The impact of the Internet of Things technologies on economy

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Abstract

This study presents the analysis of one of the major contemporary transformational forces – the Internet of Things (IoT), which significantly influences the future development of all spheres of life. The purpose of the research is to identify the potential economic effects of IoT implementation in different markets. To achieve this goal, the following tasks are consistently solved in the study: identification and classification of the main IoT applications markets; detection, assessment and analysis of the economic effects of the IoT in the selected segments within the proposed classification; formation of future directions of IoT development. Based on the combination of such methodological approaches as technology life cycle and technology adoption life cycle, perspectives of the IoT development are set out. The technology life cycle is viewed through the prism of the methodology of the research company Gartner (the Gartner Hype Cycle for Emerging Technologies), based on establishing a consensus among a wide range of assessments of leading experts in the field of information and communication technologies. Comparison of the two methods and expert assessments allows us to conclude that, according to the methodology of technology adoption life cycle, the Internet of Things is of interest only for a group of "early adopters."

Key words: Internet of Things; information and telecommunication technologies; technology life cycle; technology adoption life cycle; digitalization; smart things; globalization.

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Introduction

On the threshold to the fourth industrial revolution, we see a fusion of technology and the blurring of distinctions between physical, digital and biological spheres. Similar to previous revolutions, the explosive growth of innovative technologies should give impetus to the development of various spheres of public life. The Internet of Things (IoT) has become a large business and technology area with ever-growing market potential. The IoT technology market is expected to grow from $176 Billion in 2016 to $639.74 Billion by 2022, at a CAGR (Compound Annual Growth Rate) of 25.1% between 2017 and 2022 [1].

Largely due to the spread and penetration of information and communication technologies (ICT), the speed of technological innovation in all spheres of life is increasing exponentially today. In the coming 10–15 years, the next radical leap that will be associated with the introduction of the Internet of Things is expected [2]. As various household devices (for example, robotic complexes on digital production) equipped with sensors and connected to the Internet begin "to communicate" among themselves without human intervention, the main sectors of the economy are transformed (industrial production, transport, medicine, agricultural industry, etc.), and the model of interaction between people and machines will be reversed. The economic effect of the Internet of Things is estimated to grow from $2.7 trln to $6.2 trln annually till 2025 [3]. By 2030, the contribution of the Industrial Internet of Things to the global economy can be about $14 trln [4]. The number of connected devices in OECD countries will increase from 1 bln in 2016 to 14 bln by 2022 [5].

