Quest Journals
Journal of Software Engineering and Simulation
Volume 7 ~ Issue 2 (2021) pp: 01-06
ISSN(Online) :2321-3795 ISSN (Print):2321-3809
www.questjournals.org

Research Paper

Analysis of Blockchain Integration with IoT

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ABSTRACT: *The paper analyzes a useful method to integrate in the manufacturing process secure intelligent systems based on Petri nets. The method allows tracking and control based on a secure intelligent system template, which can be implemented on an accepted blockchain platform, and then integrated into the intelligent industrial system. One of the main advantages that the method analyzes is to visualize the errors in the nodes, to follow the workflows. Modeling intelligent manufacturing systems using Petri nets helps developers minimize logic errors - checking the properties of Petri nets, such as blockages - during modeling.*
KEYWORDS: *Manufacturing system, Petri Nets, Blockchain, Intelligent system*

Received 23 Feb, 2021; Revised: 05 Mar, 2021; Accepted 07 Mar, 2021 © The author(s) 2021. Published with open access at www.questjournals.org

I. INTRODUCTION

IoT is a development system that offers unlimited benefits, but there are many challenges to the centralized IoT architecture so that all devices can be identified, authenticated, and connected through centralized servers. This model can be used to connect a wide range of computing devices, will continue to support small-scale IoT networks because it will not be able to provide the necessary conditions for the expansion of the IoT system in the future [1][2].

IoT has unlimited benefits and adopting a decentralized approach to IoT can solve security issues [2].

Adopting a standardized peer-to-peer communication model for processing many transactions between devices has the potential to reduce the costs associated with installing and maintaining large, centralized data systems and thus distribute computing and storage reports across multiple devices that define IoT networks [4][2].

The decentralized, autonomous, and unreliable capabilities of the blockchain make it an ideal component for its role as a core element of IoT solutions. This is why enterprise IoT technologies have become a pawn that adopted blockchain technology early on [2].

Establishing peer-to-peer communications presents a set of security challenges. IoT security means more than data protection. Thus, blockchain solutions must maintain the confidentiality and security of IoT networks and use the validation and consent of participants for transitions to prevent burglary and theft [5][2].

The blockchain opens a number of difficult or even impossible IoT scenarios to implement without it. It will be possible to deal with the exchange of information between similar devices, and they will use an intelligent industrial system that has the role of shaping the agreement between two or more parties [2].

Blockchain technologies are able to track, coordinate, transact and store information from a large number of devices, allowing the creation of applications that do not require a centralized cloud. Some companies want to apply blockchain as a technology to democratize the future of the IoT [4].

The advent of IoT introduces several advantages into the system, including the provision of interconnection between objects and people.

According to the literature, so far there is an expansion of cloud computing, so we tried to adapt the manufacturing system with the principle of use and development of a fair system based on bitcoin [5].

In the paper I will use instead of bitcoin the information necessary for the manufacturing process for a simple technological flow.

IoT aims to improve operating efficiency and production flow, reduce machine downtime and improve product quality. [2]

IoT has the following features [2]:
- decentralization of IoT systems,
- the diversity of IoT devices and systems,

- heterogeneity of IoT data,
- network complexity.

II. BLOCKCHAIN WITH IOT

IoT is a development system that offers unlimited benefits, but with challenges in terms of centralized IoT architecture, so that all devices are identified, authenticated, and connected through centralized servers. This model has been used to connect a wide range of computing devices and will continue to support small-scale IoT networks because it is not able to provide the conditions needed to expand the IoT system in the future [4].

According to the literature, the decentralized, autonomous, and unreliable capabilities of the blockchain make it an ideal component to become a basic element of IoT solutions. That's why the company's IoT technologies have become a pawn that adopted blockchain technology early on [5].

Blockchain technology is considered to have key solutions to solve IoT confidentiality and reliability issues. It can be used for many connected devices, allowing transaction processing and coordination between devices, which in turn allows significant savings for manufacturers in the IoT industry. This decentralized approach would eliminate points of failure, creating a more resilient system for devices to work. In an IoT network, blockchain can keep a record of smart device history. This feature allows autonomous operation of smart devices without the need for centralized authority [5].

The blockchain will open up a number of difficult or even impossible IoT scenarios to implement without it. For example, using the blockchain, IoT solutions enable the secure and reliable transmission of information between devices in an IoT network. In this model, the blockchain will treat the exchange of information between devices similar to the information transactions in a network. To allow the exchange of information, the devices will use smart contacts that have the ability to, shape the agreement between the parties. One of the most interesting capabilities of the blockchain is the ability to maintain a decentralized, reliable registry of all transactions that take place in the network [2].

