International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-9 Issue-3, February 2020

A Novel Energy-Efficient Clustering Based on Node Dormancy for Balanced Energy Consumption

Vasudha, Anoop Bhola, Vaibhav Vyas

***Abstract*: Clustering is effective method to lessen the energy utilization in WSN. To improvise network lifespan numerous clustering approaches implement various parameters for election of CH. An effective clustering algorithm depends upon the number of factors such as number of CHs, uniform cluster size, CHs distribution, energy of the CHs etc. This paper proposes a Balanced Energy Consumption clustering algorithm. We introduce the concept of optimal number of nodes for CH selection based on heuristic approach and node dormancy mechanism for minimization of total energy consumption. This metric is incorporated with the probability function of CH selection. Mathematical analysis and simulations show the performance of proposed method.**

Keywords: Clustering, Energy efficient, Cluster-heads (CHs), LEACH, WSN, network lifetime.

I. INTRODUCTION

WSN has become as effective technology for communication with the increase in their utilization. WSN deployment is suitable for wide variety of utilization as monitoring environmental parameters, intruder surveillance, smart homes, maintenance, smart price tags , real world traffic management monitoring habitat and in disaster management[1][2]. WSN is collection of sensor node deployment over an area for a specific application. Its self-organizing capability helps to create a network model associated to a required task. Sensor transmits data to BS directly or through other nodes in case of multi-hopping. Sensor nodes are operated on constrained battery so the lifetime of the network varies which affects energy efficiency of WSN. The structural view of WSN is shown in figure 1. Energy efficiency of WSN is most challenging as it is hard to recharge or replace the node battery in hazardous areas. So the energy proficient protocol should be designed for transmission in sensor nodes and BS. To assurance balanced energy consumption the clustering protocols have been implemented. Clustering improves the efficiency and scalability of WSN. This procedure monitors the topology and group sensors into small divisions as clusters, each having a node leader as CH. All nodes transmit though their CH. CH removes duplicate information, Aggregate it then forward to BS. The nodes near BS have higher utilization of energy due to forwarding task of all the sensed data. To balance the energy utilization node rotation dormancy mechanism is implemented to minimize the load of nodes near BS.

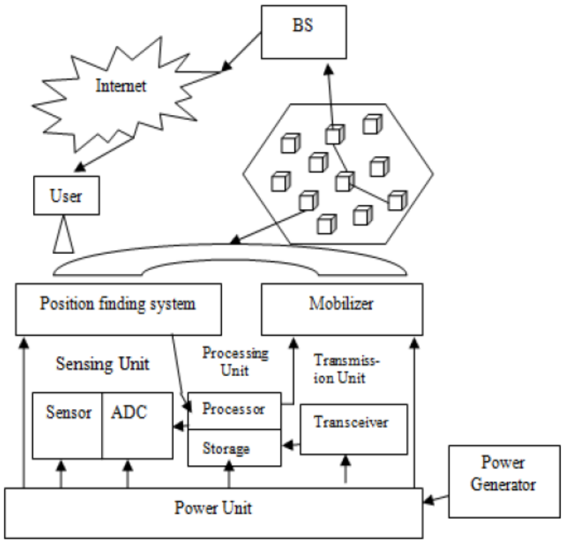


Figure 1: Structural of Wireless Sensor Network

A. Weight-Based Clustering Protocols

In this category of clustering protocols weight is election criteria for the CH node. The weighted score of node is calculated by residual energy, count of live neighbors, distance from BS and CH or how many times a node has become CH by the algorithm. The calculation of weight for each node is dependent on the iteration of clustering. Clusters are made in a way that consumption of energy comes out to be minimum. This clustering technique is used for heterogeneous networks. The main motive behind the usage of weight based clustering protocol is to enhance lifespan by election of node with higher leftover energy and to avoid electing node with lower energy node as CH.

