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An Exploration into Energy Efficient Algorithms Based on the Techniques of Particle Swarm Optimization in MANET

Haridas.S, Rama Prasath.A

Abstract: ***This paper throws understanding into nature inspired meta-heuristic algorithm; Particle Swarm Optimization based technique in designing various energy efficient MANET routing algorithms. Mobile ad hoc network (MANET) is a framework-less system of self-directed mobile nodes. Owing to the dynamic topological property of MANET, it's very rigid task to calculate the performance of routing protocol under unpredictable network conditions and the performance of the network will degrade. The performance of Mobile Ad-hoc network is measured by metrics such as packet delivery ratio, battery power and total delay in delivery. Regular variation in topology affect route selection and lifespan of network, hence it is essential to optimize these metrics parameters. There are various protocols developed for routing. These routing paths are established to send data packets through the shortest path without a satisfying multi-objective approach. The purpose of the research is to discuss different approaches of swarm based intelligence routing algorithms used in MANET under dynamic conditions by comparing the measured metrics and to design a novel effective PSO based routing procedure for MANET.***

Keywords: MANET, Network lifetime, Particle swarm optimization, Resource optimization.

I. INTRODUCTION

Mobile ad hoc network (MANET) is a pool of autonomous self-constituted terminal nodes interconnected through multi-hop wireless links without any prevailing network framework or integrated administration. These terminal nodes act as both host and router for sending, receiving and forwarding data. Data handling and transmitting is carried out by selecting appropriate routing protocols. Due to changing network topology, the most common interesting aspect in MANET is routing. At all time, most of the routing protocols to find the nearest path are not a good solution. All the nodes in an ad hoc network is contained by energy consumption for its process. In Mobile Ad-hoc Networks most of the energy is consumed during Communication: transmission and reception. The routing patterns should be flexible, reliable and robust in an ad hoc setting. Path Choice must be done by considering multiple metrics such as battery status ratio, energy consumption, and load balancing capacity of each node.

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* Correspondence Author

Haridas.S*, Assistant Professor, Dept. of Computer Science, Government First Grade College, Tumkur, Karnataka, India.

Rama Prasath.A, Assistant Professor (Selection Grade), Department of Computer Applications, Hindustan Institute of Technology and Science, Chennai, India

PSO is an optimization technique based on population and was suggested by Kennedy and Eberhart in 1995 [6]. This technique is encouraged by the performance of birds in the herding and fish swimming. The customary PSO model made up of a crowd of particles, moving associatively through the possible range of solution to find new results. Each particle's location and velocity are denoted by a position vector; and velocity vector respectively.

Every particle has a suitable value which is calculated using an equitable function. Each of the particles memorizes its best-*Pbest* performance and their group will also have the Global best- *Gbest* performance.

During each iteration, the fitness and particle position is of each particle is calculated by using fitness function. Each particle's velocity is updated using previously defined *Gbest* and *Pbest* values.

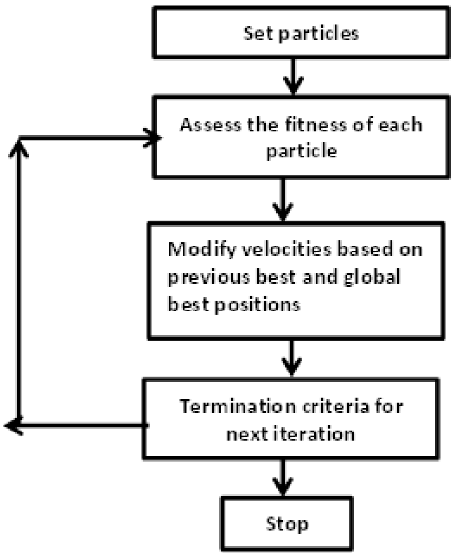

Fig.1: Flow chart for particle's velocity and position updating:

Particle Swarm Algorithm:

Updated Velocity=Inertia effect + Native search (Personal Influence) + Inclusive search (Social Influence)

In terms of equation:

$$V_{i+1}=wV_1+C_1*rand\,()*(Pbest_i-X_i)+C_2*rand\,()*(Gbest_1-X_i) \quad \ldots\ldots (1)$$

Updated Position:

$$X_{i+1}=X_i+V_{i+1} \quad \ldots\ldots (2)$$

Where, C_1 and C_2 are learning factor and w is the inertia weight and i=1, 2……N

Function ***rand ( )*** value ranges between 0 and 1.

