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Cloud Technology and the Digital Transformation of Manufacturing

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Abstract—Principles for the introduction of cloud technology in the digital infrastructure of manufacturing enterprises are outlined. Aspects of the technology are discussed.

Keywords: production, manufacturing, digital transformation, Industry 4.0, innovation, investment, cloud technology, distributed systems

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An important innovation in Russia today is the digitization of manufacturing enterprises, including high-tech enterprises. Traditionally, the manufacture of machinery has been a key industrial sector in the Soviet Union and in Russia, laying the foundation for the global competitiveness of Russian products [1].

The manufacture of machinery is of particular importance in Russia in an era of import substitution and precarious global supply chains due to the coronavirus pandemic. Accordingly, in our view, machine-building enterprises should embrace the smart automation of production.

At present, one of the main trends in industrial development is the Industry 4.0 paradigm, associated with completely new approaches to the automation of production based on digital technology [2]. In particular, the Industry 4.0 approach is associated with developments such as artificial intelligence, cyber-physical systems, intelligent industrial robots, 3D printing, virtual and augmented reality, and cloud technology [3].

Their introduction at manufacturing enterprises improves the efficiency and coordination of production processes, radically reduces equipment breakdowns, and permits the solution of qualitatively new problems associated with innovative products. Consequently, Industry 4.0 technologies are in great demand for the modernization of Russian manufacturing enterprises [4].

With the introduction of digital technologies for the smart automation of production, huge data sets must be analyzed: for example, information from cyberphysical systems regarding the operational characteristics of the enterprise's equipment; data sets for training and development in the field of artificial intelligence; and information for the formulation of predictive models of the enterprise and for risk assessment.

These types of information are gradually consolidated into vast data sets (Big Data), which are analyzed on the basis of artificial intelligence; this also requires serious computing power [5]. That results in considerable growth of the technical requirements on the computing power available at the enterprise.

One possibility is to construct a Data Processing Center at the enterprise [6]. However, that requires major financial expenditures. Note that rapid advances in computers and servers mean that the hardware at any such center would require regular modernization, at further expense.

A second option is to employ a key aspect of the Industry 4.0 approach: cloud technology. That is the best option, in our view. The fundamental principle of cloud technology is distributed computing, in which the calculations required to solve complex problems are distributed over a set of high-speed servers, each of which performs computations on a specific data flux.

Note that cloud technology occupies its own niche in the digital economy, to which specialized IT companies are devoted. These companies provide access to their computing power as a business service.

Several business models have been developed for cloud computing services. They may be considered in the context of the digital transformation of manufacturing enterprises, as follows.

1. Software as a Service (SaaS). The enterprise is able to use expensive software by subscription for a certain period, without the need to acquire a license. This model is appropriate when narrowly specialized software is required for individual projects and the purchase of a license is inexpedient.

2. Platform as a Service (PaaS). Specialists at the enterprise have access to a high-speed digital platform, where they may interact with one another, use software applications to solve specific problems, and store and backup information to the cloud. A benefit of the PaaS model is that no physical servers are required for data storage and analysis. This service is scalable in accordance with the number, the demand for servers, the volume of calculations, and other parameters.

3. Infrastructure as a Service (IaaS). The host company provides the enterprise with access to its hardware infrastructure (server, database, network resources, etc.) and its computing capacity, thereby sparing the enterprise the task of organizing its own Data Processing Center.

Each business model may be used to reduce the enterprise's expenditures on software and hardware. In addition, the use of cloud computing services means that the enterprise's specialists are freed of responsibility for servicing, repairing, and debugging such systems.

Another benefit of cloud technology is access to enormous computing potential. That allows specialists to perform calculations of great complexity (such as machine analysis of Big Data) in a short time, without any additional load on the enterprise's own computing power.

Cloud technology also permits the training of artificial intelligence for subsequent use in the enterprise's cyberphysical system. As a rule, an optimal approach is to use specialized processors intended for training single- and multiple-layer neural networks. Such processors are very expensive and are only needed in the initial stages of developing intelligent systems.

In that case, the PaaS model of cloud technology permits the use of the host company's specialized servers and processors. By that means, the enterprise may train neural networks at minimal expense under a short-time contract.

The IaaS model provides the enterprise with the computing power required to support its entire digital infrastructure. Cloud technology is largely fault-free, thanks to its parallel structure and the distribution of the load over numerous servers. Even a fault in one or more server would not affect the stability of the enterprise's digital infrastructure.

The stability offered by IaaS services is especially important for large enterprises whose production processes are closely interconnected within the life cycle of the product, so that the stopping of even one production line could lead to serious problems throughout the whole production process [7].

In our view, cloud technology within the Industry 4.0 framework permits profound rethinking of the organization of computing power in industrial production. Whereas this process used to operate within constraints associated with the enterprise's purchase of servers, network equipment, and specialized software, cloud technology makes the process more plastic and flexible. The enterprise may distribute its computational load adaptively between its own hardware and that of cloud services [8]. In a certain sense, that equalizes access to digital production between large and small enterprises. That, in turn, will accelerate the digital transformation of Russian manufacturing as a whole, in our view.

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