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Reactive routing protocol is one of the most important parameters in MANET, so a study of their performance is done in the next sub sections using NS2

Mohammed Jaber Alawadi

Department of Computer Engineering, Information Technology, Altinbas University, Istanbul, Turkey
Email: al_3wadi@yahoo.com

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Correspondence:
Mohammed Jaber Lafta Alawa
Email: Al_3wadi@yahoo.com

Abstract

Mobile ad hoc network is a creation of portable devices; they create a network with infrastructure on the fly that is ever changing. As in the previous network structure, each node performs both the action of a router and a host. Also, nodes cannot be fixed in the network; they can join or leave the network, and this increases the flexibility of the connectivity. There are routing protocols which are used for identification of efficient paths between the nodes in the network so as to seek the determination of the best routes between two nodes. This research show that routing is complex in MANETs and hence it demands the fine tuning of numerous routing protocols. We evaluate the effectiveness of these protocols by analyzing two primary metrics: are the average figures of throughput and average end to end delay. Simulation of this protocol was done using NS2 (Network Simulator) 2. 35, we investigate how well routing protocols fare in terms of different aspects including Size of the packets and number of nodes present.

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1. Introduction

As for the communication domain, wireless networks have come to the foreground in the recent years. These networks are used in virtually all the technology fields such as military applications, industries and personal area networks. It is worth noticing that wireless networks have numerous advantages which explain the variety of activities they can facilitate: simple to set up and use, considerably cheaper than wired networks, and rather dependable. Unlike wired networks they do not rely on existing infrastructure of cables and other equipment. Some of these networks are; satellite communication, wireless fidelity (Wi-Fi), mobile telecommunication and others [1]. A subset of the wireless ad hoc networks, the Mobile Ad Hoc Network (MANET) has been widely employed. The wireless network which has the mobile and portable nodes which work without a structured base station/a point of access make this kind of wireless network. Unlike other wired networks, MANETs are self-organized and do not need initial infrastructures to be in place. Some of these are: Cellular phone networks, Wireless Fidelity Wil-Fi, satellite communication, many others [2]see the mobile ad hoc network in **Figure 1**.

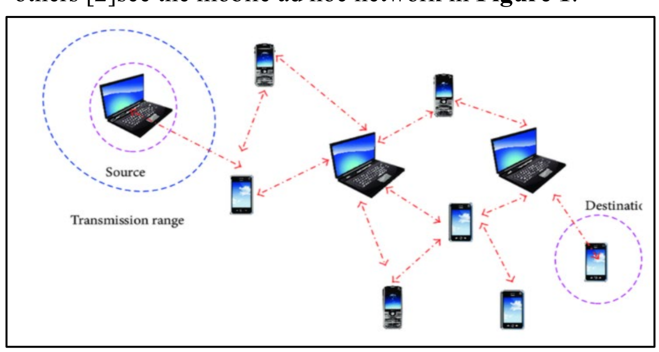

Figure 1. Mobile Ad Hoc Network

Leaving aside the numerous potential applications, MANETs are a significant area of study. According to Choudhary and Jain (2015) [3], network nodes in these networks have two roles: they are the nodes that forward data packets to other nodes and at the same time they are the source and destination of data packets. Two challenges reign in MANET research: first, the limited battery life common in nodes; second, the nodes' mobility. MANET has its function for operation independently and the ability of connecting to the global Internet. These networks emerged due to academicians' connectivity of laptops and Wi Fi in 1990s. Every node in a MANET has two functions: in one instance it can be a router and in the other a traffic router thereby providing means of communication between nodes. Since MANET nodes are characterized by mobility that allows them to join and leave the network at will and also change position within the network, mobility of nodes results into changes in the network topology. Thus, one of the key requirements for the ability of the network to adapt to these topological changes turns into a strong routing protocol [4]. To overcome the complexity that may prevail due to changes in inter-network topology some special routing protocols have been devised for ad hoc network. Some of the examples are Ad hoc On-Demand Distance Vector (AODV) [24], Destination Sequenced Distance Vector Routing (DSDV) and Dynamic Source Routing (DSR).

