



## Course guide

# 804254 - XJO - Networks and Online Games

**Last modified:** 27/08/2024

**Unit in charge:** Image Processing and Multimedia Technology Centre  
**Teaching unit:** 804 - CITM - Image Processing and Multimedia Technology Centre.

**Degree:** BACHELOR'S DEGREE IN VIDEO GAME DESIGN AND DEVELOPMENT (Syllabus 2014). (Compulsory subject).

**Academic year:** 2024    **ECTS Credits:** 6.0    **Languages:** Catalan, English

### LECTURER

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**Coordinating lecturer:** Abadal Cavallé, Sergi

**Others:** Abadal Cavallé, Sergi  
Garcia Belerda, Albert

### PRIOR SKILLS

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To be able to programme and develop computer applications  
To know and be the main Internet tools and services at user level

### REQUIREMENTS

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Programming.

### DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

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#### Specific:

CEVJ 5. Use programming languages, algorithmic patterns, data structures, visual programming tools, game engines and libraries for the development and prototyping of video games, in any genre and for any platform and mobile device.

CEVJ 13. Undertake and manage video game design and development projects, including planning, direction, execution and evaluation.

#### General:

CGFB5VJ. Interpret the structure, operation and interconnection of computer systems, and the basics of their programming.

#### Transversal:

05 TEQ N1. TEAMWORK - Level 1. Working in a team and making positive contributions once the aims and group and individual responsibilities have been defined. Reaching joint decisions on the strategy to be followed.

07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.

04 COE N3. EFFICIENT ORAL AND WRITTEN COMMUNICATION - Level 3. Communicating clearly and efficiently in oral and written presentations. Adapting to audiences and communication aims by using suitable strategies and means.

## TEACHING METHODOLOGY

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The teaching methodology is divided in four parts:

- Sessions for the contents exposition at classroom.
- Practical working sessions at classroom (training for the use of the tools, presentations and use case debates).
- Practical development of on-line games where the concepts learnt during the course will be applied.
- Autonomous work to study and carry out exercises and activities.

In the content presentation sessions, teachers will introduce the theoretical bases of the subject, concepts, methods and results, illustrating them with convenient examples to facilitate their understanding. This also includes a couple sessions where students will choose a topic related to the contents of the course and will present it to the rest of the class.

In the practical work sessions in the classroom, the teacher will guide the student in the application of the theoretical concepts for problem solving, based at all times on critical reasoning. A large project cut into with multiple deliverables will be proposed that the student solves in the classroom and outside the classroom, in order to foster the contact and use of the basic tools necessary for the resolution of problems.

The student, autonomously, must work on the material provided by the teacher and the result of the work-problem sessions in order to assimilate and fix the concepts. Teachers will provide a study and activity monitoring plan (CAMPUS).

The methodology of the subject is a combination between the face-to-face class and the realization of different complementary activities (resolution of cases, problems, etc.), either individually or in small groups, both inside and outside the classroom. In the contact hours the student receives the basic information to work on the contents of the teaching plan that guarantee the achievement of the established objectives.

In the Virtual Campus all the information relative to the subject is published (rules of evaluation, dates of delivery of the activities, etc.). Attendance at the sessions is important for the learning process, which is based on both individual or team work and classroom participation.

## LEARNING OBJECTIVES OF THE SUBJECT

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- To show understanding and application capacity in the on-line game development, about foundations of telematics networks, their capacities and limitations.
- To be able to identify the problems related to online games caused by the network limitations and propose solutions.
- To show knowledge and be able to use network game engines, for the development of online games.
- To show knowledge of game servers and to know how to use them for the development and implementation of online games.
- To show knowledge of protocols at the network, transport, and application layers.

