

Secure and Energy Efficient Scheme for smart agriculture using IoAT and Blockchain

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Abstract:

One among the latest trending technology for improving the productivity in the agriculture is named as precision agriculture. This technique connects some of the technologies such as Internet of Agricultural Things (IoAT), Wireless Sensor Networks (WSN), remote sensing for through sensors and so on. The above technologies are correlated to make many improvements in the field of agriculture for better productivity. The previous work concentrates in providing an efficient routing scheme for smart agriculture. This work focused on combining the blockchain technology with IoAT to achieve secure data transfer in cloud. Additionally, it maintains the energy efficiency through proposed Improvised IoAT-LEACH. The sensors forwards the collected data to the PIC micro controller and the acquired data is transferred to cloud through Raspberry Pi module after verifying the data through blockchain based module. Further, the blockchain technology provides a reliable and transparent data sharing approach with high data security. In proposed Improvised IoAT-LEACH protocol, a new threshold limit is introduced to improve the energy efficiency. Through the blockchain and Improvised IoAT-LEACH intelligent farming system is proposed and thus proves in increases the throughput of 63% than the other schemes. Further, extensive simulation is performed to evaluate the proposed mechanism against potential attacks.

Keywords: *IoAT, WSN, LEACH, Blockchain, Cloud*

INTRODUCTION:

In recent years, Internet of Things (IoT) plays a major role in the day-to-day activities and modifies the environment around us. Generally, IoT is termed as interconnection between the physical devices for data collection and data forwarding to the particular system [1]. Further, the global Internet of Things Standards Initiative identifies that the IoT is a common platform and infrastructure for the information society. For the development smart inventions and smart city, smart home and so on, the IoT combines with the recent other technologies like blockchain, quantum computing and more[2]. These combined technological developments penetrates the new facets of sophisticated human life through smart town, smart industrial plants, smart ecosystems and healthcare [1-3].

IoT extends its infrastructure for agriculture through internet of Agricultural Things (IoAT) that explicitly utilised for the development of precision agriculture [3]. It is a diverse system with variety of devices from variety of companies for data collection, distribution of collected data, storing of data, analysing the data and finally decision making through the collected data. In the combination of variety of devices, IoT faces many challenges in defining routing strategy

between those devices. Commonly, the agricultural field in smart farming is made up of several number of clusters with various farming activities, needs and data collection. Thus, different monitoring strategies are in need to process those activities [4]. Additionally, the IoAT devices are placed in a wide area where multicluster farms are ready in heavy data sharing with network crowding, radio interfering, issues in latency, high energy usage and so on which reduces the performance of the network. Sometimes, the incompatibility issues between the devices occurs and it reduces the network lifetime [5]. Various communication protocols are to be analysed and implement to maintain the stability in network performance. In IoAT node-level communication between the peers is not a common line of communication, excluding for some specific application like smart swarms and smart city. IoT technology (IoAT) is a known technology for smart farming, whereas it is used with particular system specific applications. To address the limitations, blockchain integration is performed with IoAT to achieve better solutions. Incompatibility issues between different IoT devices and between the different areas where IoT is deployed are also posed due to improper communication protocols as shown in Figure 1 by AWS (Amazon Web Services) [6].