Three main categories are often used to categorize routing protocols: They are divided as "Reactive," "proactive," and "Hybrid." Proactive routing protocols keep a current map with the network topology and preexisting route, which readily accessible from one location to another. On the other hand, preset routes are not always available for the reactive routing protocols and they are also referred to as the on-demand routing protocols. Thus, to be able to send a data packet, a route discovery process is initiated and broadcast queries are sent across the network. The proactive and reactive routing strategies are integrated with each other in what is known as hybrid systems. A node employs the proactive technique if the node is within the transmission range of other nodes, vice versa for the reactive technique [6]. This is done in a view to making sure that wireless nodes are always available and efficient always, they depend on power supply. Hence, to overcome these challenges and optimize power usage and the costs of managing MANETs, bio-inspired approaches are currently more and more incorporated in wireless communications. Although, not specifically designed for AODV, one of the bio-inspired algorithms, genetic algorithm (GA) has been developed for its integration. Based on the analysis done by GA algorithm, bee colonies are divided into three categories and each of them is assigned a particular role to play namely the scout bees, the employed bees and the observer bees. [6]. To ensure continuous availability and efficiency, wireless nodes rely on a consistent power source. Thus, in order to improve power efficiency and lower the administration costs of Mobile Ad Hoc Networks (MANETs), bio-inspired algorithms are increasingly being adopted in wireless communication research nowadays. Specifically designed for integration with AODV, the genetic algorithm (GA) is an example of a bio-inspired algorithm. Bee colonies are classified by the GA algorithm into three distinct groups, scout bees, employed bees, and observer bees, each of which is given a specific job. MANETs, also known as infrastructure-less networks, operate without the need for entry points or central core networks to facilitate communication among wireless nodes. In MANETs, nodes have the flexibility to move freely while maintaining wireless communication. These networks are typically employed in situations where network management or support isn't centralized, in contrast to systems involving routers or base stations. **Figure 2** illustrates a typical MANET configuration.

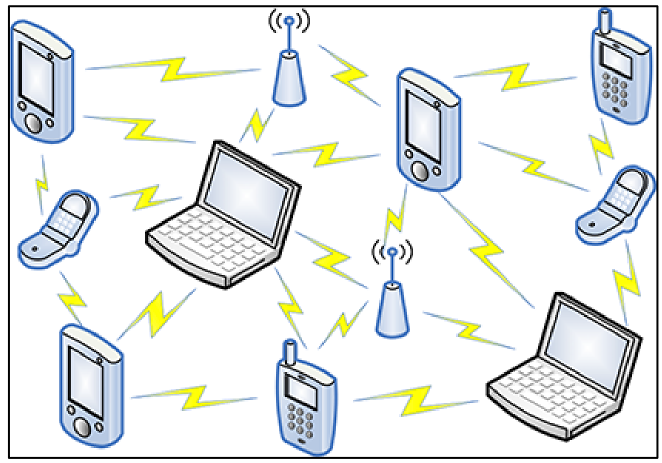

Figure 2. MANET

Existing data transmission protocols are subpar, especially for large volumes of data. The mobility speed of intermediary nodes between data sources and destinations creates instability in the network topology, leading to frequent disruptions in connections. This has led to a need for reassessment and refinement of existing protocols to address these challenges and create a more robust and reliable data transmission framework. Previous studies' protocols have poor performance in this area. Enhancing the efficacy of the Ad hoc On-Demand Distance Vector (AODV) routing protocol is the primary objective of this study. The following are the specific goals in detail: (a) develop the GA-AODV routing protocol by incorporating the genetic algorithm (GA) to improve the performance of the AODV routing protocol for Mobile Ad Hoc Networks (MANETs) and (b) assess the suggested protocol's performance, accounting for variables like packet size and node speed.

2. Related Work

This section investigates related work based on routing protocols for energy consumption optimization. We limited the research articles to those published between 2018 and 2023.

Shantaf et al., in 2020, the discussion centered on the capabilities of mobile ad-hoc wireless networks, emphasizing their potential and advantageous features for establishing networks without central management or infrastructure. These networks are characterized as independent, temporary, and deployable anywhere, showcasing extensive and ubiquitous connectivity. The pivotal requirement for their functionality lies in the intermediate nodes' ability to communicate, facilitating data transmission and reception at any given time and location. Consequently, path routing and protocol selection are the focal points of wireless network design techniques. The study explores and assesses how mobility affects the routing protocols DSDV, AODV, and DSR in two distinct contexts: shifting node densities and disparate geographic locations. The evaluation measures the efficiency of the routing protocols using the NS2.35 simulation and combines three performance metrics: average throughput, packet delivery ratio, and average end-to-end delay [7].

Abbas et al.,2021, Enhancements have been introduced to current routing protocols, with new protocols under design to tackle the challenges presented by the continuous evolution of network topology. The TORA and AODV routing protocols were thoroughly evaluated using the NS2 simulation environment. Packet delivery fraction and end-to-end latency were used as performance measures. The researchers came at the following conclusions: a rise in node intensity corresponds to a corresponding rise in the mean end-to-end delay, whereas a decrease in the mean end-to-end delay is caused by an increase in pause time. Concurrently, loop detection time experiences an increase with a greater number of nodes. In overall performance, AODV demonstrates superiority over TORA. TORA proves particularly suitable for networks characterized by a multitude of nodes, especially in scenarios involving multicasting and the establishment of multiple routes [8].

