Blockchain Technology Based Supply Chain Management System

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Abstract. One of the most important inventions and innovative developments playing an important role in the business world today is blockchain technology. Blockchain technology can be defined as a peer-to-peer distributed ledger database that is verifiable by parties and cannot be permanently updated. The hereditary features like data integrity and immutability in Blockchain is to optimize the processing model in several domains, such as financial services, healthcare, educational system, IoT, supply chain and many more. A decentralized blockchain system in which products are anti-counterfeit and manufacturers can use this system to supply genuine products without managing directly operated stores. The main objective of this study is to present a detailed overview of the use of blockchain technology in supply chain management systems. The present study examines all the relevant research done in the field related to the application of blockchain technology in supply chain operations.

Keywords: Blockchain technology · distributed ledger · anti-counterfeiting · supply chain

1 Introduction

It has been observed that the upcoming evolution of any product always has the possibility of some threats like counterfeiting and duplication, which can affect the company's name, company's income and consumer's health. E-commerce has recorded tremendous growth over the years from $39 billion in 2017 and is projected to grow to $200 billion by 2026. This is because of extending marketing and sales over the internet and cell phones. After various market reviews it has been found that counterfeit products are increasing rapidly and growth of counterfeit products adversely affects development and economic growth. And this is causing many top companies to get bad comments and lose their place from the brand list. Counterfeit products are considered copies of genuine products in the market.

Most of the reputed companies are trying to solve this problem which is dangerous for everyone all over the world. To find the reality of the product we can use blockchain technology. Blockchain provides a mechanism to arrange

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recording information in a way that makes it difficult to alter, hack or defraud the framework. Blockchain is basically a computerized record of transactions and this copy of transactions is distributed across the entire network of PC systems on the blockchain. Each block contains a number of transactions, and each time a new transaction occurs on the blockchain, a record of that transaction is added to each participant's record.

2 Background

2.1 Block Chain Overview

Blockchain is a peer-to-peer digital distributed ledger that permanently records the transaction in such a way that it cannot be modified. Blockchain first came out in October 2008, "Bitcoin: A peer-to-peer electronic cash system" published by a person or group of individuals named Santoshi Nakamoto.

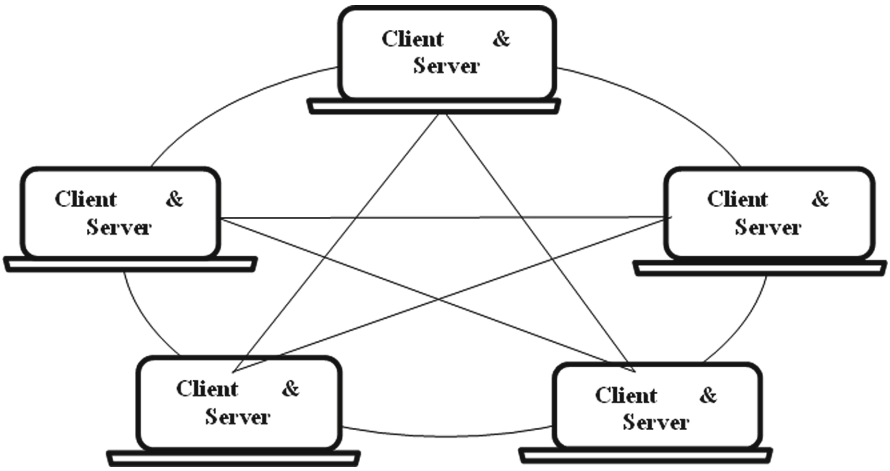

Fig. 1. Decentralized network

A blockchain is essentially a dynamic distributed ledger of transactions that creates a copy of those transactions and distributes them across a network of computer systems on the blockchain. Each block in the chain consists of a number of transactions, and whenever a new transaction occurs on the blockchain, a record of that transaction is added to each participant's ledger. The decentralized database managed by all participants in a network without a central authority (i.e., a bank, government or company) is called Distributed Ledger Technology (DLT). Blockchain is an application of DLT in which transactions are recorded with an unchangeable cryptographic signature called a hash. A blockchain network can track orders, accounts, payments, production and much more. So we can see all details of transactions end-to-end.

