International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

An Energy Aware Asymmetric Clustering Protocol for Wireless Sensor Network

Nikita Jhavre[1], Ankit Tripathi[2], Dr. Anshuj Jain[3]

[1]M. Tech. Research Scholar, [2]Associate Professor, [3]Associate Professor

[1,2,3]Department of Electronics and communication Engineering, SCOPE College of engineering, Bhopal, India

Abstract

In this work the Wireless Sensor Network (WSN) is the network of tiny sized sensor motes. Due to the limited size, sensor mote is limited in processing, memory and energy. The limitation of energy and memory in sensor mote create challenges for routing in WSN. Cluster based routing protocols in WSNs has recently increase interest for energy efficiency. A leader represents all sensor motes in the cluster called cluster head (CH) and collects sensed data from them. To balance the traffic load and the energy consumption in the network, the CH should be rotated among all motes. In this paper, we proposed An Energy Aware Asymmetric Clustering Protocol (EAACP), EAACP elects CH based on motes near to the sink distance and residual energy of the motes. In WSNs energy is mostly consumed for data transmission to sink. In this paper, the optimal sink distance is considered which decrease the length of path to sink. In addition, residual energy is also considered in the CH election in order to increase the network stability and lifetime. Furthermore, the reclustering of cluster head conserves the energy in data transmission to sink. The simulation results show that EAACP conserve more energy in data transmission compared to the well-known exiting clustering algorithms LEACH and TL-LEACH. EAACP also prolong the network stability period and lifetime than LEACH and TL-LEACH protocols.

Keywords: Data aggregation, Energy efficiency

I. Introduction

Wireless sensor networks are networks of hundreds or thousands of sensor nodes that are also called motes. Sensor nodes are having limited processing capability, limited storage, and limited battery power [1]. Sensor nodes sense the physical quantity and send the reports towards the central entity called Base station. This will process the data and make computation over that data, produces a result which is human understandable. Base station is the entity which is having unlimited amount of energy. So the routing protocol and applications for this network should be like this that will increase the lifetime of sensor network. Because the replacement of the battery of the sensor node is very difficult process when the sensor nodes is deployed and it is going to impossible when it is deployed at the remote or hazards area.

The main objective of this research work is to design joint cluster algorithm which is a combination of two different clustering algorithms. The first algorithm of the combination is Energy Efficient Hierarchical Clustering and the second algorithm in the combination is Modified Low Energy Adaptive Clustering Hierarchy. These both algorithms are combined to form a Joint Cluster approach. So the network life time, dead node, throughput etc. parameter improvement is key goal of this research.

The rest of the paper is organized under the following headings: section II describes the related work in the field of data aggregation in WSNs. The section III presents the proposed approach. The simulation results are presented in section IV. The section V concludes the proposed approach.

II. Previous Work

This section briefly describes various performance improvements in terms of network lifetime, throughput, and energy. The following reviews provide a comprehensive survey about the developments in the state of art protocol in WSNs around the world.

H. El Alami et al., [1] So as to accumulate data all the more efficiently, a clustering hierarchy calculation is utilized for data correspondence in wireless sensor networks (WSNs). This calculation is one of the significant strategies to improve the energy productivity in WSNs and it gives a powerful way to augment the lifetime of WSNs. Hierarchical conventions based on clustering hierarchy are proposed to spare energy of WSNs in which the nodes with higher residual energy could be utilized to gather data and transmit it to a base station.

In this paper, an improved clustering hierarchy (ECH) approach has been proposed to accomplish energy proficiency in WSNs by utilizing dozing waking system for covering and neighboring nodes. Hence, the data excess is limited and then network lifetime is expanded.

M. A. Hossen et al., [2] Psychological radio (CR) is an adaptive radio innovation that can naturally identify accessible diverts in a wireless range and change transmission boundaries to improve radio working conduct. Because of the dynamic idea of range accessibility and wireless channel condition, it is exceptionally difficult to keep up solid network availability. Cluster-based CR specially appointed networks (CRAHN) mastermind CR nodes into gatherings to successfully keep up solid self-governing networks.

