V. Sneha, 2021, 9:3
ISSN (Online): 2348-4098
ISSN (Print): 2395-4752

Energy Efficient Clustering Eliminating Duplicate Data (EECEDD)

Research Scholar V. Sneha, Dr. M. Nagarajan (Principal)
Department of Computer Science
KSG College of Arts and Science, Coimbatore,TN,India
snehamaelin05@gmail.com, mnaagarajan@gmail.com

Abstract- Wireless networks are used in a variety of fields of study, including medicine, agriculture, the military, geography, and so on. The primary concern of a network of wireless sensors is how to control energy consumption and extend the network's life. This paper examines various challenges in WSN and has a brief discussion of how different literature results contribute to clustering and data aggregation. To reduce energy consumption and eliminate duplicate data during transmission, a new clustering algorithm called "Energy Efficient Clustering Eliminating Duplicate Data" has been proposed. The paper concludes with insights for researchers into energy efficiency and how the proposed algorithm works well in case of energy consumption, delay, and throughput and network lifetime.

Keywords: - WSN, LEACH, Clustering, Data aggregation.

I. INTRODUCTION

A wireless sensor network is a sensor node assembly that tracks physical phenomena in a geographical region. Many of WSN's applications are extending to trends in animal tracking, climate control, medical applications, military control, and infrastructure maintenance. [1] WSN's challenge is to extend its life because each sensor has limited battery power. The sensor must feel, send, receive, and process with its limited power. [2]

Each step consumes a certain amount of power, resulting in a decrease in battery capacity. Wireless sensor networks require an energy-limited source. Different nodes in the WSN record values, which are continuously transmitted to the base station via node-to-node communication and cluster heads.

The sensing nodes on the cluster heads collect, aggregate, and transmit data to the base station. The sensor node's energy level is focused on the WSN battery. [3] When we look at remote areas where we need to deploy sensors on small aircraft, it is difficult to adjust the battery several times. Routing is frequently complicated in such a situation if nodes are absent due to excessive energy consumption. The data collected in the sensor nodes generates a lot of network traffic during transmission, which can be avoided by using efficient compost detection mechanisms. [4] Due to the limited source space, efficient source power management is critical to extending the network's lifespan. To improve network life, the resource's use should be optimized. [5]

The WSN works in multiple modes: communication and sleep estimation. During communication, the nodes expend a significant amount of energy, which is directly proportional to the distance capacity. To increase the lifespan of a WSN, we must focus more on the communication nodes.

The clustering algorithm "Energy Efficient Clustering Eliminating Duplicate Data" is used in this paper to improve energy efficiency in WSN. Section II discusses the difficult issues in WSN, Section III discusses existing clustering algorithms, Section IV discusses existing data aggregation techniques, Section V details the proposed algorithm, Section VI discusses the results, and Section VII concludes with the benefits of the proposed work.

II. CHALLENGING ISSUES IN WSN

The WSN has a plethora of issues to address in order to maximise energy and network performance. This section outlines the various issues that must be addressed in a WSN. When using a WSN, it is usually done in conditions where human interference is unlikely. At times, the nodes go unattended. If nodes are left unattended, they are more likely to fail. [6]

A sensor node's four main components are the sensor unit, processing unit, transceiver unit, and power unit. They must all fit into a small box that is also light. It must be able to run unattended in the network, which means it must be tailored to its environment.

A WSN is typically a list node with hundreds to thousands of nodes depending on the application. As a result, even as the number of nodes grows, networks must be sufficiently scalable to adapt to the scenario. Nodes in the network must be resistant to repeated failures and must be able to withstand even harsh environmental conditions. [7]

Sensor nodes must be deployed either deterministically or randomly based on their suitability for the application. [10] In the absence of proper implementation, energy consumption will be enormous, and the network may be disrupted. The sensor nodes that are deployed must be able to collect data from all nodes in every nook and cranny of the network. The deployed nodes must be interconnected in order for data transfer to be possible. [8]

If the connectivity is not correct, there is an increased risk of node failure. Because the energy nodes are heavily battery-powered, the main limitation of a WSN is its inability to efficiently use power. The aggregation of data from various sensor nodes consumes more resources.

Furthermore, data packet replication should be avoided because it can result in excessive energy waste. [9] Network nodes are connected to telephone, optical media, infrared, and other networks that can be disrupted by environmental factors such as rain, fog, snow, and so on.

III. CLUSTERING AND ROUTING PROTOCOLS

In the recent arena, various algorithms to increase energy efficiency have been proposed and investigated. This section discusses a few energy-saving algorithms. [11] LEACH is the most successful energy-saving algorithm in WSN, a one-hop topology in which the cluster head is chosen at random. The network cluster heads were created with weak and randomly distributed group heads. While this algorithm has been adapted to various WSN applications, it has not been balanced with regard to energy dissipation.

