A PERFORMANCE ANALYSIS OF ACO AND PSO BASED MULTIPATH ROUTING TECHNIQUES IN MOBILE ADHOC NETWORKS (MANET)

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Abstract:
Mobile adhoc network (MANET) is a network containing a set of mobile nodes which interacts with one another via wireless links. The data transmission reliability, widely distributed data, load balancing, interference, flooding, flat addressing, high energy utilization are the issues that the conventional multipath routing schemes face with MANET. To overcome these issues, a number of different multipath routing schemes have been developed. In this paper, we intend to assess the performance of two algorithms based on ant colony optimization (ACO) and particle swarm optimization (PSO). These two algorithms are compared and the results are investigated under several performance measures. The outcome verified that the Energy-Aware Multipath Routing Scheme Based on Particle Swarm Optimization (EMPSO) outperforms the compared method.

Keywords: MANET; EMPSO; ACO; Routing

I. INTRODUCTION

Without a central infrastructure, MANET [1] is made of mobile nodes that get connected through wireless medium. To carry out common routing operation such as forwarding data packets to a destination from source, routing method like Ad Hoc On-Demand Distance Vector and Dynamic Source Routing were executed. Routing methods also depends on the MANET characteristics. Security, data transmission reliability and multipath selection are the major requirements of a MANET which improves the performance of the network. To attain this, several researches are being done. One of the major research areas in MANET is on-demand routing. Because, in an ad hoc circumstance , the routing method must be robust, flexible and reliable. Node link failure and dynamic topology are the two factors that are constrained for routing function. The routing function complexity is increased by node mobility which is a major cause for node failure. Reduction in transmitting data, overhead in routing, reduction in network efficiency and reduced reliability are the causes of regular link failure. Therefore, MANET link failure is a significant problem. Additionally, this kind of failure usually tends to concurrent path failures. Thus, the data transmission reliability gets decreased; there will be high end-to-end delay if there in reduction in packet delivery proportion. It is costly to retransmit the data packets within a MANET and it also enhances the overhead of control message and decreases the routing function efficiency. Therefore, while a link failure occur, it is significant to choose an alternative path to increase the data transfer reliability. Among the data transferring from source towards destination, loop-free path is more involved in searching a best path. With a view to enhance the data transmission reliability which gives load balancing over nodes, Multipath routing in a MANET is used. The implication of data transfer simultaneously through several disjoint paths improves the proportion of packet delivery. Confidentiality, network lifetime, scalability and integrity are the issues that the multipath routing schemes deal with. But, in a MANET, data transmission reliability, empty set of neighbors, widely distributed data, load balancing, interference, flooding, flat addressing, large energy utilization are the issues faced by the conventional multipath routing schemes . Hence, to resolve few issues above, multipath routing method which is efficient is projected. In very often path failure and dynamic environment modification, the traditional multipath routing methods do not work well. It produces overhead in routing and the mobile node energy deplete quickly. Therefore, a multipath routing protocol that is reliable with minimum overhead will make sure the data transmission reliability. To solve the issues of multiobjective, Evolutionary system framework is flexible as they depend on population [2]. A set of solution is generated in one execution. In problems that follow multiobjective, there is no solitary solution which can be termed [3]. The probable solution of the issue in particle swarm optimization (PSO) [4], is known as particles. Swarm is a particle group which searches for a best solution. The particle in a Particle swarm optimization fly over search space and tune itself with a dynamic velocity based on the past behavior which it is stochastic optimization method. In search space, to fly an optimal search region, this procedure guides the particle [5]. Due to the very often link failure and dynamic characteristic in MANET, it is complex to make sure the data transmission reliability. To resolve this type of issue, PSO and ant colony optimization (ACO) can be implied.

In this paper, we intend to assess the performance of two algorithms based on ACO and PSO algorithms. These two algorithms are compared and the results are investigated under several performance measures. The outcome verified that the Energy-Aware Multipath Routing Scheme Based on Particle Swarm Optimization (EMPSO) outperforms the compared method.

