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Unlocking Transparency: Examining Blockchain-powered Agri-Food Traceability Systems

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ABSTRACT : Agri-food supply chains often suffer from a lack of transparency, hindering consumer trust and efficient response to food safety issues. Consumers are increasingly demanding greater transparency in the food they purchase. By using a decentralized and immutable ledger , blockchain can track the movement of food products from farm to fork, offering unprecedented visibility into origins, processing, and distribution. This paper analyses how Blockchain's distributed ledger technology can empower consumers with reliable information about food provenance, sustainability practices, and safety certifications and also explores the potential of blockchain technology to revolutionize agri-food traceability. The research highlights the potential for increased consumer trust, informed decision-making, and a shift towards more ethical food systems and also analyses the technical considerations, stakeholder collaboration, and the impact on supply chain efficiency and data integrity. Findings offer valuable insights for researchers and practitioners seeking to leverage blockchain technology for improved agri-food traceability and transparency.

KEYWORDS: Agri-Food Supply Chain, Blockchain Technology, Traceability, SHA-256 algorithm.

I.INTRODUCTION

AGRI-FOOD SUPPLY CHAIN

With its smooth connection between farmers and consumers, the agricultural supply chain is the backbone of the complex global food production and distribution system. From agriculture to harvest, transportation, processing, and finally delivery to end users, this intricate network consists of a number of interrelated steps. In addition to satisfying the needs of an expanding population, the agricultural supply chain is essential for forming political and social environments as well as promoting environmental sustainability. Every person in this chain, from those who plant the seeds to those who deliver the finished goods to our meals, makes a unique contribution to the complex dance of resource management, technological integration, and logistical effectiveness. A more resilient and sustainable food production system is the goal that drives constant innovation and change in the dynamics of the agricultural supply chain. It is essential to comprehend and optimize this supply chain in order to minimize waste, guarantee food security, and meet the difficulties brought forth by a world that is changing quickly.

BLOCKCHAIN TECHNOLOGY

Blockchain technology has become a disruptive force in the field of digital innovation, offering unmatched security, transparency, and decentralization. Fundamentally, blockchain is a distributed ledger that securely and impenetrably records transactions via a network of computers. Blockchain functions on a decentralized architecture, guaranteeing that no one entity has control over the entire network, in contrast to previous centralized systems. The primary advantage of block chain technology is its capacity to generate an unchangeable and visible ledger, wherein each data block is connected to the one before it via a cryptographic hash, so establishing a chain of information. This improves the data integrity as well as fostering a high level of participant trust. Blockchain technology was first created to support cryptocurrencies like Bitcoin, but it has now expanded beyond its original purpose and found use in a wide range of sectors, including supply chain management, finance, and healthcare. Blockchain is revolutionizing our

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understanding of trust, security, and value exchange in our increasingly digital environment by acting as a catalyst for innovation.

TRACEABILITY

The ability to track and trace the origin, path, and transformation of items and information throughout their lifecycle is known as traceability, and it is a key notion in many businesses. It is essential to maintaining accountability, transparency, and quality control. In a time when consumers' worries about sustainability, safety, and authenticity are on the rise, traceability systems provide a potent way to boost supply chains' credibility. Traceability helps stakeholders locate product origins, spot any problems, and react quickly to recalls or concerns in the food, pharmaceutical, industrial, or other industries. In addition to improving product safety, this degree of transparency gives companies and government agencies the ability to streamline operations, cut down on waste, and make wise choices. Traceability is becoming increasingly important as global connectivity and technology develop, influencing how we monitor and control the movement of information and things across different domains.

II.LITERATURE REVIEW

Dutta Pankaj [1] et al. According to the theory put forth in this paper, blockchain technology combines a number of distinctive properties, including a distributed note-taking and storage system, a consensus algorithm, smart contracts, and asymmetric encryption, to guarantee network security, visibility, and transparency. Blockchain offers enormous potential to change several aspects of the supply chain (SC), including security improvement, business process reengineering, and SC provenance. Many researches investigating the application of blockchain in SCs have surfaced. In this paper, we analyze all important research conducted in the field related to the usage of block chain integration in SC operations, taking into consideration a total of 178 papers. We draw attention to the associated opportunities, potential social effects, state-of-the-art technology at the moment, as well as significant trends and difficulties. We look at a number of industries that can be effectively transformed with block chain-based technologies through improved visibility and business process management, healthcare, agriculture. It can be used in a plethora of industries, such as creating smart contracts to detect financial fraud or safely transferring patient data between medical providers.

