ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

593000605 - Network Architecture And Protocols

DEGREE PROGRAMME

59AJ - Master Universitario En Comunicaciones Inalámbricas

ACADEMIC YEAR & SEMESTER

2024/25 - Semester 1

Index

Learning guide

1. Description

1.1. Subject details

Name of the subject	593000605 - Network Architecture And Protocols
No of credits	4.5 ECTS
Type	Compulsory
Academic year ot the programme	First year
Semester of tuition	Semester 1
Tuition period	September-January
Tuition languages	English
Degree programme	59AJ - Master Universitario en Comunicaciones Inalámbricas
Centre	59 - Escuela Tecnica Superior De Ingenieria Y Sistemas De Telecomunicacion
Academic year	2024-25

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Antonio Perez Yuste (Subject coordinator)	8304	antonio.perez@upm.es	Sin horario.

* The tutoring schedule is indicative and subject to possible changes. Please check tutoring times with the faculty member in charge.

3. Prior knowledge recommended to take the subject

3.1. Recommended (passed) subjects

The subject - recommended (passed), are not defined.

3.2. Other recommended learning outcomes

- Linux OS

- Network protocols

4. Skills and learning outcomes *

4.1. Skills to be learned

CB6 - Poseer y comprender conocimientos que aporten una base u oportunidad de ser originales en el desarrollo y/o aplicación de ideas, a menudo en un contexto de investigación/ Students have demonstrated knowledge and understanding providing the groundwork or opportunity for innovation in developing and/or applying ideas, often within a research context

CB7 - Que los estudiantes sepan aplicar los conocimientos adquiridos y su capacidad de resolución de problemas en entornos nuevos o poco conocidos dentro de contextos más amplios (o multidisciplinares) relacionados con su área de estudio/Students are capable of applying their knowledge, understanding, and problem-solving abilities in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their field of study

CB8 - Que los estudiantes sean capaces de integrar conocimientos y enfrentarse a la complejidad de formular juicios a partir de una información que, siendo incompleta o limitada, incluya reflexiones sobre las responsabilidades sociales y éticas vinculadas a la aplicación de sus conocimientos y juicios/Students are capable of integrating knowledge and making complex decisions, which, although based on incomplete or limited information, require reflection on social and ethical responsibilities linked to the application of their knowledge and opinions

CEM04 - Adquirir las destrezas que permitan analizar y diseñar la arquitectura, servicios y protocolos de la red de núcleo de un sistema de comunicaciones móviles 4G y 5G. / Adquire the skills to analyze and design the architecture, services, and protocols of the core network in a 4G or 5G mobile communication system.

CGI02 - Comprender el procedimiento, valor y límites del método científico, siendo capaz de identificar, localizar y obtenerdatos requeridos en un trabajo de investigación, de diseñar y guiar investigaciones analíticas, de modelado y experimentales, así como de evaluar datos de una manera crítica y extraer conclusiones. / Understand the procedure, value, and limits of the scientific method, being able to identify, locate and obtain data required in a research work, to design and guide analytical, modeling, and experimental investigations, as well as to critically evaluate data and extract conclusions.

CGI03 - Valorar la importancia de las fuentes documentales, manejarlas y buscar la información para el desarrollo de cualquier trabajo de investigación. / Assess the importance of documentary sources, manage them and search for information for the development of any research work.

CGI04 - Leer y comprender publicaciones dentro de su ámbito de estudio/investigación, así como su catalogación y valor científico. / Read and understand publications within their field of study / research, as well as their cataloging and scientific value.

