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Prospects of IoT technology

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Introduction. Internet of Things (IoT) is one of the promising innovative technologies. Every year more and more people are involved in the use of smart things. At the same time, a relatively small number of papers are devoted to the study of the social value of technology and the experience of human interaction with this technology. It is important to study the features and prospects of the technology, to analyze the attitude and willingness of people to use it.
Materials and Methods. We have conducted an Internet survey, in which special attention is paid to the place of IoT in the life of modern people, their attitude to the concept of devices. The obtained data is processed and systematized.
Results. The analysis of the survey results allowed us to draw conclusions regarding the attitude and willingness of young people to apply this technology. In the course of the study, the IoT concept was defined, the conditions required for the existence and functioning of the technology were described, the advantages of IoT technology were generalized, information technologies interacting with this technology were specified, the tasks that require solutions for the successful and effective implementation of IoT into Russian reality were listed.
Discussion and Conclusions. The Internet of Things is a technology that, with a consistent and systematic solution to a number of problems, can become a significant factor in the development of both individual spheres of life and activity, and the country as a whole. At the same time, it is important to study and consider the social impact of technology dissemination. This will increase trust in the IoT and eliminate negative impacts. The survey shows that young people tend to use smart things more widely. It is necessary to expand the range of smart things, to more confidently introduce the basics of practical application of IoT technology into educational programs, to discuss issues, ways to solve the tasks and pilot projects related to this technology widely in the media. This will enable to train not only people who are practically interested in IoT, but also qualified personnel who are able to solve problems in a new way.

Keywords: smart things, networks, innovative technology, IoT, Internet of things technology, online survey.

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Introduction. The Internet of Things (IoT) is a relatively new concept and a multidisciplinary field of activity, a revolutionary technology that consists in connecting people, devices, physical and virtual things, processes and systems that can interact with each other through data transmission using networks. The simplest example is the control of such things as a coffee maker, washing machine, air conditioning, indoor light switches, etc. via an application on the phone and the network. The implementation of such interaction is possible thanks to special means of identifying and measuring the characteristics of things, communication technologies that transmit data to the storage, as well as information technology that provides performing information processes for storing, processing, analyzing, presenting, and transmitting data to things.

The means of identifying things that are not connected to the Internet include radio frequency tags, optically recognizable identifiers — barcodes, Data Matrix, QR codes, infrared tags, and means of determining the location in real time. The means of identifying objects that are connected to the Internet network include the MAC address of the network adapter, which enables to identify the device at the channel level. The means of measuring the parameters of objects include sensors, smart meters, integrated systems. The means of data transmission include wireless and wired networks. Data processing tools include special applications, information and computing systems.

To implement smart things projects, a technical platform is required — a tool that will manage things and monitor their condition. A platform for remote monitoring and management of devices that have an Internet connection can be made, for example, in the form of a web server written in Java, whose prototype is called IOPT (Internet Of Pretty Things) [1]. Platforms can have free access or be commercial. Specifically, Intel ® IoT Platform is a platform for the Internet of Things in the automotive industry, energy, healthcare, industrial systems, retail, smart buildings and homes; SAP HANA Cloud Platform for the Internet of Things is designed for the transport industry, energy, construction, medical systems, retail, telecommunications, oilfield services, metallurgy, fleet management and asset management [2].

Interaction of smart things with the user is carried out through the interface, which can be made in the form of an information panel of the service, a mobile or WEB application.

Internet of Things devices are elements of equipment that have mandatory communication capabilities and additional capabilities for measuring, triggering, as well as data input, storage and processing. The device, as a rule, includes a sensor, a radio module, a microcontroller, an actuator, a power source. Sensors are sensitive elements that interact with the system, constantly measure the physical parameters of the system objects in real time and form a signal. They are combined into nodes and equipped with microcontrollers. A microcontroller is a simple computer that, receiving a signal from a sensor, implements the logic of the entire device. Microcontrollers read the information and, according to the algorithms embedded in them, send the information to the server. A sensor, e.g., can generate a signal about the reading once per second, and a microcontroller will decide whether to transfer data to the server and with what time interval to do it. An actuator is an executive device that switches the device by a signal from a microcontroller or by a remote command that can be received by a radio module. If the task of the Internet of Things is only to monitor the system, then an actuator is not required. And, conversely, when reconciliation tasks are performed, sensors in the Internet of Things devices are not needed.

