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EMPIRICAL ASPECTS OF THE ANALYSIS OF THE DIGITIZATION OF MANUFACTURING

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Abstract: *The paper presents an empirical analysis for a digitized manufacturing system. It is part of Industry 4.0. for modeling we used schematically represented systems. Thus, the complete system includes, in addition to the manufacturing system, a manufacturing management location in the cloud. The role of cloud manufacturing is to connect internally with the manufacturing system and externally with RAMI 4.0. for the simulation we will use the empirical system and Petri nets. We use Petri nets because the modeling is relatively easy to analyze and simulate. Changes in terms of optimization and elimination of errors can be done relatively easily and the results are transmitted in real time. The resulting diagrams can be easily interpreted for decision-making so that no idle times are included in the technological process.*

Keywords: *Cloud manufacturing, digitization, Industry 4.0*

1. Introduction

According to specialized literature, industry, being one of the most critical sectors within any economy, is greatly affected by the digitization of production processes through the development of new technologies that can be used to increase productivity. Digital transformation in the industry plays a vital role in keeping the organization in pace with the competition. The only way of sustainability in any competitive market is to transform business processes into a digital one [1,3,4].
More and more companies accept the fact that digitization of production is the answer to increase competitiveness and try to find products or services to meet the needs. Investments in smart machines do not guarantee success without a vision for digitization [2].
According to specialized literature, the digitization of production is a development and adaptation strategy.
Digital is no longer just a tactical aspect of the manufacturing business – it becomes vital to pursue end-to-end digital transformation to achieve goals such as improving efficiency and quality, reducing costs and waste, and creating innovative products and services.
Digital transformation is about applying technologies to radically change traditional processes, products and services into data-driven, highly connected solutions that can be monetized through extreme efficiency gains and entirely new business models. With a digital approach, firms accelerate time to market, deliver new customer value through digital experiences, manage complex global value chains, and innovate to dramatically improve customer experience and create new revenue opportunities [5,6].
The starting point is a stochastic system. For the stochastic system, the performance evaluation area can be subdivided into two sub-areas. The first refers to measurement and includes three distinct domains that can be called measurements, benchmarks, prototypes.
Measurements are performed on a real system under real operating conditions. They provide the actual performance of the system in the particular state in which the system is observed. However, the measurement results have a very small generality because they are largely dependent on detailed characteristics measuring system workload imposed on the system during the measurement.
The benchmarks will require study system available, so they can be seen. There are cases where the performance study refers to a system that is not available, it is necessary to develop a representative approximation of it, either in hardware or software [7,8].
For the elaboration of the works, we have made a link to be able to do research in particular regarding the confidentiality of the cloud manufacturing, the analysis of the IoT resources in the manufacturing

systems and which can equal it for research purposes, namely RAMI 4.0. IoT is described in the literature as being anything connected to a network that can communicate autonomously without additional human intervention. This concept used in production and other industrial processes allows machine designers to create intelligent equipment and machines so that they can track, record, display, monitor and adjust parameters autonomously. For the cloud, we turned to the simple definition Cloud is an application available only to customers with active mobile Internet, which offers a solution for data storage. Cloud storage consists of archiving, organizing and distributing on demand data between virtualized storage volumes that have been consolidated into hardware [9,10,11].

In this paper have proposed a new architectural model of the intelligent factory that will allow the production experts to make a simpler planning, optimized using all the key technologies of the industry known until today.

Manufacturers can automate and schedule purchases to align with production schedules to reduce inventory costs and positions, while automating inventory and material control.

2. Model description and analysis

The impact of digital transformation in manufacturing includes improvements in safety, quality, production, efficiency, revenue and sustainability – all while reducing costs to remain competitive in the market.

Some major benefits of digitization for manufacturing companies

- digital solutions improve safety, fewer injuries and accidents occur at the workplace
- improvements in the quality of results, reduction of product repetition, reduction of warranty work and increase of customer satisfaction.
- effective process improvement, has a positive impact on employee productivity and production output.

The existing industry architecture model provides a good overview of the industrial environment architecture, but leads to some limitations for users. To overcome these limitations, we proposed based on RAMI 4.0 models a simple smart factory architecture model based on the concept of distributed systems with accurate information and data flows between them. The proposed architectural model enables more reliable and simple modeling of the smart factory. To solve many problems the solution can come from RAMI 4.0, which provides the reference architecture model for the industry, it is a three-dimensional map that shows how to approach the problem at the industrial level in a structured manner and last but not least it ensures that all participants involved reach a common denominator.

