IIOT Within The Architecture Of The Manufacturing Company

Anastasia Levina
Graduate school of Business and Management
Peter the Great St.Petersburg Polytechnic University
St. Petersburg Russia
alyovina@gmail.com

Sofia Kalyazina
Graduate school of Business and Management
Peter the Great St.Petersburg Polytechnic University
St. Petersburg Russia
kaliazina.s@gmail.com

Alena Ershova
Graduate school of Business and Management
Peter the Great St.Petersburg Polytechnic University
St. Petersburg Russia
alenaershova13@gmail.com

Peter Cornelis Schuur
Industrial Engineering and Business Information Systems
University of Twente
Enschede Overijssel Netherlands
p.c.schuur@utwente.nl

ABSTRACT

The introduction of the Internet of Things (IoT) in industry can increase the level of production management, increase the speed of managerial decision-making, and provide higher quality products. The article discusses the use of the Industrial Internet of Things (IIoT) in the architecture of a manufacturing enterprise. The technical solutions currently used and the main effects of the introduction of the Industrial Internet of Things are analyzed.

CCS CONCEPTS

• Applied computing → Enterprise computing → Enterprise information systems → Enterprise resource planning • Networks → Network types

KEYWORDS

Internet of Things, Industrial Internet of Things, Manufacturing, ERP

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1 Introduction

The concept of the IoT finds its application in almost all areas [1]. One of the important areas of application of the IoT is the industry in which the introduction of the Industrial Internet of Things allows to manage manufacturing: track production information and carry out the necessary control actions. It should also be noted that the Industrial Internet of Things involves not only the collection of information, but also its subsequent analysis, which is important for making various production or business decisions. The development of IIoT is associated with the fourth industrial revolution (hereinafter referred to as Industry 4.0), which is marked by the transition to fully automated digital production using cyberphysical systems and cloud computing. The Industrial Internet of Things is known as a global network model that integrates industrial production systems at the level of processes and intelligent management [2]. The main motive for the implementation of the concept of "Industrial Internet of Things" in modern industrial enterprises is the benefit that these enterprises receive, namely: increased efficiency of production and technological processes and a decrease in the need for capital costs. Thus, the freed up resources make it possible to visually evaluate solutions in the field of the industrial IoT, which creates even greater demand for them. [3]. The IoT system today includes all the necessary links for its functioning: manufacturers of various devices (including sensors), software, system integrators, customers, telecom operators. The Internet of Things in manufacturing will bring automatic diagnostics that will reduce the time to investigate on-site failures and reduce equipment downtime [4]. Monitoring the condition of the product at each stage of production will reduce costs.

2 Materials and Methods

As a result of studying the relevant scientific literature and the results of case studies, the most significant characteristics of the architecture of the IIoT were highlighted.

2.1 The architecture of the IoT

The functioning of the IoT is provided by a set of information and communication technologies related to each other. Technologies can be divided into four functional levels:

- Sensor network level. This level is a pool of "smart" objects integrated with various sensors and devices, which essentially provides a link between the physical and virtual worlds. Today, technology allows to integrate sensors directly into existing objects in the physical world. There are different sensors for different types of measurements. Sensors can have some amount of memory, providing the ability to record a certain amount of data about the measured results. The sensor measures the physical parameters of the controlled phenomenon or object and then converts them into a signal that can be received by the corresponding device. Sensors are classified according to their purpose (e.g. environmental sensors, body sensors, sensors for household appliances, sensors for vehicles, etc.). As a rule, sensors are connected to the aggregator (gateway) using local area networks (LAN), such as Ethernet and Wi-Fi, or personal area networks (PAN), such as ZigBee, Bluetooth and ultra-wideband short-range wireless communications (UWB). If the sensor does not require a connection to the gateway, its communication with the server or application can be organized using global wireless WANs such as GSM, GPRS and LTE. The sensors, which are characterized by low power consumption and low data transfer rate, form wireless sensor networks (WSN).
- Gateway and network layer. Multiple sensors at any given time generate significant amounts of varied data that require a robust, well-functioning, network infrastructure to transmit. Existing communications networks using different protocols can be used to support machine-to-machine communications (M2M) and their applications. It is required to organize collaboration between the networks of all the varied technologies and protocols and to do so in a heterogeneous configuration in order to ensure the correct implementation of all application and services necessary for the IoT. It is also crucial for these networks to meet the level of the information transfer quality required, which includes specific levels of latency, bandwidth and security. Gateway and network layer is structured in a way that calls for an integration of various heterogeneous networks and forming a single network platform based on that integration. The IoT converged abstract networking layer through appropriate gateways enables users to collaborate independently without compromising security, privacy or performance [5].
- Service level. It serves the purpose of IoT business and technological operation automation and in order to do that it uses various information services. Among the main services there are the following: OSS (Operations Support System) or BSS (Business Support System), which, as the names suggest, ensure the support for various operations and business activities; data storage and analytical information processing, as well as safety of all the data, business rule management (BRM), business process management (BPM), etc.
- Application layer. On this level of architecture it is typical to have applications of varied types for the respective industries (medicine, energy, transport, trade, education, etc.). At the same time, a distinction is made between "vertical" and "horizontal" applications. "Vertical" refers to applications that are specific to different industries, while "horizontal" refers to applications that can be applied to different sectors of the economy.

