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Implementation of optimal solution for network lifetime and energy consumption metrics using improved energy efficient LEACH protocol in MANET

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Abstract

In current scenarios MANET mainly focus on low power battery operated devices. Moreover in a MANET transmission of large data consumes more energy that affects the performance of network, energy consumption, throughput, end to end delay, and packet overhead. The sum of these parameter metrics measure must be taken into account to increase the life-time and network energy efficiency. The main constraint in WSN is due to the restricted power in a node, which cannot be substituted. The node senses the data and it is moved towards the sink. This action of data movement needs to be efficient and the usage of battery in the sensor node requires to be efficiently employed to improve the network lifetime. The development of the energy efficient algorithms is of primary concern in the research arena of MANET. In any network, most of the routing protocols are focused directly to collect and bifurcate the large data for long distance communication. The prime goal of this research focused to identifies and survey more suitable routing protocol for MANET. That consumed less energy and increase life time of network. In this paper the author made on attempt on improved energy efficient LEACH protocol for MANET to reduce the energy dissipation that to life time of the network during the data transmission between source nodes and destination nodes.

Keywords*: alive nodes, cluster head, energy consumption, lnetwork lifetime, MANET*

1. Introduction

With the rapid growth of new technologies and advent of low power wireless sensors in wireless communication, large numbers of sensors are used in each application with low cost, low power consumption and large data transmission with short distance. The MANET mainly contains mobile nodes, sensor node along with a base station (BS). The WSN ad-hoc nature makes its applications in control of air traffic, military, physical security, automation process, monitoring of environment, health care and hospital monitoring and others [1-6]. The major benefits of WSN are low cost of installation, simple in positioning, scattering over an extensive area and large fault tolerance [7].

The sensor nodes in the MANET are driven by the batteries. The energy used may be very costlier and quite difficult to exchange the battery. The main constraint in MANET is the life network time. The sensor nodes energy is driven away due to the message processing, transferring and receiving. The sensor node needs energy during the stages of overhearing, collision; idle listening and interference. The sensor nodes efficiency is reduced due to the redundancy of data. Due to the constraints of the wireless nodes several techniques are designed for efficient usage of the energy by reducing the consumption to enhance the network lifetime [8]. The routing based on the hierarchy, the cluster is created and special task is allotted for sensor node selection in the cluster named as cluster head (CH). The node clustering effectively conserves the energy [9, 10].

Day by day development in technologies more efforts are made in wireless communications that could help the people to observing and segregate the data. Many routing protocol able to collect and transmit the data more efficiently with improved performance factors such as packet delivery ratio, end to end delay, throughput, routing overhead, energy consumption, with power consumption techniques, more advanced efficient algorithms and

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compressed technique that data can communicated between sensor node and the base station more efficiently.

More protocol is available based on hierarchy cluster based approaches on the type of information communicated among the cluster head, cluster nodes then base station. The performance of MANET is evaluated based on sum of performance measurement metrics are throughput, end to end delay, energy consumption, routing overhead, packet delivery ratio and etc. By analyzing the sum of parameter that are more efficient performance metrics used in LEACH algorithm that are found in the literature survey of MANET and the author made to attempt to advance the performance of MANETs in terms of measurements like life time to improve and consume less energy. The continuing research work is ordered as follows. Related work is presented in section 2. The section 3 is the objective of the proposed work. Section 4 details the proposed energy efficient LEACH protocol to select cluster head. The proposed improved energy efficient leach protocol simulation results are presented and deliberated in section 5. Section 6 concludes the work.

2. Related Work

The collection of same data or objects is known as clustering. It reduces the nodes number which plays important part in transmission of data to the BS over a lengthier distance [9]. It minimizes the data transmission through combination of same type nodes as well as selecting the one node named as CH. The data collection is done to evade the data redundancy as well as the communication load due to several neighbouring nodes. The combined data is sent to the subsequent CH or BS for further processing, storage and retrieval. The routing based on cluster proficiently preserves the sensor node energy usage by multi-hop communication under the specific cluster. The basic hierarchical protocol is the Low Energy Adaptive Clustering Hierarchy (LEACH) that was presented in [11]. Several other hierarchical protocols developed due to LEACH [12].

