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REVOLUTIONIZING AGRI-FOOD SUPPLY CHAINS: THE ROLE OF BLOCKCHAIN IN TRACEABILITY AND TRUST

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ABSTRACT— Over the past several years, there has been a significant surge in the usage of Internet of Things (IoT) devices and applications. Consequently, there has been a rise in research and development efforts aimed at creating reliable, verifiable, and easily understood traceability systems in the Agri-Food supply chain. The present condition of IoT-driven solutions for traceability and origin verification in the agri-food supply chain continues to face numerous challenges and risks. This is due to their dependence on centralized platforms, which introduces potential vulnerabilities and dangers to data integrity. Cryptocurrencies like Bitcoin employ a distributed ledger technology called "blockchains," which is an innovative and advanced approach to constructing trustless and decentralized networks. This digital technology exhibits fault tolerance, immutability, transparency, and complete traceability in the recorded transaction records. In addition, we offer dependable digital representations of tangible assets and completely self-governing transactions. Agri Block IoT is a traceability system that use blockchain technology to seamlessly incorporate IoT devices that produce and utilize digital data across the whole food and agricultural supply chain. In order to conduct a comprehensive examination of Agri Block IoT, we initially created a use case that serves as a representative example of the specific vertical market, encompassing the entire agricultural supply chain from farm to consumer. We employed two distinct blockchain technologies, namely Ethereum and Hyperledger Sawtooth, to guarantee comprehensive record-keeping. Ultimately, we analyzed the latency, CPU use, and network usage of each activity, along with their primary advantages and disadvantages..

KEYWORDS: exponential, adoption, Block chains, Ethereum and Hyperledger.

1. INTRODUCTION

Most existing logistical data systems in Agri-Food supply chains primarily function as repositories for orders and as tools for monitoring deliveries. The absence of transparency, authenticity, and auditability is evident. Individuals are increasingly drawn to these alternatives due to their highly probable ability to yield food that is both safer and of superior quality. Several research and development (R&D) teams are diligently striving to incorporate Internet of Things (IoT) technologies such as RFIDs and Wireless Sensor Networks, as well as affordable everyday connected devices, to enable accurate remote monitoring of conditions in food transportation scenarios and throughout the entire Agri-Food supply chain, spanning from production to consumption. The utilization of centralized cloud infrastructures in the majority of IoT solutions presents security issues, including data lock-in, availability, privacy, and auditability concerns.

To ensure trust and reliability in the agri-food supply chain, it is essential that documentation remain uncorrupted. In an optimal scenario, every player involved in a transaction should have the ability to carry it out autonomously. The aforementioned problems could be effectively resolved by the implementation of blockchain technology. It is a distributed digital ledger devoid of a central authority. Every block in a blockchain is immutable as it signifies the consensus of all network participants at the given moment. It is applicable for both audits and research purposes. In an IoT context, the use of sensor networks in a traceability system based on blockchain would just necessitate a robust connection to a nearby peer, rather than relying on a centralized cloud infrastructure. This approach is highly appealing. Block networks enable access to verifiable data across the whole supply chain, satisfying the criteria for decentralized food monitoring systems.

This article is a comprehensive introduction to Agri Block IoT, a decentralized system designed to monitor and trace agricultural goods across the whole supply chain, from the farm to the consumer. The proposed system has the capability to establish connections between several IoT sensor devices and is designed to work seamlessly with the Ethereum1 and Hyperledger Sawtooth2 public blockchain platforms. Agri Block IoT provides transparent and verifiable asset monitoring by collecting and utilizing crucial data from IoT devices throughout the supply chain and storing this data directly in the supporting blockchain. This is a frequent phenomenon in food traceability, and it facilitates the comprehensive and accurate monitoring of food from its origin to the point of consumption. In order to assess the practicality of the suggested approach, we devised a scenario that encompasses the entire process from agricultural production to consumption. Subsequently, the two systems are evaluated by analyzing their latency, CPU consumption, and network throughput.

