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Improving QoS Parameters for Clustering in MANET using Grey Wolf Optimization and Global Algorithm Technique

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Abstract—Manet have several nodes that are linked together wirelessly and the nodes are mobile in nature. Nodes position is flexible. The primary issue with the traditional clustering method is that it is prone to become trapped in the regional optimum path. While the nodes are being transmitted or received, energy is used. Through the use of the GWOGA clustering technique, CHs collect data from cluster participants and communicate other nodes with the cluster. While choosing the best CH to lengthen the network's lifespan is the Manet is most vital responsibility. Clustering based on the Grey Wolf Optimization and Global Algorithm (GWOGA), an attempt has been made to address this issue. GWOGA search function is employed for the best cluster centres in the supplied feature span. The cluster centres are encoded using the agent representation. When choosing the best CHs, the GWOGA dynamically balances the process of increasing and diversifying search. In addition, choosing the best CHs for the network is aided by factors like node degree, energy, distance, node centrality, Throughput, Delay, Path Loss Ratio, etc. The computational findings show that GWOGA offers improved values of excellent throughput, packet delivery ratio, end delay, energy a better lifespan segregated with the performance of normal clustering method. NS2 simulator is used for the simulation for finding QoS parameters.

Keywords-Cluster heads, Grey wolf optimization, NS2, QOS, Manet, Delay, Throughput, Energy, Path loss

I. INTRODUCTION

Global daily life and business are impacted by the increasing rise of wireless communication Global high-speed data interchange is anticipated by future wireless networks. Globally, portable devices will function digitally, facilitating communication and teamwork. Remote classrooms, training facilities, and hospitals can all benefit from wireless video. Manet are used in numerous applications, including dense domain, medical industry and business and its industrial goals. Compact and powered by a tiny battery, WSN sensors are small in size. However, due to the installation of nodes position in challenging or non-man-movement situations, replacing or switching the source of energy node is rather difficult. Scalability, fault tolerance, energy limitations, path construction, and other problems plague the WSN. If the network is unstable,[4] then these parameters degrade and lower the performance of the majority of the sensors will lose energy as a result of Three sections: 1) data collection 2) data transmission. 3. data receiver. More energy is used by directly delivering data to BS than by erecting the surroundings and processing it. The lifespan of the network will also be shortened by increased sensor energy consumption The longevity and performance of Manet are improved via energy optimization. Network stability and energy reduction are achieved through clustering. For communication purposes, clusters choose Cluster Heads (CHs). Energy is used in direct data transmission; hence effective routing techniques were developed to save energy.

Several data points are divided in a finite no of clusters with threshold value of the nodes in the cluster. By the process of clustering, which aims to maximize between-variability of group (also called as the intercluster communication with distance of the nodes) and reduce within variability of group (also called as the intracluster communication with distance of the nodes).[5] The different kinds of the currently used clustering algorithms are classical clustering and met heuristic Hierarchical clustering, model-based clustering, grid-based clustering, partitioned clustering, density-based clustering, are the different categories that can be used to categorize traditional clustering methods.[4] K–means(KM) is simple and very effective classical clustering technique .The disadvantage of KM is that it is dependent on the prime state and coveys the local optimum path . The GWOGO is a modern swarm intelligence method that Mirjaliliet [9] al. first suggested. Numerous optimization issues have been effectively solved using the GWOGO Technique. The social behavior of the animals served as the algorithm primary source of inspiration wolves and the order that rules them. Wolves as a cluster are frequently observed in packs of 6 to 14 individuals in the wild. Typically, dominant and his mate wolf are two wolves lead the pack referred to as the alpha level. Other adult wolves from the pack at the second highest level, referred as the beta level; delta wolves arrive at the third level. The lowest level of wolves is known as omega wolves. The alpha wolves are frequently organizing the hunting attacks, making decisions regarding the main pack like hunting, upholding order, determining sleeping locations, also determine waking hours. Beta wolves act as alpha wolf's advisors and relay comments from the other wolves to them. Caretaker, elders, Scouts, sentinels, hunters, and make up the delta group, which is in charge of alertness and safeguarding the flock from danger. Another intriguing activity of the grey wolves is group hunting. Wolves follow, chase, and get close to their prey before continuing. It is hunted, surrounded, and hounded until it gives up. The wolves finally charge the standing prey.

