A Blockchain-Based Implementation of IoT-Based Product Tracking

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Abstract

Blockchain is the technology behind several digital currencies. A blockchain is a chain of blocks that keeps records of information in a decentralized and distributed network, with digital signatures stored in each block. Because of the distributed nature of blockchain and other unique properties, transactions are more secure and tamper proof. The paper's methodology gives a detailed study of blockchain's fit in the supply chain industry. Data is stored on many chains using a multi-chain architecture in the framework. Additional to the data management model and block structure model, the model contains the data model and container structure model.

Keywords
Block chain, cryptocurrency IoT; internet of things; smart contract.

1. Introduction
Unlike other systems, blockchain allows direct peer-to-peer digital asset transfers. Blockchain was built to support the popular cryptocurrency Bitcoin. Nakamoto proposed Bitcoin in 2008 and developed it in 2009. It has had considerable growth since then, with capital markets expanding to a market value of 10 billion dollars in 2016. Blockchain is a network of blocks that stores all public ledger transactions. The chain grows as more blocks are added. Blockchain operates in a decentralized ecosystem that includes digital signatures, cryptographic hashes, and distributed consensus processes. Decentralized transactions eliminate the need for intermediaries to validate and verify transactions. Blockchain has decentralization, transparency, immutability, and auditability.

While the most widely known application of blockchain technology is cryptocurrency, it has been adopted in many ways far beyond currency. As a result, the use of blockchain can be applied to a variety of financial services, including digital assets, remittances, and online payments. Due to the fact that the blockchain itself has been embraced throughout various industries, including finance, healthcare, government, manufacturing, and distribution, it has penetrated a wide range of applications across numerous businesses. Despite the fact that blockchain technology shows immense potential and may eventually replace many of the present digital platforms, it has several technological limits. The issue of scalability for blockchain-based platforms is a big worry.

2. Literature Review
Using cryptography and distributed networks, Satoshi Nakamoto (2008) proposed a truly decentralized electronic money trading system. This is the very first use case for blockchain technology. Blockchain demonstrated its ability to execute peer-to-peer digital currency transactions in an untrusted environment.

In research from Liu and Li (2020) that this research aims to identify a blockchain-based framework to simplify cross-border e-commerce, and to use that framework to establish a variety of strategies and methodologies for tracking shipments and transactions within supply chain management. We introduce a broad blockchain-based product traceability platform. This framework is built on a cross-border e-commerce supply chain and incorporates a number of blockchain-based models, including a multi-chain structure model, a data management model, and a block structure model. Additionally, several fundamental methods and algorithms are established, including information anchoring, key distribution, information encryption, and anti-counterfeiting.

In research from Desai et al. (2020) presents an open-source, multi-sided B2B platform built with the aim of addressing integration issues created by connecting IoT products to Blockchain.

In research from Litke et al. (2019) presented in the article, a complete examination of the blockchain's relevance in the supply chain industry is provided. Blockchains effect supply chain by touching on several factors such as scalability, performance, consensus process, privacy considerations, location, and cost.

Mondal et al. (2019) propose a transparent food supply chain based on a blockchain-inspired architecture in this paper. In other words, the architecture is based on a proof-of-object authentication system, similar to the proof-of-work protocol used in cryptocurrencies. The physical and cyber layers were integrated by incorporating a radio-frequency identification (RFID) sensor in the lower layer and blockchain technology in the upper layer.

Wang et al. (2018) describes the taxonomy of blockchains, presents various blockchain consensus algorithms, explores the obstacles and improvements in handling those challenges, and also explains how the most common consensus algorithms work. Additionally, this paper outlines the ways in which blockchain technology will continue to evolve in the future.

3. Blockchain architecture

It is made up of ordered sets of records called blocks, and it contains an exhaustive account of all transactions recorded over time (Lee Kuo Chuen, 2015). This image demonstrates an example of a blockchain, as shown in Figure 1. Each block points to the previous block by referencing a parent block's hash value, which is a form of a reference known as a pointer. It should be noted that the family line of uncle blocks (those in the family tree of the block's ancestors) would likewise be preserved in the blockchain (Buterin, 2014). The genesis block of a blockchain, often known as the "first block," is called such because it has no parent block.

