IJEEC

International Journal of Electrical Engineering and Computing
Vol. 4, No. 2 (2020)

Original research paper
UDC 005.336.5:330.341.1
DOI 10.7251/IJEEC2002101A

The role and importance of Smart Systems concept in the Industry 4.0

Smart Agriculture System – GoGrow

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Abstract— **From the 18th century, the Industrial Revolutions led to the creation of a base for the development and progress of civilization and business. Different business models that relied on the new trends defined by the industrial revolutions significantly transformed the ecosystems of companies. This resulted in the accelerated development and entrance into the digital age, followed by the digitization of the environment and establishing a new system of values. Information and communication technologies are the backbone of the development and mapping of the physical domain into cyber-physical, leading to the emergence of new processes, knowledge, and skills that have been established in the context of Digital Transformation and the digital era. The key part of Digital transformation process is the Smart Systems concept, which is present in almost all industries and domains. Smart Agriculture is one of the most common applications of Smart Systems solutions. It aims to answer important questions regarding food production while, at the same time, taking care of the preservation of the environment, the health of the population and global development. In this paper, the key concepts of the digital transformation and smart systems are presented. In addition, the design and development of the GoGrow, commercial solution for smart agriculture is described.**

Keywords-Industry 4.0; Digital Transformation; Smart Systems; Smart Agriculture;

I. Introduction

The world's population is constantly growing so it is expected to be higher than 10 billion by 2050 [25, 26]. That fact arises many questions and challenges: how to produce enough food but, at the same time, take care of the environment preservation, the health of the population and global development [27].

One of the goals of technological progress based on the concepts of the fourth industrial revolution - *Industry 4.0* is to provide answers and solutions to cope with some of the above-mentioned problems. *Industry 4.0* systems and technological solutions could help in solving or reducing the consequences of some of the biggest global problems facing the world in modern times: population growth, food shortages, pollution, traffic jams regulation, environmental protection, unemployment, etc.

Industrial revolutions are one of the main initiators of changes and progress in global society. It can be said that the new industrial revolution - *Industry 4.0*, appeared as a result of rapid software and hardware development. Nowadays, electronic devices are increasingly equipped with sensors and actuators that can exchange data in real-time. That makes them "*smart*" and allows them to make decisions, react quickly and efficiently, based on experience gained through the exchange of information. *Industry 4.0* reflects the process of industrial and technological transformation, which naturally follows the development of scientific and production practice. Based on contemporary concepts such as digitalization and automation of production, connection and interaction of cyber-physical systems via Internet standards, processing and analysis of large data sets, artificial intelligence, robotics, digital "*clouds*", digital modeling and simulation of production processes based on virtual reality, intelligent automation, and so on, a new business models which significantly transform the companies ecosystems could be created. Transformation, as one of the basic pillars of the fourth industrial revolution, could completely change the managing of companies that use information technology to develop business, products, and services. Information technologies are no longer "just" tools that help to perform everyday assignment but bring significant changes to existing processes and solutions while creating new value chains. From the very beginning, development of information technologies has transformed the way of working and the consciousness of employees. Nowadays, this development still plays a significant role in the process of changing the whole society. This results in accelerated development and entry into the digital age, which is accompanied by the digitalization of the environment, thus establishing a new value system.

In modern agriculture, systematic collection and analysis of data using sensor stations and timely reporting valuable information allows decision-makers to better consider all possible actions that could be taken to increase the yield of individual crops and other important tasks [28]. That way, relying on information technologies and modern concepts of *Industry 4.0*, dependence on human resources is reduced to a minimum, which opens a new digital era in all branches of human activity.

The rest of the paper is structured as follows. Section 2 presents a brief history of the industrial revolution. The fourth industrial revolution is presented in Section 3. Section 4 considers the concepts of Digital Transformation, while section 5 is dedicated to smart agricultural systems concepts. In section 6 GoGrow Smart Agriculture System is described and data mining and advanced analytics smart systems possibilities are presented in section 7. Section 8 concludes the paper.

II. HISTORY OF INDUSTRIAL REVOLUTION

Historical development of civilization is closely connected with technological and economic development. Throughout the years, the goal of development has remained the same: to increase the standard of living and the overall value system. An inventive approach, finding new tools and technological solutions to increase production, leads to a significant living standard change. The production process is significantly improved by introducing industrial solutions that enable mass production. That significantly leads to lower product value. These two factors are changing the ecosystem of the modern world. Beginning of this process was the first industrial revolution that started in the 1760s in Britain, marked by the mechanization of manual labor and the introduction of wind, water, and steam into production technologies [3, 11] (figure 1.). The second industrial revolution began in the 19th century and was primarily significant for the discovery of electricity (railway development and electrification of production facilities) and introduction of a "*new organization*" concept which formed the basis of mass production [3, 11]. This technological progress had formed the nowadays outlines: the first big cities had been built, factories had been opened, the exchange of goods and human communication had been drastically increased [3].

