Foundations of Networks

Code: 102713
ECTS Credits: 6

2024/2025

Degree	Type	Year
2500895 Electronic Engineering for Telecommunication	OB	3
2500898 Telecommunication Systems Engineering	OB	3

Contact

Name: Ramon Marti Escale

Email: ramon.marti.escale@uab.cat

Teachers

Alejandro Perez Conesa

Vladimir Bellavista Parent

(External) Andreu Urruela Planas

(External) Marcos Rodríguez García

Teaching groups languages

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

Prerequisites

Students must have an adequate level of calculus, statistics, and programming.

Objectives and Contextualisation

- Know the architecture and operation of different telecommunication networks.
- Know the architecture and operation of different telecommunication protocols.
- Know the operation of interconnection mechanisms of telecommunication networks.
- Know the design and operation of distributed telecommunication applications and services.
- Know the operation and how to analyze the performance of transport media and communication techniques for data transmission.
- Know the operation and how to analyze the performance of data link control protocols and medium access techniques.

Competences

Electronic Engineering for Telecommunication

- Analyse and evaluate the social and environmental impact of technical solutions
- Communication
- Develop personal attitude.
- Develop personal work habits.
- Develop thinking habits.
- Draft, develop and sign projects in the field of telecommunications engineering designed to conceive, develop or exploit electronic systems
- Learn new methods and technologies, building on basic technological knowledge, to be able to adapt to new situations.
- Work in a team.

Telecommunication Systems Engineering

- Analyse and evaluate the social and environmental impact of technical solutions.
- Communication
- Develop personal attitude.
- Develop personal work habits.
- Develop thinking habits.
- 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.
- Work in a team.

Learning Outcomes

1. Assess the economic and social impact of telecommunication networks, systems, services and infrastructures in business, institutional or residential settings
2. Autonomously learn adequate new knowledge and techniques for the conception, development or exploitation of telecommunication systems in reference to signal processing subsystems and to basic network aspects.
3. Communicate efficiently, orally and in writing, knowledge, results and skills, both professionally and to non-expert audiences.
4. Conceive, deploy, organise and manage telecommunication networks, systems, services and infrastructures in residential (homes, cities and digital communities), business or institutional contexts and be responsible for starting them up and making on-going improvements.
5. Conceive, deploy, organise and manage telecommunication networks, systems, services and infrastructures in residential (homes, city and digital communities), business or institutional contexts taking responsibility for setup and continuous improvement
6. Describe and apply the concepts of communications network architectures, protocols and interfaces.
7. Describe and apply the concepts of network architecture, protocols and communication interfaces.
8. Describe networking and routing methods, as well as the basics of network planning and dimensioning based on traffic parameters.
9. Describe the methods for interconnecting and routing networks, as well as the basics of the planning and dimensioning of networks in accordance with traffic parameters.
10. Develop curiosity and creativity.
11. Develop independent learning strategies.
12. Develop systemic thinking.
13. Develop the capacity for analysis and synthesis.
14. Differentiate the concepts of access and transport networks, circuit switching and packaging networks, fixed and mobile networks, as well as the systems and applications of distributed networks, and voice, data, audio, video, interactive and multimedia services.
15. Differentiate the concepts of access and transport networks, circuit-switched and packaged networks, fixed and mobile networks, distributed network voice, data, audio, video applications and systems and interactive multimedia services.

16. Efficiently use ICT for the communication and transmission of ideas and results.
17. Evaluate the economic and social impact of telecommunication networks, systems, services and infrastructures in residential, business or institutional contexts.
18. Independently learn new skills and techniques suitable for the conception, development or operation of telecommunications systems in relation to the signal processing subsystems and network basics.
19. Make one's own decisions.
20. 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.
21. Work autonomously.
22. Work cooperatively.

Content

The course is divided into 2 parts. The first presents the architecture and protocols of the telecommunication networks, while the second focuses on the telecommunication network technologies.

0. Introduction

- Introduction

Part I. Telecommunication networks architecture and protocols

I.1 Network architecture, layers, protocols, and communication interfaces

I.1.1 Layer architecture
I.1.2 OSI model
I.1.3 TCP/IP model
I.1.4 Network interconnection
Repeater, Hub, Bridge, Switch, Router, Gateway

I.2 Classification of networks

I.2.1 Network topologies
Communication modes: unicast, broadcast, multicast, anycast.
Type of connections: point-to-point, point-multipoint, multipoint-multipoint.
Problems of fully connected networks.
Typical topologies: line, bus, tree, ring, star, mesh.
I.2.2 Access and backbone networks
I.2.3 According to technology: Threads, Wireless, Mobile
I.2.4 According to scope: WAN, MAN, LAN, PAN[, VPN]
I.2.5 According to type of switching: Circuits, Messages, Packets (Datagram mode, Virtual Circuit mode)