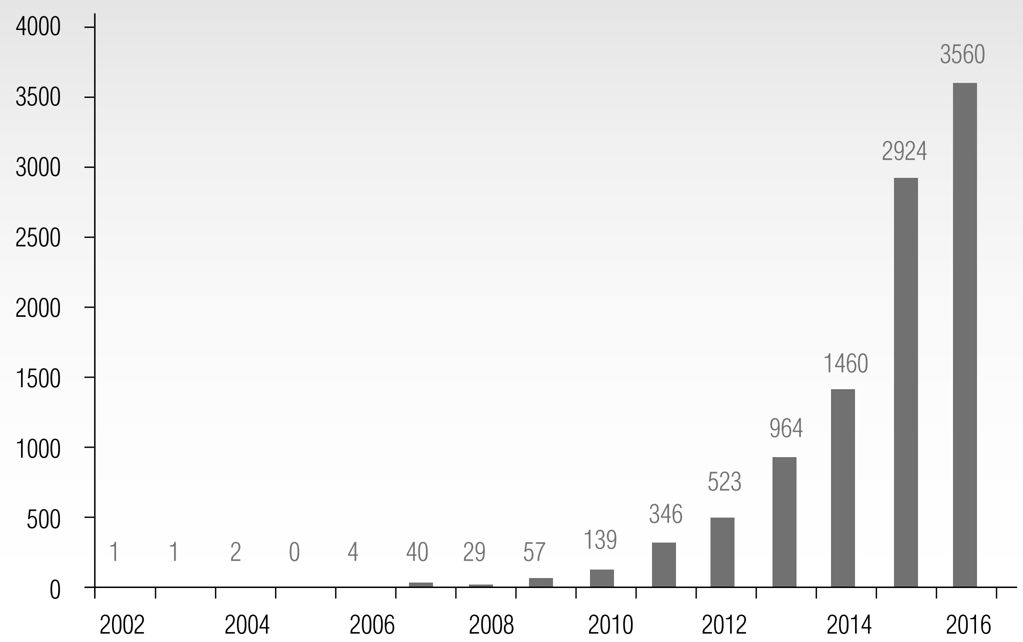

Fig. 1. Publications devoted to the IoT (based on Web on Science)

1. Review of literature

Nowadays there is a growing interest in the Internet of Things technologies as evidenced by the growth of scientific publications in this field of research (*Figure 1*).

The first reference to the Internet of Things can be attributed to Schoenberger and Upbin [6], who described the impact of the Internet of Things technologies on the economy and society. Interest in this issue is not surprising, because in 2002 Amazon launched the first cloud web service, marking the start of cloud computing and providing impetus to the development of IoT technologies. Further, in 2004 Gershenfeld et al. (Massachusetts Institute of Technology) published an article devoted to a wide range of aspects of IoT development [7]. The authors mention the benefits of the objects' ability to connect to data networks: optimization of the configuration of lights and switches at home, reduction of the cost and complexity of building construction, assisting with home health care. Nevertheless, they stressed the importance of solving the problem of standardization [7–9]. It is worth noting that nowadays this remains one of the key challenges for IoT development which can be overcome by the interaction of public authorities, as well as by the formation of consortiums of the Internet of Things.

The evolution of IoT requires the development of a bridging point (i.e., gateway) between the sensor infrastructure network and the Internet. Rahmani et al. [10] consider that it is necessary to develop the concept of Fog Computing in IoT systems by formation of a Geo-distributed intermediary layer of intelligence between sensor nodes and the Cloud. Also Cavalcante et al. [8] claim that Cloud Computing has been advocated as a promising approach to tackle some of the existing challenges in IoT which prevent exploiting its full potential and promoting tangible benefits to society, environment, economy and individual citizens.

One more challenge associated with IoT is noted by Bello et al. [11]. They explore the challenges of integration and interoperability of device to device communication technologies by focusing on network layer functions such as addressing, routing, mobility, security and resource optimization. The limitations of the current TCP/IP architecture of the Internet of Things environment require the development of a low-power wide-area network (LPWAN) which coincides with the fact that the IoT technologies are on the peak of inflated expectations according the Gartner' technologies' life cycle [12].

The development of IoT faces a great challenge – ensuring cybersecurity. Thereby Weber and Studer [13] offer applicable international regulations of a legal cybersecurity environment in the Internet of Things context and alternative approaches to addressing the security issues in IoT. Development of the Internet of Things in the future is directly related to standardization of this field. Park et al. [9] notice that collaboration between standards' bodies to provide interoperability is a key to the success of IoT, because nowadays IoT devices use different standards and are deployed in a large numbers in different domains.

Despite all the difficulties of IoT development, the Internet of Things is an emerging technology demanded in all sectors of the economy that can drive production to a new level, improve the quality of life and more. So the purpose of the research is to identify the economic effects of IoT implementation in different sectors. To achieve this goal, the following research questions are consistently solved in the study: to identify and classify the main IoT applications markets; to assess the economic effects of using the Internet of Things in the selected segments. Based on the combination of such methodological approaches as technology life cycle and technologies adoption life cycle, a scenario of IoT development is set out.

The working paper structure consists of the following parts: a description of the methodology of the study, assessments of the impact of the IoT on the economy, a forecast of the development of the Internet of Things on the basis of theories in the field of technology life cycles, the conclusion and the list of references.

2. Methodology

As the Internet of Things is an emerging technology, it seems relevant to define the segments of the IoT market in the absence of a generally accepted classification. Therefore, the first stage of the study is devoted to the identification of the IoT segments and perfection of existing classifications. The author's classification is used to reveal the impact of the Internet of Things in each segment.