UPM1 - Uso de la lengua inglesa / Use of the English language

UPM4 - Organización y planificación / Planning and organization

UPM5 - Gestión de la Información / Information management

4.2. Learning outcomes

RA5 - Interpretar los datos derivados de observaciones empíricas y mediciones en términos de su importancia y relacionarlos con la teoría apropiada/ Interpret data derived from empirical observations and measurements in terms of their importance and relate them to the appropriate theory

RA18 - Identificar y distinguir entre los interfaces y protocolos de una red de comunicaciones móviles moderna/ Identify and distinguish between the interfaces and protocols of a modern mobile communications network

RA17 - Justificar la utilización de técnicas SDN y NFV en la red central de un sistema de comunicaciones móviles moderno/ Justify the use of SDN and NFV techniques in the central network of a modern mobile communications system

RA16 - Analizar el control y tráfico de redes de comunicaciones móviles en los planos de usuario y de control/ Analyze the control and traffic of mobile communications networks in the user and control planes

RA15 - Diseñar y desarrollar los componentes de una red de comunicaciones móviles y sus protocolos a partir de especificaciones técnicas/ Design and develop the components of a mobile communications network and its protocols based on technical specifications

* The Learning Guides should reflect the Skills and Learning Outcomes in the same way as indicated in the Degree

Verification Memory. For this reason, they have not been translated into English and appear in Spanish.

5. Brief description of the subject and syllabus

5.1. Brief description of the subject

Network Architecture and Protocols (NAP) is aimed at studying he network architecture of modern mobile communication systems. as well as becoming familiar with the protocols used between the architecture components at both the control plane and the user plane, and mainly oriented to current 4G and 5G mobile communication networks.

While 4G commercial networks have been widely deployed by operators worldwide, year 2020 was the starting signal pointed out by relevant actors for 5G deployments. As 5G commercial networks are being deployed, 4G and 5G networks will coexist (both in core and radio networks). Thus, it is quite important to understand not only isolated 4G and 5G architectures but also their correspondence and merging opportunities available for operators.

Within this course, 4G and 5G architectures, interfaces, and protocols will be throughly presented, including basic procedures and low-level physical/local channels. In addition, the new Serviced Based Architecture paradigm will be introduced, and its relying technologies (SDN, NFV) will be presented.

5.2. Syllabus

1. IMT-2020, Introduction to the 5G System
    1.1. Why 5G is different?
    1.2. Roadmap of mobile communications
    1.3. Standardisation bodies
    1.4. 3GPP standardisation timeline
    1.5. 3GPP specification documents
    1.6. IMT-2020 and 3GPP usage scenarios
    1.7. Technical performance requirements
    1.8. The mobile market figures
    1.9. 5G use case study
2. System architecture evolution
    2.1. Public Land Mobile Networks (PLMNs)

2.2. Architecture of GMS, UMTS, and LTE

2.3. LTE Core Network (EPC)

2.4. LTE Radio Access Network (EUTRAN)

2.5. Carrier Aggregation (CA)

2.6. Dual Connectivity (DC)

2.7. 5G Core Network (NG-CN)

2.8. 5G Radio Access Network (NG-RAN)

2.9. Network Identities

2.10. 4G-5G Coexistence

3. Next generation core network

3.1. CUPS Architecture

3.2. 5G Service-Based Architecture (SBA)

3.3. 5G Service-Based Interface (SBI)

