Exam Optimization of Business Processes
29 May 2012

This exam consists of **4** problems, each consisting of several questions.
All answers should be motivated, including calculations, formulas used, etc.
It is allowed to use 1 sheet of paper (or 2 sheets written on one side) with **hand-written** notes.
The minimal note is 1. All questions give the same number of points.
The use of a calculator and a dictionary are allowed.
A table with the Poisson distribution is attached.

1. A production line consists of 2 station, each having exponentially distributed processing times with average 1, with infinite storage space in between. Arrivals occur according to a Poisson process.
a. What is the maximum arrival rate?
b. Compute the expected sojourn time (the time between arrival and the end of production) for an arrival rate of 0.5.
The system is modified as follows: the two steps are done at the same time in parallel, and a new item is taken into production when both steps are finished.
c. What is now the maximum arrival rate?
d. Compute again the expected sojourn time for an arrival rate of 0.5.

2a. Formulate the standard shift scheduling problem, in which the best combination of shifts is found given staffing levels for each interval.
b. Explain how these staffing levels can be obtained in a call center.
c. Extend the model to emails, that arrive during the day, but that have to be dealt with before the end of the day. Agents are assigned, for each interval, to inbound calls or emails. The load from emails can be assumed to be deterministic and consists for every interval of the number of agents required during that interval, which can thus be scheduled during the rest of the day.
d. Give a method how the performance of this call center can be further improved.

3. Consider a 2-out-of-3 system (with warm stand-by).
a. Calculate ϕ and Φ.
b. Compute the probability that the system is up at 1 when the lifetimes are exponentially distributed with average 1.
c. Answer the same question when the third component is in cold standby.

4. A small hotel with 8 rooms has 3 booking classes, with prices 200, 150 en 80 Euro, and a Poisson demand for a particular night with expectations of 3, 3 and 10 respectively, highest price books first.
a. Compute the booking limits using the EMSR-a and EMSR-b models.
b. Explain how the total revenue can be computed. Motivate why you think this is the best method.
c. Give at least two reasons why the EMSR models are less useful in practice and give an alternative method that does not have these disadvantages.

Table with value of P(X>k) with X a Poisson distributed random variable with mean mu

	values of mu									
k	1	2	3	4	5	6	7	8	9	10
0	0.632	0.865	0.950	0.982	0.993	0.998	0.999	1.000	1.000	1.000
1	0.264	0.594	0.801	0.908	0.960	0.983	0.993	0.997	0.999	1.000
2	0.080	0.323	0.577	0.762	0.875	0.938	0.970	0.986	0.994	0.997
3	0.019	0.143	0.353	0.567	0.735	0.849	0.918	0.958	0.979	0.990
4	0.004	0.053	0.185	0.371	0.560	0.715	0.827	0.900	0.945	0.971
5	0.001	0.017	0.084	0.215	0.384	0.554	0.699	0.809	0.884	0.933
6	0.000	0.005	0.034	0.111	0.238	0.394	0.550	0.687	0.793	0.870
7	0.000	0.001	0.012	0.051	0.133	0.256	0.401	0.547	0.676	0.780
8	0.000	0.000	0.004	0.021	0.068	0.153	0.271	0.407	0.544	0.667
9	0.000	0.000	0.001	0.008	0.032	0.084	0.170	0.283	0.413	0.542
10	0.000	0.000	0.000	0.003	0.014	0.043	0.099	0.184	0.294	0.417
11	0.000	0.000	0.000	0.001	0.005	0.020	0.053	0.112	0.197	0.303
12	0.000	0.000	0.000	0.000	0.002	0.009	0.027	0.064	0.124	0.208
13	0.000	0.000	0.000	0.000	0.001	0.004	0.013	0.034	0.074	0.136
14	0.000	0.000	0.000	0.000	0.000	0.001	0.006	0.017	0.041	0.083
15	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.008	0.022	0.049
16	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.004	0.011	0.027
17	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.005	0.014
18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.007
19	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003
20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
21	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
22	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
23	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
25	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000