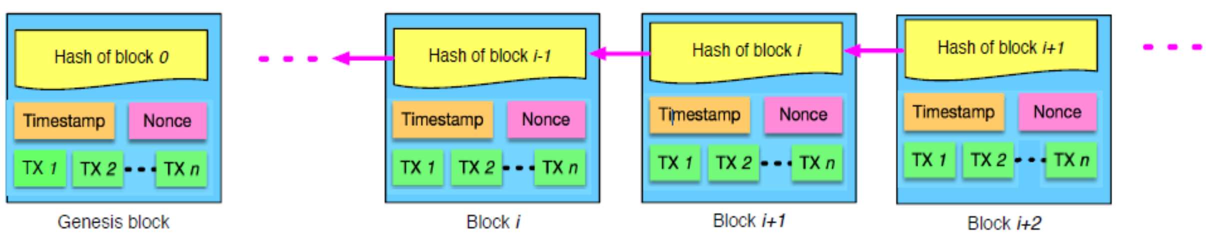

Figure 1: Blockchain that consists of a continuous succession of blocks is a real-world example of the technology

3.1 Permissionless Blockchains

Because permissionless blockchains are open to the public, putting nodes, also known as miners, can join or leave the network without gaining permission. End-user transactions are processed by miners, who keep a copy of the blockchain record.

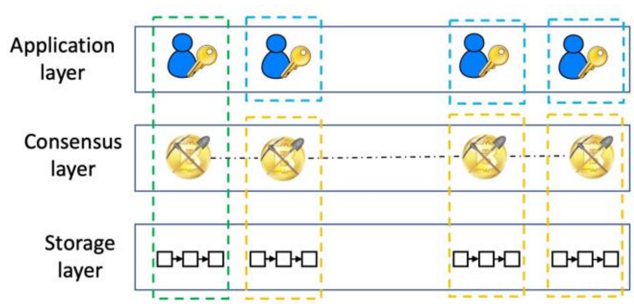

Figure 2: Permissionless Blockchains.

3.1.1 The Application Layer
End-users initiate transactions in the application layer. End-users have identities that are defined by their public keys, as well as signatures that are produced with their private keys. End users can generate transactions using digital signatures. Once transactions are created, users utilize a client library to multicast their transactions to the consensus layer's mining nodes. Assets are transferred from one end-user identity to another via transactions.

3.1.2 The Consensus Layer
Consensus is achieved in unauthorized blockchains by mining. A mining node validates the transactions it is receiving, blocks the valid transactions and tries to solve certain cryptographic puzzles.

3.1.3 The Storage Layer
The ledger is a block chain safe that each mining node retains. A decentralized, distributed leather controlled by a network of open nodes consists of the storage layer. A collection of transactions which are valid for the transfer of assets between end users is included in each bloc.

3.2 Permissioned Blockchains

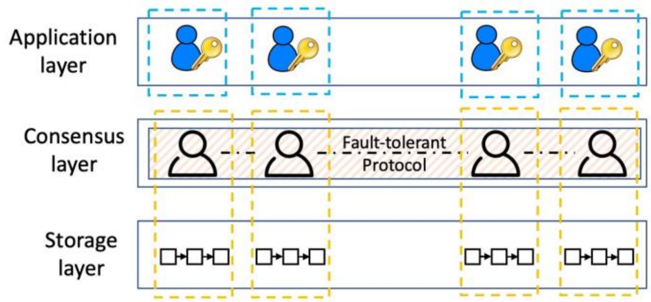

Figure 3: Permissioned Blockchains

The engineering of a permissioned blockchain comprises of Application layer, Consensus layer, and Storage layer. The application layer of a permissioned blockchain, like permissionless blockchains, comprises of end-clients who present their exchanges to the blockchain through a customer library. Anyway, the agreement layer which is mostly answerable for requesting and approving the exchanges contrasts from the agreement layer in permissionless blockchains. Truth be told, since the hubs in a permissioned blockchain are known and distinguished, mining can be supplanted with conventional agreement conventions to set up an absolute request on the solicitations.

3.3 Architecture Overview

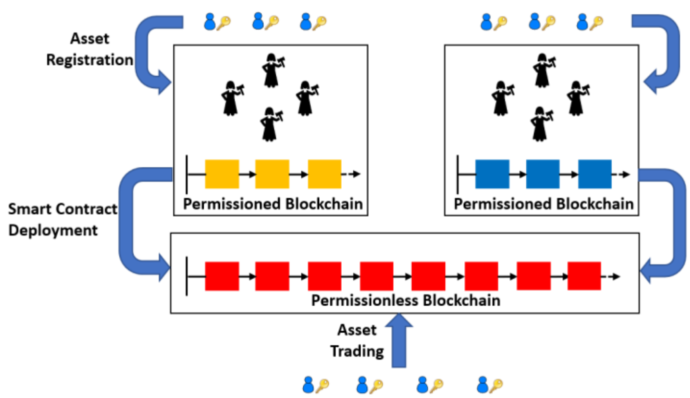

Figure 4: Architectural overview.

