UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 6 Examination in Engineering: December 2018

Module Number: EE6207 **Module Name: Wireless and Mobile Communication**

[Three Hours]

[Answer **all questions**, each question carries **10 marks**]

All notations have their usual meanings.

Q1 a) Explain briefly how frequency is efficiently allocated in cellular mobile systems.

[1.5 Marks]

b) A cellular system has 35 cells and each cell has 1.6 km radius. The system reuse factor is seven. The system is to support 336 traffic channels. Determine the,

ii) number of traffic channels per cell.

iii) number of simultaneous calls that can be supported by the system.

[2.5 Marks]

c) i) Explain in detail, a handover procedure at a cell boundary.

ii) Suppose that a Mobile Station (MS) is moving along a straight smooth surface between two base stations BS1 and BS2. The distance between two base stations is 2 km. The minimum usable level of signal is -88 dBm and the MS is currently served by the BS1 and moves towards BS2. Determine the handover margin, if the mobile speed is 100 km/hr and the handover time is 4.5 seconds. State any assumption made in the calculation.

Hint:

Assume that the received power in dBm at a base station is given by

$$P_r = P_0 - 10 \times n \times \log\left(\frac{d}{d_0}\right)$$

where d is the distance between MS and BS in meters and P_0 is the power at a distance d_0 from MS. Furthermore, $P_0 = 0$ dBm for $d_0 = 1$ m and the path loss exponent n, is 2.9.

[6 Marks]

Q2 a) What is the difference between small-scale fading and large-scale fading in a multipath environment?

[1.5 Marks]

b) List three factors influencing small-scale fading. Explain its influence in detail by considering one factor.

[2 Marks]

c) What is the main advantage of using Walfisch-Ikegami model over Okumura-Hata model for certain environments?

[1.5 Marks]

d) A cellular mobile network covering an open area has a Base Station (BS) with an antenna height of 10 m. The network operating frequency is 900 MHz. A Mobile Station (MS) situated at a distance of 3 km from the BS has an antenna height of 1.5 m. Assume that both BS and MS antennas have unity power gain and that they are in each other's line of sight. Determine the path-loss between the BS and MS using Okumura-Hata model. State any assumption made in the calculation.

Hint:
The following expression can be used for the Okumura-Hata model.

$$\text{Path Loss} = A + B \log(d) + C$$

where

$$A = 69.55 + 26.16 \log(f_c) - 13.82 \log(h_b) - a(h_m)$$

$$B = 44.9 - 6.55 \log(h_b)$$

and, the function $a(h_m)$ and factor C depend on the environment.

For small and medium size cites,
$a(h_m) = [1.1 \log(f_c) - 0.7] h_m - [1.56 \log(f_c) - 0.8]$ and $C = 0$
For metropolitan areas,
$a(h_m) = 3.2 [\log(11.75 h_m)]^2 - 4.97$ and $C = 0$
For suburban environments,
$C = -2 [\log(f_c / 28)]^2 - 5.4$
For rural areas,
$C = -4.78 [\log(f_c)]^2 + 18.33 \log(f_c) - 40.98$

Furthermore, the function $a(h_m)$ in suburban and rural areas is the same as urban (small and medium size cites) areas.

[5 Marks]

Q3 a) You are asked to design a GSM (Global System for Mobile communication) cellular network for a city of population 40,000. Suppose that you have given the permission to use a bandwidth of 8 MHz for both uplink and downlink transmissions inside 900 MHz GSM frequency band. In the initial design, 20% of the city population will become subscribers of the network and one user will make an average of 8 calls per day. It is also decided that in the busy hour a user will make a call that lasts, on the average, for 5 minutes. The blocking probability of the network has to be less than 2%.

i) Assume that each cell has a base station and, GSM uses a channel bandwidth of 200 kHz and one GSM time frame is divided in to 7 time slots. Determine the total number of base stations required for the design, if the frequency reuse concept is used having seven cells in a cluster.
Note:
Use the provided Erlang-B table entries in Table 1 for your calculations and state all the assumptions you use in the design.

ii) If the subscribers of the system is expected to be increased by three times in next year and the minimum cell size cannot be reduced half of the initial design value, what is the new blocking probability of the network?

[8 Marks]

b) Suppose that you want to have the same blocking probability value although number of subscribers of the system is increased. Suggest a method to increase the path availability of the system without further reducing the cell sizes as stated in part a) ii). Explain briefly how you achieve that.

[2 Marks]

Q4 a) What is CDMA2000 and WCDMA (Wideband Code Division Multiple Access)? What is the main difference between them?

