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A New Hybrid Technique to Improve the Path Selection in Reducing Energy Consumption in Mobile AD-HOC Networks

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Abstract

The AODV has evolved into many variants over the past ten years. The routing protocols have been improved from selecting minimum number hop counts to consider more factors affecting path selections. The transmission power increases with increased distance between each node. Hence, a higher amount of energy is consumed while transmitting than receiving data. Many traditional routing protocols consider nodes' energy consumption and several energy-related parameters, such as energy consumed per packet, remaining battery power, and energy required per transmission. This paper introduces a new technique for improving path selection by combining ant-colony optimization and lion optimization algorithm after all possible paths are discovered in the network. This technique improves the energy efficiency and the performance metrics of each node.

Keywords: AODV, LOA, ACO, ALEEP scheme, MANET, Path selection, QoS, Energy consumption

INTRODUCTION

Wireless networks have currently become a major concern in the field of communications [1]. These networks can be utilized in various areas of technology, such as in the military, in industries, and in personal area networks. Wireless networks have valuable attributes, including easy installation, cost-efficiency, and reliability, which lead to their wide range of applications. Unlike wired networks, wireless networks, such as cellular phone networks, Wi-Fi networks, and satellite communication systems, are independent of fixed infrastructure [2] [3].

A mobile ad hoc network (MANET) is a type of wireless ad hoc network that is widely used at present. It consists of a set of mobile nodes that does not rely on any fixed infrastructure, such as a base station or an access point. A MANET is commonly used to enable communication when common communication infrastructure is unavailable. MANETs are used in various applications, such as in the military [4] [5].

MANETs have become an active area of research because of their wide range of applications. A network node has two functions: as a router for data packets prepared for other nodes and as a producer and consumer of data packet flow [6]. However, limited battery life and node mobility are two important challenges in MANET research.

The wireless topology of a MANET can be changed efficiently and rapidly [7]. Furthermore, the benefit of using this type of network is its capability to work independently. A MANET can also be linked to a large Internet-scale. The use of MANETs has become common among scholars since the 1990s because of the increasing popularity of laptop computers and Wi-Fi networks.

Each node in a MANET has two purposes. That is, each node can be the source to forward information or become an intermediate node to route information for other nodes. The nodes in MANET move randomly and freely, and they can leave and join the network at any time. The topology of the network dynamically changes given the mobile nature of its nodes. Thus, a suitable routing protocol is required to enable the network to adapt to changes in topology [8] .The issue need be addressed is how the ad hoc network routing adapts to the complexity generated by subsequent movement and changes the network topology.

Different routing protocols, including dynamic source routing [9], destination sequenced distance vector routing [10], and ad-hoc on-demand distance vector routing (AODV) [11], have been constructed.

Routing protocols can be categorized into three main types: reactive, proactive, and hybrid. In proactive routing protocols, an up-to-date topological map of a network is maintained. In this mechanism, the routes are already known and available when a packet is required to be sent from the source to the destination. In reactive routing protocols, which are also known as on-demand driven routing protocols, the route is intermittently available. Therefore, when a data packet is required to be sent, a route discovery procedure is executed by sending query requests that flood the network. In hybrid routing protocols, the advantages of both reactive and proactive routing protocols are combined. This type of routing uses a proactive mechanism when a node exists within the transmission range and then switches to a reactive mechanism when a node is outside the transmission range [12] [13].

Numerous artificial and heuristic quality of service (QoS) routing algorithms that can be applied to MANET routing have been suggested [14]. Routing is divided into several categories: single- and multi-path routing, source routing and the next step, hierarchical and flat routing, centralized and distributed routing, data- and address-centric routing, QoS-based and best-effort routing, event-driven and queue-based routing, and energy-based routing. Many studies have investigated this issue and have used various methods, which are frequently heuristic and artificial intelligence tools.

RELATED WORK

Every wireless node requires a regular power source for effectiveness and node availability. To improve the power efficiency and keep the price of MANET low, the research in modern wireless communication moves towards bio-inspired algorithms. ACO is an example of a bio-inspired algorithm, which is derived from a definite self-organising characteristic seen in ant colonies. This characteristic displays the nearest method of ACO optimisation [15].