Figure shows the design outline of the permissioned and permissionless blockchain unification proposition.

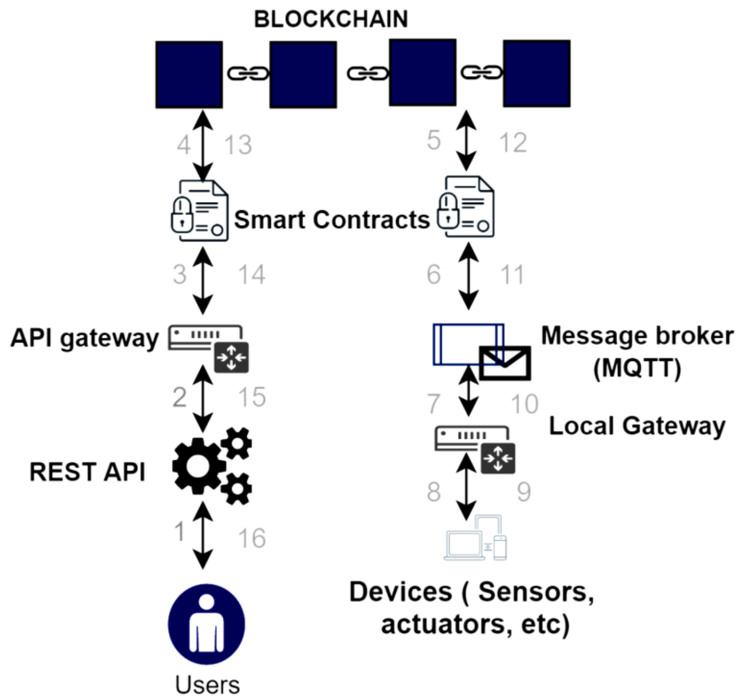

Figure 5: Transaction execution procedure.