The proposed instrument can expand the network lifetime, improve the reachability between part nodes as well as with other cluster networks, it can likewise offer steady and solid support utilizing the chose data channel and stay away from conceivable obstruction between neighboring specially appointed clusters.

X. He et al., [3] In wireless sensor networks (WSNs), gathering data with mobile sinks is a compelling method to settle the "energy gap issue". In any case, a large portion of existing calculations of mobile sinks disregard the heap equalization of meeting nodes, which will altogether abbreviate the network lifetime. Additionally, most mobile sinks are generally required to visit areas of sensor nodes without exploiting their correspondence ranges. Along these lines, this paper proposes an energy-efficient direction arranging calculation (EETP) based on multi-target molecule swarm streamlining (MOPSO) to abbreviate the direction length of the mobile sink and equalization the heap of meeting nodes. EETP plans to diminish the deferral in data conveyance and draw out the network lifetime.

W. He et al., [4] An efficient and energy-sparing calculation, K-means and FAH (KAF), has been proposed to take care of the issues of node energy limitations, short network cycle and low throughput in current wireless sensor networks. Network clustering is gotten by upgrading K-implies clustering. Based on FAHP (Fluffy Logical Hierarchy Procedure) technique, the cluster head determination is upgraded thinking about the components of node energy, good ways from base station and energy proficiency of nodes.

The reproduction results show that the proposed convention can adequately diminish the energy utilization of nodes and drag out the network life cycle.

W. Osamy et al., [5] Wireless sensor networks (WSNs) have dazzled significant consideration from both modern and scholarly examination since most recent couple of years. The main consideration behind the exploration endeavors in the field of WSNs is their tremendous scope of uses, for example, observation frameworks, military tasks, medicinal services, condition occasion checking, and human security. In any case, sensor nodes are low potential and energy requirement gadgets; along these lines, energy efficient routing convention is the premier concern. In this paper, another Cluster-Tree routing plan for social occasion data (CTRS-DG) is suggested that made out of two layers: routing and total and remaking.

Reproduction results uncover that the proposed conspire beats existing baseline calculations as far as solidness period, network lifetime, and normal standardized mean squared blunder for compressive detecting data remaking.

We studied various clustering algorithms; the parameter took for cluster heads selection are energy, density, distance and location of sensor nodes. There are some algorithms as they used one of the parameter for cluster head selection. They do not take many parameters for cluster head selection. We need such approaches which optimize the number of clusters so that stability period of network increases.

Further it is also observed that there is no research carried out for cluster optimization in non-uniformly deployed wireless sensor network.

III. Proposed Work

After the detailed description of wireless sensor networks, problem of routing protocol for maximizing network lifetime, and existing clustering techniques in we now present our proposed protocol for solving routing problem. This Section first gives you an introduction of our protocol “Energy Aware Asymmetric Clustering Protocol (EAACP)” and then briefly describes energy model that has been considered for designed protocol. After this a detailed description of the algorithm will be presented.

A. Assumptions

We make the following assumptions in our work

- Sensor nodes and base station are static.
- The base station not limits to energy.
- Sensor nodes do not aware about their geographic location.
- Sensor nodes know the relative position of the base station in the field.
- The sensor nodes are randomly distributed over sensing field as shown in figure 4.1.
- The Sensor nodes are densely deployed in the sensing field. This dense deployment of sensor network achieving Quality of Service.
- Sensor nodes are homogenous in their architectures.
- Sensor nodes are able to measure the current energy level.

B. Description of the scheme:

The EAACP clustering process consists three sub part setup phase 1, 2 and steady state phase. It requires $2 * T_{max}$ (T_{max} is the time require for clustering).

SET UP PHASE –I

In first setup phase cluster head is selected on the basis of probabilistic threshold (based on residual energy and distance to base station). At the end of first setup phase all the cluster heads are selected and formation of cluster is accomplished.

