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Competitive analysis of single and multi-path routing protocols in MANET

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ABSTRACT

A mobile ad-hoc network (MANET) refers to a dynamic and wireless network, which can be designed without an existing infrastructure as every node serves as a router. A MANET is a self-configuring system of mobile nodes that are connected wirelessly. Every node serves as a sink, as well as a router to send packets. The movement of the nodes is not restricted as they can move in any direction, and they have the ability to get organized into a network. Due to their free and independent movement, they do not have a fixed position; they often change positions. In this study, the dynamic source routing (DSR) and Ad-hoc on multipath demand distance vector (AOMDV) protocols are compared using Network Simulator NS2.35. DSR is a reactive gateway discovery algorithm whereby the connection of a MANET mobile device is established only on demand. Basically, AOMDV was specially tailored for ad-hoc networks that are highly dynamic to respond to link failures and breakages in the network. It ensures that the paths for destinations are sustained, and it defines the new routing information using destination serial numbers to ensure loop freedom always while avoiding problems. More so, it is a protocol that is based on a timer that can discover ways through which the mobile nodes respond to link breakages and change in topology. A comparison of protocols has been carried out individually and jointly with the aim of evaluating their performance. The performance is measured in terms of End-to-End Delay, Packet Delivery Ratio, Packet Loss Ratio, and Routing Overhead Ratio. The performance of the routing protocols was done using two scenarios; when there is a change in the simulation time and when there is a change in the number of nodes.

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1. INTRODUCTION

A mobile ad-hoc network (MANET) is defined as a group of digital data terminals that has wireless receivers that communicate with each other with needing a fixed network infrastructure [1, 2]. Data packets are transmitted by MANET using a common wireless channel, thereby maintaining communication. Because fixed infrastructure is not required by Ad-hoc networks, they are completely different from other wireless LANs [3-5]. Meanwhile, a mobile terminal communication such as a cellular one in an infrastructure-based network is often maintained using a fixed base station.

The designing of the ad-hoc network comes with some challenges. The first challenge is that all MANET nodes such as the source nodes, corresponding destination nodes, and the routing nodes responsible for forwarding traffic between nodes may be mobile. Due to the fact that wireless transmission has a limited range, breakage occurs in the wireless link. More so the lack of administration makes the design of MANET of the complex [6, 7]. The implementation of every function of the network such as multiple accesses, topology determination and data routing over appropriate multi-hop paths should be done in a distributed manner. Executing all these tasks is very challenging due to limited communication bandwidth [8]. These challenges are addressed by different layers, such as the physical layer which solves the problems of multi-user interference, path loss and fading with the aim of sustaining stable communication links among the nodes.

In the study carried out by the authors in [9, 10], the reactive and proactive routing protocol were compared. In the study by [11], the performance of the reactive routing protocols was evaluated. In this paper, the performances of two routing protocols, which are AOMDV and DSR are evaluated under two different scenarios (simulation time and the number of nodes). The paper attempts to facilitate the protocol selection which requires a critical circumstance like flooding and emergency. Based on the results, both of the routing protocols work properly however, they require some improvement. Subsequently, there are several algorithms and techniques are proposed to provide solutions in different domains [12-19]. These techniques can integrate with the routing protocols to improve their performance.

2. LITERATURE REVIEW

2.1. Mobile ad hoc network

For time past, MANET has been used for the purpose of improving communications in battlefields through its implementation in tactical network-related applications. The ad hoc network has its origin in the initial versions of the Packet Radio Network Project (PRNET) of the Defense Advanced Research Projects Agency (DARPA) which was created in the 1970s. In the PRNET project, the use of both Carrier-Sense Multiple Access (CSMA) and ALOHA methods was employed with the aim of enhancing the dynamic sharing of radio resources. More so, during the project, many distance vector routing protocols were introduced to facilitate multi-hop communication among nodes [20].

