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|------------------|-------------------------|----------------|---------------------------------------|
| Course Unit      | Distributed Systems     | Field of study | Computer Engineering                  |
| Bachelor in      | Informatics Engineering | School         | School of Technology and Management   |
| Academic Year    | 2023/2024               | Year of study  | 3                                     |
| Type             | Semestral               | Semester       | 2                                     |
| Level            | 1-3                     | ECTS credits   | 6.0                                   |
| Code             | 9119-706-3203-00-23     |                |                                       |
| Workload (hours) | 162                     | Contact hours  | T 30 TP - PL 30 TC - S - E - OT - O - |

T - Lectures; TP - Lectures and problem-solving; PL - Problem-solving, project or laboratory; TC - Fieldwork; S - Seminar; E - Placement; OT - Tutorial; O - Other

Name(s) of lecturer(s) Luis Filipe Rodrigues Corredeira Lobo, Rui Pedro Sanches de Castro Lopes

### Learning outcomes and competences

At the end of the course unit the learner is expected to be able to:

1. Distinguish a distributed system and understand the reasons for its implementation;
2. Understand the challenges of constructing distributed systems;
3. Differentiate between various models and architectures for distributed systems;
4. Identify problems inherent in concurrent execution of tasks in centralized and distributed environments and implement measures to address them;
5. Implement distributed systems using simple basic communication primitives;
6. Implement distributed systems using existing middleware.

### Prerequisites

Before the course unit the learner is expected to be able to:

1. Know and have experience in object-oriented programming;
2. Know the fundamental concepts of computer architectures;
3. Know the fundamental concepts of operating systems;
4. Know the fundamental concepts of computer networks.

### Course contents

Characterization of distributed systems. Models of distributed systems. Java language. Programming with threads. Inter-process communication. Indirect communication. Architecture and middleware for distributed systems. Distributed coordination.

### Course contents (extended version)

1. Characterization of distributed systems.
  - Definition.
  - Characteristics.
  - Examples.
  - Challenges.
2. Models of distributed systems.
  - Physical models.
  - Architectural models.
  - Fundamental models.
3. Java language.
  - Characteristics of the language.
  - Concepts of object-oriented programming.
  - Data types, operators, expressions, statements and blocks, flow control.
  - Classes and objects. Interfaces and inheritance. Definition and use of generics.
  - Collections framework.
  - Exception handling and streams manipulation.
4. Programming with threads.
  - Threads and Processes.
  - Advantages and applications of multi-threading.
  - Problems associated with multi-threading: Deadlock, livelock and starvation.
  - Parallelization of problems, producer-consumer, thread pools.
5. Inter-process Communication.
  - Request-response protocols.
  - UDP and TCP Protocols. Datagrams and Sockets in Java.
  - Distributed objects. Remote Method Invocation (RMI).
6. Architecture and Middleware for Distributed Systems.
  - Distributed objects systems.
  - Component based middleware.
  - Web Services.
  - Peer-to-peer networks.
7. Distributed coordination.
  - Clock synchronization.
  - Election.

### Recommended reading

1. Couloris, G, Dollimore, J. and Kinberg, T, Distributed Systems - Concepts and Design, 5th Edition, Addison-Wesley, Pearson Education, 2011
2. Andrew S. Tanenbaum and Maarten Van Steen, Distributed Systems: Principles and Paradigms, 2nd Edition, Prentice Hall, Pearson Education, 2007
3. Rogers Cadenhead, Laura Lemay, Sams teach yourself java 6 in 21 days, Sams, 2007
4. Jorge Cardoso, Programação de Sistemas Distribuídos em Java, FCA, 2008
5. Manuais de referências e tutoriais na Internet

### Teaching and learning methods

Lectures using the the expositive method. Problem-solving classes with demonstration of concepts by solving small practical exercises, with periods of resolution in the classroom and autonomous routing of additional tasks for non-presencial work hours. Use of the e-learning platform for the delivery of materials and submission of projects.

**Assessment methods**

- Alternative 1 - (Regular, Student Worker) (Final, Supplementary, Special)
- Projects - 50%
- Final Written Exam - 50%

**Language of instruction**

1. English
2. Portuguese

**Electronic validation**

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|---|--|-------------------|--------------------------|
| Luis Filipe Rodrigues Corredeira Lobo,<br>Rui Pedro Sanches de Castro Lopes | Tiago Miguel Ferreira Guimaraes<br>Pedrosa | Luís Manuel Alves | José Carlos Rufino Amaro |
| 12-02-2024  | 14-03-2024                                 | 18-03-2024        | 24-03-2024               |