Universitatea Naţională de Ştiinţă şi Tehnologie Politehnica Bucureşti
Facultatea de Electronică, Telecomunicaţii şi
Tehnologia Informaţiei

COURSE DESCRIPTION

1. Program identification information

1.1 Higher education institution	**National University of Science and Technology Politehnica Bucharest**
1.2 Faculty	**Electronics, Telecommunications and Information Technology**
1.3 Department	**Applied Electronics and Information Engineering**
1.4 Domain of studies	Electronic Engineering, Telecommunications and Information Technology
1.5 Cycle of studies	Bachelor/Undergraduate
1.6 Programme of studies	Applied Electronics

2. Date despre disciplină

2.1 Course name (ro) (en)				Sisteme de comunicaţii mobile Mobile communications systems			
2.2 Course Lecturer				Prof. Dr. Razvan Craciunescu			
2.3 Instructor for practical activities				Prof. Dr. Razvan Craciunescu			
2.4 Year of studies	4	2.5 Semester	2	2.6. Evaluation type	V	2.7 Course regime	Ob
2.8 Course type		S	2.9 Course code	04.S.08.O.114		2.10 Tipul de notare	Nota

3. Total estimated time (hours per semester for academic activities)

3.1 Number of hours per week	3	Out of which: 3.2 course	2	3.3 seminary/laboratory	1
3.4 Total hours in the curricula	42	Out of which: 3.5 course	28	3.6 seminary/laboratory	14
Distribution of time:					hours
Study according to the manual, course support, bibliography and hand notes Supplemental documentation (library, electronic access resources, in the field, etc) Preparation for practical activities, homework, essays, portfolios, etc.					28
Tutoring					3
Examinations					2
Other activities (if any):					0

3.7 Total hours of individual study	33.00
3.8 Total hours per semester	75
3.9 Number of ECTS credit points	3

4. Prerequisites (if applicable) (where applicable)

4.1 Curriculum	
4.2 Results of learning	

5. Necessary conditions for the optimal development of teaching activities (where applicable)

5.1 Course	

5.2 Seminary/ Laboratory/Project	Attendance at the laboratories is mandatory (according to the undergraduate studies regulation at UNSTPB).

6. General objective *(Reffering to the teachers' intentions for students and to what the students will be thought during the course. It offers an idea on the position of course in the scientific domain, as well as the role it has for the study programme. The course topics, the justification of including the course in the currcula of the study programme, etc. will be described in a general manner)*

The integration of IoT within mobile communications, especially in the 5G context, represents another critical dimension of the course. Students will explore how IoT and 5G complement each other, facilitating the development of innovative and efficient solutions for a wide range of applications, from smart cities to Industry 4.0. The course will also cover IoT-specific emerging technologies, such as advanced sensors and edge computing, focusing on how these can be integrated into 5G ecosystems to enhance performance, efficiency, and security.

7. Competences *(Proven capacity to use knowledge, aptitudes and personal, social and/or methodological abilities in work or study situations and for personal and proffesional growth. They refflect the empolyers requirements.)*

Specific Competences	Correlates knowledge, coherently and correctly argues and analyzes the context of applying basic domain knowledge, using key concepts of the discipline and specific methodology.
Transversal (General) Competences	Analytical and synthesis ability: concisely presents the acquired knowledge, as a result of a systematic analysis process.

8. Learning outcomes *(Synthetic descriptions for what a student will be capable of doing or showing at the completion of a course. The learning outcomes reflect the student's acomplishments and to a lesser extent the teachers' intentions. The learning outcomes inform the students of what is expected from them with respect to performance and to obtain the desired grades and ECTS points. They are defined in concise terms, using verbs similar to the examples below and indicate what will be required for evaluation. The learning outcomes will be formulated so that the correlation with the competences defined in section 7 is highlighted.)*