Most times, the network is regarded as ad-hoc because every node is capable of forwarding data to other nodes. This is dynamic as compared with the two-wire networks that employ the use of routers in executing the routine task. This is also different from managed (infrastructure) wireless networks that use a special node referred to as an access point for management of communication among other nodes. New nodes can be automatically detected and neatly inducted by the ad hoc network because it is decentralized [21].

Consequently, the existence of a node in a network makes the other nodes to be able to adapt to a new situation and reconfigure themselves automatically. If the nodes in a network are mobile, such a network is referred to as MANET. The Internet Engineering Task Force (IETF) has set up a working group which is referred to as MANET for the purpose of developing the standards for such networks. Figure 1 shows an example of the MANET.

Typically, there are two kinds of architectures that the ad hoc networks possess, and they are, flat and hierarchical. All the nodes within an ad hoc network possess a power source, transceiver, and an antenna. Normally, ad hoc networks have two types of architectures: hierarchical and flat. Every node found in an ad hoc network has an antenna, a transceiver, and a power source [22].

Figure 1. Infrastructure-less wireless networks

2.2. Routing protocols

It has become very challenging to design a reliable and efficient routing strategy for MANETs due to the scarcity of resources. In order to use limited resources efficiently, there is a need to have an intelligent routing strategy. More so, the intelligent routing strategy must be able to adapt to the dynamic network conditions like traffic density, size of the network and network partitioning. This means that the routing protocol may be required to provide different users and applications with different levels of QoS [23]. There are several kinds of routing protocols. Figure 2 represents the main types of routing protocols.

2.3. Reactive routing protocols

Basically, there are two categories of reactive protocols; source routing and hop-by-hop routing [24, 25]. Figure 3 shows the types of reactive routing protocols. Thus, each data packet is forwarded by each intermediate node in the path to the destination towards the destination using the routing table. This strategy is advantageous in the sense that the routes adapt to MANETs' continuously changing environment since the routing table of each node can be updated by the node itself when new topology information is received [24]. Here the data packets are forwarded over fresher and better routes. The use of newer routes implies that when data is being transmitted, lesser recalculations of the route are needed [8, 10, 23]. However, the limitation of this strategy is that the routing information of each active route must be stored and maintained, and each of the nodes may need to use the beaconing messages to be aware of surrounding neighbours. Several different reactive routing protocols have been proposed to increase the performance of reactive routing. In this section, some of these strategies are described, and their performances are compared. The characteristic feature of each strategy is summarized in Table 1.

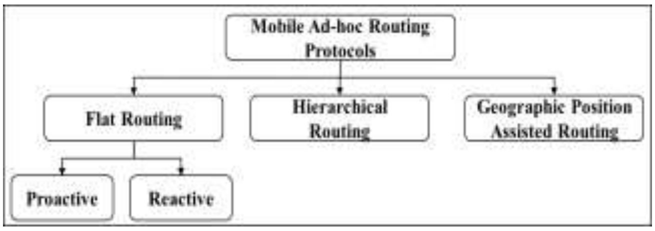


Figure 2. Types of routing protocols in MANET

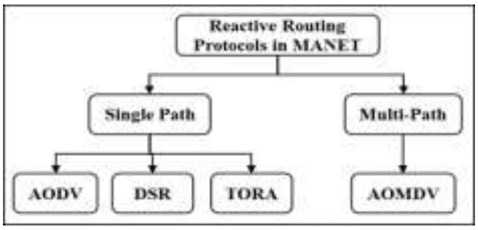


Figure 3. Types of reactive routing protocols in MANET

Table 1. Basic characteristics of reactive routing protocols [23]