LEACH-C was [13] advanced over LEACH, relying on the same metrics as LEACH except for cluster creation. The cluster was formed using the residual energy of the nodes. [12] HEED is an efficient, energy-efficient algorithm that considers neighbour nodes during cluster head distribution and randomly chooses the cluster head but changes during iteration. [17]

The EECS (Energy Efficient Clustering Scheme) is appealing due to its balanced clustering in the selection of cluster heads, and it employs a variety of parameters to achieve energy efficiency. [18]FLOC (Fast Local Clustering) creates clusters of similar size with nodes that do not overlap. [19]

DWEHC (Distributed Weight-Based Protocol for Energy-Efficient Hierarchical Clustering) generates balanced clusters with no overlaps, which are distributed in the Weight dependent Protocol for Energy Efficient Hierarchical Clusters. To some extent, these two algorithms appear to be the most effective at conserving energy in WSN. The LEACH algorithm, in conjunction with the concept of Weighted Spanning Tree, claims to perform better than LEACH. [20]

The GSTEB algorithm demonstrates efficient routing by constructing spanning trees, which has resulted in an increase in network lifetime. [21]GEAR (Geographic and Energy Conscious Routing) claims to achieve energy efficiency by taking into account various factors such as source and destination positioning, network density for interrupted contact, and energy costs. [22] PEDAP (Power Efficient Data Collection and Aggregation Protocol) is a framework of two algorithms that uses optimal spanning trees to achieve its main goal of power efficiency. [14] PEGASIS (Power-Efficient Selection in Sensor Information Systems) is an optimal chain-based protocol that focuses on improving sensor information systems. A research study reports that collecting input from sensor nodes based on fixed settings improves energy efficiency by 50%, but it creates data overhead. [23] COSEN (Chain Driven Sensor Network) is a chain-based algorithm that focuses on rapidly collecting data while consuming as little energy as possible.

When considering protocols that can encourage low energy consumption, reduce transmission costs, and balance the load, we need to conduct a thorough review to categorise the protocols based on our needs. In this section, we will look at a few cluster-based routing protocols that result in low energy consumption. [15] The Threshold Responsive Energy Efficient Network (TEEN) is an energy-saving protocol that leads to network longevity.

The only disadvantage of this protocol is that data cannot be aggregated quickly due to a lack of communication between sensor nodes and CHs. [16] Periodic Adaptive Threshold the Responsive Energy Efficient Network Protocol (APTEEN) is an improved version of TEEN that can aggregate and send data between sensor nodes but requires the support of a few protected transmission protocols. [14]

Power Efficient Gathering in Sensor Information Systems (PEGASIS) is a hierarchical protocol that uses a greedy algorithm to transfer packets to the base station in a sequential order. To relay data, the nodes form a chain, and if any node in the chain fails, the chain must be rebuilt. Each sensor node within the deployment area serves as the CH for sending data to the basic station.

The TDMA-based MAC protocol, an energy-conscious protocol used in the majority of WSNs, is [11] Low Energy Adaptive Clustering Hierarchy (LEACH). This protocol's primary goal is to reduce energy consumption and set up data transfer clusters for base stations. The stochastic algorithm is used to generate sensor nodes after each round, and the CH's function is to accumulate, compress, and transmit data. It relays data from the cluster to the base station using resident data calculation. This protocol is most effective in uniform networks but not in heterogeneous networks. [24]

Stable Election Protocol (SEP) is a heterogeneous clustered protocol based on each node's weighted chosen chance for the remaining energy to become CH. It operates on two types of nodes: standard nodes and advanced nodes. Advanced nodes require more energy than regular nodes for data aggregation and transmission. [12]

The Hybrid Energy Efficient Distributed (HEED) protocol is used to extend network life. The first is residual capacity, and the second is node density, which is used to determine which CHs to use. [25]

The DEAR protocol generates routing paths from a network node's leftover energy. Delivery time, energy consumption, and data reliability are all considered. [13] LEACH-C is a cluster-based protocol that selects CHs from the base station. The amount of energy in the nodes is transmitted to the base station at the start of each round. The bases choose the CHs based on the measurements sent by the nodes. The base station chooses the CHs based on the metrics sent by the nodes. When the sensor nodes are close to the base station, this protocol does not produce better results than the LEACH method.

The main disadvantage of this protocol is that the CHs are not distributed. [26] The deterministic energy efficient clustering (DEC) protocol promises a better option for CHs. A single hop or multiple hops completes communication. Only a single data packet is sent to the neighbour in a single hop, whereas multi-hop data packets are sent simultaneously to multiple neighbours, consuming more resources. [7]

With three levels of heterogeneity in selecting CHs, the Dual Cluster Head Routing Protocol (DCHRP) focuses on maximising network life time. The ultimate goal of this protocol is to limit CH selection in order to reduce energy consumption, as more energy is required during CH selection.

