The Seybold Report

ISSN 1533-9211

DOI 10.5281/zenodo.7116145

ENERGY AND DISTANCE BASED CLUSTER HEAD SELECTION TECHNIQUE FOR OPTIMAL NETWORK LIFETIME IN WSN

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Abstract:

In wireless sensor networks, energy efficiency in data processing and transmission is often a critical factor (WSN). As a result, minimizing transmission loss and optimizing network lifetime are critical factors in the design of WSN routing protocols. In this paper, we propose EDCH, an energy and distance-dependent clustering routing protocol based on Low Energy Adaptive Clustering Hierarchy (LEACH) protocols. In one approach (energy-based), we choose a cluster head node by selecting the node with the highest energy as the cluster head. To improve further, we pick a cluster head not only based on residual energy, but also by evaluating the distance of the node from the base station that is greater than the average distance of the nodes in the network. The implementation results demonstrate that the proposed algorithm outperforms a conventional LEACH as well as its alternatives in terms of energy conservation, thus extending network lifetime.

Keywords— Data Aggregation, Energy Efficiency, Residual Energy, Clustering, Wireless Sensor Networks

INTRODUCTION

A wireless sensor network (WSN) that can be employed in different scenarios, such as reconnaissance, home monitoring, and logistics, for adding a sensing component, a calculation element, and data gathering, in addition to multiple fields such as environmental and healthcare, among others, to disaster forecasting and transport systems is useful. The network is made up of tiny sensor nodes (SN) that can track and process data from a particular geographical location before sending it to a remote location known as the sink node or base station (BS) [1].

WSNs are usually deployed in smaller, lower-cost, resource-constrained devices and collaborate by sharing small, cheap packets of information over a multi-hop wireless network. Each WSN node is referred to as the node of the sensor, which is multifunctional, limited memory, embedded processors, low power radio. Therefore, the most crucial property of a battery node is the location: it is usually deployed in large areas, even when the battery is not attached.

Using the above example of nuclear clocks, the general age of the device is defined as the total of its entire life cycle multiplied by the amount of time required for activities like nuclear transmutation and irradiation. Although transmutation and irradiation functions might not use much energy, they are not negligible for measuring the age of the device, it. As a result, the most critical challenges for researchers are developing a WSN routing and transmission protocol, improving energy efficiency, and extending the WSN's lifespan.

Cluster-based algorithms are more efficient in meeting WSN criteria, such as energy consumption, than the other routing protocols suggested for WSNs [2-5]. By forming SNs of

ISSN 1533-9211
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each cluster or grouping them into those that are given to Cluster Heads, the SNs use their information and data and pass, it to those to the group's heads (CH). The CH nodes then send the gathered data to the BS. Since CH nodes are crucial to the efficiency of cluster-based routing algorithms, the CH node selection policy has a major effect on network parameters such as network lifetime and energy consumption rate.

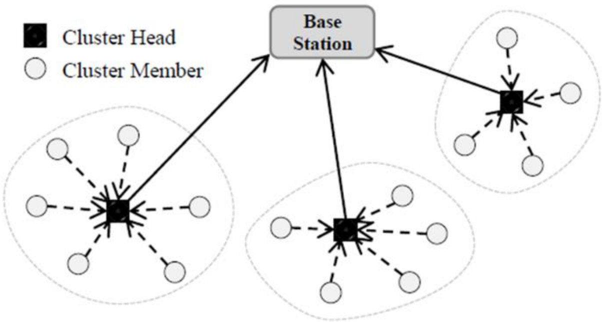

Figure 1: Schematic Model of Cluster Based Network

WSNs, as depicted in Figure 1, consist of a base station, cluster heads, and sensor nodes or cluster members deployed in a geographical area. LEACH [6], TEEN [7], and PEGASIS [8] are three protocols that use this concept; however, LEACH [6], Low-Energy Adaptive Clustering Hierarchy, is one of the most common cluster-based routing protocols in WSNs. This algorithm selects CH nodes using a random model, and non-CH nodes join the clusters by using communications with Time-Division Multiple Access (TDMA). The energy consumption and location of SNs are not taken into account by the LEACH algorithm in the CH selection process. As a result, sensor nodes die early and the lifespan of WSNs decreases.