In ants, ideal routes are considered a primary demonstration of ACO characterizing how the ants determine the path to reach the source of food. ACO is based on route behavior that applies a method called pheromones, which disseminates pheromones as they change between the nest and food source, and how they essentially proceed in the direction of locations where the intensity of pheromones is higher. This occurrence is called stigmergy. Numerous variants of combinatorial search problems have been developed with ACO, such as scheduling traveling salesmen and vehicle routing. Moreover, the broadcast outline serves an essential function in the quality of the network, and this has to be chosen carefully. There are numerous broadcasting protocols in MANET that has been designed to accomplish an effective routing protocol.

Alghamdi et al. [16] presented a new hybrid scheme that combines different techniques to reduce overhead and conserve energy. This Proposed an Energy-Efficient Adaptive Forwarding Scheme that utilized the information of the 1-hop neighboring radios. The scheme nodes do not need a positioning system or distance calculation to determine their location. The proposed protocol divides the network into different groups based on their transmission power levels. Therefore, the node which receives a hello message from different groups is considered a Gateway node. This node efficiently participates in forwarding RREQ packets and the unnecessary redundant retransmission is avoided. Their evaluation of the proposed protocol shows a reduction in the routing overhead and in energy consumption when compared with the Pure-AODV Flooding.

Vallikannu, George and Srivatsa [17] have recommended the ALEEP_ACO method as a new ant colony based algorithm that used the location of the nodes, adaptive transmission power (ATP), and energy aware metrics to increase the efficiency of routing. ALEEP_ACO is more reliable as it found at least one energetic path to the destination. This method achieved a good result but still choosing the path with minimum hop counts which can lead to limiting the lifespan of the network. Their algorithm uses a joint evaluation function where it reduces greatly power wasted by transmission by applying ATP and uses FANTs to determine eligible energetic possible paths. By using these methods energy consumption of network devices is reduced, thereby improving the lifetime of MANET.

Giagkos and Wilson [18] recommended swarm intelligence-based routing protocols, along with a newly established routing protocols inspired by bees, to provide multi-path routing in the wireless ad-hoc networks of mobile nodes. Results show that implementing swarm intelligence provides a significant amount of efficiency and adaptability which can be done under numerous network conditions.

PROPOSED TECHNIQUE

A serious issue in MANETs emerges from the lack of sufficient energy to support mobile networking devices. This shortage disrupts packet forwarding in MANETs. The energy consumption has been identified as the major problem in MANET and should be addressed accordingly.

Consequently, the amount of transmission power increases when the distance between nodes increases. A higher amount of energy is consumed during the transmission of data than during the reception of data.

The drawback proposed by Vallikannu [17] is that it chooses the path with the minimum hop counts and with the ant colonization scheme used, the pheromone vaporization occurs for discovered path not used for forwarding data.

An optimization algorithm called the lion optimization algorithm (LOA) [19] is introduced. LOA is constructed based on the simulation of the solitary and cooperative behaviors of lions, such as prey capturing, mating, mutation, territorial marking, and defense. In this study, we use a technique, namely, LOA mating, which is an essential process that ensures the survival of lions and provides an opportunity for information exchange among members. The mating operator is a linear combination of parents to produce two new offspring.

The Vallikannu scheme reduces the activities performed by nodes. Consequently, this scheme leads to an important issue when running a multi-function network: a router with a node simultaneously serving as an end system. To overcome this specific problem, the efficiency of the Vallikannu scheme should be increased to provide additional energy for delivering packets.

The proposed technique uses a new routing technique based on eligible energetic path (ALEEP) ant colony optimization (ACO) with lion optimization algorithm (LOA) to determine the best path selection between the actual node source and the destination. ALEEP is a scheme that calculates the distance between nodes in a network and then accordingly adjusts transmission power for every node in the network. Figure 1 illustrates the implementation of the proposed technique

