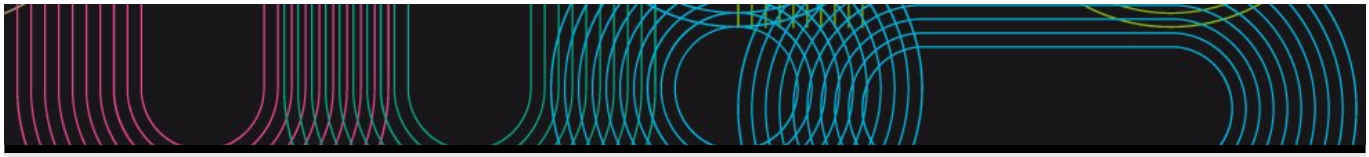

IDENTIFYING DATA				
Computer Networks				
Subject	Computer Networks			
Code	V05G306V01210			
Study programme	Bachelor Degree in Telecommunication Technologies Engineering (BTTE)			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	2nd	2nd
Teaching language	English			
Department				
Coordinator	López Ardao, José Carlos Rodríguez Pérez, Miguel			
Lecturers	López Ardao, José Carlos Rodríguez Pérez, Miguel			
E-mail	jardao@det.uvigo.es miguel@det.uvigo.gal			
Web	http://moovi.uvigo.gal/			
General description	Operating principles, architecture, technology and norms of computer networks, especially of Internet. Design-oriented course, complemented by practical skills			

Training and Learning Results	
Code	
B1	CG1: The ability to write, develop and sign projects in the field of Telecommunication Engineering, according to the knowledge acquired as considered in section 5 of this Law, the conception and development or operation of networks, services and applications of Telecommunication and Electronics.
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B6	CG6: The aptitude to manage mandatory specifications, procedures and laws.
B9	CG9: The ability to work in multidisciplinary groups in a Multilanguage environment and to communicate, in writing and orally, knowledge, procedures, results and ideas related with Telecommunications and Electronics.
C11	CE11/T6: The ability to conceive, deploy, organize and manage networks, systems, services and Telecommunication infrastructures in residential (home, city, digital communities), business and institutional environments, being responsible for launching of projects and continuous improvement like knowing their social and economical impact.
C17	CE17/T12: The knowledge and usage of concepts of communication network architecture, protocols and interfaces.
C18	CE18/T13: The ability to differentiate the concepts of access and transport networks, packet and circuit switched networks, mobile and fixed networks, as well as distributed newtwork application and systems, voice, data, video, audio, interactive and multimedia services.
C19	CE19/T14: The knowledge of methods of networking and routing, as well as the fundamentals of planning and network evaluation based on traffic parameters.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.
D4	CT4 Encourage cooperative work, and skills like communication, organization, planning and acceptance of responsibility in a multilingual and multidisciplinary work environment, which promotes education for equality, peace and respect for fundamental rights.

Expected results from this subject	
Expected results from this subject	Training and Learning Results

Comprise the general organization and the basic aspects of operation of communication networks, and particularly of computer networks	B3	C17	D2
Identify and know employ the concepts of switching, access and transport networks and wired and wireless networks	B3	C18	
Comprise the principles and the organization of distributed applications and services, either data or media oriented	B3	C17	
Comprise and know how to analyze the operation of the Internet: the architecture, the service model, the data transport, the routing methods and inter-networking, error control and congestion control	B3 B6	C11 C17 C19	D2 D3
Dominate the technical standards and the fundamental protocols of the Internet	B3 B4 B6	C17 C18 C19	
Practical capacity to design, handle and configure computer networks, from the point of view of data switching and transport	B1 B9	C11	D4
Specify common telecommunications infrastructures and structured cabling in buildings	B1 B6	C11	

