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Food Hazines and Tracking System for Farmers using Blockchain Technologies

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***Abstract*—It is quite challenging to monitor goods quality or security issues due to the intricacy of a tracking system, particularly for the fundamental farming food supply chains that contribute to making up everyday feeds of individuals. There are a number of significant issues with the current agricultural food tracking systems, including a large number of subjects, challenging interactions brought on by lengthy logistics phases, and user and centrally managed distrust of data. The traceability issue in agricultural food tracking systems is successfully resolved by the development of blockchain technology. In order to reduce the requirement for central organizations and departments and enhance the dependability, safety, and authenticity of records of transactions, this work suggests a structure based on smart contracts and consortiums to monitor and document the process of agricultural food tracking system, implement transparency and accessibility, and dismantle data centers between businesses. Farmers simultaneously store file hashes in smart contracts and record environmental and agricultural development information in the InterPlanetary File System (IPFS), which improves the safety of information and mitigates the issue of blockchain storage overflow. The proposed system demonstrated superior performance with reduced delay in response (0.035) and increased transmission speed (265), reception speed (305) and processing power (17.65) compared to Ethereum and Hyperledger Fabric.**

Keywords—food tracking, agriculture supply chain, blockchain, smart contract.

I. Introduction

In developing nations, broadening into the farming and processing of significantly worth farming commodities—mostly fruits as well as vegetables—has drawn a lot of policy attention. Diversifying the operations is being pushed in an effort to reduce farm hardship and satisfying customers' increasing need for wholesome, fresh food as part of their diets [1]. Although the health of consumers is primarily concerned with food safety, manufacturers must take part in organized or standardized worldwide distribution networks in order to increase their earnings and customer focus and lower risks and uncertainties in the provision of nutritional products [2]. To raise consumer appreciation and disposition to pay for healthy meals, the use of transparent certification processes, responsible and environmentally friendly food production practices is highly recommended. However, the agri-food sectors have faced numerous difficulties, and their international viability has been impacted by losses following the harvest of fruits and vegetables at the point of production, locations for storage, wholesale and retail sectors, and a lack of promotional platforms [3]. Food manufacturers have expressed curiosity about integrating blockchain technology with the current technological advances in information technologies, such as the Internet of Things (IoT), cloud computing, and artificial intelligence, since guaranteeing hygiene, nutritional value, traceability, and after-harvest administration are complicated and intricate issues in the supply chain for agricultural goods [4-8].

According to the literature, implementing blockchain technology in the agricultural and food industry can boost reliability, increase operational openness and effectiveness, eliminate needless middlemen from the supply chain, and increase consumer confidence in traceable food goods [9]. There is a substantial knowledge gap between the adoption of blockchain technology and newly available technologies, regardless of the prospective significance of blockchain-integrated technologies in the supply chain for agricultural products. It is yet unknown how individuals weigh the relative significance of various adoption-related criteria or how much they affect their adoption-intention decision-making processes [10]. This research, in particular, clarifies the viable structure and working of blockchain technology in the context of agriculture, food production and management of supply chains. However, industry participants' desires for blockchain adoption have not received much attention [11]. It is necessary to identify the key characteristics of the tracking system for agricultural products and the best mix of those specific characteristics that have the greatest influence on the selection or decision-making of consumers [12]. Therefore, by examining the factors that influence technology adoption, this research is intended to put forth an adaptable, accessible, identifiable, interconnected, and robust blockchain architecture to support environmentally friendly food tracking system practices. Although blockchain technology supports both the ecological and financial aspects of long-term viability, it should also make it easier to achieve a diverse food tracking system through the adoption of distributed information platforms, community-based asset control, cooperative systems, and open governance.

With an emphasis on transparency and connected devices, the study put out by the authors in [13]. explores the relationships between blockchain technology and smart farming. Beyond the suggested literature evaluations, this study will look for a broader application of blockchain technology in agricultural products. Additionally, it aims to look into the number of sectors participating in the procedure and how the advantages of distributed applications surpass their drawbacks. The development of handling supply chains through the use of Blockchain and the Internet of Things, together with other Industry 5.0 methods, is examined in [14]. The benefits of incorporating such technology range from nutritional tracking and accountability, which inform consumers of what they are buying; from preventing food waste to providing network safety, which ensures the process is secure. From the perspectives of IoT devices and customer trust, the authors also investigate the main digital safety issues in a blockchain-based supply chain network.