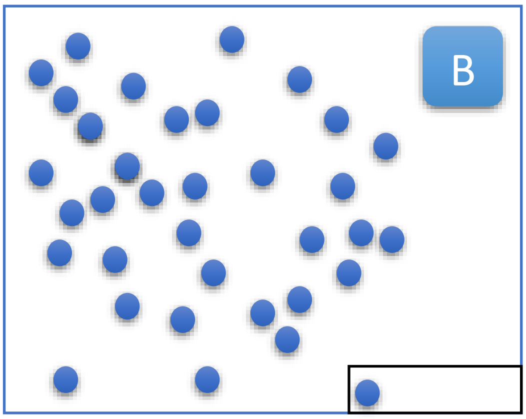


Fig 1: The sensor node deployment in EAACP protocol

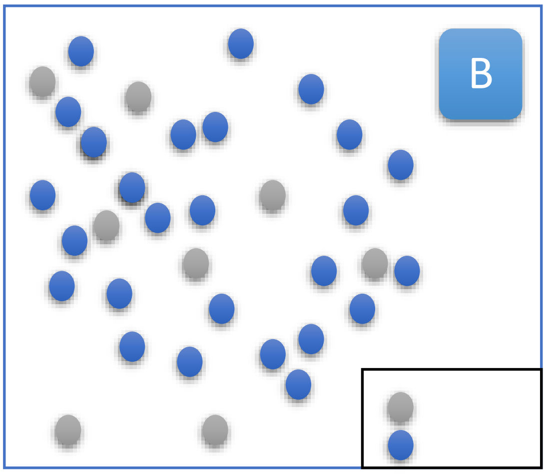


Fig 2: The cluster head selection in EAACP protocol

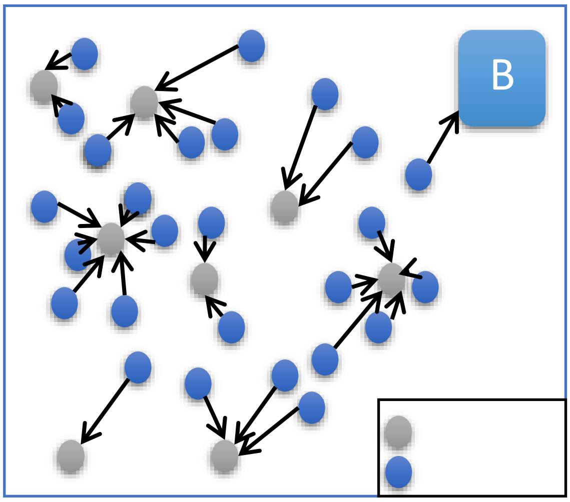


Fig 3: The cluster formation in EAACP protocol

SET UP PHASE –II

In second setup phase reclustering process starts where all the selected cluster heads reselect the new leaders on the basis of threshold used for cluster head selection with different probability.

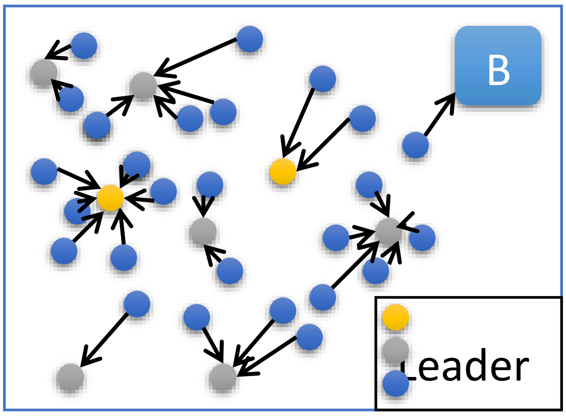


Fig 4: The leader selection in EAACP protocol

STEADY STATE PHASE

After the completion of second setup phase, in steady state phase leaders receive aggregated data from nearest cluster heads and again aggregate this data then send it to the base station.

