Utrecht University
Faculty of Science
Department of Information and Computing Sciences

Final Exam Simulation, Tuesday May 27, 2014, 13.30-15.30 hr.

- Switch off your mobile phone, PDA and any other mobile device and put it far away.
- This exam consists of 7 questions and has 3 pages.
- Answers may be provided in either Dutch or English.
- All your answers should be clearly written down and provide a clear explanation. Unreadable or unclear answers may be judged as false.
- Please write down your name and student number on every exam paper that you hand in.
- A statistical table is is distributed separately and should be returned.
- The maximum score (10 in total) is divided as follows:

Question	Score
1	2
2	1
3	1
4	1
5	1.5
6	2
7	1.5

Good luck, veel succes !

The home care company

We consider a home care company in the center of the Netherlands. It employs 10 nurses and 20 assistants. On a working day, there are n customers requiring care from the company. The care for customers is performed in two steps. Customer i ($i = 1, 2, \ldots, n$) first requires attendance from an assistant. The time in minutes(!) required for this follows an exponential distribution with an average of p_i^{assist}. After that, the customer requires attendance from a nurse. This takes an amount following an exponential distribution with an average of p_i^{nurse}. This time also is in minutes.

You may assume that the travelling time from one customer to the next follows a normal distribution with an average of 15 minutes and a standard deviation of 2 minutes, where the travelling time is set to 1 minute if the normal distribution yields a number smaller than 1.

Furthermore, customers are assigned to assistants in increasing order of their index i. This implies that, if an assistant has finished her/his work, she/he is going to travel to the customer with lowest index which has not been assigned to an assistant yet. Nurses start travelling to a customer upon request only. The company wants that the nurse arrives shortly after the assistant is finished. Therefore, a nurse is requested to start travelling 5 minutes after the start of the work of the assistant. If, at this point in time, there is no nurse available, the request in put into a FIFO queue.

The company wants to perform a simulation study to determine the *makespan*, i.e., the total time required to serve the complete set of the customers. Moreover, they want to determine the average service time of the customers.

(1) Which events are included in the event-scheduling model for this problem? Draw an event graph and for each arc give the corresponding time delay.

(2) Describe in words or pseudo code the event-handlers of the event(s) that include the arrival of a nurse at a customer.

(3) Suppose that the working process of the assistants is improved such that the variance of the working time is reduced. What is the effect on the makespan? Explain your answer.

(4) Suppose that a working day consists of 8 hours without break.
(a) Give a formula for the utilization factor of the assistants. Explain your answer.
(b) Suppose that the average working time of an assistant equals 20 minutes. What is the maximum value of n gives an appropriate amount of work for the assistants in a single day?
Remark: use the utilization factor and do not care about overtime work for the nurses.

(5) Suppose that the travelling times of care personnel are subject to disturbances δ (in minutes). If a nurse or assistant travels from one customer to another, the travelling time equals $15+\delta$ minutes, where δ follows a 3-Erlang distribution where the average of δ equals 15. How can we generate these disturbances in a program written in an imperative programming language like Java, C#, or C++ and without using **any** specific random generation libraries or functions?
Note: You do not have to give a program, but just a description or pseudo-code.

(6) The organization owns a shop where people can rent or buy specific products. For anti-allergic bath oil, which has to be bought, the demand is normally distributed with a known expected value and variance. It is known that the average demand per four weeks is 300 liters with a variance of 64 per four weeks. The weekly demands are assumed to be independent. The shop wants to use the (r, q)-model as a basis for its inventory management.

- Explain the (r, q)-model
- Given the fixed ordering cost 10 EURO and the holding cost 0.2 EURO per liter per week, determine the optimal value of q.
- Given a constant lead time of one week and a desired Stock-Out-Probability(SOP) = 0.01, compute the value of r. What is the size of the safety stock in this example? *A statistical table is attached.*

(7) The organization wants to apply an advanced planning tool to determine the assignment of nurses and assistants to customers and to determine the expected starting time of the service of customer i. They want to minimize the expected makespan.
To find a good solution for the problem the home care company asked some consultancy companies for advice.

1. Consultant A says that it is important to develop advanced optimization algorithms.
2. Consultant B proposes to perform a discrete-event simulation study.

Give an analysis of the advantages and disadvantages of these approaches, on the basis of which the management of the bus company is able to make a good choice.