II.RELATED WORKS

In searching best solution to network partition, clustering method and evolutionary systems [6] acts as a significant part. Particle swarm intelligence, genetic algorithm (GA), PSO based clustering and artificial neural network system (ANN) are the evolutionary method that are projected to find optimal global solution. Using a maximum flow model, PSO algorithm is proposed by Dengiz et al. [7] which use a robotic way of topology optimization for mobile ad hoc networks. By employing a maximum flow model, the communication of MANET is demonstrated as optimization and network flows. While examining the connectivity of network, this representation is more receptive to little modifications. When retaining swarm based intelligence algorithm benefits, Goswami et al. [8] projected a fuzzy ant colony based routing protocol employing swarm intelligence and fuzzy logic to choose best solution through assuming optimization of many aims. To decrease the traffic and to optimize the clustering numbers within network, Ali et al. [9] projected a multi objective solution through employing multi objective PSO. This method does intra cluster as well as inter cluster traffic which it is handled via cluster heads. The researcher's assumes the power utilization and node degree as performance metric. Multicast routing depending on the PSO (MPSO) has been projected by Nasab et al. [10] which aims on energy efficient utilization and multicast routing delay within MANET. In selecting the route, it choose the node that has reduced utilization of energy and with a reduced delay, it construct a multicast tree. Here present failure of route in entire methods of route discovery that results in routing overheads and loss of data. In MANET, for route recovery, PSO based Lifetime Prediction (PSOLP) algorithm has been projected by Manickavelu and Vaidyanathan [11]. This method forecast the node lifetime and link lifetime in bandwidth available depending on the attributes like rate of energy drain and nodes relative mobility. To determine the node status prediction, the attributes are fuzzified and it generate fuzzy rules. Prior to transmitting the data, the entire nodes verify the node status and the part of the data is transformed. A multicast QoS based routing method by using GA has been projected by Yun-Sheng et al. [12]. In a dynamic circumstance, it employs reduced computation time and resources available. Through choosing the suitable rates for genetic operations such as population size, mutation and crossover, this method improves the routes. To distribute the source node traffic on a path established Radi et al. [13] projected Low Interference Energy-efficient Multipath Routing protocol (LIEMRO). It gives load balancing which computes the rate of optimal traffic of paths. Once the primary is discovered, LIEMRO begins the transmission of packet. In order to the relative quality, the method of load balancing redisperse the traffic in source node while a novel path is produced. multipath routing protocol depending on AOMDV has been projected by Hurni and Braun [14]. To enhance the efficiency in energy and decrease the latency by load balancing are the main aim of using the multipath scheme by employing the data in cross layer. Every node uses the data given through MAC layer to transfer the packet towards the adjacent node with a view to diminish the data forwarding end-to-end delay. Over neural network (NN), an algorithm has been projected by Ghiasi and Karimi [15] learning automata adjusting learning value. To give a global search which is efficient, a combination of learning automata, local search algorithm and back-propagation algorithm were used. For testing and training the NN, attributes of Mobile network were measured. While the count of nodes gets enhanced within the network, learning automata method does not find best solution.

III. MULTIPATH ROUTING ALGORITHMS

3.1. Energy-Aware Multipath Routing Scheme Based on Particle Swarm Optimization

With a constrained wireless link and energy, MANET comprises of mobile nodes. From source to destination, every mobile node forwards the packets. As directed graph $G = (V, E)$, MANET is demonstrated. Neighbor node and mobile nodes symbols are vertices $v \in V$.

An edge $(u, V) \in E$ is a symbol of a wireless link among nodes u, v, that transmit packets to others. From a node u to node v, the energy utilization for forwarding packets is expressed as

$$E_{tx}(k,d) = E_{elec}(K) + E_{amp}(k,d), \quad (1)$$

where d is the distance among nodes and k is number of bits. E_{elec}, E_{amp} are energy degenerated per bit to receive and forward packets, correspondingly. For receiver, energy utilization is computed by

$$E_{rx}(k,d) = E_{elec}(K) \quad (2)$$

There are three phases; the projected EMPSO routing method is made of: (i) route setup phase, (ii) route discovery phase, and (iii) route maintenance phase. In the phase of route setup, every node gains its neighborhood metadata. Toward the goal node, to find the better next-hop node, the metadata is employed in discovering of route. While a source needs to transfer data to destiny, the discovering of route is activated in an on-demand manner which avoids multiple interferences among destination and source. While transmitting data, path failures are managed by route maintenance phase.

