International Journal on
"Technical and Physical Problems of Engineering"
(IJTPE)
Published by International Organization of IOTPE

ISSN 2077-3528
IJTPE Journal
www.iotpe.com
ijtpe@iotpe.com

September 2022 | Issue 52 | Volume 14 | Number 3 | Pages 66-72

AN IMPROVEMENT ROUTING ALGORITHM BASED ON LEACH PROTOCOL

A.H. Muosa

Faculty of Science Computers and Mathematics, University of Thi-Qar, Thi-Qar, Iraq, ali.h.m@utq.edu.iq

Abstract- Wireless sensor networks (WSNs) result from the confluence of miniature electronic systems with wireless communication systems, culminating in a technological revolution in measuring devices. These are a collection of small electronic units that can detect and measure specific physical processes in the environment in which they are used. Sensor nodes are often equipped with relatively restricted resources in terms of energy, computational capability, data storage space, and transmission rate due to the limits of downsizing and manufacturing costs. These constraints drive a big portion of the research in WSNs, particularly the energy constraint, which is a major issue. The LEACH approach is used in this study to outline a strategy for expanding the network coverage. This strategy is known as modified LEACH (M-LEACH). It addresses the lack of coverage in some network regions due to a lack of adjacent cluster-heads (CH) to undertake data gathering and transmission duties. M-LEACH also successfully balanced the network's energy burden and significantly improved energy efficiency by employing a CH competitive mechanism. The NS-2.35 simulation results show that the proposed technique can enhance the amount of data received at sinks while prolonging the network lifetime and lowering energy usage.

Keywords: WSNs, LEACH, Clustering, Network Life Time, and Routing Protocols.

1. INTRODUCTION

Many small nodes with sensing capabilities make up WSNs, processing, and wireless communication capabilities [1]. This node is positioned in the area where a required attribute's data can be collected. WSNs are becoming increasingly popular due to their suitability for a wide range of applications, including military situations, disaster management, biological and dangerous contaminants, and so on [2].

Each node contains a sensor unit, a wireless communication device, a tiny microcontroller, and an energy source, usually a battery. As a result, data transmission and other node activities in WSNs rely heavily on energy conservation [3]. WSNs should include built-in routing techniques with energy conservation as a major concern and diverse application-specific needs.

Coverage preservation is crucial in WSNs, especially when the application requires high-quality service (QoS), combat monitoring, or medical treatment. These apps require a fully functional network to ensure that information is transferred with complete coverage [4].

The two types of sensor networks are heterogeneous and homogeneous sensor networks. At first, all nodes have the same battery capacity and hardware complexity [5]. Different kinds of nodes with varying energy sources and functional capabilities are employed in heterogeneous networks [6]. Clustering is a good way to save energy because many of nodes next to each other are clustered together.

2. RELATED WORKS

The network is divided into clusters via hierarchical routing protocols. There is a leader node in each cluster. Only the CH can communicate with the base station in clustering routing protocols. Regular nodes have reduced routing overhead because they have to connect with the CH. The sections that follow go over some hierarchical routing protocols.

Heinzelman, et al. [7] Presently show outstanding results in terms of energy conservation presently. They proposed the LEACH protocol based on clustering, which divides the network into groups like cellular telephone networks do (clusters). The data is sent from the nodes to representatives of groups known as CHs, who then send it to the desired destination or base station. Before retransmitting data to the base station, the CHs execute simple processing (e.g., aggregations) on the data received in some applications. This method allows bandwidth to be reused. It also facilitates improved resource allocation and energy control in the network.

Multi-hop LEACH (LEACH-M) [8] is an improved version of LEACH that allows cluster members to be separated from their CH while still communicating with it. As a result, they demonstrate where LEACH-M outperforms LEACH. On the other hand, this proposed solution necessitates data collection from each sensor, which adds sensor overhead. Authors in [9], researchers used heterogeneous sensor networks comprising high-capacity sensors (Super Sensors) and basic sensors to improve this technology. Others are low-power sensors that connect directly or via multi-hop with the nearest CH in their area.

LEACH-Centralized (LEACH-C) [10] makes it possible to determine the optimal configuration to minimize the energy expended from the exact position of the nodes. It's a LEACH in which the base station creates clusters from the center. The transmission stage used by LEACH-C is the same as LEACH. The BS receives information about each node's location and energy reserve during the activation phase. The clusters are then formed, and their CHs are selected using a centralized cluster creation algorithm.

