

Industrial Internet in the concept “Industry 4.0”: world experience and perspectives of development in the conditions of Russian economy^a

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Abstract. At present, the world economy is at the stage of formation of the fourth industrial revolution, which is called to raise the industry to a new qualitative level. In this article we contemplated the history and prerequisites of the industrial revolution, defined its basic features and the most progressive technologies. We analyzed the particular features of development of the industrial revolution in Russia and abroad. We inspected the experience of foreign countries in implementing state programs in the sphere “Industry 4.0”. We investigated the concept of the Industrial Internet as a basis for developing of a new wave of the industrial revolution. We studied its main advantages, its influence on the world economy and the anticipated consequences. We investigated the factors hindering the implementation of the project related to the Industrial Internet in Russia. We formulated the primary tasks and evaluated the perspectives for development of the industrial Internet in the Russian economy.

1 Introduction

During the last decades, the mankind entered the path of the fourth industrial revolution [1]. Studies of many modern scientists are deal with implementation of new progressive technologies in industry and other spheres to increase productivity and economic efficiency. The Industrial Internet, which is a component and a very important direction in development of the industrial revolution, is being actively implemented at industrial enterprises bringing radically new cyber-physical approaches in organization of works, services and management. And, as a result, future changes will affect not only the industrial sphere but many other aspects of social life, such as the labor market, the system of

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education, the environment, political systems and many others. We will need to reconsider many notions and, in a certain way, the role of a man in the modern world will be changed.

The general problems of the new industrial revolution are discussed in works [2, 3, 4]. The work [5] investigates the influence of the Internet of Things onto the transformation of industry. Issues related to implementing the Internet of Things in industry are discussed in the work [6]. The influence of the Internet of Things onto the competitive advantage of some industries was discussed in [7]. Some issues related to processing large arrays of data using internet technologies were investigated in the work [8]. Studies of social, psychological and economic consequences of intellectual technologies were discussed in works [9, 10].

2 Characteristic of the fourth industrial revolution

Historically, four main stages are highlighted in the industrial revolution development. *The first* industrial revolution was related to inventing the steam engine that conditioned the transition from manual to machine works and greatly increased the labor efficiency in early XIX century. *The second* industrial revolution was related to the introduction of electricity in industry and introduction of conveyors for mass production by Henry Ford. *The third*, “digital” industrial revolution started during the 70-ies of the XX century and developed from introduction of computers to further evolution of information technologies. Its particular features are: industrial automation, introduction of industrial robots, transition to renewable energy sources and digital industry. Even though not all the components of the “digital” revolution have spread widely in the world, we can now see a radically new breakthrough in the evolution of digital technologies that has conditioned the transition to *the fourth*, “informational” industrial revolution. Its particular feature is wide introduction of cyber-physical systems into manufacturing, everyday life and entertainment. The technologies of data processing are being substituted by information technologies to form a completely digital industry based on information technologies.

For the first time, the concept of the fourth industrial revolution under the name “Industry 4.0” was formulated at an exhibition held in Hannover in 2011, defining it as implementation of “cyber-physical systems” into manufacturing processes. Industrial systems will be integrated into one network, interact in real time, self-adjust and learn new models of behavior. Such networks can support manufacturing with less errors, interact with the manufactured products and, if necessary, adapt to new requirements of the customers. This will promote development of global industrial networks. The most important technologies being the basis of cyber-physical systems are the following:

1. *Big data*. It is a method of collecting and analyzing data from a large number of various sources to become the standard for making solutions in real time.
2. *Cloud calculations*. Using cloud technologies will make it possible to create platforms for cooperation and data exchange between partners located at great distances from one another.
3. *Internet of Things*. Creating a sophisticated system of communication between things, which implies the ability of things to identify one another, exchange the required information, use it and make solutions. After implementing into industry, the Industrial Internet of Things will make it possible to greatly increase the manufacturing efficiency.
4. *Autonomous robots*. Robots are becoming more and more flexible and autonomous. A system of computer vision will make it possible for robots to interact with one another, automatically adjust their activity and work together with people.

5. *Virtual and supplemented reality.* Supplemented reality means the ability to add virtual properties to physical objects, for example by correlating them with some information that can be individualized for particular subjects of perception.
6. *3D modeling and 3D printing.* 3D modeling will make it possible to virtually model a physical process with consideration of the available raw materials and workforce, with decreasing the equipment adjustment time and improving the quality as the result. Inherent advantages of 3D industry will make it possible to cut the costs of transportation and stored reserves.
7. *Distributed lists. Block-chain.* Introducing technologies distributed lists creates the possibility to make management less centralized by delegating some functions to a certain network community, which will promote the trust of system's participants into its activity.