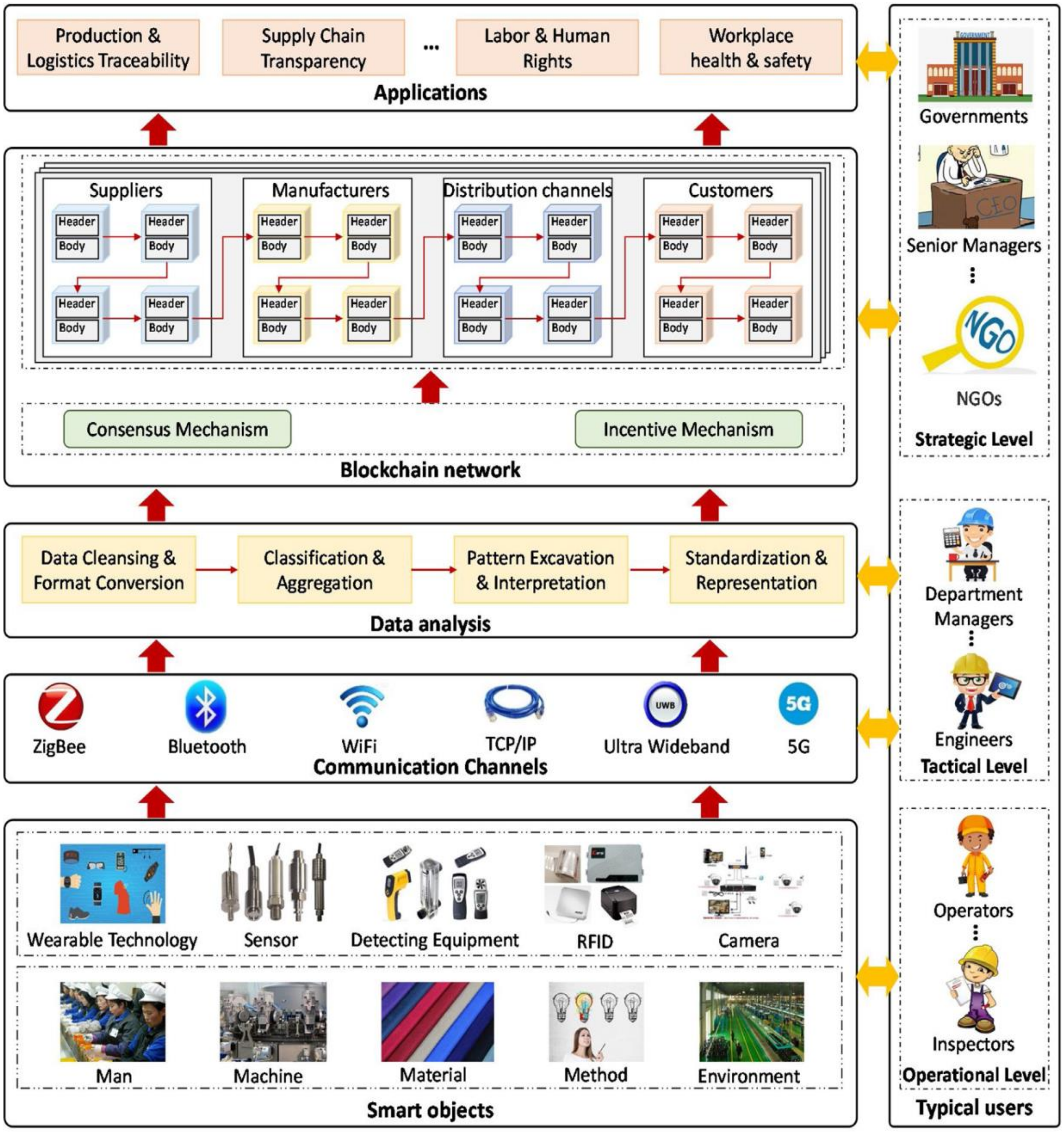

Figure 6: The blockchain-based supply chain's system architecture

4. Framework and Model

The following categories apply to the data recorded in blockchains:

(1) Digital Documents: Paper documents should be digitized in this supply chain management system to reduce management and transaction expenses. Digital documents accelerate supply chain certification automation.

(2) Internet of Things (IOT): Data IoT infrastructure is required for product traceability. Temperature, speed, and other indicators are provided by IOT at all phases of manufacturing, transaction, and delivery.

(3) Transaction Records: The blockchain is a decentralized distributed ledger that records each transaction in a secure manner. Each user has a validated copy of the distributed ledger and may access transaction data. In addition, the product's ownership information is stored with each transaction.

(4) Traceability Tag: A product traceability tag which is based on blockchain technology varies from those which use RFID or barcodes. No equipment or hardware is required, and traceability tags can be attached to a chassis or tray without extra processes. Logically related to items, the traceability tags are recorded in blocks. When products are traded, ownership of the tag used to track the product's provenance is also recorded.

(5) Execution records for smart contracts: Smart contracts are given as a programmable architecture in blockchain-based systems. Every user has the ability to deploy smart contracts that match their needs for use in blockchain transactions. To give stakeholders with clear transaction information and to help resolve disputes, all smart contract execution records are maintained in blocks.