The subsequent sections of this document are structured as follows: Sec. The second portion specifically examines the utilization of blockchain technology to track the distribution channels within the agriculture and food sectors. Section III provides detailed instructions on the installation process of the Agri Block IoT system. Section IV provides our initial discoveries, whereas Section II delves into more comprehensive explanations. The essay culminates with the letter V.

2. RELATED WORK

In recent years, there has been a surge in blockchain research and development, especially in the FinTech industry. Due to its potential to generate immutable records and instill trust among untrusted parties, this technology cannot be limited to a specific market region. Blockchain technology's potential to fundamentally transform sectors extends beyond FinTech. Prov Chain examined the potential applications of Blockchain technology in a cloud storage setting to guarantee the collection, retention, and verification of three tiers of data origin in order to enhance the reliability of the data. Based on this study, the implementation of block chains yielded favorable outcomes in terms of unchangeable, protected information and user confidentiality, despite a little rise in storage requirements. The authors conducted a study on the feasibility of utilizing blockchain technology and smart contracts to establish secure data provenance. They employed the Open Provenance Model (OPM) and a privacy-preserving access control-based technique for this purpose.

Lately, there has been significant attention towards investigating the impact of Internet of Things (IoT) devices and technologies on supply chain management. The utilization of RFID technology in transportation and the influence of autonomous vehicle identification systems exemplify the transformative effects of advancements in device and sensor technology on the overall process. The authors showcased the use of several IoT devices to enhance the level of transparency in stock-tracking, drawing upon instances from the Agri-Food sector. The objective of this study was to examine the potential use of radio frequency identification (RFID) and near field communication (NFC) devices for facilitating immediate and transparent data exchange at a location, with the data's long-term storage guaranteed by a cloud-based database shared by several users. The majority of current Internet of Things solutions are constructed upon this outdated basis. While the full exploration of the Internet of Things (IoT) and Blockchain technologies is still ongoing, both technologies hold great potential for applications in the food and agriculture sectors. A proposal has been made to use a blockchain and RFID-based system in Chinese supermarkets for the purpose of monitoring the food supply. The study examined the feasibility of utilizing RFID-based sensors to monitor perishable food resources such as meat, vegetables, and fruits. Additionally, it explored the use of blockchain technology to protect the data collected by these sensors. The researchers in this study devised a system for monitoring food safety throughout the production process, utilizing HACCP (Hazard Analysis and Critical Control Points) and a dedication to openness and clarity. The various aspects of crop plant operations, including harvesting and retailing, were addressed, but no performance study was included. Certain fundamental parts of blockchain technology remain unimplemented or unexplored, as far as our current understanding goes. One example of this is the utilization of "smart contracts," which are automated mechanisms for executing transactions.

3. AGRI BLOCK IOT: SYSTEM ARCHITECTURE

In the present agri-food industry, there are multiple obstacles to building a transparent, verifiable, and reliable system for managing the supply chain. These factors encompass, but are not restricted to, the varying levels of privacy and communication limitations inside the systems, as well as the several participants, interests, and economic models that are involved. The management of data is also ambiguous.

a) Suppliers, encompassing those involved in the trade of chemicals, insecticides, seeds, food, and other essential commodities.

b) Producer: A farmer often assumes responsibility for all aspects of production, encompassing activities such as planting and harvesting.

c) Processor: This character possesses the ability to perform a wide range of tasks, including packaging boxes and pressing olives.

d) Distributor: This entity is responsible for transporting the processor's product or other output to retail outlets for the purpose of selling it.

e) retailer: the responsibility of this individual is to sell goods by representing either a small store or a major grocery store.

The consumer represents the ultimate stage in the chain.

Authorities enforce regulations, legislation, criteria, and protocols that are obligatory for all relevant parties to adhere to.

