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	**Telecommunications**
1.4 Domain of studies	Electronic Engineering, Telecommunications and Information Technology
1.5 Cycle of studies	Masters
1.6 Programme of studies	Mobile Communications

2. Date despre disciplină

2.1 Course name (ro) (en)				Virtualizarea sistemelor de comunicaţii mobile			
2.2 Course Lecturer				Conf. Dr. Alexandru Vulpe			
2.3 Instructor for practical activities				As Răzvan Mihai			
2.4 Year of studies	2	2.5 Semester	1	2.6. Evaluation type	V	2.7 Course regime	Ob
2.8 Course type		DA	2.9 Course code	UPB.04.M3.O.08-36		2.10 Tipul de notare	Nota

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

3.1 Number of hours per week	2	Out of which: 3.2 course	1	3.3 seminary/laboratory	1
3.4 Total hours in the curricula	28	Out of which: 3.5 course	14	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.					20
Tutoring					0
Examinations					2
Other activities (if any):					0

3.7 Total hours of individual study	22.00
3.8 Total hours per semester	50
3.9 Number of ECTS credit points	2

4. Prerequisites (if applicable) (where applicable)

4.1 Curriculum	Completion of the following disciplines: – Computer programming and programming languages (1 and 2)
4.2 Results of learning	Accumulation of the following general knowledge: – fundamental programming concepts computers and operating systems.

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

5.1 Course	The course lectures needs a room with videoprojector and whiteboard
5.2 Seminary/ Laboratory/Project	The lab needs a room with videoprojector, computers, software for virtual machines (e.g. Linux) 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 main aim of this discipline is to provide students with a solid and practical understanding of the main concepts and technologies associated with the provision and use of Cloud mobile communication services. This course aims to explain the different Cloud service models such as Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS) and their fundamental characteristics. By including this course in the curriculum, the aim is to prepare students to understand and apply these technologies, considering their relevance in the current context of the mobile communications industry and the scalability and flexibility needs of modern organizations.

At the end of the course, students will acquire the necessary skills to manage Cloud resources , implement scalable solutions and optimize the use of Cloud infrastructures . They will understand the principles of virtualization, resource provisioning mechanisms, and challenges related to security and data management in Cloud environments . The course will also cover topics such as resource scalability , data storage management, as well as the interaction between the various layers of a Cloud system .

The laboratory associated with this course will give students the opportunity to put into practice the concepts discussed, through hands -on exercises that include configuring and managing Cloud infrastructures, analyzing network traffic and testing security solutions for Cloud resources . Students will have the opportunity to explore various Cloud platforms (Docker , Kubernetes , AWS, etc.) and implement real solutions, preparing them for the challenges of the professional environment.

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 existing virtualization concepts and methods for IT and communications infrastructures.** – **Apply** the acquired theoretical knowledge in practice and use virtual machines to simulate various virtualization solutions. - **Apply** standardized methods and tools, specific to the field of virtualization of mobile communications, to **carry out the process of evaluation and planning** of the process of virtualization of mobile communications systems, depending on the problems to be solved and **identify** solutions. – **Argue and analyze** coherently and correctly the context of application of the basic knowledge of the field of virtualization of mobile communications, using key concepts of the discipline and the specific methodology. – **Oral and written communication in Romanian:** uses the scientific vocabulary specific to the field studied, in order to communicate effectively and correctly, in writing and orally. – **Oral and written communication in a foreign language (English):** demonstrates the understanding and correct application of the vocabulary related to the field studied, in a foreign language

