МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
ХАРКІВСЬКИЙ НАЦІОНАЛЬНИЙ ЕКОНОМІЧНИЙ УНІВЕРСИТЕТ
ІМЕНІ СЕМЕНА КУЗНЕЦЯ

ЗАТВЕРДЖЕНО
на засіданні кафедри
інформаційних систем
Протокол № 1 від 22.08.2023 р.

ПОГОДЖЕНО
Проректор з навчально-методичної роботи

_____ Каріна НЕМАШКАЛО

АРХІТЕКТУРА КОМП'ЮТЕРІВ ТА КОМП'ЮТЕРНИХ МЕРЕЖ

робоча програма навчальної дисципліни (РПНД)

Галузь знань	**12 "Інформаційні технології"**
Спеціальність	**121 "Інженерія програмного забезпечення"**
Освітній рівень	**перший (бакалаврський)**
Освітня програма	**"Інженерія програмного забезпечення"**

Статус дисципліни	**обов'язкова**
Мова викладання, навчання та оцінювання	**англійська**

Розробник:
к.т.н., доцент підписано КЕП Дмитро ГОЛУБНИЧИЙ

Завідувач кафедри
інформаційних систем _____ Дмитро БОНДАРЕНКО

Гарант програми _____ Олег ФРОЛОВ

Харків
2024

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
SIMON KUZNETS KHARKIV NATIONAL UNIVERSITY OF ECONOMICS

APPROVED
at the meeting of the department
information systems
Protocol № 1 of 22.08.2023

AGREED
Vice-rector for educational and methodical work

_____ Karina NEMASHKALO

ARCHITECTURE OF COMPUTER AND COMPUTER NETWORKS

Program of the course

Field of knowledge	**12 "Information Technology"**
Specialty	**121 "Software engineering"**
Study cycle	**first (bachelor)**
Study programme	**"Software Engineering"**

Course status	**mandatory**
Language	**English**

Developers:
PhD (Technical sciences),
Associate Professor — digital signature — Dmytro HOLUBNYCHYI

Head of Information systems department:
Ph.D. (Technical sciences),
associate professor — _____ — Dmytro BONDARENKO

Head of Study Programme
Ph.D. (Technical sciences),
associate professor — _____ — Oleg FROLOV

Kharkiv
2024

INTRODUCTION

The development of modern information technologies is accompanied by an increase in the role of information and communication systems for various purposes and computer networks. They consist of two parts: terminal equipment and a transport network that connects the respective hosts (servers). The educational component "Architecture of computers and computer networks" consists of two parts.

The first part is aimed at studying the construction, functions, settings, modes of operation of computer equipment as end equipment, as well as certain specialized software for its diagnostics.

The second part is aimed at modern technologies of computer networks, among which local and global networks should be distinguished. This is explained by the need to use corporate information contained in corporate databases, which can be located both in individual divisions of the enterprise and outside its boundaries. Therefore, modern technologies for processing documents for various purposes should be based on means of telecommunications and computer network standards, which act as transport systems for data transmission.

In order to increase the efficiency of the functioning of enterprise networks, means of their distribution should be used in case of an increase in the number of workstations and users. This leads to the need for a more detailed study and use of special devices and appropriate standards for combining individual local networks into a single one. Under such conditions, there is a need to justify the choice of system network support in terms of client-server access technology and processing of user requests.

But the successful use of a powerful computerized tool is impossible without a clear understanding of the features of the functioning of all its constituent parts, and this, in turn, requires solid knowledge of physical processes that occur at the level of a schematic representation of the structure of computer elements and nodes during their operation.

The need to study the architecture and operation of computers is determined by the emergence of new computer architectures, which are required for compiling programs from common programming languages, as well as the development and implementation of specialized languages.

The discipline is aimed at forming the acquirers of professional knowledge related to the construction of programs at the network level, mastering the basics and principles of building local, corporate and global computer networks, studying the basic principles of the functioning of network devices, as well as determining the characteristics of the hardware and software complex of a personal computer computer

The study discipline "Architecture of computers and computer networks" is studied by students of the specialty "Software engineering" of all forms of study in the first year during the first semester.

