HYBRID SCHEME FOR ENHANCING ENERGY IN MOBILE AD HOC NETWORKS

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1. Abstract

The recent years have shown a massive development in Mobile Ad Hoc Networks (MANET) technologies and increase in their usages. However, when any new MANET applications come to the surface, more unpredictable problems come as well. One of them is the problem of optimizing energy consumption for the MANET and their routing protocols. Nevertheless, existing works tries to address the issues for the energy cost. One of recent works was proposed by Jabbar et. al in 2017 namely Multipath Battery and Mobility-Aware routing scheme (MBMA) using OLSR, but it needs more investigation for their energy cost. However, in this project we propose an enhancement for MBMA-OLSR by adding Ant Bee Colony (ABC) algorithm to reduce the packet overhead and consumed energy in MBMA-OLSR. Moreover, we implemented the proposed scheme as an extension to the MATLAB. Benefits of the innovative scheme have been demonstrated and validated under node speed scenarios based on random way point mobility model. The simulation results provide evidence of the effectiveness of our enhanced scheme, especially during the high mobility scenarios with different traffic loads where it outperforms the conventional MBMA-OLSR routing protocol in terms of energy related metrics.

2. Introduction.

Mobile nodes can handle routing functionality in MANETs, and because they are wireless, nodes can be deployed anywhere within a defined network (Loo, Mauri et al. 2016). The robust and efficient operation of mobile nodes is possible through MANETs. Furthermore, nodes can restructure their own topology, such as when they move from one place to another. Nodes can enter and leave a network depending on its feasibility. Each participating node should transfer packets from other nodes. Each node will act as a host and a router because it must send packets from its neighbor nodes given that nodes have a limited transmission rangeIn this energy-constrained, dynamic, distributed multi-hop environment, (Raza, Aftab et al. 2016). Moreover, wireless network became a rapid and challenging development nowadays (Want, Schilit et al. 2015). The rapid of the mobile devise and wireless communication through the mobility model will increase the need of the every mobility device which consider a node for the group of the network, (Perkins 2015). Many studies address the issues in MANET energy consumption, but challenging and enhancing all routing energy protocols in MANET still needs improvement (Mukundray and Sharma 2014).

3. RELATED WORKS ON ENERGY ENHANCEMENT SCHEME FOR MANET

Several papers studied and summarized the energy effect in MANET (Yadav, Gupta et al. 2015, Atif and Sattar 2017, Jabbar, Ismail et al. 2017). OLSR require a lot of energy when used as an efficient routing. OLSR nodes cannot communicate efficiently with another node due to the high energy requirements. Energy-efficient routing was developed through nodes costs computed using a fuzzy logic system (FLS), but needs more attention for the total energy cost (Chettibi and Chikhi 2013). Sahnoun et al. proposed an Energy Efficient and Path Reliability OLSR prediction-based link availability estimation and figured out how the cross-layer parameters effected the energy lifetime. In another study by Kamruzzaman et al. , the researchers invented energy aware on-demand multipath routing (EOMR) protocol for mobile cognitive radio networks, to guarantee the strength and enhance the throughput, considering the limitations on each cognitive radio user's residual energy and reliability (Kamruzzaman, Fernando et al. 2016). The researchers further utilized Knapsack algorithm in buffer management with the intent of lessening the out-of-order packets and maximizing the in-order packets at the same time, this technique utilizes the buffer internals besides vigorously regulating the buffer application for the node to broadcast the packets in the anticipated order to its consecutive nodes. Recent work by Jabbar et al (2017). Proposed using MBMA-OLSR to increase the efficiency of the MANET energy. They used a random waypoint mobility model, but need more investigation about whether their model is feasible for the MANET energy consumption.

4. A Multipath Battery-Aware Routing Protocol (MBMA)-OLSR

A multipath battery-aware routing protocol (MBA-OLSR) is a hybrid multipath routing scheme, which inherently uses a proactive mechanism to disseminate and build the topology information, with some added on Demand mechanisms for differently performing route computation in situations when there are data packets to send (Jabbar, Ismail et al. 2017). The selection of MPRs and the computation of multiple paths by integrating energy and mobility awareness techniques to reduce the energy consumption and overcome the various challenges incurred by node's mobility in MANETs. The structure and functionalities with the interconnection between different modules of the MBMA-OLSR shown in Figures 2.11. The MBMA-OLSR should extract the information on node's MCNR metric, which is included in HELLO and TC messages to make nodes aware of their medium during topology sensing. Therefore, the Multipath Dijkstra Algorithm is utilized to discovery various routes in the direction of the target, therefore adjusting flooding of topology information. The incremental cost functions such as specified in explicitly; fe and fp be present utilized to intensification the cost of links among nodes with the purpose of produce multiple joint otherwise not joint pathways.