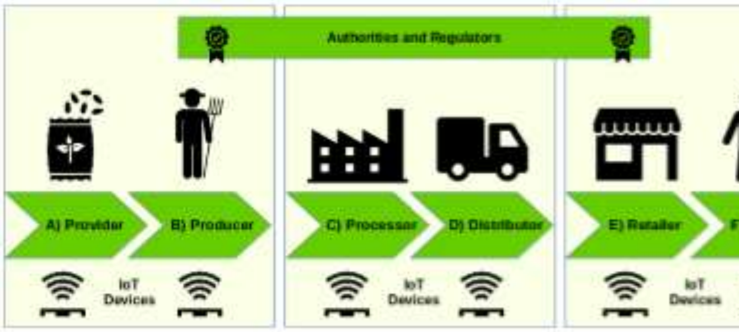

Fig. 1. Simplified version of the Agri-Food supply chain management process.

We implement a multi-tiered structure that leverages blockchain and IoT technologies to guarantee the integrity, traceability, and permanence of documents kept in unreliable locations. Blockchain technology is regarded as a complementary addition to our existing infrastructure (refer to Figure 2). Agri Block IoT is capable of interfacing with your current ERP, CRM, and other tools, as it does not depend on blockchain technology.

Gateways, mini-PCs, and other state-of-the-art peripherals are gaining popularity at an increasing rate. The proposed architecture capitalizes on this opportunity by incorporating these nodes as complete members within our multi-tiered blockchain network. This enhances the dependability, accessibility, distribution, and protection of the network. The Agri Block IoT possesses the following key attributes:

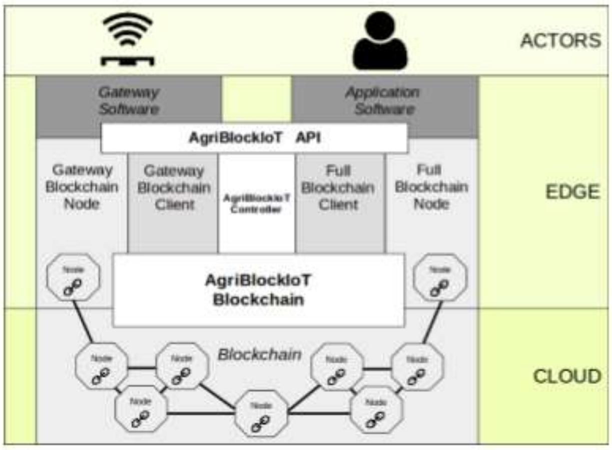

Fig. 2. Layered architecture of Agri Block IoT. The upper layer interacts with the blockchain layer, which subsequently retrieves and converts low-level data records into high-level data.

Blockchain:

The fundamental mechanism for connecting to the blockchain is constructing it with smart contracts that govern all business logic. The intricacy of this module will be contingent upon the software and client interface characteristics of the blockchain.

We employed a bottom-up approach to identify the set of requirements from a comprehensive use case known as "farm-to-fork." This use case promotes the implementation of certified food traceability throughout the whole supply chain, from production to consumption, in order to establish the top-level capabilities of Agri Block IoT. Consequently, by utilizing Agri Block IoT, buyers will have comprehensive knowledge about the products they buy. In order to digitally sign each transaction on the distributed ledger, all parties must be registered users of the underlying blockchain and possess the necessary public and private key pairs. The incorporation of IoT devices is assured. Merely performing this action will enough. These are the fundamental elements we have collected::

Raw Materials Purchasing:

A blockchain is employed to document transactions, encompassing the procurement and sale of raw materials, as well as technical data and inventory quantities of both finished products and their constituent parts. Examine the potential benefits of incorporating intelligent tags, such as barcodes and QR codes, into this approach.

Planting:

Agricultural practitioners employ blockchain technology to document essential information, such as the precise amount of seeds sown and reaped. The process of data entering can be mechanized by utilizing sensors, such as the ones commonly found in weighing scales. Smart contracts have the capability to operate autonomously and record issues, such as instances where a greater amount of seed was bought than first stipulated.

