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	Master of Science
1.6	Program of study/Qualification	Artificial Intelligence and Vision/ Master
1.7	Form of education	Full time
1.8	Subject code	

2. Data about the subject

2.1	Subject name			***Distributed Systems***			
2.2	Subject area						
2.2	Course responsible/lecturer			Prof. dr. ing. Ioan Salomie - Ioan.Salomie@cs.utcluj.ro			
2.3	Teachers in charge of seminars			Prof. dr. ing. Ioan Salomie - Ioan.Salomie@cs.utcluj.ro Prof.dr.ing. Tudor Cioara, Prof.dr.ing. Ionut Anghel			
2.4 Year of study	1	2.5 Semester	1	2.6 Assessment			Exam
2.7 Subject category	Formative category: DA – advanced, DS – speciality, DC – complementary						DA
	Optionality: DI – imposed, DO – optional (alternative), DF – optional (free choice)						DI

3. Estimated total time

3.1 Number of hours per week	3	of which	3.2 Course	2	3.3 Seminar	1	3.3 Laboratory	-	3.3 Project	-
3.4 Total hours in the curriculum	42	of which	3.5 Course	28	3.6 Seminar	14	3.6 Laboratory	-	3.6 Project	-

3.7 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	-

3.8 Total hours of individual study (sum (3.7(a)…3.7(f)))	58
3.9 Total hours per semester (3.4+3.8)	100
3.10 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) MS Teams (Online) Teaching materials will be available on MS Teams platform
5.2	For the applications (seminar)	Projector, Computer, Blackboard (F2F) MS Teams (Online) Teaching materials will be available on MS Teams platform

6. Specific competences

Professional competences	**C1** – Operation with mathematical methods and models, engineering and IT techniques and technologies • **C1.1** – Knowledge and demonstrating of advanced theoretical and practical concepts and principles in the area of distributed computing and systems. **C1.2** - Using of specific theories and instruments (algorithms, schemes, models, methods, techniques, tools, etc.) for explaining of the structure and operation of the most recent distributed systems technologies, environments, platforms and programming systems reported in the literature. **C1.3** – Using of specific models and methods for identifying of viable components and solutions for partially specified systems. **C1.4** – Formal and comparative evaluation of the features, methods, techniques and models of software development and of complex software systems. • **C1.5** – Defining the theoretical basics of complex software system features, based on modern theoretical and practical trends that are used in all phases of distributed systems development (specification, analysis, design, implementation, testing and integration, validation). **C2 -** Development of advanced algorithms, techniques, methods, and methodologies in the field of modern distributed systems design, environments and program systems and their applications. • **C2.1 -** Identifying and describing the structure and operation of complex software systems and the applications developed on these basis. • **C2.2 -** Exploitation of specialized knowledge to identify and understand the methodologies and techniques for making specific hardware and software components. • **C2.3 -** The construction of original components of advanced program systems, using algorithms, techniques, design methods, methodologies, protocols, programming languages, data structures, technologies and complex programming environments, reported in the specialized literature. • **C2.4 -** The use of methods, criteria and metrics for evaluation and selection of implementation methodologies, of the functional and non-functional characteristics of distributed systems**.** **C2.5 -** The development of original projects, their implementation, testing and validation based on the innovative combination of those reported in the literature
Cross competences	N/A

7. Discipline objectives (as results from the *key competences gained*)

7.1	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.
7.2	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.

8. Contents

8.1. Lecture (syllabus)	Number of hours	Teaching methods	Notes
Part 1 – Topics of Distributed Computing			
Fundamentals of Distributed Computing (Causality, Logical Time, Global States and Snapshots)	1		
Coordination and Agreement (termination detection, mutual exclusion, leader election, consensus)	1		
Distributed Transactions, Concurrency Control, Distributed Storage	1		
QoS, Availability, Consistency, Scalability	1		
Service Oriented Distributed Computing	1		
Event and Data Streams	1		
Resiliency, Fault Tolerance, Checkpointing and Recovery	1		
P2P, Distributed Ledgers, Decentralized Computing	1		
Distributed and Federated Machine Learning	1		
Part 2 – Modern Distributed Systems			
Decentralized Blockchain-based Systems	1		
Cloud, Edge, and Fog-based Systems	1		
IoT, Cyber-Physical Systems	1		
Big Data Analytics, Platforms and Systems	1		
Intelligent Energy, Smart Grids	1		

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

8.2. Seminars	Number of hours	Teaching methods	Notes
Contex Awareness, Autonomic Computing and Self-organizing Systems	2	Guiding students to study relevant resources (journal papers, conference proceedings, and research centers) for yielding research studies / reports about one of the listed application areas of modern distributed computing / systems,	
Edge, Fog and Clould Systems - Resource Allocation	2		
Industry 4.0, Smart Factories	2		
Web3, Virtual Worlds, Metaverse	2		
Decentralized, Blockchain-based Applications (DApps) Systems and Organizations	2		
Intelligent Energy, Smart Grids	2		

		focusing on main research questions, domain challenges and research achievements highlighting the relevant techniques, methods, algorithms, models, methodologies and platforms.	
Evaluation	2		

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/

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 in the region

10. Evaluation

Activity type	10.1 Assessment criteria	10.2 Assessment methods	10.3 Weight in the final grade
10.4 Course	The ability to conceptualize, synthesize, analyse, specify, and critically evaluate, domain specific problems	Written exam	50%
10.5 Seminars	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 highlighting the relevant techniques, methods, algorithms, models, methodologies and platforms.	Continuous evaluation during seminar sessions	50%
10.6 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 of the research study / report.
- Exam pass conditions: Grade 5 in the written exam and in the seminar evaluation.

Date of filling in:		**Title Surname Name**	**Signature**
	Lecturer	Prof.dr.ing. Ioan Salomie	
	Teachers in charge of application	Prof.dr.ing. Ioan Salomie	
		Prof.dr.ing. Tudor Cioara	
		Prof.dr.ing. Ionut Anghel	

Date of approval in the department 20.02.2024	Head of department Prof.dr.ing. Rodica Potolea
Date of approval in the faculty council 22.02.2024	Dean Prof.dr.ing. Mihaela Dinsoreanu