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ASBlock:An Agricultural based Supply Chain Management using Blockchain Technology

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Abstract

Blockchain is a distributed digital ledger technology that allows for the immutable and auditable logging of transactions without needing a central authority or centralized database. First introduced in 2008 as the technology behind the digital currency Bitcoin, blockchain has now found use in a wide range of sectors. Modern agriculture supply networks have emerged to accommodate intricate interactions between regional actors and the agricultural environment. Interactions between various participants in the supply chain, including those involved in manufacturing, processing, and delivery. One of the main reasons fraud happens so often in agriculture is the lack of transparency in the supply chain. Businesses that aren't transparent run the risk of losing money, alienating their customers, and seeing their brands decline in value. To encourage the growth of an efficient and trustworthy trading environment, several fundamental adjustments to the current supply chain architecture are necessary. The potential for blockchain technology to enhance food and agricultural supply chain transparency is well acknowledged. Companies utilize IoT and blockchain to create more equitable, sustainable, and customer-friendly food manufacturing systems. In this current work, a blockchain-based decentralized application (dApp), 'ASBlock', is developed for agricultural-based supply chain management. The primary focus of this developed application is to bring transparency and security to all participating users of the application; the users of this application include farmers or producers, suppliers or retailers, hotels, and end users. The performance analysis shows that the average gas utilization of the proposed ASBlock dApp is $\sim 2.8 \star 10^4$. The average smart contract execution time for all use cases is $\sim 112 sec$.

Keywords: Blockchain Technology; Distributed Ledger; Decentralized Application (dApp); Supply Chain Management; Transparency

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1. Introduction

Over the course of the last several years, Bitcoin has seen a meteoric rise in its level of popularity. The need for centralized organizations like banks and credit card companies is rendered obsolete thanks to the introduction of cryptocurrencies, which provide a unique and safe means of making online payments. There is a surge in the number of people interested in Bitcoin [1]. The term "blockchain" refers to the distributed ledger that is used to keep track of transactions involving cryptocurrencies [2]. The technology known as blockchain makes it possible to store ever-growing transaction listings in a decentralized manner. These transaction listings are bundled together and stored in blocks locally on a computer first before being posted to the blockchain. Before a new block can be added to the distributed ledger, it is necessary for all of the nodes in a blockchain network to reach a consensus on its contents [3]. After the data has been recorded, it is impossible to change it without affecting the blocks that came before it as well. When it comes to recording transactions that take place between two parties, the blockchain is described as "an open, distributed ledger that is able to do so in a way that can do so in a way that can be checked and is permanent" [4].

Experts are looking at the possible applications of blockchain technology in a range of sectors, including the agricultural business, to enhance supply chain transparency and traceability. Now that blockchain technology is gaining acceptance, experts are looking at its potential uses. The phrase "bring agricultural or horticultural products from the farm to the table" is the phrase that best summarises the procedures that are involved in the agri-food supply chain. Today's Consumers are concerned about the origin of their food and the methods used to produce it [5]. However, the conventional supply chain, in which only a single organization is responsible for the upkeep of the data, was unable to offer interested customers timely access to the required data. Because all parties involved may access and verify the digitalized information, blockchain applications are now being investigated as a potential solution to problems that have traditionally been encountered in conventional agri-food supply chains [6].

Because of its far-reaching effects on every aspect of human life, agriculture is often regarded as one of the most significant economic sectors. It is essential to a nation's economic well-being and their country's safety that they can produce agricultural goods. Identifying and mitigating potential hazards are crucial components of agricultural practice [7]. The market's daily gyrations are analogous to the daily gyrations of the weather. Agriculture cannot provide a source of sustenance that can be cultivated without depleting the earth's resources. Therefore, the latter is seen to be demeaning. Weeds and pests may ruin a crop that might have been otherwise successful. Alterations are also occurring in the climate of the earth. The SCM framework used in agriculture may be improved by using machine learning (ML) and big data for operations such as forecasting soil quality, weather, storage availability, etc. It is also possible to utilize it for additional objectives that have been identified, such as assessing the behavior of consumers or keeping track of inventories [8]. This allows us to use the data in line with the standard techniques in the scientific community and arrive at relevant findings at appropriate times. Machine learning applications in agriculture need a comprehensive approach that draws data and techniques from a broad range of sectors to succeed. Researchers, policymakers, farmers, and other stakeholders may utilize big data in agriculture for various applications, including but not limited to research, policymaking, decision-making, and crop management [9]. Agricultural big data can be used for these and other objectives. In addition, the current agricultural supply chain management model depends on centralized structures powered by the Internet of Things (IoT). This exemplifies the concerns with data security, having a single point of failure, and other issues that have not yet been overcome. There are still issues that have not been addressed and serious concerns, such as the security of the data. Due to the large number of individuals that are participating in the process, it may be difficult to compile reliable information for the SCM. This is because for mutual confidence between two parties, a significant quantity of information that has been independently validated and is accessible to the public must first be created [10]. Despite the fact that experts in the industry and professionals working in the field believe that a third party should be included in the chain to guarantee the integrity and safety

