Enhancement OLSR Routing Protocol using Particle Swarm Optimization (PSO) and Genrtic Algorithm (GA) in MANETS

[1]Udaya Kumar Addanki, [2]B. Hemantha Kumar
udayaka.18@gmail.com
[1]Research Scholar, Acharya Nagarjuna University, Guntur, A.P., India.
[2]Professor, Dept. of IT, RVR & JC College of Engineering, Guntur, A.P., India.

Abstract
A Mobile Ad-hoc Network (MANET) is a collection of moving nodes that communicate and collaborate without relying on a pre-existing infrastructure. In this type of network, nodes can freely move in any direction. Routing in this sort of network has always been problematic because of the mobility of nodes. Most existing protocols use simple routing algorithms and criteria, while another important criterion is path selection. The existing protocols should be optimized to resolve these deficiencies. 'Particle Swarm Optimization (PSO)' is an influenced method as it resembles the social behavior of a flock of birds. Genetic algorithms (GA) are search algorithms that use natural selection and genetic principles. This paper applies these optimization models to the OLSR routing protocol and compares their performances across different metrics and varying node sizes. The experimental analysis shows that the Genetic Algorithm is better compared to PSO. The comparison was carried out with the help of the simulation tool NS2, NAM (Network Animator), and xgraph, which was used to create the graphs from the trace files.

Keywords: *MANET, OLSR, Particle Swarm Optimization, Multipoint Relay, Genetic Algorithm.*

1. INTRODUCTION

They are very self-configured and have a collection of wirelessly connected mobile nodes, Self-healing networks despite the lack of stable infrastructure—nodes in a network serve as hosts and routers, transmitting data from one node to other. The node wants to connect with other nodes in Manet; each node uses a wireless interface. These networks are dispersed and may function anywhere without the assistance of pre-existing infrastructures such as base stations or access points.

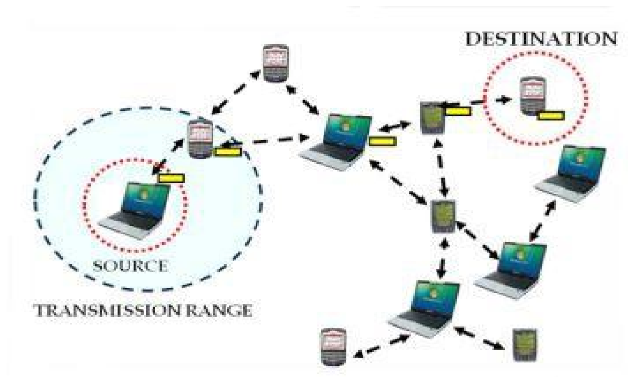


Fig 1: Network architecture of MANETs

Types of Routing Protocol

i. **Proactive Routing Protocol:** It is also termed the "Table-based protocol." Each mobile node has its routing table, which comprises routes to any potential destination mobile nodes. Because the architecture of a manet is constantly changing, the routes associated with network nodes are frequently updated. This drawback is ineffective in large networks because the routing table entries become crucial since they must provide the root data to all possible nodes, for example, the "Destination Sequenced Distance Vector (DSDV)" protocol, "Global State Routing (GSR)" protocol.

ii. **Reactive Routing Protocol:** It is also termed the "On-demand routing protocol." During this routing protocol, the route is found only when necessary. "Route Discovery and Route management" are the two key steps. The root-finding approach involves broadcasting the mobile network with root request packets. Each component in this Protocol contains the information of the nodes to its left and right. It may also ensure the journey of the data, route creation, and deletion of the routes if the network is partitioned. Examples included are "Dynamic Source Routing Protocol (DSR)" and "Ad-Hoc On-Demand Vector Routing protocol (AODV)."

Manuscript received April 5, 2022
Manuscript revised April 20, 2022
https://doi.org/10.22937/IJCSNS.2022.22.4.17

iii. **Hybrid routing protocol:** This Protocol combines the benefits of reactive and proactive routing techniques. As per the source and destination mobile nodes' zone and position, these protocols are adaptive. ZRP (Zone Routing Protocol) is one of the most extensively utilized hybrid routing technologies. The whole network is divided into numerous zones, and the locations of the source node and destination mobile nodes are determined. When the "sender and receiver, mobile nodes are in the same area," proactive routing is used to transfer packets. Reactive routing forwards the packet if the "sender and receiver mobile nodes are in different zones." Examples: Enhanced IGRP (EIGRP), Zone Routing Protocol (ZRP).

iv.

