Universitatea Națională de Știință și Tehnologie Politehnica București
Facultatea de Electronică, Telecomunicații și
Tehnologia Informației

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	**Electronic Devices, Circuits and Architectures**
1.4 Domain of studies	Electronic Engineering, Telecommunications and Information Technology
1.5 Cycle of studies	Masters
1.6 Programme of studies	Advanced Computing in Embedded Systems

2. Date despre disciplină

2.1 Course name (ro) (en)				Rețele de senzori fără fir și IoT Wireless Sensor Networks and the Internet of Things			
2.2 Course Lecturer				Conf. Dr. Razvan Craciunescu			
2.3 Instructor for practical activities				Conf. Dr. Razvan Craciunescu			
2.4 Year of studies	2	2.5 Semester	I	2.6. Evaluation type	E	2.7 Course regime	Ob
2.8 Course type		DA	2.9 Course code	UPB.04.M3.O.26-22		2.10 Tipul de notare	Nota

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

3.1 Number of hours per week	4	Out of which: 3.2 course	2.00	3.3 seminary/laboratory	2
3.4 Total hours in the curricula	56.00	Out of which: 3.5 course	28	3.6 seminary/laboratory	28
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.					61
Tutoring					2
Examinations					4
Other activities (if any):					0

3.7 Total hours of individual study	69.00
3.8 Total hours per semester	125
3.9 Number of ECTS credit points	5

4. Prerequisites (if applicable) (where applicable)

4.1 Curriculum	Operating Systems, Computer Programming, Databases, Local Networks, Communication Protocols, Embedded Systems, Microprocessor Design

4.2 Results of learning	Proficiency in using an operating system, application development environment, programming in Python and C/C++, and command-line usage

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

5.1 Course	Room with projector and whiteboard
5.2 Seminary/ Laboratory/Project	Room with computer systems and internet access

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 course aims to explain the fundamental ideas behind IoT networks and the constraints related to planning processes in such a network. It addresses the hardware and software architecture of IoT networks, focusing on communication, cost, and energy consumption constraints. The course studies techniques for optimizing IoT network design and real-time event handling. Additionally, it covers the design of operating systems for wireless sensor nodes.

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	• Demonstrates basic knowledge of theoretical concepts and methods for developing IoT systems. • Applies the acquired theoretical knowledge in practice and uses hardware components to develop IoT systems. • Uses standardized methods and tools specific to the IoT domain for the evaluation and planning process in IoT system management, based on the problems to be solved, identifying solutions. • Coherently and correctly argues and analyzes the context for applying fundamental knowledge in the IoT field, using key discipline concepts and specific methodology. • Oral and written communication in Romanian: uses the scientific vocabulary specific to the studied field for efficient and correct communication, both written and oral. • Oral and written communication in a foreign language (English): demonstrates understanding and correct application of vocabulary specific to the studied field in a foreign language

Transversal (General) Competences	• Communicates efficiently, especially during application sessions, coordinating efforts with others to solve medium complexity problems. • Autonomy and critical thinking: the ability to think scientifically, independently search and analyze data, identify solutions, and present conclusions. • Analytical and synthetic skills: presents in a synthetic manner the knowledge acquired through systematic analysis. • Observes academic ethical principles: correctly cites bibliographic sources used in documentation. • Practices emotional intelligence in socio-emotional management, demonstrating self-control and objectivity in decision-making or stressful situations.

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.* • • Knowledge of the fundamental concepts in designing an IoT sensor node. • Knowledge of the fundamental concepts related to IoT-specific protocols and operating systems. • Implementing IoT systems using IoT-specific protocols, algorithms, and operating systems. • Programming, simulating, and designing IoT nodes and networks.
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).* • Operating with scientific concepts and methods in the field of Computing and Information Technology. • Learning the basics of IoT network functionality. • Knowledge of the key elements in IoT network and sensor node design techniques. • Knowledge of basic elements specific to IoT network protocols and applications. • Solving problems using computer science and engineering tools.
Responsability and autonomy	*The student's capacity to autonomously and responsably apply their knowledge and skills.* • Carrying out professional tasks with honorable, responsible, ethical behavior in the spirit of the law to maintain the profession's reputation. • Taking different roles in project teams and clearly and concisely describing, orally and in writing, results in Romanian and an international language. • Demonstrating creativity, initiative, and action in updating professional, economic, and organizational culture knowledge.

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.)*

Teaching will explore both expository methods (lecture, presentation) and conversational-interactive methods, based on discovery learning models facilitated by direct and indirect exploration of reality (experiment, demonstration, modeling), as well as action-based methods such as exercise, practical activities, and problem-solving. Each lecture begins with a recap of previously covered chapters, with an emphasis on the concepts discussed in the last lecture.

PowerPoint presentations or different videos will be used in the teaching process, made available to students. Presentations use images and diagrams, ensuring that the information presented is easy to understand and assimilate.

