International Journal of Smartcare Home
Vol.1, No.1 (2021), pp.85-92
https://dx.doi.org/10.21742/26531941.1.1.08

Hyperledger Fabric based Intelligent MES (Manufacturing Execution System) Bigdata Implementing the Platform

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Abstract

In recent years, intelligent Bigdata systems have maximized production efficiency through analysis and monitoring of the data they produce. In addition, it has features that can reduce inventory losses by adjusting inventory and output according to market conditions. Because most of the MES system is in operation, it also contains information such as product schematics and performance. As security is strict, a security system is needed that performs better than a typical security system. This paper proposes a Hyperledger Fabric based RBAC (Role-Based Access Control) that complements the AC (Attribute Certificate), which was defined for attributing PKC (public key certificates) in the existing blockchain. We propose a Hyperledger Fabric based RBAC-PAC model that can quickly and accurately identify and reflect access and authorization to the roles of entities. The performance of the proposed system is compared with existing research in terms of efficiency. Throughout this task, we find that the proposed system has a higher number of entities, and the more frequent renewal of rights, the more efficient it is.

Keywords: *Blockchain, MES, Security, Hyperledger fabric, Bigdata*

1. Introduction

Due to recent entry into the era of the Fourth Industrial Revolution, there is a growing interest in the introduction of smart factories in the manufacturing sector. Smart Factory builds the communication system by connecting all the objects necessary for the production process through the Industrial Object Internet technology. Automating and optimizing manufacturing production is being implemented as various Information & Communication Technology (ICT) technologies such as big data, artificial intelligence, and cloud are being applied. This smart factory system is operated by intelligent and automated operation of existing labor-intensive production processes, and there have been many consequences, such as reduced defect rates and improved productivity in manufacturing. Through various business connections, the new value is created and added. The purpose of the 4th Industrial Revolution is defined to increase the efficiency of resources and to implement an intelligent and smart factory for customers and suppliers in the value chain. The core technologies are the Cyber-Physical System, the IoT (Internet of Things), Bigdata, and Cyber Security Technology [1].

In Smart Factory, with all the objects connected, a lot of information is connected and shared, from the design stage to the process of service to customers. As they are organically combined

Article history:
Received (March 21, 2021), Review Result (April 19, 2021), Accepted (June 10, 2021)

eISSN: 2653-1941 IJSH

and provided, even if some information is exposed in the product and the process, the linked attributes on the platform increase the risk of leaking up to the overall associated information accumulated on the platform. Therefore, in the era of the 4th Industrial Revolution, the security technology of the IoT’s data and the platform is as strong as the sensor or network technology. Companies must identify factors that threaten security in the industry and formulate systematic and detailed cybersecurity strategies.

In this paper, a Blockchain-based MES platform is proposed to solve the Smart Factory security issues of the 4th Industrial Revolution. The structure of this paper starts with a proposal of an intelligent MES’s Bigdata platform based on Hyperledger Fabric to enhance the security of Smart Factory systems. In Chapter 2, some of the existing studies needed are summarized, and in Chapter 3, an intelligent MES platform is designed based on the Hyperledger Fabric proposed in this paper. In Chapter 4, a conclusion is proposed by verifying the implemented system and comparing the efficiency.

2. Related research

2.1. Smart factory: MES

Smart Factory refers to an "Intelligence Factory" that is designed not to be automated but to integrate the entire process of product planning, design, production, distribution, and sales into ICT (Information and Communication Technology) to collect data and issue work orders. Through the Internet of Things (IoT), the intelligent factory collects and shares information such as the status of the machine and the progress of the process in real-time, and makes the necessary decisions while at the same time ensuring the highest production efficiency [2][3][4].

The Smart Factory has several differences from some existing automation factories. Automated factories produce products according to pre-programmed instructions and can be changed according to the process. But the Smart Factory is capable of autonomous production in real-time, so it can be judged and executed through the network according to conditions 6of equipment, materials, and environment [5][6].

2.2. Blockchain RBAC-SC (role-based access control-smart contract)

RBAC is easier to manage and more efficient than traditional access control because it can replace users or reassign jobs according to roles. In RBAC, a user can access an OB (Object) if it is assigned to a role that has permission to access it. The concept of a role in RBAC is similar to the functional role of an organization, and at the same time is a way of expressing a policy instead of including any particular security policy. The role is in the middle of the user and OB and is granted access to the role, not the user. For example, if OB is a file, it is given a read according to its role. Role-based access control of RBAC-SC (Smart Contract) has limitations in application and inefficiency as each user must reapply and register their roles each time in an environment where the role's attributes change frequently.

