Syllabus
Course Program

Design of Digital Telecommunication Networks

Specialty
172 – Electronic communications and radio engineering

Institute
Institute of Computer Modeling, Applied Physics and Mathematics

Educational program
Network technologies and telecommunications

Department
Information systems named after V.O. Kravets (169)

Level of education
Master's level

Course type
Special (professional), Mandatory

Semester
1

Language of instruction
English

Lecturers and course developers

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Senior lecturer of the department "Information systems named after V. O. Kravets " NTU "KhPI"

Author of more than 30 publications. Lecturer of courses "Mobile Communication Systems", "Access Systems", "Design of Digital Telecommunications Networks", "Information Security in Telecommunications"
More about the lecturer on the department's website

General information

Summary

This course provides an in-depth exploration of the principles, methodologies, and best practices involved in designing modern digital telecommunication networks. Students will gain insight into the underlying technologies, architectures, protocols, and standards that govern network performance, reliability, and scalability. Emphasis will be placed on understanding network planning, configuration, optimization, and security measures, preparing learners to address real-world challenges and drive innovation in the rapidly evolving field of telecommunications.

Course objectives and goals

The primary objective of this course is to equip students with the theoretical foundations and practical competencies required to design, configure, and optimize digital telecommunication networks for various applications. By examining contemporary technologies, industry standards, and emerging trends, students will learn to evaluate network performance, ensure quality of service, and implement effective security strategies. Ultimately, learners will develop the critical thinking and problem-solving skills necessary to build robust, efficient, and future-ready network infrastructures.

Format of classes

Lectures, laboratory classes, consultations, self-study. Final control in the form of an exam.

Competencies

GC 2. Ability to apply knowledge in practical situations.
GC 9. Ability to develop and manage projects.
SC 2. Ability to implement the principles of a systems approach when conducting research into processes that occur in electronic communication and radio engineering systems, complexes and devices.
SC 8. Ability to solve complex professional tasks based on the use of the latest technologies for transmitting, receiving and processing information.

Learning outcomes

LO1 – organize one's own professional, scientific research and innovation activities based on the principles of a systematic approach and scientific research methodology.
LO11 – develop and implement engineering projects, taking into account goals, limitations, social, economic, legal and environmental aspects.

Student workload

The total volume of the course is 120 hours (4 ECTS credits): lectures - 32 hours, laboratory classes - 32 hours, self-study - 56 hours.

Course prerequisites

"Switching systems in telecommunications", "System and software of telecommunications systems", "Access systems"

Features of the course, teaching and learning methods, and technologies

Classes are made interactively using multimedia technologies for lecture presentations and online demonstrations of task execution examples. The lecture classes use explanatory-illustrative, reproductive, problem-oriented methods and the method of critical thinking. Training materials are available for students through OneNote (Class Notebook).

Program of the course

Topics of the lectures

Topic 1. Introduction to Digital Telecommunication Networks:
Defining digital networks, their evolution, basic components, and the role they play in global communication systems.
Topic 2. Network Architectures and Standards:
Exploring OSI and TCP/IP models, international standards bodies, and the impact of these frameworks on network design.
Topic 3. Transmission Media and Signal Encoding:
Examining wired and wireless media, signal encoding techniques, and the selection criteria for optimal transmission performance.
Topic 4. Multiplexing and Switching Techniques:
Introducing time-division, frequency-division multiplexing, and various switching methods for efficient resource use.
Topic 5. Access Technologies and Network Interfaces:
Studying fiber optics, DSL, cable, cellular, and satellite access methods, and understanding their integration into networks.
Topic 6. Core Network Design Principles:
Evaluating backbone architectures, routing policies, and redundancy mechanisms to ensure robust, scalable networks.
Topic 7. IP Addressing and Subnetting:
Understanding IPv4/IPv6 addressing schemes, subnetting, and network addressing strategies for resource allocation.

Topic 8. Routing Protocols and Algorithms:
Analyzing interior and exterior routing protocols (e.g., OSPF, BGP) and the algorithms that govern optimal path selection.
Topic 9. Quality of Service (QoS) and Traffic Management:
Implementing QoS policies, traffic shaping, and congestion control to maintain network performance under varying loads.
Topic 10. Network Security and Risk Mitigation:
Identifying common vulnerabilities, firewalls, encryption, and intrusion detection/prevention for secure network operations.
Topic 11. Network Management and Monitoring:
Utilizing SNMP, telemetry, and analytic tools to monitor network health, troubleshoot issues, and predict failures.
Topic 12. Voice, Video, and Multimedia Integration:
Designing networks that support VoIP, video conferencing, and multimedia streaming with acceptable quality and latency.
Topic 13. Wireless and Mobile Networking:
Exploring Wi-Fi, 4G/5G technologies, mobility management, and seamless roaming in next-generation networks.
Topic 14. Software-Defined Networking (SDN) and Network Function Virtualization (NFV):
Examining how SDN and NFV redefine control and data planes, enabling dynamic, programmable network configurations.
Topic 15. Emerging Technologies and Trends:
Investigating IoT integration, edge computing, and other emerging technologies shaping the future of telecom networks.
Topic 16. Network Design Case Studies and Best Practices:
Reviewing real-world examples, industry standards, and guidelines that inform effective, future-proof network designs.

