TEST Engineering & Management

November/December 2020
ISSN:0193-4120 Page No. 59 – 71

Design and Assessment of Energy Efficient Routing Protocol in Wireless Sensor Network Using Optimized LEACH

Dr. Vijay Kumar

Professor, Department of Computer Science & Engineering, AIET, Jaipur

Email: vijay_matwa@yahoo.com

Article Info
Volume 83
Page Number: 59 – 71
Publication Issue:
November/December 2020

Article History
Article Received: *25 October 2020*
Revised *22 November 2020*
Accepted: *10 December 2020*
Publication: *31 December 2020*

ABSTRACT

Wireless sensor systems consist of, for instance, independent sensors used to measure temperature, humidity, and physical and environmental conditions spatially distributed. These sensors transmit data to a dish. Due to the huge ability of sensor network to link the physical world to the vertical world, the popularity of Wireless Sensor Networks has enormously increased. Becoming a repetitive job since those devices rely on battery power and can be put in hostile environments. It is therefore necessary to improve the energy of these networks. These sensor nodes are typically used in remote areas where a constant energy supply can be a major problem. Battery sensors are thus usually controlled and their power consumption reduced. An energy-efficient optimising algorithm will prevent nodes from becoming abusive and smart battery power users. The protocols for optimising energy consumption in WSNs are most known protocols. ILEACH is one of the most effective between them.The research is based on application of meta heuristic method for efficiency enhancement of wireless sensor

network. The cluster heads in a hierarchy are arranged to better optimise the lives of the WSN. Our Improved LEACH, in comparison with LEACH out performs it using metrics of cluster head formation, throughput and network life. Finally a brief performance analysis of LEACH, ILEACH and Improved proposed LEACH is undertaken considering metrics of figure of merits.

Keywords-WSN, LEACH, LEACH-C, Network Life Time, Base Station, Sensor Node

1. INTRODUCTION

One of the best innovations in WSNs is routing. In comparison, routing in WSNs is more exciting because of their inherent features in standard ad hoc networks. First of all, the availability, processing capacity and bandwidth of transmission resources are very small. Second, a global approach to Internet Protocol (IP) is difficult to design. In addition, IP cannot be extended to WSNs, as the updating of addresses can lead to heavy overhead in wide or complex WSNs. Thirdly, it is difficult to manage evolving and frequent change in topology, especially in a mobile environment, due to the inadequacy of resources. Fourthly, the processing of data by several sensor nodes produces a high likelihood of data consistency calculated by the protocols for the routing. Most applications of WSNs do not allow a single multi-source communication device to be multi-cast or pair-to-peer applications. Lastly , data transfers should be carried out within a certain period of time for applications of WSNs with time constraints. Therefore, in these types of applications, minimal latency for data transfers should be considered. In many applications, however, energy security is more critical than service quality (QoS) since energy, which is directly linked to the network life, is limited by all sensor nodes.

Routing protocols on WSNs may be split in two groups depending on the network structure: flat routing and hierarchical routing. Each node performs the same tasks and functionalities in the network in a flat topology. Data is typically transmitted hop by hop using the flood method. In small scale networks, flat routing protocols are fairly efficacious and are typical of a WSN's flat routing mechanism including flow and bogusing sensor protocols for negotiation information (SPIN), direct diffusion (DD), greedy perimeter stateless routing (GPSR), trajectory-based forwarding (TBF), energy-aware routing (EAR), gradient-based routing (GBR), sequential assignment routing (SAR), etc. However, in large-scale networks it is relatively unnecessary since resources are limited, but all sensor nodes provide more data processing and bandwidth. On the other hand nodes perform various tasks in WSNs, in a hierarchical topology, and are usually clustered according to different requirements or measurements into numerous clusters. In general, each cluster includes the cluster head (CH), ordinary nodes (ONs) and CH may be arranged to form additional levels of hierarchy. In general, high energy nodes function as CHs and perform the task of processing and transmission of data, while low-energy nodes act as MNs and perform the task of sensing information. In WSN, traditional clustering protocols include Low Energetic Adaptive Clustering (LEACH), Hybrid Energy Efficiency Distributed (HEED), Weight-Based Distributed Energy Efficient hierarchy (DWEHC), Position-Based Aggregator Node Election (PANEL) Protocol, LEACH (TL-LEACH) two-level hierarchy, Uneven Clustering size (UCS), Energy Efficiency (EEE) Model.A WSN consists of a setup of sensor nodes/motes which perceives the environment under monitoring, and transfer this information through wireless links to the Base Station (BS) or sink. The sensor nodes can be heterogeneous or homogeneous and can be mobile or stationary. The data gathered is forwarded through single/multiple hops to the BS/sink. The basic structure of a WSN system is depicted in Figure 1.1.

