Webology (ISSN: 1735-188X)
Volume 18, Number 6, 2021

# Energy Efficient Data Aggregation Protocol Based Iot-WSN Framework For Smart Agriculture

**Vijay Nandal[1] , Sunita Dahiya[2]**

[1]Research Scholar ECE, DCRUST Murthal.

[2]Assistant Professor ECE, DCRUST Murthal.

---

**Abstract:** The Wireless sensor networks (WSNs) is significant area of research in various fields such as communication, industry, and agriculture. For the automate agriculture, IoT-based WSN has been designed by utilizing various sensors. The agriculture production can be improved by deploying the sensors and the temperature, humidity, and irrigation systems are obtained. In this paper, an IoT-based WSN framework utilizing the Energy Efficient Data Aggregation Protocol (EEDAP) is proposed for smart agriculture. The relevant agriculture data is captured by the agricultural sensors and determine the Cluster Head (CH). In a wireless sensor network, the clustering concept uses energy efficient methods to increase the lifetime of the devices by saving their energy of the devices. The communication performance is enhanced by the proposed framework as presented by the obtained simulation results.

**Keywords:** Smart Agriculture; Wireless Sensor Networks; Energy Efficient Data Aggregation Protocol; Cluster Head

## 1. Introduction

With the development in information technology, the advance techniques are utilized for the cost management and production in the field of agriculture. In many fields, the WSN has been utilized in an effective manner for network performance improvement [1, 2]. This technology plays its role in different fields like transportation, medical, martial and agriculture. The environmental conditions are monitored by the sensor nodes which include the humidity, temperature, and illumination [3]. Additionally, the probability of weather natural disaster is also sensed by the sensor nodes. There is autonomous operation in the sensor nodes and the network infrastructure construction in an ad-hoc manner. Based on some factors, nodes have not the stable topology in such infrastructure as the suitable neighbor can be joined for the transmission of data [4, 5]. The observing data and information is sensed by the sensor node via gateway or the cluster heads (CHs). The received data packets are aggregated by the CHs and then transmit to the base station (BS). The single-hop or multi-hop path is efficiently constructed by the CHs to the BS. The mechanism of store and forward is followed by the CHs and all the received data is stored in the memory. For the required observed data recovery, the centralized BS is accessed by the end users via web based applications. The installed sensors can be fixed or portable during the transmission of data [6-8]. There are fixed constructed routing tables in non-adaptive and static sensors. While the mobile sensors routing tables are dynamic and often updated when there is change in network topology. The security of the static routing is more in comparison to the dynamic routing however for the large regions, the static algorithms are not suitable [9, 10]. Currently the IoT technology has been combined with the other domains for the communication improvement in form of load distribution, utilization of resources and the throughput. For the information conversion, many physical objects are attached in IoT while utilizing the internet. Moreover the foundation for the IoT systems is provided by the WSN technique. The basic diagram of the smart agriculture network consisting sensors, BS, sink nodes, Internet, and users is shown in Figure 1.

