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Multi-Criteria based Ant Colony Optimization to Improve Quality of Services of Manets

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Abstract: ***Mobile Adhoc Networks (MANETs) is one of the fastest growing research areas in the field of communications technologies. The constant movement of the nodes in such networks leads to topological changes which causes link breakages among the nodes. The existing work focuses on optimizing the path from source to destination using simple ant colony optimization without focusing on improving the energy consumption or reducing the link breakages. The proposed work considers different parameters such as Pheromone Value, Euclidean distance, Residual energy and mobility of the nodes into account while optimizing the route of the mobile ad hoc network. The proposed system has been implemented using NS2 and the performance has been analyzed based on remaining energy of the network, packet drops, packet delivery ratio, throughput and end to end delay. Experimental results indicate increased performance of the network against current techniques.***

Keywords: Mobile Ad hoc network, Ant colony optimization, pheromone value, Euclidean distance, Residual Energy

I. INTRODUCTION

Mobile communication is one of the most important computer technological developments. In the last decade, innovation has led to popular and diverse advances in software and hardware technology (Ishu, 2017). A mobile adhoc network (MANET) is widely used in the absence of a national communication infrastructure. In many applications, such as military (Hong,2002&Yang,2013), this type of network is used. Become an important subject for research because of its wide range of applications. Network node performs two roles: a data-packet router prepared for other nodes and a data-packet flow producer and consumer (Jain 2015). Notwithstanding this, two significant obstacles in MANET research lie in the limited battery life and node mobility. MANET can easily and rapidly alter its wireless topology (Sun 2001). The advantage of this network is that it may be linked to a big Internet scale. The MANET node has two aims: it can be routed with a different node and used for other nodes as a router. Nodes moved freely and randomly in a MANET and can always leave and join. The topology of the network is evolving dynamically because of the mobile nature of the nodes. For the network to adapt to the topological changes (Boutaba, 2005 and Zadin, 2015), the appropriate routing protocol is needed. In previous work, a lot of study has been done on optimizing the path from source to destination using ant colony optimization.

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Such works focus less on improving the energy consumption of the network and reducing the link breakages in the network simultaneously. This study focuses on using multiple factors to modify the ant colony optimization to improve performance of the network.

The main contributions of the work are**:**

- To modify the Ant Colony Optimization concept to increase the efficiency of the algorithm.
- Design the energy efficient-ACO algorithm
- Comparison of ACO and improved ACO algorithm performance.

This is how this paper is structured. Section II explains the optimization of the ant colony (ACO) cycle. Section III is a survey of literature reviews. Section IV discusses the Proposed Methodology of work. Section V shows the experiment results and paper is concluded in section V.

II. ANT COLONY OPTIMIZATION (ACO)

As a particular application (Tsutsui, 2008), ant colony optimization (ACO), influenced by feeding habits, is suggested as an application. The CAO generally uses' ants' as a tool for adaptive and continuous path updating to the secretion "pheromones" of the traveled route, as evaluation value. The use of ACO is thus difficult for successful output in a system such as WSN, where communications circumstances are shifting over short periods of time and the reciprocal perception of the state by terminals.

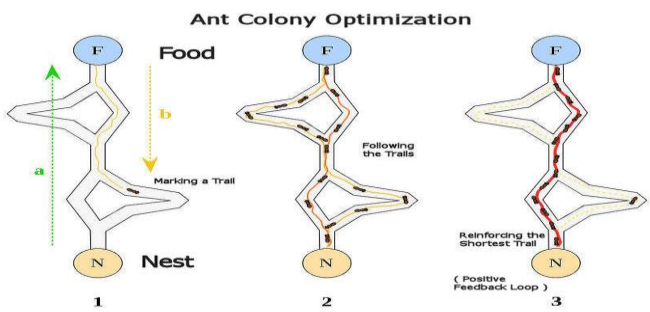

Figure 1. Behaviour of Ant Searching for food[13]

The following are the Advantages & Disadvantages of ACO:

- Can search in parallel with a population
- Can quickly identify good solutions
- Can be adapted to changes such as new distances
- Convergence guaranteed (Kavita,2017)
- The distribution of probabilities can be altered for each iteration[14]
- Have a challenging theoretical study

- Dependent sequences of random decisions
- Have more experimental than theoretical research

III. LITERATURE SURVEY

Sharma et al [15] Ant Colony Optimization Rooting algorithms based on the behavior of the ants and the respective Ant Colony Optimization (ACO) field, which is used in the communication network to solve the problem of the routing task. The routing algorithms used in Ad Hoc Mobile Ad Hoc Networks (MANETs) and ANTs have the same physique structure in urban environments, but still vary from our viewpoint in terms of the overhead rate and packet distribution ratio. ACO routing has the ability to solve a complex problem in city environments with simple ants. ACO routing is therefore the easiest and effective algorithm to find the best shortest route between sources at MANET. AntHocNet algorithm was also developed which is a mix of some other mobile Ad Hoc network routing sort (MANETs). Finally, the urban environment was discussed where the basic implications of this study were primarily examined and addressed.

