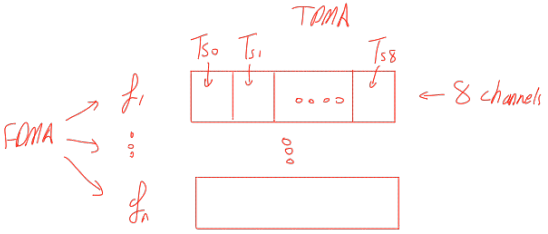


BIRZEIT UNIVERSITY

Faculty of Engineering and Technology
Department of Electrical and Computer Engineering
Wireless and Mobile Networks, ENCS5323
Dr. Mohammad K. Jubran
Working Sheet #2

Problem #1:

A new mobile network provider acquired the license to provide full-rate duplex voice communication using GSM900 technology in certain city (8 timeslots per carrier). The Area of the city is equal to 4 Km^2 (4,000,000 m^2). The mobile network provider is interested to provide service to 80 thousand subscribers. Subscribers in this city make an average of 8 calls per day and the average call duration is 3 minutes. The service provider is interested to provide the subscribers with a quality of service that guarantees a call drop probability equal to 0.02. The minimum SIR needed to correctly provide the service is equal to 13dB. Assuming -22.0 dB power is measured at a reference distance of 10 meters from base stations, the path loss exponent equals 3 (cellular urban area), receiver sensitivity = 7μ watts, calculate the following

a) Maximum distance between transmitter and receiver for reliable communication.
b) Maximum cell size assuming hexagonal cells.
c) The number of cells in the service area?
d) Traffic load in the whole cellular system in Erlangs.
e) Traffic load in each cell in Erlangs.
f) Number of cells in each cluster (*hint: number of co-channel interfering cells=6*)?
g) Minimum number of carriers needed (in the whole system) to achieve the required Quality of Service.
h) Minimum number of carriers needed (in the whole system) to achieve the required Quality of Service if QoS has changed to 0.05.

Hint: The cell size can be calculated as $\frac{3\sqrt{3}}{2}(R^2)$.

