IT.2307 – Mobile Networks
Homework 1: Planification and Dimensioning of Cellular Network

Student Name: ----------

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General Questions :

Question 1 :

We consider a mobile network that can operate on two carrier frequencies 800 MHz and 2.6 GHz.

1. Compare the communication range of these two carriers. Indicate the frequency that you recommend to an operator to deploy in an urban zone and in rural one.

2. Compare the building penetration loss of these two carriers. Which frequency would you recommend for a femtocell usage?

Question 2:

We consider an antenna gain having a radiation pattern illustrated in Figure 1. The maximal gain of this antenna is 15.7 dBi. The losses in the cables and connectors are evaluated to 5dB. The maximal transmission power of the antenna is 30 W.

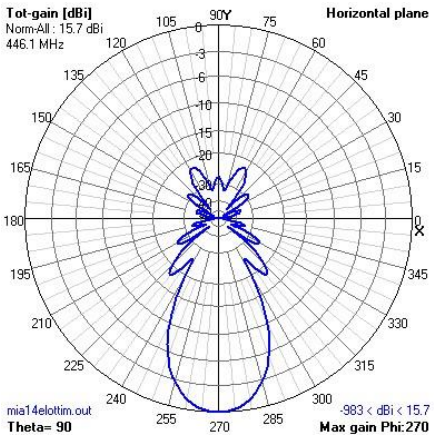

Figure 1: Horizontal radiation pattern

1. The maximal gain of this antenna is 15.7 dBi. Explain what does dBi mean?
2. Find the aperture of this antenna
3. In which situation would you recommend the usage of this antenna?
4. Find the maximal EIRP of the antenna
5. Find the EIRP of the antenna in the direction with deviation of 30^{o} from the most favorable antenna direction.

Question 3 :

1. Explain the terms multiplexing and duplexing.
2. Explain the difference between packet mode and circuit mode.
3. Compare the TDD and FDD.

Problem: Dimensioning and Planification of the network

We consider a mobile network that operates on a frequency of fp = 2.6 GHz having the characteristics in Table 1.

Uplink Budget		**Downlink Budget**	
Mobile Power	25 mW = dBm	Station Power	? dBm
Mobile Antenna Gain	0 dBi	Station Antenna Gain	17 dBi
Shadowing Loss	6 dB	Shadowing Loss	6 dB
Fading loss	1 dB	Fading loss	1 dB
Cable and Coupling Loss at the base station	2 dB	Cable and Coupling Loss at the base station	2 dB
Station Antenna Gain	17 dBi	Mobile Antenna Gain	17 dBi
Station sensitivity	-110 dBm	Mobile sensitivity	-103 dBm
Uplink Pathloss		Downlink Pathloss	

Table 1 : Link Budget

1. Using these characteristics, find the uplink tolerated uplink and downlink pathlosses.
2. Deduce the maximal total power of the station knowing that this latter is uniformly distributed among 25 users.

3. Find the communication range using the IEEE 802.16m model
4. $A_{dB} = 25.74 + 35\ log_{10}(d) + 33.81\ log_{10}(f_p)$

   with fp being the carrier frequency in MHz

The considered area corresponds to an urban zone with a total surface of 105.4 km^2 in which the density of the population is 21 000 inhabitants per km^2. A company receives a license to deploy and operate an FDD, OFDMA network in packet mode.
The administration allocates to it 3 pairs of 5 MHz bands, where each band is divided into 25 radio resources. The radio resource has a duration of 0.5 ms.

We consider:

- that the penetration rate is 30% in this city.
- that the correct operating threshold is for C / I = 7 dB.
- that the radio resource management algorithm allocates at least to an active user, within one second, 10 radio-resources (in a non-discontinuous way).

- that the coefficient of propagation is 3.3 in the cities.
- that the blockage probability is 0.5%

1. Calculate the size of the pattern and deduce the number of resources per cell.
2. Based on the Erlang B model, determine the traffic that can be supported in each cell.
3. Based on the above given data, find the traffic in Erlang generated by each user, and deduce the total traffic in the zone.
4. Calculate the number of cells needed in this urban zone
5. Calculate the area of each cell and deduce the traffic communication range
6. Indicate whether the radio planning or the dimensioning is limiting for the communication range.