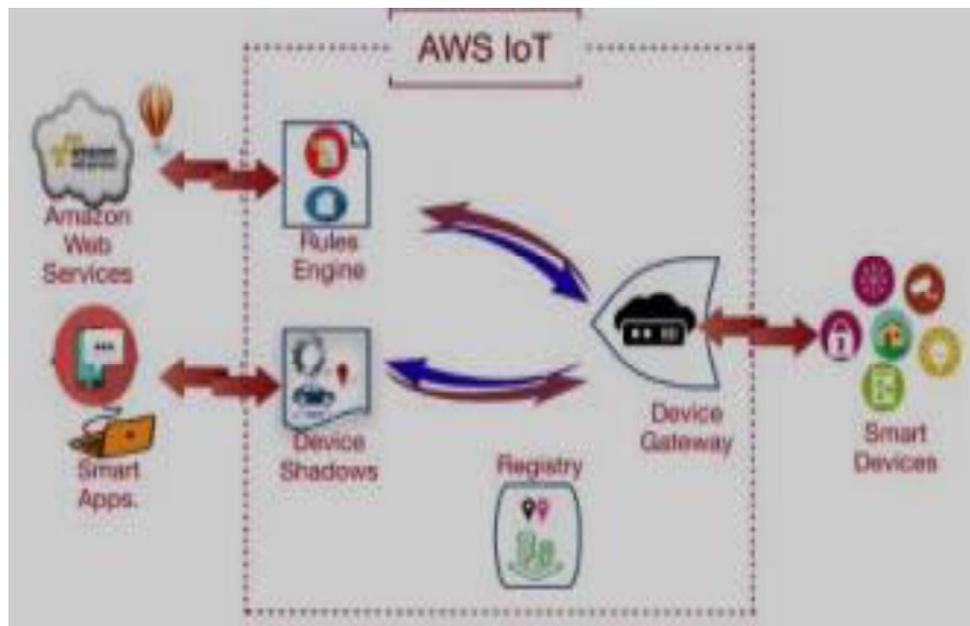


Fig. 1 IoT architecture with improper communication in AWS

Blockchain is changing many industrial concepts through new innovation paths and it mainly provides a decentralized data storage with high security. blockchain offers a decentralized network with data storage instead of storing in centralised servers [7-8]. It is an online platform to track and record the transactions through distributed registers also known as shared ledgers. In addition, blockchain technology allows tracking the ownership and duplicating transactions also shared at the same to the participating agent with in the network [9]. However, blockchain is the evolution for smart agriculture and it has great potential for smart farming and makes the data transmission as more transparent with safe and security. This technology makes the IoAT, a more safe and secured communication technique for smart farming. therefore, this research focuses on presenting a novel routing scheme for IoAT with blockchain for a feasible routing and providing better data security with low energy consumption than the existing techniques. Figure 2 presents the IoT based architecture with implementation of Blockchain [9-10].

environment. This protocol is efficient in collecting the data however, detain its performance in slow data processing, and transfer due to various checks in the protocol for data transfer.

IoAT is a specific technology for agricultural data processing through sensors. Commonly sensors life is less due to its working nature and connects with battery than the direct power. Therefore, the author introduced Low Energy Adaptive Clustering Hierarchy (LEACH) protocol in IoAT with trust management for routing to improve the network lifetime and security of the data. However, the security of the data in cloud is not highly secured due to infrastructure less cloud environment is introduced by Cui et al. [17]. The researcher proposed a multipath routing for cloud environment, where the cloud to be more secured to collect data from various Cluster Heads (CHs) simultaneously. The data aggregation should be done as fast as data collection, due to the speedy transmission to cloud. Sangeetha et al. [18] fails in aggregation that leads to slowdown the performance of the network. The author proposed a blockchain based authentication for IoT network using Public Key Infrastructure (PKI) for secure communication between the devices after identifying its IDs and this scheme provides high security in user authentication and fails in data collection (which is a major motive of the IoT environment).

Motivation:

The literature review presents a view on routing problem and energy consumption of the network and other weakness of the network. In general, CH is to communicate to the cluster members to collect the data from it and forward it to the BS. Somehow, the collected data is aggregated but not fully aggregated due to less aggregation privilege in the defined network. Better CH formation with best energy consumption and trust mechanism process that computes trust based on pre-defined time interval to develop an absolute trust degree. To resolve these problems, an energy-efficient secure IoT scheme with trust mechanism to develop a friendlier environment and efficient agricultural production (IoAT-LEACH). However, IoAT-LEACH security is less and needs to improve energy efficiency to some extent to improve the lifetime of the network.