The purpose of the course "Architecture of computers and computer networks" is to provide theoretical knowledge, methodological recommendations and practical skills regarding the organization of computer systems and networks, disclosure of

modern technologies, concepts, methods of programming computer systems and networks, and implementation of programs using system utilities, work algorithms, studying the principles of diagnosing computer systems and networks using modern special software.

The objectives of the course are:

- expanding the system of knowledge about the structure and functions of a personal computer;
- deepening the skills of working with personal computer application programs;
- development of skills to work with technical and software components of a personal computer at the level of not only the user, but also the expert;
- mastering the practical skills to adjust the hardware and software of a personal computer;
- developing skills to select and adapt the hardware and software complex to the specific needs of the user or depending on the specifics of the business entity in which such a user works;
- mastering the skills to make one's own technical proposals for optimizing the user's work with computer equipment;
- formation of skills to diagnose problems in the operation of the computer hardware and software complex and, if possible, eliminate them;
- development of skills to design and create the most typical local computer networks, taking into account the specifics of the user's activity or a certain enterprise, institution, organization;
- formation of skills for working with technical documentation for computer equipment;
- assimilation principles of construction, architecture, network protocols in accordance with the open systems interaction model;
- evaluation of hardware and technical characteristics of elements and nodes of computer networks, including various network equipment, network adapters of hosts;
- configuration of network devices (routers, switches, gateways, etc.) using interfaces and commands of the network operating system;
- performing calculations and modeling of computer networks using automated design systems, such as Cisco Packet Tracer;
- detection and elimination of hardware and software malfunctions, debugging of network equipment and components of computer equipment.

The object of the course is the architecture of computer systems and networks.

The subject of the course is modern theoretical concepts and methodologies, principles of functioning, selection and practical implementation of computer systems and networks components.

The learning outcomes and competence formed by the course are defined in the table. 1.

Table 1

Learning outcomes and competencies formed by the course

Learning outcomes	Competencies
LO 07	GK 5, SK 11, SK 13
LO 18	GK 2, GK 6, SK 7, SK 12, SK 13
LO 21	SK 6
LO 25	GK 1, GK 2, SK 13, SK 15

where, LO 07. To know and apply in practice the fundamental concepts, paradigms and basic principles of the functioning of linguistic, instrumental and computing tools of software engineering.

LO 18. Know and be able to apply information technologies for data processing, storage and transmission.

LO 21. To know, analyze, choose, competently apply the means of ensuring information security (including cyber security) and data integrity in accordance with the applied tasks being solved and the software systems being created.

LO 25. Have knowledge and skills in software development using technologies of distributed data processing and standards of parallel computing on cluster computing systems.

GK 1. Ability to abstract thinking, analysis and synthesis.

GK 2. Ability to apply knowledge in practical situations.

GK 5. Ability to learn and master modern knowledge

GK 6. Ability to search, process and analyze information from various sources.

SK 6. The ability to analyze, select and apply methods and tools to ensure information security (including cyber security).

SK 7. Knowledge of information models of data, ability to create software for data storage, extraction and processing

SK 11. Ability to implement phases and iterations of the life cycle of software systems and information technologies based on relevant models and software development approaches.

SK 12. Ability to carry out the system integration process, apply change management standards and procedures to maintain the integrity, overall functionality and reliability of the software.

SK 13. The ability to reasonably choose and master software development and maintenance tools.

SK 15. Ability to use technologies and means of distributed data processing and parallel computing in software development.

COURSE CONTENT

Content module 1. Computer architecture

Topic 1. General information about computer architecture

1.1. Introduction to computer architecture. Abstraction levels of computer architecture. The principle and architecture of Neumann machines. Harvard architecture. Disadvantages of Neumann architecture and ways to eliminate them.

1.2. Classification and characteristics of computers by architecture. Classification according to Flynn. Basic characteristics of computers. Amdahl's law.

1.3. Various computer architectures. Purpose of devices and architecture of large computers. Mini and micro computers. The principle of the common bus. Modular open architecture. Typical architecture of a personal computer.

