



## IDENTIFYING DATA

### Network Technologies

|                   |                               |           |      |            |
|-------------------|-------------------------------|-----------|------|------------|
| Subject           | Network Technologies          |           |      |            |
| Code              | V05M145V01104                 |           |      |            |
| Study programme   | Telecommunication Engineering |           |      |            |
| Descriptors       | ECTS Credits                  | Choose    | Year | Quadmester |
|                   | 5                             | Mandatory | 1st  | 1st        |
| Teaching language | Spanish<br>Galician           |           |      |            |
| Department        |                               |           |      |            |
| Coordinator       | López Ardao, José Carlos      |           |      |            |
| Lecturers         | López Ardao, José Carlos      |           |      |            |
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**General description** This subject covers the competencies in the BOE for the Master degree to achieve those professional attributions of Telecommunications Engineer related to the underlying technologies in the Computer Networks.

In any way, it is an advanced course within the scope of these technologies, continuing and intensifying the basic contents studied in the subjects of the GETT.

## Competencies

|      |  |
|------|--|
| Code |  |
| A5   | CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way   |
| B1   | CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas.  |
| B4   | CG4 Capacity for mathematical modeling, calculation and simulation in technological centers and engineering companies, particularly in research, development and innovation tasks in all areas related to Telecommunication Engineering and associated multidisciplinary fields.   |
| B8   | CG8 Ability to apply acquired knowledge and to solve problems in new or unfamiliar environments within broader and multidiscipline contexts, being able to integrate knowledge.  |
| B12  | CG12 Skills for lifelong, self-directed and autonomous learning.   |
| C4   | CE4 Ability to design and plan networks for transporting, broadcasting and distribution of multimedia signals.   |
| C6   | CE6 Ability to model, design, implement, manage, operate, and maintain networks, services and contents.  |
| C7   | CE7 Capacity for planning, decision making and packaging of networks, services and applications, taking into account the quality of service, direct and operating costs, plan implementation, monitoring, safety procedures, scaling and maintenance, as well as managing and ensuring quality in the development process. |
| C12  | CE12 Ability to use programmable logic devices, as well as to design advanced electronic systems, both analog and digital. The ability to design communications components such as routers, switches, hubs, transmitters and receivers in different bands.   |

## Learning outcomes

|  |   |
|--|---|
| Expected results from this subject   | Training and Learning Results                 |
| Know how to model mathematically the essential elements of a network of telecommunications | A5<br>B1<br>B4<br>B8<br>B12<br>C4<br>C6<br>C7 |

|   |  |
|---|--|
| Understand the fundamental results on the capacity for different types of networks  | B1<br>B4<br>B8<br>C4<br>C6<br>C7               |
| Understand, formulate and solve simple models for analyzing the performance of a computer network   | B1<br>B4<br>B8<br>C4<br>C6<br>C7<br>C12        |
| Know how to plan, design and deploy switched networks and IP networks in any application environment  | A5<br>B1<br>B4<br>B8<br>B12<br>C4<br>C6<br>C7  |
| Know and understand the internal architecture of the switching equipment, methods of resource allocation and the basic techniques of providing Quality of Service | A5<br>B1<br>B4<br>B8<br>B12<br>C4<br>C6<br>C12 |

## Contents

| Topic                                 |  |
|---------------------------------------|--|
| 1. Switching architectures            | 1.1. Data and control plane. Distributed and centralized control<br>1.2. Switching architectures. Types of switches<br>1.3. Queue models for switches and communication networks                               |
| 2. Network virtualization             | 2.1. Network virtualisation<br>2.2. Virtual switches<br>2.3. Level 2 overlay virtualization<br>2.4. Ethernet VLANs. VLAN Trunking.<br>2.5. QinQ and MAC-in-MAC tunnels<br>2.6. MAC-in-IP tunnels: VXLAN, NVGRE |
| 3. Data Center Networks               | 3.1. The network of a Data Center<br>3.2. 3 level hierarchical architecture<br>3.3. Leaf & Spine Architecture<br>3.4. Technologies for optimising the use of available bandwidth: MSTP, TRILL, SPB, ECMP       |
| 4. Intradomain Internet routing: OSPF | 4.1. Hierarchical routing on the Internet. Domains, AS and ISPs<br>4.2. Protocols for intradomain routing<br>4.3. OSPF<br>4.4. Types of OSPF areas   |
| 5. Inter-AS routing: BGP              | 5.1. BGP.<br>5.2. Attributes and path selection  |
| 6. Route filtering                    | 6.1. Route Filtering. Lists and route-maps<br>6.2. Route filtering in BGP<br>6.3. BGP Communities<br>6.4. BGP and Data Centers   |
| 7. Traffic engineering. MPLS-TE       | 7.1. Traffic Engineering<br>7.2. MPLS-TE   |
| 8. QoS architectures in ISPs          | 8.1. Basic concepts of QoS<br>8.2. Classification and traffic marking<br>8.3. Traffic policing and shaping<br>8.4. Buffer and bandwidth scheduling<br>8.5. DiffServ Architecture                               |