PROPOSED SECURE AND ENERGY EFFICIENT SCHEME FOR SMART AGRICULTURE USING IoAT AND BLOCKCHAIN

The proposed routing scheme Improvised IoAT-LEACH is processed using the preliminary concept of LEACH protocol where it works efficiently in reinforcing the overall network performance with minimum energy consumption. The objective of this research is to improve the security of precision agriculture system using blockchain technology. Additionally, to enhance energy efficiency through Improvised IOAT-LEACH protocol.

Enhancing security of precision agriculture using blockchain

The blockchain technology consists of blocks that are integrated to perform a specific task. The stacks of records are referred as “blocks”. Each individual blocks are connected through cryptographic technology for secured interconnection. The main advantage of blockchain technique is that it can verify the records/transactions in a transparent manner with high security. This technique is implemented to enhance the security of precision agriculture farms focusing on moisture sensor and temperature sensor. These two sensors are the major sensors in precision agriculture. Fig. 3 presents blockchain based IoT applications.

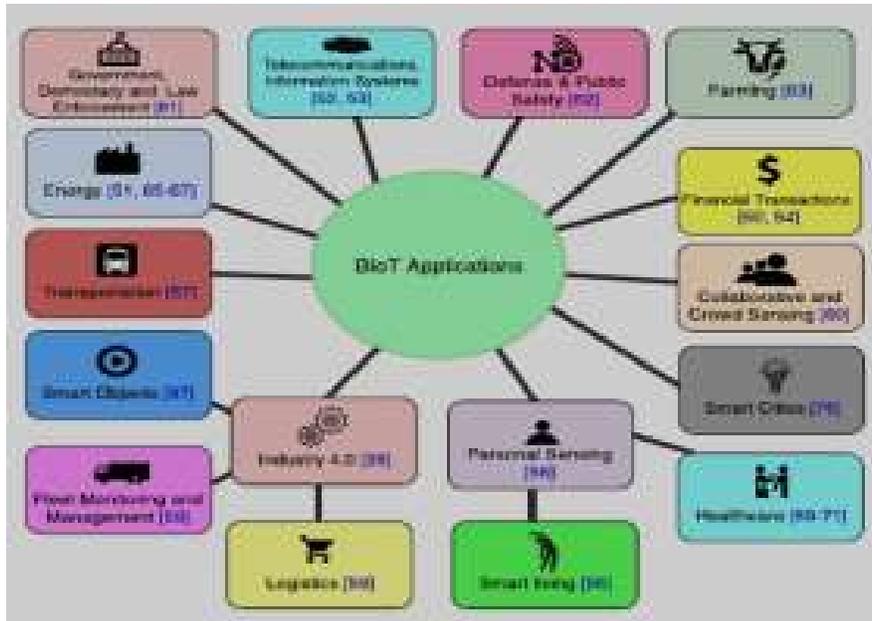


Fig. 3 Blockchain based IoT applications

As the IoAT-LEACH proposed in the early work, works based on proposed trust value and since this scheme utilising the cloud technology, the trust value can be easily altered or seen by the third party. Therefore, the security of this scheme is to be enhanced. This work, focusing on improving the security through developing a decentralised blocks to secure and perform better environment for the precision agricultural farm. Figure 4 illustrates the security enhancement of precision agriculture using blockchain.

