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INDUSTRY 4.0 – TODAY´S VISION OF THE FUTURE

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Abstract: *The aim of this paper is to analyse the new production concept Industry 4.0 based on the specification that characterizes this concept, focus on key terms, respectively activities and identify them, map innovations, benefits, and risks associated with the implementation of Industry 4.0. The paper has 6 main sections that are oriented on Cyber-Physical Systems, Internet of Things, IoT protocols, Smart factory, Big Data and Cloud Computing, which are key components of Industry 4.0 as a whole.*

Keywords: Industry 4.0, cyber-physical systems, internet of things, IoT protocols, smart factory; big data

1 INTRODUCTION

Modern industrial enterprises undergo transformation according to standard Industry 4.0. Standard Industry 4.0 is primarily a German access to introduction of new technology in the production for better efficiency. Industry 4.0 is also associated with the Smart Factory (SF). Individual businesses implemented in accordance with the SF standard may be linked to larger entities, such as virtual enterprises known as Cyber Physical Systems (CPS) [13, 14].

At present, a lot of solutions only exist in the form of models or theories, most in the test run, where we can mention companies like, for example, Trumpf, Festo, Bosch, and Siemens. The formation of such SF enterprises, however, represents a completely new approach to the realization of production, the structure of production units and the logistics and product lifecycle. It is possible to meet individual customer requirements, dynamic production planning allowing for rapid changes in the production process and respond to various barriers of suppliers and customers [11].

The successful implementation of truly functional production units (SF, CPS, IOT - Internet of Things) requires extensive structural and technological changes across the range of processes in production, logistics and consumption of the company. On the basis of the available information, we can summarize the objectives that need to be met. When creating a CPS, it is assumed to merge different businesses into individual units, and it is clear that you have to define communication interfaces and standards and ensure their real implementation. Another problem with SF implementation is the lack of resources to manage and manage truly complex and production systems. It is necessary to provide sufficient tools for planning and managing such complex structures [3, 11].

When applying SF standards, it is necessary to assume a massive increase in the volume of communication in transmission systems. Together with the development and application of new production standards, it is necessary to ensure flexibility in the legislation and social policy of the whole society. It will also be necessary to develop lifelong learning programs to keep workers in contact with the rapid development of society [15].

2 CYBER-PHYSICAL SYSTEMS

The Cyber-Physical System is a highly complex system with its own decentralized control unit and there are intelligently connected objects that are connected to a common communication network via the Internet, namely Internet of Things and Services (IoS), and these objects work independently of each other. Only with CPS is the Industry 4.0 concept real. In the future, CPS will connect intelligent machines, warehouses, machines that will handle autonomous information exchange, impulses and mutual control. Machines, devices and people will communicate. This will improve industrial processes related to production, engineering, material consumption, and the entire supply chain. Production systems are linked both vertically and horizontally [5].

CPS is supported by Embedded Systems, which are electro technical units that have a certain function and they are with the help of a microcontroller conditioned for proper operation. They work autonomously, so independent of the user, because they can react faster than a person, work on multiple tasks simultaneously, in the real time and without errors. It's an inseparable connection between hardware and software. Embedded systems will connect to the network and create an intelligent control unit that actively contributes to the correct CPS function (Fig. 1).

CPS will bring the real world with virtual cyberspace, which is referred as the digitization of production. Subsequently then will be created a Digital factory, in the real world Smart factory, where it is possible to virtually monitor, simulate and subsequently improve the production. The digital image of the production will allow monitoring the deviations of the real production and then analyzing immediately and eliminating [7].

3 INTERNET OF THINGS

The term IoT was created by Kevin Ashton in 1999. The main idea is to create smart objects, add sensors, and connect everything using Wi-Fi to the Internet. The purpose of this idea is to gradually integrate the computer into a normal life. The first example was the interconnection of cars with the Internet, which represented more secure; the next step was the navigation system with an alert for accidents or traffic jam [8].