LEACH with fixed clusters is being developed further [11]; It is based on forming clusters that are then fixed. The CH position is then rotated throughout the cluster's nodes. The advantage is that no more initialization is required once the clusters are established. The centralized cluster creation algorithm used by LEACH-F is the same as LEACH-C. Fixed clusters in LEACH-F do not allow for the addition of new nodes and do not modify their behavior in response to node death.

Arumugam and Ponnuchamy [12] proposed an EE-LEACH data collection protocol. It improved the packet delivery ratio while consuming less energy. Because they primarily concentrated on minimizing energy usage, they neglected data confidentiality and integrity.

This paper provides a new LEACH protocol strategy that maintains coverage due to random CH selection and non-uniform CH distribution.

3. MODEL OF RADIO ENERGY DISSIPATION

Because a specific measuring factor is required to compare the performance of the two suggested algorithms with LEACH, the algorithms used the radio energy model to compute the energy consumed during data transmission and reception operations. Because the radio spends $E_{Tx\text{-}elec} = E_{Rx\text{-}elec} = E_{elec}$ = 50 nJ/bit on reception and in transmitter electronics, the cost of sending an m-bit message over a distance d is given by the Equation (1) [13].

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

where, m is the total number of bits sent out, d_0, when the communication distance exceeds or equals this distance threshold, the sensor activates its amplification circuit, as depicted in Figure 1, E_{fs} = 15 pJ/b/m^2 and E_{mp} = 0.0023 pJ/b/m^4.

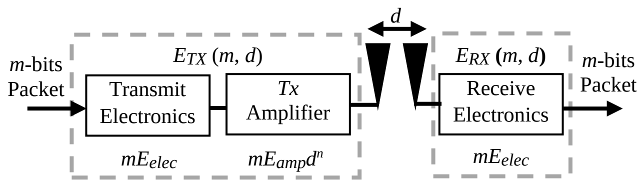

Figure 1. Model of radio energy dissipation [13]

The Equations (2) and (3) [13] can be used to calculate receiving cost and threshold distance d_0, respectively.

$$E_{RX}(m) = mE_{elec} \quad (2)$$

$$d_0 = \sqrt{E_{fs} / E_{mp}} \quad (3)$$

4. DESCRIPTION OF PROBLEM IN WSN COVERAGE

The connectivity problem is finding direct or indirect high-quality and energy-efficient communication channels between sensors and a BS [14]. This collection of links would allow for efficient and dependable data transport. Coverage solutions, on the other hand, cannot ensure network connectivity. Coverage and connectivity difficulties should be evaluated concurrently [15]. Another major difficulty in WSNs is deployment, which involves determining the best sensor placement pattern that meets coverage and connection requirements. Cluster-based routing is a good approach to save energy in sensor nodes and extend the lifetime and scalability of WSNs. Determining the optimum clusters with improving network coverage could result in a more energy-efficient WSN system, [16-18].

5. LEACH PROTOCOL

LEACH is a self-organizing algorithm based on adaptive clustering that equitably distributes the energy load among sensor nodes in the network through randomized CH rotation. It's among the first clustering-based hierarchical routing systems [7]. LEACH is built on two fundamental assumptions: the base station is fixed and located far from the sensors, and all network nodes are homogeneous and energy-constrained. LEACH's concept is to group sensor nodes based on the intensity of the received signal and use local CHs as routers to send data to the base station. If C is the set of nodes that may elect themselves as CHs at time t_1, a new set C of nodes will select themselves as CHs at time $t_1 + d$. LEACH's operation is divided into rounds, including two primary phases: a steady-state and a setup phase. And creates a cluster in self-adaptive mode during the cluster setup phase and then transmits data during the second phase.

6. THE PROPOSED ALGORITHM (M-LEACH)

The LEACH makes the unrealistic assumption that all nodes are energy homogeneous. When numerous CHs are attached to round, unequal nodes, the CH with the most related member nodes will consume its energy quicker than the CH with the fewest. Another difficulty with the LEACH routing protocol is mobility support; M-LEACH has been proposed; Initial nodes hold off on doing anything until the LEACH setup phase (cluster formation phase) is finished. If they do not receive any "advertisement message", there is no CH in their coverage area. Network partitioning and query sending are two major elements of this method. Network partitioning is essential to manage coverage across all network sections.

In contrast, query sending saves energy by reducing the energy lost by ordinary nodes that cannot work in LEACH due to a shortage of CHs. Because the proposed algorithm necessitates more nodes submitting data due to new clusters forming in previously unexplored areas, a query mechanism is utilized to send data from nodes that only perceive critical information. The sink splits the network region into equal halves based on its knowledge of regular and initial nodes' network size and communication ranges.

