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# BLOCKCHAIN-BASED POISONING ATTACK PREVENTION IN SMART FARMING

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**ABSTRACT:** Rapid progress and advancement in the Internet of Things (IoT) significantly affect how businesses are conducted in this 21st century. Smart Farming, also Intelligent Farming as a component of the IoT, allows agribusiness to generate high-yield income, ease of doing business, and with a favorable professional environment. Smart farming combines agribusiness competency recognition, data progression, and information collected from equipment with statistical analysis to highlight facts from the acquired information, allowing farmers to make wise decisions for greater harvest benefits. However, incorporating such cutting-edge technology necessitates the acquisition of more sophisticated safety and security majors. Thus, system safety testing may be the most important safety consideration to implement. This paper presents a blockchain-based smart farm security framework that effectively screens device status and sensor irregularities and alleviates security threats. In addition, a blockchain-based smart-contract application was developed to securely store security anomaly data and proactively moderate comparative assaults on other farms in the community. The study used the security-monitoring framework for smart farms, ESP32, AWS cloud, and the smart contract on the Ethereum Rinkeby. The performance evaluation of the proposed system revealed that our framework could identify and prevent security anomalies in real time while giving updates on the situation.

**KEYWORDS:** *Blockchain, Poisoning Attacks, Internet of Things, Smart Farming, Signature*

## 1. INTRODUCTION

As the population of the world increases, the need and significance of farming also grow, and farmers aimed at developing crops to deliver nourishment all over the world. The economies of most nations depend heavily on their execution within the rural division [1]. Moving forward, agricultural segment bureaus in many countries try to reinforce their country's economy, especially through agriculture. The advancement of science and technology which includes the IoT has changed how farming is practiced and has moved forward the operational capabilities of the farming sector [2]. Integrating the IoT in farm development is called smart or intelligent farming which is fast becoming the new normal as robots and smart things exhibition all over the world is anticipated to reach $15.93 billion by 2028, creating a compound annual advancement rate of 20.31% from 2021 to 2028 [3]. The rural areas are the target for competitors to conduct cyber assaults as the integration of advanced agric. frameworks are coming up in those locations. Take as an example, a meat management company, JBS, within the food transport division got a ransomware outbreak which ended the operations of 13 meat industrial facilities. The company had to pay about $11 million to keep functioning [4]. Thus, we can agree that safety is seen as a major issue in sectors such as the agric. where the progression of rural safety measures is critically needed.

In this manner, security is seen as a major issue in the smart farming domain, and the progression of rural security arrangements is critically needed.

The existing security arrangements proposed in smart cultivating and farming generally cover food-supply-chain administration and the checking of different exercises utilizing cloud innovations, ML- and AI-based data-analytic procedures, and verification and authorization arrangements for compelled IoT gadgets [12]. Cloud-based observing smart

Farming arrangements can still have security results, on the off chance that the secured code strategies are not considered amid the advancement and IoT security best hones are not taken after. To bolster the past articulation, truly IoT gadgets uncovered on the Web have been compromised and utilized as a weapon to perform large-scale denial-of-service assaults or other noxious exercises such as controlling the sensor values to information presentation [14].

In this manner, the existing cloud-based arrangements or gateway-based security arrangements for checking smart farming applications are not adequate for giving full promised security. Decentralized applications and capacity have security points of interest compared to conventional applications and capacity in terms of secured occasions capacity, traceability, permanence, and made strides security and security. Blockchain innovation is known to be utilized for decentralized application advancement. Separated from blockchain-based advanced money, smart-contract-based applications are well known and utilized for numerous applications, counting advanced personalities, budgetary security, secured capacity, and supply chain administration [16]. Analysts investigated blockchain innovation openings in settling IoT security and protection issues [17], counting smart farming security. A few of the blockchain applications in smart farming are food-production supply-chain administration, and secured exchange capacity [8,18]. Blockchain empowers keeping track of the arrangement of occasions to preserve straightforwardness and, within the conclusion, farmers are reasonably treated and pick up benefits. Considering the blockchain innovation focal points in shrewd farming, we were propelled to utilize blockchain innovation for executing shrewd farming-security-monitoring.

The current security observing arrangements in smart Farming either center on cloud-based choices or blockchain innovation [10]. Besides, as talked about prior, most of the cloud- or blockchain-based arrangements address supply-chain issues. The points of interest of cloud and blockchain innovation can be considered to propose ideal security arrangements in savvy farming. Generally, to overcome the restrictions of the existing cloud-based arrangements [10] and make strides in security utilizing blockchain applications, we utilized a cloud and blockchain solution to always handle the detecting information within the cloud and store irregularities in blockchain exchanges. Moreover, none of the existing arrangements gave an end-to-end arrangement utilizing cloud and blockchain execution for smart Farming and assessing the organized idleness execution. In this manner, we executed an end-to-end arrangement utilizing an Arduino sensor pack with a Wi-Fi module, AWS cloud, and Ethereum smart contract arrange for testing real-time applications and assessed their execution in terms of security, ease of use, and execution arrangement.

This study is therefore focused on assessing block-chain poisoning attack prevention in smart farming using signature. The objectives include;

- Assessment of various data poisoning attacks faced by smart farming in the agricultural sector
- Assessing cloud solutions in smart Agriculture.
- Assessing Blockchain solutions in Smart Farming.

Significantly, this investigation is balanced to be of extraordinary significance to the agriculturists, the government, and the information assurance specialists. The ponder set out to translate different information-harming assaults that have been experienced by smart cultivating proprietors within the world. It'll uncover different ways that information-harming assaults can be deflected through the application of different planned and executed systems within the security server of the savvy cultivate. It'll also bring to the spotlight the security and security challenges that have ruined the total working of smart cultivating within the agribusiness industry. Due to the results of information harming upon nourishment generation, this will give a conceivable arrangement that will advantage the government, shrewd cultivating specialists, and cyber-security specialists on different strategies of savvy cultivate assaults and ways to turn away the information harming separately.

