Indian Journal of Artificial Intelligence and Neural Networking (IJAINN)
ISSN: 2582-7626 (Online), Volume-3 Issue-3, April 2023

An Efficient LEACH Clustering Protocol to Enhance the QoS of WSN

Pramod Kumar, Durga Mahato, Apurba Sinha, Shashank Singh

***Abstract:** The development of an energy-efficient routing protocol for wireless sensor networks has been a challenging task for academics. It is very different from the conventional routing protocols, which are based on I.P. addresses. These conventional routing protocols are not preferable for WSNs since conventional routing protocols depend heavily on the routing tables, which often require updates. Also, the WSN varies from thousands to ten thousand, making the task of managing routing tables not easy and economical in terms of hardware resources. There is always research going on to develop an efficient routing protocol in terms of energy for WSNs. LEACH protocol is one of them. Energy consumption in WSNs became a vital factor to be focused on in enforcing an efficient routing strategy. Numerous LEACH protocol variations propose improvements to the current Protocol. In our study, we looked at different LEACH protocol iterations and adopted a modified LEACH protocol to extend the lifetime of wireless sensor networks. We adopted various power levels for transmission between the cluster node, cluster head, and base station, as well as a novel method for choosing the cluster head. Our modified Protocol performs better when compared to parameters like network lifetime, dead nodes per round, Cluster heads formed, packets sent to the base station, etc.*

***Keywords:** CH Selection, Network lifetime, Energy Efficiency, WSN.*

I. INTRODUCTION

In general, the Internet of Things shapes computing and connectivity in the future. Nowadays, broadband connectivity has become cheap and ubiquitous. This gave birth to more powerful and smaller devices available with onboard sensors. Physical objects are becoming part of the internet. This phenomenon allows various application domains, from Green-IT to energy-efficient military applications.

Manuscript received on 07 September 2022 | Revised Manuscript received on 08 April 2023 | Manuscript Accepted on 15 April 2023 | Manuscript published on 30 April 2023.
***Correspondence Author(s)**

Pramod Kumar, Assistant Professor, Department of Computer Science and Engineering, Guru Gobind Singh Educational Society's Technical Campus (GGSESTC), Bokaro (Jharkhand), India. E-mail: pramodmehta95@gmail.com, ORCID ID: https://orcid.org/0009-0002-8271-6549

Mrs. Durga Mahato*, Research Scholar, Department of Computer Science and Engineering, APJ Abdul Kalam University, Indore (M.P), India. E-mail: durgscalls@gmail.com, ORCID ID: https://orcid.org/0009-0002-7066-7954

Apurba Sinha, Assistant Professor, Department of Computer Science and Engineering, Guru Gobind Singh Educational Society's Technical Campus (GGSESTC), Bokaro (Jharkhand), India. E-mail: m.sinha0686@gmail.com, ORCID ID: https://orcid.org/0009-0000-2661-8982

Shashank Singh, Assistant Professor, Department of Computer Science and Engineering, Babu Banarasi Das Institute of Technology & Management (BBDITM), Lucknow (U.P), India. E-mail: shashank.singh@bbditm.ac.in, ORCID ID: https://orcid.org/0000-0003-2909-4728

Recent developments in the IoT field made mobile Ad Hoc and WSNs necessary [1]. Researchers in recent years have challenged WSN. It has been a challenge since conventional routing algorithms, the ones that we use in IP-based networks, which depend on routing tables are not suited for WSNs. The size of the WSN may vary from thousands to tens of thousands. This makes the routing table the size used during the routing state in conventional routing algorithms, which is not an easily maintained thing in the case of WSN because of the size and the hardware limitations of the routers and nodes [1].

Despite the fact that WSNs are a subtype of wireless Ad Hoc networks, these networks should not use the same routing techniques. The route from the origin to the destination is included in each packet sent using ad hoc network routing techniques, which presuppose a thorough understanding of the complete network. Two headers will result in more data packets and more energy being used because they include the complete path in the packet. [2].

Section I contains the introduction of WSN, Section II contains the recent related work done, Section III describes the methodology of the proposed protocol, and Section IV describes the results after the tests. Section V is the concluding section explains research work with future directions.

II. LITERATURE SURVEY

Various routing protocols control the flow of packets in the network. LEACH or "Low Energy Adaptive Clustering Hierarchy," is a hierarchical-based protocol that is widely used. It has many forms, each having advantages in its own form. LEACH protocol reduces the consumption of Energy of WSN. Essential
features of the LEACH protocol in WSN are [1,2]:

- Clusters formation and selection of the Cluster head.
- Distribution of energy consumption in the entire network evenly.
- A better lifetime of the network.

The performance of the LEACH is far better than the conventional clustering through the use of adaptive clustering and cluster head rotation making energy distribution even over the network. LEACH is able to achieve a reduction in dissipation by using an adaptive hierarchical approach. Many forms of the LEACH protocol came into existence each trying to improve the original Protocol. Some primary forms are the Comparison of different protocols in WSNs, which is either LEACH-based or Fuzzy logic-based [3],[4],[5],[6],[7].