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of the data [11], there are still some organizations that do not include a third party. Because of this, Blockchain has the potential to function as a decentralized certificate authority, checking the legitimacy of transactions and providing immutable cryptographic data to any node in the network that requests it. This would make it feasible for blockchain to check the authenticity of financial transactions and protect critical cryptographic data. Blockchain would also be able to use this to its advantage. To hasten the implementation of blockchain-based DLT in agricultural-based supply chain management (SCM), some of the most well-known food firms in the world have started collaborating with one another in an attempt to hasten the emergence of prototype models. This is being done in an effort to speed up the adoption of blockchain-based DLT. Because of the research that has been done on systems that are quite comparable, new architectural concepts for this form of the instrument have been established [12]. Some of the major food companies in the world have already started working to integrate DLT into agriculture-based SCM in order to increase the system's efficiency, and the first prototypes of this technology are just now surfacing. This technology is expected to revolutionize the agricultural supply chain management industry. By carrying out these steps, we hope to speed up the operation. Because of the study on systems quite similar to this one, new architectural concepts for this sort of instrument have been established. inside this framework, researchers have begun the process of constructing blockchain-based product traceability models for use inside the supply chain [**?**]. The only metrics for which preliminary data is currently available are latency, network traffic, and CPU consumption. Tian's recent technological advancements have made it feasible for the company to include HACCP-based real-time monitoring of food safety in the very first application [13]. However, the food processing sector and the supply chain face a number of challenges that may limit the widespread use of blockchain technology [14]. There are many more companies like this, but some examples are Costco, Walmart, Cargill, and Albert Heijn. The following are some examples of sequences that fall within this category. Introducing these characteristics into an agri-food supply chain ensures an increase in the quality and safety of the food, which is why customers favor these characteristics. Researchers from diverse fields, such as agriculture, industry, and academia, have reported making headway in improving the agricultural basis of SCM [15]. At each stage of manufacturing, new technologies such as the Internet of Things and blockchain are being used to protect the integrity of data while also enhancing visibility into its provenance. Those in need of food are going to have an easier time getting it as a result of this change that is being made. This action is being taken in order to improve the safety of food for ingestion by humans [16].

1.1. Contributions

The main contribution of this research work is summarized as follows

- To investigate the importance of blockchain in agriculture-based supply chain management.
- To develop a blockchain-based decentralized application (ASBlock) for agricultural supply chain management.
- To evaluate the performance of the proposed dApp by means of gas utilization and latency for key generation and validation.

1.2. Structure

The remaining part of the paper is structured as follows. Section 2 shows the literature survey for the current work. Section 3 shows the need for blockchain in agricultural-based supply chain management. Section 4 represents the proposed work. The proposed dApp ASBlock is evaluated in section 5. Finally, the overall conclusion of this work is drawn in Section 6.