This protocol reduces the number of clusters and achieves three levels of heterogeneity through three stages, namely CH selection, cluster formation, and finally communication to base station. The need to cluster sensors stems from the fact that transmission costs are frequently higher than computation costs. To avoid data transmission over long distances, the responsibility for data processing is delegated to one of the clusters when the cluster concept is implemented.

When data is transferred over short distances, the amount of energy required is reduced. There are several clustering algorithms based on this, and we will look at a few of them in this section.

[28] EHMR is a hierarchical approach to multipath paths that combines inherent clustering and unicast load balancing. It employs multiple paths with an on-demand load balancing function that allows the entire load to be moved to another path in the event of a path failure.

In this approach, sensor nodes are deployed at random and assigned to a specific transmission range. This method employs seven different algorithms that are linked together to achieve load balancing with minimal energy consumption. The first is the Neighbor Discovery algorithm, which is designed to categorize neighbor sensors and update their hop count to the base station. The second algorithm is the Hop Number Update algorithm, which involves the base station changing the hop number and retransmitting the HU packet to the nodes. The Path Request algorithm, which recognizes the various paths to initiate transmission among neighbors, is the third algorithm.

The Maximum Energy and Minimum Hop algorithm will define the main path that has the most residual energy but is the shortest distance from the hop. Path Request Receipt is the fifth algorithm, which retrieves the set of all neighbors and initiates the request for distinct paths. The packet ID and path information from which the packet was delivered to the source node that initiated the transmission will be provided by the Destination Reply Receipt algorithm.

In the event of a track failure, the alternative route will be determined by the final high energy and minimum hop algorithm. The route repair is usually done locally to avoid disrupting the current transmission and to move the load to the repaired route once the path is restored. In terms of load, EHMR has proven to be energy efficient, balanced, and effective. The efficiency of EHMR improves as network density increases.

In multi-hop networks, there is a method that makes use of static links. For multihop networks, a static connect approach is used to transmit data from sensor nodes to the base station. There is a chance that the data packets will flow through the network in this case. To address this issue, an efficient clusters algorithm with multiple sinks was proposed.

Then, given the typical energy conservation algorithm used in most wildcard sites, LEACH, a disadvantage is discovered: a node with low waste energy is frequently prone to failure, frequently resulting in a network interruption. To address this flaw, a particle encoding scheme for data packet routing is proposed, along with a clustering algorithm. [29]

See the Clustering Limited Member Node (LmC) algorithm, which reduces the number of cluster member nodes below a certain threshold. This algorithm selects the cluster head based on factors such as residual strength, energy consumption, and distance from the base station. The efficiency of the clusters is determined by the base station's spreading range. This algorithm has proven to be fast in terms of packet delivery while also extending network life. Traditional load balancing techniques, such as [30] Breadth First Search and Dijkstra's algorithm, which seeks the shortest path to route data packets, can be used in a WSN. The basic idea behind load balancing is to reduce hot spots in order to increase the network's survival. [33]

To equate the load, a heuristic algorithm was implemented that focuses on the transfer power in the data transmission route, where each node in the network receives the same transmission power. To increase network lifetime, the non-linear programming approach is modified based on the WSN topology and traffic distribution across the network. A research paper proposes a control principle to reduce the use of the link by establishing a network controller to track transmission. [31]

The Energy Gauge Node (EGN) is a technique for reducing energy consumption by making proper use of sensor nodes while also resolving load balancing issues. EGN nodes are also used in the WSNs of ordinary nodes because they have a large battery, a powerful processor, a fast communication speed, and plenty of storage space. The EGN nodes in the network are in charge of processing the nodes' waste energy and transmitting information about the network's Hop collection. Route requests initiated by EGN nodes and route-respond packages recognised by ordinary nodes are the two types of packets used for this purpose. To calculate the residual energy of the nodes, the EGN nodes use a node ID, signal energy, and the time of roundtrip specified in the route response packets. Initially, every normal node in the network assigns maximum energy and is considered efficient; however, the energy of the nodes drains after transmission time and falls into the regular or critical group [34].

The residual energy calculated by the EGN nodes is used to monitor the sleep cycle. Prior to the total number of node failure, the active nodes are highly functional. The network remains active for a longer period of time under this approach. [35] Energy-balanced Joint Routing and Asynchronous duty cycles are suggested for load balancing that contributes to optimizing network lifetime.

Three algorithms are integrated in a network to work together to balance energy consumption uniformly over a specific time span in order to control the transfer power of the sensors in an energy-balanced model. The network's entry is ensured on a regular basis by sending hello back packets.