Special application protocols are used to interact with all these elements and perform their tasks. There are many protocols due to various ways of organizing the interaction of the Internet of Things and a diverse element base. According to [3, 4], issues of standardization and practical implementation of these protocols are handled by international organizations (ITU-T, IEEE, ETSI, OASIS), non-governmental associations (oneM2M), alliances of manufacturers and operators (IERC, ISO/IEC), partner projects.

The use of the Internet of Things can create a number of advantages. Indeed, light sensors will provide saving electricity; smoke sensors — fighting smoking in public places; it will be possible to reasonably control the temperature in the room with easily controlled air conditioners and batteries; radio tags on cars will allow you to control cargo transportation; video surveillance system optimizes the activity of identifying outsiders and people who are late for work; medical sensors will allow you to measure the pulse, pressure and other characteristics of the human condition, which will simplify the diagnosis and increase the effectiveness of treatment; in the retail sector, timely acquisition of information about the preferences of the buyer will allow the company to adapt to his needs and requirements; in those industries where expensive equipment, perishable products are used, and financial or other risks arise, the analysis of up-to-date information from IoT sensors will reduce the risks. Thus, the use of the Internet of Things in many industries will provide comprehensive information in a timely manner in real time, the analysis of which can affect the quality of work to optimize it.

It is established that the American continent currently makes a greater contribution to health care and smart supply chains projects, and the European continent — to smart cities projects [5]. It is also known that IoT projects related to industry and intelligent vehicles, as well as smart cities and smart energy have a large market share today [5].

When considering IoT in detail, there are questions that require study and scientific analysis. First, the functioning of the IoT is associated with the formation of large volumes of information, which are called "big data" because of the huge flow of data. There is a problem of limited computing power, which is required for processing and analyzing big data on dedicated servers. The solution to this problem is to switch to cloud and fog/edge computing, which support such processing, monitoring and analysis in IoT systems [5].

Data management requires technology to protect them well from unauthorized access, cyberattacks, risks, and vulnerabilities. According to experts, insufficient authorization and authentication, insecure software, microcode software and web interface, poor transport layer encryption are important issues of trust in IoT technology [5]. Cryptographic information protection for mobile devices is an important step towards understanding the data protection of the Internet of Things. A key security goal in an IoT cloud application is to ensure that unauthorized users do not have access to sensitive private data coming from devices. The application must also prevent sending unauthorized commands to devices [6]. Approaches to data protection should be adopted through design development [7] and the formation of special optimal containers for the protection of IoT devices that can be printed on 3D printers [8].

Other problems include: the lack of consistent approaches and concepts of IoT, the presence of different ways to connect things to the network, the lack of microelectronics components, the high price of smart devices and systems, the lack of uniform standards for the production of equipment and data transmission protocols, the immaturity of hardware and software, high energy consumption of IoT systems, etc. Accordingly, the problem of interoperability, which arises due to the heterogeneous nature of various technologies and solutions used for the development of the Internet of Things, needs to be solved. These solutions are required at four levels — technical, semantic, syntactic, and organizational. They can be based on adapters/gateways, virtual networks/overlay [5]. The task of developing high-quality materials to create new IoT devices with lower energy consumption needs research [5].

Today, the Internet of Things is a set of networks that are still loosely interconnected, each of which solves its own tasks and works according to different standards, which creates difficulties when combining them into one network. A significant part of their equipment was designed for special purposes, so it is quite difficult to combine all systems using IoT, it takes time and money. It is difficult to make changes when production applications, business processes, user interaction systems and data are isolated and fragmented. But there are grounds for solving problems. These include the declining cost of computing equipment and data transfer technologies, the development of cloud technology, the increasing number of smart devices, the availability of networks. Technologies are becoming much cheaper and easier to use, therefore, there are fewer obstacles to their implementation. It is necessary to develop standards for communication, interaction, confidentiality, and security [2].

