Information and Communication Technologies Within Industry 4.0 Concept

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Abstract. Internet of Things provides connectivity and interoperability between transport entities, transported entities and product entities in Industry 4.0 concept. The market requirements are changing on daily basis and for the business processes of manufacturing organizations to be successful, it is necessary to link all the supply chain stakeholders and ensure their real-time informing, by forming an ecosystem for connecting stakeholders of Industry 4.0 concept. By implementing contemporary information and communication technologies in the production line it is possible to ensure the flexibility of production and adaptation of product entities to end user requirements. The problem of providing real-time information to all participants in supply chain has been identified by analyzing the traditional supply chain in the manufacturing industry. Based on the analysis of information and communication technologies in Industry 4.0 concept, the aim of this research is to propose optimal information and communication technologies for connecting stakeholders of logistic production chain. This extends the opportunity for all logistic production chain participants to inspect the stage of product entities from the stage of the development of product materials to the delivery stage of the product to the end users.

Keywords: Internet of Things · Cloud Computing · Automatization
Wireless Technology

1 Introduction

Contemporary Information and Communication Technologies (ICT) and concepts such as wireless sensor networks, Internet of Things (IoT), Big Data, and Cloud Computing (CC) are used in the manufacturing environment. With the development of Industrial IoT (IIoT) and Industry 4.0 concept, it is possible to link automated remote control of manufacturing machines and enable rapid response to incident situations in real-time, to provide real-time information to users or to ensure smart inventory tracking in manufacturing organizations, automated resource ordering and automated production. This research is focused on exploring the possibilities of using IoT in the manufacturing industry. The possibilities of ICT in Industry 4.0 concept were analyzed based on the available scientific literature and research. The aim of the research is to select the optimal ICT to connect all the stakeholders in the logistic production chain. The purpose of the

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research is to increase the efficiency of manufacturing organizations by linking all logistic production chain stakeholders. To provide customers with quality informing service it is necessary to monitor their activities and needs.

2 Literature Review

By analyzing the available scientific literature and previous researches, information about the contemporary ICT which are used in Industry 4.0 concept was obtained. Customer requirements and needs change daily, and for this reason it is necessary to adapt the production of manufacturing organization to meet their needs, thereby to increase the profit and reduce the costs of manufacturing organizations [1]. Market requirements and the development of new ICT change the way of manufacturing organizations' business activities. The previous research on ICT and technological solution areas related to processing, data storage, information delivery, automation of business processes, supply chain and information transfer between stakeholders who are a part of logistic production chain were analyzed.

Industry 4.0 concept is the fourth generation of the manufacturing industry and includes the processes of automation and data exchange in manufacturing organizations. The integral parts of Industry 4.0 are IoT and smart manufacturing which refer to the ability of manufacturing machines to collect data and forward them in real-time [2]. Nine technological solutions in the field of automation of business processes, data collection, processing, storage and delivery, security of information and communication (IC) system and the abilities of remote control are as follows: autonomous robots, simulations, horizontal and vertical integration systems, IIoT, cybersecurity, CC, Big Data, Additive Manufacturing and Augmented Reality [3, 4]. Autonomous robots will become represented in the manufacturing industry and will have a great impact on customer expectations that are aimed at delivery of orders [4, 5]. The available research indicates that autonomous decisions can improve business processes within the organization, reduce the probabilities of risk appearance, improve the way data are collected from the environment, and reduce long-term costs [6]. 3-D product and material simulations are already used in manufacturing organizations, and it is expected to be used in other areas of operational processes of organizations [7]. With it, it will be possible to test business processes before their implementation in a physical environment [8]. This will affect product quality and optimization of production process. Horizontal and vertical integration of the system involves connecting all system participants and manufacturing business processes. Its implementation will have a great impact on the currently existing problems related to the responsibility control, safety, confidentiality, standardization and infrastructure configuration [9]. By adopting Industry 4.0 concept into the manufacturing process and business, the functions they perform and the features they provide will become more coherent [1]. IIoT is often compared with Industry 4.0 concept but it needs to be analyzed separately. IIoT implies the use of Big Data, data collection using sensors, Machine to Machine (M2M) communication and automatization technologies within the industrial area [10, 11]. Industry 4.0 concept is focused on the manufacturing while the IIoT refers to all elements, objects, devices that can be connected to Internet and that can provide feedback and increase the business efficiency [12]. When connecting all parts of the manufacturing organization, it creates space for cyber-attacks on all data that are constantly transmitted through the entire IC system [13]. For this reason, cybersecurity strategies must ensure secure and reliable communication across the entire IC system. According to 2016 Symantec Internet Security Threat Report, the manufacturing sector is among the top three industries that have most frequently executed spear phishing attacks [14]. Latency can represent a problem for systems that require quick responses on collected data [15]. In Industry 4.0 concept, CC is used for data processing and storage, meeting the conditions of network requirements so that the collected data could be analyzed in real-time and provide the necessary feedback [16, 17]. Fog Computing has features which can solve problems that arise within CC environment, regarding latency and traffic congestion which occur during the transmission of data over Internet. Big Data represents the amount of data that can not be processed by using simple database tools. Manufacturing organizations need to analyze different types of data from different sources to benefit from the implementation of IoT within their business processes. Based on the collected data, manufacturing organizations need to make quick decisions to increase their productivity [18, 19]. With implementation of Big Data into manufacturing organization business processes, it is possible to improve the product development and market expansion, operational efficiency, market demand forecasting, and improved customer experience [20]. The key components of Industry 4.0 concept are devices which can produce fast, flexible and accurate parts/materials that are important for production [21]. These devices are a part of Additive Manufacturing, and 3D printing is one of them. 3D printing enables creation of new product solutions and solutions for the supply chain [22]. This implies a faster delivery of the product and their reduced number in the warehouse. Apart from the above, it affects new business models in terms of changing the supply chain participants and integration of users [23, 24].