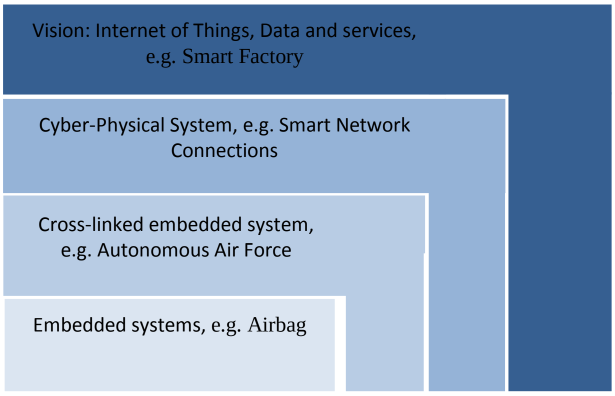

Fig. 1 Integration of Embedded Systems in IoT, IoS and Big Data [2]

The potential of the Internet of things have companies begun to connect with Industry 4.0. Although initially the Industrial Internet of Things (IIoT) was being prepared as a way to innovate efficiency, it turns out that companies can also benefit from the IIoT. In the end, Industrial Internet of Things is gaining a trend and impact on the global economy. However, to exploit the full benefits of IIoT, companies will have to pass three technological capabilities [8]:

- Sensor-controlled calculations.
- Industrial analyses.
- Applications of intelligent machines.

Operating technologies as a set of technologies that have been designed to enable the computer to perform certain functions.

These technologies may (but may not) be in any OS (Operating System), and there are often differences in their implementation. This connection is shown for better imagination in the graphical form in Fig. 2.

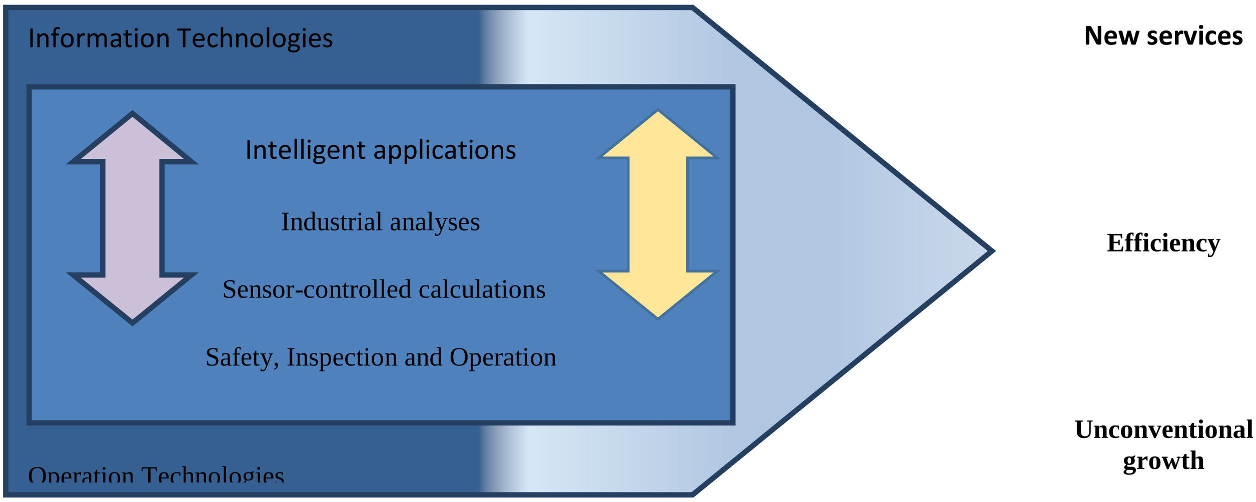

Fig. 2 Technological processes in IioT [6]

Internet nowadays supports hundreds of protocols, and it will be another hundred more with the IoT. For better orientation, we classify the protocols into categories according to their usage. These are basically the following types of protocols (Fig. 3) [8]:

- Used for device to device communication,
- Used to send collected data from a device to a server,
- Used to share data between servers (server to server).