Revised Manuscript Received on February 15, 2020.
* Correspondence Author
Vasudha*, Ph.D. Scholar, Department of Computer Science, Banasthali Vidyapith, Rajasthan(India) Email: vasudha.bahl@gmail.com
Dr. Anoop Bhola, Assistant Professor, Department of Computer Science, Banasthali Vidyapith, Rajasthan(India) Email: anupbhola@banasthali.in
Dr. Vaibhav Vyas, Associate Professor, Department of Computer Science, Banasthali Vidyapith, Rajasthan(India) Email: vvaibhav@banasthali.in

The consideration factor for election of CH is that if the node is having higher residual energy then it acts as CH else acts as member. The node is said to be dead if the energy come below the specified threshold value. Each node sends a broadcast message after each clustering round.
Then it calculates the number of live neighbors of surrounding each node. Thus the leftover energy is formulated using first order radio model energy analysis. Node with higher leftover energy elected as CH.
We propose a novel dispersed energy proficient CH election method by the weighted score on basis of leftover energy, distance and node dormancy as parameters for probability function collectively to choose energy efficient CH.

Section II presents survey related to clustering methods, III demonstrates the network structure, IV shows the steps of proposed protocol, V presents results and VI gives conclusion.

II. LITERATURE SURVEY

LEACH protocol is TDMA based MAC convention. The motive behind this protocol is to prolong lifespan of WSN by minimizing the energy utilization required to in process of selection of CH by implementing election algorithm [3]. The essential thought of clustering convention is to divide all nodes into numerous clusters each having CH capable of transmitting the information within cluster and sending it to BS. The CH is selected after each round of communication so as to equally disperse the data transmission. The CH is selected randomly and sends data to BS. The probability of selection of CH is same for all the cluster members as CH on the basis of different distances from BS, which affects the energy consumption and more distant clusters drains energy prior. Numerous conventions have been proposed for improvements, focusing on CH selection, routing and more issues as HEED protocol [4]. The table 1 shows improvement of LEACH with various modeling parameters and different research domain.

Table I: Variants of LEACH

Protocol	Parameters	Area of Research	Contributions	Improvement
CogLEACH–C [5]	Idle channels ,residual energy	Cognitive radio	employ leftover energy and idle channels	Balances energy using idle channels with leftover energy.
V–LEACH [6]	Residual energy	Multiple cluster heads in Clusters	In case of a major CH malfunction, pick a vice CH	guarantee data retrival due to two CHs
I–LEACH [7]	Residual energy	Energy efficient	appending remaining energy with threshold	lessen average energy consumption
LEACH–1R [8]	Residual energy	Cluster head changing	Change the CH when it drains out of energy	Network lifetime ,energy consumption
EEM–LEACH [9]	Residual energy , communication cost	Energy efficient	node with highest residual energy as CH and interaction between clusters	Energy consumption , packet delivery
EMOD–LEACH [10]	Energy , communication cost	Cluster head changing	Effective replacement of the CH and dual transmission capacity	Efficient CH replacement scheme enhances network lifetime
EHA–LEACH [11]	Energy harvesting capacity	Energy harvesting	Boost the lesser energy conversation	energy harvesting nodes improve network lifespan
LEACH–MAC [12]	Advertisement time , distance	Medium access control	Reduces clustering randomness by limiting the number of ads produced by CHs	Energy efficiency because county of CH ads
Improved–LEACH [13]	Distance between node , BS	Energy efficient	In choosing a cluster leader, two variables are considered to increase t he number of live nodes	Improved election of CHs and enhanced performance
LEACH–SAGA [14]	leftover energy , centroidal distance	Optimization	To determine the maximum number of cluster members, simulated anneal -ing and GA are used	Efficient division of CHs by minimizing energy consumption
EE-LEACH [15]	Residual energy	Energy efficient	Gaussian distribution, choosing relay node	Network lifetime , power consumption
IB-LEACH [16]	Consumed energy	Data aggregation	lessen the burden of CH by equal division of responsibility in members	even energy division in each cluster

Partition-LEACH [17]	CH Distance to BS	Network hierarchy	Successive layering in clusters, equal division node power	Uniform division of energy among nodes, Improved transmission efficiency
FT-LEACH [18]	Residual energy	Network reliability	universal and localize re-clustering for finding error	Fault tolerance
P–LEACH [19]	Residual energy	Data transmission	making chain of CH from the source CH to the BS	Energy conservation, tracking of mobile sink, stability
C–LEACH [20]	Residual energy , shortest path	Network division	Dividing structure in cells	Network coverage, multi–hop communication
O–LEACH [21]	Residual power , range to gateway node	Network division	Improvise the connection by adding orphan nodes	Good connectivity and coverage
EZ–LEACH [22]	Nodes locations	Network division	Ensure the distances between CH and all other nodes in each zone are equivalent	Efficient CH selection based on various zones
DL–LEACH [23]	Distance to the BS	Layered approach	Deploying dual layer of multi-hop routing method	Good energy consumption
ICH–LEACH [24]	Distance to the BS	Multiple cluster heads in clusters	Choose an midway CH based on the distance to the BS and present CH p ower	enhanced the lifespan of a network considering intermediate CH.
CL-LEACH [25]	Residual power , node to the BS range	Cross layer	network and hardware layer integrate with MAC	Network lifetime , energy consumption

