Aalto University
School of Electrical Engineering
Department of Communications and Networking
ELEC-C7210 Modeling and analysis of communication networks, Autumn 2017

Exam 25.10.2017 answers/grading briefly

1. This is about applying Little's law.
   a) 6 customers
   b) 5.2 customers (total number minus number in service)
   c) 0.8 customers (same as load of the system)
   d) 20 customers (system is stable so flow in = flow out)

   Grading: Each question gave 1.5 points and for the final points, the total was rounded to closest integer.

2. Here you need the memoryless property of exp-distribution and distribution of the minimum of exp-random variables.
   $E[Z_1] = 4$ (3+minimum of two exp-distributed rv's, memoryless after 3!)
   $E[Z_2] = 6$ (memoryless after departure of first, $Z_2 = Z_1 + \exp(1/2)$)

   Grading: For full points, a complete answer with explicit logical reasoning was expected. If you only gave the correct answer and no justification, then maximum was 2 points. If memoryless property was not EXPLICITLY mentioned, then I took -1 point even if the answer was correct. Partial points were given for partly correct answers.

3. This is the M/M/1-PS queue.
   a) $\rho = \lambda/\mu = 0.9$
   b) using LBE's, $\pi_n = \rho^n(1-\rho)$. $\rho < 1$ (stability requirement, convergence of infinite series in normalization condition!)
   c) 1Mbit/s (thput = mean SIZE/mean delay)

   Grading: a = max 1 point, b = max 3 points (partial points may have been given if your BD process was wrong), c = max 2 points.

4. a) 3 servers and 1 waiting place. Thus, BD-process with states $0, \ldots, 4$, transition rate up = λ and rate down in each state $\mu_1 = \mu$, $\mu_2 = 2\mu$, $\mu_3 = 3\mu$ and $\mu_4 = 3\mu$.
   b) use LBE's to derive $\pi_i, i = 1, \ldots, 4$
   c) by PASTA probability that arriving customer enters service without waiting is $\pi_0 + \pi_1 + \pi_2 = 18/49$

   Grading: a) 1p, b) 3p, c) 2p (must mention PASTA property!). Partial points were given for partially correct solutions. Even if your BD-process was wrong but you solved the steady state distribution correctly for the wrong model, I gave some points, max 2p.

5. a) $\phi(\mathbf{x}) = 1 - (1 - x_3(1 - (1 - x_1)(1 - x_2)))(1 - x_4)$
   b) $A_1 = A_2 = 2/3, A_3 = 1, A_4 = 1/2$ and availability of the system (justify independence!) $A_s = 1 - (1 - A_1)(1 - A_2)(1 - A_4) = 17/18$

   Grading: a) 3p (partial points given if your solution was even close with explanation), b) availability of the components 1p and availability of the system 2p (must include justification through independence when taking expectation of products, minor miscalculations in obtaining the system availability were ignored).