International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 3
DOI: https://doi.org/10.17762/ijritcc.v11i3.6342
Article Received: 01 January 2023 Revised: 30 January 2023 Accepted: 12 February 2023

Analysis of IoT and Blockchain Technology for Agricultural Food Supply Chain Transactions

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Abstract— The Block chain is a peer to peer, distributed ledger in which members must establish consensus to record every new input and transactions that are stored by all members. Over the last decade, block chain technology has grown in popularity, attracting interest from a wide range of industries, including finance, manufacturing, energy, and government sectors, health, and agriculture supply chains, land registrations, and digital identifications (IDs). Block chain facilitates better opportunities and benefits in agriculture, as well as building trust between farmers and consumers and allowing the creation of reliable food supply chains. The Chapter discusses how block chain and smart contracts can improve productivity, transparency, and traceability in agricultural insurance, smart farming, and agricultural food supply chain transactions (AFSC). By applying Block chain agri-food supply chain tracking was made easy and won the trust from different stakeholders, which was a real benefit to the real heroes of the country. The consumer can research the history of a product they are thinking about buying and consume food in their cart, learning about the entire process from planting to harvesting, transporting, and selling. Food fraud may be reduced by using the traceability and integrity of financial information to detect untrustworthy intermediaries and business practices that exploit both independent farmers and cooperatives. The agricultural industry will be transformed by block chain for supply chain management. All phases of the agriculture supply chain are being simplified, enhancing food safety and preventing the sale of counterfeit goods. Access to agricultural finance services for farmers and companies could also be facilitated by the technology. This Paper presents a review and research challenges on the existing block chain based IoT applications in the agriculture domain where maximum research focuses on food supply chain and its security of Internet of things with Block chain. The chapter presents how block chain and smart contracts can increase productivity, transparency and traceability could be very effective in Agricultural insurance, smart farming, transactions of agricultural food supply chains.

Keywords— Blockchain, Internet of Things (IoT), Ethereum, Agriculture, Smart contract, Supply Chain management.

I. INTRODUCTION

As we know, India's major occupation is agriculture. Agriculture is the backbone of a nation's economic system, and it is the major activity of the country. It serves as a source of raw materials for a variety of secondary businesses. IoT and Blockchain technologies are being incorporated into conventional farming operations to allow smart agriculture practices for farmers, who are the real heroes of the country. Smart farming is a means of incorporating IoT technology to ensure the most efficient use of resources in order to optimize agricultural yields while lowering expenditures. Specialized equipment like sensors, wireless connections, software, and IT services are all part of the Internet of Things in agriculture.

Using IoT in agriculture can decrease manual labor with automation and also increase the profit margins. With remote and real time monitoring from smartphones and wireless devices can

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minimize the cost and travel time. At anytime and anywhere farmers can do power on and off to monitor water, and also track the resources in real time, and enhance the asset in time expenses, workers, health etc. [1]

Benefits of drones in agriculture is used to improve a wide range of agricultural processes, including crop health evaluation, irrigation, crop monitoring, crop spraying, planting, and soil and field research. Drone remotely sensed data information gives field variability that is imperceptible to the naked eye, allowing farmers to detect illnesses early, respond quickly, and boost productivity [2]. Farmers have begun to recognize that the Internet of Things (IoT) is a driving factor in enhancing agricultural productivity in a cost-effective way [3].

II IoT (INTERNET OF THINGS)

Kevin Ashton created the term "Internet of Things" in 1999. It is defined as a global network of linked physical objects also known as "things", which are capable of gathering and transferring data without the need for human intervention. Embedded systems like software, electronics, networks, and sensors are often used in these devices to collect data about the environment, communicate data over a network, respond to remote instructions, and execute actions depending on that data [4]. Wearables, implants, automobiles, machines, cellphones, appliances, computer systems, and any other object that can transmit and receive data are all examples of IoT devices or things accessible today.

a) Features of Internet of Things:

The Internet of Things feature is to connect different IoT platforms to collect the data and Analyze the data which is collected, then that data is integrated. Features of Internet of Things illustrated in Fig.1.

