Федеральное государственное автономное образовательное учреждение высшего профессионального образования "Национальный исследовательский университет "Высшая школа экономики"

Факультет экономических наук
Департамент прикладной экономики

Рабочая программа дисциплины

Теория массового обслуживания

(на английском языке)

для образовательной программы «Программная инженерия»
направления подготовки 231000.62 «Программная инженерия»
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Руководитель департамента ___________________________

Рекомендована Академическим советом образовательной программы
«___»____________ 2019 г., № протокола_________________

Утверждена «___»____________ 2019 г.
Академический руководитель образовательной программы
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Москва, 2019

Настоящая программа может быть использована другими подразделениями университета и другими вузами без разрешения подразделения-разработчика программы.

1. Course description

1.1. Title of a course

Queueing Theory

1.2. Pre-requisites

- Calculus,
- Probability Theory and Mathematical Statistics,
- Statistical and Empirical Methods of Computing.

1.3. Course type

Elective

1.4. Abstract

This course gives a detailed introduction into queueing theory along with insights into stochastic processes and simulation techniques useful for modeling queueing systems. A queue is a waiting line, and a queueing system is a system which provides service to some jobs (customers, clients) that arrive with time and wait to get served. Examples are:

- a telecommunication system that processes requests for communication;
- a hospital facing randomly occurring demand for hospital beds;
- central processing unit that handles arriving jobs.

Queueing theory is a branch of probability theory dealing with abstract representation of such systems. It helps obtain useful and unobvious answers to questions concerning waiting times for both jobs and servers, like "how much nodes should a server have, so that a customer would not have to wait more than … on average?" or "what is the mean queue length corresponding to a certain capacity utilization level?" Such questions arise, for example, in computer systems performance evaluation.

These problems require knowledge of stochastic processes, therefore the course provides a review of point processes (Poisson, Erlang etc.) and Markov chains in discrete and continuous time, paying special attention to a birth-death process, often used in queueing models. It also includes a detailed insight into simulation, because queueing problems often do not have analytic solution.

The course is aimed at students interested in applied probability, Monte Carlo simulation and computer systems performance evaluation.

2. Learning objectives

The objective of the course is

- to make students familiar with stochastic process theory and its applications,
- to develop mathematical and modeling skills required for evaluating queueing systems performance,
- to give a theoretical background needed to understand academic literature on the subject.

3. Learning outcomes

By the end of the course students are supposed to know:

- the basics of stochastic processes theory,

- characteristics of queueing process,
- common areas of queueing theory application,
- measures of effectiveness for queueing systems,
- common queueing models,
- the basics of random number generation and Monte Carlo simulation;

and to be able to:

- describe the structure of a certain queueing system,
- choose appropriate model for a system,
- find a steady-state solution for basic stochastic processes and queueing models,
- evaluate measures of effectiveness,
- estimate parameters of a queueing process from data,
- simulate stochastic processes and queueing systems,
- read and understand academic literature on stochastic processes, queueing and computer systems performance evaluation.

4. Course outline

№	Topic	Lessons (1 lesson = 45 min)		Self-study
		Lectures	Seminars	
1	Introduction to queueing theory	2	2	6
2	Differential and difference equations	2	2	10
3	Generating functions	2	2	8
4	Modeling arrivals: Poisson stream and other point processes	4	4	12
5	Markov chains	4	4	12
6	Single-channel exponential queueing models	4	4	12
7	Simulating queues	2	2	16
8	Simple Markovian birth-death queueing models	4	4	16
9	Advanced models (Erlangian, priority queues)	4	4	16
10	Statistical inference in queueing	2	2	10
11	Elements of computer systems performance evaluation	2	2	8
	Total	**32**	**32**	**126**

5. Reading list

5.1. Required.

Shortle J.F., Thompson J.M., Gross D., Harris C.M. (2018). Fundamentals of Queueing Theory. 5th edition. Wiley Series in Probability and Statistics.

5.2. Optional.

Cooper R.B. (1981). Introduction to Queueing Theory. 2nd edition. North Holland.
Gnedenko B.V., Kovalenko I.N. (1989). Introduction to Queueing Theory. 2nd edition. Springer.
Khinchin A.Y. (2013). Mathematical Methods in the Theory of Queuing. Dover Books on Mathematics.
Karian Z.A., Dudewicz E.J. (1998). Modern Statistical, Systems, and GPSS Simulation. CRC Press.

6. Assessment

Type	Form	3rd year				Dept	Remarks
		1	2	3	4		
Current	Test	*					Written test, 75 min
	Homework		*				Report on a simulation model for a queueing system (developed by a student)
Final	Exam		*				Written exam, 120 min

Written test in the end of the 1st module is aimed at assessing students' knowledge of point processes, Markov chains and basic concepts of queueing theory.
Home assignment in the 2nd module includes developing a simulation model for a queueing system and conducting Monte Carlo study to evaluate its effectiveness.
Written exam in the of the 2nd module consists of questions and problems covering the topics of the whole course.

7. Grading system and guidelines for knowledge assessment

Cumulative grade $O_{cumulative}$ is calculated as an average grade for the written test in the 1st module O_{test} and the homework $O_{homework}$:

$$O_{cumulative} = 0.5 \cdot O_{test} + 0.5 \cdot O_{homework}.$$

Final grade is calculated according to the following rule:

$$O_{final} = 0.5 \cdot O_{cumulative} + 0.5 \cdot O_{exam},$$

where O_{exam} is the grade for the written exam.
All marks are in ten-point scale.
Rounding procedure: to the nearest integer number.

8. Special equipment and software support

A projector for lectures
Whiteboard
Some practical studies may require computer classes with R or MatLab installed.