Contents

Topic	
1. Introduction	1.1. Network elements, types of links, services and protocols 1.2. Switching techniques: circuits, messages and packets 1.3. Reference models and service modes
2. Packet switching (I): Link Transmission	2.1. Packet framing and Frame transmission 2.2. Forwarding techniques. 2.3. Generalized forwarding. Correspondence and action 2.4. Statistical multiplexing 2.5. ARQ Techniques 2.6. Flow control
3. Packet switching (II): Path Transmission	3.1. Fundamental performance metrics: delay, losses, equivalent capacity 3.2. Reliability (hop-by-hop vs. end-to-end)
4. The data plane (I): IEEE 802.x networks	4.1. Link lawyer. Link types 4.2. IEEE 802 project 4.3. Flat addressing in iEEE 802 4.4. Bridges IEEE 802 4.5. IEEE 802.3: Ethernet 4.6. IEEE 802.11: WiFi
5. The data plane (II): IP networks	5.1. Internet and IP 5.2. Hierarchical addressing. Structure of IP addresses 5.3. Routers and forwarding tables 5.4. Correspondence in IP (longest prefix match) 5.5. The IP protocol. IPv4 and IPv6 5.6. Addressing scopes. Private networks 5.7. NAT
6. Interconnection of link networks	6.1. IP as interconnection network 6.2. Routers vs. bridges 6.3. Translation between link and network addresses: NDP/ARP 6.4. Fragmentation in IP
7. The control plane (I): IEEE 802.X networks	7.1. Data and control planes. Distributed and centralized control. 7.2. Control plane in IEEE 802 networks 7.3. Backward Learning 7.4. Spanning Tree Control (STP)
8. The control plane (II): IP networks	8.1. The problem of routing. Key elements: Algorithms, protocols, RIB 8.2. Hierarchical routing on the Internet: Autonomous systems and domains 8.3. Format of the RIB. Obtaining the FIB 8.4. Intra-domain routing. Main IGPs: RIP and OSPF 8.5. Inter-AS routing: BGP
9. The Transport Layer	9.1. Multiplexing, reliability and transmission modes 9.2. Transport protocols 9.3. UDP 9.4. TCP: Connection management. Ordered delivery. ARQ and flow control in TCP
10. Congestion control	10.1. The problem of congestion 10.2. Congestion control: objectives, requirements, types of mechanisms 10.3. Congestion Control in TCP. The AIMD algorithm 10.4. Classic implementations: Tahoe, Reno 10.5. Delay-based mechanisms. Vegas

11. Internet Security	11.1. Secure communication systems 11.2. Confidentiality. Symmetric and asymmetric cryptography 11.3. Authenticity and integrity. Hash functions. Digital signatures 11.4. Availability. DDoS Attacks 11.5. Secure Transport: TLS over TCP
Lab Sessions	In the lab sessions we will do practicals using various network tools and utilities (GNS3, WireShark, ping, traceroute, dig, etc.) to reinforce the contents learnt in the lecturing classes. Software to be used: GNS3, WireShark, Java. Besides, there will be several sessions to explain related programming concepts (sockets, network utilities).

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	31	45	76
Problem solving	8	8	16
Laboratory practical	12	6	18
Autonomous problem solving	0	12	12
Practices through ICT	8	12	20
Gamification	0	4	4
Essay questions exam	2	0	2
Objective questions exam	1	0	1
Objective questions exam	1	0	1

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	Exposition of the ideas, concepts, technics and algorithms related to the thematic units of the course. With this methodology we will work the competences D2, D3, B3, B4, C11, C17, C18 and C19.
Problem solving	Resolution in the classroom by the professor of problems and exercises related with the contents of the master lessons. With this methodology students work the competences B3, B4, C11, C17, C18 and C19.
Laboratory practical	Networking laboratory practices, using various network tools and utilities (GNS3, WireShark, ping, traceroute, dig, etc.) to reinforce the contents learnt in the lecturing classes. Software to be used: GNS3, WireShark, Java. With this methodology, the competencies B1, B9, C17 and C19 are worked on.
Autonomous problem solving	Completion and delivery, more or less weekly, of online activities. These are self-evaluation tests and small tasks or problems to be carried out before or after the practical classes. It also includes the delivery of a small basic network program, as a training for the final network program. With this methodology we will work the competencies B4, B6, B9, C11, C17, C18, C19, D2, D3, D4
Practices through ICT	The goal is to develop small network programs in an autonomous and individual way. There will be several sessions to explain related programming concepts (sockets, network utilities), and also to solve doubts with the teacher, and to test and debug the programs in the laboratory where they will be evaluated. With this methodology we work with the competencies B1, B6, B9, C11, C17 and C19.
Gamification	In the virtual classroom, a gamification system will be used that includes activity points, mechanics and gamification elements to encourage the performance of online graded activities and to participate in a meaningful way in help forums. This will allow the student to obtain rewards to be used in the exams or in the continuous evaluation. The discussion forums will be the preferred way of answering questions and doubts related to the contents of the subject. The gamification will encourage peer support and collaborative resolution of doubts in the forums. Besides contributing to the increase of motivation, with this methodology we will also work on the competences B9, D3 and D4

Personalized assistance

Methodologies	Description
Lecturing	Personalized attention will be given individually, in a face-to-face meeting or by videoconference, during the tutorial schedule that will be made public at the beginning of the course. Students can ask for tutoring sessions following the instructions provided in the Moovi profile pages of the teacher of this subject at https://moovi.uvigo.gal/