3 Research Methodology

By analyzing technical characteristics of CC and Fog Computing, improvement by implementing Fog Computing into manufacture organizations business in Industry 4.0 concept has been noticed. Fog Computing influences on efficiency and flexibility of business as well as on resource management, and the advantages compared to CC are shown in Table 1. One of the advantages of Fog Computing is that it can be accessed by Wi-Fi, mobile network, Bluetooth and ZigBee network which provides support on

Table 1. Comparative analysis of Cloud Computing and Fog Computing.

	Cloud Computing	Fog Computing
Client and server distance	Multiple hops	Single hop
Latency	High – 5 [s]	Low – 1.5 [s]
Delay jitter	High	Very Low
Real time interaction	Yes	Yes
Mobility	Limited support	Supported
Access	Wi-Fi, Mobile Network, Ethernet	Wi-Fi, Bluetooth, Mobile Network, Ethernet, ZigBee

many devices. According to Gartner, 25 billion of devices will be connected and demand data processing by 2020 [25]. In total, 600 [ZB] of IoT data will be generated by 2020 which will require a sufficient data processing speed for avoiding latency in delivering data and information [26].

In Fog Computing, the data is sent directly from the client to the server, while in CC it passes through several points, thus affecting the slower response to the forwarded data and information. Due to the amount of generated data, Fog Computing is more efficient for the business environment to collect and process the data and forward it to CC environment [27].

ZigBee technology, in comparison to Wi-Fi and BLE technologies, can work on 868 [MHz] and 915 [MHz] which lowers the possibilities of interference of other devices that work on 2,4 [GHz] and is shown in Table 2. It is suitable for use at moment when low power consumption and transfer of collected sensor data are required. Automated manufacturing processes require communication for monitoring the work progress. ZigBee can provide low power consumption and low communication costs and increase overall control over the working processes. Implementation of Industry 4.0 concept into manufacturing organizations can provide interoperability, transparency of information, decentralization of business decision making and technical support. It is also possible to plan to increase or reduce the production output, thereby affecting the optimum and efficient production. Real time informing requires high reliability and availability of information which can provide Wi-Fi communication network. The biggest advantage of Wi-Fi technology is availability, and the biggest disadvantage is high power consumption. It is advisable to combine Wi-Fi technology with other ICT to ensure business efficiency in terms of low latency, power consumption and high reliability. BLE technology is suitable for usage because of low energy consumption. It can be used in form of BLE transmitters and tags placed on transported and product entities, but also for marking indoor areas. Barcodes require more time to scan of each delivered transported entity and do not have the ability to provide information about their real-time location. RFID devices do not have the mentioned ability, require more finances for installing the infrastructure and require workers to come on each floor and each part of warehouse area to collect data on RFID tags about transported entities. For this reason, Beacon transmitters and BLE tags have