Transversal (General) Competences	– **Communicates effectively,** especially during application hours, coordinating efforts with others to **solve problem situations** of medium complexity. – **Autonomy and critical thinking:** the ability to think in scientific terms, search and analyze data independently, identify solutions, and draw and present conclusions. - **Ability to analyze and synthesize** : present the acquired knowledge in a synthetic way, as a result of a systematic analysis process. - **Respect the principles of academic ethics:** correctly cite the bibliographic sources used in the documentation activity. – Put into practice elements of **emotional intelligence in the adequate** socio - emotional management of some situations in academic life, demonstrating self-control and objectivity in decision-making or in 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.* – Correctly **defines** the basic notions of the field of virtualization of computing resources. – Properly **describes the fundamental concepts related to the implementation of virtualization solutions and the extension of these functionalities to mobile communication networks.** – **Highlights** ways to test and evaluate performance specific to virtualization solutions. – **Understand** the differences between different types of hypervisors and cloud solutions . – **Defines and uses** the basics related to developing virtualized networks for interconnecting containerized resources. – **Is able to explain** ways to integrate virtualization solutions into mobile infrastructures, including interoperability and scalability issues . – **Understand** the challenges and solutions for securing virtualized communications 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).* – **Select** and **group** relevant information related to resource virtualization in a given context, thus being able to describe various theoretical and practical aspects of virtualization in mobile communication networks. - **Applies** the concepts of virtualization in a reasoned manner in order to correctly address the specific problems of mobile communication networks. – **Test and verify** proposed solutions for mobile network virtualization, using appropriate tools and methods. – **Formulate correct conclusions** following experiments carried out with virtualization solutions for mobile communications. – **Propose and justify** effective solutions for optimizing and securing virtualized communications networks.

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 responsiveness** to new learning contexts. - **Demonstrates collaboration** with other colleagues and teaching staff in carrying out teaching activities. – **Demonstrates autonomy** in organizing the learning context and the problems to be solved. – **Realizes the value of its contribution in the field of engineering** to the identification of viable solutions to solve problems in social and economic life. – **Analyze business** or entrepreneurial development opportunities, starting from the acquired knowledge in the field of cyber security. – **Demonstrates management skills** for real-life situations (eg proper management of learning time).

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.)*

– Courses are taught in an interactive manner, encouraging active student participation. Both classical teaching methods are used (lecture and presentation), using PowerPoint presentations through multimedia means, as well as interactive ones, based on questions - answers and student feedback , permanently adapting the pedagogical approach to the students' assimilation and learning possibilities (through additional repetition of certain notions and concepts, if this proves necessary).

Each course begins with a brief recap of the previous chapters, with an emphasis on the concepts covered in the last course. The presentations use numerous images and diagrams, so that the information presented is as easy to understand and assimilate as possible. Full course materials are available electronically on the faculty's Moodle platform .

– The teaching of knowledge in laboratory classes is based on oral communication and detailed explanation of the methods used and the results obtained, in a permanently interactive manner. Students independently implement and evaluate the same problems using the computer, software environment and hardware equipment (when appropriate). The developed applications help students in developing optimal communication relationships in a climate conducive to learning through discovery. Laboratory materials are available to students in electronic form on the faculty's Moodle platform .

10. Contents

COURSE		
Chapter	**Content**	**No. hours**
1	Introduction to the Cloud Computing and Virtualization in Mobile Networks 1.1. Cloud Definition and Evolution Computing (IaaS , PaaS , SaaS) 1.2. The importance of virtualization in mobile networks 1.3. The role and advantages of resource virtualization in communication networks	2

2	Types of Virtualization and Architectures for Mobile Networks 2.1. Types of virtualization: operating system virtualization, hardware virtualization, and paravirtualization 2.2. Virtualization in mobile communication networks: hypervisor , virtualized architecture 2.3. Classic virtualization technologies: Xen , VMware , OpenStack	2
3	Implementation and Management of Virtualized Infrastructures for Mobile Networks 3.1. Management of virtualized resources in IaaS and PaaS 3.2. Performance monitoring and scalability of virtualized systems 3.3. Load techniques balancing and automation of resource management	2
4	4. Security in the Virtualization of Mobile Communication Networks 4.1. Security challenges in virtualized networks 4.2. Security measures for hypervisors and virtualized systems 4.3. Case Studies: Attacks and Protection Methods in Virtualized Environments 2	2
5	Platform as a Service (PaaS) and Applications in Mobile Networks 5.1. The concept of PaaS and its role in mobile application development 5.2. Integrating applications with PaaS platforms in virtualized networks 5.3. Examples of platforms: Google App Engine , Microsoft Azure	2
6	Software as a Service (SaaS) and Mobile Applications in Virtualized Networks 6.1. The SaaS model and mobile applications based on cloud services 6.2. Scalability and Security of SaaS Applications in Mobile Networks 6.3. Examples of SaaS services : AWS 5G Core Network	2
7	7. Future Trends and Developments in Mobile Network Virtualization 7.1. The use of artificial intelligence in the administration of virtualized networks 7.2. Emerging technologies: B5G, edge computing and cloud integration 7.3. Future challenges and innovative solutions in mobile communication virtualization 2	2
	Total:	14