IV. DATA AGGREGATION

The device for transmitting data obtained by sensor nodes to cluster heads and base stations is referred to as the WSN data collection. This section discusses new methods for collecting effective energy use data. [37] Mobile sinks are a very common method used in deployment research today, addressing uniform energy consumption between nodes. The concept of mobile sinks, which claims to improve network efficiency, has been adopted by the vast majority of WSN applications. [38]

According to the most recent research on mobile sinks, there are three mobility models: random path sink mobility, fixed path sink mobility, and control path sink mobility. The mobile sink(s) that move randomly around the deployment area are referred to as the random track sink mobility, and if the mobile sink(s) has a predetermined track, they are referred to as the fixed track sink mobility. If a mobile sink's route can be monitored, it is referred to as a mobility route controller. Sensor node data is forwarded to the cluster heads, which then send it to the sinks via single hop or multihop communication. We discuss a few methods used in various research works that can lead to energy conservation. [39] Lowest Possible Energy Consumption Maximum Data Gathering (MDGMEC) is a method for collecting data from sensor nodes that employs the fixed path mobility paradigm. [40] Shortest Path Trees (SPT) is a data collection tool, but it has a drawback in that it causes network traffic imbalance. In this case, the mobile sinks are designed to travel at a constant speed, but the speed and time period are insufficient for the cluster heads to fully transmit their data.

To overcome this condition, we will distribute the data uniformly among the cluster heads, but this does not guarantee optimal performance. It has a significant disadvantage of knowing the patterns the mobile sink travels when using the random mobility model, but there is a possibility of collecting data in a timely manner when using pre-determined routes. In that case, a path(s) must be identified to improve the network's output and address the energy whole issue. [41] The queuing model is also recommended for effective data collection, but it has a long delay for aggregation and is not suitable for large-scale WSNs.

In several cases, it may be recommended that a large number of sinks be used to improve energy efficiency, but that the costs of implementation are reduced. Fog is a multi-mobile sink method that focuses on increasing performance while decreasing transmission latency. [42] For route detection, the Reduced k-Means (RkM) and [43] the Delay Bound Reduced k-Means (DBRkM) algorithms are used, and MS scheduling techniques are used. [44] A research study employs an efficient data aggregation technique, Ant Colony Optimization, to select the best path.

This method eliminates unused cluster centroids while focusing on energy consumption, and cluster heads are chosen based on the weights associated with them to improve transmission range. This method improves network throughput and network lifetime.

V. ENERGY EFFICIENT CLUSTERING WITH ELIMINATION OF DATA DUPLICATION (EECEDD)

The sensors are dispersed in the field at random. The cluster heads are chosen based on their proximity to the sink. One important criterion for efficiency improvements is the number of cluster heads chosen.

$$CH_i = \max \mathrm{D}\,(N_i, Sink) \qquad (1)$$

Since this initial cluster heads are chosen based on their distance from the sink, the cluster formation will result in balanced clusters, extending the network's lifetime. Every CH broadcasts its coordinates and ID to all network nodes. Each member node receives the coordinates from the CHs and calculates the distance between itself and the CH using Hop count. Following distance computation, each member node joins the CHs with the shortest distance, and clusters form. The average number of nodes in each cluster is discovered to be equal. The advantages of the method discussed below are as follows:

- Load balancing can be accomplished by using balanced clusters.
- It lowers the energy consumption of CHs.
- It increases the network's lifespan.

After determining the best cluster heads, the other nodes calculate their distance from the best cluster heads using Hop count.

To ensure efficient transmission, avoid delays, reduce energy consumption, and extend network lifetime, sensor nodes communicate with the nearby cluster head. The cluster heads are initially selected deterministically based on their distance from the sink, but as the data transmission and aggregation process progresses, the residual energy of the cluster heads is checked in each round.

The chosen CH will keep collecting data and sending it to the sink until the energy reaches a certain threshold. When the energy level of the cluster heads is less than a predefined threshold value, the CH remains. If the residual energy reaches the threshold, the CH asks the cluster's other member nodes for residual energy and the distance to the sink.
The energy Centroid coordinates are calculated using the initial and residual energy. The member node with the highest residual energy and the closest proximity to the sink is chosen as the next cluster head. This procedure is repeated until all of the cluster's nodes have been depleted. The CH gathers data from the cluster's nodes, aggregates it, and sends it to the sink. The Disthrs are calculated using a free space and multipath model to send the collected data to the sink. The distance threshold used in the following equation determines whether data communication is one-hop or multi-hop:

$$Dis_{thrs} = \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{mp}}} \qquad (2)$$

Where ε_{fs} is the free space model and ε_{mp} is the multipath model. If the distance to the sink is less than the distance threshold, the CH communicates directly with the sink (i.e., using a single hop); otherwise, it communicates with the sink via the intermediate CHs (i.e., using multihop).

Data aggregation is the summarization of data from various nodes in a network that are intended to travel to the base station. To manage data redundancy, it eliminates duplicate data and transmits the refined data stream to the base station. The proposed data aggregation refines data by removing duplicate data sensed by nodes during a specific time period and forwarding refined data to the base station while consuming minimal energy.