2. LITERATURE SURVEY

Various research in Mobile Ad-hoc Networks (MANET) has been conducted in recent years, resulting in it being widespread within analytical work.

In this paper, Kamal deep Kaur and Lokesh Pawar[8] show several approaches to optimization that fall into biologically influenced algorithms such as "Ant Colony Optimization, Artificial Bee Colony Optimization, Artificial Neural Networks, Bacterial Foraging Algorithm, Genetic algorithms, and Particle Swarm Intelligence."[8].

Al-The-Ghazal, M, in [9]. This paper is based on the Cluster Head Gateway Switching (CGSR) protocol and the genetic algorithm (GA) that enhances routing in the clustering algorithm. GA holds updated state data on adjacent networks and renders networks self-configured through GA mechanisms. The genetic algorithm finds the optimum path from transmitter to receiver in a network. Even yet, the outcome isn't the shortest path required. It permits a node to quickly and reliably change routing details to keep local topology continuously evolving, initiating less connection fractures along with increasing the overhead of the lower MAC layer.

Karthikeyan, D. Oh, and Dharmalingam, M. in [10], "This paper used an Ant Colony Optimization (ACO) algorithm." In MANETs, with this approach, the routing algorithms can be easily created, where the independent agents communicate with each other. Their mutual action analysis achieves a solution by seeking the most satisfactory solution. For MANETs, Energy-efficient routing proposes maximizing the system's lifespan by reducing node energy usage.

Alireza, S. et al. in [11] proposes an algorithm based on "the PSO algorithm for multicast routing in MANET." This algorithm is more efficient and has improved velocity than multicast routing developed on GA. The primary focus of multicast routing is the reliability and latency of energy usage. Generally, it implies selecting a node with less energy consumption and creating a multicast tree with less latency. A new algorithm for multicast routing relies on the proposed PSO algorithms.

In this paper, K.Sumathi and A.Priyadharshini [12] introduce the Adaptive HELLO Messaging Scheme. It gains information on sender-receiver links along with tracking link-state using a "dynamic on-demand routing protocol to minimize energy utilization in a particular range" [126].

Nancharaiah, B., and Mohan, B.C. employed PSO and ACO in this study [13]. In ACO, ants are "mobile agents to find the best possible path and generate PSO inputs." Because of the low cost and Delay, particle location and velocity were chosen over previous ones in PSO. This hybrid algorithm beats the ACO and PSO algorithms in terms of results.

This paper, Anuj, K., and Harsh, S. in [14], focuses primarily on the furthermost difficult assignment: routing. Based on group intelligence, ACO is a helpful method for quickly creating routing algorithms. By releasing chemicals called pheromones, the ants find the best way. There are many parallels between MANETs and ants, such as their configuration, physical structure, and route roots. The ad hoc network of researchers uses a collective intelligence approach.

This work focuses on two methodologies focusing on ACO and PSO, as described by Zulfiqar Ali and Waseem, S. in [15]. In ad hoc networks, these strategies enable loop-free routing and multipathing. [16] The "GPS/Ant Line Routing Algorithm (GPSAL)," the "Accelerated Ants Routing Algorithm (AAR)," and the "Node Neighbor Number Algorithm" are all swarm intelligence-based routing algorithms used in MANETs (NNNA).

S. K. Shah and D. D. Vishwakarma in [17], The ANN optimization approach utilized in the reactive routing protocol is proposed research (AODV). The Hello cycle occurrence between two events is used to assess the network output in this scenario. Unnecessary traffic might be generated because the information is updated at irregular intervals. As a result, the time interval between these messages must be adaptive to ensure the network's best functioning. They employ the interval for these messages to increase network performance since updating information over a given time might produce excessive wireless network traffic.

[2] This paper makes the comparison of explaining the routing protocol DSDV, AODV, OLSR, DSR, TORA. The comparison is made concerning Protocol type, Routing Overhead, Throughput, Delay, Route, Unidirectional link support, Overhead, Multicast, and QoS, in the below table-1.

Table 1: Comparison of protocols

Performance Metrics	AODV	DSR	DSDV	OLSR
Type of Protocol	Reactive Protocol	Reactive protocol	Proactive protocol	Proactive protocol
Control Overhead	Medium	low	Medium	High
Packet Delivery Ratio	Low	High	Medium	Almost equal to DSR
End-To-End Delay	High	low	Medium	Medium
Through Put	Lowest throughput	DSR is closer to OLSR but lower than DSDV	Medium	Highest throughput
An increasing number of hops	As an increasing number of hops, AODV is produced good results than DSR	Low	Medium	Medium

An OLSR protocol's performance is better than the DSR, AODV, DSDV, & TORA protocol's packet delivery percentage and Throughput latency. It is recommended that OLSR needs to be modified to decrease end-to-end Delay overhead and increase network throughput.

