Evaluation of the Quality of Service Parameters for Routing Protocols in Ad-Hoc Networks

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Abstract

Recently, many researchers have focused on the Ad-Hoc networks especially the routing protocols which include reactive and proactive routing protocols. The ultimate goal of routing protocols is forwarding data packet from the source to the destination. Consequently, several proactive routing protocols, such as routing information protocol (RIP), and reactive routing protocols, such as Dynamic Source Routing (DSR), are based on exploring, maintenance, and recuperating the route path. The likely problem in the Ad-Hoc networks is how to establish the best routing protocol that assures the requirements of the application concerning about some criteria. This work presents the evaluation of RIP and DSR utilizing the QualNet simulation. Furthermore, the achievement of these routing protocols was assessed based on the throughput, average jitter, average end-to-end delay, and energy consumption metrics. This paper demonstrates that the RIP has superior evaluation performance as compared to DSR in two different scenarios (effect of the number of nodes and effect of packet size).

Keywords

Routing Protocols; Average Jitter; Average End-to-End Delay; Throughput; Energy Consumption

Introduction

The new revolutions in wireless technology have led to the emergence of a new wireless system which is called Ad-Hoc Network. Ad-Hoc Network is a kind of wireless system which allows direct communication with each other. In Ad-Hoc network, each node plays a dual role; a router and a host in the sense at the same time. The process of sending and receiving data packages is controlled by getting some information regarding the surrounding network and dealing with algorithm. This combination between these functions is known as a routing protocol.

A number of studies have recently gained attention in using the routing protocols, particularly, proactive routing protocol and reactive routing protocol [1, 2]. Proactive routing protocols are those protocols which carry out the function of keeping track of routes for all the destinations in the Ad-Hoc networks. They are supported to be available in the form of tables. Furthermore, proactive routing protocol periodically exchange routing information in the whole network and maintains routes between different nodes dynamically. They have low latency and high overhead, and the routes are reliable. These protocols cannot scale well with the increase in network size. It is stated that one advantage of applying such kinds of protocols is that they facilitate communication to undergo minimal initial delay in the application procedure. However, their disadvantage is represented by the fact that they require additional control traffic to constantly update the entries of the stale route. On the other hand, reactive routing protocols attempt to identify a path to the destination only when a packet of data sent to the destination is received by the network protocol. This is one advantage of such kind of protocols as the degree of uncertainty in the node position is found to be high. They have also proved to be more suitable and more distinguished by their better performance in Ad-Hoc networks. However, taking more time to find a route and requiring more flooding which results into clogging the network are among the disadvantages of such protocols.

Therefore, the arrangement of forwarding data packet from the source to destination is the ultimate aim by utilizing routing protocols. The differences between these protocols are due to the differences in the searching, maintenance and recovering the route path. The decision of choosing the best routing protocol should take into account some considerations such as mobility of nodes, packet size, cost of path, application type, number of nodes, type of traffic, and Quality of Services (QoS).

On the whole, QoS shore up in wireless is an extremely demanding issue because of their dynamic character [3, 4]. Diverse techniques, as of physical layer capable of application layer, have been wished-for to supply QoS shore up in wireless Ad-Hoc networking surroundings [5]. Recently, a cross-layer design move toward in QoS conditioning in wireless networks has gained more research interest [6, 7].