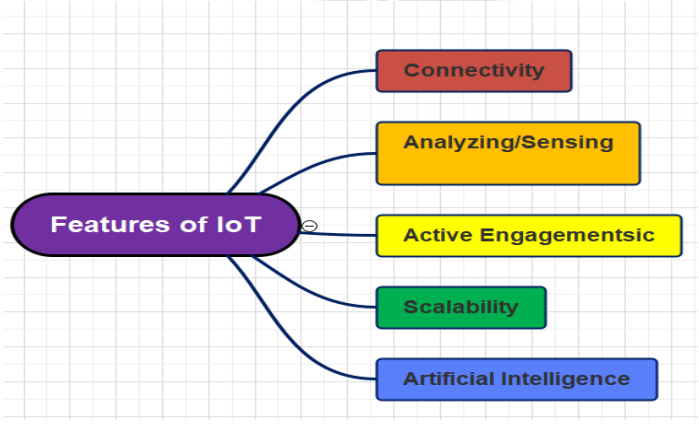

Fig:1. Features of IoT

Connectivity:
The most crucial part of IoT is connectivity. Without flawless communication among the interconnected parts or devices, the IoT ecosystem like sensors, compute engines, data hubs, etc. cannot function correctly. Radio waves, Bluetooth, Wi-Fi, and Li-Fi are all options for connecting IoT devices.

Analysing/Sensing:
The next stage is to evaluate the data that is being collected and apply it to develop efficient business intelligence when all of the necessary objects have been connected. Extracting information from the collected data is critical. For example, a sensor creates data, but then that data is useless unless it is correctly understood by humans. [6]

Active Engagements:
A major amount of today's interactions with connected technology is passive involvement. Through the Internet of Things, many items, cross-platform technologies, and services interact on an active engagement basis (with each other). All the collected data from various sources stored securely. In general, blockchain's use of cloud computing enables active interactions between IoT components as they interconnect with each other.

Scalability:
Increasingly elements are connecting to the IoT region everyday. As a result, IoT systems should be able to manage significant expansion. The amount of data created as a consequence is enormous, and it must be properly managed.

Artificial Intelligence:
AI is supporting IoT in its implementation. For example, the Internet of Items (IoT) uses data collecting, artificial intelligence algorithms, and networked technology to make things more convenient and improve people's lives. For instance, if the coffee machine's beans were just about to run out, it will place an order for coffee beans from the merchant of your choosing. [7]

b) The various IoT components

The four basic components illustrated in Fig.2 of an IoT system includes

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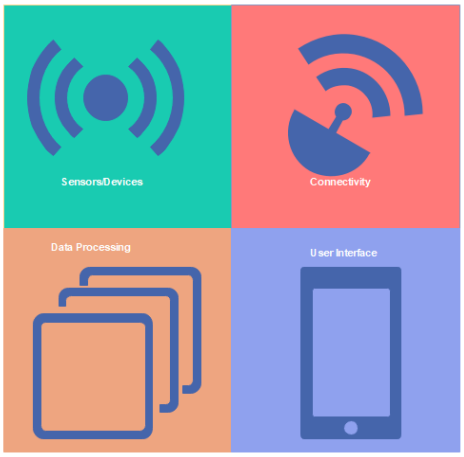

Fig.2. IoT Components

IoT Sensors / IoT Devices**:**
In IoT, the Sensors or small devices are essential components for collecting generated data from the environment. All the collected information having different levels of complexities might be difficult in some way. It might be as basic as a temperature monitoring sensor or as complex as a video-stream.
Connectivity:
The collected sensor's data should be transferred to the cloud server via a different communication data channel, for example Mobile or satellite networks, Bluetooth, WI-FI, WAN, etc.
Data Processing:
The data has been processed by a software programme which is collected by the sensors and transferred to the cloud. This is as simple as monitoring the readings of temperature of air conditioners or heaters. However, some tasks, such as recognizing objects using computer vision on video, may be rather tough. [8-9]
User Interface:
A User Interface is where an IoT device communicates with a user. A user interface is
the visible and tactile part of an IoT system that users can interact with. It comprises presenting information in a way that benefits the user. The data must be made available to the end user in some form, which may be done by sending text messages, email alerts or alarms on their cell phones and notifications.

c) The advantages of IoT

As illustrated in Fig.3. Advantages of IoT, like Improved security measures, increase in number of customers, optimization of Technology, growth in new business opportunities, Effective time management, ease of access.