The LEACH works on the cluster formation via the sensor nodes grounded on the strength of signal received and the CH as router towards the sink. It increases the consumption of the energy because the CH carries out the transmission instead of every node. The clustering technique minimizes the transmission number with in the network. The main benefit of the cluster head is the data's combinations form all the members of the cluster which helps in the minimization of the transmission duplication and enhances the performance of the network.

2.1. Leach Protocol

The Leach protocol architecture is presented in the Figure 1. Heinzelman [13] proposed the LEACH protocol for WSN. Its process is biforcated into rounds. Every round starts with a new setup-phase in which the organization of the clusters is done. In the phase of steady state, many data frames get transferred to the CH by the nodes and towards the station of the base. Its core objectives are increase in network life time, decreased energy consumption; use data aggregation to decrease the communication massages number.

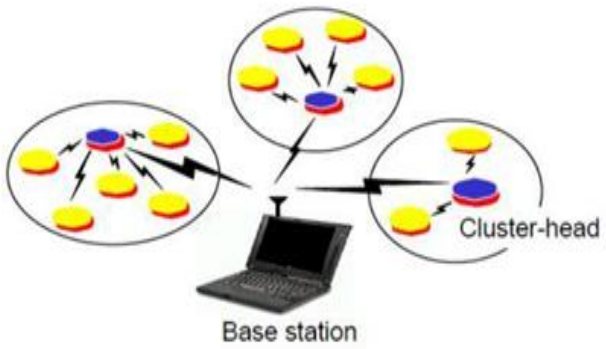


Figure 1. Leach protocol architecture

$$T(n) = \frac{p}{1-p*(rmod\frac{1}{p})} \; ; \text{If n } \mathcal{E} \text{ G} \quad (1)$$

T (n) = 0; Otherwise, in the (1).

p = possibility of the node being nominated as a cluster-head node
r = total number of rounds-passed
G = ordinary nodes collected
mod = modulo operator
T (n) = cluster head selected threshold value in every round

The CH formed based on the equation in which sensor node create the random number from 0 to 1. If the created number is less than the T (n) threshold, then the node is chosen as the CH. From the Figure 1, the higher energy node becomes the CH if its energy is greater in comparison with the remaining nodes energy. It gives the joining bid to remaining nodes in the cluster. The remaining node takes decision either to be with the CH or not. The assignment of the TDMA to the nodes is done after obtaining the acknowledgement. The CH after collecting the information from other nodes, it is sent to the BS. So it requires larger quantity of energy in comparison with the other nodes. The choice of the CH is based on the nodes possessing more energy. Whenever the CH is made as fixed, it takes more energy and perishes at the earliest. Whenever the CH becomes failure in the network the entire cluster is not reachable. In the LEACH protocol [14], the CH is changed amongst the nodes in the network. The energy consumption by every node is consistently scattered. It enhances the network lifetime. By using the TDMA technique, the allocation of time is done to every node in the CH. The CH groups the collected data from all the remaining nodes [15-22]. The LEACH protocol flow chart Figure 2 is shown for CH selection.