II. PERFORMANCE METRICS PARAMETERS &IT'S EVALUATION IN MANET

A. Delay

Delay is a time needed for a data packet to transmit from its source to its node destination taking into account any propagation, switching, or queuing delays. Manet are employed in delay employed applications to send the data packets in real time. Fast computation or communication do not constitute real-time.The packet begins it's from the host (the source), travels via numerous routers, and finally arrives at another host (the destination). The packet experiences a variety of delays as it travels via different nodes along the route. The calculation of the average packet delay is hold off and illustrated by the following formula:

$$\text{Average Delay} = \frac{\sum_{i=1}^{n} \text{ packet ingress }_i - \text{ packet initiation }_i}{n}$$

Here, packet ingress (i) is time right the packet "i" leaves the source, and packet ingress (i) is the time right after the packet "i" reaches the location. The total no of packets is "n". It is decided how long the packet's commencement and appearance periods diverge from one another. the typical Delay offers a fair average value.

B. Delay Variation

It is the alteration in end-to-end delay, sometimes referred to as delay in average values i.e. variance,that shows the fluctuation in transmission of packet times over packet networks switched path.. It is brought on by variance in queue in delays that succeeding packets encounter [1]. The formula that follows shows how to calculate average jitter.

$$\text{Average Jitter} = \frac{\sum_{i=1}^{n} \left((\text{Packet ingress }_{i+1} - \text{ Packet initiation }_{i+1}) - (\text{Packet ingress }_{i} - \text{ Packet initiation }_{i}) \right)}{n-1}$$

C. Thoughput

Sometimes referred to as bandwidth, is the actual data packets that can be transmit in a given amount of time. The transmission rate of individual data packets per second (bit/s or even bps) is known as throughput. It's a key component to support of Quality-of-service parameters[1]. The Throughput computation is represented by the formula below. In the formula, Packet initiation 0 is the time taken for the first packet abjures a source, Packet Ingress is time taken for the last packet to reached, and Packet Size are amount of packet length of the ith packet reaching the location.

$$\text{Throughput} = \frac{\sum_{i=1}^{n} \text{ Packet Size }_1}{\text{Packet ingress }_n - \text{ Packet initiation }_0}$$

The transmitting time, Packet Ingress, and packet size are typically stored for each packet. Every packet's dimension is added to the total amount of information transferred to calculate throughput. The full time is what really distinguishes the First packet commencement period from the Final packet arrival period.

D. Packet Loss

During transmission, one or perhaps multiple data packets can fall or be dropped. When wireless communication has packet loss, there could be a number of causes. For instance, when the router's barrier is erected after the packet has begun to approach the router, a few packets may fail to ship. Insufficient transmission power, equipment program issues, software issues, or even overloaded network nodes may result in additional packet loss. The formula that follows shows how to calculate packet loss in network. The ratio of information

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given through the source to information that hasn't arrived at the destination.

$$\text{Packet Loss Rate } = \frac{\sum_{i=1}^{n} \text{ Lost packet Size }_i}{\sum_{i=1}^{n} \text{ Total packet Size }_i} X100$$

Basic form of models for cluster head elected framework The cluster head selection process for Energy and node mobility plays a vital responsibility for improving the network lifetime. For the appropriate results a modelling of Energy and distance utilization representation given further in details. It's may also improve the QoS parameters of the network and also improves further the network lifetime.

E. Energy Modeling & it's framework

To adopt the energy usage model which is depends *on energy lost by the transmitter (ET) and receiver (ER), we calculated the entire network energy consumption (E) in this model, which we mathematically expressed as:*

$$\mathrm{E_{Total}}\,(\mathrm{n}, \theta) = \mathrm{E_T}(\mathrm{n}, \theta) + \mathrm{E_R}(\mathrm{n})$$