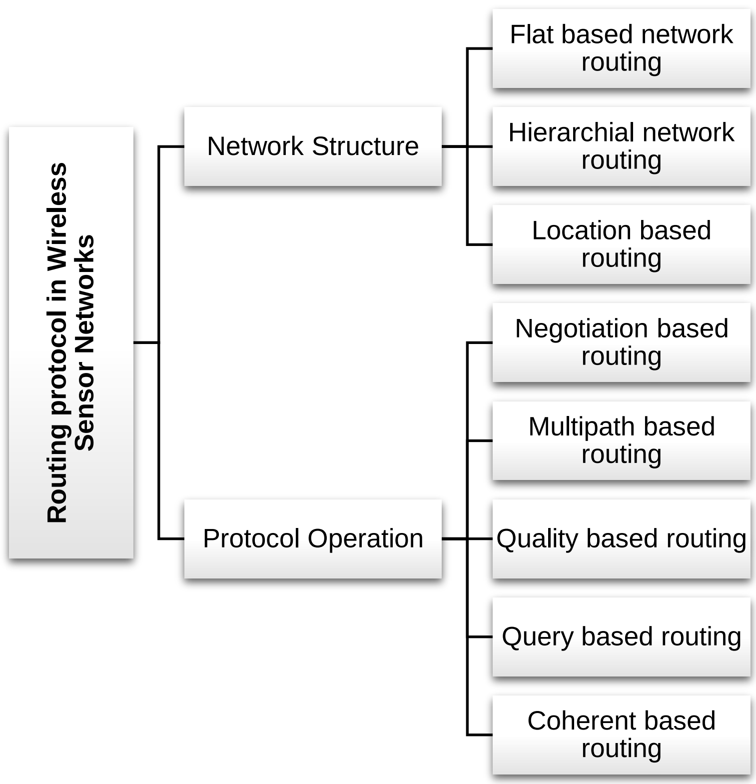

Figure 1.1 Routing protocols in Wireless Sensor Networks

LEACH is the first protocol for network networks that utilises hierarchical routing to enhance network life, all nodes in a network are grouped into local cluster groups, with the cluster head being one node. Although all non-cluster head nodes transmit their data to the cluster head, the cluster head node collects data from all the cluster members, conducts data signal processing (e.g., data aggregation) functions and transmits data to the remote baseline. As a cluster-head node, it thus takes much more resources than a

November/December 2020
ISSN:0193-4120 Page No. 59 – 71

non-cluster-head node. So all nodes that belong to the cluster lose communication power if a cluster-head node dies.

LEACH combines random rotation of the cluster-head location with a high energy effect, so that it rotates between the sensors, so that a single sensor on the network does not drain the battery. The energy load of a cluster head is distributed equally between nodes. Since the node with cluster heads knows all cluster members, a Time-Division Multiple Access (TDMA) schedule can be established, which indicates when each node will transmit its information. Moreover, the use of a TDMA data transfer schedule avoids collisions within a cluster. The LEACH process is split into pieces. A round of the clusters starts with a set-up process and a continuation phase is followed by several frames of data from the nodes to the cluster head and the base station, which are transmitted into the cluster head.. There are various key features of LEACHare:

a) Coordinated locally and manage for cluster set-up andoperation.
b) Cluster "base stations" or" Cluster-heads" rotated randomly and the Correspondingclusters.
c) Local firmness to reduce global communication.

In LEACH, the procedure is separated into fixed-length rounds, everywhere each round starts with a setup phase after that a steady-state phase. LEACH is a hierarchical protocol in which most nodes transmit to cluster heads, and the cluster heads aggregate and compress the data and forward it to the base station (sink). Each node uses a stochastic algorithm at each round to determine whether it will become a clusterheadinthisround.LEACHassumesthateachnodehasaradiopowerful enough to directly reach the base station or the nearest cluster head, but that using this radio at full power all the time would waste energy.

Nodes that have been cluster heads cannot become cluster heads again for *P* rounds, where *P* is the desired percentage of cluster heads. Thereafter, each node has a $1/P$ probability of becoming a cluster head in each round. At the end of each round, each node that is not a cluster head selects the closest cluster head and joins that cluster. The cluster head then creates a schedule for each node in its cluster to transmit its data.