Feng Huanhuan [2] and others. As suggested in this article, traceability is essential to managing food safety and quality. Some traceability systems offer workable solutions for food supply chain quality monitoring and traceability. Nevertheless, the majority of IoT solutions rely on the centralized server-client architecture, which makes it challenging for customers to obtain all transaction data and trace the provenance of goods. Blockchain is a cutting-edge technology that offers complete transparency and security, which has a tremendous potential to improve traceability performance. Nevertheless, the research now in publication does not adequately examine the advantages, difficulties, and development strategies of blockchain-based food traceability systems. Therefore, this paper's main goal is to review the features and characteristics of block chain technology, identify block chain-based solutions for resolving food traceability issues, highlight the advantages and difficulties of implementing block chain-based traceability systems, and assist researchers and practitioners in using blockchain-based food traceability systems by offering an architecture design framework and a suitability application analysis flowchart.

Kamilaris Andreas [3] et al. This paper proposes that Blockchain, an emerging digital technology that has been advocated in this system, enables widespread financial transactions between dispersed, untrusted individuals without the need for middlemen like banks. This article looks at how blockchain technology is affecting the agriculture and food supply chain. It provides current projects and initiatives, talks about their general implications, prospects, and obstacles while taking a critical look at how mature they are. Our research shows that block chain is a potential technology for a transparent food supply chain, and there are many initiatives that addresses various food items and its issues. However, there are still many obstacles and difficulties that prevent blockchain from becoming widely used by farmers and systems. Technical issues, education, legislation, and regulatory frameworks are all involved in these challenges. In order to create a reliable and trustworthy environment for transparent and sustainable food production and distribution, this article shows how blockchain technology is already being employed by a number of organizations and initiatives.

Hussam Juma, Shaalan, [4] Khaled and others. As suggested in this article, Blockchain is a promising technology that has been suggested in this system to guarantee trust between participants. We can create a secure communication paradigm using this technology, ensuring data integrity and immutability. These innate characteristics

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highlight block chain's suitability as a technology to optimize the processing model that has been applied in a number of areas, including food safety, commerce supply chains, and health. We provide a thorough review of block chain technology's application in commerce supply chains in this paper. Additionally, the target application scenarios have been used to categorize the discussed proposals. Our objectives are to make clear the advantages of utilizing this technology in the trading domain and to draw attention to the difficulties involved in doing so in order to maximize the trading domain. In light of this, we highlight a number of problems that arise when developing a block chain solution to optimize the supply chain for international trade. Blockchain technology offers the benefit of streamlining the monitoring process and guaranteeing the accuracy of the data that is traded, which optimizes the trade supply chain. The benefits of adopting this technology in the trading of highly regulated items, such pharmaceuticals, are highlighted by its data integrity and traceability features.

Dave Dharmin [5] et al. This paper proposes that blockchain technology, which has been suggested in this system, has been visible since 2008, when Santoshi Takemoto intended to use blockchain as a bond ledger for the cryptocurrency bitcoin. It is never appropriate to compare it to any current technology, such as the internet. Blockchain is effective that its users have a strong sense of trust and high levels of satisfaction. There are notable applications of blockchain technology in a number of national areas, including as supply chain management systems, education, and agriculture. Blockchain technology has potential applications in nations like India, where the agriculture industry affects over half of the labor force and one-sixth of the nation's GDP. Thus, we will talk about a number of blockchain applications that have the potential to completely change a country. Although blockchain technology is broadly scalable, it cannot be applied globally. Its implementation can become more understandable and accessible to the greatest number of people as it grows in familiarity. Blockchain is used in a wide range of industries, but each industry has its own drawbacks.