## STUDY LOAD

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| Type               | Hours | Percentage |
|--------------------|-------|------------|
| Self study         | 90,0  | 60.00      |
| Hours large group  | 18,0  | 12.00      |
| Hours medium group | 30,0  | 20.00      |
| Guided activities  | 12,0  | 8.00       |

**Total learning time:** 150 h

## CONTENTS

### 1. Introduction

**Description:**

- 1.1 Presentation of the subject and evaluation criteria
- 1.2 A brief history of networks and on-line games
- 1.3 Architectures and metrics
- 1.4 Graph theory to model networks
- 1.5 Graph algorithms

**Specific objectives:**

To obtain basic knowledge about the history of the Internet and on-line games, about the basic types of network architectures and the metrics used to measure their performance. To learn about the fundamentals of graph theory and algorithms that operate over graphs, which are common to networks and many other domains.

**Related activities:**

Programming with threads

**Related competencies :**

CGFB5VJ. Interpret the structure, operation and interconnection of computer systems, and the basics of their programming.

**Full-or-part-time:** 12h

Theory classes: 4h

Self study : 8h

### 2. The OSI Protocol Stack

**Description:**

- 2.1 Introduction. Application and transport layers
- 2.2 The lower layers: network, link, and physical
- 2.3 Other relevant protocols (NAT, HTTP, QUIC, etc.)
- 2.4 Putting it all together: Wireshark

**Specific objectives:**

To understand the layered structure used in networks, the process of encapsulation, as well as the usefulness of it all. To learn about the functionality of each layer of abstraction, as well as to know the classical protocols in each layer, paying special attention in those that are relevant for the programming of on-line games (IP, TCP/UDP, NAT). To make the connection between the game's data and the network through the data serialization process and the socket. To learn about the use of packet sniffers, and to employ them to observe the packet structure in real networks

**Related activities:**

- 2. Sockets (TCP/UDP)
  - 3. Data serialization
- (it also includes practical NAT concepts)

**Related competencies :**

CEVJ 13. Undertake and manage video game design and development projects, including planning, direction, execution and evaluation.

CGFB5VJ. Interpret the structure, operation and interconnection of computer systems, and the basics of their programming.

05 TEQ N1. TEAMWORK - Level 1. Working in a team and making positive contributions once the aims and group and individual responsibilities have been defined. Reaching joint decisions on the strategy to be followed.

04 COE N3. EFFICIENT ORAL AND WRITTEN COMMUNICATION - Level 3. Communicating clearly and efficiently in oral and written presentations. Adapting to audiences and communication aims by using suitable strategies and means.

07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.

**Full-or-part-time:** 24h

Theory classes: 8h

Self study : 16h



### 3. Impact of the network on the programming of on-line games

**Description:**

- 3.1 Introduction and general aspects. Object replication
- 3.2 Latency, jitter, and reliability
- 3.3 Latency hiding techniques
- 3.4 Scalability and massive multiplayer

**Specific objectives:**

To understand how the network impacts on the programming of on-line games through the study of problems related to the loss of information or delays.

To learn about techniques used to hide the network problems, minimizing their impact so that the game performance is not affected.

To learn about widespread techniques in nowadays games, be them with a few or many simultaneous players.

**Related activities:**

- 4. World-State Replication
- 5. Latency and jitter mitigation techniques
- 6. Complete online game

**Related competencies :**

CEVJ 5. Use programming languages, algorithmic patterns, data structures, visual programming tools, game engines and libraries for the development and prototyping of video games, in any genre and for any platform and mobile device.

CEVJ 13. Undertake and manage video game design and development projects, including planning, direction, execution and evaluation.

05 TEQ N1. TEAMWORK - Level 1. Working in a team and making positive contributions once the aims and group and individual responsibilities have been defined. Reaching joint decisions on the strategy to be followed.

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**Full-or-part-time:** 30h

Theory classes: 10h

Self study : 20h

### 4. Theory presentations

**Description:**

Students will deepen their knowledge on one of the topics of the course, chosen by them and agreed with the professor, to then perform a brief presentation during class.

**Specific objectives:**

- Deepen the knowledge on a specific topic related to networks and online games.
- Collect data and study the topic in an autonomous way.
- Present the topic in a clear way.

**Related activities:**

N/A

**Full-or-part-time:** 18h

Theory classes: 6h

Self study : 12h

## ACTIVITIES

### 1. Threads

**Description:**

Learning how to use parallel code execution mechanisms (threads) and the necessary tools to maintain a proper synchronization amongst them, and to safely access shared memory regions in a concurrent fashion.

