Syllabus
Course Program

Optimization of processes in multiservice networks

Specialty
123 Computer engineeringя

Institute
Educational and Scientific Institute of Computer Science and Information Technology

Educational program
Modern programming, mobile devices and computer games

Department
Department of Computer Engineering and Programming (326)

Level of education
Master's level

Course type
Special (professional)

Semester
2

Language of instruction
English

Lecturers and course developers

Nina Kuchuk

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Doctor of Technical Sciences, Professor

The author of more than 200 scientific and scientific-methodological works, 27 of which are indexed in the Scopus scientometric database (*h*-index – 10), and 6 in the Web of science scientometric database.
More about the lecturer on the department's website

General information

Summary

This course introduces students to the theory and practice of classical and modern methods of process optimization in multi-service systems and networks and forms the practical knowledge and skills of students necessary for the application of mathematical methods in the development of algorithms..

Course objectives and goals

The purpose of teaching the discipline is: students acquire theoretical knowledge in the field of mathematics, computer hardware and software, based on the optimization of processes used in modern multi-service systems and networks, with the aim of applying this knowledge to the development of algorithmic and software hardware and software means of supporting the functioning of multi-service systems and networks.

Format of classes

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

Competencies

C2. Ability to abstract thinking, analysis and synthesis.

C4. Ability to build and investigate models of computer systems and networks.
C11. The ability to choose effective methods of solving complex computer engineering problems, critically evaluate the obtained results and argue the decisions made.

Learning outcomes

R2. Find the necessary data, analyze and evaluate them.
R8. Apply knowledge of technical characteristics, design features, purpose and rules of operation of software and technical means of computer systems and networks to solve complex problems of computer engineering and related problems.

Student workload

The total volume of the course is 150 hours (5 ECTS credits): lectures - 32 hours, practical works - 16, laboratory classes - 32 hours, self-study - 86 hours.

Course prerequisites

To study the course, students need basic knowledge of the following disciplines: programming algebra, probability theory, discrete mathematics, computer networks. Discipline is the basis for diploma design.

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

Lectures are conducted interactively using multimedia technologies. The practical classes use a project approach to learning, game methods, and focus on the application of various optimization methods in the practice of computer systems and networks. Study materials are available to students through OneNote Class Notebook.

Program of the course

Topics of the lectures

Topic 1. Introduction. The use of unconditional optimization methods to accelerate the passage of packets in multiservice networks
The role and place of the discipline, relationship with other disciplines. Unimodal functions. Analysis of packet transit time in MSM. Dichotomy method. The "golden section" method
Topic 2. One-parameter optimization of processes in multi-service systems using multi-extreme functions
Peculiarities of the formalization of one-parameter processes in MSS. Finding the optimum of a multi-extreme function when imposing restrictions on the parameter to be optimized.
Topic 3. Multi-parameter optimization of processes in multi-service systems
Peculiarities of formalization of multi-parameter processes in MSS. Finding stationary points of the process.
Topic 4. Modeling the process of managing information flows of data in MSM using linear programming methods
General formulation of the problem of managing information flows of data in MSM. Use of linear programming methods. Graphical method of finding the optimal solution.
Topic 5. The use of analytical methods of linear programming in the management of information flows of data in multiservice networks
Formalization of the task of managing information flows of data Reduction of the management task to the standard form of the linear programming task. Analysis of existing methods of optimization of the obtained model. Simplex method and features of its application.
Topic 6. Analysis of special cases in the management of information flows of data in multiservice networks
General rules for identifying special cases. Model degeneration. Multi-alternativeness of the model. Infinity solution. No solution.
Topic 7. Use of the transport model when solving the problem of routing in multi-service networks
Bringing the routing problem in MSM to a balanced form. Transport tables. Finding the initial solution of the transport problem. The method of potentials and features of its use in solving the routing problem in MSM.