Consequently, this paper focuses on the most important factors, namely end-to-end delay, average jitter, throughput and energy consumption. The end-to-end delay is important for the Ad-Hoc networks due to the fact that some of the real-time applications are very sensitive to the delay which means that the data packet sent from the source node should be delivered to the final target node within a specific period of time without any delay. Therefore, the routing protocol will be selected based on the shortest path from the source node to the destination node. The average jitter assesses the variability over time of the packet latency across a network which associated with the delay. The network with constant delay has no jitter. Therefore, the routing protocol that satisfies the constant delay without any variation during the time will be more suitable to be selected for data routing. Moreover, the significance of throughput come from the needs to deliver the more messages to destination nodes during a specific period of time which means that the routing protocols should use some mechanisms to avoid the congestion in some paths which are more frequently used to prevent the packet drops during the data routing. Hence, the reactive routing will be getting a better chance as compared to the proactive routing, to be chosen as it can find alternative paths to be used rather than the congested one. Another mechanism to increase the throughput of routing protocols, in order to be chosen, is how to deal with the failures of the paths during the data delivery; meaning that if the current path used no more available either by the node failure or moving from the current position, the routing which deals with this issue will be more preferred by the user. Beside these, energy consumption is an important factor especially in mobile Ad-Hoc networks which has restricted energy. Therefore, the routing protocol should consider this factor by chosen the paths that consume small energy to extend the lifetime of the node and give the chance to the connectivity of the network to be longer. Moreover, the nodes of paths which routed the data packets will deplete their energy very fast and run-out their batteries. Therefore, the routing protocol must look for new paths to avoid using the same path repeatedly and consuming much energy. Again, the reactive protocols will be more preferred because of their on-demand property.

Related Works

In [8], an Ad-Hoc routing protocol, namely Ad-Hoc On demand Distance Vector (AODV) has been evaluated. According to this model, the performance of AODV in homogeneous Ad-Hoc was better than heterogeneous one. A performance analysis of proactive and reactive routing protocols for Ad-Hoc networks Dynamic Destination-Sequenced Distance Vector (DSDV), AODV and Dynamic Source Routing (DSR) showed that the performance of AODV was better in dense environment except packet loss [9]. Moreover, it was found that both DSR and AODV performed well, and they proved to be better than DSDV. However, it is not clear which protocol is the best for all scenarios, even though there are rapid growth and development in the field of Ad-Hoc network. A comparison of the parameters of routing protocols between these previous studies is shown in table 1.

TABLE 1 COMPARISON OF THE PARAMETERS OF ROUTING PROTOCOLS BETWEEN PREVIOUS STUDIES

Parameter	(Tyagi & Chauhan, 2010)	(Ismail & Hassan, 2010)
Number of nodes	10-200	5,7
Simulation time	1200 sec (20 Min)	3000 s
Simulation area	800X1200 m	500X500 m, 1000X1000 m, 1500X1500 m, 2000X2000 m, 2500X2500 m.
Routing protocols	DSDV, AODV, DSR	AODV
Transmission range	250 m	250 m
Packet size	512 bytes	100,200,300,400,500,600,700,800,900 and 1000 bytes
MAC protocol	802.11	802.11
Mobility type	Random way point	Random way point
Type of traffic	CBR	CBR
Packet rate	54 Mps	54 Mps
Speed	(10-100) m/s	2 Mps
Program simulation	NS-2	OMNeT++

A comparative review study on reactive and proactive routing protocols in MANETs provided information about several routing schemes proposed for Ad-Hoc networks [10]. These schemes were classified according to the routing strategy (i.e., Proactive and Reactive). It is shown that each protocol has definite advantages and disadvantages and is well studied for certain situations. Despite of the rapid growth in the field of Ad-Hoc networks, many challenges still exist and need more attention and consideration from researchers so that it is possible for such networks to be used more widely within the next few years. Recently, we have evaluated the routing information protocol and dynamic source routing [11]. According to this model, Routing Information Protocol (RIP) was found to be better as compared to Dynamic Source Routing (DSR).

Performance evaluation of AODV, DSDV, and DSR Routing Protocol in Grid Environment was described in a previous study [12]. According to this model, the AODV, DSR, and DSDV perform very well when the mobility is high. However, simulation results showed that the traditional routing protocols like DSR have a dramatic decrease in performance when the mobility is high. In [13], the performance of routing protocols in mobile Ad-Hoc network was compared for DSDV, AODV, and DSR and showed that DSR outperforms AODV. The DSR has less routing overhead when nodes have high mobility considering the throughput, end-to-end delay and packet delivery ratio metrics while DSDV produces low end-to-end delay compared to AODV and DSR. In [14], the evaluation four Ad-Hoc network protocols (AODV, DSDV, DSR and TORA) in diverse network scales taking into contemplation the mobility factor. Based on this model, the throughput and energy consumption in tiny size networks did not disclose any momentous differences. On the other hand, for medium and huge Ad-Hoc networks the TORA concert proved to be incompetent in this research. Above all, the concert of AODV, DSDV and DSR in tiny size networks was equivalent. Other than in medium and large size networks, the AODV and DSR formed good results and the concert of AODV in terms of throughput is good in all the scenarios that have been investigated.

