
Academic Year of Degree: 2025/26

23974 - Network Simulation and Modelling

Teaching Guide Information

Academic Course: 2025/26

Academic Center: 337 - Engineering School

Study: 3379 - Bachelor's degree in Telecommunications Network Engineering

Subject: 23974 - Network Simulation and Modelling

Credits: 5.0

Course: 3

Teaching languages:

Theory: Group 1: English

Practice: Group 101: English

Seminar: Group 101: English

Teachers: Dolors Sala Batlle

Teaching Period: First term

Presentation

This course focuses on the methodology of modeling and simulation with the objective to learn the theory behind the simulations. Simulation studies are widely used by the industry as an evaluation tool of a new system before starting it, so that to reduce risks of a final design. The actual outcome of the evaluation depends on the situation. It may want to evaluate security risks of the final system, or measure investment amounts or risks, or predict performance behavior, all before building the actual system. Hence simulations are a tool to make strategic decisions. Because of this importance, it is crucial to produce valid and accurate data according to the level of importance of the decision to be taken. Custom-made packages for the particular scenarios are common and they provide implemented design of particular systems or models. These packages provide standard modules that reduce the simulation study time for existing systems or models. But interpretation of the resulting results depends on the knowledge and experience of the engineer using the simulation tool. This course focuses on the knowledge required to produce a correct simulation program as this provides the needed theory to interpret the given ones in the packages. The course develops this knowledge to the level to know how to apply it and produce a simulation program from scratch of a particular networking scenario and produce results for taking decisions. The focus of the course is highly practical.

Associated skills | General learning outcomes

The objective of the course is to provide students with the conceptual tools and theoretical understanding to build correct simulation programs and produce valid statistics from them. To do so, it needs programming experience primarily in c, and some knowledge of probability and statistics.

The theoretical concepts addressed are theory of modeling and simulation, design of random number

generators, and application of queuing and statistics theory. These concepts are put in practice with programs provided together with the practice handouts applied to real problems (primarily networking problems), to produce results plots (and optionally the final decisions making document) to take justified decisions with the simulation results.

The competencies to acquire in this course are:

Specific Competencies	
C1	Understand how the time-driven and event-driven simulation work and know how to use them
C2	Know how to model the source of the simulation and how to model users of a network
C3	Understand what is a random number generator, how are they implemented and how to use them appropriately
C4	Understand the randomness involved in the network modeling and know how to model it in a simulation
C5	Know the necessary processes involved in the simulation of telecommunication systems
C6	Know how to design simulation programs in c (high level language)
C7	Know the metrics involved in the performance study of protocols and networks and know how to apply them
C8	Know how to analyze the precision and accuracy of the produced outcome of a simulation in order to produce statistically correct results

General Competencies	
Instrumentals	
C9	Abstraction Capacity
C10	Capacity of analysis and synthesis
Interpersonal	
C11	Capacity to work in a team
Systematic	
C12	Initiative

Learning outcomes | Specific learning outcomes

The learning process is materialized with the analysis and understanding a set of simulation programs. This set of programs becomes a tools package needed for the construction of systems and networks simulations. The students learns what a network simulation is and what theory it includes (which is a lot) to obtain statistically relevant results. An important part of the course is to learn the randomness concept and learn to control it to obtain valid results.

Contents

This course has 10 chapters grouped in 2 content blocks:

Block 1. Principles of system simulation and input modeling

- Chapter 1 (C1): Theory of Modeling and Simulation
- Chapter 2 (C2): Basics of Probability and Measures
- Chapter 3 (C3): Random number generators
- Chapter 4 (C4): Input modeling (Arrival Process)

Block 2. Output and Correctness

- Chapter 5 (C5): Queuing Models
- Chapter 6 (C6): Output analysis
- Chapter 7 (C7): Validation and verification of Results
- Chapter 8 (C8): Presentation of Results
- Chapter 9 (C9): Simulation packages
- Chapter 10 (C10): Examples of Technical Documents: A case study applied to a networking problem

The first block includes the methodology to build models and simulations including the modeling of the

randomness and the simulation input. This includes the concepts of time-driven and event-driven simulations, the analysis of random number generators, and the implementation of distribution functions to create packet generators.

The second block covers the output analysis of the simulation understanding the metrics needed how to implement and measure them and how to verify the implementation and validate the model results based on real observation or theoretical results. It also includes all necessary tools to present the data for the correct interpretation of the results, the knowledge of simulation packages and a final case study that puts all learning in practice producing the data needed to create a final decision paper of a particular scenario (the final document is optional).

The following knowledge is accomplished with this content:

Concepts		
Time-driven and event-driven simulation	Phases of a simulation (warm-up, transient and steady state)	Assumptions document
Queuing models MM1, MD1, MMC	Little's law	Law of large numbers
Random number generator and seed	Traces	Simulation workload types
Performance Metrics of a system, measures and samples	Histograms and result plots	Confidence interval
Validity and verification	Sensitivity analysis	

Processes
Event management in an event-driven simulation
Time management in a time-driven simulation
Generation of random number sequences following a particular distribution
Approximation of queuing theory results to network dimensioning concepts by simulation
Packet generators following a distribution function
Simulation termination process
Results validation by comparison
Trace generation for the validation and study of the simulation
Plot generation to represent and interpret simulation results

Attitudes
Capacity to identify and observe details (at different levels)
Interest for the precision and patience to accomplish it
Decision to learn a program that implements theoretical concepts

Evaluation and grading system

The course is based on continuous work and evaluation during the quarter. The participation in the interactive session demonstrate the knowledge of the course subjects and allow relaxing the written exams pressure. The evaluation objective is to guarantee a sufficient knowledge in each of the practices. This minimum is proven **passing the practice tests (individually) for each and every practice and it guarantees a pass of the course if ALL are passed.** Each practice test guarantees a 5 in this part of knowledge. But you still have to take written exams to decide the final grade for the subject (grades can only increase). **The practice tests are compulsory continuous evaluation**, and they are a requirement to have access to the written exams either mid-term, final or recovery in July.

