MINISTRY OF EDUCATION OF THE REPUBLIC OF BELARUS
Belarusian National Technical University

Faculty of Management Technologies and Humanitarization
Department of "Philosophical Teachings"

A.I. Loiko

PHILOSOPHY OF DIGITAL TECHNOLOGY

Textbook for general educational discipline "Philosophy and Methodology of Science"

For students, listeners mastering the content of the educational program of higher education of the II stage

For all specialties full-time and part-time forms of education

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Author:

A.I. Loiko Sci., professor, head department "Philosophical teachings" Belarusian National Technical University

Reviewers:

Volnistaya M.G., professor of the Department of Philosophy and Methodology of University Education, Republican Institute of Higher Education.

Bulygo E.K. Associate Professor of the Department of Philosophy and Methodology of Science, Belarusian State University

The educational and methodical manual on the philosophy and methodology of science supplements the lecture material with topical issues of the philosophy of digital technologies. The section "Philosophy of Natural Science and Technology" outlines the features of the classical philosophy of technology. In the section "Philosophy, science, man at the beginning of the III millennium" the prospects for the impact of the fourth industrial revolution on the applied use of digital technologies and technological features of the functioning of digital ecosystems are analyzed. development of digital technologies and the role of philosophy in the analysis of the ethical aspects of the technological modernization of modern society

INTRODUCTION

The philosophy of technology has become an important part of the philosophy and methodology of science due to the transition of engineering activities to the industry 4.0 paradigm. This paradigm assumes the intensive development of the industrial Internet and its convergence with digital ecosystems. There is a convergence of equipment and technologies of industrial production with digital logistics and marketplaces.

In the design direction, the philosophy of technology was integrated with the theory of artificial intelligence. System engineers strive to maximize the role of digital intelligent components in the functioning of technical complexes and systems. The problem is being solved to bring the capabilities of artificial intelligence closer to the potential of natural human intelligence. At the beginning of the 21st century, the failure of schematic constructions of models of society became apparent. These models predicted the end of the era of industrial culture. But the phenomenon of new industrialization refuted the pattern of successive post-industrial and information societies. After the collapse of the USSR, the Republic of Belarus did not succumb to the influence of abstract schemes and retained its industrial culture, which, under the influence of the fourth industrial revolution, is mastering the digital technologies of the smart industry. This electronic edition shows how the theory of technological processes is transformed with engineering practice based on the fundamental principles of convergence and system analysis.

1. PHILOSOPHY OF NATURAL SCIENCE AND TECHNOLOGY

1.1 Classical philosophy of technology

The term "philosophy of technology" was introduced into the intellectual space of the German language by E. Kapp in the 70s of the XIX century. With this term, he updated a new direction of philosophical anthropology, focused on expanding the concept of the human body through the definition of technical devices as a natural extension of human organs. From E. Kapp's organ-projective concept of technology, it follows that a person continues the evolution of his own body through the design of technical devices that continue the functions of arms and legs. Under the conditions of the 19th century, E. Kapp's organ-projective concept of technology was not understood in the context of philosophical anthropology. Classical philosophical anthropology, which proceeded from the value of the human body that completed the biological evolution, was not ready for this. As a result, through the efforts of the German Union of Engineers, the term "philosophy of technology" was assigned a subject content close to the subject of classical engineering activity.

The term "technique" in a literal translation from the Greek language was used in the meanings of "skill", "mastery" and turned out to be close in meaning to the characteristics of handicraft activities and technological topics. In Germany, before E. Kapp, an intellectual tradition of reflection on the features of production processes was formed. This theme was due to the first industrial revolution and the transition of England to the industrial stage of development. In Germany, this stage was also relevant. Understanding the technological revolution in production processes was facilitated by the fact that some ethnic Germans, in particular, the father of F. Engels, owned assets in the industrial sector of England. They lived in this country and knew the peculiarities of industrialization.

A systematic analysis of the industrial revolution in England and the industrialization of the economy of this country was carried out by K. Marx in his work Capital. The writing of this fundamental work was facilitated by his creative friendship with F. Engels, who knew the industry of England well. K. Marx revealed the trend of technological production and logistics processes through the use of machine tools. The owners of enterprises discovered the advantages of machine technology according to the criteria of higher labor productivity than with the manufactory organization of technological processes. The workers also concluded that they had a dangerous competitor in the labor market.

Franz Relo (1829-1905) had the practice of working in a machine factory. Then his professional activity was higher technical education. He taught in Berlin at the Higher Technical School. For several years he was its rector. He lectured on industrial engineering. She was the main subject of his interests. In a systematic form, the course of lectures by F. Relo was outlined in the book "Theoretical Kinematics". He was one of the first to question the role of technology in culture. In 1884, he gave a lecture to the industrialists of Austria-Hungary entitled "Technology and Culture." He singled out two types of human culture. One culture (manganism) uses knowledge about the forces of nature and controls them. The culture of naturism does not use knowledge about the forces of nature. She's just protecting herself from them. The culture of Manganism includes Europe and North America.

For representatives of the Union of German Engineers, the topic of technology and technology has acquired a metaphysical character. This can be seen from the publications of Eduard von Mayer and Ulrich Wendt, as well as F. Dessauer, who considers technology as an ontological and theological phenomenon. In this phenomenon lies the fundamental presence of God's creativity.

Engineering and technology became the subject of consideration by Fred Bohn. Technique means industrial equipment, which owes its existence to the achievements of physics and chemistry. Technique is instrumental. This means that it is a means of achieving specific goals within the framework of technological processes. Technique involves knowledge that is used in practice.

In the Russian Empire, the subject of the philosophy of technology was systematized by P.K. Engelmeyer (1855-1941). He outlined it in four issues of a publication called "Philosophy of Technology". Another railway engineer from Vitebsk A.A. Pavlovsky wrote a number of works on the impact of technology on religion and women. He combined his reflections with the development and implementation of original projects for the modernization of the urban transport environment and the ports of the Baltic Sea.

Despite the significant influence in the intellectual culture of Europe of the integral paradigm of supersensible reality, which patronized the phenomena of technology and technology, a tradition of critical reflection on the technical and technological development of mankind was formed on the basis of the philosophy of reassessing the values of European culture. Among the thinkers who represented this critical tradition in Prussia, Austria-Hungary, Spain and Switzerland were F. Nietzsche, O. Spengler, Z. Freud, K.G. Jung, H. Orgega y Gasset and K. Jaspers.

F. Nietzsche described the process of reassessment of values in European culture and showed its origins. He does not speak directly about the role of technology and technology in this phenomenon. But his project of a superman and an appeal to the mechanisms of a competitive environment and will indicate that humanity needs to prepare itself for great trials.

O. Spengler in his work "The Decline of Europe" under the influence of discoveries in archeology and evolutionary theory of Charles Darwin formulated the thesis about the life cycle of local cultures. This life cycle is completed by the stage of civilization, in which there are industrial military and industrial technologies. A similar assessment of the role of technology at the stage of civilization was adhered to by the Russian philosopher N. Berdyaev in his work “Man and Machine”.

Z. Freud does not write directly about industrial engineering and technology, but he takes into account their role in the dynamics of individual and social consciousness. This influence was manifested in the destruction of the value system of European culture. As a result, the normative component of activity began to weaken in the public consciousness. The institution of the crowd has appeared, which can be manipulated. The extreme conditions of the First World War opened up new facets of the functioning of individual consciousness and its complex internal contradictory state. As a result, the individual consciousness needs psychological help.

K.G. Jung continued the development of the theme of human consciousness, begun by Z. Freud. He focused on the features of the functioning of public consciousness. His thesis is that the dynamic balance of this consciousness is provided by the collective unconscious the main element of which are archetypes. He stated the trend of destruction of the structures of the collective unconscious in the public consciousness of Europeans.

H. Orgega y Gasset actually accuses industrial machinery and technology of destroying the social architecture of European culture. In his opinion, this is evident from the strengthening of the social role of the crowd and the unpredictability of social and political processes associated with it.

K. Jaspers represents existentialism, for which the conditions of the boundary situation between life and death had not yet been created in the face of the individual, but there was a mood of crisis in European culture. Therefore, his works give a general description of the phenomena of engineering and technology in the space of society.

Against the background of a critical attitude to industrial engineering and technology, the methodological programs of positivism and Marxism have become quite optimistic. Positivism, represented by O. Comte, formulated the thesis of an empirical science of applied orientation with a variation of design and technological activities. This thesis has been adopted in the United States.

Marxism, within the framework of the program for building a communist society, assigns a key role to industrial equipment and technologies. To this end, science and engineering design activities received support in the USSR within the framework of the programs for creating energy infrastructure (GOELRO), agricultural and industrial industrialization.

After the Second World War, the philosophy of technology returned to social issues. Technique began to be considered the reason for the transformation of society into a kind of machine, and the individual into a cog in this machine. E. Fromm, based on the methodology of psychoanalysis, searched for the causes of the totalitarian organization of European states in the 20th century. G. Marcuse studied the phenomenon of one-dimensional man.

In the 60s and 70s of the 20th century, studies of the philosophy of technology associated with the German Union of Engineers were not as sharp as those of the representatives of the Frankfurt school, which included E. Fromm and G. Marcuse. This is explained by the fact that authors associated with engineering wrote about technology. The subject of their consideration was the concepts of technology and technology, nature, engineering ethics. These studies were included in the publication entitled "Philosophy of Technology in Germany". It was published in Russian. Then in a more expanded geography of authors from different countries, followed by a publication in Russian called "The New Technocratic Wave in the West." W. Beck exacerbated the theme of the philosophy of technology by risk analysis. He updated the concept of risk society.

In the USA under the title "What is the philosophy of technology?" published a review monograph by K. Mitcham. It was published in Russian in 1995. In the USSR, the classical philosophy of technology acquired two methodological modifications. One of these modifications was based on the methodology of scientific and technical disciplines and was part of the philosophy of science. Among the authors were V.G. Gorokhov and M.A. Rozov. The second modification of the philosophy of technology was represented by the methodology of technical creativity. She relied on the work of P.K. Engelmeyer, who published the book The Theory of Creativity in 1910. In this context, a number of works were written by G.S. Altshuler. He developed a theory for solving inventive problems and an algorithm for solving creative problems adapted for use in computer programs. The desire of the classical philosophy of technology to take into account the achievements in the field of information technology became obvious.

The origins of the classical philosophy of technology were identified in the ancient era in the writings of Aristotle. The continuity of its evolution was ensured by the efforts of Archimedes, Vitruvius, Agricola, Lull, L. Da Vinci, R. Descartes, K. Semyanovich, I. Beckmann, G.M. Pope, F. Relo.

Aristotle in the structure of social life identified the categories of nature, knowledge, technology. Technique associated with handicraft activities, he assigned a secondary role, since the artisans who created the technique did not really influence decision-making in society. From the point of view of the criterion of creativity, they created tools according to patterns taken from nature. Knowledge had a more significant status, since it influenced decision-making, education, and intellectual culture. Nature also had a higher status than technology, since it used original forms.

The thesis of the neutrality of technology in culture has become one of the key in philosophy. Aristotle, who substantiated this thesis, proceeded from the practice that has developed in the economy of using the cheap labor of slaves. As a result, technical creativity was in the field of crafts. The achievements of engineering and technical creativity were used in construction, the organization of ancient cities, and military affairs. Of the inventors, Archimedes gained fame, who at the moment of creative insight shouted the word "eureka". As a result, heuristics as a science of discovery has become an important element of intellectual culture. Heron of Alexandria became famous for original technical inventions. But the inventions had no social order.

The dependence of technology on the human factor deprived it of its ontological status. M. Heidegger drew attention to this circumstance in the 20th century. He introduced the category of technology into the coordinate system of being and time. Based on this approach, the dialectic of potential and actual being was realized. It has two modifications. In one of the modifications, the components of potential being pass into actual forms of being through the self-organization of inorganic and organic structures. The Universe and the biosphere were updated in a similar way. They ended up in the coordinate system of time. Technique does not have the original property of self-organization. It refers to a kind of potential being that needs a mediator for actualization. Man as a generic being has become such an intermediary for engineering and industrial technologies. The motivation for a person was the need for tools and effective ways of organizing the processes of activity. Developers of artificial intelligence can bring equipment and industrial technologies to the level of self-organization and self-actualization in various modifications. This level is referred to as the technological singularity.

1.2 Classical philosophy of technological processes

The technological activity of mankind, as evidenced by archeology, was almost immediately carried out in the form of tool activity. Mechanical tools were part of the technological processes of hunting, fishing, processing animal and fish carcasses, making skins for clothing, and gathering. Stone tools are well preserved in the sites of camps of communities of hunters and fishermen. Mostly caves. The technology is focused on the organization of activity processes in the form of a certain sequence of actions and their coordination. Until the New Age, the technological culture of mankind was not comprehended. It belonged to the field of practical activity. Due to the fact that the technological processes were not described in the texts, some unique technologies were lost. Scientists have to look for ways to reconstruct them. The guild form of handicraft activity contributed to the secrecy of information about technological processes.

Industrial culture has overcome shop isolation and technological processes have become the subject of study and description in publications available for reading. As the tragic biography of K. Semyanovich showed, it was not safe to write about technology and technology in the 17th century. Craft corporations did not want the technologies they used to make technical devices to be available. And the subject of study of the native of Belarus was ballistics, pyrotechnics and the production of powder rockets. He studied ballistics in combat. The supporter of R. Descartes managed to realize only the first part of his research called "The Great Art of Artillery". This part was published in the Netherlands in Latin. The second part of the publication did not take place, since K. Semyanovich was killed.

The term "general technology" began to be used to designate the new science. Johann Beckmann (1739-1811), understanding the presence of a common basis in the form of organization of activities with state administration and economic management, divided these three areas of management. The subject of his study was the technological processes used in workshops and factories. The result of the study was a book called "Introduction to technology or knowledge of workshops, factories and manufactories" (1777). He aspired to a philosophical level of understanding the phenomenon of technology. He realized his idea in a book called Outline of a General Technology (1806).

Johann G.M. Poppe (1776-1854) continued to develop the concept of common technology. According to him, technology is the science of production processes, including crafts. It describes not only technological processes, but also the components of technology used in these processes (equipment, tools, machines). It also includes materials science. General technology studies the processes of activity characteristic of all industries. Special technologies are focused on industry specifics of production processes. General technology is described in a systemic form by I. Poppe in the book "Guide to General Technology" (1821).

In the 18th century, a higher polytechnic school was opened in Paris, which began to train engineers on a scientific basis. The training was based on the concept of general educational training of engineers, including engineering graphics, with subsequent specialization according to the industry principle. Higher technical schools in Germany began to adhere to a similar model of engineering education. As a result, books on general technology written by that time became part of the educational process, and their authors became professors of departments. Among them was Ernst Hartig (1836-1900). In his career there was even the post of rector of the Higher Technical School in Dresden.

E. Hartig realized the task of conceptualizing a common technology. To this end, he turned to such a science as logic. He used the principle of subordination from its theoretical apparatus. In the modification of engineering sciences, he designated it as the principle of technological subordination. It follows from this principle that a specific production method determines a specific list of tools and equipment for the implementation of this technological process.

K. Marx in his work "Capital" outlined a clear prospect for the modernization of technological processes in industry with economic determinism. This thesis has found confirmation in the US industrial management. G. Ford was one of the first to link the modernization of technological processes with the criterion of growth in labor productivity and wages of workers. His concern is for the growth of the consumer car market. To implement this strategy, he designed a conveyor. This technological process optimized production costs and made the production of passenger cars affordable for the mass consumer society. From that moment on, the development of effective forms of organization of production processes and the work of workers has become a key task for the US industrial business. The industrial business adheres to this strategy to the present day.

1.3 Classical philosophy of engineering activity

Engineering activity in the classical sense assumed the ability of engineering graphics to create project documentation containing basic instructions and regulations for the implementation of construction and technological tasks. The engineer was a technical specialist with a higher education who supervised the compliance of construction work with project documentation. The engineer of the enterprise was responsible for compliance with the technological processes of production.

The classical philosophy of engineering activity was created by professors of higher technical schools. The concept of training engineers was formulated and implemented at the Higher Polytechnic School of Paris by Gaspard Monge in the 18th century. It assumed two stages - general education and special. The narrow specialization in the training of engineers became the subject of criticism in the works of AloisRiedler. He believes that engineering education should be interdisciplinary and focused on the practical features of the activity. It is important for an engineer to be able to apply knowledge in practical conditions.

F. Bon was a supporter of interdisciplinary training of engineers. Against the background of a rational model of engineering education and engineering activities close to science, the formation of another modification of the classical philosophy of engineering activity was important. The author of this modification was P.K. Engelmeyer. He emphasized creative topics in engineering. He developed the theory of technical creativity. An engineer, starting to realize a need, relies on logic, intuition and physical actions. Logic helps to make a plan of action. Intuition helps to realize a creative idea. Physical actions are aimed at the transformation of natural material based on knowledge from physics and chemistry. This concept was outlined in the article "Eurology, or a general theory of creativity."

In the 20th century, there was an institutional specialization of engineering activities according to the professional competencies of a design bureau, design organization, technological organization of industrial production, labor protection, ecology, recycling and recycling of material resources. Systems engineering began to play an important role.

In the classical philosophy of engineering, the role of methodology has increased. Two modifications have been developed. One is based on the concept of scientific and technical disciplines. This methodology is one of the modifications of the scientific research methodology. It analyzes the concepts of technical theory, modeling and empirical research methods (V.G. Gorokhov, V.M. Rozin). The second modification of the methodology of engineering activity is based on the theory of technical creativity by P.K. Engelmeyer. It is compatible with the general theory of creativity (heuristics). It developed a categorical apparatus of creative thinking. The starting point of this thinking is a problem situation, which is designated as a problem that needs to be solved. Scenarios for its solution are analyzed using special search techniques, for example, brainstorming. The possibilities of analogy and similarity theory are used. G.S. Altshuler developed the theory of inventive problem solving.

1.4 Methodology of scientific and technical disciplines

In the 20th century, the disciplinary structure of the technical sciences was formed. The disciplinary approach was based on the allocation of certain classes of technical systems and subsystems, as well as technological processes. The theoretical level of technical science forms a conceptual description of the architecture of a certain class of technical devices, for example, the theory of a ship, the theory of bridge trusses, the theory of a tractor. By means of formalization and idealization methods, a description is created in the language of equations of the main elements, structure and subsystems of a technical device, or a technological process. Typical processes are described.

Functional structures are described on the basis of mathematical analogues of physical and chemical processes. The flow diagram of a technical theory contains a description of the flows of energy, information, matter within a technical system.

The block diagram in the form of equations contains a description of the architecture of the ship, aircraft, car. This description is used as a computational model of a designed technical device, as an algorithm for solving design problems. The invariant part of the model is represented by calculations of reliability, stability, safety, efficiency, and environmental friendliness. The variable part is formed by the customer based on financial capabilities, characteristics of the potential consumer market. This part is not included in the content of the technical theory. It is about design.

Scientific and technical disciplines provide designers and designers with knowledge about the open properties of materials, general trends in the evolution of engineering activities in the context of the transformation of social reality, and the growing importance of environmental criteria. The results of research in scientific and technical disciplines are also used in the process of modernization of functioning technical complexes and communications.

Empirical components of scientific and technical disciplines are used in the course of scientific research. They involve measurement, experiment, diagnostics and modeling. In construction, scientific research provides up-to-date information on the criteria and validity of site selection for project implementation. The characteristics of the site directly affect the cost of construction work and its timing. Some projects involve scientific research to study public opinion. If this opinion is not taken into account, then the terms for agreeing on the site for the construction of the facility are delayed and acquire a public outcry.

In the process of design activity, scientific research is also in demand. The designer analyzes with the help of digital search systems the availability of functional and in-line solutions for published articles and monographs. At the stage of work with a prototype, he tests the model according to clear criteria that are relevant in terms of safety, reliability, efficiency and customer requirements.

Computer simulation speeds up the process of test diagnostics of a prototype. This does not cancel the stage of testing a prototype in the field.

1.5 Historical and philosophical analysis of techniques and technologies of traditional society

Humanity evolved within traditional society until the 16th century. This society was characterized by stable practices of social organization in the form of family, clan, tribe, community and linguistic community. The economic basis of the traditional society is gathering, hunting, fishing, nomadic animal husbandry, agriculture and handicrafts. This society has a stable social hierarchy in the form of clan institutions, castes, shamans, sorcerers, tribal leaders, priests and estates.

Tool activity has become the main criterion for the emergence of mankind as a special biological and social community. According to archeology, the first tools of labor began to be made by people two million years ago. These tools were integrated into specific technological processes of gathering, hunting, fishing, breeding and maintaining fire. The biological, social and technological evolution of mankind at the stage of savagery was slow. The pace of human evolution accelerated fifty thousand years ago with the advent of the Cro-Magnon. The competitive social environment determined the formation of the institution of patriarchy, paired families and tribes.

To overcome the dependence on wildlife resources, the tribes began to create a new type of biological ecosystems, the main elements of which were cultivated plants and domesticated animals. This was the era of the Neolithic Revolution. Agriculture created a new settled way of life in open spaces in the form of fortified cities. There was a demand for construction technologies. To ensure food security, reclamation and irrigation technologies, as well as canal construction, began to be used. On the basis of cities, the institution of state power began to form. Competition among states has created a demand for military technology. In ensuring the unity of the state, the information space and related technologies of writing, law, administration and spirituality began to play an important role. On the basis of regions of intensive agriculture and urban life, local civilizations arose that united individual cities of the state. They arose independently of each other and at about the same historical time. This gave grounds to K. Jaspers to introduce the term "axial time". This term reflects the temporal synchrony in the evolution of the local social agricultural structures of humanity.

After the formation of the practice of philosophical reflection in the 7th century BC, technique and technology were not of particular interest for this reflection. This was explained by the fact that artisans were engaged in the creation of technology, and their social status did not attract the attention of thinkers. The lack of interest in engineering and technology took place against the background of the unique achievements of the civilizations of traditional societies in the field of building technologies, architecture, metal processing, and shipbuilding. Suffice it to recall the Egyptian pyramids, Babylon, the Great Wall of China, the Parthenon in Athens, the Coliseum in Rome, the Pharos lighthouse in Alexandria and Machu Picchu in the Andes.

After philosophy became a part of Christian and Islamic theology, it did not change its attitude towards engineering and technology. They remained out of her sight amid the unique advances in building technology in India, China, the Middle East and Europe. The inventive talents of Heron of Alexandria and Lull did not have a social order.

Against the backdrop of agricultural civilizations, there were many tribes whose main occupation was nomadic animal husbandry. Herds of horses needed large pastures. This type of technological agricultural activity was highly dependent on climatic conditions. Therefore, in the space of traditional society, there were constant migrations of nomadic tribes. To compete, these tribes formed alliances. They raided agricultural civilizations and seized their territories. So, the Germans and Slavs settled in Europe and began to lead a settled way of life. The Arabs captured the territories of the Near and Middle East, North Africa, and Southern Spain. Turkic nomadic tribes conquered Asia Minor, Transcaucasia (Azerbaijan) and a significant territory of Central Asia (Kazakhstan, Kyrgyzstan, Uzbekistan and Turkmenistan). Hungarians and Bulgarians settled in the Danube river basin.

1.6 Historical and philosophical analysis of technology and technology of industrial civilization

By industrial civilization we mean one or more states whose life activity is based on the use of the achievements of science and technology, as well as the international division of labor in the field of industrial and information cooperation. Industrial civilizations began to form in the 16th century on the territory of Europe. The reason was the small territory and its overpopulation. To avoid social conflicts, the Vatican constantly encouraged projects of campaigns outside Europe. In the Middle Ages, such a project was the Crusades. But they did not give results. Another project was the idea of a sea route to Asia with its enormous wealth. This project was motivated by the loss of the monopoly in trade with China along the overland section of the Great Silk Road.

At the initial stage of geographical discoveries, Europeans plundered and destroyed the civilizations of the traditional societies of America. At the second stage, a mass migration of European peasants and townspeople began, organized in Protestant and Catholic communities to America for permanent residence in the New World on a new land. These people began to engage in agricultural production in the form of farms in the North of America and slave farms in the American South. From contact with Europeans, most of the local Indian population died due to disease. People began to be imported to America from Equatorial Africa. This population was classified as slaves.

After the formation of the New World, there was a demand for handicrafts. This production could not meet the demand for these goods. In England, they reacted to this situation with the industrial revolution. There was a mass expulsion of the population from the rural regions to the cities. In the liberated territories, farmers remained, who were engaged in sheep breeding on an industrial scale. Wool went to local manufactories. The urban population has become industrial. It earned money in factories and spent it on the purchase of manufactured goods. As a result, a capacious domestic market arose, which became a potential basis for the formation of a mass consumer society.

But in itself, the physical labor of workers did not contain prospects for further growth in labor productivity. Therefore, the owners of factories and plants began to saturate technological processes with machine tools with a machine drive. K. Marx was one of the first to draw attention to the fact that workers perceived machinery as a competitor in the field of employment (work "Capital"). On their part, there were facts of damage to cars. The Industrial Revolution marked the beginning of machine production, which replaced manufactories and craft workshops.

In the 19th century, the use of machines in technological processes became widespread. For machine production, the coal industry was needed, for the smelting of metal, iron ore. Technological processes turned out to be associated with activities at the enterprises of research laboratories. Such sciences as physics and chemistry were integrated into technical creativity. Technoscience arose on their basis. Its applied tasks consisted in the scientific support of technological processes in the metallurgical, chemical, and military industries. Electricity and magnetism formed the basis of energy. Railways were electrified, electricity was supplied to the industrial, urban, household sectors of people's life. Thermodynamics made it possible to modernize the communal urban economy. The achievements of inorganic and organic chemistry were actively used in metallurgy and the chemical industry, in particular, in the development of petrochemical complexes.

From the 18th century, the Russian Empire followed the path of creating industrial civilization. After the War of Independence and the Civil War, industrial civilization began to form on the territory of the United States of America. These two local industrial civilizations initially had a significant territory, human resources and a single center of state administration. In Europe, industrial civilization was formed in conditions of territorial fragmentation and nationalism. This subsequently became the cause of constant military conflicts in the European region. After World War II, this civilization lost its leading status in global politics and became a US satellite.

In the 19th century, technological civilizations began to struggle for colonial control over the traditional societies of the planet. In this process, the most successful was Great Britain, which created the British Commonwealth of Nations. France, the Netherlands, Spain, Portugal, and Belgium acquired colonial possessions. Russia did not endow the annexed territories with colonial status. They became part of the metropolis. The United Kingdom operates according to this model, which includes the territories of England, Wales, Scotland and Northern Ireland.

Europeans failed to impose colonial status on China, Afghanistan and Japan. After the Second World War and the collapse of colonial empires, the geography of industrial civilizations in Asia and the Pacific region was formed. By the time they were formed, three industrial revolutions had taken place.

The first industrial revolution is associated with the beginning of an industrial society and the use of steam-based industrial machines and technology. The second industrial revolution gave rise to the use of electricity in industry and in everyday life. The third industrial revolution was associated with cybernetics and technical means of communication. She made information one of the main resources of management. The beginning of automation of industrial production was laid.

1.7 Concepts of technological determinism

Before the historical era of industrial civilizations, equipment and technologies had a subordinate status in relation to other types of determinism. With the beginning of the historical era of technogenic civilizations, technology and technology have acquired an argument in the form of technological determinism. This determinism reflects the obvious influence of technology and technology on the characteristics of people's professional activities, their way of life, social organization and the prospect of human evolution as a species.

Three modifications of technological determinism in the field of social reality have been developed. One of these modifications does not claim maximum dominance in the social system. She interprets technological determinism as a chance for capitalist and communist formational systems to ensure the competitiveness and success of their evolution. In the United States, positivism in the author's edition of O. Comte was enthusiastically accepted.

The works of O. Comte, describing techno science, had a significant perspective in the form of analytical philosophy. This philosophy is based on the empiricism of positivism and pragmatism. It recognizes only those scientific statements and the categorical apparatus that are verifiable by atomic statements, i.e. they have analogues in the sensuously perceived world. All abstract categories that do not have sensually perceived analogues do not make sense and should not be present in the conceptual framework of science.

Applied values of analytical philosophy in the field of techno science were actualized in the USA. Based on the convergence of mathematics and logic, a research and design basis for the formation of cybernetics, computer science, and the theory of artificial intelligence was created. N. Wiener became the father of cybernetics. The A. Turing test introduced a criterion for defining a computer program as artificial intelligence. The topic of artificial intelligence was not limited to methodology. As part of the philosophy of man, a strategy of transhumanism was formulated, which implies an era of hybrid reality for the benefit, as the authors of this strategy assure of the person himself.

Based on the philosophy of Marxism V.I. Lenin formulated the thesis about technological determinism as one of the key components of the material security of communist society. In this context, an important role was assigned to science, technology and technology. The scientific and engineering potential of capitalist society was supposed to be used for the tasks of communist construction. A particularly important role was assigned to this potential within the framework of the program for creating an industrial society and a military-industrial complex. The succession of scientific and engineering personnel played an important role in the development of the USSR, in particular, during the Great Patriotic War.

The second modification of technological determinism was substantiated by T. Veblen at the beginning of the 20th century. It is characterized by maximal in the issue of the role of technology and technology in society and asserts the absolute role of technological determinism in the evolution of industrial civilizations. In the USA and Western Europe, on the basis of this maximalist paradigm of technological determinism, the concepts of industrial, post-industrial and information societies were developed. These societies, as conceived by the developers, have linear dynamics and replace each other. This dynamic was described in concept of stages of growth.

Within the framework of industrial and post-industrial societies, the agricultural and industrial sectors of human activity are undergoing transformations according to the criteria for reducing employment and the qualifications of workers and technicians. The greatest dynamics of employment reduction was observed in the agricultural sector. She settled on employment rates of 3-5%. The downward trend in employment in the industrial sector stopped at a figure of 20%. The freed able-bodied population went to work in the service sector. Employment also began to be provided by institutions of small and medium-sized businesses.

In the second half of the twentieth century, D. Bell began to substantiate the thesis about the advent of the historical era of the information society. In his opinion, the main sectors of employment of the able-bodied population are the service sector, science and information. He substantiated the thesis of the deindustrialization of society. This thesis was believed in the conditions of the collapse of the USSR in the former Soviet republics. As a result, they lost their industry and agro-industrial complexes. The Republic of Belarus and the Russian Federation did not follow this path. They preserved the infrastructure of the industrial and agro-industrial sectors of activity and employment of the able-bodied population. At the beginning of the 21st century, new industrialization has become a trend in the development of China, the United States and Europe.

1.8 Philosophy of technocracy

T. Veblen, in the framework of substantiating the paradigm of technological determinism, believed that the structure of public administration should correspond to the dominance of this determinism in society. In his opinion, at the beginning of the 20th century there was no such correspondence, since the idle class of owners possessed real power. He did not deal with practical issues of engineering and technology. He cultivates a way of life detached from real affairs, but at the same time he owns state power. This power in the light of the dominance of technology and technology in society should belong to technical specialists of the highest qualification (engineers).

Under capitalism, it was a social utopia. But the term itself began to be used in state management practice. Technocrats in the conditions of bourgeois democracy began to include highly qualified technical specialists with management experience. These specialists occupy positions on which the functioning of society depends, regardless of the change in party coalitions and election results. With frequent changes in the cabinet of ministers, society prefers the government of technocrats - people who are able to rise above inter-party contradictions and follow national interests.

Technocrats are also the object of criticism, as they are accused of lacking humanitarian competencies. These people demand technological discipline and order. These requirements apply both to the workshops of enterprises and to offices.

The corporate power of the technocracy has increased with the formation of multinational corporations and banks. The budgets of individual transnational corporations exceed the budgets of individual states. The influence of technocracy has especially increased in corporations associated with the digital technologies of the Internet. In a number of states there was a fear of losing control over technocracy. Parliamentary hearings were organized to which representatives of corporations were invited.

1.9 Mechanistic analogues of technology in the organization of society

Technique and technology are associated with the rational organization of labor and society like a machine. With such an organization of labor and society, the implementation of unique projects is achieved with their low technical support. The lack of technical means is compensated by the number of attracted labor force and efficient technologies for using this labor force. As a result, humanity has Stonehenge, pyramids, the Great Wall of China. It admires these achievements, but says little about how many lives were lost to create these stone structures. This is how the phenomenon of society as Megamachines was formed (L. Mumford). This society uses human resources to implement not only engineering projects, but also military-political projects. Based on the Megamachine methodology, the Arabs, the Tatar-Mongols and the Ottomans were able to rise. They created powerful empires in the Middle Ages.

Industrial civilizations are also characterized by the phenomenon of the Megamachine. It was typical in the thirties for Italy, Germany, Spain, Hungary, the USSR, Japan. The power structures of these states, with the exception of the USSR, used the population of their countries not to implement unique construction projects, but to kill. The Nuremberg trials gave a legal assessment of the crimes of the Nazis of European states. The crimes of the Japanese military against the civilian population of China and Korea during the Second World War did not go unnoticed. In 1953, the Communist Party of the USSR condemned the personality cult of I. Stalin and the Megamachine mechanism associated with it. In the post-war period, thinkers of the FRG made a lot of efforts to ensure that the image of the Megamachine ceased to be part of the mental structure of the social consciousness of the Germans in the FRG.

1.10 Convergence of technological and economic determinism in an industrial society

One of the first to describe the trend of merging technological and economic determinism was K. Marx. In this convergent structure, economic determinism plays a major role, because it determines the use of technology and technology in production processes. An argument in favor of the active use of technology in agricultural and industrial production, transport logistics, was the higher labor productivity created by it. An important argument was the rapid delivery of material and commodity resources by machine vehicles.

The mechanization of production has created a hybrid cooperation between the physical labor of workers and equipment in the structure of technological processes. In addition to purchasing equipment, production owners had to spend money from profits on depreciation and payroll. Another potential cost was related to the fact that workers perceived the equipment as a major competitor in the employment market. Therefore, there were facts of damage to industrial equipment.

Despite the costs associated with the maintenance of machinery, the owners of factories and transport companies continued to adhere to the strategy of convergence of technological and economic determinism. The growth of production volumes in the conditions of the colonial model of the social organization of mankind could, due to the low capacity of consumer demand, create a situation of overproduction, which was shown by the great depression of the twenties and thirties of the twentieth century.

A solution called "mass consumer society" could balance the potential for growth in labor productivity and demand for industrial products. G. Ford was one of the first to understand the connection between production and demand when he began to implement a project for the production of cars and trucks. If he proceeded from the technology of only manual piece assembly of cars, then he would have a small circle of potential customers from the representatives of the leisure class. For the mass production of passenger cars, a more capacious domestic consumer market was needed. The key was the proportionality of the cost of production of a car, its commodity value and average wages on an annualized basis. In order to achieve this proportionality, G. Ford developed a technological process, which was called the "conveyor line". This technological process increased the productivity of workers to a level commensurate with the cost of the car they produced. The volume of car sales began to directly influence the transformation of the lifestyle of the urban population.

This process took a certain historical time, and H. Ford had to face considerable difficulties in his automobile business. Military orders helped, which created a steady demand for trucks. Economic determinism shapes the policy of industrial companies according to the criterion of profit. This is due to the fact that in addition to the costs of depreciation, modernization and innovative development, industrial companies pay taxes to the state, interest to shareholders and interest on bank loans. Therefore, they are constantly looking for sources of savings. These sources are payroll savings by optimizing the structure of corporate employment, as well as outsourcing. A resource for industrial companies in the West has become a cheap and fairly skilled workforce. Free economic zones in China became industrial sites.