2. Related Work

If the raw materials to the finished goods supply chain are to be managed effectively, all parties involved must agree on a common decision before storing it in Blockchain. The ultimate objective is to choose data that may benefit all links in the supply chain, with special attention paid to fulfilling the needs of end users and applicable legislation. Blockchain technology may have use outside of tracing as well, including in marketing. Blockchains improve a company's legitimacy, inspire customer loyalty, and entice new consumers since they are transparent and allow people to govern their things [17]. In fact, supply chain transparency and SKU-level tracking may be the only ways in which some businesses hope to set themselves apart from the competition. A company's brand value and media criticism's impact may be boosted by swiftly identifying the source of food contamination [18]. As businesses grow globally, the complexity of their supply chains increases, making it increasingly difficult to track down specific products. Stakeholder relationships are often complex in actual use. Therefore, suppliers may be broken down into tiers, with the first tier providing the firm with metal cans directly and the second tier providing the raw materials utilized to manufacture the first tier's product [19]. Most companies do not have exclusive relationships with their suppliers; many deal with many vendors on a single product. The survey found that improved product-supply chain management, product diversification strategies, ensured quality, and better detection of non-compliant goods are three of the most important aims for traceability. Traceability must also be maintained by adherence to all relevant regulations and industry standards [20]. Most existing blockchain systems for traceability management, like the Fish supply chain [21], have been built on a single-chain design to lower transaction costs, increase transaction capacities, make the system auditable, and provide product certifications. Using more secure and safe worldwide transactions improves performance, transparency, and security throughout the wine supply chain. Especially for ”bio” and DOCG goods, work on enhancing the agri-food supply chain in terms of quality and confirmed virtual identity needs to be worked on. Producers, processors, shippers, distributors, retailers, and other stakeholders in the agri-food supply chain may all have access to and share reliable data thanks to the Agri-Food Supply Chain System. The fruit supply chain may now benefit from a public, immutable, distributed ledger thanks to the stability of mining rewards. Companies and consumers benefit from a transparent pork supply chain [22]. Connecting the existing infrastructure to the blockchain used by various parties is the primary objective of the massive industrial supply chain food monitoring project. To maintain transparency in the process of farm-to-fork in the supply chain management, the farm products need to be linked with sensors (RFID tags) throughout the supply chain process. The AgriOpenData a Blockchain-based is a trending technology to ensure open, secure, and transparent communication in an agricultural-based supply chain management process. Specifically, their physical and digital identities, information on where they came from and who owns them, the seeds they planted and how they were cared for, the crop that was harvested, and the quality and virtual identity of the final result. The computerized tracking of organically cultivated products improves customer confidence in the agri-food industry and gives shoppers more assurance. The requirement for mining pools and the associated cost may be significantly mitigated by using specific FruitChain techniques. With each fruit taking up 80 bytes of storage space, allocating memory for 1000 fruits every block in a FruitChain consumes around 8% of a 1 MN block. One miner may get their first payouts 1,000 times as quickly as before using [23].

3. Need of Blockchain in Agricuture

Blockchain technology has enormous potential to improve the agricultural supply chain's efficiency, traceability, and openness. Some potential applications of blockchain technology in agriculture are listed below. Provenance and traceability: From planting to harvesting to processing to packaging and distribution, the whole supply chain may be recorded on a blockchain that is both immutable and transparent. Therefore, customers, merchants, and authorities may verify the authenticity and quality of food items by tracking their entire supply chains back to their points of origin [24]. Smart contracts: Smart contracts are legally binding computer-enforced agreements. These contracts can potentially automate and enforce commitments amongst supply chain participants. The contract might trigger the automatic cash release if farmers meet specific requirements, such as providing a particular amount of crops.

Better logistics and less waste are made possible using blockchain technology in the agricultural supply chain, allowing real-time access to stock, demand, and output data. The supply chain can be monitored more closely for quality and compliance with rules thanks to blockchain technology. Recording this information on a distributed ledger or blockchain is helpful to ensure that farms are using acceptable levels of pesticides, fertilizers, and other treatments. Because of the knowledge gap, farmers are often taken advantage of when it comes to pricing. Fairer pricing for farmers and more trust between parties is made possible by the immutability of blockchain-recorded transactions and data.

Smaller farmers in underdeveloped nations have difficulty securing official funding without a solid credit history and collateral. They may quickly get loans from financial institutions if they can access blockchain-based supply chain data, such as production and sales history. When sensors and trackers from the Internet of Things (IoT) [25] are combined with blockchain technology, keeping tabs on air and water quality, soil health, and animal well-being becomes possible. Thanks to its safekeeping on the blockchain, farmers can make more informed decisions with access to this data. Blockchain technology may be used to keep a decentralized database of certificates and auditing records for organic vegetables and other certified items. Consumers and other interested parties may readily verify claims made regarding organic or sustainable agricultural methods. Blockchain's immutability eliminates the possibility of fraudulent practices like mislabeling or counterfeit items entering the supply chain, reducing their prevalence. This is paramount when dealing with agricultural goods with a high market value, or that carry a regional indicator. Blockchain facilitates cooperation and trust by creating a secure, distributed network where all users can access the same, independently verified data. As a result, more collaboration and trust among all parties involved leads to better long-term results.

Using blockchain technology in agricultural supply chain management can increase reliability, effectiveness, and profitability for all stakeholders.