Whereas $E_{Total}(n, \theta)$ indicated the total amount of energy used by the network, $E_T(n, \theta)$ represented the energy used for various power applications and amplifier circuit.. The mathematical Expressions for the transmitter's energy usage when broadcasting n data bits is given by

$$E_T(n, \theta) = \begin{cases} n \times E_{\text{eg}} + n \times \varepsilon_{fs} \times \theta^2 & \text{if } \theta < \varphi \\ n \times E_{\text{eg}} + n \times \varepsilon_{mp} \times \theta^4 & \text{if } \theta \geq \varphi \end{cases}$$

whereE_{eg} stands for the amount of energy needed to operate the transmitter per bit. For the free and multi-path model, respectively, εfs and εmp stand for the amplification energy, while stands for the threshold value of the nodes for communicating distance, and its value is determined by

$$\varphi = \sqrt{\frac{\varepsilon_{fs}}{\varepsilon_{mp}}}$$

stands for distance parameter used to calculate how much transmitter energy is used to transmit a certain amount of data. The Transmitted energy is equal θ to if the data transfer falls inside the $\theta 2$ else $\theta 4$ [2]. As a result, it is thought that distance and workload are important factors in extending network longevity. Additionally, the energy used by the receiver section to receive data ER(n) in n bit is given by:

$$E_R(n) = n \times E_{\text{eg}}$$

For residual energy level (Erd) and total energy level the node ($Etotal$) after transmitting and receiving packetsthe network lifetime (NL) is calculated. The n-bit data is stated as follows:

$$NL(S_i, CH_j) = \frac{E_{\text{rd}}^i}{E_{\text{total}}^i\,(n, \theta)}$$

whereErd denotes the node residual energy and E_{total} denotes total energy used by the network's sensor nodes. NL(Si, CHj) denotes the lifetime of network for the i number of nodes (Si) and CHj cluster heads elected node. The network lifetime will be calculated according to the neighbor's nodes and how much time the nodes in which CH can be maintain [20].

F. Distance Modeling & its Framework

According to location of mobile node in the network, any communication among the cluster head node (CH) with other nodes may generally demand a certain amount of energy. Data transmission[18] over shorter distances between sensors can use less energy than data transmission over longer distances between other nodes in the cluster. Mathematical expression of distance modelling between cluster head and other cluster node given as:

$$\theta_i = \sqrt{(\mathrm{x} - x_i)^2 - (\mathrm{y} - y_i)^2})$$

In this formula, θi stands for the i^{th} node's distance from the CH (x, y) coordinates (xi, yi) stands for the node's position of other nodes in the cluster, and (SN) stands for the network's total number of cluster node. Additionally, the following formula is used to calculate the sensor and CH's Euclidean distance:

$$\boldsymbol{\theta(SN_i, N_{CH}) = \sqrt{\left(x_j - x_i\right)^2 - \left(y_j - y_i\right)^2}}$$

$$\boldsymbol{(i = 1, 2, \dots, SN; \quad j = 1, 2, \dots. \quad N_{CH})}$$

NCH stands for the number of elected cluster heads in the network.

III. GENERIC GREY WOLF OPTIMIZATION

An original meta-heuristic algorithm techniques motivated by the way of grey wolves hunt . The hierarchy is made up of the alpha, beta, delta, and omega wolf kinds. The main leader decision maker is alpha, takes choices, and beta provides assistance to alpha. Omega, the lowest level capable of satiating the needs of the entire group, is governed by delta, [3] who bows to alpha and beta GWOGO is used in this situation for choosing the Cluster Head.

A. GWOGA Mathematical Model

The mathematical models of (GWOGO) that are implement a unique route optimization and malicious node detection in MANET techniques[3]. Below Equations illustrates the usage of mathematical notations to encircle the prey.

$$\text{GWOGA=}|\text{ C. } X_P(\text{t})\text{-X(t)}|$$

$$X(t+1) = X_P(t) - D.GWOGA$$

$$GWOGA_\alpha = |C_1 - X_\alpha - X|$$

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$$GWOGA_{\beta} = |C_2 - X_{\beta} - X|$$

$$GWOGA_{\delta} = |C_3 - X_{\delta} - X|$$

$$GWOGA_{\omega} = |C_4 - X_{\omega} - X|$$

To provide better route optimization, the GWOGA technique is deployed by assuming the notations for dominating graph application. Assume we have a cluster of tiny settlements in a faraway region of the planet. In order to transmit messages to all of the villages in the area, we would like to establish radio stations in some of these communities. Each radio station has a broadcasting range of 50 kilometers; thus, we need to use multiple stations to reach every community. However, since radio stations are expensive, we want to find the fewest number of them that can still reach all other settlements.