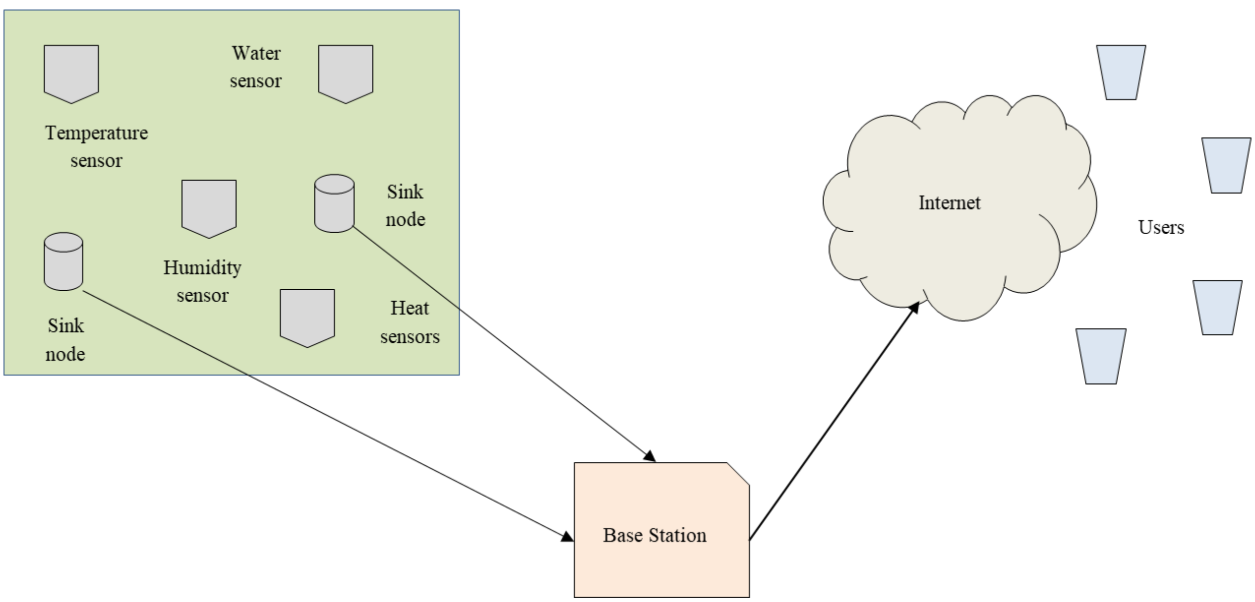


**Figure 1:** Basic diagram of the smart agriculture network

There is negative impact of the climate drastic change in the agriculture eco-system which causes heavy rains, floods, and rapid climate conditions. Such climate change threatens the food security in developing countries. The challenges related to the climate can be overcome by implementing smart agriculture utilizing IoT and the production of agriculture is increased [11]. In the last few decades, the sensor utilization in agriculture has been presented as offline data collector [12]. The sufficient information is provided by such sensor infrastructure yet they are not able to deliver frequently changed environmental data.

**Contribution:** The aim of the paper is at utilizing the IoT based sensor infrastructure for the environmental data collection and secure data transmission to BS for effective decisions. In the presented technique, the information is extracted from the agriculture land like humidity, temperature, and moisture levels. The complete environmental information is transferred to the CHs which are further forward toward the BS. On receiving the data by the BS then for the effective decision in less time, the proper information is provided to the users. Energy efficient data aggregation protocol (EEDAP) is the proposed framework for the agriculture production automation. The agricultural land productivity will be increased by effectively observing the data. The organization of the paper is as follows. The existing literature survey is detailed in section II followed by the presented method in Section III. In the Section IV, obtained simulation results are detailed. Finally, the complete work is concluded in Section V.

## 2. Literature Survey

In previous years, many researchers have worked on various WSNs based techniques for smart agriculture. Here is some state-of –the art techniques by the researchers available in literature.

Simon et. al details the WSNs that can be utilized in many application areas such as agriculture, environmental monitoring and forest fire detection etc. By packet transmission reduction, the data aggregation is the efficient technique for energy conservation [13]. In literature, many aggregation systems are presented but they are less effective for large scale WSNs. Author presented an effective technique for large scale WSNs utilizes the spatial and temporal correlation for efficient data aggregation. Babu et. al utilized the TDMA based MAC protocol for environmental data collection like moisture level and soil temperature in an irrigation system. The data is collected by the base station by utilizing the sensor nodes. The all network nodes are homogenous and energy constrained [14]. The time slot is assigned by the TDMA scheduler for data transmission in the each node. Author utilized the TDMA scheduling based two methods. The direct communication is the first method in which data is directly transmitted by each node to the sink. The data fusion (aggregation) method is utilized by the second method. The presented technique provides the high throughput as compared to existing techniques. For precision agriculture, Maurya et. al details a threshold sensitive hybrid routing framework [15]. The region-based static clustering approaches are utilized by this protocol for sensor node deployment and it provides the effective agricultural field coverage. In the proposed technique, the hybrid routing is utilized to transmit the data where the installed sensors use the direct data transfer method while others utilize the clustering method on the basis of fuzzy for data transmission to the base station. Thus, the presented threshold sensitive hybrid routing scheme reduces the overall sensor nodes energy consumption. Padmaja et. al proposed an optimal transmission manager to support multiple applications in single-hop WSNs [16]. We formulate the problem is formulated in this work with Markov decision process (MDP) model that dynamically adjust the random delay requirements based transmission instances. To operate in multi-hop WSNs, a distributed transmission manager is also presented that controls the optimal transmission manager. The results show that the presented technique consumes less energy as compared to existing technique.  