

LEACH based Clustering Technique in Wireless Sensor Network

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Article Info

Volume 82

Page Number: 4185 - 4188

Publication Issue:

January-February 2020

Article History

Article Received: 18 May 2019

Revised: 14 July 2019

Accepted: 22 December 2019

Publication: 21 January 2020

Abstract

Wireless Sensor Network (WSN) consisting of an hundred or thousand number of nodes which are deployed manually or randomly in the target region, and is useful for environment monitoring & tracking purposes. These nodes sense the environment's information, change into an acceptable form of signal, thereafter send it to the respective destination. Energy saving is the prime aim in WSN, which depends upon the clustering and packet routing. We studied various clustering protocols that were based on LEACH. We have found that dynamic Cluster Head (CH) selection process is necessary in WSN. In Low Energy Adaptive Clustering Hierarchical (LEACH), the CH selection was random, and didn't include energy aware parameters. In this paper, we give the comparison of LEACH based clustering protocols. We have also found that Three Layer LEACH (TL-LEACH) gives the better results as compare to other clustering algorithms like LEACH and E-LEACH. TL-LEACH is also useful for saving the node's energy in large geographical area and increase the lifetime of the WSN.

Keywords : Wireless sensor networks, clustering algorithms, network lifetime

I. INTRODUCTION

Sensor node is the key element of the Wireless sensor networks (WSNs), which is mostly used in Internet of Things (IoT) field [1, 2]. WSN is normally made up of huge number of sensor nodes that are randomly deployed. Such sensor nodes contain limited amount of energy, sensing capacity and memory [3]. These networks provide low cost solutions for environment problem's like military and civilian applications. Many industry Research-center promotes the development in small scale sensors [4]. Such nodes are consisting of energy consumption circuit, information processing unit and its battery. These nodes collect the information around the environment's and send it to respective destination [5]. Sensor nodes having resource constraints i.e., memory processing and battery unit. Thus the replacement of such nodes are difficult [6, 7], therefore several kind of energy saving technique have been proposed such as clustering, optimal data aggregation [5, 8-12]. In current scenario energy saving is the major challenge of the WSN, where node's energy is consumed in transmission and reception [5]. Thus the clustering is necessary in WSN that gives optimal energy consumption of the network.

In clustering, all the nodes are assigning in one of the clusters and each cluster contain one Cluster Head (CH) and

some other nodes, where CH receives information from its member, perform data aggregation, and send it to Base Station (BS) [5]. Thus, the optimal use of node's energy has been considered as the prime object in WSN that enhances the network lifetime [5]. In current scenario optimization techniques are commonly used for dynamic CH selection, and enhance the network performance [7].

We have deeply concentrated on various clustering algorithms like LEACH, E-LEACH and TL-LEACH. Low Energy Adaptive Clustering Hierarchy (LEACH) is the first clustering algorithm that is commonly used in WSNs [13]. The prime object of LEACH was to save the energy of the network by employing rotational based CH selection. Here firstly, all the CH of the network are selected thereafter clusters are formed in a distributed manner. The drawback of the LEACH is that the CH selection process was random, which didn't include the energy aware parameter. In Energy efficient LEACH (E-LEACH) [14], the CH selection was also based upon the probability based threshold, which included energy aware parameter but not used in a intelligent manner. Three Layer LEACH as (TL-LEACH) [15], in this whole network is divided into three-layer structure, where layer-0 contains only sensor nodes similarly, layer-1 contain CHs, layer-2 contain only Grid Head (GH), and layer-3 as BS.

Here, firstly all the CH are selected, thereafter one of the CH act as GH of the network. In this paper we gives the comparison of the LEACH based clustering protocols.

The remaining part of the paper organize as, Section II describe the system model, Section III represents the LEACH based clustering algorithm, Section IV discusses the results and analysis, and finally Section V describe the conclusion of the work.

II. SYSTEM MODEL

A. Network Model

We have consider some assumptions that are follow as:

1. Once the deployment of sensor nodes is finished, then all of them considered in static nature.
2. All sensor nodes contain same equal energy.
3. All the cluster members uses single hop communication, and send its information directly to the respective CH.
4. Data aggregation has been performed by every CH.

B. Radio Model

As per [13], the energy consumption model given below. in-which, k-bit data packet is transmit to a distance d, the energy requirements are:

$$E_{TX}(k, d) = \begin{cases} k(E_{elec} + \epsilon_{fs}d^2), & d < d_0 \\ k(E_{elec} + \epsilon_{mp}d^4), & d \geq d_0 \end{cases} \quad (1)$$

$$d_0 = \sqrt{\frac{\epsilon_{fs}}{\epsilon_{mp}}} = 88 \text{ meter}$$

Where E_{elec} describes about energy dissipation for 1-bit transmission or reception, d_0 is the threshold distance, k is the packet size, d is the distance between node & its destination, ϵ_{fs} describe about energy dissipation for free space and ϵ_{mp} is the energy dissipation parameter for multi-path scenario. All the above parameters are also explained in Table. I.