Published By:
Lattice Science Publication (LSP)

Table 1: Literature Survey of Different Protocols

Reference	Publication	Objective	Clustering Approach	CH Selection Approach	Metrics Used To Elect CH
Ying Zhang et al.[8]	IEEE Wireless Communications Letters	Network Lifetime and Energy efficiency	LEACH Based	Based on parameters like energy, distance etc.	Relative Energy and Neighborhood distance.
S. Lata et al. [5].	IEEE ACCESS, 2020	Network Lifetime and Reliability	Centralized Approach For Clustering,	Fuzzy Logic	Node Energy, Node Concentration, Node Centrality for CH and Node Energy, Degree and The Distance To The Base Station For Cluster Formation.
Z. Wang et al. [6].	IEEE Access, 2020	Energy Efficiency, Throughput, and Stability	Fuzzy C-Means	Improved Artificial Bee Colony	Location And Energy Of The Nodes,
Z. Zhao et al. [7].	IEEE Access, 2020	Energy Optimization and Load Balancing	Utilizing both the energy consumption model and the 3D spherical network structure model	Hierarchical Clustering Based On Residual Energy And Positions Of The Nodes	Closest Points, Furthest Points, Average Distance, Cluster Center Point, Residual Energy
J.S. Lee et al. [4].	IEEE Internet Of Things Journal, 2017	Network Lifetime But Also Reduce The Packet Loss	Distance Based Clustering	Fuzzy Logic	Residual Energy, Moving Speed and Pause Time
B. Mishra et. Al. [3].	JETIR, 2015	Network lifetime	LEACH Based	Fitness Function Based	Energy and Distance
Beiranvand et al. [2].	IEEE, 2013	Energy-efficiency and Throughput	LEACH Based	Fitness Function Based	Energy and neighbourhood information
Tong et al. [1].	IEEE, 2010	Energy Consumption and Network Lifetime	LEACH Based	Fitness Function Based	Energy and Node centrality

III. METHODOLOGY

Cluster heads are chosen at random according to the LEACH methodology. This opens the door to improving the LEACH protocol. This improves the network efficiency, especially in case of energy usage, load balancing, and the network's lifecycle [3].

3.1. Cluster Head selection strategy

Every node picks a random value in the range from 0 to 1. If this value is less than the threshold, it can be picked as a cluster head for the current round. This is the mechanism for standard LEACH. Moreover, once a node becomes the cluster head, it cannot be the cluster head for the next 1/p rounds [8].

Nevertheless, per our proposed Protocol, the threshold value calculation is based on the following logic.

$T(x) = 0.5 * [B * (P / (1-P * (k * \mathrm{mod}(1/P))) + (1-B) * E_{res} / E_{ini}]$ if x E G

Else

= 0

Where:

$B = E_{res} / E_{ini}$

E_{res} = Residual Energy of the node

$_{Mini}$ = Initial Energy of the node.

P = probability of becoming cluster head.

K = Present round number

G = Nodes set that is not clustered heads for the last 1/p rounds.

At the start of the program, the value of the B is 1. i.e., in the first round, our Protocol behaves as the normal LEACH protocol because the value of (1-B) will be 0. Only the first term contributes to the threshold value, and the second value becomes 0.

The weight of the second term in the threshold equation continues to contribute to its weightage in determining the formation of the cluster head as the value of K, the present round value, rises. Because the value of (1-B) rises as the number of rounds increases, the value of B, which represents the division of the node's initial and residual energy, begins to decline.

After a certain number of rounds, the residual energy ratio contributes more to the threshold value. It becomes a prominent factor in the network's cluster head formation.

B value should be adjusted dynamically. Initially, the value of residual energy is equal to the initial energy. So, the B value becomes 1. Gradually, the node energy decreases, and the residual energy ratio decreases and becomes 0. So, the value of the B changes from 1 to 0. So, the value of (1-B) changes from 0 to 1.

It takes more time and resources to determine the optimal amount of cluster heads for the network. Additionally, we can use an energy parameter, or the node's remaining energy, to exceed the specific threshold number. We can determine whether a residual node's energy in the current round is higher than a specific threshold value so that it can take part in the cluster head election, improving the network's load balancing metric and reducing overhead time while the cluster head is being formed. [4].

Retrieval Number: 100.1/ijainn.A38221012122
DOI: 10.54105/ijainn.A3822.043323
Journal Website: www.ijainn.latticescipub.com

Published By:
Lattice Science Publication (LSP)

The above step completes the cluster head formation step in the setup stage in the Protocol. Following this, cluster formation and schedule generator occur the same as in the original LEACH protocol. This completes the setup phase in the Protocol.