Shahzad et al [18] Swarm Intelligence (SI) is a Computational Information subfield that provides a solution to complex problems of optimization that other approaches do not tackle easily. The SI model provides Particle Swarm Optimization Frameworks for probabilistic evaluation of swarm Intelligence (PSO, ACO) results and approaches, for wireless and ad hoc routing protocol routing algorithms, performance evaluation metrics are (a) overhead routing, (b) routings optimization and (c) energy consumption. This thesis analyzes PSO and ACO-based algorithms objectively with additional methods to optimize network routing protocols for ad hoc and wireless sensory systems.

Jaladi et al [17] In a hostile environment, for example battlefield or emergency situations, MANET can be easily mounted. Due to various features such as dynamic topology, time-differentiated service quality (QoS), restricted resources and energy requirements, the complexity increases in MANET routings. Smart routing like the optimization of ant colony (ACO) algorithms showed a good way of developing MANET routing algorithms. A new QoS optimization algorithm has been suggested for the mobile ad hoc network. The algorithm combines Ant Colony Optimization (ACO) motive with Optimized Link State Routing (OLSR) protocol to define multiple secure paths to improve QoS between the source and the destination nodes.

K.Sumathi et al [16] Mobile ad-hoc multi-hop networks are versatile and do not need pre-installed infrastructure. Their use will increase with emerging wireless transmission technologies and advanced equipment. Because they are robust, effective and scalable, the old routing algorithms have attracted researchers ' attention. Investigations have shown that ant-based routing protocols can eliminate at least one or more battery- life problems, such as scalability, repair, survival and adaptability. Therefore, more researchers draw anti-based methods rather than others.

Hogrefe et al [20] The ACO meta-heuristic that provides a common framework to approach solutions to problems of NP-hard optimization applies especially to complex issues, such as MANET routing. During the last two decades, researchers developed various ACO-based MANET routing protocols. MANETs contain surveys and comparisons of several ACO-based routing protocols. This survey provides the following inputs: 1) the integration of AOC Principles into MANET routing protocols; 2) the classification into five main categories of ACO-based routing approaches described in this paper; 3) the survey and comparison of chosen routing protocols regarding the design and simulation parameters.

Yong et al [19] Reducing interference with the network and slowing contact. Furthermore, a detailed, effective route selection plan is developed and the reliable route is selected in advance to reduce the likelihood of rebooting. Eventually, the Ant Colony algorithm is used to make changes to the network topology more adaptable to the routing algorithm. The findings of simulation show that DSAR improves the routing, package delivery and performance efficiency.

Zhao et al [21] The explanation behind this is the traditional method of blind flooding and the repeated introduction of node mobility routes. The elimination of overhead routing has a huge impact on the energy savings and enhancement of MANET efficiency for the mobile nodes.

In this analysis, an effective route mechanism for MANETs is suggested with a distributed dynamic routing algorithm. A fluid positional relation between nodes is constructed on the basis of the mobility of nodes. An enhanced routing approach is established using this relationship.

Madhavan et al [22] MANET (Mobile Ad hoc Network is a dynamically configured wireless-mobile network. The suggested algorithm uses the GA-ACO, which optimizes the quality of service (qos) parameters, such as node speed, communication latency, energy and bandwidth. The GA-ACO is the most important algorithm. Safe multicast routing systems based on agents are used to optimize the parameters based on the hybrid GA and ACO approaches in the proposed model. The proposed algorithm outpaces current OLSR and AODV protocols and improves performance by 12.25% and 7.41%, improves energy consumption by 5.23% and improves energy usage by 45.34% and improves energy usage by 42.01%.

IV. PROPOSED TECHNIQUE

Because of the dynamic topology and lack of an existing fixed infrastructure, routing in a MANET has become challenging task. However, studies to date demonstrate that a number of protocols for ad hoc mobile network are developed to achieve high power, end-to-end time, and delay jitter, delivery fraction of packets and low routing load and energy standardization. The main objective is to find the optimization route to send the packets and increase the network life further.