Bibliography:

1. A. Vulpe, R. Crăciunescu, *Virtualization of mobile communication systems* , electronic course support on the Moodle platform of the ETTI faculty: https://curs.upb.ro/
2. Y. Zhang , Network It works Virtualization - Concepts and Applicability in 5G Networks , WILEY, 2018, ISBN 9781119390602.
3. S. Rommer , P. Hedman , *5G Core Networks – Powering Digitization* , ELSEVIER, 2020, ISBN 978-0-08-103009-7.
4. F. Al- Turjman , *Edge Computing – From Hype to Reality* , SPRINGER, 2019, ISBN 978-3-319-99060-6.
5. W. Stallings , L. Brown, *Computer Security. Principles and Practice* , Prentice Hall , 2008.

LABORATORY

Crt. no.	Content	No. hours
1	Introduction to Docker containerized systems – Describes how container virtualization works. The basic concepts of container management are introduced, followed by the methodology and tools needed to manage such infrastructures.	2

2	Introduction to Container Orchestration Systems - Kubernetes – Discusses the basic concepts of container orchestration, installing Kubernetes , system architecture, associated components, creating pods and managing these instances.	4
3	Using Kubernetes to orchestrate commercial services instantiation methods for containers, rollback of containerized applications, and virtualization of connections between containerized elements are discussed	2
4	Automation of virtualized infrastructures - Terraform instantiation of containerized infrastructures through Terraform are analyzed .	2
5	Cloud Audience Platforms – The operation of a public Cloud platform – AWS is analyzed and also the creation of virtual machines, containers and Kubernetes clusters automatically on it using Terraform .	4
	Total:	14

Bibliography:

1. R. Crăciunescu, *Virtualization of mobile communication systems* , electronic lab support on the Moodle platform of the ETTI faculty: https://curs.upb.ro/
2. Y. Zhang , Network It works Virtualization - Concepts and Applicability in 5G Networks , WILEY, 2018, ISBN 9781119390602.
3. B. Burns, *Kubernetes Up & Running* , O'REILLY , 2022, ISBN 978-1-098-12197-6

11. Evaluation

Activity type	11.1 Evaluation criteria	11.2 Evaluation methods	11.3 Percentage of final grade
11.4 Course	Knowledge of the fundamental theoretical notions related to the virtualization of mobile communication systems. Knowing how to apply the theory to solve specific problems in the field.	Written exam	50%
11.5 Seminary/laboratory/project	Understanding the fundamental techniques of implementing virtualized infrastructures. Knowledge of how to simulate and implement the studied methods in public Cloud systems.	Lab sheet for each lab work	50%
11.6 Passing conditions			
– Obtaining at least 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)

In the context of accelerated digitization and increasingly sophisticated cyber attacks, there is an increased demand on the labor market for advanced skills in the implementation of virtualized infrastructures . Employers and professional associations emphasize the need for graduates to have a solid understanding of virtualized systems, instance/container management, and their security. By covering a wide spectrum of topics, from basic principles to advanced management of public Cloud systems , the discipline meets these needs. Also, updating course content with the latest research and technology in the field is fundamental to preparing students to address the dynamic challenges of virtualizing mobile communication systems. Alignment with the standards of the European Higher Education Area (EHEA) contributes to ensuring the quality of education and the recognition of skills internationally, preparing students for the global labor market and the challenges of virtualized infrastructures.

In this way, the graduates of the master's program are ensured adequate skills with the needs of current qualifications and a modern, high-quality and competitive scientific and technical training, which will allow them to be quickly employed after graduation, the discipline being perfectly in line with the policy of the National University of Science and Technology POLITEHNICA Bucharest, both from the point of view of content and structure, and from the point of view of the skills and international openness offered to students. Potential employers target both the academic environment (teaching and research profile) and the research and development environment in state and private institutions that use server networks, virtualization solutions and various orchestration mechanisms of containerized services and are interested in their management , or provide advanced cloud computing services .

Date	Course lecturer	Instructor(s) for practical activities
25.09.2025	Conf. Dr. Ing. Alexandru Vulpe	As. Răzvan Mihai

Date of department approval	Head of department
26.09.2025	Conf. Dr. Serban Georgica Obreja

Date of approval in the Faculty Council	Dean
26.09.2025	Prof. Dr. Mihnea Udrea