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# TECHNOLOGY OF DIGITAL ECOSYSTEMS

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***Abstract.*** The phenomenon of technology is considered in the context of its presence in natural and artificial ecosystems. Accordingly, the features of the evolution of technology under the influence of the co-evolutionary model of human life, developed under the impression of the growing risks of destruction of the dynamic balance of the biosphere, are revealed. It also describes the features of the evolution of technology in artificial ecosystems based on convergent technologies. The possibilities of pairing the priorities of minimizing the anthropogenic pressure of the technosphere on the biosphere with smart technologies are analyzed.

**Keywords:** technology; ecosystem; coevolution; biosphere; dynamic equilibrium; convergence; smart technologies.

# ТЕХНОЛОГИИ ЦИФРОВЫХ ЭКОСИСТЕМ

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***Аннотация.*** Феномен техники рассмотрен в контексте его присутствия в природных и искусственных экосистемах. Соответственно выявлены особенности эволюции техники под влиянием коэволюционной модели жизнедеятельности человечества, разработанной под впечатлением растущих рисков разрушения динамического равновесия биосферы. А также описаны особенности эволюции техники в искусственных экосистемах на основе конвергентных технологий. Проанализированы возможности сопряжения приоритетов минимизации антропогенного давления техносферы на биосферу со смарт-технологиями.

**Ключевые слова:** техника; экосистема; коэволюция; биосфера; динамическое равновесие; конвергенция; смарт-технологии.

The term «ecosystem» was originally developed in the subject field of biology for the systemic consideration of the local environment of the biosphere, taking into account the dynamic diversity of organisms evolving in it, creating a dynamic balance within a specific geographical landscape. The biological ecosystem model has been tested on the planet for billions of years. As a result, it has reached a level of high self-organization and adaptation to the geographic environment and climatic changes.

In the course of the evolution of the biosphere, man as a generic creature became one of the organisms of natural ecosystems. According to archeological data, the evolution of this generic creature began in the local area of East Africa (finds in the Olduvai Gorge). Subsequently, communities of people through migration became part of most local ecosystems of the biosphere.

Communities of people began to modify biological ecosystems through the practices of animal husbandry and agriculture. By means of breeding technologies, they have created an additional biological diversity of plants and animals, as well as a biological environment for agriculture and a sedentary lifestyle in the form of urban-type settlements. A new type of socio-natural ecosystems was created. It began to exert anthropogenic pressure on biological ecosystems as forest areas began to decline. Nomadic livestock breeding drove wild populations out of the steppes and deserts. Technique in the form of tools, soil cultivation technologies and urban construction has become one of the tools for people to construct new ecosystems.

Agricultural civilizations have made plants and animals part of their social space. Some of them satisfied the needs of people for food others ensured safety, transport functions, and provided wool and leather. Socio-natural ecosystems were, despite the agricultural basis, in the risk zone. This is evidenced by the facts of the death of traditional civilizations. In order not to find itself in the irreversible process of death, the civilization of the medieval West was transformed into a technogenic civilization. Science, industrial technologies and market economy became the basis of its development. Having overcome the geographical isolation, part of the European population migrated to the New World.

Industrial industrial technologies created special local urban ecosystems that excluded agricultural activities and were based on a clear division of labor and a huge consumption of minerals. This immediately affected European urban ecosystems. Due to the high population density, wooden buildings, lack of sewerage, they have become a site of epidemics, a high concentration of chemical emissions in the urban air and water environment. North American cities soon faced a similar situation.

At the beginning of the twentieth century, representatives of the Chicago School, in particular, R. Park, proposed a methodology for considering the city as a living organism, with its characteristic systems of life. As a result, in the applied part of this methodology, a project was proposed for modernizing the urban environment of Chicago, taking into account environmental factors that contribute to the dynamic balance of the urban environment through the effective use of aerodynamics of air flows and sewer systems.

In the 60s of the twentieth century, a global situation of ecological catastrophe was established, due to the peculiarities of industrial technologies. The international theme of maintaining the dynamic balance of the biosphere was formulated. International protocols have been adopted. But the key issue was the modernization of energy and industrial technologies to meet recycling standards. These are expensive projects. Therefore, a significant part of the world's population hopes for the potential of self-regulation of the biosphere in the face of growing anthropogenic pressure on it.

Due to significant financial costs and because of the financial insolvency of most developing countries, in a practical aspect, they talk about ecology only in the zone of the golden billion. The former Soviet republics faced a similar situation of choice between new technologies and the costs of liquidating the consequences of industrial accidents. The reason was the accident at the Chernobyl nuclear power plant. The Republic of Belarus was forced to allocate more than $ 25 billion for the elimination of the consequences of this industrial accident over 20 years.