1.11 Philosophy of the technical and technological sphere of mankind

In the 20th century, there was every reason to believe that technology and technology created a space for communication and industrial infrastructure of mankind, comparable to the biosphere.

In 1968, the Club of Rome initiated research aimed at answering the global consequences of the intensive use of technology and technology by mankind. The ecological criterion was chosen as the main one. The first report to the Club of Rome is called "The Limits to Growth". It was prepared by scientists at the Massachusetts Institute of Technology. It clearly emphasizes a difficult future for humanity if it does not introduce an environmental component into the design activities of engineers and the overall strategy of transnational industrial, energy, transport, agricultural, and logging companies. Ecology should become a systemic criterion for the material activity of mankind. The depth and completeness of processing of raw materials, recycling of production are important. The reports to the Club of Rome reminded of the methodological approaches of R. Park and B. Burges, who created the basis of environmentalism. They also recalled the works of V. Vernadsky, who formulated the thesis about the co-evolution of the biosphere and noosphere.

The trend of increasing anthropogenic pressure on the biosphere from mankind in the form of industrial, transport, energy, and municipal emissions into the atmosphere, hydrosphere, and lithosphere has become obvious. The subject of research was the ozone layer of the planet, the dynamics of carbon dioxide in the atmosphere, pollution of the oceans, the melting of glaciers, the growth of climatic anomalies and global warming. Smog testified to the problems. A blow to the reputation of technological optimists was caused by man-made disasters at nuclear power plants in Chernobyl and Fukushima. Belarus found itself in the epicenter of a man-made accident at the Chernobyl nuclear power plant, since this plant is located several kilometers from the state border of the country. Air currents contributed to the spread and settling of radioactive waste mainly on the territory of Belarus.

In 1992, at the UN conference in Rio de Janeiro, the concept of mutual development of the biosphere and noosphere was formulated, not to the detriment of each other. It was specified in the protocols signed in Montreal and Kyoto. Ecology began to be taken into account in the industrial, transport, agricultural activities of mankind. In the form of a norm, it is used in design activities in the automotive industry, aircraft construction, and the production of low-temperature equipment. Ecology has become part of national security concepts.

1.12 The ambivalence of scientific and technological progress and the philosophy of risk

The philosophy of technology took place in the form of two reflections. One reflection ensures the methodological productivity of technical creativity and techno science. These are supporters of scientific and technological progress. Another reflection sees its task in a critical understanding of the historical path of mankind, formed by technological determinism and the economic and geopolitical determinism that contributes to it. These are also supporters of scientific and technological progress, represented by scientific and technological industrial revolutions and stages of technological modernization. But they are more careful in evaluating the technique because of its ambivalence (duality). Will these reflections be able to develop a balanced approach, and will the evolution of the biosphere and noosphere become a co-evolution? The question is still open. Another aspect of the ambivalence of engineering and technology is their war. In the conditions of using military nuclear technologies, even in peacetime, there are risks of unauthorized proliferation of nuclear weapons. The threat is terrorism. Corruption in military departments also creates risks.

After the accident at the Chernobyl nuclear power plant, humanity developed an ambivalent attitude towards nuclear energy. Anxiety was reinforced by an accident at a nuclear power plant in Japan. As a result, there was a movement to close nuclear power plants. It was especially active in Western Europe. It is part of the environmental movement. Thermal power plants using coal as fuel have also become a subject of criticism.

As a replacement for nuclear and thermal power plants, solar, wind, geothermal, tidal and hydropower are proposed. However, the capacities of these power plants are unable to cover even half of the needs of European Union users in electricity and heat. Such a resource for the production of electrical energy as natural gas corresponds to strict criteria of engineering ecology. But its reserves in the bowels of the European Union are extremely limited. The US produces liquefied gas, which has a high production cost. The Russian Federation has large reserves of natural gas.

Under the influence of strict criteria of safety, reliability and ecology, automotive and aviation equipment turned out to be. One of the sources of high accident rate of this equipment is the human factor. It creates risks through design decisions and through the operation of technical systems.

The growing concentration of uncertainties in the operation of equipment and technologies gave W. Beck reason to formulate the thesis about the transition of mankind to the historical stage of the risk society.

1.13 Technology as a physical device

Physical wear is the loss of the initial physical and chemical properties by the structural elements of the technical system, which raises the question of eliminating the system as not subject to reconstruction and modernization. If the liquidation requirement is not met, then physical deterioration inevitably leads to man-made disasters.

The technique is created by designers in the form of a prototype. After testing, it is scaled up through serial production. Each individual technical device and technical complex has a life cycle. During this life cycle, the product and the complex are regularly tested for physical condition. There are standards for diagnostics, maintenance and overhaul. Throughout the life cycle, the technical device and the technical complex accompanies service maintenance. From an economic point of view, this service involves depreciation in the form of deductions for the repair and maintenance of technical systems. This is done by repair teams and diagnostic centers.

The life cycle of the technical complex is extended by modernization. It includes the use of the latest achievements in the field of increasing wear resistance, strength of materials and structures. For these purposes, nanotechnologies and composite materials are used. Modernization may include automation, robotization of control and technical control of the technological complex. At the same time, modernization contributes to the deep processing of raw materials and the production of high value-added goods. This practice is especially relevant for petrochemical and mining chemical complexes, which play an important role in the economy of the Republic of Belarus.

The criteria for the completion of the physical life cycle of a technical device and a technical complex are their partial or complete destruction, as well as their removal from technological processes due to operating standards. This is due to the fact that with the physical wear of the technical device and the technical complex by more than 50%, there are increased risks of accidents and injuries to workers.

Moral obsolescence accelerates the decommissioning of specific generations of technical devices due to the appearance on sale of new generations of technical devices with higher rates of efficiency, resource saving, reliability, and versatility. Technical complexes are also subject to obsolescence in terms of efficiency and ecology, but their life cycle is extended by technological modernization and process automation.

At the end of the life cycle, technical devices pass into the technological stage of utilization and recycling of resources. This allows you to effectively use the resources of metals, fabrics, paper, films, wood and asphalt pavement.

In the conditions of a society of mass consumption, a market for secondary housing, cars, clothing, and computer equipment has formed. Some industries have begun to use recycling technologies. This made it possible to combine technologies for supplying water to consumers and draining water through a network of filtration systems. As a result, the ecology of rivers and lakes has improved. They have become permanent sources of water resources. Modernization is a reaction to obsolescence in order not to bring the technical system to physical obsolescence.

Modernization is based on the laws:

1. universality, repeatability of the state of certain elements, processes;
2. expanding the range of natural and artificial materials;
3. development of new energy sources;
4. development of new forms of motion of matter;
5. intensity of processes associated with pressure, temperature, speed;
6. an increase in the purposefulness of technical solutions;
7. increasing specialization and integration (interchangeability and modularity);
8. automation, robotization (cybernetization);

Modernization is based on laws. The law of completeness of parts of a technical system states that a necessary condition for the functionality of technical systems is the presence and minimum performance of the main parts of the system. The law of energy conductivity of a technical system states that a necessary condition for the functionality of technical systems is the passage of energy through its parts. The Law of Coordination of the Rhythm of a Technical System states that a necessary condition for the functionality of technical systems is the coordinated rhythm of all parts of the system.

The law of transition to a supersystem determines that heterogeneous systems contain the effect of constructive system-technical optimality. For example, an air conditioner is like connecting a refrigerator to a heater. On the example of capotechnologies, the law of transition from the macro level to the micro level is actively used.

The law of cybernetization reflects the increase in the dynamism and controllability of technical systems. The law of systems engineering fixes the increase in flexibility and internal differentiation of technical systems. The optimization law reflects the restructuring of the functional-structural, material-energy and informational components of technical systems.

The law of environmental safety has become relevant for engineering activities in the field of modernization. The law of functional non-linearity of complex technical systems determined the need for the development of systems of human activity. It is formulated as the law of localization of an abnormal technogenic process.

Any technical device is the result of human technical and scientific creativity and at the same time a natural process associated with the action of physical, chemical, biological laws.

1.14 Classical methodology of invention and design

An engineer does not deal with technical systems (devices and technological processes), but with their descriptions. It transforms these descriptions from obscure customer requirements to clear and unambiguous ones, such as drawings. At the same time, he uses the procedures of engineering activities that have been developed in engineering in accordance with the adopted regulations.

From the point of view of production, an engineer must be able to: operate and repair, design and eliminate technological processes and devices; set, develop, solve problems, predict, invent and make decisions on the implementation of technology. Understand the meaning of his work and its consequences, both in the useful functions created by him TS, and in undesirable effects.

During the activity, the engineer:

1. interacts with the customer as a user of the future product;

2. transfers to colleagues the technical documentation necessary for the development of parts of the technical system;

3. transfers the technical documentation for manufacturing to the workers;

4. conducts designer's supervision of production;

5. transfers operational documentation to the customer;

6. Actively works with the customer at new stages.

The full cycle of engineering activities includes invention, design, design, engineering research, technology and organization of production, operation and evaluation of equipment, elimination of obsolete or out-of-service equipment.

Invention. Based on scientific knowledge and technical achievements, principles of action are created, methods for implementing these principles in the designs of engineering devices and systems of individual components are prescribed.

Design. The result of the design activity is a technical device intended for mass production. The design consists of standard elements produced by the industry. For production and variation of technical characteristics, additional engineering calculations are carried out and a number of requirements are taken into account, such as simplicity and economy of manufacture, ease of use, the possibility of using standard or existing structural elements.

Technology and organization of production. The source material of this type of activity is the material resources from which the product is created, and the product is a finished technical device and a manual for its operation. The function of an engineer in this case is to organize the production of a specific type of product and develop a manufacturing technology for a specific design of this product, as well as, if necessary, tools and machines for its manufacture or its individual parts.

Exploitation, performance evaluation and liquidation. The operation of technical systems is associated with operator activities and maintenance. During the operation of a technical system, an assessment of its functioning is carried out, which is especially important for the modernization of systems.

At the stage of developing a new technical system, the requirements for the materials and components included in its composition should be formulated in terms of the possibility of their disposal with minimal damage to the environment and human health.

Classical engineering activity is characterized by the orientation of each type of engineering practice to the corresponding basic technical science, and subsequently to a complex of scientific and technical disciplines.

1.15 Classical design methodology

The design process is a special kind of human activity. Design objects can include both material (industrial buildings, machines) and intangible objects (social design). The design process is an information-processing activity of creating information models for planning technical work, technical innovations and developing methods, tools and procedures for their implementation.

Integrated system design includes knowledge of objects, social needs for them, assessment of their feasibility and assessment of the consequences of commissioning.

Design begins with obtaining information about the state of the field: information about technical devices, materials, manufacturing methods, components, processes, market conditions, etc.

The purpose of design is to create an object that meets certain customer requirements and has a certain quality (structure). The object is developed in a sign-symbolic form.

The design is guided

1. The principle of independence. Realizing this principle, the designer describes and develops the processes of the product functioning, defining them as an integral component of the first or second nature. It is believed that the de-

signer, when designing, can neglect the distortion of functioning processes resulting from engineering and design activities, since using the knowledge (regularities) of these processes, he ensures them and minimizes distortions.

2. The principle of realizability. The principle introduces a division of labor between the designer and the manufacturer. It determines the project in such a way that it can be implemented in modern production.

3. The principle of conformity. It assumes that a certain morphology (structure) can be assigned to each process of functioning, certain constructions are assigned to functions. In practical terms, this principle is fixed by a system of norms, normals, and methodological prescriptions.

4. The principle of completeness. The activity should end with a development that satisfies the needs of the customer.

5. The principle of constructive integrity. The designed object is provided with the existing technology. It consists of elements, units and relationships that can be manufactured in existing production. The designed object can be presented and developed in the form of a finite number of units specified, for example, in production catalogs, norms, rules.

6. The principle of optimality. This principle suggests effective solutions.

Science and design are closely related, since the design process involves scientific research, research in the context of solving a design problem.

1.16 Methodology of scientific and technical research

Technical knowledge is part of the design activity. It has specifics, determined by the task of objectively reflecting reality in order to increase production efficiency. Unlike natural science, which reflects natural phenomena as such, technical knowledge is focused on the way the studied objects are used in technology and technological processes. An important property of technical knowledge is normativity. Therefore, its necessary components are standards.

This is also manifested in the description of technical objects, which are characterized on the basis of a set of technical requirements.

There are the following types of technical requirements: technological, operational, ergonomic, aesthetic, environmental. Somewhat conditionally, they can also be divided into general and specific. basic and additional. All these requirements are expressed both in a positive form (the need to provide new opportunities) and in a negative one (an instruction to prevent the harmful consequences of scientific and technological progress).

Technical knowledge is also characterized by formal features. The most significant of these is the use of a graphical language. A drawing is a language of technology that performs the functions of storing and transmitting information based on the unity of sensory and logical knowledge.

By developing methods and means of theorization, research engineers contribute not only to the development of technical knowledge, but also create an opportunity for the effective participation of natural sciences in solving engineering problems.

The technical theory is aimed at describing objects that arise as a result of purposeful human activity. One of the most important tasks solved by technical knowledge is the development of methods for designing engineering objects. The contents of the prescription layer are methods, calculations for the design of specific types of technical objects. Through these layers of knowledge, abstract-theoretical models are connected with actually functioning technological processes. Production needs, conditions of experimental research and other forms of practice influence the organization of theoretical knowledge.

The more complex technical objects become, the more acutely there is a need to substantiate recipes, methods of technical activity. In order to know how to design technical objects, it is necessary to understand what they are, what their structure is, what processes take place in them, how they function. Knowledge of natural laws alone cannot form this kind of knowledge. With unchanged natural-science characteristics of artifacts, the use of technical knowledge proper leads to a wide variety of technological effects. The content of the subject layer of technical sciences is the notion of ideal artifacts fixed in the theories, i.e. artificially created objects.

To fulfill the social order, it must be expressed in a form that would allow linking the technical need with the possible means of satisfying it. This role is performed by the technical task.

Taking into account the basic requirements for the technical problem, its formulation should contain the following main components:

1) a description of the current situation (at a given workplace, at an enterprise, in an industry);

2) the purpose of the developed technical object;

3) technical requirements;

4) expected technical, economic and social effect;

5) admissible and inadmissible means of solving the problem.

The technical task contains in its formulation the necessary material for the creation of a new technical object. Further progress towards the goal involves both cognitive and practical actions. The most important point on this path is the technical idea.

An idea is a special form of organization of knowledge, which contains the prospects for further knowledge and practical activity. Reality is reflected in it not in its direct form, but in regular connections and development. The idea depends on the mental material from which it is formed and which it systematizes.

In engineering activities, ideas are used:

1) arising directly in the course of solving this technical problem;

2) borrowed from science and art, the experience of everyday life.

For an idea, the initial material is the condition of the problem. In the future, all existing and constantly updated knowledge and ideas are connected here, which are refined and reorganized in accordance with the goal.

The nature of the technical requirements and their relationships is of great importance in determining the direction of the search. In relation to each other, technical requirements can be: 1) interchangeable; 2) complementary; 3) mutually exclusive.

The difficulty of the material embodiment of an idea in a technical object necessitates a technical solution.

The technical solution must meet certain substantive and formal criteria. It should provide a positive effect.

Some formal evaluation criteria are also presented for a technical solution: it must be stated clearly and clearly for everyone on whom the recognition and further practical implementation of the idea (experts, administrative services) depends.

According to the degree of development, fundamental (preliminary) and final technical solutions are distinguished. Such a difference is determined by the distance separating them from the technical idea and the technical object. The principal decision characterizes only some essential features of this or that variant. The final decision contains a detailed program of actions for the materialization of a technical object, which involves a detailed justification of the idea and a thorough development of technical documentation. The technical solution creates the basis for the transition to the practical implementation of a new technical object.

Subjecting the technical innovation to verification, material production simultaneously contributes to the further improvement of the technical solution. Thus, one has to reckon with previously insufficiently taken into account factors, which causes, in particular, a negative result of engineering activity. This, in turn, causes the need to correct the formulation of the problem and the solutions themselves. in the process of practical use, the scope of applicability of the innovation is more precisely determined, which may be wider or narrower than originally intended. Scientific and technical research related to the possibilities of technical theory and experimental and laboratory base are called upon to contribute to this.

Quantum mechanics has become a part of engineering activity thanks to developments in the field of laser technologies. The unusual approach of quantum mechanics to the physical world required the substantiation of non-classical methodology. This task was carried out by the developers of quantum mechanics themselves. Among them were N. Born, M. Plank. The new methodology requires the description of the object to be carried out taking into account the research situation, cognitive means, and their features. This circumstance affects the content of interpretations. Under the influence of the new methodology, natural science began to predominantly use the language of mathematics and equations, which made it possible to solve both theoretical and practical problems.

1.17 Heuristics and creative methods in engineering

Heuristics is the science of patterns and methods of creative research activity. The use of heuristic methods (heuristics) reduces the time for solving the problem compared to an undirected enumeration of possible alternatives. In the psychological and cybernetic literature, heuristic methods are understood as any methods aimed at reducing enumeration, or as inductive methods for solving problems. Heuristics is the science of creative thinking. The basis for it are the laws of development of technology and the psychological characteristics of the creative process. For each task, its own solution method is sought, consisting of a set of known methods and unknown ones, since conditions, goals, and, consequently, tasks are constantly changing. The main problem in finding a solution to a problem is finding the search area in which the solution is located. Classification of methods for finding solutions:

1. heuristic methods (random search strategy);
2. methods of functional-structural research of objects;
3. class of combined algorithmic methods (logical search strategy).

Heuristic methods include:

- brainstorming (A. Osborne)
- synectics (W. Gordon);
- focal objects (Ch. Whiting);
- garlands of accidents and associations (G. Bush);
- checklists (D. Poya, A. Osborne, T. Eyloart).

The class of functional-structural research includes:

- morphological analysis (F. Zwicky);
- opening matrices (A. Mol);
- decimal search matrices (R. Povileiko);
- functional design (R. Koller);
- morphological classification (V. Odrin).

The class of combined algorithmic methods includes:

- algorithm for solving inventive problems - ARIZ (G. Altshuller);
- generalized heuristic method (A. Polovinkin);
- a complex method for finding solutions to technical problems (B. Goldovsky);
- fundamental design method (E. Matchett);
- evolutionary engineering (S. Pushkarev).

The search for solutions using these methods is systematic and targeted. Thus, the solution of the problem depends on the nature of the problem, on the degree of completeness and reliability of the initial information, and on the personal qualities of the developer: on his ability to skillfully navigate in the information environment, on the degree of knowledge of the methodology of cognition and creativity. In addition to the direct product of creative activity that meets the goal, there is also a by-product. At the right moment, this by-product may show up as a clue leading to an intuitive solution.

Heuristics gradually evolved to computer technologies, on the basis of which the time spent on enumerating and searching for possible analogues, prototypes, was sharply reduced. Network structures allow you to increase the efficiency of order fulfillment, provide feedback to the customer at all stages of development.

For engineering activities, the materials science part of natural science knowledge, heat and energy dynamic, geological, natural landscape, climatic, has always been important. Natural science knowledge is transformed into engineering at the level of functional, flow and block diagrams.

The functional diagram displays a general idea of a technical system, regardless of the method of its implementation, and is a product of the idealization of this system based on the principles of a certain theory. In technical science, functional schemes are focused on a certain type of physical process and are most often identified with any mathematical scheme or equation. For example, when calculating electrical circuits using graph theory, the elements of an electrical circuit - inductance, capacitance and resistance - are replaced according to certain rules by a special idealized functional element - a unistor, which has only one functional property - it passes electric current in only one direction. To the homogeneous theoretical circuit obtained after such a replacement, topological methods of analyzing electrical circuits can be applied. On the functional diagram, a mathematical problem is solved using a standard calculation technique based on the application of previously proven theorems. To do this, the functional diagram according to certain rules is reduced to a typical form.

A flow diagram or a functioning diagram describes the natural processes that take place in a technical system and links its elements into a single whole. Such schemes are built on the basis of natural science concepts. So for different types of functioning of the system, the elements of the circuit, for example, electrical, change their appearance.

The block diagram fixes the constructive arrangement of the elements of the technical system and connections, taking into account the proposed method of implementation. It is a theoretical sketch of this structure in order to create a blueprint for a future technical system. It reflects the result of the technical theory, as well as the starting point of engineering and design activities to develop a new technical system on its basis.

The development of natural science affects engineering activities, since physical, chemical, biological, geological laws are used in various branches of industrial and agricultural activities of mankind. The scientific revolutions associated with nuclear, quantum, genetic, logical, thermonuclear research have most actively influenced engineering developments. A harbinger of non-classical methodology in science was the theoretical work of A. Einstein.

1.18 Industrial technologies for organizing production processes: the philosophy of human capital

In an industrial society, there has been a trend towards an increase in demand for skilled workers, technicians, engineers and managers. This trend is due to the saturation of technological processes with multifunctional technical devices with numerical control. The higher education of subordinates required the transformation of managerial practices in production management. As a result, the concept of human capital has become relevant. At the level of high management of companies and banks, this concept has become commensurate with certain economic indicators of effective company management. The arrival of a highly qualified manager in the management of the company has become an indicator of its investment attractiveness.

Similar criteria began to apply to workers. At the same time, the stability of the corporate institutional environment began to be taken into account. This stability requires taking into account the social needs of subordinates. A. Maslow thinks so. He developed a pyramid of needs of a modern worker. It takes into account not only the factors of remuneration, but also self-actualization through opportunities for professional growth, values. The theory of human relations became important. Its origins are attributed to the activities of Robert Owen in the

19th century. Scientific arguments in favor of the theory of human relations were formulated by Elton Mayo in 1933. The theory claims that there is a direct relationship between management, morale and productivity. This became the basis for the formation of organizational humanism in the management structure. He combined the developments of A. Maslow and E. Mayo.

Changes in the understanding of the human component of technological processes have led to the formation of the subject of human resource management. Among the tasks were identified environmental analysis, planning the company's need for human resources, labor assessment and maintaining a moral atmosphere in the workforce. These practical tasks are based on the philosophy of human resources. This philosophy defines priorities related to human capital.

Within the framework of the methodology of the investment approach to human capital, the starting point is Adam Smith's thesis that investing in the formation of an employee's professional skills and his education should be based on the possibility of recoupment of this investment, taking into account the indefinite terms of the employee's able-bodied activity. In this context, the methodology for calculating private and social payback rates for investments in human capital is used.

The theory of human capital proceeds from the fact that the incomes of workers reflect their contribution to the results of production processes. The thesis is also formulated that the employee's contribution to the efficiency of production activity is influenced by the amount of investment in the employee's capital. But this dependence is justified only if it is linked to the quality of vocational education.

The growth of a worker's self-esteem in the process of investing in his skills and education does not cancel his obligation to recoup the investment invested in him. His professional competencies are judged not by a diploma, but by effective participation in production processes. The main criterion is the profit of the enterprise or construction company.

2. PHILOSOPHY, SCIENCE, MAN AT THE BEGINNING OF THE III MILLENNIUM

2.1 Non-classical philosophy of technology

At the beginning of the 21st century, the philosophy of technology focused research on the content of the fourth industrial revolution, the theory of artificial intelligence and cognitive sciences, the ethics and legal aspects of social engineering, the convergence of digital and traditional technologies, and technological singularity.

Engineering and industrial technologies not only restored their status in the space of technogenic civilization, but also transformed the content of the fourth industrial revolution into the modernization of the industrial complex. The notion of new industrialization has spread. The epidemiological factor began to actively contribute to the growth of the influence of technical and technological components in the life of modern society.

Integrated digital communication structures have been formed in industry (Industry 4.0), the agro-industrial sector (e-Agriculture), building life cycle management based on BIM technologies (e-Construction). There is a digital transformation of energy and petrochemistry (Smart Grid). Supply chain management (e-Supply Chain) is becoming digital. Marketing and trade (e-Trade) have switched to digital technologies. Communication in the social and labor sphere (e-Social Services) and healthcare (e-Health) has become digital.

Digital ecosystems have become the subject of the philosophy of technology. In their space, the integration of the main components of production, logistics, marketing and information communication took place. This integration has been made possible on the basis of convergent technologies.

In the structure of the non-classical philosophy of technology, new sections have been formed. These include the philosophy of systems engineering, the philosophy of artificial intelligence, the philosophy of virtual reality, the philosophy of computer science, the ethics of social engineering, the ethics of software engineering, the ethics of robotics, the philosophy of environmental engineering, formal philosophy, and the philosophy of digital ecosystems.

2.2 Methodology of systems engineering activity

In the first half of the 21st century, technical complexes in the modification of man-machine systems became the object of engineering activity. As a result, the content of engineering activity has been transformed. Along with its progressive differentiation in its various branches and types, the process of its integration is growing. To implement such integration, special specialists are required - systems engineers.

System engineering activities are carried out by various groups of specialists involved in the development of individual subsystems. The division of a complex technical system into subsystems proceeds according to different criteria: in accordance with the specialization that exists in the technical sciences; by manufacturing area in relation to design and engineering teams; in accordance with established organizational units. Each subsystem corresponds to the position of a certain specialist. This refers not necessarily to a separate individual, but also to a group of individuals and even an entire institution.

Specialists are interconnected due to the existing forms of division of labor, the sequence of stages of work, and common goals. For the implementation of system engineering activities, coordinators are required (chief designer, head of the topic, chief specialist of the project or scientific coordination service, head of the scientific and thematic department). These specialists carry out coordination, scientific and thematic leadership in the direction of combining various subsystems, operations into system engineering activities.

Systems engineering consists of a sequence of stages, including actions and operations. These are the steps:

1. preparation of technical specifications;
2. manufacturing;
3. implementation;

4. operation;

5. assessments;

6. liquidation.

At each stage of system engineering activity, a sequence of operations is performed: analysis of the problem situation, synthesis of solutions, evaluation and selection of alternatives, modeling, correction and implementation of the solution. System engineering activity is a necessary basis for the development and effective use of high technologies. In Belarus, the evolution of design structures to the level of engineering structures based on the cluster principle of activity is taking place. A similar mechanism has been worked out at the High Technology Park. This structure was able to integrate human capital in the field of information technology into the international system of division of labor. Domestic universities got the opportunity to access modern bases of practice, employment of graduates. There are similar prospects in the field of nanotechnologies and genetic engineering.

Engineering activities are related to organic design. This means that its tasks include the design of systems of activity in the entire complex of vital functions. One of the results of this design was innovation. It includes strategic marketing; R&D; technoparks, innovative production, turning into a continuously modernizing infrastructure and communications.

Strategic marketing is to study the dynamics of the market in terms of demand, rising prices, including energy, environmental requirements, safety requirements. The main tasks of R&D are: new knowledge and new areas of their application; theoretical and experimental verification of the possibility of materialization of knowledge in the sphere of production; practical implementation of innovations. R&D involves fundamental research (theoretical and exploratory); applied research; development work; experimental and experimental work.

Search works include research, the task of which is to discover new principles for creating products and technologies; previously unknown properties of materials and compounds.

R&D is the final stage of R&D, it is the transition from laboratory conditions and experimental production to industrial production. Development refers to systematic work that is based on existing knowledge obtained as a result of R&D. Developments are translated into the form of innovative projects.

An innovative project is a set of technical, organizational, planning and settlement and financial documentation, which undergoes an appropriate examination. By itself, innovative projects may not be in demand. Innovative structures are needed. They took shape in the form of technology parks, business incubators, technopolises, high technology centers.

The main tasks of these structures are

- formation of conditions favorable for the development of innovative activity;
- Creation and development of small innovative and venture firms;
- selection and support of promising scientific projects;
- successful commercialization of the results of scientific research and scientific and technical developments;
- service maintenance;
- qualitatively new approaches to the organization of work of university scientists and young researchers;
- student training;
- solution of regional problems related to the reorientation of the economy from material and energy-intensive to the development of knowledge-intensive industries;
- creation of prerequisites for the effective exchange of science-intensive products on the world market.

Technoparks solve the most important problems of regional development - they provide new jobs, promote structural restructuring and the transition of traditional industries to new technologies.

Research parks are engaged in providing conditions for the effective conduct of scientific research.

Technological - contribute to the organization of small science-intensive industries focused on technology transfer, commercialization of the results of scientific and technical developments.

Industrial technoparks ensure the placement of small science-intensive industries in a certain closed area, the creation of industrial premises and jobs.

Gründertechnoparks, being a kind of industrial ones, support the creation of new small firms in the manufacturing industry.

Incubators of small science-intensive firms, business incubators can be part of technology parks or be independent organizations.

Technoparks have such large links as

- commercial center, including consulting, engineering and audit firms,
- venture fund,
- Small business incubator
- business center.

The main functions of technology parks are related to planning; marketing; audit. They provide services in the field of legal, economic and legal, tax consulting, credit services. Assist in obtaining government orders; search for investors; organization of production; solving technical issues; mastering technologies. Are engaged in leasing of high-tech equipment; property insurance, investments, reinsurance; introduction of information databases; training and education of personnel; publishing activities; organization of exhibitions; provision of household services.

2.3 Philosophy of artificial intelligence

Artificial intelligence involves a set of technological solutions that imitate human cognitive functions, including self-learning and the search for solutions without a predetermined algorithm. The complex includes information and communication infrastructure, software, processes and services for data processing and search for solutions. To do this, the formalization of such human intellectual abilities as knowledge representation, reasoning modeling and heuristic search has been carried out. The main problem of formalization is the assessment of the situation, the ability to separate an object from the background, a moving object from a stationary object, and potential sources of danger. This is relevant for dynamic robotic systems, including drones. In this context, the philosophy of machine vision has become relevant. It turned out that the human eye and the camera obscura are not identical. This is not a process of optical copying of objects with subsequent mathematical processing of the characteristics of the scanned images.

In the human eye, light rays are converted into electrical impulses and sent along the optic nerve to the human brain. Visual images are a product of the brain. But the technologies for transforming electrical signals into images are not yet clear. For this reason, the non-classical philosophy of technology is closely connected with the development of analogues of human thinking in the form of artificial intelligence in order to automate technological processes. In this case, technology acts not only as a natural extension of the hands and feet of a person, but also his thinking. This problem has acquired a scientific basis in cybernetics, which combines the possibilities of general systems theory, mathematical simulation, computer science, and computer technology.

One of the first terms "cybernetics" was used by Ampère in his work "An Essay on the Philosophy of Sciences, or an Analytical Presentation of the Classification of All Human Knowledge", published between 1834 and 1843. In 1843, Trentovsky gave it a managerial meaning in his work “The Attitude of Philosophy to Cybernetics as the Art of Governing the People”. In the conditions of the twentieth century, the term was updated by N. Wiener. He found consonance with the works of F. Bertalanffy (the founder of the general theory of systems). As part of this approach, it was discovered that any system, regardless of its nature, is open and exists due to feedback - the constant exchange of information. It became obvious that communication is a key concept of reality. This largely explained the emergence of a direction accelerated in terms of the dynamics of inventions, associated with technical means of communication - the telegraph, telephone, mechanography, radio, television, computer.

Logic was developed to apply this technique. A. Turing formalized the concept of an algorithm, which became one of the foundations of modern computer science. The mechanographic method and related machine, which Alerint designed in 1890, used a perforated card as the information carrier. Due to the original coding, the perforation could represent any information. Computers replaced mechanographic machines in the 1940s and 1950s. Von Neumann provided decisive assistance in their development. And almost immediately, the merging of telephone and computer technology began, since they acquired a system-technical basis due to the replacement of telephone relays with vacuum tubes borrowed from radio engineering. As a result, the computer was integrated into a network type structure.

Problematic related to computer science arose, within which it was necessary to define the concept of information and ways to formalize it for use in computer systems. Shannon, using a probabilistic-statistical method, substantiated the morphology of information associated with the concept of a bit (a binary system consisting of "1" and "0"). Turing's Intelligent Machine works by converting binary sequences consisting of 0's and 1's.

The totality of the discipline that studies the properties of information, the ways of its presentation, accumulation, processing and transmission using technical means is informatics. The most important element of informatics is information technology.

Representation of information has become a key direction in the development of artificial intelligence. Artificial intelligence reflects the transition from the dominance of programs to the dominance of data in them. From a machine word located in one memory cell of a computer program, there was a transition to vectors, arrays, files, lists, abstract data types that perform the function of knowledge representation. This is possible if you have:

1. classifiable links between knowledge related to an element of the set and knowledge about this set;

2. situational relations of simultaneity, being at a point in space;

3. special procedures for generalization, filling the knowledge available in the system.

The representation of knowledge is realized on the basis of the creation of an isomorphic structure of human thinking. Based on the simulation model, a machine search for model transformations corresponding to the solution of the problem of evaluation, game, invention, recognition is carried out. The methodology of reflection is taken as a basis. This is when the subject of thought is not only a thing, but the very fact of thinking. As a result, there was a transition from the classical paradigm of artificial intelligence, with its characteristic rigid target, to the non-classical paradigm of artificial intelligence. It evaluates knowledge and goals (reflection model).

Artificial intelligence systems, using the rules of information processing embedded in them by mathematical logic develop schemes of appropriate actions based on the analysis of models stored in their memory. The ability to rebuild these models is a sign of the evolution of these systems in the form of self-learning. A certain level of knowledge representation creates a spectrum of using computer technologies in the network, system-technical terms. One of the directions is intelligent robotic systems, an invariable element of flexible production systems, security systems.

Artificial intelligence is based on physical (electrodynamics), informational (information transformation), technical (moral and physical aging) laws. Within the framework of the information law, the following tasks are solved:

1. creating devices that perform a large number of logical operations with high speed;

2. development of domain-specific languages for use in software products;

3. construction of simulation models of a rigid or non-rigid solution of the problem.

The task of developing artificial intelligence is related to:

1. development of the theory of deductive inference and proof of theorems;

2. study of game machine programs (chess, checkers, card games);

3. development of the theory of constructing dialogue systems for communication in languages close to natural languages;

4. building heuristic programs to simulate human activity in solving problems that are not amenable to formalization;

5. creation of artificial analogues of biological tissues (neurons, internal organs, muscles);

6. modeling of creative processes (composing music, creating cartoons);

7. research in the field of collective human-machine intelligence.

Technical cybernetics, in contrast to theoretical cybernetics, is occupied with the problems of automating technological processes, managing complex technical complexes, developing automated systems for technological and administrative management (integrated systems), pattern recognition, computer-aided design systems (CAD), automated systems for managing scientific research and experiments (ASNI), automated control systems for industrial tests (ASPI), etc.

The technical possibilities of cybernetics will increase significantly with the use of nanotechnologies, optical structures (not electrons, but diotons).

Thus, artificial intelligence is a technical system that solves problems and is capable of self-learning based on the transformation of mathematical models that imitate reality. Mathematical modeling should be understood as a description in the form of equations and inequalities of real processes (physical, chemical, technological, biological). Cybernetic modeling is a kind of mathematical modeling.

In Belarus, a key role is assigned to the development of information technologies. This is evidenced by the functioning of the High Technology Park. Much has been done in the field of technical cybernetics. Automation of design and engineering work took place at a rapid pace. Automated control and monitoring systems play an important role in the production system. Technical devices are saturated with automation, which contributes to higher labor productivity.