Topic 2. Architecture of computer processors

2.1. Microoperations and microprograms. Computer control device. Definition of microoperation, microcommand, microprogram and command. An example of a microprogram graph. The general structure of the computer control device. The operation of the command sampling unit during normal command sampling. Ways to increase the speed of the team selection procedure.

2.2. Control machines. Control signal generation unit. Control automata with rigid (schematic) logic. Control automata with programmable logic.

2.3. Ways of microprogramming. Horizontal, vertical, vertical-horizontal, horizontal-vertical and command-oriented microprogramming.

2.4. General principles of building processors. Hierarchy of stages of program execution in the processor. Classification of processors. CISC, RISC and MISC processor architectures. Processor duty cycle. Work cycle of the control transfer command. Software model of 16, 32 and 64-bit processor.

2.5. Processor operating modes. Real addressing mode. Secure mode of virtual addressing. Emulation mode of the real mode of addressing. System management mode.

Topic 3. Computer memory architecture

3.1. Ways of addressing commands: valid operand, deleted address, direct, direct, register, reduced, relative, intermediate, auto-increment and auto-decrement addressing. Command format.

3.2. Classification of memory devices. Purpose, characteristics and classification of memory devices. Hierarchical principle of memory construction. RAM allocation strategies.

3.3. Cache memory. Allocation of cache memory. Princeton and Harvard architecture of memory. Cache memory with direct display of information. Cache memory with fully associative display of information. Cache memory with partially associative display of information. Methods of recording information in cache memory.

3.4. External memory. Storage devices on magnetic disks. Solid state drive. Accumulators on optical media. Types (classes) of file systems.

3.5. Organization of memory protection in a computer. Memory protection by the method of protection keys. Memory protection by privilege protection method.

Topic 4. Architecture of supercomputers

4.1. Interrupt system. Purpose and characteristics of the interrupt system. Interrupt controller. Interrupt handling in the processor.

4.2. Architecture of high-performance computing networks. Prerequisites for creating high-performance computing. High-performance multi-core processors for embedded applications. Tile-64/64Pro processors. iMESH network. LARRABEE, ATAC and NEHALEM architectures. Comparative characteristics of processors. Programming of multicore processors.

4.3. Parallel computing systems. Systems with shared and distributed memory. Methods of intermodule connection (complexation). Multimicroprocessor computing systems. EPIC architecture. VLIW architecture.

Topic 5. Architecture of SIMD and MIMD class systems

5.1. Computing systems of the SIMD class. Vector and vector-conveyor computer systems. Structural diagram of a vector processor.

5.2. Matrix computing systems. A generalized model of a matrix SIMD system. An example of a PASM processor array controller device. An array of processors of the type "processor element - processor element", "processor element - memory".

5.3. MIMD class multiprocessor systems. Symmetric multiprocessor systems. Architecture of a symmetric multiprocessor system. Organization of the SMP system with a common bus. Cluster computing systems. Topology of cluster computing systems. System with massive parallel processing. Computing systems with heterogeneous access to memory.

Topic 6. Architecture of quantum computers and calculations

6.1. Architecture of quantum computers. Prerequisites for the creation of quantum computers. Quantum bits (qubits). Superposition and quantum uncertainty. The field of application of a quantum computer. Stochastic initialization. Architecture of a quantum computer. An example of solving the classic MNIST problem on a quantum computer.

6.2. Quantum computing. Examples of classic problems. Quantum bases and the Bloch sphere. Quantum gates and rotations.

6.3. Quantum programming. Software platforms. Shor's algorithm. Grover's algorithm. Quantum simulations. Quantum teleportation.

Content module 2. Architecture of computer networks

Topic 7. Basic concepts and characteristics of computer networks

7.1. General concepts of computer networks. Communication network. Basic principles of building computer networks. Addressing of computer network elements. Packages. Personnel. Transmission technologies. Topology of computer networks. Evaluation indicators of computer networks. Classification of computer networks.

7.2. Computer network architecture. "terminal-main computer" architecture. Client-server architecture. Peer-to-peer architecture. Architecture "computer-network". Intelligent network architecture.