3.1.1. Route Setup Phase

For transmitting packets from the source, in this phase, data transmission is initiated by source node. Adjacent metadata are obtained by every node in MANET that involves neighbors transmission cost (t_c) to the destination node. The (t_c) link rate denoted the needed count of transmission for receiving successful packet at the receiver end. The link transmission cost is expressed as

$$t_c = \frac{1}{p \times q}, \quad (3)$$

where p are forward probabilities and q are backward probabilities packet reception on a link, correspondingly. Every node distributes the control packets and stores the number of completely received packets from adjacent nodes in the table of routing neighbors. While a node gains a transmission cost involved in packet, transmission cost set to zero by the destination node and transmits the rate of adjacent node.

3.1.2. Route Discovery Phase

To search multiple paths to destination from source, the route discovery phase is started while there is a need for the source node to broadcast the data. Remaining energy, transmission cost and optimal traffic ratio are the reliability metrics that the projected multipath routing protocol uses. By broadcasting a route request packet (RR) to a destination node, the source node begins to discover the route. An intermediate node estimates remaining energy, transmission cost and proportion of optimal traffic for the path while it gains a RR packet. Then it chooses the path with a reduced cost to transmit the RR packet to the next hop. In node routing table, reliability metrics are stored in MANET. To search an optimal path over different paths, the projected EMPSO method employs a consequent time recurrent neural network. With a view to employ system differential equations to model, CTRNNs are more efficient. To find an optimal path, optimal traffic, energy factor and transmission cost are the three weight effects that are taken into account in CTRNN. Transmission cost weight factor is expressed as

$$w_{tc} = CR_{pkt}(t_{i,j}) + DR_{pkt}(t_{i,j}) \quad (4)$$

where w_{tc} refers to transmission cost weight factor, CR_{pkt} refers to the control packet transmission proportion and DR_{pkt} is the proportion of transmission of data packet to node j from node I, correspondingly, and $t_{i,j}$ is the time taken for DR_{pkt} and CR_{pkt}. The weight factor for optimal path proportion and outstanding node energy are computed as in

$$w_{opr} = \frac{1}{p_k \sum_{f=1}^{n} 1/p_f}, \quad (5)$$

$$w_{RE} = E_T - (E_{TX} + E_{RX} + E_{ideal})$$

For a neuron i in the network with action potential y_i the value of modification of activation is expressed as

$$T_i y_i = -y_i + \sigma\left(\sum_{i=1}^{n} w_{tc} y_i + \sum_{i=1}^{n} w_{opr} y_i + \sum_{i=1}^{n} w_{RE} y_i\right) - \theta_j + I_i(t) \qquad (6)$$

Notations employed in (5) and (6) are as below:

p_k: kth path;

E_T: total energy needed for packet forwarding to node j from node I;

E_{TX}, E_{RX}, E_{ideal}: transmitted energy, ideal energy of a node and received energy, correspondingly;

T_i: time constant of postsynaptic node;

y_i: rate of activation change of postsynaptic node;

w_{tc}: weight vector of transmission cost from presynaptic to postsynaptic node;

w_{opr}: weight vector of optimal path ratio from presynaptic to postsynaptic node;

w_{RE}: weight vector of residual energy of node;

(x): sigmoid of x;

θ_j: bias of presynaptic node; (t): input to node.

