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Cloud Manufacturing Architecture Based on Public Block chain Technology

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Abstract:

With Industry 4.0, IT infrastructure has started to be used more efficiently in manufacturing. Cyber-physical systems, IoT, cloud manufacturing, big data are some of the technologies that make up the concept of Industry 4.0. These technologies solve many problems in manufacturing. One of these technologies, cloud manufacturing technology, has emerged with the concept of pay-as- you-go. This technology enables manufacturing resources to be leased and shared globally. However, it has problems with its central structure and the need for a reliable third party. Reliability, security, continuity, scalability, data locking, single point of failure, data manipulation are some of the major concerns. Blockchain (BC) is a decentralized distributed technology. Data stored on the BC network cannot be altered in any way. With these features, we believe that a BC-powered cloud manufacturing system can overcome the above problems and eliminate the need for a reliable 3rd party. Based on this belief, in this study, the protocol and communication between resource providers and clients, which are one of the basic functions of cloud manufacturing platforms, are implemented through decentralized applications using BC-based smart contracts (SCs). realized. The designed application is called the Decentralized Cloud Manufacturing Application (DCMApp). DCMApp does not run on a fully public BC network, it has a hybrid structure and uses the Ethereum network as a public BC network. These features make DCMApp different from other BC-based cloud manufacturing applications. The hybrid structure of DCMApp enables a more transparent, economical and secure manufacturing protocol. It is also possible to store the protocol on the BC network at low cost without installing any server infrastructure. The use of the Ethereum network makes it nearly impossible to manipulate the protocol.

I. Introduction

Technological developments in manufacturing systems have changed the competitive factors in the industry. Cost as one of these factors was one of the most important factors before the 1970s, while quality became more and more important after the 1970s. By the 1990s, service and environmental factors had become increasingly important, and in the 21st century, information has become the most important factor. Information is the foundation of the fourth industrial revolution, Industry 4.0.

The term Industry 4.0 is collectively used to refer to a broad range of current concepts, including cyber-physical systems (CPS), Internet of Things (IoT), simulation, cloud computing, big data and advanced analytics, service-oriented technologies, virtualization, and more. These technologies and paradigms provide solutions to the different needs of manufacturing systems. Combining recently emerging technologies with advanced manufacturing models and information technology, cloud manufacturing is a new manufacturing paradigm that meets the needs of manufacturing systems.

Many important researches have been carried out in developing cloud manufacturing technologies, designing system architectures, and defining cloud manufacturing and key characteristics [9]. Cloud manufacturing is based on cloud computing. Cloud computing highlights two characteristics: easy access and shared use of resources [10]. Cloud manufacturing, combining these two characteristics of cloud computing, increases the way for customers to obtain manufacturing resources and capabilities through the Internet.

There is no standard art definition yet for cloud manufacturing. The first definition of cloud manufacturing was proposed by Li et al. Academia and industry have shown great interest in this new concept. There are many definitions of cloud manufacturing in academia, highlighting the different characteristics of cloud manufacturing.

II. Existing System:

- Uses existing BC network, so no additional cost. In this way, users can use the existing BC network without any investment.
- Therefore, users only pay one fee per write transaction when using the public BC network. In a private BC or federated BC network, there are administrators.

- These networks are managed by specific people. In order for the network to survive, operational costs must be incurred. However, in this application there is no extra charge for the survival of the network.
- For example, if we consider the inability of a centralized resource repository to serve, users will be able to continue to process existing information from local databases in their applications. They won't be able to get information only about the new state of the resource. This can lead to two different problems. In the first case, other users will not be aware of the newly added resources in the network.

Disadvantage:

- The central system needs a reliable intermediary.
- In a centralized or decentralized system, resources can be rented to multiple people. But this situation results in data from different users being stored at one point in a centralized system.
- User data is stored and managed in a format designed by the application owner.
- Users can access their own data within the scope allowed by the cloud application.
- Lack of standard colloquialism between cloud platforms, holding data in different forms in applications makes data access difficult and underlies data lockin problems.
- Responsibilities are distributed on the cloud manufacturing platform. You must trust the company that takes responsibility. It creates dependencies in the system.
- Users have limited control over cloud applications.

III. Proposed System:

- The proposed platform is called "BCmfg". The BCmfg platform is designed on the BC network installed using multi-chain software on virtual servers.
- The BC network used in this study is designed for this model only, not the public BC network used for other purposes. Data on this BC network is encrypted and all data is recorded on both the network and the database.
- The proposed model was evaluated in terms of both applicability and reliability. In terms of applicability, unlike other distributed cloud manufacturing applications, there are some limitations in how models can be configured on the public BC network.
- However, in private and federated network models, a network must be created. In order to be part of this network, permission must be obtained from the administrator who created the network, and payment may be required. From an individual perspective, the proposed model is more economical than private networks and consortium networks for the reasons mentioned above. The total cost spent on the network varies depending on the purpose and size of the application.