2.2. Blockchain

Blockchain is a ledger management technology based on distributed computing technology, based on the P2P method of small-scale data, which is referred to as ‘block’. Saved in the “chained based" distributed data storage environment of the created chain, no one can modify it arbitrarily and anyone can view the results of the change. This is essentially a form of distributed data storage technology and was proposed that arbitrary operations by distributed nodes' operators would be impossible as a change list that records constantly changing data on all participating nodes. There are two major features of the Blockchain that make these functions possible [7].

Users participating in the Blockchain write transactions and sign transactions with their private keys. The created transactions are broadcast to other users for delivery, and in the process of consensus, the transactions are generated as a single block through a specific consensus algorithm. Once created, the block will be connected to the default Blockchain and the information in the block is broadcast to other users. Users can check the reliability of data among users without a central system based on the information in the blocks connected to the Blockchain [8][9][10].

2.3. Hyperledger fabric

It is a Blockchain open-source project hosted by the Linux Foundation. In addition to Hyperledger, there are other Blockchain platforms, such as R3, Ripple, and Ethereum. For these reasons, Hyperledger is special because it is a suitable environment to implement a business as a private Blockchain platform and it presents technology standards that are universally applicable to many industries, unlike other platforms that are specific to a particular business model. Hyperledger produces a wide range of Blockchain technologies for businesses to implement these differentiation strategies.

2.3.1. Hyperledger fabric distributed ledger

There are 2 ways to divide Hyperledger, the distributed ledger at the core of the Hyperledger Framework; first is the ledger of the Hyperledger Fabric of the World state, which represents the current state, and second is the Blockchain that stores usage records from the time of the creation of the ledger to the present. The world state shows the current value of the distributed ledger, and the Blockchain shows all the transaction records from the time of creation to the present. Secondly, data stored in the world state can be viewed/modified/deleted via the chain code until it is included in the Blockchain by the consensus process. However, blocks and Blockchains determined at this agreement are non-deterministic. The world state must be built into a (Distributed) Database because of frequent occurrences of writing, modifying, and reading data. Because Blockchain has no data request and append-only storage is the purpose, it can be saved as a file system.

2.3.2. Hyperledger fabric MSP

MSP allows the design of the organization structure of the Hyperledger Fabric, an MSP can be created by subdividing the organization to suit the characteristics and usage of each organization and then build an authentication system. Two major types of MSPs can be seen: local MSPs and Channel MSPs. This study configured local MSPs and Channel MSPs, which played the role of MSPs among the most Hyperledger when implementing the MES platform. It can define which nodes are peers, orderers, or clients via the local MSP, and Channel MSP is used to define membership and grant permissions to channel members. Members who participate in the channel will create one Channel MSP through their MSP, and when an organization attempts to join a channel, the channel member may refer to the Channel MSP for disclaiming warranty or rejection.

2.4. Bigdata platform

The role of big data platforms is to collect and process various kinds of data to produce new results. The most representative platform is Apache Hadoop. Hadoop consists of MapReduce, a software framework for large data processing, a Hadoop distributed file system (HDFS) that manages multiple data nodes in a parallel distributed environment, and YARN (Yet Another Resource Negotiator) for compatibility and resource management across multiple platforms. Hadoop can use technologies such as Spark, Hive, Sqoop, and Oozie to construct various types of platforms. Spark is an In-memory-based, general-purpose distributed cluster framework for easy and fast processing of large data, supporting various application programming interfaces (API) to improve task performance, and supporting useful libraries such as MLlib, Graph X, Spark SQL, and Spark Streaming for user convenience. Hive is a data house system that makes it convenient to handle data in HDFS. It supports traditional Relationship Data Base Management System (RDBMS) based table environments and SQL-like languages called HiveQL (Hive Query Language) [11].

3. Suggested system

3.1. Hyperledger fabric network management function design

In this paper, a network was built so that two or more companies, usually in the Hyperledger Fabric based RBAC-PAC, can agree. Later, the company wrote the design to set up policies to suit the interests of the enterprise, and then to create channels to build the business network. In this paper, the consortium has 2 different businesses built on different channels. Org1 participates in Channel 1, Org2 participates in Channel 2, and Org3 participates in both Channel 1 and Channel 2. After building the Ordering Service node under the agreement between the participating companies and the consortium, it is pursing to design and build through configuration blocks stored in the ordering service to configure peers, channels, clients, network policies, channel policies, etc.