**Specific objectives:**

- Threads (mechanisms for parallel/concurrent code execution)
- Mutex objects (mechanism for safe concurrent data access)
- Condition variables (mechanism for synchronization among threads)

**Material:**

Instructions for the exercise and template code.

**Delivery:**

Deliverable #1 (no weight on the final score)

**Related competencies :**

CEVJ 5. Use programming languages, algorithmic patterns, data structures, visual programming tools, game engines and libraries for the development and prototyping of video games, in any genre and for any platform and mobile device.

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05 TEQ N1. TEAMWORK - Level 1. Working in a team and making positive contributions once the aims and group and individual responsibilities have been defined. Reaching joint decisions on the strategy to be followed.

**Full-or-part-time:** 6h

Self study: 4h

Practical classes: 2h

### 2. Sockets (TCP/UDP)

**Description:**

Learning the main mechanisms to use TCP and UDP sockets to transmit and receive data between two or more machines over the network. This activity will set the foundations of the communication of information between client and server in the context of a final project.

**Specific objectives:**

- Sockets TCP (connection oriented)
- Sockets UDP (non-connection oriented)
- Non-blocking usage of sockets functions (non-blocking mode, select).

**Material:**

Instructions for the exercise and code template.

**Delivery:**

Deliverable #2 (5% final score)

**Related competencies :**

CGFB5VJ. Interpret the structure, operation and interconnection of computer systems, and the basics of their programming.

07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal.

Choosing the best path for broadening one's knowledge.

05 TEQ N1. TEAMWORK - Level 1. Working in a team and making positive contributions once the aims and group and individual responsibilities have been defined. Reaching joint decisions on the strategy to be followed.

**Full-or-part-time:** 12h

Self study: 8h

Practical classes: 4h



### 3. Data serialization

**Description:**

Here we will see the importance of data serialization to transmit objects in memory that may be potentially complex, as these objects could not be represented contiguously in memory, and can contain pointers to other objects, thus making impossible copying them directly at once. This activity will expand the project adding the tools necessary to serialize, at least, one of the videogame's objects.

**Specific objectives:**

- Sequential and ordered data access.
- MemoryStream objects.

**Material:**

Instructions for the exercise and code template.

**Delivery:**

Deliverable #3 (5% of final score)

Deliverable #4 - Demo I (10% of final score)

**Related competencies :**

CEVJ 5. Use programming languages, algorithmic patterns, data structures, visual programming tools, game engines and libraries for the development and prototyping of video games, in any genre and for any platform and mobile device.

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Choosing the best path for broadening one's knowledge.

**Full-or-part-time:** 18h

Self study: 12h

Practical classes: 6h



#### 4. World-State Replication

**Description:**

Learn and apply good practice methods to correctly replicate the world-state of our game. This activity will expand the project to add the methods needed to serialize the data of any object of our world and to guarantee the correct reception at the client side.

**Specific objectives:**

- Definition of a replication manager
- Object replication types (active/passive)
- Object-oriented programming

**Material:**

Instructions and definitions.

**Delivery:**

Deliverable #5 (10% of final score)

**Related competencies :**

CEVJ 13. Undertake and manage video game design and development projects, including planning, direction, execution and evaluation.

CEVJ 5. Use programming languages, algorithmic patterns, data structures, visual programming tools, game engines and libraries for the development and prototyping of video games, in any genre and for any platform and mobile device.

CGFB5VJ. Interpret the structure, operation and interconnection of computer systems, and the basics of their programming.

07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.

05 TEQ N1. TEAMWORK - Level 1. Working in a team and making positive contributions once the aims and group and individual responsibilities have been defined. Reaching joint decisions on the strategy to be followed.

**Full-or-part-time:** 12h

Self study: 8h

Practical classes: 4h



## 5. Latency and jitter mitigation techniques

### Description:

Here we'll see the importance of issues such as latency or jitter. The student will implement techniques to mitigate these and other problems derived from the communication in online games. This activity will be an important part of the final project.