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A thorough literature assessment that considers the technical aspects and elements of blockchain-based supply chain tracking mechanisms is proposed in [15]. The authors point out that very few of the reviewed papers address realistic traceability solutions, especially when it comes to supply chain costs and practicality. In order to depict platform adoption for different stakeholders, the authors of the study [16] provide a classification and content analysis of all Blockchain-based frameworks in addition to an introduction to the adoption models. A separate investigation with minimal Blockchain-related concerns and a focus on sustainable agri-food supply networks is proposed in [17]. In addition to real-world applications and some safety concerns, [18] and [19] analyse the advantages of integrating Blockchain to agricultural food traceability in order to avoid commodity infringement, use of autonomous organizations, improved quality control systems, and traceability of goods. Other intriguing perspectives address the technology's growing international adoption [20], in relation to construction, computer networks, tracking, and uses in agriculture, as well as the nascent state of Blockchain applications [21], which are still in an early stage of development.

The implementation of blockchain technology in a food supply chain by farmers is examined by the authors in [22], who also suggest an assessment of SWOT and highlight the key potential for safeguarding the management of supply chains by safeguarding against counterfeiting issues and expenses, boosting confidence, and creating an advantageous opportunity. The authors concentrate on the absence of industry standards and interoperability problems that arises due to it. The authors in [23] suggested effort to keep an eye on the cloud-based food tracking system. It is suggested that a vast number of trucks be tracked and monitored in real time using the Cloud technology, which offers global information about the whole network of food supply trucks. The investigators in [24] suggest a combined IoT and blockchain platform for the agricultural supply network. This is a fully distributed system that gathers and disseminates information about traceability by combining blockchain technology with Internet of Things devices. Two blockchain platforms, were used for evaluating the suggested approach. Through the integration of blockchain and IoT technologies, this suggested approach produces translucent, flexible, measurable, and permanent records that may be utilized in an food tracking system. In order to address the recent issues with food monitoring, the authors in [25] suggests a blockchain-based approach. They suggest a more flexible RFID-based food supply chain administration solution with the argument that conventional farm logistic systems fall short of market demands. It is recommended that the proposed system accumulate, exchange, and distribute the initial details of agricultural products in manufacturing, processing, transportation, distribution, and revenue relationships in order to ensure food safety through tracking with reliable data throughout the whole agricultural food supply chain.

From the extensive analysis of the literature survey, it was evident that, food supply chains frequently have several middlemen, which makes it challenging to track the provenance, caliber, or path of food items. The supply chain is not well visible for customers or authorities. Item incorrect labelling, date of expiration tampering and bogus certification are examples of fraudulent acts made possible by the vulnerability of centrally stored information to exploitation. Using blockchain system, all parties involved in the food supply chain can track activities in the immutable, decentralized ledger that blockchain technology offers. This guarantees complete transparency for all parties involved, including customers. Since data contributed to the blockchain cannot be removed, there is less chance of deception and the food supply chain is guaranteed to be real. Blockchain simplifies logistics and recall procedures by enabling real-time updates on the location, state, and status of food goods. The literature study suggests that not much effort has been put into combining blockchain technology with already available advanced technologies to develop a computerized system that could meet the needs of the participants in the agricultural food tracking system and its functionality. Therefore, the creation of such a digital structure through the use of blockchain-integrated technologies in the agricultural food tracking systems is the primary objective of this research. The remainder of the paper is organized as follows: Section II presents the architecture and working of proposed system. Section III presents the outcomes of the experimental evaluation of suggested approach. Section IV concludes the present research.

II. PROPOSED METHODOLOGY

This section presents the significance of implementing the proposed blockchain-based food tracking system along with its architecture and working mechanism.

A. *Layered Architecture of Proposed System*

The various layers in the proposed Blockchain based Food Tracking System is presented in this section an depicted in Figure 1.