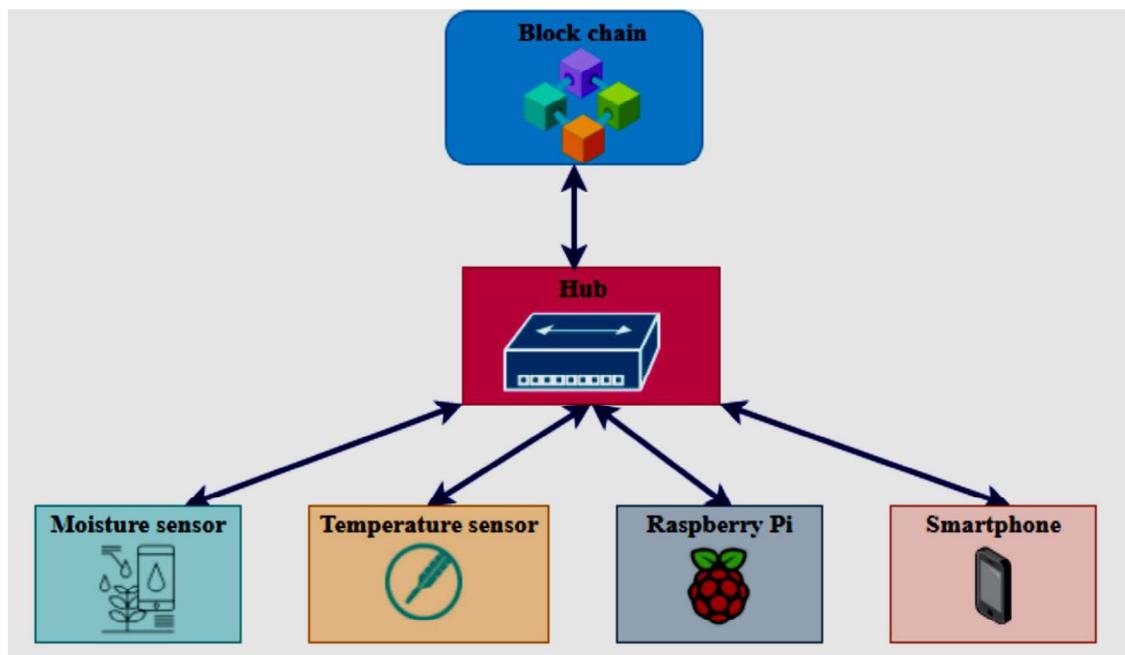


Fig. 4 Security enhancement for precision agriculture using blockchain

The figure 5 presents main components of data security through blockchain for precision agriculture application. This scheme proposed using the components such as wireless sensors, cloud, end user and water management system to utilise the water resource efficiently. Whenever a sensor acquires the data, the data is broadcasted to P2P network after the data is validated through blockchain security feature. After the validation the block will be encrypted and added to the blockchain to transmit the data to the BS/end user in a safe and secured manner.