4. Proposed Work

The primary goal of this study is to create a decentralized agricultural application that runs on the blockchain. As it is, the dApp can accommodate four distinct sorts of users. Farmers, retailers, hotel/restaurant owners, and customers are all potential users. A Farmer may make the product. The farmer then records the finished produce on the dApp. Transporting the produce from the farm to the warehouse will fall within the purview of the retailer. The hotel/restaurant owner or consumer will purchase the item from the warehouse and then scan it to verify its authenticity. Users' accounts are linked to their MetaMask wallets [26], where they can make cryptocurrency purchases. Users may sign up using the given portal by supplying the various credentials requested by the site. When the user selects the Register button, the information will be saved in the device's local IPFS server [27]. At the same time, each user in the blockchain P2P network will have their Blockchain account. Each newly formed Blockchain node will be given its unique public and private Ethereum key. The Blockchain node also comes with 100 ETH of cryptocurrency. Figure 1 shows the use case diagram for the developed ASBlock.

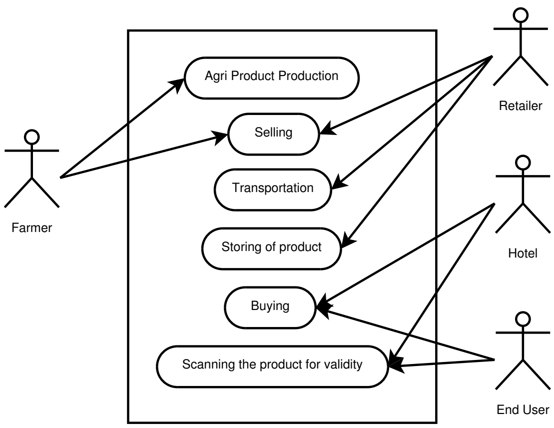

Fig. 1: Usecase diagram for proposed system

To use ASBlock, the user must be registered as an active participating node in the blockchain network. Successful blockchain participation provides a unique Ethereum address to every participating node. The user must register in the developed dApp by providing mandatory information such as Name, Email, Ethereum Address, User Type, and Organization name. Figure 2 and 3 show the layout for registration and login required to use the applications.

For the current application, 20 blockchain nodes have been created, out of which eight are dedicated to the farmer, seven are dedicated to retailers, three are dedicated to hotels or restaurants, and the remaining two are for the end-users. Figure 4 shows the Ganache layout for the created nodes.