Erlang B Traffic Table

Maximum Offered Load Versus B and N
B is in %

N/B	0.01	0.05	0.1	0.5	1.0	2	5	10	15	20	30	40
1	.0001	.0005	.0010	.0050	.0101	.0204	.0526	.1111	.1765	.2500	.4286	.6667
2	.0142	.0321	.0458	.1054	.1526	.2235	.3813	.5954	.7962	1.000	1.449	2.000
3	.0868	.1517	.1938	.3490	.4555	.6022	.8994	1.271	1.603	1.930	2.633	3.480
4	.2347	.3624	.4393	.7012	.8694	1.092	1.525	2.045	2.501	2.945	3.891	5.021
5	.4520	.6486	.7621	1.132	1.361	1.657	2.219	2.881	3.454	4.010	5.189	6.596
6	.7282	.9957	1.146	1.622	1.909	2.276	2.960	3.758	4.445	5.109	6.514	8.191
7	1.054	1.392	1.579	2.158	2.501	2.935	3.738	4.666	5.461	6.230	7.856	9.800
8	1.422	1.830	2.051	2.730	3.128	3.627	4.543	5.597	6.498	7.369	9.213	11.42
9	1.826	2.302	2.558	3.333	3.783	4.345	5.370	6.546	7.551	8.522	10.58	13.05
10	2.260	2.803	3.092	3.961	4.461	5.084	6.216	7.511	8.616	9.685	11.95	14.68
11	2.722	3.329	3.651	4.610	5.160	5.842	7.076	8.487	9.691	10.86	13.33	16.31
12	3.207	3.878	4.231	5.279	5.876	6.615	7.950	9.474	10.78	12.04	14.72	17.95
13	3.713	4.447	4.831	5.964	6.607	7.402	8.835	10.47	11.87	13.22	16.11	19.60
14	4.239	5.032	5.446	6.663	7.352	8.200	9.730	11.47	12.97	14.41	17.50	21.24
15	4.781	5.634	6.077	7.376	8.108	9.010	10.63	12.48	14.07	15.61	18.90	22.89
16	5.339	6.250	6.722	8.100	8.875	9.828	11.54	13.50	15.18	16.81	20.30	24.54
17	5.911	6.878	7.378	8.834	9.652	10.66	12.46	14.52	16.29	18.01	21.70	26.19
18	6.496	7.519	8.046	9.578	10.44	11.49	13.39	15.55	17.41	19.22	23.10	27.84
19	7.093	8.170	8.724	10.33	11.23	12.33	14.32	16.58	18.53	20.42	24.51	29.50
20	7.701	8.831	9.412	11.09	12.03	13.18	15.25	17.61	19.65	21.64	25.92	31.15
21	8.319	9.501	10.11	11.86	12.84	14.04	16.19	18.65	20.77	22.85	27.33	32.81
22	8.946	10.18	10.81	12.64	13.65	14.90	17.13	19.69	21.90	24.06	28.74	34.46
23	9.583	10.87	11.52	13.42	14.47	15.76	18.08	20.74	23.03	25.28	30.15	36.12
24	10.23	11.56	12.24	14.20	15.30	16.63	19.03	21.78	24.16	26.50	31.56	37.78
25	10.88	12.26	12.97	15.00	16.13	17.51	19.99	22.83	25.30	27.72	32.97	39.44
26	11.54	12.97	13.70	15.80	16.96	18.38	20.94	23.89	26.43	28.94	34.39	41.10
27	12.21	13.69	14.44	16.60	17.80	19.27	21.90	24.94	27.57	30.16	35.80	42.76
28	12.88	14.41	15.18	17.41	18.64	20.15	22.87	26.00	28.71	31.39	37.21	44.41
29	13.56	15.13	15.93	18.22	19.49	21.04	23.83	27.05	29.85	32.61	38.63	46.07
30	14.25	15.86	16.68	19.03	20.34	21.93	24.80	28.11	31.00	33.84	40.05	47.74
31	14.94	16.60	17.44	19.85	21.19	22.83	25.77	29.17	32.14	35.07	41.46	49.40
32	15.63	17.34	18.21	20.68	22.05	23.73	26.75	30.24	33.28	36.30	42.88	51.06
33	16.34	18.09	18.97	21.51	22.91	24.63	27.72	31.30	34.43	37.52	44.30	52.72
34	17.04	18.84	19.74	22.34	23.77	25.53	28.70	32.37	35.58	38.75	45.72	54.38
35	17.75	19.59	20.52	23.17	24.64	26.44	29.68	33.43	36.72	39.99	47.14	56.04
36	18.47	20.35	21.30	24.01	25.51	27.34	30.66	34.50	37.87	41.22	48.56	57.70
37	19.19	21.11	22.08	24.85	26.38	28.25	31.64	35.57	39.02	42.45	49.98	59.37
38	19.91	21.87	22.86	25.69	27.25	29.17	32.62	36.64	40.17	43.68	51.40	61.03
39	20.64	22.64	23.65	26.53	28.13	30.08	33.61	37.72	41.32	44.91	52.82	62.69
40	21.37	23.41	24.44	27.38	29.01	31.00	34.60	38.79	42.48	46.15	54.24	64.35
41	22.11	24.19	25.24	28.23	29.89	31.92	35.58	39.86	43.63	47.38	55.66	66.02
42	22.85	24.97	26.04	29.09	30.77	32.84	36.57	40.94	44.78	48.62	57.08	67.68
43	23.59	25.75	26.84	29.94	31.66	33.76	37.57	42.01	45.94	49.85	58.50	69.34