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POSSIBILITIES OF USING DIGITAL SHADOWS IN THE PROCUREMENT PROCESS OF TECHNOLOGICAL EQUIPMENT

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Abstract: The emergence of the fourth industrial revolution was made possible by the emergence and rapid spread of cyberphysical systems. One of the major developments of this era was the digital twin model. The digital twin is not just a 3D model or a simple simulation. It can be used to create a real-time model of the observed physical element that collects environmental data using sensors and can also predict the failure of a product based on the information provided. If the system has actuators, we are also able to feed back the change in the virtual model to the physical reality. Closely related to the modern digital model is the digital shadow, which collects data in the same way as the twin, but feedback to physical reality has not been implemented. In the dissertation, an initial concept is presented, which describes the application possibilities of digital shadow in terms of the procurement process of new technologies (stations, machines).

Keywords: *Digital shadow, logistics, procurement process*

1. INTRODUCTION

Throughout history, technological innovations have made it possible for industry and human life to take a different direction. All three industrial revolutions had the common feature that certain basic conditions had to be fulfilled for change and innovation to occur. The ongoing fourth industrial revolution is no exception. In order for Industry 4.0 to emerge, three conditions had to be fulfilled: integration of value possibility of a digital business model and customer access [1]. Naturally, the foundation for these was the Internet of Things, the speed, stability, and availability if the internet, as well as cloud-based systems [2]. Thanks to these, one of the inventions of Industry 4.0 is the digital twin model. The concept was born in the early 2000s, but at that time, the technology and technological foundations were not appropriate. The greatest advantage of this model is that it can be used in numerous areas, whether it be aerospace, the automotive industry, the food industry, include planning, manufacturing, or even maintenance.

The further parts of the publication present the most important basic concepts related to the field (digital twin, digital shadow, digital model), as well as the possibilities of using the digital shadow in the procurement process of technological devices.

2. MODERN DIGITAL SOLUTIONS

In this chapter, three concepts are presented: digital twin, digital shadow, and digital model.

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Digital twin: The essence of the digital twin is to digitize and replicate a physical process. However, it is important to note that it is not just a 3D model, as it enables real-time simulation and focuses on the process itself rather than just the appearance [2, 3]. Many industries have begun to recognize its advantages and are constantly working to improve their processes using this technology, as its essence is efficient process analysis, supervision, and optimization [2, 3]. With the digital twin, we can talk about digital prototypes and digital replicas. The former contains data and information describing the product, while the digital twin is a virtual product connected to the real product. The two are closely interconnected, and it only makes sense to talk about them in the digital environment, as together they replicate the real environment around the digital product [2, 3]. The essence of the real product or manufacturing processes that works simultaneously and in parallel with it, and any changes made on one side are automatically reflected on the other. Information exchange occurs in both directions [1-3].

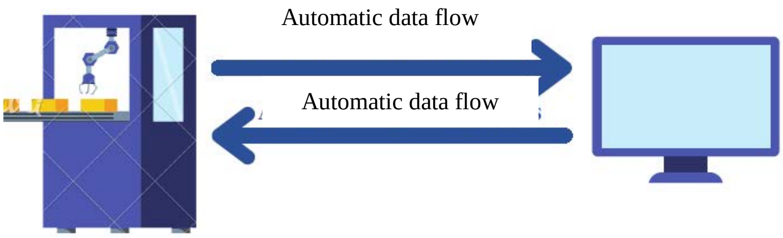

Figure 1. Digital twin

Digital shadow: The digital shadow is almost similar to the twin with the difference that changes in the real product or process automatically appear in its digital counterpart, but modifications made in the digital shadow have no effect on reality [2, 4].

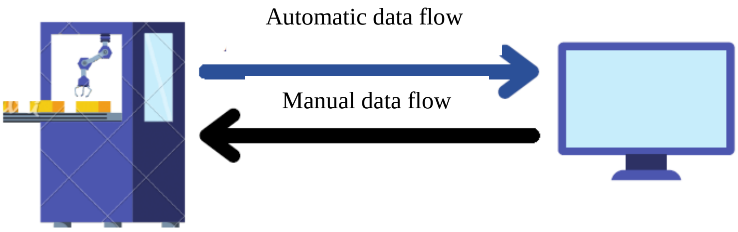

Figure 2. Digital shadow

Digital model: The digital model should not be confused with the digital twin. There is no automatic exchange of information between the model and the real product or process, and one does not affect the other. Both can be manually modified independently of each other, as shown in Fig. 3 [2, 4].