IV. Steps For Cluster Head Selection Using Gwoga

Step 1: Initial Network Deployment

In Manet Network nodes are flexible. It initially deployed, requiring the configuration of introductory parameters. The number of nodes in network and geographic size of network area are requires for some parameters.

Step 2: Choosing the CH Employing the original LEACH algorithm

For network deployment process, the LEACH algorithm is utilized for to start the Cluster Head (CH) selection process. Because it uses Time-Division Multiple Access (TDMA), this technique was chosen. Every round, utilization of each node is a stochastic method to determine whether to become the cluster head. Nodes that have served as the cluster head in the past are not taken part in the network.

Step 3: Grey Wolf Optimization and Global Algorithm (GWOGA)

The GWOGA algorithm has been set up. Alphas, betas, deltas, and omegas are the four basic wolf kinds covered by GWOGA, which was originated by the hierarchical leadership quality and hunting dynamics process of grey wolf[1]. The Entire procedure details looking for prey, surrounding the prey, and using the prey type -hunting technique.

Step 4: Contemporize Alpha, Beta, and Delta and omega Values of GWOGA

The GWOGO algorithm's alpha, beta, and delta and omega wolf values have been adjusted. Alpha is the chief executive who makes decisions. In a subordinate role to alpha, beta shares information with its subgroups, deltas, and omega which participates in decision-making. It is expected that alpha(α) , beta (β) , delta(δ) and omega (ω) wolves have superior knowledge for positions in cluster of probable prey based on mathematical simulations of hunting behavior.

Step 5: Begin the process of optimization

The modified wolves' values are expected to start their optimization process. If optimization is accomplished, further actions are taken. If not, Step 3 is called again for re-initialization.

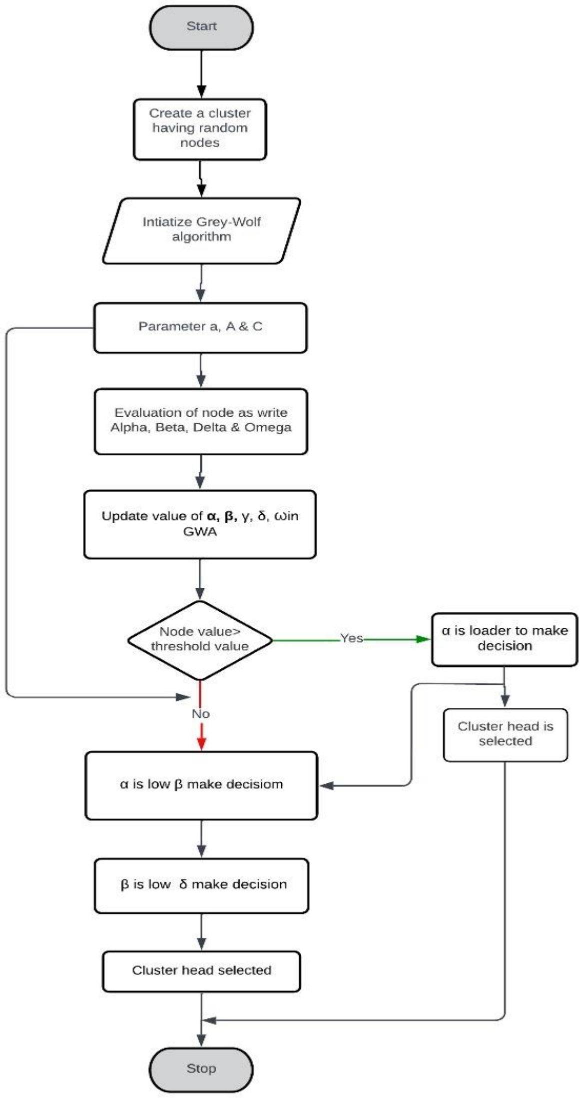
Step 6: Cluster Head Analysis and Optimization

The cluster head optimization comes next once each cluster head has been examined. The investigation of stability parameters in Manet is initiated if successful. This cycle is repeated until a cluster head that has been optimized.