Thus, our work in this present study is to use the more widely used traditional mobility models and traffic sources to create observations based on more standardized methodology that can be used to evaluate which protocol, proactive routing protocol (RIP) or reactive routing protocol (DSR), is more stabile for Ad-Hoc networks based on some criteria in QualNet simulation.

Ad-Hoc Routing Protocols

The routing protocol resolves the path of a packet from the source to the destination. To forward a packet, the network protocol requires knowing the next node in the path and the outgoing interface on which to send the packet [15]. A routing protocol computes routing information such as homogeneous and heterogeneous networks [8, 16]. Overall, routing protocols can be classified into two categories: proactive (table driven) routing protocols and reactive (on-demand) routing protocols. Popular proactive routing protocols are (DSDV) [17], Open Shortest Path First (OSPF) [18, 19], and RIP [20], whereas reactive routing protocols include DSR [21] and AODV [22].

Routing Information Protocol

RIP is a routing protocol which is dynamic as OSPF, but it is widely used in both local and wide area networks. It is classified as an Interior Gateway Protocol (IGP) which makes a use of the distance-vector routing algorithm as proposed in 1988 [23]. Since then, RIP Version 1 has been extended and updated to RIP Version 2 in 1998 [20]. It is indicated that both RIP versions are still being used today, but they have been technically supported by more advanced techniques such as OSPF and Open Systems Interconnection (OSI) protocol; Intermediate System to Intermediate System (IS-IS). Moreover, RIP has been updated to IPv6 network which is known as a standard RIP next generation (RIPng).

One of the advantages of employing RIP is that it is simple to understand and easy to configure as it is capable of being supported by all routers, support load balancing, and in general, it is free from loop. However, among the disadvantages, RIP is not efficient, slow when it is used in large networks due to its configuration, supports equal-cost load balancing, its congestion raises a problem and its scalability is limited since it is only measured as 15 hop maximum.

Dynamic Source Routing

Dynamic Source Routing (DSR) is defined by Johnson and Maltz [24] as a routing protocol which is still on demand and in which the sender of data can determine exactly the required sequence of nodes to propagate a packet. This packet header includes a number of intermediate nodes for routing. Each node works to maintain the route cache which cashes the source route being learned. It is stated that "Route Discovery" and "Route Maintenance" are the two main components of DSR which work together to determine and maintain routes to random destinations. The purpose of designing such protocol is to make restrictions to the large consumption of bandwidth caused by control packets in Ad-Hoc wireless networks. This process is done by deleting the messages of the periodic updates required which usually appears in the table-driven approach [25].

The possibility of establishing a route when necessary makes the sender to be able to choose and control routes by reducing the load of data and including routing which is free from loop containing unidirectional links in networks is all the main advantages of DSR. However, DSR may lead to significant overheads because the source route has to be included with each packet. It uses cashing excessively and lacks mechanisms by which it can detect the freshness of the routes which causes delay and reduction; hence, the route mechanism for maintenance is unable to repair a broken link locally. Therefore, this makes the delay of the connection setup higher than that found in table-driven protocols [26].

Metrics for Evaluation

Corson and Macker showed that the evaluation metrics are possible to be made a use of in evaluating the quantitatively Mobile Ad-Hoc Network (MANET) routing protocols [27]. Such quantitative measurement is useful as a prerequisite for assessing or evaluating the performance of network or even to compare the performance using different routing protocols.

