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From real – time manufacturing to IoT digital technologies

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Abstract. The paper deals with several aspects of Petri networks, their implications in the modeling, analysis, synthesis and implementation of systems in the field of manufacturing. Since these aspects are being analyzed based on discrete events systems and because everything is done in real time, it is recommended that digital technology is accessed using IoT devices. For the chosen manufacturing system, we will only model and analyze the sectors in which the importance of the component systems can be highlighted in real time. Even though Petri networks are no longer secret in use, they are easy to use in simulation and modeling, and the resulting diagrams are easy to interpret. The synthesis and implementation proposed in this paper are considered cloud-based because the security of information is much more complex. The tracking and control system is proposed to be managed using IoT systems and all levels to provide the most accurate security of the manufacturing process. This system can be used in enterprises that adopt the implementation of IoT systems, implement digital technology. The system can only be applied to manufacturing sectors, and should not cover the whole system from supply to disposal.

Keywords. manufacturing system, IoT, cloud manufacturig systems

1. Introduction

The specialized literature deals very carefully with details of Petri networks and their implications in the modeling, analysis and implementation of manufacturing systems. [4]

As digital technology follows the path of technological development of the future and more IoT is an integral part of it, I will try to consider examples for which conceptual complexity is extracted from specific systems.

In the paper are used concept and techniques dedicated to classical systems, but they are private from the perspective of digital technology. [9]

The starting point is a manufacturing system for which the flow of transport is analyzed. Only one sector in the whole system is modeled and the difficulties encountered in the monitoring and control system imposed by IoT are highlighted. This analysis is necessary because very crowded systems use systems with discrete events that most often lead to hybrid and continuous approximations. [9]

Cloud manufacturing is a modern concept that uses computing and IT, representing a distributed set of computing, applications, access to information and data storage without the need for the user to know the location and physical configuration of the systems that provide these services. [3]

2. Presentation and analysis of the model

The analyzed model contains two processing centers and an assembly center. In this system are added some additional elements to ensure good functioning. These additional elements have the role of ensuring a continuous flow and avoiding any errors. These errors can be so caused by various interruptions (maintenance) but also accidental interruptions.

In order to model these types of systems, an important role is played by level analysis, [7].

To be able to express security requirements relating to physical devices, the model must be designed to contain a description of the working environment to adapt their behaviour to situations that may occur (not provided).

Planning complex processes face the problem of describing the workload characteristics and their interactions in a concise and easy to understand. One of the basic strategies for achieving this function is a hierarchical approach.

Within the complex processes by analyzing the characteristics of the system according to the blank transported considering the general case. A particular case where it can be studied in future work in the system is to be used for the transport of hot blanks, that is, in the steel rolling system. [4]

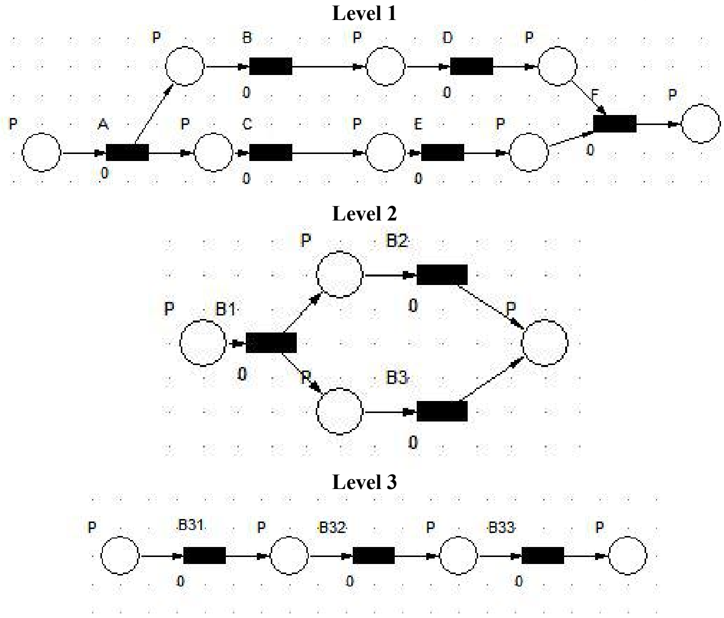

Figure 1: The hierarchical levels with Petri Nets [8]

In level 1 Petri Net is presented to the highest level network, a hierarchical transition and is used for level 2 Petri network. At level 2 transition Petri Net is a lower level hierarchical Petri Net. This mechanism can be used to achieve hierarchical decomposition of a complex system.

