UNICUSANO
ROME

Code: ING-INF/05 **Credits: 9**
Matter: Distributed Systems and Blockchain
Main language of instruction: Italian
Other language of instruction: English

Teaching Staff

Head instructor
Dr. Salvatore MONTELEONE - salvatore.monteleone@unicusano.it

Introduction

1. *Objective of the course:*

The Distributed Systems and Blockchain Course aims to provide the student with a good knowledge of the principles that govern distributed systems and decentralized systems, addressing the main issues, the most important models and architectures and finally presenting the main systems implementations of distributed and decentralized services and applications. The course proposes the basic concepts to tackle the study of distributed and decentralized systems and therefore to develop the ability to design distributed applications and services that meet the main constraints of performance, scalability, openness, transparency and security. Furthermore, the educational objective of the Course is to provide the student with detailed knowledge of recent distributed computing paradigms, such as service-oriented architectures and the Cloud, and decentralized, such as Blockchains. The e-tivities associated with the Course develop the skills necessary to design and implement distributed and decentralized systems through the use of testbeds suitable for their development and analysis.

Objectives

2. *Course Structure:*

- Basic elements and characteristics of distributed, decentralized systems and Cloud computing;
- Main models and architectures of distributed systems;
- Main paradigms of communication, synchronization and sharing in a distributed system;
- The fault tolerance problem;
- Algorithms and techniques of distributed processing;

- Environments and tools for the development of distributed systems;
- Concepts and techniques behind DLT and smart contracts.

Competencies:

A. Knowledge and understanding

At the end of the course, the student will have knowledge of advanced programming mechanisms, including asynchronous and distributed programming. Furthermore, the student will acquire the ability to use advanced development mechanisms, including collaborative and distributed development, analysis of data related to the development process, validation of concurrent systems, design and implementation of distributed systems to microservices. Finally, the student will be made able to compare the consequences deriving from the architectural choices to be made in the design of a distributed or decentralized system. Moreover, through the e-tivity, students will acquire the ability to design and implement Cloud, DLT and smart contract systems.

B. Application of knowledge

The student will be able to design distributed and decentralized software systems. E-tivities provide for the application of theoretical knowledge to practical problems, such as the design and implementation of distributed software based on advanced communication and interaction models.

C. Making judgments

The student will be able to identify the most appropriate coordination, consistency and fault tolerance protocols for the services to be provided, analyzing their compliance with the resulting requirements. Moreover, the student will also be able to interpret the performance indicators of a distributed or decentralized system, and to collect the data necessary for the design and configuration of a service-oriented architecture. Finally, the student will be able to perform bibliographic searches, analyze and interpret relevant sources, in order to analyze new protocols, algorithms and applications of interest in the context of distributed and decentralized systems.

D. Communication skills

The student will be able to describe and hold conversations on issues relating to the fundamental characteristics of distributed and decentralized systems, using appropriate terminology.

E. Learning skills

At the end of the course, the student will have knowledge of the fundamental notions necessary to face and solve design and implementation problems in realistic fields, studying, evaluating and using new technologies for distributed and decentralized systems.

Syllabus

3. *Programme of the course:*

Subject 1. Introduction and architectures

Introduction to distributed systems;
Distributed systems architectures;
Introduction to Cloud Computing.

Subject 2. Communication:

Introduction and semantics of communication;
Remote Procedure Call (RPC);
Remote Method Invocation (RMI);
Message Oriented Middleware (MOM): AMQP.

Subject 3. Virtualization and Cloud

Introduction;
Virtualization levels;
Migration: containers and unikernel;
Microservice-based and serverless solutions;
Cloud, Edge, and Fog computing;
Docker, DevOps, and Git tutorial.

Subject 4. Synchronization and coordination

Distributed algorithms;
Physical vs Logical clocks;
Mutual exclusion;
Leader election.

Subject 5. Consistency:

Consistency models;
CAP theorem;
Consistency protocols;
Replication.

Subject 6. Fault tolerance:
Dependability;
Fault tolerance models;
Byzantine fault tolerance;
Distributed consensus: Paxos and Raft;
Commit protocols: 2PC and 3PC.

Subject 7. Decentralized systems:
Introduction to DLT;
Blockchain;
Bitcoin;
Permissioned and Permissionless Blockchains.

Subject 8. Smart contracts:
Ethereum;
Solidity;
DAO as a case study.

Evaluation system and criteria

The examination consists of 5 open-ended questions (6 marks each for a total of 30 out of 30 marks).

In addition, there are four e-tivities, consisting of practical and theoretical problems. These need to be sent to the instructor in advance of the examination. Each e-tivity counts 1.5 marks for a total of 6 out of 30 marks.

Bibliography and resources

4. *Materials to consult:*

Notes written by the instructor, to cover the course contents and examination programme, will be available in English.

5. *Recommended bibliography:*

- Maarten van Steen, Andrew S. Tanenbaum, Distributed Systems, 3rd edition (2017) version 3.03.
  A personal digital copy can be downloaded for free by registering on the authors' website at the link:
  https://www.distributed-systems.net/index.php/books/ds3/ds3-ebook/

- Andreas M. Antonopoulos, Mastering Bitcoin, 2nd edition, O'Reilly Media.
  It is possible to access the text for free on the authors' webpage at:
  https://github.com/bitcoinbook/bitcoinbook/

- Andreas M. Antonopoulos, Gavin Wood, Mastering Ethereum, 1st edition, O'Reilly Media.
  It is possible to access the text for free on the authors' webpage at:
  https://github.com/ethereumbook/ethereumbook