2.4 Philosophy of virtual reality and design

The term "virtual reality" was first used at the Massachusetts Institute of Technology in the late 70s. XX century. All R. 80s of the same century, J. Lennier launched the production of interactive computers with head helmets that allow the user to immerse themselves in virtual worlds with the maximum range of sensations. These computers were integrated into complex multimedia operating environments and formed the basis for the human-machine continuum.

V.S. Babenko, N.A. Nosov et al. define virtual reality as a phenomenon associated with the activity of human consciousness.

Virtual reality exists as long as generative reality operates. The subject, who is in virtual reality, does not directly feel the intermediate links. At the same time, he sees everything virtually happening from his point of view. He himself is always the main participant in the events.

Virtual reality has properties:

1. generation (produced by the activity of some other reality external to it);

2. actuality (actually exists, only "here and now", only while the generating reality is active);

3. autonomy (has its own time, space and existence);

4. interactivity (it can interact with all other realities, including the generative one).

Electronic virtual reality:

1. ontologically substantiated by the desire of a person to create an alternative world;

2. manifests itself predominantly symbolically;

3. influential in terms of impact;

4. can change the consciousness of the subject (feedback).

Virtual reality is a fertile basis for the implementation of computer simulation in dynamics, which makes it possible to trace the technical characteristics of an artifact in a dynamic environment as close as possible to real conditions, 1) for example, combat conditions, off-road conditions for transport equipment, 2) solving landscape problems of building hydro facilities, microdistricts. Thanks to the achieved level of simulation, bionics has been updated.

Virtual reality has created a visualization phenomenon in the information society, based on people's need for communication, satisfaction of desired images, plots, intrigues, gaming needs. As a result, a huge industry of visualization of various entertainment projects has emerged. Mobile communications, combined with computer technology, gave a powerful impetus to the development of communication technologies. The philosophy of dialogue studies the features of the new informational reality. It analyzes the categories I and Other, narrative, discourse, meaning, action, text, language, information, message, slogan, intention, brand, simulacrum.

In Belarus, the information sector is actively developing. Internet users are interested in virtual reality. Mobile communications are actively used for communication. Belarusians start working with virtual reality almost from school age. This is possible thanks to the creation of the latest computer classes in schools and gymnasiums. In higher educational institutions, students master virtual technologies for designing, constructing, modeling, conducting scientific research, and implementing developments.

Computer technologies have made it possible to create network spaces, within the boundaries of which information is transmitted, coordination of activities is possible. It is important that these communication opportunities do not go beyond the legal framework, humane values. In recent years, legislators and law enforcement agencies have done a lot to regulate the activities of citizens in social networks. First of all, we are talking about the suppression of calls for violence, threats, drug and human trafficking, and pedophilia. The activity of citizens, which is aimed at organizing mass actions of violence, robberies, and riots, is especially controlled. Those who are engaged in such organizational affairs are primarily responsible for the results of violence. In addition to legal aspects, virtual reality implies moral aspects of activity.

2.5 Ethics of software engineering

Theorists of computer ethics are the philosophers J. Moore, D. Johnson, J. Snapper, L. Lloyd, W. Betchel and J. Van Dyun. They showed that computer ethics is a dynamic and complex phenomenon, involving the analysis of relationships between facts, concepts, values, taking into account constantly changing computer technology, located on the border between new technologies and normative ethics.

The ethics of computer technology is close to the ethics of business and social ethics. Traditional ethical categories do not always help to solve problems that arise in the field of computer technology. In a computerized society, the values associated with the previous concept of work were gradually revised: communicating without leaving home with a computer terminal, an employee lost constant contact with colleagues; controlling the robot by pressing buttons.

Based on the fact that computer operations remain invisible most of the time, J. Moore singled out three types of computer invisibility that have ethical significance. The first type of invisible factor he called invisible deception. This is the intentional use of invisible computer operations in order to carry out an unethical or criminal act.

J. Moore in this connection gives a hypothetical example. A programmer working in a bank could steal what is called "surplus interest." In the course of banking operations, when calculating the interest on deposits, fractions of a cent always remain after rounding the amounts. A programmer could compile and enter into a computer an appropriate program with the task of transferring these residual fractions of a cent from all bank transactions to his account, thereby carrying out the theft of "excess interest".

The second type of invisible factor in computer technology, J. Moore called the presence of invisible program values.. J. Moore gives a specific case as an example. When creating a program for the pre-sale of air tickets in the United States in the 80s. XX century programmers used the alphabetical principle. This invisible value of the program went unnoticed until it was discovered that American Airlines was gaining an advantage over Bran Airlines in the sale of air tickets, which led to the bankruptcy of the latter and ended in litigation.

The third type of invisible factor in computer technology is the invisible set of computations. The computer is capable of performing complex calculations that are beyond the scope of human consciousness, incomprehensible to understand and beyond control, even if the computer program is accessible to the intellect. This raises the question of how much you can trust the invisible calculation of artificial intelligence. This provides the basis for an alien intellect that is different from the values accepted in human society.

Using the tool of computer programs, social engineers began to invade the privacy of the individual. Computer crime has arisen. There were issues of ownership of computer programs, responsibility for errors made by the computer, changes in the structure and value characteristics of the profession. This is the ethics of a doctor, the ethics of a teacher the ethics of a businessman.

Computer ethics is an analysis of the nature and social impact of computer technology, combined with appropriate formulations of the technology's ethical justification. According to J. Moore, the global problems of computer ethics arise due to the lack of clarity in the questions of what are the ethical limitations in the application of computer technology and how to act due to the fact that computers provide society with new opportunities in choosing actions. Computer ethics is called upon to formulate the rules of these new actions it must answer questions of the ethical use of computer technologies, both social and personal. The mechanical application of normative ethical maxims becomes insufficient in a computerized society.

Social engineering exploits the phenomenon of "computer logical malleability". This means that a computer can be programmed to perform any logical operation, regardless of its ethical value. J. Snapper distinguishes those who consider the computer as an agent of action that makes decisions and is responsible for the errors that appear in these decisions, and those who believe that computers are not yet capable of answering for errors.

The issue of computer errors presents a particular problem. When it comes to medical computer programs that make a diagnosis, prescribe drugs, determine their dosage, then in this case the decision concerns the health of the patient. D. Johnson believes that knowledge and skills alone are not enough for a computer professional, he must certainly be guided by the laws and requirements of professional ethics.

Computer professionals include programmers, systems analysts, systems engineers, computer hardware salespeople, banking and engineering employees, public educators, diagnosticians, physicians, planners, and budgeters. The computer professional enters into communication with the employer, the client, with colleagues in the profession and with the whole society. That is why such a person must experience the action of a categorical imperative, which includes a number of prescriptions.

First, engineers must respect the confidentiality of their employers or customers, whether or not they signed an agreement. Secondly, the engineer should not overestimate his level of knowledge and should not consciously take on work that is outside his competence. Thirdly, it is necessary to protect the client's intellectual property with patents. Fourth, system programmers should not misuse the employer's or customer's computer resources, from workplace games to the spread of viruses.

The Code of Ethics and Professional Practice in Software Engineering is recommended by ACM/EEE-CS Joint Task Force op Softwage Engipeering Ethics and Professional Prostices and jointly endorsed by ACM and IEEE-CS as the standard for teaching and working in software engineering.

Software engineers must adhere to the following eight principles:

act strictly in the public interest;

according to the interests of the client and the employer, if they do not contradict the interests of society;

ensure the quality of its products and their modifications to the highest possible professional standards;

maintain the integrity and independence of their professional assessments;

adhere to ethical approaches to the management of software development and support and promote these approaches;

raise the prestige and reputation of their profession in the public interest;

be fair to your colleagues, help and support them;

continuously learn the skills of their profession and contribute to the promotion of an ethical approach to their activities.

2.6 Cybernetic and physical components of technology

The physical components of engineering and technology include the principles of functioning of technological processes by delegating operations to equipment with different energy sources of drive (steam, electricity). Equipment and mechanical tools are made from certain materials according to the criteria of strength, wear resistance, reliability, durability and safety. Working with physical devices requires a certain physical form and endurance from the worker. Some technological processes are extreme in terms of temperature noise and dust conditions and the risks of radioactive radiation. In a traditional industrial society, harmful conditions were compensated by certain measures of rehabilitation, insurance payments, and compensations to families.

For production owners, an important reason for the automation of production, in addition to the compensation costs created by technological processes, was the human factor in the field of labor discipline and work quality. Managers sought to minimize waste and at the same time increase the productivity of technological processes. Automation required a cybernetic component in the form of software products that were locally integrated with machine tools. As a result, machine tools with numerical software have become part of the technological processes. Demand for collaborative robots has formed. The employee uses them in the mode of human-machine interaction.

A more expensive project was the robot of conveyor production. The cybernetic component of the robot is integrated with the dominant cybernetic component of the technological process. As a result, the component of physical labor of people is reduced to a minimum. The high cost of automation has become a deterrent and has driven the development of outsourcing organizational structures.

2.7 Automation of technological processes and the philosophy of artificial intelligence

At the second stage of the implementation of technological process automation programs, the Internet of things and the creation of big data centers are taken as the basis. These information technologies require high-speed Internet and strong artificial intelligence. And here comes the difficult problem of consciousness.

This problem continues to form the main theme of the analytic epistemology of consciousness. It involves answers to the questions why people have phenomenal experiences, how sensations acquire characteristics such as color and taste, and why the subject develops certain states of consciousness. This is the problem of explaining how a physical system is capable of generating subjective experience. It is concretized by the questions: why does the brain generate consciousness, and how does it generate consciousness?

The easy problems are those that, in the study of consciousness, are solved by using standard scientific methods. These methods make it possible to explain from a third-person perspective what consciousness does, how it changes over time, and what its structure is. A difficult problem arises when asking the question "why does consciousness exist?" The answer to this question requires going beyond the application of well-known scientific methods.

The term "hard problem" was introduced in 1995 by D. Chalmers. The hard problem is the most important subject of theoretical and empirical research in psychology, neuroscience and quantum physics. There are different approaches to a difficult problem. There are options for denying its existence, the impossibility of its solution. There is an option to develop theories of consciousness aimed at solving it

Some organisms are subjects of experience. But the question of how these systems are subjects of experience remains unclear. A difficult problem arises from the fact that consciousness from the point of view of the first person does not lend itself to standard functional explanations, which are quite successfully used in psychology in the study of various types of mental activity. Thus, learning, reasoning, memory can be explained in terms of fulfilling the correct functional role. Learning performs the correct functional role if, as a result of it, behavior changes in accordance with changes in the external environment. Therefore, it is possible to clearly define what learning is, and to identify the connection between learning and processes in the brain. The hard problem stands out in that even after explaining cognitive and behavioral functions, the question remains open. Why is the flow of functions accompanied by subjective experience?

Reductive explanations can be applied to all other natural phenomena, but not to consciousness. This impossibility is due to the fact that consciousness cannot be analyzed using functional explanations. Even if you thoroughly study the brain processes and the laws of physics and create on this basis all the necessary physical conditions for the emergence of consciousness, then there is no certainty that it will appear.

The most influential deflationary theories that deny the existence of the hard problem of consciousness in the philosophy of mind are analytic functionalism, eliminative materialism, and philosophical behaviorism. There are those who solve it. The search for a solution to the difficult problem of consciousness is carried out by both supporters of non-reductive physicalism and supporters of anti-physicalism. From the point of view of inflationists, consciousness can be scientifically empirically reduced to neurophysiological or cognitive processes in the brain, but it cannot be metaphysically reduced to them.

When solving the difficult problem of consciousness on the basis of pragmatic pluralism, H. Putnam rejects both physicalism and dualism. In his opinion, the impossibility of solving the difficult problem of consciousness on the basis of these approaches lies in their commitment to the idea of a single and absolute ontology. Pragmatic pluralism rejects this idea and instead proposes the idea of many different but fundamentally equivalent conceptual systems. This approach, unlike physicalism, does not consider it possible to physically explain the existence of phenomenal consciousness. At the same time, unlike dualism, it does not consider the irreducibility of phenomenal consciousness a mystery. Pragmatic pluralism proposes to explain consciousness in terms of a wide variety of conceptual systems, including particle physics, biology, and psychology.

S. Horst believes that the difficult problem of consciousness seems to be a unique problem in psychology due to the fact that it is based on outdated ideas about the problem of reduction that are characteristic of the philosophy of science. The presence of research problems in the field of studying human consciousness does not cancel the tasks arising from the fourth industrial revolution (XXI century). In industry, this revolution is realizing the potential of information technology in convergence with additive technologies. It resulted in smart industry development programs.

2.8 Systems engineering

Systems engineering studies the design, creation and operation of structurally complex, large-scale, human-machine and socio-technical systems. It offers principles, methods and tools for their development. When developing and designing systems problems arise related to the laws of the functioning of a system object and ensuring its life cycle. Responsibility for the system distinguishes systems engineering from all other engineering disciplines.

The theoretical and methodological basis of systems engineering is the systems approach and general systems theory, as well as research methods using mathematical logic, mathematical statistics, systems analysis, algorithm theory, game theory, situation theory, information theory. In systems engineering, elements of science and practice are closely intertwined. The high complexity of systems makes it difficult to use precise formalized methods when creating them. Significant advances in science, engineering and technology, along with the rapidly growing need for automation of processes and production, stimulated the beginning of the industrial creation of large-scale systems of high complexity. These systems are distinguished by a significant increase in the number of components and functions performed a high degree of automation, a significantly increased cost of the systems created and the importance of the tasks they solve. So also the qualitative indicators of organization and management, the high complexity of the functioning of the system, the need to interact with other complex systems.

The work on the creation of such systems is based on the achievements of general systems theory, systems analysis, operations research, information theory, computer technology and cybernetics. These achievements began to be purposefully used in the complex solution of engineering and organizational and managerial tasks.

Systems engineering has focused on the issues of scientific planning, design, evaluation, construction and operation of systems created by man to meet established needs, as well as the problems of organizing collective methods of work in the creation of such systems. Systems engineering proposed a set of adaptable and automated system development methods, the essence of which was the application of a systematic, systems analysis-based approach to decision-making. It provides an efficient transition from a system concept to a usable design solution to a usable system product. Hall described the systems engineering methodology.

The goal of systems engineering is to optimally draw the functional boundaries between interests, the system and its environment. The environment is represented by physical, technical, business, social components. Priority is given to researching needs. A methodological basis and means have been created for the successful implementation of coordinated, team efforts to form and implement activities to create systems of various classes that meet the established requirements, activities that cover the stages of the system life cycle from design to manufacture, operation and termination of use. Used systems analysis, cognitive systems engineering, configuration management, automatic control, industrial systems engineering, mechatronic engineering, operations research, software engineering, performance engineering, program, project management, interface design, systems planning, engineering psychology, security engineering and risk management.

An exhaustive set of processes necessary for building a system in its development has been formed and implemented. In order to determine technical solutions and create systems architecture, systems engineering turned out to be aimed at the formation of such development processes and the life cycle of systems that allow balancing the costs of time and money in the interests of achieving the required quality of products and services, thereby ensuring the competitiveness of the systems being created.

Large system projects have thousands of contractors. Each contractor has its own professional language of communication. Complex systems can only be created by large multidisciplinary teams that require an appropriate interdisciplinary organization in the division of intellectual labor. The issues of maintaining interdisciplinary integrity and organizing interdisciplinary work are also addressed by systems engineering, providing this process through the use of a common interdisciplinary language.

The process of forming an integrated system of international standards and practices to support the creation of effective systems is nearing completion. Analytical software tools are being actively developed to assist in the practical implementation of these rules and regulations.

The methodological basis of systems engineering was formed by the school of systems-thought-activity methodology associated with the name of G.P. Shchedrovitsky, close to the ideas of the Moscow Methodological Circle. Moscow logical circle represented by A.A. Zinovieva, G.P. Shchedrovitsky, B.A. Grushinaand M.K. Mamardashvili was engaged in the development of content-genetic logic, assimilation of the cultural-historical concept of L.S. Vygotsky, Cybernetics and Systems Research. The main form of activity of the SMD methodologists was the organizational activity game (ODI), which was built according to the scheme of mental activity.

The members of the circle were forced to emigrate (A.A.Zinoviev, V.Ya.DubrovskyandV.A.Lefebvre). Systems engineering is based on a number of general abstract concepts associated with the understanding of its subject, as well as a set of initial, accepted as truth, rules that are used as a basis for reasoning and for making decisions. Systems engineering concepts guide the thinking of a systems engineer, and principles provide the necessary rules and regulations to do so.

The concepts and principles provide the knowledge and skills necessary to develop the techniques and operations of a systems engineer's practice. Systems engineering operates with concepts such as a system,

Large systems are spatially distributed systems of a high degree of complexity, in which the constituent parts also belong to complex structures. Large dimensions are additional features; complex hierarchical structure; circulation in the system of large information, energy and material flows; high level of uncertainty in the description of the system.

Complex systems are distinguished by multidimensionality, heterogeneity of structure, diversity of the nature of elements and connections, organizational different resistances and different sensitivity to influences, asymmetry of the potential for the implementation of functional and dysfunctional changes.

The concept of a system in systems engineering is related to the concepts of systems thinking and systems approach. Systems engineering focuses on engineering systems of machines, mechanisms, structures, enterprise systems, and systems of systems. In systems engineering, several points of view are necessarily used simultaneously to describe the architecture of a system.

B. Blanchard and W. Fabritzki described the life cycle approach. It has become the fundamental foundation of the practice of systems engineering. This approach assumes the use by system engineers of the concept of a system life cycle as a framework, organizational basis for engineering thinking, which, when creating complex engineering objects, allows one to consider all system aspects in their completeness and interconnection. The life cycle of a system is understood as the evolution over time of a system, product, project, or other human-created entity.

The evolution of the target system is associated in systems engineering with the passage of a sequence of certain stages, linked to a set of management decisions, for the justification of which objective evidence is used that the system at the accepted level of materialization is mature enough to move from one stage of the life cycle to another stage of the life cycle. At each stage of the life cycle, the system has a relatively stable set of characteristics.

Life cycle modeling uses sets of life cycle processes. For this, there is a number of regulatory and technical documents containing a description of the full set of processes required to simulate the life cycle of a wide range of systems created by humans.

Systems engineering involves the process of continuously adapting system requirements and solutions to deliver the results that, in a given environment, are most satisfying to stakeholders.

It is important to describe and develop the system in terms of value for stakeholders. Trust between stakeholders cannot be established in the absence of leading experts in charge of building the system. At the same time, the interested parties should be responsible for their obligations and ensure their implementation in a timely manner, as well as the adoption of the necessary decisions.

To understand needs, analyze circumstances, identify objectives and define requirements for architecture development, system design, including hardware and software, and to obtain evidence of the feasibility of a solution, it is important to adhere to the rule of concurrent rather than sequential organization of work. An important factor in making decisions is the presence of an evidence-based fact, and not a plan, schedule or calendar event.

Systems Engineering is responsible for integrating all technical aspects, domain experts, and specialized teams within the efforts of the target system development team. The work begins with identifying the needs of stakeholders and the required functionality, managing the many functional and non-functional requirements that must be transformed into a responsive system design and architecture by synthesizing design solutions. After that, the system goes through the stages of verification and validation.

The set of systems engineering processes includes providing a reliable design repository. It supports the necessary tools for multiple professionals to collaborate on multidisciplinary information while building a system and managing its life cycle. It is important to provide an accurate assessment of the information available and the identification of missing information.

A precise definition of the performance and efficiency criteria that determine the success or failure of a system project is necessary. Receiving and analyzing all initial requirements that reflect user requests and stakeholders' goals is relevant; It is advisable to conduct a system analysis to develop design solutions that reflect the behavior of the system, which must meet all functional and performance requirements;

The distribution of all behavioral elements of the system is carried out according to the elements of the architecture suitable for them. An analysis of trade-off decisions on alternative design solutions or architecture to support the decision-making process is carried out. Executable models are developed to verify and validate system performance.

Systems engineering seeks to formalize the systems development process. The totality of such typical, repetitive actions forms systems engineering processes or systems engineering methods. Systems engineering processes involve the iterative application of synthesis, analysis, and evaluation procedures:

Systems engineering standards are developed as open, universal specifications that are framework in nature and are applied on a voluntary basis. They require adaptation to the conditions of the organization or project and the high qualifications of the personnel using them, since regulations in the field of systems engineering are not developed. The main object of standardization in the field of systems engineering is the processes of creating systems. Methods for assessing the quality of processes are standardized, as well as methods for describing system artifacts. Work is underway to harmonize a set of systems engineering standards with the gradual formation of a unified information space for regulatory support for the creation of complex systems.

Internationally recognized systems engineering standards and guidelines are developed by three organizations. These include the Seventh Subcommittee of the Joint Technical Committee of the International Organization for Standardization and the International Electrotechnical Commission "System and Software Engineering", the Institute of Electrical and Electronics Engineers and the International Council for Systems Engineering.

Systems engineering specifications are not directly applicable standards. They provide guidance on what to do, leaving the decision on how to do it to the discretion of the parties setting up the system and managing the project. Many specifications are of a framework nature. It is assumed that the recommendations contained in the standards must be necessarily adapted to the conditions of a specific system engineering activity. Taking into account the recommendations of official standards, variable regulatory documents can be developed that regulate systems engineering activities.

2.9 Smart industry and new industrialization

The program for creating a smart industry in the Republic of Belarus involves a digital transformation of the industrial economy, which, despite the forecasts of sociologists about the post-industrial and information societies, remains the basic structure of nation-states, since de-industrialization has been replaced by reindustrialization. This means that a second-generation industrial society is being formed through digital transformation.

The industrial society of the first generation lasted from the 18th to the end of the 20th century. It evolved on the basis of the mechanism of technological modernization. Ideas for the modernization of technological processes were consistently supplied by three industrial revolutions. The industrial industry of the first generation reached the level of mass production of goods and technical devices. It formed the infrastructure and communications. Its economic basis was formed by the effective use of man-machine technologies. This use encouraged the development of science and technical creativity. At the same time, investment in human capital increased. Investments were directed to education.

As payroll costs increased, industrial companies began to withdraw production from the zone of expensive labor. This gave rise to the theorists of the post-industrial society to write about the de-industrialization of the industrial cultures of the United States and Western Europe. But after the process of rising labor costs in the regions of Asia and Latin America began, industrial culture began to restore its status in the form of deindustrialization in the US and the European Union. The modernization of an industrial society is not only about digitizing data. It's not just automation. Based on the platform concept, a new economy is being created. It is based on a business model for the provision of services for the coordination of market participants. It is planned to create a single complex of computing resources and physical processes. For this purpose, a special mathematical management software has been developed in the form of mathematical models and algorithms. The use of the 5G Internet is relevant, since the speed of information processing and decision-making play an important role.

Digital platforms in the macroeconomic model of the new economy are specialized in the industrial Internet, the Internet in the agro-industrial sector, building life cycle management based on BIM technologies, digital technologies for the development of smart cities, digital transformation of energy and petrochemicals, logistics, trade, financial sector, employment coordination and social services, medicine, education, science, sharing paradigm.

Digital design, mathematical modeling and product or product is life cycle management technologies. That is the implementation of the concept of digital smart design. The process is driven by the digital twin development technology. He based on the creation and application of a multi-level matrix of targets and resource constraints, on mathematical models of different classes, levels of complexity and adequacy. He described by non-stationary nonlinear partial differential equations. He based on virtual tests, the use of virtual stands and virtual testing grounds.

Particular attention is paid to the development and implementation of a digital platform for creating digital twins. It is capable of taking into account up to 150,000 targets and resource constraints. Adjacent end-to-end digital technologies of artificial intelligence, big data and distributed ledgers are used. They provide intellectual property management, expert support and first-time physical and field tests. Product lifecycle management systems are used, including competitive CAD-CAM-CAE-subsystems for design, technological preparation of production and computer, supercomputer engineering based on mathematical and simulation modeling. The systems are in demand in the aerospace, defense, and banking industries. Demand is fueled by increased attention to regulatory requirements, the need to reduce product risk, and the growing need for collaboration over the production lifecycle.

Digital technology lowers costs and enables high-performing production assets to be operated and delivered. There is a growing need to centralize business data across enterprises and track transactions across multiple enterprises through real-time data analytics.

The effects of the development and implementation of digital twin technologies are expressed in the fact that companies can reduce the time costs of the production cycle. The main task of the CAD system is to create 3D parts and assemblies of the designed object. The use of CAD systems and digital design makes it possible to reduce the development time and preparation of design documentation for a product by half in comparison with the old technology.

After creating a digital model of a future product or a separate element, computer modeling and analysis systems are used. CAE systems have various mathematical models. Using them, you can model the behavior of real objects with high accuracy. As a result, it was possible to reduce the number of real tests and replace them with computer simulations.

After product design is complete, programs are used to prepare products for production. The purpose of these systems is to simplify the mechanism of operation by transforming the 3D model into a dataset with which the machine can manufacture a given part. For CNC machines, this is the trajectory and speed of the machining tool. For selective laser fusion installations, these are the power and trajectory of the laser.

2.10 Digital engineering

Digital engineering means a set of services for digital organizational and technological design and optimization of production and logistics processes and equipment operation modes.

Services include delivery, customization, adaptation and implementation of software, engineering works. They are used in the modernization of existing or in the creation of new smart industries, logistics centers, laboratories, automated and robotic equipment and mechatronics. The basis of digital engineering lies in understanding the interconnections of physical processes occurring in a product or product at all stages of the life cycle and the ability to calculate their mutual influence on the measured characteristics.

The use of a digital information model as a tool for supporting a project at all stages of the life cycle makes it possible to increase the reliability of technical solutions, shorten the project review time and reduce operating costs. The targeted spending of funds at the stages of construction and operation and adherence to deadlines at all stages of the project.

It provides a framework to mitigate risks by participating in the early stages of the project and the possibility of a high degree of model development. The ability to control the project implementation process using digital models makes it possible to simplify the work of the project team at all stages of the examination and project support, to increase the safety of investments and the effectiveness of monitoring the investment phase.

The digital twin of a product is an analogue of a physical object in a digital environment. It is created on the basis of interconnected mathematical models of physical processes occurring in the object, based on the execution of tens of thousands of virtual tests.

The digital twin of production takes into account the technological features of production processes in the digital twin of a product within a single digital model. A smart digital twin of the first level combines the digital twin of an object / product and a digital twin of production within a single digital model. The Level 2 Smart Digital Twin combines the smart digital twin of the facility and actual operating data into a single digital model. A smart digital shadow of a product is formed on the basis of a smart model that adequately describes the behavior of a real product in all modes of operation. These are starts and stops, normal operating conditions and deviations from normal conditions, emergency situations.

Digital twin technology combines the Industrial Internet of Things and digital modeling. It is actively implemented at all stages of the product life cycle. The introduction of digital twins to simulate and evaluate various scenarios can reduce the number of equipment failures. Thanks to the use of technology, errors are corrected at an early stage of design and no breakdowns occur during testing. The quality of 3D models has improved. Reduce the time for electronic approval of design documentation and reduce the number of design errors. Companies spend less money on reworking samples for mass production.

Key digital solutions are product lifecycle management, digital product and process design, manufacturing process control systems, and the Internet of

Things. The priority is to ensure the cybernetics security of systems and the development of information infrastructure.

2.11 Digital reengineering

Reengineering involves a radical revision of the organizational structure in order to optimize the activities of the enterprise. Organizations have appeared that provide reengineering support services based on their own technological developments and solutions. Solutions for digital design of enterprises and adaptive production management have been developed. A range of tasks is solved from auditing the capabilities and limitations of enterprises on the basis of their own information developments to the introduction of automated control systems, flexible production systems and machine tools in industrial enterprises.

Weaknesses before digital management were the long lead times for the enterprise model and the unique competency requirements of people who need to understand production systems and have programming skills. By the time of construction, the model was not relevant. The external conditions, the product line, and, accordingly, production cycles as well as other indicators of the enterprise's activity, have changed. There was a need for a flexible and fast solution that would allow managing an enterprise in a rapidly changing environment. Digital platforms began to emerge.

The digital platform is based on Eliyahu Goldratt's theory of constraints. According to the theory, the limits limiting the development of the management system are discovered and worked out. These are capacities, demand, and the lead time of the production cycle. The platform includes a line of software products. These include an intelligent decision support system and an adaptive production management system.

2.12 Cyber security

The problem of ensuring fail safety in control systems is associated with the issues of ensuring their information security from cybernetics attacks. The use of cyber capabilities to achieve objectives in cyberspace or through cyberspace is defined as cyber operation. A cybernetics attack is a cybernetics operation, both offensive and defensive. A cybernetics attack can result in damage to human health, loss of life, property damage, or destruction of objects.

Cyber security means the ability of a control information system to perform its intended tasks in the face of destructive influences caused by cybernetics attacks, as well as technological disruptions and failures of composite technical means. Cyber security means a complex concept of the safe functioning of information management systems.

The main threats to the violation of cyber security in information systems are created by information attacks. This is the implementation of unauthorized access of a potential adversary to the system. Threats also create undeclared capabilities in programs and systems devices; system failures and errors, including hardware and software failures and errors, operator errors, data errors.

Complete elimination of control failures is theoretically possible, but practically not feasible, since it requires economic costs that are obviously greater than the expected damage from the impact of dangerous failures. The real way to ensure security involves determining the acceptable level of risk from cybernetics attacks and creating effective protection against dangerous failures.

A successful cybernetics attack can result in a violation of the integrity or availability of information. Servers, user workstations and communication equipment of an information system can be considered as targets of an attack. When organizing cybernetics attacks, specialized software is used to automate actions performed at various stages of an attack. A cybernetics attack includes four stages of reconnaissance, invasion and attack impact and attack development. At the stage of reconnaissance, the hacker tries to obtain as much information as possible about the object of the attack in order to plan further stages of the invasion on its basis. Information about the type and version of the operating system can serve these purposes; list of users registered in the system; information about the used application software. During the invasion phase, the hacker gains unauthorized access to the resources being attacked.

At this stage of the attacking action, the goals for which the attack was undertaken are realized. This is a malfunction of the system, deletion or modification of data. A hacker performs operations aimed at removing traces of his presence in the system. The attack is based on the presence of vulnerabilities in the management system. Using at least one of them opens the system login. After the attack, the hacker seeks to move the attack into the phase of further development. To do this, a malicious program is introduced into the system, with the help of which it is possible to organize an attack on other means of the system.

The main threats to the cyber security of information systems are created by programs such as DoS attacks. It ensures the creation of conditions under which legitimate users of the system cannot access the server resources provided by the system, or this access is difficult. The rejection of the "enemy" system can be one of the steps to mastering the system. Trojans are also used. After being introduced into the system, they violate the integrity of data and programs, activate viruses in the system. They can collect information about user profiles, passwords and other confidential information stored on a computer and then forward it to hackers. Unauthorized computer control programs are also used. These are boot viruses, software viruses, network worms.

Information attacks lead to a violation of the confidentiality and integrity of information, the availability of the information system or the data it contains. A breach of confidentiality occurs as a result of theft or loss of information. Accessibility violation occurs as a result of blocking the system or data in it, as well as a result of the destruction of access means, for example, passwords, keys, access regulations. Integrity violation is associated with the modification of programs and data, denial of the authenticity of information, the imposition of false information.

Undeclared capabilities in programs and devices of systems mean functionality of software and hardware that is not described or does not correspond to the documentation. When using them, it is possible to violate the availability, integrity, and confidentiality of the information being processed. Implementation of undeclared features are software and hardware tabs.

2.13 Philosophy of digital ecosystems

At the end of the twentieth century, the concept of an ecosystem used in biology and ecology was introduced into the terminological apparatus of the economic and management spheres. J. Moore suggested using the term "business ecosystem" to denote the social environment of an enterprise, the elements of which are participants in business processes.

The enterprise was compared to a biological ecosystem. D. Eisenberg described the environment in which entrepreneurship seeks to develop. This environment is shaped by government policy on small and medium-sized businesses, financial capital, entrepreneurial culture, technical support, human capital and markets. The quality of entrepreneurship in the country depends on the level of development of the environment. The entrepreneurial ecosystem includes a startup ecosystem, a venture ecosystem, a university ecosystem. And also a business ecosystem as a set of proprietary or partner services united around one company. The ecosystem can be centered one area of the client's life or penetrate into several of them at once.

J. Moore proposed to consider economic activity as an ecosystem, where buyers and producers play complementary roles, jointly evolving in the direction set by companies that are at the center of the ecosystem. A business ecosystem is an economic community that consists of a collection of interconnected organizations and individuals. The economic community produces goods and services of value to the consumer, which are also part of the ecosystem. Any enterprise ecosystem also includes suppliers, leading manufacturers, competitors, and other stakeholders. They co-evolve their capabilities and roles and strive to align with the direction set by one or more of the leading companies. Those companies that hold leadership roles can change over time, but the ecosystem leader function is valued by the community because it allows members to move towards shared visions in order to align their investments and find mutually supportive roles. Companies have been encouraged to become proactive in developing mutually beneficial symbiotic relationships with customers, suppliers, and even competitors. B. DeLonge defines the ecology of business as a more productive set of processes for the development and commercialization of new technologies. This involves rapid prototyping, short product development cycles, early test marketing, option-based compensation, venture funding, early corporate independence.

The application service provider industry is based on centrally managed, hosted, and provisioned applications contracted with end users. Companies inclined to coexist in an ecosystem are contributing to the inevitability of application delivery over the Internet.

Business ecology is defined as a new area for sustainable organizational management and design, based on the thesis that organizations, as living organisms, are most successful when their development and behavior are consistent with their core purpose and values. Business ecology is based on the elegant structure and principles of natural systems. To develop healthy business ecosystems, leaders and their organizations need to see themselves and their environment through the ecological environment.

Business ecology involves the study of the relationship between business and organisms and their environment. The goal of business ecology is sustainability through the complete environmental synchronization and integration of the business with the sites it inhabits, uses and touches. Platforms and digital ecosystems are promising. Ecosystems span many industries and include various sectors of industry, partners, competitors, customers, and business.

In connection with the development of digitalization and information technology, a new use of the term ecosystem has appeared. The ecosystem is the interconnection of all the services of a company. The internet has changed lives. Multifunctional mobile devices have changed the communication of people, the channels for promoting products and services. Each company strives to create its own ecosystem and make it the most demanded. Global digital ecosystem majors: Apple and Google. The Apple ecosystem includes music, storage, photo library, videos, archives, history recording and passwords. The Apple ecosystem connects services with a common design, information technology platform, accessories and stores.

Digital ecosystems use the principle of one window, working in a single mobile application. As the amount of data grows, they adapt to the client's requirements. Form a single client profile, Summarize information about purchases in the ecosystem, Form a targeted offer to the client.

Allow to remove geographical restrictions for business development for small and medium-sized manufacturers of products and services. Like conventional systems of interaction, ecosystems require regulation. There are risks of unfair competition, discrimination of participants, monopolization of technologies, misuse of personal data of clients, insufficient level of information security and protection against fraud.

2.14 Philosophy of digital economy

The digital ecosystem is a collection of platforms that provide various products and services; online and offline services; specialized ecosystems built around one or more basic needs; services not only for individuals, but also for legal entities.

Digital ecosystems are constantly expanding the number of participants. For example, retail company Amazon began by building a global server infrastructure to serve customers on its e-commerce platform. In the second phase of its evolution, the company began to lease server capacity to other enterprises.