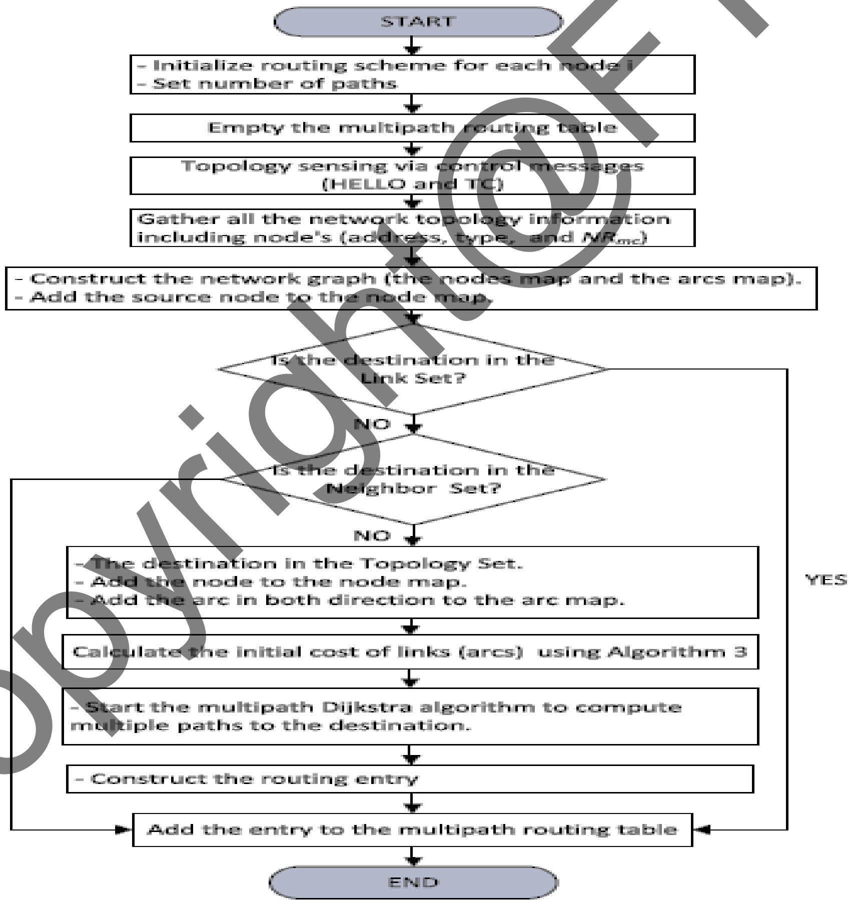


Figure 2.11 Original algorithm of Jabbar

Source : Jabbar et.al (2017)

5. MBMA-OLSR Energy Enhancement Scheme Based On ABC.

We considered the design from the previous work obstacles and explore their solutions. The theoretical design of the methodology was achieved by proving the design through simulation using MATLAB, analyzing the design with a design algorithm, and finalizing the results. The routing protocol is useful for repairing the breakage in the local link between multiple nodes. The protocol employs the ABC foraging approach for this purpose. Through this approach, additional new local RREQs are initiated to the corresponding local destination, resulting in reduce network overhead. The approach adopted in this study is similar to the ABC foraging approach as explained below: a failure node, which is analogous to the exhausted food source in a bee colony, is implemented.