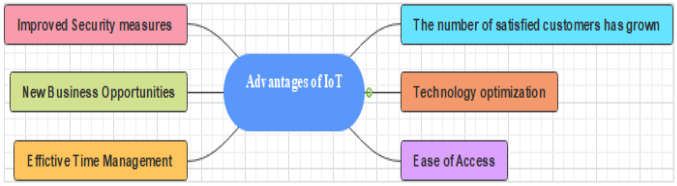

Fig.3.The Advantages of IoT

- The number of satisfied customers has grown. By automating tasks, the Internet of Things makes for a better customer experience. Any problem in an automobile, for example, in a vehicle like a car will be identified automatically by sensors. Both the driver and the manufacturer will be alerted.[10-11]
- Technology has developed and become more efficient as a result of the Internet of Things, which has made even ancient "dumb" gadgets "smart" by allowing them to send data via the internet, allowing them to communicate with people and other IoT-enabled equipment. Coffee machines, smart toys, smart microwaves, and other smart devices are examples for technical optimization
- The Internet of Things has now made it possible to access real-time data from anywhere, anytime. All you need is an internet-connected smart device, i.e Ease of Access.[12]
- The judgments are made based on superficial data, but IoT gives real-time data that leads to more effective resource management.
- Improved Insights like judgments based on superficial information, but IoT gives real-time data that leads to more effective resource management.
- The new business insights and develop new opportunities while reducing operational expenses by collecting and analysing data from the network.
- The Internet of Things can help a lot of time in the long run with Effective Time Management. For example, the latest news on phones, peruses a blog about our favourite activity, or purchase online while commuting to work.[13]

III. INTERNET OF THINGS IN SMART AGRICULTURE

Smart agriculture monitors the field environment, analyses crop development, and provides information to farmers for decision-making using modern technologies such as the Internet of Things (IoT), big data, and cloud computing. As illustrated in Fig.4 depicts an information-based management cycle for smart agriculture. [14-15]

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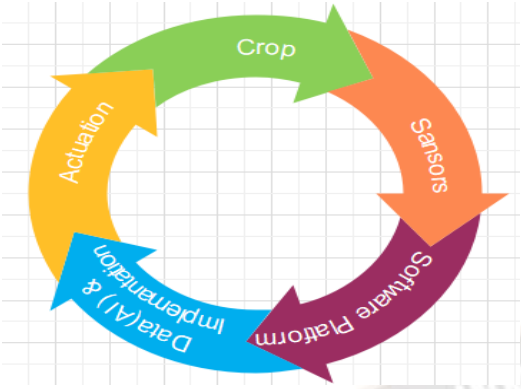

Fig:4. A management cycle based on information for smart agriculture.

Implementing IoT applications with novel technologies in agriculture enables forward-thinking organisations to boost yields while also improving food quality, safety and delivery. Figure 4: Sensors, gateways, and modules work together to gather and analyse accurate real-time data for more informed choices, cost reduction, and faster regulatory compliance on anything from crop production monitoring to water management, farm-to-fork regulatory compliance, and more.

IV. BLOCKCHAIN TECHNOLOGY

The Blockchain is a peer to peer, distributed ledger of accounts and transactions that are stored by all participants. In 2008, Satoshi Nakamoto introduced the Blockchain technology along with Bitcoin. [5]. The Components of a Blockchain illustrated in Fig.5.

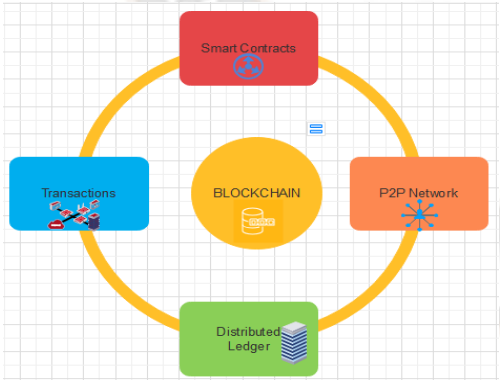

Fig. 5. Components of a blockchain

Types of Blockchain

There are also other sorts of Blockchains based on their use and distinguishing characteristics,as shown in Fig.6. Table 1. shows the different types of blockchain.