In this approach, only a fraction of aggregated data is retained in the memory of each node, reducing the amount of data that must be transmitted and consuming network energy. Each node configures two variables, Max=∞ and Min=0. The time for sensing data is defined as T. If the data sensed falls between Max and Min then the reading is normal. If it does not fall within the range then it is an outlier.

In case of outlier we define a standard value TRstd. The outliers are adjusted to the standard value. After the defined time period the average of all the readings are taken by the nodes using the equation:

$$Tr_{aggr} = Avg\left(\frac{Tr_1 + Tr_2 + \cdots Tr_n}{n}\right) \quad (3)$$

Where Tr_{aggr} is the aggregated data reading and n is the number of readings. The aggregated data is sent to the cluster heads and the cluster heads aggregate the data and sends it to the sink. The Pseudo code of the proposed algorithm is given below:

Pseudo Code: EECEDD

- Start
- Compute for all N_i Distance D to Sink S
- Compute $CH_i = \max \mathrm{D}\,(N_i, Sink)$

- CH_i broadcasts ID to all N_i
- N_i joins Closest CH_i
- Set $Energy_{thr}$=50.0
- If CH_i reaches $Energy_{thr}$
- CH_i collects $Energy_{res}$ and D to S from all N_i
- CH_i with MAX($Energy_{res}$) && MIN (D to D)
- Selected as next CH
- Set Dis_{thr}
- If D< Dis_{thr} then Single hop
- Else Multihop
- End If
- End If
- Set T, Max=∞, Min=0
- If (Tr_i> Min && Tr_i<Max) then Tr_i is Normal
- Else Tr_i is Outlier
- Then Tr_i=Tr_{std}
- After T is lapsed
- Compute $Tr_{aggr} = Avg(\frac{Tr_1+Tr_2+\cdots Tr_n}{n})$
- N_i sends Tr_{aggr} to CH_i
- CH_i sends Tr_{aggr} ϵ all N_i to S
- Repeat every round
- End

VI. RESULTS AND DISCUSSION

The proposed method has been tested with a hundred nodes in the environment depicted in Table1.

The sensor nodes are distributed at random across a 100 m x 100 m field. The sink node is assumed to be in the centre of the field's top periphery. Each cluster will contain approximately 20% of the total nodes in this work. Network lifetime, delay, throughput and energy consumption are computed and compared with the LEACH and EHMR algorithms. The energy consumption of LEACH [11], EHMR [28], and the proposed EECEDD algorithms is shown in Figure 1.

Table 1. Simulation Parameters.

Parameter	Value
Network size	100 x 100
No. of sensor nodes	100
Radio propagation range	200 m
Channel capacity	2 M bits/s
Initial energy	1 J
Data packets	3200 bits
Simulation time	180 s
ε_{fs}	10 pJ/bit/m^2
ε_{mp}	0.0013 pJ/bit/m^4

The sensing environment, data computation, and data transmission all contribute to the amount of energy consumed. According to Figure 4, the proposed algorithm consumes 50% of the energy after 900 rounds, whereas LEACH [11] consumes 50% after 350 rounds and EHMR [28] consumes 50% after 400 rounds. Because the proposed algorithm's communication is based on residual energy and distance to the sink, the energy required to transmit data is reduced, which increases network lifetime.

As shown in Figure 1, this demonstrates that energy is balanced throughout the network, which can effectively balance network load while also contributing to an increase in network lifetime. Figures 2 and 3 show the delay and throughput achieved by the proposed EECEDD as the number of rounds in the network increases.

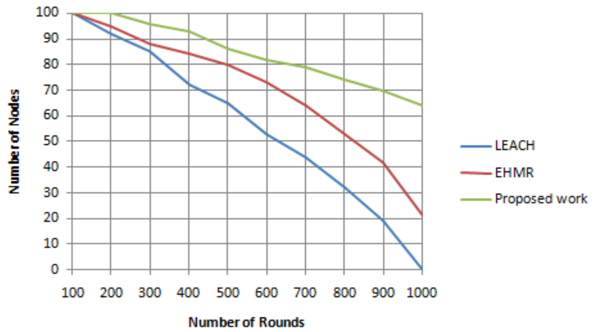

Fig 1. Network Lifetime.

When compared to the LEACH and EHMR schemes, the proposed EECEDD is found to be 12 % and 17 % faster. In contrast, the proposed EECEDD approach is found to significantly improve throughput by a remarkable margin of 13% and 15% when compared to the LEACH and ECCRP schemes. The proposed EECEDD approach's significant reduction in delay and excellent increase in throughput is primarily confirmed by its potential for enforcing performance.