3.4. Representation State Transfer (REST)

3.5. The Hypertext Transfer Protocol (HTTP/2)

3.6. Types of HTTP/2-Based Communications

3.7. 5G-CN Network Functions

4. Air Interface Layer 2

4.1. CP and UP Protocol Stack

4.2. Air Interface Protocol Stack

4.3. Radio Bearers

4.4. Service Data Adaptation Protocol, SDAP

4.5. Packet Data Convergence Protocol, PDCP

4.6. Radio Link Control, RLC

4.7. Medium Access Control, MAC

4.8. Channels in 5G

4.9. Channels' Mapping

5. Registration Management

5.1. 5G Management Procedures

6. Schedule

6.1. Subject schedule*

Week	Type 1 activities	Type 2 activities	Distant / On-line	Assessment activities
1	**U1. IMT-2020, Introduction to the 5G System** Duration: 04:00	**U1. IMT-2020, Introduction to the 5G System** Duration: 02:00		**U1. IMT-2020, Introduction to the 5G System** Progressive assessment and Global Examination Not Presential Duration: 01:00 **U1. IMT-2020, Introduction to the 5G System** Progressive assessment and Global Examination Not Presential Duration: 02:00
2	**U2. System Architecture Evolution** Duration: 06:00			**U2. System Architecture Evolution** Progressive assessment and Global Examination Not Presential Duration: 01:00
3	**U3. Next Generation Core Network** Duration: 02:00	**W1. Managing of Services in Linux** Duration: 04:00		**W1. Managing of Services in Linux** Progressive assessment and Global Examination Presential Duration: 02:00
4	**U3. Next Generation Core Network** Duration: 04:00	**W2. Open Files and Data Interchange Formats** Duration: 02:00		**U3. Next Generation Core Network** Progressive assessment and Global Examination Not Presential Duration: 01:00 **W2. Open Files and Data Interchange Formats** Progressive assessment and Global Examination Presential Duration: 02:00
5	**U4. Air Interface Layer 2** Duration: 04:00	**W3. OPEN5GS CN + 5G UERANSIM in Linux** Duration: 02:00		**U4. Air Interface Layer 2** Progressive assessment and Global Examination Not Presential Duration: 01:00 **W3. OPEN5GS CN + 5G UERANSIM in Linux**

				Progressive assessment and Global Examination Presential Duration: 02:00
6	**U5. Registration Management** Duration: 02:00	**W4. NF Service Registration and Subscription** Duration: 04:00		**U5. Registration Management** Progressive assessment and Global Examination Not Presential Duration: 01:00 **W4. NF Service Registration and Subscription** Progressive assessment and Global Examination Presential Duration: 02:00
7	**U6. Session Management** Duration: 02:00 **U7. Mobility management** Duration: 02:00	**W5. PDU Session Setting-up Process** Duration: 02:00		**U6-U7. Session Management and Mobility Management** Progressive assessment and Global Examination Not Presential Duration: 01:00 **W5. PDU Session Setting-up Process** Progressive assessment and Global Examination Presential Duration: 02:00
8				
9				
10				
11				
12				
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16				
17				

Depending on the programme study plan, total values will be calculated according to the ECTS credit unit as 26/27 hours of student face-to-face contact and independent study time.

7. Activities and assessment criteria

7.1. Assessment activities

7.1.1. Assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
1	U1. IMT-2020, Introduction to the 5G System		No Presential	01:00	5%	5 / 10	CGI04 UPM5 CEM04 CGI02 CGI03 UPM4 UPM1
1	U1. IMT-2020, Introduction to the 5G System		No Presential	02:00	10%	5 / 10	CGI04 CB6 CEM04 UPM1
2	U2. System Architecture Evolution		No Presential	01:00	10%	5 / 10	CEM04 CGI03 UPM4 UPM1
3	W1. Managing of Services in Linux		Face-to-face	02:00	10%	5 / 10	CB7 CEM04 CGI02 CGI03 UPM4 UPM1
4	U3. Next Generation Core Network		No Presential	01:00	10%	5 / 10	CGI04 CEM04 CGI03 UPM1
4	W2. Open Files and Data Interchange Formats		Face-to-face	02:00	10%	5 / 10	CB8 CEM04 CGI03 UPM1
5	U4. Air Interface Layer 2		No Presential	01:00	10%	5 / 10	CEM04 CGI02 UPM1 CGI04 CB7

5	W3. OPEN5GS CN + 5G UERANSIM in Linux		Face-to-face	02:00	10%	5 / 10	UPM1 CGI03 UPM4 CGI04
6	U5. Registration Management		No Presential	01:00	5%	5 / 10	CB8 CEM04 CGI03 UPM1
6	W4. NF Service Registration and Subscription		Face-to-face	02:00	5%	5 / 10	UPM5 UPM4 CGI02 UPM1
7	U6-U7. Session Management and Mobility Management		No Presential	01:00	10%	5 / 10	CGI04 UPM5 CEM04 UPM4 UPM1
7	W5. PDU Session Setting-up Process		Face-to-face	02:00	5%	5 / 10	UPM1 UPM5 CEM04 CB8 CB6 CGI02

