Particle Swarm Optimization based Multihop Routing Techniques in Mobile ADHOC Networks

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Abstract

Mobile adhoc network (MANET) comprises a network of mobile nodes, which communicates with one another through wireless connections. Reliability, energy efficiency, congestion control and interferences are the problems faced with the traditional routing protocols in MANET. Routing defines the process of identifying the optimal paths between two nodes in the network. For resolving these issues, several multipath routing techniques have been presented. This paper assesses the performance of the two bio-inspired multipath routing techniques namely Energy-Aware Multipath Routing Scheme based on particle swarm optimization (EMPSO) and PSO with fitness function (PSO-FF) algorithms. These two algorithms are compared and the results are investigated under several performance measures. The simulation results stated that the PSO-FF algorithm has shown better results over the EMPSO algorithm under several measures.

Keywords: MANET; Routing; Energy Efficiency; Particle Swarm Optimization; Fitness Function.

1. Introduction

A MANET is constrained with group of autonomous mobile nodes that is connected with one another with the help of multi-hop wireless connections [1] as depicted in Fig. 1. This type of networks does not have the demand of having reputed structure and captures the device which is applied for specific applications. It is mainly adoptable in the harsh environments such as highly difficult to build structure like disaster management, border facilities, and data transmission over the vehicles present in VANET. MANET allows people to send data without any definite structure. An impermanent network with no wired connections, communication structure, and centralized management is essential. At the time of transmitting data packets, every node is treated as a host and router in MANET. Additionally, the nodes are capable of moving randomly. The interoperating potency over the nodes and self-organizing capability to apply the dynamic circumstances are most important facts of networking by massive scale [2].

The protocol development in MANET is assumed to be one of the challenging issues interms of energy efficiency. For network layer, massive developers have designed diverse routing protocols; but, only the advantages like remaining battery potential, self-organization and transmission energy is considered while the data packets are routed to the target [3]. The lifespan of the network depends upon power resource management. It is better to employ minimum energy at the time of routing instead of storing the node's battery power [4]. Energy effective routing protocols can be deployed as presented in [5]. It is operated in 2 modules, such as inactive communication energy as well as powerful communication energy. In order to minimize the active communication energy, load balancing and transmission power management were applied while the inactive communication energy can be reduced by using sleep down mode. Hence, the MANET is mainly concentrated on the issue of energy-effective communication with no network coding. Due to the lack of major authority and self-configuring behavior, network controlling task becomes highly tedious. Also, scalability is another problem which earns maximum concentration in communication study.