The energy requirements for receiving k-bit message as,

$$E_{RX}(k) = (kE_{elec})$$

III. LEACH BASED CLUSTERING ALGORITHMS

Here, we discuss various clustering algorithms that were based on LEACH. These algorithm having unique feature and commonly used in WSNs, that are given below:

A. LEACH

LEACH is the first clustering algorithm of WSN [13]. LEACH reduces the energy consumption of network by employing clustering scheme, where every cluster having one CH. Once the deployment of sensor nodes are completed, as

shown in Fig. 1, thereafter clustering process begin. Here, firstly all the CHs of the network are selected, where CH selection was based on probability-dependent threshold, as given in Eqn. 2, thereafter remaining nodes of the network select the nearest CH based upon the received signal strength of the CHs. All the CHs used as a router that directly communicated to the BS. LEACH perform clustering in a distributed manner.

$$T(n) = \frac{p'}{1 - p' * \left(r' \bmod \frac{1}{p'}\right)} \text{ if } n \in G \quad (2)$$

Here $p' = 0.05$, define as the desire percentage of sensor nodes, which are able to act as CH from all nodes of the sensing region, G contain those nodes which have not have selected as CH in $1/p'$ previous rounds and r' is the current round number.

B. E-LEACH

E-LEACH is the Energy efficient version of the LEACH algorithm that commonly used in WSN [14]. E-LEACH uses the residual energy of the node in probability-dependent threshold, that used in CH selection process, where threshold is given by Eqn. 3. The remaining process of clustering is same as the LEACH.

$$T'(n') = \frac{p'}{1 - p' * \left(r' \bmod \frac{1}{p'}\right)} \left(\frac{E_{Res}}{E_i}\right) \text{ if } n' \in G' \quad (3)$$

Here E_{Res} & E_i are the residual and initial energy of the node respectively.

C. TL-LEACH

TL-LEACH forms the three layer structure [15], whereas layer-0 contain cluster-members, layer-1 contain CHs, layer-2 contain GH and layer-3 as BS. Here firstly, all the CHs are selected by probability-dependent threshold, that was used as in LEACH [13], thereafter one of the CH node act as GH, which depends upon the residual energy (E_{Res}) of the CHs, as given in Eqn. 4. It employed rotation based CH selection along-with residual energy based GH selection.

$$F_{GH} = \frac{E_{Res}}{E_i} \quad (4)$$

Where, every CH having fitness value as F_{GH} using Eqn. 4, a CH that obtain maximum fitness value, called as GH of the network.

IV. RESULT AND ANALYSIS

The simulation of the various clustering algorithms (LEACH, E-LEACH and TL-LEACH) is performed on MATLAB-2019. Fig. 1 shows the deployment of sensor nodes and simulation parameters have been given in Table. I. Here, the analysis of network lifetime has been defined in term FND (First Node Dies), HND (Half of the Nodes Die) and LND (Last Node Die) of the network. While the FND define as the number of rounds after which the first node of the network dies[14].

We have simulated clustering algorithms like LEACH, E-LEACH & TL-LEACH, and the results have been compared, and shown in Fig. 2. We have found that the FND,

HND & LND of the TL-LEACH as 1161, 1383 & 1453 round, E-LEACH as 953, 1042 & 1212, and LEACH as 892, 1152 & 1535 respectively. Thus, we have found that TL-LEACH gives better result in term of FND and HND as compare to E-LEACH and LEACH, are shown in Fig. 3. As the usage of "Three Layer structure", TL-LEACH dynamically reducing energy consumption due to distance between node & its destination.

Table- I: Simulation Parameters

Parameters	Value
E_{elec}	50 nJ/bit
ϵ_{mp}	0.0013 pJ/bit/m ⁴
ϵ_{fs}	10 pJ/bit/m ²
E_{DA}	5 nJ/bit/signal
Sensing Region	100*100 m ²
Base station	(50,175)
Number of sensor nodes (N')	150
Initial energy of node (E_i)	0.5J
Packet size (k)	3200-bit