3. METHODOLOGY

A) Particle Swarm Optimization (PSO)

It's a meta-heuristic algorithm built on the concept of swarm intelligence notion that can solve complex mathematical problems in engineering. Several simple formulas are used to move these particles around in the examination space. The particles' motions are guided by "their optimum position inside the search space and the swarm's most prominent position." The swarm's motion can be directed when better sites are identified. The technique is still in progress, and it is hoped, but not assured, that such a good solution will be found eventually [3].

Let F: R→R is "the cost function and must be decreased" [3]. A candidate solution gives this procedure as an argument within the vector ranges. It produces an actual numerical output that reflects the objective function value of the provided candidate solution [3].

PSO algorithm follows these steps [20]:

Step 1: Set the particles' velocities and placements in the search space to random values.

Step 2: Begin computing the corresponding value of the swarm particles' fitness function.

Step 3: Add the particle's current pbest value to the fitness value assessment. Make the present value the new pbest value and assign the pbest location to the current position in n-dimensional space if the present value is more critical than pbest.

Step 4: After that, compare your fitness value to your previous best overall performance. Update "gbest to the current particle's array index and value if the current value is more significant than gbest."

Step 5: Finally, apply these values to the swarm particle's matching location and velocity.

Algorithm 1 Pseudocode for PSO

```
For each node sending data packet repeat
    for each node i in neighbors of the current node do
        calculate fitness of node i by using equation
        update Pbest's position
        calculate velocity of node i by using equation
    end
    for each node i in neighbors of current node do
        find the node with highest velocity
    end
    for each node i in neighbors of current node do
        if node i has highest velocity among neighbors then
            ith element of the position vector=1
        else
            ith element of the position vector=1
        end
    end
    send data packet to neighbor i with position value 1
    current node=node i with position value 1
Until destination node
```

B) Generic Algorithm

Genetic algorithms are search algorithms, and these algorithms are based on natural selection and natural genetics. Genetics is branch biology, and it is concerned with studying genes. John holland developed GA at the University of Michigan.

PROCEDURE:

Step 1: Consider a network with an initial population of N nodes.

Step 2: Complete the setup of all of the terminals.

Step 3: The Fitness function is used to choose the neighbor node.

Step 4: The Crossover and Mutation operators are used to produce the collection of pathways to the destination.

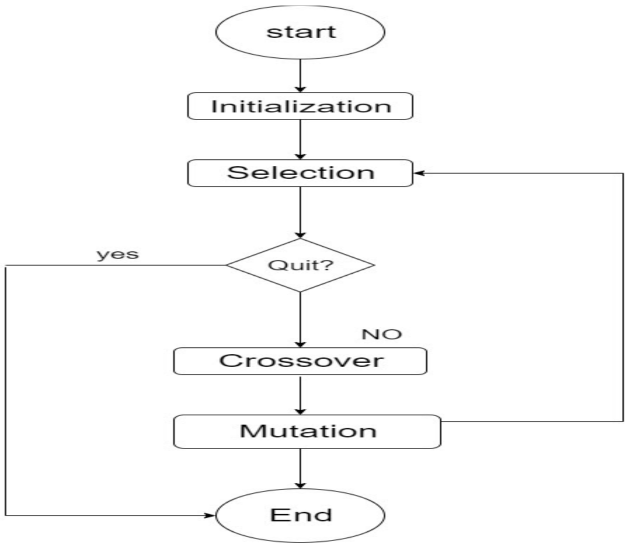
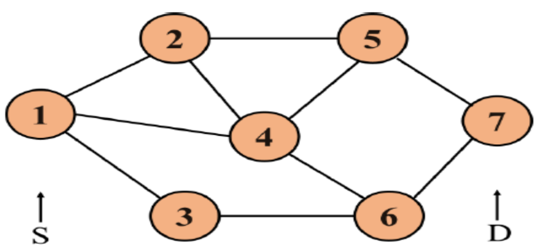


Fig 2: Data Flow Diagram for Genetic Algorithm

Example



- 1st Chromosome: 1st Path: 1-2-4-5-7
- 2nd Chromosome: 2nd Path: 1-4-6-7
- 3rd Chromosome: 3rd Path: 1-3-6-7
- After Crossover of 1st and 2nd Chromosome
- 4th Chromosome: 1-4-5-7
- After Mutation: 1-2-5-7

The process continues till it satisfies the stopping criteria.