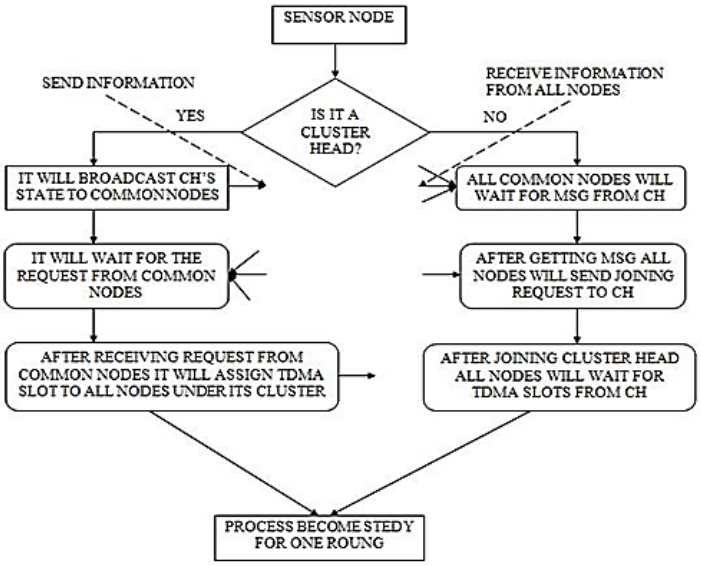


Figure 2. CH selection flow chart

3. Proposed Improved Energy Efficient LEACH Protocol

The Improved Energy Efficient (IEE) LEACH algorithm is proposed for MANET. The selection of the CH is to lengthen lifetime of the network. From the literature survey, most of the papers mainly focused on sum of the performance metrics used in MANET, Euclidian distance between the BS and node, residual energy, quantity of neighbor node in a cluster and threshold value to overcome the overhead of data transmission to minimize between the nodes and BS Euclidian distance to be considered. This research work mainly concentrated to overcome this data transmission overhead or to be minimal. This work highlights some of

the features taken into consideration [23-26] for the selection of CH that consumes high residual energy, shorted distance.

LEACH protocol randomly selects cluster heads and major drawbacks are no limits on their scattering and energy level distributions as per the (1). In this scenario in a bounded region with limited number of nodes, each node is assigned initially with predefined residual energies, at initial stage any one of the cluster head randomly is selected with 10 Joules residual energy. Here, the problem may arise that during data transmission cluster head energy may become either lower or higher than the chosen cluster head. If the cluster head with lower energies cause the problem of decreasing the lifetime of the network. During the higher residual energy cluster node data is transmitted as usual. This is a major disadvantage in Leach protocol using (1). The author proposes an innovative protocol Improved Energy Efficient Leach Protocol (IEE-LEACH) to overcome this by selecting best possible Cluster head with highest residual Energy recursively. During the data transmission the energy value may change and it repeats again in selecting the cluster head and continues till it reaches to obtain a stable data transmission so that life time of the network may increase or stable.

In the MANET, the CH selection is centered on residual energy as well as definite threshold rate of the relevant nodes T(i). Threshold value T(i) is obtained with IEE-LEACH protocol is given by (2).

$$T(i)\begin{cases}\frac{P_i}{1-P_i\times\left(r\times mod\left(\frac{1}{P_i}\right)\right)}\times c(i),\ N\in G\\ 0\end{cases} \quad (2)$$

Where Pi is the desired percentage of cluster heads,

$$P_i=\frac{(E_i-E_r)^2}{E_R} \quad (3)$$

E_i- Each node residual energy of in 1 round;
E_r- Rest nodes average energy of in the 1 round;
E_R- Rest nodes Total residual energy of in the 1 round;
Computing formula for average energy of rest nodes E_r

$$E_r=E_R\times\frac{\left(1-\frac{r_i}{r_{max}}\right)}{N} \quad (4)$$

r_i: The current round;
r_{max}: The Maximum rounds of network simulation,
Cost function can be said as:

$$c(i)=a\frac{E_{re}(i)}{E_i}+\ \mathrm{b}\ \frac{\mathrm{N_n(i)}}{\mathrm{N_a}}+\ \mathrm{c}\ \frac{\mathrm{D_B(i)-D_{Bmin}}}{\mathrm{D_{Bmax}-D_{Bmin}}} \quad (5)$$

where,
$E_{re(i)}$: node iremaining energy,
E_i: initial energy,
$N_{n(i)}$: quantity of neighbors of node i,
N_a: quantity of active nodes,
$DB_{(i)}$: node i and the BSdistance,
DB_{min}: the closest node to the BS and the BSdistance between,
DB_{max}: the maximum distance to the BS.