Fig. 2: Registration form for proposed system

Fig. 3: Log in portal form for proposed system

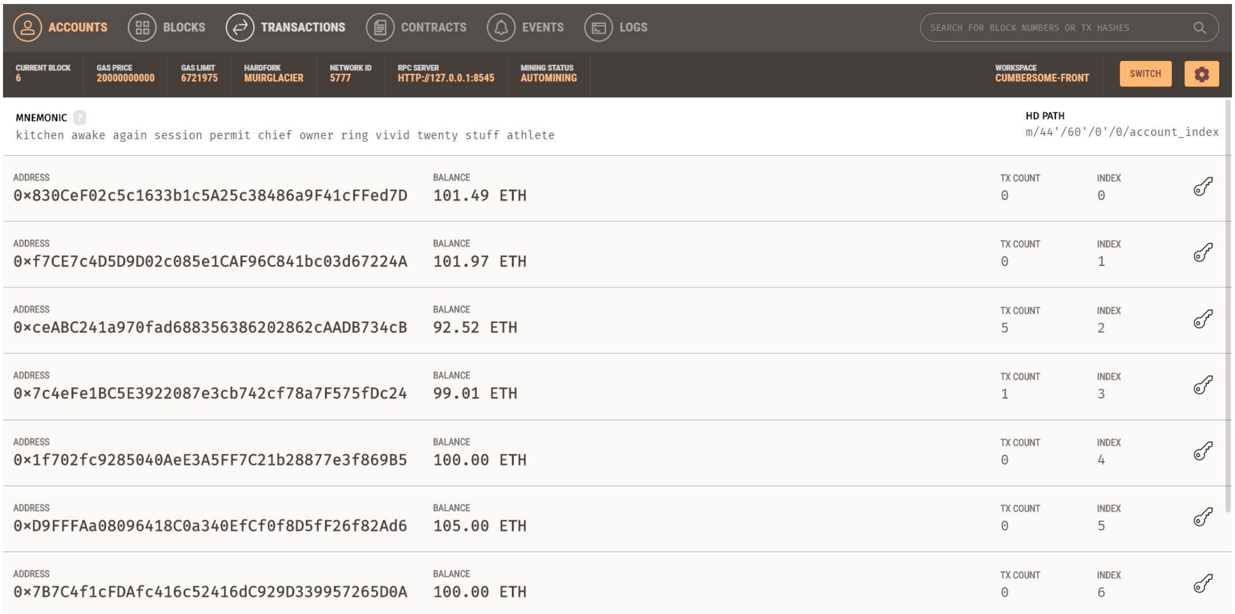

Fig. 4: Node configuration in Ganache environment

Each participating node is associated with the MetaMask wallet. The MetaMask account is linked with the Ethereum Address and public key provided by the Ganache environment. The extension known as Metamask may be added to mobile applications and web browsers. It gives consumers the ability to connect to decentralized services securely. Among the decentralized services offered is managing account identifiers like public keys and broadcasting transaction information. In addition to the functionality described above, the primary function of Metamask is to transmit and receive transactions using cryptocurrencies based on Ethereum. Figure 5 shows the MetaMask account of a Farmer. Figure 6 offers private key browsing from the MetaMask account. The private key can be used to import the given version into any system.

Fig. 5: MetaMask Account with Etherscan for Farmer1

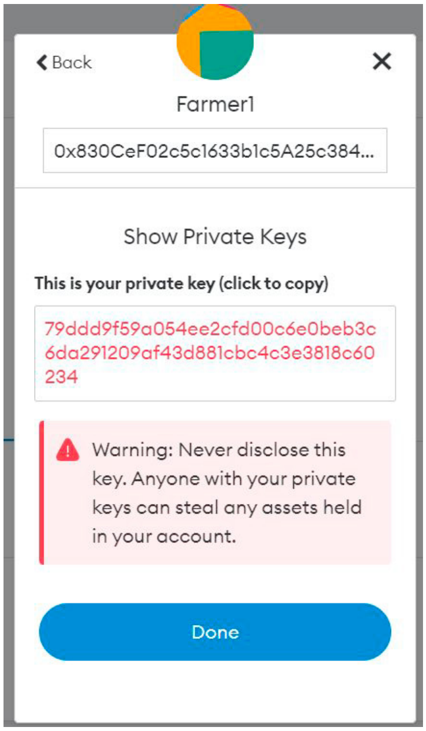

Fig. 6: Private key browsing from MetaMask for Farmer1

5. Performance Evaluation

For implementing the proposed ASBlock, Go Ethereum (GETH) with twenty nodes is used to build the suggested decentralized application. Here, we detail the supplementary conditions needed to create the proposed work. An Intel i5 CPU running at 3.6 GHz, 8 GB of RAM, with the Ubuntu 21 operating system. The blockchain nodes and smart contracts are deployed using solidity version 0.8.21 with the ganache truffle suite. The performance of the proposed dApp is evaluated over two different metrics, including gas utilization and latency of the key generation over different network sizes. For current work, the network size varies from {5,6,7,....,20}. For comparing the gas utilization of the participating nodes, 100 different transactions are executed. The gas is the unit in the blockchain that the node has to spend to do 100 transactions. The minimum gas utilization for GETH is 21000. Figure 7 shows the gas utilization for different transactions. Figure 8 shows the smart contract execution time for different use cases. Figure 9 shows the latency plot for the Key Generation process in seconds with varying network sizes.

6. Critical Analysis

The proposed ASBlock is compared in contrast to some of the existing literature. The parameters considered for comparing those include Platforms used to develop the application, MeataMask, and IPFS to deal with payment and storage. In addition to the above mentioned, two other parameters are also considered, such as availability of the Traceability and Performance evaluative parameters. Table 1 shows the comparative study for the current work.

