International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-3, January 2020

Development of Efficient Wireless Sensor Network for IoT based Applications

A. Prasanth, Divya Francis, C. Kohila, D. Gayathri

Abstract*: *Wireless Sensor Network (WSN) is a rapidly growing area for IoT based research and applications. The main concern of research in WSN is to organize the node with different abilities including sensing range, communication range in the wireless network and route the detected data from the nodes to a central sink with dynamism. Clustering or Sector Formation is a key network employed to lengthen the lifespan of WSN by reducing energy utilization. LEACH is a sector algorithm in which the sector heads are arbitrarily chosen from the nodes and utilized to identify the solution with a better location to yield the energy loss sector heads. However, the non-optimal selection of sector head in LEACH cause the lesser lifespan of WSN. To overcome these issues, the Modified Quadrature-LEACH (MQ-LEACH) scheme is proposed in this paper which efficiently formed the sectors by selecting the optimal sector heads in the network. The simulation will be conducted in the NS2 environment where the essential parameters are evaluated for both proposed and existing methods. Further, the proposed scheme improves the network lifespan and stability period compared to existing schemes.

Keywords*: *Network Lifespan, Quadrature Low Energy Adaptive Hierarchy, Sector Head, Wireless Sensor Network.

I. INTRODUCTION

Wireless Sensor Network (WSN) is a wireless network that comprises multiple sensors that supervise the physical atmosphere and collect the sensed data and communicates those data via the wireless link. Multi-hop approach is employed for transmitting the sensed data to the central sink. IoT based applications were primarily outlined for the development of WSN [1]. In general, WSN offers consistent low power and low cost for the measurements in the IoT based applications. Thus, WSN satisfied various IoT application ideas with a huge network of resource controlled sensors [2-4].

WSN is fairly challenging for real-time implementations where the energy resources are inadequate. The key crucial issues in WSN is to maintain the battery energy and communication cost of sensor nodes [5].

For appropriate distribution of battery energy among nodes, optimal protocols and algorithms should be developed which also increase the lifespan of the network.

Sector formation is one of the efficient methodologies to attain better energy consumption among the multiple nodes [6]. In sector formation, the whole network is divided into several sectors where Sector Head (SH) is chosen for every sector in the network. The remaining nodes in the sector are considered as the Sector Member (SM). The main role of SM is to sense the real-time entities and forward it to the SH [7-8]. After that, the SH will gather all detected data from several SM and forward it to the sink. The basic structure of sector formation is illustrated in Fig. 1.

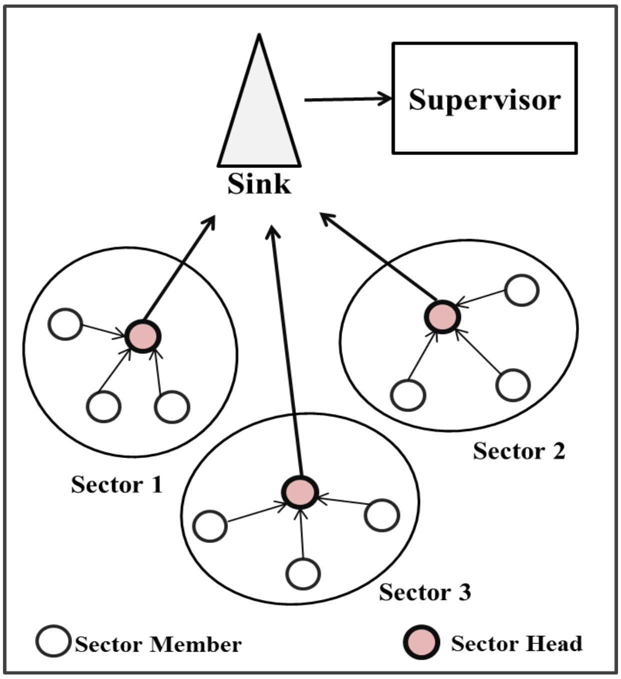

Fig.1. Basic structure of sector formation

Most of the exiting works are failed to select the proper SH in the sector formation. Henceforth, an effective selecting methodology has been well examined in this research work in the form of the novel LEACH algorithm, which is self-organizing and is considered as a suitable sectoring algorithm.