At the level of theory, the topic of ecology has become relevant in the categories of nature, man and technology [1]. The emphasis also began to be placed on the ecosystem as a fundamental category [2]. The aspect of ecosystem sustainability was highlighted [3]. The topic of co-evolution of natural and social systems turned out to be in demand [4]. A tendency in the dynamics of the ecological knowledge system towards socio science was revealed [5]. Initially, this shift looked like the study of the human community in terms of biology [6].

After sociology, the terminological apparatus of biology began to be used by economic and management sciences. The reason for turning to this terminology was not ecology, but the search for effective models of economic and managerial activity. This search was pushed by the resources of information technology created by mankind, and then by the sanitary and epidemiological isolationism of the covid era.

Representatives of economic discourse consider the ecosystem as a specific methodology for building business processes based on a systematic approach, the potential of a smart industry and convergent technologies. We take into account the communication functions of high technologies, the elements of which are technical devices integrated with digital platforms. The smartphone has become the main input device into the ecosystem for users of products and services. The convergence of local systems of engineering and technology is provided by integrated automated information systems.

The digital ecosystem is beneficial for users of goods and services in that it responds online via a smartphone to almost the entire range of customer needs, including the delivery of services and goods to their location. Digital ecosystems are beneficial for companies and banks, because they allow them to implement an individual approach to the client, study his needs and promptly respond to requests from the client base. This base can be hundreds of millions of users.

Digital ecosystems run in a single mobile app. They adapt to the client's requirements due to the fact that they form a single profile, summarize information about his purchases. They function through a targeted offer to the client. For small and medium-sized companies, they are open for joint activities.

Structurally, the digital ecosystem consists of a set of platforms that provide various products and services, online and offline services. Ecosystem interaction systems require regulation, since there are risks of unfair competition, discrimination of participants, technology monopolization, unlawful use of customer personal data, and an insufficient level of information security.

The open status of the digital ecosystem makes it possible for an ecosystem-leading company or bank to collaborate with other companies interested in increasing sales of their services by using the brand of the digital ecosystem. As a result, there is a diversification of services and goods, which increases the growth prospects of the ecosystem of the customer base.

Companies began to create their own local ecosystems based on a digital platform connected with applications. As a result, the user is able to satisfy various needs, the list of which reaches large values. This is not only the purchase of traditional goods, but also the Uber — economy, music, service, transact.

The term «innovation ecosystem» was in demand, since it updated the mechanisms of constructive dialogue between developers and potential investors through digital platforms. The products of the digital ecosystem are based on a smartphone with which the rest of the ecosystem is integrated. These include watches, headphones, fitness bracelets and laptops.

In the digital ecosystem, the goal is to combine different technical devices so that they complement each other. At the same time, we are talking about simplifying the interaction of units of equipment with each other by the parameter of automatic data exchange between devices. A uniform experience in the use of technology is being formed. A cloud service performs the function of linking system components into a single interacting mechanism. This address book is common to all devices. Documents are stored in the cloud and are available on all devices in up-to-date versions. The organizer is available for all devices. Basic programs: Notes and reminders are available on all devices. The web application allows you to work with mail, calendar, notes, reminders in any browser, gives access to document files. Photos are stored in shared cloud albums.

Music is stored locally on a computer, backed up in the cloud, synchronized with players, tablets, phones. Services for the exchange of text, photo and video messages between devices, and its own video telephony have been created. And also an application store, access to content from a TV, a protocol that allows you to transfer images and sound of portable devices. Provided access to the library and mobile content co. Synchronization of technical devices with Wi-Fi has been carried out.

The new business process strategy determined the evolution of technology in the paradigm of converged technologies. For information systems engineers, it is obvious that the development of information technology is not limited to the penetration of connected devices into all areas of activity. It is important to form a technology ecosystem in which solutions for collecting, transferring and analyzing data circulate on a platform that allows you to extract knowledge and use it to implement solutions.

The development of information technology is determined by several trends. First, the cost of computing power has dropped. Processors, memory, and storage are cheaper. Secondly, data transmission costs have decreased. Thirdly, there is a rapid growth in the number of connected devices and sensors. Fourthly, cloud technologies provide flexibility in storage and analysis as the amount of accumulated data increases.