The gaps this consider will fill incorporate:

- Recognized potential cybersecurity concerns in shrewd cultivating and displayed scenario-specific cyberattacks categorized into supply chains such as information, systems, and other common assaults.

- Presents a comprehensive evaluation of current cybersecurity inquiries and countermeasures utilizing blockchain in shrewd farming.
- Verbalize open security and security challenges over spaces such as next-generation organized security, trusted supply chains and compliance, antagonistic machine learning, and AI, get to control, and believe and data sharing.

## 2. LITERATURE REVIEW

Agribusinesses and farmers are turning to a run of shrewd cultivating strategies that utilize IoT gadgets to extend efficiency. The different sensor associations utilized on the cultivate and their communication over the Web can be hacked. This has driven an increment in cyber assaults pointed at the agrarian industry, counting information breaches, refusal of benefit assaults, site changes, and more. As of late, [8] has shed light on security and protection issues in savvy agri-ecosystems. They displayed a layered engineering and distinguished potential cybersecurity issues in smart farming. In expansion, their investigation moreover presents particular cyber assault scenarios categorized into information, arrange supply chain, and other common assaults. A prevalent assault called "The Night Mythical Serpent" is an illustration that permits assailants to take expansive sums of data from numerous petrochemical companies. Another case was the harm to a German steel plant, where aggressors utilized online phishing to pick up and get to the factory's workplaces, systems, and generation frameworks.

The exponential development in the number of internet-connected gadgets has made genuine security issues within the rural division, as agriculturists cannot endure the plausibility of misfortune and damage to their crops. Surname. Surname. Subsequently, guaranteeing the differences of sensors within the smart cultivate biological system is a critical errand of present-day farming. Maria and partners. [9] Their report highlights the importance of accuracy farming (Dad) and related cybersecurity dangers and potential vulnerabilities. This report highlights security, smartness, and accessibility models for data security in agribusiness. It distinguishes different advances included in shrewd Farming, such as on-farm gear, checking and inaccessible detecting strategies, and machine learning. It too briefly portrays significant bunches such as farmers, herders, and businesses that back or depend on farming.

Moreover, security issues that can emerge from the utilization of IoT sensors in agribusiness have been well distinguished [10]. Information and data security alludes to the assurance of information by diverting or lessening the plausibility of unseemly or unauthorized get to or illicit utilize of information, intrusion, revelation, cancellation, and assessment. , debasement, distorting records, or distorting data. and to ensure information and data by lessening chance. [11]. Aggressors can perform diverse sorts of assaults. B. Mass dissent of benefit (DoS) assaults using various IoT sensors sent in smart ranches. Manos et. al, [12] in their ponder affirmed the 2016 Mirai botnet as an illustration, misusing an expansive number of associated shrewd domestic gadgets to dispatch different DoS attacks. down. As of late, an analyst from a security company called Sucuri [13] found that a DoS botnet can make 50,000 HTTP requests per moment. Numerous websites have been hit by DDoS assaults. Comparable conditions exist in shrewd agroecosystems, so comparable assaults can happen. Such assaults not as it disturbed the typical operation of distinctive modules within the same bunch, but can too be utilized to disturb true blue arrange administrations in other domains.

The creators of [35] actualized a shrewd contract based on soil- and climate-condition observing measurements in shrewd agribusiness. In any case, nitty gritty smart-contract usage is not given. In addition, the real-time tests detecting the rural conditions and testing the proposed smart-contract-based metric checking are not performed. Ref. [36] examined Ethereum blockchain-based smart-agriculture supply-chain information arrangements. The creators observed the farming sensor information utilizing Ethereum. Be that as it may, the arrangement did not specify information capacity utilization within the cloud. Ref. [37] performed a confirmation of concept for executing the Ethereum blockchain arrangement to store Farming sensor points of interest. Be that as it may, the execution of the executed arrangement isn't decided in their work. Practical test tests by setting the sensor gadgets are moreover not performed. Caro et al. [38] proposed AgriBlockIoT, a blockchain-based arrangement for Farming nourishment supply-chain administration. The Ethereum and hyper record blockchain-based execution is performed to store the Agribusiness IoT device's information.

The creators appeared that the Hyperledger inactivity is much lower than the Ethereum arrange inactivity. In any case, the end-to-end execution of the Farming blockchain, counting empowering the sensors to send information in real-time, is lost. Moreover, the message network's idleness to overhaul the exchanges within the blockchain is higher. We address those issues and executed a more reasonable blockchain-based arrangement to send the sensor alarm information as an exchange in the blockchain. The creators of [39] outlined a smart-contract-based IoT device-to-device and device-to-gateway verification component in savvy farming. The piece is shaped by the edge server conveyed within the IoT environment. The blockchain hubs within the cloud perform the agreement component and include the squares to the blockchain. A crossover blockchain hyper ledger– sawtooth stage reenacts the author's proposed method. Although blockchain and cloud technologies are included within the author's work, the center of their work is on the plan of IoT gadget confirmation components. On the other hand, we centered on checking smart farming natural conditions utilizing cloud and blockchain innovations. We actualized an end-to-end generation-level Ethereum smart-contract arrangement.

### 2.1 CLOUD SOLUTION IN SMART FARMING

Cloud-computing integration with smart Farming is required to perform IoT detecting information capacity and analytics, counting big-data applications. Analysts proposed arrangements to address the issues in IoT-based savvy Farming utilizing cloud computing. Nurzaman et al. [2] proposed a fog-computing-based network architecture for savvy cultivating and Farming to screen ranches and control agribusiness operations. The creators presented a cross-layer-based channel get-to and steering arrangement to optimize the organized communication associated with smart-farming endpoints. This progressed the arranged inactivity of the IoT cultivating gadgets associated with the cloud. In any case, the paper did not talk about the security and security angles of IoT-based shrewd agribusiness. Chen et al. [27] displayed an IoT platform to develop turmeric outside for precision agriculture. The author's application empowers agriculturists to control turmeric cultivation with GUI, moving forward the quality and efficiency of the turmeric while keeping up the arranged inactivity that roughly matches real-time communication. However, this work is specific to smart-agriculture turmeric-cultivation application execution.