In order to acquire the efficient sector formation, Modified Quadrature-LEACH (MQ-LEACH) method is proposed in which an appropriate node is selected as SH. Moreover, this method distributes battery energy among the sensors in a uniform mode and works on the concept of sectoring.

The rest of this paper is as follows. Section 2 illustrates the related work.

Revised Manuscript Received on January 30, 2020.
* Correspondence Author

A. Prasanth*, Assistant Professor, ECE Department, PSNA College of Engineering and Technology, Dindigul, India. Email: aprasanthdgl@gmail.com

Divya Francis, Assistant Professor, ECE Department, PSNA College of Engineering and Technology, Dindigul, India.

C. Kohila, Assistant Professor, ECE Department, PSNA College of Engineering and Technology, Dindigul, India.

D. Gayathri, Assistant Professor, ECE Department, PSNA College of Engineering and Technology, Dindigul, India.

In section 3, the proposed MQ-LEACH method is described. The simulation results are specified in section 4. Finally, section 5 concludes this paper.

II. RELATED WORK

The following section describes the existing work of the sectoring and SH selection method. LEACH is the idea of selecting the SH where every node has acquires an equal chance to become SH [9]. It comprises two stages namely: setup stage and steady-state stage. The sector formation is accomplished in the setup stage and the real data is transferred in the steady-state stage. The major shortcomings of LEACH are as follows. The proper node is not selected as SH in the LEACH method which yields lesser network lifetime in WSN. The energy utilization is not properly controlled by the LEACH method.

To overcome the drawbacks of the LEACH method, a novel Modified LEACH (M- LEACH) method is proposed [10]. The proposed method depends on two enhancement approaches. Primarily, the SH selection technique is modified to guarantee a stable generation of SHs among all nodes in the network. Subsequently, the Time Division Multiple Access (TDMA) plan is modified to evade consuming additional battery energy in sparse sectors than dense sectors. By using these two modified techniques, the proposed M-LEACH method produces a higher network lifespan compared to the LEACH method. At the same time, the M-LEACH method is failed to focus on the stability period of WSN.

In [11], a multi-decision criteria tool named Analytical Network Process (ANP) is employed to elect the appropriate node as a SH among several nodes. The ANP was established to resolve dependency problems for SH selection. Here, ANP is utilized because it can compact with the interdependencies and feedback relationship between essentials and sectors. The ANP method is compared with existing methods to assess performance in terms of energy consumption and network lifespan. The key issue of using the ANP method is more chance of selecting poor node as SH. Furthermore, this method is more complex compared to traditional algorithms.

A new energy-efficient sectoring technique for multi-hop WSN using type-2 fuzzy logic is proposed to attain the energy efficiency of nodes [12]. The SH is chosen for creating flexible, smart and adoptive to spread the transmission load between the nodes to improve the network lifespan. The type-2 fuzzy logic is implemented to enlarge the function of exhausting type-1 fuzzy logic. This sectoring technique is on the most significant technique to achieve network scalability, prolonged lifespan, and decrease energy utilization. However, this method is failed to concentrate on maintaining the stability period of WSN.

In order to overcome the shortcomings of the optimal election of SH using type-1 fuzzy logic, the new method has been proposed where the type-2 fuzzy logic collaborated with LEACH-C protocol [13]. The LEACH-C is the idea of selecting the SH by considering the battery energy of all the sensors in the sector. The energy of the node is above the threshold value then that node is selected as the SH for that respective sector. But, the method is not suitable for efficient sector formation since it fully depends on the node's energy.

Another method for electing SH through fuzzy logic for WSN which enhances the energy utilization and lifespan [14]. The SH selection is based on three parameters namely: centrality, concentration, and energy. The chance of selecting a non-optimal node as SH is huge in this technique. Further, this method does not focus on uniform sectoring and balanced energy distribution.

In [15], a new protocol named ALEACH is introduced to elect SH for each sector. ALEACH method is better than traditional LEACH in terms of network lifetime and latency. The ALEACH method also attains uniform energy distribution among all nodes. However, it doesn't consider the location factor of SMs which effects selecting the non-optimal SH nodes.