Table 2. Communication and AIDC technologies

	Wi-Fi	BLE	ZigBee	NFC	RFID	Barcode
Frequency	2,4 GHz, 5 GHz	2,4 GHz	2,4 GHz, 868 MHz, 915 MHz	13,56 MHz	125–134,2 kHz, 13,56 MHz, 860–960 MHz 2,45 GHz	–
Range	Up to 100 [m]	Up to 77 [m]	10–100 [m]	Up to 10 [cm]	Up to 20 [m]	Up to 15 [m]
Two-way data transfer	Yes	Yes	Yes	Yes	Yes	No
Power consumption	High	Very low	Low	Very low	Very low	–

the advantages over above mentioned technologies in terms of scalability of service and cost efficiency. BLE Gateway collets data from BLE tags and forwards them to Fog Computing or CC environment. User device connects to CC or Fog Computing and reads data on BLE tags. BLE technology is better in comparison to RFID and barcodes because it can provide greater coverage within the warehouse. NFC technology is suitable for mobile transactions, which affects security and time savings when making payments [28, 29].

4 Results

Optimal communication technologies provide users to reduce costs in power consumption and ensure real-time communication between required entities. Figure 1 shows communication technologies used for communication between entities in logistic production chain.

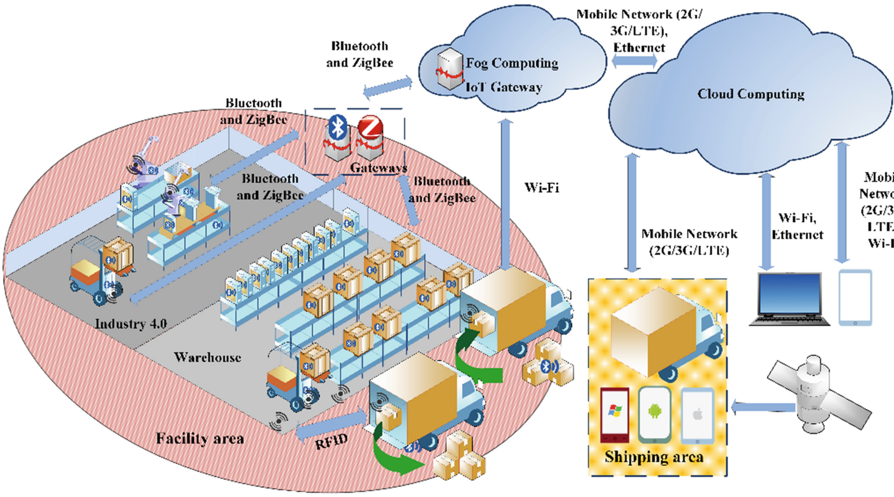

Fig. 1. ICT for communication between entities in logistic production chain.

Entities in manufacturing organizations and warehouses are connected via ZigBee and Bluetooth technologies and collected data is sent to Fog Computing. The data is processed there and forwarded to CC environment if needed for providing information to end user (consumers or business organizations). Fog Computing is used to link manufacturing facilities and warehouses, so that collected data could be processed before CC environment to reduce the latency in providing required information. ZigBee technology is used because of low power consumption for communication between sensors, indoor vehicles and production line. Transported entities are marked with BLE and RFID tags so that they could be detected while entering the warehouse.

While the transportation entity is in the field of warehouse, data is sent to Fog Computing via Wi-Fi technology. Locating transported entities within the warehouse area is possible because of BLE tags and transmitters. During the delivery of transported entities, mobile phone devices inside transporting entities can be used for location of (GPS technology) transported entities. Communication to CC environment is realized via Mobile Network. End users can, in real-time, check the information about the location of their product by using mobile phone which can connect to CC via Wi-Fi, Ethernet or Mobile Network, and computers/laptops which are connected via Ethernet or Wi-Fi.

Figure 2 shows proposition of optimal ICT for each stakeholder of logistic production chain and required information. The palette of production resources, within the procurement phase, which are brought to manufacture organization, are marked with BLE tags and placed in warehouse. Wi-Fi technology is used for sending information about storage changes to CC database. This provides real-time access to information about development of production entity. Temperature, humidity, fire, proximity and distance sensors located inside the warehouse communicate via ZigBee technology, but LoRa and Zwave technologies can also be used. This enables M2M communication between sensors and ZigBee Gateway if ZigBee communication technology is used.