Blockchain consists of Blocks is a data structure that stores a set of transactions which is then shared among all nodes in the network. The transaction is nothing but the interaction between the nodes and that data is permanently recorded using cryptography technique. The Role of cryptography in blockchain is maintaining trust and rejecting intermediates. A block records almost all recent transactions which are to be validated by the network. Once the transactions are validated, the block is closed. Then, a next block is created for new transactions to be entered and validated. Therefore A block is a permanent store of records that, once written, remains unchangeable. The first block of the block chain is called a Genesis block or main block. Blocks are joined together through each block containing the hash value of the previous block's header, by forming the blockchain. A previously published block if changed, then it would have a different hash. This would result in changing the hash value of all subsequent blocks as they include the hash value of the previous block. This makes the detection and rejection of altered blocks easier. Figure 1 shows a generic chain of blocks [20] (Fig. 2)

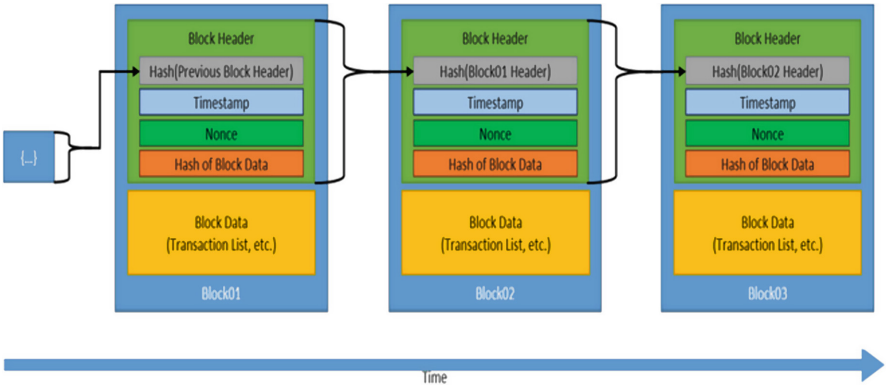

Fig. 2. Generic Chain of Block

2.2 Types of Blockchain

Public Blockchain: Public Blockchain are completely decentralized and permission less in nature. As the name suggests, it is accessible to any participant who can join by any machine or node and perform the transactions. Public blockchain allow creating new blocks of data, validating the blocks of data. This type of block chain is very transparent because each node has equal access to blocks of data on the network. Bitcoin, Litecoin, Ethereum etc. are the examples of a public blockchain.

Private Blockchain: Private Blockchain is a permissioned and partially decentralized in nature. In private blockchain the network is restricted to the users and

controlled by central authority. Private blockchains are mainly used within an organization, enterprises or small companies where they can decide who joins the network since the security, permissions, accessibility, authority is in the control of the organization. The business-to-business virtual currency exchange network, the multichain and Hyperledger projects, Quorum, Corda, Umbrella project are some examples of private blockchain.

Consortium Blockchain: Consortium Blockchain are semi-decentralized and permissioned in nature. Consortium Blockchain is partially private blockchain, the main difference is that consortium blockchain is governed by multiple organizations rather than a single entity. The Blockchain consortium provides many features of private blockchain like efficiency, transaction privacy, authority etc. The enterprise software firm R3, Energy Web Foundation etc. are the examples of consortium blockchain.

Hybrid Blockchain: Hybrid Blockchain combines the strong features of both the private as well as public blockchain. Hybrid blockchains are controlled by a single organization, but it is required to perform certain transaction validation. IBM Food Trust, Dragochain, etc. are the examples of a Hybrid Blockchain.

2.3 Key Elements of Blockchain

Distributed Ledger Technology: Blockchain is a distributed ledger technology that operates over a peer-to-peer network. Distributed ledger is a database and all network participants are able to maintain their own identical copy of a shared ledger and have to access its immutable record of transaction.

Immutable Record: Immutability is defined as the ability of blockchain ledger to remain unaltered or unchanged. Blockchain is a shared immutable database; any participant within a network cannot modify the record which has been written once on the blockchain.

Smart Contract: Smart contract is a computer program or a set of rules which is stored on a blockchain and executed automatically.

2.4 Blockchain Features

Security & Privacy: Block chain technology is extremely secured technology. The cryptography security method is used in blockchain that guarantees that hackers cannot change the data which is stored in the blocks of blockchain. In cryptography, a public key encryption method is used to secure data. Users can generate their own private keys and public keys. The private key is used to sign the data and the public key is used to verify the authenticity of the signed data. As long as the user prevents their private key from being leaked, the data remains secure.

Cannot Be Corrupted: Every node on a blockchain network has a copy of digital ledger. When the transaction is added to, every node needs to check its validity. If the majority thinks it is valid, then it's added to the ledger. This improves transparency and makes it free from corruption.