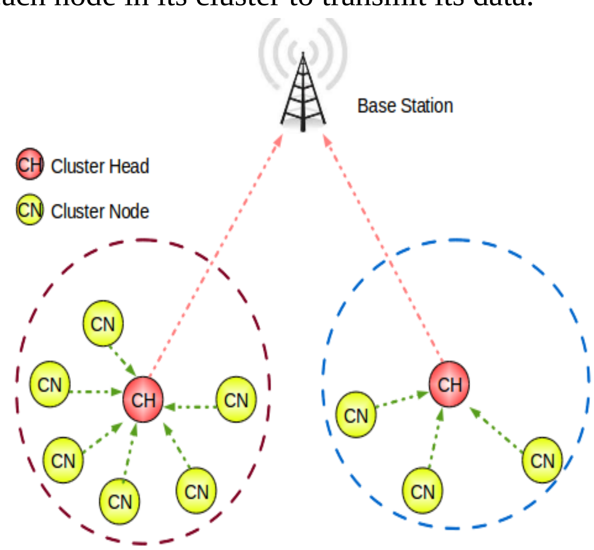

Figure 1.2 Illustration of LEACH Protocol

All nodes that are not cluster heads only communicate with the cluster head in a TDMA fashion, according to the schedule created by the cluster head. They do so using the minimum energy needed to reach the cluster head, and only need to keep their radios on during their timeslot.

2. LITERATURE SURVEY

(Anik Kumar Saha, 2020) [1] Wireless Sensor Networks (WSNs) have increased in popularity as one of the most rapidly developing new technologies for transmitting data over the internet. WSN is rapidly expanding its limbs in almost every field of science and technology today. The WSN is made up of several small nodes that handle sensing, data processing, aggregation, compression, and transmission. Since the sensor nodes are so small, the tiny battery only has a limited amount of power. As a result, the key challenge for WSN is to effectively use this insufficient battery power to extend the sensor networks' lifespan while reducing energy consumption. However, a variety of sophisticated clustering routing protocols have already been introduced in WSN to reduce the amount of energy consumed. The main goal is to improve the Low Energy Adaptive Clustering Hierarchy (LEACH) protocol by implementing a new clustering routing topology. The method for selecting cluster heads in our proposed model is identical to that used in the standard Leach protocol. We have, however, divided the network's entire area into several rectangular distributed regions. The LEACH algorithm has been used in each field. The R-LEACH process is simulated using the MATLAB simulator in this article, and the effects are then analyzed.

(Haibo Liang, Shuo Yang, Li and JianchongGao, 2019) [2] This paper illustrates the optimization of the routing protocol. To minimize the likelihood of excessive cluster head distribution. Firstly, the optimum number of cluster heads is determined on basis of the total energy consumption per round. The cluster head would then be used as the basis of the diagram of Voronoi. The nodes in the same Voronoi diagram become a cluster that would minimize the contact between the energy consumption in the intra-cluster. Lastly, an anti-colonial algorithm is applied using the cluster head next to the BS to get it out of the remote cluster head to simplify the multihop routing protocol. The protocol can significantly extend the life of WSNs compared to the LEACH protocol, based on MATLAB simulation data and increase the per unit node energy efficiency in-round. The proposed solution is just energy consumption. The first death rate of the Node (FND) was increased by 127%, by 22.2% and 14.5% over LEACH, LEACH-C and SEP respectively.

(Karan Agarwal, Kunal Agarwal and K. Muruganandam, 2018) [3] Wireless Sensor Network (WSN) is through as one of the most powerful and useful innovations for transmitting and receiving the information in today's world of science and technology. In most of the sectors, such as drugs, manufacturing, environmental monitoring and others, the WSN grows rapidly. Many mini sensor nodes in the WSN region are distributed to collect relevant information.

November/December 2020
ISSN:0193-4120 Page No. 59 – 71

They can monitor and track events such as temperature, sound, pressure, motion, humidity, etc. these nodes are used. The sensor node performs various data operations including battery energy sensing, encoding, receiving and transmitting. The mini battery has a lot less power because of the small size of the node. It is therefore very important to efficiently use this finite resource to boost the network life. The Low Energy Adaptive Hierarchical Clustering Protocol (LEACH) has been established in this direction. In this direction node becomes cluster head (CH) in this protocol. This random CH selection results in a protocol to save resources. In the paper, the LEACH process is tested by simulation of MATLAB and the results are examined to provide guidance for the future.