C) OLSR (Optimized Link State Routing)

One of the MANET routing technologies is "Optimized Link State Routing (OLSR)." The Protocol is an enhancement to the traditional link-state technique. The optimization results in lower management and traffic message flooding into the network with the aid of MPRs nodes and the chosen subset of one-hop neighbours. It's a hop-by-hop routing system, which means each routing table has a list of possible destinations. By sending and receiving hello messages frequently, each node will learn who one- and two-hop neighbours are. Greetings and messages may not be resent. A collection of one-hop neighbours could form the MPR set, with at least one MPR connecting each two-hop neighbour. The hello messages are used to report MPR node information. The information obtained creates the MPR selector set [5].

It keeps track of which nodes have identified a particular node as MPR. MPRs are the ones who send out topology control (TC) messages. No TC messages are sent or retransmitted by an empty MPR selection set node. Because the last hop to reach all nodes is contained in its selection table, the sender of a TC message promotes itself. The content of Traffic Control messages is determined by the TC Redundancy (TCR) parameter setting. The primary goal of OLSR is to choose MPRs. Any node in the network can pick the MPRs to which its TC messages will be sent.

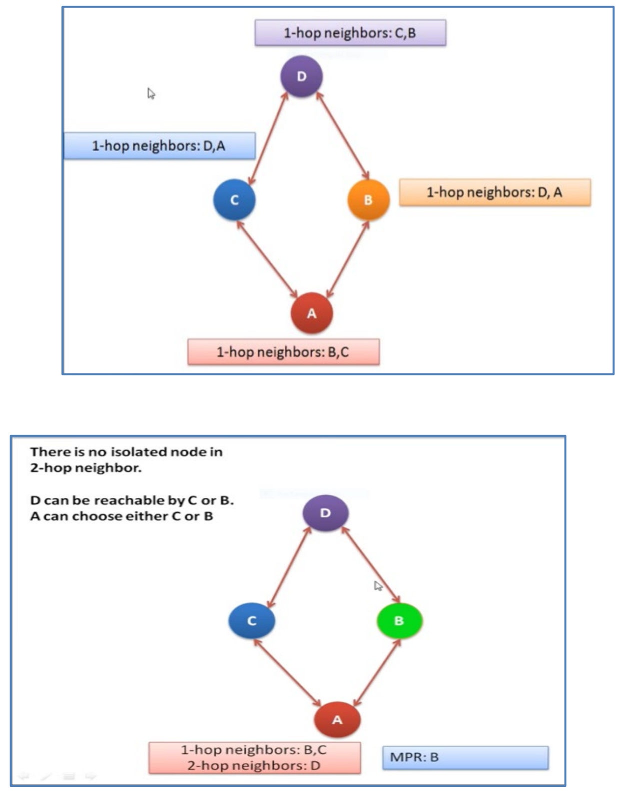


Fig 3: Optimized Link State Routing (OLSR)

1. SIMULATION

Network Simulator-2 is frequently used in ad-hoc networking groups. It's open-source software for analyzing current network protocols and evaluating new network protocols before they're deployed. The NS2 simulator may be used to simulate several Internet protocols. The object-oriented Tool Command Language (OTCL) and C++ were used to construct NS2. Components of NS-2 are simulators and network animators.

With NS2's event-driven simulation capabilities, we can dynamically generate diverse wireless network situations such as connection failure due to mobility, congestion, and assaults at different points during the simulation period. In this, it allows labeling, coloring, and distinction of nodes.

There are no apparent physical links in the network name since nodes share the wireless medium via a wireless channel. It is also possible to inspect the network by dragging and dropping nodes in the NAM tool. When the packets and links are clicked in NAM, the properties of the packets and linkages are shown. The trace annotate option may be used to annotate an ongoing network process, shown at the bottom of the network animation window. The trace file created after the simulation has a specified format for a wireless network, including event type, time, nodes involved, and data parameters such as source and destination addresses, packet type, size, and sequence number. For performance analysis, it is analyzed using wireless network-specific AWK scripts.