This paper presents our proposal for a more efficient clustering of the LEACH routing system, which goes above and beyond the base mechanism that has been proposed in the standard version. We suggest two new clustering routing protocols based on the LEACH routing protocol, one based on energy and the other a combination of energy and distance from base station. Two concerns are discussed in our proposed routing protocol. First, the distance between the candidate node and the BS must be as short as possible. Second, a candidate node that wants to be a CH must have more remaining energy than the average remaining energy of live nodes in the WSN.

RELATED WORK

One of the major challenges of IoT is the expense of servicing and maintaining a large number of sensors that will be deployed [9]. Replacing sensor batteries that are already in the network area can be a time-consuming process [10]. For example, if a sensor is to be used on a specific animal or species, the sensor's battery must last longer than the animal, which is much more feasible. This leads to another significant issue: power management. Other major issues in WSN [11] include efficient end-to-end data transmission, adequate congestion management, and a low packet loss ratio.

The Seybold REPORT
ISSN 1533-9211
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Any sensor network's primary objective is to route data gathered by sensors and forward it to the BS. Direct transmission is the most basic form of data communication, in which nodes must send their data to a base station or sink node. If the gap between the sink and the network is too great, the node will easily die out due to excessive energy consumption [12]. By grouping the network into clusters, the clustering algorithm eliminates excessive power consumption when delivering data to the BS. A CH is allocated to each cluster, and it is this CH's task to send data to BS. The CH election process, which should ensure uniform energy distribution among the sensor nodes [13], is an essential step in the clustering algorithm.

Researchers have extensively changed the LEACH protocol in order to enhance network efficiency. Scientific researchers are working hard to refine current algorithms in order to improve the efficiency of the IoT method [14]. In [15], an energy-efficient trust derivation method for WSN-based IoT networks was discussed. By assessing the optimum number of recommendations, the scheme uses risk strategy analysis to minimize network overhead. The energy-aware scheme ensures sufficient security while also lowering network latency. In [16], a time-based CH selection called TB-LEACH is proposed, which sets well-distributed clusters and increases lifetime by 20 to 30%. In [13], the gap between nodes and BS is taken into account for threshold-based CH selection, which increases lifetime by 10%.

In [16], Thein et al. adjusted the likelihood of selecting CH based on the residual energy of each node. The optimum value of CH is also considered in the paper, but only for fixed values such as 1 and 6. The network lifetime is increased by 40- 50%. [17] discusses another CH selection approach for data aggregation that reduces redundancy and increases network lifetime. The threshold value is adjusted by taking into account a hotness factor, which specifies how hot a particular sensor node is in relation to the rest of the network. In [18], CH is chosen using particle swarm optimization (PSO). In terms of node degree, intra-cluster distance, residual energy, and the number of optimal CHs, the selection criteria have an objective function. In contrast to different routing protocols, the model performs better in terms of various network metrics. PSO-ECHS is discussed in [19], where node-to node distance, distance to BS, and residual energy are used to select PSO-based CHs. [20] uses a different optimization strategy called Grouped Grey Wolf Search Optimization for security-aware CH selection in order to increase network lifetime.

[21] suggested a modification of LEACH in which residual energy is a key factor in CH selection. A simple Multi-hop approach to LEACH was also investigated, and it was discovered that both protocols outperform LEACH in terms of extending lifetime after a set amount of time. [24] describes a non-probabilistic multi-criteria based CH selection in which the network is divided into zones. The ANP (Analytical Network Process) decision tool is used to choose the CH or zone head. A collection of parameters was gathered from which the best parameters for zone head selection were chosen.

