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The Role of Digitization on a Manufacturing Flow

Ciortea Elisabeta Mihaela

University "1 Decembrie 1918" of Alba Iulia, Faculty of Computer Science and Engineering, Alba Iulia, Romania
Corresponding Author Email: mciortea@uab.ro

Abstract— The paper presents one of the empirical ways of increasing the competitiveness of enterprises, which is the digitization of production. A comprehensive process analysis is necessary for competent planning of the digitization of an enterprise and for the automation of production processes. The analysis of real processes can be replaced by a model analysis. In this sense, this paper proposes a new approach to the simulation of manufacturing processes based on an empirical model made with the help of Petri nets. Its capabilities and limitations are taken into account. The proposed empirical approach provides methods of structural and time analysis of the process under analysis. Therefore, it allows the recognition of operations and critical issues in communication and logistics within the enterprise and provides the opportunity to create a process optimization strategy. Petri nets provide the tool to analyze the possibility of parallel execution of the examined process and can provide the estimation of the effect of engineering. This paper presents an example of digitalization of the manufacturing model under analysis, grouped into three sectors, manufacturing, analysis, and control - where the effective role of digitalization is highlighted and, last but not least, the interpretation of information and decision-making.

Index Terms—digitization, manufacturing, Petri net.

I. INTRODUCTION

The starting point for the elaboration of this work is a reality that we must recognize and develop continuously, namely the fact that digitization integrates digital technologies into everyday life by digitizing everything that can be computerized to modify the business model. In the spatiality literature, the concepts of digitization and digitization are perceived in different terms. Thus digitization is the conversion of analog data into a digital form that can be easily read and processed by a computer [9].

Or digitization is defined as the material process of converting individual analog streams of information into digital bits. Internal business processes, product components, communication channels, and other key aspects of the supply chain are undergoing an accelerated digitization process. As a first summary conclusion we can consider that digitization means the transformation of the company's business processes into digital form. What is true and completely real, digital transformation is a continuous process and journey.

There must be a digital transformation strategy that is a support plan for businesses in managing transformations arising from the integration of digital technologies, changes in value creation, structural changes, and related financial aspects. Digital transformation offers advantages, where companies have the canning ability to control and manage machines, robots, and equipment through the integration of information systems [9].

The increase in industrial automation requires more IT systems to cope with the challenges arising from the complex processes of manufacturing systems [6].

According to the specialized literature, industries must develop effective strategies to design and improve their production systems, exceeding the latest sustainability standards (for example, ISO 26000 [1]). A crucial aspect in the modern era of digital manufacturing is to ensure human growth and well-being, taking social aspects into account as well, while developing new production systems alongside more traditional environmental aspects [2].

It must be analyzed that nowadays industries are moving to the new era of Industry 4.0 production, which deals with the digitization of data and the creation of knowledge to be used by intelligent production systems [3].

Changes in production practices towards increasingly flexible structures require new strategies for production scheduling and control [8]. To this end, we introduce an automatic model generation scheme that is based on a coarse description of the manufacturing process and the factory. The generated model is based on a Petri Net representation of the manufacturing process, which we slightly enhance to separate automatically evolving processes from consciously made manufacturing decisions. From the Petri Net model, we derive a state space description that can be used to synthesize feedback control for the manufacturing system. Model generation is illustrated with an example, and further possibilities for using and improving the model are discussed [5].

II. MODELING THEORY OF DIGITAL MANUFACTURING

The model, which plays an important role in system engineering, is an abstract and simplified idealized method of the system that reflects the main components of the system and the relationship and mutual effects between these components [4].

The modeling theory of digital manufacturing science aims to establish the modeling idea of the digital manufacturing system and establish a suite of modeling methods. Consequently, it would be the basic theory for analyzing and solving problems in the science of digital production [4].

The modeling idea of digital manufacturing science expresses the digital manufacturing system abstractly, and the digital manufacturing system is analyzed, synthesized and optimized by studying its structures and characteristics. Its specific purpose is to support system analysis and synthesis by better understanding and expressing the system; to support the design of new systems or the reconstruction of existing systems, and to support monitoring and control of system operation [4].

A digital manufacturing model is an indispensable tool in the entire lifecycle of the digital manufacturing system. This entire life cycle includes data acquisition, data processing, data transmission, control implementation, business management, decision support, and so on. It consists of a series of patterns in an orderly manner; these models are generally the product design model, the resource model, the information model, the operation and control model, the system organization and decision-making model, and so on. Here, the so-called "orderly mode" usually means that these models are created at different stages of the life cycle in the digital manufacturing system [4].