By using Equation (1), Particles' new velocity calculated after its own best experience (position), current position distances, its earlier velocity and the group's best experience. The new location computed using equation (2), and then the particle flies in the direction of the new location.

To solve the problem, related pre-defined fitness functions used to measure the performance of each particle.

The inertia weight influences the abilities of the particles to adjust between global and local exploration. Higher inertia weight allows for a new global search area while lower inertia weight tends to encourage local exploration to fine tune the current search field.

Hence it is very much essential to select suitable inertia weight for balanced global and local exploration ability. On an average, inertia weight in the range [0.9, 1.2] has an improved performance and has a lesser amount of iteration to find the finest search.

II. OBJECTIVES

The goals of the proposed work will be to achieve the following:

- Investigate and research different PSO-inspired algorithms in MANET.
- A Mobile Network with different variables to analyse energy consumption.
- Compare and assess the outcomes on the following metrics.

A. Packet Delivery Ratio:

It amount of the ratio of the sum of the effectively delivered data packets to the destination and the sum of data packets directed by the sender. It describes the delivery capabilities of the network. A higher value of this metric means better performance of the protocol.

$$\boldsymbol{PDR} = \left(\frac{\textbf{Packets Acknowledged}}{\textbf{Packets Directed}}\right)*100$$

B. End-to-End Delay:

It is average time consumed by the data packet to reach the destination which includes delay caused by queue, phase of route discovery process and delays in retransmission. A higher end-to-end delay value means that the network is blocked, and therefore the routing protocol fails to achieve the target and is calculated as follows.

$$\boldsymbol{End\ to\ End\ Delay} = \sum \frac{(\textbf{arrive time} - \textbf{send time})}{\textbf{No. Delivered Packets}}$$

C. Energy Consumption:

It is the limited resources in a wireless network. The Energy intake is measured with joules as the unit during transmission of packet which includes in sleep, idle state and on the amount of energy used by node in routing and is calculated in the following manner.

EC=No.of Sensor nodes * Power * Time

III. LITERATURE REVIEW

Topology Aware Resource Optimized Geographic Routing (TA-ROGR) was proposed in 2017 by Nallusamy and Sabari[1] to improve the geographic routing efficiency in MANET. It used a Memetic Algorithm with the aid of fitness function to measures the topological conditions such as mobility of nodes, signal strength, and interference before transmitting the data. The optimal route is selected through the mobile node with higher speed, signal strength, and lower interference ratio to improve the lifetime of networks. Fitness function is calculated by looking into the energy, bandwidth, delay time of mobile node for discovering the resource optimized geographic route in MANET. TA-ROGR technique uses Particle Swarm Optimization (PSO) Algorithm for realizing increased throughput and reduced energy consumption. The simulation of the TAROGR technique performed on end-to-end delay, throughput, PDR, and energy consumption parameters and is accomplished to improve the throughput of geographic routing efficiency and also to reduces the data transmission energy consumption.

In 2019, Nallusamy and Sabari[2] proposed an efficient resource-based Particle Swarm Resource Optimized Geographic Routing (PS-ROGR) technique to increase the lifespan of MANET's network and resource optimisation. In the range of solution, the position of each of the nodes (particles) was controlled based on its local best position. The communication between the nodes was accomplished with minimum energy using PSO based on the fitness value. The proposed model was matched with the existing model based on the average end to end delay, energy consumption, packet delivery ratio and lifetime of the network and the resultant displayed better performance with the proposed approach.

In 2017, J. Rangaraj and Dr. M. Anitha [4] proposed a novel hybrid ACO-FDRPSO technique for optimizing energy and network performance. This is hybrid technique of Ant Colony Optimization with Fitness Distance Ratio based PSO. It is designed to preserve time to live period to avoid keeping the node being active all the time. The ACO uses the duty cycle to select nodes with higher Residual Energy for transmission and nodes with lesser RE is moved to sleep state. The path selected by ACO is optimized by FDRPSO.

