Telecommunications Networks

Code: 102699
ECTS Credits: 6

2024/2025

Degree	Type	Year
2500898 Telecommunication Systems Engineering	OB	3

Contact

Name: Gonzalo Seco Granados

Email: gonzalo.seco@uab.cat

Teachers

(External) Josep Xavier Salvat

(External) Pere Camps

Teaching groups languages

You can view this information at the end of this document.

Prerequisites

To follow the "Telecommunication Networks" 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 telecommunications networks: telephony, broadcasting, television and data
- Evolution of telecommunications networks: from analog to digital, from circuit switching to packet switching
- Architecture of telecommunication networks: layer model and network operational plans
- Telecommunication network design issues: network architecture and technology, network interconnection, quality of service, network management, and network modeling and sizing

I.2. Local area networks

- Architecture and operation of Ethernet (IEEE 802.3) and Wi-Fi (IEEE 802.11) technology
- Protection against loops (Spanning tree, 802.1d)
- Link Aggregation (LAG/LACP, 802.3ad)
- Virtual networks (VLAN, 802.1q)

I.3 Access and transport networks

- Architecture and operation of access and transport networks
- Access networks (digital): DSL (Digital Subscriber Line), HFC (Hybrid Fiber-Coaxial) and PON (PAssive Optical Network)
- Transport networks (circuit): PDH (Plesiochronous Data Hierarchy) and SDH (Synchronous Data Hierarchy)
- Transport networks (packet): ATM (Asynchronous Transfer Mode) and MPLS (Multi-Protocol Label Switching)

I.4. Interconnection of networks on the Internet

- Principles of interconnection of networks on the Internet
- Routing algorithms: Dijkstra and Bellman-Ford
- Interior routing: distance vector (RIP, Routing Information Protocol) and link state (OSPF, Open Shortest Path First) protocols
- Exterior routing: Autonomous Systems and routing policies, Path Vector Protocols (BGP, Border Gateway Protocol)

I.5. Internet service quality

- Internet service quality principles
- Integrated services (IntServ) and differentiated services (DiffServ) models
- Traffic admission and shaping: policing (Token Bucket) andshaping (Leaky Bucket)
- Management of queues at network nodes: tail drop, random early detection
- End-to-end delivery management: Flow and congestion control in TCP (Transmission Control Protocol)

I.6. Internet network management

- Principles of network management on the Internet
- Network control protocols on the Internet: ICMP (Internet Control Message Protocol)
- Protocols for network management on the Internet: SNMP (Simple Network Management Protocol)

PART II

II.1. Modeling systems using queuing theory

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

II.2. Dimensioning of telecommunication networks

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

LABORATORIES

- Session 1: Local Area Networks (Ethernet: VLAN + LAG)
- Session 2: Internet Network Interconnection I (OSPF)
- Session 3: Internet Network Interconnection II (BGP)
- Session 4: Access and transport networks (GPON + VXLAN)

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Pràctiques de laboratori	12	0.48	2, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 20, 22, 23
Theory lectures	26	1.04	2, 4, 6, 8, 11, 12, 13, 14, 15, 16, 18, 20, 22
Type: Supervised			
Resolució de problemes	12	0.48	1, 2, 3, 4, 5, 6, 7, 8, 9, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24
Tutories	2	0.08	1, 5, 7, 8, 9, 10, 11, 12, 19, 21, 23

Type: Autonomous			
Individual work of the student: practices preparation	18	0.72	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24
Individual work of the student: study and exercices resolution	70	2.8	2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 23

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.

Assessment

Continous Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Exams	70%	6	0.24	2, 5, 6, 8, 10, 11, 12, 13, 14, 15, 16, 19, 20, 23
Laboratory	30%	4	0.16	1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24

The subject is assessed based on the following activities:

- Exams: There will be two partial exams during the course and a final exam. The two partial exams will evaluate PART I and PART II of the subject respectively, while the final exam allows you to make up for the any of the two partial exams independently.
- Laboratories: There will be four laboratories, and the grade for this part will be calculated as the average of the grade achieved in each of the laboratories. At the end of each laboratory, there will be an individual validation test. In case of not handing in the report or not passing the individual validation test, the grade for that laboratory will be zero (0).

The final mark of the subject is calculated taking into account the marks obtained in the exams (EX) and the laboratories (PR), as indicated below: NFA = 0.7*EX + 0.3*PR

Late delivery policy

- Delivery of activities outside the established 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.

Copying and plagiarism

- 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

- 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.

Bibliography

PART I

- 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.

PART II

- M. Harchol-Balter. Performance Modeling and Design of Computer Systems: Queueing Theory in Action. Cambridge University Press. 2013.
- J. F. Shortle, J.M. Thompson, D. Gross and C. M. Harris. Fundamentals of Queueing Theory. Wiley. 2018.

Software

Different software compatible with Windows, Linux and Macintosh will be used in the laboratories (i.e., Wireshark).

Language list

Name	Group	Language	Semester	Turn
(PAUL) Classroom practices	331	English	second semester	morning-mixed
(PLAB) Practical laboratories	331	English	second semester	morning-mixed

(PLAB) Practical laboratories	332	English	second semester	morning-mixed
(TE) Theory	330	English	second semester	morning-mixed