Universitat Autònoma de Barcelona

2022/2023

Telecommunications Networks

Code: 102699
ECTS Credits: 6

Degree	Type	Year	Semester
2500898 Telecommunication Systems Engineering	OB	3	2

Contact

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Use of Languages

Principal working language: english (eng)
Some groups entirely in English: Yes
Some groups entirely in Catalan: No
Some groups entirely in Spanish: No

Prerequisites

To follow the course with guarantees, the students must have taken and passed the following courses:

- Statistics
- Foundations of Networks

Objectives and Contextualisation

The aim of the course is to understand the technological evolution and the architecture of telecommunication networks, as well as the problems that arise and the solutions that exist in the process of designing and exploiting them. Therefore, once the course is over, students must be able to:

- Know the taxonomy, technological evolution and architecture of telecommunication networks
- Know the mathematical tools that allow to model the operation of a system and how to apply them to the dimensioning of a telecommunication network
- Describe the requirements of a telecommunication network regarding the quality of service and know the techniques used to implement it
- Describe the problem of network congestion and know the operating principles of the mechanisms that exist to solve it
- Describe the need of network interconnection and know the operation of the protocols that are used on the Internet
- Describe the concept of network control and management, and know the operation of the protocols that are used on the Internet

Competences

- Apply the necessary legislation in the exercise of the telecommunications engineer's profession and use the compulsory specifications, regulations and standards.
- Communication
- Design and dimension multiuser communication systems using the principles of communication theory under the restrictions imposed by the specifications and the need to provide a quality service.
- Develop ethics and professionalism.
- Develop personal attitude.

- Develop personal work habits.
- Develop thinking habits.
- Direct the activities object of the projects in the field of telecommunication.
- Draft, develop and sign projects in the field of telecommunications engineering that, depending on the speciality, are aimed at the conception, development or exploitation of telecommunication and electronic networks, services and applications.
- Learn new methods and technologies, building on basic technological knowledge, to be able to adapt to new situations.
- Perform measurements, calculations, estimations, valuations, analyses, studies, reports, task-scheduling and other similar work in the field of telecommunication systems.
- Resolve problems with initiative and creativity. Make decisions. Communicate and transmit knowledge, skills and abilities, in awareness of the ethical and professional responsibilities involved in a telecommunications engineer's work.
- Work in a team.

Learning Outcomes

1. Adapt to multidisciplinary environments.
2. Apply the techniques in networks, services, processes and telecom applications in both fixed and mobile environments, personal, local or long distance with different band widths, including telephony, radio, television and data are based from the point of view transmission systems.
3. Assume and respect the role of the different members of a team, as well as the different levels of dependency in the team.
4. Carry out management activities for the design and dimensioning of telecommunications networks considering classical and new generation methods.
5. Communicate efficiently, orally and in writing, knowledge, results and skills, both professionally and to non-expert audiences.
6. Construct, operate and manage networks, services, processes and telecom applications, understood these as systems of recruitment, transportation, representation, processing, storage, management and presentation of multimedia information, from the point of view of the transmission systems.
7. Critically evaluate the work done.
8. Develop critical thinking and reasoning.
9. Develop curiosity and creativity.
10. Develop independent learning strategies.
11. Develop scientific thinking.
12. Develop the capacity for analysis and synthesis.
13. Differentiate and classify the main algorithms dimensioning, traffic control and congestion.
14. Differentiate and understand the significance of measurements and assessments of telecommunications networks to Formenta and ensure their optimal design.
15. Discuss and apply cryptography systems aimed at improving the safety of a telecommunication network.
16. Distinguish the different nature of the problems of dimensioning and routing for each of the different types of networks and make decisions and initiatives to improve the operation and provision of telecommunications networks.
17. Efficiently use ICT for the communication and transmission of ideas and results.
18. Evaluate the advantages and disadvantages of different conceptual and technological options for different telecommunication applications.
19. Manage available time and resources.
20. Manage networks, services, processes and telecom applications according to the laws and regulations both domestically and internationally.
21. Respect diversity in ideas, people and situations.
22. Use communication and computer applications (office automation, databases, advanced calculation, project management, display, etc.) to support the development and exploitation of telecommunication and electronic networks, services and applications.
23. Work autonomously.
24. Work cooperatively.

Content

PART I

I.1. Introduction to telecommunication networks

- Taxonomy of telecommunication networks: telephony, radio and television broadcasting, and data
- Evolution of telecommunication networks: from analog to digital, from circuit switching to packet switching
- Architecture of telecommunication networks: layers model and operational planes
- Telecommunication network design problems: network dimensioning, quality of service, congestion control, network interconnection, network control and management

I.2. Systems modelling using queuing theory

- General concepts: traffic, servers, queues and service discipline
- Traffic characterization: exponential distribution, Poisson processes and Markov chains (discrete and continuous)
- Kendall's notation and basic parameters: number of servers, queue size, queue discipline, inter-arrival rate and time, rate and service time, response and wait time, average server and queue occupancy, lock/wait/loss probability
- Little's law: performance, use and stability conditions

I.3. Dimensioning of telecommunication networks

- Introduction and requirements of network sizing: degree of service
- Dimensioning of a packet switching node: M/M/1 and M/M/m models
- Dimensioning of a fixed telephony network: M/M/c/c/c (Erlang B, losses) model
- Dimensioning of a cellular telephony network: M/M/c/inf (Erlang C, delays) model

