Exam Optimization of Business Processes
25 May 2021

This exam consists of **5** 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 grade is 1, the maximal grade is 10. All questions (1a, 1b, etc.) give the same number of points (0.62), except for problem 5, these questions count half (0.31).
The use of a calculator and a dictionary are allowed.
A table with the normal distribution and a table with the Poisson distribution are attached.

1. A project has 4 activities: A, B, C, and D. The durations are 1, 3, 3, and 5. The only order relations are that A and B proceed C.
a. Compute the minimal project duration, the critical path and the slack of each activity.
b. The duration of B is now stochastic with a uniform distribution between 0 and 3. The other activities remain deterministic with the same duration. Give the distribution function of the project duration. What is the expectation?
c. Consider again the deterministic situation. Assume that B and D use the same resource and cannot be done at the same time. What is now the minimal project duration?
d. Give also a linear optimization formulation to solve the last problem. Model the choice which one of B and D goes first explicitly through a decision variable.

2. In an operating room 7 operations are scheduled that have lognormal durations with mean 1 hour and standard deviation 30 minutes. The total time the operating room is open is 8 hours.
a. Give an approximation of the probability that the operations take more than 8 hours. Motivate the approximation.
b. Give a formula, using the same approximation, of the expected tardiness.
c. In a second operating room operations are scheduled with a lower standard deviation. What is, in general, better? Keep them separate or mix both types of operations in both operating rooms? Motivate your answer.

3. A small call center has 2 agents that do both inbound and outbound calling. The average handle time of both is 4 minutes, on average 1 inbound call arrives every 6 minutes. The SL is defined as the fraction of inbound calls that wait less than 1 minute. There is a large inventory of outbound calls that need to be done. Handling times can assumed to be exponential, inbound customers have ∞ patience.
a. Suppose first that one agent does inbound and the other outbound. What is the SL on inbound and the throughput on outbound?
b. Now suppose they work in a blended mode. Inbound has priority, when an agent is available she handles an outbound call. Model this as a birth-death process and compute the SL and the throughput.
c. In the previous question you found a considerably higher throughput than under a) but a SL that is not very high. What is a smart way to improve this situation?

4. Consider a deterministic inventory control problem with holding costs h per item per unit of time and order costs K, deterministic demand d_t (at time t), shelf space M, immediate deliveries, no backorders or lost sales.
a. Formulate the dynamic programming recursion. Pay attention to the action set.
b. Do 2 steps of the recursion with the following parameters: $T = 3$ (thus $V_3(x) = 0$, and you have to compute $V_1(x)$ and $V_2(x)$ for all x), $M = 2$, $h = 1$, $K = 10$, $d_1 = 2$, $d_2 = 1$. Characterize in words the optimal policy.
c. How can you model deliveries at the end of the day? And deliveries at the end of next day? Give for both the dynamic programming recursion.

5a. Give, according to Daniel Hopman, a method that airlines use to segment between leisure and business customers.
5b. In the lectures exponential booking curves were discussed to forecast demand in revenue management. Which statistical technique did Rik van Leeuwen use to obtain more flexible booking curves?
5c. Which method does Air France-KLM use, according to Jeroen Mulder, to determine bid prices for all possible origin-destination combinations?