Small networks, for example, can be divided into two sections by a single virtual horizontal or vertical line. The sink can divide the network into four equal-sized sections using horizontal and vertical lines when the network grows. Each partitioned network's sink selects two non-adjacent initial nodes and sends messages to one of them, informing them of their choices. Initial nodes are reselected after each round for various reasons, including changes in the components from which the user wants to gather data or balance the energy consumption of head and conventional nodes in their clusters. Figure 2 depicts a network divided into four sections with two initial nodes. The initial nodes will relay the query value to their cluster members to specify the threshold of data of interest [7].

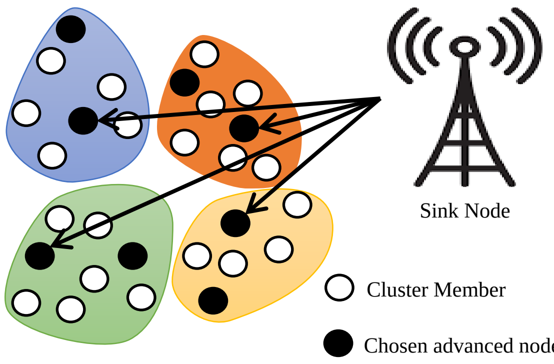

Figure 2. Network partitioning, the sink selects two initial nodes

The quantity determines and size of network sections and also the locations of active initial nodes:

- It can identify the network's active initial nodes and disregard the remainder to save energy.
- It can place initial nodes in areas where their communication range can control their portions totally or roughly.
- It can reselect the active initial nodes based on their energies and application requirements.

Not all network pieces must be reselected in the same round. This algorithm's fundamental idea is to keep coverage by having two initial nodes active at all times. The algorithm advises that just one selected initial node gathers data per round to reduce data repetition. This job is interchangeable between the two initial nodes.

Consider two non-adjacent initial nodes in the same partitioned network segment, where the distance threshold is (t_2, t_1). The network size has an impact on t_1 and t_2. Assume that RN denotes the collection of all regular nodes in this network segment, and FN_1 and FN_2 are a fraction of RN, representing the sets of regular nodes within t_1 of HN_1 and HN_2. FN_1 is separated into MN_1 (main neighbors) and DN_1 (derivative neighbors), FN_2 into MN_2 and DN_2. Where MN_1 and MN_2 are the sets of all member nodes within t_2 of HN_1 and HN_2. DN_1 and DN_2 are collections of nodes larger than t_2 but less than or equal to t_1. Figure 3 These sets and distances are depicted in a network segment [8].

Some regular nodes that are less than or equal to t_1 distances on both HN_1 and HN_2 may be shared members of DN_1 and DN_2, as shown in Figure 4 [9].

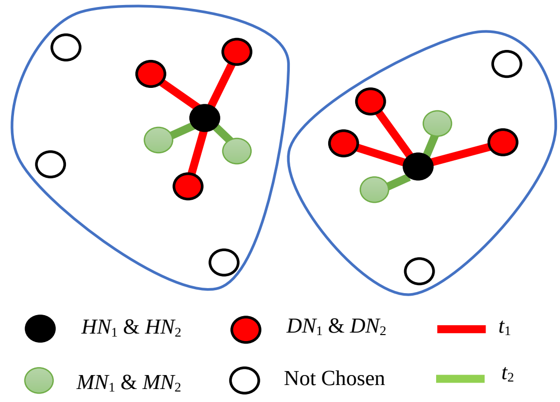

Figure 3. Classification of nodes in a network section

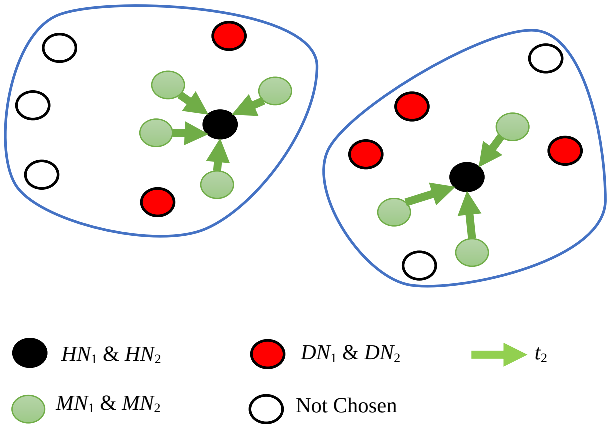

Figure 4. Two fixed clusters were produced

Because at the start of the fixed cluster creation, only one acknowledgment is sent from the regular nodes to the initial nodes. The regular node that exceeds the critical energy value sends a specific message to the initial nodes to be excluded from the fixed cluster. The pseudocode Algorithm 1 below depicts the updated CH selection approach used in M-LEACH.