Protocol	RS	Multiple routes	Beacons	Route metric method	Route maintained	Route recon figuration strategy
AODV	F	No	Yes	Freshest & SP	RT	Erase recon then SN or local route repair
DSR	F	Yes	No	SP, or next available in RC	RC	Erase route the SN
ROAM	F	Yes	No	SP	RT	Erase route & a
LMR	F	Yes	No	SP, or next available	RT	Link reversal & route repair
TORA	F	Yes	No	SP, or next available	RT	Link reversal & route repair
ABR	F	No	Yes	Strongest Associativity & SP & b	RT	LBQ
SSA	F	No	Yes	Strongest signal strength & stability	RT	Erase route then SN
RDMAR	F	No	o	Shortest relative distance or SP	RT	Erase route then SN
LAR	FF	Yes	No	SP	RC	Erase route then SN
ARA	F	Yes	No	SP	RT	Use alternate route or backtrack until a route is found
FORP	F	No	No	RET & stability	RT	A Flow_HANDOFF used to use an alternate route
CBRP	H	No	no	First available route (first fit)	RT at the cluster head	Erase route then SN & local route repair

2.4. Dynamic source routing

The Dynamic Source Routing (DSR) protocol [25] is considered as an efficient and simple protocol specially tailored for multi-hop wireless ad hoc networks of mobile nodes. Figure 4 shows the mechanism of the DSR protocol. The use of DSR makes the network totally self-configuring and self-organizing, requiring no administration or extant network infrastructure. In order to facilitate communication over multiple "hops" between nodes, the forwarding of packets is carried out jointly by network nodes (computers); the communication does not occur directly within the wireless transmission range of the nodes. The DSR routing protocols determine and maintain all routing automatically as the nodes join, leave or even move about in the network, and as changes occur in the conditions of wireless transmission. Due to the fact that changes may occur in the sequence or number of intermediate hops required to reach a given destination with prior notice, the resulting topology may be rich and could change rapidly [26].

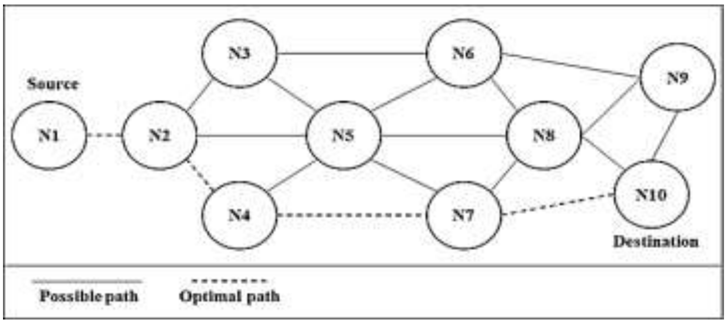


Figure 4. DSR routing protocols

2.5. Ad-hoc on-demand multipath distance vector

Ad-hoc On-demand Multipath Distance Vector (AOMDV) Routing protocol is regarded as an extended version of the AODV protocol which connects paths that are disconnected as well as computes multiple loop-free paths [5, 11]. Figure 5 represents a simple example of the AOMDV mechanism. When a greater sequence number of a route advertisement of a destination is received, re-initialization of the advertised hop count and the next-hop list is carried out. The node disjoints as well as disjointed link routes are discovered using AOMDV. For the discovery of node-disjoint routes, each node does not demonstrate direct rejection of the replica RREQs of each RREQ arriving through a different neighbour of the source, which defines a node-disjoint path. The reason for this is that the duplicate RREQs cannot be broadcasted by the nodes. Therefore, any two RREQs reaching at an intermediate node by a different neighbour of the source could not have traversed the same node. Multiple link-disjoint routes can be obtained when the duplicate RREQs are replied by the destination, which replies only RREQs that arrive via distinct neighbours. Subsequent to the initial hop, the reverse paths are followed by the RREPs, and these reverse paths are nodes disjoint and therefore link disjoint. It is possible that each RREP's, but each one follows another reply path to the source to guarantee link disjoint [27].