1. Public blockchains:
2. Private blockchains
3. Consortium blockchains

TABLE 1. Types of Blockchain

Public	Private	Consortium
Decentralized	Restricted	Controlled and restricted
Less Flexibility	Flexibility	More flexibility
Permissionless	Permissioned	Permissioned
PoW, PoS, DPoS	PBFT, RAFT	No
Bitcoin, Ethereum, Monero,Dash, Litecoin	MONAX, Multichain	R3(Banks), EWF(Energy), B3i (Insurance), Corda

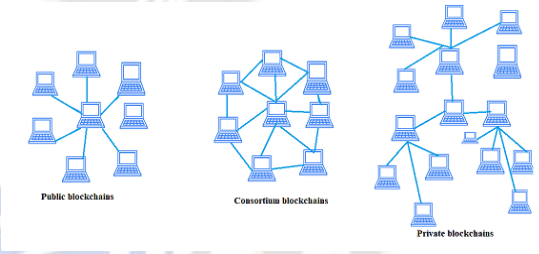

Fig. 6. Types of a Blockchain

How blockchain networks work

In Blockchain, every transaction is recorded as a “block” of data. These blocks form a chain, known as Blockchain as an entity travels from one node to other validating the exact time and the number of transactions. Every transaction in the blockchain is securely linked to prevent any block from it being moved or placed between two others, as shown in Fig.7. If a transaction record contains an error, a second transaction must be created to remedy the issue, and both transactions must be available. Each subsequent block confirms the verification of the previous block, and conforms to the verified blockchain [6].

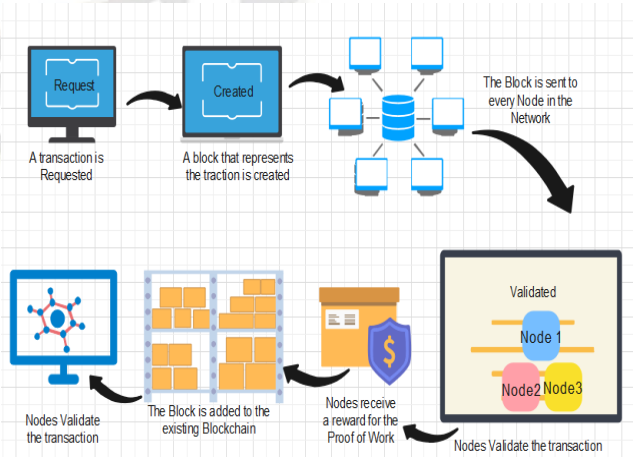

Fig.7. Working of Blockchain

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V. BCoT(BLOCKCHAIN IoT)

Blockchain technology has grown in popularity over the last decade, attracting interest from a variety of industries including finance[15], entertainment, manufacturing, energy and government sectors[16] ,health-medical[17] , real-estate and also used in relation to agriculture supply chains, land registrations and digital Identifications (IDs).Blockchain facilitate a better opportunities and benefits in agriculture, as well as building trust between farmers and consumers and creation of reliable food supply chains[19-20] .The chapter presents how blockchain and smart contracts can increase productivity ,transparency and traceability could be very effective in Agricultural insurance, smart farming, transactions of agricultural food supply chains(AFSC).

By applying Blockchain agri-food supply chain tracking was made easy and won the trust from different stakeholders, which was a real benefit to the real heroes of the country.

The consumer can check the history of the product they are considering purchasing and consume food in their cart and will know the whole process from planting, to harvesting, transporting and selling. Food fraud may be reduced by using traceability and integrity of financial information to detect untrustworthy intermediaries and business practises that exploit both independent farmers and cooperatives [19].

Data is collected at all phases of plant and produce production, from planting to harvesting to selling and shipping, so that customers may learn about the history of the food they are purchasing.

Implementing a blockchain system capable of connecting IoT devices and preserving data for transparency and accessibility may encourage faith in the country's true heroes, i.e. farmers-to-consumers [7]. This whole-chain traceability idea will enable trust in food safety and quick sensing of food degradation and its reorganization, food mislabeling, and food contamination, which are critical components of the food industry ecosystem.