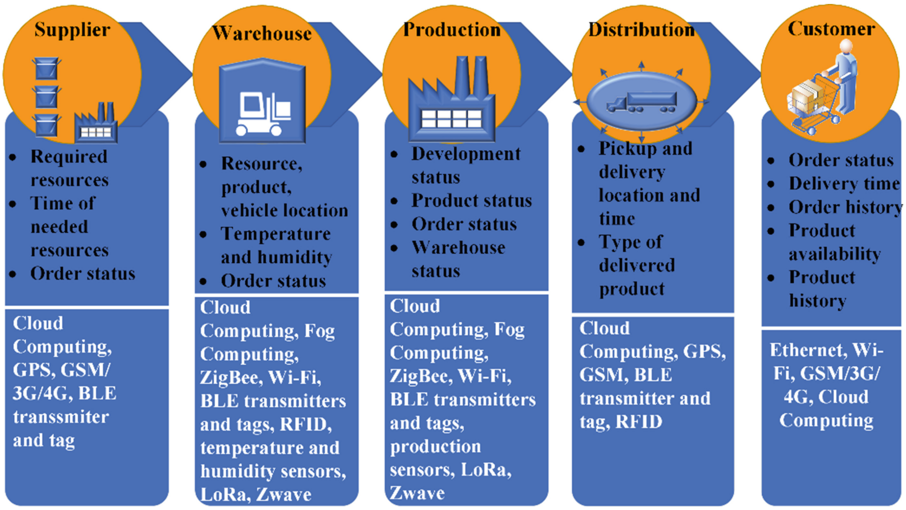

Fig. 2. Optimal ICT for stakeholders of logistic production chain.

5 Conclusions

Industry 4.0 concept offers possibility to change the way manufacturing organizations do business with the use of contemporary ICT. The available literature and scientific research were used to analyze possibilities of using ICT within Industry 4.0 concept. The traditional supply chain analysis has identified a problem in used ICT for managing business processes which affected efficiency and effectiveness of manufacture organizations' business. By using contemporary ICT, CC and Fog Computing concepts, it is possible to connect all stakeholders of logistic production chain to ensure the delivery of information without delays. By connecting the stakeholders, it is possible to influence their distribution in new business activities.

References

1. PWC: Industry 4.0: building the digital enterprise. https://www.pwc.com/gx/en/industries/industries-4.0/landing-page/industry-4.0-building-your-digital-enterprise-april-2016.pdf. Accessed 22 Nov 2017
2. Lopez Research: Building smarter manufacturing with the Internet of Things (IoT). http://cdn.iotwf.com/resources/6/iot_in_manufacturing_january.pdf. Accessed 15 Nov 2017
3. Cheng, G., Liu, L., Qiang, X., Liu, Y.: Industry 4.0 development and application of intelligent manufacturing. In: 2016 International Conference on Information System and Artificial Intelligence, pp. 407–410. IEEE-CPS, Hong Kong (2016)
4. The Boston Consulting Group: Industry 4.0 the future of productivity and growth in manufacturing industries. https://www.zvw.de/media.media.72e472fb-1698-4a15-8858-344351c8902f.original.pdf. Accessed 15 Nov 2017
5. Deloitte: Using autonomous robots to drive supply chain innovation. https://www2.deloitte.com/content/dam/Deloitte/us/Documents/manufacturing/us-manufacturing-autonomous-robots-supply-chain-innovation.pdf. Accessed 15 Nov 2017
6. Bi, Z.M., Xu, D., Wang, C.: Internet of Things for enterprise systems of modern manufacturing. IEEE Trans. Ind. Inf. **10**(2), 1537–1546 (2014)
7. Posada, J., Toro, C., Barandiaran, I., Oyarzun, D., Stricker, D., de Amicis, R., Pinto, E.B., Eisert, P., Döllner, J., Vallarino Jr., I.: Visual computing as a key enabling technology for Industrie 4.0 and industrial internet. IEEE Comput. Graph. Appl. **35**(2), 26–40 (2015)
8. Wan, J., Cai, H., Zhou, K.: Industrie 4.0: enabling technologies. In: Proceedings of 2015 International Conference on Intelligent Computing and Internet of Things, pp. 135–140. IEEE, Harbin (2015)
9. Heng, S.: Industry 4.0 upgrading of Germany's industrial capabilities on the horizon. https://www.dbresearch.com/PROD/RPS_EN-PROD/PROD0000000000451959/Industry_4_0%3A_Upgrading_of_Germany%E2%80%99s_industrial_ca.PDF. Accessed 25 Nov 2017
10. PWC: The industrial Internet of Things. https://www.pwc.com/gx/en/technology/pdf/industrial-internet-of-things.pdf. Accessed 28 Nov 2017
11. World Economic Forum: Industrial Internet of Things: unleashing the potential of connected products and services. http://www3.weforum.org/docs/WEFUSA_IndustrialInternet_Report2015.pdf. Accessed 28 Nov 2017
12. Bloede, K., Mischou, G., Senan, A., Tilow, A.: The industrial Internet of Things: making factories "smart" for the next industrial revolution. http://www.woodsidecap.com/wp-content/uploads/2017/04/WCP-IIoT-Report-Spring-2017-1.pdf. Accessed 28 Nov 2017
13. Deloitte: Industry 4.0 and cybersecurity: managing risk in an age of connected production. https://www2.deloitte.com/insights/us/en/focus/industry-4-0/cybersecurity-managing-risk-in-age-of-connected-production.html. Accessed 28 Nov 2017
14. Symantec: Internet security threat report. https://www.symantec.com/content/dam/symantec/docs/reports/istr-21-2016-en.pdf. Accessed 28 Nov 2017