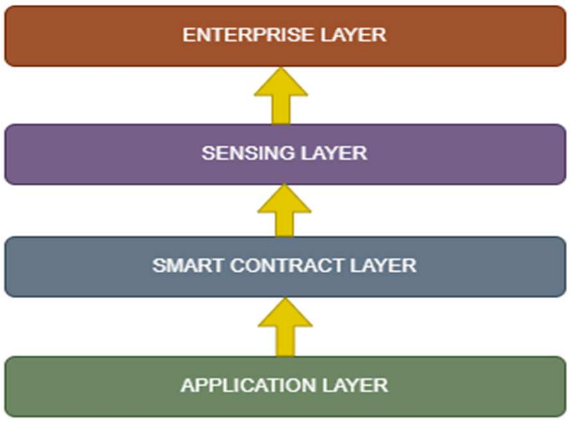

Fig. 1. Proposed Layered Architecture

1) Enterprise Layer: This layer encompasses all company processes along the entire tracking system, from agriculture to commercialization. The agricultural products tracking data is under the control and oversight of every company in the supply chain. However, there has never been an entire digital revolution in farming and agri-foods provenance. The electronic ledger technological advances using blockchain, has the greatest capacity to incorporate and control every activity and transaction throughout the tracking network in real time, which is essential to the agri-food supply chain management.

2) Sensing layer: Information on efficiency, manufacturing, resources, transportation, and transactions are all included in this layer to enhance traceability of data.

Connected gadgets such as identification tokens, RFID, Near Field Communication, wireless sensor networks, and scanner technologies are employed to record data. Conditions such as humidity, temperature, oxygen, carbon dioxide, and other information about the environment will be continually and autonomously collected and transmitted by a variety of sensors. These connected sensing devices are integrated with the Blockchain records.

3) Smart contract layer: This layer attempts to enhance the safety of agri-food tracking and promote data accessibility. Smart contracts can use the high-quality data to enable instantaneous quality oversight and control in a distributed ledger. Smart contracts can autonomously arrange transportation using the logistical data. In order to satisfy any accountability and tracking specifications, the system can also give sellers and customers a means to irreversibly record a list of operations showing how goods have moved through the business system, from manufacturers to processing companies to suppliers to grocers—and ultimately, to customers.

4) Application layer: This layer serves as an intermediary between the data stored on the system and the participants in the agricultural food tracking system. Through the application layer, individuals can watch the recording of the entire financial, knowledge, and logistical operation.

B. *Working mechanism of Proposed Food tracking system*

Every step of the manufacturing and shipping process is completed by the agricultural food tracking system, which involves numerous participating components and has lengthy and complex features that make monitoring the entire process extremely difficult. Therefore, when a transaction is started, the information is stored and added with a distinctive identification and serial number to each succeeding operation for tracking purposes, and a hash value is recorded to guarantee the transaction's legitimacy. An assortment is a collection of foods in a warehouse that are uniquely identified by their batch code. The encrypted version of the data is kept in the hyperledger, and the information about the transaction is kept in the IPFS repository in order to handle the blockchain data expansion and IPFS constraints. The various components in this system are explained in detail in this section and depicted in Figure 2.

1) Farm Agency: In order to guarantee the reliability of source data, the Farm Agency is a government entity that oversees producers and maintains records of farmers' information, crop data, plot details, and production statistics. The blockchain stores the encrypted version of the data, which is kept in the IPFS.

2) Agriculturalist: The agriculturalist is in charge of sowing seeds, utilizing devices to track and document crop development data, including the state of the soil, direct sunlight, the atmosphere, and moisture in the growing surroundings, and saving the data about the development of the crop process in IPFS as imagery data. The farmer is also in charge of developing smart contracts and putting IPFS data hashes in them.

3) Manufacturer: Crops are harvested by the agriculturalist and sold to the manufacturer, who turns them into products that the ultimate customer buys. The manufacturer then enters the entire lot, amount, and certification details of the completed goods into IPFS. The information tag is ultimately created and adhered to the good's container after the data hash is saved in the blockchain.