Growing:

At regular intervals, sensors collect data on the environment and the growth of plants, which is then stored on the blockchain. It is important to note that smart contracts can be activated independently, which might lead to problems like unreliable sensor data.

Farming:

During the growing process, farmers record data on the blockchain at different time intervals, documenting the quantity of water, fertilizer, and other inputs utilized. In essence, the utilization of sensors like chemical sensors and multisensory systems can streamline the process of inputting data, while smart contracts can expedite the generation of records in the event of abnormal events, such as sensor values exceeding predetermined thresholds.

Harvesting:

Harvest records stored on the blockchain are readily accessible to farmers. It is worth emphasizing that the use of sensors, such as interconnected scales, can automate the process of entering this data. Additionally, smart contracts can operate independently to guarantee the adherence to organic, fair trade, and other necessary standards at every stage of the process, from planting to harvesting.

Delivery to processor:

Through the utilization of blockchain technology, farmers are now able to grant shops complete ownership of their produce. It is important to note that smart contracts and sensors, especially GPS sensors, have the capability to manage or record any problems that occur during the delivery process, such as sensor readings that do not exceed the predetermined limits.

Processing:

At its simplest form, a packaging processor would utilize a blockchain to monitor the quantity of wholesale products received, the quantity of goods packaged, and the quantity of goods lost throughout the packaging procedure. It is imperative to bear in mind that smart contracts have the capability to automatically generate logs upon detecting errors, such as when the payment amount surpasses the received amount. Additionally, sensors can assist with data entry, for instance, by utilizing connected scales to measure weights.

Delivery to retailers:

The blockchain enables processors to effortlessly transfer ownership of processed commodities to distributors. In the event that faults are detected during the delivery phase, such as sensor data failing to satisfy the prescribed requirements, smart contracts and sensors (e.g. GPS sensors) have the capability to automate or uphold records.

Retailing:

Retailers log the quantity of items received from suppliers on the blockchain. Subsequently, sensors positioned throughout the store consistently and rapidly update the blockchain with data regarding the status of the company's activities. It is important to note that smart contracts can be activated independently, which might lead to problems like the presence of imprecise sensor data.

Consuming:

Given that the blockchain maintains a comprehensive log of all transactions, individuals have the ability to examine the complete transaction history of a product prior to making a purchase. It is important to highlight that intelligent labels can be affixed to each shipment, enabling clients to promptly get data.

4. PRELIMINARY RESULTS

We evaluate Agri Block IoT based on its ability to effectively include the features of IoT sensing devices that provide real-time blockchain storage of digital values. Subsequently, the data can be accessed and merged with sensor data to generate intelligent agreements that automatically execute upon meeting specific conditions. The major blockchain module was built using two private blockchain implementations, Ethereum and Hyperledger Sawtooth, consisting of six nodes each. This decision was made due of Agri Block IoT's indifference towards blockchain technology. This choice was selected because to the abundance of techniques available for customizing ledger entries, sometimes referred to as transactions, to specific requirements. Both Hyperledger Sawtooth and Ethereum support the creation of intricate business logic. However, Ethereum only permits customisation of a singular type of transaction structure.

Each network was isolated within its own virtual machine, equipped with two 2.60GHz Intel(R) Core(TM) i5-6440HQ processors, four gigabytes of RAM, and twenty gigabytes of storage capacity. For our operating system on the Linux platform, we opted for Ubuntu 16-04, the latest stable release. The blockchain node was configured with the essential software components necessary for its operation. A total of one hundred tests were conducted consecutively for each scenario. Agri Block IoT efficiently updated the sensor value in each experiment by utilizing an IoT device to collect data from environmental sensors and transmit that data through a gateway, resulting in the creation of a blockchain transaction. Table I demonstrates that, on average, Hyperledger Sawtooth surpasses its Ethereum equivalent in terms of performance. We conducted measurements of network traffic, specifically the amount of bytes delivered and received, as well as the duration it took to establish the value in the blockchain, referred to as latency.