## 9. SDN and NFV

- 9.1. Software Defined Networks (SDN). Key features
- 9.2. SDN controllers
- 9.3. OpenFlow
- 9.4. Network virtualization in SDN. Network Slicing in 5G
- 9.5. Network Functions Virtualization (NFV)
- 9.6. SDN and NFV

## 10. Transport and Access Networks

- 10.1. Fibre access: Metroethernet. FTTx, GPON
- 10.2. Radio Access Network. CRAN: Backhaul and Fronthaul.
- 10.3. Optical transport networks.

### Planning

|                            | Class hours | Hours outside the classroom | Total hours |
|----------------------------|-------------|-----------------------------|-------------|
| Autonomous problem solving | 0           | 18                          | 18          |
| Practices through ICT      | 9           | 13                          | 22          |
| Problem solving            | 3           | 6                           | 9           |
| Gamification               | 0           | 12                          | 12          |
| Lecturing                  | 24          | 36                          | 60          |
| Objective questions exam   | 2           | 0                           | 2           |
| Essay questions exam       | 2           | 0                           | 2           |

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

### Methodologies

|                            | Description  |
|----------------------------|--|
| Autonomous problem solving | Resolution of assignments, exercises, questions and self-assessment tests in the virtual classroom in a individual, autonomous way. These activities have a global weight of 15% in the case of continuous evaluation. With this methodology we will work the competences CB5, CG1, CG4, CG8, CG12, CE4, CE6, CE7, CE12  |
| Practices through ICT      | Realization of practices for planning, design, configuration and resolution of problems of network scenarios by means of the emulador GNS3. With this methodology we will work the competences CG1, CG4, CG8, CG12, CE4, CE6, CE7, CE12  |
| Problem solving            | Resolution of problems of design, planning and dimensioning of networks. With this methodology we will work the competences CG1, CG4, CG8, CE6, CE7  |
| Gamification               | In the virtual classroom, we use a gamification system that employs activity points, mechanics and gamification elements to encourage the performance of online grading activities and to participate meaningfully in discussion forums. This will allow the student to obtain rewards to be used in the exams or in the continuous evaluation.<br><br>The discussion forums will be the preferred way of answering questions 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 the motivation, with this methodology there will be worked also the competences CB5, CG12 |
| Lecturing                  | Explaining of the ideas, concepts, technics and algorithms related to the thematic unities of the course. With this methodology we will work the competences CG1, CG4, CG8, CE4, CE6, CE7, CE12  |

### Personalized assistance

| Methodologies              | Description  |
|----------------------------|--|
| Lecturing                  | Individually personalized attention, face-to-face or by videoconference, will be dispensed. The tutorial schedule will be announced at the beginning of the course. Reservation must be made through the virtual classroom or by email.  |
| Autonomous problem solving | In the case of tasks, the detailed solution will be provided in the virtual classroom. In the case of self-assessment tests, suitable feedback for the wrong questions will be provided to the student. In any case, individually personalized attention, face-to-face or by videoconference, will be dispensed. The tutorial schedule will be announced at the beginning of the course. Reservation must be made through the virtual classroom or by email. |
| Practices through ICT      | Individually personalized attention, face-to-face or by videoconference, will be dispensed. The tutorial schedule will be announced at the beginning of the course. Reservation must be made through the virtual classroom or by email.  |
| Problem solving            | Individually personalized attention, face-to-face or by videoconference, will be dispensed. The tutorial schedule will be announced at the beginning of the course. Reservation must be made through the virtual classroom or by email.  |

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 discussion forums are the way to request remote attention for doubts and questions related to the contents of the subject. Private attention about contents by means of messaging or e-mail is not available. In addition to individual attention during the tutorial schedule, the teacher will monitor the discussions in the forums, giving the appropriate response when necessary or explaining the student's answers if necessary. The forums in the virtual classroom are the preferred way of providing asynchronous attention to doubts related to the contents of the subject.

| <b>Assessment</b>          |   |               |                               |                       |
|----------------------------|---|---------------|-------------------------------|-----------------------|
|                            | Description   | Qualification | Training and Learning Results |                       |
| Autonomous problem solving | During the course, with a roughly weekly periodicity, different tasks, activities, exercises, self-assessment tests must be made in the virtual classroom in an individual and autonomous way. These activities have a global weight of 15% | 15            | A5<br>B1<br>B4<br>B8<br>B12   | C4<br>C6<br>C7<br>C12 |
| Objective questions exam   | Two intermediate one-hour multiple-choice tests will be carried out to check the progress of the subject. Each control test has a weight of 15%.  | 30            | B1<br>B4<br>B8                | C4<br>C6<br>C7<br>C12 |
| Essay questions exam       | Final exam covering the whole subject. It has a weight of 55% but a minimum score of 3.5 points out of 10 is required to pass the subject.  | 55            | B1<br>B4<br>B8                | C4<br>C6<br>C7<br>C12 |

### **Other comments on the Evaluation**

The students can choose the Assesment method, continuous or exam-only.