Jawad et. al reviewed the recent WSNs applications in agriculture research and the classification of various protocols is done in this paper [17]. For WSNs, the energy-efficient taxonomy and the energy harvesting techniques are utilized for monitoring systems in agriculture. Different limitations and challenges are explored in this domain. For long term monitoring, the power reduction techniques are also highlighted. Kamarudin et. al details the challenges and the WSN evaluation for the agriculture applications. The LEACH protocol design is effective for many applications [18]. The energy efficiency is achieved by it through clustering with “TDMA based MAC layer” technique and aggregation scheme. The radio propagation are utilized by the LEACH as shown by the analysis. The LEACH protocol performance is analyzed by the author for the agriculture environments. Qureshi et. al details that the agriculture sector also adopted WSNs for environmental friendly farming methods promotions and to achieve scientific cultivation [19]. The sensor nodes are suffered from different limitations and lead to failure in data transmission. The extra burden is caused on base station as the sensor nodes near the BS are always relaying on it due to the limitations. Author presented a “Gateway Clustering Energy-Efficient Centroid- (GCEEC-) based routing protocol” to address these issues. The data load is reduced by the gateway node and onwards the data to the BS. The presented technique is evaluated by the simulation with the existing protocols. The presented technique provides more feasible WSN-based monitoring fin agriculture sector. Abdulzahra et. al details that the data aggregation is one of the main approaches for data redundancy reduction data and efficiency improvement [20]. By an effective data aggregation protocol, there is reduction in network traffic. More than one sensor is utilized for sensing when a specific target takes place in particular area. Different protocols and aggregation methods are detailed by the author. Ohja et. al reviewed the potential WSN applications, and the particular issues associated with assembling WSNs for frame improvement [21]. The analysis of WSNs sensors and communication techniques in agriculture is done comprehensively. Several studies are presented to explore the solution in different classes according to their implementation. Haseeb et. al presented an IoT-based WSN framework for the automate agriculture which comprises the various design levels [22]. The relevant data is captured by the agriculture sensors and the CHs set are determined on the basis of multi-criteria decision function. The signal strength is measured on the transmission link while utilizing the SNR for effective data transmissions achievement. The agricultural sensors also provide the security for the data transmission while utilizing the linear congruential generator recurrence. The communication performance is enhanced by the proposed framework as proved by the obtained results. Jain et. al proposed a cluster-centered energy for agriculture data on IoT-centered WSN [23]. The selection of Clusters Head (CH) and the clustering is performed on WSN to carry the Data Aggregation (DA). The highest security level is achieved by the presented technique and the QoS requests are fulfilled concerning the delivery of packet, delay and throughput.