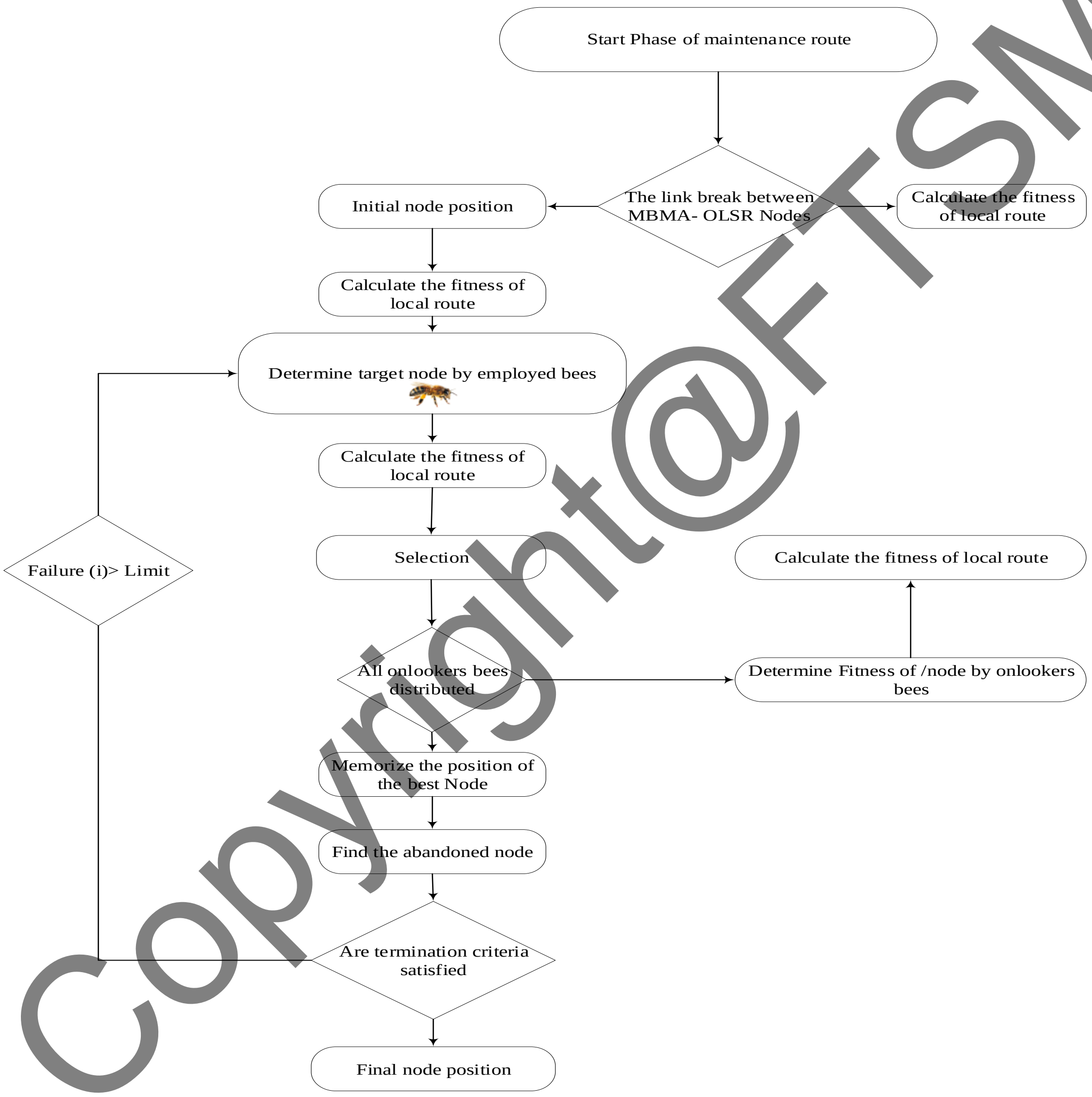
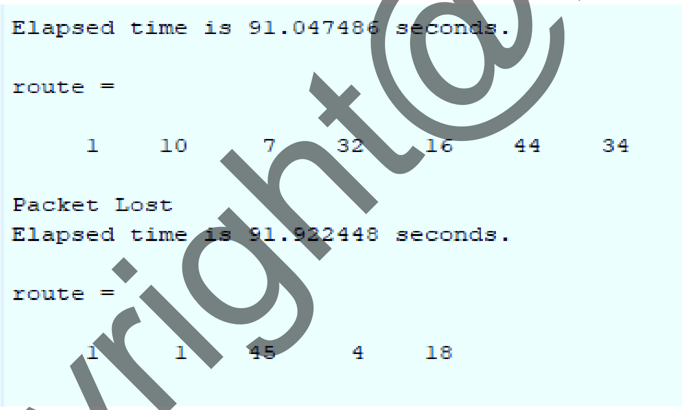


Figure 3.2 ABC architecture over MBMA-OLSR

The breakage in a link between nodes is implemented and treated as a path to the exhausted food source that is no longer used by the bees. The hive is constructed at the intermediate node that discovers the breakage in link followed by assigning the node after failure node as the targeted node. This node forms the scouts responsible for discovering new food sources by bypassing the failure nodes by means of locally issued route request. The information about the nectar is carried back through the route reply by the node after the failed node. The radius of the hive is implemented by the maximum hop count of the local route request.

6. Simulation scenario

A waypoints mobility model was used based on Jabbar's scheme and node speed was used as the main scenario for the all adopted metrics. Speed nodes with waypoints tend to cross the center of the when speed decaying. This scenario evaluates and compares the performance of ABC-MBMA-OLSR and MBMA-OLSR based on the highest speed of mobile nodes. The speed of nodes represents one of the main parameters in evaluation studies of routing schemes in MANETs. The effectiveness of the mobility awareness of the proposed techniques in ABC-MBMA-OLSR was evaluated by considering mobility-related parameters. The maximum speed in the waypoints mobility model was used to specify the maximum way point speed of nodes and it was changed from 0 m/s to 10 m/s while the pause time duration was kept constant at 60 seconds. An example for the simulation scenario snapshot found in Figure 3.3, which demonstrate the ABC iteration over 49 nodes.



```
Elapsed time is 91.047486 seconds.

route =

     1    10     7    32    16    44    34

Packet Lost
Elapsed time is 91.922448 seconds.

route =

     1     1    45     4    18
```

Figure 3.3: Snapshot for the MATLAB simulation

It has important to know about the s radius (communication range) and number of nodes as a input parameters and returns number of hops. NODE is considered as a global variable for ABC which contains variables to store in routing table such as number of Hops, next node (routing information) and state of the node. However, ABC will calculate the shortest path for the OLSR nodes by using ABC privileges for scout bee searching to find the number of hops is assigned for 49 nodes of MBMA-OLSR. Then, it will in dancing area and gathering information that is repeated throughout the whole network- which is routing table till find the optimal solution. Of the core functionalities in ABC- MBMA-OLSR, topology sensing. The key function of the **topology sensing** is to provide the nodes with information about the network's topology and the benefits from MPRs as mentioned earlier. It includes link sensing, neighbor detection and topology discovery.