### Specific objectives:

- Client-side Prediction
- Server reconciliation
- Entity Interpolation
- Lag Compensation

### Material:

Instructions for the lab sessions and auxiliary code

### Delivery:

Deliverable #6 (10% of final score)

### Related competencies :

CEVJ 13. Undertake and manage video game design and development projects, including planning, direction, execution and evaluation.

CEVJ 5. Use programming languages, algorithmic patterns, data structures, visual programming tools, game engines and libraries for the development and prototyping of video games, in any genre and for any platform and mobile device.

CGFB5VJ. Interpret the structure, operation and interconnection of computer systems, and the basics of their programming.

05 TEQ N1. TEAMWORK - Level 1. Working in a team and making positive contributions once the aims and group and individual responsibilities have been defined. Reaching joint decisions on the strategy to be followed.

07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.

### Full-or-part-time: 12h

Self study: 8h

Practical classes: 4h



## 6. Complete online game

### Description:

We will use the concepts learnt up to this point (threads, sockets, and data serialization) to develop multiplayer online game over the game's foundation developed over the semester. This deliverable will be evaluated taking into consideration the integration of the previous activities in the context of a complete game.

### Specific objectives:

- Client-server architecture.
- Authoritative server.
- Game state replication.
- Messages among hosts.
- Data synchronization mechanisms (commands, syncvars and hooks, client RCPs, etc).

### Material:

Lab session instructions.

### Delivery:

Deliverable #7 - Demo II (10% of final score)

### Related competencies :

CEVJ 5. Use programming languages, algorithmic patterns, data structures, visual programming tools, game engines and libraries for the development and prototyping of video games, in any genre and for any platform and mobile device.

CEVJ 13. Undertake and manage video game design and development projects, including planning, direction, execution and evaluation.

CGFB5VJ. Interpret the structure, operation and interconnection of computer systems, and the basics of their programming.

05 TEQ N1. TEAMWORK - Level 1. Working in a team and making positive contributions once the aims and group and individual responsibilities have been defined. Reaching joint decisions on the strategy to be followed.

07 AAT. SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal. Choosing the best path for broadening one's knowledge.

### Full-or-part-time: 18h

Self study: 12h

Practical classes: 6h

## GRADING SYSTEM

Lab sessions: 50%

(of which: Sockets 5%; data serialization 15%, which includes a mid-term demo; world-state deliverable 10%; latency and jitter management deliverable 10%; complete game demo 10%)

Theory presentation: 10%

Partial exam (theory): 15%

Final exam: 25%

All activities are evaluated by the professors, with the exception of the mid-term and final demos where the evaluation will combine feedback from professors and students.

In case the subject is not passed through the continuous evaluation, there is the option to perform a re-evaluation exam of the theoretical part, corresponding to 50% of the subject's mark. In case of passing the course through re-evaluation, the maximum final mark will be 5.

Irregular actions that may lead to a significant variation of the grade of one or more students constitute a fraudulent performance of an evaluation act. This action entails the descriptive grade of failure and a numerical grade of 0 for the ordinary global evaluation of the course, without the right to re-evaluation.

If the lecturers have indications of the use of AI tools not allowed in the evaluation tests, they may summon the students concerned to an oral test or a meeting to verify the authorship.



## EXAMINATION RULES.

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The activities are assessed on an individual basis, although the theory presentation and the lab deliverables are done in groups. For the practices it is allowed to use all learning material and their submission must be done on the indicated deadline with no option for extension.

Exams will be done with no access to any learning material.

## BIBLIOGRAPHY

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### Basic:

- Tanenbaum, A.S.; Wetherall, D.J. Computer networks. 5th ed. Boston: Pearson, 2011. ISBN 9780132126953.
- Glazer, Josh; Madhav, Sanjay . Multiplayer game programming: Architecting networked games. Addison-Wesley Professional, 2015. ISBN 9780134034331.

## RESOURCES

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### Other resources:

Additional readings that will be published in the Campus Virtual during the course, including:

- The history of Internet
- I shot you first: The Networking of HALO
- 1500 Archers on a 28.8: Network Programming in Age of Empires and Beyond
- The TRIBES Engine Networking Model