7.3. Open systems interaction model. Prerequisite for creating a model of interaction of open systems. Protocol. Level models of interaction of open systems. Data encapsulation. An example of the application of the level model of interaction of open systems. TCP/IP reference model.

Topic 8. Physical and channel layer protocols

8.1. Physical layer protocols. Protocol requirements. A set of protocols in the TCP/IP stack. Interaction of protocols when sending and receiving messages. The process of transferring data between hosts. Structure of IEEE 802.x standards. Copper and optical cables. Cable connectors.

8.2. Ethernet technology. Ethernet technology standards. Coding of Ethernet technology. Technologies Fast Ethernet, Gigabit Ethernet, 10Gigabit Ethernet.

8.3. Channel level protocols. Network addresses and data channel addresses. Address Resolution Protocol (ARP). Sublevels of the channel level. Channel level

frame. MAC address structure. One-way mailing. Broadcasting. Multi-address mailing. LLC protocol and frame format. MAC protocol. Environment access control protocols.

Topic 9. Setting up the network operating system

9.1. General information about Cisco IOS. Conventional designations of network devices. Ways to access the command line interface environment. Internal components of the router. Composition of Cisco IOS versions. Memory composition in IOS. Configuration sharing.

9.2. Navigation on the IOS operating system. Hierarchical structure of IOS modes: basic, privileged, global configuration and additional modes. Commands to access privileged mode and to return to user mode.

9.3. Management of configuration files in IOS. Command structure and notation. Context help. Checking command syntax. Setting device names in IOS. Saving and deleting configurations.

Topic 10. Network and transport level protocols

10.1. Network level protocols. Methods of collecting MAC addresses. Switch packet forwarding methods. Switching with/without buffering. Cisco Express Forwarding technology.

10.2.IP addressing. Physical, network and symbolic addresses. IPv4 address. Class addressing. Mask of constant and variable length. Broadband and multicast IPv4. Private and dedicated IPv4 addresses. Checking the local TCP/IP stack. Route tracing ("tracert" command): path verification. IPv6 addresses. Hextets Individual IPv6 addresses. Prefix /64. A global unique IPv6 address. Autoconfiguration without saving address state.

10.3. Transport layer protocols. Monitoring of communication sessions. Transport level services. Interlayer structure of the TCP/IP stack. Transport layer protocols. Port addressing. Three-way TCP handshake.

Topic 11. Routing in computer networks

11.1. Routing in computer networks. Basic definitions of Routing. Classification of routing methods. Transparent and one-step routing. Routing from the source. Routing table. Metrics of routing protocols.

11.2. Static routing. Floating static route. Default route.

11.3. Dynamic routing. Dynamic routing algorithms. Scheme of centralized, decentralized and mixed routing. Routing Information Protocol (RIP). OSPF routing protocol. Zones in the OSPF protocol. Types of OSPF packets.

Topic 12. Protocols, mechanisms and technologies of quality service in networks

12.1. Dynamic Host Configuration Protocol (DHCP). The process of leasing an IP address by a DHCP client. DHCP client configuration phases. DHCP operations. Format of DHCP messages. DHCP configuration.

12.2. Bone tree protocol. Bridge protocol data block fields. The process of data transfer using the spanning tree protocol. Port status.

12.3. Characteristics of the architectural model of integrated services (IntServ). RSVP protocol. "Pendulum" QoS. Architecture of differentiated services. RSVP resource reservation mechanism. Exchange messages using the RSVP protocol.

12.4. Traffic Shaping mechanism. Traffic leveling mechanism. Algorithm "basket of markers" for Traffic Shaping. General structure of packet processing on network nodes. Shaper. Examples of setting the shaper. Components of the access rate negotiation mechanism.

12.5. Traffic Policing mechanism. Algorithm "Basket of Markers". The "Leaky bucket" algorithm. Speed limit mechanism. The single-speed limiter operation algorithm using two "marker baskets". Algorithm of operation of two-speed limiter using two "baskets of markers".