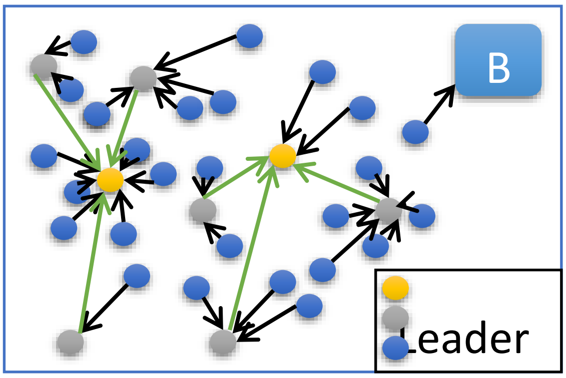


Fig 5: Data transmission from cluster head to leader in EAACP protocol

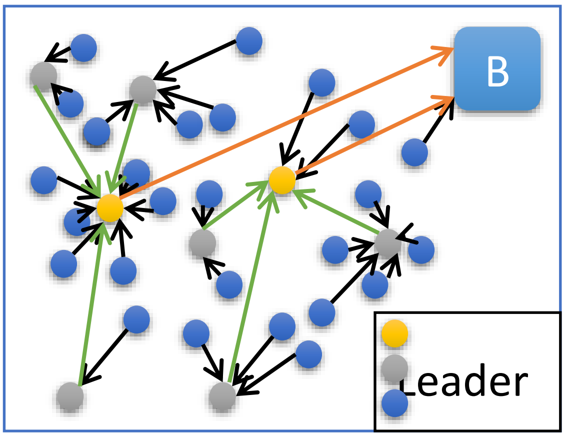


Fig 6: Data transmission from leader to base station in EAACP protocol

These two phases second setup phase and steady state phase are overlapped in time that means these phases simultaneously run at the time. This prolongs the time interval before the first node die. It is very crucial for many applications where reliability about feedback needed. The leaders receive data from its member cluster heads and aggregated it then send this data to the base station as shown in figure 6.

IV. Simulation Results

We simulate the sensor network in a 100 m X 100m dimension field. There are 100 sensor nodes i.e. n = 100. Sensor nodes are distributed randomly in the field. For doing this the vertical and horizontal coordinates on every sensor is randomly taken between 0 and 100. Sink is taken at the center so to neglect the multipath fading error on the system. Maximum distance from sink to any node will be approximately equal to 70m which is less than D0≈87m. We set the initial energy of the normal sensor node to E0 = 0.5 joules [13]. The values set is for just the simulation any value can assigned to it. Table shows the different values which we taken in our simulation [13]:-

Parameter	Value
Network size	$(100x100\ m^2)$
Number of sensor node (n)	100
Base station position	$(25\ m, 100\ m)$
Initial energy	$0.5J$
P_1	0.05
P_2	0.2
Transmitter/Receiver electronics E_{elec}	50 nj/bit
Data aggregation (E_{DA})	$5\ nj/bit/report$
Reference distance (d_0)	$87\ m$
Transmit amplifier ϵ_{fs}	$10\ pJ/bit/m^2$
Transmit amplifier ϵ_{mp}	$0.0013\ pJ/bit/m^4$
Message size (l)	$2000\ bits$
Time for clustering (T_{max})	$500\ ms$

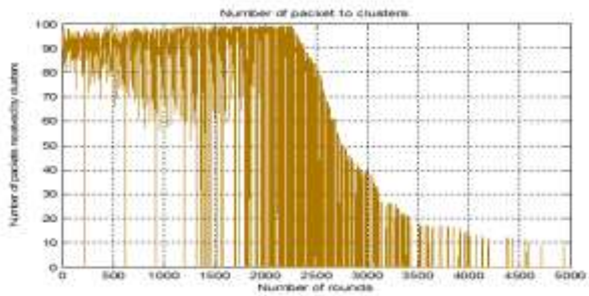
The parameters for the evolutions of results from simulation are described blow:-

- Stability period: - It is defined as the time interval between starting of the operation of the network and to the death of the first node. It is also called "stable region."
- Instability period: - It is defined as the time interval between the death of first sensor node to the death of last node.
- Cluster head per round and packet transmission: - Number of clusters formed by cluster heads and number of packets send to base station by cluster heads.
- Network lifetime: - It is defined as the staring of the network operation to the death of the last node.
- Sensitivity Analysis: - In this analysis the output of a system can be apportioned to different sources of inputs. To perform the sensitivity analysis in this work position of base station, network area and number of sensor nodes are considered.