In these (2) and (3), if there is much residual energy of each node and its value of P_i will increase, which establishes that this node has a great amount of energy in the rest energy. With the rise of P_i, $T_{(i)}$ will raise too, therefore the likelihood of this node being a cluster head is enlarged too. Therefore, in the view of the nodes residual energy, allowing the nodes having higher remaining energy as cluster heads, it avoids early close of network lifetime and also enhances the lifetime of network. After choosing CHs, for the left behind nodes also able to decide their formation cluster in successive operation have to choose its cluster by performing the performance factor p(i) in each round. The selection of nodes belongs to cluster head by

measuring the distance amongst the node and the CH. Thus all the nodes are closed by distance create their individual clusters which in turn decide the network life time for effective utilization during data transfer. This in turn increases the network life time without any performance degradation. The values of parameters a, b and c are between 0 and 1 that are found by the Analytic Hierarchy Process (AHP) technique. The energy weight parameter should be bigger than b and c. In reality, the node becoming CH should have the extreme energy level that influences results. Then, the node neighbours factor is more real than the distance amongst the node and the base station, so b>c.

4. Simulation Results

Simulation settings for LEACH protocol implementation are shown Table 1. The simulation parameters for the evaluation of the energy efficient cluster head selection shown in Table 1. By considering the fixed network size of 1000x1000 m2 and 150 nodes are created. The initial energy of every node was set to 10 Joules. Energy for data aggregation is 2nJ. The data packet size is 780 bits and data transmission time is 10 msecs.

Table 1. Simulation Parameter of IEELEACH Protocol

Type of Parameter	Value
Propagation	Two ray ground
Field size- m x m	1000 x 1000
Number of nodes	150
Channel Type	Wireless Channel
Antenna Type	Omni
Link Type	LL
Initial energy of MANET node- Joules	10
Data packet size-	780
Simulation time–ms	50
Transmission time–ms	10 to 50
Observation Parameters	Packet Delivery Ratio, End to End Delay, Routing Overhead, Throughput, Alive Nodes, Energy Consumption,

4.1. Simulation Results of IEE-LEACH Protocol

In this research work, the author made an attempt to improve the performance of the networks by measuring some of the related and reliable characteristics that are taken in to consideration. The performance factors are measured by analyzing and simulating the experimental setup using IEE-LEACH protocol. The author tabulated the simulations results that obtained using this protocol and associated with the results of LEACH protocol. Here, the simulation results are obtained for the performance parameters end to end delay, rounding overhead, packet delivery ratio, throughput, energy consumption, number of alive nodes, number of dead nodes, from the obtained simulation results, improved version of LEACH protocol is IEE-LEACH protocol performs in a better way associated to LEACH protocol.

4.1.1. Packet Delivery Ratio

Figure 3 (a) shows comparison of the performance factor the packet delivery ratio against the number of nodes for the proposed IEE-LEACH and LEACH protocols. The Simulation results illustrates that Packet Delivery Ratio is high in IEE-LEACH protocol compared to LEACH protocol. The packet delivery ratio is measured with different nodes by simulating by considering different number of uneven nodes (10, 25, 50, 75, 100 and 150) with different pause times. From the obtained simulation results, the work performs that at minimum number of nodes the PDR variation is slightly varying between LEACH and IEE-LEACH protocols where as the amount of nodes improved the PDR tends to increase. IEE-LEACH protocol performance improves approximately by 1.317%. By increase in the number of nodes and reducing the time slots the possibility of the data loss may occur. This is overcome by partially in terms of PDR by IEE-LEACH protocol than LEACH protocol.

4.1.2. End to End Delay

The simulation results for end to end delay parameter are shown in the Figure 3 (b) assigned to the number of nodes. In the beginning the end to end delay is less in both the protocols as number of nodes increases the delay also increased up to certain nodes then

remains same as in both the cases. Even though IEE-LEACH protocol performs better compared to LEACH protocol with an improvement of 6.48% end to end delay. This factor again progresses the network performance in terms of energy consumption and network life time due to reduce in end to end delay.