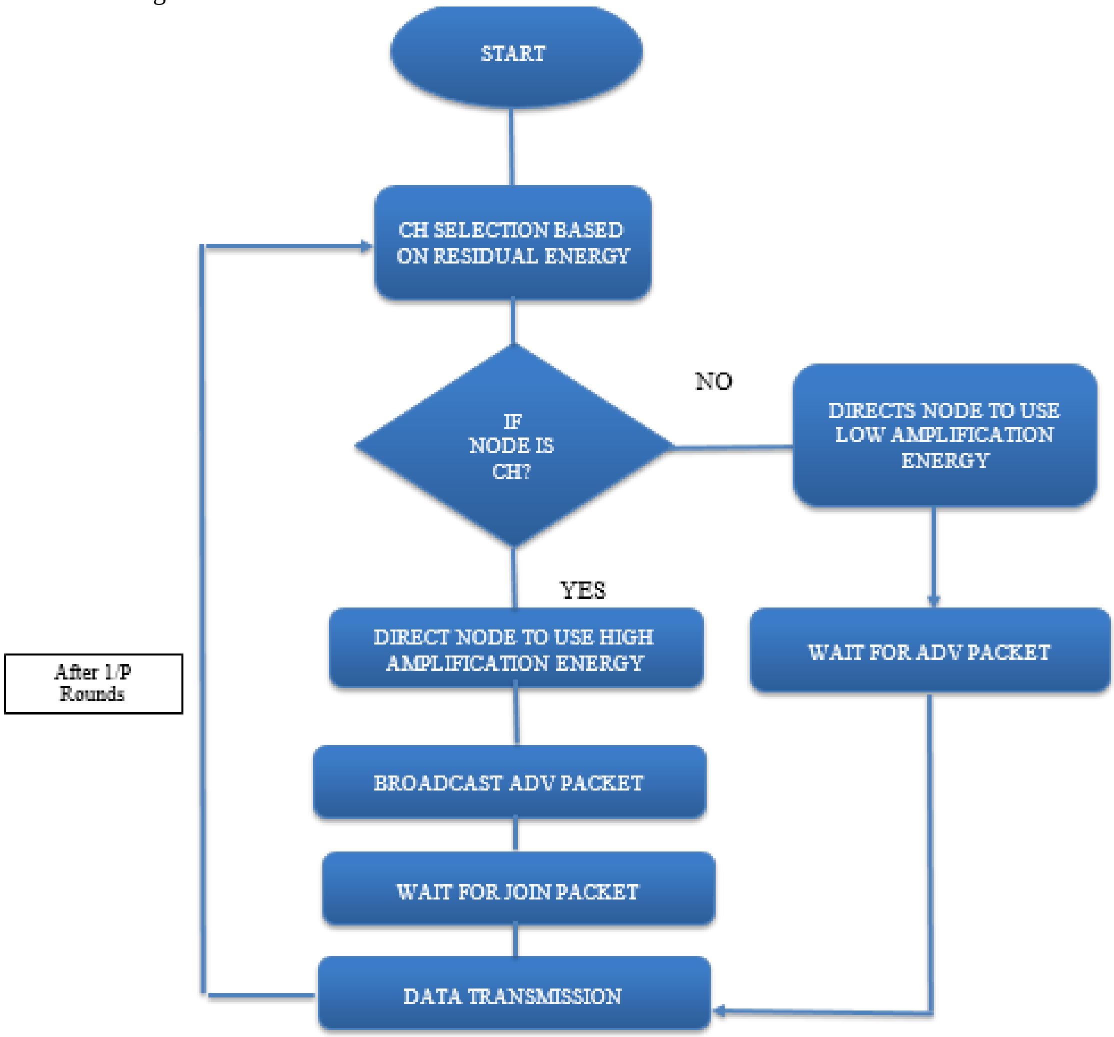

Fig. 1 Flowchart showing the proposed algorithm

The data is transmitted between the cluster heads or base stations in the steady stage shown in Figure 1.

3.2 Pseudo Code for Cluster Head Selection:

Step 1: START
Step 2: If Mod (R, 1/P) =0, go to Step 4.
Step 3: Else, wait for 1/P rounds.
Step 4: Calculate E_{res}: = Residual Energy of the node.
B: = E_{res} / E_{ini}.
Step 5: Calculate Threshold Value T as (0.5 * B (P/ (1-P*mod (R, round(1/P)) +(1-B) *B))
Step 6: Select a random value in the range 0 and 1.
Step 7: If the selected value is less than T, then go to Step 9.
Step 8: Else, Mark the node as a Normal node and direct it to use a Low Amplification Energy level.
Step 9: Mark the node as Cluster Head and direct it to use the High Amplification Energy level.
Step 10: Make data transmission.
Step 11: Calculate Energy dissipation and Update the Energy of the node.
Step 12: IF the Energy of node =0, mark it as a dead node.
Step 13: IF all nodes are dead, STOP.
Step 14: Else, go to step 2.

P is initialized as the probability of becoming Cluster Head in the network. R is the current round number or iteration number.

IV. RESULTS AND DISCUSSION

In our research, we built a 400 x 400-pixel sensor network with 100 nodes distributed randomly throughout. The base station was also considered to be a node, bringing the total number of nodes in the network up to n+1. Additionally, we presumed that the initial Energy of every node was the same and set to values of E0. Depending on the sort of cluster communication, such as intra-cluster communication and communication between the base station and cluster head, we also took into account different amplification energies. To compare various plots, we took into account a limit of 5000 rounds of iteration. Every node initially has an equal chance of becoming a cluster head because the intended percentage of cluster heads (p) is fixed at 0.1. we have made the Comparison based on the simulation parameters shown in Table 2.