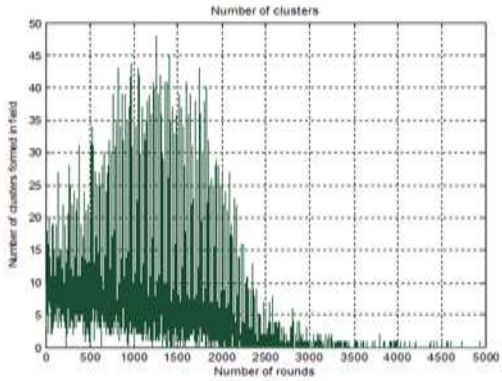
SIMULATION RESULTS FOR EAACP:

In this we simulate EAACP using MATLAB simulation tool to observe the performance in term of stability period, network lifetime, packet transmission, sensitivity analysis.

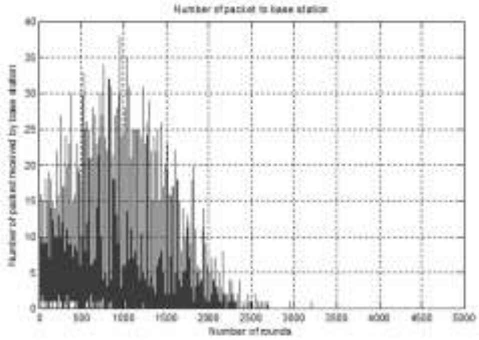
CLUSTER FORMATION AND PACKET TRANSMISSION



Number of packet received by clusters per round in EAACP



Number of cluster formed per round in EAACP



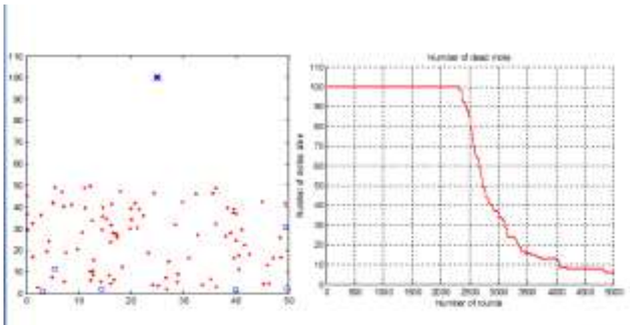
Number of packet received by base station per round in EAACP

SENSITIVITY OF EAACP PROTOCOL

POSITION OF BASE STATION

The effect of different position of base station on stability period is analyzed. We taken five different position of base station 25 × 100, 50 × 100, 75 × 100, 100 × 100, 125 × 100.

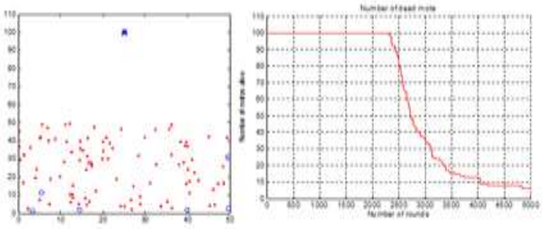
The analysis of sensitivity in EAACP protocol has been done in terms of length of stability period of three parameters: position of base station, network area and number of sensor nodes.



Base station positioned on 25 × 100

AREA OF SENSING FIELD

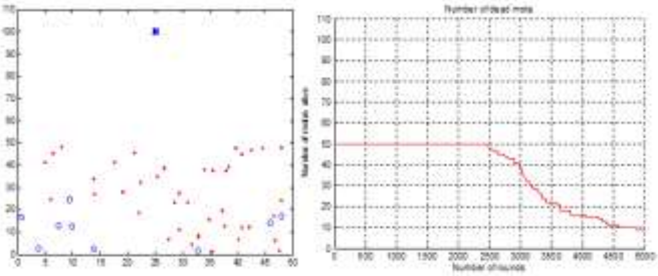
The effect of different area of sensing field on stability period is analyzed. We taken five different area of sensing field 50 × 50 m², 75 × 75 m², 100 × 100 m², 125 × 125 m², 150 × 150 m².