On the basis of a questionnaire answered by top managers of technological companies within the framework of the World Economy Forum in Davos, the key trends are cloud calculations, methods of collecting and processing of big data, the Internet of Things, robot technologies, quantum calculations, biotechnologies and medicine based on 3D printing. As it was noted at the forum, developing the basic directions can bring the profit amounting over USD 30 trillion for the world economy during the next 10 years [11].

3 World experience in implementing state programs in the sphere “Industry 4.0”

The state of the program “Industry 4.0” can be described as an actually started and irreversible process. According to the forecast of McKinsey Global institute, by 2025 the input of the Industrial Internet of Things into the world economy can be up to 11 % of the world GDP. An average yearly growth of GDP in the optimistic and optimistic scenarios of development of the Internet of Things by 2025 can be 3.9 to 11.1 USD trillion [3].

Germany was the first country to employ “Industry 4.0” [12] that, within the framework of their own “High-Tech Strategy” based on intensive implementation of the Industrial Internet of Things, started investing 40 billion Euros per year into the new Internet infrastructure. In order to promote new ideas, a consortium of the largest industrial companies was formed in Germany, such as BMW, Siemens and Bosch. By 2030, Germany plans to completely transit to a new stage of industrial development, where the Internet is used for maximizing the industrial efficiency.

In 2011, the USA started developing the program “Cloud Strategy” [13] aimed at implementing modern technologies to create “smart” industrial plants, shops, cities and transport systems, as well as solutions to the tasks of social communication, e-commerce and monitoring global logistic flows. The world leaders in the cloud technologies market are American companies IBM, Microsoft, Google, HP, AT&T. In 2014 a non-commercial consortium “Industrial Internet” was formed founded by General Electric, AT&T, IBM, Intel and others.

In the European community in 2010, the program “Digital Agenda for Europe” was started [14], with the purpose of developing the internet-economy; it is the first of seven initiatives within the framework of the strategy “Europe 2020”. Complete implementation of this program is expected to increase the GDP of the European countries by 5%, or € 1500 per person. In 2016, the European economic committee presented a program to develop digital industry “Digital Market – Digitizing the Industry: Questions and Answers” [15].

In China in 2015 a concept “Internet-Plus” was adopted, which included the best initiatives from world-leading countries to implement internet-management functions into materials processing industry, finance, medicine and agriculture [16]. Using mobile Internet

technologies, the traditional manufacturers can install hardware and software on road vehicles, household devices and other industrial products to enable remote control, automatic data collection and analysis.

Analyzing the world experience in implementing the program “Industry 4.0”, we can draw the conclusion that implementing new technologies in industry is currently in the active stage. In order to increase the competitive advantage of Russian economy, it is necessary to ensure the transition of the national industry to a new digital technological platform.

4 Industrial internet as a key factor for developing the program “Industry 4.0”

The concept of the Industrial Internet based on wide implementation of digital and internet technologies in industry can be considered the main driving force of the program “Industry 4.0”. The Industrial Internet of Things (IIoT) presumes creating the informational communication infrastructure based on the Internet connection of equipment, sensors, devices and automated systems for controlling technological processes to ensure active interaction between them. Such organization of the industry will cause forming new business models for providing products and services and delivering them to customers. The most promising spheres for introducing IIoT solutions and platform are housing services business, transport, medicine, machine-building industry, as well as power generating that, due to the active attitude of the Ministry of Power-Generating Industry, has already developed a “road-map” for using the Industrial Internet technologies.

The main result of implementing the concept of Industrial Internet is increasing the efficiency of the existing industrial and technological processes and decreasing the required capital and operational costs. After implementation into industry, the Internet of Things will bring a few advantages, such as:

- *flexibility* of production that is achieved through refusing to use rigid configurations of conveyor lines, which makes it possible to take and fulfill individual orders and implement new solutions;
- *adjustability* of production that is achieved through using a united technological platform and monitoring on all levels;
- *efficiency* of production that is achieved through minimizing the costs related to the human factor: the high cost of human labor, errors and idle time.

The Industrial Internet is used more and more widely in the world practice. Analysts from the company Ericsson predict that, out of approximately 28 billion connected devices worldwide by the year 2021, about 16 billion will be related to the IoT. According to the assessment from “DirectINFO”, the total volume of the Russian market of IoT in 2016 was 17.9 million devices, which is 42 % more than in 2015. It is expected that the total number of IoT devices will be 79.5 million by 2021 and 164.7 million by 2026. [17].

According to the forecasts from specialists of General Electric, the Industrial Internet can already be used in such sectors of economy as transport, power generating and medicine, ensuring the world GDP by USD 32.3 trillion. Becoming the basis for new economy, the Industrial Internet will bring the world economy the effect in the amount 11% of GDP, will enable an increase in the labor efficiency by 25% and decrease the energy consumption by 20% by the year 2030 [18]. The key factor for the growth will be continuous decrease in the cost of sensors and equipment, as well as the cost of communication, data processing and system integration.