TABLE I

PERFORMANCE OF AGRIBLOCKIOT IN TERMS OF LATENCY, NETWORK TRAFFIC, AND CPU LOAD.

	latency [seconds]	network tx [bytes]	network rx [bytes]	CPU load [%]
Ethereum	16.55	528'108	682'415	46.78
Sawtooth	0.021	19'303	20'641	6.75

5. CONCLUSION

Agri Block IoT combines Internet of Things (IoT) and Blockchain technology to establish a traceable, transparent, and resilient system of information. The information can be utilized to establish an agricultural and food monitoring system. The initial test demonstrated the superior performance of the Hyperledger Sawtooth-based implementation compared to the Ethereum-based implementation. However, it is crucial to thoroughly evaluate the advantages and disadvantages of both solutions before reaching a final conclusion. For certain purposes, it may be advantageous to sacrifice Ethereum's significant delay in favor of its expansion and dependability, as it enables a larger number of individuals to engage and possesses a significantly more advanced development framework compared to Hyperledger Saw. It is important to note that there are no costs associated with becoming a member of the Ethereum network if you connect over a private network. Nevertheless, the limitations of smart contracts, such as the requirement for a single language implementation and a single data storage format, might pose challenges when designing intricate business logic. The current Ethereum consensus method's intensive CPU demands may pose difficulties for low-powered routers and peripheral IoT devices. Conversely, the Hyperledger Sawtooth version offers a consensus mechanism that may be more appropriate for these little machines. Reducing development timeframes and system integration issues should be possible by enabling developers to build logic and modify data using many programming languages. Hyperledger Sawtooth is still in the process of development and does not now possess the comprehensive capabilities of Ethereum.

Subsequent investigations will examine the efficacy of the suggested framework for practical Internet of Things (IoT) devices and ports in the Agri-Food supply chain. This will be accomplished by evaluating its performance on a broader spectrum of hardware setups.

REFERENCES

1. C. Verdouw, H. Sundmaeker, F. Meyer, J. Wolfert, and J. Verhoosel, Smart agri-food logistics: requirements for the future internet, in Dynamics in Logistics. Springer, 2013, pp. 247–257.
2. M. Armbrust, A. Fox, R. Griffith et al., A view of cloud computing,Commun. ACM, vol. 53, no. 4, pp. 50–58, 2010.
3. X. Liang, S. Shetty, D. Tosh, C. Kamhoua, K. Kwiat, and L. Njilla, ProvChain: A blockchain-based data provenance architecture in cloud environment with enhanced privacy and availability, in Proc. of the CCGRID, 2017, pp. 468–477.
4. A. Ramachandran and K. Murat, Using blockchain and smart contracts for secure data provenance management, arXiv preprint arXiv:1709.10000, 2017.
5. D. McFarlane and Y. Sheffi, The impact of automatic identification on supply chain operations, The International Journal of Logistics Management, vol. 14, no. 1, pp. 1–17, 2003.
6. C. Sun, Application of RFID technology for logistics on Internet of Things, AASRI Procedia, vol. 1, pp. 106–111, 2012.
7. S. Srinivasan, D. Shanthi, and A. Anand, Inventory transparency for agricultural produce through IoT, IOP Conf. Ser.: Mater. Sci. Eng, vol. 211, no. 1, p. 012009, 2017.
8. F. Tian, An agri-food supply chain traceability system for china based on rfid and blockchain technology, in Proc. of the ICSSSM. IEEE, 2016, pp. 1–6.
9. F. Tian, A supply chain traceability system for food safety based on HACCP, blockchain and Internet of Things, in Proc. of the ICSSSM, 2017, pp. 1–6.
10. C. Brewster, I. Roussaki, N. Kalatzis, K. Doolin, and K. Ellis, IoT in Agriculture:

Designing a Europe-Wide Large-Scale Pilot, IEEE Commun. Mag., vol. 55, no. 9, pp. 26–33, 2017.