SYLLABUS

1. Data about the program of study

1.1 Institution	Technical University of Cluj-Napoca
1.2 Faculty	Faculty of Electronics, Telecommunications and Information Technology
1.3 Department	Communications
1.4 Field of study	Electronic Engineering, Telecommunications and Information Technologies
1.5 Cycle of study	Bachelor of Science
1.6 Program of study / Qualification	Telecommunications Technologies and Systems/ Engineer Applied Electronics/Engineer
1.7 Form of education	Full time
1.8 Subject code	TST-E39.00/EA-E108.00

2. Data about the subject

2.1 Subject name	Switching and Routing Systems						
2.2 Subject area	Theoretical area Methodological area Analytic area						
2.3 Course responsible	Professor Virgil DOBROTA, Ph.D, Virgil.Dobrota@com.utcluj.ro						
2.4 Teacher in charge with seminar / laboratory / project	Assist. Prof. Andrei Bogdan RUS, Ph.D, Bogdan.Rus@com.utcluj.ro Assist. Robert BOTEZ, Ph.D student, Robert.Botez@com.utcluj.ro						
2.5 Year of study	3	2.6 Semester	6	2.7 Assessment	E	2.8 Subject category	DS/DI

3. Estimated total time

3.1 Number of hours per week	4	of which: 3.2 course	2	3.3 laboratory + project	3
3.4 To Total hours in the curriculum	100	of which: 3.5 course	28	3.6 laboratory + project	42
Distribution of time					hours
Manual, lecture material and notes, bibliography					14
Supplementary study in the library, online specialized platforms and in the field					-
Preparation for seminars / laboratories, homework, reports, portfolios and essays					10
Tutoring					3
Exams and tests					3
Other activities:					0

3.7 Total hours of individual study	30
3.8 Total hours per semester	100
3.9 Number of credit points	4

4. Pre-requisites (where appropriate)

4.1 curriculum	N. A.
4.2 competence	Graph theory, Mathematical statistics

5. Requirements (where appropriate)

5.1. for the course	Cluj-Napoca
5.2. for the seminars / laboratories / projects	Cluj-Napoca

6. Specific competences

Professional competences	**C4. Design, implementation and operation of data, voice, video and multimedia services. This is based on the understanding and the application of fundamental concepts in telecommunications and transmission of information** C4.3 Explanation and interpretation of the main requirements and specific approach techniques for data, voice, video, multimedia transmissions C4.4 Use of the main specific parameters in evaluations based on the concept of quality of service in communications C4.5 Development of simple communications services **C5. Selecting, installing, configuring and operating fixed or mobile telecommunications equipment. Equipping a site with usual telecommunications networks** C5.1 Defining the principles of the main technologies for fixed and mobile telecommunications, through various transmission media C5.2 Explanation and interpretation of the technologies and of fundamental protocols for integrated fixed and mobile communications systems C5.3 Installation, configuration and exploiting of communications networks C5.4 Use of evaluation techniques and diagnostics for communications systems and equipment C5.5 Endowment with communications means of a location with a small/ medium degree of complexity
Transversal competences	N / A

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

7.1 General objective	Development of competences regarding switching and routing in telecommunications networks
7.2 Specific objectives	1. Understanding the basic concepts regarding switching and routing algorithms 2. Development of skills and abilities for configuring IP-Based Asterisk telephone exchange 3. Development of skills for virtualization of switches and routers and their cloud applications

8. Contents

8.1 Lecture (syllabus)	**Teaching methods**	**Notes**
1. Digital Switching Functions. Single Stage Space-Division Switch. Classification of Multiple Stage Switches	Presentation, heuristic conversation, exemplification, problem presentation, teaching exercise, case study, formative evaluation	Use of .ppt presentation, projector, whiteboard
2. Multiple Stage Switch with Complete Permutation Paths (Clos). Strictly Non-Blocking Three-Stage Clos Switch. Blocking Probabilities. Lee's Method. Generalization of Clos Condition		
3. Multiple Stage Switches with Single Path (Banyan). Batcher-Banyan Switches. Software Package for the Simulation of Batcher-Banyan Switches		
4. Multiple Stage Switches with Multiple Path. Time-Division Switching: T. Time-Space-Division Switching: TS		
5. STS Switch. TST Switch. TSSST Switch. Examples of Telephone Exchanges and Switch Fabrics (optional). Switches in cloud		
6. Traffic Analysis. Characteristics of a Queueing System. Models for Clients Arrivals: Bernoulli, Poisson		
7. M/M/1/infinite System. M/M/1/N System		
8. M/M/m/∞ System. Erlang C Formula. M/M/m/m System. Erlang B Formula.		
9. M/D/m/∞ and M/D/1/∞ Systems. M/G/1/∞ System. Pollaczek-Khinchin Formula. Traffic Processing in Telecommunications		
10. Routing Algorithms. Basics of Routing: Definitions		
11. Bellman-Ford Algorithm. Dijkstra's Algorithm		
12. Floyd-Warshall Algorithm. Comparison between Bellman-Ford, Dijkstra's and Floyd-Warshall Routing Algorithms. Cost function		
13. Optimal routing. Link capacity. Latency. Link flow. Round-trip delay. Cost function. Minimizing the cost function. Randomization and metering methods.		
14. Review. Examples of subjects given in the previous academic year		

References

1. V. Dobrota, *Retele digitale in telecomunicatii. Volumul I: Comutatia digitala, Analiza traficului. Editia a III-a,* Editura Mediamira, Cluj-Napoca 2002
2. P. Van Mieghem, *Performance Analysis of Communications Networks and Systems,* Cambridge University Press, 2014