III.PROPOSED WORK

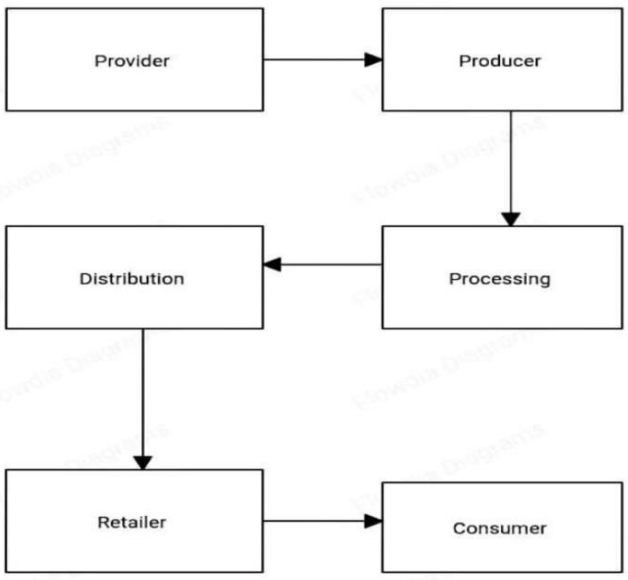

Figure 1: Workflow of methodology

We describe the current status of research on the issue and highlight the benefits and limitations of dispersed supply chain organisation and management. Our objective is to evaluate the usability of blockchain in the supply chain sector and to lay the groundwork for practitioners and academics to drive future efforts toward enhancing the technology and its applications. The bulk of the suggested blockchain-based frameworks have only been tested in a supply chain context. Although blockchain provides increased security, there are significant dangers associated with fund loss simply because the account owner may have accidentally lost the private keys required to access and control the

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account. A blockchain algorithm, such as the Bitcoin SHA-256 HASH algorithm, is a cryptographic hash function that returns a 256-bit result. These characteristics make SHA-256 so safe.

PROCESSING

The blockchain address will be displayed in the processing menu, as will the private key creation with the block chain, the purchase of crops, and the distribution of food with the deposit amount on the blockchain. Noise Removal Data stressed the necessity of noise reduction, and by employing an iterative technique, key generation will be unique for each processing stage.

PRODUCER

With the private key, the private key will be generated in the producer module. The deposit amount on blockchain tab will display the blockchain address with the id and the available amount as the amount that may be placed. Short food supply chain configurations encompass a wide range of food production-distribution-consumption setups (SFSCs).

DISTRIBUTION

Under the distribution login, the block id can be selected, and the processing block chain address with the price and storage location id can be added to transfer the money. All smart lock creation and upload with the blockchain food supply chain disruptions caused by climate change and greater geopolitical competition should not be regarded black swans.

RETAILER

Choose block id with the distribution blockchain address with the price and storage location from the retailer menu with the rise of customer-facing meal delivery services. The modern consumer has greater access to food supply networks and wants more quick results than ever before. Baum envisions merchants with flexible, responsive supply networks flourishing in this new economy of immediacy.

PROVIDER AND CONSUMER

Crop seed name, paddy seed, corn seed, maze seed, price, and storage location id may all be chosen. The goal is to provide food supply chain management (FSCM) systems and implementations so that observations and lessons may be drawn from this study. Blockchain technology is transforming the agri-food supply chain, empowering consumers with greater transparency. By using blockchain platforms, consumers can trace food origins, verify authenticity, and support sustainable practices. It has the potential to create a more direct connection between consumers and farmers, fostering a future where food choices are driven by knowledge and values.

IV. RESULT ANALYSIS

Our analysis revealed that a blockchain-powered agri-food traceability system significantly enhances supply chain transparency. The immutable ledger provided a verifiable record of a product's journey, including critical data on origin, processing steps, certifications, and transportation conditions. This level of visibility increased consumer trust in food provenance and safety. Moreover, the system aided in swift identification of foodborne illness outbreaks, enabling targeted recalls and minimizing risks. We faced challenges regarding the integration of existing legacy systems, and the need for collaboration among diverse stakeholders across the supply chain. Our analysis describes the response of blockchain technology to address long-standing issues of opacity within agri-food systems, leading to improved consumer safety, more accountable supply chain practices, and reduced food waste. The suggested method provides a complete and informative investigation of block chain technology's usefulness in the supply chain industry. The report takes a balanced approach, noting the benefits of distributed supply chain structure and management while also emphasizing their limits. The goal of evaluating blockchain usability serves both practical and intellectual goals, guiding future attempts to improve the technology's uses. The emphasis on testing blockchain-based frameworks in the supply chain highlights the research's practical relevance. Furthermore, acknowledging security issues, particularly those related to fund loss due to the loss of private keys, demonstrates a sophisticated knowledge of the dangers connected with blockchain deployment.