III. NETWORK MODEL

The assumptions for the proposed network model are:

- Nodes are randomly deployed and are static.
- Nodes send data to CH in the given slots and CH communicates to BS.
- Node communicates adjoining straight away and with rest via midway nodes on the basis of routing technique.

The model use traditional radio model [26] to evaluate our proposed model in figure 2.

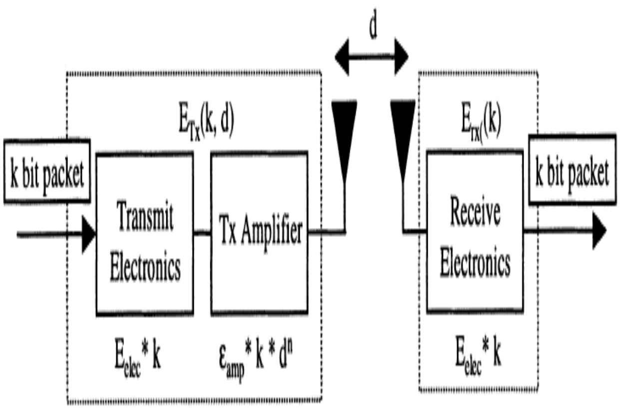


Figure 2 Energy consumption model (Heinzelman et al., 2002)

The radio energy for transmission is:

$$ETx(k,d) = ETx\_elec(k) + ETx\_amp(k,d)$$

$$ETx(k,d) = Eelec * k + \varepsilon\, fs * k * d^{2} \qquad if\ d < do$$

$$ETx(k,d) = Eelec * k + \varepsilon\, mp * k * d^{4} \qquad if\ d \geq do$$

Where threshold is: $do = \sqrt{(\varepsilon fs / \varepsilon\, mp)}$

To retrieve this message, the radio is:

$$ERx(k) = ERx_{elec}(k) = Eelec * k$$

IV. BALANCED ENERGY CONSUMPTION CLUSTERING PROTOCOL

The clustering approach proposed optimizes the utilization of energy and lifespan of sensors. The algorithm proposed uses traditional model given in [26]. The algorithm is based on heuristic technique for finding set of optimal clusters member that can be candidate for cluster head and further applied node dormancy mechanism to find CH.

The steps of algorithm are given as:

1) Setup all the sensor nodes in Hierarchical Clustering Approach using LEACH protocol.

Identify the adjacent node (node degree) D (n) of each node n, in range of transmission radius (Rn)

$$D(n) = \{n' | \, distance(n, n') <= Rn\}$$

Distance (n, n') = $(\sqrt{((x_i - x_j)^2 + (y_i - y_j)^2)}) \leq R$

Find distance between BS and nodes.

$D_{BS\text{-}n} = \sqrt{((X_{BS}\text{-}Xn)^2 + (Y_{BS}\text{-}Yn)^2)}$

Where (X_{BS}, Y_{BS}), (Xn , Yn) are coordinates of BS and nodes.

Compute the left over energy of all the nodes

The leftover energy of node ni (Er_i): computed after the transmission of k bits message located at distance d from receiver [27, 28, 33]

$Er_i = E - ((k, d) + E_{Rx\ elec}(k))$

Where

(i) E is current energy of node

(ii) $(k, d) = k * E$elec $+ k * E$amp $* d2$, energy for sending data

(iii) Eamp is amplifier energy

(iv) $E_{Rx\ elec}(k) = k\ E$elec energy used in receiving message.