4.1.3. Routing Overhead

Routing discovery places a main role in deciding the routing performance in MANET. The simulation results of Routing overhead using NS2 tool are shown in Figure 3 (c). For example when nodes number increases from 10 to 150 randomly the routing overhead parameter decreases in this proposed method IEE-LEACH protocol. The percentage of improvement in IEE-LEACH protocol is 7.027% compared to LEACH protocol. This enhances the performance of network life time and energy consumption which place major advantage in MANET.

4.1.4. Throughput

Figure 3 (d) shows simulation results obtained for throughput using NS2 tool from 10 to 150 numbers of nodes. Initially throughput remains till 75 numbers of nodes beyond that the throughput drastically increases by an averages of 17.482% in the proposed IEE-LEACH protocol compared to LEACH protocol. Throughput of IEE-LEACH protocol is increased up to 35.12 as a number of nodes reaches to 150.

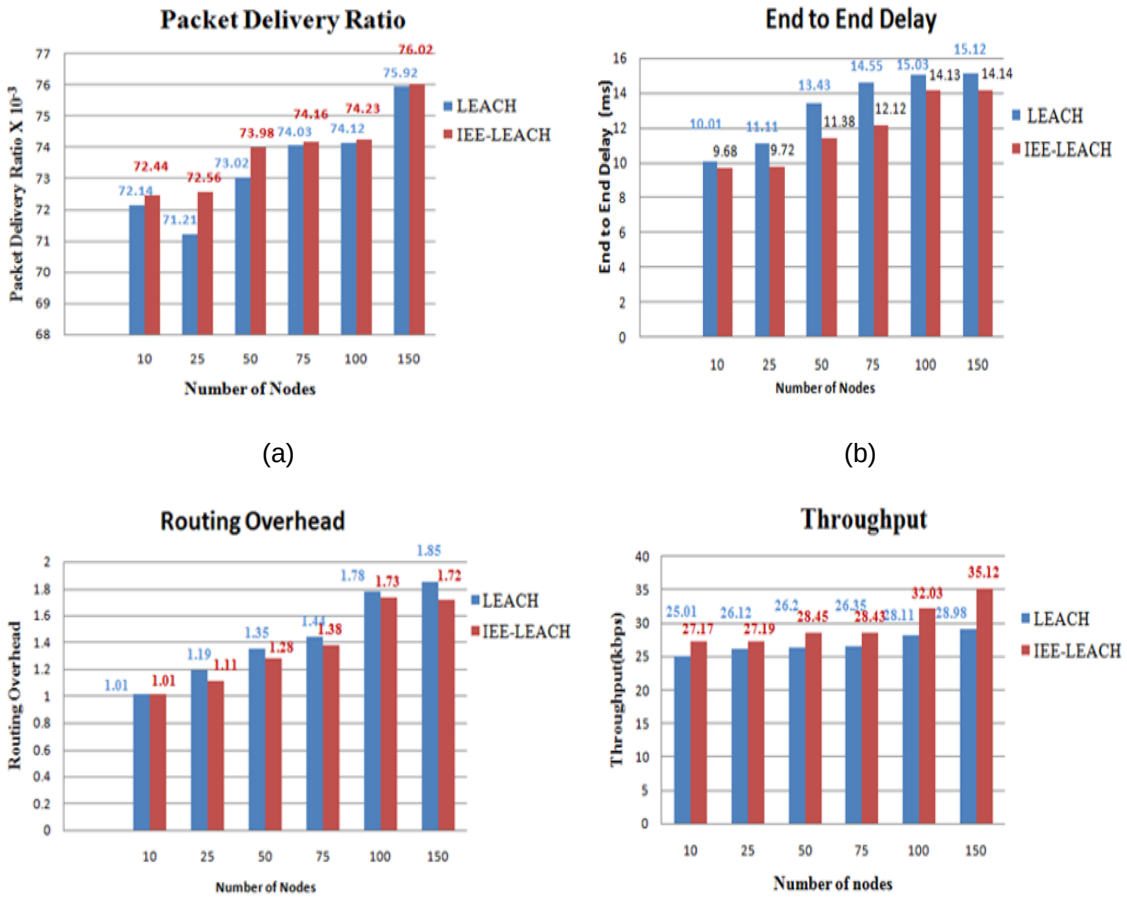


Figure 3. (a) Comparison of packet delivery ratio vs Number of nodes
(b) End to end delay vs number of nodes (c) Routing overhead vs number of nodes
(d) Throughput vs number of nodes