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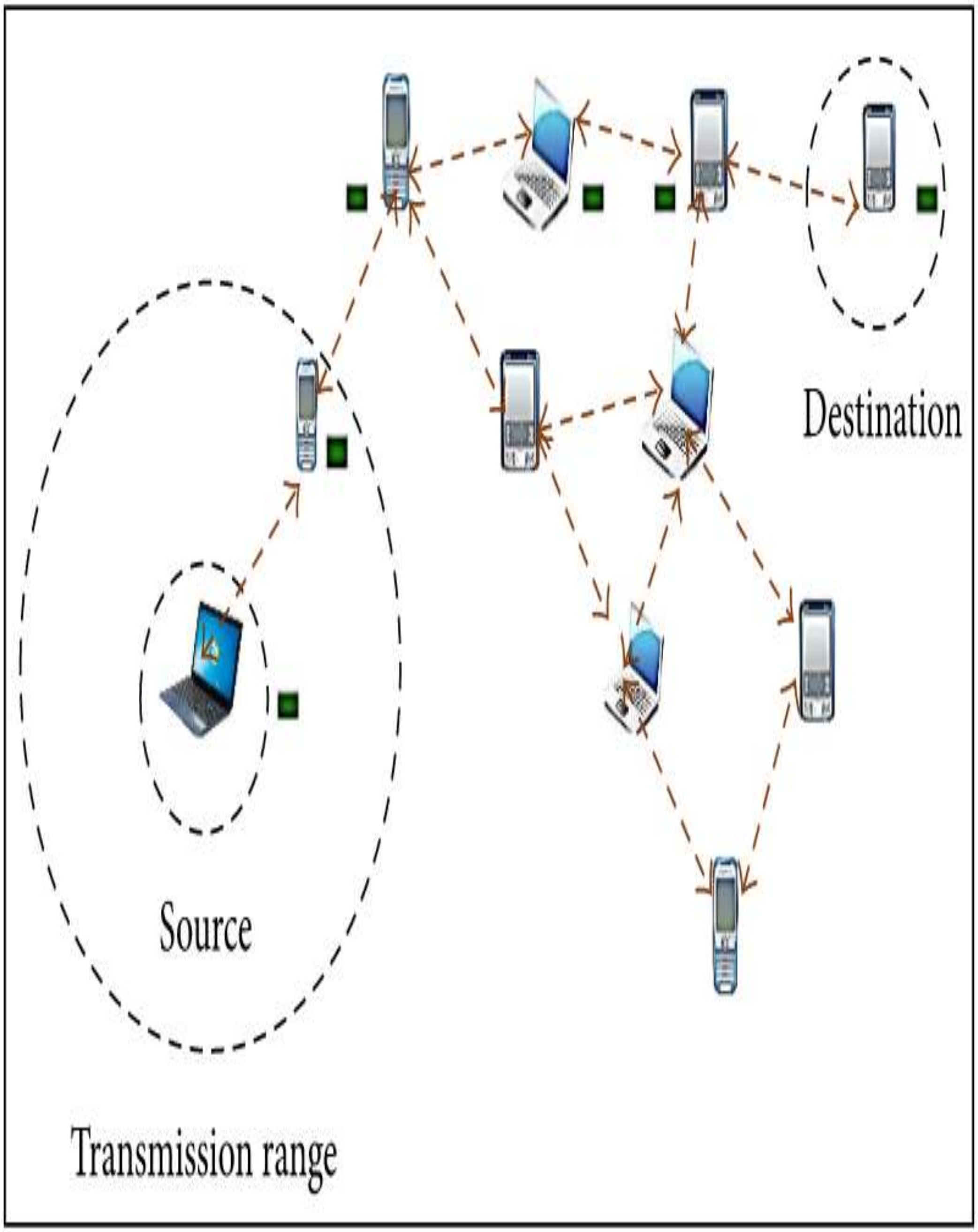

Figure1: MANET architecture

Different MANET issues are solved under the help of clustering that is considered to be more important model which enhances the network lifetime and scalability. Generally, every cluster has the separated node which is operated by virtual groups named as local coordinator. With the help of Cluster Heads (CH), node interaction is processed from source to destination, in the communication range of each other. The network control has been enhanced under the employment of clustering. The exact application of clustering process activates the CH election and residual nodes are termed as cluster members (CM) as demonstrated in Fig. 1. CM represents sensing task and forwards the data to CH. Furthermore, CH needs additional overhead of inter-cluster and intra-cluster transmission. It provides primary energy deterioration and CH death which classifies the network and reduces network lifespan. Thus, the node mobility is one of the major causes of link failure, especially when CH selection has maximum mobility than the alternate node.

Due to the existence of mobility, an equated cluster would be suspended prominently and requires diverse inter-cluster path that is from source to destination. Alternatively, in versatile situations, it is in need of re-clustering. Due to the CH movement, data transmission stability is reduced and routing overload is improved outcomes in decreasing network lifespan. For maximizing the network lifetime, an effectual clustering model with limited overhead has been

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developed. Numerous routing protocols and clustering approaches were created that is applied for MANET in the early stages [5]. The limitations such as mobile nodes battery dependency and mobility constraints can be resolved using various models. The clustering model classification of MANET is projected in Bokhari et al. [5], that minimize the node power consumption as well as boosts the battery utilization is the major problem of MANET. Using minimum work load, an individual parameter is applied in CH election modules with no assumption of alternate nodes have the probability of being a CH. A novel Weight Based Clustering Algorithm (WCA) is proposed by Chatterjee et al. [6]. Many numbers of parameters are combined in this mobility, time and connectivity degree till a node has been treated as CH and CH election, the distance sum to node's neighbors were determined. It is the base for models of weight relied clustering, that considers CH election metrics. However, the aspects which reduce the efficiency of WCA. In MANET, Distributed WCA (DWCA) is presented by Choi and Woo [7] which hold back the cluster reconfiguration and configuration across CHs with respect to power necessity. While CH determining task is carried out, no parameters describe the network reliability.