This led to the rapid creation of services. The advantages of these services were that they were the main users and received packages faster, had access to music, and could even watch TV series and films from the main library.

In the third phase, the company attracted many third-party companies to participate in this ecosystem. It pioneered and allowed competitors to use the infrastructure of services and tools offered by the company. This was a huge success. The digital ecosystem is focused on creating added value for customers by optimizing data and workflows from various internal departments, tools, systems, as well as from customers, suppliers and external partners. It removes barriers to the customer and enables each member of the ecosystem to use modern technologies and systems to meet their individual needs.

The ecosystem offers customers a single, easy-to-use system that delivers value through a variety of services, products and knowledge. This allows the platforms to grow exponentially and outperform the mainstream market. When scaling an ecosystem, different business models are possible.

Better understanding of the consumer and reorientation of the offered products allows to the number of offered services and products at the expense of the number of ideas received from buyers. This makes digital ecosystems so powerful and also so profitable that companies using the power of digital ecosystems topped the list of the most valuable companies in the world. Companies are leveraging their customer base and ecosystem approach to drive revenue and offer better products and services to their customers.

There is a focus not only on customer service or personalized advertising / marketing of the company's offerings, but rather on the full spectrum of customer focus that is only possible due to the scale of the business. This means holistic operations and collaboration between departments and between products and services to integrate the customer journey as best as possible.

One of the main advantages of using the digital ecosystem is the ability to collect additional information about processes, customers, transactions. This makes data a key factor in every digital ecosystem. The more you can learn about a customer, the better you can offer services, software, technology, and tools to improve the customer experience.

With the tremendous understanding that digital ecosystems receive from customers, suppliers, and third parties, it is also possible to make that understanding actionable. Automation is one of the key elements in lowering prices, increasing customer satisfaction, and proposing new services and products to increase the value stream. Digital ecosystems enable collaboration between countries, regions and languages. They remove cultural barriers.

The ecosystem participant mentality should be very dynamic. This is because ecosystems must quickly adapt and respond quickly to changing market dynamics otherwise the user base will move forward and switch platforms. Business intelligence, rapid decision making, and the use of new technologies and business models must be at the center of every decision. Before you start imagining yourself as an ecosystem builder, you need to dive deeply into your company and your offerings. It also means that you need to determine which ecosystems are important to you and what role you will play in which ecosystem. There are three different roles a company can play in an ecosystem. This is the role of the ecosystem organizer. In this case, the company takes on the risk, complexity, and challenges of building a digital ecosystem and allows others to participate in the ecosystem and sell goods and services through that system.

This is the role of the modular manufacturer. In this case, the company contributes to the ecosystem and monetizes the value in different ecosystems. Through its services, the company offers various platforms and ecosystems of services to have a single payment gateway so that customers can pay easily. A module maker can add essential services to ecosystems that meet the needs of consumers, businesses, and buyers and sellers in a certain sense. In the third modification, the customer can be a person or business that benefits from the ecosystem. By booking a digital platform, you become a customer of the ecosystem. Companies can sometimes use, sometimes organize, and sometimes add services to multiple digital ecosystems.

It is imperative that companies and individuals understand the power and implications of the growth of digital ecosystems around the world, and find ways to participate in, create, or interact with them in their own contexts to harness their power and perhaps create their own and project.

Initially, the idea of an ecosystem came from the IT business. IT companies were the first to feel the need for closer interaction between all participants in the value chain (IT product) than traditional contractual relationships. A typical example is the experience of developing a new generation of IT products - popular corporate messengers that integrate various applications into their mobile services, forming an ecosystem. The value of such an ecosystem increases for each of its participants. Business is constantly looking for new approaches and new forms of interaction with suppliers, consumers, transport and logistics companies, payment systems, with players from adjacent and competing industries.

Traditionally, a successful network business configuration has been a platform that allowed third parties to use the original infrastructure as a means of distributing value. However, the increase in the functionality of platforms faced limitations not so much of a technological as of an economic nature: many innovative ideas could not be implemented on the basis of existing platforms, since their implementation.

The ecosystem of a firm is not limited to the business network and includes both business partners and non-business partners, but those affected by the company's activities. The first ecosystems arose on the basis of innovative clusters, then in the future, multiactor networks, management of IT and social platforms, and the dynamic evolution of product service systems were involved in the formation of such structures.

The effectiveness of an ecosystem does not depend on the quality of its individual components (participants), but on the quality of their interaction with each other. The digital ecosystem is a recently emerging model for such an organization. The digital ecosystem provides for a certain industrial metabolism of the business network. Information and communication flows of the firm and business networks interact (harmoniously or not) with the surrounding economic and social environment, and this environment covers the entire global world. This evolution fundamentally changes not only business practice, but also the self-image of the essence of what a particular business is doing.

Examples are the transformation of the tourism industry into a hospitality ecosystem and fintech as a special digital ecosystem in the financial sector. An increasing number of business consultants recommend their clients to form an ecosystem or integrate into a ready-made ecosystem of business strategies. By 2025, such ecosystems will account for about 30% of the global revenues of organizations and more than 40% of their global profits.

The trend towards consolidation of players within the business ecosystem can be traced in different countries through the example of taxi aggregators, food delivery services and e-commerce. The emphasis is on network collaboration and multiplier effects in business networks as features of the behavior of modern companies. This determines the specifics of making key decisions in the business space of the modern world. Competitive collaboration (collaboration) is taking place as the dominant trend in the networked economy and as a driver for the transformation of business models.

At the same time, collaboration does not negate tough competition. A specific business configuration is being formed, within which competition and cooperation take on new forms.

The ecosystem goes beyond one firm, so it cannot be called a business model or business strategy. The ecosystem is not a traditional form of inter-firm contact. With the advent of the digital ecosystem, the interaction of companies is taking place at a qualitatively new level. The ecosystem is characterized by high dynamism and high flexibility. The ecosystem is focused on results: firms within the ecosystem do not sell a product or service, but the result that the client wants. The ecosystem is not a firm, not a business strategy, or ordinary inter-firm interactions.

The ecosystem is a fundamentally new, flexible, business configuration that includes a variety of participants, cooperating and at the same time competing.

In a digital ecosystem, the interdependence of economic actors is felt stronger and deeper than in a traditional value chain. In the networked economy, the predominant form of rivalry between companies is platform competition, and platforms can be of a very different nature: technological, social, virtual, and others. With the development of network interactions, the concept of a platform from a purely technical sphere is transferred to all other areas of interfirm relations and acquires a broad meaning as a kind of portal, a definite, real or virtual, space of common standards, acting as an intermediary that unites disparate participants that create value only when joint participation. Organizational fields and organizational networks are crystallizing into platform ecosystems. Digital platforms create space for the movement of information flows, ensuring the interchange of data between various participants.

In traditional platform competition, a pioneer firm is able to quickly reach a critical mass of users, develop a broader set of mutually complementary products, and set a lower price. All this leads to a significant superiority of the leader. Latecomers either have no chance of market penetration at all, or are forced to settle for an extremely small, marginal market share. Competition between platform-based business ecosystems shows other patterns. The winner-take-all principle only works when the platform's consumers prioritize and value the entire network as a whole.

First, the quality and competitiveness of the platform depends not only on the direct network effect - the number of users, but also on the quantity and quality of complementary resources and products (indirect network effect). When deciding which platform to choose, a potential user must carry out a complex process of processing information regarding the presence and depth of direct and indirect network effects. This requires a rare resource - attention. Concentration of attention is distributed unevenly: new information receives a stronger "dose", attention to old, already familiar information turns out to be weaker. Limited rationality of people, poor ability to attract attention, selective concentration and selectivity of user interest affect how consumers evaluate the usefulness of the platform, and, therefore, make decisions about its choice.

Second, consumers are not interested in the overall network of the platform. The small number of people who use this network product influences their choice, but the number of acquaintances, employees, colleagues, friends who recommend this platform, since they are constantly present in this particular network. Users want to be in touch not with the global platform world, but with their local community. Platform competition demonstrates a small world effect, or preference for a local network. Therefore, a firm that uses unusual, interesting, personalized, creative incentives and focuses on a local social network can be successful in platform competition, even if it is far from the first to take this path. Leader advantage is losing its former importance.

A new feature of networked platform competition is the transfer of company rivalry to virtual space. The conquest of the virtual space is a new criterion for a firm's efficiency. Social networks and the company's website are becoming part of a virtual competition. Firms are adopting platform ecosystem strategies where the main effort, assets, and investment are in related industries to gain competitive advantage in both core and complementary industries. Competition virtualization spawns an important strategy for today's networked competition - the collection and analysis of big data. The traditional concept of the firm as an unstructured data system is dying out. The exchange of data between IT applications during production, distribution, market sale and consumption creates an independent, holistic ecosystem of goods and services in the business space.

Modeling the company's network strategies within the digital ecosystem allows us to distinguish two basic options. The first option is the choice of a unique technology and / or network that is incomparable and incompatible with competitive products. The company creates technological difficulties for competitors and high switching costs for consumers. The second option is a compatible network with relatively low switching costs for consumers and the ability to use products from competing companies. In the first case, there is fierce competition, which is traditional for the network economy, at the first stage of network development for market dominance. Here, the main method of competition is aggressive pricing to achieve rapid industry dominance through escalation effects, creating an investment trap for consumers, and quickly gaining a critical mass of users. Fierce initial competition subsequently turns into monopoly or domination by one winning company.

In the second case, firms do not need to compete fiercely, the problem of obtaining a critical mass of users is not worth it. Weak non-price competition prevails here, resulting in a fragmented market. Network competition helps to develop network products of different firms, stimulates cooperation between companies and defines each business organization its place, its own niche in the overall business network.

In the neoclassical model, firms and individuals are independent in decision-making and interact with each other only through prices. The price mechanism equalizes all participants and leads to an almost endless growth in space and time of inter-firm interactions. In the digital ecosystem, as the number of web users grows, there is a small world effect. The small world effect suggests that network participants regularly enter into short-term relationships and, from time to time, long-term relationships outside of price patterns. The small world effect suggests that network participants regularly enter into short-term relationships and, from time to time, long-term relationships outside of price patterns. The average firm in such a network has short-term relationships and contacts with a wide range of partners. Social relationships turn out to be more significant than price ones.

Chaotic and random participants in the network form ordered structures (clusters), so that any two participants in the network will be connected to each other through a relatively small series of contacts. In chaotic networks, each participant has the same probability of contact with any other participant. In cluster networks, participants with a common neighbor are characterized by a higher probability of interconnection (contact). In such networks, even small initial changes have large net impacts.

The higher efficiency of the small world network is based on such factors as: joint organizational and economic evolution, intertemporal exchange of information, deeper and shorter learning effect and similarity of technological profiles of firms. The competitiveness of modern innovations is largely based not on technological innovations (although it does not exclude them), but on the flexibility of the supplier network. The cooperation of suppliers that are part of the business network of the enterprise lead to a reduction in costs for innovative projects and an increase in the quality of innovative products.

An innovation ecosystem can include a variety of actors from outside the business sector. The small world effect makes it possible to distinguish two clusters within the framework of the overall innovation ecosystem: the ecosystem of knowledge and the ecosystem of the business itself. The knowledge ecosystem includes organizations responsible for the creation of private and public (collective) goods: research institutes and educational institutions. The business ecosystem is usually represented by commercial enterprises of an industrial and commercial nature, as well as financial institutions.

Diversified open innovation platforms have allowed the development of innovative services that have been accompanied by reduced business costs and increased business efficiency based on the knowledge triangle. The efficiency of the modern economy requires the simultaneous and parallel development of both parts of the innovation ecosystem in harmonious interaction. However, unlike the second, the first is that the knowledge ecosystem requires government support for its advancement (especially in terms of creating public goods, the production of which may turn out to be underfunded, which will slow down the progress of the entire innovation ecosystem).

The emergence and development of ecosystems leads to a significant change in the purpose of the firm. It is evolving towards taking into account the needs of all stakeholders.

2.15 Systems Engineering of Digital Ecosystems

Systems engineering is based on an interdisciplinary approach. The goal is to transform customer needs and constraints into effective solutions, to support those solutions throughout the life cycle. She substantiates the methodological criteria for the activity and responsibility of a system engineer, develops a toolkit for activity.

A dedicated guide accompanies the complete lifecycle of a digital system and focuses on productive technical design solutions and technical integrity. It is a creative activity aimed at realizing new opportunities based on a combination of technical knowledge, ability to solve problems, creativity, ability to lead and to exchange knowledge and opinions. System solutions management focuses on the use of many different technologies, participation in the work of several organizations, and complex technical activities. This is a formalized activity aimed at the development and systematization of knowledge necessary for the effective management of the development and functioning of complex systems. Good governance involves the use of a systematic, orderly, quantifiable approach that can be used recursively at different system levels, is reproducible and suitable for observation and demonstration.

Systems Engineering Thinking manages an engineering team that is tasked with a model-based systems methodology. It provides for the use of logical structural and physical numerical formal models. They can be directly processed, tested, optimized. Models are checked for errors. Not only numerical physical models are used, but also logical models with the apparatus of discrete mathematics, as well as algorithmic programming models.

Search-based systems engineering plays an important role. The calculation of optimal technical solutions for goals and contracts is carried out. After describing the goals and contracts, the synthesis and optimization of the architecture corresponding to the goals and contracts is done. Artificial imagination plays an important role. It is based on genetic algorithms and trained neural networks. Engineering modification is generative design. The technique of direct reflection on an engineering project, 3D modeling and 3D CAD systems is used. But this line of work is also associated with the synthesis of the model (3D models in this case).

A higher level of artificial imagination involves computer search. This requires the economical generation of suitable engineering options and an artificial engineering taste. It lies in the ability to evaluate options. Hybrid numerical logical computing is used. The target system is described in terms of system structures, in particular, components, modules, placements in their hierarchies and numerical parameters of physical properties. The system architecture is obtained by looking for a combination of logical / functional and physical architectures.

The conceptual apparatus of systems engineering is formed by the theories of target systems, engineering activities and management. The target system (digital ecosystem) is considered as open in the context of its interaction and adaptation to other systems that are in the functioning environment, as having open, interacting subsystems in its composition, and as a part of the system in a broader sense or an encompassing system. To obtain a solution, the parts come together to function and interact as a whole.

EFFECT: increased efficiency of work as a result of connection, integration, merging of separate parts into a single system (synergistic effect). The stages of description, design, selection of components, their connection with each other so that the necessary interaction and the necessary properties of the whole are achieved are important. When making decisions, the system is considered as a whole. The properties and behavior of systems are considered in dynamics.

It is important to adapt the characteristics of a complex system to changes in its state, in the external environment and in other systems. It is also important to provide opportunities for continuous improvement in system performance to maintain optimal performance in the face of changes in the operating environment. Successful systems engineering involves the process of continually adapting system requirements and solutions to deliver the results that, in a given environment, are most satisfying to stakeholders. This includes two components.

Systems engineering seeks to formalize the systems development process. The collection of such typical, repetitive actions is called the systems engineering process and the systems engineering method.

The subject of systems engineering is an integrated, holistic view of large-scale, complex, high-tech systems that interact at the enterprise level using human-machine interfaces. The creation of such systems involves the development of systems architecture, design of systems and their elements; operations research; management of engineering activities; selection of technologies and techniques; effective management of the life cycle of the digital ecosystem.

Systems engineering is associated with organizational and management, design and management, design and engineering and technological activities. A systems analyst studies a business and determines how it can be made more efficient by implementing information systems. There is a need for specialists with a technical background and developed soft skills who can optimize the development process.

The main task of a systems analyst is to develop an information system that meets the needs of the company and allows you to establish business processes.

He develops a list of tasks and communicates them to the team so that colleagues have a clear idea of the goals and methods of achieving them. The systems analyst collects and analyzes the requirements of the source programs, conducts interviews with the customer. It coordinates the requirements and manages their changes, including monitoring requirements changes to prevent inconsistencies; prepares design, technical, user documentation. It captures the flow of information to avoid confusion; presents the work to the customer; synchronizes the context of the team and the customer: ensures high-quality communication, minimizes conflicts.

To perform work tasks, the systems engineer must understand the basic principles of software development; be able to determine the boundaries of systems and their areas of responsibility to analyze opportunities and limitations. It is important for him to know how to distinguish subsystems and their functions; be able to find explicit and implicit requirements for finding solutions; have modeling skills to visualize processes.

The development process involves a constant exchange of information. To correctly request and communicate it clearly, it is important for a systems analyst to develop soft skills.

In retail, when automating processes, client-server systems are often used, so the systems analyst must understand the relevant requirements and architecture. Experience in prototyping will help you create user interfaces for easy communication between the user and the program. It is important for cyber security to understand encryption systems and data protection.

The business analyst is focused on optimizing business processes, reducing costs and increasing profits through automation. He develops the solution and passes it on to the systems analyst, who shifts this solution to the technical implementation and helps the engineers understand what should be the result of the development.

The data analyst processes the data and builds hypotheses based on this. The data analyst works with metrics, and the systems analyst works with processes. The systems analyst translates the collected requirements into development tasks. The systems engineer monitors the progress of the project, coordinates shifts in the plan manages resources and risks. He is responsible for product strategy from hypothesis to analysis of results. He knows what the user needs, and the systems analyst understands how to do it.

The systems analyst thinks over the structure of the digital ecosystem, and the architect creates it. The system architect designs the architecture in such a way that the developed system not only meets the current business requirements, but also can be flexibly expanded and modified as new needs arise.

The technical writer is responsible for the documentation. The responsibilities of a systems analyst also include the preparation of documents, but the scope of his responsibilities is much broader. Software ecosystem and related terms are widely used by software manufacturers and researchers. A survey of the websites of leading software manufacturers shows that most of them use the term “software ecosystem” to refer to systems that include the developer's enterprise, its software and partners. Ecosystems are viewed as a level of abstraction over software products and projects that can be described by analyzing the lower levels. The point is to analyze the information of the project components to obtain high-level design views that characterize the organization, software components and the conditioned social structure. There is a trend towards using ecosystem concepts to refer to socio-technical software systems. This is explained by the similarity of modern large-scale software systems to dynamic communities of independent and competing organisms in a complex changing environment. Organisms include people, computing devices, and organizations. Among the properties of ecosystem concepts that are useful when considering large software systems, such as complexity, decentralized management, complexly predictable effects of certain types, complexity of monitoring and evaluation, competition in niches, resilience, adaptability, stability and viability are distinguished.

Thus, developers and researchers have formed a new view of software as a socio-technical system with characteristics similar to biological ecosystems. The scale of such ecosystems ranges from a specific set of projects in an organization to a global set of all software. A comparative study of biological ecosystems and software ecosystems has shown that they have holistic properties that characterize the system as a whole, and merological properties that characterize the internal structure of the ecosystem. A generalized model of a software ecosystem can be thought of as an ecosystem within established boundaries, in which the environment is at the entrance and the environment is at the output.

The environments show the exchange of specialists and software. The holistic model of the software ecosystem stipulates a number of possible aspects and properties of software ecosystems to explore. First, the requirement to define the boundaries of a specific ecosystem allows us to substantively consider the exchange of an ecosystem with the environment and to establish characteristics of the size of the ecosystem. The boundary also forces the researcher to clearly separate the elements of the ecosystem from the elements of the environment. So, such elements of the ecosystem as states, educational institutions can only relate to the software ecosystem of a global format, or the scale of the state. For smaller ecosystems, most will be environments. Secondly, the definition of environments at the input and output in the model allows you to identify and describe the essential relationships of the ecosystem with the environment, the volume and composition of the exchange.

The concept of software life cycle processes makes it possible to show relationships more specifically, using known products and resources of processes and phases - programs, documentation, personnel. The merological model makes it possible to define and use a wide range of ecosystem properties, some of which are already used in software. The properties of a merological model can describe the composition, number of elements and structure of an ecosystem, the intensity of connections between elements. Software development is a gradual iterative process, each cycle of which provides new opportunities. The evolution of software cannot be considered without taking into account the development of its ecosystem, since it requires the corresponding development of other elements of the ecosystem - the qualifications and experience of developers and partners, the skills and expectations of users. Therefore, software ecosystems can become an additional tool for researching and evaluating the evolution of software.

2.16 Digital ontology

The birth of the semantics of possible worlds is associated with the theories of G. Leibniz. In one of them, he claims that the Divine mind contains a variant of an infinite number of worlds. God chooses the best of these worlds, creating him as he is. The philosopher determined the logical direction of the development of the theory. The semantics of possible worlds are used to determine the meaning of expressions. Their semantic status does not depend on a single position, but on many possible states of affairs. The prevailing direction is the structuring of the truth value, its multi-level description. Complex models are constructed that combine the concepts of a possible world, a moment in time, a subject of utterance (the worlds of the observer) and subjects of propositional attitudes (the worlds of knowing).

The concepts of S. Kripke and D. Lewis are considered to be extreme in terms of principles. S. Kripke considers the real world as one of many logically possible worlds. This set is considered as some abstract concepts that serve to interpret the laws of reality. D. Lewis's modal realism asserts the equal reality of all existing worlds. The philosopher insists that when we talk about the difference between our world and other possible ones, about its reality, we only mean that this is our world.

R. Stolnaker put forward the theory of moderate realism, according to which possible worlds exist as an alternative way of being things, in which the things themselves are no longer identical to those that exist in the real world. The uncertainty principle was asserted as a condition for the existence of possible worlds. In linguistics, the theory of possible worlds has found quite strong positions in semantics, pragmatics, and literary criticism. In a semantic context, possible worlds are used to designate entities, relative to which the truth values of propositions are determined (S. Kripke). They are described as the most consistent classes of propositions (J. Hintikka), or they are declared the reason for a person's rational activity in the form of reflection, communication and study in order to establish differences between concepts (R. Stolnaker).

Among the main directions of using the theory of possible worlds in semantics, the consideration of the semantics of the question and the pragmatics of the question-answer system of relations, the analysis of presuppositions are distinguished. The role of context and contextual changes in the interpretation of discourse is investigated. According to B.Kh. Parti, if a method is created that makes it possible to analyze propositions without appealing to possible worlds, then the theory of these worlds will cease to be in demand.

The theory of possible worlds in literary criticism sets as its task the definition of literary truth, the study of the nature of the fictional context and the establishment of links between the worlds of literature and our real world. It is especially relevant for the analysis of works with a clearly defined combination of fiction and reality - hagiographies (V. Lurie), alternative history (M. Nazarenko). In relation to fiction, the application of the theory of possible worlds was developed by U. Eco, M.-L. Ryan, L. Dolezel. Scientists have tried to classify texts according to the principle of truth (L. Dolezel), to rank worlds according to the role of the author, characters and reader (U. Eco), to explain the nature of the dynamism of the plot through the combination of character worlds

(M.-L. Ryan). Methods of linguistic analysis of ways of mapping worlds turned out to be in demand.

In a narrow sense, the semantics of possible worlds is a method of logical analysis of the semantic constructions of modal and intensional concepts. It is based on the consideration of possible worlds as conceivable states of affairs (ideal alternatives, descriptions of states, points of correlation). It is based on the consideration of possible worlds as conceivable states of affairs (ideal alternatives, descriptions of states, points of correlation).

D. Scott proposed to clarify the meaning of modal concepts in the process of analyzing alternative states of affairs. Possible worlds are understood by him as an area of conceptual consistency. Among the logical possibilities, classes of equivalent areas are distinguished on the basis of the ratio of their possibilities. Of these, one class of the real world stands out. Some logical possibilities are understood as real alternatives to the real world. The idea of possible worlds by G.V. Leibniz used to interpret the necessarily true as what takes place in all possible worlds, and incidentally true as what takes place in some of them.

The classically possible world (description of the state of affairs) is a collection of elementary (atomic) statements and their negations. For each elementary statement, this totality includes either itself or its negation, but not both. An elementary statement is considered true (realizable) in a given possible world if it belongs to it. The truth of a complex statement is determined by induction on the construction of this statement.

A statement is necessarily true if it is true in all possible worlds. R. Carnap, proceeding from the ideas of G. Leibniz, constructed the first meaningful semantics for a modal language through the refinement of the concept of a possible world by the concept of "description of a state". Its logical system contains an exhaustive definition of complete and consistent descriptions of the states of atomic facts. Exact methods of semantics of possible worlds were created by S. Kanger ("classes of structures", "properties of modal operators"), R. Montague (relations between "ideal models", "points of reference", "neighborhood semantics"), B. Johnson, A. Tarski (connection between algebraic characteristics and properties of binary relations). And also J. Hintikki ("model sets", the relation "co-resolution", the relation of alternativeness), K. Meredita, I. Thomas, A. Pryor ("world jumps", "world-jumping"), S. Kripke. These are works on relational semantics, in which the relation of reachability between worlds, as well as alternativeness, informativity is introduced.

The method of semantics of possible worlds is used to determine the meaning of expressions, the semantic status of which does not depend on a single state of affairs, but on many possible states of affairs, as, for example, in languages of modal logic.

Possible worlds in terms of quantity and quality are subdivided into complete (incomplete) and consistent (contradictory) worlds. The notion of a complete possible world involves the construction of models in which individual and predicate constants are defined. This means that you can calculate the value of any well-formed formula.

Semantically, there is a distinction between solid designators and non-solid designators. Contradictory descriptions of the state contain logically contradictory formulas. Incomplete and contradictory worlds can serve as examples of non-classical worlds or impossible possible worlds. The models introduce special functions that identify individuals in possible worlds. These are "transworld lines" in Hintikka's terminology.

In non-classical logics, the meanings of the concept of "possible world" vary from the field and objectives of the study. You can distinguish between logical and physical necessity. Research on non-classical logics focuses on structuring truth value. Complex models are constructed that combine the concepts of a possible world, a moment in time, a subject of utterance (worlds of an observer), subjects of propositional attitudes (worlds of cognizers). Possible worlds are distinguished as global descriptions of states, including all considered points of reference, and as local descriptions (possible worlds in the narrow sense). The structuring of meaning involves the construction of multilevel semantics of possible worlds.

One aspect is the study of information frames. The frame reflects the way knowledge is represented in artificial intelligence. This is a real-world scenario. The term was introduced by M. Minsky to designate the structure of knowledge for the perception of spatial scenes. A frame is a model for an abstract image. This is the minimum possible description of the essence of an object, phenomenon, event, situation, process. Frames are used in expert systems.

The theory of possible states is proposed, designed to describe the relationship between situations. In theory, modal operations serve as a mathematical tool for expressing which situations are possible and which are not. The key point is that the concept of the possibility of a state cannot be adequately expressed in a first-order language, it is expressible only in a second-order language. This approach was formulated by Drezke on Semantic Information Theory, to research by Stalnaker and Shannon, where it is used implicitly.

Modal logics generated by information frames are defined through semantic constructions. Barwise set the task of axiomatizing modal logics generated by information frames. The development of the general mathematical theory of information frames has become topical. Axiomatic systems are constructed for modal logics of complete information frames, correct and complete information frames, hereditary and complete information frames, complete, correct and inherited information frames, and joint and complete information frames. Weak modal logics generated by information frames became the object of research.

Logic also needs semantics to give meaning to symbols. Formal logic uses semantics that are not based on the use of words. The scope of semantics in formal logic is limited to a direction similar to the choice of meaningful names for variables in conventional programming. The topic of knowledge representation is considered one of the main areas of work in the field of artificial intelligence.

The choice of the correct way to represent knowledge is no less important factor on which the successful creation of the system depends, than the development of the software itself, which uses this knowledge.

Related to the topic of knowledge representation is the topic of data representation, which is considered in such an area of computer science as database design. Databases are viewed as repositories of current data such as inventory data, accounts payable, accounts receivable, not knowledge. Companies are active in analyzing the hidden patterns in data to extract knowledge.

Analyzing hidden patterns in data seeks to use historical data in data warehouses to predict trends. The value of analyzing hidden patterns in data is that it allows you to detect trends that are not obvious to humans, but are detectable by analyzing huge amounts of historical data that are stored in the company's archive. In the process of analyzing hidden patterns in data, not only classical statistical methods are used, but also such artificial intelligence methods as artificial neural systems, genetic algorithms, evolutionary algorithms and expert systems, not only taken separately, but also in various combinations.

Expert systems are designed to use a certain type of knowledge representation based on the rules of logic, called inference methods. Usually, the term inference means obtaining logical conclusions based on facts. The representation of knowledge can do without taking into account semantics, but expert systems are designed to conduct reasoning based on logic, therefore, they should not be influenced by the emotional coloring that can be introduced into reasoning under the influence of semantics.

The purpose of inference is to arrive at a valid factual conclusion using evidence in an admissible form. The reason the representation of knowledge is important is that the entire development process, as well as the efficiency, speed and maintainability of the system, depend on the correct choice of the way of such representation. In this, the indicated position is completely analogous to the position that develops in ordinary programming, where the choice of the correct data structure is of fundamental importance when developing a program. A good program design always starts with choosing the right way to represent data, be it simple named variables, arrays, linked lists, queues, trees, graphs, networks, or even such standalone external databases.

It is necessary to separate true knowledge from semantic coloring, the influence of which may lead to invalid conclusions. One should not argue with an expert in knowledge, make impossible demands on him, and all the more, one should not seek to obtain those logical conclusions that are required under the terms of the assignment, since this is tantamount to an unsuccessful completion of the project.

An expert system can contain hundreds and thousands of small pieces of knowledge about the use cases on which it relies. Each rule in the expert system can be viewed as a micro-precedent that contributes to the solution of the problem. Knowledge plays a very important role in expert systems. Knowledge is part of a hierarchy of ways of presenting information.

At the lower level of this hierarchy is noise, consisting of information elements that are not of interest and can only complicate the perception and presentation of data. At a higher level, there is unformatted data containing data elements that, in principle, may be of some interest. The next level contains information (processed data) of interest to users.

Expert systems can separate data from noise, second, transform data into information, and third, transform information into knowledge. In a fact-based expert system, it is extremely dangerous to use unformatted data, since the reliability of the resulting conclusions may be unacceptable.

In the absence of knowledge of the sequence, it may appear to be a manifestation of noise. But if there is reason to believe that this sequence makes sense or it is reliably known, then the specified sequence is considered as data. Certain knowledge may relate to how data is to be converted into information.

Expert knowledge is a specialized kind of knowledge and skills possessed by experts. These are the tacit knowledge and skills of an expert that must be extracted and transformed into explicit knowledge so that it can be represented in the expert system. The reason that knowledge is implicit is that the true expert has such a good command of this knowledge that it has become second nature and does not require reflection.

An expert system can be designed with knowledge of several different problem areas, but this is undesirable, since as a result the system becomes less well defined. Expert systems work successfully, the use of which is limited to the smallest problem area of all possible. If the expert system is designed to detect diseases caused by bacteria, then it makes no sense to use it also for diagnosing malfunctions in cars.

In expert systems a ontology represents metaknowledge that describes everything that is known about the domain under consideration. Ideally, the ontology should be presented in a formal form so that inconsistencies and inconsistencies can be easily detected. A variety of free and commercial tools can be used to build ontologies. The construction of the ontology must be completed before the implementation of the expert system, since otherwise it may be necessary to revise the rules as additional information about the given subject area becomes available, which leads to an increase in costs. In connection with the need to reduce the need for memory and increase the speed, it would be inefficient to keep all knowledge bases in memory at the same time, since during the operation of the network, all the rules in the network are constantly being modified in the memory.

Conflicts can arise if the antecedents of a rule contain the same pattern and the conclusions are different. The work of the expert system slows down with an increase in the number of rules in the system, as the network becomes larger. And meta knowledge can be used to decide which knowledge base should be loaded into memory, and also serve as a general guide to the design and maintenance of an expert system and its ontology. A number of methods of knowledge representation have been proposed. These include rules, semantic networks, frames, scripts, logic conceptual schemas. Syntax defines form, and semantics defines meaning.

The metalanguage is intended to describe other languages. A system of linked frames can form a semantic web. Frames are used in expert systems and other intelligent systems for various purposes. The structure of a frame is understood as a way of using a scheme, a typical sequence of actions, a situational modification of a frame. A frame includes a certain default knowledge called a presumption. A frame is distinguished by the presence of a certain structure. It consists of a name and individual units called slots. It has a homogeneous structure.

The slot value can be the name of another frame. Frames are networked. Frame properties are inherited from top to bottom, that is, from upstream to downstream frames. An empty frame is called a proto frame, and a filled one is called an exo frame. The role of the proto frame as a shell in the exo frame is important. This shell allows you to carry out an internal interpretation procedure, thanks to which the data in the system memory is not faceless, but has a certain meaning known to the system.

A slot can contain not only a specific value, but also the name of a procedure that allows it to be calculated according to a given algorithm, as well as one or more heuristics that are used to determine this value. A slot can contain not one, but several values. Sometimes this slot includes a component called a facet that defines a range or a list of its possible values. The facet indicates the boundary values of the slot placeholder. In addition to a specific value, a slot can store procedures and rules that are called when this value needs to be calculated. Among them, there are demon procedures and servant procedures. The first ones start automatically when a certain condition is met, and the second ones are activated only in a special way.

A collection of frames that models a subject area represents a hierarchical structure into which frames are collected using generic relationships. At the top of the hierarchy is the frame that contains the most general information that is true for all other frames. Frames have the ability to inherit the values of the characteristics of their parents at a higher level of the hierarchy.

These values can be passed by default to frames that are below them in the hierarchy, but if the latter contain their own values of these characteristics, then they are accepted as true ones. This circumstance makes it possible to easily take into account various kinds of exceptions in frame systems. A distinction is made between static and dynamic frame systems. In systems of the first type, frames cannot be changed in the process of solving a problem, while in systems of the second type, this is permissible.

Each frame corresponds to some subject area object. Slots contain data describing this object. The slots contain the values of the attributes of the objects. A frame can be represented as a list of properties, and if using database tools, then as a record. In complex semantic networks, which include many concepts, the process of updating nodes and controlling the connections between them becomes difficult. At the same time, the number of mediated generic relations between concepts increases sharply. A frame is a data structure that represents a stereotyped situation. Several types of information are attached to each frame. At each node, concepts are defined by a set of attributes and their values, which are contained in the frame's slots.

Framework analysis is used to analyze how people understand situations and events. The method helps to select certain aspects of reality and make them more visible in the communicative text, popularizing a certain interpretation of the problem, interpretation of its causes, moral assessment and possible solution. The researcher examines the text to identify the frames. The framework is considered as a scheme for information processing. They are embodied in keywords, metaphors, concepts, symbols and visuals.

The framework analysis methodology includes logic and framing tools. Logic tools provide an explanation or reason for a main position, its consequences and adherence to principles. Concepts such as "visibility", "formatting" and "importance" facilitate analysis. Working with different systemic modifications of information has created a certain hierarchy of predicate logics. At the top is higher-order logic. This form of predicate logic differs from first-order logic in additional predicates and richer semantics. Higher-order logics with their standard semantics are more expressive, but their model-theoretical properties are more difficult to apply compared to first-order logic.

The difference is due to the fact that first-order logic only quantifies variables. Second-order logic allows for the quantification of predicates and function symbols over sets. Third-order logic uses and quantifies predicates over set predicates. Higher order logic includes lower order logic. It allows statements with predicates (over sets) of lower nesting depth.