According to the aforesaid methods, most of the existing research works are not focused on the stability period of WSN since the stability period has a direct impact on the overall performance of WSN. Thus, this parameter is more essential for evaluating network performance. By considering these issues as the primary influences for the problem statement of proposed work. Hence, in this paper, a novel method is proposed to prolong the stability period of WSN by enhancing the energy balancing among all the sectors.

III. PROPOSED MQ-LEACH METHOD

A novel Modified Quadrature-LEACH (MQ-LEACH) method is proposed to enhance the network lifespan and stability period of WSN. In general, the MQ-LEACH method consists of two phases: setup phase and node association phase. The setup phase used to select the SH node whereas the sector is formed in the node association phase.

Setup phase:

Initially, the nodes are randomly distributed around the sensing area. Fig.2 defines the ideal method of load distribution among SMs. Besides, it also provides a concept of effective sectoring mechanism that produces significantly in enhanced coverage of the entire network. The random nodes are distributed in a 100m×100m area.

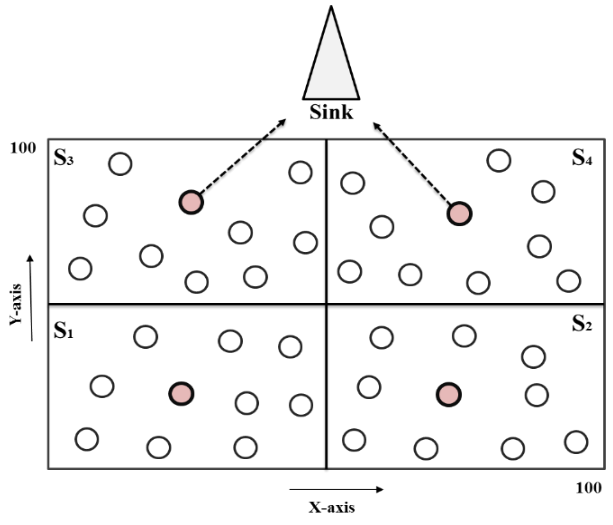

Fig.2.Network topology of the proposed method

Based on position statistics, the entire network is separated into four equal sectors i.e., (s1, s2, s3, s4). The global network sector is defined as below equation,

$$S = s_1 + s_2 + s_3 + s_4 \tag{1}$$

$$s_i = S(x_k, y_k)$$

Where i=4 and k=100.

In traditional LEACH, sectors are arbitrary in size and certain SMs are situated far away. Owing to this dynamic sector formation, farther SMs affect large energy drainage and hence, network performance destroys. On the other hand, in MQ-LEACH, the entire network is partitioned into quadrants yields ineffective energy consumption of SMs. By using this division process, the finest positions of SHs are well-defined. Furthermore, the communication load of intermediate nodes is also decreased. In each round of the MQ-LEACH method, nodes choose to become SH depends on probability (we take P-value as 0.05) and threshold T(m).

Table 1 states the SHs election mechanism. The entire network is separated into four sectors as given Eq. (1). Primarily, every node chooses whether or not to become a SH. The sensor selects a random number in the range between 0 and 1. If the selected number is lesser than the definite threshold value T(m), and circumstance for the chosen number of SHs in a particular sector is not met, then the node turns into a SH. Likewise, the same procedure continues for the remaining set of sectors and an ideal number of sectors are created.

Table 1. Setup Phase Algorithm of MQ-LEACH

1. Begin
2. **If** sensor node εW → W = sensor nodes which did not turn into SHs in current round **then**
3. **If** (Node_ Corresponds_To == 'Sector s_1') **then**
4. **If** (Number_Of_SHs <= ($\frac{Q}{M}$)) **then**
5. TEMP=random number (0-1)
6. **If** (temp <= $\frac{P}{1-P(r,\text{mod}1/P)}$) **then**
7. node=SH_ s_1
8. Number_Of_SHs = Number_Of_SHs +1
9. **end if**
10. **else if** (Node_ Corresponds_To == 'Sector s_2')
11. Repeat Step 4 : 8
12. **else if** (Node_ Corresponds_To == 'Sector s_3')
13. Repeat Step 4 : 8
14. **else if** (Node_ Corresponds_To == 'Sector s_4')
15. Repeat Step 4 : 8
16. **end if**
17. **end if**
18. **end if**

The election of sectors will be based on the Received Signal Strength Indicator (RSSI) of advertisement. Once sectors decision is finalized, nodes need to inform SHs about their association. According to the collected information from intermediate nodes, definite time slots are allotted to nodes by means of the TDMA technique. Further, these collected information's are again announced to nodes in the sector.