Advantage:

With cloud manufacturing, businesses can meet their needs without any investment by using a centralized remote access system. To take advantage of CM, users can use the cloud manufacturing software interface. Cloud manufacturing platforms include two types of users: service providers and customers. Service providers identify and market their superior resources and competitive capabilities in cloud platforms. Customers publish their customized needs, such as design drawings, process requirements, quality metrics, lead times, and green standards [20], and discover and rent resources or functions available in the system. A service provider is the party that is solely responsible for the services it provides in cloud manufacturing.

IV. Module Description: Cloud manufacturing

Academia and industry have shown great interest in this new concept. There are many definitions of cloud manufacturing in academia, highlighting the different characteristics of cloud manufacturing. Cyber-physical systems, IoT, cloud manufacturing, big data are some of the technologies that make up the concept of Industry 4.0. These technologies solve many problems in manufacturing. One of these technologies, cloud manufacturing technology, has emerged with the concept of pay-as-you-go.

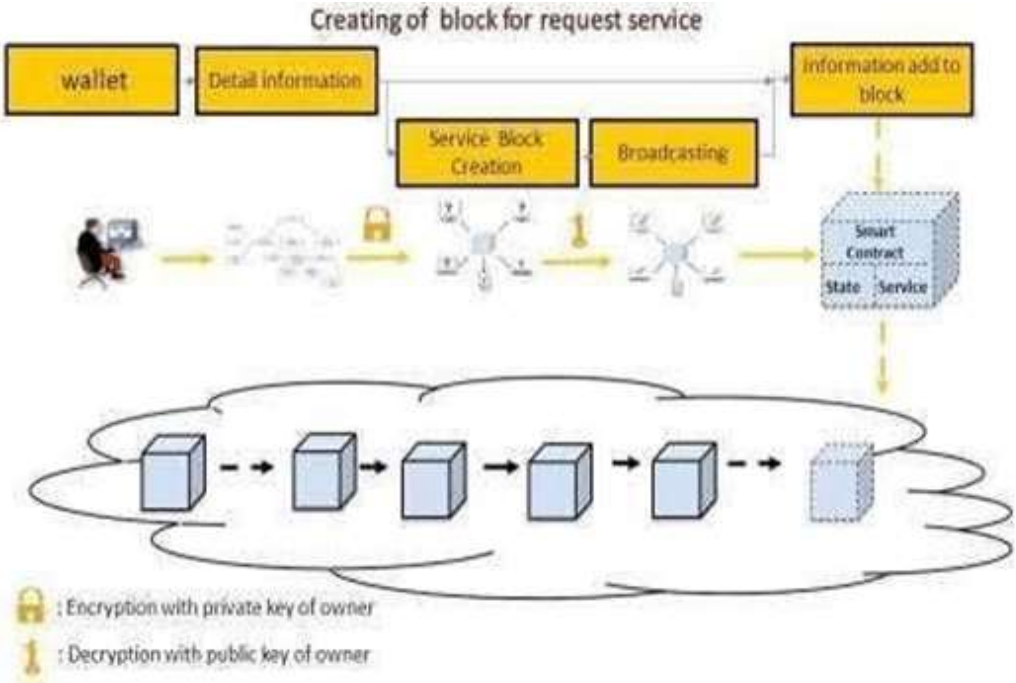

Figure 1.1 Module

Cloud manufacturing is an intelligent networked manufacturing model that includes cloud computing to meet the growing demand for higher product personalization, wider global collaboration, knowledge-intensive innovation, and increased market responsiveness.

- Verification of data in the network is provided by the entire network through a consensus algorithm.
- After each activity on the network is confirmed, it is permanently recorded as a block. These blocks are linked to the previous block by hash information. Therefore, transactions can be traced from the starting point to the final state.
- Copies of approved information are available on all nodes on the network. This can be seen as a security hole. However, this is a requirement to ensure reliability.
- Network management is provided by network rules, eliminating the need for a centralized management system.

Decentralized manufacturing

These features make DCMApp different from other BC-based cloud manufacturing applications. The hybrid structure of DCMApp enables a more transparent, economical and secure manufacturing protocol. It is also possible to store the protocol on the BC network at low cost without installing any server infrastructure. The use of the Ethereum network makes it nearly impossible to manipulate the protocol.

Bitcoin is based on classic BC technology. The classic BC technology has data synchronization and double spending problems in distributed systems. Attempts have been made to solve the data synchronization problem by applying a consensus model.

Due to the large amount of data, too many write operations need to be performed, which can greatly increase the cost paid. In this study, a hybrid structure was preferred both for dispersing applications and keeping costs at a reasonable level. Storing important data on the Ethereum network keeps applications running forever without any central server infrastructure. The highlights of our preference for the Ethereum network are as follows.