Algorithm 1. The procedure that has been proposed

Pseudocode: M-LEACH Algorithm

HN = calculate ()
If (t_2<t_1)
For (i=1; i< θ; i++)
Calculate HN_1 and HN_2: All nodes in RN residing at a (t_1) distance between HN_1 and HN_2 emit "neighbors sensing" signals
DN_1 sends a "join message" to HN_1 and DN_2 sends a "join message" to HN_2
Calculate MN_1 and MN_2:
Else (θ has not been reached)
The LEACH set-up procedure will begin as usual

7. RESULTS AND DISCUSSION

We use the NS-2.35 network simulation environment to evaluate the performance of our suggested M-LEACH and the original LEACH in this section. A network and only one node type are used to simulate the original LEACH protocol. In contrast, the suggested methodology requires heterogeneous networks, sufficient initial nodes, and regular nodes with the same number and position as the first network.

Both networks use the same simulation parameters, and the outcomes for three distinct simulation iterations are reported. Repeating a procedure aims to confirm that the results are accurate. Table 1 shows the simulation parameters in more detail.

Table 1. Simulation Parameters

Parameter Name	Value
Environment Size	100×100 m
Initial Energy	0.5 J
Number of Rounds	30
Number of Active Nodes	50, 75
E_{elec}	50 nJ/bit
RN	100
HM	19
d_0	87 m
Data Packets Size	4500 bits
Data Packet rate	1 packet/s
Nodes Percentage	0.005

As described in the LEACH protocol, each simulation run consists of many rounds. In each cycle, the number of nodes that transferred data for the sink nodes - either regular or head CHs - is recorded, allowing the LEACH and the suggested augmentation M-LEACH to be compared. The term "active nodes" will be used to refer to nodes that have been active since the formation of a new CH in network parts that were experiencing coverage gaps due to random CH selection.

The number of active nodes that have been active since the formation of a new CH in network parts experiencing coverage gaps due to random CH selection is one of the most critical factors to consider when evaluating the suggested algorithm's efficacy. The regular node's energy levels are the second factor in the M-LEACH evaluation. M-LEACH proposes deploying started nodes to assume CH tasks when there is no CH within their communication ranges. New data-gathering duties will be assigned to the standard nodes of starting node clusters, which should not substantially influence their energy level. After the last rounds of each simulation run, the energy level of the regular nodes is recorded in each of them to compare LEACH with M-LEACH. The lengths between nodes must be determined to use these numbers in the radio energy model's computation of energy expended.

Figure 5 represents the numbers of the active node in 50-node networks throughout a simulation of the LEACH and M-LEACH algorithms. Figure 6 shows a typical node's energy level in a 50-node network following the first simulation run's final round.

Figure 7 represents the number of active nodes in 50-node networks throughout the simulation of the LEACH and M-LEACH algorithms. Figure 8 shows a typical node's energy level in a 50-node network following the second simulation run's final round.

Figure 9 represents the numbers of active nodes in 50-node networks throughout the simulation of LEACH and M-LEACH algorithms. Figure 10 shows a typical node's energy level in a 50-node network following the third simulation run's final round.

Using 50 node networks, Table 2 shows the sum of the energy consumed by nearby CHs before and after their merging.

Figure 11 represents the numbers of an active node in a 75-node network throughout the simulation of the LEACH and M-LEACH algorithms. Figure 12 shows a typical node's energy level in a 75-node network following the final round's simulation result.

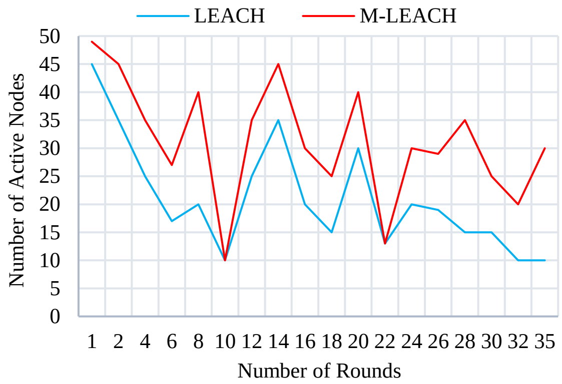

Figure 5. The numbers of an active node in LEACH with M-LEACH at the initially simulation result