[28] proposed an intelligent security framework to screen gadgets within the farming field. The creators actualized the framework on Rasberry Pi 2. The framework can communicate information remotely and send SMS alarms to a farther client. Be that as it may, the work did not consider blockchain innovation to make savvy contracts and safely store the information when observing the gadgets in Farming. Li *et al*. [11] talked about the confinements of utilizing big-data arrangements in IoT-based savvy farming. The creators utilize the K-means calculation to perform the agribusiness information analytics and highlighted that information is deficient to apply big-data arrangements. Anandarup *et al.* [29] proposed a strategy for recognizing connection disappointments between neighborhood hubs and ace hubs and recognizing nearby hubs from organized parcels. The MLP facilitated in farther hubs is utilized to test the recognizable proof of the hubs. Generally, the writing shows that cloud arrangements advantage the agribusiness industry by remotely observing and making strides in efficiency in agriculture. However, the cloud-based arrangements are inclined to information exposures and may lead to security breaches on the cloud benefit provider if security controls are not legitimately actualized.

### 2.2 BLOCKCHAIN SOLUTIONS IN IOT AGRICULTURE

Blockchain innovation has points of interest such as secure capacity, namelessness, and straightforwardness. The client's personality and private key will not be uncovered in the open, even though the user's open key and exchange data can be seen within the open blockchain. A few analysts investigated the utilization of blockchain innovation in IoT applications [19,30–32]. Ferrang et al. [33] portrayed blockchain conventions in IoT and displayed danger models to blockchain conventions in IoT. The IoT application spaces for blockchain are talked about, and the state of the art of blockchain advances within the Web of Things are examined, emphasizing security and protection. The inquiry about challenges and future headings for utilizing blockchain in IoT are talked about. Ref. [8] examined the security and security issues in green IoT-based agriculture. The application of blockchain innovation in protecting protection in green IoT-based agribusiness is examined. Anusha et al. [31] performed a writing survey of the information-security investigation advance in blockchain-based smart-agriculture applications. Oscar et al. [32] performed a nitty gritty consideration of utilizing blockchain in savvy

farming. The creators highlighted that security and security issues are one of the most concerns of shrewd agribusiness. The state-of-the-art survey on utilizing the blockchain in Farming [32] portrayed that most of the works centered on understanding the nourishment or agribusiness supply-chain issue, and secure information capacity, further checking, and computerization are the slightest centered on regions in blockchain-enabled shrewd agribusiness. To entirety up, the earlier blockchain innovation in IoT agriculture review articles demonstrate that blockchain arrangements can make strides in the security and protection of savvy agribusiness. In any case, challenges such as information capacity in blockchain and tall organize association rates in country regions to perform agreement movement still have to be addressed within the agribusiness application setting. Saikat [12] proposed a blockchain-based IoT design for the nourishment supply chain. RFID sensors captured the distinguishing proof ID from the item bundle from different stakeholders within the nourishment supply chain and were included in the blockchain to preserve astuteness. Any partner can confirm the open blockchain information concerning the products' status. Mubariz et al. [34] presented blockchain-based cloud hubs to confirm the benefit given by the edge servers for benefit verification to IoT devices. The proof-of-specialist (POA) instrument is considered for keeping up the agreement among blockchain cloud hubs. IoT gadgets grant the rating to the edge servers based on the edge-server benefit given and utilized for deciding the benefit confirmation. Mohamed et al. [19] investigated blockchain innovation to actualize security arrangements and their execution. The creators highlighted that expansive throughput and capacity are the specialized challenges in executing security arrangements. Generally, blockchain arrangements have been utilized within the literature to address a few issues in savvy farming.

### 2.3 SMART FARMING, SENSING TECHNOLOGY, AND SECURITY ATTACKS

A normal cloud-enabled IoT-savvy Farming is shown in Figure 1. The cloud-based design is comprised of the IoT gadget associated with the ranches and rural arrive to screen different physical conditions such as fertilizer utilization, appropriate seed spilling, climate state, nourishment developing quality, and capacity environment conditions. Different sensors such as temperature, mugginess, and weight are utilized to screen the cultivating condition. The IoT gadgets are associated with the common portal to pass the state data to the third-party cloud seller, who gives the item administrations. The door can be a nonexclusive or committed switch outlined for the savvy cultivate. The cloud supplier can be any essential benefit supplier such as AWS, Google Cloud, Microsoft Sky blue, or a self-managed cloud. The portal is associated with the cloud assets to prepare the IoT gadget demands.

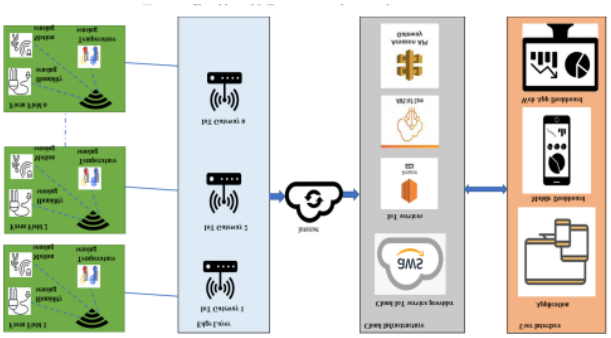

*Fig. 1. Cloud-based IoT smart-agriculture application.*

The various IoT sensors and their applications in smart agriculture include;

**Temperature sensor**: The sensor detects temperature changes within the application. The water temperature, the surrounding air temperature, and plant temperature monitoring capabilities improve the effectiveness of agriculture duties.

**Humidity sensor**: The humidity sensor measures the humidity changes in the agricultural land environment. The humidity sensor helps measure the soil moisture and water consumption rate, tracking waterfall trends for future irrigation requirements estimation. The normal humidity ranges are 0%RH–100%RH.

