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Permissioned Blockchain Network and Hyperledger in Manufacturing Industry

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Abstract. The need for transparency and traceability is a vital business challenge in manufacturing and maintaining supply chains both locally and globally [1]. Many companies and buyers have little to no information on their second and third tier suppliers and customers. Particularly in the automotive and vehicle engine manufacturing industry, the need for transparency and trust have become a concerning issue. Blockchain as a distributed ledger system can improve transparency and traceability within every tier of the manufacturing supply chain. In this paper, we demonstrate how blockchains can improve transparency and traceability through the implementation of Hyperledger Fabric, a framework that facilitates permissioned and private blockchains, in the production and tracking of car engine blocks by a car manufacturer. We also explore the key challenges and limitations we discovered during the implementation of these blockchain networks. The powerful use of blockchains to track each part of a vehicle through its manufacturing process until reaching the end buyers not only facilitates the buyers and gains their trust, but rather it works both ways as car manufacturers are directly able to know the specific details about the raw materials they are receiving from their parts suppliers and about the specific preferences of customers who are purchasing and using their engine blocks.

Keywords: Permissioned Blockchain Networks, Hyperledger Fabric, Distributed Ledger System, Federated Blockchains, Chain Code, 51% Attack

1 Introduction

The need for transparency and traceability is a vital business challenge in manufacturing and maintaining supply chains both locally and globally [1]. Many companies and buyers have little to no information on their second and third tier suppliers. Incidents in the past decades that illustrated that even tight and expensive security mechanisms are unable to guarantee complete data security, thus leaving organizations at potential risks. The arrival of blockchain comes to the rescue as a blessing. At its core, a blockchain is a decentralized distributed system, which is a collection of autonomous components (computers) that appears to its users to run as a single coherent system as in Fig. 1 [2].

Both blockchain and Hyperledger are emerging concepts and technologies. A blockchain protocol runs on top of the Internet on a peer-to-peer network (i.e. the Internet) of computers (called nodes) that run the protocols individually. Blockchains can be categorized into permissioned and permissionless blockchains, public and private/federated blockchains, and other sub-categories. While Bitcoin is a permissionless and public blockchain - used in the exchange of digital cryptocurrency, there is Hyperledger which is a permissioned and restrictive blockchain but allows private channels to be created for communication among specific participants only.

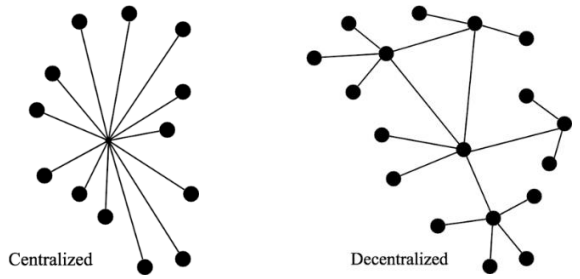

Fig. 1. Diagrammatic representation of (*centralized)* and (*decentralized)* networks. A (*centralized)* network has a single point of failure and resources are shared all the time.

The implementation of distributed ledger technology can improve transparency and traceability issues within every tier of the manufacturing supply chain through the use of immutable records of data or items, distributed storage of the records, and controlled user accesses, and Hyperledger Fabric provides an excellent opportunity as it facilitates permissioned networks [1]. This study exemplifies how distributed ledger technology, such as Hyperledger Fabric, can facilitate the manufacturing industry with an example of blockchain implementation for car engine tracking during car manufacturing process.

2 Experimentation

In order to test the viability of blockchains in the manufacturing industry, we choose a car manufacturer in a developing country[1]. There is a lack of trust in the automotive industry as the distributors and customers have little to no information on the suppliers of raw materials which dictates the quality of parts like tires, engines, etc. and their durability besides many other important factors that decide the price of the cars. Currently, the car company manufactures several models of model X including X-D and X-L[2].

[1] The name of the car manufacturer and the country it is located are kept undisclosed upon request of the car manufacturer.

[2] The original model names are kept undisclosed, instead X, XD, and XL are used to represent the different models the company manufactures.

In Hyperledger Fabric, assets (e.g. engine blocks) that are managed on the blockchain was defined by a model of key-value pairs. The concept of a chain code or smart contract was then implemented based on the business logic on the assets (e.g. engines, tires) and the owners (suppliers of raw materials and the car manufacturer's employees). The chain code can be implemented in high-level programming languages such as Go, Java or Node.js that defines the rights to read and alter any part of the smart contract. It is this place where the information will be stitched during the manufacturing process.

The execution of a chain code function can read and return asset information, create or alter stored information, and store new information in the local ledger database. When all changes were finalized, the changes were proposed to the blockchain network for endorsement and inserted into the blockchain after the endorsement had taken place.