6.1 Simulation Parameters

The ABC-MBMA-OLSR topology where 49 mobile nodes. The position of nodes is only an initial position and they will move randomly based on the mobility model. In order to simulate MANETs with heavy traffic loads, the corner nodes and the mid-nodes on each side are chosen as sources and destinations. In addition, 12 parameters have used from Jabbar's scheme for their original MBMA-OLSR topology. MBMA-OLSR have used as a routing protocol in MATLAB to prepare it for the hybrid model with ABC. Three numbers of path used as well for the ABC-MBMA-OLSR. The maximum number of bits that can be transmitted is defend by the total battery energy divided by the required energy per bit. There are four states for the mobile node in a wireless network: transmit, receive, idle, and sleep. Each state consumes a particular amount of power ($P_{transmit}$,P_{reciv}, P_{idel} and P_{sleep}).In our simulation model, we used a radio energy model which is derived to estimate the consumed energy based on the circuitry power consumption and time spent. The strength of the simulation enrichment proposed and their designed topologies are presented in Table 3.1.

Table 3.1 Simulation parameters.

No.	Parameter	Value
1	Routing Protocol	MBMA-OLSR
2	No. of paths	3
3	Incremental cost function	fp(c) = 3c fe(c) = 2c
4	Link Layer Notification	Yes
5	Packet Size	512 byte
6	Applications traffic	CBR
7	Energy Model	Generic: Ptrans = 1400 mW ,Prec = 1000 mW PIdle = 0 mW PSleep = 0 mW Supply voltage 5.0 Volts
8	Transmission Signal Power	Pt = 31.623 mW
9	Battery Model	Linear Battery Model
10	Mobility	RWP, Min speed 10, Max speed 60 m/ s, pause time 60 sec
11	Path loss Model	Two Ray
12	Node numbers	49 nodes

6.2 Simulation Metrics

The objective of the experiments with the MATLAB simulator is to validate and evaluate the performance of ABC -MBMA OLSR routing scheme in terms of energy efficiency, by analyzing the following performance metrics:

6.2.1 Throughput.

Throughput defined as the total number of bits successfully received at the server within a definite time duration. The throughput at the receiver can be calculated as follows.

$$\text{Throughput} \qquad = \frac{\boldsymbol{Total\ \ bytes\, received\, x\, 8}}{\boldsymbol{(t - t_f)}} \qquad \boldsymbol{(3.1)}$$

Where tf is the time of first packet received, and t represents either the time of last packet received.

6.2.2 Average end-to-end delay.

End-to-End delay is the amount of time required for a packet to travel from the source until it reaches its destination. Typically, it can be calculated by:

$$\text{Average ETE delay} = \quad \frac{\sum(arrival\_time - sent\_time)}{\sum number\_of\_connections} \qquad (3.2)$$

The most common measurement unit is milliseconds and it is really important, depending on the use of a network, for this value to be small. In regards to routing protocols the smaller the end-to-end delay is the better a protocol is performing.

6.2.3 Packets Drop.

It refers to the total empirical probability of packets drop as shown below equation:

$$\text{Packet Loss} = \left(\frac{\text{NO.of packet sent} - \text{NO.of packet receved}}{\text{No.of packet sent}}\right) * 100 \qquad (3.3)$$

6.2.4 Energy cost.

The cost associated with each packet at a node, M is represented as the total of incremental cost proportional to the packet size which resulted in more congestion in the network and a fixed cost b associated with channel acquisition:

$$\text{Energy Cost} = \text{m} \times \text{size} + \text{b} \qquad (3.4)$$

So that the formula can be write as follow:

$$\text{Energy Cost} = m_{send} \times size\ send + b_{send} + \sum_{n \in S} (m_{recv} \times size\ resived + b_{recv})$$

S= set of nodes within transmission range of transmuting node.

$m_{send}\ and\ b_{send}$ = incremental and fixed cost for sending the broadcast packet.

$m_{recv}\ and\ b_{recv}$ = incremental and fixed cost for receiving the broadcast packet.

6.2.5 Energy consumption:

It specifies the average of remaining charge of all batteries attached to nodes at the end of simulation time. It can be calculated as follows:

$$\text{Energy Consumption} = \frac{1}{n}\sum_{i=1}^{n} \text{RB}(i) \qquad (3.5)$$

Where RB is the residual battery energy of node, i at the end of simulation, and n is the total number of nodes in the network.