**Light sensor**: The light sensors in agriculture monitor the light in the agricultural greenhouse, cloud shadow, and the required light to grow the plants.

**Accelerometer sensor**: Accelerometer sensors in agriculture help to maintain the agriculture or farming equipment. The movement and vibration changes in the equipment are monitored to detect the equipment replacement needs.

**pH sensor**: The pH sensors in agriculture improve the productivity of crops. The pH sensor detects unwanted chemicals in the soil and soil nutrient deficiencies. Soil-pH fluctuation monitoring can help farmers to take precautions and effectively grow plants.

**GPS sensors**: An animal herd or any objects in the agricultural location can be monitored using a GPS sensor. Remote monitoring and location tracking helps to achieve precise agriculture. **Pressure sensor**: A pressure sensor in agriculture may be used to monitor pipes and tanks. The pressure sensor improves water management, irrigation management, and precision farming. **Infrared sensor**: Infrared sensor integrated with drones monitors the crop and measures the plant's strength. The plants can be adjusted and optimized for the agriculture resources to manage agriculture activities effectively

### 2.4 DATA POISONING ATTACKS IN AGRICULTURE

The attack surface of IoT in smart agriculture opens up a new range of cyberattacks and several security defenses that can be integrated into IoT devices due to memory and processing limitations. As a result, we may need to rely on security detection and protection mechanisms at the port or network level. This work will address the following attacks using IoT state and anomaly data monitoring solutions.

**Denial of Service (DoS):** The adversary can send malicious network traffic to the victim farmer's network to shut down services, including detection devices and routers connected to the network. This can disrupt operations as these devices are used for food supply chain applications. The attack can also originate from many different source IP addresses, making it difficult to detect and block attack traffic. DoS attack scenarios in IoT include resource consumption of IoT devices, congestion of IoT devices and gateways, or flooding of ports with traffic.

**Physical security attack:** Intruders into agricultural fields and farm facilities to destroy property or with other evil purposes like theft, arson, etc. Camera sensors installed on the farm premises will send data to monitor and alert the farm owner when physical attacks occur in smart agriculture. Enemies can also access the farm to install or compromise the farm network.

**Data manipulation attack detected**: Malicious manipulation of IoT sensor data before it reaches its destination is another type of attack seen in IoT. An adversary can perform a man-in-the-middle attack to read data passing through the communication channel and embed malicious data to carry out attacks. Zero-day vulnerabilities in IoT devices can also be exploited to compromise sensors and spoof sensor data to mask malicious activity. There are different ways to access the network and manipulate data unless we have good security controls that cover protocols from the data link layer to the application layers.

## 3. MATERIALS AND METHOD

The proposed approach improves the security and monitoring of smart farming by incorporating technologies into multiple layers of smart agriculture architecture. The Ethereum blockchain is used in another layer to run smart contracts

and trigger events when anomalies are identified during smart farming security monitoring. Figure 2 illustrates the layered architecture of the proposed method. The smart farm layer contains different sensor devices on the farm premises for different purposes. A smart farming community is formed with IoT sensor devices installed on every farmland. These sensors continuously generate events like device health, device data, etc. Generated events are transmitted to the cloud using an edge gateway or a router connected to the sensor. The cloud layer consists of components that continuously listen to sensor events and process event data to retrieve the desired information. MQTT is the typical protocol for end-to-end packet data transmission. We have defined a lambda function in the AWS cloud to parse data from the AWS IoT core component and extract the required data from sensor devices connected to the farms. Whenever the lambda function logic defines a security alert observed from the sensor generation data, the lambda function executes an infura-API POST request to update the Ethereum blockchain. The updated transaction may include abnormal values of sensor data, device status, etc. Infura runs Ethereum nodes and provides an API to update transactions from user accounts if they have an account with them. Updated blockchain transactions will be updated on all nodes in the Ethereum network. Although the user layer is not shown in Figure 2, the GUI can read transactions from the Ethereum node using an API call and display the details in the GUI when the user wants to see smart farming alerts.

The description of the main components used in the proposed approach is discussed in the following paragraph.

**AWS IoT core**: Several IoT sensing devices exist in the smart-farming environment. An IoT message-processing infrastructure is needed to support the IoT message protocols such as MQTT and accommodates the network bandwidth to collect messages from numerous IoT devices. We selected AWS IoT core service to perform the smart agriculture IoT data processing. The AWS IoT core offers low latency and high throughput performance, and these characteristics support the building of real-time production-level IoT monitoring systems.

**AWS Lambda**: The collected IoT data should be processed and given as input data to the Ethereum blockchain. Therefore, AWS Lambda runs the code in the backend and stores the smart-farming information in the Blockchain. AWS Lambda is a serverless computing service to run code virtually without provisioning the server infrastructure.

**Infura API:** The study did not rely on deploying the Ethereum full node to create and run the farming smart contracts. Infura is an Ethereum API service to run smart contracts in Ethereum nodes and performs Ethereum-based transactions. We leverage the Infura API calls to interact with Ethereum nodes once we collect and process the farming sensor data.

**Ethereum**: The study implemented the Ethereum-based smart contract to store the farming sensor data and check the farming environment conditions. The Ethereum first version works on the proof-of-stake (POS) consensus mechanism to approve and add the transactions to the Ethereum blockchain. A Web3 frontend application is implemented to review and alert the farmers when security events are detected.

