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Study of Internet of Things (IoT) Smart Contract Blockchain System

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Abstract

Blockchain technology has recently undergone substantial investigation into the prospect of integrating it with several service sectors, having originally been designed for the Peer-to-Peer cryptocurrency network, Bitcoin Database security could be an expensive and time-consuming operation. When discussing a legally binding contract, the phrase "automated transaction protocol that, executes the terms of the agreement" is used. The Internet of Things (IoT), big data artificial intelligence technologies, and blockchain technology into the supply chain may help solve the transparency and traceability issue stated in the literature.

Keywords: Internet of Things, Blockchain, technology, transparency and traceability

Introduction

The Internet of Things (IoT), big data artificial intelligence technologies, and blockchain technology into the supply chain may help solve the transparency and traceability issue stated in the literature. The term "cloud-based decision support systems" basically describes the practice of using real-time big data to inform supply chain activities. With the use of blockchain technology, supply chain integration allows for more efficient administration of the whole supply chain network, many supply chains are already making use of the Internet of Things (IoT) to monitor performance and keep tabs on items, which is a great example of a linked ecosystem. Even more supply chain transparency and traceability may be achieved by integrating IoT devices with blockchain technology.

This boosts transparency and security. In addition to improving efficiency, this technology eliminates room for error by making sure everyone in the supply chain can rely on the same, accurate information. In addition to bolstering supply chain security, this solution helps bring the car industry up to speed on safety regulations. In order to guarantee the sustainability and traceability of its goods, the Japanese seafood sector is also using blockchain technology. This technology gives customers information about the techniques used to capture the seafood as well as its origins

Blockchain technology provides supply chain management (SCM) with unmatched security and transparency. With blockchain technology, businesses can monitor their products from their inception to their final sale. Blockchain technology's capacity to increase security is one of its main benefits in supply chain management. Many security risks, including as fraud, theft, and cyber-attacks, may compromise traditional supply chains. The immutable record of all transactions made possible by blockchain technology reduces the likelihood of these negative outcomes. Cryptographic algorithms guarantee the authenticity and integrity of data, achieving this security.

Database security could be an expensive and time-consuming operation. Since Blockchain transactions have their own evidence of validity and authorization to impose limits, using the technology may be avoided. What this also

implies is that each transaction may be separately handled and confirmed. Security and transparency in the supply chain are of utmost significance in today's global economy. When combined, AI and blockchain provide formidable solutions to the problems with conventional supply chain management, such as its inefficiencies and inherent weaknesses Also, blockchain's built-in security features make it easier for stakeholders to trust one other when sharing information.

Literature Review

Sunny, Justin *et al*. (2020) [1]. To address the drawbacks of centralized traceability systems, blockchain-based alternatives might be considered. To increase transparency by tracing and monitoring occurrences, firms have begun integrating blockchain into their supply chain operations. This paper's overarching goal is to survey the literature on blockchain-based traceability solutions. First and foremost, this study sheds light on the potential of blockchain traceability systems for enhancing supply chain transparency. Besides this, it outlines how technologies like the Internet of Things (IoT) and smart contracts enhance blockchain's potential, and it examines how blockchain traceability solutions impact the visibility of different supply chain distribution network designs. The purpose of this Proof of Concept (PoC) is to demonstrate, using Microsoft Azure Blockchain Workbench, how blockchain traceability technologies enhance supply chain transparency in a cold chain scenario

Subramanian, Madumidha *et al*. (2021) [2]. The idea of connecting everyday objects to the web in order to streamline human operations is known as the "Internet of Things" (IoT). It fails to guarantee total network security despite the fact that it has vast amounts of data in its network. Blockchain is a decentralized database that prioritizes the safety of user information. Threats like massive data loss cannot occur in a blockchain network because each block is linked to the next block. There are problems with data integrity or data manipulation in the agri-food supply chain, an area where the internet of things is crucial. Improper management of the supply chain, delays in product delivery, food spoiling, etc., may result from this. Therefore, in order to guarantee food safety and boost confidence between all parties involved and consumers, the agri-food supply chain must be traceable. Cold chain monitoring and the prevention of many illicit operations are both made possible by increasing visibility and tracking capabilities.

Santhi, Abirami *et al*. (2022) [3]. An immutable ledger that records transactions digitally, distributed, and decentralized is called a blockchain. Its appealing features for use cases involving transactions include trust, transparency, and traceability. While the technology's initial focus was on facilitating monetary transactions, it has since attracted interest from non-financial industries like healthcare, manufacturing, retail, and government services. The research found that logistics and the supply chain may be made more transparent, trustworthy, agile, and safe with the use of blockchain technology. The advantages of blockchain technology in supplying crucial items with provenance and traceability are shown via a conceptualized application case. In conclusion, industries involving several organizations, including logistics and supply chains, are well-suited to private or permissioned blockchains. Future advantages of smart contracts, asset tracking, and Internet of Things (IoT) integration with blockchain technology are enormous.