Table 2: Simulation Setup

Parameter Type	Parameter Value
Simulation time	10s
No of nodes	50, 100, 150, 200
Area of simulation	1216m x 768m
Packet type	CBR
Transport protocol	UDP
Packet size	512 bytes
Rate of packets	4 Packets / sec
Maximum packets	Constant Bit Rate
Propagation model	TwoRayGround
Initial Energy	1000J
RxPower	1.4 w
TxPower	1.3 w

3. Performance Metrics

1) **Throughput(t)**

It is "the rate at which data packets are successfully delivered between sender and receiver over a network channel." The system's Throughput is the sum of the rates at which all terminals receive data packets during an interval. It is the measurement of the actual system's performance.

$$t = \frac{\sum Received\ packet\ size}{Stop\ time - Start\ time}$$ bytes / sec or bit / sec ---(1)

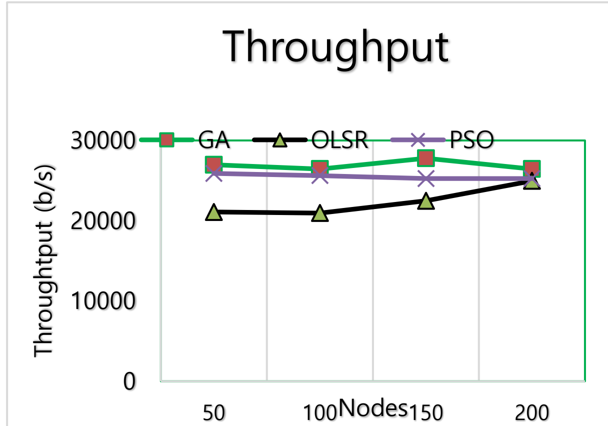


Fig 4: performance analysis of Throughput

2) **Delay (End-To-End Delay)**

"The time it takes for a packet to go from a sender node to a receiver node across a network is known as end-to-end delay" [19].

$$Delay = \frac{\sum Packet\ Received\ \ Time - Packet\ Sent\ Time}{Packet\ Received\ Successfully}$$ ---(2)

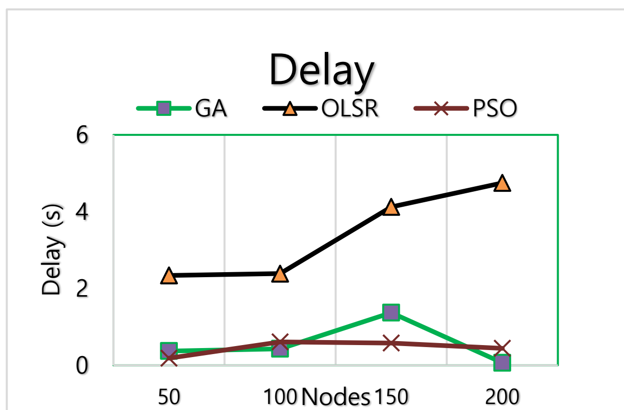


Fig 5: performance analysis of Delay

3) **PDR (Packet Delivery Ratio)**

It is defined as "The ratio of the number of data packets communicated to the total amount of data packets sent from the sender node to the receiver node in the network." [6].

$$PDR = \frac{Total\ number\ of\ packets\ receievd}{Total\ number\ of\ packets\ sent}\ X\ 100$$

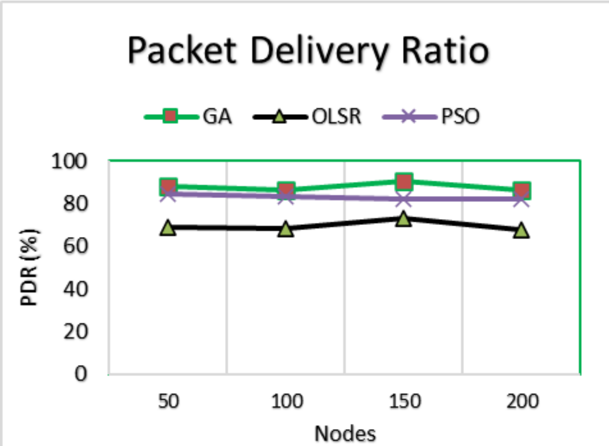


Fig 6: performance analysis of PDR

4) Average Energy Consumption (AEC)

The nodes in MANET are entirely dependent on a constant power supply reserve, and the nodes' Energy may be used for data transmission, data overhearing, and congestion management. This energy consumption can be determined using the following equation [5].