Retrieval Number: 100.1/ijainn.A38221012122
DOI: 10.54105/ijainn.A3822.043323
Journal Website: www.ijainn.latticescipub.com

Published By:
Lattice Science Publication (LSP)

Table 2: Simulation Parameters

S.No.	Parameters	Values
1.	Software	MATLAB 8.3
2.	Tool	Communication tool box
3.	Simulation area	500m X500m
4.	Total rounds	1000
5.	Total nodes	200 to 800
6.	Methodology	Modified Leach
7.	Total live nodes	800
8.	Dead node till end of simulation	100
9.	Average energy consume each node	1 nJ
10.	Average residual energy	380 J
11.	Count of cluster heads	95
12.	Packet sent to base station per round	110
13.	Packet to cluster head	140 Kbps

Now by running the code that we modified, we obtain the below results and are compared by plotting them in the same graph. Performance evaluation is done based on the above-discussed discussed number of packets sent to the base station vs. the number of rounds, the number of nodes that are dead vs. the number of rounds, etc.

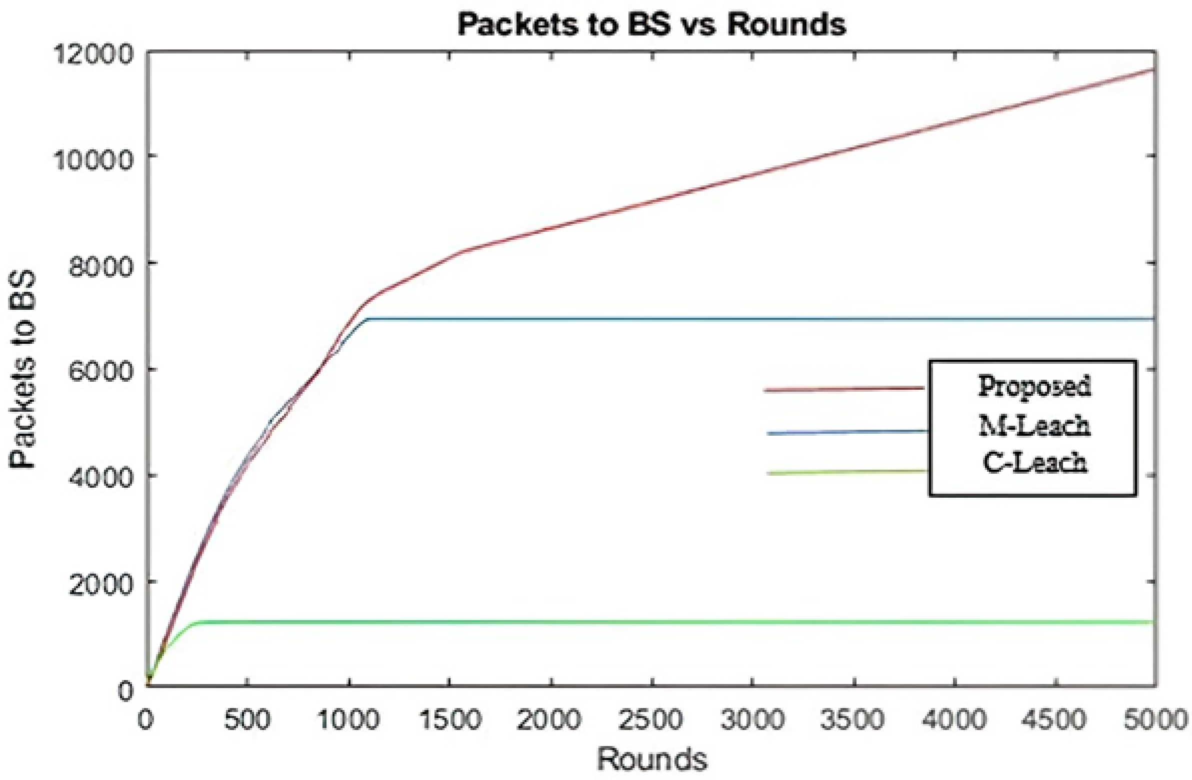

Figure 2: Packets to B.S. vs. Rounds

In figure 2, the red color line in the graph represents the output of the protocol that we proposed whereas the blue line in the graph is the output obtained by the protocol that already exists. In this graph, in the existing protocol, the number of packets sent to the base station is less than that of our proposed protocol. As the number of rounds reaches 5000 the number of packets sent to the base station in the existing protocol is 7000 whereas in the existing protocol it reaches 8500. Through this, we can say that as the number of packets that are sent is more, this is more efficient than the existing protocol.