Prediction of the development path of IoT technologies is based on the identification of the level of readiness of IoT technologies through the construction of a timeline. The timeline is a common tool for scientific and technological forecasting and is widely used in Foresight and roadmaps. Similar studies were conducted by Utterback and Abernathy [14], who proposed the dynamic model of process and product innovation presenting the close relationship between innovation (the end product), the innovation process and the company's strategy. The dynamic model of innovation is a combination of the product life cycle model, the process life cycle model and various competitive strategies. The authors identified three phases. Each differently affects individual companies, the market and the resources required to create innovation. Gartner's methodology was chosen as a theoretical basis because of the availability of expert assessments of the emerging technologies' development. Based on a joint analysis of Gartner's Hype Cycle for Emerging Technologies and the technology adoption life cycle, prospects for IoT development were brought into focus.

Gartner's methodology for visualization, the "emerging technology hype cycle," is widely used both in corporate and public environments for more precise decisions concerning the future development of technologies, speed of their adoption, mutual influence and competition of various technologies. The vertical axis on the graph illustrating the Gartner's hype cycle of emerging technologies denotes evolving expectations. Until 2009, the ordinate axis had a different name – visibility, but later that was replaced by "expectations" as a more suitable characteristic. The latter approach includes the attitude of both potential and actual users to the innovative technology, as well as investment decisions regarding its further development [15].

Gartner's methodology includes five key stages: scenarios, surveys, pattern recognition, "stalking horse" and verification. At the first stage it is necessary to establish research objectives using a survey method exploring tough situations or outcomes that other firms might not want to use. By analyzing data from multiple sources such as analytical reports, scientific articles, monographs, statistic collections and others, emerging patterns on markets are identified [16]. Further, there is a need to modify assumptions and update the scenarios. At the fourth stage, a "stalking horse" is a position released into the analyst community to be examined and debated from various viewpoints. Finally, findings are validated against multiple internal and external sources.

Concerning the influence of technology on the economy, the technology adoption life cycle has presented even greater interest [17]. The logic of the life cycle of the new technology adoption is based on the fact that technology is perceived by any community in stages in keeping with the psychological and social portraits of various segments of this community. According to this approach, the population is divided into five groups up to the degree of new technology adoption: innovators, early adopters, early majority, late majority, laggards.

By combining the two approaches outlined above, it is possible to determine which group of consumers should be oriented by the companies developing marketing strategy for promotion of the products from the IoT market. The method was described by several scholars [18; 19].

This approach allowed the authors to determine the portrait of the consumer of products and services created with the Internet of Things technologies. Thus, using this approach, the authors were able to identify a group of consumers for which decisions of the Internet of Things are of the greatest interest at present and a potential group of consumers in the short-term period. The combination of theoretical approaches allowed the authors to transfer the results of the extensive expert poll of Gartner to the field of another theoretical concept (technology adoption life cycle, for which such large-scale expert surveys are not conducted) and to analyze the phenomenon of the Internet of Things through the given prism.

3. Internet of Things market

Based on the analysis of different practices (Gartner, IDC, McKinsey, Forrester, IoT Analytics, Rostelecom, etc.), an author's classification of the IoT market was made. The criterion of this classification is the actors of the market: business, consumers, government. The consumer segment of the Internet of Things includes product solutions used by consumers in everyday life based on the technologies of IoT. The Industrial Internet of Things covers various branches of the economy where the use of IoT technologies can radically change business processes, increase productivity and operational efficiency. Using IoT in the government segment is aimed at improving public safety including re-offense prediction. The information and communication technologies are distinguished by their interdisciplinary nature and relevance in all the afore-mentioned segments, including cloud computing, big data, IoT platform technologies and sensor technologies. The author's classification of the IoT market reveals potential prospective segments of the implementation of IoT technologies attracting a wider range of consumers.