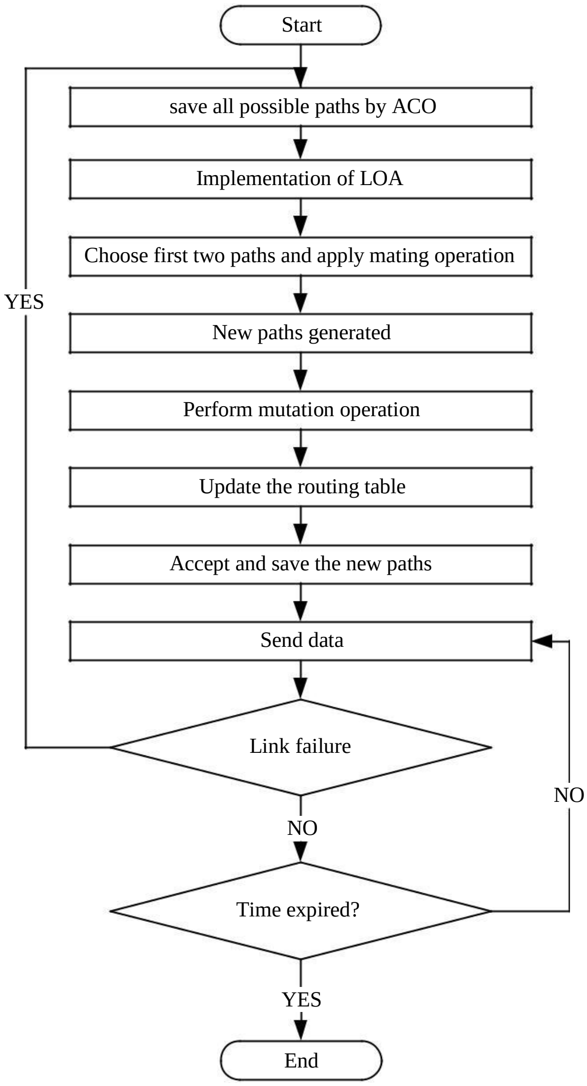

Figure 1: Flowchart of the implementation

After the transmission power of all the nodes is adjusted, ACO identifies all possible paths by broadcasting a forward ant technique to deposit the pheromone on the paths from the source to its destination. The source node S initially broadcasts a forward ant (FANT) as a route request (RREQ) packet to its 1-hop neighbor nodes from the list of K values. The routing table (RT) entry of each node contains a list of 1-hop neighbor K values. Through this RREQ packet, each node explores destination D and searches for entries of D in its RT until all possible paths are discovered.

A mobile ad hoc network (MANET) has a changing topology, hence, a node may move out of range and toward the nearest node or rebroadcast an RREQ. Eventually, the RREQ packet will reach destination D. For each RREQ received within the route discovery expiration time, a route reply packet is generated by D as a backward ant (BANT) technique and send to S by backtracking on the path through which a particular RREQ is delivered. After all possible paths are discovered as shown in figure 2, LOA will implement a specific strategy to enhance and select the best path from all possible paths. LOA will use a mating strategy to enhance path selection by comparing the parameters of paths.

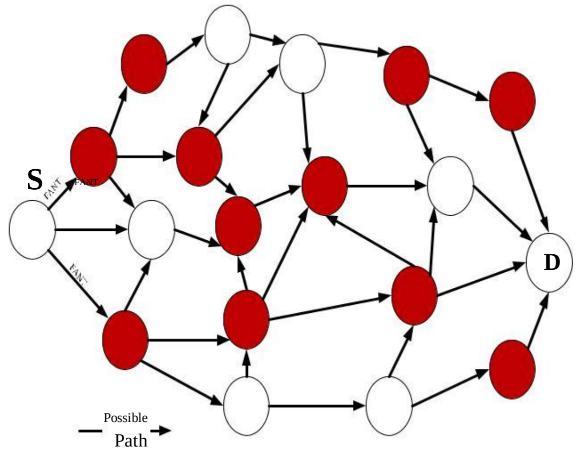

Figure 2: All possible paths

The LOA chooses first two paths which are established by ACO and compares their parameters. The parameter used for comparison is energy level in each node. This procedure will generate two new offsprings. Each offspring is considered as a new path. The mutation operation checks if there is a node within the same transmission range that has a higher energy level that can enhance the path. If higher energy node is available, the path will include this node. After mutation operation, the best path will be stored by the source node and store it in its memory. The new generated path will be considered as the best path, and data transmission can begin along with it.