15. Bonomi, F., Militio, R., Zhu, J., Addepalli, S.: Fog Computing and its role in the Internet of Things. In: Proceedings of the First Edition of the MCC Workshop on Mobile Cloud Computing, pp. 13–16. ACM, Helsinki (2012)
16. Oracle: CLOUD: opening up the road to Industry 4.0. https://www.oracle.com/webfolder/s/delivery_production/docs/FY16h1/doc30/reportIaas.pdf. Accessed 29 Nov 2017
17. Givehchi, O., Trsek, H., Jasperneite, J.: Cloud Computing for industrial automation systems—a comprehensive overview. In: 2013 IEEE 18th Conference on Emerging Technologies & Factory Automation (ETFA), pp. 10–13. IEEE, Caligari (2013)
18. Lee, J., Kao, H.A., Yang, S.: Service innovation and smart analytics for Industry 4.0 and big data environment. Procedia CIRP **16**, 1–6 (2014)
19. Yin, S., Kaynak, O.: Big data for modern industry: challenges and trends. Proc. IEEE **103**(2), 143–146 (2015)
20. ISACA: Big data impacts & benefits. White paper (2013)
21. Deloitte: Industry 4.0 challenges and solutions for the digital transformation and use of exponential technologies. http://www.industrie2025.ch/fileadmin/user_upload/ch-en-delloite-ndustry-4-0-24102014.pdf. Accessed 30 Nov 2017
22. PWC: Turning additive manufacturing into business. https://www.pwc.nl/en/assets/documents/pwc-turning-additive-manufacturing-into-business.pdf. Accessed 30 Nov 2017
23. KPMG: The factory of the future, Industry 4.0—the challenges of tomorrow. https://assets.kpmg.com/content/dam/kpmg/es/pdf/2017/06/the-factory-of-the-future.pdf. Accessed 16 Dec 2017
24. McKinsey & Company: Industry 4.0: how to navigate digitization of the manufacturing secor. https://www.mckinsey.de/files/mck_industry_40_report.pdf. Accessed 22 Dec 2017
25. Gartner: https://www.gartner.com/newsroom/id/2905717. Accessed 27 Dec 2017
26. Forbes: https://www.forbes.com/sites/gartnergroup/2015/02/12/gartner-predicts-three-big-data-trends-for-business-intelligence/#3284874c6de4. Accessed 27 Dec 2017
27. Al-Doghman, F., Chaczko, Z., Ajayan, A.R., Klempous, R.: A review on Fog Computing technology. In: 2016 IEEE International Conference on Systems, Man and Cybernetics, pp. 001525–001530. IEEE, Budapest (2016)
28. Peraković, D., Periša, M., Sente, R.E.: New challenges of ICT usage in transport and logistics. In: The Sixth International Conference Transport and Logistics, pp. 9–16. University of Niš, Faculty of Mechanical Engineering, Department for Material Handling Systems and Logistics, Niš, Serbia (2017)
29. Periša, M., Cvitić, I., Kolarovszki, P.: Challenges of information and communication technologies usage in E-business systems. In: E-Business—State of the Art of ICT Based Challenges and Solutions. InTech (2017)