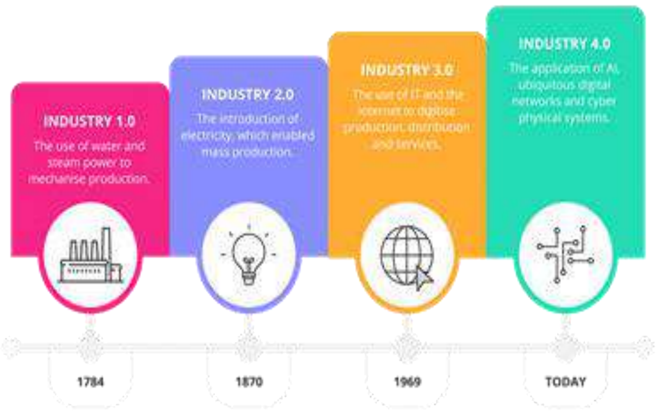

Figure 1. Industrial revolutions

In the middle of the 20th century, with the development of electronics and electrical circuits (the discovery of transistors), the world entered the third industrial revolution, also known as the "*Digital Revolution*". In the 1960s, programmable mainframe computers were launched. That significantly accelerated the data processing and was based on the concepts of digitalization of the world around [1]. Electronic devices were becoming smaller, and the invention of integrated logical circuits with many transistors, diodes, and resistors had allowed mass production of computers and microcomputers of large capacity and data processing speeds. In the same time, a new computer applications and general-purpose computer operating systems development began. Computers became widely available and used in everyday operational tasks around the planet. A key turning point in the third industrial revolution arose with the emergence of the concept of creating a "*network*" of remote computers with the goal of data exchange, which is today known as the Internet [3]. By the end of the 20th century, electronic communication was increasingly used, as well as the application of the Internet and the *World Wide Web* in the daily work of companies, which led to the first digitalization of business. These innovations have brought a significant transformation in the employees' ways of working and thinking and, as most important, they have changed the way companies communicate with their end customers. The development of e-commerce and e-business in the late 1990s was the foundation for today's digitalization, although information technology has been mainly used to support existing processes such as logistics, buying and selling, marketing, and customer relationship [1].

The digital revolution relies entirely on the concept of digitization, which can be observed as [2]:

- a process aimed at converting analog information into digital form, where the transformation is performed using electronic devices, i.e. analog-to-digital converters (increases the possibility of their processing, structuring and categorization, and storage and transmission of information via the digital environment).
- the process of transformation, i.e. as an environment that integrates digital resources, services and domain experts who participate in the process of creating, storing, analyzing, and processing information.

Today, digitalization in the value system is observed significantly different and can be defined as digital enabling of analog or physical artifacts (values and sizes) for the purpose of their integration into business processes, which ultimately aims to acquire newly formed knowledge and create new value for investors [2]. The general conclusion is that digitalization implies the use of digital technologies and data (digitized and originally digital) with the goal of generating revenue, improving business, replacing/transforming business processes (not only their digitalization), and creating an environment for digital business where the digital information represents its core [4].

Jeremy Rifkin defines a review of technological trends from the point of view of economic opportunities, i.e. business perspective, which has a direct impact on the digital revolution [1]:

- ***Easy access to information*** – The Internet provides unlimited access to a large amount of information via personal devices. In this way, clients change their habits and have the opportunity to collect relevant data. Companies provide new services and services that dictate the change of the entire ecosystem, which requires a change/adaptation of the existing architecture of their information systems.

- ***Exchange of ideas/opinions through social networks*** – expansion and global application of social networks enables the exchange of ideas and opinions of users, but also impressions about products and services consumed ("bloggers", "influencers", etc.). Company products and services are transparent, and companies can identify new business opportunities.
- ***Decentralized cooperation*** – The Internet provides the possibility of cooperation of different actors and exchange of information for the purpose of new product development (local, regional or international), and the establishment of a commercial network. Combining resources and expertise enables companies to work collaboratively, create new value chains, make faster decisions, better share knowledge, and encourage innovation.
- ***Mass use of data*** – the growth of data produced by today's systems is almost exponential. The key advantage of using and analyzing a large set of data (Big Data) in business is the recognition of consumer behavior through monitoring their activities on the Internet and social networks, which enables a targeted offer of services and products.

The new value system, defined with each industrial revolution, makes changes not only in economic development but also in the sociological, cultural, and educational aspects of development.