A technology ecosystem, a set of relevant tools and a platform allows you to use data to implement smart solutions. The creation of such largely depends on the effectiveness of the introduction of technologies and the benefits that companies representing a particular field of activity expect. The effectiveness of this work depends on the technical departments. They function in the structure of corporate organizations. Their task is to protect current operations through gateways and data encryption.

The intersection of digital ecosystems is used. For example, cash payment programs have evolved into an ecosystem element of mobile, social, information and banking services. The Internet of Things has also become an ecosystem as a number of applications interact with each other. Access to one ecosystem makes it possible to connect to other network components, expanding the customer base with new sources of information.

The nature of the digital ecosystem precludes focusing solely on securing as such a tactic limits the company's ability to exploit new opportunities. Digital adaptation provides for the simultaneous convergence of external technologies, means of protection and methods of managing technological protocols

It is important for engineers to use a simplified version of the company's technological architecture based on micro services and APIs, which will allow third parties to connect to the new ecosystem. On the app platform, consumers will be able to choose the options they want when they have robust data privacy tools.

Ideally, all services should be connected into a single ecosystem that will offer the user a package of services through the universal technological backbone of the telecommunications company. Cloud development contains the ability to create authoring applications. The practice is to embed a third-party chat feature in customer support on the company's website.

The challenge for engineers is to think about how external, already available services can be used by the internal assets of the enterprise to create a market offer. It is important to complement the developed current processes with external specialization by changing the structure of information technology applications. It is the responsibility of engineers to test new technologies so that they can be prepared to use them in the event of positive results. Their role is great in the formation of partnerships and alliances with suppliers of software or other digital services in order to adequately assess the usefulness of technology in a particular industry.

To this end, financial services companies have formed internal corporate venture funds to promote tools such as the Internet of Things. When developing a technology platform, it is important to take into account the economic objectives of the corporate structure. The company's master data management directory should be expanded to include information from third parties, and care should be taken to enforce uniform database management standards.

In the case of a technical call from users, it is problematic to identify the location of the points of failure in the digital ecosystem, which will require the enterprise to restructure the infrastructure support processes. Agreeing on service principles with clear protocols for resolving conflicts and escalating risks is paramount to the stability of the enterprise. The creation of standard identifying tags, as well as their implementation in existing services of the digital ecosystem and third parties, is valuable for quickly identifying problems and making appropriate adjustments.

Increasing the internal information technology infrastructure through the inclusion of third-party partners and vendors involves the development of a new set of cyber security standards that clearly define the integration process and the types of data available for exchange. Working with third parties involves other legal issues. There are licensing issues between cloud providers and firms due to competing business models. Resolving conflicts requires negotiation skills and a wide range of information technology standards to avoid the constant rethinking of internal systems due to the emergence of a new partner.

Forging partnerships with a network of suppliers requires changes in skills certification and performance management. It is important to clearly define the rules and procedures by which suppliers are required to operate, with the introduction of the guidelines into the partner's internal policy. The digital environment provides for more active interaction with the outside world to understand competitive threats and

price policy factors. They start with the formation of an external application that is compatible with the internal information technology infrastructure.

As banks and companies rely on tools from external ecosystems, individuals with software expertise and experience in integrating technology into internal company resources are essential. The presence of such experts is essential to overcome the imbalance between the organization's business goals and the technological requirements of the digital ecosystem. Many companies have outsourced their integration functions. The tactics of forming an internal team of information technology architects are relevant. A digital ecosystem means the interconnection of all company services with each other. All devices are connected to each other by a common design, information technology platform, services, accessories, stores. All brand elements are united by a single value.

The design and development of the product was dominated by the concept of platform development by increasing their functionality. Companies created value by allowing other companies to use their products or create new products based on their services. As a result, most of the large information technology companies were formed. But platform methodology has boundaries. The main idea of the platform is to allow third parties to use the infrastructure as a vehicle for the distribution of value. However, this creates limitations. A good idea may not be implemented on existing platforms due to their locality. To overcome this limitation, information technology hubs are needed. Their essence is that products as they evolve open interchangeable interfaces that allow other products to integrate with them, creating value for people. This allows other products to use the product interface as an intermediary that will deliver value to the end user. Companies committed to providing a specific solution to meet customer needs do so with a product. This has two benefits.

The cost of the product rises without the efforts of the developers. Users can use more functions. At the same time, there is no need to allocate resources for their development, support, promotion and continuous improvement. Value creation and profit making are separate. Value is the priority. It is formed through interaction. The creator of the digital ecosystem, by allowing other products to use its user interface, creates new functions for users. They learn to do more things, spend more time in the service, leave data that will allow the creator of the ecosystem to make the product even better and turn it into a part of their daily life.