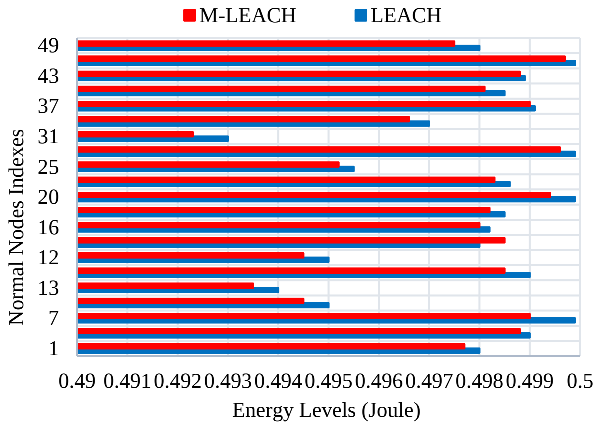

Figure 6. A typical node's energy level in a 50-node network for the first simulation

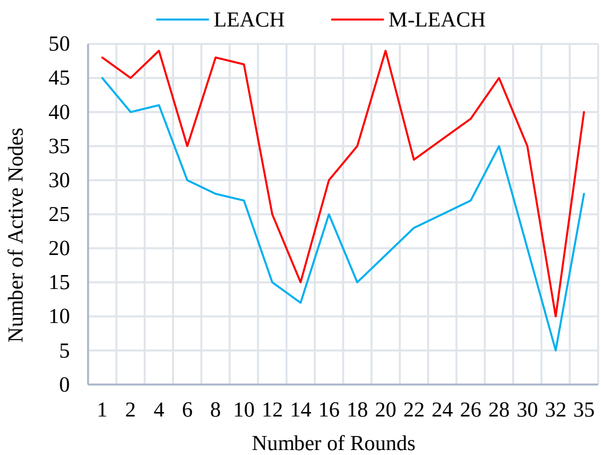

Figure 7. There are the number of active nodes in LEACH with M-LEACH at the second simulation result

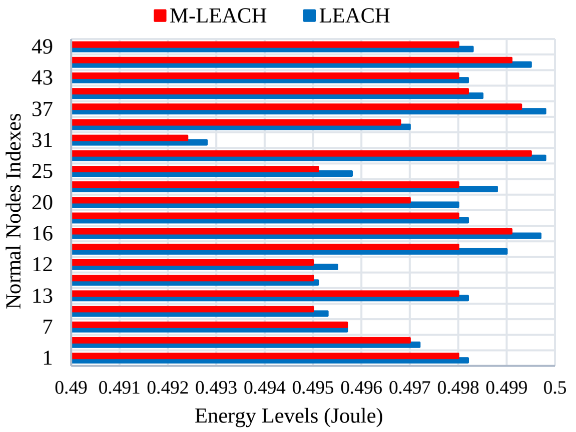

Figure 8. A typical node's energy level in a 50-node network for the second simulation

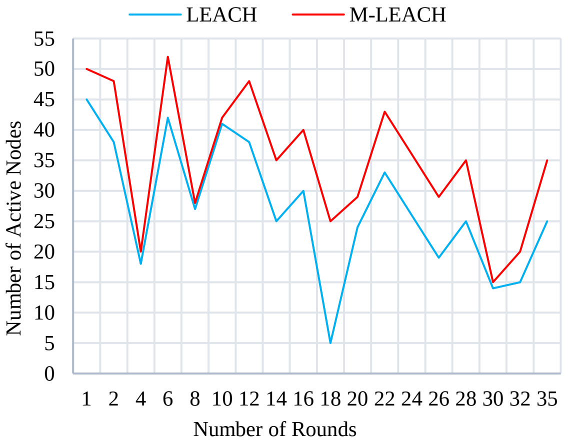

Figure 9. The numbers of an active node in LEACH with M-LEACH in the third simulation result

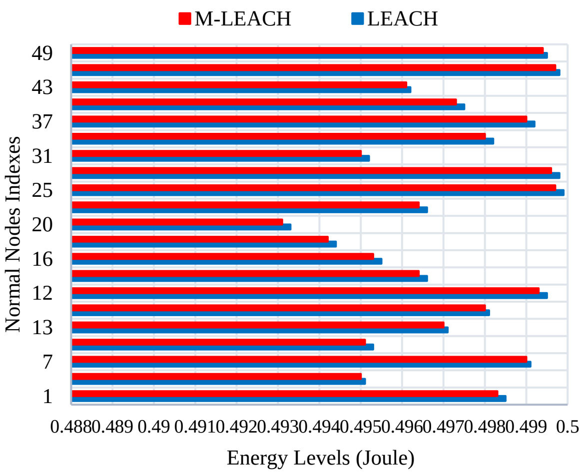

Figure 10. A typical node's energy level in a 50-node network for the third simulation