A new enhanced weighted clustering method is deployed in [8] named as Enhancement on WCA (EWCA). The factors like Communication range, lifetime of a battery, transmission energy and mobility were assumed as the metrics used for CH election. By eliminating the dynamic modifications in CH, the maximum cluster data instance has been reduced. For MANET, EWCA controls the load balancing and maximizes the cluster reliability. In addition, using bio-inspired processing as well as evolutionary proliferation makes a qualified model of dividing the best network and deploying the route in wireless networks. Recently, various stochastic and deterministic approaches were developed in [9-15]. Such schemes are based on the gradient model as it is very difficult in processing geometrical equations that remains the same. It is inspired by living organisms; the stochastic method is the issue in multimodal directions.

In MANET, a complete review of diverse bio-inspired population relied meta-heuristic approaches as proposed in [9]. To compute the minimum weighted CH election and node similarity as deployed in [10] has provided a Breadth-First Search Tree (BFS) based clustering approach. The frameworks like Genetic Algorithm (GA) model in [11] which resemble the Darwinian theory of network lifetime. For WSN, the GA based load balanced clustering is presented in which the maximum loads across gateway nodes can be limited and joined nodes generate load-controlled clusters.

This paper assesses the performance of the two bio-inspired multipath routing techniques namely Energy-Aware Multipath Routing Scheme based on particle swarm optimization (EMPSO) and PSO with fitness function (PSO-FF) algorithms. These two algorithms are compared and the results are investigated under several performance measures. The simulation results stated that the PSO-FF algorithm has shown better results over the EMPSO algorithm under several measures.

2. PROPOSED METHOD

2.1. Energy-Aware Multipath Routing Scheme Based on PSO

By the controlled wireless link and power, a MANET is comprised with mobile nodes. Every mobile node forwards the data packets from source to target. Since intended graph $G = (V, EG)$, MANET showed neighboring node as well as mobile nodes symbols are vertices $v \in V$.

An edge $(u, V) \in EG$ is defined as the representation of a wireless link between nodes u, v which broadcast the data packets to one another. From node u to node v, the power consumption to forward packets is illustrated as

$$EG_{tx}(z,d) = EG_{elec}(Z) + EG_{amp}(z,d), \quad (1)$$

where d refers the distance between nodes and z implies number of bits. EG_{elec}, EG_{amp} are energy reduced for each bit for receiving and forwarding packets correspondingly. In case of receiver, energy deployment is calculated with

$$EG_{rx}(z,d) = EG_{elec}(Z) \quad (2)$$

The presented EMPSO routing model is constrained with the following:

(i) route setup
(ii) route discovery
(iii) route maintenance

Initially, all nodes gain the neighborhood metadata. For the target node, the optimal next-hop node is determined and metadata is used to explore the best route. As the source requires transferring data to intention, the route identification is enabled in required approach that eliminates various interferences between the source and destination. While data broadcasting is processed, path failures are controlled using route maintenance stage.

2.1.1. Route Setup Phase

The neighboring metadata is received with nodes in MANET which contains nearby transmission cost (t_c) to destination node. The (t_c) link rate implies the effective packet present in the receiver side which is demonstrate as,

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$$t_c = \frac{1}{p \times q} \tag{3}$$

where p is forward possibility while q is backward possibility of packet reception, respectively. All nodes allocate the packets and save the received packets from neighboring table of routing neighbors at initialization. As the node gains a transmission cost, it is set with 0 with the target node and broadcasts the rate neighboring node.

2.1.2. Route Discovery Phase

Residual energy (RE), transmission cost and best traffic ratio are the stability measures which presented multipath routing protocol utilize. With the transmitting a route request packet (RR) to destination node, the source nodes start to find the route. In node routing table, reliability measures are saved in MANET. For searching a better path among others, the presented EMPSO technique utilizes a consequent time recurrent NN. By the analysis to use original system differential equations, CTRNNs are effective path to apply the device. CTRNN is applied to compute the bets path and additionally, best traffic, energy and transmission costs are the 3 weight factors considered which is defined as,

$$w_{tc} = CR_{pkt}(t_{a,b}) + DR_{pkt}(t_{a,b}) \tag{4}$$

where w_{tc} denotes the transmission cost weight, CR_{pkt} represents the control packet transmission proportion and DR_{pkt} refers the ratio of transmission of data packet to node b from node I, and $t_{a,b}$ implies the time consumed by DR_{pkt} and CR_{pkt}. The weight factor used in finding best path proportion and excellent node power are calculated by