III. FOURTH INDUSTRIAL REVOLUTION

Henning Kagermann defined the main ideas for the development of *Industry 4.0*. Those ideas where foundations of the Manifesto presented in 2013 by the German National Academy of Science and Engineering – Acatech [11]. The reason for the new industrial revolution initiation had been found in rapid technological development, primarily of hardware components, and their connection on a global level. The devices are equipped with sensors that make them "smart", so they themselves became part of the distributed data processing and analysis systems. That way, the behavior of the system can be predicted, which in turn enables its autonomous control. This technological progress significantly affects industry production processes and new business models appear, but it also affects everyday life and communication. *Industry 4.0* reflects the process of industrial and technological transformation that naturally follows the development of scientific and production practice, building on well-known concepts such as digitization and automation of production, connection, and interaction of cyber-physical systems via Internet protocols and standards, processing and analysis of large data sets, artificial intelligence, robotics, digital "clouds", digital modeling and simulation of production processes based on virtual reality, intelligent automation, mass production of individualized products, and the creation of new business models [3, 6, 11].

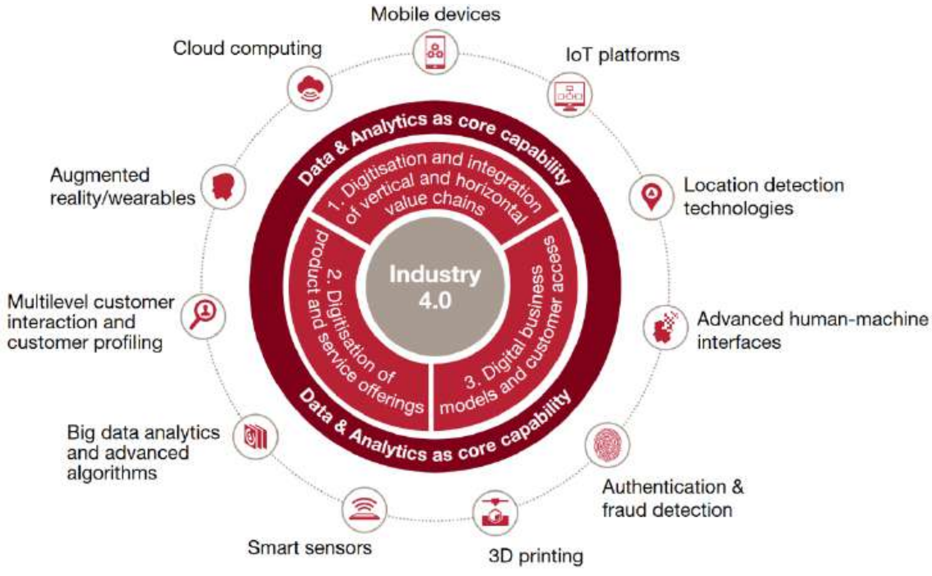

Figure 2.Main initiators of Industry 4.0 [12]

Digitization of physical assets, as well as their integration into digital ecosystems, contributes to the process of creating new values in which the core is represented by data and analytics. According to [11, 12], main digitization components and initiators are (figure 2.):

– ***Digitization and integration of vertical and horizontal value chains*** – the processes are digitized and integrated into the vertical value chain within the organization: from product development and purchase, through production, logistics, and services. Data that form and support the vertical value chain, such as data on operational processes, operation planning, process efficiency and quality management are available in real-time and can be used for analysis, optimization, and simulation. Horizontal value chain integration, as opposed to vertical, extends beyond the organization's internal operations and extends from suppliers to all customers, relying on technologies and approaches such as tracking devices and real-time planning.

– ***Digitization of product and service offers*** – Product digitization involves the expansion of existing products with digital technologies (connection or integration with sensors or communication devices) that can be connected to specialized data analysis tools. This approach provides companies with the opportunity to perform a detailed analysis of product utilization. Based on obtained information, it is possible to adjust or upgrade the products in order to meet the needs of target customers. Also, digitalization refers to the creation of new digitized products that offer fully integrated solutions.

– ***Digital business models and customer access*** – companies are expanding their offer, providing services to customers through digital integrated platforms that offer complete solutions by connecting different ecosystems (physical and virtual). New business models are often focused on generating additional income, through optimizing customers access and interacting with them.

In the available literature, a set of technologies are listed as the foundation for creation of the entire digital industry ecosystem 4.0 [3, 5, 6]. The most important technologies are:

- ***Internet of Things*** – the basis for connecting various devices via the Internet, whether personal or industrial. On that way, a new digitally connected world is created with billions of users, providing new opportunities in the field of knowledge, data processing and exchange.

- ***Cloud technologies*** – "cloud" encompasses two concepts: cloud computing and cloud-based manufacturing. The first concept can be observed as the provision of computer services (servers, data warehouses, network infrastructure, software and application solutions, etc.) via the Internet with the aim of faster innovation, more flexible access to computer resources and economic growth. The second concept implies coordinated and connected production that is available at the request of the user.

- ***Large amounts of data (Big Data)*** – large amounts of diverse data, which are generated or stored on the Internet, need to be quickly processed and converted into useful information that helps estimation of the current situation, configure different machines, analyze environmental and other conditions which may have an impact on production. Data analysis can bring a significant competitive advantage to companies, because they can adequately and timely assess the entire work process.