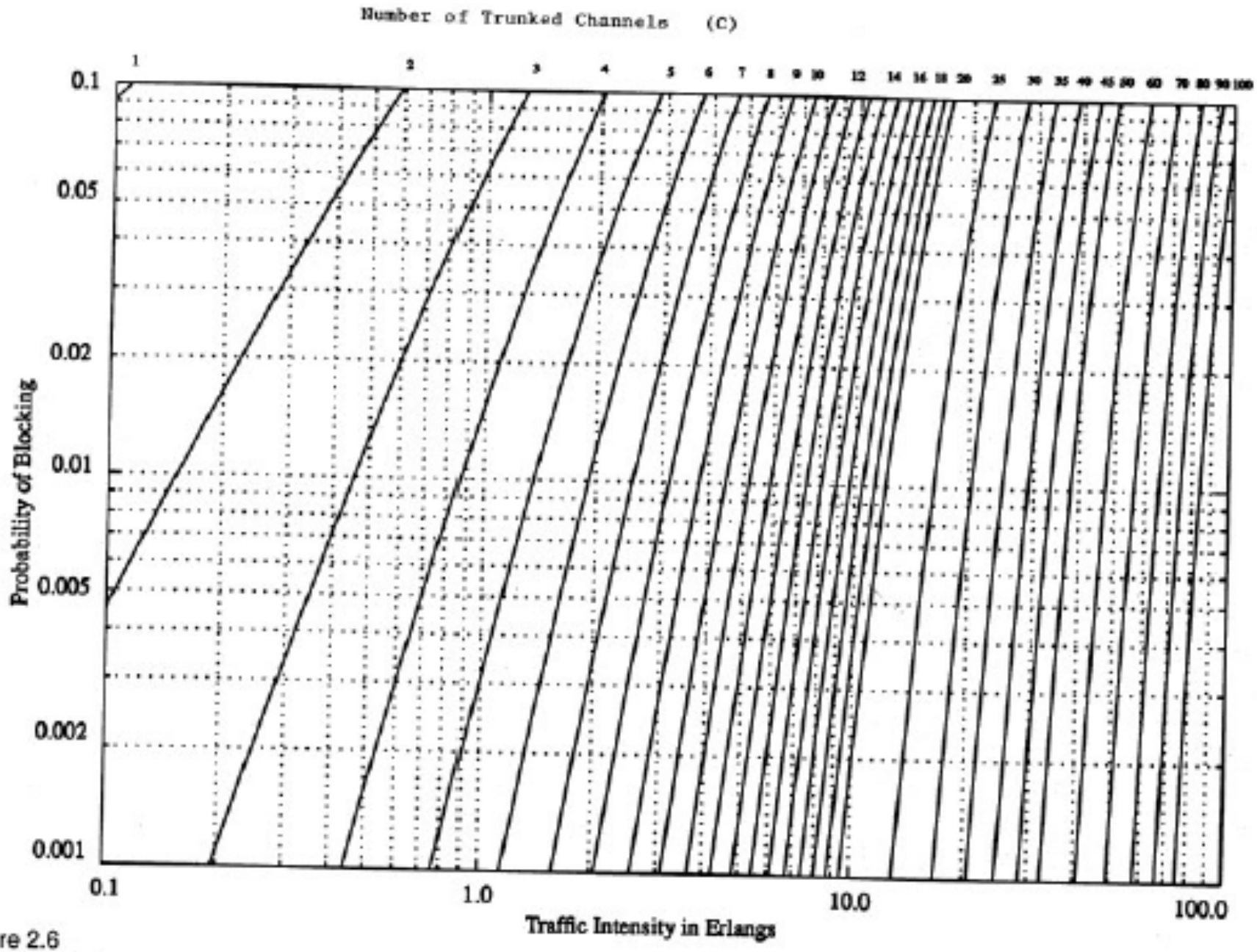


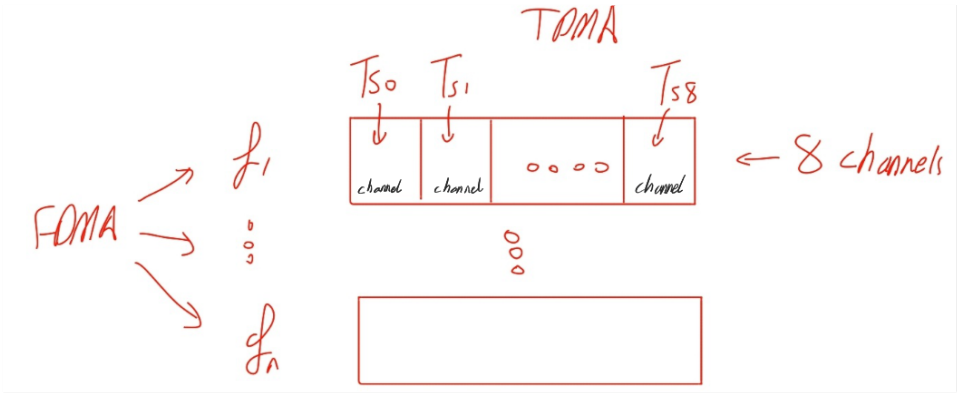
Figure 2.6

The Erlang B chart showing the probability of blocking as functions of the number of channels and traffic intensity in Erlangs.

