IoT analysis of manufacturing using Petri Nets

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Abstract. The activity of modeling and evaluating the performance of the manufacturing system plays an important role in theoretical research and technological improvement with IoT. The study presents the method of modeling and evaluating performance based on Petri networks and the expression of the behavior of the whole system. According to the system information diagram, the constraint relationship between locations and transitions is identified, after which the extended graphic model is built, and the behavioral expression method is then chosen to obtain a set of performance indicators. The study is designed to verify the effectiveness and efficiency of the system.

1. Introduction
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. [1]

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.

These approximations must be quite detailed and are normally called prototypes. Then, observations are made about such prototypes, possibly with the help of benchmarks as artificial workloads.

In all cases, the performance of the system is obtained by observing the behaviour of the system or its approximations in operation, i.e. when loaded by either the actual or referenced user requests. However, studying the performance of a system is not only an important task during and after the implementation of the system but also in the design stages to compare the alternative architectural possibilities. This is especially true when developing new systems is motivated by increasing demand for performance, such as in the field of computers or machines that have different computing components in components. [1]

During the design process, measurements on real systems are not possible and prototype implementations are difficult due to the need to specify many details.

An important stage of performance evaluation is modelling. It is divided into two areas:
- simulation models,
- analytical models.
In both cases, the performance study is done using a description that includes only a few important system features. For simulation models, the description is given through a computer program, while in the case of analytical models the description is given in mathematical terms.

In this paper, only the simulation model is presented using the Visual Object Net ++ package. [1] 
A stochastic process is a mathematical model useful for describing phenomena of probabilistic nature as a function of a parameter that usually has the meaning of time.

Since the definition of a stochastic process is based on the notion of a random variable, it is necessary to recall some basic concepts of the theory of probability.

2. Internet of Things
In the case of IoT systems, results of performance modeling and evaluation are the basis for its design, planning and improvement. Modeling an IoT system is based on building an abstract stochastic model that describes the relationship between process and system performance and provides a quantitative analysis of system performance. Modeling and evaluation helps to identify errors that can occur in the network, so you can intervene to improve overall performance in a very short time. [5]

The introduction of the Internet into the systems of analysing and controlling the flow of technology required major changes in the company's general architectures. The role of the Internet has been to manage internal applications, provide permanent access to the Internet, providing basic information for the most effective integration with enterprise functions such as marketing, sales, logistics, production. As businesses have started to take advantage of the capabilities of the Internet, the new features and structures have evolved over time. [4]

Security is the most important, has a defining role in all web-based information systems, forcing the creation of special security architectures to ensure data security and operational integrity. The enterprise architecture for the Internet continues to grow with new approaches, such as micro-based services introduced to address operations, scalability and security. [4]

The Internet of Things suddenly introduces a new type of product for businesses. This is the connected product that, at fixed intervals, communicates with web servers - IoT servers - using local connectivity and the Internet. [4]

In figure 1, IoT presents challenges to the existing enterprise architectures and requires the development and creation of new IT systems and organizations as well as new evolving business architectures.

Considering [4] and analyzing the technological enterprise, we customize our case study IoT systems access to organizational architecture.

Because if IoT systems, products not only connect to a web server. Each company decides what protocol and language use and connectivity server This server does not host applications, but acts as an intermediary that provides some basic functions: managing and providing information; collects, processes and normalizes data; supports applications and supports development.

Many IoT servers offer features such as databases, storage, and security management. Today there are many companies that offer IoT servers as enterprise software, cloud software or services. Selecting the correct IoT server is a challenging proposition because no market leader has emerged. [4]
Figure 1. Enterprise Architecture for the Internet of Things [4].

IoT servers provide dedicated database, storage, and security management functions, but there are also IoT servers that offer enterprise software or cloud services. These servers are more useful, taking into account cloud-based manufacturing systems on levels. The general information management principle in cloud-based systems has been highlighted in [3].

IoT servers require configuration and operation, knowledge of how to program all basic functions, how to configure interfaces with IoT applications, and how to monitor the entire manufacturing flow. Different from a web server, which is basically a file system with a database interface, an IoT server is a complex system that requires trained personnel to manage and operate. Because this system needs to be integrated with all the other IOT functions, it is necessary for businesses to be considered for the first time as complex stochastic systems after which the actual systems are modified to use the purpose for which it was created. In this case, it is considered a complex stochastic system that allows the management of the entire transport system and can identify any error that it transmits to the IoT system.

IoT does not introduce new components into the enterprise architecture but uses existing parts of the Internet application: web server, internet browsers and web browsers and phone applications. They need to be tailored so that they can serve a wider set of internal and external applications developed as part of the new business opportunities and object of Internet operations [4].