The mid-term exam (part 1) evaluates the practice and theoretical content of part 1. If you get a 4,5 grade or higher in the exam, this grade can be used to average with the rest of grades. If the grade is lower than 4,5 you have to retake all part 1 exam in July. Likewise, the final exam (part 2) evaluates the practices and knowledge of part 2. And a pass is a grade of 5 but with 4,5 or higher it averages with the rest of grades. If overall grades do not reach 5, the 4,5 grades need to be recovered in July. Part 1 (mid-term) counts 60% of the grade while part2 (final) counts the remaining 40% of the total subject grade.

Evaluation of each practice		
Practice Evaluation	Evaluation	Comments
Pre-submission (optional, individual)	5 % extra ⁽¹⁾	Submission must be done seriously. It gets an extra grade proportional to the work done.
Submission (optional, in teams ⁽⁵⁾)	10% extra ⁽¹⁾	
Oral presentation (optional, in teams ⁽⁵⁾)	5 % extra ⁽¹⁾	The group decides the format to lead the session. The opinion of the rest of students is taken into account to grant the partial or full extra grade.
Practice tests for each practice (compulsory, individual)	Competent / No Competent	Computer tests
Exams (midterm, final) (individual, compulsory)	Numeric grade [1..10]	The exam evaluates theoretical and practice knowledge of all course material

Course Evaluation
- Part 1 – Mid-term: 60% of the subject grade. A 4,5 is required to average with Part 2⁽²⁾⁽³⁾ - Written exam (mid-term)⁽¹⁾: part 1⁽⁴⁾ - Part 2 – Final: 40% of the subject grade. A 4,5 is required to average with Part 1⁽²⁾⁽³⁾ - Written exam (final)⁽¹⁾: only part 2⁽⁴⁾ - Practices: (non-compulsory) submissions give extra grade (up to 15%)⁽¹⁾ - Practices tests: The practice tests are compulsory, and a competent in each of them guarantees a 5 in the part of the content of the practice in the written exam⁽⁴⁾

⁽¹⁾ This extra grade is applied only when the evaluation of the part is passed (either through practice tests or written exam but it counts only in December (but not in July).

⁽²⁾ The grades below 5 have to be retaken in July if the average grade does not pass the course in December.

⁽³⁾ The mid-term exam can be recovered in July. The final exam evaluates part 2 of the course (it does not include the mid-term content of Part 1).

⁽⁴⁾ The competent practice tests do not apply for the July exam, although participation in the practice tests are a requirement to be able to attend the July exam.

⁽⁵⁾ The practice submission teams and oral presentation teams may be different if the students want as some students may not want to do both. But students who present have to submit, and they can only present the parts of the submission they have actively participated in doing them.

The practice submissions must be done in the aula global by the time required to follow the course, and to get the extra grade, as solutions are provided later. The **late submissions (after solutions are published) will not count for extra grade**. The practice submissions are not evaluated and only counts the effort to do them. It is your responsibility to review the solutions and understand them and ask for your doubts to correctly consolidate the correct knowledge.

Recovering: July recovery is allowed as long as you have participated in the practices tests during the quarter. Part 1 and Part2 can be recovered separately in July. Only the part with grade less than 5 will need to be recovered in July. Grades below 5 must be retaken. The computation of the final grade in July follows the same rules as in December with the exceptions: 1) The exam grade in July **must be 5 or more to pass** (to average with the rest of grades); 2) The extra grades do not apply in July, and 3) in July the **maximum course grade is limited to 6.5 in July**.

The following table shows the evaluation possibilities of the different evaluation parts of the course:

	During the quarter	December Exam	July
Extra practice grades	SI	SI	NO (1)

Competent practice tests	SI	SI (2)	NO (2)
Part 1 exam	SI	NO	SI (3)
Part 2 exam	NO	SI	SI (3)

(1) Extra practice grades do not apply in July.

(2) Competency in a practice guarantees a 5 in the corresponding question in the December written exam, but not in the July exam. To attend the July exam you must have attended the practice tests during the quarter.

(3) In July the complete exam must be taken either for part 1 or part 2 or both if the grade did not reach 5 in December.

IMPORTANT: If copy or plagiarism is detected in any assignment or evaluation activity, the submission is not accepted. And this is equivalent to a Non-Submitted of a compulsory submission, and hence this **represents a fail of the course**. In addition, **the academic integrity commission is notified so that they apply the disciplinary protocol**. Therefore, **make sure that all work and text submitted are created by the authors** signing the submission and in your own words, and cite appropriately any resource information you use to do the task. **If you have any doubt of what it may be possible to use and how, ask the faculty before doing the task.**