Retrieval Number: 100.1/ijainn.A38221012122
DOI: 10.54105/ijainn.A3822.043323
Journal Website: www.ijainn.latticescipub.com

Published By:
Lattice Science Publication (LSP)

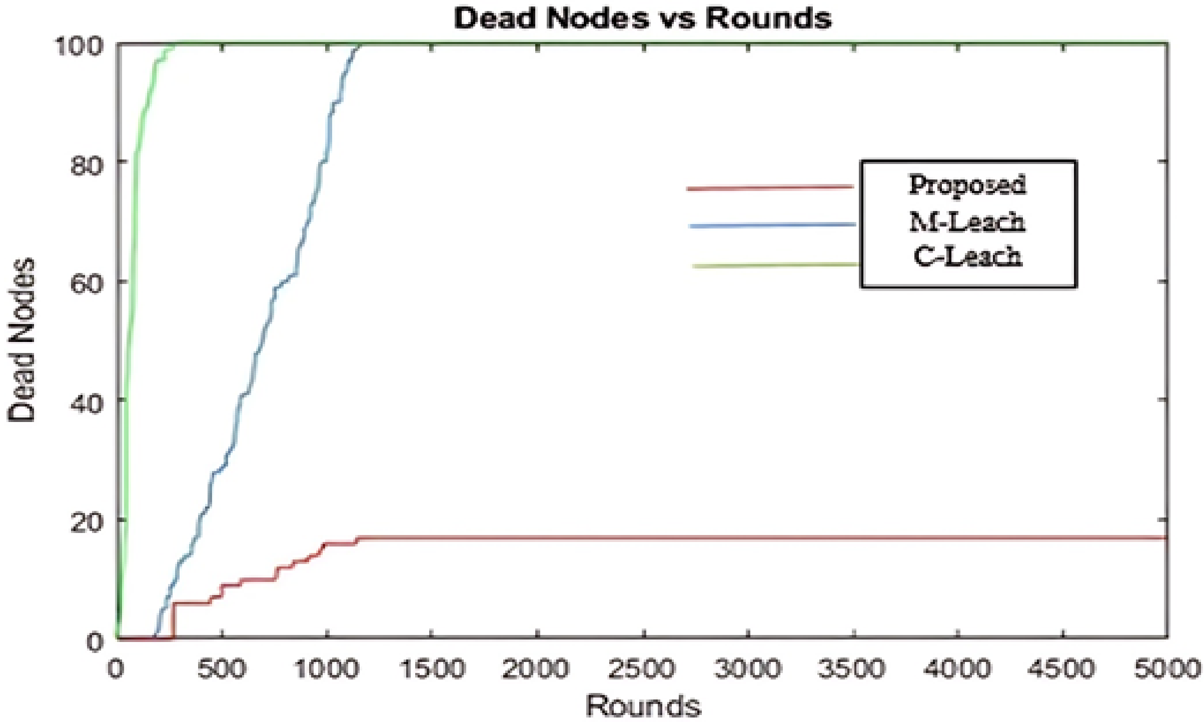

Figure 3: Dead Nodes Vs. Rounds

In figure 3, the red color line in the graph represents the output of the protocol that we proposed whereas the blue line in the graph is the output obtained by the protocol that already exists. Here in this graph in the existing protocol as then, the number of rounds increases the number of dead nodes increases and it reaches maximum nodes i.e.100 whereas in the proposed protocol the dead nodes reach 20 So according to this graph we can say that suggested protocol operates better than the current one because here all nodes are not going to be dead and still take part in routing the packets.