## 3. Proposed Methodology

The WSN technique is widely utilized in many research domains and in the agriculture field, it also plays the significant role. It effectively observes and manages the agriculture land on the basis of crops, water usage and climate. Still, there are some challenges in the agriculture field like energy effectiveness, routing of data and the transmission data security. The proposed IoT-WSN technique is designed by utilizing energy efficient data aggregation protocol for efficient agriculture monitoring and production. For the creation of network clusters and CHs, K means clustering algorithm is utilized in this model. The Euclidian distance formula is used for the for the nodes and CHs distance detection. For identification and fault handling in cluster, fault tolerance mechanism is utilized in this model. The flowchart of the proposed technique is shown in Figure 2.

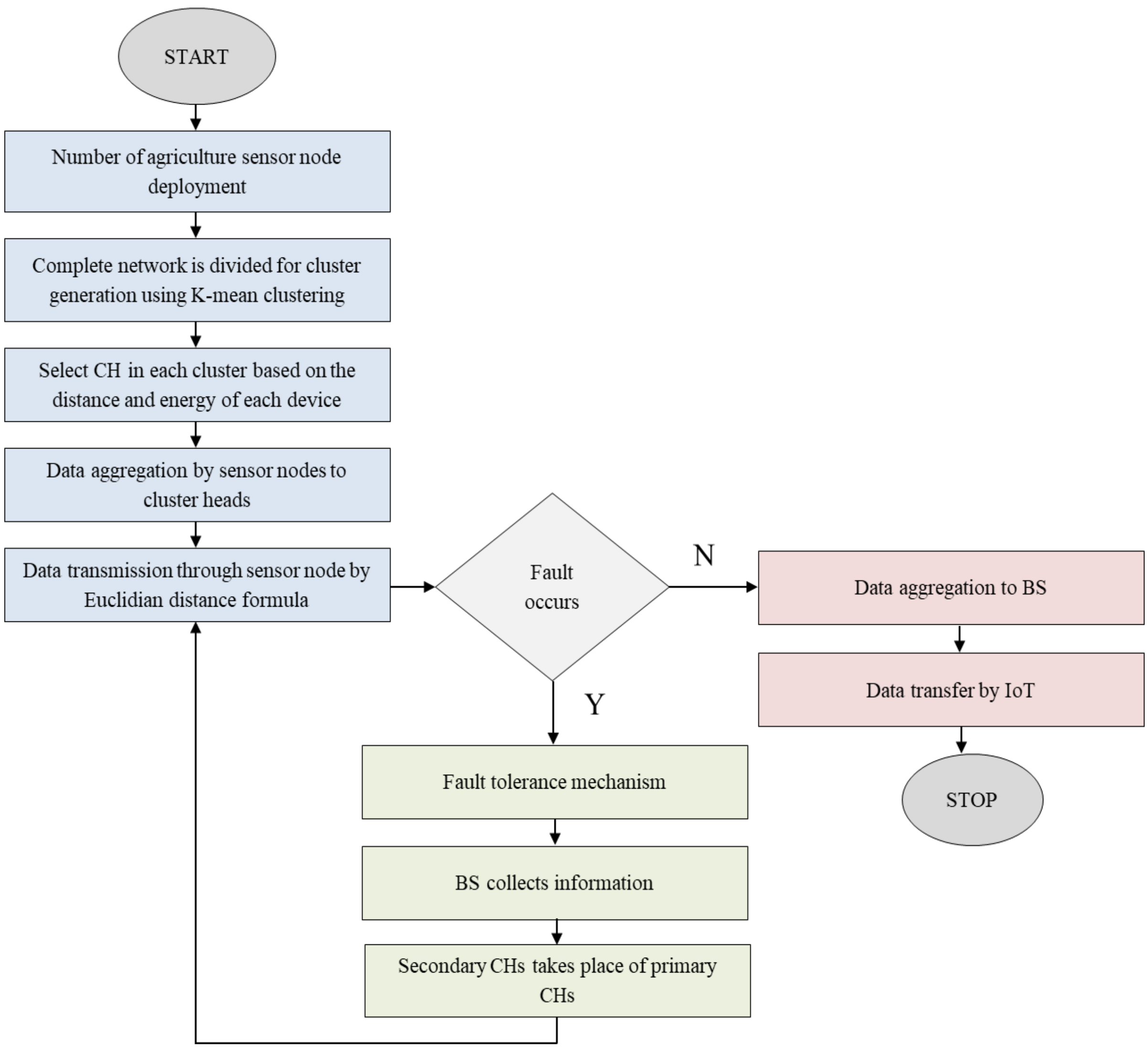


**Figure 2:** Flowchart of the proposed technique

Initially, the WSN having enough power is generated by deploying the finite number of sensors in this model utilized for the data transmission to the other nodes. The k means clustering algorithm

is used for dividing the cluster which divides the nodes on the basis of power consumption and the distance from the base station. Then on the basis of nodes energy levels well as the distance from the BS, the CHs will be decided. CHs will be responsible for collecting the data from sensor nodes and relay it to the BS. All the sensor nodes in the WSNs other than the CH will do the data aggregation. There is communication between the sensor nodes for hop by hop data transmission. With the help of the Euclidean distance, data transmission is done in between the nodes and CHs by utilizing the intermediate sensor nodes. Data is transmitted by each sensor node to the next node having the minimum distance. If any sensor node fails then the sensor node will transmit data to the next sensor node which is again determined by utilizing the Euclidean distance formula. If there is low energy level then fault will occur and it will stop the data transmission to the next node leading the sensor nodes failure. Then the fault tolerance mechanism is utilized to handle the fault. All the information regarding the fault is then received by the BS which helps to determine the faulty node from the cluster so that any other path can be established for the data transmission and any new node can be deployed on its replacement. Now primary CH is replaced by the secondary CH which is decided on the basis of energy level and the distance from the base station. The new cluster node must have higher energy as compared to other nodes so that there is reduction in failure chances of node. If there is fault occurs then the data will be aggregated by the CH to the base station and IoT is utilized for the data transmission.
In the presented technique, the agricultural sensors are dispersed for data collection like temperature, humidity etc. In terms of residual energy, the sensor nodes are heterogeneous such that the heterogeneous nodes energy level is greater as compared to the sensor nodes. In various distant area of agriculture land, the agriculture sensors are dispersed and in each area there is one CH. The agriculture CH receives the information from the agriculture land and then transmits it to the BS in energy effect and fault tolerant manner. For the network latency reduction, hop by hop transmission is utilized by the proposed framework instead of multi-hop paradigm.

## 4. Results and Discussion

### 4.1 Simulation result analysis

The simulation results of the presented technique are described in this section. The proposed technique performance is evaluated on the basis of dead nodes with increasing number of rounds, number of packets received by the BS, Packets received at CH, packets received at BS per round and the residual energy. The sensor deployment in agriculture field is shown graphically in Figure 3.