- ***Embedded Cyber-physical Systems*** – is a concept of integrating physical processes with computer and network devices, driven by intelligent software solutions that process, monitor and control physical processes.

- ***Artificial Intelligence and Autonomous Systems*** – is a concept that would allow computer systems to behave in a way that could be characterized as "intelligent". Such systems are able to learn and make self-development based on artificial intelligence algorithms (neural networks, genetic algorithms, etc.), and have the ability to think, solve problems and cope with new situations.

- ***Augmented reality*** – includes the modification of reality with augmented objects and elements in order to enrich the user's perception with additional information. Specialized applications connect graphical interfaces to the user's view of the current environment, after which users can directly influence the visual display of elements using control commands.

- ***Cyber security*** – the collection of large amounts of data, as well as their processing, define the responsibility for the companies to protect user's privacy and their personal information (passwords, fingerprints, corneal scans, etc.). Data storage and transmission process security is a challenge that is very important and should be solved in all today's technologies: "clouds", smart devices, robots, automated systems, etc.

- ***Mobile technologies*** – contemporary mobile devices are equipped with high quality technological equipment (processors, microphones, cameras and sensors), as well as communication technologies for connecting to the Internet, which gives them the ability to transmit and process large amounts of information. Using mobile technologies, users can recognize and react to the problems much faster, especially when information is generated very quickly, so user reaction can be almost direct, in real-time. Mobile devices can communicate with process equipment, smart devices, as well as other users or systems.

IV. DIGITAL TRANSFORMATION

A whole range of different definitions of the term Digital Transformation can be found in the literature, but almost every of them includes a couple of key components: digitalization, business transformation, collaboration or cooperation, modern digital technologies, value chain, and sometimes even digital economy. Schallmon and Williams [2] establish a general definition of digital transformation:

Digital transformation is the networking of actors, such as businesses and customers, through every value-added chain segment, with the application of new technologies. As such, Digital transformation requires skills that involve extracting and sharing data as well as their analysis and converting data into available information. This information should be used to calculate and evaluate options, to enable decision-making and / or trigger activities that increase the company's performance and market share. Digital transformation and the transformation process include companies, business models, processes, relationships, products, etc.

Companies use information technology to develop new business models, products and services, where information and communication technologies are no longer simple tools that serve to support business but allow significant change in existing processes and value chains. Business models represent the basic idea of the company and describe what benefits the company provides to customers and partners, but also provides answers to questions about the benefits that the company offers in the form of revenue. The business model includes dimensions and elements such as: customers (contains segment customers, customer channels and customer relationships), benefits (products, services and values), added value (resources, skills and processes), partners / associates, partnership channels and partnerships), and finance (revenues and expenditures). The goal of every company is to establish optimal combinations of elements that mutually reinforce each other, achieve stability and financial growth in a way that competition is difficult to emulate.

Three basic steps define the *Digital Transformation* within modern companies:

- ***Digital work environment*** – application of technologies such as mobile devices, tablets and laptops, collaborative tools and social networks and application of initial technologies intended for private users.
- ***Digital user experience*** – optimal user experience is a key factor in the process of digital transformation. Negative user experience has a direct impact on the perception and sales of products, which can affect the company's business. In front of companies, the challenge is to develop comprehensive, individualized systems that provide the user optimization of experience in all digital and traditional spheres of business. Although the way of displaying and designing such systems plays the most important role for the user (interaction with the user), for optimal user experience it is necessary to perform *Digital transformation* of all processes in the company (logistics, accounting, warehousing, and development). Therefore, in addition to the transformation of marketing and sales, the *Digital transformation* must include customer-oriented digitalization and integration of the entire process in the company (front-end and back-end process).
- ***Digital business models and ecosystems*** – independent companies will no longer be able to withstand the pressures competition in the market (especially small and medium enterprises), which will lead to the formation of digital ecosystems and service networks in which companies will connect and develop collaborative business models. In this way, the companies will jointly offer a better service compared to competitors, which will significantly increase their market value. On this way, cooperation will lead to the emergence of new sales, production, and business models, which will result in the emergence of new digital ecosystems.

According to [2], the most important element of the *Digital transformation* is the digital transformation of business models, that can be related to individual elements or the entire business model, value-added chains, as well as networking of different actors in the value-added network. The *Digital transformation* of business models is based on an approach that involves a series of tasks and decisions that are interconnected in logical and time context, and affect four target dimensions: time, finance, space, and quality [2].