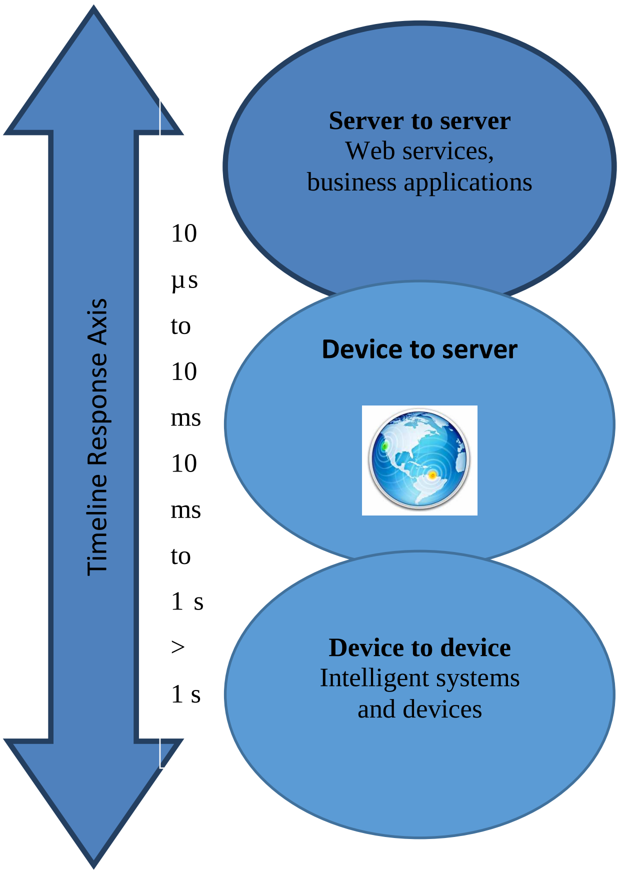

Fig. 3 Categorization of protocols in IoT [9]

4 SMART FACTORY

Smart factory has a lot of definitions. But what all definitions mean is the digitization of production, the interconnection of devices using the Internet with CPS, and the use of Smart Technology that will be the major motor of Industry 4.0.

Industry 4.0 is a term that comes from Germany. German Trade and Invest (GTAI) defined this concept as "Linking the virtual world with real-world via CPS, which flows from technical processes and business processes".

According to GTAI, Smart Factory is the basics of CPS, which has to link Smart Product, resources, and processes. This linkage will allow tracking the process in real time, optimizing resource distribution, reducing time, increasing productivity and reducing costs. The product itself will be individual and the production will take place based on the order of the product. Production will be highly automated. Flexible production systems that are capable to respond in real time will optimize the production process as much as possible. Fig. 4 shows the Smart factory concept.

Smart factory can be seen as a factory that can dynamically respond to changes in the market. It offers the customer the possibility to customize the product according to his own needs, quick execution and maximum after-sales service according to the PULL principle. Smart factory contains many elements. As already mentioned, the basic of the factory is CPS, the connection of machines, workers, intelligent systems and especially products to the network. This enables them to communicate and work together efficiently. Communication will be done wirelessly via the Internet. The initiator is the product that controls the production flow. Production is highly automated and robotic. Sensors and cameras enable to use the digital production, which will help us to compare the real state with the virtual state and to solve the errors in real time.

Smart Maintenance is important for continuous production. Sensors and cameras together bring independent machine maintenance when the machine can identify a fault or warn of an interval when the service is required. Logistics will change to Smart logistics, where material, spare parts and finished products will be transported by autonomous means of transport. IT, technologies, automation and the Internet will bring a whole new industrial revolution. We can say that such factories bring benefits to the production as well as to the final customer. Smart factory will have these characteristics in Industry 4.0 (see Table 1).