I.3 Application layer: Distributed applications and services

I.3.1 Client / server architecture
I.3.2 Distributed communication models: RPC, RMI, packets/datagrams, flows, messages, Web servers, new paradigms
I.3.3 Programming of distributed applications
Sockets
Servers
Customers
Concurrent servers

I.4 Transport and Network layers: TCP/IP protocols

I.4.1 Introduction

I.4.2 UDP
I.4.3 TCP
I.4.4 IP

I.5 Network layer: Creation of networks and subnets
I.6 Network layer: Basic routing

I.6.1 Introduction
I.6.2 Direct/indirect delivery
I.6.3 ARP

I.7 Link and Physical layers: Network technologies

I.7.1 Introduction
I.7.2 Ethernet Physical layer
I.7.3 Cable: ADSL and Optical fiber

I.8 Internet services

I.8.1 DHCP
I.8.2 DNS
I.8.3 NAT

Part II. Telecommunication network technologies

II.1 Overview of telecommunications networks

II.1.1 Functional organization of a telecommunication network: data, control and management planes
II.1.2 Logical organization of a telecommunication network: access, transport and core network
II.1.3 Mechanisms for the implementation of the data plan: circuit and packet switching
II.1.4 Application requirements: speed, delay, jitter and packet loss

II.2 Data transmission media and techniques

II.2.1 Transmission media: guided and wireless
II.2.2 Modulation techniques: amplitude, frequency, and phase
II.2.3 Channel characteristics: attenuation, distortion and noise
II.2.4 Channel capacity measurements: Nyquist and Shannon's theorems
II.2.5 Coverage analysis: propagation models and power budget

II.3 Data link control mechanisms

II.3.1 Topology: point to point, point to multipoint
II.3.2 Line configuration: half-duplex, full-duplex
II.3.3 Synchronization: asynchronous, synchronous
II.3.4 Framing: character, bit
II.3.5 Error detection and correction: parity and cyclic redundancy
II.3.6 Flow control: stop and wait, slidingwindow and ARQ

II.4 Physical medium sharing

II.4.1 Multiplexing: time, frequency, space, and code
II.4.2 Deterministic multiple access: TDMA, FDMA, SDMA and CDMA
II.4.3 Random multiple access: ALOHA, Slotted ALOHA and CSMA

II.5 Evolution of telecommunication networks

II.5.1 Access Network: POTS, xDSL, xDSL, xPON
II.5.2 Core Network: SDH, PDH, X.25, Frame Relay, ATM/SONET
II.5.3 Local and Personal Area Networks: Ethernet, Wi-Fi, Bluetooth
II.5.4 Cellular Networks: 1G, 2G, 3G, 4G

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Laboratory sessions	12	0.48	2, 3, 7, 8, 10, 12, 13, 15, 16, 18, 20, 22
Problems classes	10	0.4	3, 7, 8, 15
Theory classes	26	1.04	1, 2, 4, 5, 6, 7, 8, 9, 14, 15, 17, 18, 20
Type: Supervised			
Tutored jobs and portfolio queries	8	0.32	3, 7, 8, 15, 16
Type: Autonomous			
Laboratory preparation and autonomous work	26	1.04	3, 7, 8, 15, 21, 22
Preparation of the virtual portfolio of the course	30	1.2	1, 2, 3, 4, 5, 6, 7, 8, 9, 14, 15, 16, 17, 18, 21, 22
Study and preparation of the evaluation tests	28	1.12	2, 7, 8, 15, 18, 21

During the course, we will carry out the following activities:

- Theory sessions, where the teacher will provide information on the knowledge of the subject and on strategies to acquire, expand and organise this knowledge. The active participation of the students will be encouraged during these sessions, for example posing discussions in those points that admit diverse technological solutions.
- Problems sessions, where the students will have to actively take part to consolidate the knowledge acquired by solving, presenting and debating related problems. Problems are distinguished from the exercises, which can be considered as trivial problems. Problems will often admit several solutions and may cause debate among the students.
- Laboratory practical sessions, where small projects will be proposed to be analysed and developed by the students in a group. The sessions will be previously prepared, documented and programmed by the teacher, and the students will have to prepare them before attending, reviewing the related theoretical knowledge and the basic technical aspects of the development. The laboratory sessions should serve students to achieve the skills of the subject and contribute to achieve some skills such as autonomous work.
- Preparation of the Portfolio of the subject, in a virtual way. Students will have to work autonomously in teams in the research and the preparation of the corresponding material of the evidences of his theory and problems learning, and in the study of this material. The evidences include extensions of the different topics exposed to the sessions of theory and collaborative problem solving. The teacher will monitor the work of the different teams, provide feedback to the teams depending on the task done and the doubtsthey raise or the errors they manifest. The preparation of the Portfolio should serve students to help achieve the competencies of the subject. The teaching methodology and assessment are closely linked to the Virtual portfolio system, which is the cohesive element of the different teaching activities during the course, and which allows a system of continuous and formative assessment, incorporated into the teaching/learning process. The Portfolio will help the students to develop a constant work that will take them to reach the proposed knowledge, and the skills and competences associated with the theory and problems parts.