Materials and Methods. Industry analysis company Gartner estimated that 8.4 billion Internet-connected things were used in 2017, which is 31% more than in 2016 [9]. Every year, an increasing number of people are involved using smart things, such as mobile devices, smartphones, tablet computers and portable devices, fitness trackers and smart watches, industrial machines and transport systems, continuous blood glucose monitoring monitors and digital blood pressure monitors [9]. Therefore, it is important to analyze people's attitude to the Internet of Things technology, their readiness to use devices that can see, hear, feel and create new data. According to analysts, only a relatively small number of studies have investigated the life experience of people using IoT technology [9].

To get answers to some questions related to IoT, an Internet survey was conducted, in which 102 people took part. Let us characterize a group of respondents through graphically presenting data about them. The majority of respondents are young people (65 %) (Fig. 1). They will implement the concept of the Internet of Things in life and use its results.

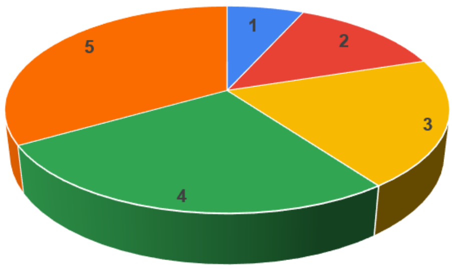

Fig. 1. Ratio of respondent categories: 1) student; 2) student-worker; 3) schoolboy; 4) worker; 5) unemployed

Fig. 2. Ratio of respondents by city of residence: 1) Rostov-on-Don; 2) St. Petersburg; 3) Novocherkassk; 4) Kamensk-Shakhtinsky; 5) Vladimir; 6) Glubokiy; 7) Moscow; 8) Kiev; 9) Bataysk; 10) Aksai; 11) Volgograd; 12) Volgodonsk

Most of the respondents (75 people) are residents of Rostov-on-Don (Fig. 2). Residents of Moscow, St. Petersburg, Vladimir, Volgograd and Kiev are presented in the group (Fig. 3). Global networks are ideal for conducting surveys.

The average age of the respondents is 20 years, the minimum age is 10 years, the maximum is 33 years. The average salary of respondents is 8,778 rubles, the maximum is 50,000 rubles.

The gender ratio of respondents is shown in Fig. 4: men (44 %) and women (56 %) make up the group of respondents in approximately equal proportions.

Fig. 3. Cities whose residents took part in the survey are marked in red

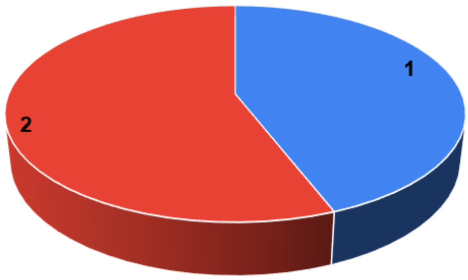

Fig. 4. Gender ratio of respondents: 1) men; 2) women

According to the histogram shown in Fig. 5, most respondents are moderately busy with work or study. It can be assumed that the survey participants are active and educated people who follow the development of technology. This is confirmed by the diagram in Fig. 6. About 83% of respondents rated their level of activity highly.