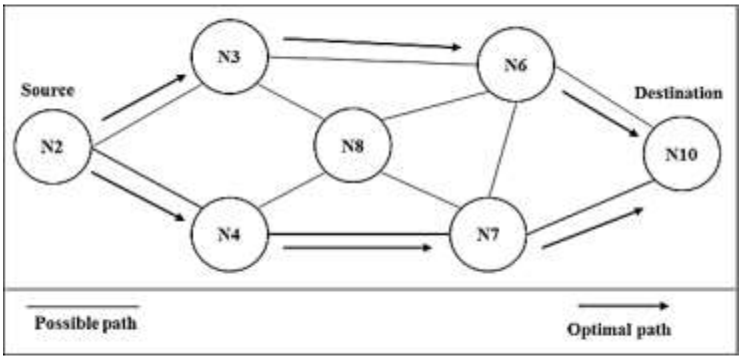


Figure 5. AOMDV routing protocols

2.6. Related work

The authors basically aimed at assessing the quality of routing protocols in MANET by implementing several parameters. In a study by Jubair et al. [8], the AODV and AOMDV were compared through the use of evaluation criteria of simulation time and some nodes. In another study, the authors Bouhorma et al. [24] investigated how the performances of DSR and AODV are affected by the variation in speed and pause time. Similarly, in a study by Chadha et al. [25], the effect of the number of nodes on the performance of AOMDV and DSR was studied. Consequently, this paper, an attempt is made to evaluate the performance of the AOMDV and DSR routing protocols in MANET environment. The methodology used in this paper is the same as the one used in [11, 21]. The methodology is used in describing the behaviour of the routing protocols in different scenarios. The major contribution of this paper is considering the factors of some nodes and network size for implementing and assessing the AOMDV and DRS in a MANET environment.

3. SIMULATION ENVIRONMENTS

In order to evaluate the efficiency of the recommended method, two scenarios were evaluated, i.e simulation time and a number of nodes. The simulation was carried out in a 1000-m2 network area employing the Constant Bit Rate (CBR) as a traffic source. The random movement and dispersal of nodes could cause an abrupt change in the network topology. The selection of the parameters and values was made based on previous studies and literature. In the first scenario, the number of nodes was changed as (25-150) nodes. The second the simulation times were varied and set at (30-110) seconds. Table 3 shows all the simulation parameters [22, 24].

Table 2. Simulation parameters

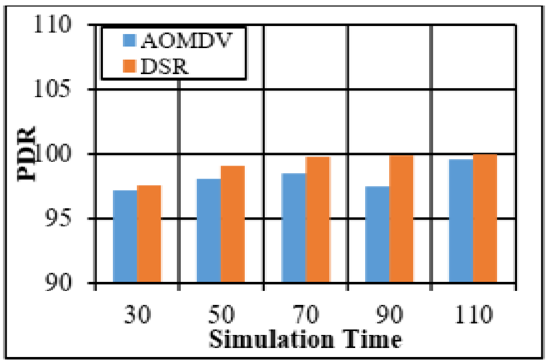
Parameter	Value	Unit
Area	1000	m2
Queue size	50	Packet
Mobility Model	Random Way Point	-
Packet Size	512	Byte
Transmission Range	250	Meter
Protocol	AOMDV and DSR	-
No. of nodes	(25-150)	Node
Simulation time	(30-110)	Second
Traffic type	CBR/UDP	-

4. RESULTS AND ANALYSIS

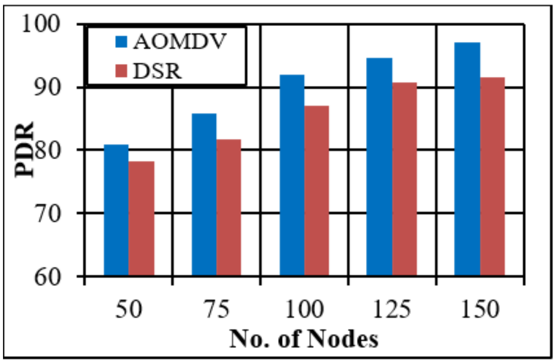
This section evaluates the quality of two routing protocols under different scenarios; simulation time and the number of nodes. The simulation time altered as (30-110:20) second and the number of nodes is change as (50-150:25) node. The performance of the protocols is measured based on PDR, E2E delay, PLR, and ROR.