4.1.5. Energy Consumption

The simulation results of energy consumption using NS2 tool from 10 to 100 numbers of nodes are shown in Figure 4 (a). Initially energy consumption gradually increases as the nodes number increases from 10 to 150. The energy consumption of IEE-LEACH protocol is decreased up to 72.10. So, the results show that energy consumption is improved in this proposed IEE-LEACH protocol by 5.03% compared to LEACH protocol. Measures of packet delivery ratio, end to end delay, routing overhead, and throughput in LEACH vs IEE-LEACH protocols as shown in Tables 2-5. Measure of energy consumption LEACH vs IEE-LEACH protocols as shown in Table 6.

Table 2. Measures of Packet Delivery Ratio LEACH vs IEE-LEACH Protocols

Number of Nodes	Packet Delivery Ratio	
	LEACH	IEE-LEACH
10	0.7214	0.7244
25	0.7121	0.7256
50	0.7302	0.7398
75	0.7403	0.7416
100	0.7412	0.7423
150	0.7592	0.7602

Table 3. Measures of end to end Delay LEACH vs IEE-LEACH Protocols

Number of Nodes	End to end delay-ms	
	LEACH	IEE-LEACH
10	10.01	9.68
25	11.11	9.72
50	13.43	11.38
75	14.55	12.12
100	15.03	14.13
150	15.12	14.14

Table 4. Measures of Routing Overhead LEACH vs IEE-LEACH Protocols

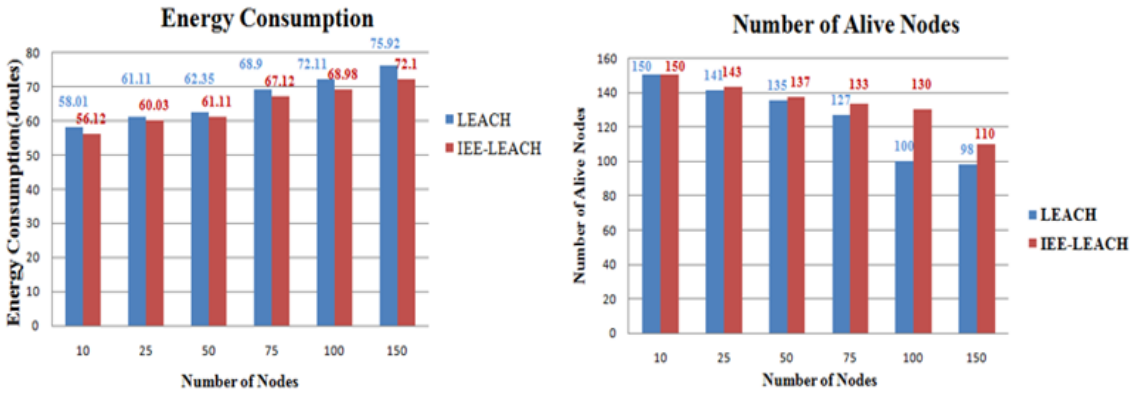
Number of Nodes	Routing overhead	
	LEACH	IEE-LEACH
10	1.01	1.01
25	1.19	1.11
50	1.35	1.28
75	1.44	1.38
100	1.78	1.73
150	1.85	1.72

Table 5. Measures of Throughput LEACH vs IEE-LEACH Protocols

Number of Nodes	Throughput	
	LEACH	IEE-LEACH
10	25.01	27.17
25	26.12	27.19
50	26.20	28.45
75	26.35	28.43
100	28.11	32.03
150	28.98	35.12

4.1.6. Number of Alive Nodes

Figure 4 (b) is shows expresses of the number of alive nodes in LEACH and and IEE-LEACH Protocol for routing protocol. The obtained results of number of alive nodes obtained from simulation results using NS2 is tabulated in Table 7. It clearly states that improvement in number of alive nodes rises the functionalities of the network and also energy consumption and network life time in MANETs. The performance is improved in this proposed method by 7.03% compared to LEACH protocol.



