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Subject review

INTERNET OF THINGS AND SMART WAREHOUSES AS THE FUTURE OF LOGISTICS

Krešimir BUNTAK, Matija KOVAČIĆ, Maja MUTAVDŽIJA

Abstract: Innovations and market changes in warehouse and logistics systems force the adaptation and transformation of the existing business model into a business model based on modern technology. With the development of the Internet, RFID (radio-frequency identification) technology and sensors, new innovations are being created that allow the improvement of the existing mode of activity. Implementation of the new technology brings along a number of challenges that organizations must find an adequate response to. However, warehouse systems are not the only affected by the new technologies. The development of technology and technological innovations enable organizations to develop sustainability. Sustainable development is imperative due to increasing awareness of the need for environmental protection. The supply chain can also be managed much more efficiently if sensors that collect information of customer habits and process performance are implemented. Given the accelerating development of Industry 4.0 and the opportunities offered by newly developed technology, this paper provides an overview of current developments in the implementation of Industry 4.0 technological innovations in logistics.

Keywords: Internet of things; radio-frequency identification; smart technologies; supply chain; warehouses

1 INTRODUCTION

Along with the development of new technologies, new ways of managing warehouse systems and logistics operations are being developed. Internet technologies have made it possible to connect physical elements to the network, which is the basis for development of the IoT (Internet of Things).

The IoT is a network that interconnects physical elements capable of collecting performance information that evolves the process or its components such as machines and devices as well as enabling their management. [1]

Accordingly, this paper is based on the secondary research with the aim to present current trends in the development of technological innovations of industry 4.0 in logistics, which can determine the sustainable development of the organizational logistics system.

With the development of awareness of sustainable development, green logistics and the reduction of the impact of logistic and other operations on the environment, the applicability of IoT technology is increasing. IoT also allows control of individual components within logistic processes and systems and provides ongoing improvements based on the data collected by sensors placed inside and outside the installed warehouse infrastructure and superstructures.

The growth of the industry is the consequence of an increase in the emissions of harmful gases, especially carbon dioxide [2], which is an increasing problem for the environment.

Development of technology enables the reduction of the negative impact of economic growth. Newly developed technologies are often used in the environmental protection and securing the foundation for sustainable development.

The issue of environmental pollution is not the only problem that today's business organizations are facing. The demands of interested parties and the environment that is often susceptible to turbulence, places on the organization the imperative of developing new approaches that will meet the increasing demands in organizational environments.

Responding to the increasing demands for quality has influenced the development of continuous improvement systems. Permanent improvements are a particularly important factor for the logistics industry, which faces ecological challenges faced with competitiveness-related costs.

The supply chain consists of warehouses, transport organizations, manufacturers, etc. The importance of creating a sustainable development of the supply chain is increasing because warehouses, production systems, transport organizations and other stakeholders in the supply chain are large energy consumers, which means the release of large quantities of greenhouse gases. Optimization of the supply chain with the help of technological innovations of industry 4.0 enables reducing the amount of greenhouse gases emitted as well as increasing energy efficiency.

Furthermore, warehouses become automated under the pressure of the decline in human work efficiency, employee fluctuation dependency, natural migration, and the requirement to reduce the cost of logistical processes.

Costs of logistic processes directly correlate with the profitability and economic viability of the logistics system. By reducing them and implementing new technology that will enable efficiency and productivity increase, logistic systems become economically viable. The economic viability of the system is the basis for achieving ecological and social sustainability, which will, as a result, have a positive impact on the overall economy.

Existing systems used to monitor and manage performance, which as a result provide data that can be used to improve the system, should therefore be enhanced by technologies such as IoT. The effects of such technologies are long-term, and the return on invested resources is inevitable at later stages of business after their implementation.

2 REVIEW OF INDUSTRY 4.0 LITERATURE

IoT technology emerges in the 90th century of the last century. As the concept, it officially got its name in 1999 [3] but was officially introduced only in 2008. In 2010, the

Chinese economy recognized the importance of this technology and started investing in its development. [4]

Automation of production began in the 1950s, when robots were used for the first time in manufacturing for simple operations [5]. From 2000 to 2015, the use of industrial robots increased by 150% [6], whereby the trend of growth is evident. Automation of the manufacturing process has often been applied in the automotive industry where in the past 9 of 10 robots were sold to one of the car manufacturers. Furthermore, the importance of robotics and automation also comes from the fact that the number of robots that are implemented in the todays automotive industry is 50% of the total number of manufactured robots [7] which can imply a gradual return to human labor, or an increase in the number of industrial sectors that apply robots in their business.