Step 7: Network parameter analysis

The various network parameters are thoroughly analyzed. These metrics include Packet Delivery Ratio (PDR), Dead and Alive Nodes, Throughput.Cluster Head attributes, and Dead and Alive nodes.

Flow Chart for Cluster Head Selection In Gwoga Technique



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V. ALGORITHM: GREY WOLF OPTIMIZATION AND GLOBAL ALGORITHM FOR CLUSTER HEAD SELECTION

VI.

1. Initialize wolf location and its required population in cluster such as Xi (i =1, 2,..,n)
2. Analyzed, A, C and a.
3. Generate the random location of nodes in the cluster.
4. Adapt the fitness of the wolves within the cluster.
5. Determine values of Dominant wolves such as α, β, and ω.

   Where α = the leader, β = the second most leader, δ = the third most leader, ω= the Fourth most leader

6. while (x≤max $\_Iter$) // Initially, x=1
7. for i=1: Np
8. For Energy parameter: Update the Dominate wolves such as α, β, δ and ω
9. For Mobility parameter: Update location of the leader agent such as α, β, δ and ω.
10. Compute fitness of the wolves within the cluster.
11. end for
12. Adapt a, A, and C and its cluster and search agent
13. Increase value of x by 1 for every periodic iteration (x+1)
14. end while
15. return α

VII. RESULTS AND DISCUSSIONS

Nodes	Delay (ms) Normal method	Delay (ms) GWOGO	Energy (mJ) Normal method	Energy (mJ) GWOGO	Throughput (kbps) Normal method	Throughput (kbps) GWOGO	Path Loss (%) Normal method	Path loss (%) GWOGO
20	5.03	3.94	8.27	5.02	332.33	537.8	92.73	96.4
40	5.5	4.19	8.99	5.3	362.25	569.6	91.53	95.87
60	6	4.42	9.72	5.57	392.87	600.01	90.31	95.37
80	6.48	4.63	10.43	5.84	422.69	628.2	89.11	94.9
100	6.96	4.87	11.16	6.11	452.81	659.08	87.91	94.38
120	7.44	5.08	11.88	6.4	482.93	688.68	86.7	93.89
140	7.92	5.33	12.6	6.69	513.06	721.34	85.5	93.34
160	8.41	5.58	13.33	6.98	543.18	753.94	84.29	92.8
180	8.89	5.82	14.05	7.26	573.31	785.13	83.09	92.28
200	9.37	6.06	14.77	7.54	603.44	816.44	81.88	91.76

Table 1: Comparison of results in GWOGO and Normal Clustering

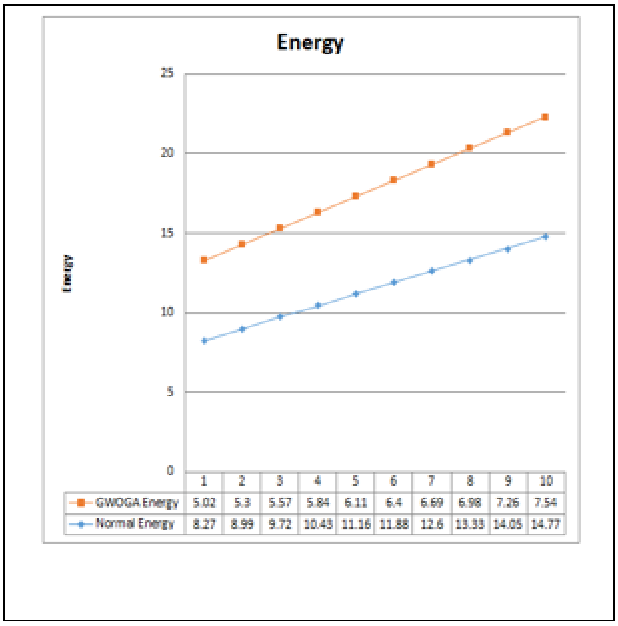

Figure 1 Comparison of Energy utilization in normal Clustering and GWOGA Technique