Erlang B (Blocked Calls Cleared)

No. of Channels	Traffic in erlangs for P = 0.1%	0.2%	0.5%	1%	1.2%	1.3%	1.5%	2%	3%	5%	7%	10%	15%	20%	30%
1	0.001	0.002	0.005	0.010	0.012	0.013	0.02	0.020	0.031	0.053	0.075	0.111	0.176	0.250	0.429
2	0.046	0.065	0.105	0.153	0.168	0.176	0.19	0.223	0.282	0.381	0.470	0.595	0.796	1.00	1.45
3	0.194	0.249	0.349	0.455	0.489	0.505	0.53	0.602	0.715	0.899	1.057	1.271	1.602	1.930	2.633
4	0.439	0.535	0.701	0.869	0.922	0.946	0.99	1.092	1.259	1.525	1.748	2.045	2.501	2.95	3.89
5	0.762	0.900	1.132	1.361	1.431	1.464	1.52	1.657	1.875	2.218	2.504	2.881	3.454	4.010	5.189
6	1.1	1.3	1.6	1.9	2.0	2.0	2.1	2.3	2.5	3.0	3.3	3.8	4.4	5.1	6.5
7	1.6	1.8	2.2	2.5	2.6	2.7	2.7	2.9	3.2	3.7	4.1	4.7	5.5	6.2	7.9
8	2.1	2.3	2.7	3.1	3.2	3.3	3.4	3.6	4.0	4.5	5.0	5.6	6.5	7.4	9.2
9	2.6	2.9	3.3	3.8	3.9	4.0	4.1	4.3	4.7	5.4	5.9	6.5	7.6	8.5	10.6
10	3.1	3.4	4.0	4.5	4.6	4.7	4.8	5.1	5.5	6.2	6.8	7.5	8.6	9.7	12.0
11	3.7	4.0	4.6	5.2	5.3	5.4	5.5	5.8	6.3	7.1	7.7	8.5	9.7	10.9	13.3
12	4.2	4.6	5.3	5.9	6.1	6.1	6.3	6.6	7.1	8.0	8.6	9.5	10.8	12.0	14.7
13	4.8	5.3	6.0	6.6	6.8	6.9	7.0	7.4	8.0	8.8	9.5	10.5	11.9	13.2	16.1
14	5.4	5.9	6.7	7.4	7.6	7.7	7.8	8.2	8.8	9.7	10.5	11.5	13.0	14.4	17.5
15	6.1	6.6	7.4	8.1	8.3	8.4	8.6	9.0	9.6	10.6	11.4	12.5	14.1	15.6	18.9
16	6.7	7.3	8.1	8.9	9.1	9.2	9.4	9.8	10.5	11.5	12.4	13.5	15.2	16.8	20.3
17	7.4	7.9	8.8	9.7	9.9	10.0	10.2	10.7	11.4	12.5	13.4	14.5	16.3	18.0	21.7
18	8.0	8.6	9.6	10.4	10.7	10.8	11.0	11.5	12.2	13.4	14.3	15.5	17.4	19.2	23.1
19	8.7	9.4	10.3	11.2	11.5	11.6	11.8	12.3	13.1	14.3	15.3	16.6	18.5	20.4	24.5
20	9.4	10.1	11.1	12.0	12.3	12.4	12.6	13.2	14.0	15.2	16.3	17.6	19.6	21.6	25.9
21	10.1	10.8	11.9	12.8	13.1	13.3	13.5	14.0	14.9	16.2	17.3	18.7	20.8	22.8	27.3
22	10.8	11.5	12.6	13.7	14.0	14.1	14.3	14.9	15.8	17.1	18.2	19.7	21.9	24.1	28.7