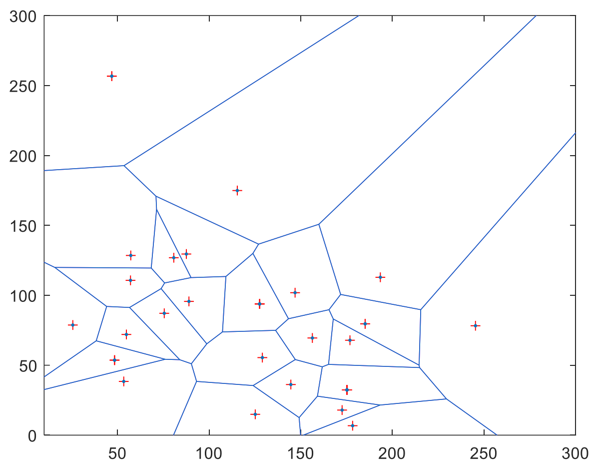


**Figure 3:** WSN network in agricultural field

The Figure 4 shows the increase number of rounds effect on the number of dead nodes for the agriculture data. With increase in number of rounds, number of dead nodes is not increased rapidly. There is slight change in the dead nodes with increasing number of rounds. There is increase in number of dead nodes with increasing rounds because of the high power consumption of nodes in a cluster.

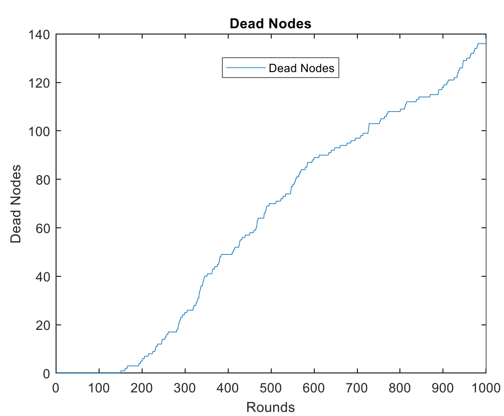


**Figure 4:** Effect of number of rounds on dead nodes

The increase number of rounds effect on the number of live nodes for the agriculture data are shown in Figure 5. The number of live nodes is not decreased rapidly with increase in number of rounds. There is decrease in number of live nodes with increasing number of rounds.

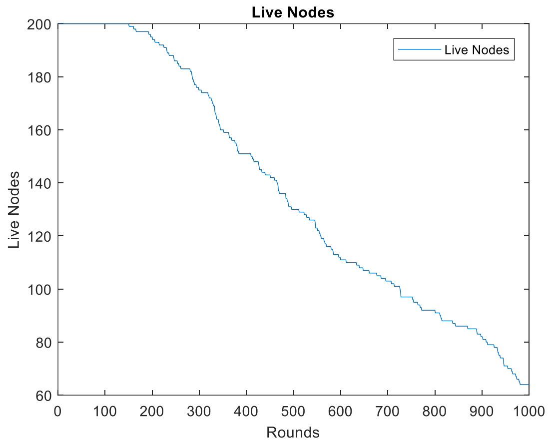


**Figure 5:** Effect of number of rounds on live nodes

The number of successfully received packets at the BS is represented in Figure 6 with increasing number of rounds when the proposed technique is utilized in the cluster of WSN. It is seen in the figure that the numbers of received packets are increasing with increases number of rounds. Till 1000 rounds, the number of packets received at the BS goes on increasing; there is no decrease in the number of received packets till 1000 rounds.

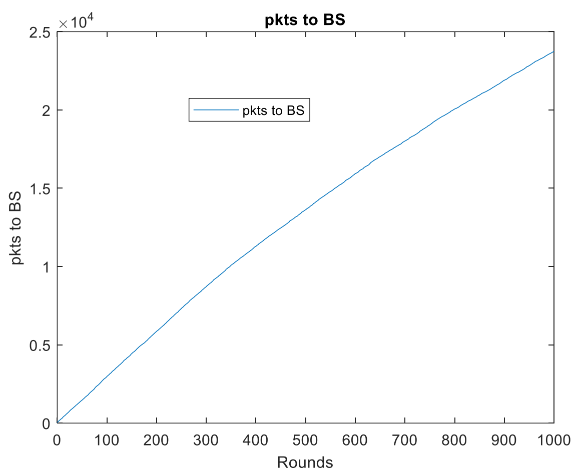


**Figure 6:** Number of received packets at the BS

The number of received packets at the CH is represented in Figure 7 with increasing number of rounds when the proposed technique. It is clear from the figure that there is increase in numbers of received with increasing number of rounds. The number of packets received at the CHs keeps on increasing with increasing number of rounds. Cluster formation with increasing number of nodes is shown in Figure 8. With increasing the number of simulation rounds, cluster formation rate decreases due to increasing number of dead nodes.