Problem solving	Personalised attention will be given individually, in a face-to-face meeting or by videoconference, during the tutorial schedule that will be made public at the beginning of the course. Students can ask for tutoring sessions following the instructions provided in the Moovi profile pages of the teacher of this subject.
Practices through ICT	Personalised attention will be given individually, in a face-to-face meeting or by videoconference, during the tutorial schedule that will be made public at the beginning of the course. Students can ask for tutoring sessions following the instructions provided in the Moovi profile pages of the teacher of this subject.
Autonomous problem solving	In the case of tasks, the detailed solution will be provided in the virtual classroom. In the case of self-assesmemt tests, suitable feedback for the wrong questions will be provided to the student. In any case, personalised attention will be given individually, in a face-to-face meeting or by videoconference, during the tutorial schedule that will be made public at the beginning of the course. Students can ask for tutoring sessions following the instructions provided in the Moovi profile pages of the teacher of this subject.
Gamification	In addition to individually personalized face-to-face attention, the professor will be monitor the discussions in the forums making suitable answers when necessary or explaining the answers of the students. The forums in the virtual classroom are the preferred way to request asynchronous attention for doubts and questions related to the contents of the subject.
Laboratory practical	Personalized attention will be given individually, in a face-to-face meeting or by videoconference. Students can ask for tutoring sessions following the instructions provided in the Moovi profile pages of the teachers of this subject.

Assessment

	Description	Qualification	Training and Learning Results
Autonomous problem solving	During the course, with an approximately weekly periodicity, tasks, resolution of exercises, questions and self-evaluation tests will be proposed in the virtual classroom that must be carried out by the students individually, autonomously and not presencially, always with a deadline. These tasks have an overall weight of 10% for the student who chooses option B of continuous assessment. Those who choose option A of continuous assessment can do the tasks but the score does not count for the final mark, being only indicative for their self-assessment.	0-10	B4 C11 D2 B6 C17 D3 B9 C18 D4 C19
Practices through ICT	The student must develop several small network programs. There will be several classroom sessions for the explanation of the related programming concepts (sockets, network utilities) and also for tutoring with the teacher and for the development, testing and debugging of the programs in the laboratory, where it will be evaluated. The mark obtained for these programs will be multiplied by the mark obtained in a question about them in the final exam, with a value between 0 and 1.	10	B1 C11 B6 C17 B9 C19
Essay questions exam	Final exam covering the whole subject. It has a weight of 60% but a minimum mark of 4 out of 10 is required to pass the subject.	40	B3 C11 D2 B4 C17 C18 C19
Objective questions exam	One-hour multiple-choice tests to check the progress on the subject. It has a weight of 20% for the students who choose option B of continuous evaluation and 25% for the students who choose option A	20-25	B3 C11 D2 B4 C17 C18 C19
Objective questions exam	One-hour multiple-choice tests to check the progress on the subject. It has a weight of 20% for the students who choose option B of continuous evaluation and 25% for the students who choose option A	20-25	B3 C11 D2 B4 C17 C18 C19

Other comments on the Evaluation

Students can choose the method of Assessment:

Continuous or Global Assessment.

Continuous Assessment (CA)

There will be **two possible ways or options to go through Continuous Assessment, which we call A and B.** Students must choose the option in the subject virtual classroom during first month, one day before the first assessment exam. After this deadline, the chosen continuous assessment option cannot be changed. Students who do not make any explicit choice follow the global assessment.

Given the necessary collaborative and social character of option B, groups that do not reach a minimum of 30 students, will only have option A for continuous assessment.

Continuous Assessment consists of four types of activities or tests:

- **Qualifying activities in the virtual classroom**. During the course, with an approximately weekly periodicity, tasks, resolution of exercises, questions and self-evaluation tests will be proposed in the virtual classroom for the students to carry out after school hours individually, autonomously. All activities will have a strict deadline. The completion of these activities allows students to obtain "merit points" (**MP**) up to a maximum of 100 points (in the case of the correct completion of all of them). **The mark in this part will be calculated as the amount of MP divided by 100**. In order to facilitate the achievement of the maximum number of points, it will be possible to obtain a certain amount of PM through rewards, and in tasks with submissions, peer evaluation will be used, which will allow students to obtain additional PM.