Sensing field of $50 \times 50\ m^2$

NUMBER OF SENSOR NODES

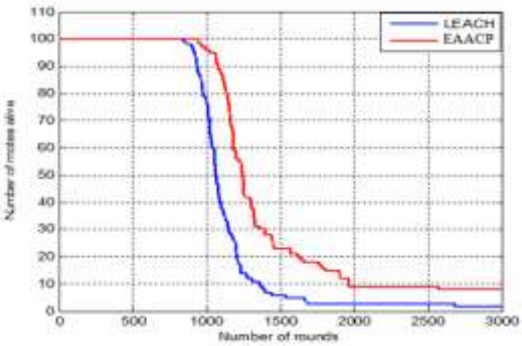
- The effect of different number of sensor node (within the same field) on stability period is analyzed. We taken five different value of sensor nodes 50,75,100,125,150.



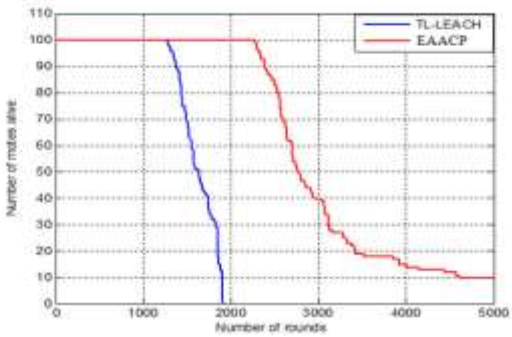
50 sensor nodes distributed over $50 \times 50\ m^2$ sensing field

STABILITY PERIOD AND NETWORK LIFESPAN

The stability period and network lifespan are used as key indicators to evaluate performance of the proposed protocol. The data transmissions from sensor nodes were simulated until all the sensor nodes died. Here the performance of the EAACP protocols is compared with LEACH [13] and TL-LEACH [34] in term of stability period and network lifetime in the same setting. The network lifespan has been compared with other protocols shown in the subsequent graphs.



Comparison between EAACP and LEACH protocol



Comparison between the EAACP and TL-LEACH protocol

DISCUSSION AND ANALYSIS

It is observed that number of clusters in sensing field has significant impact on energy conservation. In this thesis a detailed analysis for cluster head selection has been done on different parameters. Our key observations are as follows:

1. The number of cluster in EAACP more than LEACH and data transmission in lower than LEACH.
2. The stable region of EAACP protocol is better than previous LEACH and TL-LEACH protocol because of the lower number of message transmitted in inter cluster communication.
3. The network lifespan increases in EAACP than previous LEACH and TL-LEACH protocol because of better selection of cluster head in clustering process.

SUMMARY

In this Section simulation of EAACP is shown. Simulation results show that EAACP has longer stability period and network lifespan. It is further observed that on varying the position of base station, network area and number of sensor node, EAACP is more robust and scalable than other protocols.

V. Conclusions and Future Work

We proposed a clustering protocol EAACP to conserve the energy in clustering process. A new threshold has been formulated for cluster head selection which is based on the remaining energy of the sensor node and the distance to base station. In EAACP sensor nodes elect itself cluster head independently, and energy based threshold is also there which in not centralized unlike [38] where global knowledge of the residual energy is required. A reclustering approach also has been proposed to decrease the energy consumption in data reporting to the base station. EAACP is very simple to implement in the senor nodes. This is a dynamic protocol it will work automatically over no prior distribution of the levels of energy in the nodes. This protocol is asymptotic i.e. this protocol works on large sensor network and also in the small sensor network. EAACP is scalable protocol because we have seen that for this protocol to run there is no need of prior knowledge of the placement of the sensor nodes in the field. The sensor network life time is increased in this case by a large amount as we have seen from the simulation results. So we can say that this protocol is best one for the homogenous Wireless Sensor Network.

WSNs is quite a hot concept in wireless communication meaning that much research is going on and many issues are subjected to be investigated in this domain. Due to the time limitations, our focus was only on the energy efficient load balancing routing protocol. Though, there are many possible directions needed to be explored.