Materials and Methods

Simulation Tools

The objective of this QualNet Version 5 simulation is to evaluate the proactive routing protocol and reactive routing protocol in Ad-Hoc networks in two scenarios. In a previous study [11], the effect of the number of nodes was evaluated. Beside this effect, the current study also covered the effects of packet size. It has five experiences with different number of nodes for scenario I (effects the number of nodes), and seven experiences with different packet size for scenario II (effects of packet size). The evaluation metrics used are throughput, end-to-end delay, average jitter, and energy consumption.

a. Average End-To-End Delay

This refers to the interval taking place between the data packet generation time and the time of the arrival of the last bit to the destination i.e. the average amount of time taken by a packet to move from source to destination. The process includes all possible delays which happen due to buffering during route discovery latency, queuing at the interface queue, retransmission delays at the Media Access Control (MAC) and propagation and transfer times [9].

b. Average Jitter

Average Jitter is known as the time variation measured between the arrival of the packets due to the congestion of the network, the drift in timing, or changing of the route [2].

c. Throughput

Throughput is the number of delivered packet per unit of time [28].

d. Energy Consumption

It is defined as the amount of energy consumed in a process or system, or by an organization or society. It is the summation of the idle mode, transmit mode, and receive mode [29].

Simulation Environments

In this paper, the QualNet simulation was implemented; 802.11 MAC [30]. The parameters in the simulation such as number of nodes, time of simulation, packet size, and type of traffic were summarized in Table 2.

TABLE 2 PARAMETERS SETUP

Parameter	Scenario I	Scenario II
Number of nodes	50,90,130,170,210	7
Simulation Time	1200sec(20Min)	3000s
Simulation area	800X1200m	500X500m
Routing protocols	RIP and DSR	RIP and DSR
Transmission Power	25dBm	25dBm
Transmit Power Consumption	100mW	100mW
Receive Power Consumption	130mW	130mW
Idle Power Consumption	120mW	120mW
Transmission range	270m	270m
Transmission Power	25.0	25.0
Item Size	512 bytes	100,200,300,400,500,600 and 700 Bytes
PHY	802.11b	802.11b
Type of traffic	CBR	CBR
Data Rate	11Mbps	11Mps
Speed	(10-100) m/s	(10-100) m/s

The number of nodes ranges from 50 to 210 nodes which divided into 50, 90, 130, 170, and 210 and the packet size range from 100 bytes to 700 bytes which divided into 100, 200, 300, 400, 500, 600, and 700 bytes. Five reasons experiences with different number of nodes and seven reasons experiences with different packet size were implemented in this work.

Evaluation of Results

Results are obtained after the experiments have been conducted. The present paper aims to demonstrate the evaluation performance of each routing protocol with respect to the effects of the number of nodes and effects of packet size. The evaluation metrics considered for average jitter, end-to-end delay, throughput, and energy consumption. The tests highlight the evaluation performance of RIP and DSR in Ad-Hoc network.

Scenario I

Average End-To-End Delay

Data set of the effects of the number of nodes by QualNet simulation of Average End-to-End Delay (scenario I) is shown in Table 3.

TABLE 3 DATA SET OF AVERAGE END-TO-END DELAY

Scenario I		
Average End-to-End Delay(s)		
No of Nodes	DSR	RIP
50	0.079186	0.058514
90	0.197886	0.069717
130	0.207281	0.052935
170	0.063845	0.03455
210	0.191009	0.04776