Sarao et al. in 2018, A fuzzy-based scheme has been proposed to enhance the effectiveness of AODV in ad hoc wireless networks. The selection of the next hop is determined by factors such node energy, node degree, and the node energy of its neighbor. When choosing the next hop, this method takes into account a variety of factors, including the number of hops. Node lifetimes and network lifetimes are enhanced by implementing energy-based criteria for next hop selection. Every node has a fuzzy controller system installed, which determines the output parameter's chance value. This chance value is used to choose the subsequent hop. The AODV, DSR, and DSDV routing protocols have been compared with the suggested protocol, F-EEAODV. Our suggested system performs better than AODV in terms of throughput, end-to-end delay, and propagation delay, according to simulation studies using NS-2 [9].

Ajibesin et al., in 2019, three MANET routing protocols were simulated. One is the DSDV which is a destination-based proactive protocol. Others are DSR and AODV which are topology-based reactive protocols. Also, three metrics namely, Throughput, Packet delivery ratio (PDR) and Jitter were considered for the performance evaluation. The protocols were simulated using network simulator 2. The results showed that the average Throughput, the PDR and average Jitter of the protocols increased as the number of network topology (nodes) increased. Overall, AODV protocol outperformed the other two protocols for all the observed metrics when the network exceeds 35 nodes while the DSR is the better protocol in smaller networks. Thus, the two reactive protocols (DSR Topology-based and AODV Destination-based) have shown better performance over the DSDV Destination-based proactive protocol. Furthermore, the trend analysis based on the cumulative performance in different network scenarios is useful information for the network designers [10].

3. Methodology

3.1 NS2 Simulator

Version NS2 of the object-oriented, discrete event-driven Network Simulator was created at the University of California, Berkeley. The main purpose of NS2, which is built using a combination of C++ and OTcl, is to simulate both local and wide area networks. The use of the abovementioned programming languages has its reasons, the most important of which can be attributed to their internal characteristics. C++ is efficient in implementing a design, but has difficulty in graphic representation. Modifying and assembling different components and changing different parameters could be complicated without a visible and easy-to-use expressive language. NS2 separates data path and control path implementations in order to improve efficiency. To reduce packet and event processing overhead, C++ is used in the construction and execution of the event scheduler and key network component objects in the data route. Because OTcl has several features that C++ does not, combining these two languages can be quite useful in real-world scenarios. The whole protocol is developed in C++, but OTcl is used by users to manage simulation scenarios and event scheduling. In this example, the OTcl script is used to start the event scheduler, set up the network topology, and tell the traffic source when to start and stop sending packets using the event scheduler. By entering commands into the OTcl script, it is easy to change the situations. With the provided object library, users may build composite objects or start from scratch when creating new network objects. Data flow connections can then be made between these entities. Because of its adaptability in linking parts, NS2 is an extremely powerful simulator [11].

3.2 Simulation Parameters and Scenarios

This section of the work has focused on the simulation that was done on the proposed GA-AODV technique. The main purpose of this simulation was to improve the capability and reliability of MANET and to prolong its working time. The objective was to use the proposed GA-AODV protocol to find out the shortest paths, higher throughputs, and low delay times. The main procedures followed in incorporating the simulation for the new proposed GA-AODV protocol. We have chosen two real scenarios: One of which is installed in an urban area and the other is installed at a highway. In particular, Auckland CBD has been chosen for the urban area and Auckland motorway for the highway area. These are the four major units that form the substantive of the simulation model. First of all, the MANET environment was constructed in order to give opportunities to create concrete simulation scenarios. Also in this module, basic properties of MANETs, such as size, number of nodes, bandwidth, etc., were incorporated into the design. Routing protocols were the next step followed, in which several optimization algorithms were used to address solution advancement. However, the last but not the least, the performance analysis of the GA-AODV protocol has been done using two scenarios. First, the maximum speed in nodes for the movements allowed are 5, 10, 15 and 20 m/s. Second, there are different packets which were chosen for this simulation; namely, 128, 256, 512 and 1024 bytes.In conclusion, the protocol's performance was assessed using key metrics, including packet delivery ratio, average delay, and average throughput.