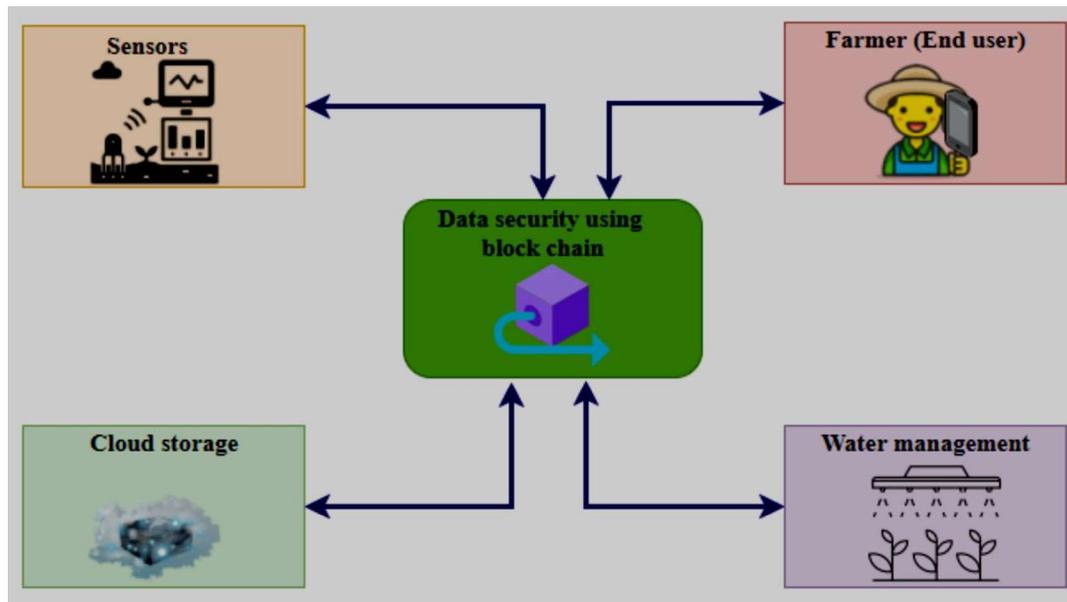


Fig. 5. Data security using blockchain

PROPOSED IMPROVISED IoAT-LEACH PROTOCOL

The proposed Improved IoAT-LEACH Protocol is an enhanced form of IoAT-LEACH proposed in the previous work. This enhancement is to increase the energy efficiency of the network system in precision agriculture. Figure 6 shows the proposed Improved IoAT-LEACH security process.

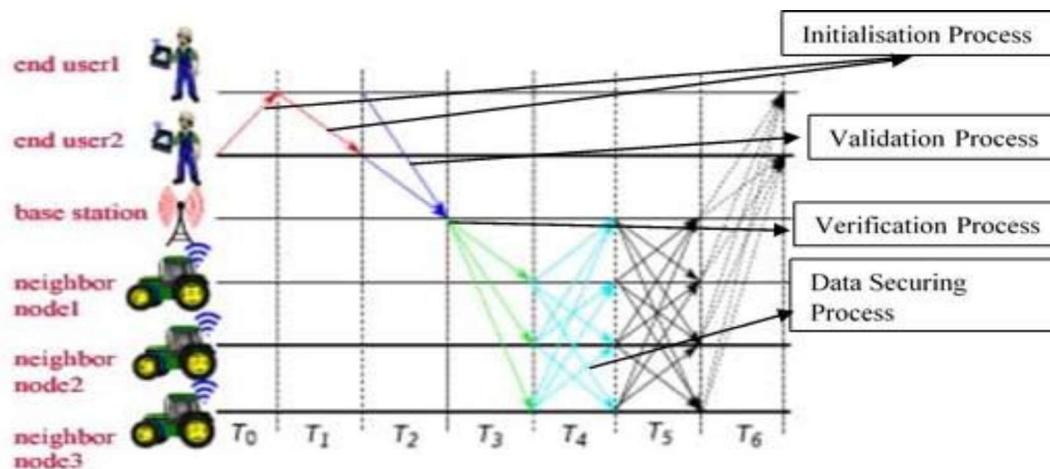


Fig. 6. Improved IoAT-LEACH Security Process

LEACH protocol works based on time division multiplexing scheme, where each sensors transmits their data to the BS through elected CH. There are two process involved in this scheme. They are initial setup stage and steady stage. In initial setup stage, the sensor nodes are assigned to a random value between 0 (zero) and 1 (one). Then, the threshold value will be calculated and the node, which holds nearby value or same value as of threshold value will be called as CH. This process will be processed once when a LEACH is initiated. In LEACH, each process is termed as round and on round 0 (zero) the setup stage will be initiated. From round 1 steady phase will be initiated. In steady phase, the CH is elected based acquired threshold value. This process is done continuously based on the allocated time slot in TDMA schedule. The IoAT-LEACH, which is proposed previously, follows the trust management scheme for data transmission between member nodes to CH, CH to BS and BS to cloud environment.

Now, the trust for BS to cloud environment is proposed in Figure 7..

Algorithm 3: Trust Degree calculation for BS to Cloud Server data Transmission

1: procedure TRUST EVALUATION

2: Current Trust Evaluation:

$$c_{cog}^T = \sum (ob_1^{dis} + ob_2^{dis} + \dots + ob_n^{dis})$$

$$c_{ro}^T = \sum (ob_1^{cre} + ob_2^{cre} + \dots + ob_n^{cre})$$

$$c_{re}^T = \sum (ob_1^h + ob_2^h + \dots + ob_n^h)$$

3: Trust Development

$$Current_T = \sum_0^1 (c_{dis}^T + c_{cre}^T + c_h^T)$$

$$Pre_T = \sum (p_{dis}^T + p_{cre}^T + p_h^T)$$

$$Aggregate_T = \emptyset \left[\sum_0^1 (Current_T + Pre_T) \right]$$

4: Trust Degree Obtained

5: Maximum Power = $P_{CH} = P_{max}$. All data transmission is scheduled

6: Transmitting $CH_{data} \rightarrow Cloud_{data}$

7: Verifying $\theta(Cloud_{data})$

8: Initiating Encryption Phase.