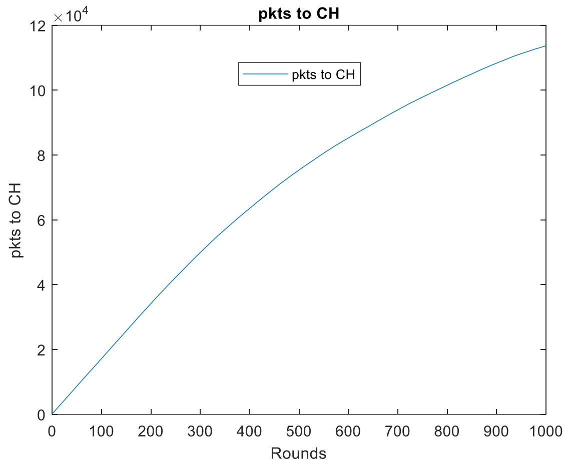


**Figure 7:** Number of received packets at the CH

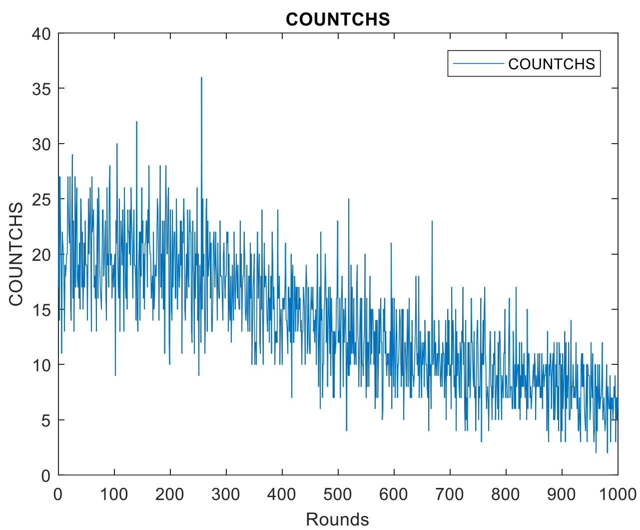


**Figure 8:** Cluster formation with increasing number of nodes

The performance analysis of the proposed framework is shown in Figure 9 under varying rounds in terms of average residual energy.

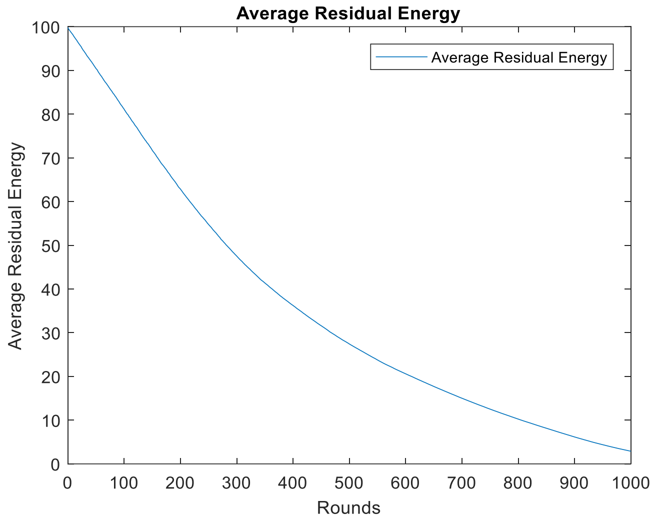


**Figure 9:** The average residual energy of the network

It is clear from the results that the residual energy is high at the lower simulation round and it goes on decreasing with increasing the number of simulation rounds. The energy consumption load is distributed evenly between the sensors by the proposed technique. Furthermore, the BS controls the cluster formation and cluster heads selection process. The average residual energy decreases which enhanced data delivery performance in the agriculture domain.

### 4.2 Comparison of the proposed technique with the existing technique

The performance of the proposed technique is compared with the existing techniques LEACH, MOD-LEACH and CH-LEACH in terms of number of rounds on dead nodes as shown in Figure 10. It is clear from the figure that the best performance is achieved by the proposed technique as compared to the other techniques. With increase in number of rounds, number of dead nodes is not increased rapidly by the proposed technique. The dead nodes are increasing slightly with increasing number of rounds. Because of the high power consumption of nodes in a cluster, numbers of dead nodes are increasing with increasing rounds.