III. THE BENEFITS OF INTEGRATING THE IOT BLOCK

According to the literature, there are several advantages of adopting blockchain with IoT [1]:

- all participants have the ability to see all transactions and all blocks because each participant has their own register. The content of the transaction is protected by the participant's private key, so that all participants can see them, but cannot intervene directly on the action and are protected. IoT is a dynamic system in which all connected devices can exchange information, but at the same time the confidentiality of participants is ensured.

- the majority of participants must verify the transactions in order to approve them and add them to the distributed register. There is no single authority that can approve transactions or establish specific rules for accepting transactions. There is massive confidence, as most network participants need to reach an agreement to validate transactions. Blockchain owns and will provide a secure platform for IoT devices.

- each node has its own copy of the record containing all the transactions that were part of the network. Blockchain is able to withstand attacks of any kind. Even if one node has been compromised, the blockchain is kept active via another node. If there is a copy of the data at each node in the IoT, information exchanges can be improved.

- The blockchain has the ability to ensure a secure network, which is required in the IoT with numerous and heterogeneous devices.

- a blockchain transaction is distributed over the network in a few minutes and will be processed at any time during the day.

- existing IoT solutions are expensive due to the high infrastructure and maintenance costs associated with centralized architecture, large servers, and network equipment. A major disadvantage is the amount of communications that need to be managed when there are a lot of IoT devices, which lead to a substantial increase in costs.

- having a complete registry is one of the main advantages of blockchain technology. Any changes to the distributed record must be verified by most network nodes. Transactions cannot be easily modified or deleted. Having a registry for IoT data will increase security and privacy, which are major challenges of this technology.

- as all participants will use anonymous and unique address names to maintain their private identity for processing, this critical feature may lead to an increase in the use of cryptocurrencies in the illegal online marketplace.

So far, various blockchains have been implemented and the technology seems to work properly, even though most suffer from a lack of application of developing software engineering principles.

In this paper use an approach to Petri nets in blockchain analysis with a direct impact on the IoT. Using Petri nets, a single model is defined, a small data structure through which to highlight the main information about transactions and addresses. The general architecture and the scheme of transactions are analyzed and implemented in a known and easy to interpret formalist.

In the analysis block, the information is analyzed in a short time, what is noteworthy is the variable duration of information processing. This procedure can be seen in figure 1.

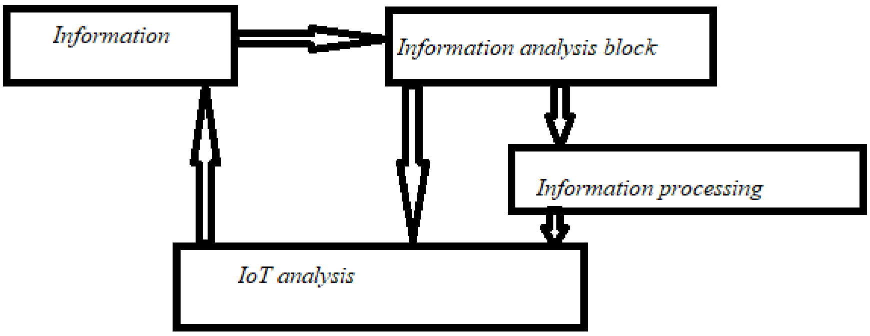

Figure 1: the flow of information in optimal operating conditions of the system

Flow variations in case of interventions or errors occurring from outside the system, for automatic information flow is presented following the simulation of the system with Petri nets.

A Location / Transition Petri dish is shaped [3][6], $\sum = (P, T, F, W)$.

Where

- P, Tthere are two non-empty sets, which represent the set of locations and the set of transitions, respectively,

- $P \cap T = \phi$,

- $F \subseteq (P \times T) \cup (T \times P)$ is a binary relation, called the network flow relation,

- $W: F \to N$ is the weighting function of the network$\sum(W(f))$e is called the weight of the element (f).

Whether $\sum = (P, T, F, W)$ a location / transition network is called network marking

Any function $M: P \to N$with the property $M(p) \leq K(p)$, for any $p \in P$, where $K: P \to N \cup \{\infty\}$is the capacity function of the network $\sum$.

