Note: Problem 3 is a homework exercise. Deliver your answer sheet (labelled with your student id, name, and signature) into the mail box of the course, or directly to the course assistant *before* the next exercise class on 29 November.

1. Consider a *symmetric* telephone network with two hierarchial levels. Assume that there are n_1 (higher level 1) areal exchanges completely connected to each other with two-way links (fully meshed topology). What is the total number l_1 of links at this level? Assume further that, for each areal exchange, there are n_2 (lower level 2) local exchanges connected to the areal exchange with two-way links (star topology). What is the total number l_2 of links at this level? All the subscribers are connected to the local exchanges, so that the areal exchanges are just used as transit exchanges.

2. Consider the symmetric telephone network defined in problem 1. Let $T = T(i,j)$ denote the traffic matrix, where $T(i,j)$ tells the offered traffic originating from local exchange i and destined to local exchange j. Assume now that

$$T(i,j) = \begin{cases} t_1, & \text{if } i \text{ and } j \ (i \neq j) \text{ are connected to different areal exchanges,} \\ t_2, & \text{if } i \text{ and } j \ (i \neq j) \text{ are connected to the same areal exchange,} \\ t_3, & \text{if } i = j. \end{cases}$$

   a) What is the total offered traffic a generated from the subscribers of any single local exchange?

   b) Assume further that $n_1 = 3$ and $n_2 = 4$. Write down the traffic matrix.

3. *Homework exercise* (deadline 29 November at 9 o'clock): Consider still the symmetric telephone network defined in problems 1 and 2. Assume that $n_1 = 3$, $n_2 = 4$, $t_1 = 1$ erlang, $t_2 = 3$ erlang, and $t_3 = 9$ erlang. Assume further that the shortest path routes are used, and the mean call holding time is $h = 3$ minutes.

   a) (Node dimensioning) What is the rate λ_i of call requests arriving at a level-i node, $i = 1, 2$? Dimension the nodes so that the traffic load $\rho < 0.5$ in all nodes.

   b) (Link dimensioning) What is the traffic a_i offered to a level-i link, $i = 1, 2$? Dimension the links so that the call blocking probability $B \leq 1\%$ in all links. (Table on Erl(n, a) function are given on page 2.)

n (channels)	a (erlangs)
1	0.01
2	0.15
3	0.46
4	0.87
5	1.36
6	1.91
7	2.50
8	3.13
9	3.78
10	4.46
11	5.16
12	5.88
13	6.61
14	7.35
15	8.11
16	8.87
17	9.65
18	10.44
19	11.23
20	12.03
21	12.84
22	13.65
23	14.47
24	15.29
25	16.12
26	16.96
27	17.80
28	18.64
29	19.49
30	20.34

n (channels)	a (erlangs)
31	21.19
32	22.05
33	22.91
34	23.77
35	24.64
36	25.51
37	26.38
38	27.25
39	28.13
40	29.01
41	29.89
42	30.77
43	31.66
44	32.54
45	33.43
46	34.32
47	35.21
48	36.11
49	37.00
50	37.90
51	38.80
52	39.70
53	40.60
54	41.50
55	42.41
56	43.31
57	44.22
58	45.13
59	46.04
60	46.95

Table 1: $B = \mathrm{Erl}(n, a) = 1\%$