Given the ubiquity of digitalization and automation, when the organizational units of the enterprise are integrated into a single network many production and administration processes can be managed online using cloud computing and IoT systems. According to Verizon, the Internet of Things market in the business segment (Industrial Internet of Things, IIoT) will reach 5.4 billion devices by 2020 [20; 21].

The **Industrial Internet of Things** transforms business processes, increases the effectiveness of the whole value chain, ultimately leading to the formation of new business models and markets. The main directions of IoT technologies application are effective supply management, freight and asset management, machine diagnostics, machine telemetry, inventory control, industrial automation control, real-time monitoring of equipment, etc. The greatest effect from the spread of the Internet of Things in Russia will be observed in the following sectors: health (74% of Russian respondents – representatives of companies from various sectors of the economy); manufacturing (56%); the energy sector (32%) according to the survey conducted by Accenture [4]. *Table 1* presents estimates of economic effects from the implementation of the IIoT in various sectors of the

Table 1.

Economic effects of the Industrial Internet of Things

B2B Industrial IoT (IIoT)			
Manufacturing	**Logistics**	**Energy**	**Mining**
• 2,5–5% saving in operational costs, including maintenance and input efficiencies; • 30% improvement of time–to–market; • 40% reduction in planning and equipment costs; • 10–25% increase in manufacturing productivity; • 40% reduction in factory equipment maintenance costs; • 50% reduction in equipment downtime; • 5% reduction in capital equipment investment costs; • 20–50% reduction in factory inventory carrying costs	• 30% reduction in labor costs; • 30% reduction in the time of order processing; • 12% reduction in the repair expenses; • 30% reduction in overall maintenance costs; • 70% reduction in the downtime	• 2–4% reduction in demand peaks in the grid	• 5–10% saving in operating costs from productivity gains; • $3.7 trln economy in global mining operating costs up to 2025
Agriculture	**Transport**	**Construction**	**Finance**
• 25% reduction in cost of vehicle damage from collision avoidance and increased security; • $1.2–1.3 trln in agricultural production (wheat, maize, rice, soybeans, barley); • 20–40% adoption of advanced irrigation systems and precision farming; • 10–20% increase in yields from precision application of fertilizer and irrigation	• $28 mln in value over 10 years with smart buses; • $53 mln in value over 10 years with smart parking; • 20–25% savings in fuel costs; • 79% reduction of crashes; • 40% reduction in vehicle wait time; • 26% reduction in travel time	• 20% reduction in total life–cycle costs of a project	• 30% reduction in building management system deployment and operating expense in financial organizations

economy: manufacturing, logistics, energy, mining, agriculture, transport, construction, finance (based on [22–26]).

Using IIoT technologies provides the opportunity to bring manufacturing to a qualitatively new level. As a result, it becomes possible to integrate flexible production systems as well as digital control systems into manufacturing, all of which makes it easier to control production, accelerate it and significantly increase its flexibility. In this regard, it is necessary to introduce promising technologies in a timely manner and, due to the high cost, the effective use of funds becomes a key issue. It is also important to pay enough attention to the competence of employees and promote their skills [27].

Maximum automation of routine manufacturing operations (advanced manufacturing) through the implementation of IIoT technologies will help to link the activities of various divisions (including suppliers, logistics, marketing and even involve consumers in the production process by obtaining product information from them in real time) through the creation of a single information field. That will help to increase the flexibility of production, the speed of the product's release to market, as well as the optimization cost. Development of IoT technologies in Russia is based on strong competencies of the specialists in the field of algorithms and software. This provides good opportunities for equal participation of Russian organizations in international consortiums and projects related with Internet of Things [28].

There are plentiful examples of the implementation of the Industrial Internet of Things at the nation level, for example, Smart metering in Germany [29] and also at the enterprise level – the ERP system for creating a smart factory in B&R Industrial Automation in Austria and etc. [30].

