

City University of Hong Kong
Department of Electrical Engineering

EE4316 Mobile Data Networks

Test 1

4 March 2020

Duration: 60 minutes

Total marks: 60

Remarks: This is an open-book test

Declaration:

I pledge that the answers in this exam/quiz are my own and that I will not seek or obtain an unfair advantage in producing these answers. Specifically,

- o I will not plagiarize (copy without citation) from any source;*
- o I will not communicate or attempt to communicate with any other person during the exam/quiz; neither will I give or attempt to give assistance to another student taking the exam/quiz; and*
- o I will use only approved devices (e.g., calculators) and/or approved device models.*

I understand that any act of academic dishonesty can lead to disciplinary action.

Name:

Signature:

Student ID:

1. What is the key difference between first- and second-generation cellular systems? [1 mark]

2. Consider a cluster of three cells. The offered traffic to each individual cell are, 40 Erlangs, 70 Erlangs, and 80 Erlangs, respectively. With fixed non-uniform channel allocation and designated blocking probability of 0.01, what is the total number of channel needed in this cluster? [4 marks]

3. We have an installed cellular system with 100 sites, a frequency reuse factor of $N=7$, and 500 overall two-way channels:
- Give the total number of channels available to the operator if the channel density (number of channels/unit area) of each cell is equal. [2 marks]
 - To expand the network capacity, we decide to create an underlay-overlay system where the new system uses a frequency reuse factor of $K=3$. Let D_0 and R_0 be the co-channel distance and radius of macro cell, respectively, and D_1 and R_1 be the co-channel distance and radius of micro cell, respectively. Given that $D_1 = 3 R_0$, by expressing R_1 in terms of R_0 , determine the number of channels assigned to inner and outer cells to keep a uniform channel density over the entire coverage area. [5 marks]
4. Consider a cellular network that employs omnidirectional antennas. The radius of a cell is R .
- A cell is split into smaller cells, each with a radius $R/2$. Show that a cell can be split into 4 smaller cells. [2 marks]
 - Assume that the path-loss gradient $\alpha = 3$, how should the transmitter power be changed in order to split a cell into 4 smaller cells. [4 marks]
 - Provide a sketch that show how the new cells would fit within the original macro cells, subject to the constraint that the base stations of macro cells do not need to be relocated after splitting. [6 marks]
5. Figure 1 shows a worst-case scenario in a cellular network with 120° sectorization, where the mobile is located at the corner of the cell, R is the cell radius, and D is the distance between the adjacent cochannel cells. Considering that the frequency reuse factor is 7 and the path-loss gradient $\alpha = 4$, determine whether such a deployment of 120° sectoring would satisfy the 18dB requirement.

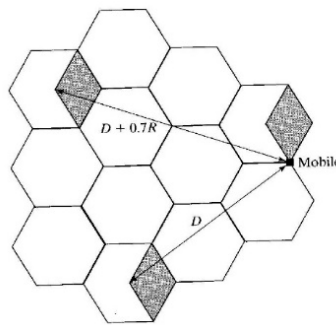


Figure 1. Worst-case scenario in 120° sectoring.

[8 marks]

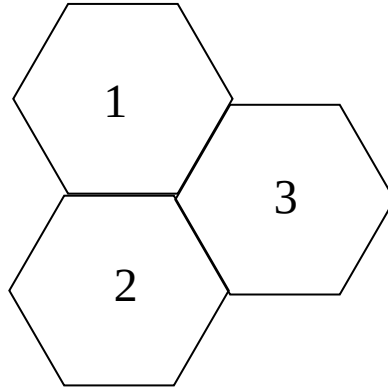
6. A mobile terminal samples signals from four BSs as a function of time. The times and signal strengths (in dBm) from the samples are given in the following table. The mobile makes handoff decisions by considering the signals from the BSs at each sampling time. Determine which base station the mobile is associated with at each sampling time using the following criteria. If a condition is met for more than one BS, assume the best one (strongest RSS) is selected.
- RSS + threshold of -55 dBm
 - RSS + hysteresis of 3 dBm + threshold of -55 dBm

Time(s)	0	2.5	5	7.5	10	12.5	15	17.5	20
BS ₁	-47	-57	-52	-55	-60	-62	-60	-65	-64
BS ₂	-59	-56	-55	-54	-52	-51	-49	-60.5	-52
BS ₃	-70	-72	-75	-70	-58	-50	-60.5	-62	-75
BS ₄	-72	-71	-65	-60	-55	-53	-40	-49	-56

[4 marks]

7. A cellular system has three cells as shown below. Cell i , $i = 1, 2, 3$, is characterized by the following parameters:

- λ_i new call arrival rate at cell i
 $\mathcal{G}_i$ total call arrival rate at cell i
 B_i call blocking probability at cell i
 p_{ij} probability of handover from cell i to cell j



The call duration and cell dwelling time is exponentially distributed with means equal to $1/\mu$ and $1/\nu$, respectively.

- Write down a set of equations relating $\mathcal{G}_i$ to λ_i, B_i, p_{ij} , for $i = 1, 2, 3$.

[2 marks]

- b. Each cell has 85 voice channels. Given that $1/\mu = 3$ minutes, $1/\nu = 2$ minutes, $\lambda_1 = \lambda_2 = \lambda_3 = 45$ calls/minute, and $p_{ij} = \frac{\nu}{\nu + \mu} p_{ij}^*$, where p_{ij}^* are tabulated below:

p_{12}^*	1/3
p_{13}^*	2/3
p_{21}^*	2/3
p_{23}^*	1/3
p_{31}^*	1/3
p_{32}^*	2/3

Using Erlang-B tables, calculate B_i , $i = 1, 2, 3$, by successive substitution, with a tolerance of 2%. Show the results of each iteration step.

[12 marks]

8. In a cellular network, the total number of channels per cell is 10. The new call arrival rate is 2.5 calls/minute, the handoff request rate is 1.5 calls/minute and the mean channel holding time is 2 minutes.

- a. Use the Erlang-B formula to calculate the blocking probability of a handoff request.

[3 marks]

- b. Now, one channel is reserved exclusively for handoff request, calculate the new blocking probabilities of a new call and a handoff request.

[7 marks]

-END-