[2 Marks]

b) Why are both FDD (Frequency Division Duplex) and TDD (Time Division Duplex) access methods used in UMTS (Universal Mobile Telecommunications Service) radio access networks? What are the main advantages of using FDD and TDD respectively?

[2 Marks]

c) Explain the relationship between spreading factor and user data rates in UMTS?

[1 Mark]

d) What is the relationship between spreading factor and transmitter power in UMTS?

[1 Mark]

e) In UTRAN (Universal Terrestrial Radio Access Network) both spreading code and scrambling code are used. What is the purpose of using these two codes?

[1 Mark]

f) How does UTRA (UMTS Terrestrial Radio Access)-FDD counteract the near-far effect? Why is this not a problem in GSM?

[1 Mark]

g) Why is time slot also used in UTRAN FDD mode? How large is one time slot?

[2 Marks]

Q5 a) In the frame structure of a normal burst, what is the purpose of using a 26-bit field?

[1 Mark]

b) Compared with other bursts, "access burst" consists of 68.25 bit large guard period. Briefly explain the reasons for that.

[1 Mark]

c) Considering the guard period of the access burst, find the maximum size of the cell (distance between base transceiver stations to mobile station) which is possible to initiate a call.

[2 Marks]

d) TDMA (Time Division Multiple Access) is used in GSM. Why there is a 3 timeslot difference for signal transmission between uplink and downlink (i.e., a mobile replies 3 timeslots receiving a message from the base station)?

[2 Marks]

e) What is the main difference between handover and roaming?

[1 Mark]

f) How many time slots are there in a GSM TDMA frame? How long does a GSM TDMA frame last? How can we conclude that the channel data rate in GSM is 270.833 kbps?

[3 Marks]

Blocked-Calls-Cleared (Erlang *B*)

