SYLLABUS

1. Data about the program of study

1.1 Institution	The Technical University of Cluj-Napoca
1.2 Faculty	Faculty of Automation and Computer Science
1.3 Department	Computer Science
1.4 Field of study	Computer Science and Information Technology
1.5 Cycle of study	Masters
1.6 Program of study / Qualification	Artificial Intelligence and Vision / Masters
1.7 Form of education	Full time

2. Data about the subject

2.1 Subject name	***Distributed Systems***			Subject code	**3**
2.2 Course responsible / lecturer	Prof. dr. eng. Salomie Ioan - Ioan.Salomie@cs.utcluj.ro				
2.3 Teachers in charge of seminars / Laboratory / project	Prof. dr. eng. Salomie Ioan - Ioan.Salomie@cs.utcluj.ro				
2.4 Year of study	I	2.5 Semester	1	2.6 Type of assessment (E - exam, C - colloquium, V – verification)	E
2.7 Subject category	Formative category: DF – fundamental, DS – speciality, DC – complementary				DF
	Optionality: DOB – mandatory, DOP – optional (alternative), DFA – optional (free choice))				DOB

3. Estimated total time

3.1 Number of hours per week	3	of which:	Course	2	Seminars	1	Laboratory	-	Project	-
3.2 Number of hours per semester	42	of which:	Course	28	Seminars	14	Laboratory	-	Project	-
3.3 Individual study:										
(a) Manual, lecture material and notes, bibliography										30
(b) Supplementary study in the library, online and in the field										15
(c) Preparation for seminars/laboratory works, homework, reports, portfolios, essays										11
(d) Tutoring										-
(e) Exams and tests										2
(f) Other activities:										-

3.4 Total hours of individual study (suma (3.3(a)…3.3(f)))	58
3.5 Total hours per semester (3.2+3.4)	100
3.6 Number of credit points	4

4. Pre-requisites (where appropriate)

4.1 Curriculum	-
4.2 Competence	-

5. Requirements (where appropriate)

5.1. For the course	Projector, Computer, Blackboard (F2F) Teaching materials will be available on MS Teams platform
5.2. For the applications	Projector, Computer, Blackboard (F2F) Teaching materials will be available on MS Teams platform

6. Specific competence

6.1 Professional competences	• define technical requirements • analysis specifications • identifies client needs • defines system architectures • integrate system components • design process • develops services for distributed systems • develop creative ideas • creatively use digital technologies • use data processing techniques • align software with system architectures • create data models in the context of distributed systems • create algorithms and specific programs • designs and implements distributed resources • generates technical documentation • integrate design enterprise architecture • design information system • utilise machine learning • ensures conformity to standards • defines and implements instruments for diagnosis
6.2 Cross competences	The graduate: • develop an analytical approach • taking a proactive approach • developing strategies to solve problems • being open minded • coordinate engineering teams

7. Expected Learning Outcomes

Knowledge	The student has knowledge of: • distributed computational models • distributed algorithms and programs, snapshots and checkpointing • causality and systems of logical clocks • availability and consistency, CAP • termination detection • scalability techniques • coordination, agreement, consensus and associated algorithmsrollback and recovery from errors • fault modeling • dependability, fault tolerance and resiliency • distributed and federative learning models
Skills	The student is able to: • uses digital technologies in a creative way • applies systems theory • defines technical requirementsuses machine learning • designs architectures of complex distributed systems • integrate system components • identifies processes for re-engineering • aligns software and service platforms to systems architecture • designs information systems • designs processes • manages system testing • implements security policies • implements scalability techniques • implements resilient and fault tolerance techniques • applies critical thinking in designing and assessing distributed systems

Responsibilities and autonomy	The student has the ability to work independently in order to: • develop an analytical approach • take a proactive approach • develop strategies to solve problems • be open-minded • coordinate engineering teams

8. Discipline objective (as results from the *key competences gained*)

8.1 General objective	The in-depth study of concepts, techniques, algorithms and advanced methods of specification, modeling, analysis, design, implementation and validation of complex distributed systems; Knowledge of current distributed computing and systems and their applications.
8.2 Specific objectives	-Knowledge and working with specification, modeling, analysis, critical evaluation, design, implementation and validation of complex distributed systems' concepts, methods, techniques and algorithms regarding coordination and agreement, quality of service, availability, consistency and scalability, distributed transactions, service oriented computing, event and data flows, resilience, fault tolerance and recovery, distributed ledgers and decentralized computing, distributed and federated machine learning. -Knowledge of distribution systems based on modern technologies such as Blockchain, Edge, Fog and Cloud, IoT, Cyber-Physical Systems, Big Data, Intelligent Energy and Smart Grids.