References

1. H. El Alami and A. Najid, "ECH: An Enhanced Clustering Hierarchy Approach to Maximize Lifetime of Wireless Sensor Networks," in IEEE Access, vol. 7, pp. 107142-107153, 2019, doi: 10.1109/ACCESS.2019.2933052.
2. M. A. Hossen and S. Yoo, "Q-Learning Based Multi-Objective Clustering Algorithm for Cognitive Radio Ad Hoc Networks," in IEEE Access, vol. 7, pp. 181959-181971, 2019, doi: 10.1109/ACCESS.2019.2959313.
3. X. He, X. Fu and Y. Yang, "Energy-Efficient Trajectory Planning Algorithm Based on Multi-Objective PSO for the Mobile Sink in Wireless Sensor Networks," in IEEE Access, vol. 7, pp. 176204-176217, 2019, doi: 10.1109/ACCESS.2019.2957834.
4. W. He, "Energy-Saving Algorithm and Simulation of Wireless Sensor Networks Based on Clustering Routing Protocol," in IEEE Access, vol. 7, pp. 172505-172514, 2019, doi: 10.1109/ACCESS.2019.2956068.
5. W. Osamy, A. M. Khedr, A. Aziz and A. A. El-Sawy, "Cluster-Tree Routing Based Entropy Scheme for Data Gathering in Wireless Sensor Networks," in IEEE Access, vol. 6, pp. 77372-77387, 2018, doi: 10.1109/ACCESS.2018.2882639.
6. S. Phoemphon, C. So-In and N. Leelathakul, "Optimized Hop Angle Relativity for DV-Hop Localization in Wireless Sensor Networks," in IEEE Access, vol. 6, pp. 78149-78172, 2018, doi: 10.1109/ACCESS.2018.2884837.
7. S. Si, J. Wang, C. Yu and H. Zhao, "Energy-Efficient and Fault-Tolerant Evolution Models Based on Link Prediction for Large-Scale Wireless Sensor Networks," in IEEE Access, vol. 6, pp. 73341-73356, 2018, doi: 10.1109/ACCESS.2018.2882389.
8. H. Wu, F. Yao, Y. Chen, Y. Liu and T. Liang, "Cluster-Based Energy Efficient Collaborative Spectrum Sensing for Cognitive Sensor Network," in IEEE Communications Letters, vol. 21, no. 12, pp. 2722-2725, Dec. 2017, doi: 10.1109/LCOMM.2017.2758376.
9. K. Rajeswari and S. Neduncheliyan, "Genetic algorithm based fault tolerant clustering in wireless sensor network," in IET Communications, vol. 11, no. 12, pp. 1927-1932, 24 8 2017, doi: 10.1049/iet-com.2016.1074.
10. L. Sivagami and J. Martin Leo Manickam, "Cluster-Based MAC Protocol for Collision Avoidance and TDMA Scheduling in Underwater Wireless Sensor Networks," in The Computer Journal, vol. 59, no. 10, pp. 1527-1535, Oct. 2016, doi: 10.1093/comjnl/bxw049.