The list of laboratory studies in the course is given in table 2.

Table 2

The list of laboratory studies

Name of the topic and/or task	Content
Topic 1.	Evaluation of the performance of computer components
Topic 2.	Study of computer bus architecture
Topic 3.	Study of cache memory and methods of addressing commands and data
Topic 4.	Study of computer RAM
Topic 5.	Study of the device for inputting data from the keyboard
Topic 7.	Study of system utilities and commands for checking network settings and connections
Topic 8.	Calculation of Ethernet and Fast Ethernet networks
Topic 9.	Research of network devices and means of communication in Cisco Packet Tracer
Topic 10.	Calculation of IP address. Splitting the network into subnets
Topic 11. Topic 12.	Collecting and analyzing ICMP data using Wireshark

The list of self-studies in the course is given in table 3.

Table 3

List of self-studies

Name of the topic and/or task	Content
Topic 1 - 12	Studying lecture material
Topic 1 – 5, 7 – 12	Preparation for laboratory classes
Topic 1 - 12	Preparation for the exam

The number of hours of lecture and laboratory classes, as well as hours of self-study, is given in the technological card for the course.

TEACHING METHODS

In the process of teaching the course, in order to acquire certain learning outcomes, to activate the educational process, it is envisaged to use such teaching methods as:

Verbal (lecture (Topic 1, 3, 5, 7, 8, 9, 10, 12), problem lecture (Topic 11), lecture-visualization (Topic 2, 4, 6)).

Visual (demonstration (Topic 1-12)).

Laboratory work (Topic 1 – 5, 7 – 12), case method (Topic 1 – 3, 7).

FORMS AND METHODS OF ASSESSMENT

The University uses a 100-point cumulative system for assessing the learning outcomes of students.

Current control is carried out during lectures, laboratory classes and is aimed at checking the level of readiness of the student to perform a specific job and is evaluated by the amount of points scored:

– for courses with a form of semester control as an exam: maximum amount is 60 points; minimum amount required is 35 points.

The final control includes current control and an exam.

Semester control is carried out in the form of a semester exam.

The final grade in the course is determined:

– for disciplines with a form of exam, the final grade is the amount of all points received during the current control and the exam grade.

During the teaching of the course, the following control measures are used:

Current control:

defense of laboratory work (40 points);

written control work (testing) (20 points).

Semester control: Grading including Exam (40 points)

An example of an exam card and assessment criteria.

An example of an examination card

Simon Kuznets Kharkiv National University of Economics
First (bachelor) level of higher education
Specialty "Software Engineering"
Educational and professional program "Software engineering"
Semester V
Course "Architecture of computers and computer networks"

EXAM CARD

Task 1 (diagnostic, 10 points).
To conduct a study of the performance of the central processor of the computer system by the method of combined evaluation of the central processor and the memory subsystem due to data

compression. Compare its results with two other processors of the same manufacturer. Record the results in the form of a table. Build a suitable schedule. Provide an explanation for the specified characteristics. Confirm the value of the parameters with the corresponding screenshots.

Task 2 (situational, 20 points).
Pass the test according to the basic definitions and provisions of the course on the distance learning website
For example, the following questions are generated from the question bank:

1. What is the name of the register of the processor, which is part of the arithmetic logic device according to the von Neumann architecture?
2. What fundamentally distinguishes Princeton computer system architecture from Harvard?
3. Name the architecture according to Flynn's taxonomy, which can be attributed to the data pipeline?
4. What device combines the processor with other peripheral devices in the architecture of microcomputers?
5. Name the addressing method used to work with data arrays?
6. What devices make up the computing cells in the iMesh network?
7. Name the standard for implementing parallel computing based on the concept of message exchange only?
8. Choose the type of MIMD class systems that have the largest number of processors used in it?
9. What principle makes it possible to transmit a quantum state over a long distance?
10. How many processors should be used as much as possible in systems with heterogeneous access to memory? etc.

Task 3 (heuristic, 10 points).
For the specified segment (route) of the Fast Ethernet network:
1. Conduct network analysis and identify conflict domains;
2. Find paths of the greatest length;
3. Calculate the PDV indicator (double signal circulation time) of networks
4. To draw a conclusion about network performance.