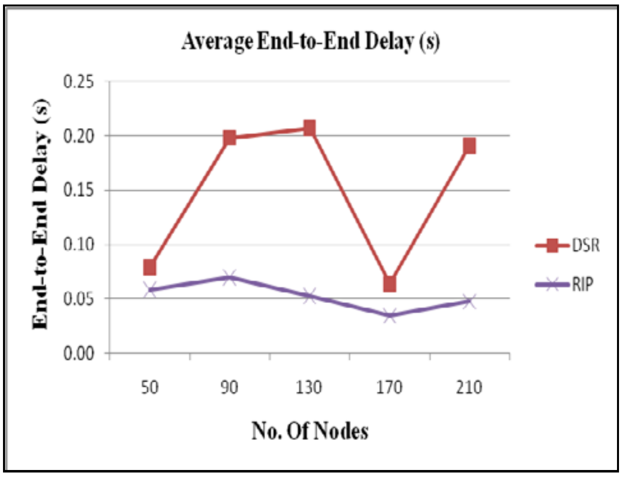

FIG. 1 AVERAGE END-TO-END DELAY BETWEEN RIP AND DSR IN SCENARIO I

Figure 1 shows the influence of the number of nodes on network average end-to-end delay for two routing protocols. The average end-to-end delay values increased according to the number of nodes for DSR. The maximum average end-to-end delay gained simulation with 130 numbers of nodes from DSR and the minimum average end-to-end delay gained from simulation 170 numbers of nodes from DSR. The increase average end-to-end delay values the increase and the decrease according to the number of nodes for RIP. The maximum average end-to-end delay gained simulation with 90 numbers of nodes from RIP and the minimum average end-to-end delay gained from simulation 170 numbers of nodes from RIP. From the graph, it is clear that RIP out performs DSR for scenario I or II of varying pause time, varying simulation time, varying speed and varying number of nodes. In case of DSR, delay time increased sharply with increasing number of nodes. However, a sharp decrease was noticed when the number of nodes is 170. On the other hand, RIP increased and then decreased with increasing number of nodes. It is important to note that RIP gave a low end-to-end delay as compared to DSR.

Throughput

Data set for the effects of the number of nodes by QualNet simulation of Throughput (scenario I) is demonstrated in Table 4.

TABLE 4 DATA SET OF THROUGHPUT

Scenario I		
Throughput (bits/s)		
No of Nodes	DSR	RIP
50	2312	2320
90	3	2301.75
130	6	1532.33
170	14	2285
210	6	2343.25

Figure 2 shows the influence of the number of nodes on network throughput for two routing protocols (RIP and DSR). The throughput values increased according to the number of nodes for RIP while in DSR it first increased when the number of nodes rose to 50 after which it starts to decrease sharply with increasing number of nodes. The maximum throughput was gained from simulation with 210 nodes for RIP and the minimum throughput was gained from simulation with 130 nodes. The maximum throughput was gained from simulation with 50 nodes from DSR and the minimum throughput has gained from simulation with (90,130,170,210) numbers of nodes. RIP have higher throughput value compared to DSR.

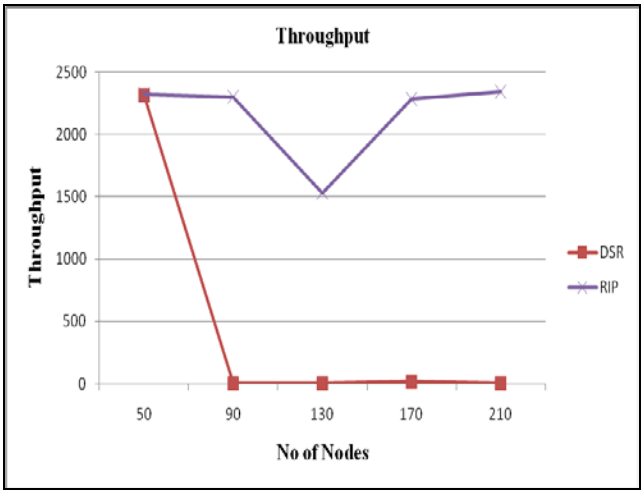

FIG. 2 THROUGHPUTS BETWEEN RIP AND DSR IN SCENARIO I

Average Jitter

Data set for the effects of the number of nodes by QualNet simulation of Average Jitter (scenario I) is shown in Table 5.

TABLE 5 DATA SET OF AVERAGE JITTER

Scenario I		
	Average Jitter (s)	
No of Nodes	DSR	RIP
50	0.0365204	0.015466
90	0	0.036365
130	0.0248375	0.018677
170	0.0143463	0.000938
210	0.0224834	0.01431

The two kinds of routing protocols have different jitter with the increased number of nodes, as shown in Figure 3. Overall, RIP showed a better jitter than DSR when the number of nodes is greater than 50 while DSR showed the better jitter than RIP, when the number of nodes is 90 but when the number of nodes is above 90, the RIP gave a better jitter than DSR.