Whether $\sum = (P, T, F, K, W)$the P / T network, where it is noted, $N^P$the set of all network markings is thus obtained $N^P = \{M | M: P \to N \wedge (\forall p \in P)(M(p) \leq K(p))\}$

If the network has only infinite capabilities, then N^Pcoincides with the multitude of applications from P to N.

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

For network transitions $\sum$ functions are considered $t^-, t^+: P \to N$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 $p \in P$

For a more representative modeling we chose a simple, classic system containing all the necessary components, figure 2. Thus we outlined a general repository, a system that adopts blockchain technologies with three elements of analysis, which in some situations can be considered as being three customers, a cloud manufacturing system and finally the IoT system.

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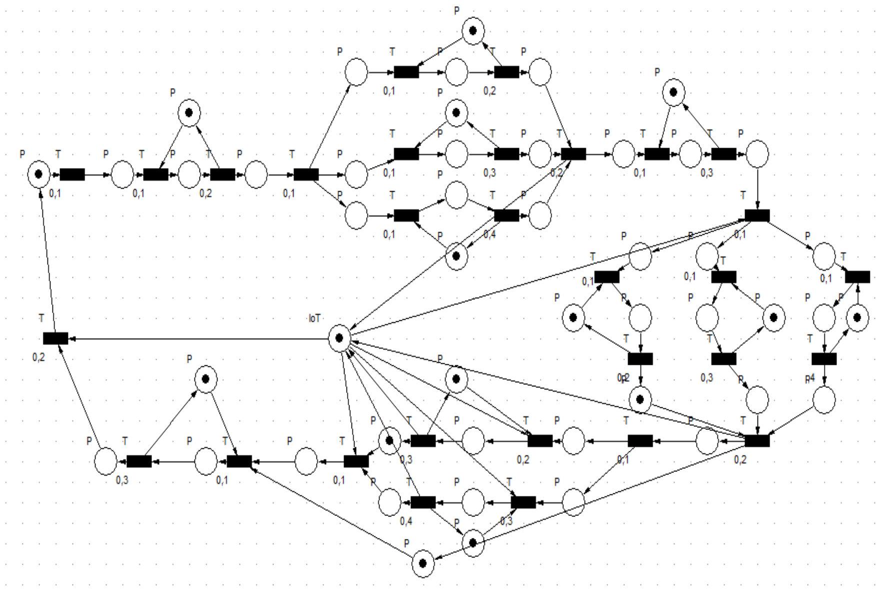

Figure 2: schematic network architecture

We analyzed this system in random timing conditions and it can be seen in figure 3, that there are some variations of flow in the IoT representation, otherwise the system is linear. Production times and capacity do not change regardless of the type of process studied. Figure 4 shows the variation of the information flow with the highlighting of the errors that may occur along the way up to IoT devices, for the simple classical manufacturing system. In the case of the automated production system, figure 5, there is a sudden and dense variation of the information flow. It can be seen in Figure 6 that the optimization of the system from a logistical point of view does not bring many improvements, but introduces a linear variation of the flow on a slow circuit. Figure 7 highlights the role of IoT by graphically representing the variation of information flow through two consecutive nodes and with an important technological role. In terms of activity in blockchain and cloud systems is linear, so no representative errors occur using the timing used for simulation.

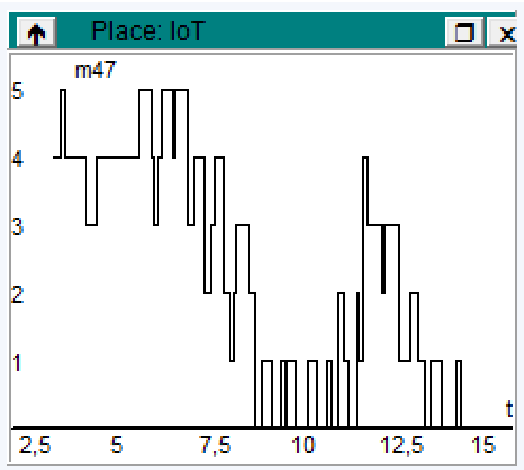

Figure 3: visualization of the information flow in case of a complete system with timing