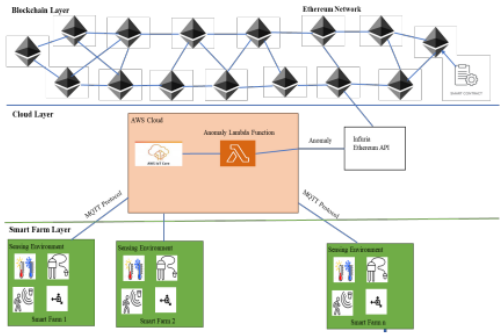


*Fig. 2. Blockchain cloud-based smart-agriculture application.*

ADVANTAGES OF OUR PROPOSED METHODOLOGY

This research solution inherits the benefits of secure data storage using blockchain. Only certified farmers with access to smart farming records are included. Cloud-based data storage carries the security risk of data breaches due to access control misconfiguration. Blockchain enables secure storage of records with no maintenance costs for storage. Our solutions are cloud-scalable and provide solutions for a variety of security use cases in smart agriculture. Blockchain transaction alert data immutability can be used as evidence in litigation, can be used to ensure the security of insurance claims, and data corruption-free security investigation data to protect farmers' farm assets and property. For example, natural disasters can severely affect agricultural land. Evidence of when, what, where, and how it can be captured as blockchain transaction data and used for insurance claims. A farm cannot deny ownership of a transaction once it has been added to the blockchain. This property can be used to identify malicious farmer activity and maintain transparency. Some of the use cases for the proposed smart farming approach are discussed below. **Sensor status**: Sensors constantly monitor farmland and farm physical conditions and transmit these data to farmers or crop owners to effectively manage their farms for higher yields, lower losses, and increased productivity. need to do it. Sensors/actuators must work continuously to receive regular updates. Sensors are attacked with passive and active attacks. Therefore, monitoring the health of these device sensors is essential and continuously monitored. A mobile application needs to notify the farmer when the health status of the device is turned off. Farmers can then find the root cause and fix the problem.

**Abnormal sensor data**: You can flag anomalies in sensor data to draw attention and look for anomalies. Set thresholds to trigger alarms and monitor smart farming applications. For example, temperatures in agricultural warehouses are constantly monitored to keep goods safe. A temperature sensor is installed in the storage tank to monitor the temperature of the storage tank. A blockchain-based monitoring solution alerts storage unit owners when temperatures exceed threshold temperatures. Similarly, an image sensor installed near the storage unit is used to identify moving objects. Image processing techniques were applied to detect unauthorized access to the storage unit. Cloud resources integrated into the solution can process images and generate output.

**Community Farming Blockchain**: The crop productivity or quality impact on any single farm may gradually affect other farms in the community or nearby farms in the surrounding area. The effect can be due to the infection of bugs, severe weather disturbing the crop's life cycle, or more. Communication of this information to the community farmers may save their crops from infection and stop the infection from spreading. Therefore, the blockchain-based community can use this as a farm blockchain for sharing the latest updates among the farmers and keep connected to be aware of what is happening on the surrounding people's farms for awareness. For instance, a burglar with unauthorized farmland storage access can be reported to the farmers around the premises using the proposed blockchain-based application. The number of applications is numerous using the smart-farm community blockchain.

## 4. IMPLEMENTATION OF THE PROPOSED BLOCK-CHAIN DEFENSE

To evaluate the proposed method for smart agricultural security monitoring using blockchain and cloud technology, we implemented a prototype using the Arduino Sensor with Wi-Fi capability to mimic various sensors deployed in farmland, AWS cloud components to process sensor data, Ethereum blockchain to store monitoring alerts and other important information using the smart contract and develop a web interface to view alerts for users.

**Test setup**: The following hardware/software components such as the Arduino sensor, EP8266 Wi-Fi module, AWS IoT core component, AWS lambda function, infura Ethereum API account, and Web Javascript were used to perform the experiment. The Arduino module with Wi-Fi is connected to the home Wi-Fi router to communicate with the cloud. Our security monitoring application can be developed as a third-party security monitoring product or tool to secure smart agricultural IoT devices. The Arduino Sensor Kit contains a potentiometer, light sensor, sound sensor, air pressure sensor, temperature sensor, and accelerometer to monitor and capture environmental, physical, and other conditions. different conditions. The circuit board is used to connect these sensors to the communication device. Wi-Fi module H. The WLAN module also acts as a peripheral gateway for all the detection devices mentioned in the test setup. The Arduino C language

code is written to connect a Wi-Fi module to a home router and communicate externally with its remote AWS IoT node to update events. His SSID and password key details for his home Wi-Fi router are provided with the Arduino to connect to the internet. AWS IoT core services are built on top of the AWS cloud with some common configuration settings. AWS IoT Core runs on the free RTOS operating system to process data from IoT devices and exchange data via the MQTT protocol. AWS IOT Core can expose sensor device data and store it in cloud storage like S3. AWS Lambda functions are written in the JavaScript programming language and continuously poll the AWS core for sensor event data.

The observing rationale is executed within the AWS lambda work to distinguish the sensor status and sensor information irregularities. The infrua API calls were too performed utilizing the AWS lambda work to upgrade the sensor observing data for changeless capacity within the blockchain. The infura account is required to produce the API key and build up an association with the Ethereum organization. Hence, the alarm data is upgraded to the blockchain and put away within the exchange. To execute the end-to-end application, the infura API calls are utilized to recover the caution exchange from the Ethereum blockchain. The rancher may download the portable application or web app to screen the cultivate alarms remotely. Figure 3 shows the Arduino microcontroller utilized to control and interface to the IoT-detecting gadgets. The temperature sensor and mugginess and light sensor are associated with the microcontroller, and the microcontroller underpins a Wi-Fi association to communicate with cloud administrations. The sensors can be considered agribusiness application conclusion gadgets. As appeared in Figure 3, the temperature and light sensor positive terminals such as A3, and D3 are associated with the microcontroller PINS. The negative terminals are grounded to avoid short-circuiting issues. The microcontroller is control provided with 5V, which is appeared in Figure 3 with a ruddy wire association.