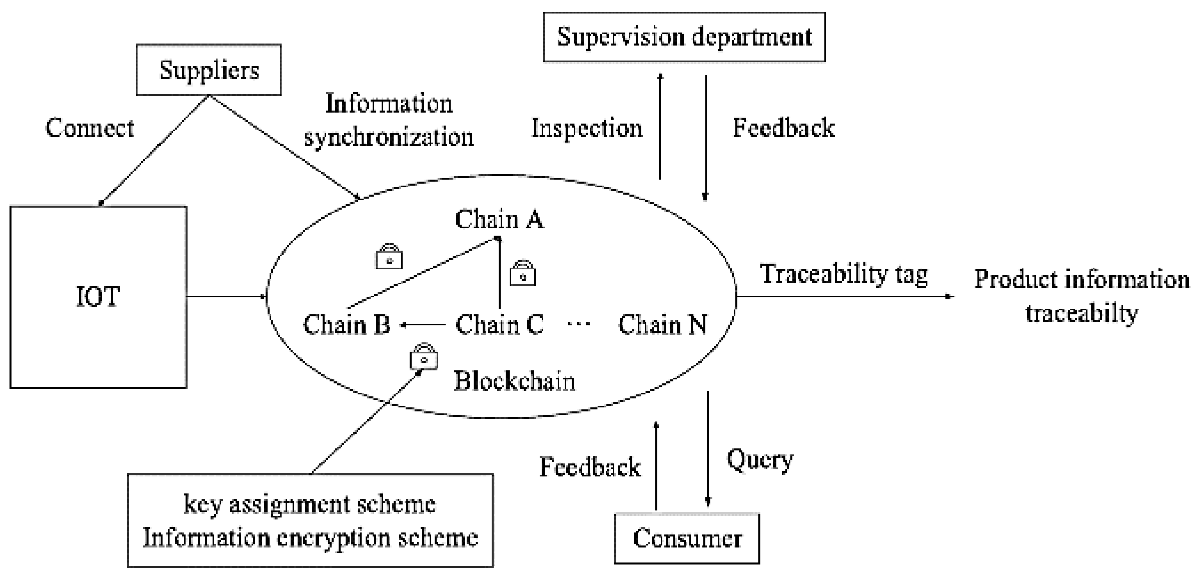

Figure 7: A Blockchain-based Product Traceability Framework

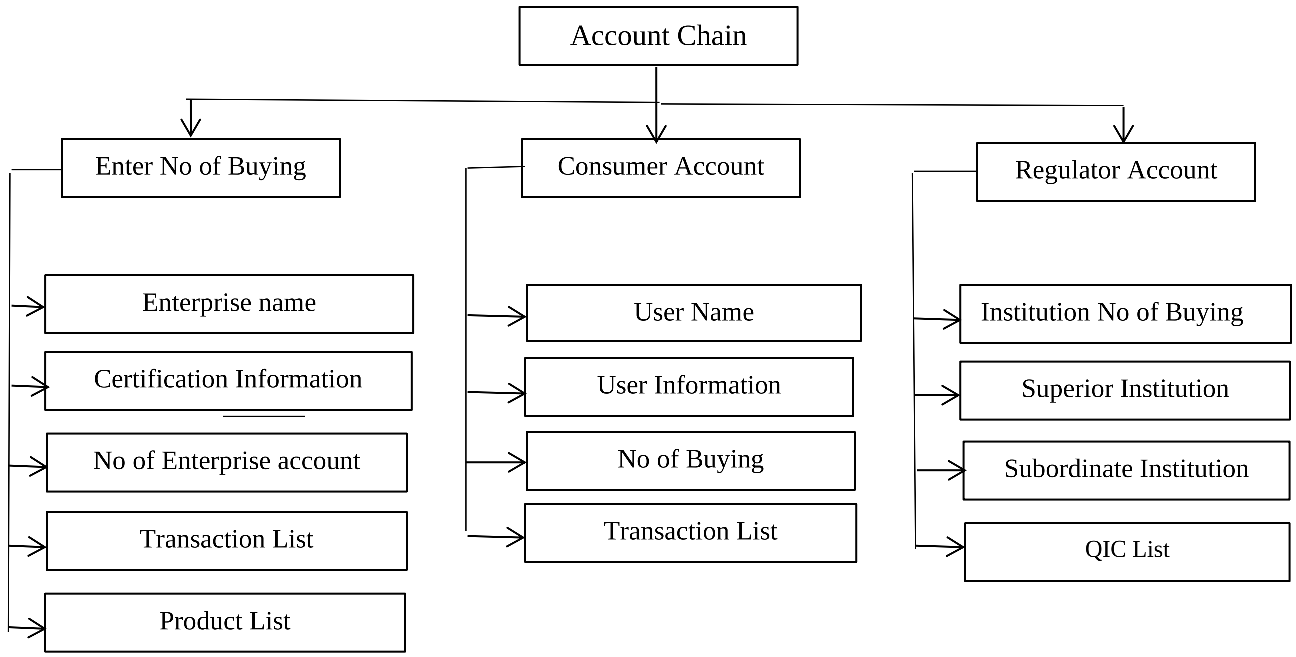

Figure: Data Structure of Account Chain.