Under this system could be divided into different levels of detail from top to bottom. The concept of hierarchical structure information can be used effectively. The upper level offers a higher level of abstraction and detail a complete plan without extensive and complex hierarchical system. At the lowest level it offers a high level of detail on Petri Nets modelling form and is working at the complex tasks of system. [8]

Figure 2 presents the classical structure modeled with Petri nets, from which depart in order to analyse hierarchical system. The classic is the representation of Petri Nets model with factors indicated in the first chapter.[7]

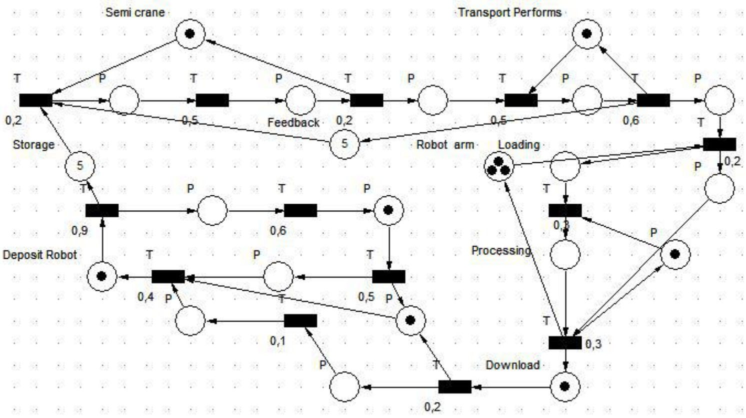

Figure 2: Classical structure modeled with Petri nets[7]

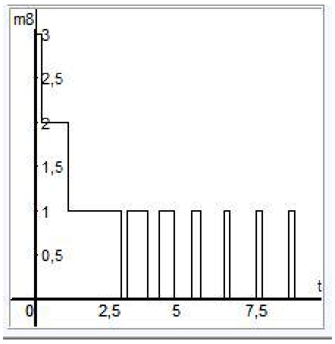

Figure 3: Increased flow after initial processing [7]

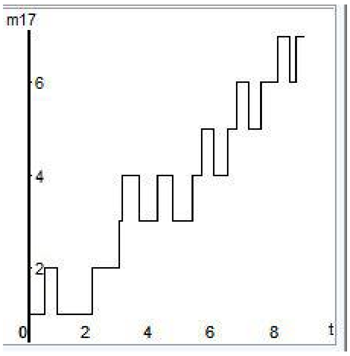

Figure 4: Transport blank in the classical system [7]

In the initial state, the processing centers and the robot are inactive and the warehouses are empty.

The following types of handling systems are used in manufacturing systems:

-Transfer linear for automatic lines,

-Conveyors,

-Transfer palletizing on processing centers,

- Industrial robots for handling materials.

The factors that infuse material handling at all levels, especially at the level of abstraction, are:

-The amount of material that may be small or large, continuous or discontinuous,

-The rhythm imposed by the material flow is determined by time, an important factor in the establishment of architecture,

-The Schedule of Material Flows routes, aims at the distribution, management and dispatching of the transported materials,

-Transport itineraries, defining each transport route, manipulation including distance and time.

For smart systems, common problems that may occur are failure, machine repair, variation in processing times.

The advantages of the Petri networks used in the modeling and analysis of the manufacturing systems are:

- Explicit relations between events.

-The modeling language can serve to describe the system on different levels of abstraction.

- System properties analysis to validate the solution.

For the chosen manufacturing system, I will design and evaluate on the basis of factory data collected but reduced so that a complete simulation can be made. Because it is a theoretical research, it is attempted to model stochastic petrochemical networks, which with the help of the chosen technologies can be achieved with IoT devices.

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- system properties analysis, validating the solution.

