



INTERNATIONAL  
CAMPUS OF  
EXCELLENCE

COORDINATION PROCESS OF  
LEARNING ACTIVITIES  
PR/CL/001



E.T.S. de Ingeniería y Sistemas  
de Telecomunicación

# ANX-PR/CL/001-01

## LEARNING GUIDE

### SUBJECT

**593000605 - Network Architecture And Protocols**

### DEGREE PROGRAMME

59AI - Master Universitario En Comunicaciones Inalámbricas

### ACADEMIC YEAR & SEMESTER

2022/23 - Semester 1

## Index

---

### Learning guide

|   |    |
|---|----|
| 1. Description.....                                   | 1  |
| 2. Faculty.....                                       | 1  |
| 3. Skills and learning outcomes .....                 | 2  |
| 4. Brief description of the subject and syllabus..... | 3  |
| 5. Schedule.....                                      | 6  |
| 6. Activities and assessment criteria.....            | 8  |
| 7. Teaching resources.....                            | 10 |

## 1. Description

### 1.1. Subject details

|                                       |  |
|---------------------------------------|--|
| <b>Name of the subject</b>            | 593000605 - Network Architecture And Protocols                             |
| <b>No of credits</b>                  | 4.5 ECTS   |
| <b>Type</b>                           | Compulsory   |
| <b>Academic year of the programme</b> | First year   |
| <b>Semester of tuition</b>            | Semester 1   |
| <b>Tuition period</b>                 | September-January  |
| <b>Tuition languages</b>              | English  |
| <b>Degree programme</b>               | 59AI - Master Universitario en Comunicaciones Inalámbricas                 |
| <b>Centre</b>                         | 59 - Escuela Tecnica Superior De Ingeniería Y Sistemas De Telecomunicación |
| <b>Academic year</b>                  | 2022-23  |

## 2. Faculty

### 2.1. Faculty members with subject teaching role

| <b>Name and surname</b>                      | <b>Office/Room</b> | <b>Email</b>                       | <b>Tutoring hours *</b> |
|--|--------------------|------------------------------------|-------------------------|
| Antonio Perez Yuste<br>(Subject coordinator) | 8304               | antonio.perez@upm.es               | Sin horario.            |
| Yolanda Blanco Archilla                      | 8203               | yolanda.blanco@upm.es              | Sin horario.            |
| Juan Anton Moreno Garcia-Loygorri            | 8418               | juan.moreno.garcia-loygorri@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. Skills and learning outcomes \*

---

### 3.1. 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

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

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

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.

CGI02 - Comprender el procedimiento, valor y límites del método científico, siendo capaz de identificar, localizar y obtener datos 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.

CGI03 - Valorar la importancia de las fuentes documentales, manejarlas y buscar la información para el desarrollo de cualquier trabajo de investigación.

CGI04 - Leer y comprender publicaciones dentro de su ámbito de estudio/investigación, así como su catalogación y valor científico.

UPM1 - Uso de la lengua inglesa

UPM4 - Organización y planificación /

## 3.2. Learning outcomes

RA20 - RA05.- Interpret data derived from empirical observations and measurements in terms of their importance and relate them to the appropriate theory.

RA32 - Justify the use of SDN and NFV techniques in the central network of a modern mobile communications system

RA33 - Identify and distinguish between the interfaces and protocols of a modern mobile communications network

RA31 - Analyze the control and traffic of mobile communications networks in the user and control planes

RA30 - 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.

## 4. Brief description of the subject and syllabus

---

### 4.1. Brief description of the subject

Network Architecture and Protocols (NAP) is aimed to review the network architecture of modern mobile communication systems and to study the protocols used between the architecture components, both control plane and user plane protocols, mainly oriented to present 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 thoroughly 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.

## 4.2. Syllabus

1. System architecture evolution
  - 1.1. Main components of the EPC and its evolution to 5G
  - 1.2. High-level protocol architecture
  - 1.3. Network function virtualization
  - 1.4. Software-defined networking
  - 1.5. Network slicing
2. Architecture of the Core Network
  - 2.1. Architecture of the Evolved Packet Core
  - 2.2. Architecture of the 5G Core Network
  - 2.3. Service-based Architecture
  - 2.4. Network Areas, Slices, and Identities
  - 2.5. Protocol Model: Control Plane / User Plane
  - 2.6. Signaling Protocols
  - 2.7. The Hypertext Transfer Protocol
3. Air Interface Layer 2
  - 3.1. Medium Access Control Protocol
  - 3.2. Radio Link Control Protocol
  - 3.3. Packet Data Convergence Protocol
  - 3.4. Service Data Adaptation Protocol
4. Circuit Switched Fallback
  - 4.1. System architecture
  - 4.2. Attach procedure
  - 4.3. Mobility management
  - 4.4. Call setup
  - 4.5. SMS over SGs
5. VoLTE and the IP Multimedia Subsystem
  - 5.1. Hardware architecture of the IMS

- 5.2. Signaling protocols
- 5.3. Service provision in the IMS
- 5.4. VoLTE registration procedure
- 5.5. Call setup and release
- 5.6. Access domain selection
- 5.7. Single radio voice call continuity
- 6. Security procedures
  - 6.1. Network access security
  - 6.2. Network domain security
- 7. Mobility management
  - 7.1. Transitions between mobility management states
  - 7.2. Cell reselection in RRC\_IDLE
  - 7.3. Measurements in RRC\_CONNECTED
  - 7.4. Handover in RRC\_CONNECTED
- 8. EPC-5G Interoperation
  - 8.1. Interoperation architectures
  - 8.2. Registration modes
  - 8.3. Use of the migration architecture
  - 8.4. Interworking without N26
  - 8.5. Interworking with N26