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

$$w_{RE} = EG_T - (EG_{TX} + EG_{RX} + EG_{ideal})$$

For a neuron a in the network through action potential y_a the measure of alteration activation is illustrated as

$$T_a y_a = -y_a + \sigma\left(\sum_{a=1}^{n} w_{tc} y_a + \sum_{a=1}^{n} w_{opr} y_a + \sum_{a=1}^{n} w_{RE} y_a\right) - \theta_b + I_a(t) \tag{6}$$

Notations utilized in (5) and (6) are:
p_k: zth path;
EG_T: total power required to forward the packet from node b to node I;
EG_{TX}, EG_{RX}, EG_{ideal}: transmitted energy, ideal energy of a node and received energy, respectively;
T_a: time constant of postsynaptic node;
y_a: rate of activation change of postsynaptic node;
w_{tc}: weight vector of transmission cost from pre-synaptic to post-synaptic node;
w_{opr}: weight vector of best possible path ratio from pre-synaptic to post-synaptic node;
w_{RE}: weight vector of remaining node's energy;
(x): sigmoid of x;
θ_b: bias of pre-synaptic node; (t): input to node.

2.2. PSO-with Fitness Function

An efficient routing method to MANET named FF-OLSR technique is developed to optimize the energy consumption of optimized link state routing (OLSR) method. A total working method is clearly illustrated in Fig. 2. The FF based on the optimization function with utilize of 2 parameters such as energy level and path distance between 2 broadcasting nodes to choose the better paths. Besides, a dynamic replication procedure is involved to remove the path regeneration on the incidence of link disjoint paths. Usually, if the RREQ is transmitted with a broadcasting side, several paths to the obtaining node are recognized and data forwarding occurs using this path with no knowledge on its quality. However, utilizing the execution of the projected method in the same condition, the chosen of paths is totally various. Upon the transmitting and reception of a RREQ packet, the broadcasting node obtains 3 types of data to determine the shortest and optimized routes with minimum energy utilization. The aspects are

- Data connected to the energy level off all nodes
- Distance to every path and
- Energy utilized to determine paths

The path that utilizes minimum energy is the path with less distance, high energy level or both. The transmitter node I broadcast the information with the path that has high energy level and after that it is calculate the entire amount of energy utilized. In contrast to other multipath routing methods, the projected technique has initiated to find discover paths upon the failure of each route to receiving node. On the failure of selected routes, the broadcasting node is

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selecting an alternate path from the routing table represents the shortest path with least energy utilization. The optimum path with minimum distance to the receiver utilizes lesser energy and is determined utilizing Eq. (7):

$$Opt.route\ 1 = \frac{\sum v(n) \in r\ \ ene\ (v(n))}{\sum v \in V\ \ ene\ (v)} \tag{7}$$

Where v and V denotes the vertices occur in the better route and every vertex in the system. It relates the energy level of routes and selects a node with maximum energy level. The alternate route is calculated depends on its distance. The FF-OLSR technique updates the routing table even after the chosen of routes with high energy and also continues the details of the route with minimum distance. To find the shortest path is computed utilizing Eq. (8):

$$Opt.route\ 2 = \frac{\sum e(n) \in r\ \ dist\ (e(n))}{\sum e \in E\ \ ene\ (v)} \tag{8}$$

Where e denotes the edges in the better route r and E refers the edges. It relates to the distance of links in best path and undergone a comparison with all other link in the network. Some of the steps involved in FF are:

- Select the broadcasting and receiving node
- Route find procedure obtains started from the transmitting node
- Transmitting routing Packet to dedicated nodes
- Routing details obtains updated in the broadcasting node

For implementing this, OTcl script is given by the network metrics and topology like traffic source, node count, queue size, node speed, routing methods utilized etc. The group of 2 files such as trace files and network animator (NAM) are created to visualize the execution. For proper understanding, a sample route chosen of FF-OLSR method utilizing existing variables is provided.