3.2. Hyperledger Fabric Transaction

The processing of transaction flows in this paper is as follows. shown in [Figure 1], Supposing Client A sends a request to stock an inventory on the Blockchain network, the request targets A and Peer B, which represent Client A and Client B. Since the endorsement policy requires 2 peers to guarantee all transactions, the request goes to Peer A and Peer B, and when transaction proposals are being written, applications using Node, Java, and Python have been designed to take advantage of one of the available APIs that generate.

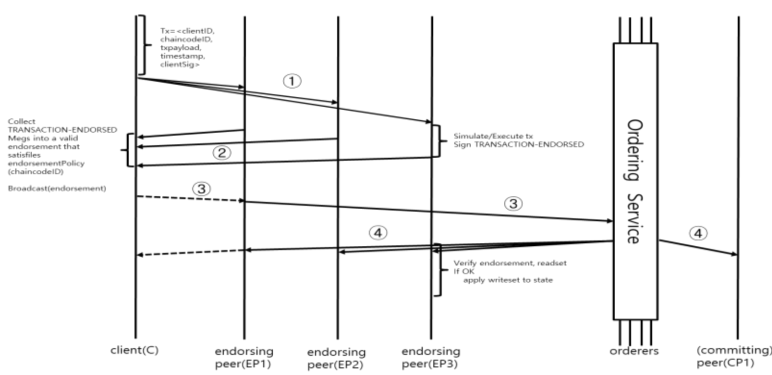

Figure 1. MES Transaction Flow Processing

3.3. Hyperledger fabric based RBAC-PAC model

Transaction generation is based on AC Profile, and each role is designed in a hierarchical structure to inherit the PA of the parent role. It will be decrypted with a secret key that was released at the time of authentication. It can then satisfy both the verification and integrity of the PAC. When transactions signed by the registrant by the blockchain are distributed through the blockchain, they are stored on each node through the broadcast function, and the integrity of the block is maintained. This establishes a reliable PAC. Blocks registered in blockchain consist of headers and payloads.

3.4. Execution of endorsing peer signed operation transaction

When the Endorsing Peer receives a transaction, it was made sure that the contents are filled in to fit the transaction type before execution. Then, reference was made on previously submitted transaction history and checked to see if the client who submitted the transaction had permission. After the confirmation, the transaction code is taken as the argument, and execution of the chain code causes the chain code to run in the state DB's wallet. The result returns the Read/Write Set. The value sets were then designed to return to the "suggested response", which analyzes the application's payload, along with the signature of the guarantee Peer.

4. Verification

4.1. Efficiency analysis environment

To compare the efficiency of RBAC-PAC proposed in this paper, the required transactions were investigated by dividing them into Reg, Access Control, and Privilege Renewal, and the total number of transactions was shown as [Table 1]. RBAC-SC requires at least six transactions per A.Control session to verify the role, replacing these verification procedures with digital signatures. In addition, RBAC-PAC renews on a role-by-role basis, assuming that the number of entities assigned to a single role is 30.

4.2. Validation of efficiency

The application verifies the warranty peer signature and matches the suggested responses to verify that the suggestion responses are identical. If the chain code only queries the ledger, the application can't check the query response and send a transaction to the 'Ordering Service'. After the client application checks to see if the specified warranty policy is met, a validation operation is planned so that transactions within the block can be checked to verify and that the ledger status has not changed by the execution of a transaction.

Table 1. Transaction comparison of hyperledger fabric

	N.Entities	Reg	A.Control	P.Renwal	TotalTran
RBA-SC	1	3	6	2	12
	300	900	1800	600	3600
Hyperledger Fabric (RBAC-PAC)	1	2	3	1	7
	300	600	900	10	1810

In this paper, we could check the results of the data processing speed based on the extracted data for real-time transactions for Blockchain creation data when using Composer. To compare the efficiency of the Hyperledger Fabric proposed in this paper with RBAC-SC, it was broken down into the Registration Process (Reg), Access Control (A.Control), and Permission Renewal (P.Renwal) to investigate the necessary transactions, and the total number of transactions is shown in [Table 1]. A.Control At least 6 transactions per transaction are required, and 3 such procedures are required by replacing these verification procedures with digital signatures. In addition, when updating roles, Hyperledger Fabric assumes that they will be updated by the role unit. To compare the efficiency of RBAC-SC and Hyperledger Fabric based on [Table 1], first, the efficiency according to the number of entities is shown in [Figure 2] Graph A when an entity has registered, accessed, and renewed permissions once. Graph B in [Figure 2] compares the efficiency when one entity performs 10 access control and 10 permission updates after performing the registration procedure once. Graph A shows that the total number of entities is reduced to 41% when the number is 30,000.