Agri-BlockIoT, a blockchain system that can incorporate IoT devices and store data for dependability and traceability, was discussed in [8]. Data is collected at all phases of plant and produce production, from planting to harvesting to selling and shipping, so that customers may trace the origins of the food they are purchasing. An experiment was carried out to examine the latency, CPU, and network use of Ethereum with Hyperledger Sawtooth. The results indicated that Hyperledger Sawtooth is more efficient and suited for IoT devices than Ethereum since it requires less CPU and has lower latency. Aside from performance, there are additional factors to consider while selecting a blockchain platform. Because of the greater number of participants, Ethereum, for example, is more dependable, than Hyperledger Sawtooth.

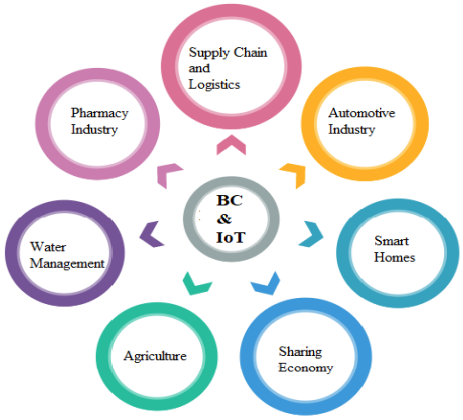

Fig: 8. Applications of blockchain IoT

Supply Chain and Logistics

Many parties are involved in a worldwide supply chain network, including traders, feedstock providers, etc. [10]. As illustrated in Fig8, the supply chain makes end-to-end visibility more difficult, and it can potentially span months and include numerous payments and invoices. The biggest challenge is delivery delays, as there is involvement of multiple stakeholders.

As a result, corporations are attempting to make vehicles IoT-enabled so that movement can be tracked throughout the shipping process. With the present supply chain and logistics' lack of transparency and complexities, combining Blockchain with IoT can Sensor data is subsequently recorded in the blockchain, which improves the network's integrity and transparency.

Agriculture Sector

Cultivating food for the growing population while minimizing environmental impacts and guaranteeing supply chain transparency is critical for optimal customer satisfaction.

The combination of blockchain and IoT has the ability to completely transform the food processing industry, i.e. getting directly from farm to the nearest grocery store and again from store to house. Deploying small IoT sensors in fields and transferring the data straight to the blockchain can assist to improve the cultivation of the food chain. [21]

VI. BLOCKCHAIN IN AGRICULTURE

On the basis of blockchain technology, a new system architecture [14] proposed for something like the complete food grain supply chain was presented. And also a multimode storage mechanism that integrates chain storage to achieve transparency regarding the state

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of products, resulting in a stronger interaction between the producer and the customer. All of the procedure is transparent to the farmers and officials engaged in the transportation by keeping the details in the blockchain, illustrated in Fig.9.

The goal of [21] is to develop a blockchain-based architecture grain proper inventory management control system, to realize the management and privacy protection of different roles. And also new technique is introduced to increase the storage capacity, by adding of chain storage with a distributed database known as multimode storage with multilevel backup. Smart contracts used for reading and writing of data to improve reliability and decrease the risk of business data and danger information.

AgriBlock IoT is decentralized traceability blockchain, introduced by [22] developed the Agri-Food supply chain, capable of integrating smart IoT devices that produce and consume digital information along the chain, to achieve traceability and analyzed two blockchain i.e. Ethereum and Hyperledger, in terms of network utilization, response time, CPU, as well as their primary advantages and disadvantages.

Hua J et al. [23] The dependability of data and the integration of information systems of diverse entities are two main challenges in agricultural traceability systems. These issues are addressed in [22], which proposes a decentralized peer-to-peer network. The writers create two key structures in the agriculture traceability system: basic planting information and an origination record.

Fig.9.Blockchain in agriculture [24]

The current research trends and new challenges are to determine the economic applications and organizational impact on agricultural supply chains using blockchain, for this, it needs empirical data [26] which gets from IoT devices. The IoT and blockchain relationship is great, as IoT generates a huge amount of data and blockchain makes data secure [27]. The credibility of the blockchain technology is mainly authenticity and transparency [28].