Algorithm:

The Merkle root field holds the hash of the merkle tree in BC. Approved transactions are included in the Merkle tree, and if the transaction changes, the root hash of the local tree associated with the transaction changes, and all blocks created after the block is modified will be lost. The difficulty target field indicates the difficulty of the PoW algorithm. The nonce value is a random value used in the proof-of- work algorithm.

Registered users have public and private keys. Anyone with the private key has the right to execute all transactions on this account. Transactions formed by people in BC are evaluated through a consensus algorithm. Transactions verified by the consensus algorithm are included in the chain as a block. These blocks are visible to everyone in the blockchain.

Technique:

The term Industry 4.0 is collectively used to refer to a broad range of current concepts including cyber-physical systems (CPS), Internet of Things (IoT), simulation, cloud computing, big data and advanced analytics, service-oriented technologies, virtualization, and more. These technologies and paradigms provide solutions for the different needs of manufacturing systems.

- After each activity on the network is confirmed, it is permanently recorded as a block. These blocks are linked to the previous block by hash information. Therefore, transactions can be traced from the starting point to the final state.
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Methodology:

The developed applications can run in a distributed fashion on a continuous living network. It is not necessary to use a single version of the software prepared in this architecture. Users in the Ethereum network can use different versions at the same time. With the new version of the code, users who wish to benefit from the improvements will be able to update their apps to take advantage of the new protocol.

As we said before, DCMApp attributes its ability to work in a distributed structure to the Ethereum network. The Ethereum network is a very reliable network and it is almost impossible to change operations performed on this network. In order to change past operations on the network, the number of nodes in the network must be at least 50% of the total number of nodes. This attack is called a 51% attack. To attempt such an attack would require more than half of the immediate processing power for an extended period of time.

V. Literature survey:

S. No	Author	Technique	Advantage	Disadvantage	Dataset	Accuracy
1.	D. Wu, D. Rosen, and D. Schaefer	Cloud- based design and manufacturing	Introduces the reader to game-changing ways of building and utilizing internet- based service related design	Aids in reducing costs through social networking and negotiation platforms between service	MapReduce, a parallel programming model,	95%
2.	K. Zhou, Taigang Liu, and Lifeng Zhou	Industry 4.0 and cloud manufacture	In this context, two important concepts for manufacturing- Industry 4.0 and cloud manufacturing, have been proposed	Industry 4.0 refers to the fourth industrial revolution, which is characterized C	Cyber physical system	85%
3.	Y. Liu and X. Xu	A survey on technologies, applications and open research issues	The main roles of CPS are to fulfil the agile and dynamic requirements of productions and to improve the efficiency	The goals of Industry4.0 is are to archieve a higher level of operational efficiency and productivity, as well as a higher level of automatization	European Interoperability Framework (EIF)	70%
4.	Jay Lee,Behrad Bagheri, Hung -AnKao	A cyber-physical systems architecture for industry 4.0- based manufacturing system	Recent advances in manufacturing industry has paved way for a systematical deployment of Cyber-Physical Systems	A unifled 5-level architecture is proposed asa guideline for implementation of CPS	European Interoperability Framework (EIF)	60%
5.	H. Lasi, P. Fettke, H.- G. Kemper, T.	Internet of things and edge cloud computing	Productivity, quality, safety, and the ability to respond to changing conditions are essentials	IOT and cloud computingto enhaces the efficiency of manufacturing plant	Edge datacenters support smart manufacturing plants (SMPs)	75%

	Feld, andM. Hoffmann	roadmap for manufacturing	to maintainingthe industry competitiveness	operations, improve product quality		
6.	J. Lee, B. Bagheri, and H.-A.Kao	Cloud manufacturing a critical review of recent development and future trends	Cloud computing semanticweb, service-oriented technologies, virtualization and advanced high-performance computing technologies	It is envisioned that companies in all sectors ofmanufacturing will be ableto package their resources and know-hows in the cloud	Virtual Factory Framework (VFF),a Virtual Factory Data Model (VFDM)	90%
7.	Lin Zhangb, Yongliang Luo, Fei Tao, Bo Hu Li, Lei Ren, Xuesong Zhang	Cloud manufacturing a new manufacturing paradigm	Combining with the emerged technologies suchas cloud computing, IOT, service oriented technologies and high performance computing	The concept of CMfg, including its architecture, typical charcteristics and the keytechnologies for implementing a CMfg service plateform is discussed	Description model of manufacturing capability (DMMC)	80%
8.	Lihui Wang, Xi Vincent Wanga, Liang Gaob, József Váncza	A cloud based approach for were manufactur-ing, CIRP Annals	The modern manufacturing industry calls for a new generationof integration models thatare more interopable, intelligent, adaptable and distributed	A novel service oriented remanufacturing platformis proposed based on the cloud manufacturing concept	Standardised cloud service description method	60 %
9.	Lei Renab, Lin Zhangab, Lihui Wangc, FeiTaoa & Xudong Chaid	Cloud manufacturin gkey characteristics and applications	Manufacturing industry towards service oriented, highly collaborative and innovative anufacturing in the future	The key charcteristics of cloud manufacturing are also presented inorder to clarify the cloud manufacturing concept	Virtual manufacturing society and flexible manufacturing system	70 – 85 %
10.	Mohamed H. Mourad,Aydin Nassehic, Dirk Schaeferd, Stephen T. Newmana	Assessment of interoper-abilityin cloud manufacturin g	Cloud manufacturing is defined as a resource sharing paradigm that provides on demand access to a pool of manufacturing resources and capabilities	In this context interoperability has been identified to be a key enabler for implementingsuch vertically or horizontally integrated cyber physical system	The CMARS activity-based model namely; C-MARS-ABM	60%