Node Association Phase:

Table 2 states the association of sensor nodes with their suitable SHs. Non-SHs nodes localize themselves in the stated area they belong to. After that, they examine for all probable SHs, and on the source of RSSI, the association of sensor node begins. The above procedure continues until the association stage originates to an end.

Table 2. Node Association Algorithm of MQ-LEACH

1. M ∈ *Collection of nodes*
2. WC ∈ *Collection of SHs*
3. **if** M ∈ (S, s_1) **then**
4. where
5. $S = s_1 + s_2 + s_3 + s_4$
6. Check all probable S_1SHs
7. Check RSSI of SHs
8. Associate with S_1SHs
9. then
10. transfer of detected data arises
11. **end if**
12. **if** M ∈ (S, s_2) **then**
13. Repeat Step from 5 : 8 for S_2CHs
14. **end if**
15. **if** M ∈ (S, s_3) **then**
16. Repeat Step from 5 : 8 for S_3SHs
17. **end if**
18. **if** M ∈ (S, s_4) **then**
19. Repeat Step from 5 : 8 for S_4SHs
20. **end if**

Once the sector setup stage is finished and sensor nodes are allocated with TDMA slots where each sensor node connects at its assigned time period. The sensed data of all SMs is received at the SHs then, the sensed data is aggregated and is forward to the central sink. The current round finishes and the next election of SHs are started for the following round.

IV. SIMULATION RESULTS

The performance assessment metrics and the comparison results are examined by means of the NS2 Simulator. The proposed MQ-LEACH method is compared with LEACH and M-LEACH methods.

Table 3. Simulation settings

Parameters	Value
Network size	100 m x 100 m
No. of nodes	100 - 600
Channel	Wireless
Channel type	Bidirectional
Node deployment	Random
Mobility(sink, sensor node)	Fixed
Sink initial position	(50,50)
Initial energy	1 J
Data aggregation energy	5nJ

There are five metrics such as Stability Period (SP), Network Lifetime (NL), Average End to end delay (AED), Average Energy Consumption (AEC) and Packet Delivery Ratio (PDR) are used to assess the performance of the proposed method. The simulation settings of the proposed method are shown in Table 3.

In the simulations, 'M' static nodes are randomly deployed in the monitoring field with 100 m x 100 m. Only one sink node is considered in the simulation which is located at (50, 50). The initial batter energy of all nodes is 1J. The data aggregation energy is considered as 5nJ. Each simulation has to proceed nearby 50 times and therefore the average value was computed.

Analysis 1: Stability Period (SP)

The SP denotes the number of alive nodes in the network during data transmission. A comparison of SP for various methods is depicted in Fig.3. The SP has been evaluated with 100 sensor node arrangement for MQ-LEACH, M-LEACH and LEACH methods.

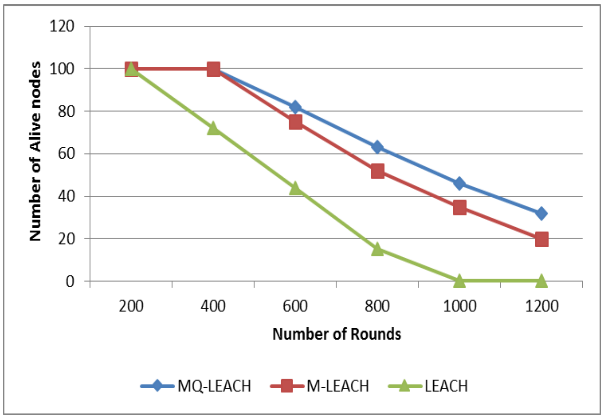

Fig.3. Stability Period Comparison

The SP of MQ-LEACH is 58% and 15% greater than the LEACH and M-LEACH methods respectively. According to the aforesaid examination, larger SP is gained by means of the MQ-LEACH method owing to suitable energy utilization in both SM and SH. Moreover, the proposed method maintains 32% of lively nodes at 1200th round. The existing methods are failed to concentrate on the energy utilization of nodes yields lesser SP in the network.