This is done by balancing the residual energy of all network nodes. The main objective of the research is to implement and increase the performance of energy efficient Ant Hoc networks. Mobility is one of the important factors when optimizing the route from source to destination.

The breakdown leads to a higher overhead routing because the nodes are required again to maintain the route, where control messages are to be retransmitted.

The four main factors to be considered in optimizing route between source and destination are as:

•**Pheromone value** which is stored at each intermediate node by the forward ant agents. The node having the highest pheromone level is chosen to optimize the route towards the destination.
•**Residual energy** of the nodes which represents the lifetime of the node. The more remaining energy a node has, the longer it will continue to be active in the network.
•**Mobility of the nodes-** important in optimizing the route in mobile ad hoc networks. If the highly mobile nodes are chosen while forming the route, the nodes will move away to a new place very soon resulting in the link breakage. The optimized path must contain relatively less mobile nodes in the network.
•**Euclidean distance** between node and destination- Fourth parameter that will be deciding the optimized route is the Euclidean distance between the nodes and the destination. The route between source and destination must be short in length.
The paper aims to design hybridized ACO system consisting of the three parameter - pheromone value, residual energy of the nodes and the Euclidean distance between the node and the destination. Further mobility has been taken into consideration and an effort has been put to enhance the developed ACO system. The common feature in hybridized ACO and mobility driven hybridized-ACO will be the reward and penalty system.
In the hybridized ACO system, the reward penalty system is as:

•The highest pheromone value path will be rewarded with more points as compared to others.
•The path with nodes having highest residual energy levels will be rewarded with more credit points.
•The shortest path will be given more credit points.
•Reverse will follow: for the paths having less pheromone value, less residual energy and longer paths, they will penalized.

In Mobility driven hybridized-ACO the reward penalty system works same way as the hybridized ACO system with the additional factor that the path having less mobile nodes will be rewarded with more credit points.The path with more credit points is meant as the best optimized path and chosen for transmitting the data from source to destination node.
Moreover, hybridized ACO based on mobility is assumed to have the source node available for the location of the destination information so that the forwarding ACOs will be broadcast only in the direction of the destination node rather than in each direction.

V. EXPERIMENTAL RESULTS

The system proposed was implemented with NS2. Network Simulator (Version 2), often referred to as NS 2, is simply an event-led open-source simulation tool used to study the dynamic nature of communication networks. Wired as well as wireless network functions and protocols can be simulated with NS2 (such as routing algorithms, TCP, UDP). It has different standards and features such as multi-layered array of different protocols, Ad-hoc Routing (ASDV, DSR, AODV), MAC (802.11, 802.3, TDMA), Tracing etc. Results of proposed technique are evaluated on the basis of various parameters:

- **Remaining Energy:** It is computed as the difference between initial and consumed energy in the network. Better values of remaining energy shows better network lifetime.

Remaining Energy = Initial Energy-Consume energy

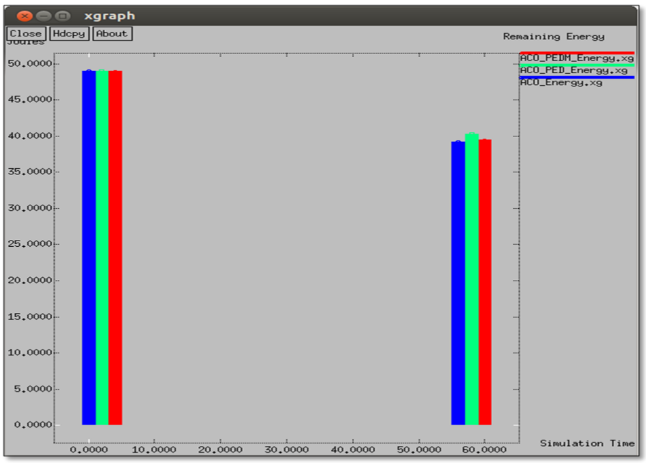

Figure 2: Comparison of the proposed system with existing energy techniques

The figure2 above shows the remaining energy in the network for the three variations of ACO. Initially the network had nodes with initial energy of 50 Joules. Out of the three techniques, the remaining energy was maximum for scenario when path selection was done using the pheromone value, distance and remaining energy of the nodes. It is indicated by green bar in the above figure.

Table 5.1: Remaining Energy for three protocols

ACO	39.22
PED-ACO	40.32
PEDM-ACO	39.483

- **Packet Drop:** It is defined number of packets dropped in the network.