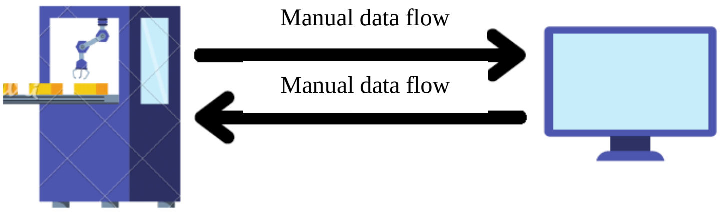

Figure 3. Digital model

3. Applications of Digital Shadow

The use of a digital shadow depends on which stage of the product life cycle it represents. It can be used in three main parts: product development, manufacturing and product design, and performance improvement [1-2].

Digital shadows are already being used for the development of airplanes. All components and units are transformed into data for complete replication, creating a digital airplane prototype in virtual space [5]. The virtual replicas of airplanes perform test flights in numerous simulated environments, enabling engineers to identify areas for improvement before real-world testing takes place, addressing any possible errors or shortcomings. This contributes to reducing the cycle time of prototype manufacturing and physical development [5].

In the case of manufacturing processes, digital shadows can be used to optimize the processes. In the case of fully automated production processes, remote control of the manufacturing can be achieved. Material supply from the warehouse can be carried out on a just-in-time basis, so there would be no need for intermediate storage.

The digital shadow technology can also be applied to remote control operations, such as energy production of deep-sea water turbines or monitoring the proper operation of oil and gas pipelines [6].

The time and frequency of maintenance can be minimized by predicting problems before they occur using the digital shadow technology. It is possible to prepare in advance for the time, nature, necessary components, and tools required during the fault occurrence. Therefore, the capacity of maintenance personnel can also be optimized.

In logistics processes, digital shadows play a major role in the modelling and simulation of transport processes, as the quality and quantity of data allow critical points in terms of the quality of the goods to be predicted and corrected in time. Last but not least, digital shadows can also be used in selecting and designing appropriate packaging for logistics purposes [7].

4. Possible Applications of Digital Shadows in the Procurement Process of Technological Equipment

The general procurement process of technological equipment is complex, as illustrated in Fig. 4. The procurement process starts with the communication of the needs and ends with the handover of the machine in the expected and functional condition. In most cases, the request for new station is received from production and/or management and is usually followed by a designated coordinator contacting external machine manufacturing partners. The coordinator, together with the production support, quality assurance engineer, health, safety, environmental specialist, and other relevant representatives, reviews the preliminary plan prepared by the manufacturer, analyses the risk, and, in consensus, places an order for the selected stations. In most companies, a separate department is responsible for the acceptance of the ordered stations, which includes coordinating the acceptance of production line equipment, determining scheduled maintenance plans, determining spare parts inventory, and conducting safety inspections of production line equipment. The procurement coordinator considers the task complete after the successful handover of the machine within the company, and naturally supports the production side during the ramp-up period until the start of series production.

Usually, the problem is that the pre-acceptance at the machine manufacturer is done according to specifications, and the trial production is successfully carried out, but is only under continuous load and use that a significant number of faults occur. The coordinator's task is completed with the acceptance of the machine, so it is not his responsibility to solve further problems, while the production support engineers do not have sufficient time to identify and address the root causes of the problems that arise, dure to the complexity of the systems under test and the long lead times to provide the data needed to apply the problem-solving methods.

Many companies have well-developed problem-solving methods, but their application is extremely time-consuming due to the low level of digitalization in the examined process. Typically, the necessary data and variables, such as cycle time, proper execution of tasks, operator training, manufacturing errors, and resulting technical downtimes, must be collected manually. These pieces of information need to be gathered from multiple sources, pages, and individuals, which makes the process very time-consuming and prone to human error.