11. A. Ray and D. De, "Energy efficient clustering protocol based on K-means (EECPK-means)-midpoint algorithm for enhanced network lifetime in wireless sensor network," in IET Wireless Sensor Systems, vol. 6, no. 6, pp. 181-191, 12 2016, doi: 10.1049/iet-wss.2015.0087.
12. P. T. A. Quang and D. Kim, "Clustering algorithm of hierarchical structures in large-scale wireless sensor and actuator networks," in Journal of Communications and Networks, vol. 17, no. 5, pp. 473-481, Oct. 2015, doi: 10.1109/JCN.2015.000085.
13. H. Lin, L. Wang and R. Kong, "Energy Efficient Clustering Protocol for Large-Scale Sensor Networks," in IEEE Sensors Journal, vol. 15, no. 12, pp. 7150-7160, Dec. 2015, doi: 10.1109/JSEN.2015.2471843.
14. S. Hamed Javadi and A. Peiravi, "Reliable distributed detection in multi-hop clustered wireless sensor networks," in IET Signal Processing, vol. 6, no. 8, pp. 743-750, October 2012, doi: 10.1049/iet-spr.2011.0341.
15. N. Gautam and J. Pyun, "Distance aware intelligent clustering protocol for wireless sensor networks," in Journal of Communications and Networks, vol. 12, no. 2, pp. 122-129, April 2010, doi: 10.1109/JCN.2010.6391368.
16. Asaduzzaman and H. Y. Kong, "Energy efficient cooperative LEACH protocol for wireless sensor networks," in Journal of Communications and Networks, vol. 12, no. 4, pp. 358-365, Aug. 2010, doi: 10.1109/JCN.2010.6388472.
17. L. Wang, C. Wang and C. Liu, "Optimal Number of Clusters in Dense Wireless Sensor Networks: A Cross-Layer Approach," in IEEE Transactions on Vehicular Technology, vol. 58, no. 2, pp. 966-976, Feb. 2009, doi: 10.1109/TVT.2008.928637.
18. Z. Quan, A. Subramanian and A. H. Sayed, "REACA: An Efficient Protocol Architecture for Large Scale Sensor Networks (Corrected)*," in IEEE Transactions on Wireless Communications, vol. 6, no. 10, pp. 3846-3855, October 2007, doi: 10.1109/TWC.2007.0596402.
19. M. Yu, K. K. Leung and A. Malvankar, "A dynamic clustering and energy efficient routing technique for sensor networks," in IEEE Transactions on Wireless Communications, vol. 6, no. 8, pp. 3069-3079, August 2007, doi: 10.1109/TWC.2007.06003.
20. H. M. F. AboElFotoh, S. S. Iyengar and K. Chakrabarty, "Computing reliability and message delay for Cooperative wireless distributed sensor networks subject to random failures," in IEEE Transactions on Reliability, vol. 54, no. 1, pp. 145-155, March 2005, doi: 10.1109/TR.2004.842540.
21. O. Younis and S. Fahmy, "HEED: a hybrid, energy-efficient, distributed clustering approach for ad hoc sensor networks," in IEEE Transactions on Mobile Computing, vol. 3, no. 4, pp. 366-379, Oct.-Dec. 2004, doi: 10.1109/TMC.2004.41.
22. H. Gharavi and K. Ban, "Multihop sensor network design for wide-band communications," in Proceedings of the IEEE, vol. 91, no. 8, pp. 1221-1234, Aug. 2003, doi: 10.1109/JPROC.2003.814919.
23. S. Lindsey, C. Raghavendra and K. M. Sivalingam, "Data gathering algorithms in sensor networks using energy metrics," in IEEE Transactions on Parallel and Distributed Systems, vol. 13, no. 9, pp. 924-935, Sept. 2002, doi: 10.1109/TPDS.2002.1036066.
24. S. Singh and C. S. Raghavendra, "PAMAS: Power Aware Multi-Access Protocol with Signalling for Ad Hoc Networks", *ACM Computer Comm. Rev.*, July 1998.
25. K. Sivalingam, J. Chen, P. Agrawal and M. Srivastava, "Design and Analysis of Low-power Access Protocols for Wireless and Mobile ATM Networks", *ACM/Baltzer Wireless Networks*, vol. 6, pp. 73-87, Feb. 2000.
26. A. Chandrakasan, R. Amirtharajah, S.-H. Cho, J. Goodman, G. Konduri, J. Kulik, et al., "Design Considerations for Distributed Microsensor Networks", *Proc. IEEE Custom Integrated Circuits Conference (CICC)*, pp. 279-286, 1999.
27. N. Bambos, "Toward Power-Sensitive Network Architectures in Wireless Communications: Concepts Issues and Design Aspects", *IEEE Personal Comm.*, pp. 50-59, June 1998.
28. .B. Chen, K. Jamieson, H. Balakrishnan and R. Morris, "Span: An Energy-Efficient Coordination Algorithm for Topology Maintenance in Ad Hoc Wireless Networks", *Proc. SIGMOBILE*, July 2001.
29. .L. Clare, G. Pottie and J. Agre, "Self-Organizing Distributed Sensor Networks", *Proc. SPIE Conf. Unattended Ground Sensor Technologies and Applications*, pp. 229-237, 1999.
30. M. Dong, K. Yung and W. Kaiser, "Low Power Signal Processing Architectures for Network Microsensors", *Proc. Int'l Symp. Low Power Electronics and Design*, pp. 173-177, 1997.