Syllabus
Course Program

Optimization 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
Optional

Semester
2

Language of instruction
English

Lecturers and course developers

Maksym Okhrymenko

maksym.okhyrmenko@khpi.edu.ua
Senior lecturer of the department "Information systems named after V. O. Kravets " NTU "KhPI"

Author of more than 30 publications. Lecturer of courses "Theory of Teletraffic", "Digital Signal Processing", "Operations Research", "Frequency-Selective Devices of Radio-Telecommunications Systems".
More about the lecturer on the department's website

General information

Summary

This course explores advanced methods and techniques for optimizing digital telecommunication networks to improve performance, reliability, and scalability. Topics include network traffic analysis, resource allocation, energy efficiency, Quality of Service (QoS) enhancement, and optimization of routing and switching protocols. Through a combination of theoretical frameworks and practical applications, students will gain the skills necessary to design and optimize modern telecommunication infrastructures for diverse use cases and emerging technologies..

Course objectives and goals

The objective of this course is to equip students with the knowledge and tools required to analyze, evaluate, and optimize digital telecommunication networks. By focusing on the interplay between network performance, resource utilization, and system scalability, students will learn to identify bottlenecks, propose optimization strategies, and implement solutions that enhance the efficiency and reliability of telecommunication systems. The course aims to foster critical thinking and technical skills necessary for tackling optimization challenges in next-generation networks..

Format of classes

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

Competencies

GC 7. Ability to conduct research at the appropriate level.
SC 1. Ability to apply scientific facts, concepts, theories, principles and methodologies of scientific research.
SC 3. Ability to reasonably choose and effectively apply mathematical methods, computer modeling technologies, as well as approaches and methods for optimizing electronic communication and radio engineering systems, complexes, technologies, devices and their components at all stages of their life cycle.
SC 7. Ability to search for and evaluate information on the problems of electronic communications, radio engineering and related issues.
SC 8. Ability to solve complex professional tasks based on the application of the latest technologies for transmitting, receiving and processing information.
SC 9. The ability to solve current scientific problems in the field of electronic communications and radio engineering with the justified use of modern theoretical and experimental research methods.

Learning outcomes

LO 4 – plan and carry out scientific and applied research in the field of telecommunications and radio engineering, apply methods of mathematical and physical modeling, information processing, interpret research results and justify conclusions
LO 7 – localize and assess the state of the problem situation at the stages of research, design, modernization, implementation and operation of modern and promising telecommunications and radio engineering systems, complexes, technologies, devices and their components, formulate proposals for its solution with the elimination of identified shortcomings

Student workload

The total volume of the course is 120 hours (4 ECTS credits): lectures - 16 hours, laboratory classes - 32 hours, self-study - 72 hours.

Course prerequisites

"Digital signal processing"; "System modeling methods"; "Modern telecommunication technologies".

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 Telecommunication Network Optimization:
Overview of optimization goals, challenges, and key areas of focus in digital networks.
Topic 2. Fundamentals of Network Performance Metrics:
Understanding throughput, latency, packet loss, jitter, and their role in network evaluation.
Topic 3. Traffic Analysis and Load Balancing Techniques:
Exploring traffic modeling, network congestion analysis, and load distribution methods.
Topic 4. Quality of Service (QoS) Optimization:
Techniques to prioritize traffic, manage bandwidth, and meet application-specific performance needs.
Topic 5. Resource Allocation in Telecommunication Networks:
Dynamic allocation of bandwidth, power, and processing resources for efficient operation.
Topic 6. Routing Optimization in IP Networks:
Examining routing protocols and algorithms to minimize delays and maximize data flow.
Topic 7. Energy Efficiency in Telecommunication Systems:
Strategies for reducing power consumption in network components and infrastructures.