Figure 13 represents the number of active nodes in 75-node networks throughout the simulation of the LEACH and M-LEACH algorithms. Figure 14 shows a typical node's energy level in a 75-node network follows the final result of the second simulation run.

Figure 15 represents the numbers of an active node in a 75-node network throughout the simulation of the LEACH and M-LEACH algorithms. Figure 16 shows a typical node's energy level in a 75-node network follows the final result of the third simulation run.

Using 75 nodes networks, Table 3 shows the sum of the energy consumed by nearby CHs before and after their merging.

We may deduce that the location of the sink is critical for node stability and energy usage when a sink is misplaced, the quality of the signal, and the amount of energy used to degrade. The total energy of the network can be increased by adding more nodes.

Table 2. The energy levels of adjacent CHs in a 50-node network.

	In LEACH, the nearby CHs consume energy (Joule)	In M-LEACH, the nearby CHs consume energy (Joule)
First Simulation Run's	0.4998	0.4987
Second Simulation Run's	0.4972	0.4821
Third Simulation Run's	0.4999	0.4995

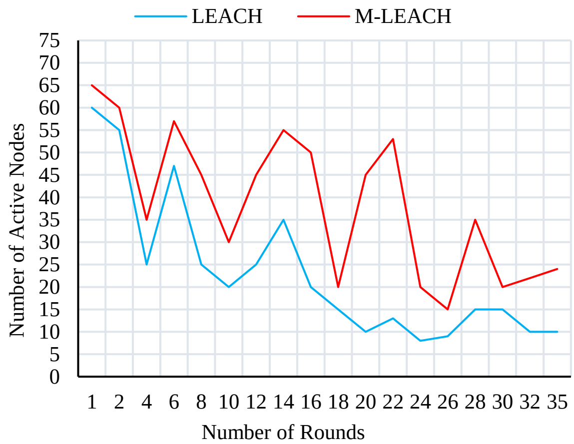

Figure 11. The numbers of an active node in LEACH with M-LEACH at the initially simulation result

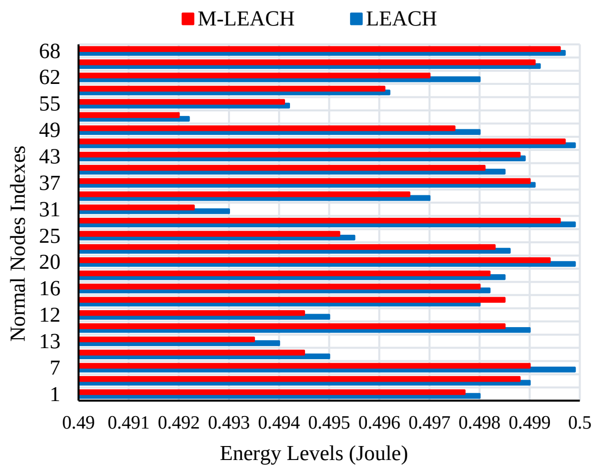

Figure 12. A typical node's energy level in a 75-node network following the first round's simulation result

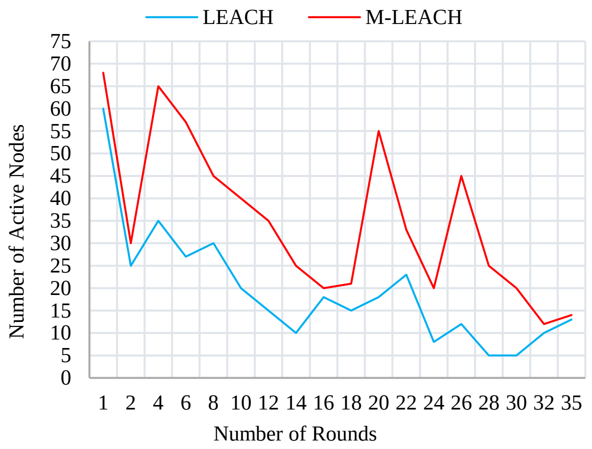

Figure 13. The numbers of an active node in LEACH and M-LEACH in the Second Simulation Result