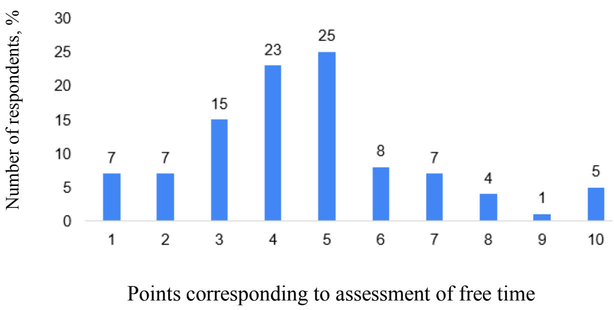

Fig. 5. Ratio of respondents by the availability of free time

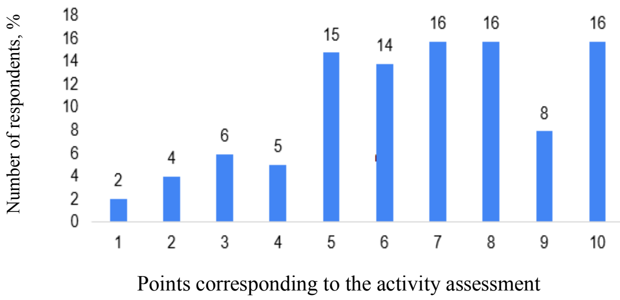

Fig. 6. Ratio of respondents by activity level

According to the diagram shown in Fig. 7, most of the respondents have a good command of a computer. Indeed, the respondents are young people who study information technologies at all levels of education and widely apply them in life and activities.

The presented data allow us to form a social portrait of a group of respondents.

Survey Findings. In the process of statistical analysis of the survey data, the following results were obtained regarding the use of the Internet of Things.

Figure 8 shows the ratio of respondents by the number of smart things at their disposal. These include: a smartphone; a smart watch / bracelet; a smart vacuum cleaner; a speaker with a voice assistant; a smart refrigerator; a smart washing machine; a car with artificial intelligence (autopilot). As you can see, in most cases, the respondents have 2, 3 or 4 smart things at their disposal. The maximum number of such things is 16.

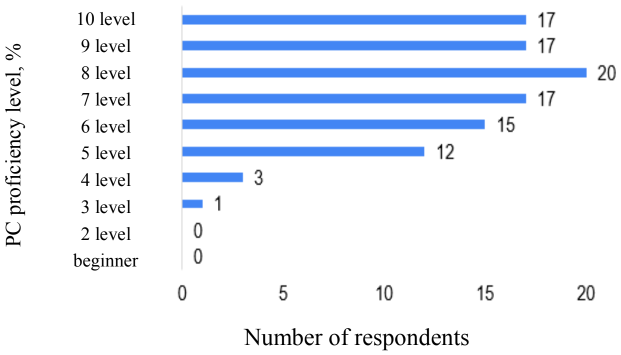

Fig. 7. Ratio of respondents by the level of computer proficiency

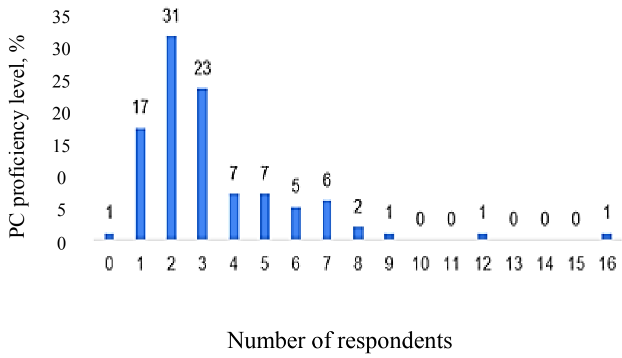

Figure 8. Ratio of respondents by the number of smart things at their disposal

Influence of the factor of the level of personal computer proficiency on the number of smart things available to respondents is not statistically proven (p-value of one-way analysis of variance is 0.73).

There is a weak correlation between the number of smart things and the average monthly income of respondents (0.141). Probably, the smart things that are noted in the survey were purchased on the income of all family members of the respondents. At the same time, there is an average degree of correlation between the age and the average monthly income of the respondents (0.52).

There is no correlation between the factors of age and the number of smart things that are available to respondents (-0.036). Accordingly, during the one-way analysis of variance, the influence of the age factor on the number of smart things available to respondents was not proved (p-value of one-factor analysis of variance is 0.55).

