

## 3. Exercise

Out Discussion  
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Contact by questions  
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### Problem 1: Manual Simulation

A taxi company operates one vehicle during 09:00 to 17:00 o'clock. Currently, consideration is being given to the addition of a second vehicle to the fleet. The demand for taxis follows the distribution shown:

Time between calls [Minute]	15	20	25	30	35
Probability	0.14	0.22	0.43	0.17	0.04

The distribution of time to complete a service is as follows:

Service time [Minute]	5	15	25	35	45
Probability	0.12	0.35	0.43	0.06	0.04

Simulate five individual days of operation of the current system and of the system with an additional taxicab. Compare the two systems with respect to the waiting times of the customer and any other measures that might shed light on the situation.

### Problem 2: Simulation in Java

On the Website of the course you will find the Java source code for the discussed grocery simulation with one server. The simulation is designed to run for 1000 customers. Download the source code and work out the following tasks:

- Run the simulation for  $\mu = 4.5$  and  $\lambda = 3.2$ .
- Modify the source code so that you can run independent experiments for  $\rho = 0.1, \dots, 0.9$  where  $\rho = \lambda/\mu$  is the load of the system. Display the resulting performance metrics in a graph.
- Develop and interpret flow diagrams for a queueing system with  $k$  servers, see slide 6 of Chapter 2 for the flow diagrams for a queueing system with 1 server.
- Modify the source code so that a queueing system with  $k$  servers can be simulated.
- Run independent experiments for  $\rho = 0.1, \dots, 0.9$  and  $k = 2, 5, 10, 20$  servers. Display the resulting performance metrics in a graph.

### Problem 3: OMNeT++

We have discussed OMNeT++ as a modern object oriented simulation framework designed for network simulation.

- a) Download the current release of OMNeT++ from the project homepage (<http://www.omnetpp.org/>). Install it on your computer or in the CIP pool and get familiar to it by reading the manual.
- b) Go to the web page: <http://www.omnetpp.org/doc/omnetpp41/tictoc-tutorial/.part1.html> presents a very first network simulation. Follow the steps given there and run your first simulation experiment.

## Problem 4: Simulation models, reading

Download the paper »On the modeling and analysis of computer networks« by Leonard Kleinrock from the website of the class.

Discuss the paper and the findings of the author. What is his main point?