Residual power computed during a single epoch as

$$Er(x) = Ex - Ediss(x)$$

For ease, suppose highest range of node and BS, CH dissipated power is [77]:

$$Ech = FE_{select}\left(\frac{n}{k}\right) + FE_{da}\left(\frac{n}{k}\right) + FE_{select} + F\varepsilon_{fs}\, d_{BS}^{2}$$

Energy in non-CH node [29]:

$$E_{n-CH} = F\ E_{select} + F\ \varepsilon_{fs}\ d_{CH}^{2}$$

Sensor vanish energy only in sending its sensed information to its CH. so, the total energy dissipated in the cluster during a round is [29,34]:

$$E_{cluster} = E_{ch} + \left(\frac{n}{k}\right) E_{n-CH}$$

Total dissipated energy:

$$E_{round} = F(\ 2nE_{select} + n\ E_{da} + k\ \varepsilon_{\ mp}\ d_{BS}^{4} +\ n\ \varepsilon_{fs}\ d_{CH}^{2}$$

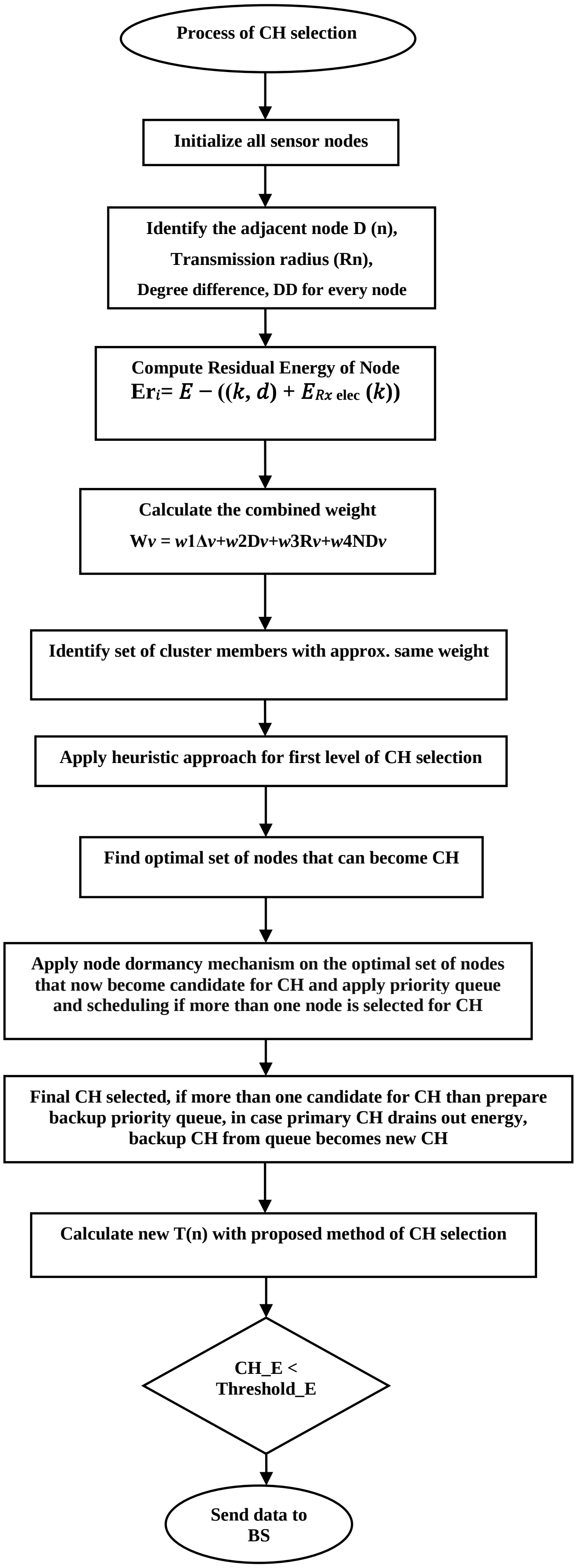
Considering the consistent spread of sensors in network, we get [30], [31],[29]:

$$d_{to\ CH} = \frac{DM}{\sqrt{2\pi k}},\quad d_{\ to\ BS} = 0.765 * \frac{DM}{2}$$

Now, the optimum count of CHs can be identified. After identifying the weight of node, it communicates data to rest of nodes in cluster. Then all nodes employ the accepted information to compute mean weight in its cluster radius as

$$w_c(x) = \sum_{y \in Ix} w_s\ (y)$$

CH election method by the weighted outcome based on residual power, distance and node dormancy as parameters for probability function collectively to choose energy efficient CH. The proposed approach is presented as:



2) Cluster will be formed on the basis of heuristic technique for selection of CHs to identify the optimal set of cluster members that can become CH and further node dormancy mechanism is applied to identify second optimal set of number of CHs to lessen the power utilization of WSN.