Descriptive logic [developed a knowledge representation language that allows describing the concepts of the subject area in an unambiguous, formalized form, organized by the type of languages of mathematical logic. These logics combine rich expressiveness and good computational properties. Among them are the solvability and low computational complexity of the main logical problems. Descriptive logicians operate with the concepts of "endpoint" and "role", corresponding in other sections of mathematical logic to the concepts of "one-place predicate" (or set, class) and "two-place predicate" (binary relation).

Once the ontology is built, the question arises of how it is possible to extract the knowledge resulting from the knowledge contained in the ontology, whether it can be done programmatically and what are the corresponding algorithms. These questions are solved theoretically in descriptive logic. In practice, many software systems (reasoning mechanisms) have been implemented that allow automating the derivation of knowledge from ontologies and performing other operations with ontologies. To formulate the syntax of any descriptive logic, it is necessary to specify non-empty sets of atomic concepts and atomic roles, from which expressions of the language of this logic will be built.

Concrete logic is characterized by a set of constructors and an inductive rule, with the help of which the composite concepts of a given logic are built from atomic concepts and atomic roles using these constructors. The semantics of description logics is set by interpreting its atomic concepts as sets of objects selected from a certain fixed set of atomic roles (binary relations on a domain).

2.17 Automated processing of information semantics

Ontology is an important element of modern information technologies. They allow for automated processing of the semantics of information provided via the Internet for the purpose of its effective use (presentation, transformation and search). The principle of processing Internet data is focused not on the comprehension of information by a person, but on the automated interpretation and processing of information.

Ontology is intelligent tools for finding resources on the web with new methods for representing and processing knowledge and queries. They accurately and effectively describe the semantics of data for a certain subject area and solve the problem of incompatibility and inconsistency of concepts. Ontology is their own means of logical inference, corresponding to the tasks of semantic information processing.

Thanks to ontology, when accessing a search engine, the user has the opportunity to receive in response resources that are semantically relevant to the query. Therefore, ontology is become widespread in solving problems of knowledge representation and knowledge engineering, semantic integration of information resources, information retrieval.

Ontology is viewed as a formal specification of a shared conceptualization that takes place in a certain domain context. Conceptualization includes the collection of concepts and information related to concepts. These are properties, relationships, constraints, axioms and assertions about concepts that are necessary for describing and solving problems in a chosen subject area. Informally ontology consists of terms and rules for the use of these terms, limiting their meanings within a specific area. At the formal level, ontology is a system consisting of a set of concepts and a set of statements about these concepts, on the basis of which classes, objects, relations, functions and theories can be built.

Since there may be different understandings of the same terms in each area ontology defines an agreement on the meaning of terms and is an intermediary between a human and a machine-oriented level of information representation. It exists within the framework of agreements between users of some information system. Ontological modeling answers the question of how to describe the domain and corresponding type dictionaries in a declarative, reusable manner. And also how to restrict the use of this data, assuming an understanding of what can be inferred from this description.

Special cases of ontology are a dictionary and a thesaurus, in which the number of relations between terms is limited. Ontology can be used as a component of knowledge bases, object schemas in object-oriented systems, conceptual database schema, structured glossary of interacting communities, a dictionary for communication between agents, class definitions for software systems. They allow the corresponding software tools (intelligent agents) to automatically determine the meaning of the terms used in the description of resources and compare it with the meaning of the task at hand.

Ontology can be multiple composite. They differ in their representations of the context of the same domain. They can also identify abstract levels of ontology. Be a level above other ontology. Several levels of abstraction can be identified, at each of which ontology can be defined.

Thus, in the field of each scientific discipline, ontology can be defined. At a higher level, one can describe the ontology of scientific fields located at the junction of separate scientific disciplines. Let us put the ontology of a scientific discipline in general even higher. The next level of abstraction will be general categories of knowledge structures. Generalization leads to the need to distinguish the types of ontology in order to organize them into ontology libraries.

The key point in ontology design is the choice of an appropriate ontology specification language. The purpose of the language is to create the ability to indicate additional machine-interpreted semantics of resources, to make the machine representation of data more similar to the state of affairs, to significantly increase the expressive capabilities of conceptual modeling of loosely structured data. The difference between the traditional and Web-languages of the specification of ontology lies in the expressive possibilities of describing the domain and some of the possibilities of the inference engine for these languages.

Typical language primitives additionally include constructs for aggregation, multiple class hierarchies, inference rules, and axioms; various forms of modularization for recording ontology and relationships between them; the possibility of meta description of ontology. There are many semantic data description tools, many of which are considered expressive enough for semantic data modeling tasks.

The following processes are important in the life cycle of ontology creation: project management, development itself, and development support. Project management procedures include planning, control and quality assurance. Planning determines what tasks need to be completed, how they are organized, how much time and what resources are needed to complete them. Monitoring ensures that scheduled tasks are completed and exactly as intended. Quality assurance is needed to ensure that the components and the product as a whole are at the specified level. Development includes specification, conceptualization, formalization, and implementation. First, a glossary of terms is built, which includes all terms (concepts and their instances, attributes, actions) that are important for the subject area, and their natural language descriptions.

When a glossary of terms reaches a significant amount, concept classification trees are built. This is how the main taxonomies of the domain are identified, and each taxonomy creates ontology. The next step is to build binary relationship diagrams. Diagrams can serve as a source material for the integration of different ontology. Then a dictionary of concepts is built, containing all the concepts of the domain, instances of such concepts, attributes of the instances of concepts, relations, the source of which is the concept, as well as optionally synonyms and acronyms of the concept.

A table of binary relations is constructed for each relation, the initial concept of which is contained in the classification tree. For each relationship, its name, names of the source concept and target concept, inverse relationship and characteristics are recorded. It also builds an instance attribute table for each instance from the concept dictionary. The main characteristics are the attribute name, value type unit of measure, precision, range, default value, attributes, formula or rule for displaying an attribute.

A class attribute table for each class is created from a vocabulary of concepts with similar characteristics and a logical axiom table that defines concepts in terms of true logical expressions. The definition of each axiom includes its name, natural language description, the concept to which the axiom refers, the attributes used in the axiom, a logical expression that formally describes the axiom. A table of constants is built, where for each constant its name, natural language description, value type, value itself, unit of measurement, attributes that can be displayed using this constant, as well as a formula table for each formula included in the instance attribute table are indicated. Each table, in addition to the formula, must specify its name, the attribute displayed using this formula, natural language description, accuracy, restrictions under which it is possible to use the formula.

Attribute classification trees are created that graphically show the corresponding attributes and constants used to display the value of the root attribute and the formulas used to do so. Trees are used to verify that the attributes represented in the formula have descriptions and that none of the attributes are missing. An instance table is built for each entry into the concept dictionary. The name of the instance, its attributes and their values are specified.

Domain ontology are used in the construction of search engines, knowledge representation systems, knowledge engineering, and in solving problems of semantic integration of information resources. Ontology is understood as a formal specification of conceptualization that takes place in a certain context of the subject area. The main relation taken into account when constructing ontology is a generic relation between concepts. This is a hyponym-hyperonym relationship on the basis of which a taxonomy of concepts is formed. The representation of a set of concepts of the subject area and their relations is realized in ontological systems based on the model of the semantic network of frames.

Network nodes represent individual concepts of the domain, arcs represent relationships between concepts. A separate concept in this model is represented by a frame, the slots of which contain the attributes of the concept. Derived child concepts inherit the attributes of the base parent concepts. At the stage of defining ontology concepts, their attributes are usually given the name and type of the attribute. These attributes receive specific values when they are created based on the concepts of the ontology of instances (objects). The operations of creating instances of concepts are supported by most ontological systems. Moreover, the instances often correspond to the concepts of the lower levels of the ontological hierarchy.

Ontology represents a hierarchy of concepts that characterize the objective world, the objects of which correspond mainly to the concepts of the lower levels of the ontology, and its intermediate and upper levels are, as a rule, abstractions of varying degrees of generalization. Existing systems built on the basis of ontologies are designed to work with the ontology of software agents that process certain information requests. One of the promising directions in the development of ontological systems is the construction of systems that use ontological systematization as a tool for classifying objects in the domain with which users work, and as a means for organizing semantically oriented user access to these objects.

Potential areas of productive application of this approach include the work of personal computer users with files and documents. Traditional file access is based on the user's selection of folders and files in a hierarchical file system. In this case, the access tool is a program that implements the functions of a file manager. As the number of files grows and the structure of the file system becomes more complex, finding the desired document and file becomes more and more difficult for users. The solution to the problem can be the organization of access through semantically oriented interfaces, implemented on the basis of domain ontology.

A document can be found and selected based on its own semantic features, regardless of its physical location on any disk or in any folder. When implementing these systems, it is required to build ontology of the subject area and provide objects of the subject area, files and documents with semantic annotations, on the basis of which access to the objects will be carried out.

Annotated resources are included in the ontological system as objects of ontology instances. On the basis of such a system, navigation through the collection of resources available to users can be carried out by moving through the levels of a hierarchical menu, the items of which correspond to the concepts of the subject area of different levels of generalization.

The selection of objects available to the user can be based on the processing of queries that specify templates and restrictions for the attributes of the resources of interest to the user. As a result, an ontological information system can combine the functions of a navigation system and a search system.

When creating a modern integrated automated production, the development of an automated information system comes to the fore as the basis for most of the tasks that arise at different stages of design, creation and operation of products. The properties of production systems coincide with the properties of complex systems: uniqueness, weak structured composite character, heterogeneity of subsystems and elements that make up the system, etc., therefore, an information system can be based on knowledge and, in addition to the data itself, should include knowledge management tools, modeling and assessment of situations, inference and assessment of decision making. The model of a knowledge-based system is based on a domain ontology, the task of which is to extract and concentrate knowledge and its detailed formalization using a conceptual system.

Information in the system should be presented at different levels of abstraction and with varying degrees of detail. For complex systems, which include production systems, there are several models for calculating their parameters, depending on the purpose of the study. First, as a rule, an aggregated calculation is performed to determine the structural parameters or a general scheme is outlined to determine the dynamics of the system.

Then, within the framework of the decisions made, a more accurate calculation is performed. This process of detailing can be repeated several times depending on the problem to be solved, and at each stage the search for the most rational solution is carried out. The solution found at one stage, when returned to a higher level, may not satisfy the developer. In this case, additional conditions are developed for the problem to be solved at a lower level.

The scheme for developing the parameters of a complex system using several models of the system at different levels of detail with feedback allows for movement both inward and upward, depending on the degree of detail of the system. It becomes realistically feasible only on the basis of a unified knowledge base. The upper levels are characterized by management tasks. Organizational tasks are characteristic of the middle levels. For the lower levels, design tasks are relevant. All these tasks are interconnected, and the division of production tasks into separate types is conditional.

Another important requirement for the subject ontology under consideration is the creation of a basis for the analysis and synthesis of a production system that are interconnected. So, in the process of technological preparation of production, the technologist must go through a number of stages in describing the actions that must be performed in order for the finished product to meet the high requirements of modern quality standards. It is necessary to build a chain of workshops, sections through which the part passes during the manufacturing process, indicating the types of work. The choice of material, assortment, from which the part will be made is important; calculation of workpiece parameters, dimensions, weight, consumption rates; preliminary assignment of auxiliary materials required during processing with indication of consumption rates. And also the design of single, group, typical technical processes.

It is required to calculate the time norms for transitions, additional techniques, operations for the technological process required for processing a part, depending on the equipment, tooling, auxiliary materials, calculated modes and other parameters that may affect the final result selected in the technological process. Relevant is the receipt of various summary sheets on the composition of products, a list of products, a list of technological processes, in which it is required to display any necessary technological information.

The ontology of the area under consideration should have a hierarchical structure. Conceptual terminology should include only terms that denote categories in relation to domain terms. Any concept denoted by the term of subject ontology, when generalized, always falls under one or another category of metaontology. The scope of a concept denoted by the term subject ontology is included in the scope of one or more concepts of metaontology. The number of conceptual terms should be sufficient to describe the subject area, but should not exceed the number necessary to avoid duplication. This can complicate the system and create situations that are not resolvable from a logical point of view during interpretation and program processing. Metaontology should be logically consistent and be the backbone of the entire ontology. Its structure determines the structure of the subject ontology. On its basis, an algorithm for checking the integrity of the system is built. Conceptual terminology should be expanded without drastically changing the structure and content of the software.

The structure of ontology is determined by the structure of a conceptual ontology. Each term of a subject ontology denoting a particular concept is necessarily associated with terms of conceptual terminology denoting categorical concepts. The subject ontology includes conceptual terms, the structure of which is formed by the theoretical concepts of the subject area. It is presented in terms of conceptual terminology. When adding new elements to the conceptual terminology, the existing structure of the subject terminology should not be disturbed. Only add-ons are possible.

An important component of subject ontology is the set of relationships between concepts. The hierarchical structure of ontology can formally be represented in the form of a directed graph, in which the vertices are the terms and concepts of the subject area, as well as the connections between them. These are associative and logical connections that reflect the relationship between objects of the subject ontology. Among them: system – element, genus – species, object, property.

When implementing ontology, a knowledge base is created in the form of an entity and relations between them and a complex of programs designed for knowledge processing. These are interpretation functions defined on the entities and relationships of the ontology. The knowledge processing system can represent a set of modules created by different programmers in accordance with the tasks assigned to them by specialists working in the subject area.

The knowledge base processing subsystem is based on the knowledge base and the capabilities that can be implemented in it. They depend on the structure and completeness of the base. The knowledge base is being created taking into account its future use. It is the core of the system. It determines its capabilities.

The knowledge processing subsystem should be based on the principles of formal logic. The construction of ontology is based on theoretical knowledge, which, from a logical point of view, is a system of interrelated concepts and statements in the subject area under consideration. They are linked in accordance with the concepts. The logical concepts are the main ones. The forms in which knowledge is recorded, such as "concept", "statement", "reasoning", "inference", are already contained in some formalized form in the knowledge base. They can be obtained algorithmically based on this base.

The domain ontology can serve as a basis for connecting to it various models designed to optimize various parameters of production systems when solving organizational problems, management and design problems. The same objects of the subject ontology can be considered from different points of view due to their inclusion in different conceptual constructions. This property of the information system allows you to establish links between different subject areas, which is important for complex systems.

2.18 Engineering and Industrial Internet

The Industrial Internet involves digital support of the product life cycle, including production, logistics, and after-sales service. Creating an industrial Internet system is an expensive project, since it is necessary to purchase all the necessary components for unmanned production, first of all, robotic complexes, as well as integrate physical components with cybernetic components of the technological process. A large amount of information circulates in a feedback mode and requires the creation of peripherals in the form of sensors, sensors, cameras, as well as a data center in the form of a server. Intermediate components in the form of digital controllers also play an important role. Data on the state of technological processes are displayed on the control of the operator, where the parameters of the subsystems of the technical complex are reflected on the digital display.

Programs have been developed for the practical creation of industrial Internet systems. In Germany, this program is being implemented under the name "Industry 4.0". It is proposed to create a hybrid reality based on communication, exchange and sharing of data, to focus on the consequences and possibilities of the hybridization process. The concepts of mixed reality (augmented reality and augmented virtual) have been put into circulation. There is a search for modifications to the Internet of things. digital platforms based on complementary realities. One such platform has become an immersive virtual environment.

Augmented reality allows you to enter any sensory data into the field of perception in order to supplement information about the environment and improve data perception. The worker can receive instructions on what to do when he looks at the object through the augmented reality AR glasses.

One of the technologies was the overlay of digital data on the image of real objects. The hybridization of information and physical technologies and processes has created the space of the Internet of things (devices). The generalization of this reality made it possible to formulate the concept of a cyber-physical system. It represents the information technology concept of integrating computational processes into physical processes. Sensors, equipment, information systems are connected throughout the process of creating value that goes beyond the boundaries of a single enterprise. As a result, production management, marketing, and logistics turned out to be integrated. At the level of technical devices, cyber-physical systems are represented by robots, intelligent buildings, medical implants, drones, self-driving cars, TVs.

Systems interact with each other using standard Internet protocols to predict, self-adjust and adapt to changes. Within an automated production line, devices (Internet of things) interact with a computer program coordinating the process of creating value through special tags. The computer program that recognizes the marks independently decides on the application of the operation to the thing (semi-finished product) located on the Internet line. Devices to maintain constant contact with the computer technology program send certain sensory data in the form of digital characteristics, such as temperature, humidity. They share an ID on a reciprocal basis. That is why internet access is so important.

In connection with the transition to network technologies for organizing processes, the management of goals is being transformed. SMART technologies, which involve setting working goals, have become a priority. They are analyzed according to the criteria of specificity, measurability, achievability, significance, temporality (limited time). The goal in this sense allows you to see the result.

Intelligent machines are connected in a network. It is a combination of industry and information technology. Smart machines communicate with each other and with people. An important role is played by the ability of hybrid systems to implement situational understanding of tasks. Global networks unite smart machines, warehouse systems, equipment. They provide horizontal and vertical integration of production systems. It is the integration of digital network elements from start to finish.

Hybrid reality in technical systems is synchronous with hybrid reality in the form of human thinking and cognition functions imitated by artificial intelligence. Cognitive psychology and cognitive logic are considered in the categories of emotional thinking, the theory of speech acts represented by frames, scenarios. These are not normative provisions of psychology and logic, but social everyday patterns in the form of mental structures. Everyday life is updated by means of the language of cognitive linguistics. In this context, it is important not to teach people how to properly build emotional thinking, but to study and imitate it in its natural functioning in a cultural environment, for example, in a cafe, in front of a laptop and computer monitor. As a result, the task of creating a robot of a waiter, a robot of a consultant, a robot of a social worker is achievable.

The shift in emphasis to the possibilities of the fourth industrial revolution has updated the innovation innovation methodology. One of the solutions was proposed by G. Itskowitz in the form of a triple helix model. This model involves the conjugation of three institutional areas related to science (scientists), the state, and industrial companies. A modification of the technological platform based on the development of the methodology of institutionalism is proposed.

In the conditions of adaptation of Belarusian industrial companies to the new content of globalization, their institutional resources represented by economic networks, organizational practices, marketing strategies, logistics, and corporate communications play an important role. There has been a convergence of advertising and media communication. The e-commerce sector plays an important role in the activities of a number of Belarusian industrial companies associated with the consumer goods market. There has been a convergence of industrial and trading companies, resulting in a well-developed trading network within Belarus and the Russian Federation. Created through advertising and PR technologies, effective mechanisms for motivating the consumer and adapting him to consumer demand have increased the capacity of the domestic consumer market.

2.19 Digital technology of System analysis

Systems analysis includes the principles, methods and tools for the study of systems and the analysis of these systems. Any object is considered as a complex of interrelated constituent elements, their properties and processes. Systems analysis is used in the study of artificial systems in which human activities play an important role. System analysis was applied in the theory and practice of management in the development, adoption and substantiation of decisions related to the design, creation and management of complex, multi-level and multi-component artificial systems.

When developing, designing and operating systems, problems arise that relate not only to the properties of their constituent parts, but also to the regularities of the functioning of the system object and ensuring its life cycle. This is a complex of specific management tasks that are solved using the methods of system analysis. Systems analysis belongs to the field of systems engineering.

System analysis involves a complex of general scientific, special scientific, experimental, statistical, mathematical methods. The theoretical and methodological basis of the analysis is the systems approach and general systems theory. Methods of mathematical logic, mathematical statistics, algorithm theory, game theory, situation theory, information theory, heuristic programming, and simulation are also used.

Systems analysis involves the use of rigorous formalized methods and procedures and non-formalized tools and research methods. Systems research is integrated with cybernetics, operations research, decision theory, expert analysis, simulation modeling, situational management, structural-linguistic modeling.

The use of computers as a tool for solving complex problems made it possible to move from the construction of theoretical models of systems to their practical application. System analysis is closely related to target-oriented management methods. There are schools of systems analysis that apply systems theory to the areas of strategic planning and enterprise management, project management of technical complexes and decision-making on certain types of activities in the event of various problem situations in the process of functioning of socio-economic and technical objects. In 1972, the International Institute for Applied Systems Analysis was established.

The predecessor of the school of systems analysis was A.A. Bogdanov. He called the concept of general organizational science tectology. The concept states that existing objects and processes have a certain level of organization, which is the higher, the more the properties of the whole differ from the simple sum of the properties of the component elements. The analysis of the properties of the whole and its parts was laid down as the main characteristic of the concept of a system. A.A. Bogdanov studied not only the static state of structures, but also the dynamic behavior of objects, the development of an organization. He emphasized the importance of feedbacks, pointed out the need to take into account the organization's own goals, noted the role of open systems. He paid particular attention to the role of modeling and mathematical analysis as potential methods for solving problems of organization theory.

System analysis is designed to research and design large-scale systems, to manage them in conditions of incompleteness of information, limited resources and lack of time. Such systems are characterized by a significant number of elements with the same type of multilevel connections. These are spatially distributed systems of a high degree of complexity. Their constituent parts are complex structures. Additional features of the systems are large dimensions; complex hierarchical structure; circulation in the system of large information, energy and material flows; high level of uncertainty in the description of the system.

Complex systems are distinguished by multidimensionality, heterogeneity of structure, diversity of the nature of elements and connections, organizational resistance and sensitivity to influences, asymmetry of the potential for the implementation of functional and dysfunctional changes.

A complex system has properties that none of its constituent elements possesses. It functions under conditions of uncertainty and the impact of the environment on it, which determines the random nature of changes in its indicators. She makes a purposeful choice of her behavior.

The methods and procedures of system analysis involve identifying goals, proposing alternative solutions to problems, identifying the scale of uncertainty for each of the options and comparing options according to performance criteria, as well as related organizational tasks.

System analysis involves studying a problem situation, finding out its causes, developing options for its elimination, making a decision and organizing the further functioning of the system. The initial stage of a systemic study is the study of the object of the system analysis being carried out with its subsequent formalization. On the one hand, it is necessary to formalize the object of systemic research, on the other hand, the process of studying the system, the process of formulating and solving a problem, is subject to formalization.

The next task of systems analysis is the problem of decision making. The problem of making a decision is associated with the choice of a certain alternative for the development of the system in conditions of various kinds of uncertainty. Uncertainty can be due to the presence of many factors that cannot be accurately estimated. They are formed by the influence of unknown factors on the system, the multicriteria of optimization problems, insufficient certainty of the development goals of the systems, the ambiguity of the system development scenarios, insufficient initial information about the system, the influence of random factors in the course of the dynamic development of the system.

It is important to take into account the uncertainty associated with the subsequent influence of the results of the decision made on the problem situation. Complex systems behave ambiguously. After making a decision, various options for the system's behavior are possible. Evaluation of these options, the likelihood of their occurrence is one of the main tasks of system analysis. In conditions of uncertainty, the choice of an alternative requires an analysis of information. The purpose of the application of system analysis is to increase the degree of validity of the decision made, to expand the set of options, among which a reasoned choice is made. For this, decision-making models, methods for choosing decisions and justifying criteria that characterize the quality of decisions are being developed.

At the stage of development and decision-making, it is important to take into account the interaction of the system with its subsystems, combine the goals of the system with the goals of subsystems, and single out global and secondary goals. An important task is to study the processes of goal formation and study them. It is supposed to develop means of working with goals through the formulation, structuring, or decomposition of target structures, programs and plans, as well as links between them.

System analysis is defined as a methodology for the study of purposeful systems. The formulation of a goal in solving problems of system analysis is one of the key procedures, because the goal is an object that determines the formulation of the problem of systemic research. The subject of system analysis is the organization tasks and management problems in hierarchical systems, the choice of the optimal structure, optimal modes of operation, the optimal organization of interaction between subsystems and elements.

The simulation models are created using computer simulation methods. The study provides a basis for a meaningful understanding of the situations of interaction and the structure of relationships that determine the place of the system under study in the structure of the super system, of which it is a component.

A separate group of tasks of system analysis is made up of the tasks of studying the complex of interactions of the analyzed objects with the external environment. Solving such problems involves drawing a boundary between the system under study and the external environment, which predetermines the maximum depth of influence of the interactions under consideration, which limits the consideration, determination of the real resources of such interaction, consideration of the interactions of the system under study with a higher-level system. Problems of this type are associated with the design of alternatives for the interaction of the system with the external environment, alternatives for the development of the system in time and space.

System analysis is based on a number of applied logical and mathematical disciplines, technical procedures and methods used in management activities, including formalized and non-formalized research tools, as well as on a set of principles and rules that are used as a basis for constructing analysis methods. The methodological basis of systems analysis is a systematic approach. To organize the research process during the system analysis, a set of methods is developed that determine the sequence of the analysis stages and the procedure for their implementation.

Common to all methods of system analysis is the determination of the regularities of the functioning of the system, the formation of variants of the structure of the system of several alternative algorithms that implement the given law of functioning and the choice of the best option, carried out by solving the problems of decomposition, analyzing the system under study and synthesizing the system, and eliminating the problem of practice.

The basis for constructing a methodology for analyzing and synthesizing systems in specific conditions is a list of principles of systems analysis, which represent a generalization of the practice of working with complex systems. The principle of the final goal implies the priority of the final (global) goal, the achievement of which must be subordinated to the activity of the system. The goal is defined as the state of the organization, which must be achieved by a certain point in time, spending certain limited resources on it. The measurement principle states that the quality of the functioning of a system can only be judged in relation to a system of a higher order. To determine the efficiency of the functioning of the system, it should be presented as part of a more general one and the external properties of the system under study should be assessed in relation to the goals and objectives of the supersystem.

The principle of finality shows that the system can reach the required final state, which is independent of time and is determined by the intrinsic characteristics of the system under different initial conditions and in different ways. It is a form of stability with respect to initial and boundary conditions. According to the principle of unity, the system should be considered as a whole, consisting of separate elements interconnected by certain relationships. The principle of connectivity implies a procedure for identifying connections between the elements of the system under consideration and connections with the external environment. In accordance with the principle of modular construction, the modules in the system under study are distinguished and considered as a set of modules.

A module is a group of system elements described only by its input and output. The division of the system into interacting modules depends on the purpose of the study and can have a different basis, including material, functional, algorithmic and informational. The division of the system into modules contributes to a more efficient organization of the analysis and synthesis of systems. It turns out to be possible, abstracting from the minor details, to understand the essence of the basic relationships that exist in the system and determine the outcomes of the system.

In accordance with the principle of hierarchy, a hierarchy of parts of the system under consideration is introduced and ranked, which simplifies the development of the system and establishes the order of consideration of parts. Hierarchy is inherent in all complex systems. The hierarchy in the structures of organizational systems is ambiguously associated with the nature of management in the system, the degree of decentralization of management. In linear hierarchical organizational structures, the idea of complete centralization of management is realized. In complex nonlinear hierarchically structured systems, any degree of decentralization can be implemented.

According to the principle of functionality, structure and functions in the system under study are considered together with the priority of function over structure. The principle states that any structure is closely related to the function of the system and its constituent parts. When giving the system new functions, its structure is revised. The functions performed are processes. They boil down to the analysis of the main flows in the system. These are material flows, flows of energy and information, change of states.

The structure represents many restrictions on flows in space and in time. In organizational systems, the structure is created after defining a set of functions and is implemented in the form of a set of personnel, methods, algorithms, technical devices for various purposes. When new tasks and functions appear, it may be necessary to adjust the structure. After the creation of the system, it is possible to clarify the structure of the system and individual functions within the framework of existing goals and objectives.

The reverse effect of the structure on the functions is possible. Sometimes an organization and its structure are created before the goals and objectives of the system are clarified. This is followed by optimization of the structure. The principle of development implies taking into account the variability of the system, its ability to develop, adapt, expand, replace parts, and accumulate information. The synthesized system is based on the possibility of development, build-up and improvement. Expansion of functions is provided by providing the ability to include new modules that are compatible with existing modules.

When analyzing, the development principle focuses on the need to take into account the prehistory of the development of the system and trends in order to reveal the patterns of its functioning. One way to accommodate this principle is to consider the system in relation to its life cycle. The conventional phases of the life cycle of a system are design, manufacture, commissioning, operation, modernization and termination of operation or use.

The principle of centralization and decentralization implies a combination in complex systems of centralized and decentralized management, which means that the degree of centralization should be minimal, ensuring the achievement of the set goal. The main disadvantage of decentralized management is the increased adaptation time of the system. It affects the functioning of the system in rapidly changing environments.

The uncertainty principle implies taking into account uncertainties and chances in the system and is one of the basic principles of the systems approach. It is believed that one can deal with a system in which the structure, functioning, external influences are not fully defined. Complex open systems do not obey probabilistic laws. When analyzing such systems, probabilistic estimates of forecasted situations can be obtained if these estimates objectively exist. Uncertainties can be taken into account using the guaranteed result method, statistical estimates, clarification of structures, and expansion of the set of goals. These methods are used when uncertainties and chances are not described by the mathematical apparatus of the theory of probability.

If there is information about the probabilistic characteristics of randomness, it is possible to determine the probabilistic characteristics of the outputs in the system. In cases of incomplete knowledge about the subject of research, fuzzy or stochastic input information, research results will be fuzzy or probabilistic, and decisions made on the basis of research may lead to ambiguous consequences. It is necessary to strive to identify and evaluate all possible, seemingly unlikely consequences of decisions made, to provide feedback that will ensure timely disclosure and localization of undesirable developments.

Methods of systems analysis help to formulate a problem, identify goals, propose alternative solutions to problems, identify the extent of uncertainty and compare options according to performance criteria. The problematic situation is revealed as the inconsistency of the existing situation with the required position. To resolve the problem situation, a systemic study is carried out through the methods of decomposition, analysis and synthesis of the system.

At the stage of decomposition of the system, the determination and decomposition of the research goals and the main function of the system is carried out as a limitation of the trajectory in the state space of the system of admissible situations. There is a separation of the system from the environment: the definition of the near and distant environment of the system, the identification and description of influencing factors, as well as the description of development trends, limitations and uncertainties. Compliance with the principles of completeness and simplicity, gradual detailing of the model is required.

The problem of decomposition is that in complex systems there is no one-to-one correspondence between the law of functioning of subsystems and the algorithm that implements it. Therefore, the formation of several variants or one variant is carried out if the system is displayed in the form of a hierarchical structure of the system decomposition. Functional decomposition is based on the analysis of system functions. The division into functional subsystems is based on the generality of functions performed by groups of elements.

In the production life cycle in accordance with ISO 9000, marketing stages are distinguished; design; preparation and development; production; control and testing; packaging and storage; sales and distribution; installation and operation; technical service assistance; recycling.

In the life cycle of management of the organizational and economic system, the stages of planning are distinguished; initiation; coordination; control; regulation. In the life cycle of information systems, its stages correspond to the stages of information processing. This is registration; collection; broadcast; treatment; display; storage; protection; destruction.

At the stage of analyzing the system, which ensures the formation of its detailed representation, a number of methods are used. Cognitive analysis focuses on knowledge in a specific subject area, on the processes of their representation, storage, processing, interpretation and production of new knowledge. It is used when the volume and quality of information does not allow the use of traditional methods, and it is required to extract the knowledge of experts, study the processes of understanding the problem and additional structuring of the data.

Structural analysis allows you to look at an existing system in order to formulate the requirements for the system being created. It includes clarifying the composition and regularities of the functioning of elements, algorithms for the functioning and interactions of subsystems, separating controlled and uncontrolled characteristics, setting the state space and parametric space in which the behavior of the system is specified, analyzing the integrity of the system, and formulating requirements for the system being created.

Morphological analysis allows you to select a group of basic features in the analyzed system. The elements of the structure of the system or the functions of the elements can be taken as signs. For each feature, various alternative options for its implementation are proposed. The proposed options are combined with each other. Acceptable combinations are selected from the set of obtained combinations. The most effective options are selected based on quality criteria.

Efficiency analysis allows evaluating the system in terms of efficiency, resource intensity, and efficiency. It includes the choice of a measurement scale, the formation of performance indicators, justification and formation of performance criteria, direct assessment and analysis of the estimates obtained. Formation of requirements allows you to formulate requirements for the system being created, including the choice of evaluation criteria and restrictions.

At the stage of system synthesis, a model of the required system is developed. This stage includes the choice of a mathematical apparatus corresponding to the study, modeling the system, evaluating the model according to the criteria of adequacy, simplicity, correspondence between accuracy and complexity, balance of errors, multivariance of implementations, modularity of construction. The resulting model is investigated in order to find out the proximity of the result of applying one or another of the options for its implementation to the expected result, the comparative costs of resources for each of the options, the degree of sensitivity of the model to various undesirable external influences.

At the stage of synthesis of alternative structures of the system, the results of structural and morphological analysis are actively used to generate alternatives. At the stage of synthesis of system parameters, qualitative and quantitative characteristics of the functional elements of the structure and a description of their functions are used, as well as the main characteristics of flows entering and leaving the system and the parameters of their interaction with the external environment. Evaluation of alternative variants of the synthesized system is carried out with the involvement of experts, and includes the justification of the scheme for evaluating the options for implementing the system model, conducting an evaluation experiment, processing the evaluation results, analyzing the results, and choosing the best option.

When carrying out a system analysis, a set of procedures is used. They are aimed at formulating a problem situation and determining the general goal of the system, the goals of its individual subsystems. It is also supposed to put forward many alternatives to achieve these goals, which are compared according to the criteria of efficiency, as well as to build a generalized model that reflects the factors and relationships of the real situation that may appear in the process of implementing decisions. As a result, an acceptable way of solving the problem situation, achieving the required target state of the system is selected.

One of the most important characteristics of artificial systems is the goal-oriented nature of their activity. In systems analysis, the goal is understood as a subjective image (abstract model) of a non-existent, but desired state of the system. The goal can be set by the requirements for performance indicators, resource intensity operational efficiency of the system, or for the trajectory of achieving a given result. The discrepancy between the existing and target state of the system under a certain state of the external environment is called a problem situation.

The starting point for defining goals in systems analysis is related to problem formulation. There are a number of features of the associated system analysis tasks. The need for system analysis arises when the customer has already formulated his problem. The problem not only exists, but also requires a solution. But the problem formulated by the customer represents a rough working version. When formulating a problem for the system under consideration, it is necessary to take into account how the solution to this problem will affect the systems with which this system is connected. The planned changes will affect the subsystems that are part of this system, and the supersystem that contains this system.

The starting point for defining goals in systems analysis is related to problem formulation. There are a number of features of the associated system analysis tasks. The need for system analysis arises when the customer has already formulated his problem. The problem not only exists, but also requires a solution. But the problem formulated by the customer represents a rough working version. When formulating a problem for the system under consideration, it is necessary to take into account how the solution to this problem will affect the systems with which this system is connected. The planned changes will affect the subsystems that are part of this system, and the supersystem that contains this system.

The goal is determined after the work has been done to structure the initial problem and the problem situation that needs to be overcome in the course of the system analysis has been formulated. In order to determine the purpose of the system analysis, you should answer the question of what needs to be done to resolve the problem. To formulate a goal means to indicate the direction in which to move in order to solve an existing problem, and to identify paths that lead away from the existing problem situation. The purpose of the research is assumed to be an external factor in relation to the system and becomes an independent object of research.

Ultimate goals characterize a certain result that can be obtained in a given time and space. In this case, the goal can be set in the form of an area of desired values of the system parameters. The ultimate goal can be represented as some point in the state space. Endless goals define the overall direction of action. An infinite goal can be specified as a vector in the state space of the system, for example, in the form of functions of maximizing or minimizing state parameters.