The key technology that enables the integration of distributed manufacturing resources, their transformation into manufacturing services and centralized service management is cloud manufacturing. This concept allows multiple users to request services at the same time by submitting the tasks of their requirements to a cloud production platform.

According to specialized literature, the integration of decentralized production resources and the establishment of a collaboration infrastructure between these units is fundamental. This idea requires building the networked manufacturing environment to integrate manufacturing resources and applications.

Manufacturing resources and knowledge can be put into the cloud and thus become accessible on demand by consumers.

3. Presentation of the system

In order to ensure good information management, I will use a tiered cloud system. Research using Petri nets has become very widespread due to the mathematical and graphical model used. Petri nets have at their disposal appropriate platforms in the field of modeling and design of concurrent systems, computer systems, manufacturing systems and performance analysis.

The present work is based on three objectives for IoT but also for the Cloud, these being key elements for RAMI 4.0 as well:
- fundamental study of Petri nets that can be analyzed and validated by a discrete system,
- petri nets are useful for modeling and analyzing systems with discrete events,
- validation methods and results obtained from the analysis of the subject model, deterministic and stochastic model that are used to reorganize and re-evaluate the system and increase its flexibility.

The figure 1 highlights the essential steps of a cloud manufacturing system in the ideal case. All the elements used in the simulation are discrete, which is difficult to obtain in practice.
The modeled system chosen is schematic and contains the basic components IoT, cloud, RAMI 4.0 and the connection between them. It is a generic system and has the role of highlighting the component elements.
In simulations, one can observe the intense activity throughout the requested period in the IoT area, because here the technological manufacturing flow takes place. In the Cloud area there is action at the required levels. Only three basic levels are represented in the scheme. These are at the beginning and end of the process and an intermediate level that can play a role in monitoring the activity.