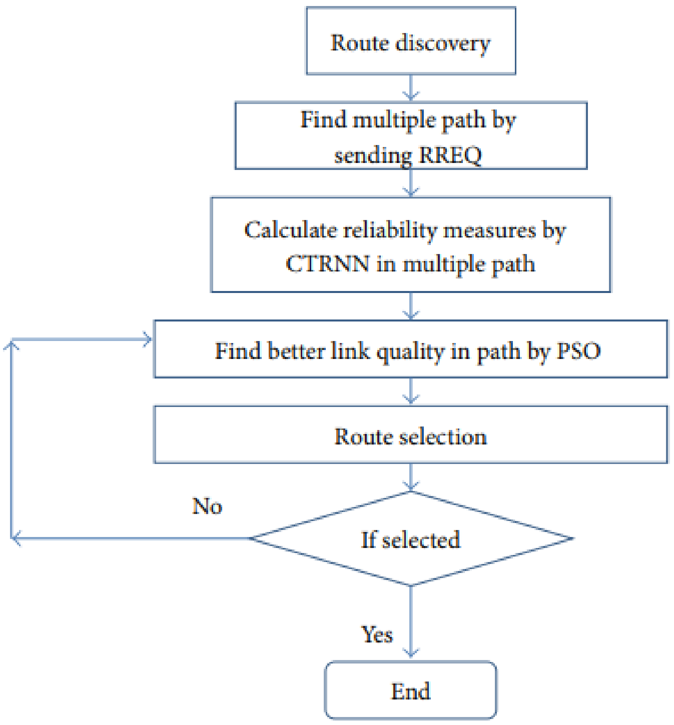

Figure 1: Flow diagram of the proposed system

Projected method flow diagram is demonstrated in Figure 1. Through the phase of route discovery, primarily, multiple paths are established. With CTRNN support, reliability metric for a path are estimated. To search a good quality of link within a path, an optimization method known as PSO is used. To search a better weight set in CTRNN, PSO is an evolutionary optimization method which is employed. To search the best nodes included in a path, PSO is implicated. Huge spaces of candidate solution are searched by PSO which is metaheuristic. For passing the data from source to destination, a route with a good link quality is chosen. PSO function is done repetitively till the global optimal solution is found if a good link quality is not found. In an ad hoc network, PSO decreases the routing overhead and traffic of the procedure of optimization and searches for the node with enhanced link quality.

3.2. AntHocNet

AntHocNet is a hybrid multipath algorithm. At node s, while a data session is initiated with destination d, s checks whether it comprise up-to-date routing data for d. Otherwise, to find paths to destination d, it reactively sends out agents known as reactive forward ants. These ants collect data about the path quality it followed, and when they reach d, they become backward ants to record the travelled path and modify the routing table. The node i estimates the value of goodness of path T_{nd}^{i} for all subsequent hops n to destination d, that is known as pheromone and maintains it in the routing table T_i . This pheromone value helps to choose multiple best routes through which data packets can reach the destination. When link failures occur, nodes tries to repair the path or send a notification to neighbors to update their routing table.

3.2.1. Reactive Path Setup

When broadcasted, the reactive forward ants travel towards destination using different paths. The intermediate nodes compare the paths of ants it received with the empirically set constraints. If it is satisfied, then it will forward the ants. Otherwise, it will drop the ants to reduce the unnecessary overhead. The reactive forward ant keeps record of nodes it has visited till it reaches destination. When it return back as backward ant, it estimate the time taken to reach each next hop in the path. The ant make an entry in the routing table with the pheromone value T_{nd}^{i} ,which is the goodness of path towards destination. The sum of the estimate time is $T_p = \sum_{i=0}^{n-1} T_{i\to i+1}$ towards destination through this path.

3.2.2. Stochastic Data Routing

Based on pheromone entries rate, data can be forwarded among nodes. The nodes comprising more neighbours to reach destination chooses the arbitrarily one with the probability of square to its pheromone. This routing strategy automatically balances the load by evenly spreading the data load over the network.

3.2.3. Proactive Path Maintenance and Exploration

The source node sends the proactive forward ants in between data session to get information about the quality of path and for updating the pheronome value.If there is no path while it travels,it is broadcasted to the neighbors to find the new path.But the broadcast is limited to two to control the flooding of forward ants in the network.

3.2.4. Link Failures

In the unicast data transmission, nodes can detect link failure. But if there is an alternative path to destination, the routing table will be updated and the notification will be send to the neighbors. When there is no alternative path then the node should find way to repair the path .For this , the route repair ant is broadcasted by the respective node . The broadcast limit is set to two. If it could not receive backward repair ant, it consider there is no path to the destination and removes the entry from the routing table.

IV. RESULTS AND DISCUSSION

In network simulator, the projected method has been done. The main goal of this is to make sure trustworthiness while transmitting data in routing. In 1000 m× 1000 m area of interest, nodes are deployed arbitrarily. 20 m was the rate of transmission. In a MANET, arbitrary way point model search for the connection path availability. By comparing with ACO, the proposed method performance was examined by means of latency, path optimality, routing overhead, energy consumption and packet delivery ratio. By network size varying from 50 to 200, the simulation outcomes were researched. To improve the reliability and energy efficiency through choosing an optimal path, the projected method has combined PSO and consequent time recurrent NN. With the relative method, the projected method has designed a PSO by means of reliable functionality routing.

4.1. Performance Metrics

To examine the proposed method and the projected method, the following are the performance metrics that are used

- *Packet Delivery Ratio*. It refers to the proportion of the count of data packets established effectively at the target node.
- *Latency*. It refers to the average time taken via the sent data packets from source node towards the destination node.
- *Routing Overhead.* while transmitting the data in routing, the number of control packets was produced.