ENERGY BASED CLUSTER ROUTING

The proposed protocol is a two-stage hierarchical clustering algorithm with two stages: setup and steady state. Sensor nodes are deployed throughout the network and subdivided into

ISSN 1533-9211
DOI 10.5281/zenodo.7116145

clusters led by a CH responsible for data collection from sensing nodes during the initial set-up process. By eliminating any redundant bits, the data is fused to reduce the amount. The actual data routing occurs during the steady-state stage, when the network's CHs forward the collected data to the BS.

The clusters and CHs are generated in the first round using the standard LEACH algorithm, with CHs selected following equation.

$$T(n) = \begin{cases} \dfrac{P}{1 - P(r \bmod \frac{1}{P})}; \textit{for} \text{ all n ÚG} \\ 0; \text{ Otherwise} \end{cases}$$

Following data transmission, each node in the network expends a certain amount of energy, which varies from node to node. The amount of power expended is determined by the distance between the sending and receiving nodes, which is represented by the letter ‘d.' As a result, for the next round, the CH is chosen using a modified equation as follows:

$$T(n) = \begin{cases} \dfrac{P}{1 - P(r \bmod \frac{1}{P})} \times \dfrac{E_{residual}}{E_{initial}} \text{k}_{opt}; \textit{for} \text{ all n ÚG} \\ 0; \text{ Otherwise} \end{cases}$$

Where $E_{residual}$ denotes the node's remaining energy level and $E_{initial}$ denotes the node's initial allocated energy level. [22] Can be used to determine the optimum number of cluster k_{opt}.

$$k_{opt} = \sqrt{n/2\pi}\sqrt{\frac{E_{fs}}{E_{amp}d^4(2m-1)E_0 - mE_{DA}}}M$$

The network diameter is denoted by the letter ‘M,' and the initial energy supplied to each node is denoted by the letter ‘E0.' If the CHs for the current round have been chosen, they send information about their CH announcements to member nodes in their clusters. The sensing nodes assess the request message's signal intensity before determining which CHs to enter. To prevent data collisions, the CH broadcasts TDMA (Time Division Multiple Access) schedules for the member nodes to transmit data in different time slots. The process repeats for the remaining rounds until all of the nodes in the network have used up all of their resources.

ISSN 1533-9211
DOI 10.5281/zenodo.7116145

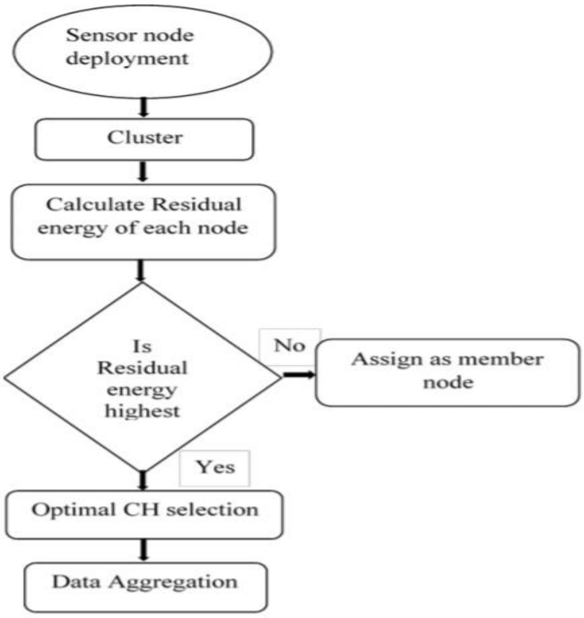

Figure 2: Flowchart of Energy based Cluster Routing

Data is transmitted to CHs during the time slot allocated to each node. To save energy, only the transmitting node remains involved, while all other nodes in the cluster switch off their radios. The CH will begin processing the data after all of the nodes in the cluster have finished transmitting data. The CH receives data, then aggregates it to remove redundancy and compresses it as much as possible to maximize bandwidth utilization. The data is then sent to the sink or BS via single-hop or multi-hop communication by the CHs. The entire procedure is represented in Fig. 4 as a flowchart.