Cloud monitoring is essential for automated and autonomous data control systems, but also for service logic feedback. Scalability and security are critical to cloud monitoring. In general, monitoring is done locally, and shared information is monitored and not available outside of resources. [2]

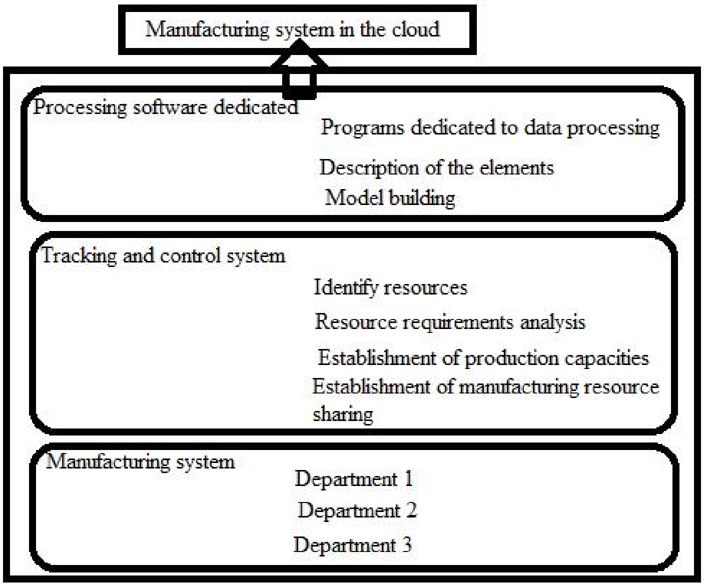

Figure 5: Cloud manufacturing systems [3]

This paper analyzes the path on the three components, but bases from Component 1 on Building the Model as close as possible to reality so that there are as few errors as possible in the simulation, Component 2 analyzes the Determination and Analysis of Resources, but also Establishment of Manufacturing Capacities, where required by the introduction of temporary warehouses or storage facilities. For Component 3 only one department is selected that deals with actual production.

Cloud manufacturing service providers are motivated to manage their activity because the ability to obtain fast and accurate information is grouped together in an advantageous way.

In this paper, a cloud manufacturing system is defined as a global activity of an enterprise that has activities for both manufacturing resources, which can be resources one or more manufacturing resources. [3]

3. Model for IoT

A model for preparation for the adoption of production is presented below:

- Size and investment capacity of the manufacturing and supply chain. Micro-enterprise ecosystems are the fastest and most destructive innovators, due to insufficient investment. Feasibility and economic sustainability is the major maturity criterion addressed in this dimension;
- Industry dimension and ICT awareness, in which high technology industries already have knowledge of certain technologies and well-trained young people in digital competences. Low-tech industries are heavily dependent on the knowledge and experience of older workers and engineers, and migration in many cases implies the meaning of knowledge transfer;
- Another dimension considers the political and societal environment in which the supply chain operates.

Some changes to IoT include:

- communication and interaction solutions,
- capitalizing data on system evolution,
- the use of specialized services for the extraction, synthesis and use of information.

The advantages of IoT are that users can focus on connecting the equipment, selecting the necessary options, using the results provided by the platform.

A useful platform that can be used in manufacturing systems is Oracle Integrated Cloud IoT, which provides real-time IoT data analysis, device visualization, data collection management, user notification.

Among the evaluation criteria are the IoT Platform type, which is often provided through cloud, either as a Platform as a Service (PaaS) or as a Software as a Service (SaaS). In PaaS, platforms provide cloud computing for IoT devices and data, while SaaS focuses on interconnecting data sources using cloud computing capabilities.

4. Analysis of the Petri network

A Petri net type Location / Transition is form [4][5][6],

$\sum = (P, T, F, W)$ where:

- P, T are two non-empty sets, which represents the set of places and transitions respectively crowd, $P \cap T = \phi$,
- $F \subseteq (P \times T) \cup (T \times P)$ is a binary relation, called the relation of the network flow,
- $W : F \to N$ is the function of the network share $\sum (W(f))$ is called the weight of the element (f).