(T. Alhmiedat, 2017) [4] Because of the high degree of Multi-Hop Data Transmission, environmental monitoring systems using the Wireless Sensor Networks (WSN) face the challenge of high electricity consumption. A proof of the concept implementation reveals, that the use of an algorithm for clustering in environmental monitoring applications significantly reduces overall energy consumption for environment sensor nodes, in order to address the question of quick energy depletion. This paper provides and deploys an energy-efficient WSN environmental surveillance network using eight sensor nodes deployed in Tabuk, Saudi Arabia, over an area of 1 km2. A series of actual experimental studies have been carried out to show the feasibility of the proposed environmental monitoring program.

(H. Liang, J. Zou, Z. Li, M Junaid, Y. Lu, 2019) [5] This article proposes to optimize the support vector retransmission (SVR) by means of a fluid multilevel algorithm, which takes the leakage risk as an example. This article is based on particle swarm optimization (PSO). And there have been two primary targets. First, a flowing multi-level leak risk assessment framework will be developed. Second, the PSO-SVR algorithm will be used to analyze the outcomes of risk assessments and to carry out the dynamic risk assessment in real time. The paper offers a first description of the phenomena of characterization and laws associated with the acquisition and loss parameters and uses them as an indicator to create a multilevel risk assessment index framework. Second, a risk assessment model is developed in accordance with fluctuating theory. And lastly, the SVR model parameters C and g are optimized by using a PSO-enhanced SVR algorithm, which solves the difficulty of selecting parameters like penalty factor c, kernel function k and sensitivity coefficient β in conventional SVR model, increases model precision, and allows more precise dynamic assessments of risk in real time. This paper has two objectives with the algorithm suggested. Taking the 20-oil field as an engineering example, the results show, with a high degree of convergence clearly greater than the multi-layered perceptron neural network model, that the PSO-SVR model can be accurate at 99%.

November/December 2020
ISSN:0193-4120 Page No. 59 – 71

(H. Liang, 2019) [6] This paper suggested an early-warning method of data mining sand plug fracturing. First, a precocious alerting model of a double logarithm sand plug is developed and the algorithm of time series analysis is used to predict the oil pressure and pressure of the case in a double logarithmic sand plug of a fracturing hazard warning model, thereby improving early warning accuracy. Then the GRNN algorithm is intended to optimize the prediction effects of the analytics of the time domain. The improved clustering algorithm for affinity propagation (AP) is used for clustering monitoring data to improve the accuracy of following pitching measurement, in order to improve the correlation rate of sand plug and fracturing risk. Finally, the on-site risk alert model is applied and analysed and the model's validity and accuracy is tested. In order to carry out intelligent online monitoring of the threats, the model is incorporated in the remote monitoring program.

3. PROPOSED METHODOLOGY

In this work we set certain parameters at the beginning of the simulation. The results are collected and analysed following the completion of the desired number of rounds. The diagrams are illustrated by the result and then the results are illustrated and explained. Finally, some similar work in the literature was compared with our results.

The measurement and transmission/receipt of the sensor nodes has proliferated tremendously. Any network application may be available implemented by hundreds of them being deployed. Sensor nodes must be used effectively due to their limited availability of power to improve the life of the network. This performance is highly dependent on the routing protocol used. Nodes far away while transmitting directly die early because of more from the base station. In transmitting their signal, energy is dissipated. The nodes that are far apart in clustering techniques data to their cluster heads can be passed on. This leads to lower consumption of electricity. The purpose is to maintain a long-term network alive. Similar LEACH, DEEC and SEP routing protocols and TEEN are some of the routing protocols implemented. ILEACH is one of the most common and advanced techniques in this respect. This research builds on the protocol ILEACH by introduction of a multi-hop technique. The hierarchy between the heads of the cluster. Every cluster head gets packets first from its nodes then move them to another head of the cluster. This is what we are talking about identified by the cluster heads tree. The use of many hops power discharged directly into the transmission of data saved from base station. Proposed protocol is a multi-stores routing protocol with two levels of clustering using heuristic quest for the best path between cluster Head to the sink, sending packets.

The definition of weighting is used in the ILEACH Protocol ways to become a CH (Cluster Head) each node is allocated. The condition of likelihood of weighting is as follows-

$$P_{\text{nonual}} = \frac{P}{1 + a \times m}$$

$$P_{\text{advanced}} = \frac{P}{(1+\alpha X m)} \times (1+\alpha)$$

where, m is the advanced node fraction and α is where additional power factor for advanced and advanced standard nodes and normal nodes. Each hop determines an optimal way for its packets to be sent in proposed improved protocol's static node network to mitigate extensive energy loss in the network via the root network (sink). Instead of energy loss to the minimum the way to minimize the individual node the networks total loss.