PART II

II.1. Network interconnection on the Internet

- Principles of Internet network interconnection
- Routing algorithms: Dijkstra and Bellman-Ford
- Interior routing: distance vector (RIP) and link-state protocols (OSPF)
- Exterior routing: autonomous systems, routing policies and path vector protocols (BGP)

II.2. Quality of service and congestion control on the Internet

- Quality of Service: concept, requirements, integratedservices (IntServ) and differentiated services (DiffServ)
- Traffic admission and shaping: policing (Token Bucket) and shaping (Leaky Bucket)
- Network nodes queue management: tail drop, random early detection
- Extreme shipping management: flow and congestion control in TCP

II.3. Network control and management on the Internet

- Notion and infrastructure for network control and management
- Internet Network Control Protocols: ICMP
- Protocols for internet network management: SNMP
- New directions in network control and management: SDN

LABORATORY

- Session 1: Interconnection of networks on the Internet I (OSPF)
- Session 2: Interconnection of networks on the Internet II (BGP)
- Session 3: Quality of Service and congestion control on the Internet
- Session 4: Network Management Protocols (SNMP)

Methodology

Directed activities:

- Theory classes: delivery of theoretical contents
- Practical classes: solving questions and problems related to theory classes
- Laboratory classes: development of a challenge related to a course topic using hardware or simulators

Autonomous activities:

- Individual study of the subject: preparation of block diagrams, summaries and answering to questionnaires
- Problem solving: complement to the individual study and work prior to the practical classes

Supervised activities:

- Individual or group tutoring: aimed at resolving questions, advising on the development of the course, or attending to other specific issues

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Classes magistrals	30	1.2	11, 12
Classes pràctiques	10	0.4	11, 12, 8
Pràctiques de laboratori	15	0.6	5, 11, 12, 9, 8, 23
Resolució de problemes	12	0.48	1, 3, 7, 5, 12, 9, 19, 24
Type: Supervised			
Tutories	5	0.2	7, 11, 10, 12, 9, 8, 17, 19, 23
Type: Autonomous			
Estudi	55	2.2	12, 8, 19

Assessment

The evaluation of the subject is based on the following activities:

- Exams. There will be two partial exams during the course and a final exam on the official date of the course. The two partial exams will evaluate the PART I and PART II of the course respectively, while the final exam allows recovering the grades of the two partial exams independently. In case of going to both the partial and final exam of each of the course parts, the best grade obtained in each of the exams of each part will be used to calculate the average.
- Laboratory. The final grade of this part will be calculated as the average of the grades obtained in each of the laboratory activities. At the end of the course, there will be an individual exam to validate the

laboratory activities. In case of not submitting all the laboratory activities or not passing the individual laboratory validation test (grade obtained higher than 5 out of 10), the average will not be calculated, and the grade of this part will be zero (0).
- Activities. The final grade for this part will be calculated as the average of the grade obtained in each of the activities. No minimum grade is required for this part, but a minimum of 80% of activities must be submitted to calculate the average. Failure to submit the minimum number of required activities will result in the average not being calculated, and the grade for this part will be zero (0).

The final course grade is calculated considering the grades obtained in the exams (EX), the laboratory activities (LA) and the activities (ACT), as indicated below:

- If the average grade of the exams is equal to or higher than 4 (EX >= 4) the final course grade (FCG) is calculated as: FCG = 0.6*EX + 0.2*LA + 0.2*ACT
- If the average grade of the exams is less than 4 (EX < 4) the final course grade (FCG) is calculated as: FCG = min (0.6*EX + 0.2*LA + 0.2*ACT, 4.0)

Late delivery policy

- Delivery of activities outside theestablished deadlines will not be accepted unless it is requested in advance and with due justification (e.g., medical, labor, etc.). In the case of late deliveries without due justification, a penalty of 0.5 points per day of delay in the delivery of the activity will be applied to the grade obtained.

Copy and plagiarism policy

- Without prejudice to other disciplinary measures deemed appropriate, and in accordance with current academic regulations, irregularities committed by the student that may lead to a variation in the grade will be graded with a zero (0). Therefore, copying or allowing to copy in any evaluation activity, including laboratories or weekly quizzes, will lead to a zero (0) grade. Assessment activities qualified in this way and by this procedure will not be recoverable and, therefore, the course will be suspended directly without the opportunity to recover it in the same academic year.

Not assessable policy

- The grade of "Not assessable" can only be obtained if the student does not do not take any of the written evaluation activities, i.e., partial and final exam, but without taking into consideration laboratories or activities.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Activities	20%	15	0.6	2, 18, 5, 6, 11, 10, 12, 8, 13, 14, 15, 16, 19, 20, 23, 22
Exams	60%	6	0.24	2, 5, 6, 11, 10, 12, 8, 13, 14, 15, 16, 19, 20, 23
Laboratory	20%	2	0.08	1, 2, 3, 7, 18, 5, 6, 11, 12, 9, 8, 13, 14, 15, 16, 4, 17, 19, 20, 21, 24, 22

Bibliography

- M. Harchol-Balter. Performance Modeling and Design of Computer Systems: Queueing Theory in Action. Cambridge University Press. 2013.
- A. Tanenbaum, D. Wetherall. Computer Networks. Prentice Hall. 2011.
- W. Stallings. Data and Computers Communications. Pearson Education. 2014.
- Peterson & Davie. Computer Networks: A Systems Approach. Prentice Hall. 2014.
- Kurose & Ross: Computer Networking: A Top-Down Approach. Prentice Hall. 2014.

Software

The Python programming language and the eve-ng network emulator will be used to develop the course laboratories.