ENERGY AND DISTANCE BASED CLUSTER ROUTING

In the second proposal, which we call Energy and Distance dependent Cluster Routing, this algorithm considers important factors such as the location of the sensor node relative to the BS and the amount of residual energy of each sensor node when selecting the appropriate CH nodes in the CH nodes selection process. It creates a new threshold dependent on distance, similar to the first one. Furthermore, it incorporates the node's current and initial energy into the CH election likelihood, ensuring that nodes with higher remaining energy have a higher chance of being CHs than those with lower remaining energy. The CH nodes that are selected have a direct effect on WSN performance factors like load distribution, energy consumption, and network lifetime.

$$T(n) = \begin{cases} c \times \frac{|d_{toBSavg} - d(i, BS)|}{d_{toBSavg}} \times \frac{E_i}{E_{init}}, & \text{if } n \in G \\ 0 \end{cases}$$

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In this case, E_i is the current round's residual energy of candidate node i. The initial energy of the node before transmission is referred to as E_{init}. The threshold value is determined by the geographical distance between the sensor node and the BS, as well as the residual energy of the candidate node, as seen in the equation above.

RESULT ANALYSIS

Following are Results generated during the implementation of the system.

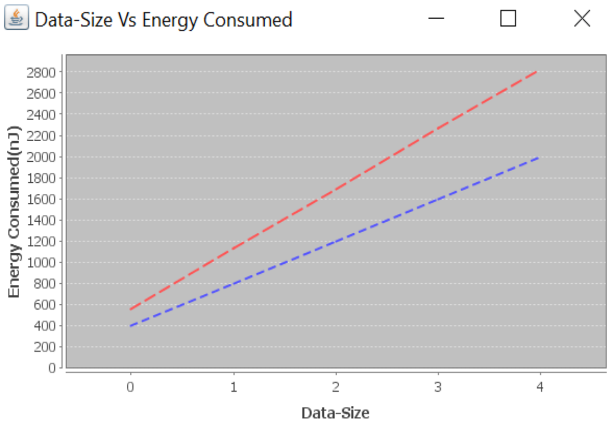

Figure 2: Energy Consumption for Send the Data

Figure 2 shows the results, and Figure 3 shows the energy and time consumed while sending the information. We illustrated the effects of 5 tries to allow for a more detailed investigation of the outcomes. Currently, the resources and time spent during transmission include the properties used in delays. We describe handling delay as the amount of time it takes part nodes to construct their ciphertexts and compare marks. The aggregation delay is determined by measuring the time spent testing the marks from component nodes, collecting ciphertexts and marks, and producing the mark of the cumulative result. Unscrambling delay indicates the amount of time spent in the end on gathering the first information for the BS by confirming totaled marks and decoding accumulated ciphertexts.

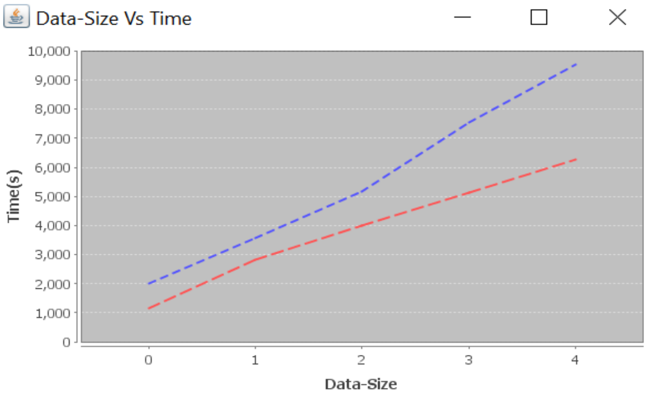

Figure 3: Time Consumption for Send the Data

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DOI 10.5281/zenodo.7116145

The system has been tested with various sets of nodes for both the current system and the proposed system to further test the performance. The system has been tested for 30, 50, 80, and 100 nodes. The obtained findings are depicted in Figures 4 and 5.