The **Internet of Things in a consumer segment** contributes to the improvement of the quality of life due to automation of many routine household operations, release of free time, and granting new opportunities previously inaccessible to consumers (*Table 2*, based on [25; 26; 31–43]). Self-driving cars are one prospective application of IoT technologies. According to the forecasts of Hitachi, by 2020 90% of new cars in Europe will be connected to the Internet (versus 30% in 2016). Complementary technologies for self-driving cars are the intellectual transport systems created for these vehicles. Since 2011, in Moscow there is an intelligent transportation system under construction, including management of the technical means of regulating and organizing traffic, controlling parking, photo-video fixation of violations of traffic regulations, monitoring of traffic flow parameters, control and regulation of traffic organization [44].

The technologies of the "smart" home are aimed at providing the most comfortable accommodation, safety and resource-savings. By 2022, the "smart" home market is expected to reach $121.7 bln, CAGR – 14.1% [45]. The "smart" home market includes lighting control, security & access control, HVAC control, entertainment & controls, home healthcare, and the smart kitchen.

The technologies of the Internet of Things are in demand in the sphere of utilities, and their use facilitates the reduction of costs to the general population for electric power, water and heating. Such saving of resources has a positive effect on the environment due to reduced consumption of natural resources including non-renewables. By 2050, a 55% increase in demand for water resources is projected. Furthermore the demand for energy resources will increase for 37% by 2040 [46]. In this regard, the need for resource-saving and energy efficient technologies becomes more acute every year.

Table 2.

Economic effects of IoT in the consumer segment

Consumer segment of Internet of Things (B2C)		
Smart city	**Wearable smart devices, healthcare**	**Smart home**
• 10–20% reduction in average travel time through control of traffic and congestion; • 10–20% reduction in water consumption and leaks with smart meters and demand control; • 10–20% reduction in cost of waste handling; • 60% energy savings by moving to smart street lighting; • 20% reduction in water losses; • 30% reduction in street crime	• 10–20% cost reduction in chronic disease treatment through remote health monitoring; • 80–100% reduction in drug counterfeiting; • 0.5–1 hour time saved per day by nurses; • the value of improved health of chronic disease patients through remote monitoring could be as much as $1.1 trln per year in 2025; • 25% reduction in costs from clinical and operations inefficiencies (or about $100 bln per year); • 50% reduction in mean time required to repair connected devices; • $2,000 reduction in service costs for each problem resolved remotely; • 20% fewer technician dispatches worldwide	• 30–50% reduction in water usage; • $50–90 reduction per water bill; • 88% reduction in power consumption; • 96% of construction waste is recycled; • 30–50% reduction per energy bill (extra $198 per year or $16.5 per month)
Trade and repair	**Sports, leisure, entertainment**	**Education**
• 1.5–7% increased sales; • 99.5% inventory accuracy; • 50% reduction in out–of–stocks;	• 25% reduction in operational expenses	• 60% of energy can be saved from IoT connected smart devices in schools/colleges

One more benefit of applying IoT technologies in the utilities sector is time saving for paperwork (filing receipts, collection of information about monthly expenditure of water and electric power). Release from repeating routine transactions is possible due to the establishment of “smart” counters adjusted to the water, electric power and heat meters via

IoT connections capable of sending notification about the payment to smartphones [44].

The additional possibility of power consumption control relates to "smart" home appliances (washing and dishwashers, dryers, etc.) using built-in sensors and applications of the Internet of Things that can turn them on automatically during the period of lowest daily tariffs. In addition, they can notify the owner about undesirable starts in case of the maximum rate applied.

Numerous "smart" home systems' applications require particular attention and research as they have significant gaps and shortcomings. These issues are related to security systems, safety, energy consumption, marketing and device interoperability. Furthermore, the use of IoT gadgets and IT infrastructure deserves special mention. It is necessary to conduct more research on practical use of new-generation built-in sensors that are equipped with electrical devices as noted in the works of Alaa et al. [47].