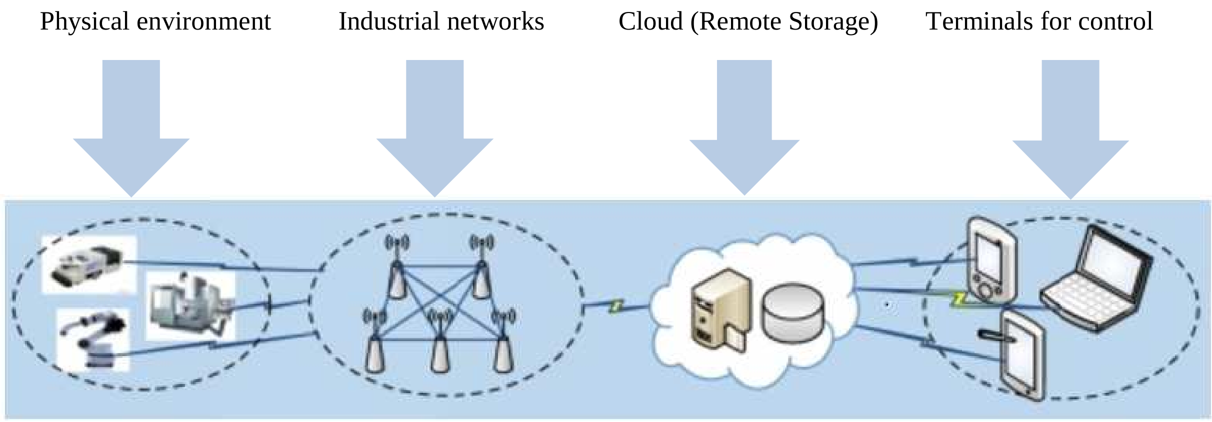

Fig. 4 Smart factory concept [4]

Table 1 Smart Factory characteristics in Industry 4.0 [10]

Smart Factory characteristics	Description
Energy management	higher energy efficiency, power consumption
Active maintenance	real time data collection
Connection with suppliers	mutual information about material flow and time in the production process
Automation	effectiveness and reduction of human activity mistakes
Remote monitoring	tailored services throughout the production cycle
New services	new customer values before buying the product and post-warranty service
Big data	ability to analyze the huge amount of data generated during production and to identify and streamline them in real time
Effective planning	better process optimization enables efficient factory planning of the entire factory
Optimized decisions	all production sites in a timely and efficient schedule
Flexibility	flexible use of aspects such as time, quality and price
Production orders	individual adjustments and changes to the products at the last minute

The elements characteristic for the Smart factory in the production process can be summarized as follows (see Table 2).

Table 2 Elements characteristic for the Smart factory in the production process [10]

Element characteristic for the Smart factory	Description
Data analytics	advanced algorithm for data processing and real-time analysis
Cloud storage	sending and archiving data from all departments to a secure server
Cybersecurity	data protection against threats of hacking attacks, e.g. firewall, data encryption
Intelligent sensors	sophisticated sensors embedded in a machine with wireless data transfer and self-analysis
Smart maintenance	maintenance of machines changes from manual to automated, because of the sensors, CPS and autonomous decision-making
Cyber Physical system	interconnected systems with machines and devices that provide autonomous control
Mobile workforce	workers are equipped with smartphones, deliver real-time production data
Autonomous vehicles	the material is transferred into the line by self-guiding devices
Smart products	products are equipped with chips, which makes the product the initiator of production
Cooperation	cooperation of machines with people
Smart grids	use of renewable energies
Robotics	use of artificial intelligence

The smart product linkage in the production is shown in Fig. 5.