#### **Continuous Assesment (CA)**

It will consist of:

- Two intermediate one-hour multiple-choice tests (**C1 and C2**) will be carried out to check the progress of the subject. Each control test has a 15% weight in the Final Grade (**FG**). The schedule of the midterm/intermediate exams will be approved in the Comisión Académica de Máster (CAM) and will be available at the beginning of each academic semester
- The participation in the online activities in virtual environment, that represent 15% of the Final Grade (**FG**). During the course, with a roughly weekly periodicity, different tasks, activities, exercises, self-assessment tests will be proposed in the virtual classroom. These activities must be realized by all students in an autonomous, individual way. The realization of these activities allows students to obtain "merit points" (**MP**) up to a maximum of 150 points (in case of all activities are evaluated with the maximum grade). The grade of this section will be equal to the **amount of MP divided by 100**. In order to facilitate the achievement of the maximum amount of points, additional optional tasks will be proposed throughout the course.
- The virtual classroom includes a **gamification** system based in other types of points and several gamification elements and mechanisms to motivate students to make the activities and participate in a meaningful way in forums of doubts and discussions. This system allows students get **rewards** to be used in exams and assignments.
- A final exam (**FE**) covering all contents, with a weight of 55% of the Final Grade (**FG**). A minimum qualification of 3.5 points on 10 is required

$$FG-CA = 0.15x(C1 + C2) + MP/100 + 0,55xFE \text{ if } FE \geq 3.5$$

$$FG-CA = FE \text{ if } FE < 3.5$$

It is considered that a student chooses CA when presenting to any midterm control test (C1 or C2). If any of these control tests are not made, the grade will be "0". These control tests will be not recoverable.

#### **Exam-only Assesment (EA)**

It will only consist of the same FE at the end of the term.

Students who do not take any midterm exam, compulsorily opt for the Exam-only Assesment.

#### **Second call**

A new final exam (FE) will be done in the official dates only for students not passing in the first call.

Those students who have failed in the first call by going through Continuous Assessment and wish to renounce it in order to choose the Eventual Assessment, will have to request it in writing to the coordinator before the review date of the first final exam. In this case, any reward obtained by the CA activities carried out in the virtual classroom is also waived.

### **Other comments**

All students taking any final exam are considered to be presented to the subject. The grades for all exams, partial or final, and activities will affect only the actual 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 works/test/exams, including the activities on the virtual platform, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution.

In case of any contradiction that may occur between the different versions of the guide, due to some error in the translation, the version that will prevail is the Galician language version.

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### **Sources of information**

#### **Basic Bibliography**

J.F. Kurose, K.W. Ross, **Computer networking: a top-down approach featuring the Internet**, 7ª,

Diane Teare, **Implementing Cisco IP Routing (ROUTE) Foundation Learning Guide**, Cisco Press,

P. Görason, C. Black, T. Culver, **Software Defined Networks: A comprehensive approach**, 2ª, Morgan Kaufman, 2017

Gary Lee, **Cloud Networking: Understanding Cloud-Based Data Center Networks**, Morgan Kaufmann, 2014

R. Chayapathi, S. Hassan, P. Shah, **Network Functions Virtualization (NFV) with a Touch of SDN**, Addison Wesley, 2016

#### **Complementary Bibliography**

Kun I. Park, **QoS in packet networks**, 1ª,

Richard Froom, Balaji Sivasubramanian, Erum Frahim, **Implementing Cisco IP Switched Networks (SWITCH)**

**Foundation Learning Guide**, Cisco Press,

William Stallings, **Foundations of Modern Networking: SDN, NFV, QoE, IoT and Cloud**, Addison Wesley, 2016

Jim Doherty, **SDN and NFV Simplified**, Pearson Education, 2016

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### **Recommendations**

#### **Subjects that it is recommended to have taken before**

(\*)Redes de Ordenadores/V05M145V01403

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### **Contingency plan**

#### **Description**

The subject is planned in such a way that, in the event of activation of the alert caused by COVID-19 which requires switching to a semi-presential or totally non-presential teaching model, no changes are required in the contents, teaching planning, teaching methodologies, personalised attention mechanisms or evaluation.