Digital transformation of Existing Systems in the Fourth Industrial Revolution (*Industry 4.0*) represents a strategic and long-term endeavor that requires large capital investments, training employees, and changes in the environment and culture at all levels of the value chain. For successful digital transformation, it is necessary to change the mind of employees and make capital investments in their education so they can be ready for the challenges. The transformation of the business ecosystem can only be successful if the company's information culture is supported (to a large extent information literacy, use and application of new technologies, and modernization of business processes). Companies need to invest and adopt brand new digitally managed IT strategies technology, as well as a competitive offer based on digital processes. By connecting traditional industries with modern digital systems that are part of the Digital Transformation process, i.e. digitalization of production, companies remain competitive in the market and adapt to the new values dictated by *Industry 4.0*. The four basic trends of *Digital transformation* in the business environment are the basis of *Industry 4.0* [15]:

- ***Connected consumers - customized experience*** – It is a trend of great importance for *Industry 4.0*. Consumers are directly connected to producers through electronic communications and social networks, so the adaptation of products is done directly to the requirements and needs of customers, which provides the opportunity to combine their needs with mass production.
- ***Empowerment of employees*** – Employees in industries become more motivated to work and empowered because they are supplied with the necessary information at the right time. Companies and manufacturers benefit multiple times from this approach because employees are able to use digital tools to monitor the complete supply chain that allows them to make independent decisions and business strategies.
- ***Production optimization*** – By introducing digital technologies into the production process, companies get real-time information that dictates their decisions. This approach has long been available only to large companies that invest significant resources in the modernization of their production facilities. However, with the development of the ICT industry and the mass production of hardware devices, small and medium enterprises today can also afford this type of optimization.
- ***Transformed products*** – The modern approach in production is based on the elimination and prevention of failures and errors with the help of the analysis of the collected data. On this way, companies save large financial resources, as well as accelerate the process of improving innovation. Companies are introducing IoT systems and machine learning systems to monitor product behavior, and act preventively.

Today, Digital Transformation can be found in almost all segments of the digital ecosystem. Scardovi in paper [7] deals with the impact of the Digital Transformation on the financial sector (global financial system, transactions, capital risks, financing, investment management, lending, risk management, insurance, etc.), while Dastbaz et al. [3] show the application of Digital Transformations on the whole spectrum of different applications (health system, systems for billing, energy systems, the automotive industry, blockchain technologies, etc.). A review of the digital economy is presented in the collection of papers "Digital Economy: Emerging Technologies and Business Innovation" [8], where a group of authors elaborates the areas such as digital marketing, e-banking systems, information systems, and technologies in the field of banking as well as e-learning, e-government and e-health. In [9], Nissen and other authors deal with the impact of digital transformation on the field of consulting industry, while the Digital Transformation of the supply chain is presented in the paper [10], and the public sector in the paper [4].

V. SMART SYSTEMS AND SMART AGRICULTURE

From previous chapter, it is certainly clear that the key concept of *Industry 4.0* in *Digital transformation* process is *Smart Systems*. This concept can be defined as systems of heterogeneous electronic components that are connected by different communication protocols to perform specific tasks. *Smart Systems* are "*Machine to Machine*" (M2M) systems whose elements have the ability to independently process data and communicate with each other without direct human influence. On that way, the human error factor is excluded, and data transmission takes place with great precision and accuracy in real-time. These features of Smart Systems have led to their representation in almost all industries and domains and some of them can be grouped in the areas of *Smart City*, *Smart Agriculture*, *Smart Mobility*, *Smart Healthcare*, *Smart Community*, etc.

Smart Agriculture is one of the most common applications of *Smart Systems* solutions because it represents a modern approach in the process of mass production of food without harmful elements to human health. With the growth of the world's population, food is a resource that is becoming even more valuable, so it is necessary to find adequate technological solutions that would increase the production of agricultural goods. Because of the insufficient food production, utilization and improvement of the Smart Agriculture system is of great importance and is directly related to *Industry 4.0* as a new generation concept. Smart Agriculture systems are based on IoT technology that enables the transmission and distribution of data and information through communication channels, enabling sophisticated electrical systems that use new technologies to measure, transmit and display the parameters of agricultural land.

One of the most important tasks in agriculture is improving crop yields. In smart agriculture, it can be easily and more efficiently performed by monitoring conditions and measuring individual environmental parameters during the crops growing (for example, control of irrigation of agricultural land during the summer months directly affects the yield, quality and sales of crops). Applying the Smart Agriculture system, sensor stations are set up on agricultural land which, depending on the agricultural crop, measure parameters of interest at defined time intervals (air and soil humidity, temperature, lighting, etc.).

The data collected from the sensor stations are forwarded to data concentrator (usually a gateway or router), located in the agricultural area. It accepts the data packet and forwards it to the Internet to be stored in one place in the central unit of the system. Only after storage and processing, the data reaches the end users who have to receive the information in some comprehensible form. Figure 3. shows an illustration of a smart agriculture system, i.e. device communication and process monitoring [13].

A key segment of any Smart Agriculture system is the storage and distribution of data to the user application. In practice, commercial Cloud systems that are owned by corporations such as Google, Amazon, Oracle, Microsoft, etc. are most used and their service providers guarantee stability, availability and security of data access.