Shakila, M. *et al*. (2024) [4]. Blockchain technology, which is both decentralized and promising, raises privacy concerns and improves data security, especially in the healthcare and supply chain industries. To demonstrate the extent to which the medical supply chain may be protected from unauthorized access while still guaranteeing the validity of items and keeping track of their whereabouts, four blockchain-based data security and privacy algorithms were evaluated and shown to have great outcomes. The results demonstrate that blockchain technology is capable of handling issues such as medical product counterfeiting, privacy violations, and tampering. Full integration is still a way off, however, due to issues with application scalability and regulator acceptance. This article contributes to the construction of an all-encompassing framework that might use blockchain technology to safeguard healthcare and other supply chain systems, opening up new possibilities for the digitalization of data security

Emrouznejad, Ali *et al*. (2023) [5]. In today's fast-paced, globally interconnected supply chain ecosystems, where efficiency, adaptability, and social responsibility are paramount, blockchain technology (BCT) has arisen as a game-changing tool for more transparent, traceable, and attribution of goods and services. One of the most revolutionary technologies, it offers a decentralized platform for online transactions, smart contracts that execute themselves, and intelligent asset management. All parties engaged in the transaction may see the whole picture. Thus, current supply-chain business models, digital transformation pathways, operational strategies, connections within the supply chain, and organizational governance will all be profoundly affected by BCT's defining features. By combining BCT with other technologies like the Internet of Things (IoT), big data analytics, and artificial intelligence (AI), supply chain efficiency can be enhanced. This is because BCT allows for data-driven decisions that are based on high-quality data stored in Block-chain, which makes the process even more transparent. This transparency in turn allows for product traceability, authenticity, and legitimacy. The social sustainability issues plaguing multi-tier supply networks will be reduced as a result of improved sub-supplier transparency.

Internet of Things (IoT) Smart Contract Blockchain System

Nick Szabo first proposed the idea of a "smart contract" in 1994. When discussing a legally binding contract, the phrase "automated transaction protocol that, executes the terms of the agreement" is used. Thanks to the blockchain and the underlying peer consensus, which creates the conditions for trust, a smart contract may operate as a trusted distributed program inside the blockchain ecosystem. The blockchain stores the unique address of each smart contract, which the user may use to submit a transaction directly to that contract. Next, the data provided by each node in the network will decide whether the smart contract can run freely and independently according to the requirements.

The need for blockchain developers to acquire a new language is a significant barrier to the widespread use of smart contracts. Because of this need, there may be some coding obstacles. Among blockchain's many fascinating applications, smart contracts stand out. In order to go on to the next transaction, each peer must finish the current one. This is a big slowdown in the transaction execution process This strategy, when executed concurrently, might significantly reduce the system's total footprint while simultaneously increasing its performance. The distributed ledger that combines the blockchain with the state database may be accessed by users using the suggested smart contract. In order to conduct things like generate, edit, and query device data stored in the ledger; users may send transactions to the smart contract. Furthermore, it offers methods for managing the operations that the device suggests, including keeping tabs on sensor data and actuator statuses. To guarantee the integrity of the ledger, every block contains the hash value of the transactions as well as the hash value of the block before it. Because the ledger is dispersed over the network, pretending to change only one peer's hosted copy would fool all the other peers. The four constituent blocks of a blockchain are shown in Figure 1, which is an example of a ledger structure.