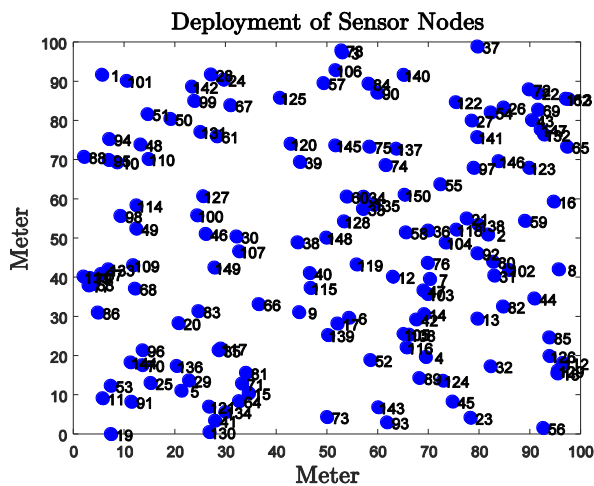


Fig. 1. Show the deployment of sensor nodes

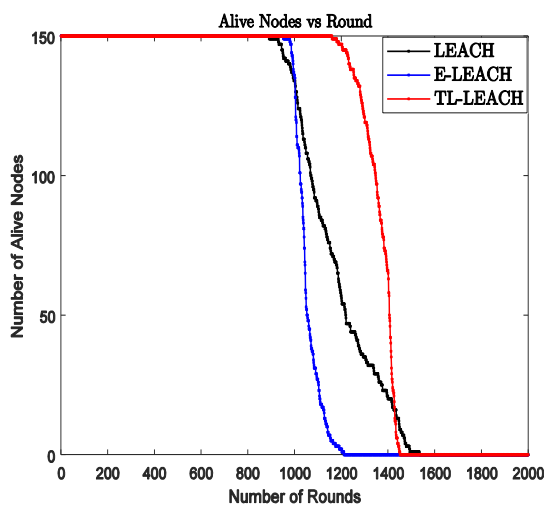


Fig. 2. Alive nodes of the network

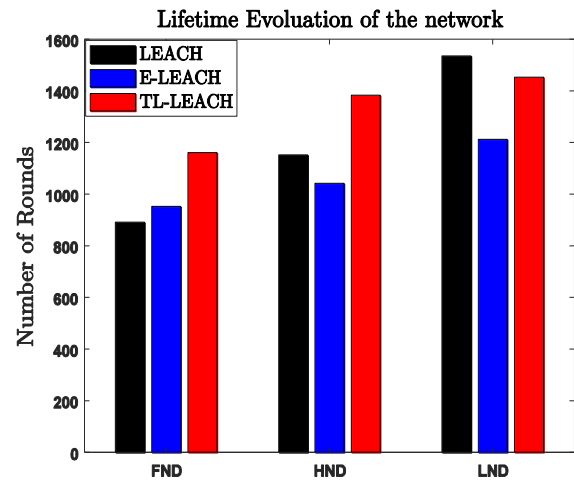


Fig. 3. FND, HND and LND of the network

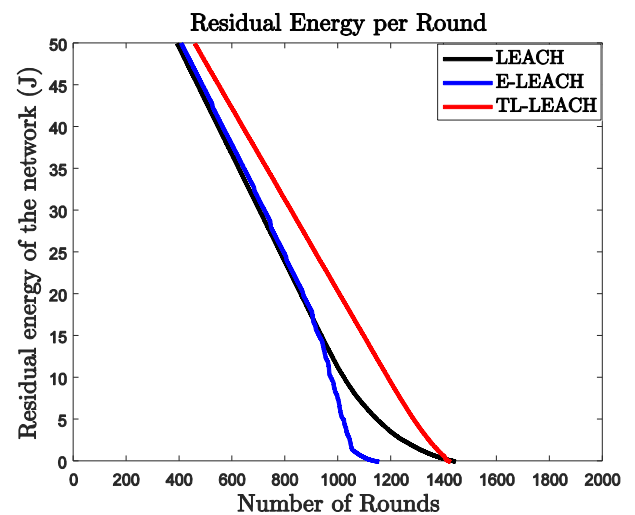


Fig. 4.. Residual energy of the network

Basically energy consumption of the network depends upon the usage of the node's energy. We have simulated the clustering algorithms like LEACH, E-LEACH and TL-LEACH for residual energy of the network and comparison shown in Fig. 4. We have found that TL-LEACH consumed optimal energy as compare to LEACH and E-LEACH.

We have found that the one of the drawback of LEACH is that the number of clusters are change very frequently like sinusoidal wave because CH selection is random. Similarly in E-LEACH number of clusters is varied with upcoming rounds in a unpredictable fashion. TL-LEACH gives the more stability w.r.to total number of clusters as compare to LEACH and E-LEACH, as shown in Fig. 5. Overall TL-LEACH stabilized the total number of clusters of the network in upcoming round as compare to LEACH and TL-LEACH.