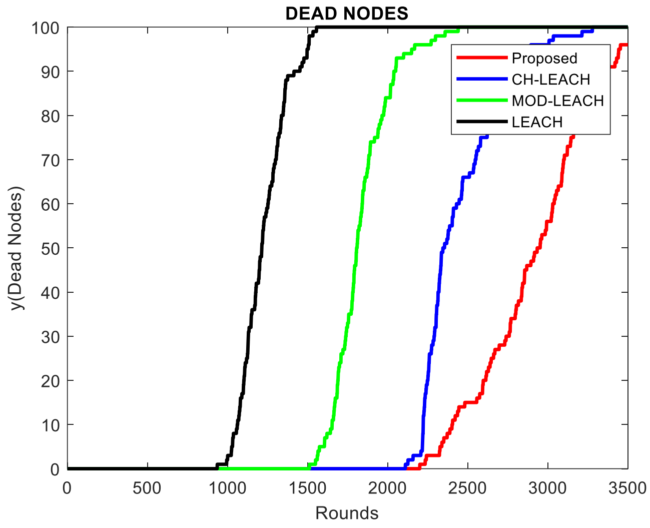


**Figure 10:** Comparison of the proposed technique in terms of dead nodes with increasing number of rounds

Comparison of the proposed technique is also compared with the other existing techniques LEACH, MOD-LEACH and CH-LEACH in terms of live nodes as shown in Figure 11. With increasing number of rounds, the live nodes start dropping. The live nodes by the proposed technique are maintained at large number of rounds as compared to the other techniques.

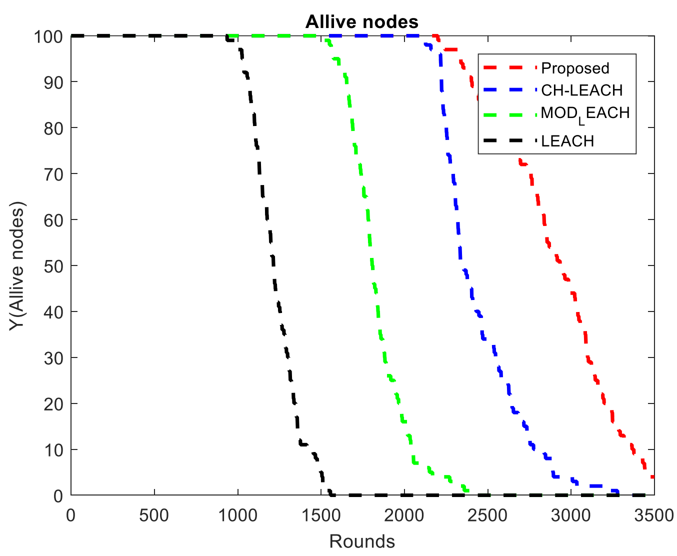


**Figure 11:** Comparison of the proposed technique in terms of live nodes with increasing number of rounds

## 5. Conclusion

The significant role is performed by the WSN in the agriculture field. This paper proposed the IoT-WSN framework utilizing the energy efficient data aggregation protocol for smart agriculture. The proposed technique adopts hop by hop data transmission so it decreases the bottlenecks chances among agricultural sensors and BS. The performance of data delivery is improved in the agriculture field. The EEDAP is utilized in the proposed design to increase the cluster life cycle in WSN. After the simulation analysis, it is obtained that the proposed technique performs well in the agriculture field. The life cycle of the nodes are increased by the proposed technique and the future work would be focus on more decreasing the nodes death rate for increasing the life cycle of the cluster effectively in a WSNs.