Topic 8. Wireless Network Optimization:
Addressing unique challenges in 4G/5G networks, including spectrum utilization and mobility management.
Topic 9. Software-Defined Networking (SDN) and Network Optimization:
Leveraging SDN controllers to dynamically adjust network configurations for improved performance.
Topic 10. Multi-Objective Optimization in Networks:
Balancing competing objectives such as cost, performance, and energy in network designs.
Topic 11. AI and Machine Learning in Network Optimization:
Applying intelligent algorithms to predict, detect, and resolve network inefficiencies.
Topic 12. Optimizing Network Security and Risk Management:
Techniques for enhancing security while minimizing performance trade-offs in optimized networks.
Topic 13. Cloud and Edge Computing Network Optimization:
Integrating edge resources and cloud systems to improve data handling and reduce latency.
Topic 14. Network Monitoring and Feedback Systems:
Utilizing monitoring tools and feedback loops to dynamically adjust network parameters.
Topic 15. Case Studies in Network Optimization:
Analyzing real-world examples to identify challenges, solutions, and best practices.
Topic 16. Future Trends in Telecommunication Network Optimization:
Exploring emerging technologies and methods shaping the future of network optimization.

Topics of the workshops

Not included

Topics of the laboratory classes

Topic 1. Network Traffic Analysis Using Simulation Tools:
Setting up simulation environments to analyze traffic patterns and identify bottlenecks.
Topic 2. Implementing QoS Policies in a Simulated Network:
Configuring traffic prioritization and bandwidth management techniques to meet QoS goals.
Topic 3. Load Balancing Implementation:
Testing load balancing algorithms and measuring their impact on network performance.
Topic 4. Routing Optimization with Dynamic Algorithms:
Simulating routing changes to evaluate delay reduction and path efficiency.
Topic 5. Energy Efficiency Analysis in Network Components:
Measuring power consumption and exploring techniques to optimize energy usage.
Topic 6. Optimizing Wireless Network Parameters:
Configuring spectrum allocation and mobility management in a simulated wireless environment.
Topic 7. SDN-Based Network Optimization:
Using an SDN controller to dynamically adjust network paths and configurations.
Topic 8. Machine Learning for Traffic Prediction:
Building and testing predictive models to anticipate network congestion and demand.
Topic 9. Resource Allocation Strategies:
Simulating resource distribution across multiple applications to ensure optimal utilization.
Topic 10. Security Optimization in Network Protocols:
Testing encryption techniques and security configurations for performance impact.
Topic 11. Latency Reduction in Cloud-Based Systems:
Evaluating methods to minimize delays in cloud and edge computing environments.
Topic 12. Packet Capture and Analysis:
Using tools like Wireshark to monitor and analyze network traffic for optimization opportunities.
Topic 13. Monitoring and Feedback System Configuration:
Setting up monitoring systems to collect data and dynamically adjust network parameters.
Topic 14. Multi-Objective Optimization Experiment:
Testing optimization methods that address multiple network performance goals simultaneously.
Topic 15. Case Study Implementation:
Reproducing optimization strategies from real-world examples in a simulated environment.

Topic 16. Final Optimization Project:
Designing, implementing, and testing a comprehensive optimization strategy for a given network scenario.

Self-study

Students are expected to actively engage in self-directed learning by reviewing additional readings, exploring advanced optimization tools, and working on practical exercises to refine their technical skills. Independent research on emerging trends and technologies in network optimization is encouraged, along with the development of small-scale projects or case studies that apply theoretical principles to practical challenges. By dedicating time to self-study, learners will enhance their problem-solving abilities and be better prepared for complex real-world scenarios in telecommunication networks.

Course materials and recommended reading

1. Optimization of Communication Networks: Advanced Techniques and Applications by Anjali Jain and Michael K. Wong (2021)
2. Digital Network Performance Metrics and Optimization by Sarah E. Clarke and Omar A. Rahim (2022)
3. AI-Driven Network Optimization by Priya R. Menon and Carlos J. Lopez (2023)
4. Software-Defined Networking for Optimization by Elena K. Fernandez and Robert T. Lang (2021)
5. Next-Generation Wireless Networks: Optimization Techniques by Andrew B. Miles and Julia S. Carter (2023)
6. Quality of Service in Telecommunication Systems by Martin R. Patel and Fiona M. Lee (2020)
7. Energy Efficiency in Modern Networks by Vincent T. Garcia and Emily S. Moore (2022)
8. Traffic Engineering for Scalable Telecommunication Systems by Jonathan P. Holmes and Rachel Y. Zhang (2021)
9. Edge Computing and Optimization in Networks by Marcus L. Rivera and Sonia K. Patel (2023)
10. Emerging Trends in Telecommunication Optimization by David J. Simmons and Clara N. Adams (2022)

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