Birla Institute of Technology and Science Pilani (Rajasthan)

EEE F431 Mobile Telecom Network
Second Semester 2021-22

Date : 20/05/2022 **Comprehensive Exam** **Max. Marks: 50**
(Part-B OPEN NOTES)

Name: _____ID No. _____ **Time: 120 min**

Instructions:

1) This is an open notes exam. Only your hand-written notes and class notes are allowed.

2) Show all the steps clearly. If I cannot interpret it, I cannot grade it.

Q.1) Assume a Rayleigh fading environment in which the sensitivity level of an receiver is given by a signal amplitude r_{min}, then the probability of outage is defined as $P_{out} = \Pr\{r \leq r_{min}\}$.

a) Considering that the squared signal amplitude r^2 is proportional to the instantaneous received power C through the relation $C = k.r^2$, where K is a positive constant, determine the expression for the probability of outage expressed in terms of receiver sensitivity level C_{min} and the mean received power $\bar{C}$. **(4)**

b) If the fading margin (level of protection against fading) is expressed as $M_{dB} = \bar{C}_{dB} - C_{\min dB}$, determine the closed form expression for the required fading margin, in dB, as a function of outage probability $P_{out.}$ **(4)**

c) Now consider that the outage probability P_{out} is restricted to a small value (say, below 5 %), determine the closed form expression for the required fading margin $\widetilde{M}_{dB}$, as a function of outage probability P_{out} with this condition. **(2)**

Q.2) Consider a square shaped cellular cluster with K square cells on each side. Let D be the reuse distance between 2 co-channel cells, and R be the distance from cell center to the midpoint of cell edge.

a) Derive the expression of cluster size (number of cells per cluster) in terms of D and R. **(2)**

b) Let the cluster size in the above setting be 10 and each cell can accommodate 100 users. If the cell area is $1\ sq\ km$, find the total number of users that can be accommodated in the system and the maximum time it takes for a mobile user to traverse a cell (approximate time needed for handoff) when moving at $30\ km/hr$. **(4)**

c) If the cell area is reduced by a factor of 10^4 keeping the cluster area constant, everything scales in the system such that still 100 users can be accommodated in each of these smaller cells. Find the total number of users the system can accommodate and the length of time it takes to traverse a cell when moving at the same speed. **(4)**

d) Determine the factor by which the number of users in the system increase (or decrease) and the handoff time increases (or decreases) in c) compared to b). Justify your answer. **(2)**

Q.3) a) Consider a 4×4 MIMO channel given as $\begin{pmatrix} 1 & 1 & -1 & 1 \\ 1 & 1 & -1 & -1 \\ 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & -1 \end{pmatrix}$, what is the maximum multiplexing gain for this channel? **(3)**

b) Consider a 2×2 MIMO channel with channel gain matrix given as $H = \begin{pmatrix} 0.3 & 0.5 \\ 0.7 & 0.2 \end{pmatrix}$. Assume that H is known both to the transmitter and the receiver and that there is a total transmit power of $10\ mW$ across the two transmit antennas, AWGN with $N_o = 10^{-9}\ W/Hz$ at each receive antenna and bandwidth is $100\ KHz$. Find the SVD for H and calculate the capacity of this channel. **(6)**

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Q.4) A large population of slotted ALOHA users manages to generate 50 requests/sec, including both originals and retransmissions. Time is slotted in units of 40 msec.

a) What is the chance of success on the first attempt? **(2)**
b) What is the probability of exactly k collisions and then a success? **(2)**
c) What is the expected number of transmission attempts needed? **(2)**
d) Now consider that a group of N stations share a 56-kbps pure ALOHA channel. Each station outputs a 1000-bit frame on average once every 100 sec, even if the previous one has not yet been sent. What is the maximum value of N? **(2)**
e) Consider the delay of pure ALOHA versus slotted ALOHA at low load. Which one is less? Justify your answer. **(2)**

Q.5) GSM systems have 25 MHz of bandwidth allocated to their uplink and downlink, divided into 125 TDMA channels with 8 user timeslots per channel. The transmission rate is 270.833 kbps.

a) Sketch the structure of a GSM frame and a timeslot within that frame that supports transmission of a normal data burst. **(2)**
b) Find the fraction of data bits within a time slot as well as the information data rate for each user **(2)**
c) Calculate the duration of a timeslot and the frame duration. Also find the latency between timeslots assigned to a given user in a frame, neglecting any preamble and trail bits between two frames. **(3)**
d) What is the maximum delay spread in the channel such that the guard band and stop bits prevent overlap between timeslots? **(2)**

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