Analysis 2: Network Lifetime (NL)

Generally, numerous metrics are delivered to define the NL of the WSN. In this work, First Sensor node Die (FSD) has been engaged to compare and assess the NL. FSD designates the number of rounds before the death of the first node in the monitoring area.

The NL of MQ-LEACH has superior by 51% and 6% as compared to LEACH and M-LEACH methods respectively which is shown in Fig.4. This arises owing to the election of more constant nodes as SH in the MQ-LEACH method in which SH selection can be carried out using the novel setup phase and node association phase. The selection of unsuitable node as SH in existing methods cause lesser NL compared with the proposed method.

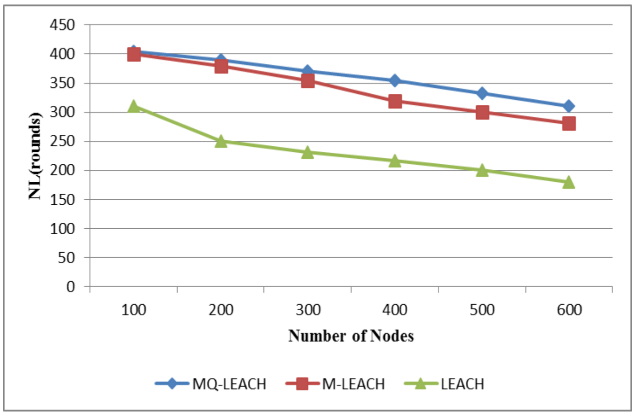

Fig.4. Network lifetime Comparison

Analysis 3: Average End to end delay (AED)

AED denotes the average time reserved by a data packet to travel from sender to receiver. According to the Fig.5, it was detected that the delay of MQ-LEACH linearly increases from 0.031 to 0.19 seconds, the AED of M-LEACH and LEACH method increases from 0.034 to 0.24 seconds, 0.036 to 0.28 seconds respectively. The AED of MQ-LEACH has superior by 17% and 14% as compared to LEACH and M-LEACH methods respectively. This results due to proper sector formation in the proposed method.

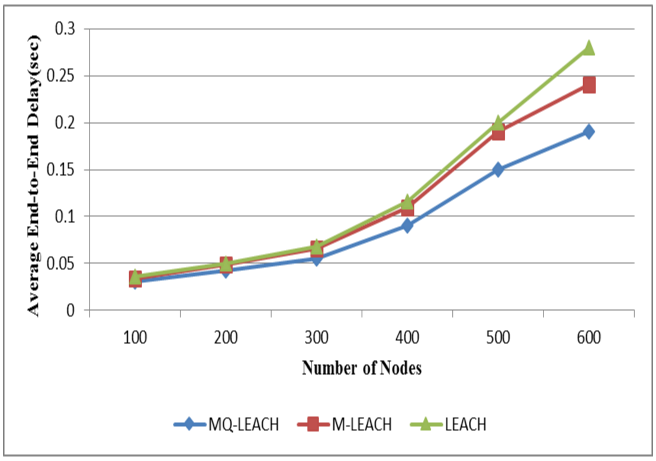

Fig.5. AED Comparison

Analysis 4: Average Energy Consumption (AEC)

The AEC comparison is shown in Fig. 6. From Fig.6, the AEC of MQ-LEACH has been condensed by 58% and 15% as compared to LEACH and M-LEACH techniques respectively. The major reason behind this reduction is to form the efficient sectors along with appropriate SH and energy utilization methodology. Moreover, it takes lesser time for the SH selection strategy. On the other hand, not proper energy balancing and selection strategy occurred in LEACH and M-LEACH methods cause more AEC than the proposed method.