Packet drop=Number of Packets Sent - Number of Packets Received

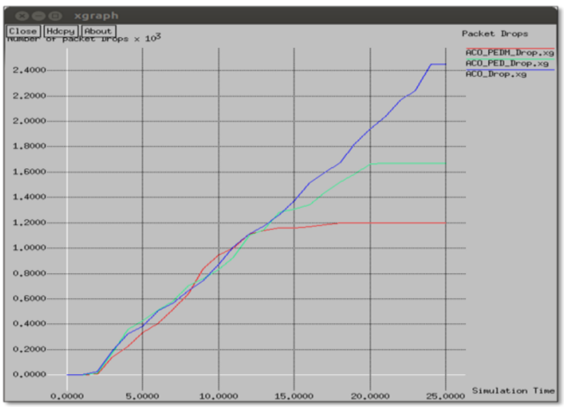

Figure 3: Comparison of the packet drops

The above figure3 shows a comparison of the techniques proposed on the basis of packet drops. The best case scenario was the one where the ACO was modified using pheromone value, remaining energy, distance and mobility of the nodes. The inclusion of the mobility of the nodes to select the optimal path leads to less link breakages in the network. This also reduces the packet drops in the network.

Table 5.2: Packet drop for three protocols

Simulation times (ms)	Packet Drops		
	PEDM-ACO	PED-ACO	ACO
5	333	425	384
10	944	831	870
15	1159	1306	1371
20	1200	1662	1941
25	1200	1669	2451

- **Packet Delivery Ratio:** It is defined as the ratio of Number of packets received to number of packets sent in the network.

$$\textbf{PDR} = \frac{\textbf{Number of packets Recieved}}{\textbf{Number of packets Sent}}$$

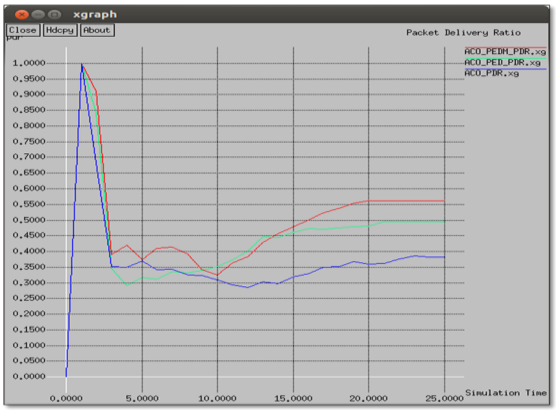

Figure 4: Comparison of PDR for three techniques

The figure4 above shows the comparison of packet delivery ratio of the three techniques. The best values for PDR is obtained when the path selection is optimized using

Jitter = Time at which packet received - Time at which packet is sent

pheromone deposited over the links, Euclidean distance between the nodes, residual energy of the nodes and mobility of the nodes.

Table 5.3: PDR for three protocols

Simulation times (ms)	Packet Delivery Ratio		
	PEDM-ACO	PED-ACO	ACO
5.0000	0.3700	0.3200	0.3600
10.0000	0.3300	0.3500	0.3100
15.0000	0.4700	0.4600	0.3200
20.0000	0.5600	0.4700	0.3600
25.0000	0.5600	0.5000	0.3800

Time at which packet is received -Time at which packet is sent

Delay: It is the time taken by the packets to travel from source to destination node in the path.

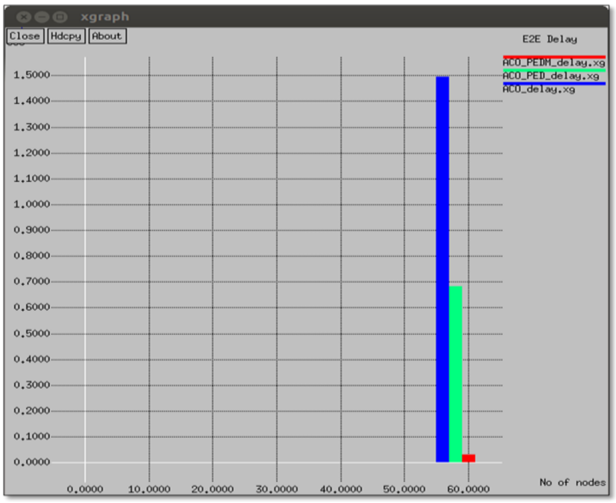

Figure 5: Comparison of End to End Delay for three techniques

On the basis of the end to end delay, the above figure5 shows the end to end delay was maximum for ACO. The reason behind this is that it does not considers the distance of the nodes or the mobility of the nodes to select the optimal path. This often causes network interruptions which result in higher values for the network end-to-end delay. This was also true when ACO was modified with residual energy and node distance. Although the distance between nodes was incorporated in selecting the optimal path, the end-to-end delay was reduced a while, the best results were achieved when selecting the optimal path for the mobility of nodes.