Decentralized Technology: Through decentralized operations the data which is in the database is shared among several nodes within a network. If somebody tries to change the record at any one instance, then other nodes would not be altered and thus would stop hackers from doing so. The blockchain technology doesn't have any governing authority or a single person looking after the framework.

Consensus: The consensus protocol or consensus algorithm allows distributed systems to work together and keep secure. A consensus mechanism refers to any number of methods, which are used to attain agreement, security and trust, across a decentralized computer network. It is also helpful in keeping the record among other things. The consensus mechanism is like a fault-tolerant mechanism which is used in blockchain to accomplish the essential agreement on a single stake of the network through a distributed process, such as a cryptocurrency. Within this framework of blockchain and cryptocurrencies, the two most commonly used consensus mechanisms are Proof-of-Work (PoW) and Proof-of-Stake (PoS).

Transparency: Blockchain's decentralized nature is completely public and anyone can query the data. In a network, when information flows, anyone can clearly see who is sending data to whom because the blockchain keeps a continuous transaction log file.

Flexibility: Blockchain technology is open source and anyone can use it to modify their own version. There are already many flexible blockchain platforms available and users can also redevelop new blockchain platforms if they wish. Blockchain is a unique technology that means users can build multiple applications based on blockchain.

3 Supply-Chain Management System

Supply-chain is a network between the manufacturer and its suppliers to produce and deliver a specific product or services to consumers. Supply-Chain Management (SCM) process starting from raw material and transforming into finished goods and delivered to the end user. The five key elements of SCM are: 1) Planning (developing an overall strategy produces efficient and effective products to customers and meets company goals). 2) Sourcing (choose the sources of raw-material or services needed to create the product). 3) Manufacturing (focused on

productivity and efficiency). 4) Delivery and logistics. 5) Returning (for defective or unwanted products). The supply chain includes manufacturers, suppliers, transporters, warehouses, retailers and even customers themselves.

In recent years, the area of supply chain management (SCM) has become very popular. According to a World Trade Organization (WTO) report, the international trade volume keeps growing at a high rate in the past decades. Behind this growth, supply chain plays a critical role. Smooth movement of goods and international transportation cost reduction, modern supply chain system is performing several business activities such as predicting/planning, obtainment, client services and performance measurement. The large scale and complex functionality of modern supply chains makes managing them efficiently a challenge. Much work has been done to improve the functionality of supply chain management systems and add more features. For example, Researchers propose integrating sensors (e.g., GPS receivers and radio-frequency identification/RFID) into the supply chain to provide more information to the end user, and more tightly tying the cyber world and the physical world. With the emergence of cloud computing technology, cloud-based supply chain management systems have also been developed to improve reliability and reduce costs.

However, current supply chain management systems suffer from limitations that prevent users from realizing the most value of supply chain information. Two key points are as follows. Two key points are as follows. 1) Supply chain in nature involves multiple parties and is a distributed system. However, these days most companies and stakeholders use their own supply chain management systems, which are difficult to integrate to provide a unified platform. Therefore, it is not convenient to offer end-to-end tracking and share information to enable new functionality and services. Furthermore, supply chain information is sensitive and companies may not be willing to disclose and share it with others. 2) As an IT system, supply chain management systems are exposed to all types of cyber threats, which can breach the integrity of supply chain information and lead to fraud, loss of goods and non-compliance in trade. The recent rise in ransomware attacks also poses a significant threat to supply chain management systems as loss of access to historical data can lead to financial losses.

Decentralized blockchain technology provides a way to organize records in a distributed manner through a consensus mechanism. It has been used in Bitcoin and other similar cryptocurrency systems to record and share transaction history and is created collectively by a group of users who each maintain a local copy of the ledger. A group of transactions are embedded in a block and the blocks are linked by hash values. When a new block is added to the system a consensus mechanism helps these users achieve agreement. If the chain contains more than one branch, the "longest-chain" principle is usually used, that is, users will follow the branch which contains more blocks and add new blocks on this same branch. To change an existing block, an adversary has to compete with all authentic users to create a long branch. Therefore, Distributed Ledger Technology (DLT) provides a collaboration mechanism that can protect historical data.

4 Literature Survey

Counterfeit products are a fraudulent copy of a trusted or branded product is one of the most important and challenging issues to face in the national or international market. Over a decade, radio frequency identification (RFID) technology has been effective in measuring anti-counterfeit in the supply chain. The authenticity of RFID tags cannot be guaranteed in the post supply chain, as these tags can be easily copied in public spaces [1]. Proposed a novel product ownership management system (POMS) which is based on blockchain for anti-counterfeits product. The RFID attached products are used in the post supply chain which works very effectively for the post supply chain. The authors in [1] apply a proof-of-concept experimental system which is to be implemented on the Ethereum platform. The performance evaluation results showed that the cost to manage products with the proposed POMS is less than US$1 when the number of owner transfers is less than or equal to six.