$$\text{Average Energy consumption} = \frac{i-r}{N} \qquad \text{---(4)}$$

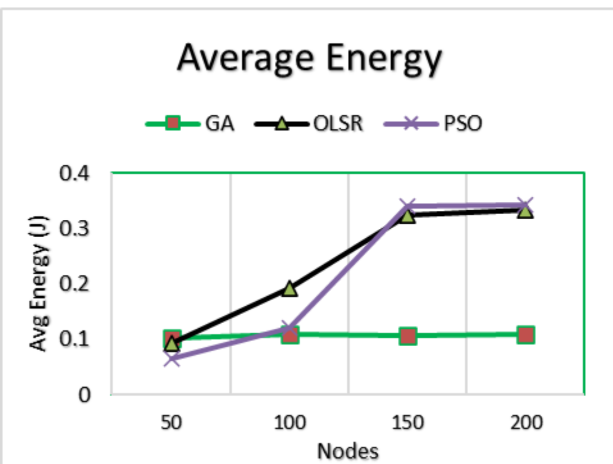


Fig 7: Performance Analysis of AEC

5) PLR (Packet Loss Ratio)

Packet loss represents the number of packets successfully conveyed from one node in a network but abandoned during data transfer and never arrived at their destination. PLR is considered "The total quantity of lost packets to the total packets transferred from the source terminal to the destination terminal. [4]".

$$PLR = \frac{Total\ number\ of\ packets\ lost}{Total\ number\ of\ packets\ sent}\ X\ 100$$

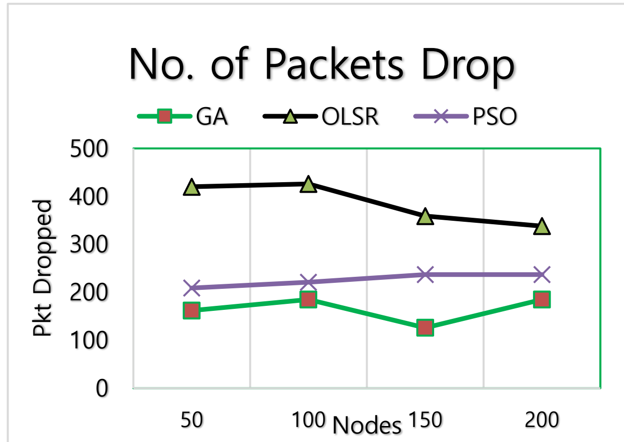


Fig 8: performance analysis of packets Drop

6) Goodput

Goodput is a metric that quantifies how quickly and precisely helpful data flow over the network and reaches its intended destination. Goodput is the good data, not undesirable data such as retransmissions or overhead data. It is calculated by " the number of relevant information bits supplied by the network from source to destination per unit of time."

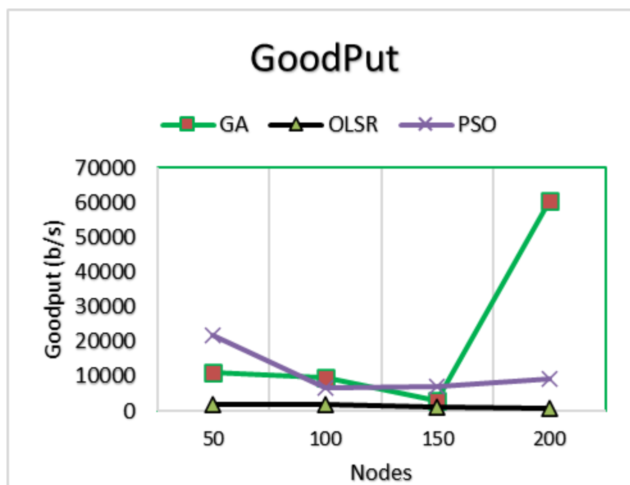


Fig 9: performance analysis of goodput

7) Jitter

The temporal delay between when a signal is delivered and received across a network connection is Jitter. It is considered "The total quantity of lost packets divided by the total packets transferred from the source to the destination node " [4].

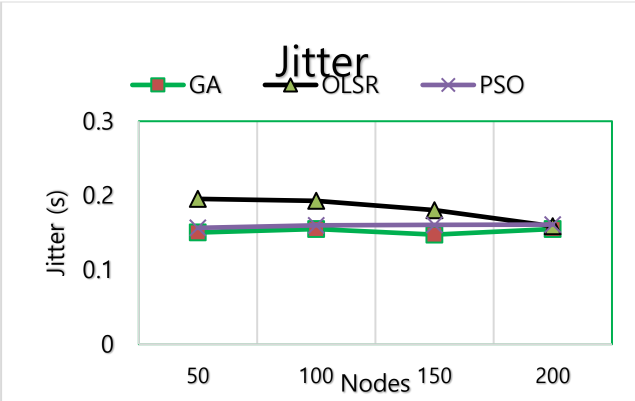


Fig 10: performance analysis of Jitter

8) Network Lifetime

The Network lifetime is when the packet loss rate is above a threshold value. It is defined as "the failure time of the first sensor node."