The influence of the factor of the sphere of activity to which the respondents refer themselves on the number of smart things at their disposal was statistically proved during a one-way analysis of variance (p-value is 0.03) (Fig. 9).

According to the diagram in Fig. 10, the majority of respondents believe that smart things can be used for work, training, entertainment (29.4 %), for training and entertainment (23.5%), or for training (16.7%). This suggests that the use of the Internet of Things is still poorly implemented in production, only 8.8 % of respondents use smart things for work. Indeed, many experts note such problems of the spread of the Internet of Things in our country as the lack of understanding of the results from using IoT, the unwillingness of business to change, the lack of real experience in implementing and serious research on the effectiveness of investments in the Internet of Things.

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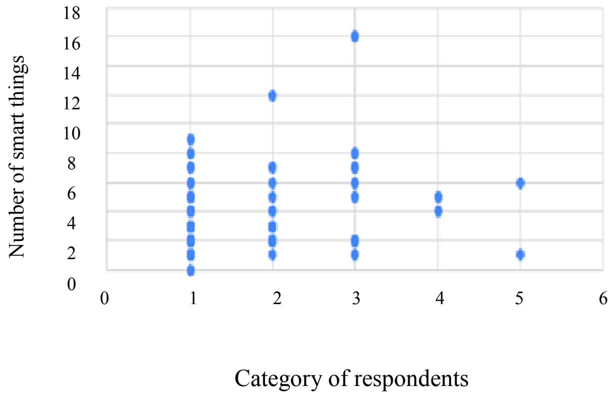


Fig. 9. Scatter chart of the number of smart things that respondents have: 1) student; 2) student-worker; 3) schoolboy; 4) worker; 5) unemployed

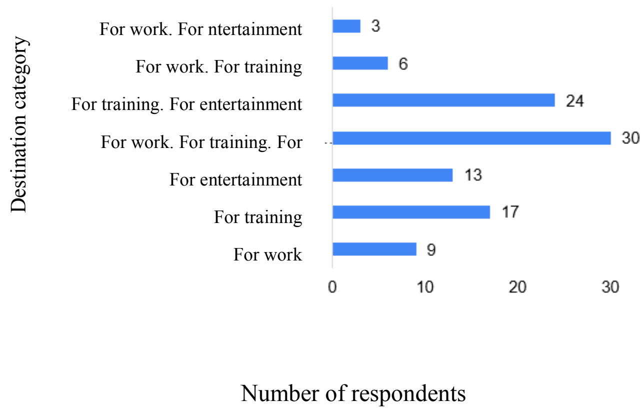


Fig. 10. Ratio of respondents according to the nature of the use of smart things

Linking smart things into a network provides a system of things that interact with each other and with the outside world, which can increase the significance of their use separately. According to previous surveys, 30 % of respondents say that the issue of implementing the Internet of Things in the activities of enterprises is not very important or not at all important. On the contrary, 34 % believe that the introduction of the IoT is very important. According to the survey (Fig. 11), the overwhelming majority of respondents (94 %) have a positive attitude to the idea of sharing smart things and turning them into Internet things.

The majority of respondents rather highly assess the security of data obtained through the Internet of Things (microphone in the speaker, GPS in the bracelet, sensors that measure pulse, temperature, etc.) (Fig. 12). There is such an opinion along with the fact that currently, the issues of the need to improve the security of electronic data are widely discussed in society. Probably, the results obtained are due to the lack of a deep understanding of the functioning of the IoT and its still small practical application.