3. PERFORMANCE VALIDATION

In network simulator, the newly developed model is processed. The major aim of this method is to ensure the loyalty at the time of sending data in routing. In 1000 m× 1000 m region of interest (ROI), nodes are installed in random manner. 20 m was assumed to be a transmission rate. The random point model explores the connectivity path accessibility. When PSO-FF is compared, the performance of EMPSO is analyzed with respect to latency, path optimality, routing overhead, power application as well as PDR. Under the adjustable network size like 50 to 200, the results are studied. For improvising the stability and energy efficiency by selecting a best path, the presented technique has integrated PSO-FF and subsequent time recurrent NN. Under the application of comparative approach, the newly deployed technique has developed a PSO-FF interms of stable functionality routing.

3.1. Performance Metrics

In order to compute the compared models and the proposed approaches, some of the performance measures are applied as given in the following:

- *PDR.* It shows the percentage of number of data packets introduced effectually at the desired node.
- *Latency*. It means the maximum time consumed by the transmitted data packets from source to target node.
- *Routing Overhead.* While sending data in routing, it generates the control data packets.
- *Path Optimality.* It is defined as the number of hops in direct paths to the count of hops in the paths consumed by data packets.
- *Energy application.* In routing, it is maximum power applied to send the data in routing.

3.2. Packet Delivery Ratio (PDR) Analysis

During the PDR estimation, the impact of packet size, network size and mobility are assumed. The packet size varies; the developed model manages the improved PDR of around 63%. Under the application of PSO-FF approach, a calculation of performance demonstrates that the established model has better ability to find a best route. When the node count is increased, Fig. 2 shows that the presented method improved. While compared with PSO-FF, the presented EMPSO framework provides optimal PDR rate.

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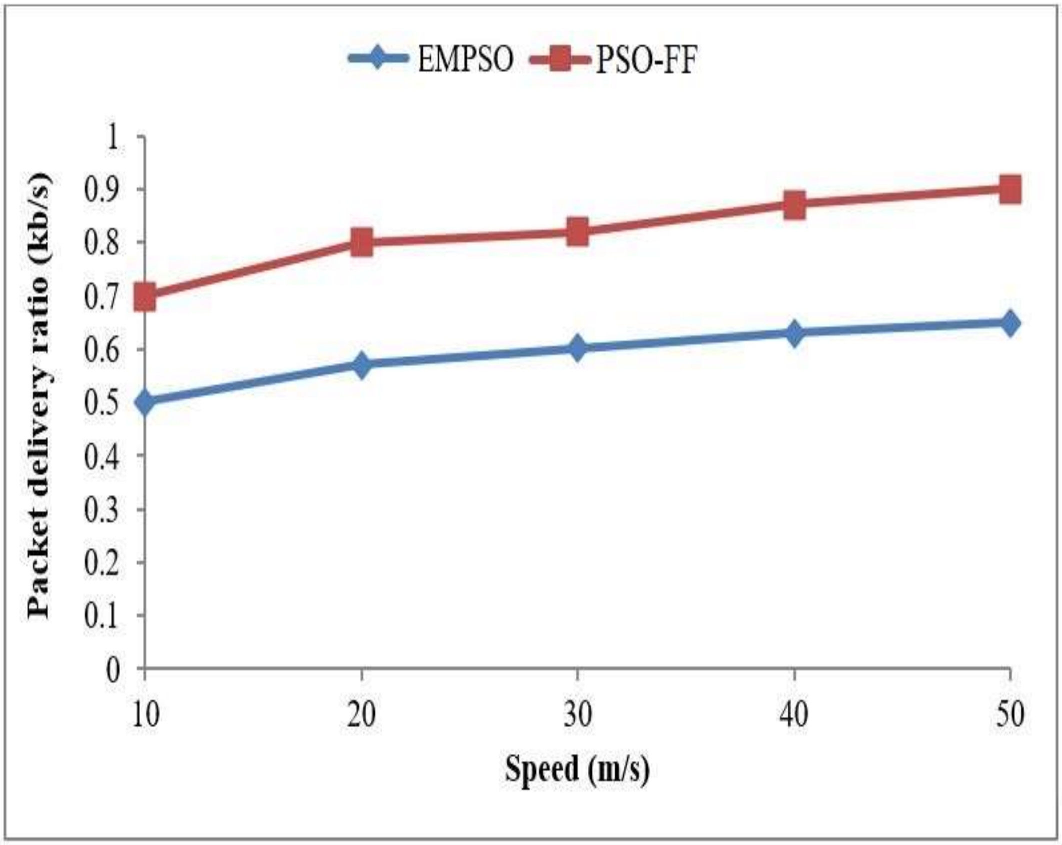