  The Merit Points only count for students who have chosen option B of continuous assessment. Those who chose option A of continuous assessment can also do the tasks and tests, but the MP obtained do not count for the final mark, being only indicative of their self-assessment.
- **Network programs (PR):** Students will have to develop several small network programs in an individual and autonomous manner during the course. Several practical sessions will be dedicated to explain the related network programming projects needed to make the programs (sockets, network utilities…), and also to solve doubts with the teacher, and to test and debug the programs in the lab before being delivered for evaluation. The mark obtained by these programs **(PR)**, between 0 and 10, will be multiplied by the mark obtained in a question about the programs that is part of the final exam **(CR)**, with a range between 0 and 1.
- **Two intermediate one-hour multiple-choice tests to assess the progress of the subject (C1 and C2)**. Each control test has a weight of 25% on the final mark (FG) for students who chose option A of continuous assessment and 20% for those who opt for option B. The schedule of the different intermediate evaluation tests will be approved by the *Comisión Académica de Grado* (CAG) and will be available at the beginning of the term.

- **A final exam (FE) covering all contents,** has a weight of 60% of the Final Grade (FG). A minimum qualification of 4 points over 10 is required to pass the subject. Included in the final exam there will be a question about the network programming projects (CR) but its mark, between 0 and 1, will not be part of the final exam and will only be used to ponder the qualification obtained in the network programming projects.

The final mark of the continuous assessment evaluation will be, according to the chosen evaluation method, A or B:

FG-CA-A = 0.25 × (C1+C2) + 0.1 × CR × PR + 0.4 × FE, if FE ≥ 4

FG-CA-A = 0.2 × (C1+C2) + MP/100 + 0.1 × CR × PR + 0.4 × FE, if FE ≥ 4

If FE < 4, the Final Mark will be equal to min{4, FG-CA} where FG-CA would be the final mark of the continuous assessment evaluation calculated before (FG-CA-A or FG-CA-B)

As said above, it is mandatory to choose the CA option, A or B, in the established period, that will be until the day before the C1 control test. Students that do not make any explicit choice will be subjected to global assessment (EA).

Failure to take any of the control tests, C1 or C2, implies a mark of "0" on the test. These tests are not recoverable.

Global Assessment (EA)

Students who do not made any choice of continuous assessment within the stipulated time period are required to take the Global Assessment (EA)

The Global Assessment will consist of the same FE at the end of the term, including the additional question (**CR**) about the network programming projects. The final mark is calculated as:

FG-EA = 0.9 x FE +CR

Extraordinary exam

In the official dates, a new extraordinary exam (FE) will be done only for students that failed in the ordinary call. This exam will also include the question about the network programming projects (CR).

These EF and CR tests of the extraordinary call are an opportunity to raise the mark in these two tests with respect to the ordinary call. In the calculation of the Final Grade, the highest mark obtained in these tests between the two attempts will

prevail.

Those students who had chosen continuous assessment and that want to change to global assessment in this extraordinary call, must communicate it to the subject coordinator in written form before 8pm on the day before the review session of the first call. In this case, the conditions to pass the subject will be identical as those of students who had chosen global evaluation on the first place. In particular, it will not be possible to use in the exam any of the rewards obtained during the term as part of the continuous assessment.

The final marks are obtained in the same way as in the first-call evaluation.

End-of-program exam

The same procedure as for the global assessment will be used for the end-of-program call.

Other comments

All students presenting to any FE are considered to be presented to the subject. The marks for all exams, intermediate or final, and activities will only have effects on the current academic year.

The virtual classroom platform has tools to detect possible anomalous and dishonest behaviors in self-assessment tests (tests carried out among several people, previously known answers, etc.), as well as to detect plagiarism in written works or in software programs.

Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism is detected in any of the works/test/exams, including the virtual platform activities, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution.

All the official communications of the Subject will be published in the News Forum of the virtual classroom, to which all the students are necessarily subscribed by email. It is assumed that all students reads these messages and are properly informed of their content.

In the event of any contradiction that may have occurred between the different versions of this guide, due to any error in the translation, the prevailing version will be the Galician language version, except for English group, for which the English version of the Guide will be considered.

Sources of information

Basic Bibliography

J.F. Kurose, K.W. Ross, **Computer networking: a top-down approach**, 8,

L. Peterson, B. Davie, **Computer networks: a systems approach**, 5,

Complementary Bibliography

C. López, M. Rodríguez, S. Herrería, M. Fernández, **Cuestiones de redes de datos: principios y protocolos**, 1,

Peterson, Brakmo, and Davie, **TCP Congestion Control: A Systems Approach**,

Larry Peterson and Bruce Davie, **Computer networks: a systems approach**, 6.2-dev,

Recommendations

Subjects that it is recommended to have taken before

Data Communication/V05G301V01204

Other comments

To take the course, in order to carry out the network programs, it is very important to have a certain programming skills in an object-oriented language such as Java (or C ++). The skill level obtained after passing the Programming II course is enough.