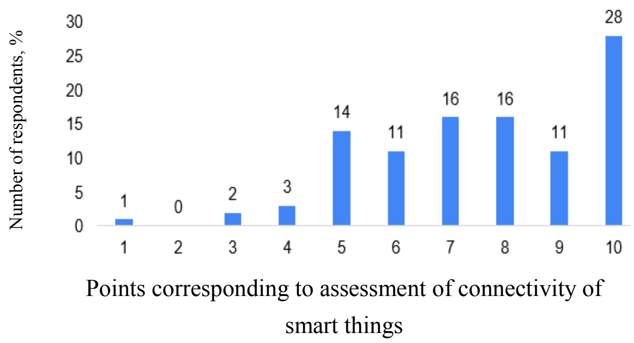


Fig. 11. Ratio of respondents according to the opinion about the connectivity of smart things

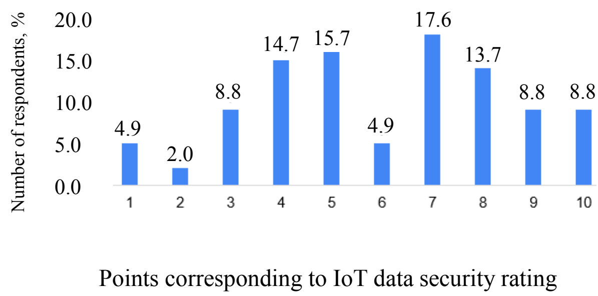
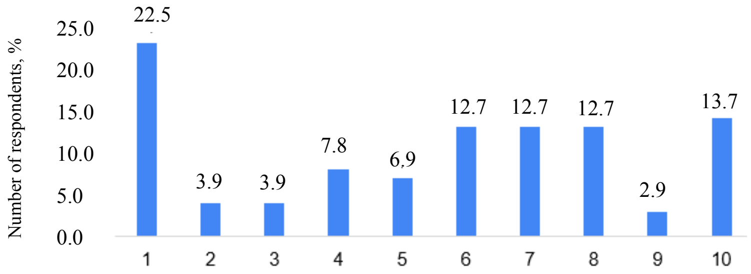


Fig. 12. Ratio of respondents in their opinion about the IoT data security rating

To this date, according to the survey, 22.5% of respondents believe that the problems of the Internet of Things are currently very poorly discussed. On the contrary, 53 % of respondents gave ratings from 6 to 10 on a ten-point scale to the level of discussion of IoT issues (Fig. 13). Indeed, the mass media pay sufficient attention to new solutions of smart things, giving examples of their practical application in various fields of activity: medicine, service, training, logistics, etc.



Points corresponding to the assessment of breadth of discussion of the IoT problems in society

Fig. 13. Ratio of respondents according to the opinion on breadth of discussion of the IoT problems in society

Based on the results of the information received, it can be concluded that:

— in most cases, the respondents have 2, 3 or 4 smart things at their disposal, maximum number of such things is 16;

— there is no correlation between the factors of age and the number of smart things that are available to respondents;

— there is weak correlation between the number of smart things and the average monthly income of respondents;

— influence of the sphere of activity factor on the number of smart things has been statistically proven;

— influence of the factor of the level of personal computer ownership on the number of smart things available to respondents has not been statistically proven;

— the number of smart things that respondents have tends to increase due to the increasing discussion of IoT technology in society;

— respondents aged 20 to 30 years are more likely to use smart things for work and entertainment;

— respondents under the age of 20 are more likely to use smart things for training;

— only 8.8 % of respondents use smart things for work;

— respondents who have little free time are more likely to use smart things for work and training in practice;

— respondents who have a lot of free time are more likely to use smart things for entertainment;

— the more the respondent plans his activities, the more smart things he owns;

— the vast majority of respondents (94 %) have a positive attitude to the idea of sharing smart things and turning them into Internet things;

— as the level of computer proficiency increases, the importance of linking smart things to the network grows;

— the more attention is paid to the discussion of the IoT technology in society, the more respondents have hopes for linking smart things together;

— 22.5% of respondents believe that the problems of the Internet of Things are currently very poorly discussed;

— 53 % of respondents gave ratings from 6 to 10 on a ten-point scale to the level of discussion of IoT issues;

— the majority of respondents quite highly appreciate the security of data obtained through IoT (microphone in the speaker, GPS in the bracelet, sensors that measure pulse, temperature, etc.).