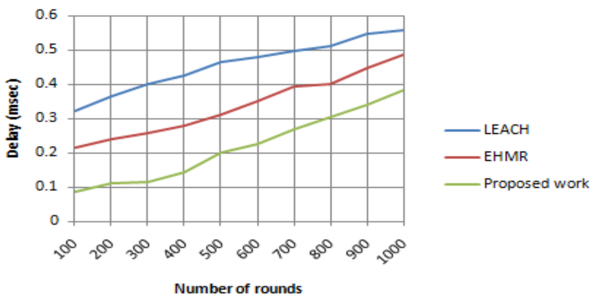

Fig 2. Delay.

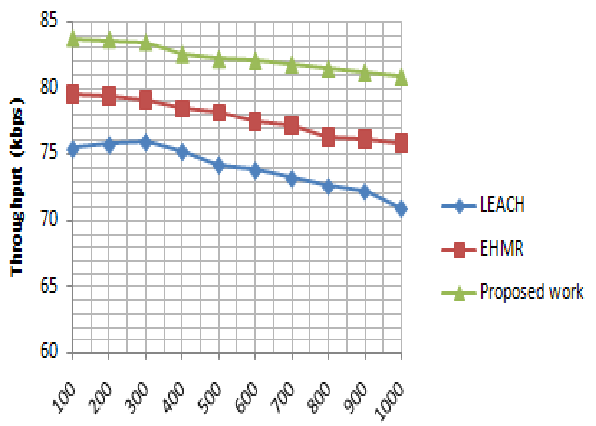

Fig 3. Throughput.

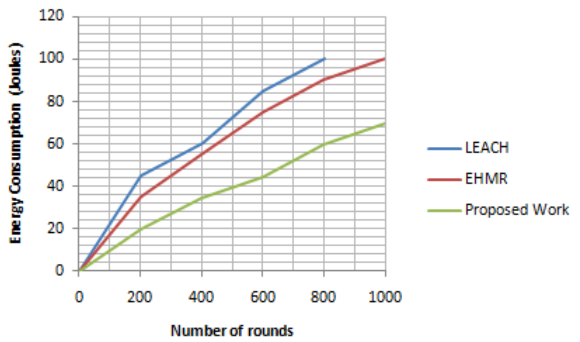

Fig 4. Energy Consumption.

VII. CONCLUSION

This paper proposes a new energy efficient clustering algorithm that claims to improve network lifetime and throughput while minimizing energy consumption and delay. The algorithm efficiently generates balanced clusters to balance network load. As the cluster heads are rotated, the death of nodes is reduced, resulting in a more stable network. In the future, energy-efficient routing mechanisms could be used to perform transmission in an energy-efficient manner.

REFERENCE

[1] M.Ezhilarasi, V.Krishnaveni, "A survey on Wireless Sensor Network: Energy and Lifetime Perspective", 2018, Taga Journal, vol 14, pp. 3099-3113, ISSN: 1748-0345.

[2] M.Nagarajan, S.Karthikeyan, "A New Approach to Increase the Lifetime and Efficiency of Wireless Sensor Network", 2012, IEEE International Conference of Pattern Recognition, Informatics and Medical Engineering (PRIME), pp. 231-235.

[3] Dr.Nagarajan Munnusamy, Sneha Vijayan, Ezhilarasi, M. "Role of Clustering, Routing Protocols, MAC protocols and Load Balancing in Wireless Sensor Networks: An Energy-Efficiency Perspective", Cybernetics and Information Technologies (Open Access), ISSN 1314-4081, Volume 21, Issue 2, June 2021.

[4] Shahraki, Amin, Amir Taherkordi, Øystein Haugen, and Frank Eliassen. "Clustering objectives in wireless sensor networks: A survey and research direction analysis." Computer Networks 180 (2020): 107376.

[5] Mazumdar, Nabajyoti, Saugata Roy, and Soumen Nayak. "A survey on clustering approaches for wireless sensor networks." In 2018 2nd International Conference on Data Science and Business Analytics (ICDSBA), pp. 236-240. IEEE, 2018.

[6] Rostami, Ali Shokouhi, Marzieh Badkoobe, Farahnaz Mohanna, Ali Asghar Rahmani Hosseinabadi, and Arun Kumar Sangaiah. "Survey on clustering in heterogeneous and homogeneous wireless sensor networks." The Journal of Supercomputing 74, no. 1 (2018): 277-323.

[7] Jan, Bilal, Haleem Farman, Huma Javed, Bartolomeo Montrucchio, Murad Khan, and Shaukat Ali. "Energy efficient hierarchical clustering approaches in wireless sensor networks: A survey." Wireless Communications and Mobile Computing 2017 (2017).

[8] Jain, Neeraj, P. Sinha, and S. K. Gupta. "Clustering protocols in wireless sensor networks: A survey." International Journal of Applied Information System (IJAIS) 5, no. 2 (2013).

[9] Akyildiz, Ian F., Weilian Su, Yogesh Sankarasubramaniam, and Erdal Cayirci. "Wireless sensor networks: a survey." Computer networks 38, no. 4 (2002): 393-422.