Protocol No. ____ dated "___"_____20___ was approved at the meeting of the Department of Information Systems

Examiner PhD, Associate Professor Holubnychyi D.

Chief department PhD, Associate Professor Bondarenko D.

Assessment criteria

The final marks for the exam consist of the sum of the marks for the completion of all tasks, rounded to a whole number according to the rules of mathematics.

The algorithm for solving each task includes separate stages that differ in complexity, time-consumingness, and importance for solving the task. Therefore, individual tasks and stages of their solution are evaluated separately from each other as follows:

Task 1 (diagnostic).

The first question is devoted to issues of diagnostic study of the characteristics of computer system architecture elements (processor, memory, buses, input/output devices, etc.). As a result of performing the diagnostic task, the applicant must provide a reporting document, which will display the answers, which are confirmed by screenshots. After the inspection, the applicant receives K1 points according to the following requirements (Table 4). This task is evaluated on a 10-point scale.

Table 4

Assessment criteria for the diagnostic task

Points K1	Requirements
0	The applicant does not have the educational material, the answer to the question is missing or completely incorrect.
1-2	the learner reproduces the main provisions of the educational material at the level of memorization, the corresponding task is performed in a very concise, not in full form, the characteristics are incorrectly defined, there are erroneous values, misinterpretation of some parameters. The results are not confirmed by screenshots.
3-4	The acquirer at the level of memorization reproduces the main provisions of the educational material, the corresponding task is performed in a very concise, incomplete volume, the characteristics are defined in an incomplete volume, there are erroneous values, misinterpretation of some parameters. The results are partially confirmed by screenshots.
5-6	The applicant has sufficient knowledge, reproduces the main provisions of the educational material, the relevant task is completed in a very concise, but not complete manner, there are minor errors and/or misinterpretation of some parameters. There are no explanations for the specified characteristics. The results are partially confirmed by screenshots.
7-8	The applicant has sufficient knowledge, reproduces the main provisions of the educational material, the relevant task is completed in full, but there are minor errors and/or misinterpretation of some parameters. Partial explanations of the specified characteristics are provided. The results are confirmed by screenshots.
9-10	The applicant has solid knowledge, reproduces the main provisions of the educational material, the corresponding task is completed in full, there are no errors and/or misinterpretation of some parameters. The specified characteristics are fully explained. The results are confirmed by screenshots.

Task 2 (situational).

The second question is devoted to the solution of the logical-theoretical task according to the basic definitions and provisions of the course. The main goal is to organize the terminological apparatus of the course according to the materials of the lecture part of the discipline. The form of conduct is testing on the distance learning website. Each task is generated randomly from a bank of questions. The total number of questions in the bank is 342 questions. A sample of 40 questions is randomly generated for each applicant. Each question has a weight of 0.5 points. If the question contains several correct answers, the weight of the question is divided by the number of correct answers in a proportional ratio. As a result, the test taker receives K2 points. This task is evaluated on a 20-point scale.

Task 3 (heuristic).

The third question is devoted to determining the characteristics of the Fast Ethernet network and its performance. The acquirer must:

- conduct a network analysis and identify conflict domains;

- find paths of the greatest length;
- calculate the PDV indicator (double signal circulation time) of networks;
- to draw a conclusion about network performance.

The main purpose of solving this problem is to check the applicant's practical skills in analyzing a computer network. At the same time, the acquirer is allowed to use the existing reference literature. This task is evaluated on a 10-point scale (for the PVV analysis of the network – 2 points; for the correct definition of the collision domain – 2 points; for the correct search of the longest path – 2 points; for the calculation of the PDV indicator – 2 points; for the analysis of the calculation results and determination of computer network performance – 2 points).

RECOMMENDED LITERATURE

Main

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9. Отрох С.І. Комп'ютерні мережі. Комп'ютерний практикум: навч. посіб. для студентів спеціальності 122 «Комп'ютерні науки» / С.І. Отрох, Н.М.

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