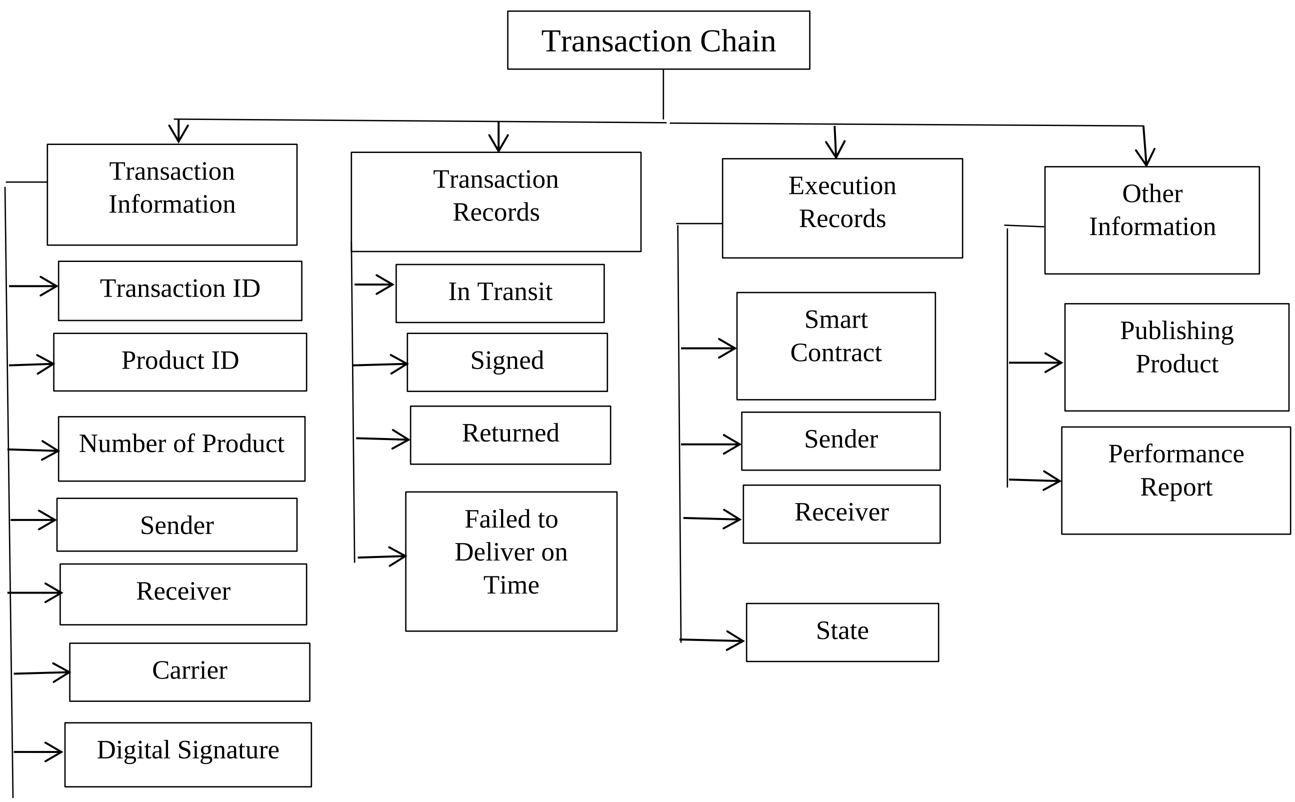

Figure.8: Data Structure of Transaction Chain.