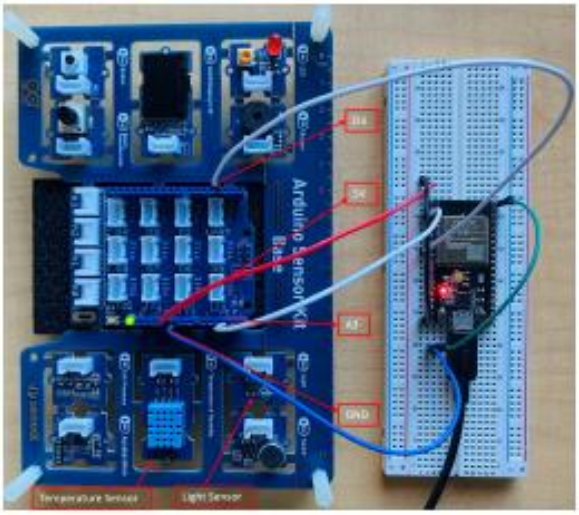


*Fig. 3. Arduino sensor kit to sense the environment.*

As appeared in Figure 4, the detecting device's status will be checked utilizing the desktop application. The Arduino controller is associated with the tablet using wired communication. The sensor measures real-time movement such as temperature and light within the cultivating. We introduced the Arduino computer program application on the portable workstation machine to run the C code on the Arduino pack. The code comprises the WIFI association qualifications; AWS IoT Center association necessities such as Client ID, and AWS Have URL; and the MQTT point title and the programming rationale to study the sensor information as an MQTT subject and publish the MQTT point within the AWS IoT cloud utilizing the arrange association. The code is dumped on the Arduino microcontroller to run the application and post the information in AWS IoT Cloud. Figure 4 shows the print explanations demonstrating the Arduino pack associated with the author's domestic WIFI organization "maverick creek-7-709" and starting an association with the AWS Cloud. Once it is associated with the AWS, the sensor information is distributed as an MQTT subject with values temperature: 26, light: 26, and mugginess 51. The data publish-success message can moreover be seen in Figure 4.

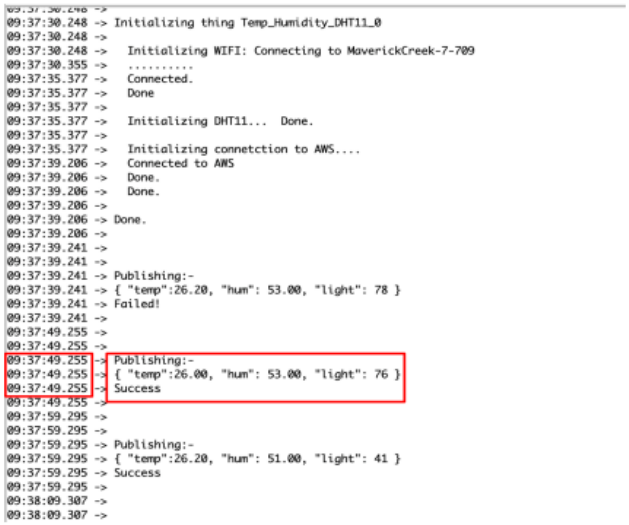


*Fig. 4. Sensor devices connected to Wi-Fi and initializing connection to AWS Cloud.*

The MQTT publishes messages and can also log in to the AWS IoT Core. Figure 5 displays the published IoT sensor data in the AWS Cloud. As seen in Figures 4 and 5, the data publication time in the IoT core cloud is 2 s. The highlighted red boxes in Figure 5 indicate the timestamp and sensing temperature, humidity, and light values in the Arduino kit environment**.**

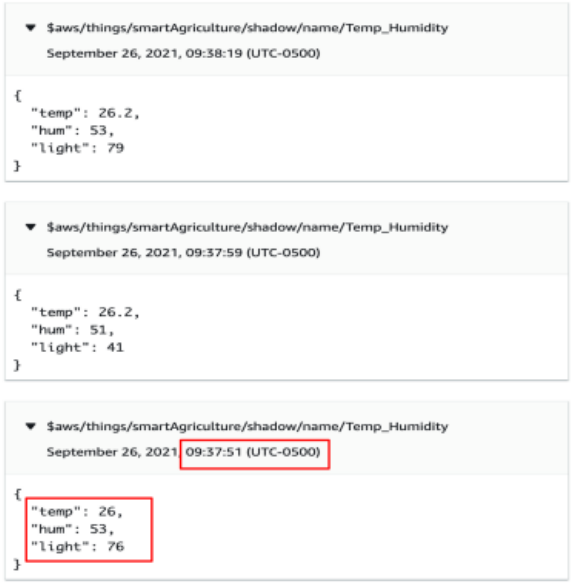


*Figure 5. Sensor data real-time recording in AWS Cloud-IoT core service*

The AWS lambda work composed in JavaScript peruses the AWS IoT Center distributed information and compares the sensor limit values for irregularity discovery. The code may trigger a sensor gadget wellbeing alarm on the off chance that the information isn't gotten for a particular time interim. To connect with the Ethereum blockchain, the Infura API qualifications are put away as factors, and the AWS lambda work reads the credentials to put through with Infura to keep up Ethereum's primary hub. The meta mask application is utilized for the program wallet and to be associated with the

Ethereum blockchain. The wallet subtle elements are moreover given within the AWS lambda work to perform the exchanges in Ethereum. The smart-contract code is written using robustness programming dialect and sends the caution-activated information as an exchange within the Ethereum blockchain. Figure 6 appears that Ethereum exchanges subtle elements when the temperature-threshold-exceeded alarm is seen within the AWS IoT core. The exchanges incorporate the piece number, from and to address, exchange expense, gas cost, and timestamp. Based on the timestamps watched within the end-to-end blockchain- and cloud-based execution, we decided that the time to overhaul the agriculturist when the agribusiness environment inconsistency cautions trigger is 9 s. The Ethereum exchange completion time is 7 s. Be that as it may, we utilized the Rinkeby testing arrange to test the Ethereum arrange, and the general caution notice organizes idleness will not be the same within the Ethereum generation organize. In general, we prove that organize idleness is negligible when performing farming security observing utilizing blockchain and cloud administrations and alarming the farmers.