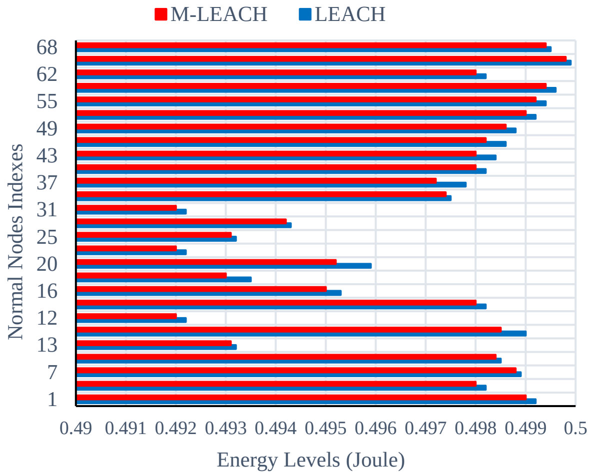

Figure 14. A typical node's energy level in a 75-node network following the second round's simulation result

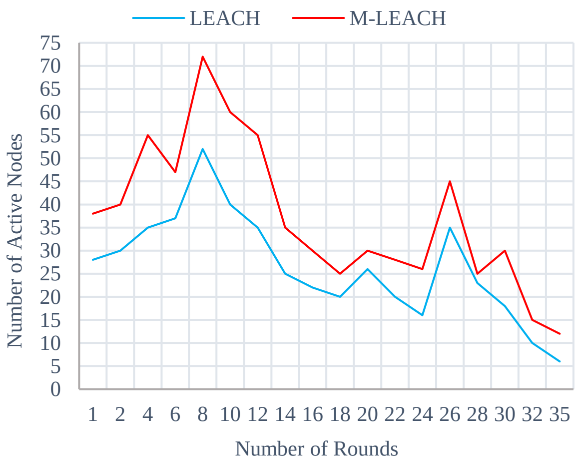

Figure 15. The numbers of an active node in LEACH and M-LEACH in the Third Simulation Result

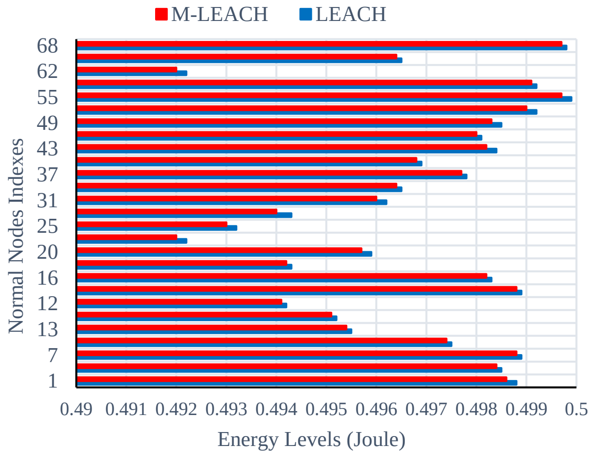

Figure 16. A typical node's energy level in a 75-node network following the third round's simulation result

Table 3. The energy levels of adjacent CHs in a 75-node network

	In LEACH, the nearby CHs consume energy (Joule)	In M-LEACH, the nearby CHs consume energy (Joule)
First Simulation Run's	0.4999	0.4981
Second Simulation Run's	0.4953	0.4891
Third Simulation Run's	0.4911	0.4812

8. CONCLUSION

The use of clustering for WSNs has gained popularity in recent years, posing unique issues compared to wired networks. This paper introduces an energy-efficient M-LEACH method for WSNs. However, acquiring data from nodes in certain locations can effectively ensure that data from all network components are tracked. Despite the increased data collection work proposed by M-LEACH, typical nodes are unaffected because they do not need to interact across long distances. M-LEACH is a very effective strategy for avoiding the formation of a few clusters that cannot manage the entire network, especially in extensive networks. With M-LEACH, an effective network energy management may be achieved under the control of the sink; only the areas where vital data is expected should be commended to use M-LEACH.

REFERENCES

[1] A.H. Muosa, A.M. Hamed, "Remote Monitoring and Smart Control System for Greenhouse Environmental and Automation Irrigations Based on WSNs and GSM Module", IOP Conference Series, Materials Science and Engineering, Vol. 928, No. 3, p. 032037, 2020.

[2] A.H. Muosa, A.H. Ali, "Internet Routing Anomaly Detection Using LSTM Based Autoencoder", The 2022 International Conference on Computer Science and Software Engineering (CSASE), pp. 319-324, 2022.