**References**

1. Khujamatov, K. E., & Toshtemirov, T. K. (2020, November). Wireless sensor networks based Agriculture 4.0: challenges and apportions. In 2020 International Conference on Information Science and Communications Technologies (ICISCT) (pp. 1-5). IEEE.
2. Rajput, A., & Kumaravelu, V. B. (2019). Scalable and sustainable wireless sensor networks for agricultural application of Internet of things using fuzzy c-means algorithm. Sustainable Computing: Informatics and Systems, 22, 62-74.
3. Kiani, F., & Seyyedabbasi, A. (2018). Wireless sensor network and internet of things in precision agriculture.
4. Khanna, A., & Kaur, S. (2019). Evolution of Internet of Things (IoT) and its significant impact in the field of Precision Agriculture. Computers and electronics in agriculture, 157, 218-231.
5. Jawad, H. M., Jawad, A. M., Nordin, R., Gharghan, S. K., Abdullah, N. F., Ismail, M., & Abu-AlShaeer, M. J. (2019). Accurate empirical path-loss model based on particle swarm optimization for wireless sensor networks in smart agriculture. IEEE Sensors Journal, 20(1), 552-561.
6. Idrees, A. K., & Al-Qurabat, A. K. M. (2021). Energy-efficient data transmission and aggregation protocol in periodic sensor networks based fog computing. Journal of Network and Systems Management, 29(1), 1-24.
7. Sankar, S., Srinivasan, P., Luhach, A. K., Somula, R., & Chilamkurti, N. (2020). Energy-aware grid-based data aggregation scheme in routing protocol for agricultural internet of things. Sustainable Computing: Informatics and Systems, 28, 100422.
8. Nandhini, A. S., & Vivekanandan, P. (2020). A novel security and energy efficient data aggregation for medical Internet of Things using trust. Journal of Medical Imaging and Health Informatics, 10(1), 249-255.
9. Parveen, N. (2021). Comparative Analysis on Energy-Efficient Data Aggregation Methods in Wireless Sensor Network.
10. Jan, S. R. U., Khan, R., & Jan, M. A. (2021). An energy-efficient data aggregation approach for cluster-based wireless sensor networks. Annals of Telecommunications, 76(5), 321-329.

11. Lakshmi, T. A., Hariharan, B., & Rekha, P. (2019, July). A Survey on Energy Efficient Routing Protocol for IoT Based Precision Agriculture. In 2019 International Conference on Communication and Electronics Systems (ICCES) (pp. 1284-1288). IEEE.
12. Gialelis, J., Fokaeos, M., Theodorou, G., Paparizos, C., & Tsafas, N. (2020, June). A Low Cost Energy Efficient IoT Node Utilized in the Agricultural Field. In 2020 9th Mediterranean Conference on Embedded Computing (MECO) (pp. 1-6). IEEE.
13. Simon, S., & Jacob, K. P. (2013). HEAP: Hybrid energy-efficient aggregation protocol for large scale wireless sensor networks. International Journal of Computers & Technology, 4(2c2), 713-721.
14. Babu, A. S. TDMA and Data Aggregation Method for Energy Efficient Data Transmission in Automatic Irrigation System. agricultural systems, 6, 12.
15. Maurya, S., & Jain, V. K. (2017). Energy-Efficient Network Protocol for Precision Agriculture: Using threshold sensitive sensors for optimal performance. IEEE Consumer Electronics Magazine, 6(3), 42-51.
16. Padmaja, P., & Marutheswar, G. V. (2018). Energy efficient data aggregation in wireless sensor networks. Materials Today: Proceedings, 5(1), 388-396.
17. Jawad, H. M., Nordin, R., Gharghan, S. K., Jawad, A. M., & Ismail, M. (2017). Energy-efficient wireless sensor networks for precision agriculture: A review. Sensors, 17(8), 1781.
18. Kamarudin, L. M., Ahmad, R. B., Ndzi, D. L., Zakaria, A., Kamarudin, K., & Ahmed, M. E. E. S. (2016). Simulation and analysis of leach for wireless sensor networks in agriculture. International Journal of Sensor Networks, 21(1), 16-26.
19. Qureshi, K. N., Bashir, M. U., Lloret, J., & Leon, A. (2020). Optimized cluster-based dynamic energy-aware routing protocol for wireless sensor networks in agriculture precision. Journal of sensors, 2020.
20. Abdulzahra, S. A., & M Al-Qurabat, A. K. (2021). Data Aggregation Mechanisms in Wireless Sensor Networks of IoT: A Survey. International Journal of Computing and Digital System.
21. Ojha, T., Misra, S., & Raghuwanshi, N. S. (2015). Wireless sensor networks for agriculture: The state-of-the-art in practice and future challenges. Computers and electronics in agriculture, 118, 66-84.
22. Haseeb, K., Ud Din, I., Almogren, A., & Islam, N. (2020). An energy efficient and secure IoT-based WSN framework: An application to smart agriculture. Sensors, 20(7), 2081.
23. Jain, J. K., Chauhan, D., & Jain, P. (2021). An Energy Efficient and Bandwidth Aware Optimal Routing for IoT in Agriculture.

Vijay Nandal is pursuing Ph.D. in Electronics and Communication Form DCRUST Murthal. He received the Master Degree in Electronics and Communication from BMIT, Sonepat , in 2011. He received B.E. in Electronics and Communication form PDM college of Engineering Bahadurgrah ,in 2008.

Sunita Dahiya is assistant Professor in Electronics and Communication department in DCRUST Murthal. She received Ph.D. from DCRUST Murthal.