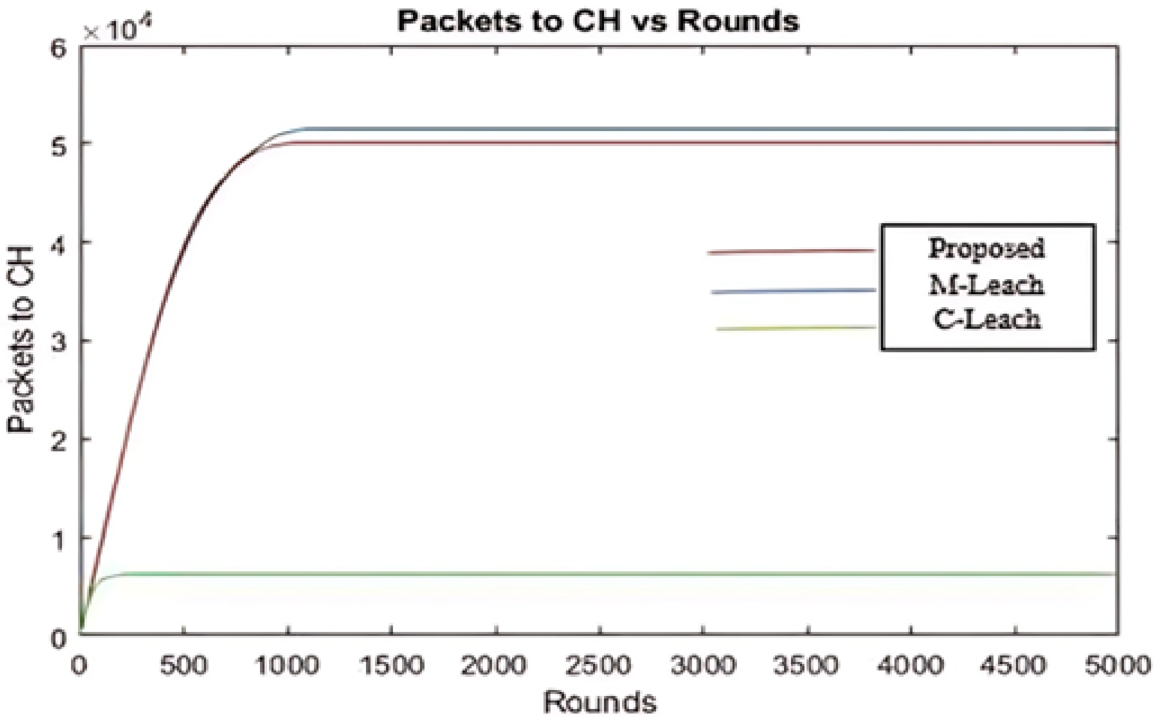

Figure 4: Packets to C.H. vs. Rounds

In figure 4, the red color line in the graph represents the output of the protocol that we proposed/modified whereas the blue line in the graph is the output obtained by the protocol that already exists. In this graph in the existing protocol, the number of packets sent to the cluster heads is more than that of the number of packets sent to cluster heads in the proposed protocol. This is the only parameter where our proposed protocol works the same as the existing protocol initially and constantly decreases for the larger number of rounds.

Retrieval Number: 100.1/ijainn.A38221012122
DOI: 10.54105/ijainn.A3822.043323
Journal Website: www.ijainn.latticescipub.com

Published By:
Lattice Science Publication (LSP)

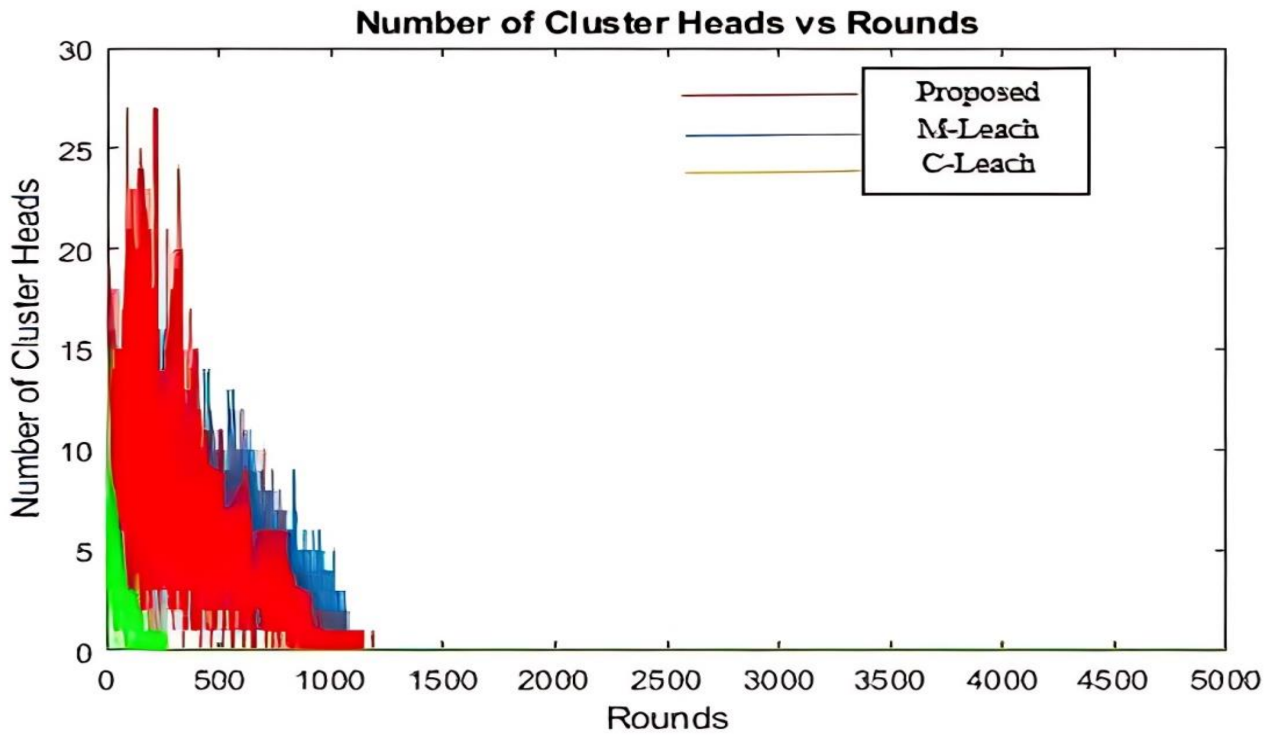

Figure 5: Number of cluster heads vs. Rounds

In the figure 5, the red color line in the graph represents the output of the protocol that we proposed/modified whereas the blue line in the graph is the output obtained by the protocol that this already existing. The number of cluster heads formed in the proposed protocol is more than that of the existing protocol. The number of cluster heads increased with the previous one form which we can say that that the suggested protocol operates better than the current one which is obtained by the efficient CH method.