RESULTS AND DISCUSSION

The simulation is studied under one scenario. The number of the node was varied from 10, 30, 60 and 100.Random Way Point (RWP) has been considered as a mobility model in our simulation. The higher speed of nodes leads to frequent changes in topology and hence more difficult scenario. Simulations at 0 m/s were used as a baseline for comparison with the previous experiments to evaluate the performance of protocols, we used one scenario such as several nodes as shown in table 1.

Table 1: Simulation parameters (Vallikannu et al. 2015)

Parameter	Value
Area	1000 ^{m2}
No of Nodes	[10 30 60 100]
Simulation time	100ms
Traffic type	CBR
Initial energy	200 J
Packet size	64 byte

PERFORMANCE METRICS

To evaluate the performance of proposed technique we will use different performance metrics as shown below

Packet Delivery Ratio :

Packet Delivery Ratio (PDR) means the ratio of the data packets that were delivered to the destination node to the data packets that were generated by the source. This metric shows a routing protocol's quality in its delivery of data packets from source to destination. The packet delivery ratio is computed via the following formula:

$= \Sigma$

Throughput :

Throughput is defined as packets delivered over the total simulation time. Throughput measures a routing protocol's efficiency in receiving data packets by destination. Throughput is calculated as follows:

Where N is the number of bits received successfully by all destinations.

Remaining Energy:

The remaining energy is the residual energy of each node. When the total remaining energy is calculated by summing up all the residual energy of each node.

$= \Sigma$

Where E_{tot} is the total remaining energy of the network, whereas E_i is the remaining energy of i^{th} node

Number of Packets Dropped:

Number of packets dropped is the ratio of the difference between the number of data packets sent and the number of a data packet received when a router receives a packet while processing another packet. The received packet needs to be stored in the input buffer while waiting its turn. A router has input buffer with limited size. A time may come when the buffer is full and the next packet needs to be dropped. The effect of packet loss in the network is that packet needs to be resent, which in turn may create overflow and cause more packet loss as well. It's a good metric to observe paths that have been taking by our algorithm. This metric also shows us the reliability of the path chosen by our algorithm. Packet drop is calculated as follows.

$(\%) =$

THE SIMULATION RESULTS

Remaining Energy :

The varying of remaining energy when increasing the number of nodes presents in figure 3. While the number of nodes increases as 10, 30, 60 and 100 nodes the remaining energy decreases. AODV dropped from 106.5 to 10.8 joules, ALEEP_ACO decreased from 64.95 to 17.25 joules and ALEEP_ACO with LOA reduced from 190.56 to 35.12 joules. The results show the number of the node has negative effective on the remaining energy for all types of protocols. It is shown that the proposed technique conserves energy more than other protocol. Because it establishes an optimal path from source to the destination node. This path has the highest energy level, this approach reduces the probability of exhausting nodes.

Table 2: The effect of number of node on Remaining Energy

No. of Nodes	AODV	ALEEP_ACO	ALEEP_ACO with LOA
10	106.5	164.95	190.65
30	46.25	69.86	103.02
60	22.17	35.22	54.21
100	10.8	17.25	35.12

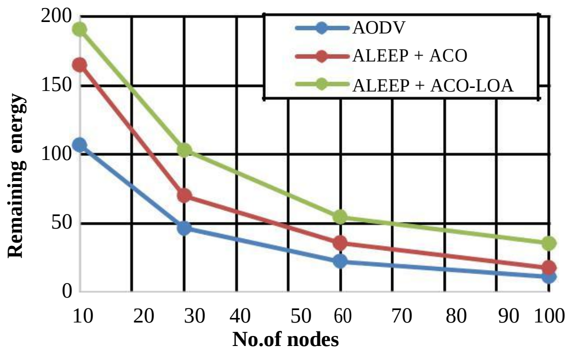

Figure 3 Remaining Energy

Packet Delivery Ratio:

Figure 4 depicts the varying of PDR with increases the number of nodes. The results show the PDR decrease while the number of nodes increases. The probability of link failure increase also increases which in turn increase the packet loss. However, the proposed approach better than both AODV and ALEEP_ACO

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Table 3: Effect of number of nodes on Packet Delivery Ratio

No. of nodes	AODV	ALEEP_ACO	ALEEP_ACO with LOA
10	61.05	84.75	94.2
30	29.08	35.56	56.01
60	19.56	22.39	30.89
100	14.1	16.65	24.15