End;

Fig. 7 Proposed Trust Degree calculation for BS to Cloud Server data Transmission
The Proposed Improved IoAT-LEACH Protocol is presented in Figure 8.

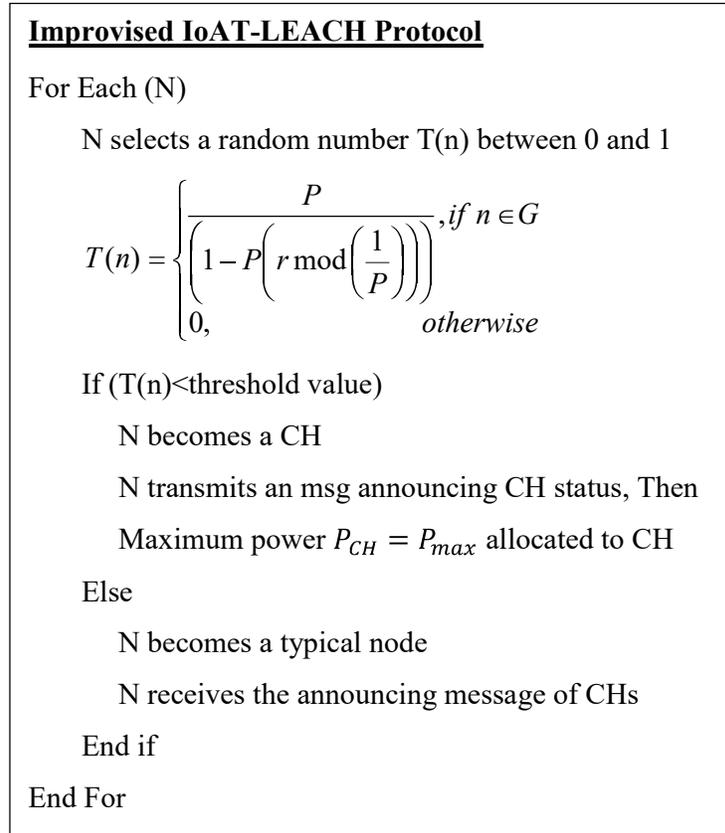


Fig. 8 Proposed Improved IoAT-LEACH Protocol

When the Improved IoAT-LEACH is called, the maximum power is allotted to the CH to collect the aggregated data from the member nodes and forwards the data after aggregation to the block for verification of data and securing it from the intruders.

RESULTS AND DISCUSSION

Network Simulator (NS3) version 3.25 [19-21] is used to simulate the proposed scheme, and NS3.25 outperforms in compared with the other simulation tools. The implementation of NS3 becomes flexible with the help of Otcl and C++ programming techniques. The tool helps analytically prove the theory.

In the simulation, 300 nodes were placed in 500 X 500 Meter square region for 400 seconds of simulation time. Table 1 presents the simulation parameters used in proposed scheme.

Table 1 Simulation Parameters for the proposed Scheme

Parameters	Value
Network Space	500 X 500
Number of Nodes	300 (0-299)
Number of CH	5 (5%)
Base Station	300th Node

Position of BS	50,100
Initial Energy	1 Joule (J)
Packet Length	200 bits
Simulation Time	400 Seconds
Time for each Round	10 Seconds
Protocol	LEACH

A. Energy Consumption

The energy consumption is significant need for implementation of Improved IoAT-LEACH, since there are some remote areas where the continuous supply of energy is not possible and thus the proposed protocol supports in improving the lifetime of the network. Fig. 9 presents energy utilisation between proposed and existing schemes.