Therefore, implementation of the Industrial Internet is the main factor to increase the production efficiency, the level and quality of life. However, development of this process

will bring certain difficulties and will require reconsidering many notions and renovating many spheres of life. First of all, we can mention the transformation of the labor market and a possible growth of unemployment. In this respect, it is necessary that the state starts reforming the system of education and creating new jobs as soon as possible.

5 Tasks and perspectives of implementing the industrial internet in Russia

The Russian market for implementing the Industrial Internet technologies is in the beginning of development. However, the statistical data in the RF show that the specific weight of the industrial segment in the Russian market of the Internet of Things is prevailing. In 2015, its share was 64%, which means good perspectives for development of the Industrial Internet technologies in Russia [19]. According to the results of polling the top managers in different spheres of economy, in the RF in general, about 30% of companies are planning to implement the technologies of the Internet of Things or are already implementing them in their companies, and 11% of companies have already implemented projects that use the Internet of Things [19].

We can also mention that, currently, its use is more characteristic for the systems of automated data collection from devices installed at industrial objects. For example, it deals with the machine-building industry, power generating and mining. The interaction between machines develops more in transport companies that intensively use navigation systems. A positive trend is the growth of the share of the organizations that use information systems in manufacturing. From 2010 to 2015, their percentage grew from 25 to 30 %. Most of all, they are implemented in the spheres of communication, chemistry, electric equipment manufacturing and smelting industry [20].

The main factors hindering integration of the Internet of Things into manufacturing are: low level of knowledge and availability of technologies, limited investment and shortage of skilled workforce capable of working with new technologies, deficiencies in the legislation in the sphere of IT technologies, insufficient elaboration of safety issues and data protection, issues related to psychology and the red tape. Ensuring the availability and safety of using progressive technologies for big data processing, cloud and quantum calculations systems, the ability to use “smart” devices, robots and computer control systems are the priority tasks for businessmen and the state to attract more enterprises to the system of the Industrial Internet in Russia.

The Russian companies that are planning to implement the technologies related to the Industrial Internet of Things should start with creating a digital model of the industrial business process to eliminate digital gaps in the manufacturing cycle. One of the leaders in this sphere in Russia is the company Rostelecom acting as an engineering center for digital support during the life cycle of products. Rostelecom is developing a platform for the Industrial Internet on the basis of the analysis of foreign experience with consideration of the specific features of the Russian market [17]. With participation of the company Rostelecom, the “National Association of Market Participants” has been formed. The strategy of development of the Industrial Internet in the RF is being carried out by the Ministry of Trade of the RF (development of the road map for the Internet of Things, with participation of the “Fund for Developing Internet Initiatives”). However, the issues of organizational and legal support for industries related to the development of information technologies require still more elaboration. Therefore, the primary tasks for developing the Industrial Internet in the RF are as follows:

1. Creating an information-telecommunication infrastructure ensuring a technological possibility to use innovative internet technologies.

2. State or state-private financing to implement projects related to the Internet of Things. Support to pilot projects.
3. Support to domestic developers of high-tech products and research in the sphere of artificial intellect, information systems of management and cooperation through networks.
4. Ensuring the availability of IoT platforms for data collecting and processing.
5. Reforms of the system of education and training the IT specialists.
6. Developing the legal base promoting development of new technologies and ensuring their legal status and data protection.
7. Developing universal standards and requirements for new products. Ensuring compatibility with other IT systems, developing the export.

6 Conclusion

Transition of the national industry to the digital technological platform is becoming a topical issue for the competitive advantage of the Russian economy. Currently, the most perspective technologies are related to the Internet of Things, methods of dealing with large volumes of data, cloud and quantum calculations, robots, biotechnologies, digital 3D modeling and 3D printing. The Industrial Internet based on using the technologies of the Internet of Things is becoming the primary driving force of the industrial revolution. Implementing the projects in the sphere of the Industrial Internet is the main factor for increasing the efficiency of production, as well as the level and quality of life.

The first-priority task for efficient implementation of the Industrial Internet into the Russian economy is ensuring the availability of modern technologies for industrial plants. Solving this task is related to providing the state support of domestic developers and manufacturers of modern high-tech products, financing the implementation of projects in the sphere of the Industrial Internet of Things. Another prerequisite for development is creating the normative and legal base and standardization, as well as ensuring data safety. At the level of development of the society as a whole, it is important to maintain balance between development of various industries and spheres of life. Renovating the system of education, timely training of IT specialists, transforming the labor market is a necessity.

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