Topic 8. Methods of distribution of network resources in the management of information flows
The general formulation of the problem of distribution of network resources in the management of information flows. Methods of reducing the problem to a problem of linear programming. Application of existing optimization methods. Determination of individual cases of quick finding of the optimal solution.
Topic 9. Methods of finding the optimal route when managing the information flow of data for networks without cycles
Formulation of the network minimization problem. Kruskal's algorithm. .Dijkstra's algorithm for a loop-free network.
Topic 10. Methods of finding the optimal route when managing the information flow of data for networks with cycles
Features of routing in the presence of cycles. Dijkstra's algorithm for a network with loops. Floyd's algorithm and its features when used in routers.
Topic 11. Parallelization of data processing management process stages in multiservice systems
General formulation of the problem. Use of network planning methods. Critical path. The SRM method. Finding the critical path and time reserves at each stage. The SRM method in multiservice networks.
Topic 12. The use of a mathematical decision-making apparatus under conditions of risk to optimize processes in multiservice systems
General formulation of the problem. The use of a probabilistic apparatus in the optimization of the process in the MSS. Compilation of a decision tree, features of finding the optimal solution for the process in the MSS.
Topic 13. The use of a mathematical decision-making apparatus under conditions of uncertainty to optimize processes in multiservice systems
General formulation of the problem. The use of the game theory apparatus in the optimization of the process in the MSS. Saddle point of the process. Payment matrix. Game theory methods for determining the flow route.
Topic 14. Calculation of characteristics of request flows in multiservice systems using the mathematical apparatus of mass service theory
Methods of analysis of request flows in multiservice systems. The simplest flow, calculation of its characteristics in the MSM node. Analysis of processes in a separate MSM node using the mathematical apparatus of mass service theory.
Topic 15. Analysis of queues in multiservice systems using the mathematical apparatus of mass service theory
Queue analysis methods in multiservice systems. Selection of the optimal buffer size of the service device and the maximum delay time of packets in the queue.
Topic 16. Nonlinear conditional optimization algorithms in multiservice systems and networks
Application of separable programming in MSS. Application of quadratic programming in MSS. Dynamic programming in the optimization of MSM processes. Application of integer programming in MSS.

Topics of the workshops

Topic 1. Solving problems using unconditional optimization methods to speed up the passage of packets in multi-service networks.
Topic 2. Solving problems related to multi-parameter optimization of processes in multi-service systems.
Topic 3. Solving problems related to the use of analytical methods of linear programming in the management of information flows of data in multiservice networks.
Topic 4. Solving problems regarding the use of the transport model when solving the problem of routing in multi-service networks.
Topic 5. Solving problems related to methods of finding the optimal route when managing the information flow of data for networks without cycles.
Topic 6. Solving problems related to the parallelization of the stages of the data processing management process in multiservice systems.
Topic 7. Calculation of requirements flow characteristics in multi-service systems using mass service theory.
Topic 8. Calculation of parameters of queues in multiservice systems using mass service theory.

Topics of the laboratory classes

Laboratory work 1. Development of a software model for optimizing the time of passage of a packet in the MSM.

Laboratory work 2. Development of a program that uses the scanning method to optimize packet transit time in multiservice networks.
Laboratory work 3. Development of a program for finding the optimal distribution of MSM resources during the simultaneous passage of two informational data streams.
Laboratory work 4. Use of additional features of MS OFFICE when modeling the process of managing information flows of data in MSM.
Laboratory work 5. Programming of routing algorithms.
Laboratory work 6. Software construction of a decision tree for the process of selecting an IT project of a multi-service network.
Laboratory work 7. Construction of a software model of a separate node of a multi-service network.
Laboratory work 8. Development of an integer optimization program in multiservice networks.

Self-study

Elaboration of lecture material.
Preparation for practical classes and modular controls.
Independent study of topics and issues that are not taught in lectures

Course materials and recommended reading

1 Kuchuk H. Green IT Engineering: Social, Business and Industrial Applications / Andriy Kovalenko, Komari I.E., Svyrydov A., Vyacheslav Kharchenko // SSpringer, 2017, XIV, 355 p.
ISBN 978-3-319-55594-2 (Part IV. Resource-oriented approaches to implementation of traffic control technologies in safety-critical I&C systems, pp. 313-338)

2 Ruban, I. Redistribution of base stations load in mobile communication networks / I. Ruban, H. Kuchuk, A. Kovalenko // Innovative technologies and scientific solutions for industries. – 2017. – No 1 (1) – P. 75-81. – DOI : https://doi.org/10.30837/2522-9818.2017.1.075

Assessment and grading

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

Tests or control papers - 16 points.
Laboratory works - 32 points.
Practical classes - 16 points.
Self-study in the form of a calculation task - 19.
Exam - 20 points.
Total - 100 points.

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 Oleksandr ZAKOVOROTNYI
	Date, signature	Guarantor of the educational program Svitlana GAVRYLENKO