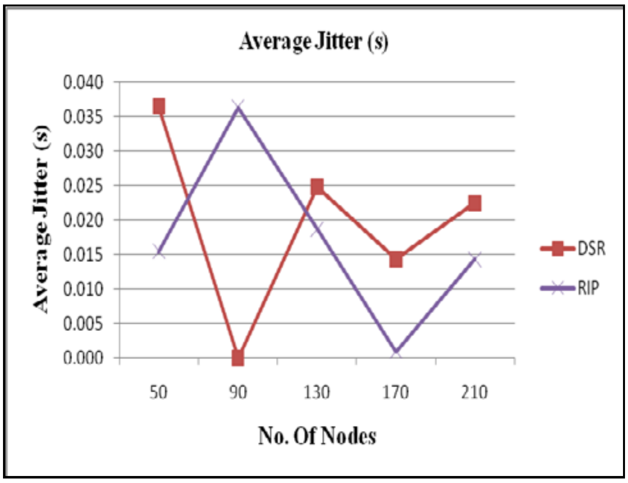

FIG. 3 AVERAGE JITTER BETWEEN RIP AND DSR IN SCENARIO I

Energy Consumption

In energy consumption, the result was calculated by collecting Idle mode + Transmit mode + Receive mode. The energy consumption was represented in two tables: Table 6 for the Idle mode, Transmit mode and Receive mode and Table 7 for the collected energy consumption (Idle mode + Transmit mode + Receive mode).

TABLE 6 ATA SET FOR ENERGY CONSUMPTION FOR IDLE MODE, TRANSMIT MODE AND RECEIVE MODE

DSR					
No of Nodes	50	90	130	170	210
Receive mode	0.066248	26.4599	33.6272	36.8386	29.895
Transmit mode	0.020879	0.008001	0.013737	0.007616	0.007551
Idle mode	39.9387	15.5754	8.95939	5.99503	12.4046
RIP					
No of Nodes	50	90	130	170	210
Receive mode	2.25513	2.35914	2.96544	3.51517	4.11252
Transmit mode	0.21928	0.398631	0.577919	0.718834	1.01791
Idle mode	37.9164	37.8188	37.2575	36.7488	36.1947

TABLE 7 DATA SET OF THE COLLECTED ENERGY CONSUMPTION

Scenario I		
Energy Consumption		
No of Nodes	DSR	RIP
50	40.02583	40.39081
90	42.0433	40.57657
130	42.60033	40.80086
170	42.84125	40.9828
210	42.30715	41.32513

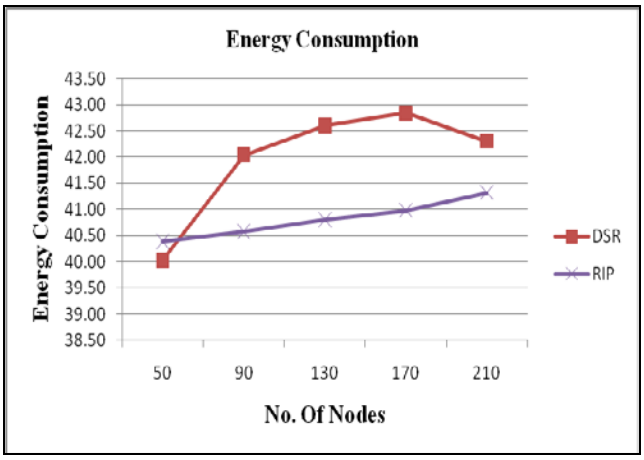

FIG. 4 ENERGY CONSUMPTION BETWEEN RIP AND DSR IN SCENARIO I

The energy consumption for the two routing protocols increased at the beginning of this work, as shown in Figure 4. DSR has a longer consumption than RIP. Therefore, RIP has the better energy consumption than DSR except when the number of nodes is 50 nodes.

Scenario Ii

Average End-to-End Delay

Data set of the effects of packet size by QualNet simulation of average End-to-End Delay (scenario II) is presented in Table 8.

Figure 5 shows that the average end-to-end delay for two routing protocols decreased; except when the packet size of DSR was higher than 100 bytes. Thus, DSR has longer delay than RIP and RIP exhibits shorter delay than DSR.