VI. ARCHITECTURE

The central application must run on a server belonging to an individual or company. However, this comes at a price. Funds must be generated for developing, maintaining and managing server costs as well as applications.

Fees are charged to traders due to the commercial issues with the centralized system. Pricing policies may vary by company. Some companies charge a recurring fee, while others charge a commission per transaction. In the architecture proposed here, the fees paid are paid as rents for computers running on the network.

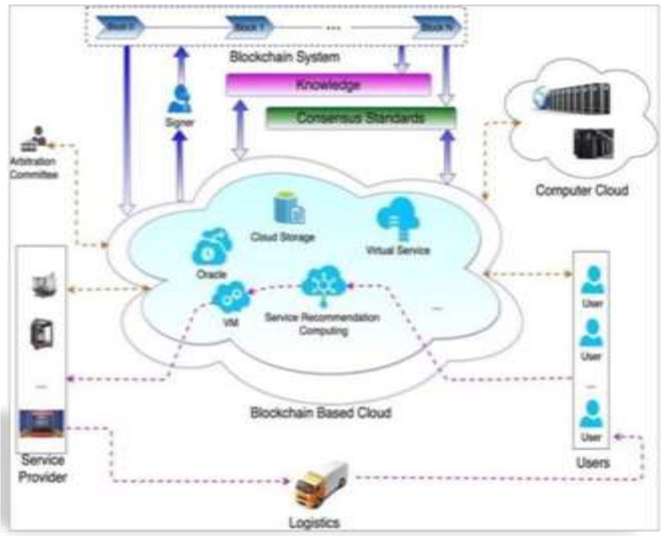

Figure 1.2 Architecture diagram

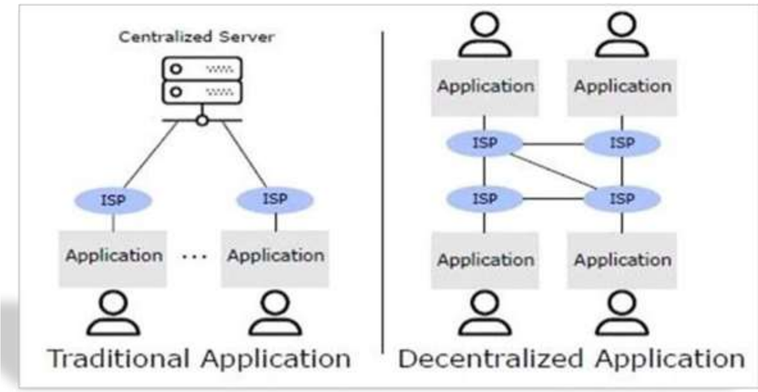

Figure 1.3 Block diagram

VII. Conclusion

With the capabilities of cloud manufacturing, resource owners and resource seeking users can easily share resources through the platform. However, the reliability of the platform is seen as a question mark for users. In this study, a BCbased application is introduced for users to make agreements between them without the need for any third party. The originality of this study is that the protocol is implemented through the Ethereum network, a public BC network that supports SC. However, the app is designed to be a hybrid structure.

Thanks to the hybrid structure, users only pay for the protocols that need to be protected. If the application runs in a completely public structure, all information must be stored on the public network, which will incur huge costs. In addition to this, in a private network, the fact that the network is controlled by an individual or organization creates serious problems for users.

VIII. Future Work:

The server infrastructure must be provided by one party in the private network. For these reasons, hybrid structures are preferred. Using this model, users will be able to enter into manufacturing agreements with each other and make payments without any intermediaries.

In this study, an example application is attempted to explain the use of BC technology in cloud manufacturing and aims to elucidate future research. For future work, a designed SC may be developed and other services such as machining as a service can be integrated directly into the system.

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