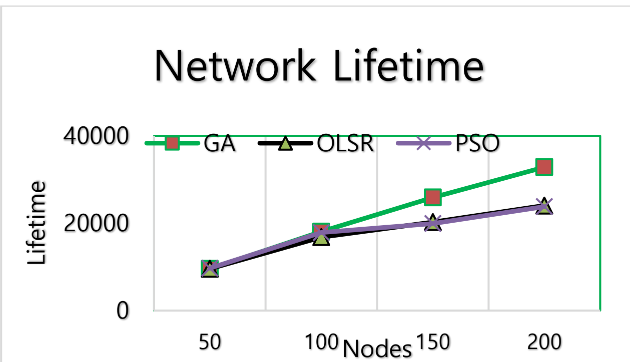


Fig 11: performance analysis of Network Lifetime

9) Remaining Energy

"Remaining Energy is calculated as "The total number of lost data packets divided by the total volume of data packets delivered from the sender node to the destination node" [4][18].

$$RE = \frac{\text{Initial\_Energy} - \text{Total\_Consumed\_Energy}}{Total\ number\ of\ Nodes} \quad \text{---(6)}$$

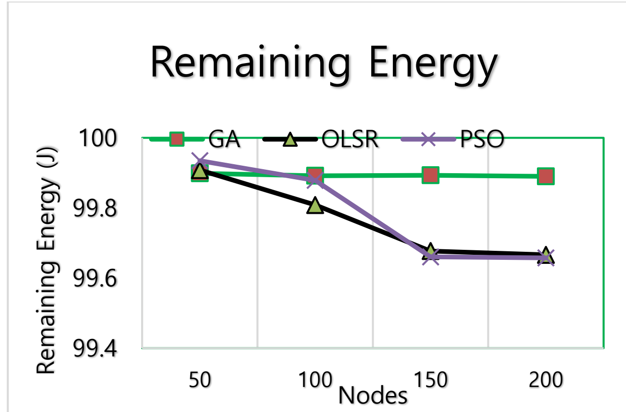


Fig 12: performance analysis of Remaining Energy

Observations

1. From Figure 4, we can conclude that Throughput for GA is better than OLSR and PSO.
2. From Figure 5, we conclude that the Delay of GA decreases with the scaling up of the number of nodes compared to OLSR, PSO.
3. From Figure 6, we conclude that the PDR of GA and PSO is better than OLSR.
4. From Figure 7, we can conclude that GA's average energy consumption is better than OLSR and PSO.
5. From Figure 8, we can conclude that packet dropping in GA is less than PSO and OLSR.
6. From Figure 9, we conclude that the Goodput of GA increases in nodes compared to PSO and OLSR.
7. From Figure 10, we can conclude that Jitter for all the three models is the same with the increase in nodes.
8. From Figure 11, we conclude that the Lifetime of GA is more compared to OLSR and PSO.
9. From Figure 12, we conclude that the remaining Energy of GA is constant while the remaining Energy of OLSR, PSO decreases with the increase in nodes.

From the above observations, the Genetic Algorithm is better than PSO and OLSR.

4. CONCLUSION

The energy consumption of the nodes determines the life span of a wireless network. The frequency of node failure can be reduced by lowering the node's energy consumption, which increases the network's lifetime. Optimization is one of the essential techniques for extending network lifetime by lowering energy consumption. In this paper, we presented optimization models for the Manet. We have tested these models on an ad-hoc network under varying network sizes.

We implement using NS2 network simulator and visualize using the NAM tool. Here, the simulation is based on the routing technique in MANET using simple or traditional OLSR routing and an enhanced routing using the PSO and GA methods. After performance analysis, we found that GA had better performance than conventional routing and PSO.

References

[1] Prabhleen Kaur and Sukhman. "An Overview on MA-NET-Advantages, Characteristics, and Security Attacks." IJCA Proceedings on International Conference on Advances in Emerging Technology ICAET 2016(1):6-9, September 2016.

[2] Manickavelu, D., Vaidyanathan, RU. "Particle swarm optimization (PSO)-based node and link lifetime prediction algorithm for route recovery in MANET." J Wireless Com Network 2014, 107 (2014). https://doi.org/10.1186/1687-1499-2014-107

[3] Gill, A & Singh, P. (2021). Optimal penetration of distributed generation system in radial distribution network using the adaptive scheme. Journal of Physics: Conference Series. 1914. 012027. 10.1088/1742-6596/1914/1/012027.