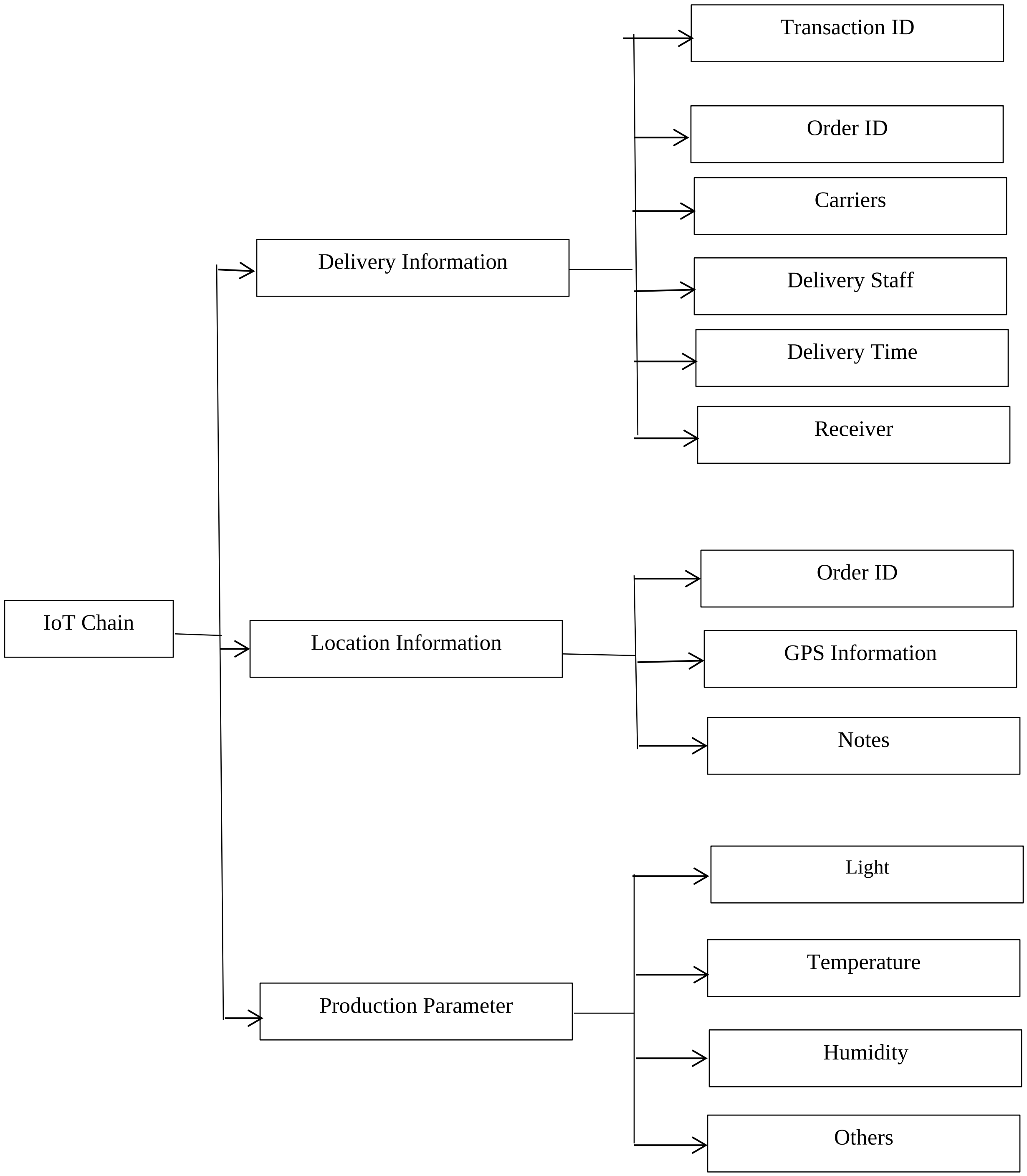

Figure 9: Data Structure of Logistics Chain

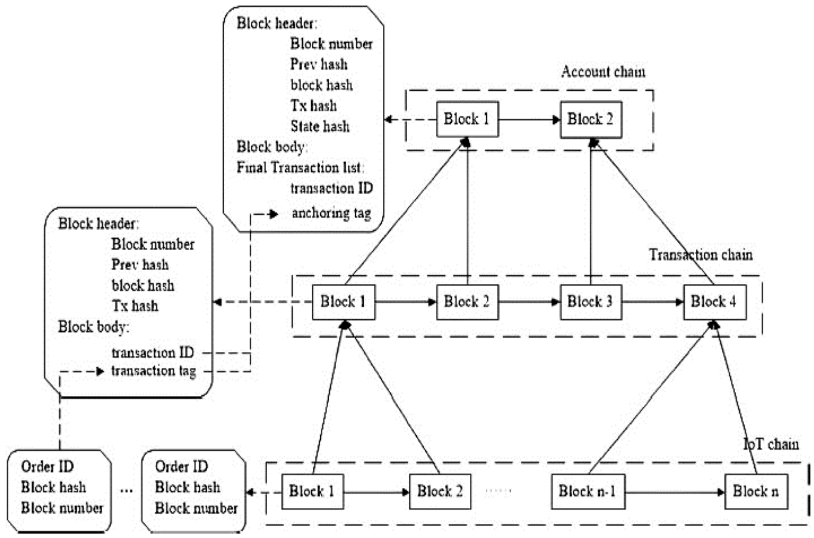

Figure 10: Information Anchoring Model

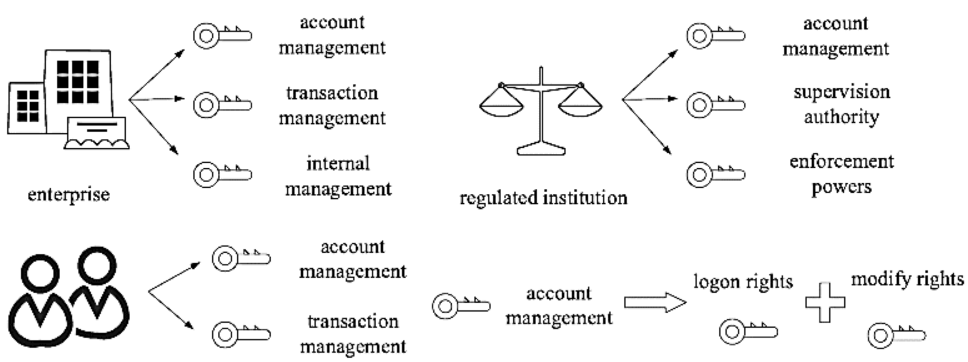

Figure 11: Key Assignment Scheme.