Figure 3. Smart Agriculture Illustration [13]

However, users often use their own Cloud solutions. In that case, it is necessary to have their own hardware infrastructure, which requires significant technical resources. Whatever storage system is chosen, the collected data is available for further processing and applying some analysis methods in order to transform data in desirable and useful form [13].

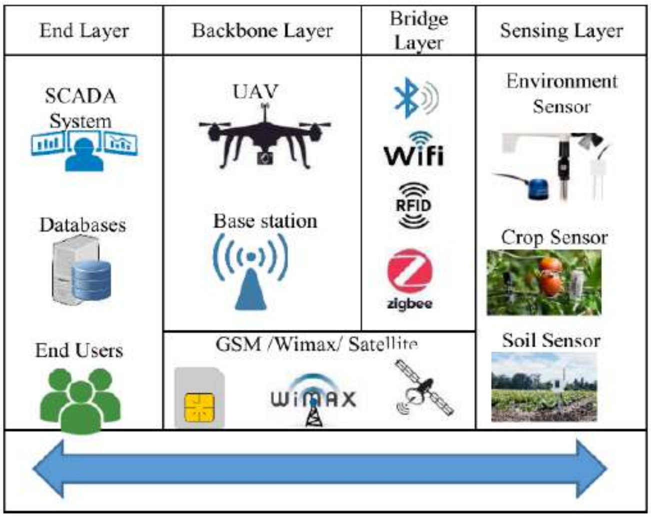

Figure 4. Smart Agriculture Technology in Industry 4.0[14].

Industry 4.0 transforms the production capabilities of the entire industry, so agriculture is no exception. A key aspect of agricultural transformation is in connectivity, as well as in IoT systems that have become part of modern agricultural equipment. Therefore, in the available literature for Smart Agriculture it can be found the term Agriculture 4.0. This term, under the influence of *Industry 4.0*, implies the transformation of production infrastructure and the creation of new concepts such as enlarged farms, new production equipment, related agricultural machinery (tractors, combines, etc.). These concepts enable a drastic increase in productivity and production capacity, as well as environmental protection. With the introduction of new *Industry 4.0* concepts, there are changes in the value chains and business models of agricultural companies, so the emphasis is shifted to new technologies, analysis and data exchange, as well as knowledge collection (Figure 4.) [14].

VI. GOGROW SMART AGRICULTURE SYSTEM

GoGrow is a commercial system that allows users to have real-time access to information from the agricultural area. System was implemented according to the scope of problem domain and specific requests form the clients. During the system design process, an analysis was performed in order to provide the infrastructural elements for the realization of the project. According to the obtained results of the analysis, the main system components were identified:

- ability to monitor atmospheric parameters,
- ability to monitor soil parameters, and
- possibilities for geopositioning locations of sensor stations.

The functionalities of system had to include periodically delivering data from the sensor stations to the cloud system, as well as processing and providing data to the end users. It also had to ensure controlling and managing hardware devices connected to sensor stations, which serves to control environmental resources (e.g. irrigation, ventilation, lighting, etc.), and notifying users in real-time about interesting and important information.

The architecture of the GoGrow smart agriculture system is shown in figure 5. The architectural design is based on four parts:

1. ***Network infrastructure*** – after analyzing the problem and goals, LoraWAN LPWAN network was chosen as the most suitable for implementation.
2. ***End devices (sensors)*** – conceding the choice of LoraWAN network infrastructure, it was necessary to provide sensors that have support for this network, or sensors equipped with Lora transceiver.
3. ***Cloud system*** – a private cloud system and data center of the company LANACO d.o.o. were used for data storage.
4. ***User applications*** – depending on the needs and the necessary access, two versions of the application were created: web and mobile.

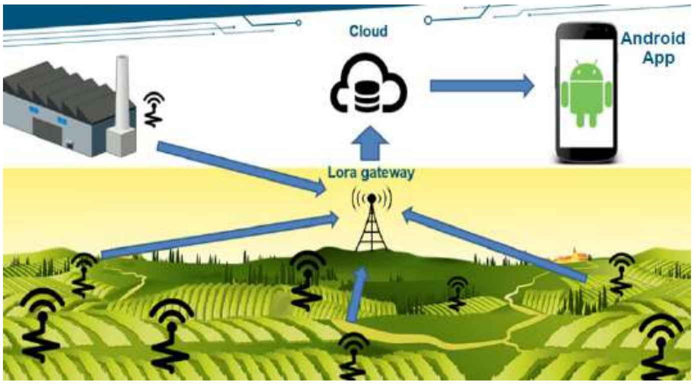

Figure 5. GoGrow Smart Agriculture System Architecture

The sensor network consists of Tinovi LoRa sensors with a broad-spectrum modulation technique. The main features of a LoRa device are low power consumption, wide range, wireless transmission, and the fact that the platform is open-source and available for private or commercial use. Its biggest drawback is the limited network bandwidth and data transfer rate. However, for most IoT networks, using the LoRa long-distance data transmission technique is very popular, because information and data are transferred in real-time at the lowest possible data cost.