If $\sum = (P, T, F, W)$ a network location type / transition is called the marking network $\sum$ any function $M : P \to N$ with the property , for any $p \in P$, where $K : P \to N \cup \{\infty\}$ is the function of network capacity $\sum . M(p) \le K(p)$

If $\sum = (P, T, F, K, W)$ Network P / T, where notes N^P set of all the indications of the network, obtain $N^P = \{M \mid M : P \to N \wedge (\forall p \in P)(M(p) \le K(p))\}$

If your network has infinite capacity only when N^P coincides with the set of applications from P to N.

A network P / T is marked by a pair $\gamma = (\Sigma, M_0)$, where Σ is a network of support network γ, and M_0 is marking the initial network γ.

Network transitions Σ is considered functions $t^-, t^+ : P \to N$ i and $\Delta t : P \to Z$ defined by:

$t^-(p) = W(p, t)$, $t^+(p) = W(t, p)$, $\Delta t(p) = t^+(p) - t^-(p)$, for any $p \in P$.

From the entire processing flow we chose only the assembly sector for this work.

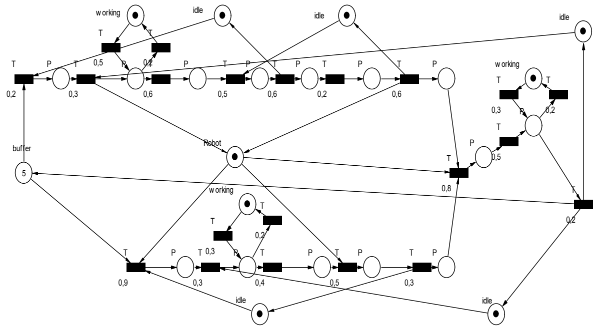

Figure 6 : Model under analysis

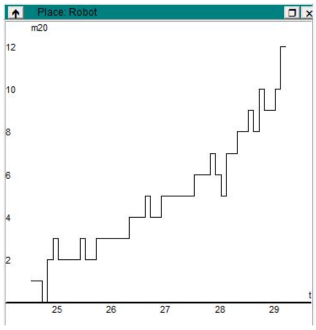

Figure 7 : Robot activity variation for a complete cycle

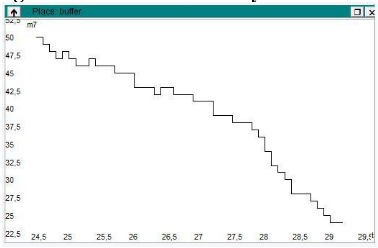

Figure 8: Activity flow from the central repository - output to processing

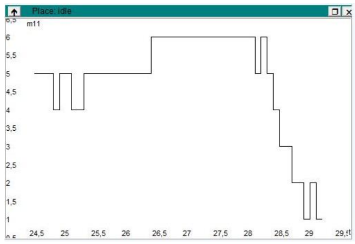

Figure 9: Temporary storage site activity

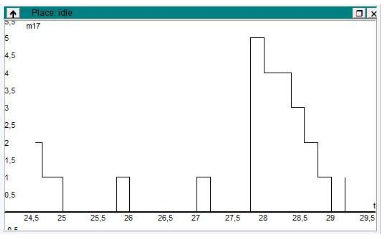

Figure 10: Assignment site storage center assembly temporarily

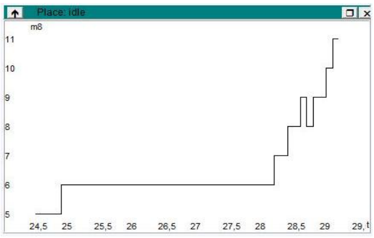

Figure 11: The activity of the permanent storage site

This system is linear. Because during normal operation, that is to say, in compliance with pre-established operating conditions, no errors are encountered, real-time monitoring of the entire process on levels will be attempted. For this I will appeal to the application of cloud systems on levels. This system was presented and analyzed in the paper [3]. Here we come to the conclusion that the proposed mechanism is flexible because the cloud manufacturing services are decoupled from manufacturing resources. The resources used can be located and obtained according to the production capacities and imposed constraints. This is how to define and outline the dynamic and automated services on which the cloud system is based.