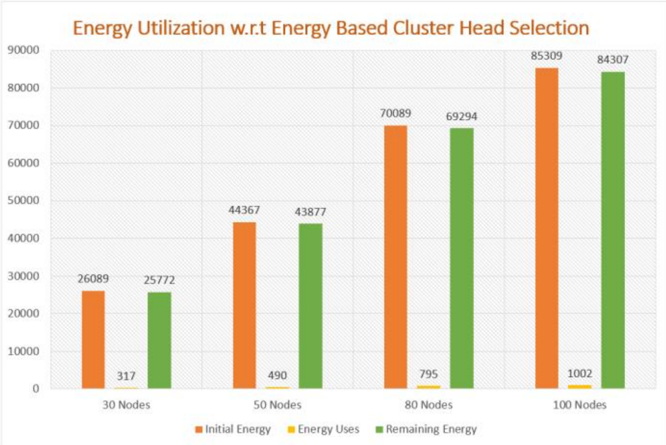

Figure 4: Energy utilization for Energy Based Cluster

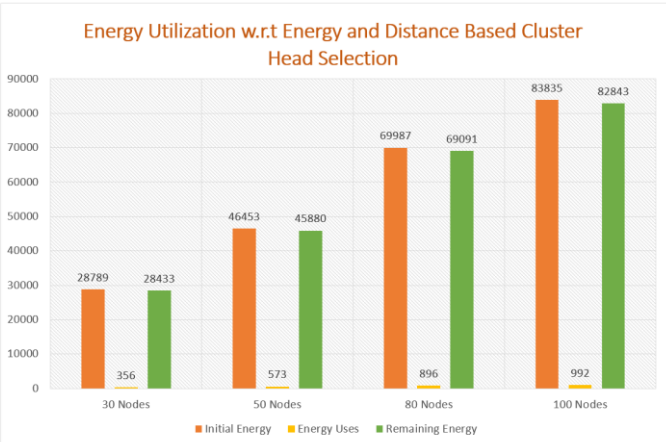

Figure 5: Energy utilization for Energy and Distance Based Cluster Routing

CONCLUSION

In this paper, we proposed two variants of cluster based routing, one is energy based and other is energy and distance-based clustering routing protocols for WSN. The proposed CH selection strategies involve two problem resolutions: the distance between the candidate node and the BS must be optimal, and the remaining energy of a candidate node that wants to be a CH must be greater than the WSN's average remaining energy level of live nodes. The result show that the energy and distance based routing protocol has worked more efficiently in reducing the energy

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consumption and thus affecting the network lifetime. The further work can be done by considering the density of the node as third parameter while selecting the cluster head.

References

[1] I. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "Wireless sensor networks: a survey," Compu. Netw. J., pp. 393-422, 2002.

[2] S. Tyagi and N. Kumar, "A systematic review on clustering and routing techniques based upon LEACH protocol for wireless sensor networks," J. of Netw. and Comput. Appl., vol. 36, no. 2, pp. 623-645, 2013.

[3] A. Abbasi and M. Younis, "A survey on clustering algorithms for wireless sensor networks," Computer Communications J., pp. 2826-2841, 2007.

[4] Q. Bian, Y. Zhang, and Y. Zhao, "Research on clustering routing algorithms in wireless sensor networks," in Proc. IEEE Int. Conf. on Intelligent Comput. Technology and Automation, vol. 2, pp. 1110-1113, May 2010.

[5] P. Zhang, G. Xiao, and H. Tan, "Clustering algorithms for maximizing the lifetime of wireless sensor networks with energy-harvesting sensors," Comput. Netw. J., pp. 2689-2704, 2013.