6.2.6 Packet Delivery Ratio (PDR).

Packet Delivery Ratio, The result of the computation of the successfully delivered packets to a destination, by the number of packets sent. The greater this figure is, the better a routing protocol performs.A general formula for calculating packet delivery ratio as a percentage is as follows:

$$\text{PDR} = \frac{\sum packets\_received}{\sum packets\_sent} x100 \qquad (3.6)$$

7. SIMULATION RESULTS.

7.1 Throughput.

The data are plotted in Figure 4.1, which shows the throughput comparison of MBMA-OLSR and MBMA-OLSR (ABC). The figure shows that throughput of ABC-MBMA-OLSR, which is higher than that of MBMA-OLSR. This is because ABC-MBMA-OLSR fitness value is mainly based on energy consumption and calculating the route which has minimum energy consumption. Hence, more packets are delivered to the base station and the network can operate longer. The hybrid algorithm shows an increase of approximately 40% of throughput compared to the MBMA-OLSR algorithm.. As known, MPRs are selected to build routes from their selector to the destination besides their main role in flooding control messages. Thus, in ABC-MBMA-OLSR, stable nodes (high residual battery and low speed) were selected in order to contribute as MPRs form multiple routes, thus, considerably reducing the loss rate caused by the frequent link breakage. Nonetheless, once the packets reach their destination without any delay and without any drop, the channel bandwidth is utilized properly, thereby leading to high throughput.

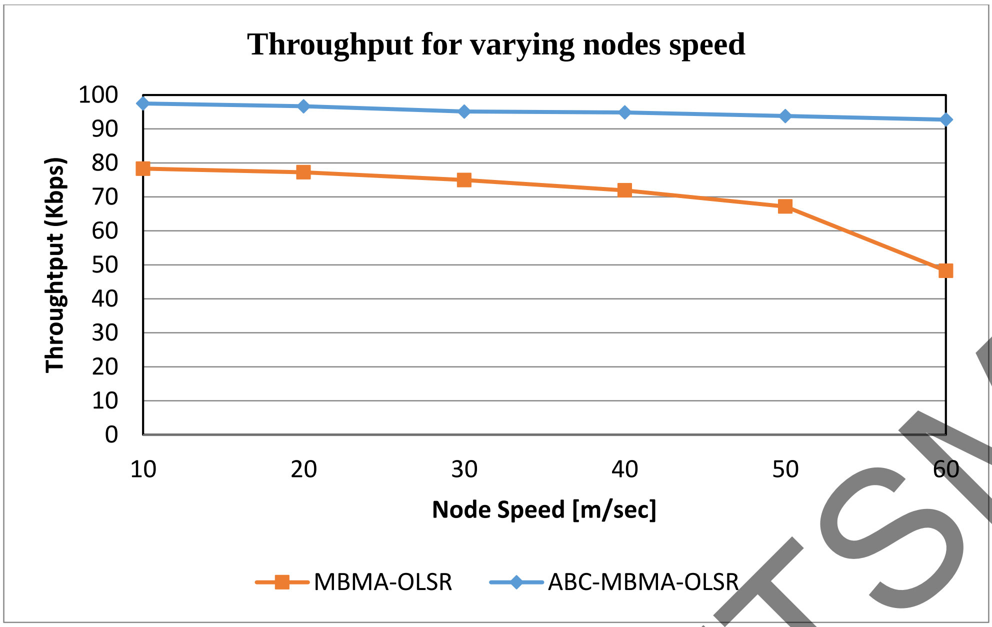


Figure 4.1 **Throughput for varying nodes speed.**

7.2 Average End-to-End Delay

The speed of nodes is varied from 10m/sec to 60m/sec at an increment of 5 m/sec and the simulation is run for 200 seconds as shown in Figure 4.2 respectively. Increase in speed of the nodes leads to increase in delay and the retransmission time increase due to failure links which also tend to increase the end to end delay. ABC-MBMA-OLSR is highly fault tolerant and tend to repair the link quickly which reduces the transmission time. As a result, the average end-to-end delay in ABC-MBMA-OLSR and under mobility scenarios is always higher than it is in MBMA-OLSR.