7.1.2. Global examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
1	U1. IMT-2020, Introduction to the 5G System		No Presential	01:00	5%	5 / 10	CGI04 UPM5 CEM04 CGI02 CGI03 UPM4 UPM1
1	U1. IMT-2020, Introduction to the 5G System		No Presential	02:00	10%	5 / 10	CGI04 CB6 CEM04 UPM1
2	U2. System Architecture Evolution		No Presential	01:00	10%	5 / 10	CEM04 CGI03 UPM4 UPM1
3	W1. Managing of Services in Linux		Face-to-face	02:00	10%	5 / 10	CB7 CEM04 CGI02 CGI03 UPM4 UPM1

4	U3. Next Generation Core Network		No Presential	01:00	10%	5 / 10	CGI04 CEM04 CGI03 UPM1
4	W2. Open Files and Data Interchange Formats		Face-to-face	02:00	10%	5 / 10	CB8 CEM04 CGI03 UPM1
5	U4. Air Interface Layer 2		No Presential	01:00	10%	5 / 10	CEM04 CGI02 UPM1 CGI04 CB7
5	W3. OPEN5GS CN + 5G UERANSIM in Linux		Face-to-face	02:00	10%	5 / 10	UPM1 CGI03 UPM4 CGI04
6	U5. Registration Management		No Presential	01:00	5%	5 / 10	CB8 CEM04 CGI03 UPM1
6	W4. NF Service Registration and Subscription		Face-to-face	02:00	5%	5 / 10	UPM5 UPM4 CGI02 UPM1
7	U6-U7. Session Management and Mobility Management		No Presential	01:00	10%	5 / 10	CGI04 UPM5 CEM04 UPM4 UPM1
7	W5. PDU Session Setting-up Process		Face-to-face	02:00	5%	5 / 10	UPM1 UPM5 CEM04 CB8 CB6 CGI02

7.1.3. Referred (re-sit) examination

No se ha definido la evaluación extraordinaria.

7.2. Assessment criteria

The type of course and the approach described above make more convenient to select an assessment mechanism different to the traditional final exam. A progressive evaluation methodology is here proposed for this course, based on a set of short quizzes. This way, main concepts can be properly set up while the attractive of the contents are increased. In addition, the assessment of lab practices are based on the realisation of a report by the students. This report will be also evaluated in order to get the final grade.

Those students who do not meet the goals and do not pass the regular activities, will be able to attend an extraordinary exam organised on July. This will consist on two parts: firstly, a questionnaire selected among all topics in this course must be responded on-line and, secondly, a lab practice with several exercises related to the practical activities carried out along the course must be duly done. It is mandatory to pass the first part before moving to the second part, which also needs to be passed in order to get the final grade

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
Cox, 2014	Bibliography	Cox, C., "An Introduction to LTE. LTE-Advanced, SAE, VoLTE and 4G Mobile Communications", 2nd ed, Ed. John Wiley & Sons, 2014.
Cox, 2021	Bibliography	Cox, C., "An Introduction to 5G. The New Radio, 5G Network and Beyond", Ed. John Wiley & Sons, 2021.
Dahlman, 2011	Bibliography	Dahlman, E. et al, "4G: LTE/LTE-Advanced for Mobile Broadband", Academic Press, 2011.
Dahlman, 2018	Bibliography	Dahlman, E. et al, "5G NR: The Next Generation Wireless Access Technology", Academic Press, Elsevier, 2018.

Yi, 2012	Bibliography	Yi, S. et al, "Radio Protocols for LTE and LTE-Advanced", S. Yi et al., Ed. John Wiley & Sons, 2012.
Sudhakar-2021	Bibliography	Sudhakar, R. et al, "5G Mobile Core Network. Design, Deployment, Automation, and Testing Strategies", Ed. Apress, 2021.