[10] Sneha, V., and M. Nagarajan. "Localization in Wireless Sensor Networks: A Review." Cybernetics and Information Technologies 20.4 (2020): 3-26.

[11] Chunyao FU, Zhifang JIANG, Wei WEI, Ang WEI, "An Energy balanced algorithm of LEACH protocol in WSN", International Journal of Computer Science, Vol 10, Issue 1, 2013, ISSN: 1694-0814.

[12] Sqatish Chand, Samayveer Singh, Bijendra Kumar, "Heterogenous HEED protocol for Wireless Sensor Networks", Wireless Personal Communications, No.77, 2014, pp.2117-2139.

[13] Xinhua, Wu, and Wang Sheng. "Performance comparison of LEACH and LEACH-C protocols by NS2." In 2010 Ninth International Symposium on Distributed Computing and Applications to Business, Engineering and Science, pp. 254-258. IEEE, 2010.

[14] Ishu Sharma, Rajvir Singh, Meenu Khurana, “Performance evaluation of PEGASIS protocol for WSN using NS2”, International Conference on Advanced Engineering and Applications, IEEE, 2015, Ghaziabad, India. DOI: 10.1109/I CACEA.2015.7164838.

[15] Robertus Bria, Ahdi Wahab, Mudrik Alaydrus, “Energy efficient analysis of TEEN Routing protocol with isolated nodes”, 4th International Conference on Informatics and Computing (ICIC), IEEE, 2019, Semarang, Indonesia. DOI: 10.1109/ICIC47613.2019.8985668.

[16] Murat Dener, “A new energy efficient hierarchical routing protocol for Wireless Sensor Networks”, Wireless Personal Communications, No.101, 2018, pp. 269-286.

[17] Saranya, V. Shankar, S. Kanagachidambaresan, G, R., “Energy Efficient Clustering Scheme (EECS) for Wireless sensor Networks with Mobile sink”, Wireless Personal Communications, No.100, 2018, pp. 1553-1567.

[18] Jiang, C. Daomin Yuan, Yinghui Zhao, “Towards Clustering Algorithms in Wireless Sensor Networks- A Survey”, IEEE Wireless Communications and Networking Conference, Hungary, 2009. DOI: 10.1109/WC NC.2009.4 917996.

[19] Xuxun Liu, “A survey on Clutering Routing Protocols in Wireless Sensor Networks” Sensors, Vol. 12, Issue 8, 2012, pp.11113-11153. https://doi.org/10.3390/s120811113.

[20] Han Z, Wu J, Zhang J, Liu L, “A general self organized tree based energy balance routing protocol for wireless sensor networks”, IEEE Transactions on Nuclear Science, Vol. 61, Issue. 2, 2014. DOI: 10.1109/TNS.2014.2309351.

[21] Bo Tang, Dingcheng Wang, Hui Zhang, “A centralized clustering Geographic Energy Aware Routing for Wireless Sensor Networks”, IEEE International Conference on Systems, Man and Cybernetics, IEEE, 2013, Manchester, UK. DOI: 10.1109/SMC.2013.8.

[22] Kai Peng, “A survey of Energy-efficient Data gathering in Wireless Sensor Networks”, Journal of software engineering, Vol. 11, Issue 1, 2017, pp. 94-101, ISSN:1819-4311.

[23] Salim, A. Badran, A, A., “Effective chain-based routing algorithm for Wireless Sensor Networks”, Journal of Computational and Theoritical Nanoscience, Vol. 14, No. 1, 2017, pp. 728-735.

[24] Singh, Samayveer, and Aruna Malik. "hetSEP: Heterogeneous SEP protocol for increasing lifetime in WSNs." Journal of Information and Optimization Sciences 38, no. 5 (2017): 721-743.

[25] Charan, Piyush, Tahsin Usmani, Rajeev Paulus, and Syed Hasan Saeed. "Performance of Distributed Energy Aware Routing (DEAR) Protocol with Cooperative Caching for Wireless Sensor Networks." Wireless Sensor Network 11, no. 3 (2019): 35-45.

[26] Samundiswary, P., and M. Raj Kumar Naik. "Performance Analysis of Deterministic Energy Efficient Clustering Protocol for WSN‖." International Journal of Soft Computing and Engineering (IJSCE) ISSN (2013): 2231-2307.

[27] Istwal, Yasha, and Shashi Kant Verma. "Dual cluster head routing protocol in WSN." In 2017 8th International Conference on Computing, Communication and Networking Technologies (ICCCNT), pp. 1-6. IEEE, 2017.

[28] Naushad, Alamgir, Ghulam Abbas, Shehzad Ali Shah, and Ziaul Haq Abbas. "Energy Efficient Clustering with Reliable and Load-Balanced Multipath Routing for WSNs." In 2020 3rd International Conference on Advancements in Computational Sciences (ICACS), pp. 1-9. IEEE, 2020.