3. Presentation of the system
In the production system mainly used as handling systems:
- Linear automatic lines,
- Transfer pallets on processing centers,
- Industrial robots for handling materials.

As the manufacturing process is monitored in cloud levels, there are a number of factors that influence handling:
- Quantities of materials transported,
- Transport times,
- Changing the layout.

A very important role is to ensure the maintenance of the system influenced by the malfunctions that may occur and implicitly the time to repair the malfunction.

The advantages of Petri nets modelling and analysis systems used in manufacturing are:
- Explicit relationships between events.
- Same modelling language can serve to describe abstract of the system on different levels.
- Analysis of the properties of the system to validate the solution.

For the chosen fabrication system, I will model 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 trying
to model the Petri networks, which with the help of the dedicated technologies can be done with IoT devices.

In the paper is analysed the behaviour of the entire system for filling the cans (boxes), so that the storage of the boxes, the manufacturing (the filling processing system, the boxes filling, the washing, the preparation for preservation, drying, packaging) and the dissolution form a whole. The contradictions that arise are generally determined by the calling sequences imposed in the system. The constraints can also be determined by the manual system - when a finite product is needed in small quantities, possible transport system failures (automatic box filling system or spiral box closure system or even the closed box section - which contains washing and drying the boxes).

The transport system model can be assimilated to a system with discrete events. These systems form a class of nonlinear dynamic systems using their own mathematical tools other than the differential equations used in the theory and practice of automatic regulation. The systems are used to designate the mathematical model, but also the process under analysis, consisting of the six components: supply, production and sales.

The system description is based on events that are: arrivals and exits. The state of the system is given by the total number of elements found in the system. [2] A Petri Network is a modelling and system analysis tool. Analysing a Petri-supported system can provide information about its structural properties and dynamic behaviour that is useful for the system for improvement, verification, and testing.

Petri models can capture relationships and interactions of events with a strong mathematical basis, so they have been used in manufacturing and management systems for a long time.

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

This sub-nets must be connected into a bigger network / main network for an entire smart factory and also this network can be as sub-network for another bigger network consisting of more internal network form a group of smart factories.

Specified sub-networks can be also divided in pointers / dots of automatic places of process such as robots or other hardware devices.

Cloud computing can be used to resolve a lot of problems for traffic and status of stored data.

Also some software applications can be run it directly on cloud for specified tasks /rules of process.

Starting from the case study presented in [3] where only the production system for the automatic packing and packing system was analyzed. In this paper, the system is made up of three components: supply, production and sales.

The analyzed system is considered to be grouped on three levels. The basic level remains the one of cloud manufacturing analyzed in the paper [3] besides adding the storage level of the boxes and selling the products, figure 2.

Following a complete process, the most representative variations that can be observed during manufacture are those in the following figures: 3, 4, 5, 6.

Tracking system has the ability to maintain network coverage for error detection and communication of necessary information. Human errors that can occur have a significant influence on the reliability of the system, sometimes more than technological failures. Research results show that the vast majority of industrial accidents are attributable to human errors. IoT systems are considered as a tracking and supervision technique for preventing errors and managing operations in real time. Control techniques that have been centrally supervised have been studied to overcome the inherent limitations of decentralized approaches, including the lack of ability to provide rapid and global solutions to be optimal.
As can be seen in the previous figures, major variations are observed only at the processing system. There are no flux variations in storage and sales systems. If these variations occur, they can be remedied without the need for a very careful follow-up.
Figure 5. Closed box system variations (box cleaning and drying).

Figure 6. Variation of system when switching from manual filling of boxes to automatic box closures.

4. Conclusions

Such a system monitored based on IoT systems is effective and has high efficiency because information can be obtained in real time at any level and at any time. It is possible to determine possible errors, their type and can intervene promptly without looking for a fault.

IoT offers opportunities to advance production businesses in achieving better system performance.

The modeling and assessment of IoT performance sets the basis for theoretical analysis, technological improvement and its quantitative results.

For the best and most efficient operation, the system parts have to meet several conditions:

- Must be as a complete and complex system to digitization / automation of a factory, to change that factory into a smart one, a system composed by hardware modules, software modules / applications and network(s).
- Must contain the auto-evaluation module and auto-correct of partial invalid data or partial invalid processes.
- Must contain a security module also internally (for traffic, processed or stored data), also externally, as a secure communication between smart factories / group of smart factories.
- Must contain the reporting module for some reports necessary for users.
- Must contain Dashboards and other types of interfaces for users.

5. References

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