Knowledge	*The result of knowledge aquisition through learning. The knowledge represents the totality of facts, priciples, theories and practices for a given work or study field. They can be theoretical and/or factual.* It lists the most important stages in an IoT and 5G-IoT system. Defines notions specific to the field of hybrid communications. Describes/classifies notions/processes/phenomena encountered in a hybrid communication system
Skills	*The capacity to apply the knowledge and use the know-how for completing tasks and solving problems. The skills are described as being cognitive (requiring the use of logical, intuitive and creative thinking) or practical (implying manual dexterity and the use of methods, materials, tools and intrumentation).* Analyzes and compares different techniques encountered in hybrid communication systems
Responsability and autonomy	*The student's capacity to autonomously and responsably apply their knowledge and skills.* Select appropriate bibliographic sources and analyze them. Respect the principles of academic ethics, correctly citing the bibliographic sources used. Demonstrates collaboration with other colleagues and teaching staff in carrying out teaching activities

9. Teaching techniques *(Student centric techniques will be considered. The means for students to participate in defining their own study path, the identification of eventual fallbacks and the remedial measures that will be adopted in those cases will be described.)*

The teaching is based on the use of the video projector (covering the communication function and demonstrative); the oral communication methods used are the expository method and the problematization method, used frontally. Course materials are: course notes and presentations, collections of proposed problems (theoretical and with computer or blackboard solutions). All materials are available in electronic format, through the course site (Moodle)

10. Contents

COURSE		
Chapter	**Content**	**No. hours**
1	Evolution of Mobile Networks – from 1G to 6G Objectives: Provide a historical overview of the generations (1G-4G): key technologies, limitations. Transition to 5G: requirements, use cases (eMBB, URLLC, mMTC). Introduction to 6G: development directions (THz, AI-native, sensing integration).	2
2	5G Architecture – Components and Principles Objectives: 5G Architecture: RAN (Radio Access Network) vs. Core Network. Service-Based Architecture (SBA) and function decomposition (NFs). The role of cloud computing and virtualization in 5G.	4
3	Radio Access Network (RAN) in 5G Massive MIMO: digital/analog beamforming New Radio (NR): FR1/FR2, flexible numerology Open RAN: the split as per the O-RAN Alliance (RU/DU/CU) Physical dimension: small cells vs. macro cells	2
4	Key Technologies in the Core Network Objectives: Software-Defined Networking (SDN): centralized control and separation of planes. Network Function Virtualization (NFV): migrating from hardware to software. Network Slicing: creating dedicated virtual networks (e.g., slice for URLLC vs. eMBB).	2
5	Artificial Intelligence in 5G Objectives: AI for network optimization: traffic management, congestion prediction. Network Automation: resource orchestration using machine learning. Case studies: algorithms for load balancing and energy efficiency.	4

6	Advancements in Networks – Slicing, Edge Computing, SON, Zero-Touch, and Virtual Base Stations Objectives: Introduce technologies that enable the flexibility and scalability of modern networks. Topics: Network Slicing: concepts, implementations, and challenges. Edge Computing: the importance of processing at the network edge. SON (Self-Organizing Networks): network automation and optimization. Zero-Touch Management: approaches for autonomous administration. Virtual Base Stations: the role and benefits of virtualizing base stations.	2
7	Positioning and ISAC in 5G/6G Objectives: Positioning technologies: GPS, 5G Positioning. Integrated Sensing and Communication (ISAC): using radio signals for sensing. Applications: autonomous systems, obstacle detection.	2
8	Security in 5G/6G Networks Objectives: Security challenges: virtualization, multi-tenant slicing. Encryption and authentication methods. The role of AI in intrusion detection.	2
9	LPWAN and LoRa – Networks for IoT Objectives: Low-Power Wide-Area Networks (LPWAN): principles and standards (LoRa, NB-IoT, Sigfox). LoRaWAN Architecture: gateway, network servers. Comparison between LPWAN and 5G-mMTC.	4
10	6G Vision – Emerging Technologies and Future Perspectives Objectives: Present the concepts and technologies that will define 6th generation networks. Topics: New paradigms: holographic networks, ultra-low latency communications, and integrated systems (ISAC). The role of artificial intelligence and automation in 6G networks. Challenges and research directions.	2

