Course guide
270633 - SNM - Stochastic Network Modelling

Last modified: 13/07/2022

Unit in charge: Barcelona School of Informatics
Teaching unit: 701 - DAC - Department of Computer Architecture.

Degree: MASTER'S DEGREE IN INNOVATION AND RESEARCH IN INFORMATICS (Syllabus 2012). (Optional subject).

Academic year: 2022 **ECTS Credits:** 6.0 **Languages:** English

LECTURER

Coordinating lecturer: LLORENÇ CERDÀ ALABERN

Others: Primer quadrimestre:
LLORENÇ CERDÀ ALABERN - 10

PRIOR SKILLS

Probability, random variables and distribution (continuous and discrete) algebra: systems of equations, determinant, eigenvalues ☐ and eigenvectors, diagonalization.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CEE2.1. Capability to understand models, problems and algorithms related to distributed systems, and to design and evaluate algorithms and systems that process the distribution problems and provide distributed services.
CEE2.2. Capability to understand models, problems and algorithms related to computer networks and to design and evaluate algorithms, protocols and systems that process the complexity of computer communications networks.
CEE2.3. Capability to understand models, problems and mathematical tools to analyze, design and evaluate computer networks and distributed systems.

Generical:
CG1. Capability to apply the scientific method to study and analyse of phenomena and systems in any area of Computer Science, and in the conception, design and implementation of innovative and original solutions.
CG3. Capacity for mathematical modeling, calculation and experimental designing in technology and companies engineering centers, particularly in research and innovation in all areas of Computer Science.

Transversal:
CTR6. REASONING: Capacity for critical, logical and mathematical reasoning. Capability to solve problems in their area of study. Capacity for abstraction: the capability to create and use models that reflect real situations. Capability to design and implement simple experiments, and analyze and interpret their results. Capacity for analysis, synthesis and evaluation.

TEACHING METHODOLOGY

There will be 4 hours per week, dedicated to theoretical classes to explain the theory and solve problems. The students' activities will consist of reading material and solving practical problems that will be proposed at each theoretical unit. The problems will be collected and corrected during the course. There will be research oriented problems to be solved using numerical tools as MATLAB.

LEARNING OBJECTIVES OF THE SUBJECT

2.Being able to model a process that evolves over time with a discrete and continuous time Markov chain
3.Being able to compute the steady state and transient solution of a Markov chain
4.Being able to model processes that engage the formation of queues
5.Being able to resolve the basic queues: M/M/1, M/G/1, M/G/1/K

STUDY LOAD

Type	Hours	Percentage
Self study	96,0	64.00
Hours large group	54,0	36.00

Total learning time: 150 h

CONTENTS

Introduction

Description:
Concept of probability space, sequence of random variables and stochastic processes.

Discrete Time Markov Chains (DTMC)

Description:
Definition of a DTMC, Transient Solution, Classification of States, Steady State, Finite Absorbent Chains

Continuous Time Markov Chains (CTMC)

Description:
Definition of a CTMC, Transient Solution, Steady State, Semi-Markov Process and Embedded MC, Finite Absorbent Chains

Queuing Theory

Description:
Kendal Notation, Little Theorem, PASTA Theorem, The M/M/1 Queue, M/G/1 Queue, Reversed Chain, Reversible Queues, Networks of Queues, Chains with Matrix Geometric Solutions

ACTIVITIES

Probability Review

Full-or-part-time: 20h
Theory classes: 4h
Practical classes: 4h
Self study: 12h

Discrete time Markov Chains

Specific objectives:
2, 3, 4

Related competencies :
CG1. Capability to apply the scientific method to study and analyse of phenomena and systems in any area of Computer Science, and in the conception, design and implementation of innovative and original solutions.
CG3. Capacity for mathematical modeling, calculation and experimental designing in technology and companies engineering centers, particularly in research and innovation in all areas of Computer Science.
CEE2.2. Capability to understand models, problems and algorithms related to computer networks and to design and evaluate algorithms, protocols and systems that process the complexity of computer communications networks.
CEE2.1. Capability to understand models, problems and algorithms related to distributed systems, and to design and evaluate algorithms and systems that process the distribution problems and provide distributed services.
CEE2.3. Capability to understand models, problems and mathematical tools to analyze, design and evaluate computer networks and distributed systems.
CTR6. REASONING: Capacity for critical, logical and mathematical reasoning. Capability to solve problems in their area of study. Capacity for abstraction: the capability to create and use models that reflect real situations. Capability to design and implement simple experiments, and analyze and interpret their results. Capacity for analysis, synthesis and evaluation.