Figure 2: PDR versus speed

3.3. Latency Analysis

Fig. 3 implies the delays of PSO-FF and EMPSO, which is calculated from the final results. When the speed is boosted from 10 to 50m/s, it is referred that delay happens in the combined models. While the speed is enhanced, then delay is maximized if the probability of route break is in higher speed. While PSO-FF is compared, the newly developed EMPSO approach depicts the superiority of a link accurately, for PSO-FF is the delay is 0.3 % less. It is evident that the projected technique performance is effective and précised when compared with alternate approaches.

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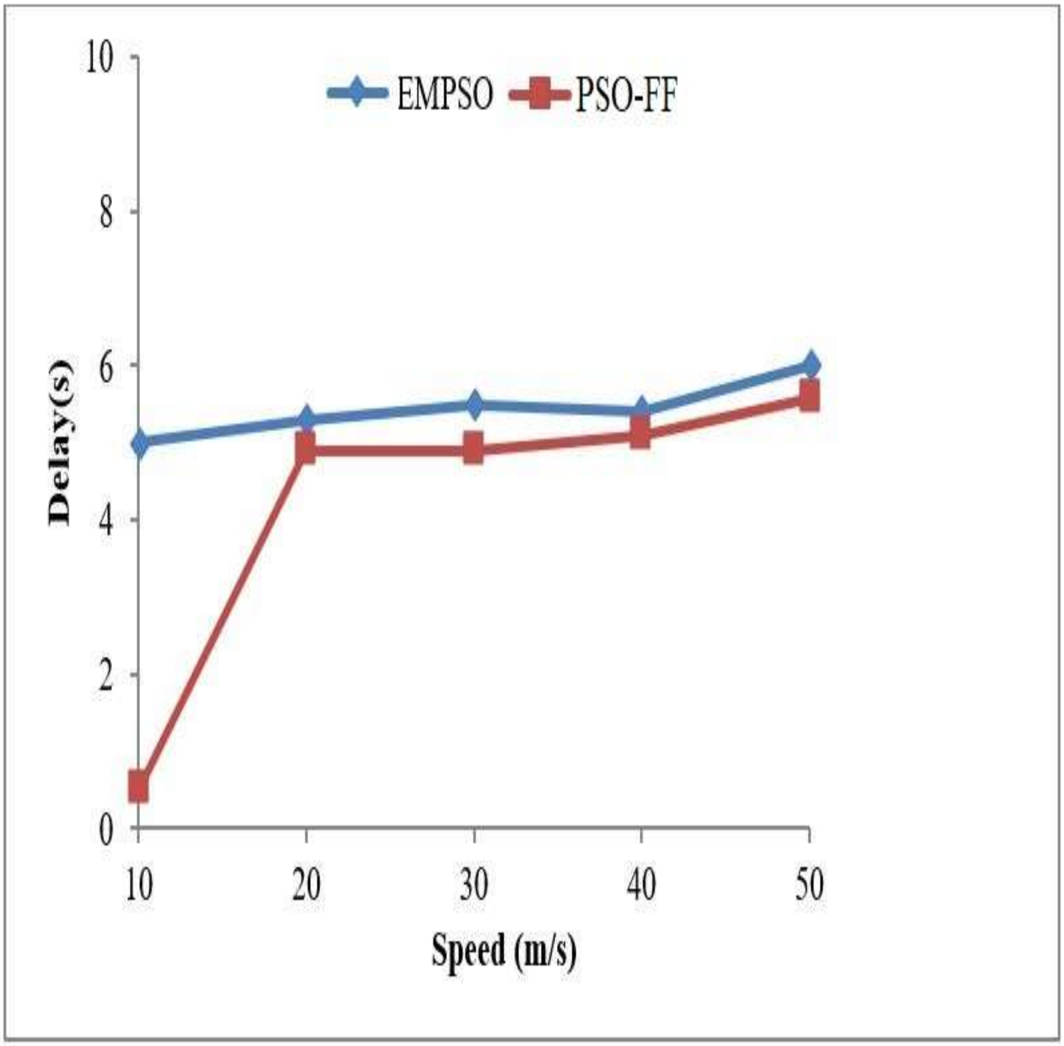