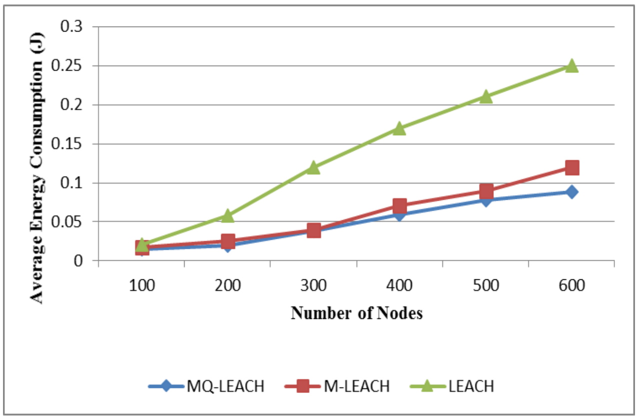

Fig.6. AEC Comparison

Table 4. Comparison of MQ-LEACH method for the 600 nodes setup

Methods/metrics	MQ-LEACH	M-LEACH	LEACH
Network lifetime (rounds)	310	281	180
AED (sec)	0.19	0.24	0.28
AEC (J)	0.08	0.12	0.25
PDR (%)	78	52	17

Analysis 5: Packet Delivery Ratio (PDR)

The PDR is computed as follows

$$PDR = \frac{Total\ data\ packets\ delivered}{Total\ data\ packets\ sent} \quad (2)$$

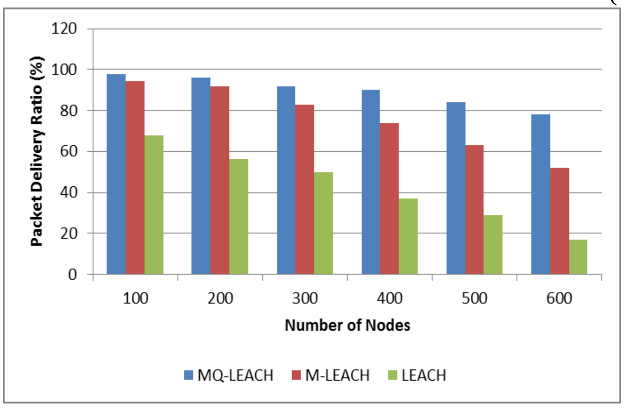

Fig.7. PDR Comparison

In order to compute PDR, a total number of data packets transmitted and received packets is required. Fig.7 reveals the PDR of MQ-LEACH which is linearly reduced from 98% to 78%, the PDR of M-LEACH and LEACH method reduces from 94% to 52% and 68% to 17% respectively. Henceforth, the PDR of MQ-LEACH is superior by 46%, 13% as compared to LEACH and M-LEACH methods respectively. This enhancement is because of ideal time slot allocation by a proposed method where the number of packet drop is minimized. The comparison of the MQ-LEACH method for the 600 nodes setup is depicted in Table 4. According to Table 4, it is evident that the proposed method is better than all existing methods in terms of NL, AED, AEC, and PDR.

V. CONCLUSION

Most of the existing sectoring algorithms are aimed to attain suitable energy utilization of WSN. However, the stability period of WSN is not properly managed by existing methods. The main objective of this research work is to acquire the stability period and energy efficiency of WSN. The proposed MQ-LEACH worked with two efficient phases in which proper SH selection and sector formation occur significantly.

The simulation results are evaluated in the NS2 environment. The SP, NL, AED, AEC, and PDR of the proposed method are improved by 58%, 51%, 17%, 58%, and 46% respectively. The aforesaid results manifest that the MQ-LEACH method enhances the network parameters and looks to be an efficient choice for IoT based applications by prolonging and improving overall network quality parameters. The proposed method will be more useful for disaster management applications and environmental monitoring systems.