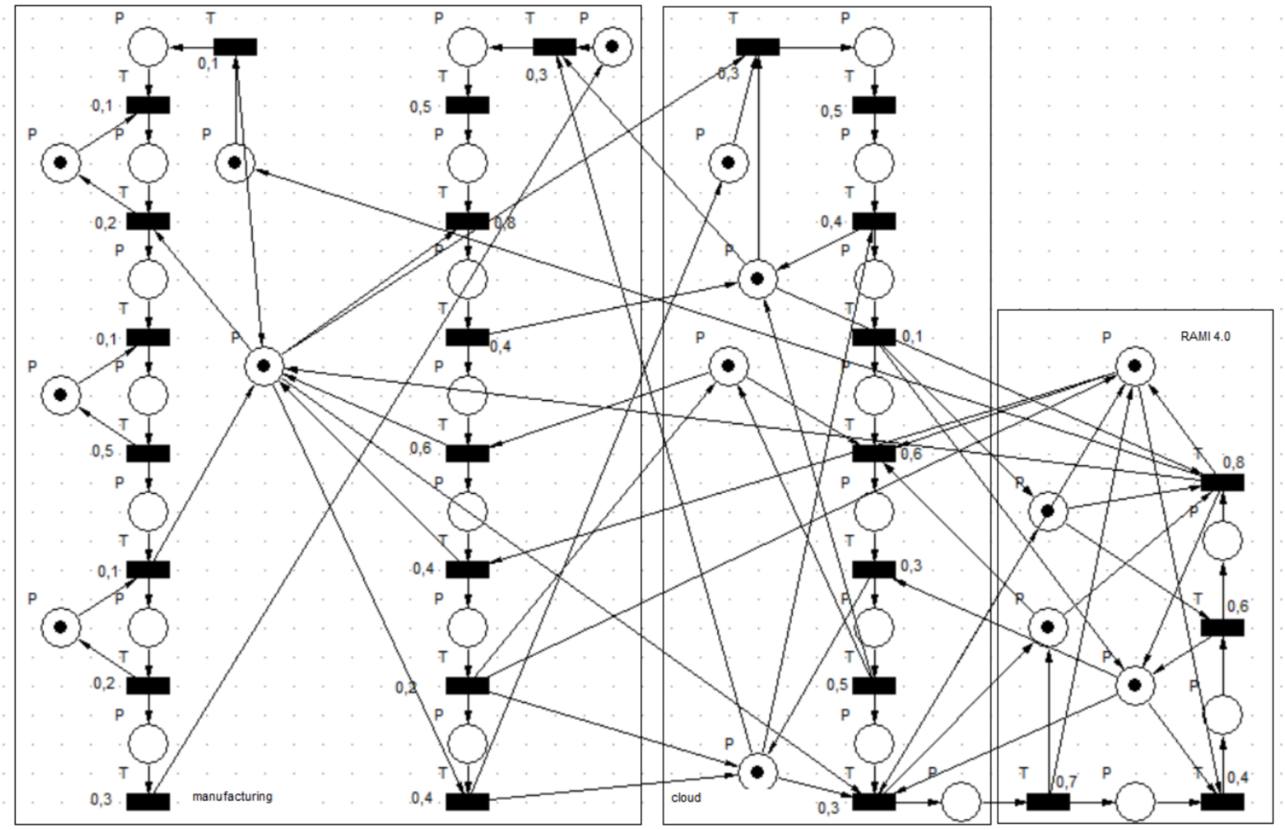

Fig. 1. The general model under analysis.

As for the times used in the simulation, they are comparable to those used in the work in which we dealt with Cloud systems and manufacturing systems. The times are chosen randomly to be able to see on the simulation result the variations that can occur as a result of using the three technologies and their own architectures, Cloud, manufacturing and RAMI.
As a result of the simulation it is observed that intense activity on the entire surface of the technological flow is only in the manufactuing area.
In the cloud, figure 2, and 3, area the activity from the beginning and the end of the model is actively

monitored, and the intermediate zone is the activity of tracking, the role of these areas is also to signal any possible defects that may occur in the technological process or errors that occur in the system.

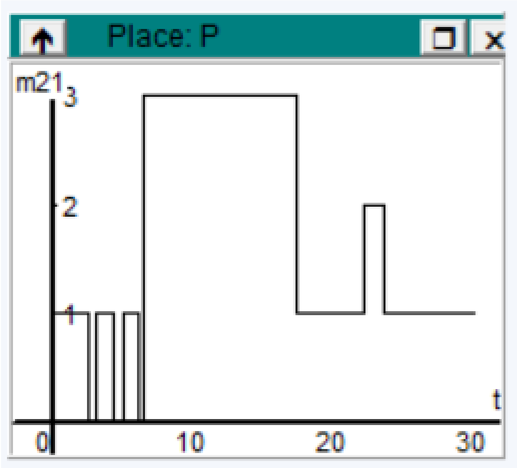

Fig. 2. Cloud-level simulation, as an intermediate control system.

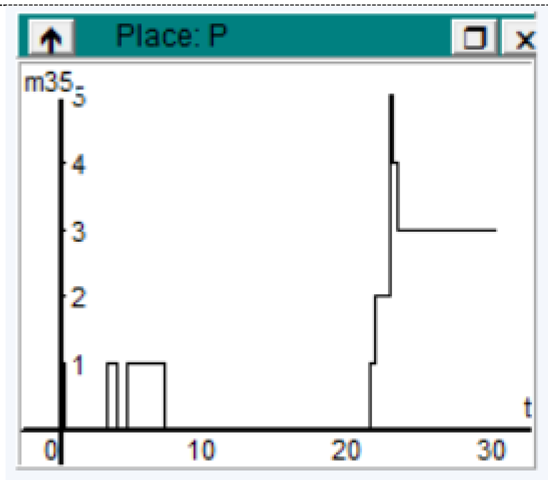

Fig. 3. Cloud-level simulation at the end of the stream.

In the area dedicated to RAMI 4.0 on the graphical representations, figures 4, 5, 6 and 7, we observe at the beginning a determined variation of relations, connections, internal and external requests. These are up to the stability of the system at the cloud level, and then everything unfolds linearly without any variations and sudden differences in representations. All this representation is until the end of the lot.