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
Assessment of the development of the virtual portfolio	30% The minimum grade required for this part is 5 out of 10	1	0.04	1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 14, 15, 16, 17, 18, 21, 22
Class activities	15% No minimum grade is required for this part	2	0.08	1, 3, 6, 7, 8, 9, 12, 13, 14, 15, 17, 19, 22
Follow-up of the practical sessions	25% The minimum grade required for this part is 5 out of 10	3	0.12	2, 3, 7, 8, 10, 12, 13, 15, 16, 18, 20, 22
Knowledge validation tests	30% The minimum grade required for this part is 5 out of 10	4	0.16	2, 3, 4, 5, 6, 7, 8, 9, 14, 15, 18, 20

Scheduled assessment process and activities

The final grade of the subject, which includes assessment on the acquisition of knowledge, skills and competences, will be calculated by weighting:

- In 30% the qualification of the work done in the Portfolio. The minimum grade required for this part is 5 out of 10.
- In 30% the validation qualification of knowledge. The minimum grade required for this part is 5 out of 10. To carry out the validation of knowledge, two partial tests will be done during the course (a partial test to assess part I of the subject and another partial test to assess part II of the subject) and a final exam (which will assess both parts). If the student takes more than a 4 in one of the two parts in the partial tests, it should not be assessed again of this part in the final exam (the note for this part will be that of the partial). The validation note will finally be the average of the marks obtained in the two parts. In order to make the average, the student must have obtained more than 4 in the theoretical exam of each part (either partial or in the corresponding part of the end).
- In 15% the qualification of the work done to the activities in class. No minimum grade is required for this part.
- In 25% the qualification of the laboratory sessions. The minimum grade required for this part is 5 out of 10. In order to make the average, the student must have obtained more than 4 in each one of the practices, and pass their validation tests.

A minimum final grade of 5 is required to pass the course.

When a student does not pass any of the parts that require a minimum mark, the average will be calculated with the marks obtained. If this average is equal to or less than 4.7, the final grade will be this average, whereas if it is greater than 4.7 the final grade will be 4.7 (S).

This course does not consider the single assessment system.

The assessment mechanisms used in the subject are described in more detail below.

Schedule of assessment activities

The dates of continuous assessment and delivery of works will be published the first day of the course on the Virtual Campus and may be subject to possible changes due to adaptation to possible incidents. These changes will always be reported on the Virtual Campus since it is understood that this is the usual platform for the exchange of information between teachers and students.

The following assessment activities are planned:

- Portfolio Part I: weekly
- Portfolio Part II: Practical cases, according to calendar
- Classroom activities: weekly
- Laboratory: 5 sessions during the course, day, and time depending on the group of practices
- Validation test of practices: once the practices are finished
- Theory partial exams of parts Iand II of the subject: around weeks 10 and 15
- Theory final exam

Retaking process

Students may take the retaking process if they have taken a set of activities that represent at least two-thirds of the total grade of the course.

Retaking mechanisms will focus on activities 1) Portfolio, 2) Validation of Knowledge, 3) Laboratory sessions. In the event that a student has not passed any, or all of these parts, before the date of the final exam, this part can be retaken by means of a written test (cases 2 and 3), making a second delivery of the laboratory report (case 3) or finishing the Portfolio before that date (case 1). In case 1, if the student retakes the Portfolio part, a pass, or fail will be obtained. If the student passes, a maximum mark of 5 will be obtained. If the student fails, the mark previously obtained in this part will be obtained.

Review of the exam procedure

For each assessment activity, a place, date, and time of revision will be indicated in which the student will be able to review the activity with the teacher. In this context, claims may be made about the activity mark, which will be assessed by the teacher responsible for the subject. Unless otherwise noted, if the student does not attend this revision, this activity will not be reviewed later.

Special grades

When a student has not done any work in laboratory, has not taken any of the partial or final theory written tests, and has a mark lower than 5 in the Portfolio, it will be considered that there are not enough assessment evidences, and the final mark will be "not assessable." The rest of students who have not passed the course will get a "Suspens" (fail) grade, with the mark obtained in the subject. Those students qualified with "Suspens" due to not having reached the minimum mark in any of the assessment tests, will have the mark got in the assessment exam that has not reached the minimum required (always taking the minimum mark in the case that the minimum in several tests is not obtained).