Figure 3: Delay versus speed

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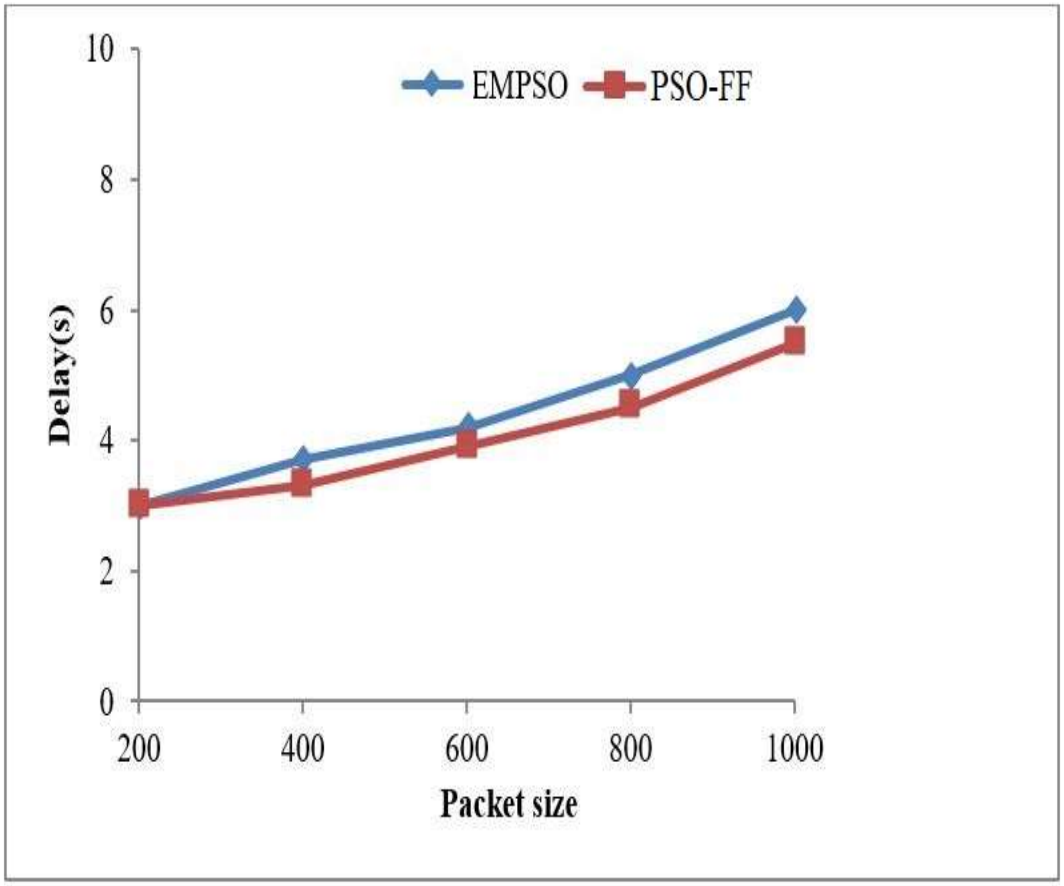

Figure 4: Delay versus packet size

Routing latency for 2 approaches is illustrated in Fig. 4 when there are different packet values. Using multipath cases, the presented EMPSO routing latency is 5.3 sec over the network and 7 sec for PSO-FF respectively. Maximum amount of time is taken by PSO-FF to convey the packets to the destination. A higher conversion provides packets to the targets and link failure in routing are major causes for delay in PSO-FF model. For generating network multipath, the deployed system applies the metrics of stability. In MANET, it offers best performance and stable routing.

3.4. Routing Overhead Analysis

If the packet size is varied with diverse phases, the routing work load has been analyzed. In routing, Fig. 5 implies the overhead that exists in routing. When compared with PSO-FF, EMPSO has minimum overhead of 2.13% that represents the management of routing packets and hence varying routing would be accelerated. Hence, the routing work load is reduced. In PSO-FF, the exploration of loop-free routing is processed until reaching the control packet floods throughout the system. It is one of the major causes for routing overhead. As the PSO-FF model in EMPSO shows lower overhead when compared with PSO-FF. The proposed approach has decreased routing overhead of 43% while optimal node path is selected.