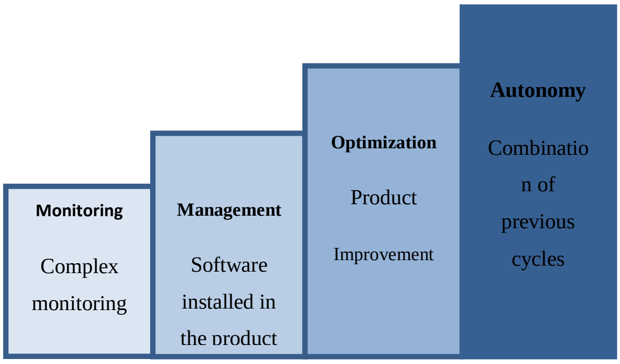

Fig. 5 Smart product linkage in the production [17]

Technologies for information transfer are summarized in Table 3.

Table 3 Technologies for information transfer [17, 18]

	Technology type		
Characteristics	Barcode	Image recognition	RFID chips
ID code	✓	✓	✓
No printing		✓	
Removable			✓
Memory			✓
Communication			✓
Sensors			✓

5 DATA

The word Big Data is referred to as the buzzword in IT. Together with Cloud computing (public IP and virtual servers) is said about their interconnection. Together, these elements would serve to acquisition, store, and analysis of the data in Industry 4.0. The aim of the Big Data collection and its subsequent analysis is to obtain background material for future predictive systems and explore the potential of these elements.

IoT link and IoS that are linked via CPS and this will allow mutual communication associated with a huge amount of data from which information will be generated later. Big Data together with Cloud (remote storage) will allow data collection, analysis and processing of large data files and through filters their easy search. Data from the Web configurator and social networking will be uploaded to Big Data in order to capture customers' requirements, and this will help make the market more efficient.

Furthermore, the collection of data from sensors, Internet and RFID chips will be happened. These data are then used for resource planning, virtual production, maintenance, and project prediction. In practice this will mean that the data will be obtained not only from the factory, but also from potential customers, or suppliers. There will be only one way data flows. The availability of this data is critical to the information system because the data will serve as a source of information for the database. The data size will grow exponentially due to the involvement of sensors, the Internet and all other technologies. Therefore, online archiving will be very important.

6 CLOUD COMPUTING

The idea of Cloud computing was first introduced in 1963. It is a computing service that has the basics of Internet-based implementation (public IP), represented as a virtual network cloud using a virtual server. It offers calculation tools that are paid from CPU hours or GB saved. It offers unlimited access to the network on demand of a user who has access to computer resources - servers, networks, applications and repositories. It has fast access, resource sharing and high elasticity. In the Cloud, all means must be virtualized, which means access from software to hardware through a web application. The Cloud model is divided into [1]:

- Public.
- Private.
- Community.
- Hybrid.

Cloud computing is available to users in three models [1]:

- Software as a Service – allows users to run many software applications over the Internet without the need for ownership (such as Gmail).
- Platform as a Service – provides users the computing platform to support Web applications over the Internet (e.g. Google Apps).
- Infrastructure as a Service – allows the use of computer hardware and system software and operational and communication systems (e.g. Amazon EC2).

The benefits of Cloud computing are:

- Remote data storage.
- Hardware performance.
- A large variation of options.
- Price.
- Independence from localization,
- Maintenance.
- Reliability.

On the other side, a large proportion of companies are considering whether to use Cloud computing because everything works over the Internet.

7 CONCLUSION

Industry 4.0 is focused on Smart Process, which is a big change compared to conventional production. The basic of the concept is the creation of Smart factory. These factories will be able to handle fluctuations in demand, will be more resistant to failures, and will be able to produce the most efficiently. Machines, people and resources can not only communicate, but also work together. The machines themselves report to the maintenance worker and precisely define the problem. Products with RFID chips will be able to control their flow through production and know where to deliver. The product itself will be actively involved in the production process. Enterprise flow infrastructure will control and manage Smart grid, Smart logistics and Smart distribution [15, 16].

In other words, is will start the transformation of the value cycle into a completely new one. The Industry 4.0 concept also talks about how individual parts in the value chain work in isolation, but everything will be interconnected and effective. Industry 4.0 will maintain closer contacts between supplier, producer and customer.

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