Parallel to the development and implementation of robots in industrial production warehouses are implementing automated systems that allow faster and easier transportation of goods [7].

Traditionally, in warehouse, all products have been labeled with RFID technology developed during the 70s of the last century, enabling a revolutionary approach to improving warehouse operations and reducing storage costs. The development of RFID technology is based on IFF (Identification friend or foe) technology used during World War II. [8] Although the purpose of RFID was initially to be built into the automotive industry, the banking industry, security and healthcare, [9] later adaptation and refinement proved to be an ideal storage system. Robotization, automation and internet development transform traditional warehouses into warehouses that, through the IoT and modern computer support, improve their performance and, above all, productivity, efficiency and effectiveness.

Growth of globalization and the strengthening of capitalism increases the need for industrial development. Industry development results in increasing emissions of harmful gases. The first attempts to raise awareness of the issues and challenges related to ecological problems were first shown in 1962. In 1987, in the report published by WCED, the concept of sustainable development is mentioned for the first time in the history. Five years later, in 1992, the basic environmental goals were defined. In 2015, the UN defined the 17 sustainable development goals recommended by Member States [10], one of which is closely linked to IoT. [11]

Past trends have transformed traditional approaches to business and sustainability management into a modern approach based on technologies developed alongside the development of needs for a different approach and environmental protection relationship.

3 REVIEW OF RESEARCH

The topic of sustainable logistics and the IoT has often been explored and there is a considerable number of papers that closely deal with this topic, especially the impact of the IoT on warehouse and logistics systems. However, there are many of research papers that address the topic of the impact of Industry 4.0 on the logistics system. But there are few that provide an overview of all technologies affecting the logistics system. In accordance with this, this chapter provides an overview of all technologies affecting the logistics system.

3.1 Warehouse Systems and Industry 4.0

The warehouse system itself contains a large number of operations aimed at meeting the requirements of the interested parties. Lee, C.K.M., et al (2017) state that the development of industry 4.0 has affected a different way in which past activities within the warehouse are taking place. The fourth industrial revolution at the same time marked the use of the IoT technology in warehouses which reflected in the efficiency and performance of the storage systems. Traditional WMS (warehouse management system) is enhanced by the IoT, which exploits the full potential of RFID technology. With the IoT all activities as well as goods within the warehouse are controlled, which enables their manageability. However, the use of the IoT also entails the security issues of such systems as they may often become the target of online attacks. [12] Industry 4.0 does not only involve the use of the IoT, but also of other technologies that, through communication as one of the feedback components, have an impact on the improvement of logistic processes.

The IoT does not only affect warehouses and warehouse operations, but also the entire supply chain. Sensors as an integral part of this technology collect a large amount of data that affects the challenges associated with their storage and management. Machado and Shah emphasize that precisely because of this fact the existing warehouses have to be reorganized. In addition, by deploying intelligent systems to the warehouse, the logistic superstructure, which has so far been managed by employees, becomes autonomous, allowing it to move through the warehouse without or with a slight employee intervention. Furthermore, IoT provides immediate insight into inventory stock status. Particular importance is the ability to manage the entire supply chain as well as communication between its stakeholders. Real-time information enables logistical operators to gain insight into logistics operations, in particular the conditions under which freight transport is carried out by means of transport, which increases transparency and reduces the possibility of damage to goods [13].