An important responsibility of policy makers and administrative bodies is to plan safety and security for their citizens and consumers for companies. The main concern of [2] is counterfeiting goods in today's time. In their research proposal authors uses SWARA (Step-wise Weight Assessment Ratio Analysis) is applied to evaluate the rate of the criteria and WASPAS (Weighted Aggregate Sum Product Assessment) is to evaluate prioritize the alternatives. This methodology uses three research questions which are applied for developing a decision system. These questions are 1. Which major sectors are affected by counterfeit products? 2. What is the weight of each area in terms of fabrication? 3. What areas need priority attention to combat counterfeiting? An author answered these three questions and justifies the contribution.

To ensure the identity and traceability of genuine products throughout the supply chain, [3] uses the distributed blockchain technology which makes sure that customers do not fully trust the sellers to determine the products are genuine. Ethereum [32] is used to record product ownership on the blockchain. Authors in [3] propose a fully functional Anti- Counterfeit products system based on blockchain. The system is composed of Producer, Vendor and User roles. Manufacturers can use this system to store appropriate information about products in blockchain which is available for everyone. The total numbers of products that can be sold and currently left products by the sellers are transparent. By paying a very low transaction cost, the users do not have any chances for getting counterfeited products. This system analysis result, the cost of the initial product record contract will only cost 1.2893394289 US dollars, and the cost of each product sale process will cost 0.17415436749 US dollars, which is very lower than cooperating with reliable large chain stores. Counterfeit products are affecting the sales and profits of companies, blockchain based fully functional product genuineness system is used to stop product counterfeiting [4].

The authors in [5] presents a detailed overview of the use of blockchain technology in international trade supply chains. The data integrity, traceability and immutability features of this technology can help detect counterfeit goods and monitor the transport environment. The main goal is to clearly identify the

benefits of applying this technology to the trading domain and highlight the challenges associated with it.

Blockchain is a type of distributed ledger which does not have any central authority and it allows creating a decentralized and immutable ledger of transactions which are verifiable and traceable. Due to these unique features, it has been used for various applications mostly in the financial sector [6]. Present a blockchain-based traceability framework in a multi-tier textile and clothing supply chain. The traceability feature of the blockchain system would provide a unique opportunity, flexibility, and authority to all partners to trace-back their supply network and create a transparent and sustainable supply chain. Key areas of decentralization, basic system requirements and viable mechanisms for developing decentralized product anti-counterfeiting and traceability ecosystems using blockchain technology are identified in [7].

Blockchain is also supportive in the Healthcare sector, to record information about patient, medicines in secured databases. Blockchain technology adds their features like traceability, security and visibility which is helpful to supply drugs and overcome the problem of counterfeiting in the pharmaceutical supply chain [8]. Blockchain offers potential solutions to improve the security, integrity, data provenance and efficiency of the healthcare supply chain [13]. A distributed application (DApp) has been developed that runs on a smart contract to record authorized drug information over a distributed network in the pharmaceutical supply chain [15].

A blockchain is a distributed ledger or public registry that stores records across thousands of computers. All records entered in the system with the proof-of-work, based on consensus mechanism, cannot be tampered with. Therefore, the correct records in blockchain systems can be used to address the integrity issue. Blockchain is used to detect fraud for online businesses. This system is very effective in preventing objective information fraud, such as loan application fraud, where fraudulent information is fact-based [9].

In the Industry 4.0 and Industrial Internet of Things (IIoT), blockchain is proposed as a way to organize records in a distributed manner through consensus mechanism [10]. This paper surveyed the latest research work conducted on blockchain applicability in multiple IIoT-specific industries such as healthcare industry, supply chain/logistics, power industry, agriculture industry, manufacturing industry, E-commerce and retail industry etc. And further discussed the challenges faced by each of these industries for implementing blockchain. Blockchain helps reduce logistics costs and optimize operations and research challenges [11].

The use of data and information becomes ever more critical for the agriculture sector to improve productivity and sustainability. Blockchain like a distributed ledger and smart contracts can increase efficiency, transparency and traceability in agricultural supply chains. The Ethereum blockchain and smart contracts capably perform business transactions for soybean tracking and traceability in agricultural supply chain [12].