[6] W.B. Heinzelman, A.P. Chandrakasan, and H. Balakrishnan, "An Application-Specific Protocol Architecture for Wireless Microsensor Networks," IEEE Trans. on Wireless Commun., pp. 660-670, 2002.

[7] A. Manjeshwar, and D. P. Agrawal, "TEEN: a routing protocol for enhanced efficiency in wireless sensor networks," in Proc. Int. Parallel and Distributed Process. Symp., pp. 2009-2015, 2001.

[8] S. Lindesey and C. S. Raghavendra, "PEGASIS: Power-Efficient Gathering in Sensor Information Systems", in Proc. of IEEE Aerospace Conference, vol. 3, pp. 1125-1130, 2002.

[9] Y.-K. Chen, "Challenges and opportunities of the internet of things," in 17th Asia and South Pacific Design Automation Conference, 2012, pp. 383–388.

[10] A. Ali, Y. Ming, T. Si, S. Iram, and S. Chakraborty, "Enhancement of RWSN Lifetime via Firework Clustering Algorithm Validated by ANN," Information, vol. 9, no. 3, p. 60, 2018.

[11] C. Wang, K. Sohraby, B. Li, M. Daneshmand, and Y. Hu, "A survey of transport protocols for wireless sensor networks," IEEE Netw., vol. 20, no. 3, pp. 34–40, 2006.

[12] M. C. M. Thein and T. Thein, "An energy efficient cluster-head selection for wireless sensor networks," in Intelligent systems, modelling and simulation (ISMS), 2010 international conference on, 2010, pp. 287–291.

[13] S. H. Kang and T. Nguyen, "Distance based thresholds for cluster head selection in wireless sensor networks," IEEE Commun. Lett., vol. 16, no. 9, pp. 1396–1399, 2012.

[14] J. A. Stankovic, "Research directions for the internet of things," IEEE Internet Things J., vol. 1, no. 1, pp. 3–9, 2014.

[15] J. Duan, D. Gao, D. Yang, C. H. Foh, and H.-H. Chen, "An energyaware trust derivation scheme with game theoretic approach in wireless sensor networks for IoT applications," IEEE Internet Things J., vol. 1, no. 1, pp. 58–69, 2014.

[16] H. Junping, J. Yuhui, and D. Liang, "A time-based cluster-head selection algorithm for LEACH," in Computers and Communications, 2008. ISCC 2008. IEEE Symposium on, 2008, pp. 1172–1176.

[17] K. Maraiya, K. Kant, and N. Gupta, "Efficient cluster head selection scheme for data aggregation in wireless sensor network," Int. J. Comput. Appl., vol. 23, no. 9, pp. 10–18, 2011.

The Seybold Report
ISSN 1533-9211
DOI 10.5281/zenodo.7116145

[18] B. Singh and D. K. Lobiyal, "A novel energy-aware cluster head selection based on particle swarm optimization for wireless sensor networks," Human-Centric Comput. Inf. Sci., vol. 2, no. 1, p. 13, 2012.

[19] P. C. S. Rao, P. K. Jana, and H. Banka, "A particle swarm optimization based energy efficient cluster head selection algorithm for wireless sensor networks," Wirel. networks, vol. 23, no. 7, pp. 2005–2020, 2017.

[20] A. Shankar, N. Jaisankar, M. S. Khan, R. Patan, and B. Balamurugan, "Hybrid model for security-aware cluster head selection in wireless sensor networks," IET Wirel. Sens. Syst., 2018.

[21] F. Xiangning and S. Yulin, "Improvement on LEACH protocol of wireless sensor network," in Sensor Technologies and Applications, 2007. SensorComm 2007. International Conference on, 2007, pp. 260–264.

[22] S. Hussain and A. W. Matin, "Energy efficient hierarchical cluster-based routing for wireless sensor networks," Jodrey Sch. Comput. Sci. Acadia Univ. Wolfville, Nov. Scotia, Canada, Tech. Rep., pp. 1–33, 2005.