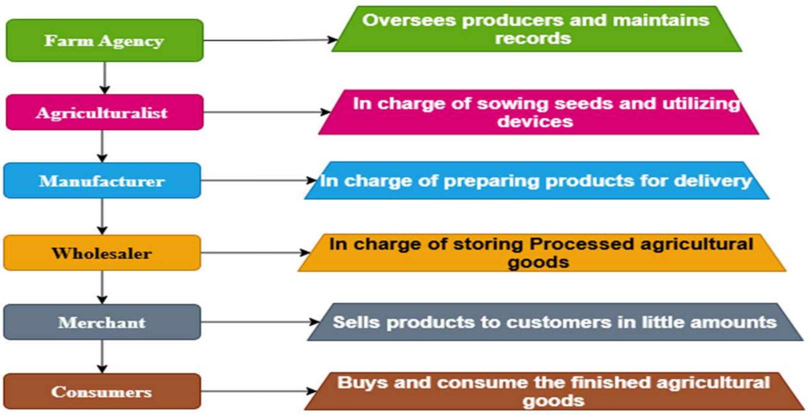

Fig. 2. Workflow of Proposed Food tracking system

4) Wholesaler: Before the final product reaches the merchant, it could pass through several transmission stages. Processed agricultural goods must be stored by the wholesaler before being sold in bulk to retailers. IPFS stores business information, sale hours, prices, and various other details. The blockchain stores the hash value to guarantee that the data that follows is unaltered.

5) Merchant: The wholesaler sells prepared products to the merchant, who then sells it to customers in little amounts. The essential details of the merchant, the time of sale, the quantity sold, and other information are stored as IPFS records in the form of hash value within the blockchain.

6) Consumers: Consumers are the ones who buy and consume the finished agricultural goods. They can access the entire food tracking system details of the product by scanning the barcode or quick response code on the product packaging, which enables the agricultural food data to be traced conveniently.

C. *Implementation of Proposed Food tracking system*

The agriculturist is the one who creates the smart contracts. When the smart contracts are first being established, they will verify that the agriculturist has been authorized. After that, the manufacturer submits an inquiry about purchasing, and it must be verified that the desired manufacturer is an authorized individual and that the invoice has been received. The agriculturist notifies all relevant parties about transferring crops to the manufacturer if these two requirements are met. The agricultural product application will be cancelled if the first two requirements are not fulfilled. The crop is thereafter sold by the manufacturer to a wholesaler, who subsequently sells it to a merchant. Two requirements must be met before the items may be transferred from wholesaler to merchant, such as the proposed merchant must be an officially authorized organization; secondly, the merchant must accept the contract of purchase; and the reimbursement for agricultural products must be provided. The contract will carry out the exchange of goods promptly if these two requirements are met. The contract will notify the merchant of the successful shipment after the transaction is complete. The contract notifies all parties of the failure if the two aforementioned requirements are not met, and the delivery request will be denied. Finally, the product must be transferred to the consumer from the merchant. Smart contracts limit the ability of consumers who enroll with a merchant to request purchases. At this point, the client location, merchant location, transaction date and transaction identification numbers are crucial characteristics. The transaction will be completed once the consumers successfully make payments for agricultural food costs. The transaction will be denied if the payment is unsuccessful or the price paid is inaccurate. The algorithmic steps are presented in Figure 3.

Algorithm: Blockchain-Based Agricultural Tracking system
Step 1: Create Smart Contract by agriculturist
1.1 If agriculturist is an authorized individual
1.2 Then
Step 2: Manufacturer submits an inquiry for purchasing crops
2.1 If manufacturer is an authorized individual
2.2 Then
2.3 If invoice has been received
2.4 Then Notify all relevant parties about transferring crops to the manufacturer
2.5 Else
2.6 Cancel the agricultural product application
Step 3: Manufacturer sells crops to a wholesaler
Step 4: Wholesaler sells crops to a merchant
4.1 If merchant is an officially authorized organization
4.2 Then
4.3 If merchant makes successful payment
4.4 Execute exchange of goods and notify merchant of successful shipment
4.5 Else
4.6 Deny the delivery request
Step 5: Merchant sells the product to the consumer
5.1 Verify consumer eligibility
5.2 If consumer is an authorized individual
5.3 Collect and record transaction details
5.4 Verify payment
5.5 If payment is successful, complete the transaction
5.6 If payment fails or the price is inaccurate, deny the transaction

Fig. 3. Implementation algorithm

III. Results And Discussion

The outcomes of the proposed system are benchmarked against the performance metrics of Hyperledger Fabric and Ethereum. Matlab has been used to create an environment of simulation for gathering and comparing this information. The variables that maintain the data acquired in this simulation environment are the delay in response which is measured in seconds, transaction speed which is measured in bytes, reception speed which is measured in bytes, and processing power which is measured in % values. The goal is to concisely and effectively demonstrate how this simulation platform differs from other platforms using the data collected.