2.2 IOT Platform Architecture

The IoT platform is an integration platform for the Internet of Things that offers solutions for the four main tasks of any application: receiving, storing, processing, and integrating with enterprise applications. The platform implements a chain of data processing and analysis on the server. Platform services allow to send and receive messages from devices, visualize received data using a database optimized for working with big data and for storing messages. Also important for the IoT is data aggregation, ensuring the security of data transmission, using the capabilities of predictive analytics when analyzing data received from Big Data sensors [6]. With these features in mind, IoT architecture is usually divided into three levels: the perception level, which based on the usage of sensors, the network level, and, lastly, the application level. The main objective on the level of perception is gathering reliable data from the sensors in a timely manner. On the next level – the network level – it is possible to access data, transfer it, process and store it. Usually, network level's structure consists of two sublevels. The first of those levels is the access level, which is based on the usage of mobile networks. The second level is the main exchange level. This one includes such networks as Internet, next-generation NGN networks, virtual private networks. Typically, sensor networks use such wireless networks as WLAN, which is a wireless local area network, for example, Wi-Fi; WPAN, a personal area network, for example, Bluetooth; wireless metropolitan area networks (WMAN) (usually WiMAX), wireless WAN (WWAN) (for example, 2G, 3G and 4G networks), satellite network (e.g. GPS). Sensor networks on the Internet of Things

are implemented using IP-based communication protocols (as a IPv6). The application level is the level where data analysis and processing happens. This allows to ensure proper control over management, applications and services, and that correct decisions are being made [7]. As well as that, application level is also the point where data is gathered and stored, etc.

Without the synergy of technical capabilities provided by ERP systems, useful data can easily be lost. Therefore, organizations need to use the best of ERP and IoT to optimize their business processes or create new business models. ERP systems are needed to connect unstructured data from devices to structured data in a business. It is expected that ERP systems will be organically interconnected between devices, things and people [8]. However, there are some concerns about the collaboration of ERP and IoT systems:

- It is required from The ERP system to have capabilities to process a large amount of additional data at high speed. This means that it should use a powerful database as a basis that could provide functionality for managing, analyzing and displaying all data in real time.
- The integration of the ERP system and the platform for the IoT is also a very important point. There should be no delays in data transfer, because for some processes, delays even in a few seconds can be critical.
- Security of data transmission. Information must be transferred from one system to another through a specially open "tunnel" and must be reliably protected.

Many modern information systems are focused on collecting and processing information from a large number of different sources, as well as on requests for servicing this information from different categories of users. However, traditional ERP systems currently reach their limits and, most likely, will not be able to respond to upcoming tasks and market requirements [9]. To use all market opportunities, enterprises need new types of ERP systems, intelligent ERP systems. Such systems should be direct, intelligent and integrated in order to be able to connect all the processes of the company and provide the most relevant information and conclusions [10].