- *Path Optimality.* It refers to the proportion of the sum of hops in the shortest paths to the count of hops in the paths taken through the data packets.
- *Energy Consumption.* In routing, it is the average energy utilized for the transmitting the data in routing.

4.2. Packet Delivery Ratio

While measuring PDR, in simulation, the effects of packet size, network size and mobility are observed.

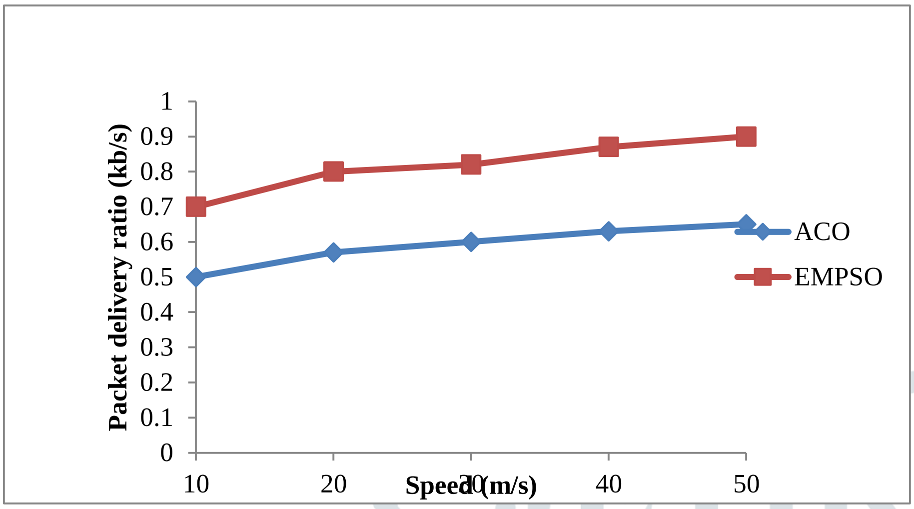

Figure. 2. Packet delivery ratio versus speed

During the packet size varying enhances, it demonstrates the projected method handles enhanced PDR of about 63 percent. With the aid of PSO method, an evaluation of performance depicts that the projected method has good ability to search an optimal route.While the count of nodes enhances, figure 2 depicts that the projected method enhanced. When compared to ACO the proposed EMPSO proposed method gives good PDR rate.

4.3. Latency

Figure 3 shows the delays of ACO and EMPSO, measured from the simulation. While the speed is enhanced from 10 to 50m/s, it has been seen that the delay occurs for the technique together. While the speed has increased, the delay starts to enhance when the probability of route break is in high speed. When compared with ACO, the projected EMPSO method predicts the quality of link in a more accurate manner, for ACO is the delay is 0.3 percent less. It is clear that the proposed method EMPSO performance is highly efficient and accurate than related method ACO.