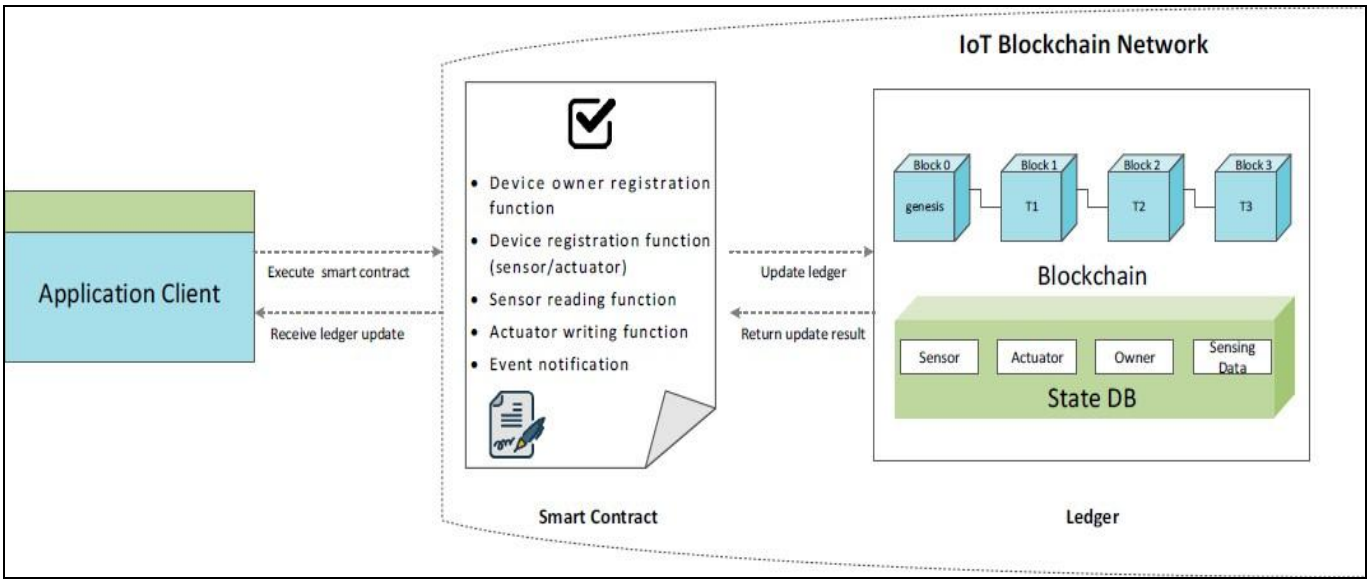

Fig 1: Internet of Things blockchain

IoT Blockchain Platform Execution Plan

As noted, before, in order to participate in the blockchain network and suggest transactions, a user requires credentials. This means that two separate sequence diagrams may cover all of the system's possible ways of execution. Proceeding to the next step requires the owner to confirm their identification, register their device, and enroll in the program. To get their device's unique identification, owners must first register their devices with the blockchain network. The client application registration procedure cannot be completed without the secret key, which is supplied by the identity management module. When a customer goes to request enrolment after enrolling, they will be requested to provide their enroll ID and secret. The public key and enrolment certificate (ECert) are part of the response from the identity management service. A transaction certificate (TCert) may be obtained using an electronic certificate (ECert), and it is necessary to sign transactions using it. After subscribing to the service, the owner of the device will have access to the network's features. The many components of the platform that are being considered could interact with each other in various ways

The owner of a new Internet of Things device is responsible for registering it by providing the necessary details in a client application. The server is unable to finish the device registration process without both this data and the request. This agreement's parameters will be defined by the smart contract. Every node in the network adds to the overall consensus by adding the transaction to the distributed ledger and storing the device's data in its own state database. To complete the process. An immediate answer notifies the buyer that their purchase went through without a hitch when the ledger is updated.

Planned Application of an Internet of Things Blockchain Platform: Because there are three unique components to the proposed platform, three different tables must be created in order to accommodate its development settings. Table 1 below provides a summary of the technology stacks used in the blockchain infrastructure for the Internet of Things that was constructed using Docker. The computer is powered by an Intel Core i5-8500 processor operating at 3.00 GHz and comes with 12 GB of RAM. Version 18.04 of Ubuntu Linux with Long Term Support is the operating system You may now deploy docker images and containers inside of a virtual machine with the help of docker-compose version 1.13.0, which contains both the IDE and the docker OS. An open-source blockchain technology project, Hyperledger Fabric (v1.2) was used by our organization. In charge of this endeavor is the Linux Foundation.

Table 1: Development environment for the IoT blockchain network

Component	Description
CPU	Intel Core i5-8500 @ 3.00GHz
Memory	12 GB
Operating Systems	Ubuntu Linux 18.04.1 LTS
Docker Engine	Version 18.06.1-ce
Docker-Compose	Version 1.13.0
Node	v8.11.4
Hyperledger Fabric	v1.2
IDE	composer-playground
CLI Tool	composer-cli, composer-rest-server
DBMS	Couch DB
Programming Language	Node.js

The Raspberry Pi comes pre-installed with Android Things to make Java programming easier. The server's physical resources, such as a humidity sensor, two LEDs, and a few other things, have been abstracted using CoAP resources. The server is able to identify each resource thanks to its unique Uniform Resource Identifier (URI).