Digital manufacturing modeling abstractly expresses each object and process in the entire digital manufacturing life cycle through an appropriate modeling method, and analyzes, synthesizes, optimizes, and simulates them by researching their structures and characteristics. The target of digital modeling is firstly to establish the model of the whole digital system and then to establish the important models that target one or more objects mentioned above by using a specific modeling method [4].

Digital manufacturing science is a new discipline and the digital manufacturing system modeling method is still in the exploratory stage. Therefore, its specific modeling method must be created following the discipline theory to build its modeling method system [7]. The basic idea is that a generalized model of the entire digital manufacturing system is created using the theory of sets and relations, based on which basic models related to the system architecture, such as the functional model, the organization model, the information model, and the operation and control. the pattern is established. By reconstructing the existing manufacturing system modeling method, the digital manufacturing science modeling method system can then be established according to the characteristics of the digital manufacturing system. Finally, each link in the digital manufacturing system is modeled by the model system detailed above to create an implementation model, and this is a theoretical basis for the specific implementation of each manufacturing link [4].

III. DESCRIPTION OF THE SYSTEM UNDER ANALYSIS

For analysis, the paper proposes an empirical study dedicated to the control and analysis of a manufacturing flow in an evolutionary context, based on digitalization. The role of the control is to highlight the activity by highlighting the activity through different means of storage (both through databases and video monitoring systems). The role of the analysis is dedicated to a system to optimize the entire process, both manufacturing, and transportation.

For the simulation, we used an empirical, schematic, simplified system, which includes all the basic elements, which are part of the chosen case study. The package used for the simulation is Visual Object Net++ because the results can be obtained in real-time the diagrams can be read and interpreted relatively easily, and last but not least, the system can be intervened in order to eliminate possible errors and to optimize the manufacturing flow, figure 1.

Thus, in the diagram, the manufacturing flow is schematically represented on a single line (it is assumed from previous research that no major changes will occur), there are two control and analysis systems, and finally an interpretation system. This interpretation system within the simulation is designed to be able to provide general information and without following the path of the control and analysis system. This system will provide important information and highlight the role of digitization.

The connection between the three major components (1 manufacturing, 2 control, and analysis, 3 interpretation) is represented on the diagram by a robotic network. This network is of high capacity and works through continuous connection relations between the three components (1-2-3), and also between (1-2).

Why is the relationship between systems (1-2) necessary? This network is an automated system that provides manufacturing information and data interpretation. This interpretation can even be a final analysis of the manufacturing flow (warehouses). It is useful when carrying out large-scale maintenance work (changing a transport route, changing a piece of manufacturing equipment or even introducing a new product into production). Charts can provide useful information and real-time results can lead to process optimization. In terms of analysis and control (1-2-3), the system is much more complex and digitization is making a visible impact. In this way, each component in the system can be analyzed, allowing real-time access to any node in the technological flow or the department that is part of the system. The results in this case, are more complex and must be studied carefully because the variations are almost continuous, linear and the charts provide timings (displays as a function of time) over longer intervals because the information is more abundant than in the manufacturing process, which respects the imposed conditions and from which no great deviations can arise.

When working with information (in our case in system 2-control and analysis) information is abundant, at high speed, and requires large storage capacities. From here you can see the role of digitization, which is very important with a well-defined role in the development of new technologies.

It can be seen that the digital manufacturing system is not just a simple manufacturing process; it includes many links such as relevant market demand, production organization, marketing, and product maintenance. It is therefore a complex system linked by many links. The stable mode of operation that supports digital manufacturing systems should include a large number of subsystems, such as management and decision-making of manufacturing individuals or alliances, market demand analysis, collaborative product design and simulation, collaborative production management of the product, and operation. product manufacturing equipment control, product quality management, product marketing, and customer service. A complex approach, which includes as many subsystems as possible, will represent a research topic for the future.

After analyzing the general model, we studied the variation of the flow of information in several areas of interest highlighted in figure 2. These areas of interest were named so that it is possible to intervene in real-time in the event of the appearance of various errors, or if an intervention is desired in order to optimize the process. In this sense, the role of digitization is obvious. And thus system performance will increase.