IoT technologies in the urban environment are aimed at the development of innovative solutions for infrastructure, energy saving, construction and organization of public space. Thus, connection of the installed sensors on vehicles and roads makes possible real time traffic control. In addition, the development of similar city infrastructure increases the probability of detection of the stolen cars. In the future, traffic information about vehicles will be generated by intellectual transport systems. It will be the means of urban transport system's operation and will lead to the reduction of difficulties with traffic on roads, to decreases in CO_2 emissions, etc.

The strategic direction called "Smart Urban Mobility" was developed within the framework of Singapore's Smart Nation initiative. Implementation of the projects is aimed at improving the system of public transport by introducing digital technologies and the use of data generated by various devices [48]. In Singapore, the development of the Internet of Things is stimulated by providing software development companies with access to a system of sensors deployed throughout the city. Thus, data, IoT platforms and APIs are becoming open and enabling creation of innovative products and services within the ecosystem of the Internet of Things.

The technology of the Internet of Things in healthcare can exert an enormous effect not just on the quality of medical services but also on the capabilities of modern medicine. Use of sensors can detect disease at early stages. The diagnosis of sharp respiratory infections by means of "pocket" biosensors will lead to the reduction of costly treatment and reduced losses from disability. IoT technologies in healthcare aim at forming steady demand for a new quality of life. Medical biotechnology and personalized medicine services may significantly increase the life expectancy of the population, as well as achieve significant progress in treating cancer, cardiovascular and infectious diseases [46].

The Internet of Things opens new opportunities in retail and finance activities. Monitoring information on movements of goods using "smart" packaging with an RFID tag (Radio Frequency IDentification) will let producers develop more efficient marketing strategies (develop various loyalty programs, individual offers for clients, increase the average sales value).

The Internet of Things also impacts on the scope of penetration of financial services due to the use of contactless payments made possible by the technology of wireless high-frequency communication with small radius of action (to 10 cm) – NFC (Near Field Communication) supported by smartphones. Moreover, in banking it is also possible to deepen the customization and personalization of services based on analysis of data consolidated in the development of the IoT technologies.

Media and the entertainment are changing as a result of the development of IoT technologies. Improvement in the quality of telecom services opens the possibility to use media with high resolution at any time and in any circumstances. Virtual reality accessible through mobile devices and applications affects almost all social activities. Virtual reality is becoming not just the popular way of social interaction but also one of the forms of entertainment. Virtual and augmented reality technologies assume immersion of the user inside content directly working with his or her emotions. The viewer will watch a movie and becomes a kind of participant in the story. There is the possibility to act inside the movie, select the view or hero on behalf of the narrator or in the manner he or she wants to act. Virtual and augmented reality technologies are most widely applied in the consumer segment (54%), while the share of government and business segment accounts for only 46% [49].

New directions of IoT concept development in the Social Internet of Things (SIoT) represent an integration of IoT and social networks. The synthesis of two these phenomena provides users with an opportunity to access direct "smart" things (without an intermediary). Thus, the IoT become social. Moreover, in SIoT smart devices are able to establish social links and communicate with each other, just as people do in a social network. This is made possible by the Search Social Internet of Things model (the SSIoT model), where the search engine serves as the medium between two elements of integration. Correspondingly, the SSIoT influences significantly SIoT capabilities and specifications while at the same time it contributes to the speed-up of malicious code propagation which is emphasized in the study of Fu et al. [50].

The new paradigm of the Social Internet of Things (SIoT) has great potential for IoT applications and various networking services which increase the efficiency, speed of development and spread of this innovation. The types and the characteristics of the social relations which can be installed by technologies in the SIoT have been identified: OOR relationships (Ownership Object Relationship), SOR relationships (Social Object Relationship) and C-WOR relationships (Co-work object relationship). In accordance with different types of relationships, the Social Internet of things will have a different architecture, mobility and scalability [51].

IoT smart objects provide people with a perfect opportunity to transfer the reality into the virtual dimension in online protected mode and create augmented reality. In the IoT, smart devices are able not only to be part of people's social network but they are capable of creating their own "social" network. This state of affairs can lead to development of new complex effective services and apps for people. Correspondingly, in the framework of IoT a new concept of the Web of Things has appeared. This paradigm relates to the ability to automatically post various information and data on social network sites. The problem lies in the management of numerous devices and web application architecture [52].