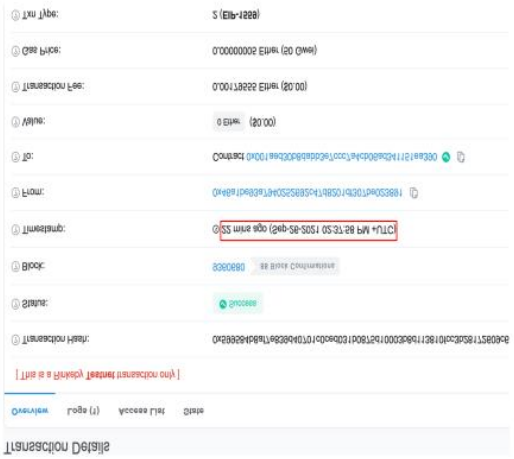

*Figure 6. Ethereum smart-contract transaction details.*

Figure 7 indicates the data field format in the Ethereum transaction. The sensor threshold value, current value, and alert message are stored in the data transaction. This data will not be tampered with and will be stored securely in the blockchain. The boxes highlighted in red clearly show that the temperature value of 25 does not exceed the threshold value of 26.

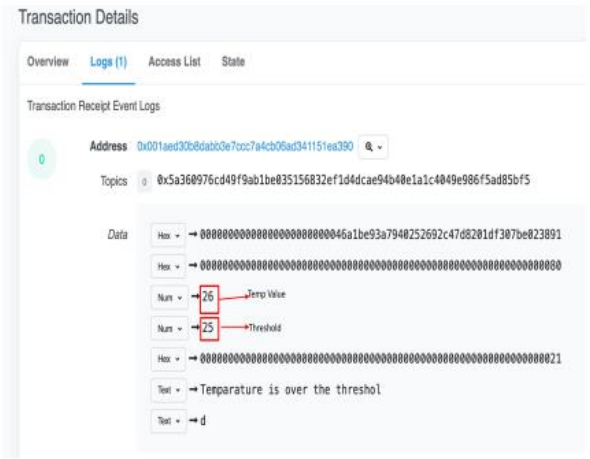


*Figure 7. Ethereum smart-contract transaction storing the sensor data.*

The experimental transaction performed on the rinkeby network can be seen publicly for reader understanding. Figure 8 displays the list of transactions stored in the Ethereum test network. The from and to address, transaction hash value, and block ID can be seen for each transaction.

We have developed a front-end web application to receive farm safety alerts such as device status and anomaly alerts. The UI app displays an alert message as an Ethereum transaction. Figure 9 shows a warning message with details about sensor data and policy violations. For example, block number 9363208 in Figure 9 notifies farmers of temperature changes in the monitoring environment. When the temperature exceeded the threshold value, a policy violation message was displayed on the UI test web application. We used the vertical web platform to develop our test web application. Users may also want to update transactions using the user interface application. For example, users should store sensor anomaly data for future reference. We have integrated this functionality into the front-end web application to update the breach detection data conditions in the blockchain. Figure 10 shows the front-end web application with interactive options for updating transactions in the Ethereum test net. This feature helps farmers or web application users control the blockchain platform used to monitor farm safety. To add a new transaction using the web interface, the user must log in to their wallet and fill in the transaction details. The temperature, humidity, and light sensor values and their optimal values are entered and these are sent using the web application. The infura API is connected to the blockchain node and adds a new transaction when the config sensor data policy is violated. Other users can view the transaction data after the transaction is updated in the blockchain.

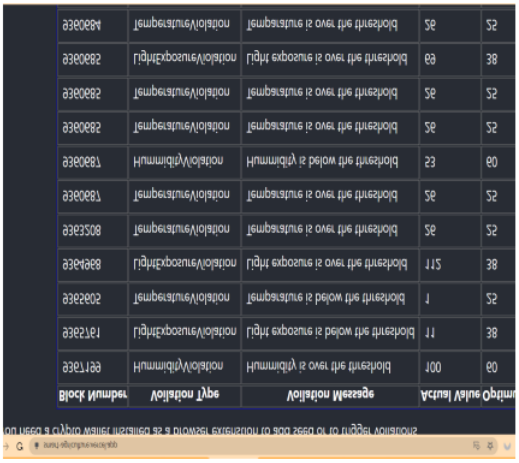

*Fig. 8. Smart-contract web application frontend—alert notifications.*

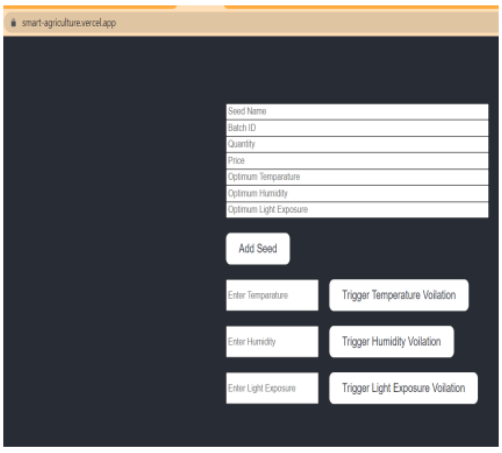

*Fig. 9. Smart-contract web application—frontend GUI.*

Our blockchain solution can be used on the farming community blockchain platform. As shown in Figure 10, a farmer can update the real-time agriculture environment condition to fellow farmers so that fellow farmers do not have to visit the farming location and can effectively make decisions from home to perform daily agriculture and farming operations. Although we only used three sensors to test our prototype, our solution can be easily tweaked to support processing multi-sensor data, and our implementation is used for various IoT applications.