The employed traffic type is Constant Bit Rate (CBR), a common choice in multi-hop scenarios utilizing UDP transport layers. CBR traffic is well-suited for real-time applications. Node speed was capped at a maximum of 30 km/h. Each node's transmission range was configured at 250m. The simulation area spanned 1200m x 800m across all scenarios, with a simulation duration of 40 seconds. A total of thirty nodes were randomly dispersed, and two nodes located at substantial distances were designated as the source and destination. All simulation parameters are summarized in **Table 1** for reference.

Table 1. Simulation parameters

Parameters	Value	Unit
Number of nodes	30	Nodes
Queue size	100	Packet
Scenario Dimension (m x m)	1200 x 800	M2
Protocols	GA-AODV, AODV, BEEIP	Protocols
Packet size	128, 256, 512, 1024	Bytes
Transmission range	250	m
Application layer	CBR	_
Simulation time	40	Second
The average speed of nodes	20	(Km/h)
Transport layer	UDP	_

3.3 The Proposed GA-AODV Protocol

The AODV routing protocol has been created and implemented in this work using the Genetic Algorithm. Effective cooperation between all nodes in a Mobile Ad-Hoc Network (MANET) is necessary for improved operational efficiency through the sharing of data about node links and restricted paths. Our paper introduces genetic algorithm as a means to identify the optimal path, leveraging its adaptability and context-aware metrics. The genetic, utilizing the AODV, then employ this algorithm to determine the most efficient route. The GA-AODV protocol, briefly described below, encapsulates these concepts:

1) New Simulator

2) Create Multiple Trace

3) Creating New Topology **[*New Topography*]**

4) Configuring the Nodes in the Topology **[ns_node-config]**

5) New Node creation [***Set*** $i = 0, i < 30$***, incr*** i]

6) Assign the position for each node [***n s_at 0.0 node_(30) setdest xyz***]

7) Randomly assign the speed for each node ***[n s_at tm node_(30) setdest [expr rand 0*** $* 50 + x$][***expr rand*** $0 * 50 + y$][***expr int (rand 0 *10)]]***

8) Select the sours and destination nodes ***[set sink (i)[new Agent/LossMonitor] ns_attachagent sour_(i), dist_(i)]***

9) Create a CBR agent and attach it to the node ***[set CBR (new Application/Traffic/CBR)]***

10) Select Packet Size ***(cbr set packetSize_size = 1024)***

11) Select Interval Time ***(cbr set interval_itval = 0.48)***

12) Initialize the population $X_i, i = 1, \dots, S_n$

13) Each node sends a hello message to its neighboring nodes to determine their state (free or busy). For each particle X:

- Iterate until the entire network is covered.

- Select the route for X_i (number of solutions).

- Identify the neighbors along the route.

- Calculate the distance between each node.

- Compute the energy probability value for the solutions X_i.

14) Repeat these steps until all particles are processed. Store the best energy routes in the array (ID).

15) While the maximum number of cycles is not reached:

16) - Choose another route for X_i.

17) - Calculate the probability value Pi for the solution (Step 19).

18) - Update the contents of (ID).

19) - Increment the loop counter.

20) - If the current combination of solution routes surpasses the combination stored in its memory, update the particle's position.

21) End the cycle once the maximum number is reached.

22) Memorize the best solution achieved thus far.

23) Broadcast data from the source to the destination using DSDV based on the best energy route.

To describe the proposed GA-AODV protocol, first, we generate a new simulator object, multiple trace and a new topology and then we set the configuration of nodes in the topology. Second, we create the number of nodes (*i=0*) of *nn*, where *nn* denotes the number of nodes or population size. After creating the number of nodes we assign the position of each node at a time *t=0* using *setdestx,y,z* and randomly assign a speed for each node (*rand()*20*). In addition, we select the sours and destination nodes *sour (i), dist(i)* and create CBR agent and attach it to the sour's node. Thirdly, initialize the solution,X_i. Each solution X_i *(i=0, 1…, Sn)* is a dimensional trajectory, where "S_n" is the total of solutions. All node broadcasts hello message to it is neighbors to verify the node in idle or non-idle mode. A Genetic algorithm analyzes the ("population") of the new ("new solution") source and updates the location ("solution") in its memory based on local ("visual") information. The ants that are observing evaluate the best path that the other ants have created and then select a food source according to the likelihood that is established by the amount of food. Here's how this approach is expressed:The Genetic algorithm mechanism integrated with the AODV routing protocol. We used the Genetic algorithm beside the discovery mechanism in AODV, this mechanism discovers the top accessible node as well as the shortest route based on the node distance. The ant will evaluate both the node and its distance from other nodes. When a node is placed in a far-off area, the whole data packet will not reach the destination, this will cause a low throughput of the network.