One of the most effective systems for providing public services electronically in the **government segment of Internet of Things** is the Estonian X-Road platform through which citizens can perform almost any operation [53]. Cybersecurity of the X-Road is based on blockchain technology (KSI blockchain), which allows the user to track any interaction with the system [54]. Such convergence of the Internet of Things and blockchain technologies will improve the security of IoT-devices and also increase the scalability of the IoT-system and the speed of interaction of devices included in it. Nowadays there are plans to attract small and medium-sized enterprises to use the platform as well as to expand its borders by involving B2B and B2C segments [55].

For faster penetration of the Internet of Things concept, it is necessary to strengthen the activity in various fields. First of all, this means improving the ICT infrastructure as well as strengthening public support for the introduction of new technologies. For example, in the UK IoTUK Boost launched a program aimed at deployment of IoT networks that can be used by small and medium-sized enterprises [56].A successful example of the deployment of the Internet of Things infrastructure is Estonia, where the international IoT operator Sigfox has created a national IoT network, access to which is planned to be provided for the entire population of Estonia.

Due to digitalization, companies need to revise the formats of partnerships, expand access to information and provide a new level of decentralization of the working environment. For more effective interaction between counterparts, new types of organizational structures will be required at the enterprise level, including those based on platform technologies. Moreover, it will be necessary to develop and implement new standards for interoperability and cybersecurity [21; 57].

Despite effective, dynamic technological progress and outcomes, an IoT vision has not been generated yet. It will be quite difficult for realization, since it is necessary to develop the technological infrastructure and social Internet culture. But due to this, it is indispensable to create and establish criteria and unique standards for the IoT. Consequently, there are not only technical challenges but political, economic, human and social problems. Within the escalating number of users, the variety of mechanisms and usage scenarios will increase as well. It is necessary to consider the evolution of the Internet of Things in connection with the interoperability of human activities and electronic devices. The current state of affairs involves solving a number of problems and conducting social, economic and technological research [58].

The development of the Internet of Things is inextricably linked with the need to increase consumer confidence in new, innovative products and services, based on confidentiality and security of data generated from various devices [59].

A significant initiative in this direction is the activity of the ITU. In 2012, the International Telecommunication Union issued its Recommendation ITU-T Y.2060 with the object in mind to lead standardization in the area of IoT. It explains the definition and the ambit of the IoT, determinates key characteristics, features and high-level direction and objectives for IoT. A reference model IoT is described. Ecosystem and business models are presented as well. Thus, the implementation of these standards has led to the unification of requirements, interoperability of smart objects, the expansion of the range and an increase in the scope of technology and solving the problem of heterogeneity in computing systems [60].

In order to solve IoT problems, various international organizations are developing recommendations and standards in this field. Indeed, the CSA Mobile Working Group issued an IoT Initiative – Security Guidance. The manual in this document was created in such a way as to provide useful guidance in different sectors. It was achieved by researching data and architectures in different industries and screening the security controls that would able to support any one industrial sector. In order to avoid duplication, efforts were made to promote and harmonize working groups of the various sectors [59].

The common world practice is to unite efforts aimed at stimulating innovation by forming global, voluntary standards developed by regulatory bodies or industry consortiums necessary to ensure interoperability and the growth of the IoT ecosystem. Among the key characteristics of consortiums, we can single out the following: prototyping and increasing the scale of production as the main line of business; the network principle of interaction; self-repayable (after the end of budget financing) and an indefinite type of activity based on the cooperation of businesses (including small and medium-sized enterprises), scientific and educational organizations. In March 2014, the Industrial Internet Consortium was founded, with Intel, IBM, Cisco, GE and AT&T among its participants. The main objective of the IIC is to unite organizations to promote and accelerate the growth of the Industrial Internet of Things by identifying, collecting and sharing best practices[1].