The choice of this or that class of goals depends on the nature of the problem being solved. When defining goals, it is necessary to proceed from the general interests of the system. The formulation of goals can be expressed in both qualitative and quantitative form. In relation to the target parameter, the system can be in modes of functioning and development. In the first case, the system fully satisfies the needs of the external environment and the process of its transition and its individual elements from state to state occurs the constancy of the set goals. In the second case, it is considered that the system at some point in time ceases to meet the needs of the external environment and an adjustment of the previous target settings is required. Targeting is carried out using the method of constructing a tree of goals. The idea of the method was proposed by W. Churchman in the framework of his study of decision-making processes in industry. A complex and global goal is being transferred to a final set of relatively simple subgoals, for the implementation of which specific tasks and procedures for their solution can be defined.

The next stage of the system analysis is the creation of many possible ways to achieve the formulated goal. It is important to generate many alternatives, from which the choice of the best path for the development of the system will be carried out. If the set of alternatives does not include the best of them, then even the most advanced methods of analysis will not help to calculate it. The difficulty of this stage is due to the need to generate a sufficiently complete set of alternatives, including even the most unrealizable ones. The search for alternatives is carried out using methods of collective idea generation. Expert recommendations are used.

2.20 Digital pattern

The central procedure in systems analysis is modeling. This is the process of studying a real system, including the construction of models that reflect the main properties, characteristics, phenomena and processes, the relationship of a real system. The procedure involves formalizing the system under study, building a model of the system, studying its properties and transferring the information obtained to the modeled system. The resulting model is investigated in order to clarify the proximity of the result of applying one or another of the alternative options to the desired result, the degree of sensitivity of the model to unwanted external influences.

Modeling functions are description, explanation and prediction of the behavior of a real system. The purpose of modeling is to find optimal solutions, assess the effectiveness of solutions, and determine the properties of the system. The result of the entire system analysis depends on the quality of the model. The quality of the model is determined by the correspondence of the performed description to those requirements that are imposed on the study, and the correspondence of the results obtained using the model to the course of the observed process or phenomenon.

Modeling is understood as a process of adequate display of the essential aspects of the object under study with the accuracy that is necessary for practical needs. Modeling can also be called a special form of mediation, the basis of which is a formalized approach to the study of a complex system. The theoretical basis for modeling is the theory of similarity. Similarity reflects a one-to-one correspondence between two objects, in which the functions of transition from the parameters of one object to the parameters of another object are known.

The mathematical descriptions of these objects can be converted into identical descriptions. The theory of similarity makes it possible to establish the presence of similarity or allows you to develop a way to obtain it. As a result, modeling is the process of representing the research object with an adequate (similar) model and conducting experiments with the model to obtain information about the research object.

The model is analogous to the object. This analogue is similar to the prototype and serves as a means of describing, explaining, predicting the behavior of the prototype in accordance with the objectives of the study. An important quality of the model is that it gives a simplified image that reflects the properties of the prototype that are essential for research. It is a physical or informational object that replaces the original. The model reflects only some aspects of the original. In order to gain more knowledge about the original, a set of models is used. The complexity of modeling as a process lies in the appropriate choice of such a set of models that replace a real device or object.

Complex systems are characterized by functions performed by processes, structure and behavior over time. For adequate modeling of these aspects in complex systems, functional, informational and behavioral models are distinguished. The functional model of the system describes the set of functions performed by the system. It characterizes the morphology of the system and its construction, the composition of functional subsystems, their interconnection. The information model of the system reflects the relationships between the elements of the system in the form of data structures of composition and relationships. The behavioral model of the system describes information processes and the dynamics of their functioning. It includes such categories as system state, event, transition from one state to another, transition conditions, sequence of events.

The level of structural or simulation modeling of complex systems using their algorithmic models (modeling algorithms) is in demand. It involves the use of specialized modeling languages, set theories, algorithms, formal grammars, graphs, queuing and statistical modeling. At the level of logical modeling of functional circuits of elements and nodes of complex systems, models are represented in the form of equations of direct connections (logical equations).

They are constructed using the apparatus of two-valued or multivalued algebra of logic. At the level of quantitative modeling and analysis of schematic diagrams of elements of complex systems, the models are presented in the form of systems of nonlinear algebraic, integral-differential equations. They are investigated by the methods of functional analysis, the theory of differential equations, and mathematical statistics.

The set of object models at the structural, logical and quantitative levels of modeling represents a hierarchical system. It reflects the interconnection of various aspects of the object's description and provides the systemic connectivity of its elements and properties at all stages of the design process. When moving to a higher level of abstraction, the data on the modeled object is folded. When moving to a more detailed level of description, a sweep of this data is given. At each of the levels of modeling, descriptions of the object are possible with varying degrees of completeness and generalization. This is due to the fact that there are different degrees of detailing of structural, logical and quantitative properties and relationships.

The abstract level of the description of the system is the black box model. The methodology for using the black box arose from the lack of information about the internal structure of the system. Therefore, the system is depicted as an opaque black box. It reflects the properties of its integrity and isolation from the environment. The system symbolized by the black box is not isolated. It is connected with the external environment through a set of inputs and outputs. The outputs of the black box model describe the outputs of the system. Inputs describe its resources and limitations. At the same time, we do not know anything and cannot know about the internal content of the system.

The black box model does not consider the internals of the system. To detail the description of the system, it is required to create a model of the composition of the system. The model describes the main components of the system. For a deeper study of systems, it is necessary to establish in the model the composition of the communication system between its constituent elements and subsystems. We left only the general for each communication scheme. A meaningful graph theory was built, which received practical applications.

As a result, a number of research situations were formulated in the modeling methodology. The system is simple and transparent enough that it can be examined and understood by observing or interviewing people working with the system. Directly based on the results of studying the system, you can construct its model. If the structure of the system is obvious, but the methods of description are not clear, you can use the similarity of the system under study with another system, the description of which is known.

The structure of the system is unknown, but it can be determined by analyzing data on the functioning of the system. A hypothesis about the structure will be obtained, which then needs to be verified experimentally. Analysis of data on system performance does not allow us to determine the effect of individual variables on the performance of the system. It becomes necessary to conduct an experiment in order to identify the relevant factors and their influence on the operation of the system.

The possibility of carrying out an experiment on the system is assumed. Sufficient descriptive information about the system is not available. Experimenting on the system is not allowed. A sufficiently detailed model of artificial reality can be built, which is used to accumulate statistics on the possible functioning of the system by means of statistical tests of hypotheses about the real world.

Deterministic modeling displays processes in which the absence of random influences is assumed. Stochastic modeling takes into account probabilistic processes and events. Static modeling is used to describe the state of an object at a fixed point in time. Dynamic modeling is used to study an object over time.

Mental modeling is used when models are not realizable in a given time interval or there are no conditions for their physical creation. With visual modeling, models are created that reflect the phenomena and processes occurring in the object. Diagrams and diagrams are examples of models. The hypothetical modeling is based on the hypothesis about the regularities of the process in a real object. It reflects the level of knowledge of the researcher about the object and is based on the cause-and-effect relationships between the input and output of the object under study. This type of modeling is used when knowledge about the object is not enough to build formal models.

Analog modeling is based on the application of analogies at different levels. For fairly simple objects, the highest level is complete analogy. As the system becomes more complex, analogies of subsequent levels are used, when the analog model displays several sides of the object's functioning. Prototyping is used when the processes occurring in a real object cannot be physically modeled or may precede other types of modeling. The construction of mental models is based on analogies based on causal relationships between phenomena and processes in an object.

Symbolic modeling represents the artificial process of creating a logical object that replaces the real one and expresses its basic properties using a certain system of signs and symbols of a certain language. The language modeling is based on the thesaurus, which is formed from a set of concepts of the studied subject area, and this set must be fixed. A thesaurus is understood as a dictionary that reflects connections between words or other elements of a given language, designed to search for words by their meaning.

If you introduce a conventional designation of individual concepts, signs, as well as certain operations between these signs, then you can implement sign modeling and use signs to compose separate chains of words and sentences. Using the operations of union, intersection and addition of set theory, it is possible to describe a real object in separate symbols.

Mathematical modeling reflects the process of establishing correspondence to a given real object of a certain mathematical object. To study the characteristics of any system by mathematical methods, formalization of this process should be carried out a mathematical model should be built.

The mathematical description of the model begins when a system of axioms is formulated that describes not only the object itself, but some algebra of the set of rules that determine the permissible operations on the object. The type of mathematical model depends both on the nature of the real object and on the tasks of studying the object, on the required reliability and accuracy of solving the problem. A mathematical model describes a real object with some degree of approximation.

The model can be represented as a collection of inputs, outputs, state variables and global equations of the system. In analytical form, models represent explicit expressions for output parameters as functions of inputs and state variables. In analytical modeling, only the functional aspect of the system is modeled.

In this case, the global equations of the system, which describe the law (algorithm) of its functioning, are written in the form of some analytical relations (algebraic, integro-differential, finite-difference) or logical conditions.

The analytical model is investigated by several methods. An analytical method, when they seek to obtain dependencies connecting the required characteristics with the initial conditions, parameters and state variables of the system. By the numerical method, when they seek to obtain numerical results for specific initial data. A qualitative method can be used to find some properties of the solution and evaluate the stability of the solution.

To implement a computer mathematical model, it is necessary to build an appropriate modeling algorithm. We need to record the relationships between the model and the selected numerical solution method in the form of an algorithm. Among algorithmic models, an important class is made up of simulation models designed to simulate physical or information processes under various external influences. Simulation of processes is called simulation.

In this simulation, the algorithm of the system's functioning in time is reproduced. The elementary phenomena that make up the process are simulated, while maintaining their logical structure and sequence of flow. This makes it possible to obtain information about the states of the process at certain points in time using the initial data. They provide an opportunity to evaluate the characteristics of the system. The main advantage of simulation is the ability to solve more complex problems. Simulation models make it possible to take into account such factors as the presence of discrete and continuous elements, nonlinear characteristics of system elements, and numerous random influences.

They often create difficulties in analytical research. In simulation, a distinction is made between the Monte Carlo statistical test method and the statistical modeling method. The numerical method is used to simulate random variables and functions, the probabilistic characteristics of which coincide with the solutions of analytical problems. It consists in multiple reproduction of processes that are realizations of random variables and functions, followed by information processing by methods of mathematical statistics.

The simulation method is used to assess the options for the structure of the system, the effectiveness of various algorithms for controlling the system, the effect of changing various parameters of the system. Simulation modeling can be used as the basis for structural, algorithmic and parametric synthesis of systems, when it is required to create a system with given characteristics under certain constraints.

Combined analytical and simulation modeling allows you to combine the advantages of analytical and simulation modeling. When constructing combined models, a preliminary decomposition of the object's functioning process into its constituent sub-processes is performed. Analytical models are used. Simulation models are built for the subprocesses. This approach makes it possible to cover qualitatively new classes of systems that cannot be investigated using analytical or simulation modeling separately.

Information models are based on the reflection of some information management processes, which makes it possible to assess the behavior of a real object. To build a model, it is necessary to select the investigated function of a real object. Try to formalize this function in the form of some telecom operators between input and output. Reproduce this function on a simulation model in another mathematical language and another physical implementation of the process. Structural modeling is based on specific features of structures that are used as a means of studying systems or serve to develop specific approaches to modeling using other methods of formalized representation of systems (set-theoretic, linguistic, cybernetic). Object-oriented modeling is a development of structural modeling.

Structural modeling of systems analysis includes methods of network modeling; combination of structuring methods with linguistic methods. As well as a structural approach to formalizing the construction and study of hierarchical, matrix structures and arbitrary graphs based on set-theoretic representations and the concept of a nominal scale of measurement theory.

The structure of the model can be applied to both functions and system elements. The structures are called functional and morphological. Object Oriented Modeling combines both types of structures into a class hierarchy that includes both elements and functions.

Situational modeling is based on the model theory of thinking. On its basis, it is possible to describe the main mechanisms for regulating decision-making processes. At the center of the model theory of thinking is the idea of the formation in the structures of the brain of the information model of the object and the external world. This information is perceived by a person on the basis of the knowledge and experience he already has.

Reasonable human behavior is built by forming a target situation and mentally transforming the initial situation into a target situation. The basis for building a model is the description of an object in the form of a set of elements interconnected by certain relationships that reflect the semantics of the subject area. The object model has a multi-level structure and represents an information context against which control processes take place. The richer the information models of the object and the higher the possibility of manipulating it, the better and more diverse the quality of the decisions made during management.

In real modeling, the ability to study the characteristics either on a real object as a whole or on a part of it is used. Research is carried out both on objects operating in normal modes and when organizing special modes to assess the characteristics of interest to the researcher. The values of variables parameters, in a different time scale. Real modeling is the most adequate, but its capabilities are significantly limited.

One of the most common types of real-world modeling is full-scale modeling. It involves conducting research on a real object with the subsequent processing of the experimental results based on the theory of similarity. Full-scale modeling is subdivided into scientific experiment, complex testing and production experiment. A scientific experiment is characterized by the widespread use of automation tools, the use of a variety of information processing tools, the possibility of human intervention in the experiment. In the course of complex tests, general patterns are revealed about the characteristics of the quality and reliability of objects. Modeling is carried out by processing and generalizing information about homogeneous phenomena. It is possible to implement full-scale modeling by generalizing the experience gained during the production process. On the basis of the theory of similarity, statistical material on the production process is processed and its generalized characteristics are obtained.

Physical modeling is carried out on devices that preserve the nature of phenomena and have physical similarity. Some characteristics of the external environment are set, and the behavior of either a real object or its model is investigated under given or artificially created influences of the external environment. Physical simulations can be performed in real and pseudo-real time, or viewed without regard to time.

Before starting the experiment, the model must be tested, which is the last step in model development. The test is carried out to determine the plausibility of the model to ensure that it behaves as intended. There is a qualitative correspondence between the behavior of the modeled system and the model, including the order of their outcomes, as well as behavior and results.

Calibration of the model is the refinement of the coefficients of the model. This is the identification of the coefficients of the relations connecting the exogenous and endogenous variables of the model. Calibration is carried out by comparing the results obtained on models with the results obtained when testing a real system, or with the results of analytical calculations. For this, reference examples and tasks are used. The system model is validated by reference tasks covering all the properties of the model. It is advisable to construct such a set of examples in order to cover only some part of the model dependencies with the help of one example and determine a part of the coefficients. One of the tasks of the test is to test the model for sensitivity. This means how sensitive the model's outcomes are to changes in the input variables.

The tests use statistical methods such as regression, correlation and analysis of variance. Statistical methods can lead to incorrect results if the researcher does not have a clear understanding of the system being modeled and the characteristics of the information used.

To ensure the adequacy of the model, control of dimensions is provided. Only quantities of the same dimension can be compared and added. In extreme situations, the behavior of the model should coincide with the behavior of the system in similar situations. Functions must take on certain values at the boundary. The signs and values of the model variables should not contradict the possible values of the simulated physical quantities.

Since the testing of models of complex systems is associated with significant costs, it is necessary to be extremely strict in the planning of tests. The test results should provide the required level of model adequacy at all stages of its use. With a reasonable choice of test cases and reference problems, this problem is solved with a minimum cost of funds and resources.

2.21 Computing Philosophy

Computing is the science of information processes. These information processes are carried out in the form of calculations and have a technical and technological infrastructure in the form of software and hardware. They are based on specific architectures. In the applied sense, computing is treated as a computing service. It uses computational methods and computational models. These are calculation models with types, calculation models with classes, and typeless calculation models. The basis for reasoning in terms of objects is the lambda calculus and combinatorial logic. The elements of calculations are a one-place function and the operation of applying a function to an argument. The function is primary in relation to the set.

Computing is the subject of computational philosophy. This is a set of concepts based on the idea that any object being studied and constructed is subject to quantitative laws. Philosophy studies the specifics of the existence of computing systems, the ontological status of virtual worlds. The modern philosophical understanding of computing and computing machines is based on the concept of G. Leibniz, according to which reality is described and constructed by means of formal calculus. Each of the elementary units of the natural language is associated with a digital symbol that replaces the natural language term.

It only remained to formulate the general principles of universal symbolism in the form of rules for the use and combination of symbols. This task was carried out by G. Frege and B. Russell, as well as D. Gilbert. Computation has come to be used as a transformation of input signals into output signals, independent of the transformations themselves. Data transformation leads to the emergence of new information.

The work of intelligent technical devices was originally based on the von Neumann architecture. The calculations were carried out according to the pipeline principle. Data was transferred from the processor to memory and vice versa. Calculations were used as a methodology for solving equations, deciphering codes, analyzing data, and managing business processes. Prior to 2001, nine basic information process technologies were used. Since 2001, the number of technologies has increased to 36.

A wide range of computing models has been developed. Computing processes are integrated with hardware components of intelligent systems based on silicon integrated circuit technology. In this part, computing is based on the general theory of connection with its constituent signal theory, noise immunity theory and information theory. Technical information is transmitted via communication channels and displayed after decoding on display screens.

Computational methodology has passed the stage of transition from sequential algorithms to algorithms of parallel computing systems. The main goal of the transformations is the social order for the processing of big data at a higher speed. The evolution of intelligent computing systems is therefore closely related to the synchronous transformation of software and hardware. Special demand has arisen for cognitive computing (computer analytics), as it forms the basis of decision making.

Consolidation of knowledge in the form is carried out in books. But a virtual reader became necessary against the backdrop of an increased amount of knowledge. This determined the interest in semantic networks. Calculation models sensitive to semantic instability began to be developed. In the hardware part, new processors, interfaces and bit buses for connecting internal devices and graphics buses have been developed. The throughput of the system bus has increased. A market for professional graphics stations has formed and the concept of visual computing has been implemented. Software applications that work with text sources (humanitarian computing) are used.

Against the backdrop of a growing variety of basic intelligent computing technologies, computing remains a recipe-based technology. This hinders the development of computational thinking. The task is to find invariants, since they play the role of global constants (building components). The underlying principle is assumed to be an identifier. A value is built for it. Calculation is the process of constructing a value.

Computing develops technologies for the implementation of construction. The relationship between an identifier and its value is parameterized by the environment. The mapping thesis is accepted, for which the domain of definition (domain) and domain of value (range) are known in advance. As a result, the interpretation of the variable has changed. There are two difficulties. One of them is in the field of hardware. It is associated with the development of new architectures. The second difficulty is that new forms of computing must be equipped with suitable software, since new schemes for organizing calculations and new algorithms must be developed.

Autonomous computing involves implementing an approach to creating self-managing systems with minimal human involvement. To do this, you need to create database self-tuning tools. To activate the intelligent system, you will only need to set the parameters. The system itself will select the output for these parameters. As a result, it became possible to build infrastructures that adapt themselves to applications. It is supposed to go beyond the boundaries of the artificial intelligence hypothesis based on rewriting the programs themselves. The goal is an intelligent system that responds to changing conditions.

The evolution of computing is associated not only with silicon integrated circuits, but also with the organization of computing on nanofibers, carbon nanotubes, organic molecules, bio-DNA and quantum entanglement effects. As a result, optical, micro-nanofluid, chaotic calculations are being worked out. Against the background of these new modifications for computing, the functioning of information processes in the human brain remains an actual model.

The result was the creation of a generation of meme computers. These computers are supposed to combine the processing and storage of information in one place in order to avoid its transfer. Thanks to this, the calculations take place in one place. The intellectual system consists of meme elements. The technical basis is special resistors, capacitors and coils. The meme resistor was created in 2008. It changes its resistance depending on the strength of the current that has passed through it in the past. By combining the device meme, you can get a computing machine.

2.22 Logic and computing digital

Logic plays one of the key roles in computer science, since the choice of information description, information units, information structures and information models depends on it. The role of logic in computer science is associated with the identification of unstructured systems, the development of methods for the logical structuring of information descriptions, the construction of their logical structures. This role is also manifested in the application of cognitive factors in analysis systems, formalization of the semantic content of information, transformation of information into information resources, functional use of the logical laws of self-organization.

For informatics, the informative of logical procedures is important, expressing in the transformation of their forms, reducing uncertainty, and obtaining new knowledge. Based on the classification of information systems, logic distinguishes procedural, descriptive, attributive systems, databases, classifiers, and inference systems.

Information units are used in computer science as the basis for logical construction. A logical procedure is relevant as an informational unit of analysis.

Logic is an applied branch of philosophy. In a systemic form, it was presented by Aristotle. In the 17th century, the subject matter of logic was supplemented by the logic of scientific research, in which a special role was assigned to induction and deduction. In the 19th century, the subject matter of formal logic was expanded by J. Boole, O. de Morgan, B. Russell. The foundation of mathematical logic was formed. The logic of syntax was developed. She deals with the quantitative aspects of information presentation and is not interested in the qualitative aspects of information.

One of the key methods of informatics is the formulation and solution of problems through formal, computer languages. For the subject area of interest, a formal language is chosen in which it is possible to describe the class of problems to be solved. After the formalization stage, the possibility of solving a class of problems is studied at the level of a formal language using the methods of mathematics and computer science.

The properties of the language as mathematical objects are investigated. As a result, logical programming, methods of representing knowledge, methods of reasoning about knowledge were developed. The study of the computational complexity of typical problems in formal languages with the semantics of truth problems, the consistency of logical inference of statements in logical formalisms made it possible to outline the limits of applicability of a number of approaches in the field of informatics and gave impetus to the creation of effective methods for solving algorithmically complex problems.

Logic methods are a rich toolkit for computer science. A number of information technologies that have changed the world were created through the use of methods of formal logic. For example, algorithmic results on checking the properties of Boolean formulas and methods for their optimization are the foundation in the development of electronic components, allowing you to create compact and energy-efficient circuits, microprocessors.

The use of first-order logic, as a formalism of queries and data integrity constraints, made it possible to obtain a number of fundamental algorithmic results that determined the development of database technologies and their implementation in the framework of relational algebra. The possibility of evidentiary verification of properties formulated in a number of applied logics opened the way for the verification of programs, communication protocols and provided the basis for the development of critical software systems such as compilers, onboard software, protocols for the interaction of autonomous stations and robotic systems.

The symbiosis of logic and computer science gave methods of automated theorem proving, which are not only applied in the indicated directions, but also offer new tools for educational and research activities for mathematics itself. Reasoning automation traditionally belongs to the field of artificial intelligence, a significant part of research and development is devoted to it.

Modern advances and challenges in automation in areas that were previously available only to humans are leading to the creation of increasingly powerful intelligent systems. Without denying the positive aspects of this process, it should be noted that progress here, too, largely depends on the improvement of the methods of logic. One of the key issues remains the question of combining computations on data of a numerical nature and symbolic nature within the framework of uniform formalisms. Associated with this, among other things, are the problems of constructing formal systems that connect logic and probability.

Algebra of logic (Boolean algebra) is a branch of mathematics that arose in the 19th century thanks to George Boole. The subject of this section is the correct construction of inferences.

This is a sequence of judgments that are proven one from another. Unlike classical mathematics, which operates with variables that can take on an infinite number of values, mathematical logic most often operates with binary variables that can take true or false values. In intelligent systems, two types of logic are most often used: propositional logic and first-order logic.

Propositional logic (zero-order logic) operates with binary statements, which can take the meaning of true or false, from the internal structure, which we abstract from. A propositional formula consists of atoms and logical connectives, including conjunction, disjunction, negation, as well as parentheses that determine the order in which logical connectives are applied.

First-order logic operates on binary statements (predicates) that have one or more arguments. The number of arguments of a predicate is called its arity. The fundamental difference between first-order logic and propositional logic is that a predicate represents a set of instances, which are determined by the values of the arguments. It is necessary to use quantifiers of existence and universality.

The laws and apparatus of the algebra of logic began to be applied in the design of parts of computers, in particular, memory and processor. Algebra of Logic studies methods of determining the truth or falsity of complex logical statements using algebraic methods.

A complex logical statement is described by a function, the result of which can be either true or false. Truth is compared with 1, falsehood - 0. The arguments of functions are simple statements, which can also have only two values - 0 or 1. The algebra of logic is engaged in calculating the result of complex logical statements based on the previously known meanings of simple statements. Boolean algebra formalized the statements of natural language, introduced strict rules for obtaining an unambiguous result. Unions began to be called logical operators. The basic operations are conjunction, disjunction and a negation.

Electronic computers use various devices, the operation of which is described by the algebra of logic. Such devices include groups of switches, triggers, adders. The connection between Boolean algebra and a computer is provided by the number system used in electronic computers. She is binary. Therefore, both numbers and values of logical variables can be stored and converted in computer devices.

Electronic computers use electrical circuits consisting of many switches. One switch can only be in two states - closed and open. In the first case, the current passes, in the second, it does not. It is convenient to describe the operation of such circuits using the algebra of logic. Depending on the position of the switches, you may or may not receive signals at the outputs.

A gate represents a logical element that accepts some binary values and outputs others depending on its implementation. There are gates that implement logical multiplication (conjunction), addition (disjunction), and negation. Triggers and adders, as complex devices, consist of gates. The flip-flop can store one binary bit, due to the fact that it can be in two stable states. Triggers are used in processor registers. Adders are used in the arithmetic logic devices of the processor and perform the summation of binary digits.

G. Frege developed two types of quantifiers. K. Gödel proved two incompleteness theorems, describing the impossibility of combining the set of provable statements with the set of true statements. The thesis was formulated that the proofs of mathematics depend on initial assumptions, and not the fundamental truth from which the answers originate. No set of axioms is capable of proving its consistency.

Classical formal logic began to use the language of equations. Informal logic has shifted to the subject field of rhetoric. Regulatory laws apply to two kinds of logic. The law of identity states that one cannot replace one concept with another concept. The law of consistency states that the same statement cannot be true and false at the same time.

The third law of exclusion states that a statement can be either true or false. Of the principles, the normative role is played by the principle of sufficient justification. It states that such factual and theoretical grounds are sufficient, from which this judgment follows with logical necessity.

Sentential logic (propositional algebra) includes basic operations, which include negation, conjunction, disjunction, implication, and equivalence. After the development of predicate logic under the influence of the works of G. Leibniz and G.Frege, programming languages began to be based on it. Informatics has become in demand in computing as the science of storing, processing and transmitting information. It consists of sections that study algorithmic, software and hardware.

The author of the concept of an algorithm is Aristotle. The theory of algorithms is related to program control. V. M. Glushkov in 1965 defined algorithmic algebra as a modification of algorithmic logics. F. Engeler in 1967 proposed the use of languages with infinitely long formulas to express the infinite variety of possibilities arising from different executions of a computer program. The languages of algorithmic logic were developed by R.W. Floyd (1967), C.A.R. Hoare (1969), A. Salvitsky (1970). They are used as one of the ways to move from specification to algorithm. This is done in the form of reasoning in a logical system with predicates.

Assertions {A} 5 {B} are written in the logic of predicates. The execution of the operator S is preceded by the definition of the initial state of the program A. B is a postcondition state. PreconditionsA are axioms of a logical system and are defined by the constructs of the programming language. The synthesized program is obtained in the form of a statement output in dynamic logic. The result of the program execution satisfies the given postcondition if the task arguments satisfy the given precondition.

The law of the excluded third formulated as the law of complement, in an equivalent formulation, as the law of double negation, states that only the statement P or the inverse statement -iP can be true. Laws deny the existence of a third or other true solution and limit the language's ability to define the process of constructing an algorithm.

A. N. Kolmogorov considered logic as a calculus of problems. He assumed a constructive interpretation of predicate logic. Logical connectives are understood as a means of constructing more complex problem statements from simpler problems. Axioms are understood as problems whose solutions are given. Inference rules are understood as ways of transforming solutions to some problems into solutions to other problems. The solution to the problem proves that the solution meets the requirements.

AA Voronkov defined the conditions under which classical logic can be regarded as constructive. Its completeness is a prerequisite. This means deducibility in logic of either the formula F itself or its negation iF. Examples of classical theories that have a constructive interpretation are elementary geometry and the algebraic theory of real numbers. The complete system of constructive inference rules (logic Q,) allows constructing a proof of the transformation A into B based on the given functions.

Intuitionistic logic has retained the language of predicate calculus and logical connectives of classical logic. The descriptive power of this logic is higher than that of propositional logic (sentence logic). In predicate logic, capital letters denote predicates, not whole statements. A predicate is a mathematical function that maps many subjects to many statements. There are two operations used in predicate logic: universal and existential quantifiers. The peculiarity of quantifiers is that you can write the expression true for all possible variables "x" or at least for one true value. With the introduction of the existential quantifier, predicate logic became a complete system.

Elements of mathematical logic are integrated into logical elements and logical devices of electronic computers, in the basics of algorithms and programming languages, in data retrieval procedures, and logical programming systems. The relevance of logic in computer science is due to the presence of errors in algorithms and programs, as well as the inability of specialists to identify and correct errors in algorithms and programs.

Software testing can reveal the presence of errors in computer programs, but cannot guarantee their absence. The guarantees of the absence of errors in algorithms and programs can only provide proof of their correctness. An algorithm is error-free if it gives correct solutions for all valid data. To overcome these problems, it is important to teach systematic methods of compiling algorithms and programs with a simultaneous analysis of their correctness in the framework of evidence-based programming from the very beginning of learning the basics of algorithms and programming.

The difficulty for professional programmers lies in the fact that they must be able to write not only algorithms and programs without errors, but also at the same time write proofs of the correctness of their algorithms and programs. Weak evidence base leads programmers to write programs with a large number of errors that they can neither identify nor fix. The logical approach to the creation of artificial intelligence systems is aimed at creating expert systems with logical models of knowledge bases using the predicate language. The language and the logical programming system are taken as a basis.

The logical model of knowledge bases allows you to record not only specific information and data in the form of facts, but also generalized information using the rules and procedures of logical inference, including logical rules for defining concepts that express certain knowledge as specific and generalized information. The study of the problems of artificial intelligence in computer science within the framework of a logical approach to the design of knowledge bases and expert systems is aimed at the creation, development and operation of intelligent information systems, including the issues of teaching students, as well as training users and developers of intelligent information systems

Logic programming is based on automatic theorem proving, using inference mechanisms based on given facts and inference rules. The language and logic programming system are based on the predicate calculus language, which is a subset of first-order logic. The main concepts are the concepts of facts and rules of inference, as well as requests for searching and displaying information in knowledge bases.

Facts are described by logical predicates with specific values. Rules are written in the form of inference rules with logical conclusions and a list of logical conditions. A database is an objective form of presentation and organization of a collection of data, systematized in such a way that this data can be found and processed. Databases are used in all areas of activity where accounting and storage of information is important.

There are flat databases in which information is located in a single table. Each record contains the identifier of a specific object and relational databases consisting of several tables. The connection between them is established using the matching values of the fields of the same name.

Relational databases store data as tables of rows and columns. Each table has its own predefined set of named fields. Columns of tables in a relational database can contain scalar data of a fixed type, such as numbers, strings, or dates.

Information search in relational databases is carried out using the query language. It is a universal computer language used to create, search, and modify information in databases. It consists of operators for determining, searching and processing information in databases. Information search operators contain logical search terms, which can be simple or compound terms. Simple conditions are in the form of equalities and inequalities of the type name = value, where name is the name of a column in the table, and value is a specific numeric or symbolic value (depending on the type of the column in the table).

Compound conditions in queries are written using logical connectives expressing logical statements - conditions for searching for information in relational databases. The search terms in queries are fully consistent with the propositional calculus (with equalities) - fully equivalent to the logic of Aristotle's propositions. Knowledge in databases represents specific and generalized information about people, things, events, properties, processes and phenomena of the objective world.

2.23 The semantic logic

Information about things and people, like any information, can be reliable and unreliable. Reliable information is perceived as true, and inaccurate information is perceived as a lie. From a logical point of view, knowledge bases in expert systems represent applied logical theories within the framework of which false and true conclusions can be drawn. Knowledge bases of expert systems become logical models of human experts with reliable and unreliable knowledge. So computer science faced the problem of formalizing ambiguous statements the quality side of information. The problem of the experts' fuzzy reasoning was discovered.

In order to expand the possibilities of informatics in the creation of programs, the semantic logic was updated. By means of it, the relations of language expressions to denoted objects are studied on the basis of languages built for the purposes of logic. This is done through the use of semantic rules in the form of a metalanguage.

G. Frege, A. Tarski, K. Gödel played an important role in the development of semantic logic. Semantics for modal logics have been developed. This is the merit of S. Kripke, J. Hintikka, S. Kanger, R. Montague. And also developed semantics for intuitionistic (E. Beth, S. Kripke) logic. The semantics of epistemic contexts are being developed. Non-semantic predicates are considered definite, and semantic predicates are indefinite. According to S. Kripke, it is possible to construct self-applied statements that assert their own truth. In this case, paradoxes do not arise, since the truth predicate is not everywhere definite.

Fuzzy logic began to be used, which is a generalization of classical set theory and classical formal logic. Fuzzy logic (theory of fuzzy sets) operates on a linguistic variable, in which the variable is able to take on the values of phrases. As a result, physical quantities are described that require more positions than just 0 or 1. Using this approach, computing systems can work with fuzzy definitions, which is typical for human thinking.

According to L. Zadeh, the membership function grades the degree of membership of the elements of the fundamental set to a fuzzy set. So, the value 0 means that the element is not included in the fuzzy set, 1 describes the fully included element. A value between 0 and 1 is not clear about the included elements. L. Zadeh operated with linguistic variables and compositional conclusions based on the mathematical apparatus of the theory of fuzzy sets. He proved that such a method allows one to form an approximate, but still adequate way of describing the functioning of nontrivial fuzzy systems, for the description of which it is impossible to use rigorous mathematical methods.

This is especially true in studies that are conducted in the humanities and are related to the study of society. Since there are no mathematical methods for measuring the behavior of such a complex system as society, the application of this method today is practically the only effective way to study a complex dynamic system of society. A fuzzy set and a classical, clear set is a set of some non-rigid principles that, in order to achieve the assigned tasks, operate with various concepts, assumptions on an intuitive basis, or, for example, expert opinion in a certain area of knowledge. Fuzzy judgments involve abandoning rigid rules. Artificial intelligence, neural networks and expert systems are the most common areas of application of L. Zade's theory.

A set of variables “true”, “false”, “probably”, “at times”, “forgot”, “vaguely”, “let's try”, “give me time”, “refrain” is applied. According to L. Zadeh, the task of fuzzy logic is to develop a methodology for performing calculations in words. There is no other methodology for this yet.

Expert systems capable of partially or completely replacing a human specialist in resolving a problem situation are also based on methods. The construction of models of approximate human reasoning opens up new possibilities in the application of artificial intelligence technologies in robotics.

The expert system facilitates the exchange of data between users through the computing environment and between users and the computing environment. Language facilities and input languages are a special case of external specifications. We will call a program heuristic if there is no single exact algorithm that it implements. It is also proposed to call an algorithm fuzzy if it is used for operations with fuzzy variables, or it is used to describe fuzzy relations. The choice of a more or less strict definition of "expert system in general" is made further.

The most common definition of an expert system, made on the basis of an external specification, is the statement that it is a computing system operating with the knowledge of specialists in a certain subject area and capable of making a subject area and capable of making decisions at the level of these specialists. In this definition, it remains unclear what should be understood by the term "knowledge" and what means the ability to make decisions by a computing system at the level of these specialists. This ambiguity disappears if the term "computing system" is taken strictly.