4.Performance Metrics

To assess MANET routing protocols in a quantitative manner, performance metrics are employed. Quantitative measurement is essential for analyzing network performance and comparing the efficacy of different routing strategies. This study's evaluation encompasses a variety of performance criteria.

A. Average Throughput

As will be seen in the following sections, in order to quantify the MANET routing protocols their performance indicators are used. Quantitative measurement is quite critical in evaluating the performance of the network and even the effectiveness in the application of different routing algorithms. Here we examine some performance aspects of this study. :

B. Packet Delivery Ratio

For assessing the performance of the method the packet delivery ratio is used, this is calculated by the total number of received packets by the destinations divided by the total generated packets by sources. This metric evaluates the ability of the protocol to deliver packets in the right destination end to end delivery. Good figures are depicted by a high packet delivery ratio concerning the consequences making it evident that the routing protocol is efficient and accurate. The packet delivery ratio is calculated using the following formula:The packet delivery ratio is calculated using the following formula:

$$Average\ Throughput = \frac{\sum Packets\ received\ by\ destination}{stop\ time - start\ time} * \frac{8}{1000} \quad (1)$$

C. Packet Delivery Ratio

Concerning average energy consumption, much has been said and written. This metric is obtained by dividing the energy consumed by each node of the network and the amount of energy it has at the start of the simulation. The energy level of the node at the start of the simulation run as well as at the end of the run is also calculated. The average energy consumption is calculated using the following formula:The average energy consumption is calculated using the following formula:

$$= \frac{\sum packets\ received\ by\ destination}{\sum packets\ sent\ by\ sources} * 100 \quad (2)$$

D. Average Energy Consumption

After the simulations regarding to the scenarios I and II were completed, the performance analysis was assessed in terms of average throughput, end to end delay and packet delivery ratio. A simulation was done using different node speeds and packets size for purposes of illustrating the effectiveness of the GA-AODV routing protocol implemented through the genetic algorithm. The node speeds varied from 5, 10, 15, 20 m/s while the packet sizes varied 128, 256, 512, 1024 kbps.

$$Average\ energy\ consumption = \frac{\sum energy\ consumed\ in\ each\ node}{initial\ energy} * 100 \quad (3)$$

5. RESULTS AND DISCUSSION

Once the simulations were finalized for scenarios I and II, the performance analysis was evaluated utilizing parameters such as average throughput, end to end delay and packet delivery ratio. A simulation analysis employing various node speeds and packet sizes was carried out to show the efficacy of the GA-AODV routing protocol using the genetic algorithm. The node speeds ranged from 5, 10, 15, and 20 m/s, with packet sizes ranging from 128, 256, 512, and 1024 kbps.

5.1 Node Speed

A. Average End to End Delay

Table 2 illustrates the impact of node speed on end-to-end (e2e) delay for the GA-AODV, BeeIP, and AODV protocols. The proposed GA-AODV protocol underwent evaluation across various node speeds. Figure 3 presents the average e2e delay for the GA-AODV, AODV, and BeeIP protocols. As the node speed increased from 5 to 20 m/s, the average e2e delay for the AODV protocol showed a rise from 31.336 to 32.201. In contrast, the BeeIP protocol experienced an increase from 37.109 to 37.983. Notably, the proposed GA-AODV protocol exhibited lower delay compared to BeeIP and AODV, ranging from 13.922 to 27.807. The results unequivocally demonstrate that the GA-AODV protocol outperforms both BeeIP and AODV in terms of e2e delay.

Table 2. End To End Delay With Node Speed

Node Speed	BEEIP	AODV	ANT-AODV
5	37.109	31.336	13.922
10	37.118	32.192	23.902
15	36.81	30.448	23.357
20	37.983	32.201	27.807