LoRa gateway is a bridge between a sensor network and a network server. The gateway's task is to constantly scans the spectrum and communicates with end devices (in this case, sensors) that have a LoRa chip embedded, and forwards the received packets to the network if they are valid. In order to communicate with the gateway, each of the end devices must contain a transceiver designed by Semtech. These devices use a technique that is a combination of a Semtech LoRa Radio Concentrator and a built-in Linux machine. In this case, which has been experimentally processed, the LorixOne Outdoor gateway was used with the range of up to 20km, depending on the optical visibility. Optical visibility is typically directly impacted by the number of obstacles the sensors have in their path while sending data.

The Cloud system is divided into two parts:

- ***network server*** – LoRaWAN network server performs authentication of the device from the sensor network and communicates with the application server. This server accepts and verifies the frames it receives from the gateways. If the authentication is neat and recognized, the network server allows device to join the network. Server stack (network and application server) was implemented using open source ChirpStack solution.

- ***application servers*** – The application server manages device profiles, encrypts data that arrives at the server, and integrates with one of several data collection capabilities supported by the application ChripStack server. It also stores, filters, processes and delivers data to the client applications. In this case, integration with the PostgreSQL database was used, and SSL protocol and encryption for information exchange was applied.

In process of user application development, special attention was given to the user interfaces, the graphic design, and interaction with the end-user. Another important consideration was how to inform the user if certain parts of the system become unavailable to avoid misreporting or false alarms.

User Application was realized through two components:

- ***Microservice Web Application*** – provides the API for communication between Cloud and Mobile Application clients. Also, it controls implementation of users' access and authentication strategies.

- ***Android Mobile Application*** – based on data stored in the Cloud, Android Mobile Application provides visual representation of information to the different groups of end users.

Using GoGrow system, the client's production and business environment has been digitized and the production and distribution of services on the market has been significantly facilitated. GoGrow system controls the water level in the soil and plant drying processes in the dryer. Sensors are monitoring soil water level, detecting the start and end of the drying process. In this way, the user has full control of the processes in real-time (Figure 6).

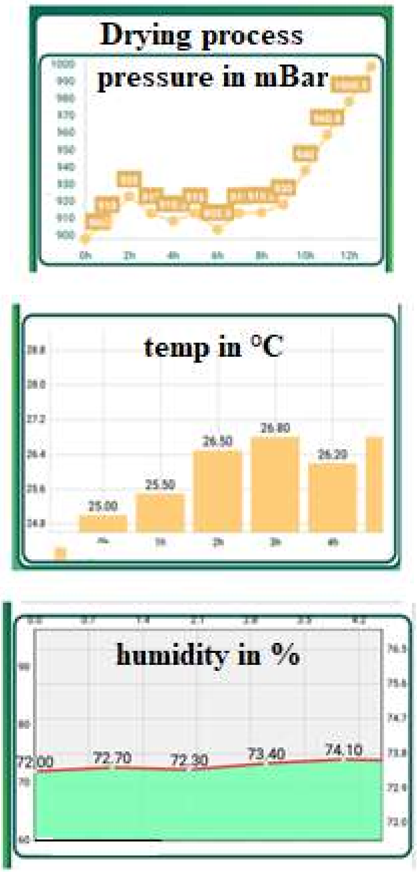

Figure 6. Parameters in the drying process.

Clients has real-time access to field conditions, so they are able to provide an ideal environment for plants growing in order to maximize the production of agricultural products. A whole process is monitored and managed by users' mobile devices.

The suburbs of Derventa, Bosnia and Herzegovina, were selected for the geolocation where the pilot project was implemented. The prototype of the system was tested, as well as the level of security, speed of data exchange and performance of the system with real data and parameters. Also, the communication network was examined. (Figure 7).

The main problem of the proposed solution was the communication between the devices, which is significantly hampered due to the geographical configuration of the terrain and numerous physical obstacles (trees, vegetation, etc.). That reduced optical visibility and introduced significant interference into the wireless network signal. Also, the problem arose due to poor GSM network coverage.

VII. SMART AGRICULTURE SYSTEMS DATA ANALYSIS

A huge amount of digital data that can be generated in any kind of *Smart systems* can represents a valuable source of potentially useful information. *Smart systems* data can be collected in various ways from heterogeneous sources and can have a different structure, meaning, origin, importance, etc. One of the very important smart systems implementation issues is to provide environment, conditions and tools for successful data collection, transmission, storage and transformation in order to make them suitable for applying some of the analytics methods. No matter how this data is generated, their amount usually falls within big data domain. That is why special, sophisticated analytics methods and techniques must be applied for their efficient processing. Using special software tools and powerful computers, it is possible to obtain useful knowledge that will be fundamental for future improvement of systems where analyzed data is generated.