An expert system, like any computing system, at no point in time of its creation and functioning is inseparable from the user and the developer accompanying the system from its conception to its complete obsolescence. The first essential feature that allows considering an expert system as an independent class of computing systems is that it should not become obsolete. Knowledge is often understood as a set of rules that determine the nature of data processing, as a result of which a new set of rules can be produced. The above definitions operate with the concepts of "knowledge" and "data".

Data in computing systems represent, with a predetermined accuracy, encoded images of objects in the real world that have a quantitative measure. The presence of a quantitative measure indicates the possibility of matching objects. Based on the definition of data, it is possible to formulate a definition of the term "knowledge". It is about knowledge in computing systems, not knowledge in general. If the measurability of objects in the real world follows from the possibility of establishing relations between them, then among these relations it is always possible to single out a subset that unites knowledge.

Data is a special case of knowledge. The existence of data about an object presupposes its comparability with some other object conventionally taken as a standard. This mapping allows you to establish a relationship between objects that can be encoded and represented in the computing system. If the result of this comparison is encoded by constants, variables or functions, then we are talking about data representation. If in a computing system the method and result of the comparison are encoded and the essence of this information is the relationship between data, which can also be encoded by constants, variables and functions, then such data is knowledge.

The most common forms of knowledge representation are logical, semantic, production models and fuzzy systems. These systems contain the ability to 1) operate with fuzzy input data: for example, values continuously changing in time (dynamic tasks), values that cannot be set unambiguously (results of statistical surveys, advertising campaigns, etc.); 2) fuzzy formalization of the evaluation and comparison criteria: operating with the criteria "majority", "possibly", "predominantly"; 3) conducting qualitative assessments of both input data and output results: you operate not only with data values, but also with their degree of reliability and its distribution; 4) fast modeling of complex dynamic systems and their comparative analysis with a given degree of accuracy: using the principles of system behavior described by fuzzy methods

The apparatus of the theory of fuzzy sets, having demonstrated a number of promising applications - from aircraft control systems to predicting election results, turned out to be difficult to implement. Given the current level of technology, fuzzy logic has taken its place among other special scientific disciplines between expert systems and neural networks. The development of the theory of fuzzy logic took place in the early eighties of the twentieth century, when several groups of researchers from the United States and Japan created electronic systems for various applications using fuzzy control algorithms.

The shift in the center of research on fuzzy systems towards practical applications has led to the formulation of a number of problems. These include new computer architectures for fuzzy computing; element base of fuzzy computers and controllers; development tools; engineering methods of calculation and the development of fuzzy control systems. Fuzzy logic works with natural language. This language has evolved over hundreds of years as a means of communication and as a structure that reflects the objective world. Cognition of the world is based on thinking, and thinking, in turn, is impossible without a certain sign system of natural language. This language is capable of operating with contradictory, complex and ambiguous concepts.

In the course of making a decision, the expert takes control of the situation, dividing it into events, finds solutions in difficult situations using the decision-making rules. The language the expert uses is fuzzy natural language. The resulting model of the system is not unified: it either describes the properties of fragments of an object, or is a set of several local models set in certain conditions. Local models do not use numeric values. Having some generality, they are easy to understand at a natural level.

There is an intensive development and practical application of fuzzy systems for the purposes of control and regulation of technical objects. For the first time, the theory of fuzzy sets and fuzzy logic was applied by E. Mamdani. He used a fuzzy controller to control the steam engine. In Japan, the first fuzzy controller was developed by Sugeno for water purification.

F. Cosco proved the fuzzy approximation theorem, according to which any mathematical system can be approximated by a fuzzy logic system. As a result, using the statements "if - then", with their subsequent formalization by means of the theory of fuzzy sets, it is possible to reflect an arbitrary relationship "output - input" without using the complex apparatus of differential and integral calculus used in control and identification.

The fuzzy language is included in the International standard for programmable controllers IEC 1131-7. The conceptual apparatus of fuzzy logic is used to solve problems in which the initial data are unreliable and poorly formalized. The mathematical theory of fuzzy sets allows you to describe fuzzy concepts and knowledge, operate with these descriptions and make fuzzy conclusions. Fuzzy control is useful when the processes under investigation are difficult to analyze using generally accepted methods.

Fuzzy logic, which represents a means of displaying the uncertainties and inaccuracies of the real world, is closer to human thinking and natural languages than traditional logical thinking. The main reason for the emergence of a new theory was the presence of fuzzy and approximate reasoning when a person describes processes, systems, objects. Fuzzy logic is a multi-valued logic, which made it possible to determine intermediate values for evaluations yes - no, true - false. Fuzzy methods based on fuzzy set theory are characterized by: the use of linguistic variables instead of numeric variables. Simple relationships between variables are described using fuzzy statements; complex relationships are described by fuzzy algorithms.

Fuzzy expert systems for decision support are used in medicine and economics. Software packages have been developed for building fuzzy expert systems. They are used in the automotive, aerospace, transportation, home appliance, finance, analysis and management industries. The number of fuzzy applications is in the thousands. The characteristic of a fuzzy set is the membership function. Basic logical operations are defined for fuzzy sets. Necessary for calculations are intersection and union.

In the theory of fuzzy sets, a general approach to the execution of intersection, union and complement operators has been developed, implemented in triangular norms and conorms. The given implementations of intersection and union operations are the most common cases of t-norm and t-conorm. To describe fuzzy sets, the concepts of fuzzy and linguistic variables are introduced.

A fuzzy variable is described by a set (N, X, A), where N is the name of the variable, X is a universal set (area of reasoning), A is a fuzzy set on X. The values of a linguistic variable can be fuzzy variables. This means that the linguistic variable is at a higher level than the fuzzy variable. Each linguistic variable consists of a name and a set of its values, which is called the base term-set T. Elements of the base term-set represent the names of fuzzy variables.

The linguistic variable consists of a universal set X; syntactic rule G, according to which new terms are generated using words of natural or formal language; semantic rule P, which assigns a fuzzy subset of the set X to each value of a linguistic variable.

There are over ten typical curve shapes for assigning membership functions. The most widespread are: triangular, trapezoidal and Gaussian membership functions. A triangular membership function is defined by a triple of numbers (a, b, c). For (b-a) = (c-b), we have the case of a symmetric triangular membership function, which can be uniquely specified by two parameters from the triple (a, b, c). To set the trapezoidal membership function, you need four numbers (a, b, c, d). When (b-a) = (d-c), the trapezoidal membership function takes on a symmetric form. The membership function of the Gaussian type operates with two parameters. The parameter c denotes the center of the fuzzy set, and the parameter {\ sigma} σ stands for the steepness of the function.

The number of terms in a linguistic variable rarely exceeds 7. The basis for the operation of fuzzy inference is a rule base containing fuzzy statements in the form "If-then" and membership functions for the corresponding linguistic terms. The following conditions must be met. There is at least one rule for every linguistic term in the output variable. For any term in an input variable, there is at least one rule in which this term is used as a prerequisite (the left side of the rule). Otherwise, there is an incomplete fuzzy rule base.

The result of fuzzy inference is the crisp value of the variable based on the defined crisp values. The inference mechanism includes four stages: fuzzy introduction (fuzzification), fuzzy inference, composition and reduction to clarity, or defuzzification. Fuzzy inference algorithms differ in the type of rules used, logical operations and a type of defuzzification method. Fuzzy inference models for Mamdani, Sugeno, Larsen and Tsukamoto have been developed.

The Mamdani mechanism is the most common way of inference in fuzzy systems. It uses minimax composition of fuzzy sets. The mechanism assumes the following sequence of actions. The first step is the phasification procedure. It determines the degrees of truth - the values of the membership functions for the left sides of each rule (prerequisites). The second action is fuzzy inference. The third action is composition, or combining, of the resulting truncated functions. The fourth action is defuzzification, bringing to clarity. There are several methods of defasification.

As a result of combining several artificial intelligence technologies, the term “soft computing” appeared, which was introduced by L. Zadeh in 1994. Soft computing combines areas such as fuzzy logic, artificial neural networks, probabilistic reasoning, and evolutionary algorithms. They complement each other and are used in various combinations to create hybrid intelligent systems.

Fuzzy logic has become the basis of most Data Mining methods, endowing them with functionality. So, fuzzy neural networks make inferences based on the apparatus of fuzzy logic. Membership function parameters are tuned using learning algorithms. To select the parameters of such networks, we will apply the error backpropagation method proposed for training a multilayer perceptron. For this, the fuzzy control module is presented in the form of a multilayer network. A fuzzy neural network consists of four layers: a phasification layer for input variables, a condition activation value aggregation layer, a fuzzy rule aggregation layer, and an output layer.

Fast learning algorithms and the interpretability of accumulated knowledge have made fuzzy neural networks one of the most promising and effective soft computing tools. In adaptive fuzzy systems, the selection of parameters of a fuzzy system is carried out in the learning process on experimental data. Learning algorithms for adaptive fuzzy systems are laborious and complex compared to learning algorithms for neural networks. They consist of the stages of generating linguistic rules and adjusting membership functions.

The first stage refers to an enumerated type problem. The second stage is towards optimization in continuous spaces. In this case, a certain contradiction arises. Membership functions are required to generate fuzzy rules. And to draw a fuzzy inference, you need rules. When generating fuzzy rules automatically, it is important to ensure their completeness and consistency.

A significant part of the methods of training fuzzy systems use genetic algorithms. Fuzzy database queries are an important trend in information processing systems. This tool makes it possible to formulate queries in natural language. For this purpose, fuzzy relational algebra and special extensions of the SQL languages for fuzzy queries have been developed. Most of the research belongs to D. Dubois and G. Prade. Fuzzy association rules is a methodology for extracting patterns from databases that are formulated in the form of linguistic statements. The special concepts of fuzzy transaction, support, and reliability of a fuzzy association rule have been introduced.

Fuzzy cognitive maps were proposed by B. Kosko in 1986 and are used to model the causal relationships identified between the concepts of a certain area.

Unlike simple cognitive maps, fuzzy cognitive maps are a fuzzy directed graph, the nodes of which are fuzzy sets. The directed edges of the graph not only reflect the causal relationships between concepts, but also determine the degree of influence (weight) of the related concepts.

The active use of fuzzy cognitive maps as a means of modeling systems is due to the possibility of a visual representation of the analyzed system and the ease of interpretation of cause-and-effect relationships between concepts. The main problems are associated with the process of building a cognitive map, which does not lend itself to formalization. It is also necessary to prove that the constructed cognitive map is adequate to the real modeled system. To solve these problems, algorithms have been developed for the automatic construction of cognitive maps based on data sampling.

Fuzzy clustering methods, in contrast to clear methods, for example, Kohonen's neural networks, allow one and the same object to belong simultaneously to several clusters, but with varying degrees. Fuzzy clustering in many situations is more natural than clear-cut, for example, for objects located on the border of clusters. The c-means fuzzy self-organization algorithm and its generalization in the form of the Gustafson-Kessel algorithm, fuzzy decision trees, fuzzy Petri nets, fuzzy associative memory, fuzzy self-organizing maps and other hybrid methods are actively used.

Expansion of the subject of logic determined the relevance of metalology. This is a section of modern logic, which examines the ways of constructing various logical theories, the properties inherent in them, as well as the relationships that exist between them. The rudiments of metalological problems can be found already in the Analytics of Aristotle, who tried to substantiate the completeness of his assertive syllogistic by syntactic methods. However, in the true sense, metalology began to actively develop in connection with the construction of various logical systems and their use in the substantiation of mathematics (in metamathematics).

Logic is understood as a set of sentences interconnected by a meaningful (semantic) relationship of logical consequence. Logic studies the possibilities of constructing a logical theory in which this relation would be given by some formal analogue of it. In the theory, the derivability relation acts as such a formal analogue. Logical theories are built in several basic forms - in the form of axiomatic calculus, natural calculus, or in the form of sequent calculus. For theories, there are their deductively equivalent representations in all the indicated forms. For a number of logicians, the question of one form or another of their formalization remains open and constitutes the content of the corresponding metalological studies.

In metalogics, each logical theory is tested for its semantic and syntactic consistency. A logical theory is considered semantically consistent if every statement proved in it is generally valid in the given logic, i.e. is its law. On the other hand, a logical theory is considered syntactically consistent if it cannot prove some statement and its negation. For some logical theories, other concepts of syntactic consistency are used. Metalogic proves the meta-statement that a theory is semantically consistent if and only if it has a model. A theory that has no models does not describe anything, and therefore this kind of theory is of no scientific interest. The same applies to syntactically contradictory theories, since any statement becomes provable. When constructing a theory, the goal is to separate the being from the non-being.

Consistency metatheorems have been proved for a number of logical theories. In particular, the theorems are proved for the first order predicate calculus. The proof of relatively stronger theories is limited by the result that in such proofs it is necessary to use more powerful deductive means than those that are formalized in the theory itself. For some logical theories, other concepts of syntactic consistency are used. Metalogic proves the meta-statement that a theory is semantically consistent if and only if it has a model. A theory that has no models does not describe anything, and therefore this kind of theory is of no scientific interest. The same applies to syntactically contradictory theories, since any statement becomes provable. When constructing a theory, the goal is to separate the being from the non-being.

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The concepts of syntactic and semantic completeness of theories are important for metalology. A logical theory is considered semantically complete if every sentence formulated in its language and which is the law of a given logic is provable in it. The fulfillment of this condition for some logical theory, together with the fulfillment of the condition of its semantic consistency, means that this logical theory adequately formalizes the corresponding logic. The semantics of the theory is adequate to its syntax.

A theory is syntactically complete if no sentence formulated in its language and unprovable in it can be included in the theory without contradiction. Syntactically complete theories do not allow new statements to be added to themselves as deductive means. Syntactically and semantically complete theory is the classical propositional calculus. The classical first-order predicate calculus is semantically complete. But it does not possess the property of maximality. This means that it allows the addition of new statements to itself as axioms.

Non-maximal classical first-order predicate calculus can be supplemented with special axioms. As a result, some non-logical theory will be syntactically complete. Such a theory is the theory of partial order. Second-order predicate calculus is not only a syntactically incomplete system, but also semantically incomplete. The class of logical laws of classical second-order logic is not formalized. Non-formalizability, in the light of Gödel's theory of the incompleteness of formal arithmetic, is of a fundamental nature. This theory is not only semantically incomplete, but in principle it cannot be made complete.

In metalogics, the concept of categorical theory is considered. A theory is considered categorical if all its interpretations (models) are isomorphic. The classical logic of propositions is categorical. The categorical nature of theories is the exception rather than the rule. The non-categorical nature of the theory speaks of the ambiguity of the description within its framework of the class of interpretations.

Another important property of logical theories is the property of their decidability. A theory is considered decidable if there is a certain algorithmic procedure that gives an answer to the question whether a certain statement is a theorem of the theory or not. The decidability property is possessed by the classical propositional calculus. The procedure for constructing truth tables is used as a permissive procedure. Some simple mathematical theories also have the property of decidability. As A. Church proved, the classical first-order predicate calculus is not a decidable theory.

For a fairly wide class of theories, including logical ones, A. Tarski proved a metatheorem about the indefinability of the predicate "truth" by logical means formalized in these theories. This result is similar to the result of K. Gödel on the unprovability of the statement about the consistency of formal arithmetic by the means that are formalized by this theory.

Another testable property of logical theories is the property of independence from each other of their deductive principles. In metalogics, the problem arose of proving metatheorems about the normalization of inferences, the removability of a special cut rule in sequential calculus, the algorithmization on this basis of proof processes in various logical systems and the construction of computer implementations of these algorithms for automatic theorem search. Various computer implementations of algorithms for automatic search of theorem proofs have been constructed.

Since theories are classes of sentences, all the operations that are performed on sets can be performed on them. The only condition is that the result of these operations must be a theory. Tarski showed that the class of all theories formulated in the same language on the basis of classical logic forms a Brauer algebra. If we restrict ourselves to considering only finitely axiomatizable theories, then the class of all such theories forms a Boolean algebra.

Metalogic refers to the consideration of the various relationships that exist between logical theories. A huge number of such relationships have been identified and investigated. The most important are the relations of deductive equivalence of the two theories.

Thus, different formulations of the classical propositional calculus, given by a different set of axioms, are equivalent theories. Intuitionistic propositional logic is under the theory of classical propositional logic. The classical first-order predicate calculus is a non-creative (from the Greek, creation - creation) extension of the classical propositional calculus. The concept of translatability of one theory into another is important. Various relations between theories are introduced, in particular, the concept of immersion of one theory into another. A large number of theorems have been proved that substantiate the immersion of one theory into another. A result is obtained on the immersion of the classical propositional calculus in intuitionistic logic.

2.24 A new paradigm of professional communication and work organization: freelancing

The search for new forms of professional communication, organization of the workplace for a long time did not go beyond the space of the firm, company and transnational corporation. Managers believed that workers should be directly supervised in the office. At the same time, they did not take into account the costs associated with the risks of employees being late for work, their illness, conflicts in the professional environment.

The pandemic epidemic that began in 2020 prompted managers to overcome stereotypes in the field of organizing work processes. A tendency has emerged to strengthen the role of non-standard forms of employment in the labor market. The experts carried out a thorough analysis of the problems of non-standard forms of employment and the prospects for their solution. The categories of full standard employment and non-standard forms of employment are singled out.

The expansion of the role of non-standard forms of employment is influenced by the factors of the economic crisis, the epidemiological situation, the development of technologies, the desire of companies to reduce production costs, and changes in organizational strategies. Based on these trends, the flexicurity policy has been formulated. It implies flexibility in the legal regulation of labor through the modernization of existing social models of employment.

One of the directions for the development of non-standard forms of employment in the digital economy has become e-employment (distance employment). It involves the employee being at a distance from the employer and the use of information technology for communication, control, transfer of tasks, labor results, remuneration.

E-employment is presented as a permanent job in a specific organization or as freelance. Institutional support for freelancing requires legal support. Most freelancers would like to work paying taxes and have pension security. It is urgent to create an effective system of enforcement of legislation in the field of e-employment.

There is a need to develop electronic payment systems, improve electronic signature and electronic document management technologies. The use of an electronic labor contract may become promising.

The institutionalization of labor market information platforms has been implemented. Network labor market institutions unite many participants. Their status is formed by the establishing set of stably functioning rules.

Institutions arise because people have a need for them. A group of people participating in the virtual labor market is united by a common interest in the form of specific information, as well as systematized processed information suitable for solving practical problems.

Network institutions of the labor market suggest: the division of roles, the formation of communication rules, internal forms of sanctions for violators of generally accepted norms. The network institution of the labor market is a network where each node can simultaneously act as a client (recipient of information) and a server (data provider).

The infrastructure of the virtual labor market is represented by a network of institutions. These are network information institutions of the labor market. They are connected by search servers. These are institutions in the form of a labor exchange for IT specialists, resources for students and graduates, social networks and communities for various professions, cities in the form of websites of government bodies, electronic bulletin boards. An important role is played by network consulting educational institutions of the labor market. This is a distance market of educational services operating on the basis of higher professional, postgraduate education.

2.25 Technology Convergence and Business Process Transformation

An innovation ecosystem is a system of interconnected institutions that produce, store and transfer knowledge, skills and created products used in the development of new technologies. Post-industrial innovative ecosystems create a high-tech product. Technology will be understood in a narrow sense, as a way to solve a specific practical problem in a fixed context of application. A technological product is both a technical product and methods for solving a set of practical problems in a wide range of possible application contexts. A technological product differs from a technical product in that it contains not only a material component, but also an intangible, informational component related to the technology of its operation. An example of a technological product is a microprocessor, which contains, in addition to the technical product itself, information about how it can be connected to other microelectronic devices, about how it can be programmed. The same microprocessor can be used in the context of creating thousands of different devices: automated machine tools, navigation systems.

Technologies, the source of which is research, we will call high. And accordingly, products created on the basis of research are high-tech. Innovation ecosystems producing technologies are industrial. Innovative ecosystems producing high-tech products are post-industrial.

Direct investments of large technological firms in production in the territory of the industrial park, as well as individual experimental investments in new firms, solve the problem of financing new industrial enterprises of the ecosystem. Public funding helps to maintain a greater diversity of research. Growth was received by the semiconductor microelectronics industry. The transistor market is not limited to military orders. A two-tier semiconductor market emerged. These are proven products that are affordable, produced in large volumes and with little added value.

There were devices that were more technically advanced which were produced in small batches and sold at a higher unit profit.

2.26 Mobile Startup Culture

Startup companies work in the digital engineering genre. Their product is prototypes and projects that require funding in order to scale them up. Finding an investor is a key task.

The basis of digital engineering lies in understanding the interrelationships of physical processes occurring in a product or product at all stages of the life cycle and the ability to calculate their mutual influence on the measured characteristics.

The use of a digital information model as a tool for supporting a project at all stages of the life cycle makes it possible to increase the reliability of technical solutions, reduce the time for project consideration and reduce operating costs. And also to ensure the targeted spending of funds at the stages of construction and operation and compliance with deadlines at all stages of the project.

It contains a framework to reduce risks through participation in the early stages of the project and the possibility of a high degree of model development. The ability to control the project implementation process using digital models makes it possible to simplify the work of the project team at all stages of the examination and support of the project, increase the safety of investments and the efficiency of monitoring the investment phase.

The digital twin of a product is an analogue of a physical object in a digital environment. It is created on the basis of interconnected mathematical models of physical processes occurring in an object, on the basis of performing tens of thousands of virtual tests in a specially organized process.

The digital twin of production takes into account the technological features of production processes in the digital twin of the product within the framework of a single digital model. The Level 1 Smart Digital Twin combines the site's digital twin and the production's digital twin into a single digital model. The second level smart digital twin combines the smart digital twin of an object and data on actual operating conditions within a single digital model. A smart digital product shadow is formed on the basis of a smart model that adequately describes the behavior of a real product in all operating modes. These are starts and stops, normal operating conditions and deviations from normal conditions, emergency situations.

Digital twin technology combines the industrial Internet of things and digital simulation. It is actively implemented at all stages of the product life cycle. The introduction of "digital twins" for modeling and evaluating various scenarios reduces the number of equipment failures. Through the use of technology, errors are corrected early in the design process and no breakage occurs during testing. Improved quality of 3D models. The terms for electronic approval of design documentation have been reduced, and the number of design errors has decreased. Companies spend less money on finalizing samples for mass production. The main digital solutions are the product life cycle management system, digital design of products and technological processes, production process control systems and the Internet of things. The priority is to ensure the cyber security of systems and the development of information infrastructure.

The systems approach involves the synergy of smart building, full life cycle, lean building and BIM. Smart building involves a building model based on the project life cycle, including project approval, decision making, design. The information platform is being used. Coordination of project resources, integration of data flow, lean information management are provided.

The main intermediaries in organizing a meeting of startup developers with a potential investment environment are digital crowdfunding and crowdsourcing platforms. Crowdfunding involves posting information about a startup on the platform website indicating the cost of the project, its relevance and relevance, as well as a bank account accumulating money transfers. To this end, the crowdfunding platform enters into an agreement with a specific bank. If the amount declared for the project is collected, then the startup is updated. If the amount of investment declared for it is not collected, the startup is not updated. The transferred funds are returned to investors in the prescribed manner.

The crowdsourcing platform is organized on the principle of free participation of any of the network users in a permanent digital project. An example of such a project is Wikipedia.

There are many startups, but they lack experience in their chosen field. Companies partner with these startups and complement their technical capabilities with their accumulated experience, which provides benefits to both parties.

Information technologies are implemented through a network of partners, each of which contributes to the creation of the final solution. The introduction of information technology leads to a rapid growth in the number of partner digital ecosystems and opportunities to attract customers to cooperation. Many companies, together with customers, develop optimal solutions with reusable horizontal modules that are characterized by openness and compatibility. This is a complex strategic transition for both providers and users of technology solutions. As a result, an open digital ecosystem of standards-oriented developers of information technology solutions has been formed. This is the economy of cooperation.

Key player partnerships that give all parties a technological and market knowledge edge result in cost-effective solutions faster. If any important element is missing, a startup can fill the gap. Once all key partners have been assembled, a team of vertical specialists and vertical integrators joins, able to combine components from different vendors and combine them with the client's existing or new business processes to create a single business solution. A logical ecosystem of complementary skills and know-how is being formed. Collaboration develops into an alliance, then into a set of strategic partnerships and into a symbiotic information technology ecosystem.

This is facilitated by moving away from proprietary embedded information technology technology in favor of standards-based systems that are compatible with competitor-developed information technology applications. The company is building a vast ecosystem of applications and partnerships. The manufacturer receives great opportunities in a wide area in the context of the growth of the information technology market.

Superapp plays an important role in the formation of its own network of partnerships. This is a multifunctional mobile application that provides access to products and services of the digital ecosystem. It's an ecosystem of proprietary and third-party services packed into one app. As a result, in the application you can not only communicate, but also order a taxi, food delivery, buy movie tickets, play games, read the news, make an appointment with a doctor, pay utility bills, and donate to charity.

A business ecosystem represents a partnership of independent producers of goods or services that together constitute an interconnected solution. The strengths of the digital ecosystem express access to external opportunities, rapid scaling, flexibility and sustainability. Ecosystems do not imply a mandatory digital business model.

Superapp is a platform around which digital ecosystems are created and developed. An ecosystem can build from an existing platform, or assemble existing products and services. Superapps, like ecosystems, can be open to partners and closed. Superapps have an application with a large and loyal audience, a payment system, mini-apps. These are lightweight apps inside a superapp. Ecosystem partners present their services through mini-apps. A unified methodology is important for quick access to the capabilities of built-in services. Superapps help to keep the audience within the ecosystem due to a large number of services. For this reason, a superapp has a higher chance of gaining a foothold on the first screen of a smartphone: more benefits for customers, a higher need for an application.

It is cheaper to attract users to one super app than to several separate ones.

2.27 Digital architecture

Architecture is a space of social information. It contains the components of metaphor, syntax and semantics (C. Jencks). In architecture, there are not only styles, but also eras. B. Zevi largely prepared the transition of architecture to a digital basis. Visually, this manifests itself in the phenomena of murals, combining the functions of digital frescoes and three-dimensional animation, when viewed through a digital application.

Start-ups of buildings covered with smart polymers have received implementation. These polymers connect to smartphones. Building facades provide tourist and administrative services. The augmented city combines the virtual infrastructure with the physical infrastructure of the settlement and acts as a tour navigator.

Architects use methods of generative design, information modeling and immersive visualization. Basically, digital architecture implements its functions with the help of computer simulation. This function is provided by programming. It combines modeling and visualization to construct virtual shapes and physical structures. Digital practices also apply to other aspects of the architecture, such as being applied to digital skins. The digital design of the building includes a digital skin.

Digital format architecture may not include the use of physical materials such as brick, stone, glass, steel, and wood. It operates on a set of numbers stored in an electromagnetic format. These sets of numbers are used to create representations and simulations. They correspond to the material characteristics and display the built artifacts. Digital architecture uses not only the theory of similarity in information technology, but also forms the internal space of the Internet. These are websites, multiplayer dungeons, MOOs, and web chats.

Using computer algorithms, architects create a variety of complex forms of interior space. Scripted, iterative and index digital architecture has created new possibilities in architectural design. A philosophical and methodological component of discussions about the role of technology in society has emerged. The result was the emergence of new forms of non-standard architecture. They are cultivated by ZahaHadid, KasOsterhuis and UN Studio.

Technologically, digital architecture involves complex calculations. They provide design creation for non-traditional architectural forms. Simulations illustrate the interaction of materials, structures and shapes. The conditions are created by architectural design software. As a result, the architect creates complex free forms. The shape of the building is created as a simulation of various processes, like fabric sleeves. The architect chooses one of the shapes offered by the computer program.

Information technology allows the use of digital materials. They are created in non-traditional shapes using 3D modeling software. Digital material is created not as a separate object, but as a set of units. They are arranged by algorithms in certain structures. Digital materials are actualized as textures or planes and as plastic shapes with depth. Such materials are made using 3D printers, laser printers, robots.

The architect controls the building design processes. Digital simulation allows you to design a building based on the required performance parameters in the field. This is important when assessing climatic conditions, costs, and ecology. The main obstacle to the use of information technology in architecture is the high cost of digital materials. The robotics technologies involved in their manufacture are costly and complex.

2.28 Philosophy of convergent technologies

Convergence reflects the trend of merging dissimilar technologies and technical devices in order to interact and exchange technological information in order to coordinate actions and operations. In this context, we are talking about the Internet of things. It is a network of physical objects made smart by electronics, sensors, software, network connectivity.

Convergence is also understood as the merging of operational and information technologies to the level of hardware and software platforms. Operational technologies include technical components in the form of machinery, equipment and hardware. These are programmable logic controllers, remote terminal blocks, interfaces, man-machine supervisory control systems, embedded computing technologies.

Information technology uses computers, storage, network devices to create, process, store, protect and exchange electronic data. The information model unifies the interaction interfaces of information systems. An important role is played by the convergence of computer and telecommunication networks. Telecommunication networks include telephone, television, computer networks and radio networks.

The telecommunications network includes an access network. It ensures the concentration of information flows from users in the nodes of the backbone network. The backbone connects separate access networks and provides traffic transit. As a result, user service is carried out on the basis of the network's own information resources. This function is performed by service control centers.

Computer networks are networks of telecom operators, service providers. They provide public services via the Internet. There are also corporate computer networks. They are used only by employees of the organization or enterprise.

The main trend was the development of information systems and software systems by the criterion of increasing their functionality. The performance of personal computers, workstations, mobile devices, bandwidth of networks and communication channels are taken into account. For a long time, the emphasis was on the development of computer hardware.

One of the resources was the convergence of heterogeneous information environments based on cross-platform components. Complex information systems are distinguished by a large branching of technological subsystems, a large number and diversity of equipment, software and hardware platforms, and the complexity of control algorithms. Algorithms, methods and software tools for the convergence of heterogeneous information systems, as well as protocols, are being developed.

Companies specializing in the production of hardware and software systems have created a market for convergent technologies in the form of invariant hardware and software platforms and data types. These complexes are more expensive than the hardware equipment of multiservice networks. These networks are a means of organizing uniform communications. They include the presence of a single traditional layer that provides the transfer of all data formats provided, quality assurance for data types and management of all data flows within the console (single management system).

Converged networks contain the ability to quickly supplement, change the services operating within the network. The user has the possibility of unified access to services. A converged infrastructure implements a hardware and software solution. The goal is to overcome the limitations and inefficiencies of an independent, structure for storage and computing resources.

Converged solutions integrate network computing resource administration, storage systems, and software into a pre-configured package that works as a single system. Hardware and software systems that create a converged environment include a server, storage device, network equipment, control and automation programs. The goal is to overcome the limitations and inefficiencies of an independent, siled structure for storage and computing resources.

Converged solutions integrate network computing resource administration, storage systems, and software into a pre-configured package that works as a single system. Hardware and software systems that create a converged environment include a server, storage device, network equipment, control and automation programs. The goal is to provide a single point of entry for technical support and to simplify component maintenance.

The idea is to combine memory, computing and network resources into a pool configured to work in a data center. In a converged infrastructure, storage is combined with physical servers. Flash storage is used for high-performance applications and data caching. Converged technologies use a solution that is fully configured by the vendor according to customer requirements, as well as a solution in the form of a reference architecture, which is followed to build solutions certified by the manufacturer for specific customer requirements.

The service solves the problems of any customer, regardless of his needs. In parallel with the converged infrastructure, hyper-converged infrastructure began to be used. In a converged infrastructure, each component in a building block is discrete and can be used separately. In a hyperconverged infrastructure, all components are integrated. Management is carried out through a common administration console. This allowed the creation of manageable compatible and universal platforms. One system administrator is enough for maintenance.

2.29 Philosophy of digital automated technological reality

Automated technological reality consists of human-machine systems. These systems include an operator and an automatic control device. The operator performs the functions of a technologist. He controls the processes. Monosystem includes one operator. The polysystem involves the participation of several operators.

The design of human-machine systems involves taking into account the psycho-physiological limitations of the operator. This is important because 80% of accidents are due to human error. The stages of designing a human-machine system include:

1) development of an automation concept and pre-design analysis;

2) preparation of terms of reference; 3) development of a preliminary design;

4) development of a technical project and working documentation;

5) testing of a prototype; 6) drawing up operating instructions.

The tasks of interaction between the operator and the automatic control device are solved in the software systems of the human-machine interface. The tasks of the operator include regulation, tracking, stabilization and bringing the coordinates of the system output to their specified value. The system is closed through the operator. Each side is subject to its own laws. It turns out a system with elements of different nature. These natures have entered the stage of co-evolution. D. Norman writes about this.

From the mechanism of co-evolution it follows that the basis of the life of modern man is associated with an artificial habitat. This fact affects the content of the design. Previously, firmware was designed as input-output devices. The computer was designed as a computing machine. Now I / O devices have become part of the social environment. Usabilityists are involved in its construction. Interface and protocol have become key components of digital social reality. These are interfaces with users and interfaces between technical systems.

There is a development of interfaces for automated systems, as well as interfaces for interaction between a person and the technical components of automated systems. The first is the development of machine-machine interfaces. Then comes the human connection. The interfaces of automated systems are close to the human senses, for example, augmented reality glasses. New generations of interfaces have voice and visual components. The creation of digital avatars has become important. Collaborative spaces function with their participation. It became possible to transfer the image and perception of a person into a virtual environment.

Human-machine interaction devices are being developed that allow using direct decoding of human brain signals to control external executing technical devices. Neurointerfaces of specialized software are being created, in particular, robotic complexes for controlling avatars in virtual reality based on the use of user biological biometric data in a hybrid mode.

2.30 Philosophy of Intelligent Robotics

The topic of artificial intelligence is related to the development of special mechanisms and machines that imitate mental activity and complex physical actions of a person. This is the task of creating intelligent robots. An intelligent robot is a system capable of purposeful interaction with the environment. The system is able to a) perceive and recognize environmental objects; b) form an internal idea of the environment and the processes taking place in it; c) make decisions and form plans for their own actions in accordance with the set goals based on accumulated knowledge and experience; d) change the environment by manipulating its objects; d) communicate with a person.

An intelligent robot is an element of a flexible production system. It can be reprogrammed to solve various production tasks. At the same time, there is no need to reorganize production sites and industrial workshops.

An intelligent robot receives visual, sound and tactile information from the outside world through a special sensory system through which it is connected with the environment. The main instrument of the robot's impact on the environment is its manipulator. The necessary degrees of freedom during its operation are provided by the movement system of the robot and its manipulator. Other important subsystems of the robot are the human communication system and the cognitive system. In the cognitive system, the received information is processed, which is necessary to control the robot's own behavior in a real production environment. It is in this system that functions are implemented, in aggregate, reminiscent of the human psyche, such as: perception, memory, problem solving and learning.

Intelligent robots consist of a manipulator, sensors of visual and tactile information, a system for recognizing visual images, mechanisms for determining distances, software for processing information about the environment and planning the actions of the robot and the control system. Intelligent robots also have speech recognition and understanding tools, a learning subsystem, an automatic problem solver, mechanisms for searching and processing various types of information, and advanced inference tools, including in the presence of incomplete, fuzzy and uncertain information.

Robotic problems lead to great difficulties in organizing calculations associated with the need to process large amounts of frequently changing data in real time. Such tasks include: perception and analysis of scenes with moving objects, reasoning, inference and planning of activities, recognition and understanding of continuous speech. Tasks can be efficiently solved only on parallel computers with very high performance. In addition to the task of creating advanced computer architectures using the latest types of chip manufacturing technologies, an important task is the development of parallel algorithms and programs for robotics tasks.