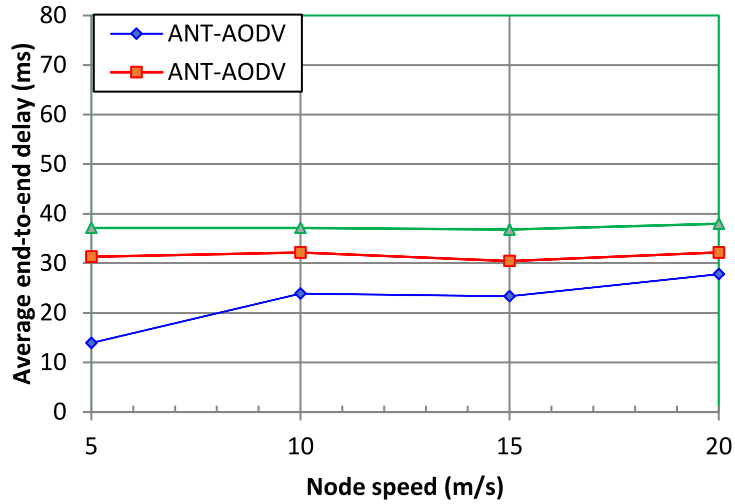

Figure 3. Average End-to-End Delay

B. Average Throughput

Table 3 illustrates the impact of node speed on Average Throughput delay for the GA-AODV, BeeIP, and AODV protocols. The proposed GA-AODV protocol underwent evaluation across various node speeds. Figure 4 presents the Average Throughput for the GA-AODV, AODV, and BeeIP protocols. As the node speed increased from 5 to 20 m/s, the Average Throughput delay for the AODV protocol showed a decrease from 43.2925 to 40.92944. In contrast, the BeeIP protocol experienced a decrease from 44.1916 to 43.8177. Notably, the proposed GA-AODV protocol exhibited lower delay compared to BeeIP and AODV, ranging from 48.61704 to 46.16. The results unequivocally demonstrate that the GA-AODV protocol outperforms both BeeIP and AODV in terms of Average Throughput delay.

Table 3. Average Throughput With Node Speed

Node Speed	BEEIP	AODV	ANT-AODV
5	44.1916	43.2925	48.61704
10	44.1828	40.96004	47.46709
15	43.8844	40.95078	47.1921
20	43.8177	40.92944	46.16

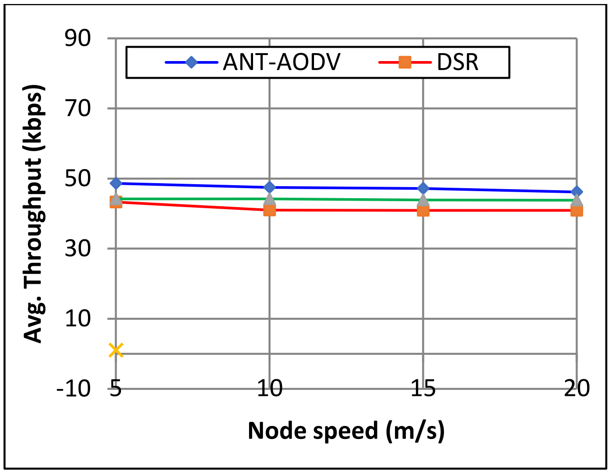

Figure 4. Average Throughput with Node Speed

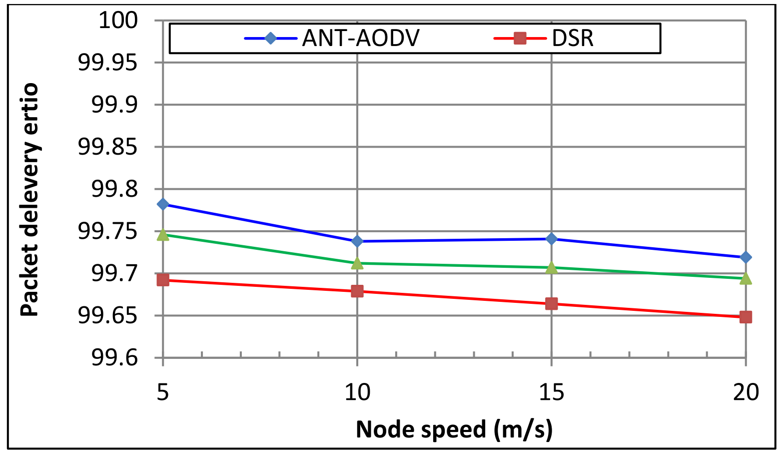

Figure 5. Packet delivery ratio with Node Speed

C. Packet delivery ratio

The latter looks at the effect of node speed on Average Throughput delay in the GA-AODV, BeeIP, and AODV protocols, as reflected in table 4. There is a need to test the proposed GA-AODV protocol with an aim of considering different node speeds. The average throughput of the GA-AODV, AODV and BeeIP are depicted in the following figure 5. While, when the node speed was raised from 5 m/s to 20 m/s, the comparison of Average Throughput delay for the AODV protocol slightly decreased and it was 99. 648. Nevertheless, the BeeIP protocol declined slightly from 99. 746 to 99. 694 from what has been observed. Most of all, the GA-AODV showed lesser delay than BeeIP and AODV, with the corresponding value ranging from 99 to 99. 719. The results unambiguously depicted the potentiality of the proposed GA-AODV protocol in comparison with the BeeIP and AODV in respect of Average Throughput delay.