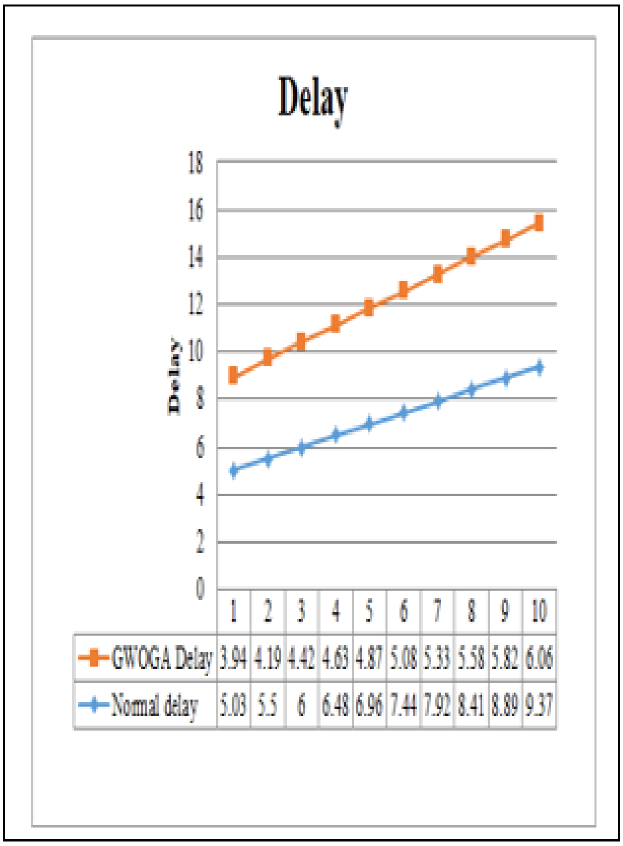

Figure 2 Comparison of Delay utilization in normal Clustering and GWOGA Technique