(a) (b)

Figure 4. (a) Energy consumption vs number of nodes, (b) Number of alive nodes vs number of nodes

Table 6. Measure of Energy Consumption LEACH vs IEE-LEACH Protocols

Number of Nodes	Energy consumption (joules) LEACH	IEE-LEACH
10	58.01	56.12
25	61.11	60.03
50	62.35	61.11
75	68.90	67.12
100	72.11	68.98
150	75.92	72.10

Table 7. Measure of Number of Alive Nodes LEACH vs IEE-LEACH Protocols

Number of Nodes	Energy consumption (joules) LEACH	IEE-LEACH
10	10	10
25	21	23
50	35	37
75	38	40
100	78	80
150	119	128

5. Conclusion

From the literature survey it was found that LEACH protocol shown better performance and emanate features are obtained in terms of performance factors like delay, energy consumption, throughput and etc. the major short coming of LEACH protocol is selecting CH. This drawback is eliminated by proposing an improved protocol IEE-LEACH by considering the number of nodes up to 150. From the obtained simulation results using NS2 tool the performance factors PDR, End to end delay, throughput, routing overhead, energy consumption, number of dead nodes, number of alive nodes shows better performance in terms of energy consumption, life time of the network and location of the cluster with shortest distance. In this proposed method improvement occurred in terms of PDR by 1.317%, end to end delay by 6.48%, throughput by 17.482%, routing overhead by 7.027%, energy consumption by 5.03%, number of alive nodes by 7.03% and number of dead nodes by 9.6% compared to LEACH protocol. The short comings of performance measures may be improved in feature by incorporating fuzzy logic and genetic algorithm concept during data transmission in MANET. With overall results the proposed methodology IEE-LEACH protocol reduces overall energy consumption and network life time.

References

[1] Akyildiz IF, Weilian S, Sankara subramaniam. A Survey on Sensor Networks. In *IEEE Communications Magazine*. 2002; 40(8): 102-114.
[2] Mainwaring A, Polastre J, Szewczyk J, Culler D J. Wireless Sensor Networks for Habitat Monitoring. In WSNA'02, 2002.
[3] Tubaishat M, Madria S. Sensor Networks: an Overview. *IEEE Potentials*. May, 2003: 20-23.
[4] Yu L, Wang N, Meng X. *Real-time forest fire detection with wireless sensor networks*. Int. Conf. on Wireless Comm, N/w & Mobile Computing. 2005.
[5] Youssef M, Yousif A, El-Sheimy N, Noureldin A. *A Novel Earthquake Warning System Based on Virtual MIMO-Wireless Sensor Networks*. Canadian Conference on Electrical and Computer Engineering. April, 2007.
[6] KS Ananda Kumar, R Balakrishna. Evaluation of Energy Consumption using Receiver–Centric MAC Protocol in Wireless Sensor Networks. *International Journal of Electrical and Computer Engineering (IJECE)*. 2018; 8(1): 87-93.
[7] Loscri V, Marano S, Morabito GA. *Two-Levels Hierarchy for Low-Energy Adaptative Clustering Hierarchy (TL-LEACH).* In Proceedings of VTC2005. Dallas USA. 2005: 1809-1813.
[8] Chaurasiya, Kumar S, Pal T. *An Enhanced Energy-Efficient Protocol with Static Clustering for WSN.* In International Conference on Information Networking (ICOIN). Kuala Lumpur, Malaysia. 2011: 58-63.
[9] Eleburuike IO, Dekunle SS. Energy Efficient Wireless Sensor Network Using Hierarchical Routing Technique: Blekinge Institute of Technology, Karlskrona, Blekinge, Sweden, 2010.
[10] Prasad AY, R Balakrishna. *A Survey on Efficient Protocol Identification of MANET Cluster Head Formation and Selection Routing for Wireless Sensor Networks*. Third International Conference on Electrical, Electronics, Communication, Computer Technologies and Optimization Techniques (ICEECCOT). 14-15, December, 2018.
[11] Yang J, Zhang D. An Energy-Balancing Unequal Clustering Protocol for WSNs. *Information Technology Journal*, 2009: 57-63.
[12] Prasad AY, DR R Balakrishna. An Optimized Solution For Measures of Network Life Time and Energy Consumption Using Improved Energy Efficient Leach Protocol in MANET. *Global Journal of engineering Science and Researches*. 2018; 5(8): 102-112.
[13] Heinzelman WR, Chandrakasan A. *Energy efficient Communication Protocol for Wireless Microsensor Networks*. In IEEE Computer Society Proceedings of the 33rd Hawaii International Conference on System Sciences (HICSS '00). January, 2000; 8: 8020.