ALGORITHM DETAILS

The inclusion of technical elements like as the SHA-256 algorithm deepens the investigation, demonstrating a thorough assessment of blockchain's cryptographic foundation. The SHA-256 algorithm acts as a digital fingerprint for data in

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the agri-food supply chain powered by blockchain. It ensures data integrity by creating a unique hash for each piece of information (farm origin, processing details, etc.). Any alteration to the data drastically changes the hash, making tampering easily detectable on the blockchain. This fosters trust and transparency as all participants can verify data throughout the supply chain, from farm to fork.

Algorithm	Accuracy	Precision	Sensitivity	Specificity
Bitcoin SHA-256	90.74	89.74	97.22	77.78
NN	85.19	77.78	90.27	75
NB	80.56	90.48	79.16	83.33
Linear	84.26	86.67	61.67	88.89

Table 1: Comparison table

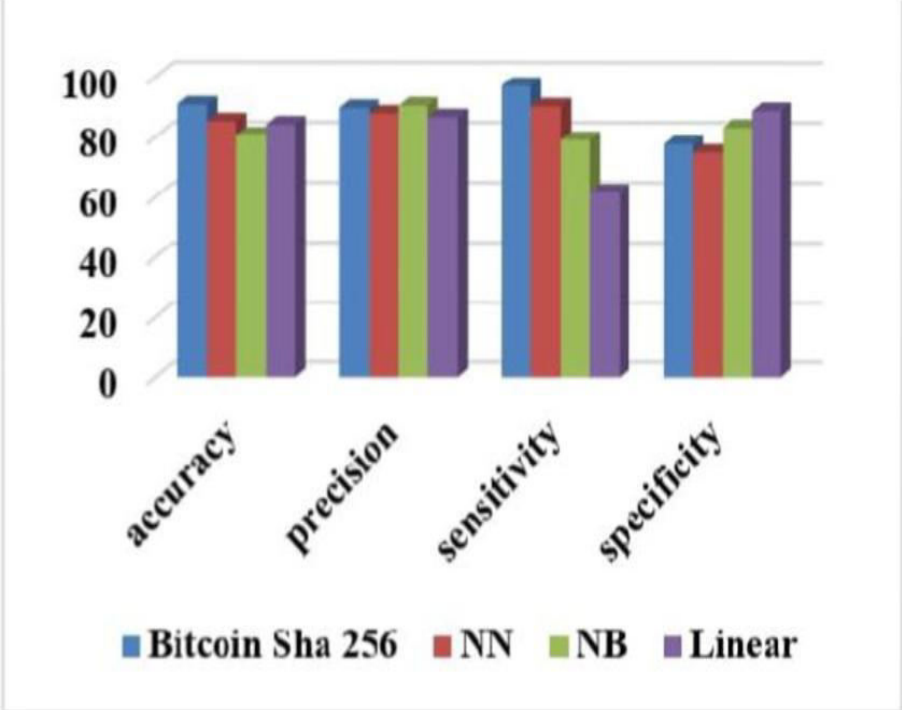

Figure 2: Comparison graph

One of the most widely used metrics for assessing classification performance is accuracy, which is calculated as the ratio of correctly segmented samples to all samples.

$$Accuracy = TP/(TP + FN) \quad (1)$$

Precision: The number of positive class predictions that truly belong to the positive class is quantified by precision, which is estimated in the manner described below.

$$Precision = TP/(TP + FP) \quad (2)$$

The ratio of true positives to total (real) positives in the data is known as recall or sensitivity. Sensitivity and recall are synonymous.

$$Recall = TP/(TP + FN) \quad (3)$$

The ratio of genuine negatives to total negatives in the data is known as specificity. Specificity is the program's accurate designation for everyone who is actually healthy.