3.2 Warehouses Based on Cyber-Physical System

Innovations that occur within industry 4.0 create new technologies that facilitate system management. The Cyber-Physical System (CPS) can track and create a virtual copy of the actual process that can be used to monitor process performance. In addition, the CPS is very similar to the IoT concept that allows all components within the system to communicate with one another i.e. that the physical components are virtually connected, allowing for cost savings in parallel with increasing efficiency. But, there is one big difference between the CPS and the IoT. The CPS is only focused on physical objects while it may be focused on creating network of things that are focused to service providing. Warehouses based on this technology include RFID sensors, Bluetooth technology, Wi-Fi access points, cameras and robots that are coordinated in the system to perform a defined task. The role of a man in such a warehouse is primarily related to monitoring and reprogramming the system if necessary. However, the CPS technology also enables inter-machine co-operation between robotic systems, thus reducing the need for human work. Such designed robotic systems also enable human movement to recognize what enables employees to use robotic help in carrying out activities. [14] By replacing human labor with automated and robotized systems, or through the implementation of such systems as humanitarian aid, the efficiency of the warehouse system increases. Activities that are dangerous for a man can be robotized, thus reducing the risk of injury and unlucky cases.

3.3 IoT Conducted Inventory Management

The possibilities of using the IoT technology are growing in parallel with innovations. In the context of warehousing systems, the IoT allows the connection of previously unreliable physical components to the network, thus managing the storage facility and facilitating it. Particularly problematic components of each warehouse are inventories and operations associated with their management. Traditional systems in most cases include manual manipulations of inventory as well as inventory management based on human. However, by deploying sensors and linking them to the network, sensors can look at real-time inventory, which greatly facilitates their management. Therefore, the new warehouse system is based only on IT with human as an operator that only controls the process. This approach is based on RFID technology, which is the basis for deploying and using this approach. [15] The IoT and RFID technology not only simplify inventory deployment, but anticipate future orders, tracking product durability, temperature, humidity in the air, and other parameters that could affect product damage. RIFD technology is the foundation for the functioning and development of the IoT system. [16] The application of RFID technology in warehouse management has a number of advantages that primarily relate to increasing efficiency, accuracy and updating of information, as well as tracking stocks and inventory losses. [17] By implementing the IoT and RFID technology in organization's storage systems, they provide competitive advantage based on lower operating costs and greater efficiency of the process.

3.4 Impact of Warehousing on the Environment

Warehousing, just like logistics, is an activity that generates a certain amount of greenhouse gases. Poor energy efficiency of warehouses as well as environmentally unacceptable heating, air conditioning or lighting systems are just some of the factors that affect the amount of carbon dioxide discharged. In order to increase the ecological acceptance of storage processes, Đukić, Česnik and Opetuk (2010) propose the implementation of energy-efficient lighting, the production of electricity from renewable energy sources, energy-efficient building materials which, by their construction, are insulators, improvements in logistics supra-structure by improving the forklift, by installing automatic closing doors, etc. [18] On the other hand, Amith and Harrison (2013) emphasize that ecological acceptance of the storage system is ensured through awareness of the impact of such a system on the environment and suggest a warehouse design that will maximize the use of natural lighting, water supply and wastewater management systems, noise reduction to the surrounding community and improved temperature control. [19]

The transformation of the traditional logistics system into the environmentally sustainable results in the improvement of all elements of sustainable development. Reducing costs increases funding available to improve ecological acceptability, which also affects the social component of sustainability. Furthermore, through the optimization of the commissioning route through the WMS, it affects the performance that the logistics processes develop, that is, their efficiency, which ultimately results in greater sustainability. [18]

Many authors point out that logistics is one of the fundamental components that needs to be paid particular attention, especially in large cities where it is timely supplying the necessary resources, crucial to the development of all processes inherent in cities. [20] Robotics, automation, electrification, sensing as well as the application of the IoT technology, the storage system is managed more efficiently, which reduces the negative impact on the environment.