5. Hardware, Software and Network

What would hardware need to create a digitization and turn an automated factory into a smart factory?

The general infrastructure may be something like [1]:

a) sensors, IoT devices (devices that can transfer / transmit data over the Internet) to read / capture some data from the main, if not all, automated modules involved in this manufacturing process

b) physical network infrastructure to traffic for specified data (inside an intelligent factory also specified externally between smart factories)

c) servers / modules that can process the data received from the production modules

d) Modules for storing processed data or data to be processed

e) other modules designed to organize this complex (internally) system designed for a smart factory

Maintenance for this structure of this system can be created / administered by humans (partly for the whole process) or it can also be controlled by the artificial intelligence module.

The main disadvantage is created by the high costs generated by the purchase of necessary hardware and software. Additional costs are generated by the maintenance system that must be implemented for the computing technique. In addition to the costs of purchasing and maintaining equipment that allows for virtual engineering implementation, the costs of employee training and the costs of time lost during technology implementation and verification are added.

The deficiency resulting from the application of this complex manufacturing concept, based on virtual reality, is that the digital information of a product becomes very complex and a single computer can not satisfy the necessary system resources. It takes the development of a whole computer system.

Empowering a manufacturing plant / entire system of this "brain and autonomous muscles" also contains this section of software applications that need to run on dedicated hardware / machines to have a "live system".

By analyzing the cloud, he provides all the features of a high performing software with the ability to track online data, accessing information from any device with an Internet connection.

This section may contain different types of software, such as [1]:

a) Embedded software / embedded software

b) Operating systems

c) dedicated software for tracking the entire manufacturing process or for a specific process of manufacturing the product

d) Process automation software (brain, can learn and make decisions)

e) Security Software

f) Software for data traffic

g) Comprehensive data storage software (may be in the cloud)

h) Software designed for self-control (to check the entire system for valid data and processes)

i) Software that can generate reports with / for the human interface

j) Dedicated software for system-wide support (for specified system updates and bug fixes)

All in all, this system must be able to process complex information and also be autonomous in decision-making on management processes for this intelligent factory based on the manufacturing steps of a product. It also has to have the right results (data, time and processes).

A major disadvantage is the need to use specific software tools to access digital information. In most cases, these tools are very expensive and require the same software version that created the original digital information. Given the large amount of software vendors on the market, this can be a big problem in a collaborative work environment. The solution to this problem is to simplify digital models according to the needs of each user so that the amount of digital information is reduced. In this way, the necessary hardware and software resources can be kept to a minimum.

The network is a very important part of this automated management system for a smart factory.

This network must be organized into subnetworks (kernel-based interconnected subnetworks as division-based software modules because there is no need to upload a lot of resources / overload resources) [1]. These subnets need to be connected to a larger network / main network for an entire intelligent factory and also this network may be a subnet for another larger network consisting of several internal networks forming a group of intelligent factories .

Some dedicated servers can be used with a multitude of processing power and a minimal Gigabit data system to get faster communication between the different parts of the factory and management modules.

The specified subnetworks can also be divided into automated processing point locations / points, such as robots or other hardware devices.

Cloud computing can be used to solve a lot of traffic-related issues and the status of stored data.

Also, some software applications can be directed directly into the cloud for certain tasks / process rules.

Another disadvantage is that due to the flexible manufacturing lines required, employees need to be trained faster and more efficiently so that they can cope with rapid changes.

6. Conclusions

The main benefit of IoT is the ability to collect data and turn them into activities.

IoT is a launching platform for quantitative and qualitative transformation, monitoring and control of complex manufacturing systems.

The IoT platform is appreciated for the facilities offered, related to:

- collecting and preparing data,
- communication protocols,
- monitoring, follow-up and control,
- security,
- data analysis, processing, easy interface from system functions.

The technological advantages are: security, data analysis, monitoring, low power networks, real-time event flow processing.

The implementation of digitized technologies by large companies may hinder their suppliers, small companies. They are forced to adopt a computing technique that is compatible with that used by customers to meet the requirements, for which reason they have to increase the price of the products provided to repay their investments.

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