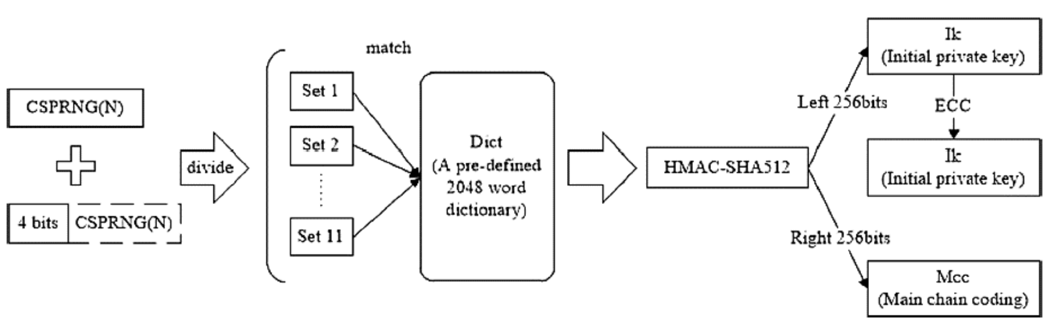

Figure 12: Initial Key Distribution Scheme

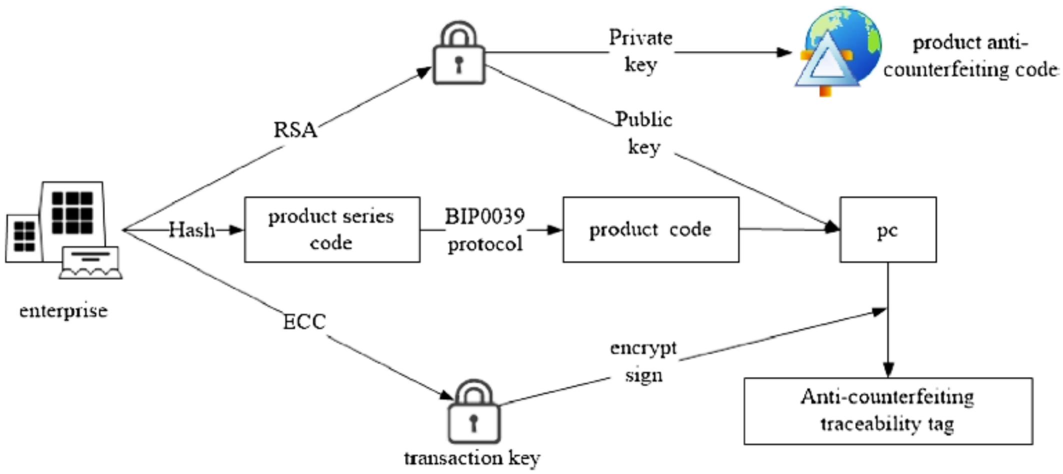

Figure 13: Anti-Counterfeiting Traceability Tag Scheme.

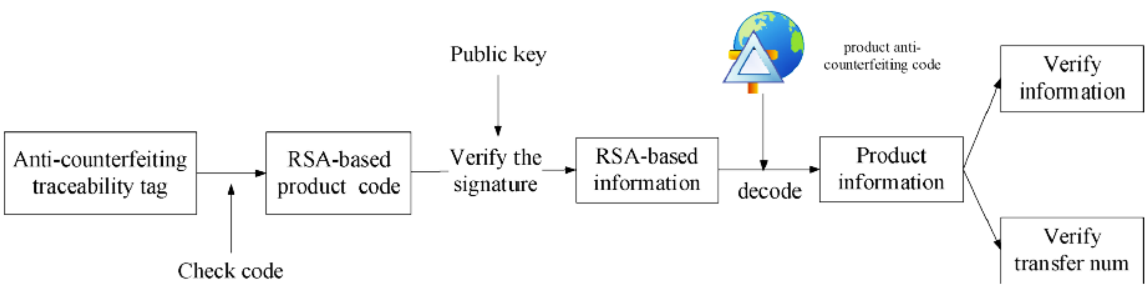

Figure 14: Process of Verifying Product.

5. Conclusion

To overcome the product traceability problem in e-commerce supply chains, a blockchain-based architecture is presented. In order to better handle varied qualities of data, the framework incorporates a multi-chain structure that employs blockchain technology. The block structure concept and data management model are proposed, as well. Completing the supply chain management of e-commerce involves utilizing several strategies, including anchoring methods, distribution methods, and encryption methods. To find solutions to real-world challenges, an organization uses frameworks and methods for application to a number of potential difficulties, including key recovery, clone attack, counterfeit tag assault, and counterfeit product attack.

6. Future Scope

Blockchain has enormous promise in academia and industry, according to the researchers. We have explored briefly the various prospective applications of Blockchain technology in this area, including standardization, asset protection, big data, and smart contracts. Blockchain performance to entice investors with the prospect of a massive profit. Prior to incorporating this technology into a business solution, it is critical to determine whether it meets the requirements. As a result, there should be a standardized testing mechanism for blockchain-based solutions to ascertain their significance and tradeoffs. This procedure can be divided into two stages: standardization and testing. The first step will validate developers' assertions about their blockchain solutions using a set of predefined criteria. The testing step is used to determine the solution's performance on a blockchain. For instance, the owner of an online retail business is concerned about the solution's performance. As a result, there should be some testing and standardization techniques in place to verify the acquired solution platform's throughput, capacity, and latency.

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