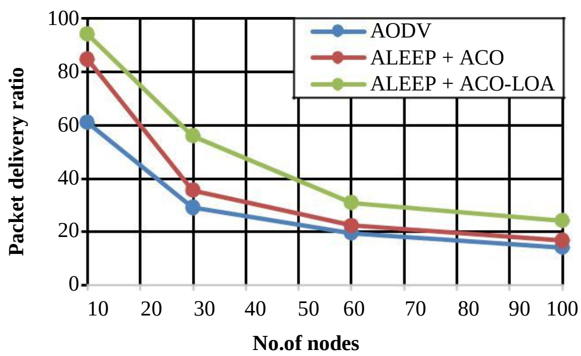

Figure 4: Packet Delivery Ratio

Throughput:

Figure 5 depicts the varying of throughput with increases the number of nodes. The results show the throughput decrease whereas the number of nodes increases. Due to the increasing in a number of nodes leads to more number of collisions and high loss of a packet. Moreover, the proposed approach has the highest throughput in comparing with AODV and ALLEP_ACO. Because the ALEEP_ACO with LOA establishes a path rely on the shortest path as well as highest energy. This mechanism leads to selecting a more stable path from source to the destination nodes. Furthermore, decrease the probability of collision and packet loss.

Table 4: The effect of number of nodes on throughput

No. of nodes	AODV	ALEEP _ACO	ALEEP_ ACO with LOA
10	280.19	446.52	642.14
30	129.21	216.83	377.84
60	82.28	120.19	209.51
100	32.05	81.09	180.19

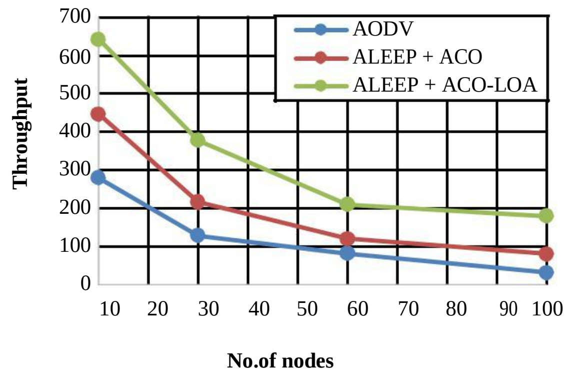

Figure 5: Throughput

Number of packets dropped:

The varying of packets drops when the number of nodes increases is present in figure 6. The results show clearly the proposed approach conserves the packets drop better than another approach. Due to the proposed approach select the path between source and destination nodes based on highest energy and shortest path. This leads to the steady path between source and destination nodes. This, in turn, reduces the packets drop.

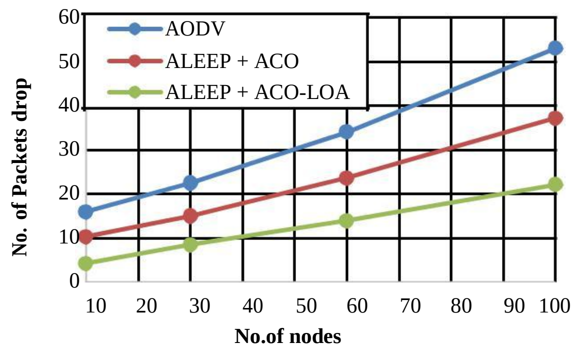

Figure 6: Number of packets dropped

Table 5: The effect of number of nodes on total number of packets dropped

No of nodes	AODV	ALEEP _ACO	ALEEP_ACO with LOA
10	15.9	10.29	4.18
30	22.46	14.91	8.46
60	34.7	23.52	13.85
100	53	73.1	22.1

CONCLUSION

There is a wide range of applications deployed for MANETs such as commercial and military applications. Thus, it is essential to establish a path from its source to its target destination and to ensure that the data packet delivered meets the QoS requirements. This study proposes a QoS routing algorithm applicable in MANET, which satisfy the energy constraints that improve the network lifetime. Using ALEEP_ACO_LOA techniques, the study enhanced the network lifetime which the algorithm used will compare with the stander AODV protocol and the recent approach.

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