The node dormancy mechanism works in two divisions (a) selecting certain area of nodes to be dormant located at different locations on random basis (b) selecting nodes in different areas to be dormant on the basis of their distance to CHs. Based on the weighted score of residual energy, distance, degree difference and radius an optimal set of nodes are identified, then node dormancy technique suggested on this set of nodes leads the cluster member with lower energy and longer radius to become dormant which finally elect CH for cluster, that minimizes the energy utilization on CH and thus enhancing the network throughput.

Set up dormancy parameters Sdor for all of cluster members as [32]:

$$S_{dor}\ (s(x) * E\ d_{BS}^{x} = (\ s(x).\frac{E}{d_{BS}^{x}})$$

The Sdor and mortality rate of the node i are indirectly proportional and the more will be dormancy probability. So, node dormancy ratio P [32] is:

$$p = \frac{c(y) * n - \frac{n}{k}}{c(y)} * n$$

CH is selected. In case more than one member have same weight score, then priority scheduling is followed for final election of CH. Further threshold function of LEACH is modified with the weighted score and data is send to BS.

3) Selected CH will transmit its status announcement having node-id, deployment statistics and distance statistics.

4) A proposed priority function will provide better deployment of nodes and adequate residual energy and node dormancy mechanism for balancing the energy consumption.

V. SIMULATION RESULTS

Simulations are performed on set of 200 nodes in dimensions of 200X200 where WSN is deployed in random manner in network area on Matlab. Proposed algorithm is compared with the pre-existing LEACH protocols. The factors for simulations are given in Table II.

Table II Simulation Parameters Table

Parameter	*Value*
area	200 × 200 m2
Number of round	4000
Number of nodes	200
probability of becoming CH , p	0.5
Initial energy of node	1 J
BS location	50 × 175
Eelec	50 nJ/bit
Efs	10 pJ/bit/m4
Emp	0.013 pJ/bit/m4
Data packet size	500 bytes
Round time	10 * initial energy [26]
Control packet size	25 bytes

The results are analyzed for various characteristics given below in comparison table III. Our proposed protocol shows increase in network lifetime.

Table III. Comparison of few protocols

Protocol	Energy Efficiency	Cluster Stability	Routing	Load Balancing	Reliability	Scalability
LEACH	Very Low	Average	hierarchical	Average	low	low
MOD-LEACH	low	Good	hierarchical	Good	Medium	low
DEEC	good	high	Flat/ hierarchical	good	good	high
TEEN	Very High	high	Flat/ hierarchical	good	low	good
LEACH-GA	high	high	hierarchical	good	medium	high
HEED	average	high	Flat/ hierarchical	average	good	medium
LEACH-VF	average	high	hierarchical	good	good	good
PEGASIS	Low	low	hierarchical	average	medium	medium
Proposed	high	Very good	hierarchical	Very good	medium	good

VI. CONCLUSION

Clustering has proved out to be most proficient method for saving energy in WSNs. However, WSN based on hierarchical clustering CH utilize more energy because of extra overhead for received data and aggregating the data to BS. Therefore, the appropriate election process of CHs is utmost important to conserve vitality of nodes for extend lifespan of WSNs. We proposed a novel dispersed energy proficient CH election method by the weighted outcome based on leftover power, distance and node dormancy as parameters for probability function collectively to choose energy efficient CH.