The integrated approach of distributed blockchain technology and supply chain means that end users in the supply chain are not completely dependent on the seller to establish whether the product is fake or not, and this can be done by validating the product at every stage in the supply chain. One Time Password (OTP) authentication is used to verify authentic supply chain members and products [14].

Implementing Blockchain can intensely reduce time delays, costs and mainly the human error as well as it can increase transparency, can give greater scalability and provide security. Blockchain can also help in attaining robust cybersecurity which in turn improves the trust and security at the same moment. The effects of Blockchain technology combined with the Internet of Things (IoT) in terms of transparency, validation and traceability purposes in various industries; such as e-commerce, food, and warehousing [16].

Blockchain functions work in a decentralized manner and records are organized in a distributed ledger through consensus mechanism [28]. It has the potential to transform supply chain through its features like decentralization, traceability, immutability, and currency properties [24], lower losses from counterfeit, reduction of cost, and reduced paperwork and administrative costs. All the transactions supported by the block chain are secure, transparent, efficient [25].

Table shows Benefits of utilizing blockchain in supply chains [30].

Benefits of blockchain in SCs	Details
Data management	-Enables calibration of data located in various supply chains. -Improves security of data stored. -All information is captured in genuine time.
Improves transparency	-Helps track item status during processing. -Automates data analysis activities. -End to end transparency predicated on sanction level via hierarchy.
Improves response time	-Creates a dynamic and real time SC with optimal utilization of its resources.
Smart contract management	-Customized and individual contracts can be defined for each task and coordinated with each other. -Assists in process design for business operations. -Improves visibility and eliminates the need for an intermediary.
Operational efficiency	-Improves end to cultimate speed of SC process. -Identify bugs and issues early to strengthen the process.
Disintermediation	-Leads to a seamless chain of transactions. -Increases speed. -Builds trust between stakeholders in the process.
Immutability	-Consensus mechanism for all amendments. -Ascertains security of all transactions.
Intellectual property Management	-Intellectual property protection and registration.

5 Methodology

The hybrid approach of MCDM (multi-criteria decision making) is considered in [2]. This methodology can be applied to the decision making by top management and policy making in real situations.

The GUEST methodology [18], [19] used in [11] was developed by a group of researchers from the Politecnico di Torino for use case design. GUEST focuses on providing innovative structures for business management to companies. The methodology aims to be easy to understand and apply throughout the decision-making process, increasing efficiency and improving quality for companies. The GUEST methodology evaluates the procedure, from its original idea to implementation, by providing theoretical and practical tools to different actors, enabling them to communicate their vision, constraints and opportunities in a common structure. The procedure is explained in five steps (GO, UNIFORM, EVALUATE, SOLVE, and TEST), and each step allows artists to monitor their projects and, at the same time, formalize the documents and tools used to predict ideas, achievements, actions and outcomes.

Go: The researcher has to be able to fully understand the system, the actor and their interaction.

Uniform: It's goal is to standardize the information collected during the first phase.

Evaluate: The third step of methodology is the operational step. Its goal is to access the company's current state by analyzing the results of the previous steps and start developing.

Solution: It's goal is to analyze in detail the solutions to the problem previously identified.

Test: This is the last step and its goal is to follow up on the action plans, their actual implementation and the evaluation of their outcomes.

The Paper [15] uses System Design and Development Methodology. This Method Focuses on Distributed Application (DApps), which uses Backend Distributed File System (DFS) approach providing a Private Blockchain Network, it uses Smart contracts. Ethereum blockchain platform, which is subsequently one of the most used blockchain network. The Algorithm called Ethash uses a Proof-of-work(PoW) consensus mechanism.

The Paper [13] uses a methodology in such a way that a chronicle review was conducted by analyzing different literature reviews as well as industry publications in the aim of sorting and identifying the stakeholders involved in investigating blockchain solutions for supply chain.

6 Conclusion

Blockchain is essentially a distributed ledger technology that operates without a central authority and allows for the creation of decentralized and immutable accounts of transactions that are verifiable and traceable. Blockchain has a huge potential to transform the supply chain, locally as well as globally, by

improving operational efficiency, transparency, security, data management and smart contract management. The characteristics like data integrity, traceability and immutability can be guaranteed to establish a secure communication paradigm. This paper makes available a different review article and covers several aspects of blockchain technology in supply Chain Management System. It adds the overview of blockchain technology, its concepts, types of blockchain and its characteristics. This work also analyzes the recent development in blockchain and examines its potential application in various sectors such as healthcare, finance, agriculture, energy, trade etc.

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