[4] Sumesh, JayaMohanan & Maheswaran, Chella. (2021). Energy conserving ring cluster‐based routing protocol for wireless sensor networks: A hybrid model. International Journal of Numerical Modelling: Electronic Networks, Devices, and Fields. 34. 10.1002/jnm.2921.

[5] Priyambodo, Tri & Wijayanto, Danur & Gitakarma, Made. (2020). Performance Optimization of MANET Networks through Routing Protocol Analysis. Computers. 10. 2. 10.3390/computers10010002.

[6] S. Baccari, H. Touati, M. Hadded, and P. Muhlethaler, "Performance Impact Analysis of Security Attacks on Cross-Layer Routing Protocols in Vehicular Ad hoc Networks," 2020 International Conference on Software, Telecommunications and Computer Networks (SoftCOM), 2020, pp. 1-6, doi: 10.23919/SoftCOM50211.2020.9238259.

[7] K. T. Selvi, "The secured OLSR protocol for MANET," International Conference on Information Communication and Embedded Systems (ICICES2014), 2014, pp. 1-6, doi: 10.1109/ICICES.2014.7033969.

[8] K. Kaur and L. Pawar, "Review of Various Optimization techniques in MANET Routing Protocols," Int. J. Sci. Eng. Technol. Res., vol. 4, no. 8, pp. 2830–2833, 2015.

[9] M. Al-Ghazal, A. El-Sayed, and H. Kelash, "Routing optimization using genetic algorithm in ad hoc networks," ISSPIT 2007 - 2007 IEEE Int. Symp. Signal Process. Inf. Technol., pp. 497–503, 2007.

[10] D. Karthikeyan and M. Dharmalingam, "Ant-based Intelligent Routing Protocol for MANET," Int. Conf. pattern recognition, informatics Mob. Eng., pp. 11–16, 2013.

[11] Alireza Sajedi Nasab, Vali Derhami, Leyli Mohammad Khanli, Ali Mohammad Zareha Bidoki, Energy-aware multicast routing in manet based on particle swarm optimization, Procedia Technology, Volume 1, 2012, Pages 434-438, ISSN 2212-0173, https://doi.org/10.1016/j.protcy.2012.02.097.

[12] K. Sumathi and A. Priyadharshini, "ENERGY OPTIMIZATION IN MANETS USING ON- DEMAND ROUTING PROTOCOL," ProcediaComput. Sci., vol. 47, pp. 460–470, 2015.

[13] B. Nancharaiah and B. C. Mohan, "MANET link Performance using Ant Colony Optimization and Particle Swarm Optimization Algorithms," Int. Conf. Commun. Signal Process., pp. 767–770, 2013.

[14] Gupta, H. Sadawarti, and A. Verma, "MANET routing protocols based on Ant Colony Optimization," Int. J. Model. Optim., vol. 2, no. 1, pp. 42–49, 2012.

[15] Z. Ali and W. Shahzad, "Analysis of Routing Protocols in AD HOC and Sensor Wireless Networks Based on Swarm Intelligence," Int. J. Networks Commun., vol. 3, no. 1, pp. 1–11, 2013.

[16] S.V. Manikanthan, T.Padmapriya, "United Approach in Authorized and Unauthorized Groups in LTE-A Pro," Jour of Adv Research in Dynamical & Control Systems, Vol. 10, 10-Special Issue, 2018, pp. (1137-1145).

[17] S. K. Shah and D. D. Vishwakarma, "Development and Simulation of Artificial Neural Net-work-based decision on parametric values for Performance Optimization of Reactive Routing Protocol for MANET using Qualnet," Int. Conf. Comput. Intell. Commun. Networks, pp. 167–171, 2010.

[18] Shi, Jinfa & Habib, Misbah & Yan, Hai. (2020). A Review Paper on Different Application of Genetic Algorithm for Mobile Ad-hoc Network (MANET). International Journal of Online and Biomedical Engineering (iJOE). 16. 119. 10.3991/ijoe.v16i05.13325.

[19] N. Srivastava and P. Raghav, "A review on swarm intelligence based routing algorithms in a mobile ad-hoc network," 2017 8th International Conference on Computing, Communication and Networking Technologies (ICCCNT), 2017, pp. 1-7, doi: 10.1109/ICCCNT.2017.8203988.

[20] Kumaravel, A. & Muthial, Chandrasekaran. (2019). Performance analysis of malicious node detection in MANET using ANFIS classification approach. Cluster Computing. 22. 10.1007/s10586-018-1955-z.