Topics of the workshops

Not included

Topics of the laboratory classes

Topic 1. Network Simulation Environment Setup:
Configuring simulation tools (e.g., GNS3, Cisco Packet Tracer) to model basic network topologies.
Topic 2. Implementing IP Addressing and Subnetting:
Assigning addresses, creating subnet plans, and verifying connectivity in a simulated network scenario.
Topic 3. Configuring Routing Protocols:
Setting up OSPF or BGP on routers, analyzing routing tables, and ensuring optimal path selection.
Topic 4. VLAN Configuration and Trunking:
Creating VLANs, setting up trunk links, and verifying segmented traffic flow within a LAN environment.
Topic 5. QoS and Bandwidth Management:
Applying QoS policies, rate limiting, and traffic shaping techniques, then measuring their impact on network performance.
Topic 6. Network Security Implementation:
Implementing access control lists, firewalls, and basic encryption to secure a test network environment.
Topic 7. SNMP and Network Monitoring:
Utilizing SNMP and other monitoring tools to gather performance metrics and detect network issues.
Topic 8. Wireless Network Setup and Troubleshooting:
Configuring a basic Wi-Fi network, analyzing signal coverage, and resolving interference issues.
Topic 9. Voice over IP (VoIP) Configuration:
Implementing a simple VoIP setup, verifying call quality, and adjusting parameters to improve performance.
Topic 10. Virtual LAN and Inter-VLAN Routing:
Creating multiple VLANs, configuring inter-VLAN routing, and testing data flow across segmented domains.

Topic 11. Load Balancing and Redundancy:
Implementing load balancing strategies and redundancy protocols (e.g., HSRP) to enhance network reliability.
Topic 12. Exploring SDN Controllers:
Installing and interacting with an SDN controller to dynamically manage routing and switch configurations.
Topic 13. NFV-based Network Services:
Deploying virtualized network functions (e.g., virtual routers, firewalls) and observing their flexibility and scalability.
Topic 14. Traffic Analysis and Packet Capture:
Using packet capture tools (e.g., Wireshark) to analyze traffic patterns, identify issues, and validate configurations.
Topic 15. Network Optimization and Tuning:
Adjusting parameters (e.g., MTU sizes, queuing disciplines) to optimize network performance and reduce latency.
Topic 16. End-to-End Network Design Project:
Combining learned techniques to design, implement, and test a fully functional, secure, and scalable network solution.

Self-study

Students are expected to dedicate additional time outside of formal instruction to independently review lecture notes, research emerging trends, practice lab configurations, and explore advanced topics in digital telecommunication networks. By engaging in these self-directed activities, learners will deepen their understanding, refine their technical skills, and cultivate critical thinking abilities that will enable them to address complex challenges and stay current in this rapidly evolving domain.

Course materials and recommended reading

1. Digital Communications and Network Design by M. R. Tanenbaum and Jorge A. Fernandez (2020)
2. Principles of Next-Generation Networking by Li Q. Song and Arun K. Patel (2021)
Software-Defined Networking and Network Function Virtualization: Concepts and Applications by Beatriz M. Alonso (2022)
3. 5G and Beyond: Architectures, Protocols, and Applications by David G. Torres and Elena V. Liu (2023)
4. QoS in Modern Telecommunication Networks by Felipe R. Gonzalez and Miriam Y. Chan (2021)
Wireless Networking in the Age of 5G: Fundamentals and Design by Sarah E. Carroll and Omar L. Rahman (2022)
5. IP Routing and Addressing: A Comprehensive Guide by Carlos J. Bernard and Ivana S. Reyes (2020)
6. Network Security Essentials for Modern Telecom by Rajan P. Gupta and Nicole J. Evans (2022)
7. IoT and Edge Computing in Telecommunication Systems by Anthony R. Woods and Priya A. Singh (2021)
8. Emerging Technologies in Telecommunications: Challenges and Opportunities by Linda Y. Matthews and Chen Zhao (2023)

Assessment and grading

Criteria for assessment of student performance, and the final score structure

The final grade is made up of 100% assessment results in the form of an exam (50%) and current assessment (50%).
Breakdown of the grading:
Laboratory work: 30%
Independent work and computational tasks: 20%

Grading scale

Total points	National	ECTS
90–100	Excellent	A
82–89	Good	B
75–81	Good	C
64–74	Satisfactory	D
60–63	Satisfactory	E
35–59	Unsatisfactory (requires additional learning)	FX
1–34	Unsatisfactory (requires repetition of the course)	F

Norms of academic integrity and course policy

The student must adhere to the Code of Ethics of Academic Relations and Integrity of NTU "KhPI": to demonstrate discipline, good manners, kindness, honesty, and responsibility. Conflict situations should be openly discussed in academic groups with a lecturer, and if it is impossible to resolve the conflict, they should be brought to the attention of the Institute's management.
Regulatory and legal documents related to the implementation of the principles of academic integrity at NTU "KhPI" are available on the website: http://blogs.kpi.kharkov.ua/v2/nv/akademichna-dobrochesnist/

Approval

Approved by	Date, signature	Head of the department Pavlo PUSTOVOITOV
	Date, signature	Guarantor of the educational program Vitaliy BRESLAVETS