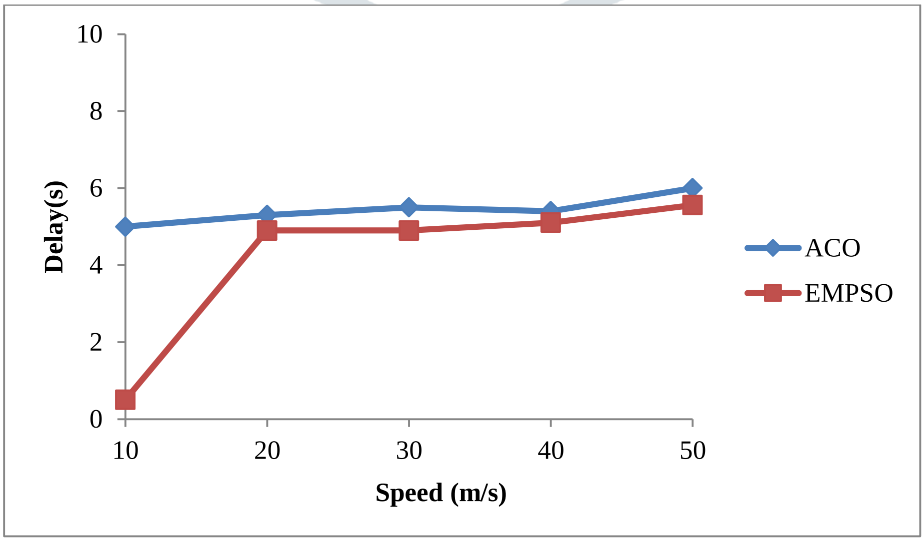

Figure 3: Delay versus speed

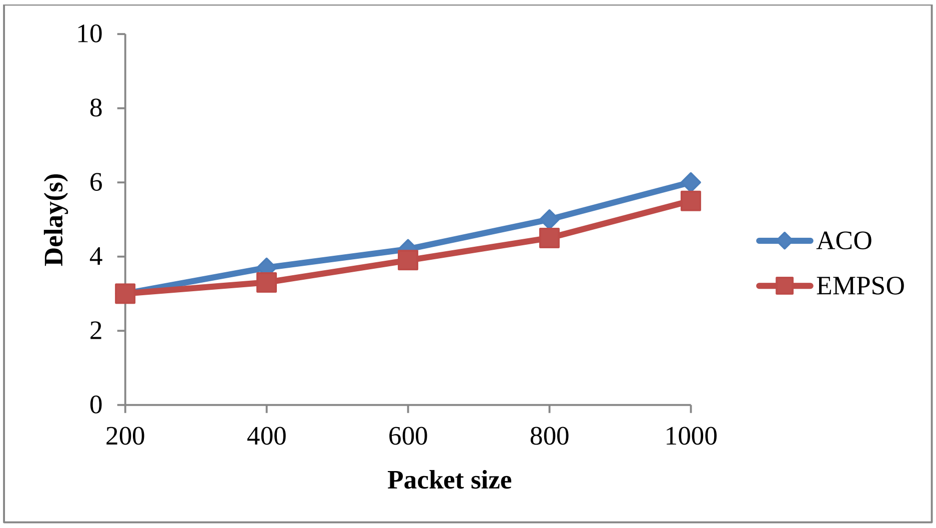

Figure 4: Delay versus packet size

Routing latency for two schemes are demonstrated in Figure 4 while the packet numbers differs. With multipath circumstances, the projected EMPSO routing latency is 5.3 sec over the network and 7 sec for ACO correspondingly. More time is consumed by ACO to pass packets to their targets. High transformations to pass packets to its targets and failure of link in routing are the reason for the delay of ACO method. To generate network multipath, the projected method employs the measures of reliability. In MANET, it gives enhanced performance and reliable routing.

4.4. Routing Overhead

By differing packet size, the routing overhead was examined in this simulation. Figure 5 shows the overhead which occurs while routing. While comparing with ACO, EMPSO has lower overhead of 2.13% and therefore varying routing will be triggered. Thus, the overhead in routing is decreasing. In ACO, till it reaches the target to search a loop-free routing, the control packet floods over the entire network. This is the reason for routing overhead. Due to the PSO scheme in EMPSO, it exhibits less overhead than ACO. The projected method has reduced routing overhead of over 43% while the node optimal path was chosen.

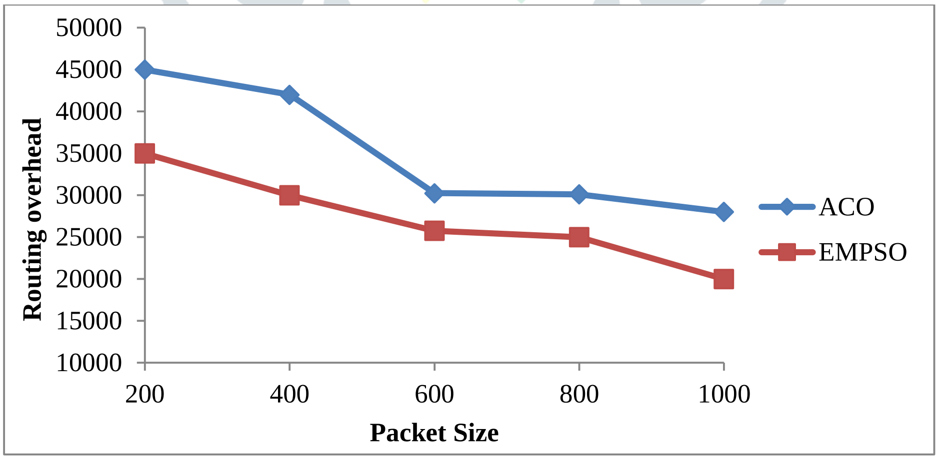

Figure 5: Routing overhead versus packet size

4.5. Energy Consumption

When the packet size increases in the range from 250 to 1000 bytes, Figure.6 demonstrates the energy utilization for two methods. When compared to the other methods, EMPSO has relatively less energy utilization of 0.28%