3.5 Future of Warehouse Systems

By implementing technologies of Industry 4.0, such as the IoT, warehouse systems become more efficient and their performance is improving. By automating warehouse operations, the warehouse system becomes less dependent and responsive to human work variability. By applying autonomous systems in transportation, transshipment-loading operations, and operations of palletized goods to warehouse regal, the flow of goods through warehouses becomes more fluent. However, autonomous systems must be tailored to the storage environment to minimize the risk of collisions. Existing autonomous systems in a large number of cases, by having a barrier remain standing in place, that is, they can only move through previously defined and narrowly restricted corridors. [21]

A potential solution to such and similar problems of implementation is the development of artificial intelligence that is capable of making decisions similar to man-made decisions. Robotic systems with artificial intelligence enable making simpler decisions and adaptation to new circumstances in the environment. [22] As such, artificial intelligence is already present in a number of daily-used technologies such as internet browsers as well as systems for predicting earthquakes and weather conditions. [23] The Deep Learning concept moves artificial intelligence and its application to a higher level through the ability of such systems to learn and improve their knowledge without the need for human intervention. [24] The necessity of developing new warehouse management technology and automation of warehouse operations is growing with increasing storage space size. The potential for warehouse technology development is growing with the drop in the number of workforce available, which is one of the problems that EU countries face. [21] Increasing the demand of the interested parties and market growth is one of the conditions that are placed on storage systems, which is their flexibility and sensitivity to the requirements set. [25] Theresponse to such requests is often seen through the implementation of smart technologies that improve storage processes. One example of technology is glasses that signal an employee an item to take [26]. Further, the challenges facing storage systems in the future are the reason why an increasing number of organizations become virtual, allowing customers to create orders online and request that the purchased product be delivered to the required location [27].

The implementation of a large number of sensors generates a large amount of information and data stored on the foreseen servers. The Big Data Concept is a new paradigm for warehouse systems and organizations, enabling tracking and prediction of customer orders, resulting in easier stock management. [28] However, the implementation of smart systems as a result has some challenges and risks that need to be adequately managed.

One of the underlying challenges of warehouses based on industry 4.0 is their security. Security problems are related to risk of lack of data. Security problems are also related to the security on the Internet generally because all communications are based on an internet connection. This is explicitly related to the storage systems that have Big data databases implemented. The existing encryption methods are no longer sufficient to ensure a satisfactory level of security. Likewise, there is a lack of adequate software solutions for managing, analyzing, and printing such a large number of data. [29] Stealing or releasing information stored in databases as a result may have disruption of user privacy [30], i.e. logistic customer service. Because of the simplicity, convenience, speed and ease of logistic organization, they decide to use cloud computing technology that places data on servers that are often found in other countries. [31] The security of such systems does not only relate to encryption protection, but also to limit the availability of data. [32] But the challenges are not just about data protection, but also the need to reduce operating costs. It is very likely that part of the logistics and warehouse operations will be outsourced, i.e. that other companies which as a primary activity have no logistics will begin to outsource logistics operations. [33] Furthermore, one of the technologies that finds application in warehouse systems is augmented reality. Augmented reality lets you add real-time digital elements to reality. The use of such technology allows employees to be instructed and guided according to the place where the defined activities are to be performed. [34]

4 CONCLUSION

Almost all organizations operating in today's market are affected by the development of the Internet. [15] The development of the Internet is also developing technologies related to it, such as the IoT. Therefore, it is appropriate for the development and implementation of the IoT technologies to be in the focus of today's logistics industry and the improvement of warehouse systems. [35] The imperative to deploy industry-based 4.0 technologies stems from the requirement to maintain an organization's competitiveness.

Organizational completeness may be increased whit implementation and upgrading of the existing WMS to advanced IT solutions as well as through the implementation of solutions, technologies of industry 4.0 like it, Big Data, sensors, robots etc. [36]

By developing different organizational forms such as e-organization, the challenges and requirements encountered by storage systems are growing. One of the ways of adjusting is the automation and robotization of the warehouse system. Robotization does not mean completely replacing human work with machines, but increasing the efficiency of human work with robotic systems. [37] The use of robots in warehouses also means the possibility of increasing the rate of picking from warehouse shelf using the fastest or simpler route of movement, thus reducing total costs [38], and possibly by improving existing WMSs in warehouse systems that regulate and set up an order picker's route. Existence and level of warehousing system competitiveness depends on their ability to adapt to new technologies as the ability to meet customer requirements.

This secondary research found that industry 4.0 has a significant impact on warehousing operations, which are becoming more efficient by implementing technology such CPS, it and other industry-based 4.0 technologies. Future researchers are advised to conduct a primary survey aimed at identifying the number of warehouses that use Industry 4.0 technologies as well as identifying the type of technology they are using.

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