TABLE 8 DATA SET OF AVERAGE END-TO-END DELAY

Scenario II		
End-to-End Delay(s)		
Packet Size	DSR	RIP
100	6.5376	0.00089
200	6.54139	0.00085
300	6.43877	0.000777
400	6.73125	0.000939
500	6.06969	0.000761
600	6.41203	0.000566
700	6.81644	0.000714

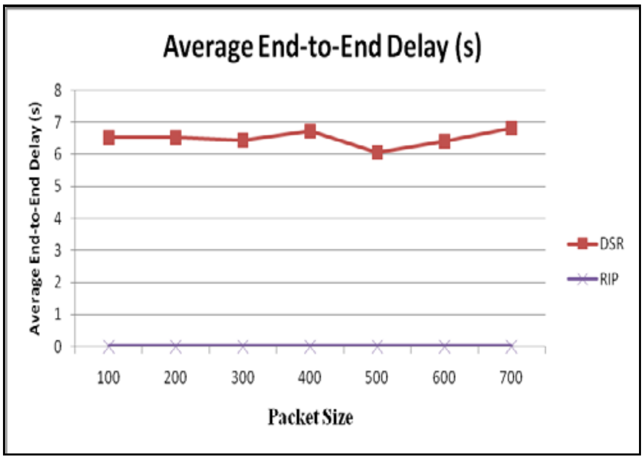

Fig. 5 Average End to End Delay between RIP and DSR in scenario II.

Throughput

Data set of the effects of packet size by QualNet simulation of Throughput (scenario II) is shown in Table 9.

TABLE 9 DATA SET OF THROUGHPUT

Scenario **II**		
Throughput (bits/s)		
Packet Size	DSR	RIP
100	6.5376	0.00089
200	6.54139	0.00085
300	6.43877	0.000777
400	6.73125	0.000939
500	6.06969	0.000761
600	6.41203	0.000566
700	6.81644	0.000714

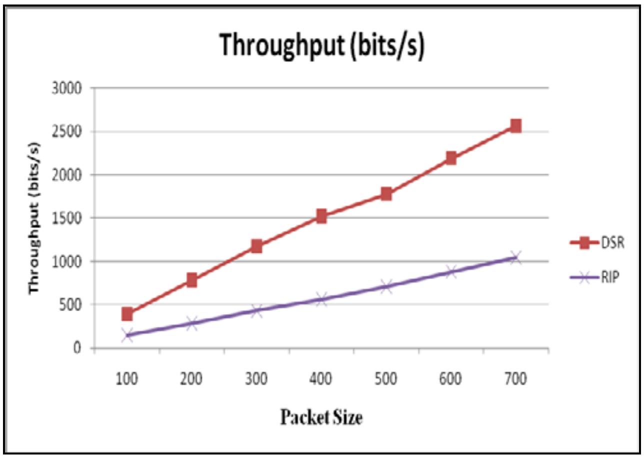

FIG. 6 THROUGHPUTS BETWEEN RIP AND DSR IN SCENARIO II

Figure 6 shows the influence of the packet size on the network throughput for two routing protocols. Overall, the throughput value increased with the packet size for the two routing protocols. The maximum throughput gained from simulation with 700 bytes packet size, while the minimum throughput gained from simulation with 100 bytes packet size. On the other hand, DSR has the maximum throughput values according to increase packet size compared to RIP. Therefore, the DSR has better throughput than RIP.

Average Jitter

Data set of the effects of packet size by QualNet simulation of Average Jitter (scenario II) is presented in Table 10.

TABLE 10 DATA SET OF AVERAGE JITTER

Scenario II		
Average Jitter (s)		
Packet Size	DSR	RIP
100	0.956555	0.001107
200	1.03527	0.000909
300	0.997965	0.000897
400	1.04567	0.001143
500	1.03995	0.000736
600	1.04009	0.000409
700	1.05922	0.000677