Ethics is based on the three laws of robotics. A robot cannot harm a person or by its inaction allow a person to be harmed. A robot must obey commands given to it by a human, except in cases where these commands are contrary to the first law. The robot must take care of its safety, as far as it does not contradict the first and second law. Intelligent robotics is understood as a set of methods, methods of research and development of systems that integrate the capabilities of robotics and artificial intelligence to create intelligent agents capable of autonomous or partially autonomous actions in various environments.

The interdisciplinary nature of intelligent robotics makes it one of the most promising research areas with a significant impact on our civilization as a whole. This determines the high relevance of the development of philosophical and methodological issues in the development of intelligent robotics and its role in the creation of general artificial intelligence.

General artificial intelligence is understood as a software and hardware complex that has the ability to learn and act better than a person, achieving goals in a wide range of environments with limited available resources. Since its inception in the last century, the development of robotics and artificial intelligence has followed different trajectories. Robotics has found application in industry by adapting the applied problems to be solved for the limited mechanical capabilities of robots. Artificial intelligence, remaining largely a research paradigm aimed at studying the possibilities of imitating human mental activity, used the wide possibilities of software, in particular, machine learning methods. Robotics has developed much more slowly due to its inherent dependence on the physical and chemical properties and design features of the components of the robot.

Artificial intelligence, whose main components are mathematical and software, has developed much faster than robotics due to its direct dependence on research and development in the field of microelectronics, which still follows

Moore's empirical law. It states that the number of transistors placed on an integrated circuit chip doubles every 24 months. This gave artificial intelligence the opportunity to use the exponential development of the element base of components. Such as graphics accelerators, data storage systems, various sensors and broadband communications for creating software that develops machine learning approaches to solving a large type of applied problems.

New programming tools and environments, such as deep learning artificial neural networks, allow you to find answers to complex robotics problems. In turn, this gives rise to new ways of human-machine interaction that require deep philosophical, ideological and epistemological understanding with the involvement of the principles of post-nonclassical rationality (V. S. Stepin, V. A. Lektorsky). Artificial intelligence and robotics, along with energy and transport, are a technology that, on the one hand, acts as an independent branch of industrial production, and on the other hand, creates productive forces for other industries, which resembles an effect similar to the invention of a steam engine in the era of the first industrial revolution.

Intelligent robotics acts simultaneously in two qualities. This is an area of scientific research that studies the principles and laws of physical objects endowed with intentionality. It is transmitted by a person and is capable of transmitting to a person information about the results of the task. Robotics includes such heterogeneous groups of technologies as robots-performers of economic functions, robots-cars, drones and industrial manipulators. Artificial intelligence gives any technical device the ability to change its behavior based on data from sensors, thereby turning it into a robot.

As robotics and artificial intelligence technologies improve, the empirical definition of a person is also changing. Virtual intellectual assistants, devices that play the role of exocortex, internal and external organs, body presence are artificial additions (expansions) of human capabilities.

At an early stage in the development of artificial intelligence and robotics, a narrowly disciplinary approach prevailed, combining relatively clear methodological and ethical aspects and practical steps for the development of technologies (Turing machine, von Neumann architecture). However, the modern specialization of artificial intelligence and its latest results reveal a significant gap between theoretical research in the field of philosophy and methodology of artificial intelligence and the practical efforts of researchers to create intelligent machines (robots) that will have abilities that are not inferior to human ones.

The idea ofrelying on Moore's law, on a purely quantitative increase in computing power while maintaining the conceptual approach of A. Turing means a methodological dead end. New relevant approaches and methodologies can not only reduce the time and effort to create a new generation of smart and useful machines, but also realize the potential of artificial intelligence and robotics to solve the global problems of our civilization.

The starting position was set from the very beginning by A. Turing within the framework of classical rationality, focused on the capabilities of "thinking machines" as objects of study. In his 1950 work "Computing Machines and the Mind", the British mathematician and logician laid the foundations for an operational approach to the creation of "thinking machines" even before the term "artificial intelligence" itself arose.

Since 1956, when J. McCarthy first used the term "artificial intelligence", this area has been associated with the mathematical, linguistic and algorithmic problems necessary to simulate human intelligence using a computer. In parallel with the philosophical and methodological justifications for artificial intelligence, the subject area of intellectual robotics is developing.

In the fundamental works on artificial intelligence, A. Turing emphasized the connection between the cognitive functions of the brain and human motor skills. This served as the basis for another theoretical and practical discipline, cybernetics, which was founded by N. Wiener. The term "intelligent robotics" appeared in the 1960s and 1970s. XX century thanks to the work of two research groups in the United States. The Stanford Research Institute has created an autonomous robot "Shakey", capable of fully moving in physical space. Another direction was the creation by T. Winograd at MIT at about the same time of the "SHRDLU" program. She understands a limited subset of natural language and operates in the virtual world of simple geometric blocks. This program could be called a "virtual robot".

The principles of the development of artificial intelligence at the end of the 20th century as a field of software development that can help make computers "smarter" were subjected to significant rethinking for various reasons, including high expectations of research results in this area (M. Minsky). In the 90s of the twentieth century, calls began to be heard to combine the areas of "artificial intelligence" and "robotics" into a single conceptual space (R. Brooks). Another reason for the emergence of the term "intelligent robotics" was the constant criticism of the direction denoted by the term "artificial intelligence" as allegedly too far from real achievements (R. Penrose).

In an attempt to differentiate research, many scientists resort to the creation of new terms, such as "intelligent systems", "cognitive systems" or "cognitive robotics". However, there is no need to analyze the subtleties of terminology, since "intelligent robotics" in fact completely closes all the possibilities of applying artificial intelligence methods to robotics.

Intelligent robotics is an operational direction based on the works of H. Moravec and D. Liklider, which defines the subject area through the actions of agents that must correspond to the functional description of three simultaneously realized abilities: sensation, understanding and action. Philosophical understanding of the issues of robotics and artificial intelligence was carried out in the works of such representatives of analytical philosophy as H. Putnam, J. Fodor, T. Nagel, J. Searle, D. Dennett, D. Chalmers and N. Block. Soviet scientists P. K. Anokhin, A. I. Berg, N. A. Bernshtein, V. M. Glushkov, and A. N.

Kolmogorov took an active part in the research. It is possible to distinguish the contexts of the computer model of "I", the inclusion of conflictology and the principle of limited rationality in the study of multi-agent systems (M.A. Shestakova), the problem of emotional reactions and physicality of virtual people (D. Bourdin and M. Savin-Baden). As well as the problems of the socialization of robots, their inclusion in public spaces (O. Scherer and J. Parvienen), the problems of approaches of different cultures in creating robots, attempts to comprehend the phenomenon of the “soul” of computers (K. James).

The issues of ethics and safety in the use of robots are widely discussed. Researchers in robotics are focused on solving applied problems, focusing mainly on particular, limited examples of the interaction between the robot and the environment, leaving aside approaches that require the solution of theoretical and philosophical and methodological issues of a general order.

The research program, which was initiated by A. Turing and took a purely operational approach as a basis, is largely outdated, since the simulation of human intellectual behavior is possible using deep learning artificial neural networks. Therefore, it is necessary to develop new approaches in artificial intelligence research. The subject of the research is the conceptual foundations (principles) of intelligent robotics in the light of post-Turing methodology.

Any technical product of a person is an intelligent robot if it has three abilities at the same time. The ability to perceive the world around with the help of camera, sonars, laser rangefinders and radars. The ability to autonomously (i.e., independently of the human operator) build models of their behavior, choosing the best ways to solve the problem based on dynamically adaptable behavior models. The ability to perform actions in the physical world by manipulating the objects of the physical world and its own movement. VK Finn's model shows that a number of abilities of natural intelligence can be implemented on a non-biological basis in a fully automatic mode without human intervention.

The advent of cheap vision systems has greatly simplified the creation of new types of robots whose behavior is based on a visual assessment of the environment and the adaptation of behavior models based on the information received. The available data sets (arrays of textual, visual information) are marked up for further training by neural networks on an industrial scale. This makes it possible to use multilayer artificial neural networks. Calculation accelerators based on the software used for calculations in computer graphics have become widespread.

Cognitive sciences have made significant progress in studying the mechanisms of the human brain. A number of theories describing the work of consciousness and the human brain receive sufficient experimental confirmation (J. Rizzolati, A. Damasio, K. Koch, V. Ramachandran). In particular, the human brain carries the code structures of multiple patterns.Their decoding using neuroscience methods opens up new possibilities for modeling complex intellectual functions in order to develop intelligent robotics and the development of general artificial intelligence. The conclusion is made about the increased relevance of the autonomy and reliability of artificial intelligence and robots.

Among the theoretical difficulties, the epistemological problem of the subjectivity of artificial intelligence and robotics products is noted. A robot or, in general, a computing device equipped with actuators has objective characteristics (a program, the physics of its manipulators or a motor platform), but its perception by a person is determined by the capabilities of the robot itself.

This implies the problem of the subjectivity of the robot or the implemented models of artificial intelligence. The discussion of this issue began with A. Turing, who replaced the question “can a machine think” with an operational test of what is considered to be a mental act. This attitude marked the beginning of the philosophical direction of functionalism and was of fundamental methodological significance for the entire course of the development of artificial intelligence and many branches of scientific knowledge.

In analytical philosophy, this direction was developed in the works of H. Putnam and J. Fodor. It was subjected to critical analysis in the works of J. Searle and T. Nagel. They criticized machine functionalism for ignoring epistemological issues of value and meaning, emphasizing the computer's lack of understanding of the meaning of perceived reality. For an extremely simplified interpretation of the concept of natural intelligence. These philosophers expressed fundamental objections to the creation of machine intelligence, which has capabilities comparable to human thinking.

Doubts about the possibility of creating a strong artificial intelligence received empirical support in the 70s of the twentieth century in connection with the description of the so-called “uncanny valley” effect, according to which a robot that has a significant similarity with a person, but is far from being identical with him, is naturally rejected by our psyche as a subject and does not deserve the same trust as in communication with a person (M. Mori, K. McDorman and V. Hanson). The difficulties of creating not only natural, but also artificial general intelligence (and the corresponding type of robots) have been repeatedly discussed in philosophical and specialized literature, without reaching a generally accepted solution.

A. Turing did not rule out the creation of embodied physically intelligent machines, but did not see the technical possibility for their implementation. Functional approaches, to the development of which A. Turing made a great contribution, opened up new broad prospects in solving theoretical and methodological problems not only of artificial intelligence, but also of neuroscience, psychological and social disciplines, and many topical interdisciplinary problems. Nevertheless, the paradigm of functionalism allowed various interpretations, some of them were behaviorist or reductionist in nature, in which the role of the problem of consciousness was excluded.

The phenomena of consciousness were considered superfluous for solving problems of artificial intelligence, or they were identified with functional processes, reduced to them, as in the case of some representatives of analytical philosophy (D. Denet). The interpretation of the uselessness of consciousness, close to the behaviorist attitudes, was also inherent in A. Turing.

At the first stage of the development of artificial intelligence, it did not slow down research. Tasks are described in terms of functional relationships, on the basis of which algorithms and programs are developed. The program is loaded into a computer, and the problem is solved, and the results are practically used. A similar methodology has been retained by most specialists in the field of artificial intelligence to this day, since consideration of the phenomena of consciousness is not a necessary element for the implementation of practical, highly specialized applications.

The creation of universal artificial intelligence and robotics based on its use requires different approaches and new methodological solutions. After the appearance of the first intelligent robots with cybernetic feedback and building their own dynamically adaptable models, the operationalist approach of A. Turing began to be transferred to robotics. The list of typical artificial intelligence activities formulated by A. Turing already in the early 1950s (games, cryptography, language learning, translations, solving mathematical problems and verbal interaction) has expanded significantly. This approach has resulted in a large family of private Turing tests that attempt to answer the private question: "can a machine perform a certain action?".

Particular Turing tests are loosely ordered, do not have a unified methodology, and need to be classified. This task is an important condition for the development of post-Turing methodology.

Particular Turing tests are classified into four classes of techno-umwelts, located along two fundamental axes: virtual-physical and non-verbal-verbal. Thus, it can be shown that all private Turing tests created earlier or created in the future are classified according to four techno-umwelts that form the Turing space of human-machine interaction: 1) virtual verbal; 2) virtual - non-verbal; 3) physical - non-verbal; 4) physical verbal.

Each of the spaces is characterized by a slice of perception and a set of available actions, which are manifested in a particular Turing test, which is passed by a robot capable of acting in a given techno-umwelt. The space in which the techno-umwelt robot operates is initially limited for it. Turing's methodology was based on a behavioral approach that implied the exclusion of consciousness and the observer. What is important is not what kind of answers (or actions) the machine gives, but what is important is that it gives answers (actions) similar to a person for a similar situation. However, this reveals a fundamental barrier that must be overcome in order to get out of the limitations of the paradigm of machine functionalism, which has become the basis of the Turing methodology.

Overcoming the shortcomings of the Turing methodology can become the basis for achieving significant progress in the field of artificial intelligence and robotics. The Turing wall separating the subject of the test (judge) and the object of the test (human or machine) is a fundamental epistemological barrier to the development of artificial intelligence and intelligent robotics. The reason for this is that the wall forces the robot (and indirectly the creators of robots or artificial intelligence) to implement only those tasks that can be solved by the robot in complete isolation from the person.

However, modern research in various areas of human-machine interaction (V. Unhelkar, J. Sha) suggests that the maximum effect from the use of robots or artificial intelligence is achieved through joint use, collaboration of man and machine. The separation of man and machine in operationalist comparison is an unnecessary constraint that hinders the development of the entire field of artificial intelligence and the anthropological transition.

It is necessary to compare the effectiveness of the actions of the joint work of artificial intelligence and a person, in contrast to the effectiveness of the actions of a person by himself. Rigid mutual opposition and mutual exclusion generates an insoluble conflict that hinders the solution of the problems of creating a general artificial intelligence. The concept of embodied artificial intelligence is reflected in the works of R. Brooks and B. Herzl.

The design of specific systems should include the possibility of sequential actions in different "techno-umwelts", remaining within the same architecture and one robot or artificial intelligence system. This significantly increases the complexity of the task due to the universalism of the developed systems. A wider use is required to create appropriate cognitive architectures of the results of phenomenological research.

It is theoretically possible that a system capable of perceiving the world and acting in all four types of techno-umvelts. She may have her own consciousness. A system operating in only one type of techno-umwelt is in principle incapable of possessing consciousness, since it cannot abstract phenomena and independently create concepts. Using the results of the phenomenology of consciousness and achievements in the field of neuroscience research is a necessary condition for building new post-Turing cognitive architectures for creating intelligent robots and general artificial intelligence.

The application of post-Turing methodology in the creation of an experimental intelligent robot-TV presenter is considered. A. Turing proposed to create intelligent machines that work only in one type of umwelt "virtual-verbal", the operating space of which is limited only by the reception and transmission of symbolic verbal information. It was possible to create and patent an experimental robot that made it possible to combine two "techno-umwelts" - the traditional "virtual-verbal" for the Turing test and the new "techno-umwelt" - "virtual-non-verbal", previously used only in computer games.

An intelligent robot is a virtual humanoid that has a virtual humanoid body endowed with facial expressions. It can use natural language, is autonomous and does not require operator actions when performing basic functions. It has its own persona depending on the persona of the chatbot and has the primary ability to learn from changes in the outside world. The intelligent robot implements face recognition of the interlocutors of the robot. The architecture of an intelligent robot is described. When constructing the robot, a number of characteristics of the subjective reality of a person (studies of the phenomenology of consciousness) and a complex of external manifestations of human activity - facial expressions, eye expression, gestures, voice intonations were used.

In this context, ethical issues are considered. It is one thing when it comes to the indistinguishability of the behavior of a human and a robot by a human observer in some specific cases, another aspect when it comes to the actual identity of a human and a robot. In the context, a global question is raised about a new stage in the development of robotics, when a robot acquires an increasing number of human abilities, can reach the level of a person and then surpass him.

Modeling and programming the properties of robots that would meet legal and ethical principles, completely exclude their aggressiveness and unfriendly intentions, will require the creation of virtual people in the form of computer programs that will emotionally identify themselves with people, have the features of human self-consciousness and identity.

The issues of using such robots in the fields of education, production and entertainment are considered. These are questions about the creation of autonomous virtual teachers based on the personal, including genetic, characteristics of students, or, for example, copyright issues for works of art created by robots, including products based on digital twins of famous personalities.

The question of how to draw the line between human and technological intelligence is raised and discussed if the level of general intelligence is reached. All this testifies to the growing role of philosophical and methodological approaches in solving the problems of developing intelligent robotics and artificial intelligence in general.

This is associated with the development of post-Turing methodology. Based on the developed conceptual approach, it is possible to achieve significant results: in the construction of new hybrid cognitive architectures for general artificial intelligence and intelligent robotics; in the development of effective operational tests to measure progress in the creation of new types of robots and artificial intelligence technologies; as well as in a more thorough understanding of the future communications between a person and a robot and issues of an ethical approach to the creation of general artificial intelligence.

2.31 Philosophy of Internet Generations

The digital ecosystem is focused on creating added value by optimizing data and workflows from internal departments, tools, systems, as well as from customers, suppliers and external partners. It removes obstacles and empowers every member of the ecosystem to use technologies and systems to meet corporate needs. The formation of platforms is exponential and ahead of the traditional market. Under such conditions, the mentality of ecosystem participants must be very dynamic. This is because ecosystems must quickly adapt and respond quickly to changing market dynamics, otherwise the user base will move forward and switch platforms. Business intelligence, rapid decision making, and the use of new technologies and business models are at the center of every decision. This feature is applicable to the thinking of youth.

It is important to accumulate the human capital of generations Y and Z in the field of high technologies. Millennials work on the principles of subordination, meeting deadlines and understanding corporate responsibility. You can count on representatives of this generation, because they are characterized by diligence, patience, bringing projects to the final implementation.

Millennials are next to generation Z. The situation of interaction between generations before the digital and digital eras also remains. Baby boomers and X continue, despite their age, to occupy key positions in the management of the state, companies and banks. For the older generations, the situation of the loss of the traditional scheme of authority is obvious. This aspect is updated in the studies of M. Mead. The monopoly of authority lost by older generations created the problem of mutual adaptation of generations to each other. It is difficult for older generations to recognize the right of younger generations to be able to manage the key institutions of society.

The topic of understanding communication has become relevant. It aims to preserve the constructive environment of the business process. The understanding setting of consciousness is the setting of value consciousness. Generation Z can't stand being alone. It is constantly in contact mode in the social network.

Understanding for him means the possibility of dialogue, including in the format of historical consciousness, which has a digital modification. This modification is consonant with the general process of youth socialization. The individual's behavior is shaped by reaction through text and image. In the process of communication, a special role in the dialogue is assigned to the sign.

The sign stimulates dialogue and forms the basis of feedback in the form of verbal communication. In the process of operating with a sign system, the primary mental processes of memory, attention, and thinking are transformed into sociocultural processes. Therefore, socialization methods should be focused not only on the present and past of culture, but also on the factors of anticipatory reflection of reality, knowledge that create the prospect of creativity, self-realization and self-identification of the individual in specific research and design niches of the future.

A special role belongs to childhood, within the boundaries of which the individual appropriates the main array of cultural values that form his creative resources. The coordinates of understanding are at the point of synergy, consensus, participation, experience, the formation of ideas, projects, programs of joint activities and social activity. In this process, there are stages of adaptation to the emerging situation of dialogue, understanding of the organizational structure and social hierarchy, transformation of the discussion platform into a space of opportunities for dialogue. Communication processes are regulated by cultural resources accumulated by the participants in the dialogue. In a relaxed environment, the ability of each individual participant to remain faithful to the dialogue and resist the egoistic desire to turn it into a monologue is tested.

The multicomponent nature of the dialogue situation determines the presence in the space of the individual consciousness of young people of emotional experiences, jealousy, and claims to leadership. In a dialogue situation, there are high risks of conflict situations motivated by the ambitions of individual participants. An important factor in shaping the strategy of generations has become the tendency to strengthen the role of information about risks in the field of politics, economics, and ecology in modern society.

Generations Y and especially Z have become characterized by fear and uncertainty about social stability. The pandemic has exacerbated that uncertainty and uncertainty. In these conditions, it is important for older generations to demonstrate confidence and readiness for dialogue.

2.32 Philosophy of Identity in the Digital Age

The values of interpersonal communication have always played an important role in the social life of people. At the same time, there was no acute issue of the threat of loss of identity in the process of continuous communication with other people. The problems began to become actual in the context of the growing opportunities for freedom in the information space and the security of users of this space, primarily the protection of their privacy.

As a result, the possibility of individual self-realization began to be accompanied by the problem of maintaining identity with oneself. This problem was specialized through the concept of Internet identity, within which the issues of self-sufficiency of the individual in the interactive space of information, dialogue are analyzed. This space is saturated with simulacra, manipulation technologies, shadow interests.

From the point of view of humanism and anti-humanism, social networks are ambivalent, like classical culture, which uses legal and moral standards. But while these networks were being formed, the criteria of responsibility were not applied to them. Users enjoyed a more valuable opportunity for them - freedom, their own positioning. To implement it, they actively use the images of heroes, plots, behavior, semiotics, game practice of virtual solutions that exist in popular culture. Practically no one noticed that in the atmosphere of the samples continuously set by the Internet for individual consciousness, the basic dominants of the personality's self-identity with a specific life world were being tested at the micro level. The key issues were the adequacy and authenticity of everyday life, its transformation in the context of technogenic factors of artifact emancipation (computer, mobile and multimedia).

Technogenic innovations at the consumer stage of their implementation have created marketing technologies for actively influencing the basic structures of individual consciousness at the level of everyday life. Branding has become one of the technologies for testing individual identity, since through utilitarian reality it has become associated with a certain lifestyle, social stratification. In such a situation, it was important to discover the boundary between borrowings and identity stability. It became obvious that many generations of marginalized people faced an identity crisis. Those who saw this as a stable trend formed the social basis of neoconservatism, radical nationalism. These features have been developed at the multicultural level of social life. As a result, identity began to synthesize content that became characteristic of individual and social consciousness. These trends indicate a significant transformation of the mechanisms of cultural determinism.

The most convincing essential manifestation of the self-identity of a social system is economic identity. It is constituted through the mechanisms of industrialization and modernization. At each of these stages of activity, methodology plays an important role. The search for this methodology is carried out by national and regional economies. One of the latest discoveries is related to the methodology of cluster structures, corresponding to the solution of the problems of effective use of the modernization potential.

The methodology of the cluster approach is based on the idea of system-technical design of the space of activity, the creative environment, within which the production and logistical contingency of the structures of the innovation cycle is achieved, and the safety of the social environment is ensured. Classical philosophy fixed the features of individualization of a person. One is designated by Socrates. He connected the concept of freedom with moral responsibility, the right to choose and make decisions, to conduct a dialogue based on thinking and arguments of reason, to construct one's own essence, to help others, to independence from nature.

G.F. Hegel, K. Marx, F. Engels introduced the concept of freedom into a dialectical context, practical activity. Supporters of F. Brentano asked the question about the inner world of a person and his motivational basis. They were also interested in certain statistics of the growth of neuroses and stresses caused by the intensification of social life. All this created the conditions for researchers and practitioners to enter philosophy. One of these young people was Z. Freud.

He analyzed not only his own practical experience in treating patients, but also got acquainted with the methods of work of other practicing doctors. In Paris, he collected additional information on the problem of interest to him and came to the conclusion that the basis of the internal motivation of the individual are both social and mental factors of motivation arising from the characteristics of sexual education. The idea had the form of a hypothesis and was presented in the works "Interpretation of Dreams" and "Psychopathology of Everyday Life". It was she who formed the basis of the concept of psychoanalysis.

Z. Freud showed that philosophy needs to study the aspect of freedom more not from the point of view of the external relationships of the individual, but his inner world. It is here that the secrets of limited freedom lie. This limitation makes many individuals enemies of freedom and pushes them to cultivate the institution of the crowd, the masses. The fear of freedom feeds on internal complexes that individuals cannot cope with, do not want to, and even use as a tool to suppress the individual freedom of other people. At the same time, the arguments of thinking give way to affects. The triumph of affectivity means the destruction of the internal organization of the mass and its transformation into a crowd. Socialization results in the fact that a person is not so much established in his individuality as fits into a certain form of culture and becomes a transmission device. It is not so much dignity as dependence that prevails in it.

The main task of philosophy is to free a person from paranoid dependence on Western influence. This is necessary in order to reveal the inner possibilities of historical memory. They are contained in singularities that spontaneously generate the content and self-organization of the individual and the culture he creates. Individual singularities create a rhizomorphic social environment as an alternative to paranoid structuredness. In this environment, mismatch and dysfunction take place. They do not so much threaten to unbalance the system as they create conditions for branching and diversify the range of system capabilities. These possibilities are revealed in the form of modernizing particular structures. Recognition of the heterogeneity of culture means the definition of its new mechanism of functioning, in which there is no central western root and trunk.

F. Guattari and F. Deleuze proposed to see the basis of culture in a tuber, or bulb. In this case, we do not know strictly unambiguously in which direction the stem will break through, we only know that it will and cannot know with the accuracy of the toponymy of budding. In this pluralistic space, a person can acquire the necessary sense of freedom and responsibility, significance. It can become one of the key singularities that works fruitfully at the macro level. The main thing is that his natural desires find the necessary socio-cultural conditions.

The rhizome socio-cultural space is rather a desirable background for the self-realization of humanity. In reality, there is a Western culture built on the principles of simulation and manipulation.

Simulation is brought to life by a whole range of reasons, primarily economic ones. The practice of producing simulacra has become characteristic of the financial sector (financial pyramids), cinema, and gaming culture. As a result, the virtual reality of simulacra occupies an increasing place in the space of culture. Simulation, advertising, show industry reflect a certain anthropological split of modern society into those who see the essence of social processes and those who follow the dictated prescriptions of Western political technologists. Some have freedom, others have virtually no privacy.

Consumer fantasies are disproportionate to the business qualities of Internet users. It is on this basis that the marginal culture of pogroms and immoral behavior is formed. Z. Freud, J. Orgega y Gasset once wrote about the threat from marginal dependency. An analysis of the modern information space shows that the individual freedom of social network users is not supported by the necessary level of moral and legitimate behavior. Freedom therefore remains outside the context of security.

Interactive technologies create the appearance of the maturity of modern society. At the same time, the facts of the unarmedness of individual consciousness remain obvious. In addition to the formal right of freedom, this individual consciousness does not see the presence of value problems in the space. The individual found himself in a social space where the standards of mass culture play a role, which determine the pursuit of money, brands, and the standard of living of the middle class. As a result, difficult times have come for identity, since in the environment of its presence the positions of conflict consciousness and nihilism are strong.

2.33 Philosophy of technology and futurology

In the structure of non-classical philosophy of technology, the aspect of the technological future plays an important role. This aspect reflected the fears of mankind for the loss of a leading role in the system of human-machine interaction. Man, by his own efforts, can make himself an intermediate link in the evolution of the Earth's space. So, he has already created the noosphere, which exerts anthropogenic pressure on the biosphere.

It is also actively creating a technosphere, in the space of which it is gradually giving way to artificial intelligence. But this gradualness may be replaced by a technological singularity.

Another aspect of concern about the future of humanity is related to employment prospects, the growing digital divide. These are the social aspects of concern. There are also environmental aspects of concern, since the technosphere significantly affects the dynamics of climate processes on the planet.

Within the space of the Earth, there is another disturbing aspect of futurology. It is associated with the continuing practice of geopolitical confrontation of mankind, which is carried out in the presence of destructive nuclear technologies of the military-industrial complex. The two world wars showed not only the dynamics of the growth of the variety of weapons, but also the dynamics of the growth of crimes against humanity.

The behavior of the Nazis in the occupied territories of the USSR was especially cruel. Especially in difficult conditions of occupation were the western regions of the USSR. The Nazis carried out the genocide of the Belarusian people. It was expressed in the mass executions of civilians, the burning of villages, the functioning of concentration death camps. Children and the elderly were used by the Nazis in the front-line concentration camps as human shields. The children were used to donate blood.

China suffered huge civilian casualties during the Second World War. Scorched earth tactics were used by the United States during the Vietnam War.

Terrorist organizations in different regions of the planet were distinguished by cruelty. Significant human losses from terrorist attacks were suffered by Russia, the United States and Western Europe. It became obvious that a certain part of humanity is the bearer of a conflicting aggressive consciousness. Under the conditions of this factor, technical and technological developments will create additional risks for the evolution of mankind.

2.34 Philosophy of engineering ecology

Engineering ecology is represented by a new industrial paradigm, which was the result of the adaptation of the activities of industrial companies to national legislation in the field of ecology and environmental protection. The legal aspect of environmental protection, followed by significant penalties, turned out to be relevant for oil and refining companies. Sufficiently stringent environmental engineering criteria have been introduced for manufacturers of automotive and aviation equipment, as well as for the chemical industry and energy.

Energy and industrial companies have attracted increased attention to themselves due to major accidents at nuclear power plants, in the offshore oil production area, and the failure of engines installed in cars and trucks to meet environmental standards. Civil society organizations have formed that detect environmental engineering threats and publicize them. This applies to the transportation of spent nuclear fuel from nuclear power plants and nuclear repositories. This concerns the regulation of the activities of agricultural companies and farms. This also includes the issues of spilling oil and oil products in the waters of the oceans and on land.

Legal and civil instruments of influence on industrial activity have formed a trend in the development of entire areas of engineering science in the field of alternative energy, green economy, industrial technologies for recycling and recycling of resources. Developed and implemented projects for the collection and processing of secondary industrial and domestic resources.

In the energy, industry and municipal services of cities, circuits have been developed to reuse water resources using special filtration and cooling technologies. In mining, the design of quarries and mines involves taking into account their full life cycle, followed by reclamation of the area.

At the level of philosophy, the ideas of engineering ecology were formulated at the beginning of the 20th century by scientists from the University of Chicago. The basic principles of the philosophy of environmentalism were formulated by R. Park. He proposed to consider the urban environment as an organism. This organism must have a respiratory system (ventilation system) and a waste disposal system (sewer system). With this consideration of industrial Chicago and the Great Lakes, a number of projects became necessary. One of them concerned the need to link the direction of the streets with the air currents in which the city is located. The second project involved the creation of a sewer system with the discharge of filtered water into the Great Lakes. As a result of the project, the water environment of the Great Lakes has improved.

One of the options for implementing the tasks of engineering ecology has become the methodology of the cluster approach. It assumes the presence in the immediate vicinity of various industries and energy facilities. As a result of the convergence of technological flows, the wastes of some industries become resources for other industries, in particular, for the construction industry.

2.35 Ecosystem sustainable development goals

The sustainable development goals imply reliance on systemic structures. Ecosystems are such system structures. The concept of an ecosystem used in biology and ecology has been introduced into the terminological apparatus of the economic and managerial spheres. J. Moore suggested using the term "business ecosystem" to refer to the social environment of an enterprise, the elements of which are participants in business processes. This definition is relevant for the educational process at a technical university, in particular, at the Belarusian National Technical University, where engineers-economists are trained.

D. Eisenberg described the environment in which the institution of entrepreneurship is developing. This environment is shaped by government policy on small and medium enterprises, financial capital, entrepreneurial culture, technical support, human capital and markets. The quality of entrepreneurship in the country depends on the level of development of the environment. The entrepreneurial ecosystem includes a startup ecosystem, a venture ecosystem, a university ecosystem. As well as a business ecosystem as a set of own or partner services united around one company. The ecosystem is focused on the parameters of sustainable development. In it, buyers and producers occupy complementary roles, co-evolving in the space of the ecosystem.

The economic community produces goods and services of value to the consumer that are part of the ecosystem. The ecosystem also includes suppliers, leading manufacturers, competitors. They co-evolve their capabilities and roles and strive to meet the parameters of sustainable development, despite the rotation of roles. B. DeLong defines business ecology as a more productive set of processes for the development and commercialization of new technologies. This includes rapid prototyping, short product development cycles, early test marketing, option-based compensation, venture capital funding, early corporate independence. The application service provider industry is based on centrally managed, hosted and delivered applications negotiated with end users. Companies that are willing to co-exist in an ecosystem contribute to the inevitability of delivering applications over the Internet.

Business ecology is defined as a new area for sustainable organizational management and design, based on the thesis that organizations, as living organisms, are most successful when their development and behavior are consistent with their core purpose and values. Business ecology is based on the elegant structure and principles of natural systems. For the development of ecosystems, leaders are relevant parameters of the ecological environment.

Economic ecology involves the study of the mutual relationship between business and organisms and their environment. The goal of business ecology is sustainability through full ecological synchronization and integration of business with the sites it inhabits, uses and affects. Platforms and digital ecosystems are promising. Ecosystems span many industries and include different industry sectors, partners, competitors, customers, and businesses.

In connection with the development of digitalization and information technology, a new use of the term ecosystem has appeared. An ecosystem is the interconnection of all the services of a company. Multifunctional mobile devices have created a unique social environment.Each structure seeks to create its own ecosystem and make it consistent with the parameters of sustainable development. Digital ecosystems use the principle of one window, working in a single mobile application; as the amount of data grows, they adapt to the requirements of the client. They form a single client profile; summarize information about acquisitions in the ecosystem; form a targeted offer to the client; allow removing geographic restrictions for business development for small and medium-sized producers of products and services.

Ecosystems require regulation. There are risks of unfair competition, discrimination of participants, monopolization of technologies, misuse of personal data of clients, insufficient level of information security and protection against fraud. Digital ecosystems are constantly expanding the number of participants. This led to the rapid creation of services. The advantages of these services were that they were the main users and received packages faster, had access to music, and could even watch series and movies from the main library.

Ecosystems have attracted many outside companies to participate in their space. This allowed competitors to use the infrastructure of services and tools offered by the company. It brought success.

The digital ecosystem is focused on creating added value for customers by optimizing data and workflows from various internal departments, tools, systems, as well as customers, suppliers and external partners. It removes barriers to the customer's journey and empowers each member of the ecosystem to use modern technologies and systems to meet their individual needs.

The ecosystem offers customers a single, easy-to-use system that delivers value through a variety of services, products, and knowledge. This allows platforms to grow exponentially and outperform the regular market. When scaling an ecosystem, different business models are possible. From direct sales of products and services to advertising. A better understanding of the consumer and the reorientation of product offerings allows you to increase the number of services and products offered due to the number of ideas received from customers.

This makes digital ecosystems so powerful, and also so profitable, that the list of the most valuable companies in the world is topped by companies that harness the power of digital ecosystems. Companies use their customer base and ecosystem approach to increase revenue and offer better products and services to their customers.

The described features of economic ecology do not diminish the role of the traditional ecology of the biosphere. The formation of a new direction in ecology is determined by the goals of sustainable development of mankind and the characteristics of digital generations, since the presence of a dynamic balance in both ecosystems is an important condition for sustainable development. This thesis transformed the approach of the Department of Philosophical Studies to providing students and undergraduates of the Belarusian National Technical University with electronic publications. The semantics of the presentation of the material has changed. It clearly emphasizes the co-evolution of ecosystems in the space of smart society and smart industry.

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