REFERENCES

1. R.Oma, S.Nakamura, D.Duolikun, T.Enokido, and M.Takizawa, "An energy-efficient model for fog computing in the Internet of Things (IoT)", *Internet of Things*, Vol.1, 2018,pp. 14–26.
2. T.M.Behera, S.K.Mohapatra, U.C.Samal, M.S.Khan, M.Daneshmand and A.H.Gandomi,"Residual Energy Based Cluster-head Selection in WSNs for IoT Application", *IEEE Internet Things Journal*, Vol. 6, 2019, pp. 5132-5139.
3. N.Gharaei, K.A.Bakar, S.Hashim, and A.Pourasl, "Inter- and Intra-Cluster Movement of Mobile Sink Algorithms for Cluster-based Networks to Enhance the Network Lifetime", *Ad Hoc Networks*, Vol. 85, 2019, pp. 60-70.
4. M.Faheem, R.A.Butt, B.Raza, M.W.Ashraf, Md.A.Ngadi, and V.C.Gungor, "Energy Efficient and Reliable Data Gathering Using Internet of Software- Defined Mobile Sinks for WSNs-based Smart Grid Applications", *Computer Standards & Interfaces*, Vol.66, 2019.
5. S.Savitha,S.C. Lingareddy, and S.Chitnis, "Energy Efficient Model for Maximizing the Network Coverage Time in Non-Deterministic WSN Model", *International Journal of Innovative Technology and Exploring Engineering (IJITEE)*, Vol.9, no.2, 2019. pp. 27-32.
6. A.Prasanth, and S.Pavalarajan, "Implementation of Efficient Intra- and Inter-Zone Routing for Extending Network Consistency in Wireless Sensor Networks", *Journal of Circuits, Systems, and Computers*, Vol. 29, no.8, 2020.
7. D.Chakraborty, J.K. Das, Md.Islam, "Performance Reasoning of MANET Routing Protocols Varying Node Density", *International Journal of Innovative Technology and Exploring Engineering (IJITEE)*, Vol.9, no.2, 2019, pp. 93-102.
8. A.Prasanth, and S.Pavalarajan, "Zone-Based SinkMobility in Wireless Sensor Networks", *Sensor Review*, Vol. 39, no.6, 2019, pp. 874-880.
9. W.B.Heinzelman, A.P.Chandrakasan, and H.Balakrishnan, "An application-specific protocol architecture for wireless micro sensor network", *IEEE Transactions Wireless Communication*, Vol. 1, 2002, pp. 660-670.
10. M.Elshrkawey, S.M.Elsherif, and M.E.Wahed, "An enhancement approach for reducing the energy consumption in wireless sensor networks", *Journal of King Saud University – Computer and Information Sciences*, Vol. 30, no. 2, 2018, pp. 259–267.
11. H.Farman, H.Javed, B.Jan, J. Ahmad, S.Ali, and F.N.Khalil, "Analytical network process based optimum cluster head selection in wireless sensor network", *PLoS ONE*, Vol.12, no. 7, 2017, pp. 1-28.

12. P.Nayak and B.Vathasavai,"Energy Efficient Clustering Algorithm for Multi-Hop Wireless Sensor Network Using Type 2 Fuzzy Logic", *IEEE Sensor Journal*, Vol.17, no.14, 2017.
13. I.Gupta, D.Riordan and S.Sampali, "Cluster Head Election using Fuzzy Logic for Wireless Sensor Networks", in Proceedings of the 3rd *Annual Communication Networks and Services Research Conference*, 2005, pp. 255-260.
14. D.V.Pushpalata and P.Nayak (), "A Clustering Algorithm For WSN To Optimize The Network Lifetime Using Type2 Fuzzy Logic Model", in Proceeding *3rd International Conference on Artificial Intelligence, Modeling and simulations*, Kota Kinabalu, Malaysia, 2015, pp 53-58.
15. M.S.Ali, T.Dey, and R.Biswas, "ALEACH:Advanced LEACH routing protocol for wireless micro sensor networks", *International Conference on Electrical and Computer Engineering*, 2008, pp. 909–914.

AUTHORS PROFILE

A.Prasanth received the B.E. degree in Electronics and Communication Engineering from Anna University, Chennai and the M.E degree in Computer Science and Engineering (with specialization in Networks) from Anna University, Chennai. He is currently working as an Assistant Professor. His research interests include Wireless Sensor Networks, and Ad hoc Networks.

Divya Francis received the B.E. degree in Electronics and Communication Engineering from Anna University, Chennai and the M.E degree in Applied Electronics from Anna University, Chennai. She is currently working as an Assistant Professor. Her research interests include Digital Image Processing, Wireless Sensor Networks and Computer Networks

C.Kohila received the B.E degree in Electronics and Communication Engineering from Anna University, Chennai and the M.E degree in Electronics and Communication Engineering from Anna University, Chennai. She is working as an Assistant Professor. Her research interests include Communication Systems, Antennas.

D.Gayathri received the B.E. degree in Electronics and Communication Engineering from Anna University, Chennai and the M.E degree in Applied Electronics from Anna University, Chennai. She is currently working as an Assistant Professor. Her research interests include Artificial intelligence, Robotics and Medical Electronics