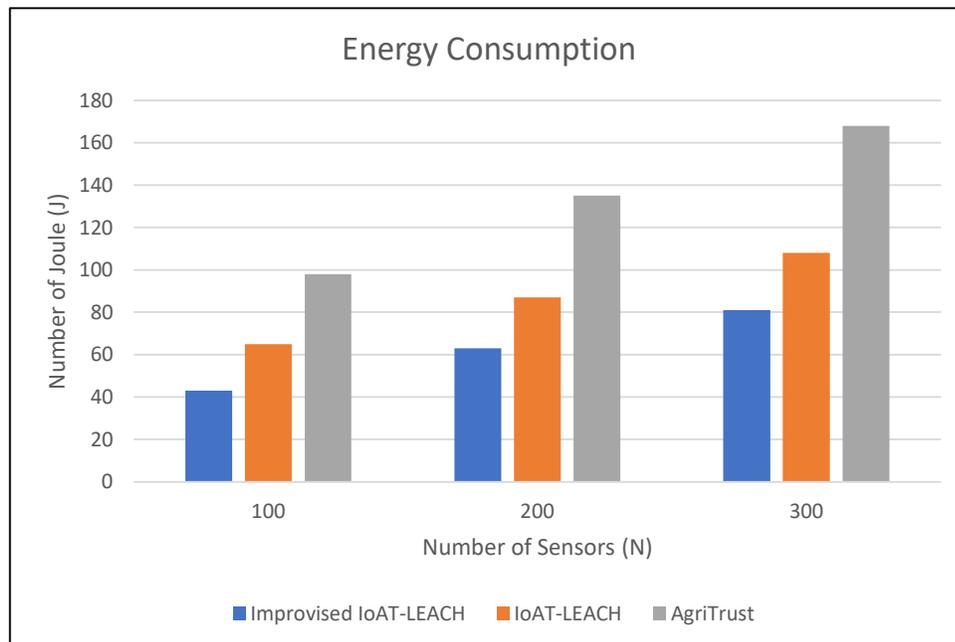


Fig. 9 Energy Consumption

The proposed Improved IoAT-LEACH attains better energy consumption (23%) than the other existing approaches.

B. Delivery Ratio

The delivery ratio represents the number of successful packet delivery from source to destination (member nodes to CH, CH to BS and BS to cloud server). The Fig. 10 represents delivery ratio between member nodes to CH, CH to BS & BS to Cloud Server respectively.