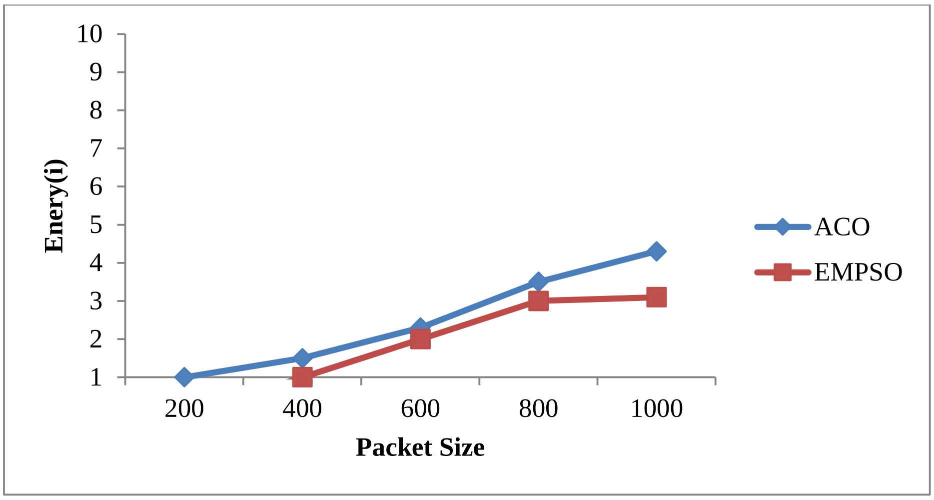

Figure 6: Energy consumption versus packet size.

hence it assumes CRNN mechanism for searching multipath. It is remarked that the reduced energy is consumed by EMPSO as 3.22J. ACO has large energy utilization to discover the route attempt. With low energy consumption, the projected method chooses best path which shows good solution. When the number of node enhances, the node energy utilization enhances slightly in projected method.

4.6. Path Optimality

Various routing protocol path optimality is shown in Figure 7. To transmit the packets to destination from source, EMPSO reduced hops. Because of the PSO scheme, the method attains high number of hops. As a result, in the projected EMPSO method, average hop count is minimized. When compared with ACO, the projected EMPSO scheme attains path optimality.

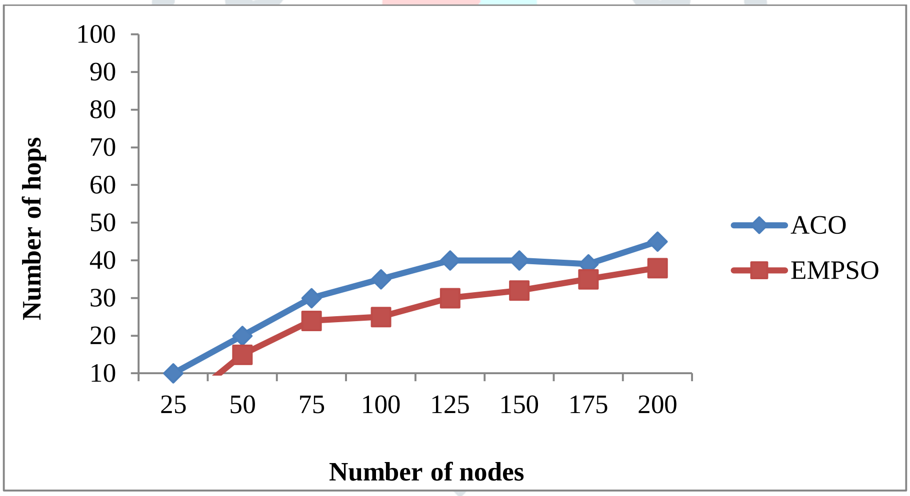

Figure 7: Number of hops versus number of nodes

V. CONCLUSION

In this paper, we evaluated the results of the two algorithms based on ACO and PSO for multipath routing in MANET. These two algorithms are compared and the results are investigated under several performance measures. The outcome verified that the projected EMPSO scheme attains better performance over the compared methods. In addition, this work can be extended by the use of hybridization of the bio-inspired methods.

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