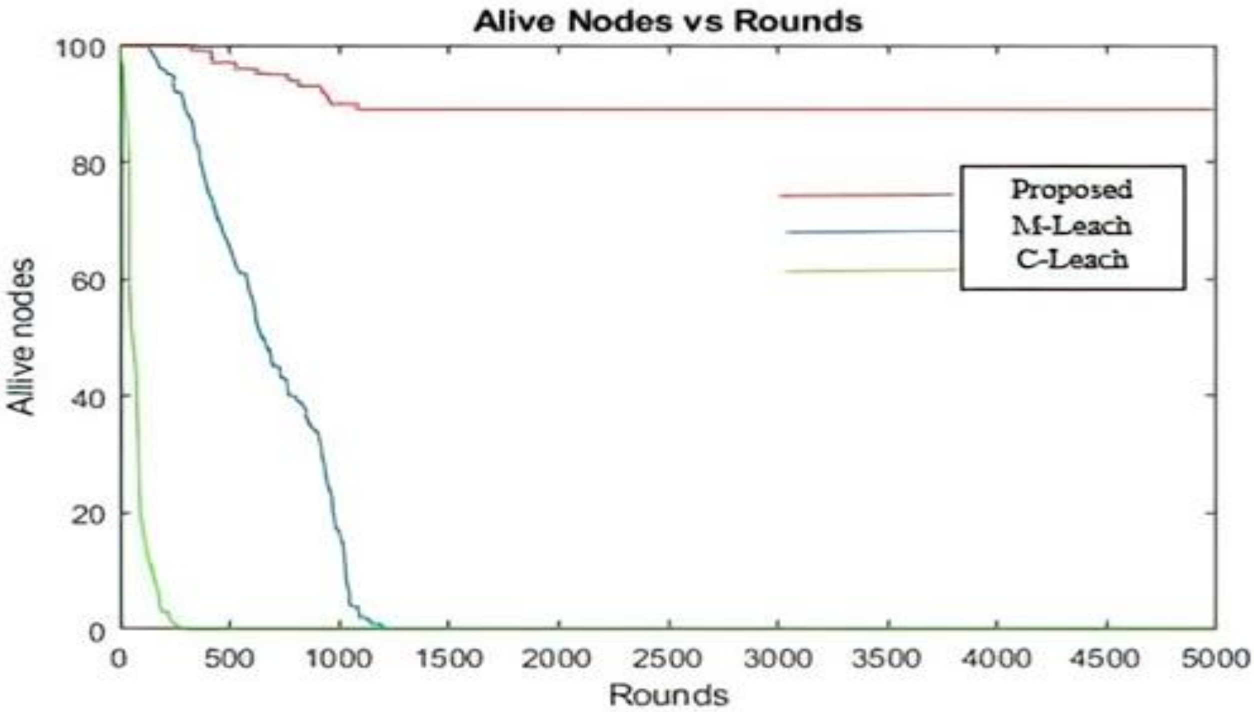

Figure 6: Alive nodes vs. Rounds

In figure 6, The blue line in the graph is the output of the protocol that already exists, and the red line in the graph depicts the output of the protocol that we proposed or modified. In comparison to the current protocol, the proposed protocol has a higher number of active nodes. This algorithm is more effective than the current one because there are more active nodes.

Retrieval Number: 100.1/ijainn.A38221012122
DOI: 10.54105/ijainn.A3822.043323
Journal Website: www.ijainn.latticescipub.com

Published By:
Lattice Science Publication (LSP)

Table 3. Performance Parameters Comparison

Parameters	Previous Work	Proposed Work
Simulation area	500m X500m	500m X500m
Total nodes	200 to 800	200 to 800
Methodology	M- Leach	
Network transfer rate (Throughput)	250 Kbps	270 kbps
Data size	200 byte	400 byte
MA code size	5 nJ	1 nJ
Node Energy consumed	1024 bytes	200 bytes
Execution time	1000 Sec	164.9 seconds
Overall energyconsumption	1000 J	380 J

V. CONCLUSION

In order to enhance the performance of the WSN, we suggest a new LEACH Protocol version that takes into metrics like reliability, network lifetime, and energy efficiency. The proposed work defines new rules for cluster head selection in the setup stage. We define the threshold value for assigning cluster heads predicated on the node's remaining energy. This energy residual does not impact the threshold value initially, but when the number of rounds increases, it keeps on adding more weight to the threshold value and becomes an essential metric feature for cluster head selection.

We compared the results of this proposed Protocol with the existing Protocol in MATLAB (Shown in Table 3), ran the simulation for 2000 rounds, and took 100 nodes initially. We found that the proposed protocol results are better than the original One. We can still improve more features for the Protocol, like Quality of Services (QoS). There is no classification for the type of data flowing in the network. Adding more fields in the data packet to improve reliability and quality of service can be done by assigning priority to the data. Selecting the right amount of cluster heads for the network can maximize cluster head formation while minimizing energy loss.

ACKNOWLEDGMENT

We appreciate the BBDNITM faculty in Lucknow, India, for their inspiration and unwavering support. We also want to thank Mr. Rudrendra Badahur Singh for his insightful comments and efforts.