10. Contents

COURSE		
Chapter	**Content**	**No. hours**
1	Introduction to Internet of Things systems	2
2	Presentation of use cases and real-world applications of IoT systems.	2
3	Physical layer. Wireless Communication. Antennas and signal propagation. Modulation and channel capacity.	3
4	IoT communication protocol stack: IEEE 802.15.4, 6LoWPAN, CoAP, MQTT, DDS, AMQP.	3
5	IoT communication models: client-server, publish-subscribe, push-pull, exclusive pair. REST communication. Web Sockets communication.	3
6	IoT system design methodology. Presentation of practical examples of IoT system design and implementation.	3
7	Operating systems for IoT. Requirements and constraints for IoT operating systems. TinyOS, ContikiOS, RIOTOS, NuttX OS.	3
8	MQTT Protocol. Publish-subscribe model. QoS levels. Implementing an IoT application using MQTT.	3
9	CoAP Protocol. Web and REST model. Features and operation of the protocol. Message types. Comparison between CoAP and MQTT. Implementing an IoT application using CoAP.	3
10	IoT network security. Main attack types. Security assurance mechanisms. Secure protocols.	3
	Total:	

Bibliography:

1. Razvan Craciunescu, course Internet of Things, moodle
2. Al-Masri, Eyhab, et al. "Investigating messaging protocols for the Internet of Things (IoT)." IEEE Access 8 (2020): 94880-94911.
3. Tsiknas, Konstantinos, et al. "Cyber Threats to Industrial IoT: A Survey on Attacks and Countermeasures." IoT 2.1 (2021): 163-188.
4. Stoyanova, Maria, et al. "A survey on the internet of things (IoT) forensics: challenges, approaches, and open issues." IEEE Communications Surveys & Tutorials 22.2 (2020): 1191-1221.
5. Tournier, Jonathan, et al. "A survey of IoT protocols and their security issues through the lens of a generic IoT stack." Internet of Things (2020): 100264.
6. Sobin, C. C. "A survey on architecture, protocols and challenges in IoT." Wireless Personal Communications 112.3 (2020): 1383-1429.
7. Kassab, Wafa'A., and Khalid A. Darabkh. "A–Z survey of Internet of Things: Architectures, protocols, applications, recent advances, future directions and recommendations." Journal of Network and Computer Applications 163 (2020): 102663.
8. Buratti, Chiara, et al. "IoT protocols, architectures, and applications." Inclusive Radio Communications for 5G and Beyond. Academic Press, 2021. 187-220.
9. Bansal, Malti. "Performance Comparison of MQTT and CoAP Protocols in Different Simulation Environments." Inventive Communication and Computational Technologies. Springer, Singapore, 2021. 549-560.
10. Bansal, Sharu, and Dilip Kumar. "IoT ecosystem: A survey on devices, gateways, operating systems, middleware and communication." International Journal of Wireless Information Networks (2020): 1-25.

LABORATORY

Crt. no.	Content	No. hours
1	Introduction to the architecture of wireless sensor networks.	4
2	Introduction to OMNeT++ for network simulations.	4
3	IoT system with long-distance transmission (LoRa + Data Processing Platform).	4
4	LTE CAT-M and NB-IoT. Theoretical introduction and applications.	4
5	Data analytics. Theoretical introduction and applications.	4
6	Exploring cloud technologies: Using Raspberry Pi sensors for innovative solutions	4
7	Exploring cloud technologies: Presence monitoring system with Raspberry Pi camera and MQTT communication.	4
	Total:	

Bibliography:

1. Razvan Craciunescu, lab Internet of Things, moodle
2. Al-Masri, Eyhab, et al. "Investigating messaging protocols for the Internet of Things (IoT)." IEEE Access 8 (2020): 94880-94911.
3. Tsiknas, Konstantinos, et al. "Cyber Threats to Industrial IoT: A Survey on Attacks and Countermeasures." IoT 2.1 (2021): 163-188.
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11. Evaluation

Activity type	11.1 Evaluation criteria	11.2 Evaluation methods	11.3 Percentage of final grade
11.4 Course	Final exam	Written evaluation through final exam	50%
11.5 Seminary/laboratory/project	Lab activity	Written evaluation based on laboratory work	50%
11.6 Passing conditions			
Obtaining 50% of the total score. Fulfilling the obligations specific to laboratory activities (participation in the scheduled sessions).			

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 alignment of the course content for "Wireless Sensor Networks and the Internet of Things" with the expectations of employers and professional associations, 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 imparted to students. In the context of rapid technological advances and the increasing need for innovation in the telecommunications sector, employers are seeking well-prepared professionals who are

able to understand and implement advanced solutions that integrate IoT technologies. This course is designed to meet these requirements directly, providing students with critical skills in the design, implementation, and management of advanced mobile communication systems.

Professional associations emphasize the importance of a deep understanding of new technologies and their societal impact, 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 in concrete projects and case studies relevant to the industry.

Furthermore, the alignment of the course content with the educational practices of higher education institutions in 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 preparing graduates to navigate technological complexity and collaborate effectively within multidisciplinary teams.

By aligning with industry expectations, professional standards, and leading educational practices, the course "Wireless Sensor Networks and the Internet of Things" 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
09.09.2022	Conf. Dr. Razvan Craciunescu	Conf. Dr. Razvan Craciunescu

Date of department approval	Head of department
31.10.2024	Prof. Dr. Claudius DAN

Date of approval in the Faculty Council	Dean
01.11.2024	Prof. Dr. Mihnea Udrea