By allowing other products to integrate with its main user interface, the digital ecosystem offers features that its own developers would have to create. This significantly increases the value of the ecosystem for users. With its help, they can receive many services. Otherwise, they would have to use other applications and services. But this is not necessary. Users can read analytics reports, respond to customer requests, and call Uber using the same interface. Once accustomed to command logic, they can do almost anything they need to do. They get into the habit of constantly using the digital ecosystem.

This requires an interface and marketing effort to raise awareness of potential users and convince them to try the product. Developers can focus on building core functionality. This approach allows access to product functionality through any user interface. The idea of convergence of information and operational technologies arose in the 80$^{s}$, XX century, when personal computers began to be used in industry. Consider how the convergence of these technologies evolved.

Information technology companies are set to consolidate workloads for enterprises. This will allow the latter to optimize production and technological processes

simultaneously with management systems and become more competitive in their industries. Among the advantages of the convergence of information and operational technologies obvious great openness of the system, deterministic control in real time using multi-core processors, the use of web technologies and machine learning.

There is also clear benefit to machine control architectures. Advances in this area have led to changes in standardized chipsets, board designs and have given impetus to the development of complex operating systems. But industrial companies have stuck to traditional technologies.

The operating technology logic controllers used proprietary chipsets, proprietary board designs, and proprietary software. As a result, a technological gap has arisen in the development of digital technologies focused on consumers and production processes. National programs for the development of the industrial Internet and smart industry are trying to bridge this gap. One of these programs is Industry 4.0. One of the technological solutions was the introduction of industrial Ethernet protocols. The technology reduces the costs associated with switches and additional equipment by providing deterministic management of thousands of devices on the network. As a result, the functionality of industrial fieldbuses has increased. An important role is played by the use of multi-core processors, human-machine interfaces of web technologies and a simplified network protocol. Machine learning is applied. Converged service has become relevant. Any cloud service is a converged service in which telecom technologies are combined in the form of Internet access, network infrastructure, billing and the implementation of application functionality on the server, supporting the service of data center technologies, Internet protocols.

As a result, optimized technological hardware and software-hardware complexes have been created. They create conditions for solving specific problems. Synergy of technologies of social networks, geo-information services related to the location of the consumer and mobile devices and technologies.

Convergent technologies are the subject area of computer engineering. In applied terms, this is the area of computer systems engineering. It combines computer science and electronic engineering. A computer engineer is a specialist in computer networking and technology. Computer engineers have professional training in electrical engineering, software, and hardware-software integration. They do computations, from designing individual microprocessors, computers and supercomputers to circular design. Computer engineering functions include writing software and firmware for embedded microcontrollers, designing VLSI circuits, analog sensors, mixed signal boards, and developing operating systems. Computer engineers conduct research for robotics, with the aim of using digital systems to control and monitor electrical systems — motors, communications systems, and sensors.

One of the areas of computer systems is software engineering. To achieve results, software engineering integrates the principles of mathematics and computer science with engineering approaches developed for the manufacture of physical technical devices. She develops systematic models and reliable methods for the production of high quality software.

The economic ecosystems of the smart industry have a priority so far as they have opened up opportunities for optimizing their business and making a profit. This business does not ignore traditional environmental issues. She became part of the advertising dialogue with potential buyers. At the same time, the solution to the traditional

environmental problems of modernizing industrial and energy infrastructure remains dependent on the political elites and on their determination to insist on the inevitability of environmental responsibility for severe consequences for the environment. In the Russian Federation, one of the most recent examples was the elimination of the consequences of a spill of oil products in the industrial zone of Norilsk. The reason was the deterioration of tanks for storing petroleum products. Industrial companies find it hard to get used to the conclusion that upgrading infrastructure and communications is cheaper than eliminating the consequences of accidents on energy and industrial ecosystems. Without this understanding, there will be no prospects for reindustrialization, which implies the return of production in areas with high environmental expectations.

The pandemic has shown another side of the relevance of converged technologies. This relevance is due to the connection between the organism and the environment through the mediation of their constant companions in the form of viruses and bacteria. The sanitary and epidemiological ecology in megalopolises has become especially relevant, where a qualitatively new environment of dynamic equilibrium of the dynamic diversity of carriers and distributors of viruses and bacteria has been formed. The situation resembles the corridors of migration of epidemics to Europe created by the Great Silk Road. In this context, a new model of priority innovation ecosystems related to biotechnology is being formed in the structure of the world economy.

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