Full-or-part-time: 60h
Theory classes: 12h
Practical classes: 12h
Self study: 36h

First assessment

Full-or-part-time: 12h
Guided activities: 2h
Self study: 10h

Continous time Markov chains

Specific objectives:
2, 3, 4

Related competencies :
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CG3. Capacity for mathematical modeling, calculation and experimental designing in technology and companies engineering centers, particularly in research and innovation in all areas of Computer Science.
CEE2.2. Capability to understand models, problems and algorithms related to computer networks and to design and evaluate algorithms, protocols and systems that process the complexity of computer communications networks.
CEE2.1. Capability to understand models, problems and algorithms related to distributed systems, and to design and evaluate algorithms and systems that process the distribution problems and provide distributed services.
CEE2.3. Capability to understand models, problems and mathematical tools to analyze, design and evaluate computer networks and distributed systems.
CTR6. REASONING: Capacity for critical, logical and mathematical reasoning. Capability to solve problems in their area of study. Capacity for abstraction: the capability to create and use models that reflect real situations. Capability to design and implement simple experiments, and analyze and interpret their results. Capacity for analysis, synthesis and evaluation.

Full-or-part-time: 32h
Theory classes: 7h
Practical classes: 4h
Self study: 21h

Second assessment

Full-or-part-time: 12h
Guided activities: 2h
Self study: 10h

Queueing theory

Specific objectives:
2, 3, 4, 5

Related competencies :
CG1. Capability to apply the scientific method to study and analyse of phenomena and systems in any area of Computer Science, and in the conception, design and implementation of innovative and original solutions.
CG3. Capacity for mathematical modeling, calculation and experimental designing in technology and companies engineering centers, particularly in research and innovation in all areas of Computer Science.
CEE2.2. Capability to understand models, problems and algorithms related to computer networks and to design and evaluate algorithms, protocols and systems that process the complexity of computer communications networks.
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CTR6. REASONING: Capacity for critical, logical and mathematical reasoning. Capability to solve problems in their area of study. Capacity for abstraction: the capability to create and use models that reflect real situations. Capability to design and implement simple experiments, and analyze and interpret their results. Capacity for analysis, synthesis and evaluation.

Full-or-part-time: 26h
Theory classes: 5h
Practical classes: 6h
Self study: 15h

Final exam

Specific objectives:
2, 3, 4, 5

Related competencies :
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CEE2.2. Capability to understand models, problems and algorithms related to computer networks and to design and evaluate algorithms, protocols and systems that process the complexity of computer communications networks.
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Full-or-part-time: 17h
Guided activities: 2h
Self study: 15h

GRADING SYSTEM

The theory mark will be calculated from the problems delivered by the student, assessment marks and a final exam mark. The formula for calculating the mark for the course is:

NF = 0.1 * NP + 0.15 * max{EF, C1} + 0.15 * max{EF, C2} + 0.60 * EF

where:
NF = final mark
EF = final theory exam
NP = Problems delivered by the students
C1,C2 = marks of midterm assessments

BIBLIOGRAPHY

Basic:
- Nelson, R. Probability, stochastic processes, and queueing theory: the mathematics of computer performance modelling. Springer, 1995. ISBN 0387944524.
- Kemeny, J.G.; Snell, J.L. Finite markov chains. Springer-Verlag, 1976. ISBN 0387901922.
- Trivedi, K.S. Probability and statistics with reliability, queuing, and computer science applications. 2nd ed. John Wiley & Sons, 2001. ISBN 0471333417.

Complementary:
- Feller, W. An introduction to probability theory and its applications: volume I. 3rd ed. John Wiley and Sons, 1968. ISBN 0471257117.