11	Practical Applications – Smart Cities, Industry 4.0, and Autonomous Vehicles Objectives: Illustrate how 5G/6G and IoT technologies are transforming various industrial sectors. Topics: Case studies on implementations in smart cities and urban infrastructures. Applications in industry and the role of IoT in Industry 4.0. Communication for autonomous vehicles and dedicated networks.	2
	Total:	28

Bibliography:
Razvan Craciunescu - lecture notes - Moodle
STEFAN ROMMER, PETER HEDMAN, MAGNUS OLSSON, LARS FRID, SHABNAM SULTANA, CATHERINE MULLIGAN, 5G CORE NETWORKS, Academic Press 2020, ISBN 978-0-08-103009-7

LABORATORY

Crt. no.	Content	No. hours
1	Introduction to Docker Containers	2
2	Introduction to Kubernetes	2
3	IoT System with Long-Range Transmission (WiFi + Data Processing Platform + Cloud Platform)	4
4	IoT System with Long-Range Transmission (LoRa + Data Processing Platform + Cloud Platform)	4
5	Private 5G Mobile Networks	2
	Total:	14

Bibliography:
Razvan Craciunescu, Lucrari de laborator SHCM, Moodle

11. Evaluation

Activity type	11.1 Evaluation criteria	11.2 Evaluation methods	11.3 Percentage of final grade
11.4 Course	Knowledge of theoretical notions fundamentals related to IoT and 5G-IoT systems. Knowing how to apply of the theory at solving some problems specific the domain.	Written exam in last week, of courses.	20%

11.5 Seminary/laboratory/project	Understanding techniques fundamentals of IoT and 5G-IoT systems.	Laboratory sheet for each laboratory work	80%
11.6 Passing conditions			
Obtaining 50% of the total score. Carrying out the obligations characteristic of the laboratory activity (participation in the planned works)			

12. Corroborate the content of the course with the expectations of representatives of employers and representative professional associations in the field of the program, as well as with the current state of knowledge in the scientific field approached and practices in higher education institutions in the European Higher Education Area (EHEA)

The correlation of the "Hybrid Mobile Communications Systems" course content with the expectations of employers and representative professional associations in the relevant field, as well as with the current state of knowledge in the field of mobile communications and IoT, is essential to ensure the relevance and applicability of the knowledge conveyed to students. In the context of rapid technological advances and the increasing need for innovation in the telecommunications sector, employers are looking for well-prepared professionals capable of understanding and implementing advanced solutions that integrate 5G and IoT technologies. This course is designed to directly meet these requirements, providing students with critical skills in designing, implementing, and managing advanced mobile communication systems.

Professional associations emphasize the importance of a deep understanding of new technologies and their impact on society, promoting high standards in education and professional practice. The course aligns with these expectations by integrating the latest research and innovations in the field, as well as by adopting a practical approach that allows students to apply theory to concrete projects and case studies relevant to the industry.

Furthermore, correlating the course content with educational practices in higher education institutions within the European Higher Education Area (EHEA) ensures that the program remains up-to-date with international standards in engineering education. This includes the adoption of innovative learning methods, such as project-based learning and interdisciplinary collaboration, which are essential for training graduates capable of navigating technological complexity and effectively collaborating within multidisciplinary teams.

By aligning with industry expectations, professional standards, and leading educational practices, the "Hybrid Mobile Communications Systems" course positions itself as a crucial element in training future specialists in mobile communications and IoT, preparing students not only for current challenges but also for future innovations in the field.

Date Course lecturer Instructor(s) for practical activities

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25.09.2025	Prof. Dr. Razvan Craciunescu	Prof. Dr. Razvan Craciunescu
Date of department approval	Head of department	
26.09.2025	Conf. Dr. Bogdan Cristian Florea	
Date of approval in the Faculty Council	Dean	
26.09.2025	Prof. Dr. Mihnea Udrea	