Table 4. Packet Delivery Ratio With Node Speed

Node Speed	BeeIP	AODV	ANT-AODV
5	99.746	99.692	99.782
10	99.712	99.679	99.738
15	99.707	99.664	99.741
20	99.694	99.648	99.719

5.2 Packet Size

A. Average Throughput

In this section, only the average throughput of GA-AODV, BeeIP, and AODV routing systems are shown with emphasis to the changes in packet sizes. Table 4. 4 also gives an understanding on how the average throughput varies with different packet sizes. When comparing the proposed GA-AODV with other protocols with the packet size enlarging from 128 to 1024 bytes, we can noticed that the average throughputs have a significant improvement. 6411% to 133. 3468%. By contrast, average throughput in BeeIP rose from 26 08562 to 121. DOWN: 8802, and AODV's from 20. 52148 to 99. 554379. No less significant is Table 5 where shows the impact of packet size on the average throughput for GA-AODV, BeeIP and AODV protocols. The findings held by the data prove that the GA-AODV emerges with the better average throughput standard for the assorted paket sizes. The average throughput has been graphically represented in figure 6 for GA-AODV, BeeIP and AODV protocols.

Table 6. Average Throughput With Packet Size

Packet Size	BeeIP	AODV	ANT-AODV
128	26.08562	20.52148	72.6411
256	44.21113	41.02791	85.26032
512	93.65283	84.02914	110.1801
1024	121.8802	99.554379	133.3468

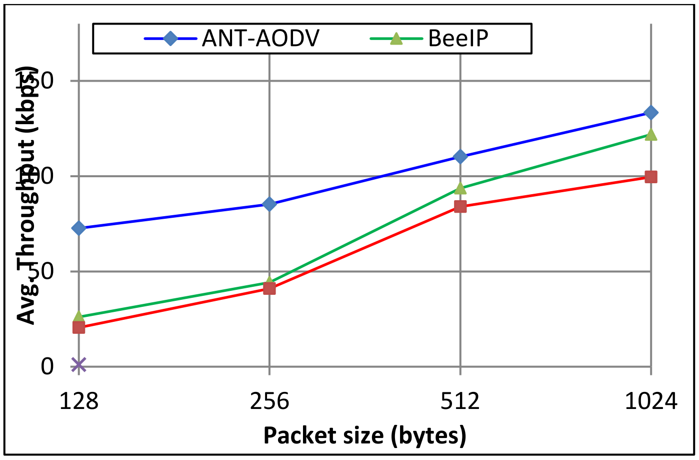

Figure 6. Average Throughput with Packet Size

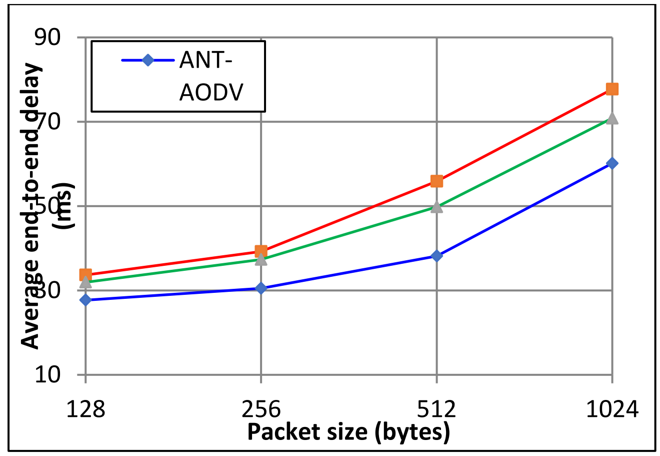

Figure 7. Average End to End Delay with Packet Size

B. Average End to End Delay

This section gives the Average End to End of GA-AODV, BeeIP, and AOD to the best of the authors knowledge, and details the influence of packet size on these routing systems. Table 4. 5 illustrates the possible way of how Average End to End depends on the packet size. When increasing the packet size from 128 to 1024 bytes, the results of Average End to End for the developed GA-AODV are significantly higher than before, namely from 27. 7% to 60. 151%. On the other hand, BeeIP average End to End was has rise from 31 as is shown in the following figure. 942 to 70. The total number of messages that was sent by DSR was 853 and for AODV was 33. 665 to 77. 727. Table 6 gives the comparison of effects observed on Average End to End based on packet size for GA-AODV, BeeIP, and AODV protocols. The data conveyed portray how appreciably, GA-AODV has an improved Average End to End performance than the other protocols at different packets sizes. The Average End to End for GA-AODV, BeeIP and AODV protocols are shown in **Figure 7** below:

Table 7. Average End To End Delay With Packet Size

Packet size	BEEIP	AODV	ANT-AODV
128	31.942	33.665	27.7
256	37.348	39.252	30.511
512	49.783	55.885	38.175
1024	70.853	77.727	60.151