Table 1 shows the comparison of Conventional and Proposed methods. The value for delay in response for the suggested system came out to be 0.035. The values for both transmission as well as reception per second are 265 and 305, respectively, while the rate of the processing power is 17.65. The usage of Ethereum has produced a delay in response of 12.25 with transmission speed and reception speed of 58s and 76s respectively with a processing power of 3.65%. The adoption of Hyperledger Fabric has exhibited a delay in response of 5.65s. The transmission speed achieved by Hyperledger was observed to be 102 with a corresponding reception rate of 154s for a processing power of 8.26%.

In comparison to Ethereum, the acquired value is quite acceptable, especially taking into account the delay in response. There is a slight increase in delay when compared to Hyperledger Fabric. The primary causes of this are the greater information amount and the additional complex system design. It was also observed that both the reception and transmission per second numbers are significantly lesser than Hyperledger Fabric. The comparison of the transmission as well as reception speed and processing power is depicted graphically in Figure 4 and 5.

TABLE I. Comparison Of Conventional And Proposed Methods

Methods	Delay in Response (s)	Transmission speed (bytes)	Reception speed (bytes)	Processing power (%)
Ethereum	12.25	58	76	3.65
Hyperledger Fabric	5.65	102	154	8.26
Proposed system	0.035	265	305	17.65

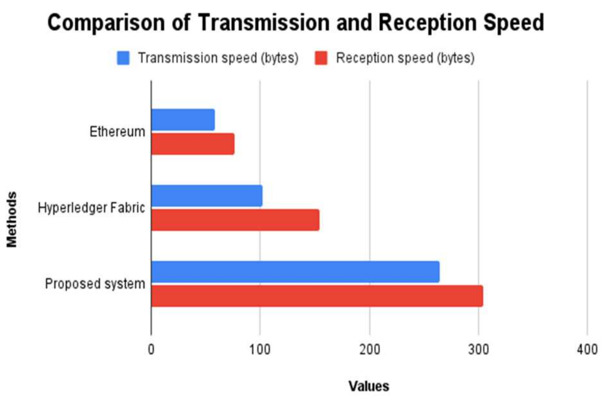

Fig. 4. Comparison of Transmission and Reception Speed

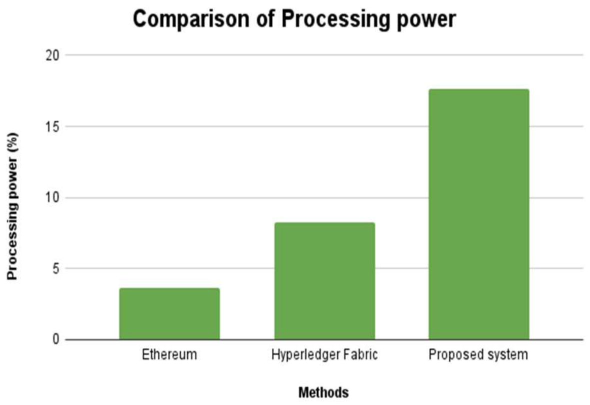

Fig. 5. Comparison of Processing power

Further, three performance metrics were utilized to analyse the impact of applying blockchain technology to the food tracking system. Transaction time, Productivity and block length are the metrics used to assess the effectiveness of the system. The typical amount of time taken by the blockchain layer to validate a delivery or reception is considered to be the transaction time. The typical quantity of transfer messages and receipts that are accurately entered into the blockchain each second is termed as productivity. Block length is anticipated that the total dimension of the chain will increase in tandem with the difficulty of the encryption algorithm. The comparison of the change in transaction time, productivity and block length with increase in the number of nodes is depicted Figure 6, 7 and 8.