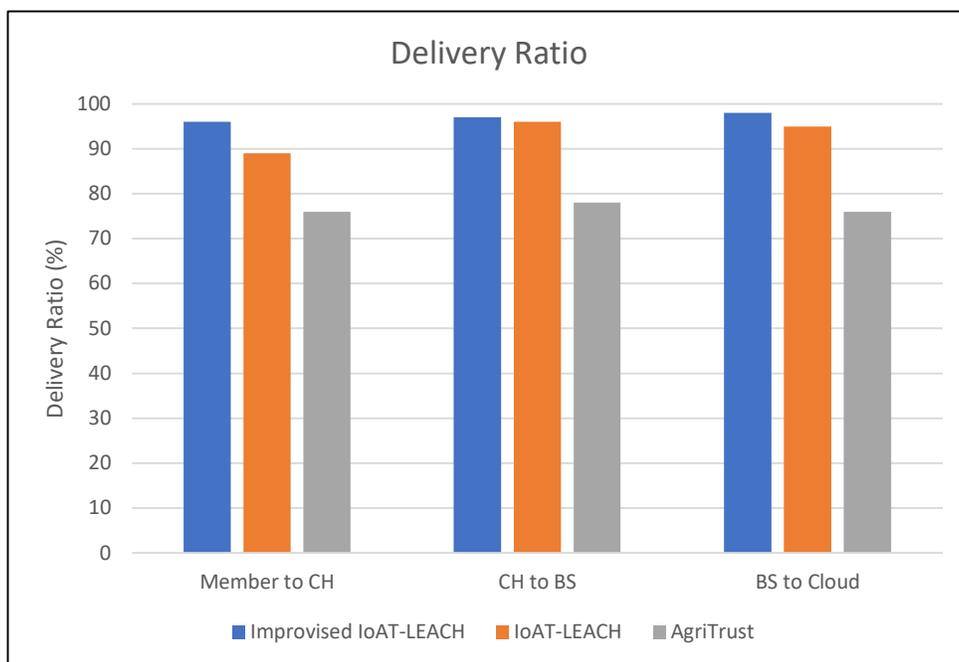


Fig. 10 Delivery Ratio

The delivery ratio between the member to CH, CH to BS and BS to Cloud is identified and the proposed work Improved IoAT-LEACH maintains better performance than the other two existing schemes. Additionally, the proposed work maintain 11% of better performance than the existing schemes.

C. Number of Alive Nodes

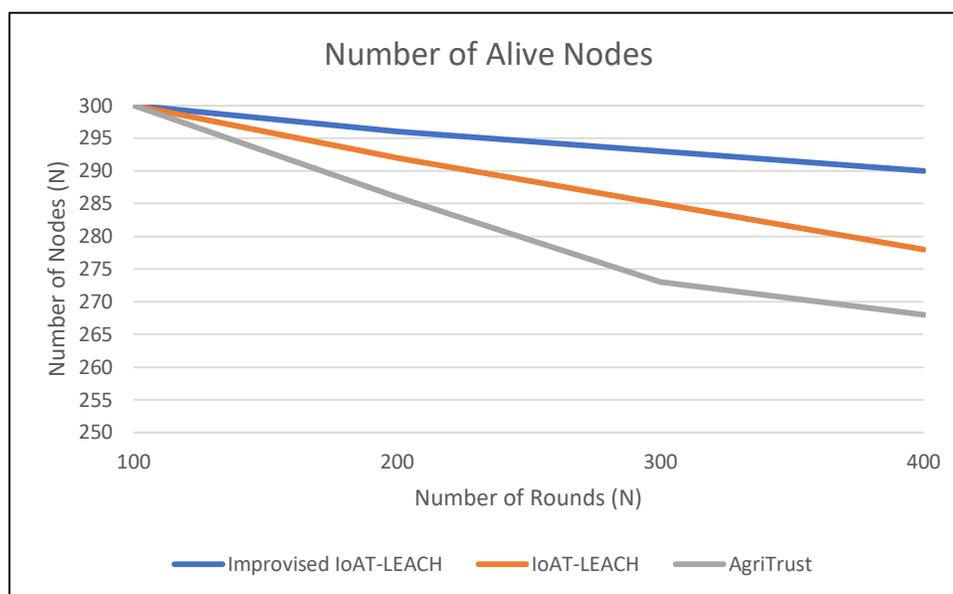


Fig. 11 Number of Alive Nodes

Number of Alive nodes is the parameter to identify the lifetime of network, Where the proposed scheme Improvised IoAT-LEACH outperforms than the other schemes and maintains 12% of better performance than the other schemes.

CONCLUSION

This paper focuses on a novel technique to enhance the security and energy efficiency in IoAT based precision agriculture. First, for enhancing the security, the blockchain approach is implemented to encrypt the cloud data in a decentralised server and then the block is added up to the cloud to enhance the security. The trust value obtained in the previous work (IoAT-LEACH) is enhanced to maintain high security. Second, the energy efficiency scheme is enhanced from IoAT-LEACH to maintain better energy efficiency. The security enhancement of the proposed Improvised IoAT-LEACH is evaluated through throughput (Delivery Ratio), where the proposed scheme maintains 11% of better performance than the existing schemes. The Energy efficiency of the proposed scheme is evaluated through energy consumption and number of alive nodes where, the Improvised IoAT-LEACH outperforms 23% and 12% than the existing schemes respectively.

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