C. Packet delivery ratio

In this part the PDR for the GA-AODV, BeeIP and the AODV routing algorithms, and the effect of the various packet sizes on the routing algorithms are explained in detail. Table 4. 6 offers understanding of the Packet Delivery Ratio which depends on the packet size. The Packet Delivery Ratio increases with the increasing of the packet size from 128 to 1024 bytes in the proposed GA-AODV protocol with significant differences. 597% to 99. 654%. Commissioned to it, therefore, is judging the efficiency of BeeIP, which saw its Packet Delivery Ratio rise up to 99. 500 to 99. 555, and AODV's from 99. 359 to 99. 466. Consequently, the Packet Delivery Ratio of offered protocols specifically in relation to packet size is presented in table 7. The data reinforce the fact that GA-AODV always outperforms AODV in terms of PDR across all the packet size. The values of Packet Delivery Ratio of GA-AODV, BeeIP, and AODV protocols are shown graphically in **Figure 8** below.

Table 8. Packet delivery ratio with packet size

Packet size	BEEIP	AODV	ANT-AODV
128	99.500	99.359	99.597
256	99.510	99.395	99.607
512	99.530	99.430	99.637
1024	99.555	99.466	99.654

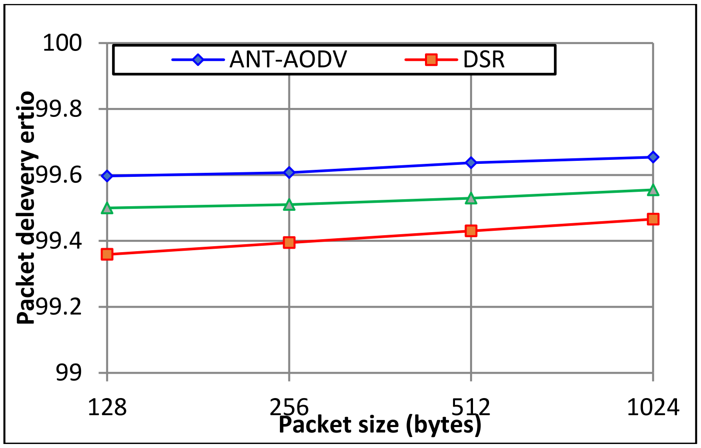

Figure 8. Packet delivery ratio with Packet Size

Conclusion

In conclusion, this study provides a comprehensive exploration of mobile ad hoc networks (MANETS), covering various aspects ranging from infrastructure distinctions to the applications and unique characteristics of MANETS. The detailed examination of routing protocols, including proactive, reactive, and hybrid approaches, sets the stage for a focused investigation into the AODV protocol and its significance in MANETS, further introduces the fundamentals of the genetic algorithm and outlines the research approach, culminating in the proposal of a novel routing protocol, GA-AODV. The subsequent simulation using ns2 validates the conceptual proof, and the analysis of node speeds and packet sizes demonstrates the adaptability and efficiency of GA-AODV in dynamic scenarios.Based on the results of the evaluation of manet routing protocols, identifying speed, average through put with the end-to-end delay, packet delivery ratio, with average energy consumption as indicators, it is evident that GA-AODV outperforms both BEEIP and AODV under difference network conditions. The constant-time factor in the nodes' speeds as well as the reliable adaptability of the protocol to the packet size increases the probability of the protocol to thrive in changing conditions. With these results, it is possible to add important information into the field of manet routing protocols, which can help to specify the advantages of the GA-AODV protocol. Nonetheless, this work understands that MANETS is an evolving concept and therefore, there is moral duty to continue with the research to tackle the new challenges as well as enhance the existing protocol in this dynamic field. Thus, the work done in this study prepares a platform for further research studies to be conducted with an aim of improving the knowledge and performance of MANETS under different and challenging circumstances.

Future investigations related to the present study can be categorized into several areas outlined below: Future investigations related to the present study can be categorized into several areas outlined below:

Implement the AODV and analyze the outcomes to other high energy effectively routing algorithms like AOMDV. Compare the results obtained by employing different types of swarm intelligent routing, in regard to the node speed as well as the packet size.

Examine bee algorithm & fuzzy logic as means to improve AODV energy cost as one of the key protocols in mobile ad hoc networks. Include the same parameters and performance measures as the existing book.

The results will be compared to those obtained in the current study with the intention of validating the proposed study which will be simulated using NS2. Consider the present hypothesis to be stated in the context of its contribution to reduction of routing delay and improvement of throughput. These should be assessed in order to determine the impact of the proposed approach.

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Conflict of interest

None.

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