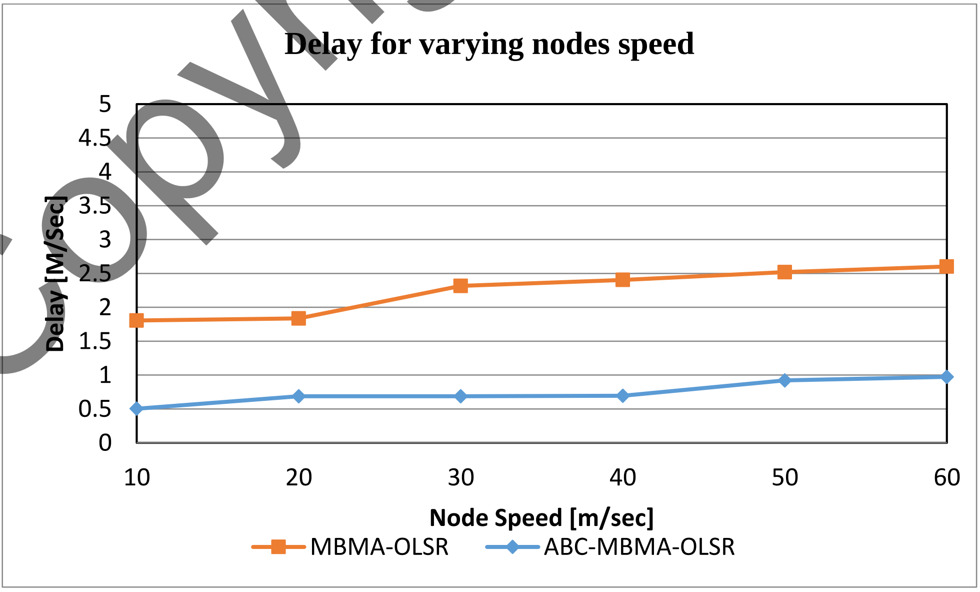


Figure 4.2 **Delay for varying nodes speed.**

7.3 Packets Drop

Packets drop is one of the important performance metric to analyze the performance of algorithms. The packet drop increase with increase in number of dead nodes. Since hybrid algorithm considers energy consumption as the fitness function hence it reduces the number of packets drop which is presented in the table below. The increase in mobility allow the nodes to find the forwarder node quickly so the packet drop reduces with increase in speed of node. The graph shows that the number of packet drop in ABC-MBMA-OLSR is less than that of MBMA-OLSR by around 40% approximately as shown in Figure 4.3 respectively.

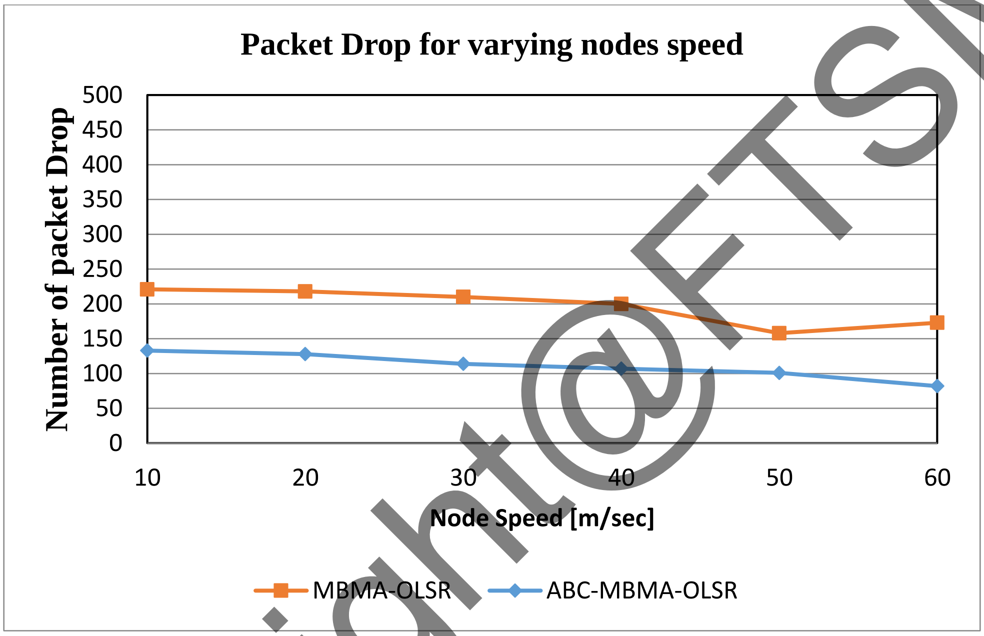


Figure 4.3 Drop packet for varying nodes speed

The key function of the **topology sensing** is to provide the nodes with information about the network's topology and the benefits from MPRs. ABC Route selection is performed via MPR node and routing information table. Our protocol selects a number of MPR nodes based on higher energy (ignoring the node which has low energy) and number of two hop neighbor covered by the node. The increasing number of packets dropped in MBMA-OLSR is attributed to the absence of mobility awareness support to select the best routes especially in case of link failure due to the mobility of nodes. However, the impact of mobility awareness techniques from the proposed ABC-MBMA-OLSR routing scheme is obvious based on the number of packet drops due to the retransmission limit in the MAC layer. The ABC-MBMA-OLSR seemed to benefit from its mobility awareness swarm nature in minimizing the number of retransmission trails of packets when link failure occurred due to the high speed of mobile nodes.

7.4 Energy Cost

The Figure 4.4 shows the comparison of Energy Cost with varying speed of the mobile nodes. The ABC-MBMA-OLSR tends to have less energy cost than that of MBMA-OLSR. The energy cost is the ratio of the average energy consumption to the receive packets. Furthermore, the ABC-MBMA-OLSR considers the status of nodes in terms of energy cost and speed to select the MPR set using EMA-MPR and discover the most stable routes to the destination based on the MCNR. Therefore, it reduces the total energy cost during data transmission. Consequently, it decreases the energy cost per packet and achieves the lowest cost compared to the MBMA-OLSR-which depends more on the energy status of nodes in the static and low mobility scenario not as ABC shortest path mechanism , and it becomes an energy-aware scheme rather than a mobility-aware routing scheme.

