain

It is not very good for rural area

OR

What is the difference between large-scale and small-scale propagation model. Explain the Hata propagation Model. Also write the advantages and disadvantages of this model. 10

Answer:

Difference between large-scale and small-scale propagation model

large-scale Propogation Model	small-scale Propogation Model
Propagation model that predict the mean signal strength for an arbitrary T-R separation distance are useful in estimating the radio coverage area of a transmitter and are called large-scale propagation model.	Propagation model that characterize the rapid fluctuations of the received signal strength over very short travel distances are called small-scale propagation model.
This model provide path loss over very large T-R separation	This model provide path loss for very small T-R distance variations

Hata Model for Path Loss calculations:

This model is an empirical formulation of graphical path loss provided by Okumara and is valid for following data ranges:

frequencies of 150 MHz to 1500 MHz

Base station antenna heights (hte) 30m to 200m

Mobile antenna height (hre) from 1m to 10m

This model is most widely used in radio frequency propagation for predicting the behavior of cellular transmission in built up areas. This omodel also has two more varieties for transmission in suburban and open areas. Hata model predicts the path loss along a link of terrestrial microwave or other type of cellular communications.

This model is applicable for transmission inside the cities and is suited for point-to-point and broadcast transmission.

Hata Model for urban areas is formulated as:

L_{50} (urban)= 69.55 + 26.16 log (f) – 13.82 log (hte) - a (hre) + (44.9 – 6.55 log (hte)) log d ----(1)

For small and medium cities, the mobile antenna correction factor is given as:

a(hre) = (1.1 log fc – 0.7) hre – (1.56 log fc – 0.8) dB ----(2)

For large cities

a(hre) = 8.29 (log 1.54 hre)^2 - 1.1 dB for fc <= 300 MHz ----(3)

a(hre) = 3.2 (log 11.75 hre)^2 - 4.97 dB for fc > 300 MHz ----(4)

To obtain path loss in suburban areas, the standard Hata model in above eqn-1 is modified as:

L_{50}dB = L_{50}(Urban) – 4.78 (log fc)^2 + 18.33 log fc - 40.94

Advantages:

Okumara model does not have any of the path-specific correction which are available in Okumara model.

Hata Model though modified version of Okumara model but compares very closely wit the original Okumara Model.

This moel is well suited to large cell mobile systems.

Disadvantages:

Equations are hard to remember as compared to easy readable graphical model given by Okumara

Hata model is not suited for personal communication system which have cell on the orders of 1Km radius.