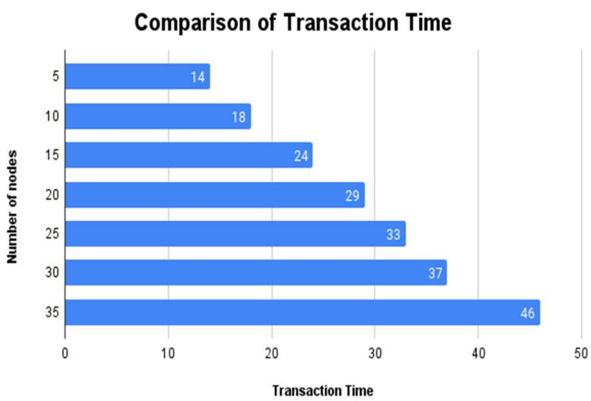

Fig. 6. Comparison on Transaction Time

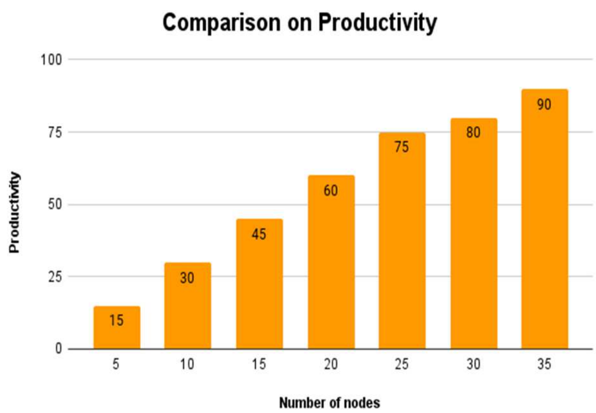

Fig. 7. Comparison on Productivity

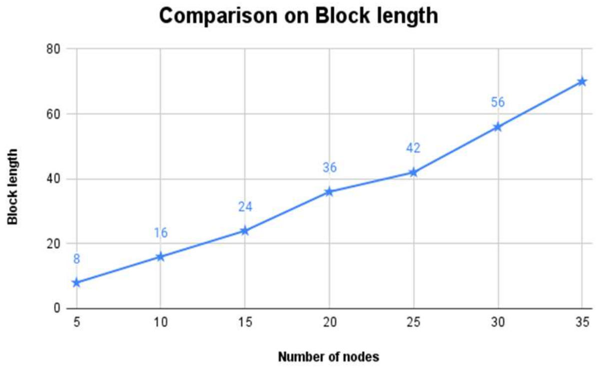

Fig. 8. Comparison on Block Length

First, the generated blockchain-based system data's transaction time information is examined. As the number of endpoints and activities that need to be verified rises, it is evident that the time needed for confirmation increases at a faster pace. Second, analyzing data on the number of transactions per second reveals that productivity is great while there are a few nodes and operations, but as the number rises, efficiency acceleration falls and even approaches stabilizing. Additionally, one of the crucial factors influencing CPU consumption is block-length data. The CPU use rate will increase with bigger block sizes, necessitating performance tweaking. Analysis of the block-length data revealed no anomalous circumstances, and the block length increased in tandem with the data and activity volume.

A. Limitations

Agricultural food tracking system could undergo a change due to blockchain technology; however, a number of issues have been noted in spite of its seeming advantages, such as storage space, flexibility, concerns about privacy, obstacles to regulation, and and expensive prices. The problems integrating with current systems and a lack of knowledge about blockchain is another challenge to be considered. The issues with space utilization and adaptability are particularly concerning because they affect the distributed nature of the supply chain and have a significant impact on various aspects of the blockchain, including data dimensions, transaction processing rate, and data transfer delay. These issues are made worse by the growing volume of transactions in tracking systems, which leads to demanding of resources, decreased system ability, and extended synchronization times for new customers.

IV. CONCLUSION

In order to meet the growing need for food production tracking, this research suggests a framework for monitoring and carrying out transactions using blockchain based smart contracts. This model alters the centrally managed system, gets rid of intermediaries , and realizes the distributed structure of the agricultural food tracking system. This work explains the significance of food safety accountability, reviews the pertinent studies, presents blockchain and smart contracts for tracking and implementing the agricultural food trade. It also presents system architecture design and explains the relationships and interactions between various entities that make up the agricultural food supply chain. Despite its potential, the suggested architecture has drawbacks, such as potential integration issues with current agricultural systems and scalability issues in blockchain networks as transaction volumes rise. The model's usefulness might be further increased by extending it to assist cross-border agricultural trade, and future research could concentrate on investigating AI-driven analytics on the blockchain for predictive insights.

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