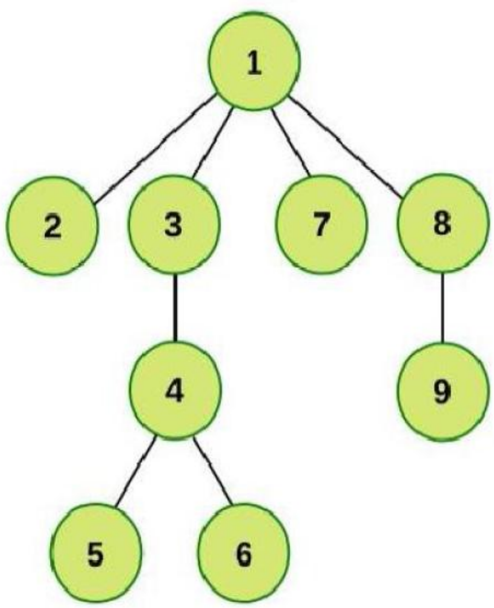

Figure 3.1Process of Forming Tree Using Proposed Methodology

Two additional nodes must be stored in proposed improved protocol elements or values: elements or values: parent: every node, which cluster head each node or sink it's going to give your packet to. The node the parent becomes and this information is required forms the arrangement of the nary tree. Estimated en loss: loss of energy if a packet sent from this node is entire network. Save this value provides an estimate of other nodes the loss of energy that would occur if you transfer your packets across the network node. This variable is shown in the pseudo code cluster head energy loss array. The following algorithm is used to get cluster head, u the best route. The best route. Ep(v) is a qualifying number of parents, for that node. For that node. All the nodes closer to sinking in this package absolute distance (distance of euclides) from u is the energy loss for the node u sends her packet. Sends her packet. First of all, we sort the spectrum of in increasing order of distance cluster heads. Let the cluster head index in the node array that we want to calculate for the loss of energy is i. Then we'll go into the array the index is j that is between 0 and i1. Everyone we regard j as a parent of i of this iteration. We find that j sends energy loss through in the total network, it will be minimum. We add energy loss for node to quantify this energy loss j (and j<i would have already been j energy loss calculated) energy loss for packet sending from i to j.

4. RESULT ANALYSIS

The system has been simulated with variable number of nodes, variable area and with initial energy. The comparative analysis has been done on the basis of number of dead nodes, number of alive nodes, packets send to sink node and the number of rounds taken to death of all nodes over round. The simulation and comparative analysis has proved the efficiency of proposed methodology with respect to operational variations.This section represents the comparative analysis of proposed algorithm with existing algorithm for both cases. The comparison has been done on 200 nodes and 400 nodes respectively. Figure 4.3 and 4.4 indicates the comparative analysis for test case-1 with 200 nodes whereas figure 4.1 and 4.2 indicates the analysis with respect to 400 nodes. Both analysis proves that the heuristic algorithm augmented with LEACH performs better than conventional and improved LEACH respectively.