It should also be noted that among the tasks of IoT development in various applications, one of the hardest ones is making sure all the information is protected [11]. At the network level, the main problem is the extremely fragmented nature of the structure that includes many connections in accordance with various standards and protocols, as well as a large quantity of varied objects. IoT forms a connection with an extensive amount of various devices, accumulates big data in various formats from a very large and diversified group sources. As a result, this can lead to network downloads and crashes, software failures [12]. It is important to ensure physical security at the level of sensors and data collection, which is characterized by its location in an inaccessible environment in the absence of standards, a large variety, limited energy supply [13]. At the application level of the IoT, there are additional problems of information security: information protection when applying calculations in the cloud, information processing, intellectual property rights, confidentiality [14].

J 'son & Partners Consulting study [15] presents a great analysis of the best IIoT implementation practices globally. Said study lists manufacturing as the main application area for solutions in the field of the industrial Internet. It is important to point out the following important conditions, the presence of which is characteristic for said practices:

- production of a large amount of different types of products requiring a wide range of components;
- a requirement for product quality improvement;
- the need for effective customer support;
- a requirement for lowering production operating costs;
- high levels of production energy intensity;
- production is conducted in tough conditions;
- the need to quickly determine equipment failures in order to lower the risks of unintended production stoppage;
- a requirement for maintaining a high level of staff productivity;
- a requirement for maintaining safety at the manufacturing plant;
- a requirement for a large scale system integration [16].

An important part when applying IIoT-based solutions is the IoT platform. This platform connects the data collected from sensors with user applications on mobile devices and SaaS applications [17].

The key features of IoT applications are presented in Figure 1:

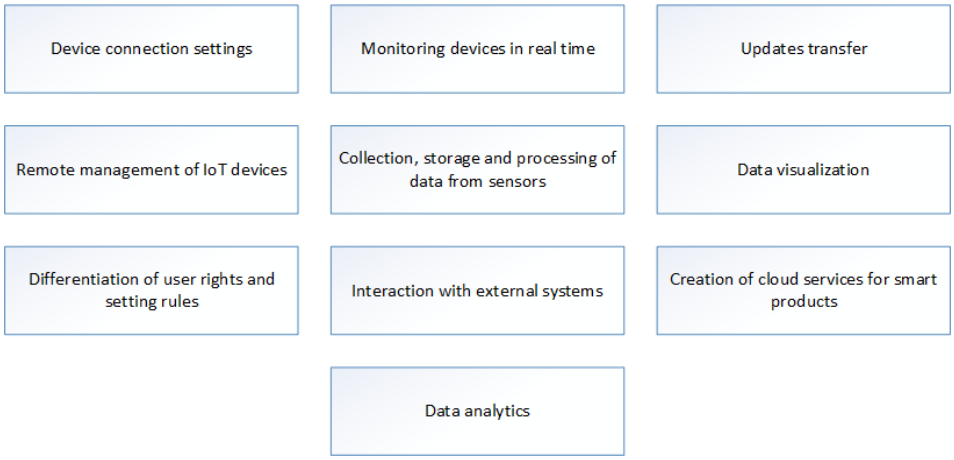

Figure 1: The key features of IoT applications

Industrial Internet of Things is used in manufacturing companies in order to control production, ensure safe working conditions, and measure environmental parameters.

Real-time data from the Industrial Internet of Things is important for the effective integration of data and business processes in a manufacturing organization for Enterprise-level systems such as CRM, ERP. The data obtained from the IoT ecosystem and enterprise systems ensures the automation of an industrial company. In addition, they can provide integration with Quality Assurance (QA) or Product Lifecycle Management (PLM) systems, which can help improve product performance, solve equipment problems, helping to increase customer satisfaction.

The methodological basis of the conducted study is the analysis of literature on the research problem, as well as data generalization and systematization. An architectural approach has also been applied to describe business processes and services.

3 Results

Consider the business layer (typical processes of a manufacturing company) and the processes that IoT technology can support (Figure 2).