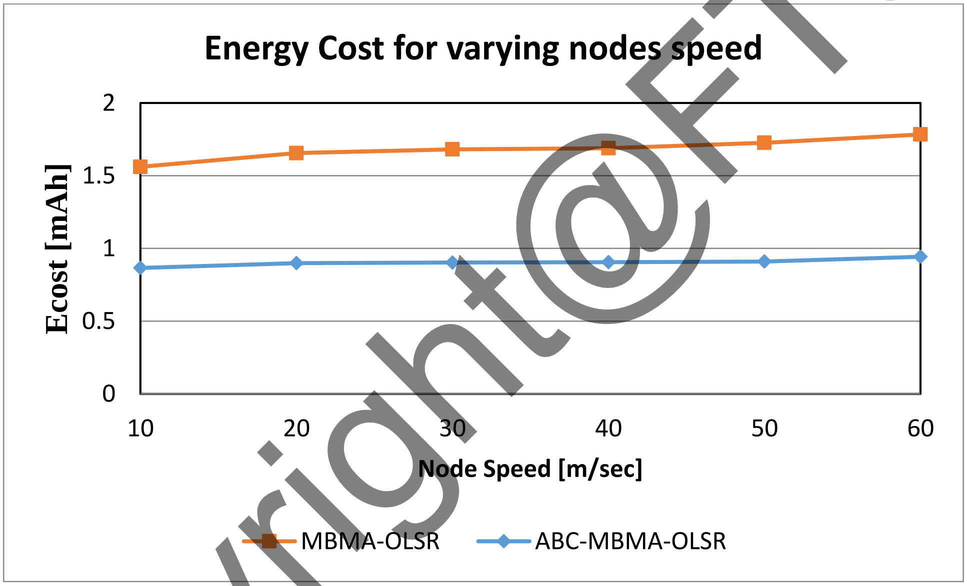


Figure 4.4 **Energy cost for varying nodes speed.**

7.5 Packet Delivery Ratio

Packet Delivery Ratio (PDR) is the ratio of the total packet received over the total packet sent. The ABC-MBMA-OLSR algorithm tends to have a stable packet delivery ratio of 90% and above for all the mobility conditions. This shows that hybrid algorithm behaves perfectly during all the conditions and is aware of broken links and provides repair to increase the delivery ratio. The graph shows that hybrid algorithm has higher delivery ratio than that of MBMA-OLSR algorithm and performs well at all the speed conditions. These results collected in Figure 4.5.

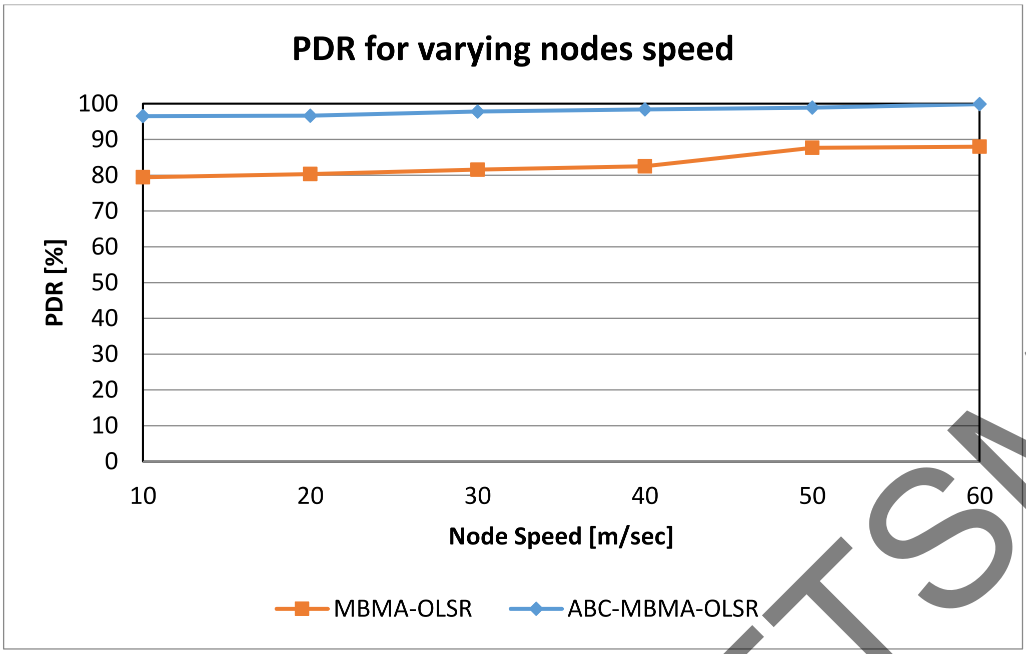


Figure 4.5 PDR for varying nodes speed

7.6 Energy Consumption

As shown in Table 4.6 and Figure 4.6 respectively, ABC-MBMA-OLSR finds the optimized route depending upon the minimum energy consumption among the routes. Since our algorithm focuses on energy consumption, the graph shows that average energy consumption of ABC-MBMA-OLSR is less than that of MBMA-OLSR. The routes are established taking into turns among the nodes with routes consuming less energy from source to destination. This tends to increase the lifetime of the network. In ABC-MBMA-OLSR, less energy is consumed during the route computation and flooding of topological information because it selects the shortest path nodes with low speed and high residual battery to exchange control messages and forward the data packets to the destination. As a result, there is a balance in the energy consumption and an increase in the average residual battery capacity. Based on the mobility model, each node moves away from its current path with time, and this imposes more complexity on the route computation process to discover new routes. In addition, MPR nodes consume their energy resources faster than other nodes since they have to forward the packet from their selectors to other nodes, and also relay data packets intended to their selectors.