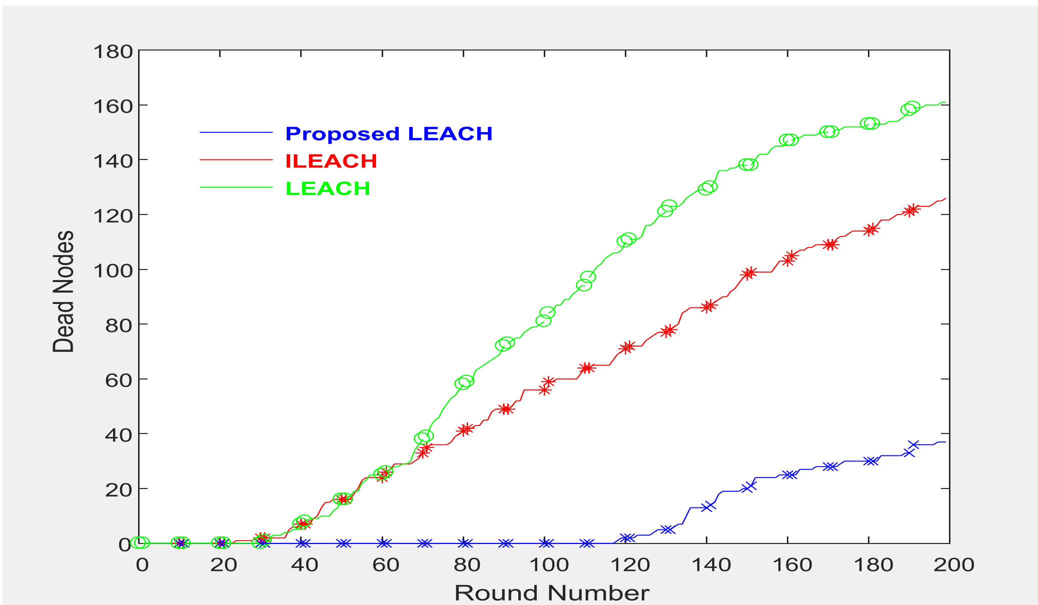

Figure 4.1 Comparative Analysis of Dead Nodes for Proposed System-Test Case-1

November/December 2020
ISSN:0193-4120 Page No. 59 – 71

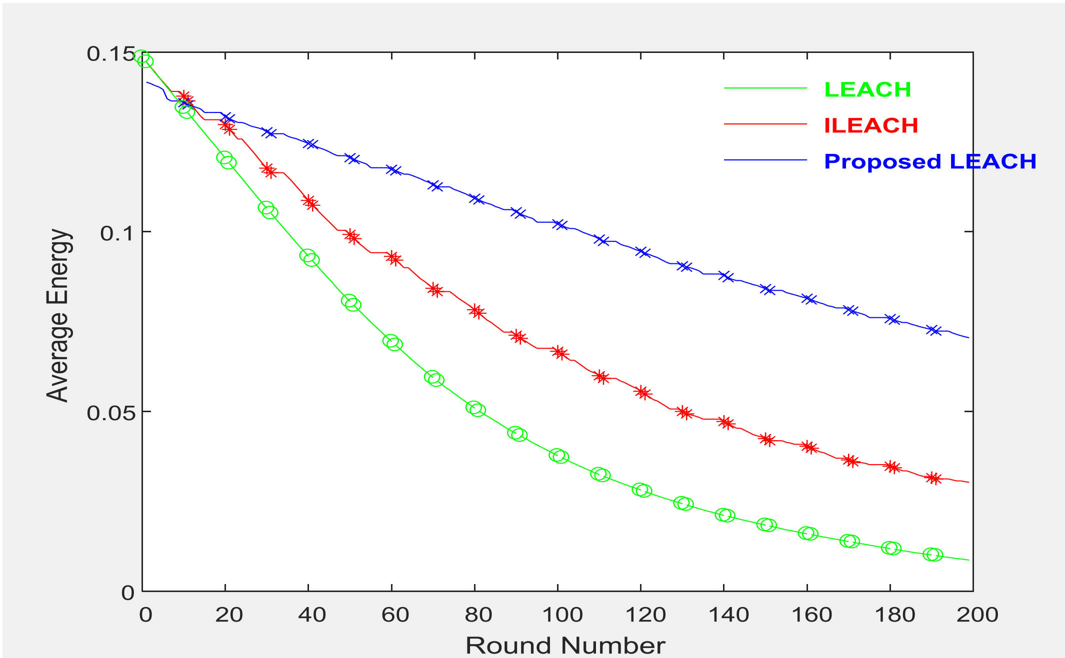

Figure 4.2 Comparative Analysis of Average Energy for Proposed System-Test Case-1