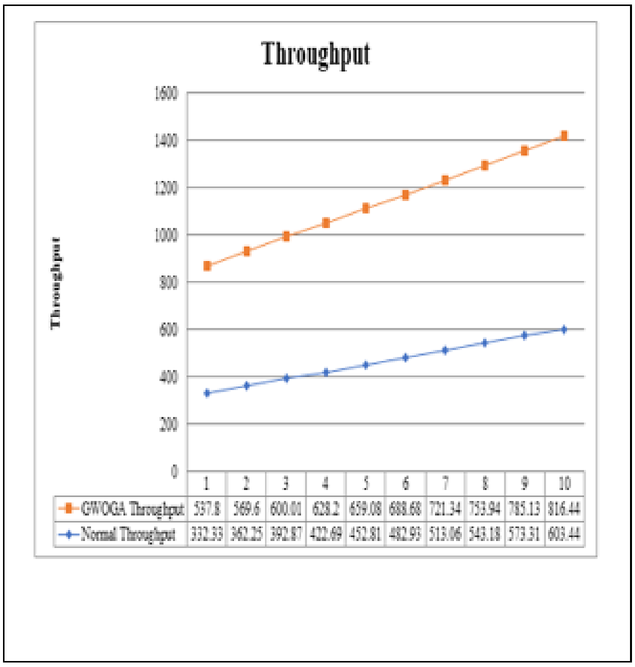

Figure 3 Comparison of Throughput in Normal Clustering and GWOGA Technique

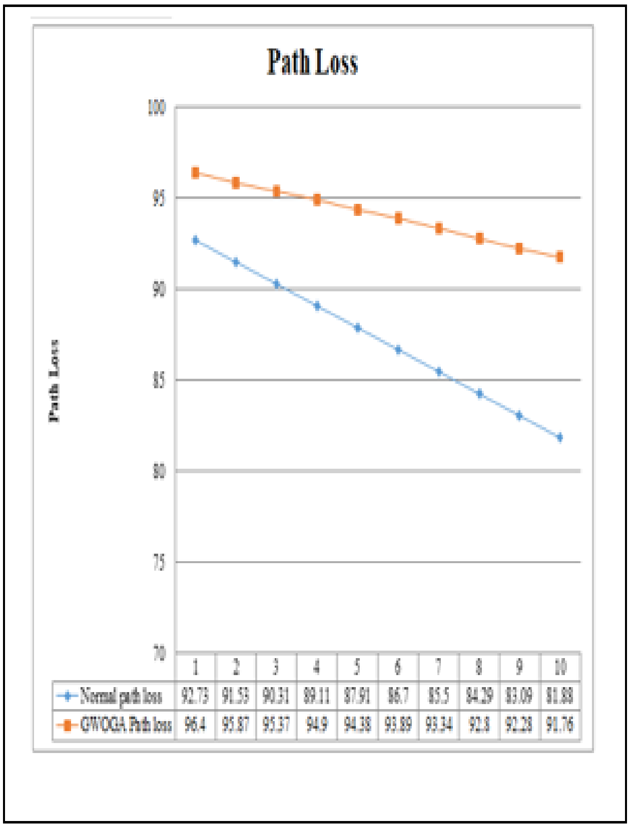

Figure 4 Comparison of Pathloss utilization in normal Clustering and GWOGA Technique

CONCLUSION

Conclusion part depicts the main points as the constructivefinds Utilization of Energy and QoS metrics like throughput and time delay, packet delivery ratio and packet loss all have a direct impact on how stable a network is. Network stability depends on energy. Here, we have addressed how this affects the performance of the system. WSNs. assuming that no source is using the energy produced by the WSN nodes. In this instance, packet send, receive, and routing are utilized to carry out the communication process, which consumes and gradually depletes energy. If the QoS parameters for this path are favorable, the QoS parameters will be reduced relatively quickly. In this research, we have introduced a brand-new algorithm for choosing a new cluster head in a MANET that is based on artificial intelligence. Our algorithm disqualifies nodes from being chosen as the cluster head on the basis of the less packet loss ratio and any malicious behavior on the node. GWOGA Results and evaluations demonstrate that the technique is more effective and only needs a minimal amount of resources to choose a cluster head. With the aid of our suggested protocol, the MANET lifetime experiences a considerable escalation. A further improvement in lifetime of MANET with adequate process of consuming energy can be made by GWOGA Technique.

REFERENCES

[1] AmardeepKaur, &Rajat Joshi, “Energy Efficient Cluster base routing approach by GWO and Tabu search optimization with Cluster Topology in Wireless sensor Network”, International Journal of Advance Research, Ideas and Innovations in Technology. ISSN: 2454-132X pg:1792-1797

[2] R. Rajakumar1*, K Dinesh1, M Sreedevi1, Abdul Jaleel1, Kadiyala Kundan Koushal2, G Thanuja3, R Reddy Prakash3, “An Opposition-based Grey Wolf Optimization for Cluster Head Selection in Wireless Sensor Networks “July 5th, 2022 DOI: https://doi.org/10.21203/rs.3.rs-1785283/v1

[3] Aljarah, Ibrahim, Mafarja, Majdi, Heidari, Ali Asghar, Faris, Hossam, Mirjalili, Seyedali “Clustering analysis using a novel locality-informed grey wolf-inspired clustering approach” Knowledge and Information Systems https://doi.org/10.1007/s10115-019-01358-x

[4] P. S. Rao, P. K. Jana, and H. Banka, “A particle swarm optimization-based energy efficient cluster head selection algorithm for wireless sensor networks,” Wireless Netw., vol. 23, no. 7, pp. 2005–2020,2017.

[5] KhalidHussain,1 AbdulHananAbdullah,1 SaleemIqbal,1 Khalid M.Awan, and FarazAhsan" Efficient Cluster Head Selection Algorithm for MANET " Journal of Computer Networks and Communications Hindawi Publishing Corporation Volume2013,ArticleID723913,7pages http://dx.doi.org/10.1155/2013/723913

[6] M. Faheem and V. C. Gungor, “Energy efficient and QoSaware routing protocol for wireless sensor network-based smart grid applications in the context of industry 4.0,” Appl. Soft Comput., vol. 68, pp. 910–922, Jul. 2018.