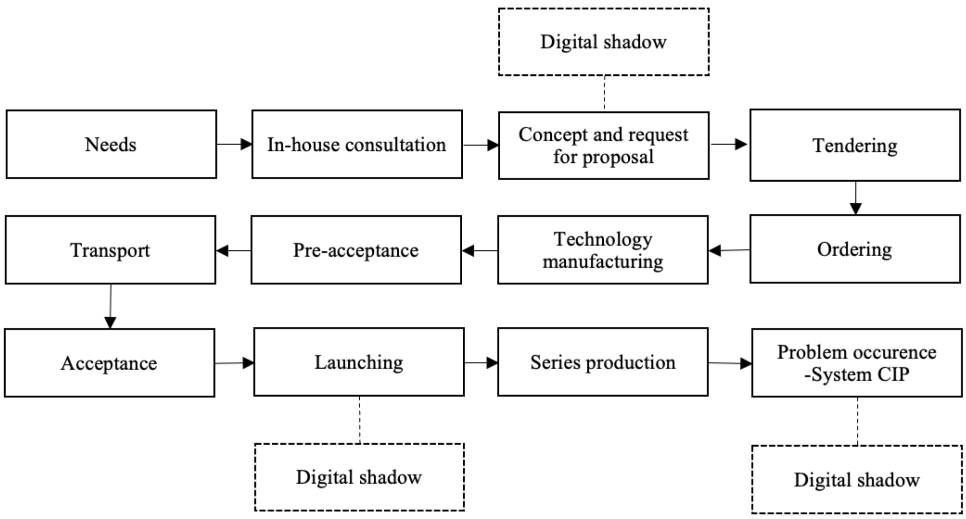

Figure 4. Possible application of the digital shadow in the procurement process

Form templates are used to collect data, which needs to be printed, manually filled out, and then digitized each time. These are all time-consuming, costly, and environmentally burdensome processes.

The application of the digital shadow model can be examined at several points during the procurement process of new technological equipment (Figure 4). The most effective approach would be to use it during the technology design phase, but it could also be beneficial during the implementation phase and in solving problems that arise during serial production following delivery. In our opinion, the goal is not to create a digital twin, since in this case we do not need to feed back to the physical reality, but to create a digital shadow that collects, models, analyses and possibly predicts the failure of the station. Creating a periodically deployable module may prove to be sufficient, which consists of easily implementable sensors and cameras with a long lifespan. Depending on the observed process, the required sensors and cameras may naturally vary, but essentially, the following are among the most important ones:

- temperature sensor,
- noise sensor,
- light intensity sensor,
- vibration sensor,
- motion-capturing camera system.

When applying digital shadow technology in the process of procuring new technological equipment, the following changes can be expected:

- The expected duration of failures will be shorter due to in-depth and rapid analysis of problems.
- The time required to collect data necessary to solve problems is expected to significantly decrease.
- The reliability of available data is expected to increase, as manual data collection will be replaced by automatic methods.
- The cost impact associated with operation is expected to decrease due to the shorter duration and/or improved quality of problem solving.

5. Summary

The paper provides an overview of modern digitalization solutions, namely the digital twin, digital shadow, and digital model concepts. In addition to introducing the basic concepts, the paper identifies the potential applications of the digital shadow, following a general procurement process for new technological equipment. The benefits of applying the digital shadow are summarized, and the paper sets out to further develop and implement the defined basic concept in a corporate environment. The publication was based on the Scientific Students’ Associations thesis of Zoé Bogdán Rebeka.

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REFERENCES

[1] Bányai, T., Bányainé Tóth, Á., Illés, B. & Tamás, P. (2019). *Industry 4.0 and Logistics (in Hungarian)*. Miskolc, ISBN: 978-963-358-182-7

[2] Matyi, H. & Tamás, P. (2021). Application of digital twin technology in the development of logistics process, *Advanced Logistics Systems - Theory and Practice* **15**(1), 12-19, https://doi.org/10.32971/als.2021.002

[3] Mobinius Editor (2020). *Digital Twins Technology in Logistics 2021: In-Depth Guide*, Retriewed from https://www.mobinius.com/blogs/digital-twin-technology-in-logistics (accessed: 20 March 2022)

[4] A. Fuller, Z. Fan, C. Day. & C. Barlow. (2020). *Digital Twin: Enabling Technologies, Challenges and Open Research*. IEEE Access, **8**, 108952-108971, https://doi.org/10.1109/ACCESS.2020.2998358

[5] *Digital twin – the best tool to increase production efficiency (in Hungarian)* (2020). Retrieved from https://www.mazakeu.hu/hu/h%C3%ADrek-esem%C3%A9nyek/term%C3%A9k-h%C3%ADrek/digitalisikrek/ (accessed 27 March 2022)

[6] *The rise of digital twin markets (in Hungarian)* (2022), Retrieved from https://www.cnc.hu/2022/02/a-digitalis-ikerpiacok-felemelkedese/ (accessed 25 March 2022)

[7] Bogdán, Z. R. (2022): *Possibilities of using digital shadows in the procurement process of technological equipment (in Hungarian)*, Scientific Students' Associations thesis, University of Miskolc, Institute of Logistics

[8] Hardai, I., Illés, B. & Bányai, Á. (2021). View of the opportunities of industry 4.0. *Advanced logistic systems - Theory and Practice* **14**(2), 5-14. https://doi.org/10.32971/als.2020.009