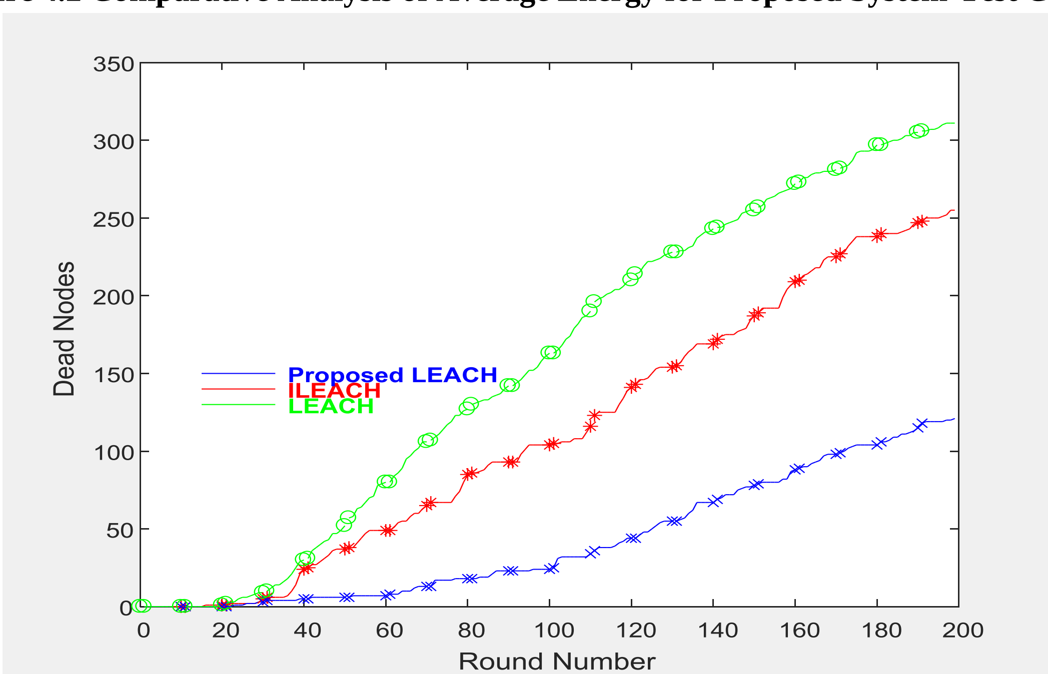

Figure 4.3 Comparative Analysis of Dead Nodes for Proposed System-Test Case-2

November/December 2020
ISSN:0193-4120 Page No. 59 – 71

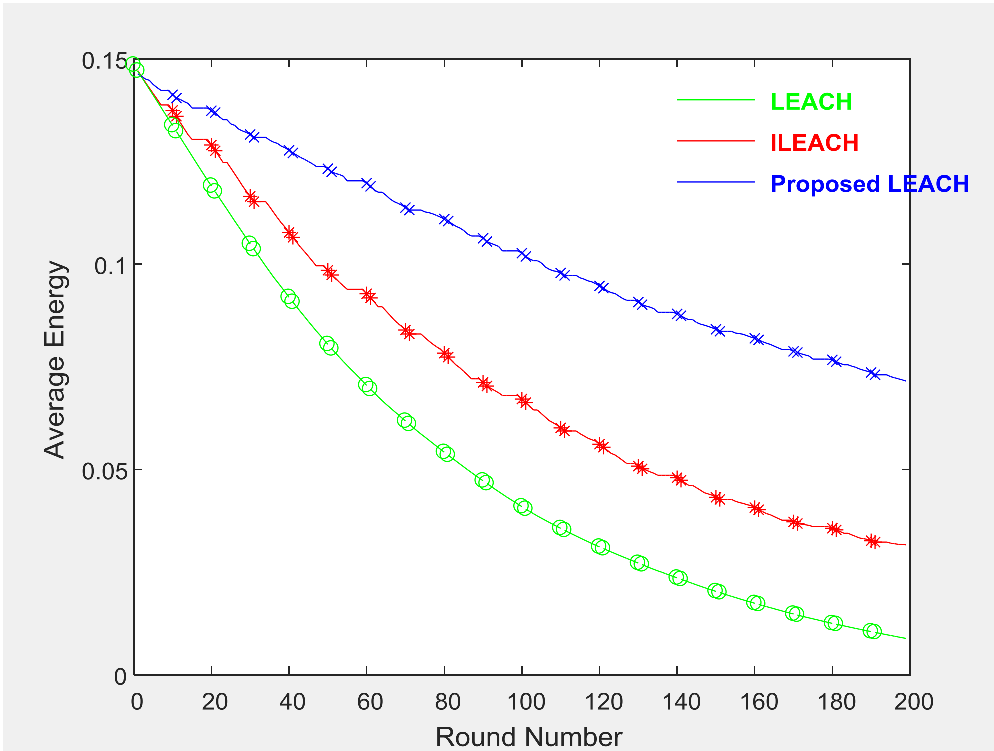

Figure 4.4 Comparative Analysis of Energy for Proposed System-Test Case-2

A comparative study of the performance of LEACH, ILEACH and proposed protocol based on different parameters is shown below in a tabular form. We compare the performance of the three protocols based on the number of dead nodes. We compare the number of dead nodes for each protocol after a specified number of rounds.

Table 4.1

Comparison of Number of Dead Nodes

Rounds	**Total Dead Nodes**		
	LEACH	ILEACH	**Proposed**
40	12	12	**1**
80	60	52	**2**
120	105	70	**5**
160	137	115	**25**
200	160	132	**41**

Table 4.2

Comparison of Average Energy

Rounds	**Average Energy(J)**		
	LEACH	ILEACH	**Proposed**
20	0.128	0.13	**0.137**
40	0.098	0.108	**0.14**
80	0.056	0.08	**0.117**
120	0.039	0.056	**0.105**
160	0.02	0.044	**0.094**
200	0.01	0.028	**0.075**

Table 4.1 and4.2 presents a comparative performance analysis of LEACH, ILEACH and the proposed protocol based on various parameters. The output of the three protocols is compared according to the

November/December 2020
ISSN:0193-4120 Page No. 59 – 71

number of dead nodes. After a given number of rounds we compares the number of dead nodes for each protocol. Based on their average energy, we compare the efficiency of the three protocol. After a number of rounds for each of the three protocols, we compare the average energy of each node.

