

## Queueing Analysis and Simulation (E011322)

**Course size** (nominal values; actual values may depend on programme)

**Credits 6.0**                      **Study time 180 h**                      **Contact hrs**                      60.0 h

**Course offerings and teaching methods in academic year 2017-2018**

A (semester 1)	project	1.25 h
	seminar: coached exercises	22.5 h
	lecture	30.0 h
B (semester 1)	self-reliant study activities	0.0 h
	project	1.25 h

**Lecturers in academic year 2017-2018**

Fiems, Dieter	TW07	lecturer-in-charge
Walraevens, Joris	TW07	co-lecturer

**Offered in the following programmes in 2017-2018**

	crdts	offering
Bridging Programme Master of Science in Electrical Engineering (main subject Communication and Information Technology )	6	A
Bridging Programme Master of Science in Computer Science Engineering	6	B
Bridging Programme Master of Science in Computer Science Engineering	6	A
Master of Science in Electrical Engineering (main subject Communication and Information Technology )	6	A
Master of Science in Electromechanical Engineering (main subject Control Engineering and Automation)	6	A
Master of Science in Electromechanical Engineering (main subject Electrical Power Engineering)	6	A
Master of Science in Electromechanical Engineering (main subject Maritime Engineering)	6	A
Master of Science in Electromechanical Engineering (main subject Mechanical Construction)	6	A
Master of Science in Electromechanical Engineering (main subject Mechanical Energy Engineering)	6	A
Master of Science in Computer Science	6	A
Master of Science in Mathematical Informatics	6	A
Master of Science in Computer Science Engineering	6	B
Master of Science in Computer Science Engineering	6	A
Exchange Programme in Computer Science (master's level)	6	A

**Teaching languages**

Dutch, English

**Keywords**

Queueing systems; Stochastic modelling; Performance evaluation of computer and communication systems; Markov chains; Simulation.

**Position of the course**

This course introduces basic concepts of queueing analysis and simulation for assessing the performance of computer and communication systems. Specifically, the course discusses techniques for dimensioning queues and buffers and for the

estimation of loss probabilities, blocking probabilities and delays in such queues.

## **Contents**

- Introduction: Queues in communication networks and computers; Stochastic modelling; Terminology of queueing systems; Kendall notation.
- Birth-death queueing systems: Poisson arrivals see time averages; Global and detailed balance equations; Erlang's formulas.
- Waiting times: Little's law; Waiting time analysis of first-come-first-served birth-death queueing systems; Laplace-Stieltjes transform approach.
- Quasi-birth-death queueing systems: Phase-type distribution; Markovian arrival process; Numerical solution of quasi-birth-death Markov chains.
- Queues with generally distributed service times: Mean-value analysis; Transform analysis; Calculation/approximation of performance measures from transforms.
- Networks of queueing systems: Reversibility of Markov chains; Burke's theorem; Jackson networks.
- Pseudo random number generators: Generic description and desirable properties of pseudo random number generators; Linear congruential generators; Inversion method; Box-Mueller algorithm; Acceptance-Rejection method.
- Simulation: Monte Carlo simulation; Simulating trajectories of discrete and continuous-time Markov chains; Discrete-event simulation; Confidence intervals; Batch-means method; Comparison of scheduling disciplines for queues.
- Variance reduction techniques: Antithetic method; Reduction by conditioning; Reduction by control variates; Importance sampling.

## **Initial competences**

Basic probability theory and statistics; elements of stochastic processes in general, and Markov chains in particular

## **Final competences**

- 1 To master mathematical solution techniques for queueing problems
- 2 To construct a simulation program and to process simulation results
- 3 To select the most suitable models, methods and techniques for specific queueing problems
- 4 To assess the performance of queueing systems quantitatively and qualitatively

## **Conditions for credit contract**

Access to this course unit via a credit contract is determined after successful competences assessment

## **Conditions for exam contract**

This course unit cannot be taken via an exam contract

## **Teaching methods**

Lecture, project, self-reliant study activities, seminar: coached exercises

## **Learning materials and price**

Course material: English syllabus + slides (via Minerva)

## **References**

- M. Harchol-Balter, Performance Modeling and Design of Computer Systems: Queueing Theory in Action, Cambridge University Press, 2013.
- L. Kleinrock, "Queueing Systems, Volume 1, Theory" (Wiley, New York, 1975)

## **Course content-related study coaching**

### **Evaluation methods**

end-of-term evaluation and continuous assessment

### **Examination methods in case of periodic evaluation during the first examination period**

Written examination with open questions

### **Examination methods in case of periodic evaluation during the second examination period**

Written examination with open questions

### **Examination methods in case of permanent evaluation**

Report

### **Possibilities of retake in case of permanent evaluation**

examination during the second examination period is possible

**Calculation of the examination mark**

Examination: 80%

Project: 20%