[3] M. Sivaram, M.A. Salih, S. Porkodi, V. Manikandan, "Securing the Sensor Networks Along with Secured Routing Protocols for Data Transfer in Wireless Sensor

Networks", Issue 10, Vol. 5, October 2018.
[4] A. Singh, A. Payal, S. Bharti, "A Walkthrough of the Emerging IoT Paradigm: Visualizing Inside Functionalities, Key Features, and Open Issues", Journal of Network and Computer Applications, Vol. 143, pp. 111-151, 2019.
[5] K.O. Ibrahim, C.A. Tavera Romero, S. Hassan, M.T. Iqbal, "Mitigating Hotspot Issues in Heterogeneous Wireless Sensor Networks", Journal of Sensors, Vol. 2022, pp. 1-14, February 2022.
[6] K. Redjimi, M. Redjimi, "The DEEC and EDEEC Heterogeneous WSN Routing Protocols", International Journal of Advanced Networking and Applications, Vol. 13, No. 4, pp. 5045-5051, 2022.
[7] W.R. Heinzelman, A. Chandrakasan, H. Balakrishnan, "Energy-Efficient Communication Protocol for Wireless Microsensor Networks", The 33rd Annual Hawaii International Conference on System Sciences, p. 10, 2000.
[8] Y.M. Bani, Y. Khamayseh, W. Mardini, "Improvement on LEACH Protocol of Wireless Sensor Network VLEACH", Int. J. Digit. Content Technol. Appl., 2009.
[9] M. Peng, Y. Sun, "Architectures, Key Techniques, and Future Trends of Heterogeneous Cellular Networks", Encyclopedia of Wireless Networks, pp. 46-53, 2020.
[10] W.B. Heinzelman, A.P. Chandrakasan, H. Balakrishnan, "An Application-Specific Protocol Architecture for Wireless Microsensor Networks", IEEE Transactions on wireless communications, Vol. 1, No. 4, pp. 660-670, 2002.
[11] P. Sood, "A Fuzzy Logic-Based Clustering Algorithm for WSN to Extend the Network Lifetime", Journal of Global Research in Computer Science, Vol. 9, No. 6, pp. 19-25, 2018.
[12] G.S. Arumugam, T. Ponnuchamy, "EE-LEACH: Development of Energy-Efficient LEACH Protocol for Data Gathering in WSN", EURASIP Journal on Wireless Communications and Networking, Vol. 2015, No. 1, pp. 1-9, 2015.
[13] C.D. Valle Soto, C. Mex Perera, J.A. Nolazco Flores, R. Velazquez, A. Rossa Sierra, "Wireless Sensor Network Energy Model and its Use in the Optimization of Routing Protocols", Energies, Vol. 13, No. 3, p. 728, Basel, Switzerland, 2020.
[14] S.M. Altowaijri, "Efficient Next-Hop Selection in Multi-Hop Routing for IoT Enabled Wireless Sensor Networks", Future Internet, Vol. 14, No. 2, p. 35, 2022.
[15] S.R. Angajala, "Coverage Problems in Sensor Networks", IJECCE, Vol. 3, No. 1, pp. 104-110, 2012.
[16] O. Gurewitz, M. Shifrin, E. Dvir, "Data Gathering Techniques in WSN: A Cross-Layer View", Sensors, Vol. 22, No. 7, p. 2650, 2022.
[17] A.R. Babayeva, "Procedure for Choice of Power and Placement Location of Controlled Shunt Reactors in High Voltage Electric Networks of Power Systems", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 41, Vol. 11, No. 4, pp. 46-50, December 2019.
[18] H. Chahkandi Nejad, M. Farshad, R. Havangi, "Designing of a New Online Time Delay Observer and its Application in Unknown Time Varying Delay Estimation on Wireless Sensor Networks (WSNs)", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 41, Vol. 11, No. 4, pp. 37-45, December 2019.

BIOGRAPHY

Ali Hassan Muosa was born in Thi-qar, Iraq, 1979. He completed his Bachelor of Computer Science degree from Thi-Qar University, Thi-Qar, Iraq, in 2002. He completed his Master of Computer Science degree from Islamic University, Lebanon, in 2010. He joined as a faculty member in Department of Computer Science at the same University after graduation. His Ph.D. is ongoing in Computer Network at University of Kufa University, Kufa, Iraq, since 2019. He has more than 11 years of teaching experience. His research interest is in computer networks and machine learning.