4.1. PDR

Figure 6(a) displays the difference in packet delivery ratio for AOMDV and DSR. When the simulation time increases as (30-110:20) m/s, the PDR increase. The AOMDV protocol has higher PDR than and DSR due to, AOMDV protocol establish multi-path to the destination node. This mechanism reduces the probability of the link failure as well as increases the data received by the destination node. Figure 6(b) demonstrations the variation of the PDR for AOMDV and DSR routing protocols. While, the number of nodes increases as (50-150:50) nodes, the PDR increase. The efficacy of the AOMDV has outperformed the DSR protocol in terms of the PDR, as AOMDV reduces packet loss by sending data via a different path.



(a)



(b)

Figure 6. PDR (a) Simulation time, (b) no. of nodes

4.2. E2E delay

Figure 7(a) depicted the E2E variety for AOMDV and DSR protocols. Whilst, the simulation time is changed as (30-110:20) second, the E2E increase. The AOMDV has less E2E delay compare to DSR. Figure 7(b) illustrations the alteration of E2E delay for AOMDV, and DSR. When the number of nodes increases as (50-150:50) node, the E2E increases also. In both scenarios, the AOMDV requires less time due to, the criteria of path selection in AOMDV protocol depend on different parameters, which saves the time for the transmit the data packets over the network.

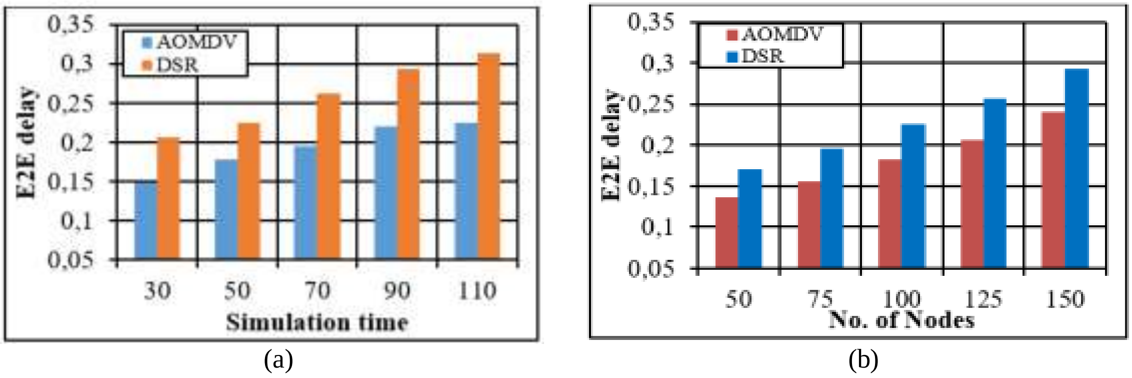


Figure 7. E2E delay (a) Simulation time (b) no. of nodes

4.3. Packet loss ratio

In MANET, packet loss happens because of transmission errors, congestion, and mobility. The physical channel has a direct effect on the transmission error. The variation of PLR between AOMDV and DSR routing protocols are depicted in Figure 8(a). Once, the simulation time increases as (30-110:20) m/s, the PLR increase for both protocols. Due to this, when the simulation time increases the probability of the nodes exhausting and link failure is increasing also. These problems have a negative impact on the packets that transmit over the network. Figure 8(b) demonstrations the variation of the PDR for AOMDV and DSR protocols. While, the number of nodes increases as (50-150:50) nodes, the PDR increase. The results are clearly shown both routing protocols are affected by increasing the number of nodes. While the number of nodes is increased, the protocols consume a high amount of discovering messages that used to discover all possible paths between source and destination nodes, furthermore, decrease the network lifetime.