5.CONCLUSION & FUTURE RESEARCH

In many cases, wireless sensor networks are usually dispersed across broad areas. There is a requirement in this respect for methods that can better manage the WSN. The limited battery capacity is used for wireless sensor networks. The key challenge in designing Wireless Sensor Network protocols is energy efficiency as the sensor nodes are restricted in capacity. The last motivation behind every routing protocol is to make the network work for a longer period of time as energy-efficient as possible. In this work, we introduced clustering as a means of overcoming this energy efficiency problem. We propose proposed heuristic LEACH, a new ILEACH protocol variant which can be further used for improved efficiency in other clustering protocols. It uses efficient cluster head replacement after the very first round to minimize network energy consumption. A cluster head is not replaced in heuristic LEACH until its energy falls below some threshold, which minimizes the protocol routing load. Therefore, at the beginning of each round, the cluster head substitution process requires residual energy of the cluster head. After 200 rounds, heuristic LEACH decreased the number of dead nodes by 74.5 % compared to LEACH and 68.5 % as compared to ILEACH. There was significant rise in energy of nodes thus contributing to network lifetime enhancement and better efficiency.

REFERENCES

1. Saha, Anik Kumar, Md Sharif Uddin Khan, and MdMezanur Rahman. "Region based low energy adaptive clustering hierarchy (R-LEACH) protocol: prolonging the lifetime of WSN." In ACM Proceedings of the 6th International Conference on Networking, Systems and Security, pp. 127-132. 2019.
2. Haibo Liang1*, Shuo Yang1, Li Li1 and JianchongGao, Research on routing optimization of WSNs based on improved LEACH protocol, EURASIP Journal on Wireless Communications and Networking (2019) 2019:194.
3. Karan Agarwal, Kunal Agarwal and K. Muruganandam, 2018, Low Energy Adaptive Clustering Hierarchy (LEACH) Protocol: Simulation and Analysis using MATLAB, International Conference on Computing, Power and Communication Technologies (GUCON) Galgotias University, Greater Noida, UP, India. Sep 28-29, 2018.
4. T. Alhmiedat, Low-power environmental monitoring system for ZigBee wireless sensor network.

ISSN:0193-4120 Page No. 59 – 71

KSII Transaction on Internet and Information Systems 11(10), 4781–4803 (2017).
5. H. Liang, J. Zou, Z. Li, M. Junaid, Y. Lu, Dynamic evaluation of drilling leakage risk based on fuzzy theory and PSO-SVR algorithm. FuturGenerComputSyst 95, 454–466 (2019).
6. H. Liang, An sand plug of fracturing intelligent early warning model embedded in remote monitoring system. IEEE Access 7, 47944–47954 (2019).
7. S. Han, Z. Gong, W. Meng, Automatic precision control positioning for wireless sensor network. IEEE Sensors Journal 16(7), 2140–2150 (2016).
8. M.S. Elgamel, A. Dandoush, A modified Manhattan distance with application for localization algorithms in ad-hoc WSNs. AD HOC Networks 33, 168–189 (2015).
9. M. Erazo-Rodas, M. Sandoval-Moreno, et al., Multiparametric monitoring in equatorial tomato greenhouses (III): environmental measurement dynamics. Sensors 18(8) (2018).
10. S. Singh, P. Kumar, J. Singh, A survey on successors of LEACH protocol. IEEE Access 5, 4298–4328 (2017).
11. S. Peng, Energy neutral directed diffusion for energy harvesting wireless sensor networks. Computer Communication. 63, 40–52 (2015).
12. X. Fu, G. Fortino, P. Pace, G. Aloi, W. Li, Environment-fusion multipath routing protocol for wireless sensor networks. Information Fusion (2019). https://doi.org/10.1016/j.inffus.2019.06.001
13. S. Soro, W.B. Heinzelman, Prolonging the lifetime of wireless sensor networks via unequal clustering. IEEE International Parallel & Distributed Processing Symposium 365 (2005)
14. F. Bagci, Energy-efficient communication protocol for wireless sensor networks. Ad Hoc & Sensor Wireless Networks 30(3-4), 301–322 (2016).
15. Y. Zhai, L. Xu, Ant colony algorithm research based on pheromone update strategy, 2015 7th Int. Conf. Intell. Human-Machine Syst. Cybern. 1(2), 38–41 (2015).