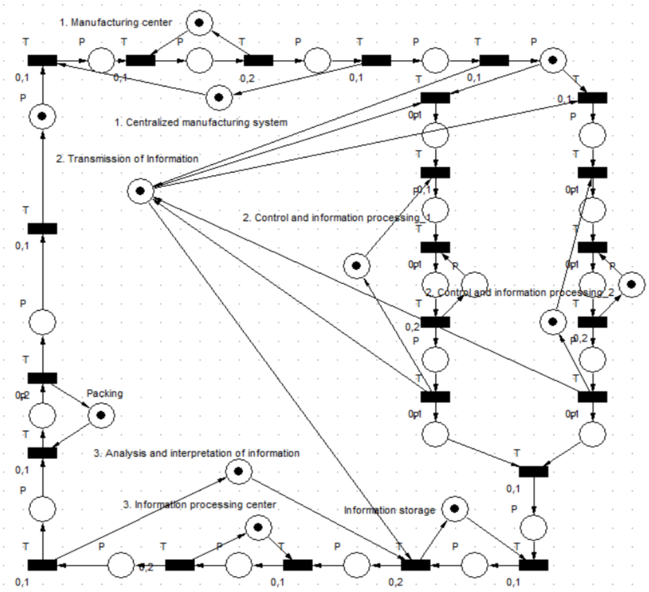
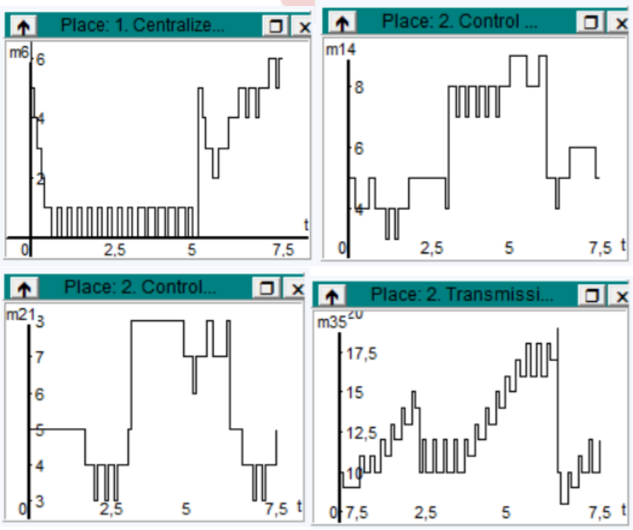


Figure 1. Presentation of the general model



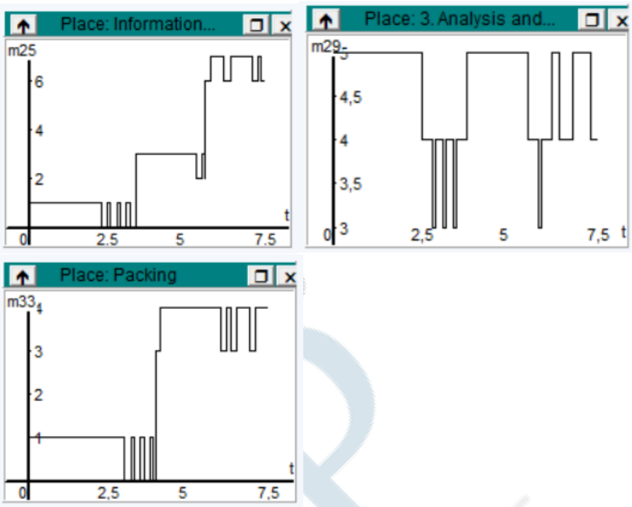


Figure 2. The results of the simulation in the nodes of interest, with the visualization of the flow of information

IV. CONCLUSION

Digital manufacturing science is a new discipline. To build an integrated system, it must be researched from the aspects of the digital manufacturing process and digital manufacturing system. This paper presents the empirical operation mode and architecture of the digital manufacturing system, which is considered to be a requirement of building the theoretical, empirical system of the digital manufacturing system.

Petri net modeling establishes the basic model system, including the generalized model, the organization model, the operation mode, and the operation and control model. The scientific foundation of digital manufacturing science is highlighted and the theoretical, empirical support system of digital manufacturing science is presented.

The content of this paper will be further improved with the constant enrichment and development of digital fabrication theory and methods.

The research presented in this paper showed the level of knowledge of digitization, about different types of solutions related to the digitization of the manufacturing process, and to what extent these solutions are implemented in enterprises. Many solutions are known, but the level of implementation of many of them is low, which means that in the near future, the market requirements may not be met, especially when it comes to digitization.

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