23	11.5	12.3	13.4	14.5	14.8	14.9	15.2	15.8	16.7	18.1	19.2	20.7	23.0	25.3	30.1
24	12.2	13.0	14.2	15.3	15.6	15.8	16.0	16.6	17.6	19.0	20.2	21.8	24.2	26.5	31.6
25	13.0	13.8	15.0	16.1	16.5	16.6	16.9	17.5	18.5	20.0	21.2	22.8	25.3	27.7	33.0
26	13.7	14.5	15.8	17.0	17.3	17.5	17.7	18.4	19.4	20.9	22.2	23.9	26.4	28.9	34.4
27	14.4	15.3	16.6	17.8	18.2	18.3	18.6	19.3	20.3	21.9	23.2	24.9	27.6	30.2	35.8
28	15.2	16.1	17.4	18.6	19.0	19.2	19.5	20.2	21.2	22.9	24.2	26.0	28.7	31.4	37.2
29	15.9	16.8	18.2	19.5	19.9	20.0	20.3	21.0	22.1	23.8	25.2	27.1	29.9	32.6	38.6
30	16.7	17.6	19.0	20.3	20.7	20.9	21.2	21.9	23.1	24.8	26.2	28.1	31.0	33.8	40.0
31	17.4	18.4	19.9	21.2	21.6	21.8	22.1	22.8	24.0	25.8	27.2	29.2	32.1	35.1	41.5
32	18.2	19.2	20.7	22.0	22.5	22.6	22.9	23.7	24.9	26.7	28.2	30.2	33.3	36.3	42.9
33	19.0	20.0	21.5	22.9	23.3	23.5	23.8	24.6	25.8	27.7	29.3	31.3	34.4	37.5	44.3
34	19.7	20.8	22.3	23.8	24.2	24.4	24.7	25.5	26.8	28.7	30.3	32.4	35.6	38.8	45.7
35	20.5	21.6	23.2	24.6	25.1	25.3	25.6	26.4	27.7	29.7	31.3	33.4	36.7	40.0	47.1
36	21.3	22.4	24.0	25.5	26.0	26.2	26.5	27.3	28.6	30.7	32.3	34.5	37.9	41.2	48.6
37	22.1	23.2	24.8	26.4	26.8	27.0	27.4	28.3	29.6	31.6	33.3	35.6	39.0	42.4	50.0
38	22.9	24.0	25.7	27.3	27.7	27.9	28.3	29.2	30.5	32.6	34.4	36.6	40.2	43.7	51.4
39	23.7	24.8	26.5	28.1	28.6	28.8	29.2	30.1	31.5	33.6	35.4	37.7	41.3	44.9	52.8
40	24.4	25.6	27.4	29.0	29.5	29.7	30.1	31.0	32.4	34.6	36.4	38.8	42.5	46.1	54.2
41	25.2	26.4	28.2	29.9	30.4	30.6	31.0	31.9	33.4	35.6	37.4	39.9	43.6	47.4	55.7
42	26.0	27.2	29.1	30.8	31.3	31.5	31.9	32.8	34.3	36.6	38.4	40.9	44.8	48.6	57.1
43	26.8	28.1	29.9	31.7	32.2	32.4	32.8	33.8	35.3	37.6	39.5	42.0	45.9	49.9	58.5
44	27.6	28.9	30.8	32.5	33.1	33.3	33.7	34.7	36.2	38.6	40.5	43.1	47.1	51.1	59.9
45	28.4	29.7	31.7	33.4	34.0	34.2	34.6	35.6	37.2	39.6	41.5	44.2	48.2	52.3	61.3