REFERENCES

1. F Akyildiz, W Su, Y Sankarasubramaniam, E Cayirci, "Wireless sensor networks a survey" published in Computer networks Volume 38 Issue 4, March 2002 pp 393–422.
2. J Yick, B Mukherjee, D Ghosal, "Wireless sensor network survey proceedings in Computer networks" Volume 52(12) 2008:2292–2330.
3. Liu Xuesong , Wu Jie, "A Method for Energy Balance and Data Transmission Optimal Routing published in Wireless Sensor Networks" , Sensors 2019 doi:10.3390/s19133017

4. Younis O, Fahmy S , "HEED: a hybrid, energy-efficient, distributed clustering approach for ad hoc sensor networks" IEEE Transactions on Mobile Computing, Volume 3 Issue 4 pp 366–379, (2004) doi:10.1109/tmc.2004.41
5. Latiwesh A, Qiu D "Energy efficient spectrum aware clustering for cognitive sensor networks: Cogleach-c" . Proceedings published in 10th International Conference on Communications and Networking held at China, August 2015 pp. 515–520.
6. S.D Sasikala, N Sangameswaran, P Aravindh, "Improving the energy efficiency of leach protocol using VCH in wireless sensor network" published in IJERS volume 3(2015) pp 918–924.
7. Z Beiranvand, A Patooghy, M Fazeli, "I-leach: An efficient routing algorithm to improve performance amp to reduce energy consumption in wireless sensor networks" proceedings of 5th Conference on Information and Knowledge Technology (IKT) held at Shiraz(Iran) on 28–30 May 2013 pp13–18.
8. M Omari, W Fateh, "Enhancing multihop routing protocols in wireless sensor networks using leach-1r" Proceedings published in 2nd World Symposium on Web Applications and Networking (WSWAN), Sousse, Tunisia, 21–23 March 2015 pp1–6.
9. A Antoo, A Mohammed, "EEM-LEACH: Energy efficient multi-hop leach routing protocol for clustered WSNs" Proceedings of the International Conference on Control, Instrumentation, Communication and Computational Technologies (ICCICCT) held at Kanyakumari (India) 10–11 July 2014, pp 812–818.
10. D Singh, S Nayak, "Enhanced modified LEACH (EMODLEACH) protocol for WSN" in Proceedings of the International Symposium on Advanced Computing and Communication (ISACC) at Silchar(India) on 14–15 September 2015 pp328–333.
11. C Tang, Q Tan, Y Han, W An, H Li, H Tang, "An energy harvesting aware routing algorithm for hierarchical clustering wireless sensor networks" KSII 2016.
12. P Batra , K Kant, "Leach-Mac: A new cluster head selection algorithm for Wireless Sensor Networks" proceedings published in wireless networks volume 22 pp 49–60(2016).
13. A Krishnakumar, Anuratha, "Improved LEACH: A Modified LEACH for Wireless Sensor Network" Proceedings in IEEE International Conference on Advances in Computer Application held at Coimbatore (India) on 24th October 2016.
14. H Zhang, S Zhang, W Bu, "A clustering routing protocol for the energy balance of wireless sensor network based on simulated annealing and genetic algorithm" International Journal Hybrid Information Technology Vol 7(2014) pp 71–82.
15. G Arumugam, T Ponnuchamy, EE-LEACH: Development of energy efficient leach protocol for data gathering in WSN published in EURASIP Journal Wireless Communication Network (2015) pp1–9.
16. A Salim, W Osamy, A Khedr, IBLEACH: Intra-balanced LEACH protocol for wireless sensor networks proceddings in Wireless Network(20) 2014 pp 1515–1525.
17. S Cho, H Li, B Joo, S Han, "P-LEACH: An efficient cluster-based technique to track mobile sinks in wireless sensor networks" International Journal of Distributed Sensor Network(10) 2014 pp 1–10.
18. S Chouikhi, I Korbi, Y Ghamri-Doudane, L Saidane," A survey on fault tolerance in small and large scale wireless sensor networks" proceedings in Computing Communication Volume 69 (2015) pp 22–37.
19. R Abdul, A Musbah, J Chaitrali, A Fathi, C Mrunal," P-LEACH: Energy efficient routing protocol for Wireless Sensor Networks" Proceedings published in IEEE Long Island Systems, Applications and Technology Conference (LISAT) 20 June 2016 at Farmingdale New York USA.
20. A Yektaparast, F Nabavi, A Sarmast, An improvement on leach protocol -Cell-LEACH Proceedings in 14th International Conference on Advanced Communication Technology (ICACT) held at PyeongChang, South Korea, on 19–22 February 2012 pp 992–996.