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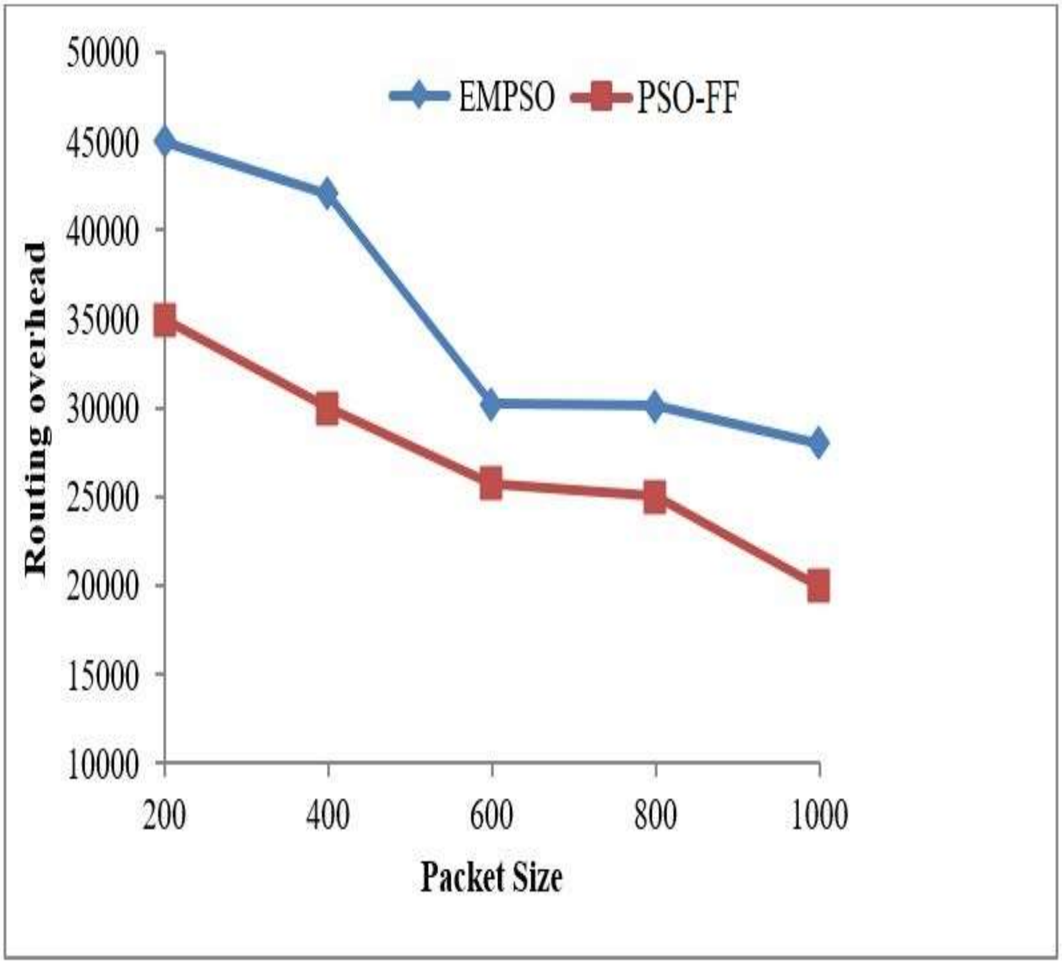

Figure 5: Routing Overhead Versus Packet Size

4. Conclusion

Reliability, energy efficiency, congestion control and interferences are the problems faced with the traditional routing protocols in MANET. Routing defines the process of identifying the optimal paths between two nodes in the network.

For resolving these issues, several multipath routing techniques have been presented. This paper has assessed the performance of the two bio-inspired multipath routing techniques namely EMPSO and PSO-FF algorithms. These two algorithms are compared and the results are investigated under several performance measures. The simulation results stated that the PSO-FF algorithm has shown better results over the EMPSO algorithm under several measures. The experimental outcome indicated that the PSO-FF algorithm is superior to other algorithms interms of PDR, routing overhead and delay.

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