Mobility Aware Energy Efficient Clustering for MANET: A Bio-Inspired Approach with Particle Swarm Optimization- MEPSO was proposed in 2017 by Naghma Khatoon and Amritanjali[3]. This paper focused on movement and energy efficiency limitations to develop a clustering algorithm inspired by particle swarm optimization. CH is selected on the basis of their less mobility and retained energy for a longer duration and to increase lifespan of the CH (cluster heads). The cluster formation is developed by the use of particle swarm optimization technique to take multi-objective fitness function. The planned research showed success in terms of lifetime of the network, energy consumption, PDR, an average number of clusters created and the average number of re-cluster needed. Also, the simulation results showed its success over the prevailing associated algorithms.

IV. COMPARATIVE ANALYSIS OF SWARM INTELLIGENCE BASED ROUTING ALGORITHM

References	Methodology	Performance Metrics	Parametric Analysis	Conclusion
2017, Naghma Khatoon and Amritanjali[3]	Mobility aware energy-efficient clustering based on particle swarm optimization (ME-PSO)	Prolonging the network's lifespan by enabling movement as well as mobile node energy	Lifespan of network, energy consumption, PDR, average number of clusters and the average number of clusters needed	Proved its success over the prevailing associated algorithms (A-PSO) and (CLPSO)
2017 Nallusamy and Sabari [1]	Topology Aware Resource Optimized PSO algorithm employed Geographic Routing (TA-ROGR)	PSO algorithm is used in TA-ROGR method to achieve improvement of the geographic routing in MANET with topological stability, with resource optimisation	Residual energy, bandwidth, and time delay	Increased the topological stability of data communication, improved throughput and energy reduction
2019 Nallusamy and Sabari [2]	Efficient Particle Swarm based Resource Optimized Geographical Routing (PS-ROGR)	Improving the network's lifespan with the help of particle swarm optimization, to reduce energy consumption.	Lifetime of network, PDR, average end to end delay and energy consumption	Good use of minimum energy consumption, packet delivery ratio and higher the lifespan of network with least end-to-end delay.
J. Rangaraj and Dr. M. Anitha [4]	A hybrid ACO-FDRPSO method	To achieve energy optimization in.	Throughput, delay, energy, overhead and PDR networks retaining the strength of the nodes concerning energy.	The duty cycle of node energy increased multiple times, improved network throughput and PDR, with minimum delay and energy depletion

V. RESULTS AND DISCUSSION

A. Packet Delivery Ratio:

Table 1. Tabulation for Packet Delivery ratio

No of Nodes	ME-PSO	PS-ROGR	TA-ROGR	ACO-FDR PSO
9	77	74	81	97
18	69	76	83	96
27	57	78	85	94
36	51	80	88	92
45	46	83	90	89
54	40	84	91	86
63	38	86	93	82
72	35	90	94	80

Table 1 shows simulation results with varied nodes from 9 to 72, used to find the result of the algorithm. The movement of nodes is set to 15 m/s. Fig 2 displays the graph of packet delivery ratio versus number of nodes. Here we can see once the node count increases, PDR reduces. At node 70 the maximum packet delivery is saturated.

B. End to End Delay

Table 2. Tabulation for End to End Delay

No of Nodes	ME-PSO	PS-ROGR	TA-ROGR	ACO-FDR PSO
9	24	8	4.5	3
18	45	9	8	10
27	57	11	17	14
36	71	13	13	21
45	85	14	15.4	23
54	90	18	17.6	30
63	95	21	21	38
72	102	23	24	41

In fig. 3 the PS-ROGR algorithm has shown a better result than another model. Here the end to end delay is displayed against number of nodes. In the above scenario when the no. of node increases, there is a constant decrease in delay as availability of neighbouring node increases. When the counting of the node becomes more than 90 the possibility of packet drop arises because of collision.