DECLARATION

Funding/ Grants/ Financial Support	No, I did not receive.
Conflicts of Interest/ Competing Interests	No conflicts of interest to the best of our knowledge.
Ethical Approval and Consent to Participate	No, the article does not require ethical approval and consent to participate with evidence.
Availability of Data and Material/ Data Access Statement	Not relevant.
Authors Contributions	All authors have equal participation in this article.

REFERENCES

1. M. Tong and M. Tang, "LEACH-B: An Improved LEACH Protocol for Wireless Sensor Network," 2010 6th International Conference on Wireless Communications Networking and Mobile Computing (WiCOM), 2010, pp. 1–4, DOI: 10.1109/WICOM.2010.5601113 [CrossRef]
2. Z. Beiranvand, A. Patooghy, and M. Fazeli, "I-LEACH: An efficient routing algorithm to improve performance & to reduce energy consumption in WSN," The 5th Conference on Information and Knowledge Technology, 2013, pp. 13-18, DOI: 10.1109/IKT.2013.6620030. [CrossRef]
3. B. Mishra, S.S. Rai, and N.K. Saur, "M-LEACH: A modified version of LEACH for WSNs," International Journal of Emerging Technologies and Innovative Research (www.jetir.org), ISSN:2349-5162, Vol.2, Issue 12, page no.82-87, December-2015, Available: http://www.jetir.org/papers/JETIR1512014.pdf
4. J.S. Lee and C. -L. Teng, "An Enhanced Hierarchical Clustering Approach for Mobile Sensor Networks Using Fuzzy Inference Systems," in IEEE Internet of Things Journal, vol. 4, no. 4, pp. 1095-1103, Aug. 2017, DOI: 10.1109/JIOT.2017.2711248 [CrossRef]
5. S. Lata, S. Mehfuz, S. Urooj, and F. Alrowais, "Fuzzy Clustering Algorithm for Enhancing Reliability and Network Lifetime of WSN," in IEEE Access, vol. 8, pp. 66013–66024, 2020, DOI: 10.1109/ACCESS.2020.2985495. [CrossRef]
6. Z. Wang, H. Ding, B. Li, L. Bao, and Z. Yang, "An Energy Efficient Routing Protocol Based on Improved Artificial Bee Colony Algorithm for WSN," in IEEE Access, vol. 8, pp. 133577–133596, 2020, DOI: 10.1109/ACCESS.2020.3010313. [CrossRef]
7. Z. Zhao, D. Shi, G. Hui, and X. Zhang, "An Energy-Optimization Clustering Routing Protocol Based on Dynamic Hierarchical Clustering in 3D WSNs," in IEEE Access, vol. 7, pp. 80159–80173, 2019, DOI: 10.1109/ACCESS.2019.2923882. [CrossRef]
8. Y. Zhang, T. Liu, H. Zhang and Y. Liu, "LEACH-R: LEACH Relay With Cache Strategy for Mobile Robot Swarms," in *IEEE Wireless Communications Letters*, vol. 10, no. 2, pp. 406-410, Feb. 2021, doi: 10.1109/LWC.2020.3033039. [CrossRef]

AUTHORS PROFILE

Mrs. Durga Mahato in pursed Bachelor of Engineering in E&TC from North Maharashtra University, Maharashtra, India in year 2004 and Master of Technology in Control System from BIT Sindri, Jharkhand in year 2010. She is PHD scholar at A.P.J Abdul Kalam University, Indore, India. Her main research work focuses on Network Security, Wireless sensor network and Privacy. She has 14 years of teaching experience.

Mrs. Apurba Sinha in pursed Bachelor of Technology from Bengal college of engineering and technology, Durgapur, West Bengal, India in year 2008 and Master of Technology from HIT, Kolkata, West Bengal in year 2016. She is currently working as Assistant Professor in Department of Computer Sciences and Engineering, GGSESTC, Bokaro, India since 2019. Her main research work focuses on Network Security, Wireless sensor network. She has 6 years of teaching experience.

Mr. Pramod Kumar in pursed Bachelor of Technology from Cambridge Institute of Technology, Ranchi, India in year 2010 and Master of Technology from RVSCET Jamshedpur, Kolhan University Chaibasa Jharkhand Bengal in Year 2016. He is currently working as Assistant Professor in Department of Computer Sciences and Engineering, GGSESTC, Bokaro, India since 2019. Her main research work focuses on Wireless sensor network and Privacy. He has 4 years of teaching experience

Mr. Shashank Singh have completed B.tech Computer Science and Engineering from ICFAI University Dehradun in year 2013 and M.tech in Computer Science & Engineering, From Shri Ramswaroop Memorial University Lucknow, India in 2015. He is currently working as Assistant professor at AKTU, lucknow, India. His area of Research is computer Networks, trying to get more and more achievements in this field. He has 2 years of teaching experience and 2 years of Research Experience.

Retrieval Number: 100.1/ijainn.A38221012122
DOI: 10.54105/ijainn.A3822.043323
Journal Website: www.ijainn.latticescipub.com

Published By:
Lattice Science Publication (LSP)