	A, erlangs												
	B												
N	1.0%	1.2%	1.5%	2%	3%	5%	7%	10%	15%	20%	30%	40%	50%
1	.0101	.0121	.0152	.0204	.0309	.0526	.0753	.111	.176	.250	.429	.667	1.00
2	.153	.168	.190	.223	.282	.381	.470	.595	.796	1.00	1.45	2.00	2.73
3	.455	.489	.535	.602	.715	.899	1.08	1.27	1.60	1.93	2.63	3.48	4.59
4	.869	.922	.992	1.09	1.28	1.52	1.75	2.05	2.50	2.95	3.99	5.02	6.50
5	1.36	1.43	1.52	1.66	1.88	2.22	2.50	2.88	3.45	4.01	5.19	6.60	8.44
6	1.91	2.00	2.11	2.28	2.54	2.96	3.30	3.76	4.44	5.11	6.51	8.19	10.4
7	2.50	2.60	2.74	2.94	3.25	3.74	4.14	4.67	5.46	6.23	7.86	9.80	12.4
8	3.13	3.25	3.40	3.63	3.99	4.54	5.00	5.60	6.50	7.37	9.21	11.4	14.3
9	3.78	3.92	4.09	4.34	4.76	5.37	5.88	6.55	7.55	8.52	10.6	13.0	16.3
10	4.46	4.61	4.81	5.08	5.52	6.22	6.78	7.51	8.62	9.68	12.0	14.7	18.3
11	5.16	5.32	5.54	5.84	6.30	7.06	7.69	8.49	9.69	10.9	13.3	16.3	20.3
12	5.88	6.05	6.29	6.61	7.14	7.95	8.61	9.47	10.8	12.0	14.7	18.0	22.2
13	6.61	6.80	7.05	7.40	7.97	8.83	9.54	10.5	11.9	13.2	16.1	19.6	24.2
14	7.35	7.56	7.82	8.20	8.80	9.73	10.5	11.5	13.0	14.4	17.5	21.2	26.2
15	8.11	8.33	8.61	9.01	9.65	10.6	11.4	12.5	14.1	15.6	18.9	22.9	28.2
16	8.88	9.11	9.41	9.83	10.5	11.5	12.4	13.5	15.2	16.8	20.3	24.5	30.3
17	9.66	9.89	10.2	10.7	11.4	12.5	13.4	14.5	16.3	18.0	21.7	26.2	32.3
18	10.4	10.7	11.0	11.5	12.2	13.4	14.3	15.5	17.4	19.2	23.1	27.8	34.2
19	11.2	11.5	11.8	12.3	13.1	14.3	15.3	16.6	18.5	20.4	24.5	29.5	36.2
20	12.0	12.3	12.7	13.2	14.0	15.3	16.3	17.6	19.6	21.6	25.9	31.2	38.2
21	12.8	13.1	13.5	14.0	14.9	16.2	17.3	18.7	20.8	22.8	27.3	32.8	40.2
22	13.7	14.0	14.3	14.9	15.8	17.1	18.2	19.7	21.9	24.1	28.7	34.5	42.1
23	14.5	14.8	15.2	15.8	16.7	18.1	19.2	20.7	23.0	25.3	30.1	36.1	44.1
24	15.3	15.6	16.0	16.6	17.6	19.0	20.2	21.8	24.2	26.5	31.6	37.8	46.1
25	16.1	16.5	16.9	17.5	18.5	20.0	21.2	22.8	25.3	27.7	33.0	39.4	48.1
26	17.0	17.3	17.8	18.4	19.4	20.9	22.2	23.9	26.4	28.9	34.4	41.1	50.1
27	17.8	18.2	18.6	19.3	20.3	21.9	23.2	24.9	27.6	30.2	35.8	42.8	52.1
28	18.6	19.0	19.5	20.2	21.2	22.9	24.2	26.0	28.7	31.4	37.2	44.4	54.1
29	19.5	19.9	20.4	21.0	22.1	23.8	25.2	27.1	29.9	32.6	38.6	46.1	56.1
30	20.3	20.7	21.2	21.9	23.1	24.8	26.2	28.1	31.0	33.8	40.0	47.7	58.1
31	21.2	21.6	22.1	22.8	24.0	25.8	27.2	29.2	32.1	35.1	41.5	49.4	60.1
32	22.0	22.5	23.0	23.7	24.9	26.7	28.2	30.2	33.3	36.3	42.9	51.1	62.1
33	22.9	23.3	23.9	24.6	25.8	27.7	29.3	31.3	34.4	37.5	44.3	52.7	64.1
34	23.8	24.2	24.8	25.5	26.8	28.7	30.3	32.4	35.6	38.8	45.7	54.4	66.1
35	24.6	25.1	25.6	26.4	27.7	29.7	31.3	33.4	36.7	40.0	47.1	56.0	68.1
36	25.5	26.0	26.5	27.3	28.6	30.7	32.3	34.5	37.9	41.2	48.6	57.7	70.1
37	26.4	26.8	27.4	28.3	29.6	31.6	33.3	35.6	39.0	42.4	50.0	59.4	72.1
38	27.3	27.7	28.3	29.2	30.5	32.6	34.4	36.6	40.2	43.7	51.4	61.0	74.1
39	28.1	28.6	29.2	30.1	31.5	33.6	35.4	37.7	41.3	44.9	52.8	62.7	76.1
40	29.0	29.5	30.1	31.0	32.4	34.6	36.4	38.8	42.5	46.1	54.2	64.4	78.1
56	43.3	43.9	44.7	45.9	47.7	50.5	52.9	56.1	61.0	65.9	77.0	91.0	110.1
57	44.2	44.8	45.7	46.8	48.7	51.5	53.9	57.1	62.1	67.2	78.4	92.6	112.1
58	45.1	45.8	46.6	47.8	49.6	52.6	55.0	58.2	63.3	68.4	79.8	94.3	114.1
59	46.0	46.7	47.5	48.7	50.6	53.6	56.0	59.3	64.5	69.7	81.3	96.0	116.1
60	46.9	47.6	48.4	49.6	51.6	54.6	57.1	60.4	65.6	70.9	82.7	97.6	118.1
76	61.7	62.4	63.4	64.9	67.2	70.8	73.8	77.8	84.2	90.8	105.5	124.3	150.0
77	62.6	63.4	64.4	65.8	68.1	71.8	74.9	78.9	85.4	92.0	106.9	125.9	152.0
78	63.5	64.3	65.3	66.8	69.1	72.8	75.9	80.0	86.6	93.3	108.4	127.6	154.0
79	64.4	65.2	66.3	67.7	70.1	73.8	76.9	81.1	87.7	94.5	109.8	129.3	156.0
80	65.4	66.2	67.2	68.7	71.1	74.8	78.0	82.2	88.9	95.7	111.2	130.9	158.0
132	114.4	115.5	117.0	119.1	122.6	128.1	132.8	139.3	149.7	160.5	185.4	217.6	262.0
134	116.3	117.4	119.0	121.1	124.6	130.2	134.9	141.5	152.0	163.0	188.3	220.9	266.0
136	118.2	119.4	120.9	123.1	126.6	132.3	137.1	143.7	154.4	165.5	191.1	224.2	270.0
138	120.1	121.3	122.9	125.0	128.6	134.3	139.2	145.9	156.7	168.0	194.0	227.6	274.0
140	122.0	123.3	124.8	127.0	130.6	136.4	141.3	148.1	159.1	170.5	196.8	230.9	278.0