Table 2: Environment for developing Raspberry Pi Internet of Things devices

Component	Description
Hardware	Raspberry Pi3 Model B
Memory	1 GB
Operating Systems	Android Things v0.8
Server	CoAP Server
Resources	Temperature, Humidity, Green LED, Red LED
IDE	Android Studio 3.1.4
Library and Framework	Californium CoAP, HttpURLConnection
Programming Language	Java

The various stacks used in developing the blockchain web application are detailed in Table 3. A server is constructed using the Californium CoAP framework to translate between the two protocols, allowing a web app and an IoT device to communicate in both directions. The program's front end is built using several web technologies, including JavaScript, HTML, and CSS.

Table 3: Development environment for web applications based on blockchain technology

Component	Description
Operating System	Windows 10 Pro 64 bit
Server	Apache Tomcat
IDE	Eclipse Photon (4.8.0), WebStorm (2018.2.3)
Browser	Chrome, Firefox, IE
Library and Framework	Californium CoAP, Notify.js, Bootstrap, jQuery
Programming Language	Java, HTML, CSS, JavaScript

The Smart Space Case Study Procedure and Outcomes

A request to do a job (like "read temperature") from the owner of the connected device is first collected by the Internet of Things server. Perhaps a temperature sensor is the intended recipient of the data once the server has reformatted it. Additionally, a client notice is sent via WebSockets if the value of the sensor above the threshold specified in the smart contract. web services that are accessible via RESTful APIs and may be used to evaluate client snapshots and the replies they provide. After that, the client may ask the REST server to add the transaction to the blockchain network.

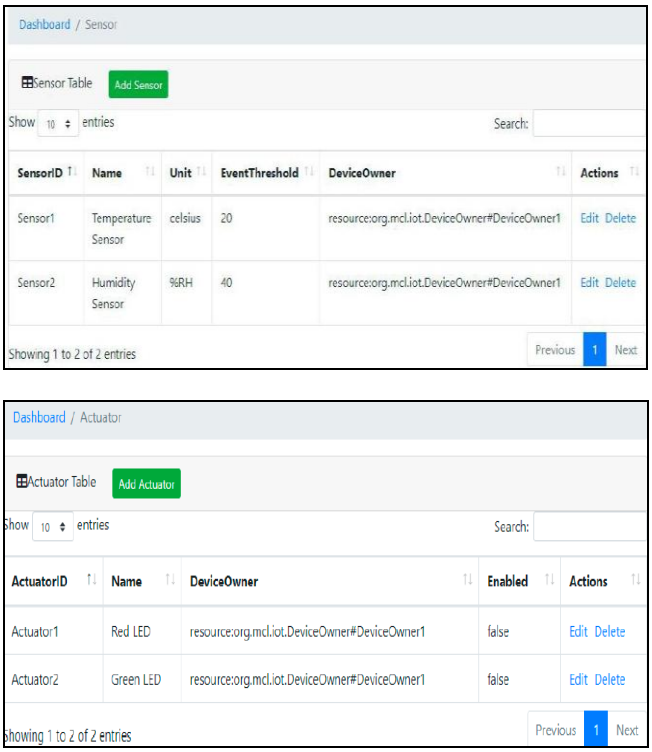

Fig 2: A system of dashboards for sensors and another for actuators

The dashboard, enables users to establish and delegate tasks related to the Internet of Things. The Internet of Things (IoT) gadget makes accessible a service endpoint, and each job has its own unique URI. The request is sent to the actual device when the operation is successfully completed. Any given gadget may have a specific task assigned to it by its owner.

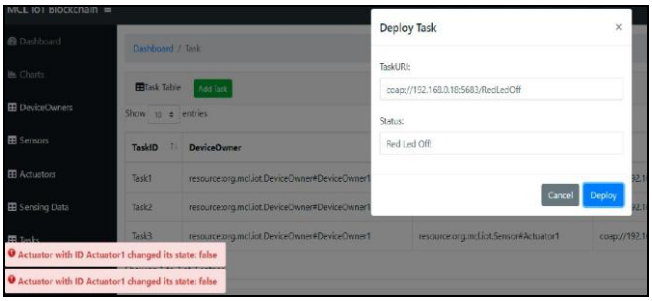

Fig 3: Dashboard.

Conclusion

The Internet of Things (IoT), big data artificial intelligence

technologies, and blockchain technology into the supply chain may help solve the transparency and traceability issue stated in the literature Thanks to the blockchain and the underlying peer consensus, which creates the conditions for trust, a smart contract may operate as a trusted distributed program inside the blockchain ecosystem. Many upcoming breakthroughs fall under the broad umbrella of blockchain technology's potential applications in supply chain management. Blockchain technology has the potential to enhance supply chain operations when combined with AI and Internet of Things (IoT) Blockchain technology provides supply chain management (SCM) with unmatched security and transparency. With blockchain technology, businesses can monitor their products from their inception to their final sale.

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