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	**Telecommunications**
1.4 Domain of studies	Electronic Engineering, Telecommunications and Information Technology
1.5 Cycle of studies	Masters
1.6 Programme of studies	Services and Network Management

2. Date despre disciplină

2.1 Course name (ro) (en)				Protocoale și tehnologii pentru servicii de comunicații în Internet			
2.2 Course Lecturer				Conf. Dr. Octavian Catrina			
2.3 Instructor for practical activities				Conf. Dr. Octavian Catrina			
2.4 Year of studies	1	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.M1.O.11-17		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.					41
Tutoring					0
Examinations					3
Other activities (if any):					0

3.7 Total hours of individual study	44.00
3.8 Total hours per semester	100
3.9 Number of ECTS credit points	4

4. Prerequisites (if applicable) (where applicable)

4.1 Curriculum	Course on telecommunications networks in the undergraduate program that includes the TCP/IP protocol stack.

4.2 Results of learning	Basic knowledge of telecommunications networks: principles, architectures and protocols, especially the TCP/IP protocol stack used in the Internet.

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

5.1 Course	Lecture hall equipped with video projector, screen, blackboard/whiteboard.
5.2 Seminary/ Laboratory/Project	Laboratory equipped with computers with Windows (or Linux) operating system and video projector. The network emulator GNS3 and the protocol analyzer Wireshark are free.

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 goal of this course is to extend, in depth and in breadth, the students' knowledge of key technologies used to build global networks with integrated services. The target audience consists of students of the master program Service and Network Management, so we assume basic knowledge of telecommunications networks from their undergraduate studies. However, being a first year course of the program, the course material is designed to be relatively self-contained, such that it can be followed by a broader audience, and to provide a solid foundation for the next specialization courses.
The course contents focus on key technologies used in packet-switched networks based on MPLS (label switching) and the TCP/IP protocol stack: in-depth study of intra-domain and inter-domain routing, multicast communications, in-depth study of MPLS-based networks, virtual private network (VPN) services based on MPLS, traffic engineering in MPLS networks.
The course aims at providing theoretical and practical knowledge that enable the students understand the architectures and the interctions, and prepares them for network design, deployment, and management tasks. The presentation of theoretical concepts is accompanied by experiemnts with networking devices in the lab. In these experiments, the students build representative examples of network and services and analyze their operation in various scenarios, examining how the state of the devices evolves using specific commands of the operating system and analyzing their communications using a protocol analyzer.

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	- Describe, analyze and explain the architecture and the operation of networks and services based on standard technologies and protocols used in the Internet, using domain-specific concepts and terminology, mainly: intra-domain and inter-domain routing for unicast and for multicast communications, MPLS networks, virtual private network services based o BGP and MPLS, traffic engineering solutions in MPLS networks. - Develop efficient and scalable solutions for global telecommunications networks with integrated services, using standard technologies.

Transversal (General) Competences	- Methodical analysis of the problems encountered in the activity, identifying the elements for which there are established solutions, and thus ensuring the fulfillment of professional tasks. - Ability to adapt to new technologies and to document oneself (in English and Romanian), for professional and personal development, through continuous training. - Ability to reason using scientific concepts and domain specific terminology, to independently explore and analyze information, as well as to find and present conclusions and/or solutions. - Ability to analyze and summarize the acquired knowledge by systematic analysis. - Ability to cooperate with other specialiss and work in a team; efficient communication and coordination with the other team members. - Observe academic ethics principles, such as citing correctly the bibliographical sources used during documentation.

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.* - Knows the rigorous definitions of domain-specific notions presented in the course: layered architectures, addressing, connectionless and connection-oriented packet switching and packet forwarding, with or without resource reservation; multicast communications; main protocols used in IP and MPLS networks (intra/inter-domain routing, routing policies, label distribution, resource reservation); ntypes of network devices; etc. - Knows how the network components interact, locally (using interfaces) and remotely (using protocols) and cooperate to fulfill the users' communication requirements.
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).* - Identifies and formulates the basic functional requirements of telecommunications networks. - Analyzes, describes and explains the purpose and operation of the main components of a packet-switching network (devices, protocols), using specific terminology. - Identifies, implements and tests solutions for data networks based on the TCP/IP stack and MPLS, including virtual private network services and traffic engineering solutions.
Responsability and autonomy	*The student's capacity to autonomously and responsably apply their knowledge and skills.* - Selects and understands relevant bibliographic sources. - Observes the principles of academic ethics, such as correctly citing the bibliographic sources. - Demonstrates responsiveness to new learning contexts. - Collaborates with colleagues and instructors during the teaching activities. - Demonstrates autonomy in organizing the learning situation or in solving problems. - Realizes the value of his contribution in the field of engineering to the identification of viable and sustainable solutions to solve problems in social and economic life (social responsibility). - Analyzes and capitalizes on business/entrepreneurial opportunities in the specialization field. - Demonstrates management skills real-life situations.

