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In 2005-2006, the course INFOSIM was given by Dr. Ir. J. M. van den Akker.

Final exam Simulation (INFOSIM)
July 4th 2006

Answers may be provided in either Dutch or English.
All answers should be clearly explained.
A case description as well as a statictical table is attached.
You are allowed to use a calculator.

The maximum score per question is as follows:
Question 1: 50 points: (a) 10 (b) 8 (c) 8 (d) 8 (e) 8 (f) 8
Question 2: 50 points: (a) 6 (b) 6 (c) 8 (d) 6 (e) 6 (f) 6 (g) 12

Question 1

We consider the bus station that you have simulated in ED in the first simulation assignment. The case description is attached to this exam paper. When you implement a simulation model in ED, you do not have to include all details about events. However, now we are going to study a simulation model for the bus station based on **event-scheduling**.

a) Which are the events that have to be included in an event-scheduling model? Draw the event-graph corresponding to these events.

b) What is the state of the system that has to be maintained during the simulation?

c) What are the performance measures that are needed to answer the questions that were the reason for the simulation study? Also explain how these performance measures can be determined within a computer program that is based on the event-scheduling approach.

d) Describe the event-handler in words or pseudo-code for **two** of the events that you identified in part (a).

e) In the scenario that we have simulated in the assignment, the arrival of busses at the station was subject to uncertainty. Give two other entities that may have to be modelled as stochastic variables in the simulation of the bus station. For each of these, suggest a probability distribution that is generally known to be used for the modelling of the entity that you identified.

f) Describe four techniques or methods to validate the simulation model of the bus station.

Question 2

We consider a medium-sized hospital. In this hospital, each patient entering the hospital has to check in at the reception. The patients arrive at the hospital according to a Poisson proces with an average of 45 per hour. At the reception, there is one employee for checking in the patients which takes on average 75 seconds. The service times follow an exponential distribution.

a) Determine the average length of the queue in front of the reception.

b) Is there a reason to assign an additional employee to the reception or to take measures to speed up the check-in process? Explain your answer.

Part of the patients need an operation. These patients can be divided into m types depending on the operation that they need. The operation of a patient of type i $(i = 1, \ldots, m)$ takes on average p_i minutes. Moreover a patient of type i has to stay in the hospital for d_i days on average and requires on average n_i hours of time from a nurse during each day that the patient stays in hospital. Here the day that the operation takes place is counted as the first day in the hospital.

c) For one of the types of patients, the operation time p_i follows the 4-Erlang distribution with an average of 40. How can we generate these operation times in a program written in an imperative programming language like Java or C++ and without using specific libraries?
Note: You do not have to give a program, but just a description or pseudo-code.

The hospital wants to work with a cyclic admission pattern of patients, i.e., for each working day of the week and for each type of patients the management wants to determine a fixed number q_{it} of patients of type i that gets an operation on day t $(i = 1, \ldots, m;\ t = 1, 2, 3, 4, 5)$. In total, the hospital has to accomodate Q_i patients of type i per week. We are given that on day t $(t = 1, 2, \ldots, 5)$ the available amount of time in the operation theatre is P_t and the number of available nurses equals V_t. Moreover the number of available beds for patients that had surgery equals B. The management of the hosptial wants to make planning in which the utilization factor is as stable as possible, i.e., the difference between available and used capacity is more-or-less constant during the week. Note that the planning proces in complicated by the fact that the operation times p_i, the required durations d_i to stay in the hospital and the required nursing time n_i are subject to uncertainty.

d) To support the hospital in solving this planning problem, optimization algorithms as well as discrete-event simulation can be useful. Shortly describe the benefits of each of these approaches.

e) One can characterize different types of simulations with respect to output analysis. Explain these different types. How does the above problem fit into this characterization?

f) Let 18, 17, 21, 22, and 19 be the average number of nurses that are needed on Tuesday observed in 5 independent runs of a simulation of the surgery department for a given admission pattern. Determine $\bar{X}(5)$, $S^2(5)$, and a 95 percent confidence-interval for the expected value μ and explain the meaning of the computed quantities.

g) Describe the above problem as a combined optimization and simulation problem, i.e. formulate (either in words or formulas) the objective function and the constraints and indicate at which point a simulation has to be performed. Sketch how you can solve this problem with a local search algorithm.