Figure 2: Landscape production processes of the enterprise

- Business process "Provision of materials"
- IIoT technology provides improved inventory management and significantly improves the efficiency of logistics processes in the industry. For example, industrial companies use the RFID system to track important components moving from one unit to another, which provides automatic control, reducing the number of errors and the cost of finding the necessary parts on the production line.
- Business process "Production Planning".
- An example of the positive effect of using the industrial Internet of things when planning production can be an accurate calculation of the schedule of preventive maintenance, repairs, replacement of parts based on the analysis of the data received. This reduces maintenance costs while avoiding equipment downtime [18] and, therefore, reduce costs.
- Business process "Dispatching production"
- Installing an IoT sensor on production equipment or a direct connection to the Internet, if there is a controller, gives knowledge of the actual and planned load, and gives an opportunity to create an automated network of orders between different industries in a long chain starting with the suppliers of materials and ending with consumers of final products. It is done in a way that requires forming a connection between all production sites and a single software platform. It is possible that all parties are legally different companies. In addition, it allows tracking the status of the operation at any time.

Figure 3 shows the architecture of IT services using IIoT.

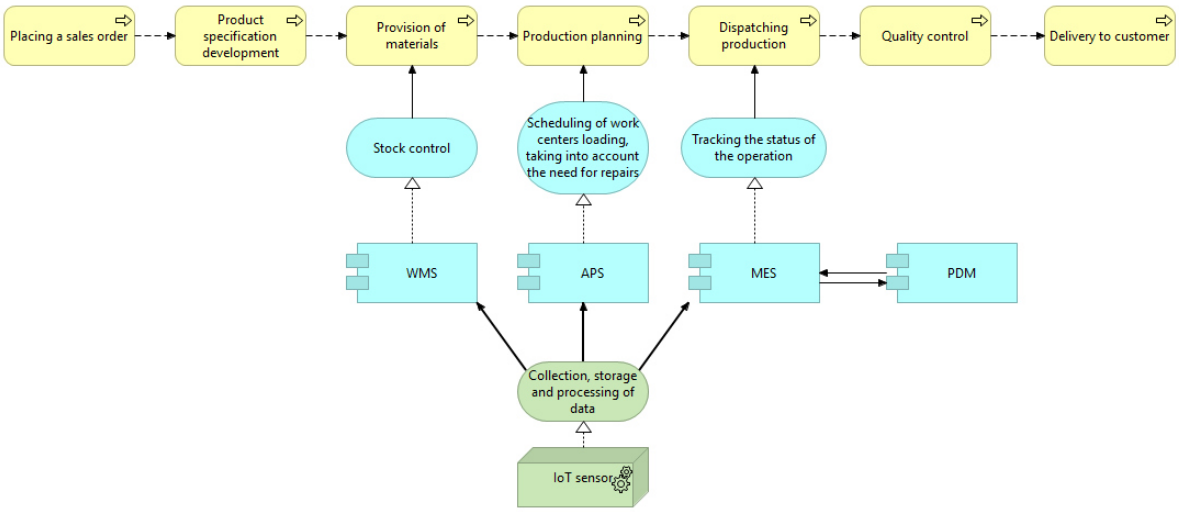

Figure 3: Architecture of IT services using IIoT

The potential effects of introducing IIoT technology at a manufacturing enterprise include:

- improving the energy efficiency of equipment (if the energy consumption of the sensors does not exceed the initial readings) and reducing operating costs by reading data on equipment wear in real time and the possibility of organizing a concept of predictive maintenance;
- improved planning;
- reducing the time of product preparation by tracking stocks using the RFID system in automatic mode (minimizing the human factor in stock analysis) [19];
- minimization of data errors for planning, as well as significant savings in human resources.

4 Discussion

Further research will be aimed at building architecture at all levels of the manufacturing enterprise, which provides synergy between the platform of the IIoT and the ERP system of a new level (intelligent ERP system). It is also planned to reveal in more detail the issues of ensuring information and physical security in a wide range.

5 Conclusion

Thus, the introduction of IIoT technology in combination with existing types of information systems can increase energy efficiency, reduce operating costs, improve the planning of the production enterprise and reduce the time for production preparation.

The combination of data obtained from the IIoT system and other applicable corporate information systems ensures the automation of a manufacturing company, which in turn allows to improve product quality and end-user satisfaction.

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