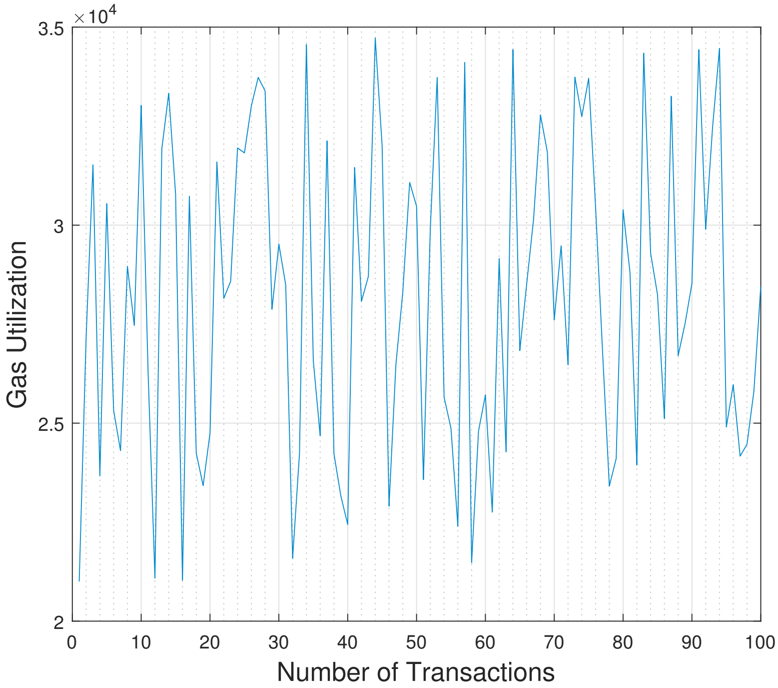

Fig. 7: Gas Utilization for different transactions

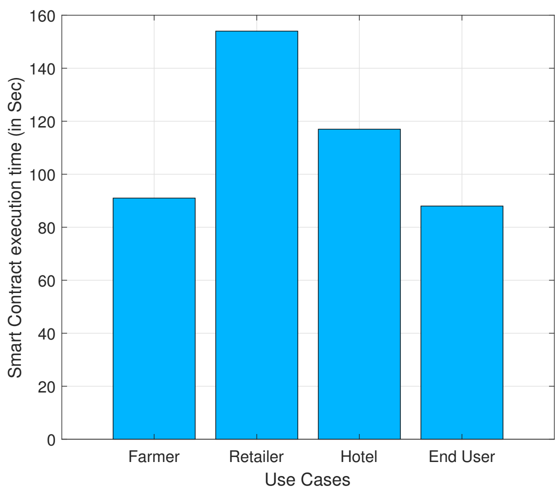

Fig. 8: Smart Contract execution time for different Use Cases

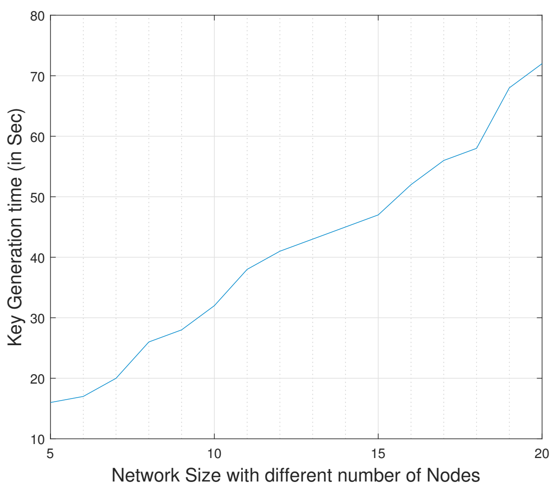

Fig. 9: Key generation time for different network size

7. Conclusion

This research is based on the notion that the Blockchain idea may be used to increase reliability and openness in the agricultural-based supply chain management system. The methods used to cultivate crops and harvest their ingredients have seen dramatic changes recently. It was investigated how best to connect the farmer who provides the market's goods with the consumer. The blockchain's design and ideas were adopted to instill trust and transparency

Table 1: Comparison of the proposed dApp ASBlock with existing literature

Reference	Platform	MetaMask	IPFS	Traceability	Performance Evaluation	
					Gas Utilization	Latency Measurement
[17]	–	✗	✗	✓	✗	✗
[21]	–	✗	✗	✓	✗	✗
[22]	–	✗	✗	✗	✗	✗
[23]	–	✗	✗	✗	✗	✗
Proposed ASBlock	Ethereum	✓	✓	✓	✓	✓

among users and transactions. The main motive of this research is to develop a Blockchain-based dAPP 'ASBlock' to interact with four different types of users: Farmers, retailers, hotel/restaurant owners, and customers. This developed application aims to provide an ease-of-use UI to efficiently and securely communicate with others. In addition, the developed dApp has built-in support for the MetaMask wallet, which means that payments can be made safely and conveniently. In addition, the farmer learns the true worth of the finished product, which may increase their enthusiasm for farming and, in turn, boost agricultural output. Finally, the developed 'ASBlock' performance is evaluated using three different parameters: gas utilization, time to generate the Key with different network sizes, and the time required to execute the smart contract for different use cases to show the efficacy. The analytical study shows that the average gas utilization of the proposed ASBlock dApp is $\sim 2.8 \star 10^4$. Similarly, the average smart contract execution time for all use cases is $\sim 112sec$.

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