Channels were created to provide privacy. If an entire chain code is deployed on a single channel then all suppliers of raw materials and distributors as well as the end-buyers can see the details of each other's transactions which is not desirable, for instance, in circumstances when the car manufacturer provides discounts to a specific distributor. As a result, several channels were created to accommodate private business transactions between the manufacturer and the different parties - raw materials suppliers and distributors. In Hyperledger Fabric, each participant (i.e. peer node) within a channel keeps a copy of the ledger thus creating a blockchain data structure for the existing channel.

3 Implementation

The scheme of network participants, transactions and events was defined in Hyperledger Composer Modeling Language and flows of each transaction flows were implemented on an API through JavaScript code. In addition, frequently used queries on the stored data were defined in the Composer Query Language, a SQL-like language [3]. All required files were packaged to a Business Network Definition (BND) or .bna file.

The prototype and demo were built on Composer Playground that provides a user-friendly and modern web interface to access configurations of the Composer Command-Line-Interface (CLI). In order to track the engine blocks from their manufacturing to distribution stages, the manufacturers, dealers and customers were added as network participants and engine blocks and vehicles as assets [3].

The raw material suppliers, distributors of cars and the car manufacturer are identified as organizations in the blockchain network. The Hyperledger Fabric chain code that we created to demonstrate the feasibility and usability of our proposal facilitates the following functionalities:

a) the production of a car's engine block with a unique serial number
b) transfer of engine block from the car manufacturer to a dealer after production
c) tracking the car with its unique serial number
d) the installation of an engine
e) block into the registered vehicle that buyers can track.

4 Results

The transparency of the Hyperledger blockchain enabled the suppliers of parts, the car manufacturer as well as distributors and dealers to find out the manufacturing and installation dates, serial number, slot number, location of manufacture, and other specific details of the engines.

From a survey conducted where car manufacturing company employees and top-level executives, car and engine parts suppliers, distributors and end-buyers participated, it was discovered that the implementation of blockchain not only increased transparency and traceability significantly but also the trust of the distributors about the manufacturer and of the manufacturer about the suppliers of the parts as it lessened the risks of counterfeit parts to be used during the manufacturing process of the car engines.

5 Limitations

In spite of all the benefits and potentials in Hyperledger Fabric implementation for car engine tracking in the manufacturing process, several key challenges and limitations were also discovered:

a) Centralization: participants, particularly, distributors expressed their fear that manufacturers can exploit the blockchain networks at their will leading to the centralization of the networks and such networks' vulnerability to 51% attack.
b) Processing power and time: financial information needs to be encrypted before they are stored into the blockchain and decrypted to be read or accessed. Thus, the computing capabilities of the components of the distributed systems need to be interoperable (e.g. participants most likely will need to be running the same version of Operating System and same encryption/decryption algorithms).
c) Storage: blockchain eliminates the need for a centralized server to store all data, but as more and more data are collected and with the emergence of Big Data in the manufacturing industry, a significant portion of the data will need to be stored on the end devices (i.e. Edge/Fog Computing) for efficient searching and processing (insertion, retrieval and modification) performed on the data, but these end devices have only limited storage capabilities.
d) Lack of skills: initially, most people in the survey were not able to understand the concept of blockchains or distributed ledger systems, particularly those who work in non-IT sectors. As a result, it may require more time and effort to teach them the day-to-day operations on the blockchains and to equip them with the skills necessary for secure and efficient updating of the systems when required.
e) Legal and Compliance Issues: the use of blockchains in manufacturing is a completely new field, and there aren't any real standards against which to measure the performance, quality or vulnerability of the blockchains [4]. This can lead to difficult situations when the manufacturers and the participants (e.g. distributors or raw material suppliers) cannot come to an agreement on the legal or compliance issues.

6 Future Work

The resulting blockchain network was only executed locally for one manufacturer; we did not expand the configuration of the peer organizations or the ordering service. In the future, we can expand and execute the network globally, and the performance of the global blockchain network can be evaluated with several manufacturers and many mutual distributors and raw materials suppliers among them. In addition, mechanisms to reduce, if not to eliminate, the possibility of a Majority Attack are to be devised and implemented as other participants within the channels fear the possibility of illegal data manipulation and control over the network or even getting banned from channels if disagreement arises with the manufacturer or the host organization.

7 Conclusion

Through the implemented blockchain application case about the production and tracking of engine blocks, we were able to demonstrate the powerful use of blockchains to track each parts of a car through its manufacturing process until reaching the end buyers. It not only facilitates the buyers and gains their trust, but rather it works both ways as the car manufacturer is now directly able to know who their customers are and their preferences. In addition, we were also able to discover the key challenges and limitations of implementing Hyperledger Fabric in the manufacturing industry.

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