Figure 7. Option in GoGrow mobile app

In the current GoGrow system implementation, a large amount of data was statistically processed and presented to the end users in the form of daily, weekly and monthly reports (figure 8.).

One of the future improvements of the system will be applying some of the advanced data analysis techniques.

One of the most effective ways for smart systems data analyzes is data mining. Data mining can be defined as the process of finding useful patterns and new knowledge from various data sources [16]. The main objective for applying data mining techniques and methods is detection and extraction interesting and useful patterns and implicit knowledge. According to [17], discovering and describing structural patterns among data, a new knowledge can be generated, new implicit relationship among data can be identified and models based do that relationship can be created. Using those models and gained knowledge, a *Smart systems* improvement can be realized providing some kind of artificial intelligence. That way, smart systems can develop a certain degree of autonomy, which could lead to their more efficient future utilization.

Besides data mining technique, a valuable information for *Smart systems* users can be obtained applying business intelligence tools and techniques. In the last years, a sophisticated Big data methods and techniques for data collection, storage and analyzes were also used. Whatever tools or techniques was chosen, finding and extracting useful and worthwhile information from data sources and their presentation in comprehensive structural forms that are suitable for further processing and utilization, it is possible to make management and business improvement or gain significant new scientific perception.

Figure 8. GoGrow data analysis

Applying those techniques in smart agriculture area is very popular. A review of applying data mining techniques in smart agriculture is presented in [18]. The authors emphasized urgent needs for transformation of many productive agricultural processes through smart agriculture practices. Analyzing a large amount of meteorological and agronomical data, an efficient utilization of available agronomical resources and climate changes negative effects reduction could be made. 34 relevant studies related to practice of big data analysis in order to solve various relevant problems in agriculture is presented in [19]. A huge potential that can be provide applying data mining methods is represented. In [20], a review of IoT technological solutions in agroindustry and environmental fields was made. All analyzed applications were divided and classified in one of the four technological domains. The authors concluded that the biggest numbers of applications was dominantly developed for monitoring of agricultural processes using some kind of visualization techniques and only small number of studies was dedicated to development of applications that had some possibilities for prediction of future behaviors which could lead to better decision making processes. In [21], an IoT and data science-based information system is described. Developed system provided tools for data collection, processing, visualization, simulation and analysis. Two experiments were conducted to simulate the impact of environmental changes on targeted agroecosystems.

A significant number of studies is dedicated to applying data mining techniques for solving smart farming issues. The authors in paper [22], describe the system for optimally watering agricultural crops. In proposed solution, applying data mining on analyzed data a prediction of optimal values of temperature, humidity and soil moisture for future management of crops growth was performed. In [23], a system consisted of three modules was proposed: IoT module, data mining module and mobile application module. Proposed solution provided guidance to the farmers regarding the cultivation of preferable crops. In book chapter [24], description of some smart farming most popular technologies and several case studies from different countries was described. The authors concluded that precision farming and IoT are technologies that can help to increase yields and optimize the resources and the investment in many countries. The authors in [18], emphasize that applying data mining techniques for analyzing real time collected data will have key role in successful solving many problems that exist in agricultural domain. Accordingly, significant efforts will be made for future improvement of system that is presented in this paper.

CONCLUSION

For manufacturers and companies, digital transformation is crucial for business success. *Industry 4.0* is not just a concept and one way of work organization, but the only sure path for the survival and successful business in the industry of the future. The Digital Transformation trends driving *Industry 4.0* are just an introduction and first steps. Next years will clearly indicate in what direction and with what success *Industry 4.0* will develop and influence the world order. Certainly, a digitalization is a process that has already begun and will be a prerequisite for the companies' survival and success.

According to the results of the research presented in Forbes magazine, after implementing the Digital Transformation in their business, 86% of manufacturers expect a significant reduction in costs and an increase in revenue in the first 5 years. This could be taken as a confirmation of the hypothesis that the implementation of *Industry 4.0* through the process of Digital Transformation brings costs reduction, higher revenues and overall positive impact on business.

The GoGrow Smart Agriculture system is a conceptual solution that has been implemented for commercial purposes and relies on the defined concepts of digitalization and digital transformation of the company's business ecosystem. GoGrow introduces concepts such as IIoT, real-time management and control, but also the processing of large amounts of data in order to provide information useful for the production and strategic decision-making process.

In the future, the system will be expanded with the advanced analysis of collected data which would provide users with important data regarding the production process, as well as the introduction of product traceability from farm to consumer. The application of autonomous processes and units to control the production and distribution of agricultural goods will also be considered.

ACKNOWLEDGMENT

The project was developed under the auspices of LANACO d.o.o. from Banja Luka. The product and data tested are protected by the company. The name of the GoGrow system refers to the implementation of IIoT technology and the entire infrastructure in the field of smart agriculture.

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