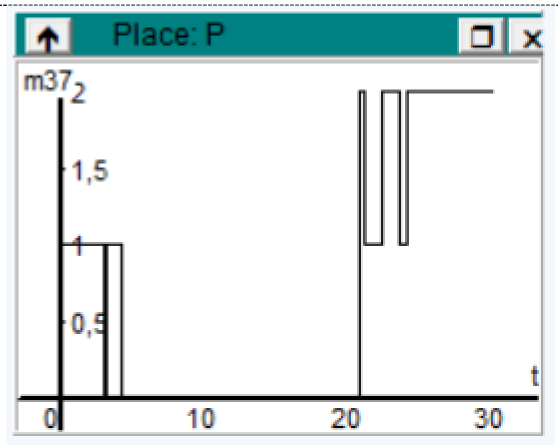

Fig. 4. Simulation at RAMI nodes with rules for manufacturing

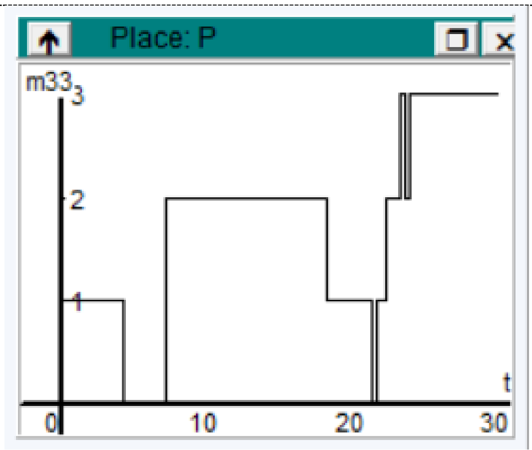

Fig. 5. Simulation at RAMI nodes with rules for Cloud.

At the beginning of a new manufacturing batch determined by the same type of product established for processing, the entire RAMI 4.0 system will again have variations determined by the internal actions of the system and the external actions due to the imposed specifications. This simulation refers only to the product life cycles, the orders with the hierarchical levels of the industry. The life cycles of the factories and machines are not debated because in the model we included only one working point.

All simulations were performed in the same time frame for a single batch, in order to be able to observe as explicitly as possible the variation corresponding to the production flow and the level of orders accessed by RAMI for the system chosen as the simulation model.

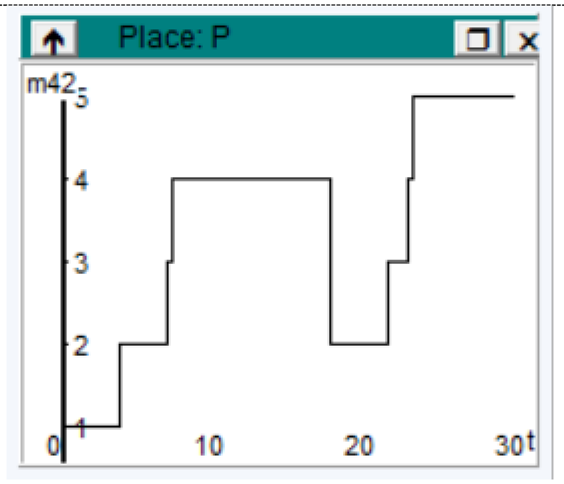

Fig. 6. Simulation at RAMI nodes with rules for manufacturing

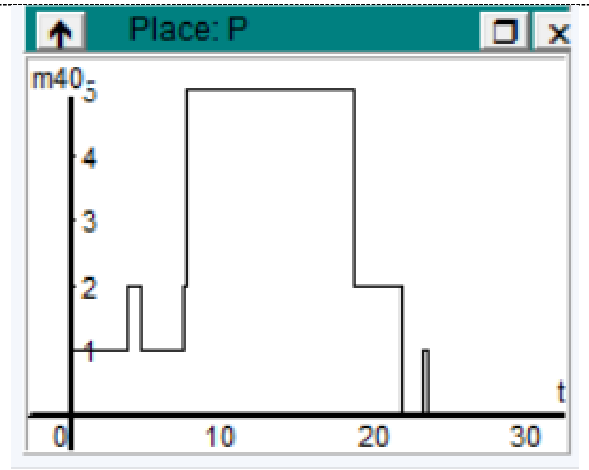

Fig. 7. Simulation at RAMI nodes with rules for Cloud.

4. Conclusions

Digitization is radically changing the face of manufacturing companies. Digital factories are transforming manufacturing as companies implement innovative technologies and seek employees with fundamentally different skill sets.

Leading manufacturing companies are implementing a number of key technologies to digitize manufacturing as well as their entire supply chain. These include end-to-end big data analytics solutions, real-time planning and connectivity, autonomous systems, digital twinning and worker augmentation, among many others. These technologies offer significant efficiency gains and enable companies to produce highly customized products, often at batch size. However, the full effect of digitization is only realized when companies are connected in real time to their key suppliers and critical customers.

Through digital trainings and a communication concept, it motivates employees to contribute to the digital success of their companies.

Digital change is easier said than done. While the benefits of digital transformation are tremendous, there is no one-size-fits-all approach.

Digital transformation is changing the structure of modern business, the scale of operation, consumer behavior, product life cycles, innovative behavior and company culture, legal regulation, promoting broader innovations to meet consumer demands, increasing efficiency and improving the quality of goods and services produced delivered.

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