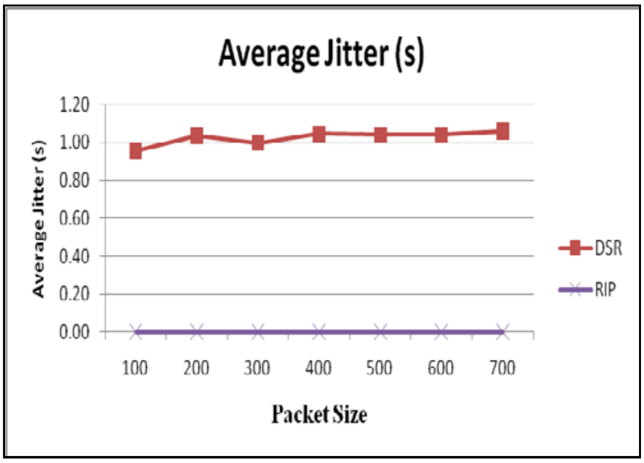

FIG. 7 AVERAGE JITTER BETWEEN RIP AND DSR IN SCENARIO II

The two kinds of routing protocols have different jitter with increased packet size (Fig 7). In general, RIP had better jitter than DSR while DSR showed longer delay than RIP. Thus, RIP showed the best evaluation performance.

Energy Consumption

There are two tables to show the energy consumption: table 11 for the Idle mode, Transmit mode and Receive mode while table 12 was for the collected result (Idle mode + Transmit mode + Receive mode).

TABLE 11 DATA SET FOR ENERGY CONSUMPTION OF IDLE MODE, TRANSMIT MODE AND RECEIVE MODE

DSR							
Packet Size	100	200	300	400	500	600	700
Receive mode	0.01317	0.015901	0.017571	0.016744	0.018613	0.018896	0.0192
Transmit mode	0.045568	0.056014	0.063108	0.060627	0.068709	0.069231	0.071318
Idle mode	149.958	149.948	149.942	149.944	149.937	149.937	149.935
RIP							
Packet Size	100	200	300	400	500	600	700
Receive mode	0.008079	0.007198	0.012669	0.00829	0.007753	0.010093	0.009364
Transmit mode	0.029998	0.027191	0.046771	0.031318	0.029584	0.036045	0.03608
Idle mode	149.973	149.975	149.957	149.972	149.973	149.967	149.967

TABLE 12 DATA SET OF THE COLLECTED ENERGY CONSUMPTION (IDLE MODE + TRANSMIT MODE + RECEIVE MODE)

	Scenario II	
	Energy consumption	
Packet Size	DSR	RIP
100	150.0167	150.0111
200	150.0199	150.0094
300	150.0227	150.0164
400	150.0214	150.0116
500	150.0243	150.0103
600	150.0251	150.0131
700	150.0255	150.0124

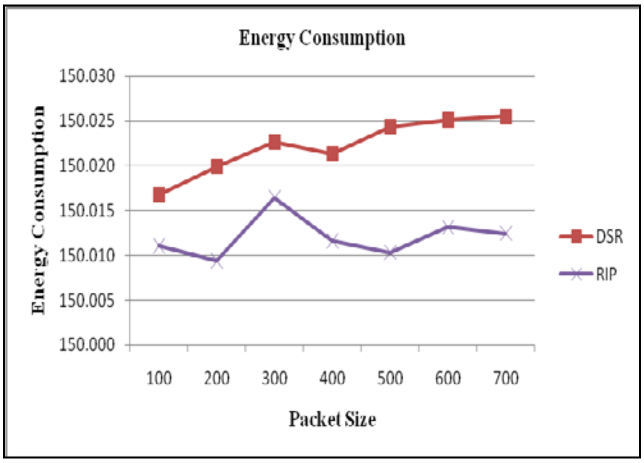

FIG. 8 ENERGY CONSUMPTION BETWEEN RIP AND DSR IN SCENARIO II

The two types of routing protocols have different energy consumption with increasing packet size as shown in Figure 8. DSR has longer energy consumption than RIP, while RIP has smaller energy consumption than DSR. As a result, the RIP showed the best evaluation performance in energy consumption.

Conclusion

In the present paper, an evaluation for routing protocols was carried out on acquired simulation results of two routing protocols, RIP and DSR using QualNet V5. RIP and DSR were selected to represent the Proactive routing protocols and Reactive routing protocols, respectively. We found that Routing Information Protocol preformed better than DSR for all evaluation metrics in 2 different scenarios.

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