W. Lin et al [29] FTSCON, an integrated food trading system using consortium blockchain, was established to allow inexpensive and simple trade of agricultural goods in China.

when several collaborators are participating in a project, the agricultural research sector, is advocating for more transparent methods to boost confidence in research findings. The Food Science Research Society, for example, suggests using blockchain to record and exchange obtained research information.

Brewster et al. [30] evaluated the development of large-scale IoT trials in agriculture. Ray et al. [31] offered a rigorous assessment on IoT adoption for better farming. Recently, studies explored the essential structures of IoT and their influence on IoT-blockchain based agriculture.

Farmers are able to boost crop yields, optimize irrigation efficiency, and reduce agricultural expenses development of smart agriculture based on IoT technology [32].

Derhab et al. [34] proposed two security elements. BICS is a blockchain-based integrity checking system, whereas IDS is an intrusion detection system. These two technologies are linked to form the SDN-architecture (software-defined networking), which may be utilized in IoT-based agriculture to ease software and hardware upgrades while also allowing for easy control and management from a centralized location. A blockchain-based secure SDN architecture is being used to identify any fake injection data.

The paper [35] reviewed, working of blockchain in the agricultural domain by recording and tracking data. It also specified four aspects for food safety like enhancing the features like traceability, lucidity, financial aid is reduced, and also illustrated about the case study of Walmart pork traceability system where blockchain used for traceability of food in agri-foods.

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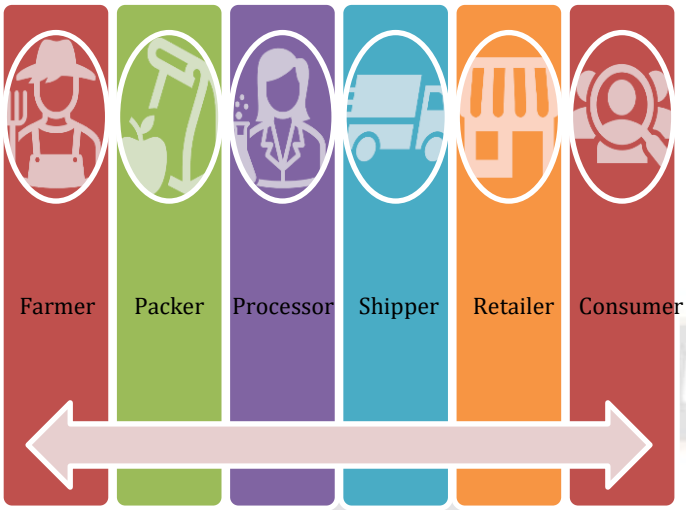

Fig. 10. The blockchain technology may be able to track data across various parties.

The highly functional principle of blockchain for data recording and tracking is outlined briefly in this chapter. The present blockchain applications on agri-foods are analyzed in terms of collaborative models, shown in Fig.10. Moreover, four areas of using blockchain to improve the safety and quality of agri-foods are discussed: increasing data transparency, achieving data traceability, improving food safety and quality monitoring, which in fact lowering financial expenditures.

A traceability system, commerce and delivery techniques, and a reputation system for ensuring entity credibility, and an autonomous transaction system were proposed [31]. IPFS-Interplanetary File Storage System contains data of all transactions with the hash value stored in blockchain to ensure the secure, efficient, reliable approach. It performs a detailed vulnerability assessment, robustness and ensures security against malicious attacks.it achieved the desired properties like accountability, credibility, auditability, autonomy, and authenticity.

VII CONCLUSION

An overview of the literature on the use of IoT and blockchain technologies in the agricultural, food, and supply chain management industries is presented in this study. A detailed review on current research trends in the agricultural supply chain and its challenges.And also examined many important problems in the present usage of IoT with blockchain-related technology in agricultural applications and Scalability, interaction with existing legacy systems, security, and privacy are among the concerns.we provided a comprehensive survey on existing current IoT and blockchain based agricultural applications, innovations and advancements. scalability, integration of IoT with blockchain in existing legacy systems for security and privacy are some of the challenges in the present use of IoT with blockchain technologies in agricultural applications.

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