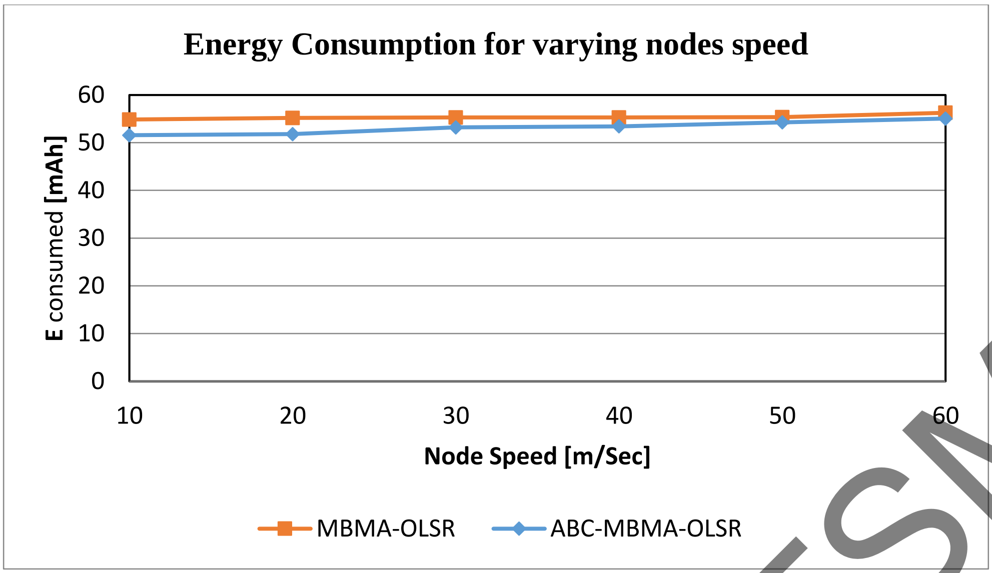


Figure 4.6 **Energy Consumption for varying nodes speed.**

7.7 Metrics Comparison

After done all the comparative analysis with existing scheme of Jabbar. We need to know which is the highest metrics have achieved. We can see the energy conception have achieved less usage When located at node speed of 60 m/s. Energy cost has achieved a good results and better than Jabbar work also in node 60 as shown in Table 4.1 and Table 4.2 respectively. While for the PDR and throughput it shows a high satiability numerical results when applied in different node speed mobility under roadway model.E22 it shows the lowest metric in term of network performance -which gives why our energy results is feasible enough ,which led to achieved the objectives and goal for this research thesis.

Table 4.1 ABC- MBMA-OLSR results

Node Speed	Throughput	E2E	Drop packets	Energy cost	PDR	Energy consumption
10	78315.52	1.805102	221	1.560682	79.45395804	54.84739
20	77250.56	1.835797	218	1.655173	80.34169497	55.18877
30	74956.80	2.316325	210	1.681515	81.5718355	55.27814
40	71925.76	2.404192	200	1.688767	82.51604916	55.28256
50	67174.40	2.518873	158	1.726281	87.67282578	55.35245
60	48250.88	2.601642	173	1.783851	88.004385	56.26493

Node Speed	Throughput	E2E	Drop packets	Energy cost	PDR	Energy consumption
10	**97484.80**	**0.504210**	**133**	**0.866034**	**96.53548532**	**51.55498**
20	**96665.60**	**0.686662**	**128**	**0.898900**	**96.64994197**	**51.79546**
30	**95109.12**	**0.687420**	**114**	**0.902598**	**97.8224247**	**53.20118**
40	**94863.36**	**0.694284**	**107**	**0.905415**	**98.40877343**	**53.42832**
50	**93798.40**	**0.921760**	**101**	**0.910181**	**98.91126603**	**54.25795**
60	**92733.44**	**0.973651**	**82**	**0.943181**	**99.90**	**55.05485**

Table 4.2 MBMA-OLSR results.

8.CONTRIBUTION OF RESEARCH

This research focuses on the development of new techniques to reduce the energy cost for the. The objectives of this research are as follows: Phase one: Enhancing the exiting energy scheme of Jabbar et al. (2017) achieved the first objectives of this research using the bio influence intelligence movement of the ABC for the best selection path for the MBMA-OLSR over MANET. Phase Two: An evaluation was performed for the enhanced scheme in terms of throughput, average end-to-end delay, drop packets, packet delivery ratio, energy cost and energy consumption. The energy cost and energy consumption metrics showed a feasible result in comparison with Jabbar et al. and a simulation performed in MATLAB. All results were achieved for the second objective of this thesis. The future works will consecrate of this study came from the inspiration of the swarm intelligence. However, a Grey Wolf Optimizer (GWO) algorithm may

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