9. Contents

9.1 Lectures	Hours	Teaching methods	Notes
Part 1 – Topics of Distributed Computing	2	Presentations with video-projector, chalk and blackboard, live discussions, questions / answers Students are invited to participate in research projects.	
Fundamentals of Distributed Computing (Causality, Logical Time, Global States and Snapshots)	2		
QoS, Availability, Consistency, Scalability	2		
Classes of Distributed Algorithms, Performance metrics	2		
Coordination and Agreement (termination detection, mutual exclusion, leader election, consensus)	2		
Distributed Transactions, Concurrency Control, Distributed Storage	2		
Service Oriented Distributed Computing	2		
Resiliency, Fault Tolerance, Checkpointing and Recovery	2		
P2P, Distributed Ledgers, Decentralized Computing	2		
Distributed and Federated Machine Learning	2		
Part 2 – Modern Distributed Systems	2		
Cloud, Edge, and Fog-based Systems	2		
Decentralized Blockchain-based Systems	2		
IoT, Cyber-Physical Systems	2		
Big Data Analytics, Platforms and Systems	2		
Intelligent Energy, Smart Grids	2		

Bibliography:

1. Maarten van Steen, Andrew S. Tanenbaum - Distributed Systems, 4e, 2023
2. Ratan K. Ghosh, Hiranmay Ghosh - Distributed Systems, Theory and Applications, Wiley, 2023
3. R. Vitillo – Understanding Distributed Systems, 2022
4. Coulourris, G., Dollimore, J., Kindberg, T. - Distributed Systems. Concepts and Design, Addison - Wesley, 5th Edition, 2012
5. Kshemkalyani, A.D., Singhal, M - Distributed Computing. Principles, Algorithms and Systems, Cambridge Univ. Press, 2008
6. Santoro, N. - Design and Analysis of Distributed Algorithms, Wiley 2007
7. Guanhua Wang - Distributed Machine Learning with Python, Pact Publishing, 2022
8. M. Tamer Özsu, Patrick Valduriez - Principles of Distributed Database Systems, 4e, Springer, 2020

9. Sukumar Ghosh - Distributed Systems, Chapman & Hall/CRC, 2015
10. Ioan Salomie, Tudor Cioara, Ionut Anghel, Tudor Salomie - Distributed Computing and Systems. A Practical Approach, Editura Albastra, 2008
11. Clauda Daniela Antal, Ioan Salomie – Blockchain-based Decentralized Technologies for IoT Systems, Asset Markets and Smart Grids, UT Press, 2021

9.2 Applications - Seminars/Laboratory/Project	Hours	Teaching methods	Notes
Context Awareness, Ambient Intelligence, Smart Buildings, Smart Cities	1		
Autonomic Computing and Self-organizing Systems	1		
Web3, Virtual Worlds, Metaverse	1		
Cloud Computing, Resource Allocation, Edge and Fog computing	1		
Bio-inspired/Nature-inspired Computing in Distributed Computing	1		
Business Process Management	1		
Internet of Things (IoT), Platforms and Systems	1		
Cyber-Physical Systems (CPS), Industry 4.0 (Smart Factories), Smart Grids	1		
Complex Systems: Modeling, Simulation, Optimization, Adaptivity	1		
Green Computing, Data Centres	1		
Distributed Data Streams, Big-Data, Map-Reduce, Hadoop, Spark	1		
Distributed and Federated Machine Learning	1		
Decentralized Systems and Applications (DApps). Blockchain	1		
Evaluation	1		

Bibliography

1. IEEE Explore Digital Library, https://www.computer.org/csdl/home
2. ACM Digital Library, https://dl.acm.org/
3. Elsevier Science Direct Journals, https://www.sciencedirect.com/
4. Springer Lecture Notes in Computer Science (LNCS), https://link.springer.com/
5. MDPI Journals, https://www.mdpi.com/
6. Relevant conference proceedings (subdomain specific)
7. Relevant research centers

**Se vor preciza, după caz: tematica seminariilor, lucrările de laborator, tematica și etapele proiectului.*

9. Bridging course contents with the expectations of the representatives of the community, professional associations and employers in the field

Periodical discussions with representatives of outstanding employers.

10. Evaluation

Activity type	Assessment criteria	Assessment methods	Weight in the final grade
Course	The ability to conceptualize, synthesize, analyse, specify, and critically evaluate, domain specific problems	Written exam	50%
Seminar	The ability to yield and present a research study / report about the state of the art of a modern distributed computing / system as a result of investigating relevant resources (journals, conference proceedings, and research centres to identify main research questions, domain challenges and research achievements and	Continuous evaluation during seminar sessions	50%

	highlighting the relevant techniques, methods, algorithms, models, methodologies and platforms.		
Laboratory	-		
Project	-		

Minimum standard of performance:
- Knowledge of the notions, concepts, issues, techniques and fundamental elements and their inter-relationship, related to distributed computing and modern distributed systems.
- Elaboration of an original, critical, research study / report about one of the application areas of modern distributed computing / systems.
- Exam participation condition: Elaboration and submission of the research study / report.
- Exam pass conditions: Grade 5 in the written exam and in the seminar evaluation.

Date of filling in: 29.04.2026	**Responsible**	**Title First name Last name**	**Signature**
	Course	Prof.dr.eng. Ioan SALOMIE	
	Applications	Prof.dr.eng. Ioan SALOMIE	
		Prof.dr.eng. Ionut ANGHEL	

Date of approval in the department	Head of department, Prof.dr.eng. Rodica Potolea
Date of approval in the Faculty Council	Dean, Prof.dr.eng. Vlad Mureșan