On-line references:

3. V. Dobrota, *Switching and Routing Systems.* Technical University of Cluj-Napoca, 2025-2026 https://el.el.obs.utcluj.ro/scr/en_index.htm
4. D. Bertsekas, R. Gallager, *Data Networks. Second Edition*, Prentice-Hall Inc., USA 1992 https://web.mit.edu/dimitrib/www/datanets.html
5. L. Peterson, B. Davie, Computer Networks. A Systems Approach. Sixth Edition. Morgan Kaufmann, 2020, Available: https://book.systemsapproach.org/index.html

8.2 Laboratory	**Teaching methods**	**Notes**
1. Linux Fedora Installation	Didactic and experimental proof, didactic exercise, team work	Use of laboratory instrumentation, experimental boards, computers, magnetic board
2. Introduction to Linux. Working with files.		
3. Strictly Non-Blocking Three-Stage Clos Switch. Software Package for Designing of Clos Switches		
4. Software Package for the Simulation of Rectangular Delta Switches. Software Package for the Simulation of Rectangular Omega Switches		
5. Multiple Stage Switches with Multiple Paths (Benes). Software Package for the Simulation of Benes Switches.		
6. STS Switch. Software Package for the Designing of STS Switches		

7. TST Switch. Software Package for the Designing of TST Switches		
8. Software Package for the Calculation of Binomial Bernoulli, Normal Laplace-Gauss and Poisson Distributions. Software Package for the Calculation of Erlang B and Erlang C Formulas		
9. Problems within Chapter 2 (Traffic Analysis)		
10. Problems within Chapter 1 (Digital Switching) + Chapter 2 (Traffic Analysis)		
11. Software Package for Bellman-Ford Algorithm		
12. Software Package for Dijkstra's Algorithm		
13. Floyd-Warshall Algorithm. Software Package for Floyd-Warshall Algorithm		
14. Recovery Laboratory. Questions		
On-line references: 1. V. Dobrota, *Switching and Routing Systems.* Technical University of Cluj-Napoca, 2025-2026 https://el.el.obs.utcluj.ro/scr/en_index.htm		
8.3. Project	**Teaching methods**	**Notes**
1. Adrese IPv4	Didactic and experimental proof, didactic exercise, team work	Use of laboratory instrumentation, experimental boards, computers, magnetic board
1. IPv4 Addressing		
2. Create a dial plan for an AsteriskNOW IP PBX installed on a CentOS virtual machine, with at least two SIP subscribers and at least two IAX2 subscribers. The mandatory part for managing phone calls will be implemented (DIAL, RINGING, ANSWER and HANGUP functions). Implementation of two particular functions (e.g. VOICE-MAIL, CONFERENCING, SAY, PLAY, WAIT, AUTHENTICATE, TIMEOUT, RECORD).		
3. Working for project: Call one SIP subscriber, one IAX subscriber		
4. Working for project: Implementation of SIP functions		
5. Working for project: Implementation of IAX2 functions		
6. Working for project: Integrate SIP and IAX functions. Optional: testing in OpenStack-based cloud		
7. Project defending		
References 1. J.Van Meggelen, R.Bryant, L.Madsen, *Asterisk: The Definitive Guide*. Fifth Edition. O'Reilly Media, 2019		

9. Bridging course contents with the expectations of the representatives of the community, professional associations and employers in the field

The discipline content and the acquired skills are in agreement with the expectations of the professional Competences acquired will be used in the following COR occupations (Electronics Engineer; Telecommunications Engineer; Electronics Design Engineer; System and Computer Design Engineer; Communications Design Engineer) or in the new occupations proposed to be included in COR (Sale Support Engineer; Multimedia Applications Developer; Network Engineer; Communications Systems Test Engineer; Project Manager; Traffic Engineer; Communications Systems Consultant).

10. Evaluation

Activity type	10.1 Assessment criteria	10.2 Assessment methods	10.3 Weight in the final grade
10.4 Course	The level of acquired theoretical knowledge and practical skills	Theoretical Test (mark T) : 9 questions	T, max 10 pts. 50%
10.5 Laboratory/Project	The level of acquired knowledge and abilities	Project (P1): oral and practical exam based on laboratory and	P1, max. 5 pts. 25%

		project work Problem (P2) written exam to solve a problem covering all chapters	P2, max. 5 pts 25%

10.6 Minimum standard of performance

Qualitative point of view

Minimal theoretical and practical knowledge:

- ✓ 1. Understanding the basic concepts regarding switching and routing algorithms
- ✓ 2. Development of skills and abilities for configuring IP-Based Asterisk telephone exchange

Minimal acquired competences:

- ✓ Ability to develop simple private branch exchange (PBX) applications
- ✓ Ability to analyze and improve performance of a switching and routing systems

Quantitative point of view

- ✓ T ≥ 5
- ✓ P=P1+P2 ≥ 5, P2≥1.5
- ✓ (T+P)/2≥ 4.5

Data of filling in:	**Responsible**	**Title First name SURNAME**	**Signature**
16.06.2025	Course	Professor Virgil DOBROTA, Ph.D.	
	Applications	Professor Virgil DOBROTA, Ph.D.	
		Assist. Prof. Andrei Bogdan RUS, Ph.D.	
		Assist. Robert BOTEZ, Ph.D. student	

Date of approval in the Council of the Communications Department 18.06.2025	Head of Communications Department Prof. Virgil DOBROTA, Ph.D.
Date of approval in the Council of the Faculty of Electronics, Telecommunications and Information Technology 25.06.2025	Dean Prof. Ovidiu POP, Ph.D.