21. W Jerbi, A Guermazi, H Trabelsi, O-LEACH of routing protocol for wireless sensor networks published in 13thInternational Conference on Computer Graphics, Imaging and Visualization (CGiV), Beni Mellal, Morocco on 29th March–1st April 2016 pp 399–404.
22. H Salmabadi, M Agha Sarram, F Adibnia, An improvement on LEACH protocol (EZ-LEACH) Proceedings in 2nd International Conference on Knowledge Based Engineering and Innovation at Tehran(Iran) 5th –6th Nov. 2015 pp 956–960.
23. J Lee, K Jung, S Moon, H Jeong," Improvement on LEACH protocol of a wide-area wireless sensor network" Multimedia Tools Application volume 76(2017) pp 19843–19860.
24. M Bennani Mohamed Taj, M Ait Kbir, ICH-LEACH: An enhanced LEACH protocol for wireless sensor network Proceedings of the International Conference on Advanced Communication Systems and Information Security, Marrakesh, Morocco on17th –19th October (2016) pp1–5.
25. P Marappan, P Rodrigues, "An energy-efficient routing protocol for correlated data using cl-leach in WSN" published in Wireless Network volume 22(2016) pp 1415–1423
26. W. Heinzelman, A. Chandrakasan , H. Balakrishnan, Energy-efficient Communication Protocols for wireless micro sensor networks published in Proceedings of the Hawaii International Conference on Systems Sciences, January 2000.
27. Dahane, N. E. Berrached, B. Kechar, "Energy efficient and safe weighted clustering algorithm for mobile wireless sensor networks," in Proceedings of the 9th International Conference on Future Networks and Communications (FNC '14), volume 34 Procedia Computer Science (Elsevier),Niagara Falls, Canada, August 2014 pp 63–70
28. S. Soro , W. B. Heinzelman, "Cluster head election techniques for coverage preservation in wireless sensor networks," Ad Hoc Networks, volume 7 issue 5, 2009 pp 955–972.
29. Hicham Ouchitachen , Abdellatif Hair, Najlae Idrissi, Improved multi-objective weighted clustering algorithm in Wireless Sensor Network, Egyptian Informatics Journal (2017) volume 18, pp45–54, Production and hosting by Elsevier B.V. on behalf of Faculty of Computers and Information, Cairo University.
30. Q Wang, H Hassanein, G Takahara, "Stochastic modeling of distributed, dynamic, randomized clustering protocols for wireless sensor networks," in IEEE International Conference on Parallel Processing Workshops(ICPP)2004 pp 456–463.
31. H Liu, L Li, S Jin, "Cluster number variability problem in leach," in International Conference on Ubiquitous Intelligence and Computing Springer, 2006 pp 429–437.
32. Zhidong Zhao ,Kaida Xu , Guohua Hui , Liqin Hu," An Energy-Efficient Clustering Routing Protocol for Wireless Sensor Networks Based on AGNES with Balanced Energy Consumption Optimization" published in Sensors 2018 doi:10.3390/s18113938
33. Trupti Mayee Behera, Sushanta Kumar Mohapatra, Umesh Chandra Samal, Mohammad S Khan, Mahmoud Daneshmand, Amir H Gandomi , (2019) Residual Energy Based Cluster-head Selection in WSNs for IoT Application, IEEE INTERNET OF THINGS JOURNAL, VOL. 2019
34. Damien Wohwe Sambo, Blaise Omer Yenke, Anna Förster Paul Dayang, (2019), Optimized Clustering Algorithms for Large Wireless Sensor Networks: A Review, Sensors 2019 doi:10.3390/s19020322
35. Mengjia Zeng , Xu Huang , Bo Zheng Xiangxiang, A Heterogeneous Energy Wireless Sensor Network Clustering Protocol Research Article , Hindawi, Wireless Communications and Mobile Computing Volume 2019, Article ID 7367281, 11 pages doi:10.1155/2019/7367281

AUTHORS PROFILE

Vasudha, has done M.Tech in Computer Science and is a research scholar in Department of Computer Science, Banasthali Vidyapith. Her research areas are sensor networks, wireless networks and data communications.

Dr. Anoop Kumar, has done his Ph.D. from Banasthali Vidyapith, Rajasthan. His research domains include Wireless Sensor Networks, Cloud Computing, Internet of Things and Mobile Computing.

Dr. Vaibhav Vyas, has done his Doctoral from Banasthali Vidyapith. His research domains include Data Analytics, Software Engineering, Distributed Systems, Bit Coin Management, Programming Languages, Cloud Computing.