[14] Rajendra Prasad Mahapatra, Rakesh Kumar Yadav. *Descendant of LEACH Based Routing Protocols in Wireless Sensor Networks*, Procedia Computer Science 2015; 57: 1005-1014.
[15] Kong Hyung Yun. Energy efficient cooperative LEACH protocol for wireless sensor networks. *Journal of Communications and Networks.* 2010; 12(4): 358-365.
[16] S tilak et al. A Taxanomy of Wireless Microsensor Network Models‖. *Mobile Computing and Communications Review*. 2002; 6: 28-36.
[17] Bhaskar Bhuyan, Nityananda Sarma, Avijit Kar, Rajib Mall. Quality of Service (QoS) Provisions in Wireless Sensor Networks and Related Challenges. *Scientific Research*, 2010: 861-868.
[18] Pooja L Popat, Maulik D Trivedi, Optimization of cluster Head Selection Technique in LEACH Protocol. *International Journal of Computer Application.* 2015; 5(4): 2250-1797.
[19] Jyoti Rathi, M S Dagar. Improving LEACH Protocol in Wireless Sensor Networks. *IJSETR*. ISSN: 2278-7798. May, 2016; 5(5): 1454-1458.
[20] Fuzhe Zhao, You Xu, Ru Li. Improved LEACH Routing Communication Protocol for a Wireless Sensor Network. *International Journal of Distributed Sensor Networks*. Article ID 649609. 2012; 6: 1-6.
[21] Mortaza Fahimi Khaton Abad, Mohammad Ali Jabraeil Jamali. Modify LEACH Algorithm for Wireless Sensor Network. *IJCSI International Journal of Computer Science*. ISSN (Online): 1694-0814. 2011; 8(5): 219-224.
[22] Jayashri W Polkade, Prof H M Baradkar. Leach Algorithm Based on Clustering for Enhancement of Wireless Sensor Network. *IJETT*. 2016; 42(3): 142-145.
[23] Liaqat M, Gani A, Anisi MH, Ab Hamid SH, Akhunzada A, Khan MK, et al. Distance-Based and Low Energy Adaptive Clustering Protocol for Wireless Sensor Networks. PLoS ONE: e0161340. doi:10.1371/journal.pone.0161340. 2016; 11(9): 1-29.
[24] Changle L, Hanxiao Z, Binbin Hao, Jiandong L. A Survey on Routing Protocols for Large-Scale Wireless Sensor Networks. Sensors, 2011; 11(4): 3498-3526.
[25] Abidi, Wided, Tahar Ezzedine. New Approach for Selecting Cluster Head based on LEACH Protocol for Wireless Sensor Networks. 2017: 114-120.
[26] Salah, M Ben, A Boulouz. Energy-efficient Transmission based on Hierarchical Routing Protocol for Wireless Sensor Networks. *International Journal of Computer Applications.* 2017; 166(2): 17-20.