Honour grade (Matrícula d'Honor, MH): Granting an honour grade qualification is a decision of the faculty responsible for the subject. The regulations of the UAB indicate that MH can only be awarded to students who have obtained a final grade of 9.00 or more. It can be granted up to 5% of MH of the total number of students enrolled.

Student irregularities, copy, and plagiarism

Without prejudice to other disciplinary measures deemed appropriate, and in accordance with current academic regulations, any irregularities committed by the student that could lead to a variation of the grade of an assessment act will be graded with a zero. Therefore, copying or allowing to copy a laboratory work/report or any other assessment activity will involve failing with a zero, and if it is necessary to pass it to pass the course, the whole course will be failed. The assessment activities qualified in this way and by this procedure will not be retaken, and therefore the course will be failed directly without the opportunity to retake it in the same academic year.

Assessment of repeater students

The repeater students will be able to validate the theory part of the subject. The way to calculate the final mark will be the same as mentioned above, taking the mark from the Portfolio, classroom activities and partial exam(s) of the part(s) of the theory to validate.

Repeater students will also be able to validate the practices separately. The way to calculate the final mark will be the same as mentioned above, taking the mark from the practice(s) to validate.

Details about the laboratory sessions

The laboratory sessions consist in the accomplishment of a series of works with which try to reach knowledge and abilities already seen in theory classes or totally new. It is considered equally important to have worked throughout the development of the practice, as well as having understood and learned the knowledge from them.

In the development of the course, four projects will be carried out in the fields of:

- Distributed applications programming (2 weeks * 2 hours)
  - Application programming with Berkeley sockets
  - Case study (concurrent clients and servers)
- Network creation and administration I (1 week * 2 hours)
  - Network design and operation
  - Case study (net/subnet design)
- Network creation and administration II (1 week * 3 h)
  - Implementation and configuration of networks
  - Case study (basic network equipment configuration)
- Network creation and administration III (1 week * 3 h)
  - Network and protocol analysis
  - Case study (capture and analysis of network traffic)

The specific details on the organization of the practices (groups, calendar, weighting, ...) and on their follow-up (reports, attendance requirements, policy on originality of the code, ...) can be downloaded from the Virtual Campus.

Bibliography

Basic bibliography

- W. Stallings (2007). Comunicacions informàtiques i de dades, 8a Edició. Pearson Prentice Hall. Fundació privada Torrens-Ibern, 2010. (http://www.torrens-ibern.cat/?page_id=163)
- W. Stallings (2004). Comunicaciones y redes de computadores, 7a Edición. Pearson Prentice Hall.
- N. Barcia, C. Fernández, S. Frutos, G. López, L. Mengual, F.J. Soriano, F.J. Yágüez (2005). Redes de computadores y arquitecturas de comunicaciones. Supuestos prácticos. Pearson Prentice Hall.

Supplementary Bibliography

- Kurose & Ross. (2021). Computer Networking: A top-down Approach, 8th Edition. Pearson.
- D.E. Comer (2005). Internetworking with TCP/IP, 5th Edition. Prentice Hall.
- A.S. Tanenbaum (2002). Computer Networks, 4th Edition. Prentice Hall.
- M. Schwartz (2015). "Mobile Wireless Communications". Cambridge University Press.

Web links

- http://williamstallings.com
- http://www.cs.purdue.edu/homes/dec/netbooks.html

Software

For the realization of the laboratory sessions will be used:

- C compiler (an Integrated Development Environment, IDE, may be used).
- eve-ng network emulator

For the practical cases, the following may be used:

- Python, GNU Octave or Mathlab

Language list

Name	Group	Language	Semester	Turn
(PAUL) Classroom practices	311	Catalan	first semester	morning-mixed
(PAUL) Classroom practices	312	Catalan/Spanish	first semester	morning-mixed
(PAUL) Classroom practices	331	Catalan/Spanish	first semester	afternoon
(PLAB) Practical laboratories	311	Catalan/Spanish	first semester	afternoon
(PLAB) Practical laboratories	312	Catalan/Spanish	first semester	morning-mixed
(PLAB) Practical laboratories	313	Catalan/Spanish	first semester	morning-mixed
(PLAB) Practical laboratories	314	Catalan/Spanish	first semester	morning-mixed
(PLAB) Practical laboratories	315	Catalan/Spanish	first semester	morning-mixed
(PLAB) Practical laboratories	316	Catalan/Spanish	first semester	afternoon
(TE) Theory	310	Catalan	first semester	morning-mixed
(TE) Theory	330	Catalan/Spanish	first semester	afternoon