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 process will use both expository (lecture) and conversational-interactive teaching methods, based on discovery learning models facilitated by direct and indirect exploration (experiment, demonstration, modeling), but also using action-based methods, such as exercise, hands-on activities and problem-solving.
The teaching activity uses lectures based on PowerPoint presentations illustrated with images and diagrams (architectures, messages, algorithms, interactions), so that the information is easier to understand and to assimilate. PowerPoint presentations are supplemented with examples built interactively on the board. The introductory presentations of the courses and laboratory work highlight the connection with the notions presented earlier.
In the lab, the students build and configure using an emulator examples of networks and systems that are small-scale models of the networks and systems used in the Internet. Then, they carry out experiments that allow them to examine and analyze the evolution of the state of each device and the interactions between them (e.g., the discovery of destinations and routes in IP networks, establishment of labeled-switched paths with and without resource reservation in MPLS networks).
The teaching process takes into account the important differences between computer communications and the other courses in the area of electronics and telecommunicatios engineering: the students have to understand a different kind of systems and technologies: large, complex distributed systems with many components that run in parallel and cooperate by communicating locally and remotely in order to perform their various communications functions. The analysis and understanding of the operation of these distributed systems require the experimental study mentioned above. The experiments are greatly facilitated by the network emulators and protocol analyzers that are currently available.
The lectures include many examples of experiments similar to those erformed in the laboratory, ensuring that these two teaching approachesare better connected. Moreover, the network emulator and the protocol analyzer used in the lab are free software and the students can install them on their own computers for further practice.

10. Contents

COURSE		
Chapter	**Content**	**No. hours**
1	Intra-domain routing. Routing protocols based on distance vector and link state methods. In-depth study of the protocols RIPv2 and OSPF; background knowledge for the next chapters.	4
2	Multicast communications. Applications, requirements, principles. Multicast addressing. Group management using IGMP. Multicast routing protocols: PIM-DM and PIM-SM.	5
3	Inter-domain routing. Policy-based inter-domain routing in the Internet. In-depth study of the BGP protocol and background knowledge for the next chapters.	6
4	Multi-Protocol Label Switching (MPLS). Motivation, goals, applications. In-depth study of the protocols for MPLS networks (MPLS, LDP). Network interconnection using MPLS and BGP (BGP-free core).	4
5	Virtual Private Networks (VPN) based on BGP and MPLS. VPN requirements and categories. Standard techniques for building VPNs using BGP and MPLS.	4

6	Traffic engineering in MPLS networks (MPLS-TE). Motivation, objectives, introduction to constraint-based routing and resource reservation using RSVP. Protocols used for traffic engineering in MPLS networks: RSVP-TE, OSPF-TE.	4
	Total:	28

Bibliography:

1. Catrina Octavian, Protocols and Technologies for Internet Communications Services. Lecture presentations (platforma Moodle): https://curs.upb.ro/
2. L. Peterson, B. Davie. Computer Networks. A systems approach. Ediția 6, 2019, available online : https://www.systemsapproach.org/
3. Luc De Ghein. MPLS Fundamentals. Cisco Press, 2006.
4. Specifications of TCP/IP protocols published by the IETF online (http://www.ietf.org).

LABORATORY

Crt. no.	Content	No. hours
1	Intra-domain routing in the Internet. RIP and OSPF routing protocols. Router configuration and experimental analysis for various scenarios, including link or router failure.	4
2	Multicast communications in IP networks: group management using IGMP, multicast routing using PIM-DM and PIM-SM. Router configuration and experimental analysis for various multicast communication scenarios.	4
3	Inter-domain routing in the Internet. BGP routing protocol. Scalable interconnection techniques. Policy-based routing. Router configuration and experimental analysis.	4
4	Internetworking using BGP and MPLS. The MPLS and LDP protocols. GRE tunnels. Router configuration and experimental analysis for transit using MPLS or GRE tunnels.	4
5	Virtual private network (VPN) services based on BGP and MPLS. Standard techniques for implementing layer-3 VPN services using BGP and MPLS. Router configuration and experimental analysis.	4
6	Traffic engineering in MPLS networks. Establishment of MPLS-TE tunnels using RSVP-TE and OSPF-TE. Router configuration and experimental analysis for various scenarios (including network failures, tunnel preemptiob, etc.).	4
7	Evaluation of lab activity.	4
	Total:	28

Bibliography:

Catrina Octavian, Protocols and Technologies for Internet Communications Services. Lab descriptions (Moodle platform): https://curs.upb.ro/

11. Evaluation

Activity type	11.1 Evaluation criteria	11.2 Evaluation methods	11.3 Percentage of final grade

11.4 Course	- Knowledge of the concepts, methods, algorithms, architectures and protocols studied in the course. - Ability to describe, analyze, and explain network operation in practical situations, by applying the the aquired knowledge (examples of networks, services, communication scenarios).	Written exam	50%
11.5 Seminary/laboratory/project	Ability to configure, test, analyze and troubleshoot netwoks and services that use the protocols presented in the course	Laboratory examination.	50%
11.6 Passing conditions			
The students must obtain minimum of 50/100 for the exam paper and minimum 50/100 for the laboratory examination.			

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 global communication network interconnecting fixed and mobile terminals is rapidly converging towards a common infrastructure that uses the TCP/IP protocol stack, in both the data plane and the control plane. Moreover, the service provider networks use MPLS technology, to take advantage of its efficiency, versatility, and scalability, e.g., for traffic engineering, VPNs, and services with differentiated QoS. The IT industry, especially the service providers and the vendors of telecommunications equipment, need engineers with solid knowledge of networks based on TCP/IP and MPLS.
The course syllabus answers to these trends and to the current and future requirements of the global economy in the area of Electronics and Telecommunications Engineering, by providing the graduates with essential competences and training in key technologies used in modern telecommunications networks, enhancing their competitivity, and enabling their rapid employment after graduation. Therefore, it matches the policies of the University Politehnica of Bucharest, both in terms of content and structure, and in terms of skills and international openness for students.

Date	Course lecturer	Instructor(s) for practical activities
10.10.2024	Conf. Dr. Octavian Catrina	Conf. Dr. Octavian Catrina

Date of department approval	Head of department
27.10.2024	Conf. Dr. Serban Georgica Obreja

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