There is also a consortium in the field in Russia – the Russian Association of the Industrial Internet[2]. The majority of its members is represented by the information technology sector (55.6%), but representatives of such sectors as telecommunication services, aerospace, electrical equipment and commercial services are also available (11.1% each). This indicates importance of Internet of Things technologies for various sectors of the economy.

Analysis of the members of the Industrial Internet Consortium visually demonstrates those sectors of the world economy that are already showing an interest in solutions based on IoT technologies. In addition to IT companies, scientific organizations, research and consulting companies also are participating in the development and standardization of the Internet of Things. Unlike the foreign consortiums under analysis, Russian scientific organizations are not participants of the RAII. In this regard, as measures to develop the Internet of Things in Russia, authors would like to recommend that scientific organizations take a proactive stance and get involved in the work on the development and standardization of the Internet of Things within the framework of the Russian consortium, as well as companies from other sectors such as energy, finance and machinery.

4. Prospects for IoT development

Regarding the supply side of the IoT market, there is the very important question to be answered: how the suppliers on the IoT market can improve their performance? The correlation between Gartner's 2015 Hype Cycle for Emerging Technologies and the technology adoption life cycle was investigated to determine the target group of population with most likely potential as IoT market consumers.

Comparison of the two afore-mentioned methods [18; 19] shows that IoT solutions are attractive to early adopters who understand the advantages of the new technology, evaluate them and link potential benefits of the IoT with their interests. Their decision to buy something will be based on the degree of this commonality. Because early adopters do not rely on authorities for purchasing decisions, they use their own intuition and foresight. So they a play key role in opening any new digital technologies market segment. According to the technology adoption life cycle, there is a challenging goal

[1] https://www.iiconsortium.org/members.htm2016, No. 1758
[2] http://iotunion.ru/en/uchastniki?limitstart=0

to overcome the “chasm” stage and attract the “early majority” group interested in IoT technologies.

Conclusion

The rate and efficiency of IoT development within the coming 15 years will to a large extent depend on further distribution of fixed and mobile broadband communication and reduction in the cost of connected devices [5; 28]. Moreover, development of the IoT potential is possible thanks to the development and use of processing technologies and big data analysis generated from various sensors and other devices. Skills for data analysis are the key asset for the future. In this regard, there is the possibility to increase social inequality: some part of the population will take advantage of the new opportunities opened by the Internet of Things improving their quality of life while for others these benefits are unavailable [46].

For further research, it seems interesting to compile socio-psychological portraits of consumers for each segment of the IoT market directly affecting the economy. Identification of these groups of consumers will be important for marketing departments of companies, for the Internet of Things providers, as well as for government.

Concluding the research, it is worth mentioning that some people do not notice how the technologies of the IoT are becoming part of their daily lives. When buying a new apartment, consumers often already are acquiring IoT solutions aimed at saving electricity, water and heating. It is necessary to inform the population about the new opportunities opening up for Internet of Things users in order to stimulate the demand for IoT solutions.

It should be stressed that the Internet of Things is one of the key technologies of the fourth industrial revolution, similar to the case of previous industrial revolutions and so it has an impact on the labor market. The latter aspect could be a prospective field for further research. On the one hand, there is growing demand for highly qualified specialists particularly in the field of cloud computing and big data. But on the other hand, the spread of the Internet of Things leads to a reduction in the demand for low skilled labor. In order to settle the social problems which arise, it is necessary to carry out programs to improve the skills of employees both at the governmental level and at the micro (enterprise) level. Therefore, it is necessary to expand the intake of university applicants in ICT technologies, to open new programs within the bachelor’s and master’s programs aimed at training highly qualified specialists in the field of the Internet of Things, cloud computing, big data, distributed computing, etc. For example, in the USA more than half a million students with a specialty in STEM (science, technology, engineering and mathematics) graduate from educational institutions each year and in China – 4.7 mln students [61]. In addition, at the micro level companies need to improve the skills of employees in order to remain competitive on modern dynamically changing markets. ■

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