[7] C. Hong, Y. Zhang, Z. Xiong, A. Xu, H. Chen, and W. Ding, “FADS : Circular/Spherical Sector based Forwarding A real Division and Adaptive Forwarding A real Selection routing protocol in WSNs,” Ad Hoc Networks, vol. 70, pp. 121–134, Mar. 2018.

***Article Received:** 25 July 2023 **Revised:** 12 September 2023 **Accepted:** 30 September 2023*

[8] H. H. R. Sherazi, L. A. Grieco, and G. Boggia, "A Comprehensive Review on Energy Harvesting MAC protocols in WSNs: Challenges and Tradeoffs," Ad Hoc Networks, vol. 71, pp. 117–134, Mar. 2018.
[9] Mirjalili S, Mirjalili SM, Lewis A (2014) Grey wolf optimizer. AdvEngSoftw 69:46–61(grey)
[10] Sekaran, Kaushik, R. Rajakumar, K. Dinesh, Y. Rajkumar, T. P. Latchoumi, SeifedineKadry, and Sangsoon Lim. " An energy-efficient cluster head selection in wireless sensor network using grey wolf optimization algorithm." TELKOMNIKA (Telecommunication Computing Electronics and Control) 18, no.6 (2020): 2822-283
[11] Rajakumar, R., K. Dinesh, and T. Vengattaraman. "An energy-efficient cluster formation in wireless sensor network using grey wolf optimisation." International Journal of Applied Management Science 13, no. 2 (2021): 124-140.
[12] J. Sathiamoorthy, B. Ramakrishnan, M. Usha, A Trusted Waterfall Framework Based Peer to Peer Protocol for Reliable and Energy Efficient Data Transmission in MANETs, Springer Journal of Wireless Personal Communication 102 (1) (September 2018) 95–124.
[13] Vajdi, G. Zhang, Y. Wang, T. Wang, A new self-management model for largescale event-driven wireless sensor networks, IEEE Sens. J. 16 (20) (2016) 7537–7544.
[14] Kaushik, S. Indu, D. Gupta, A Grey Wolf Optimization Approach for Improving the Performance of Wireless Sensor Networks, Wireless Personal Communications 106 (3) (2019) 1429–1449.
[15] P. Kevin, U.T. Samarakoon, Performance analysis of wireless sensor network localization algorithms,International Journal of Computer Networks and Applications (IJCNA) 6 (6) (2019) 92–99
[16] Yu, Jiguo, Yingying Qi, and Guanghui Wang. "An energy-driven unequal clustering protocol for heterogeneous wireless sensor networks." Journal of Control Theory and Applications 9, no. 1 (2011): 133-139.
[17] D. Nguyen, P. Minet, T. Kunz, and L. Lamont, "New findings on the complexity of cluster head selection algorithms," in Proceedings of the IEEE International Symposium on a World of Wireless,Mobile and Multimedia Networks(WoWMoM'11),June 2011.
[18] H. H. R. Sherazi, L. A. Grieco, and G. Boggia, "A Comprehensive Review on Energy Harvesting MAC protocols in WSNs: Challenges and Tradeoffs," Ad Hoc Networks, vol. 71, pp. 117–134, Mar. 2018
[19] S. K. S. L. Preeth, R. Dhanalakshmi, R. Kumar, and P. M. Shakeel, "An adaptive fuzzy rule based energy efficient clustering and immune-inspired routing protocol for WSNassistedIoT system," J. Ambient Intell. Humaniz. Comput., pp. 1–13, Dec. 2018
[20] P. S. Rao and H. Banka, "Energy efficient clustering algorithms for wireless sensor networks: Novel chemical reaction optimization approach," Wireless Netw., vol. 23, no. 2, pp. 433–452, 2017.

APPENDIX

1. Author

Ms. Minal Suresh Patil has completed her Master in Technology in VLSI Design and currently pursuing Ph.D. under Electronics Engineering at Yeshwantrao Chavan College of Engineering, Maharashtra, India. Her research interests include wireless sensor networks and communication networks. she has 11 years of teaching experience. She has 15 papers published in scopus and several papers presented in national and international journals and conferences. She has attended 20 workshop and organized 11 Student Training program .More than 10 NPTEL Courses attended and secure First Class in each Course.

2. Author

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