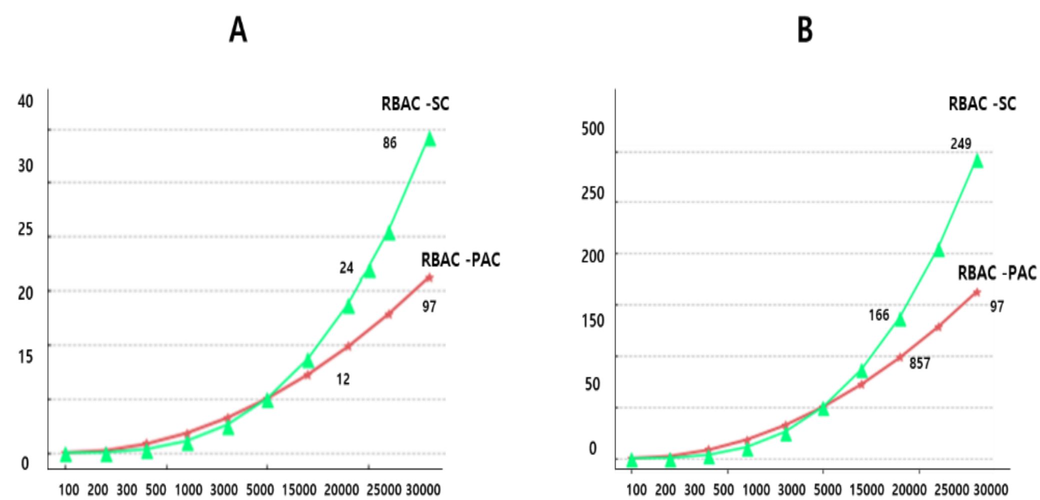

Figure 2. Comparison

In this study, Real-Time Analytics is studied and a technology that can analyze a variety of real-time events. Although Data (event) modeling and processes were designed and implemented, horizontal scale-out suitable for Big Data is impossible. Yet, load balancing across multiple servers per event stream, or multiple cards, is required and can handle large amounts of events that require the use of a high-performance server with main memory. As so, the cost is high and not suitable for small and medium enterprises. Thus, the real-time processing method suggested in this paper is Real-Time Analytics Storm, which reduces the complexity of implementation of distributed real-time processing, and provides native languages such as Cloojure, Java, and Python, and allows users to use any language they are familiar with. It can automatically manage the failures of nodes and can be designed to handle parallel processing by using Process and Server, and it is easy to further expand. Unlike Hadoop, the task of managing a cluster is very simple, making it easy to test because there are no complex setup or management points.

4.3. Hyperledger fabric MES transaction design limits

In Hyperledger Fabric, transaction delivery process design, peers participating in the channel take the steps to validate the transactions before they are delivered. The more remote peer was operating, the slower the network's performance, the longer it took for the transaction to be delivered. also, Kafka's performance as an Order was affected to ensure order when multiple Peers tried to send transactions to the same channel at the same time. To address this phenomenon, the company attempted to increase performance, such as by storing and delivering multiple tasks in one transaction. but These methods can be applied to the common blockchain. However, as the Peer increased, the TPS, which fell, showed a fatal weakness.

Hyperledger Fabric is a platform designed to target MES blockchain. While the public blockchain was armed with improvements in performance, such as DPoS, and new features, Hyperledger Fabric had a complex configuration that resulted in slower performance. so, RA, RB, RC, and RD were jointly deployed and resolved in Hyperledger Fabric BlockChain Network.

5. Conclusion and feature work

In this paper, access control methods are defined, such as Blockchain, Real-time Processing, and Transaction in the Smart Factory. To use it efficiently in this paper, the concept of inheritance was applied by hierarchically designing the structure. Even during certification and approval, the digital signature was used to distribute the Blockchain so that it could efficiently check the permission attributes and use them for access control. This simplifies the registration and management tasks that need to be performed repeatedly, and the verification tasks to increase efficiency. And this makes it possible to utilize the newly deployed Hyperledger Fabric in the Smart Factory environment, where efficiency is important, allowing for safer and more efficient access control. In the future, more diverse, efficient, and secure Blockchain techniques should be studied.

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