Results and Discussion. According to popular belief, the most effective development tool is the Internet of Things technology [10−12]. It is an integral attribute of the information society, a form of communication between people and things. Linking smart things into a network can be characterized by different levels of complexity and coverage of interaction. Experts point to the prospects of "smart" homes, factories, hospitals, cities, agriculture, transportation, retail, the environment, the planet, etc. [13].

IoT technology can seriously affect production, the nature of business processes, and an ordinary human life. Its joint use with other information solutions (Table 1) will multiply the pace and determine innovative ways of the desired transformations [14, 15]. If we consistently and systematically solve a whole range of tasks, the IoT technology can become a significant factor in the development of Russia (Table 1).

Table 1

Characteristics of the Internet of Things technology

IoT advantages	Solving IoT problems in Russia	Technologies interacting with IoT
Data consolidation	State support for technology	Automatic data processing
Analyzing large amounts of data	Development of the legislative framework	Big Data solutions
Up-to-date receiving of comprehensive information	Tax incentives for enterprises	High performance networks
Condition monitoring and prediction	Development of a unified ontology, codifiers, reference books	Distributed computing
Automated quality control	Building an open technical dictionary technology	Machine learning
Interaction automation	Development of own production of IoT devices	Virtual reality (VR)
Remote process control	Formation and regulation of IoT market	Augmented Reality (AR)
Automatic diagnostics	Development of IoT standards	Robotics
Uninterrupted manufacture	Development of unified data transfer protocols	Cloud technologies
Production output in automatic mode	Development of technologies for cryptographic information protection	Video analysis
Mobile interaction of personnel	Creation of unified IoT information collection centers	Neural networks
Improving the quality of interaction between different departments of the enterprise	Creation of industry databases for IIoT	Artificial intelligence
Selection of the optimal mode of equipment operation	Development of mobile technologies	Cybersecurity
Reducing risks and incidents	Forming public opinion	Mobile technologies
Optimization of logistics and production chains	Building real IoT experience	Computer simulation
Reducing the significance of human factor in production	Research on the effectiveness of investments in IoT	Manufacturing of high-tech hand prostheses
Immersive training of specialists	Creating service-oriented business models	Digital Twin technology
Creating a complete portrait of the consumer	Short pilot projects	3D modeling
Provision of product quality monitoring services	Development of high-quality materials with lower energy consumption	3D scanning and printing
Introduction to agriculture (greenhouses, etc.)		Virtual SIM cards (eSIM)
		Digital workplace
		Machine-to-machine interaction
		Additive manufacturing technology

In addition, it is important to study and take into account the social impact of the spread of technology [12]. Reliable conclusions of this study will increase confidence in IoT and eliminate negative impacts, such as: blurring the boundaries between private and public; possibility that algorithmic decision-making processes in IoT will be preconceived and will exacerbate social inequality and social marginalization; concentration of smart city technologies on rich cities or districts that are able to pay for their services; possibility of not meeting expectations from the use of technology [9, 12, 16], etc.

Conclusions. The survey has shown that young people are ready to practically use IoT. Young people aged 20 to 30 years are more likely to use smart things for training and leisure activities, and not just in everyday life. Schoolchildren use smart things to a greater extent for learning. These are undoubtedly important areas of smart things application. The most significant would be the use of IoT in production and support activities, in which currently, for objective reasons, the use of Internet of Things technology is low. Positive steps towards the use of IoT are critical. It is required to further expand the range of smart things that could be used in the educational and entertainment spheres to form the skills of young people to use this technology in practice and turn it into a reasonable need. It is important to introduce into educational programs the basics of practical application of the Internet of Things technology in parallel with other technologies that work effectively together. This will contribute, on the one hand, to the deepening and expansion of knowledge of innovative information technologies; and on the other hand, it will help to interest young people, provide an indicative basis for practical application, further development and implementation of this technology in various fields of activity. It is also essential to widely discuss problems, ways to solve them and pilot projects related to Internet of Things technology in the media. This will allow us to train not only people who are practically interested in IoT, but also qualified personnel who are able to solve problems in a new way.

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