C. Energy Consumption:

Table 3. Tabulation for Energy Consumption in Joules

No of Nodes	ME-PSO	PS-ROGR	TA-ROGR	ACO-FDR PSO
50	840	753	705	920
100	875	785	743	930
150	920	890	768	960

200	950	920	797	988
250	987	962	825	1010
300	1020	986	849	1022
350	1040	1010	876	1058
400	1063	1023	902	1072
450	1082	1050	935	1120
500	1100	1073	980	1148

Power is required for the transmission of the packets; this energy consumption is calculated with Joules (J) as unit. Figure 4 displays the energy consumption calculations based on the number of nodes; the energy consumption PS-ROGR technique is better than other models.

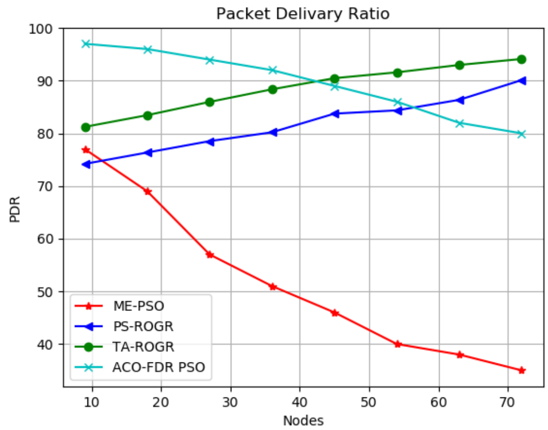

Fig2: Measurement of Packet Delivery Ratio

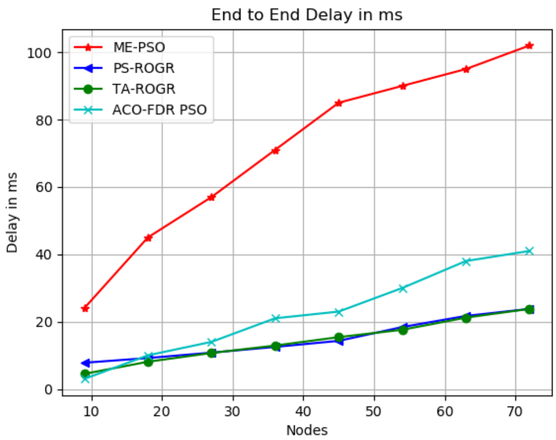

Fig 3: Measurement of End to End Delay

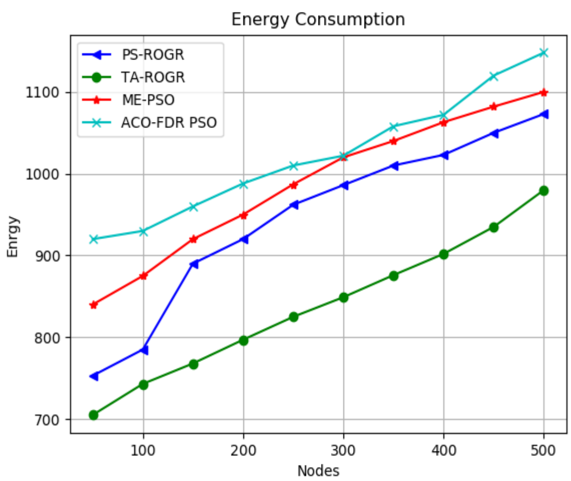

Fig 4: Measurement of Energy Consumption

VI. CONCLUSION:

From the result, research presented the versatility nature of MANETs. A simulation result shows that these hybrid algorithms can minimize data transmission delays and can improve the network's throughput and packet delivery ratio. Under varied simulation, it is seen that PS-ROGR is better positions in end to end delay and Packet Delivery Ratio. But energy consumption is least in the case of TA-ROGR. Hence it is suggested to improve the energy consumption of PS-ROGR technique; thereby the lifetime of network can be improved.

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AUTHORS PROFILE

Haridas S, Assistant Professor, Dept. of Computer Science, Government First Grade College, Tumkur, Karnataka, India. Research Scholar, Hindustan Institute of Technology and Science, Chennai.

Dr. A. Rama Prasath Assistant Professor (Selection Grade), Department of Computer Applications, Hindustan Institute of Technology and Science, Chennai, India. His research interests are in the area of evolutionary algorithms, image processing and wireless network.