Solution:



Total area = 4000,000 m^2

U = 80 000 user

λ = 8 call/day

H = 3 min / call

GOS = P_B = 0.02 Erlang B

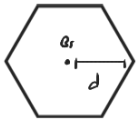
SIR = 13 dB

$P(d_o = 1_o)$ = −22 dB

n = 3

$P_{r,sen}$ = 7 n watt (the min power to detection)

A) $P(d) = P(d_o)\left(\frac{d_o}{d}\right)^n$



$7 * 10^{-6} = 10^{-2.2}\left(\frac{10}{d}\right)^3$

$d = 10 \Big/ \left(\frac{7 * 10^{-6}}{10^{-2.2}}\right)^{\frac{1}{3}} = 96.597\ m$

B) $A_{cell} = \frac{3\sqrt{3}}{2} R^2 = 2424\ 3\ m^2$

C) # of cells $= \frac{Area}{A_{cell}} = \frac{4000000}{2424\ 3} = 164.99$ cell

D) $A_u = \lambda H$

$= \frac{8\ calls}{day} \times \frac{1\ day}{24 * 60\ min} * \frac{3\ min}{call} = \frac{1}{60}$ Erlang

$A = UA_u = \frac{80000}{60} = 1333.33$ Erlang..

E) $A_{cell} = \frac{A}{\#\ of\ cell} = \frac{1333.33}{165} = 8.08$ Erlang

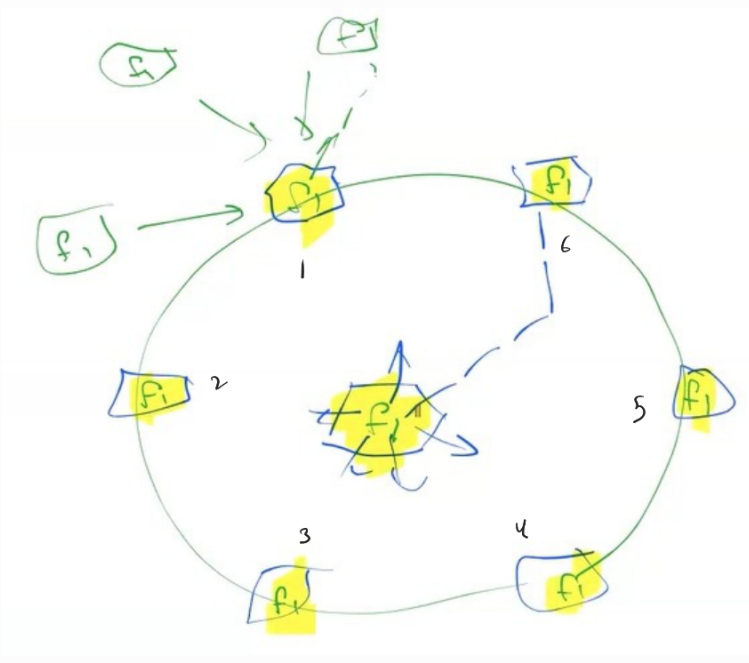
(f) $SIR = \frac{(\sqrt{3N})^n}{i_0 = N_B} = \frac{(\sqrt{3N})^3}{6} \geq 10^{1.3}$

$(3N)^{\frac{3}{2}} \geq 6 \times 10^{1.3} \rightarrow 3N \geq (6 \times 10^{1.3})^{\frac{2}{3}} \rightarrow N \geq \frac{1}{3}(6 \times 10^{1.3})^{\frac{2}{3}}$

$N \geq 8.097 = N = 9$ ✓

$i^2 + ij + j^2$

$i = 0 \quad j = 3$



(g)

From Erlang B Table

with $P_B = 0.02$ and $A_{cell} = 8.08$ Erlang

Number of channels = 14 channel

Number of carrier = $\frac{14}{8} = 1.75$ that mean two carrier per cell

Number of carrier of whole system : $N * 2 =$ 18 carrier

in one cluster

& numer of cluster = 18.33

$N = 9$
cell = 165

(h) $P_B = 0.05 \rightarrow$

# of channels / cell = 13

# of carriers / cell = $\frac{13}{8} \Rightarrow 2$

total number of carriers in the whole system = $9 \times 2 = 18$

$\Rightarrow$ If total number of available carries is 9 ?

# of carrier per cell = 1 carrier

# of channel per cell = 8 channels

$P_B = 0.02$, # of channels = 8 [from table] $\Rightarrow$ $A_{cell} = 3.6$

Number of cell = total traffic / traffic per cell = $1333.33 / 3.6 = \frac{370.36}{371}$ cell

cell Area = total Area / # cell = $4000,000 / 371 = 10781.67$

cell Area = $\frac{3\sqrt{3}}{2} R^2$ then $R = 64.4$ m [calculate P_t (G_t, G_r, A_t, ...)]