Table 5.4: end to end delay for three protocols

Number Of Nodes	E2E Delay		
60.0000	PEDM-ACO	PED-ACO	ACO
	0.03 seconds	0.682 seconds	1.49 seconds

- **Jitter:** Jitter is time taken by packets, both data and control packets, to travel between two nodes.

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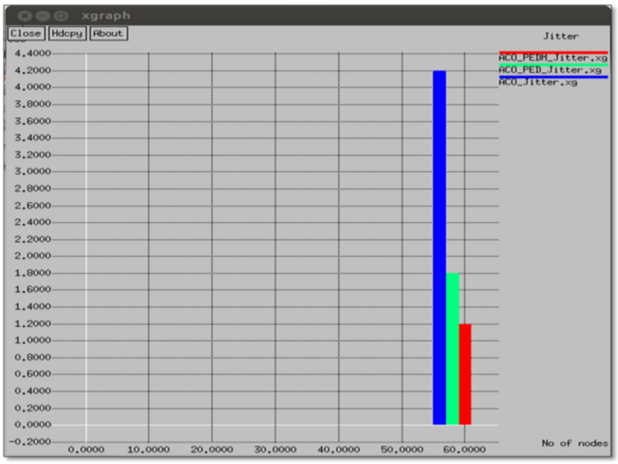

Figure 6: Contrast by Jitter of the three techniques

The above figure6 shows the values of jitter for the three techniques. Similar to the end to end delay the value of jitter was best for ACO-PEDM scenario. The less values shows lesser control packets being sent in the network to maintain the links between two nodes.

Table 5.5: Jitter for three protocols

Number of nodes	Jitter		
60	PEDM-ACO	PED-ACO	ACO
	1.19 seconds	1.79 seconds	4.19 seconds

- **Throughput:** This is amount of data received at destination node per unit of time

$$\textit{Throughput} = \frac{\textit{Number of packets recieved} * \textit{Size of Packets}}{\textit{Time}}$$

The figure7 below shows throughput for the three techniques. The value of throughput was maximum for ACO-PEDM variation which showed lesser packet drops in the network due to lesser link breakages. Therefore owing to lesser packet drops the value of throughout was higher in the network.

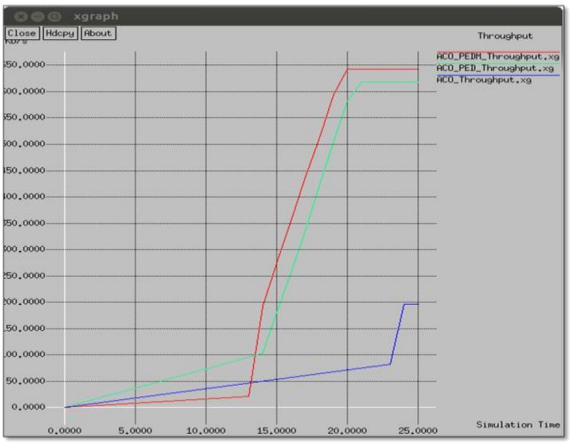

Figure 7: Comparison of the Throughput among the techniques

Table 5.6: Throughput for three protocols

Throughput		
PEDM-ACO	PED-ACO	ACO
643.072 Kbps	618.496 Kbps	196.608 Kbps

VI. CONCLUSION

In this study, optimizing of the path from source to destination is done by modifying ant colony optimization. The aim of this document was to develop a hybridized ACO system using three parameters, node residual energy, mobility of the nodes and the Euclidean distance between the nodes. The system proposed was implemented in NS2. The results of the proposed technology are assessed by means of performance, packet drop number, packet delivery rate, end-to-end delay, jitter, throughput and residual energy of the network. Results showed that when the path selection was done using ACO-PEDM (pheromone deposited at the nodes, residual energy of the nodes, distance among the nodes, and mobility of the nodes) the path experienced lesser link breakages in the network. This led to lesser packet drops in the network which consequently improved packet delivery ratio and throughput of the network. Also, when the links are not getting broken frequently in the network, the lesser control packets need to be sent in the network to maintain the links. Therefore, the end to end delay and jitter was also best for this scenario.

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