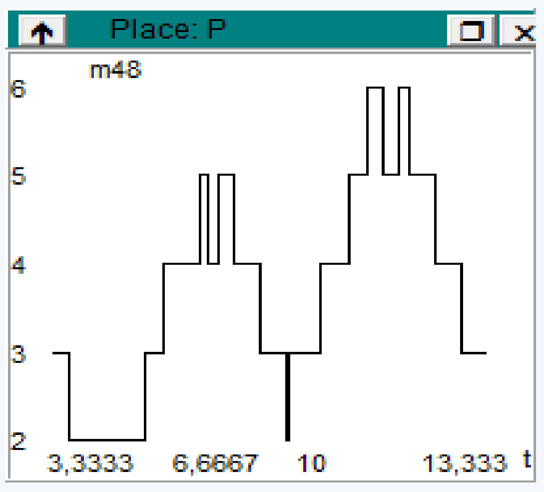

Figure 4: view the flow of information highlighting errors that may occur along the way to IoT devices

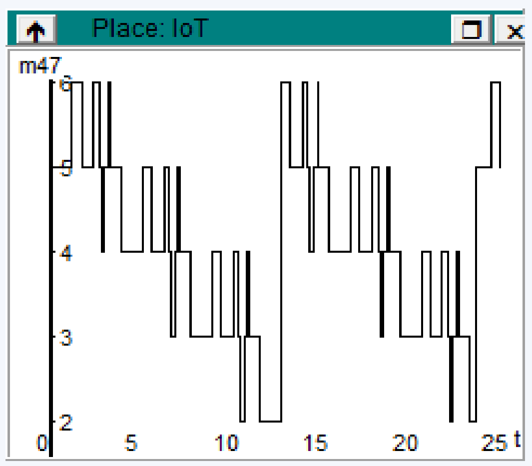

Figure 5: visualization of information flow in automated conditions

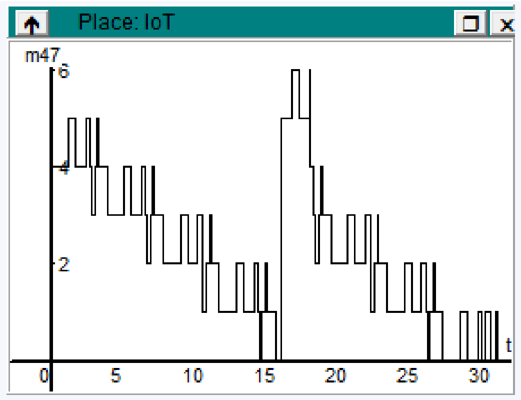

Figure 6: visualization of information flow in optimal operating conditions

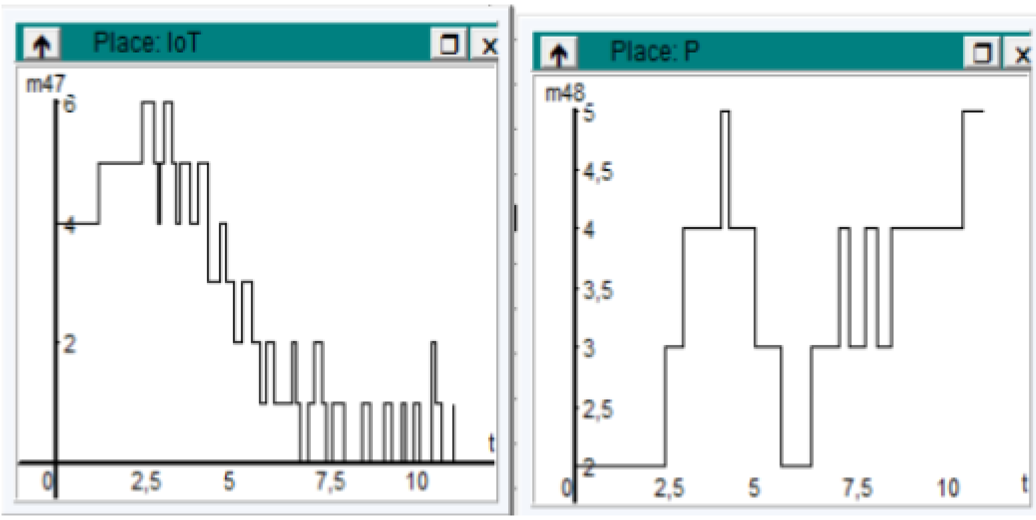

Figure 7: variation of information flow corresponding to IoT technologies

IV. CONCLUSION

Presented a general framework based on Petri nets. Generating frame designed in a modular system consists of several main components:

a) a visual modeling engine based on Petri nets, extended for the analyzed system;

b) an execution module for making transitions and simulating the workflow for the manufacturing system;

c) a verification and validation module;

d) an analysis module for generating intelligent representations from the workflow modeled with Petri nets.

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