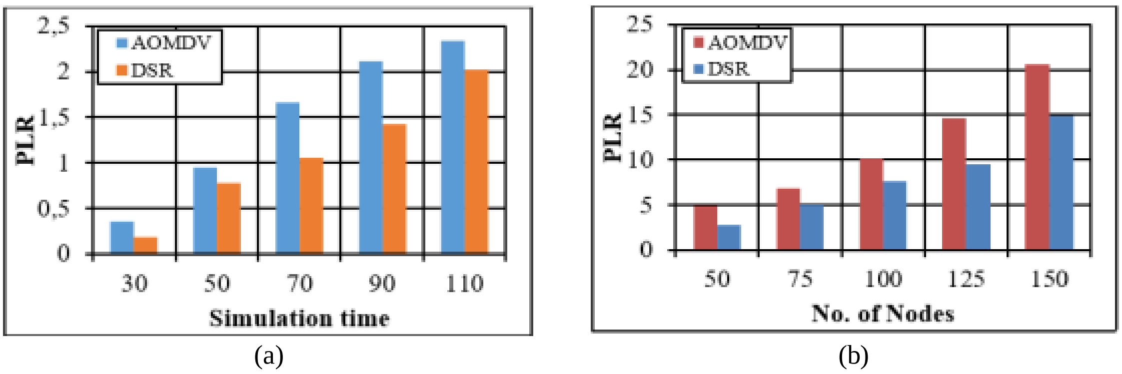


Figure 8. PLR (a) Simulation time (b) no. of nodes

4.4. Routing over-head Ratio

The connection between nodes is constructed by a flooding mechanism, this mechanism used to discover all information about the network nodes. However, this mechanism consumes a huge amount of traffic messages. To assess the amount of the messages that spend in the network the ROR performance metric is presented. Consequently, Figure 9 shows the difference between ROR for AOMDV and DSR. As mentioned above, two scenarios are used, simulation time and a number of nodes. The results clearly show the ROR increased in both routing protocols, with two scenarios, due to, the number of beacons messages are increased. The DSR has better performance than AOMDV in term of ROR. The main reason is the DSR establish a single route from source to destination nodes, whereas, the AOMDV establish a multi path, this mechanism require a huge amount of the ROR as well as energy.

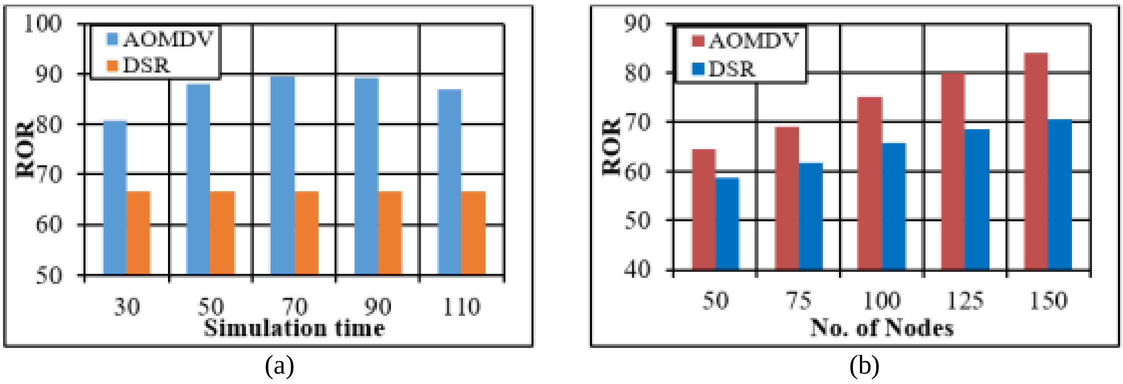


Figure 9. ROR (a) Simulation time (b) no. of nodes

5. CONCLUSION

The performance of the two routing protocols in MANET is evaluated in this paper. The simulation and examination are done by using NS2.35. There are two applied test scenarios: No. of nodes and simulation time. The first test scenario concerns with the effects of the change in the number of nodes on the protocols' performance and the second test scenario concerns with the effects of the change in the simulation time. The performance is evaluated according to the metrics of PDR, E2E delay, PLR, and ROR. The simulation results show that the AOMDV outperforms the DSR in both scenarios due to the AOMDV constructs multipath from source to the destination. This mechanism leads to reduce the delay and increase the PDR. However, the AOMDV is considered as a power-consuming protocol because it spends high energy to create the path from source to destination nodes. Future work considers proposing a hybrid protocol for MANET environments to improve the network then compare the results statistically using mean, median and standard deviation.

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