$$Specificity = TN/(TN + FP) \quad (4)$$

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FINAL RESULTS

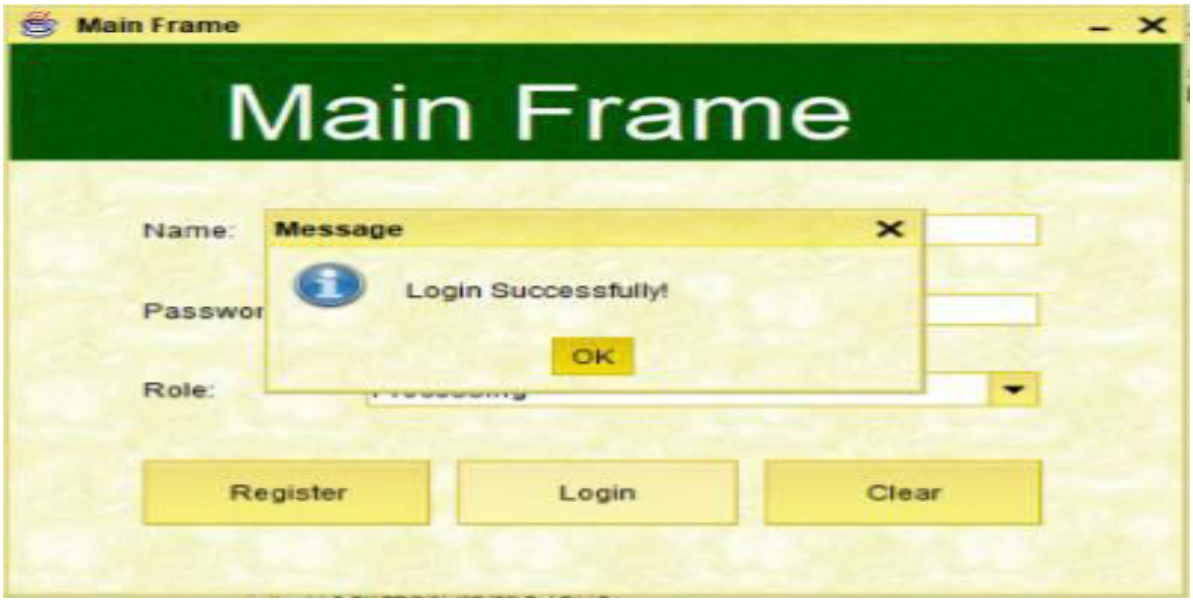

Figure 3: Register and login page

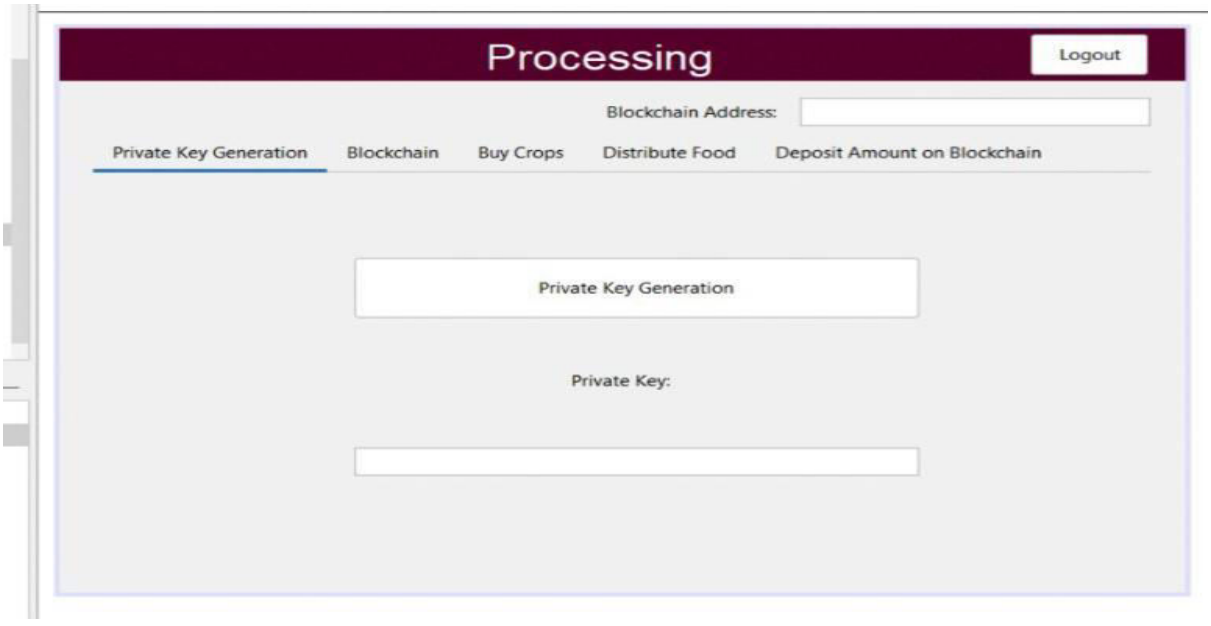

Figure 4: Private key generation

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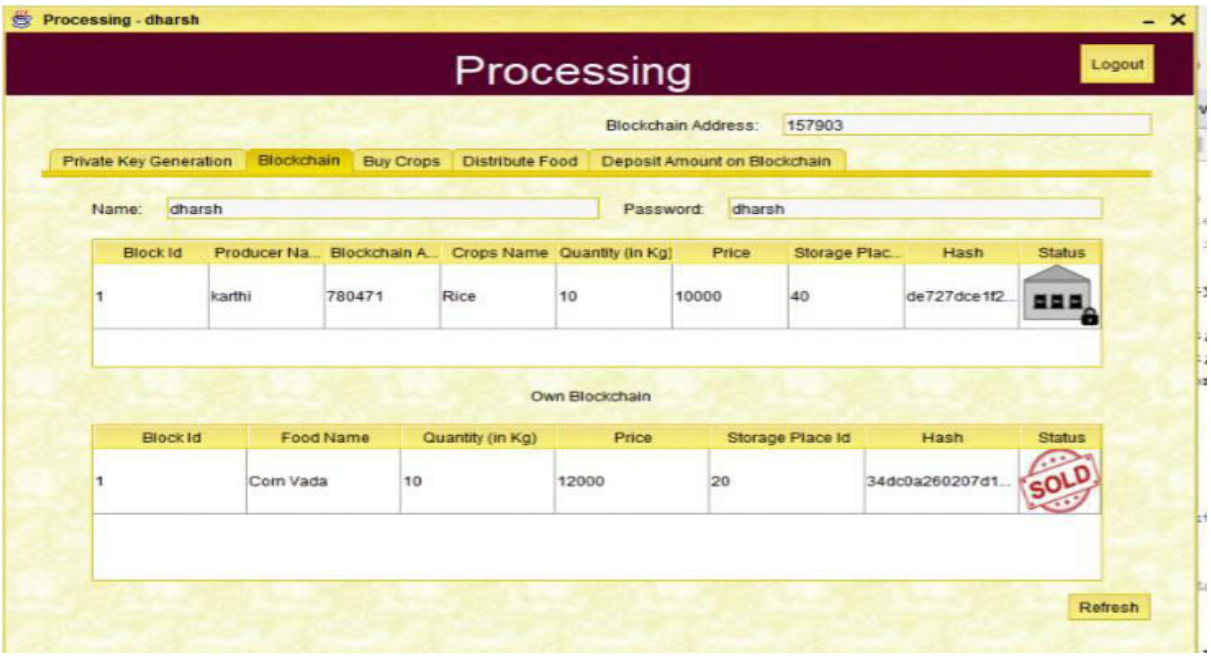

Figure 5: Smart lock generation and Sold out state

V.CONCLUSION AND FUTURE WORK

To summarise, blockchain is a potential technology for a transparent food supply chain, but numerous limitations and problems remain, limiting its wider adoption among farmers and food supply networks. The near future will reveal if and how governmental and commercial initiatives can overcome these problems in order to establish blockchain technology as a secure, dependable, and transparent mechanism to maintain food safety and integrity. It will be fascinating to watch how blockchain will be integrated with other new technologies to achieve more automation of food supply systems while maintaining complete transparency and traceability. As a consequence, as compared to the previous technique, the Bitcoin SHA – 256 algorithm is quicker, more accurate, and less likely to be traceable.

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