[29] Gupta, Sindhu Hak, R. K. Singh, Jwalant Bodi, and Dhruv Chandhok. "Evaluation & analysis of energy efficient extension to LEACH protocol for WSN." In 2015 IEEE Power, Communication and Information Technology Conference (PCITC), pp. 686-690. IEEE, 2015.

[30] Khoshkangini, Reza, Syroos Zaboli, and Mauro Conti. "Efficient routing protocol via ant colony optimization (ACO) and breadth first search (BFS)." In Proceedings of the 2014 IEEE international conference on internet of things (iThings), and IEEE green computing and communications (GreenCom) and IEEE cyber, physical and social computing (CPSCom), Taipei, Taiwan, pp. 1-3. 2014.

[31] Adil, Muhammad, Rahim Khan, Mohammed Amin Almaiah, Muhammad Binsawad, Jehad Ali, Adeeb Al Saaidah, and Qui Thanh Hoai Ta. "An efficient load balancing scheme of energy gauge nodes to maximize the lifespan of constraint

oriented networks." IEEE Access 8 (2020): 148510-148527.

[32] Sahoo, Prasan Kumar, Jonathan Jen-Rong Chen, and Ping-Tai Sun. "Efficient security mechanisms for the distributed wireless sensor networks." In Third International Conference on Information Technology and Applications (ICITA'05), vol. 2, pp. 541-546. IEEE, 2005.

[33] Pal, Sougata, Simon Oechsner, Boris Bellalta, and Miquel Oliver. "Performance optimization of multiple interconnected heterogeneous sensor networks via collaborative information sharing." Journal of Ambient Intelligence and Smart Environments 5, no. 4 (2013): 403-413.

[34] Adil, Muhammad, Rahim Khan, Jehad Ali, Byeong-Hee Roh, Qui Thanh Hoai Ta, and Mohammed Amin Almaiah. "An energy proficient load balancing routing scheme for wireless sensor networks to maximize their lifespan in an operational environment." IEEE Access 8 (2020): 163209-163224.

[35] Zhang, Han, Liang Li, Xin-fang Yan, and Xiang Li. "A load-balancing clustering algorithm of WSN for data gathering." In 2011 2nd International Conference on Artificial Intelligence, Management Science and Electronic Commerce (AIMSEC), pp. 915-918. IEEE, 2011.

[36] Dagar, Mousam, and Shilpa Mahajan. "Data aggregation in wireless sensor network: a survey." International Journal of Information and Computation Technology 3, no. 3 (2013): 167-174.

[37] Krishnan, A. Muthu, and P. Ganesh Kumar. "An effective clustering approach with data aggregation using multiple mobile sinks for heterogeneous WSN." Wireless Personal Communications 90, no. 2 (2016): 423-434.

[38] Tang, ShaoJie, Jing Yuan, XiangYang Li, Yunhao Liu, GuiHai Chen, Ming Gu, Jizhong Zhao, and Guojun Dai. "DAWN: Energy efficient data aggregation in WSN with mobile sinks." In 2010 IEEE 18th International Workshop on Quality of Service (IWQoS), pp. 1-9. IEEE, 2010.

[39] Kumar, Naween, and Dinesh Dash. "Flow based efficient data gathering in wireless sensor network using path-constrained mobile sink." Journal of Ambient Intelligence and Humanized Computing 11, no. 3 (2020): 1163-1175.

[40] Bechkit, Walid, Mouloud Koudil, Yacine Challal, Abdelmadjid Bouabdallah, Brahim Souici, and Karima Benatchba. "A new weighted shortest path tree for convergecast traffic routing in WSN." In 2012 IEEE Symposium on Computers and Communications (ISCC), pp. 000187-000192. IEEE, 2012.

[41] Jayarajan, P., R. Maheswar, V. Sivasankaran, D. Vigneswaran, and R. Udaiyakumar. "Performance analysis of contention based priority queuing model using N-policy model for cluster based sensor networks." In 2018 International Conference on Communication and Signal Processing (ICCSP), pp. 0229-0233. IEEE, 2018.

[42] Raj, PV Pravija, Ahmed M. Khedr, and Zaher Al Aghbari. "Data gathering via mobile sink in WSNs using game theory and enhanced ant colony optimization." Wireless Networks 26, no. 4 (2020): 2983-2998.

[43] Kaswan, Amar, Kumar Nitesh, and Prasanta K. Jana. "Energy efficient path selection for mobile sink and data gathering in wireless sensor networks." AEU-International Journal of Electronics and Communications 73 (2017): 110-118.

[44] Liao, Wen-Hwa, Yucheng Kao, and Chien-Ming Fan. "Data aggregation in wireless sensor networks using ant colony algorithm." Journal of Network and Computer Applications 31, no. 4 (2008): 387-401.