PERFORMANCE EVALUATION MONITORING SYSTEM PERFORMANCE

The end-to-end framework execution has to be assessed to assess the solution's adequacy. The organized idleness and throughput are the pointers seen within the writing as performance components for blockchain-based applications. The time is taken to get the sensor alarm when a peculiarity of the arranged inactivity may be a few seconds. The organized throughput was not tried utilizing our usage due to the infura API free-access restriction. Execution comparison with existing works:

Our arrangement execution is compared with the existing works utilizing blockchain in shrewd contracts. Even though none of the existing works actualized the end-to-end arrangements with AWS cloud and smart contracts, we included the closely related smart-contract execution for smart farming. Table 3 delineates the message organize idleness in comparison of our work with existing works. The creators [38] actualized Ethereum-based smart contracts to overhaul the IoT detecting information to the blockchain and assessed the arranged idleness of issuing an exchange within the blockchain. The creators detailed an ad up to arrange inactivity of 16.55 s. This work is closely related to our work in terms of including the IoT sensor information in the blockchain. Our arrangement performed much superior to the work [38] since we utilized real-time usage applications, counting IoT centers and smart contracts using Infura API. The extra idleness in [38] can moreover be caused by the blockchain hub running in the virtual machine. The work [27] performed reenactments to test the IoT devices sending upgrades to the blockchain and evaluated the arrange idleness. They considered 4G as a communication medium to show the communication connection and gotten less than 0.2 s idleness. We utilized the domestic WiFi to perform the tests and got the matchable execution with [27]. The creators [34] moreover utilized Ethereum to construct the farming savvy contract. The creators detailed that it took 272 s to total one exchange. The tall organize idleness may be caused by the utilization of the genuine Ethereum organize. Our arrangement detailed a add up to arrange inactivity of 0.11 s, which is real-time caution announcing. We moreover decided the cruel time to distinguish (MTTD) when the 95% certainty interim is utilized. The MTTD is detailed as 0.115 with an edge of mistake of 0.00919 and a standard deviation of 0.016. occurs within the sensor environment straightforwardly demonstrates the arranged inactivity. Our test comes about on Rinkeby appears that the network inactivity may be a few seconds. The organized throughput was not tried utilizing our usage due to the infura API free-access restriction.

EXECUTION AND COMPARISON WITH EXISTING WORKS

Our arrangement execution is compared with the existing works using blockchain in shrewd contracts. Even though none of the existing works implemented the end-to-end arrangements with AWS cloud and smart contracts, we included the closely related smart-contract execution for savvy agribusiness. Table 3 delineates the message arrange inactivity comparison of our work with existing works. The creators [38] actualized Ethereum-based smart contracts to overhaul the IoT detecting information to the blockchain and assessed the arranged inactivity of issuing an exchange within the blockchain. The creators detailed an ad up to arrange inactivity of 16.55 s. This work is closely related to our work in terms of including the IoT sensor information in the blockchain. Our arrangement performed much way better than the work [38] since we utilized real-time usage applications, counting IoT centers, and smart contracts utilizing Infura API. The extra inactivity in [38] can too be caused by the blockchain hub running within the virtual machine. The work [27] performed recreations to test the IoT gadgets sending upgrades to the blockchain and assessed the organized inactivity. They considered 4G as a communication medium to show the communication connection and gotten less than 0.2 s idleness. We utilized the domestic WiFi to perform the tests and got the matchable execution with [27]. The creators [34] moreover utilized Ethereum to construct the farming smart contract. The creators detailed that it took 272 s to total one transaction. The tall organize

idleness may be caused by the utilization of the genuine Ethereum organize. Our arrangement detailed a add up to arrange inactivity of 0.11 s, which is real-time alarm announcing. We too decided the cruel time to distinguish (MTTD) when the 95% certainty interim is utilized. The MTTD is detailed as 0.115 with an edge of mistake of 0.00919 and a standard deviation of 0.016.

## 5. DISCUSSION, LIMITATION, AND FUTURE WORK

We actualized a real-time situation agribusiness security-monitoring framework, which screens the sensor device's well-being status and sensor peculiarities to perform accurate agribusiness and profitable cultivating. Be that as it may, we did not send the sensors to the agriculture field to capture the farmland environment conditions. We imagine that the network inactivity will be unimportant, considering the wide spread of the web in provincial regions. Our arrangement can indeed screen the rural conditions in rural areas as long as an online association is accessible. We did not actualize the IoT gateway in our work. We utilized the domestic switch as an IoT portal and associated the IoT sensor devices with the arrange using domestic WiFi. This is often one of the restrictions of our work. Implementing an IoT organize with an IoT portal and different detecting gadgets to imitate the reasonable smart-agriculture environment is one of the expansions of our work. The current execution as it were works on the Ethereum proof-of-work (POW) agreement mechanism blockchain. One future work will be implementing the current arrangement within the Ethereum 2.0 arrangement, which is backed by the proof-of-stake (POS) agreement

There are various IoT applications to screen the IoT environment, counting agribusiness applications, savvy homes, smart well-being, smart transportation applications, etc. In this manner, we imagine our model will too be utilized to execute the observing arrangements in other areas. The arranged traffic can be collected from a smart-agriculture edge gateway and stored the arranged events data within the cloud. Organized occasions can be utilized to apply machine-learning and deep-learning techniques and recognize the anomaly network activity in a smart-agriculture arrangement. One future work will be executing ML- and DL-based network-security observing arrangements in savvy agribusiness and utilizing blockchain to store the arrange inconsistency occasions as transactions. The generation Ethereum blockchain gas cost is tall. Subsequently, blockchain advances such as Cardano and Solano-based blockchain implementation are considered to plan more network-latency applications and decrease the end user/farmer exchange fetched in shrewd farming. 9. Conclusions In this article, we proposed a cloud- and blockchain-based security observing framework for smart-agriculture IoT applications. The end-to-end application model was executed utilizing an Arduino sensor pack, AWS cloud components, web application GUI, and the Ethereum blockchain smart contract to caution the farmers of security anomalies and sensor-device status. The prototype was able to alarm the farmers in real-time, permit inaccessible observation of the cultivated and farming environment, and empower the cultivating community to communicate using blockchain. The execution assessment in terms of organized idleness is appeared to be ostensible with our model and it may be expressed that the delay can indeed be diminished with the execution of high-performance exchange blockchain technologies such as Cardano. We talked about the limitations and future openings to progress the security of shrewd farming.

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