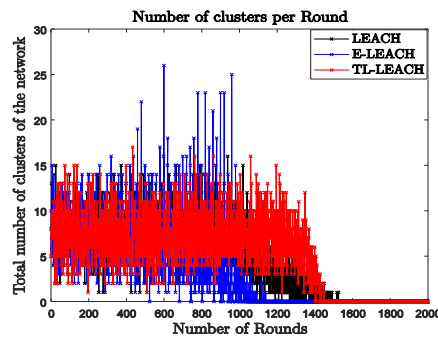


Fig. 5.. Number of Clusters in the network

V. CONCLUSION

Efficient technique of CH selection plays a important role for optimal usage of node's energy. We have found that TL-LEACH used the three layer structure for reducing energy consumption due to distance between nodes. It employed the GH selection using residual energy of the CHs, and reduces the distance between CH & BS. Overall, TL-LEACH gives better results in term of performance metrics like lifetime, energy consumption of the network as compare to LEACH & E-LEACH. TL-LEACH gives the optimal energy consumption & extended the network lifetime and also try to stabilize the total number of clusters of the network.

REFERENCES

1. C. I. Zhong, Z. Zhu and R. G. Huang, "Study on the IOT Architec-ture and Access Technology, 2017 16th International Symposium on Distributed Computing and Applications to Business, Engineering and Science (DCABES), Anyang, 2017, pp. 113-116.
2. H. C. Lee and K. H. Ke, "Monitoring of Large-Area IoT Sensors Using a LoRa Wireless Mesh Network System: Design and Evalua-tion, in IEEE Transactions on Instrumentation and Measurement, doi: 10.1109/TIM.2018.2814082.
3. S. Ozdemir and Y. Xiao, "Secure data aggregation in wireless sensor networks: A comprehensive overview," *Comp. Netw.*, vol. 53, no. 12, pp. 2022-2037, Aug. 2009.
4. T. Zoller, C. Nagel, R. Ehrenpfordt and A. Zimmermann, "Packaging of Small-Scale Thermoelectric Generators for Autonomous Sensor Nodes, in IEEE Transactions on Components, Packaging and Manufacturing Technology, vol. 7, no. 7, pp. 1043-1049, July 2017.
5. Pratayay Kuila and Prasanta K. Jana, "Approximation schemes for load balanced clustering in wireless sensor networks," *The Journal of Supercomputing* pp. 1-19, 2013.
6. D. S. Deif and Y. Gadallah, "Classification of Wireless Sensor Networks Deployment Techniques," in *IEEE Communications Surveys & Tutorials* vol. 16, no. 2, pp.834-855, Second Quarter 2014.
7. A. A. Abbasi, M. Younis, "A survey on clustering algorithms for wireless sensor networks," *Computer Communication* vol. 30, pp. 2826-2841, 2007.
8. R. Rajagopalan and P. K. Varshney, "Data-aggregation techniques in sensor networks: A survey," in *IEEE Communications Surveys & Tutorials* vol. 8, no. 4, pp. 48-63, Fourth Quarter 2006.
9. K. Fan, S. Liu, and P. Sinha, "On the potential of structure-free Data Aggregation in Sensor Networks," *Proc. IEEE INFOCOM* pp. 1-12, Apr. 2006.
10. B. Krishnamachari, D. Fstrin, S. Wicker, "The impact of data aggre-gation in wireless sensor networks," *Proceedings 22nd International Conference on Distributed Computing Systems Workshops* pp. 575-578, 2002.
11. M. Ma and Y. Yang, "SenCar: An Energy-Efficient Data Gathering Mechanism for Large-Scale Multihop Sensor Networks," in *IEEE Transactions on Parallel and Distributed Systems*, vol. 18, no. 10, pp. 1476-1488, Oct. 2007.
12. D. Wong and M. H. Wong, "An Fast and Simulation Data Aggregation Over Multiple regions in Wireless Sensor Networks," *IEEE Transactions on System, Man and Cybernetics, Part C (Applications and Reviews)*, vol. 41, no. 3, pp. 333-343, May 2011.
13. N. Wang and H. Zhu, "An Energy Efficient Algorithm Based on LEACH Protocol," *2012 International Conference on Computer Science and Electronics Engineering, Hangzhou, 2012*, pp. 339-342.
14. M. J. Handy, M. Haase and D. Timmermann, "Low energy adaptive clustering hierarchy with deterministic cluster-head selection," *4th In-ternational Workshop on Mobile and Wireless Communications Network*, 2002, pp. 368-372.
15. Deng Zhixiang and Qi Bensheng, "Three-layered routing protocol for WSN based on LEACH algorithm," *2007 IET Conference on Wireless, Mobile and Sensor Networks (CCWMSN07)*, Shanghai, 2007, pp. 72-75.