## 5. Schedule

### 5.1. Subject schedule\*

| Week | Classroom activities   | Laboratory activities   | Distant / On-line | Assessment activities  |
|------|--|---|-------------------|--|
| 1    | <b>System Architecture Evolution</b><br>Duration: 04:00  | <b>System Architecture Evolution</b><br>Duration: 02:00         |                   | <b>System Architecture Evolution</b><br>Continuous assessment and final examination<br>Not Presential<br>Duration: 02:00     |
| 2    | <b>Architecture of the Core Network</b><br>Duration: 06:00   |   |                   |  |
| 3    | <b>Air Interface Layer 2</b><br>Duration: 04:00  | <b>Architecture of the Core Network</b><br>Duration: 02:00      |                   | <b>Architecture of the Core Network</b><br>Continuous assessment and final examination<br>Presential<br>Duration: 02:00      |
| 4    | <b>Air Interface Layer 2</b><br>Duration: 02:00<br><br><b>Circuit Switched Fallback</b><br>Duration: 02:00                 | <b>Air Interface Layer 2</b><br>Duration: 02:00                 |                   | <b>Air Interface Layer 2</b><br>Continuous assessment and final examination<br>Presential<br>Duration: 02:00                 |
| 5    | <b>Circuit Switched Fallback</b><br>Duration: 02:00<br><br><b>VoLTE and the IP Multimedia Subsystem</b><br>Duration: 04:00 |   |                   |  |
| 6    | <b>Security procedures</b><br>Duration: 02:00<br><br><b>Mobility management</b><br>Duration: 02:00                         | <b>VoLTE and the IP Multimedia Subsystem</b><br>Duration: 02:00 |                   | <b>VoLTE and the IP Multimedia Subsystem</b><br>Continuous assessment and final examination<br>Presential<br>Duration: 02:00 |
| 7    | <b>Mobility management</b><br>Duration: 02:00<br><br><b>EPC-5G Interoperation</b><br>Duration: 04:00                       |   |                   |  |



|    |  |  |  |  |
|----|--|--|--|--|
| 8  |  |  |  |  |
| 9  |  |  |  |  |
| 10 |  |  |  |  |
| 11 |  |  |  |  |
| 12 |  |  |  |  |
| 13 |  |  |  |  |
| 14 |  |  |  |  |
| 15 |  |  |  |  |
| 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.

\* The schedule is based on an a priori planning of the subject; it might be modified during the academic year, especially considering the COVID19 evolution.

## 6. Activities and assessment criteria

### 6.1. Assessment activities

#### 6.1.1. Assessment

| Week | Description                           | Modality | Type          | Duration | Weight | Minimum grade | Evaluated skills  |
|------|---------------------------------------|----------|---------------|----------|--------|---------------|---|
| 1    | System Architecture Evolution         |          | No Presential | 02:00    | 25%    | 5 / 10        | UPM5<br>CGI03<br>CGI02<br>CGI04<br>UPM1<br>CEM04<br>CB8<br>UPM4 |
| 3    | Architecture of the Core Network      |          | Face-to-face  | 02:00    | 25%    | 5 / 10        | CGI03<br>CB6<br>CGI02<br>CGI04<br>UPM1<br>CEM04<br>CB7<br>UPM4  |
| 4    | Air Interface Layer 2                 |          | Face-to-face  | 02:00    | 25%    | 5 / 10        | CGI03<br>CB6<br>CGI02<br>CGI04<br>UPM1<br>CB7                   |
| 6    | VoLTE and the IP Multimedia Subsystem |          | Face-to-face  | 02:00    | 25%    | 5 / 10        | UPM5<br>CB6<br>CGI02<br>UPM1<br>CEM04<br>CB7<br>CB8             |

#### 6.1.2. Global examination

| Week | Description | Modality | Type | Duration | Weight | Minimum grade | Evaluated skills |
|------|-------------|----------|------|----------|--------|---------------|------------------|
|------|-------------|----------|------|----------|--------|---------------|------------------|

|   |                                       |  |               |       |     |        |   |
|---|---------------------------------------|--|---------------|-------|-----|--------|---|
| 1 | System Architecture Evolution         |  | No Presential | 02:00 | 25% | 5 / 10 | UPM5<br>CGI03<br>CGI02<br>CGI04<br>UPM1<br>CEM04<br>CB8<br>UPM4 |
| 3 | Architecture of the Core Network      |  | Face-to-face  | 02:00 | 25% | 5 / 10 | CGI03<br>CB6<br>CGI02<br>CGI04<br>UPM1<br>CEM04<br>CB7<br>UPM4  |
| 4 | Air Interface Layer 2                 |  | Face-to-face  | 02:00 | 25% | 5 / 10 | CGI03<br>CB6<br>CGI02<br>CGI04<br>UPM1<br>CB7                   |
| 6 | VoLTE and the IP Multimedia Subsystem |  | Face-to-face  | 02:00 | 25% | 5 / 10 | UPM5<br>CB6<br>CGI02<br>UPM1<br>CEM04<br>CB7<br>CB8             |

### 6.1.3. Referred (re-sit) examination

No se ha definido la evaluación extraordinaria.

## 6.2. 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 continuous evaluation methodology is here proposed for this course, based on a set of short quizzes, a short project, or both. This way, main concepts could be properly set up while the attractive of the contents are increased.

The assessment of lab practices based on the realization of a report should be also considered in addition to the former one, in order to get the final grade.

## 7. Teaching resources

---

### 7.1. 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.                           |