

Mobile ad-hoc network routing protocols of time-critical events for search and rescue missions

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ABSTRACT

The most important experiences we discovered from several disasters are that cellular networks were vulnerable, and the loss of the communication system may have a catastrophic consequence. Mobile ad-hoc networks (MANETs) play a significant role in the construction of campus, resident, battlefield and search/rescue region. MANET is an appropriate network for supporting a communication where is no permanent infrastructure. MANET is an effective network that uses to establishing urgent communication between rescue members in critical situations like, disaster or natural calamities. The sending and receiving data in MANET is depending on the routing protocols to adapt the dynamic topology and maintain the routing information. Consequently, This paper evaluates the performance of three routing protocols in MANET: ad-hoc on-demand distance vector (AODV), destination sequenced distance vector (DSDV), and ad-hoc on-demand multipath distance vector (AOMDV). These protocols are inherent from different types of routing protocols: single-path, multi-path, reactive and proactive mechanisms. The NS2 simulator is utilized to evaluate the quality of these protocols. Several metrics are used to assess the performance of these protocols such: packet delivery ratio (PDR), packet loss ratios (PLR), throughput (TP), and end-to-end delay (E2E delay). The outcomes reveal the AOMDV is the most suitable protocol for time-critical events of search and rescue missions.

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1. INTRODUCTION

There are two categories of the wireless network: Infrastructure and Infrastructure-less. In Infrastructure-less or specially appointed remote (ad hoc wireless) systems, the mobile nodes during communication perform routing functions and have mobility [1-3]. There are no fixed base stations and these portable nodes can progressively make directing channels among themselves on the move to create their very own system as appeared in Figure 1. The progress in topographical perception framework and telemetry related to the conveyance of data through sensor innovations have immensely expanded the requirement for use of communication or correspondence advancements in catastrophe management [4-6]. Then again, the dynamic and self-configuring nature of MANETs makes it fundamental and appropriate for disaster management interchanges [7].

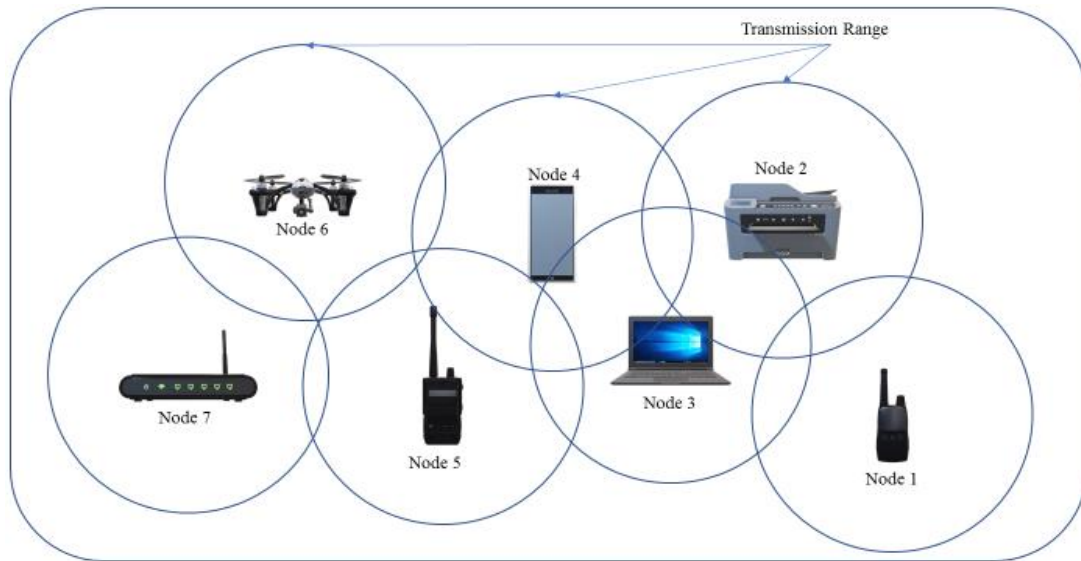


Figure 1. Infrastructure-less wireless networks

Routing protocols in MANET are methods for sending information in data bundles or packets to a destination from an originating point or source in a system. Before correspondence can happen between nodes, two activities take place in routing protocols [8-10]. Firstly, is the assurance of the best routeway and the sending of bundles through the system while keeping up a low power consumption in computing. Also, for the above activities to be achieved, various parameters are used by each routing protocol to look at the ideal way that packets should utilize during packets transmission in the system [11-13]. Efficient execution can be accomplished in a system if cautious thought is given to the idea of routing calculations, structure and execution issues. Two categories of routing protocols are available. These are proactive and reactive protocols [14-17]. The variance between them is, the reactive routing protocols are determining the route when a packet is required to be forwarded, while, the proactive routing protocols are determining the route periodically. Ad hoc on-demand distance vector routing (AODV) and dynamic source routing (DSR) protocols are examples of reactive routing protocols. Destination sequenced distance vector (DSDV), and optimized link state routing (OLSR) are examples of proactive routing protocols. Figure 2 represents the main types of routing protocols [18-20].

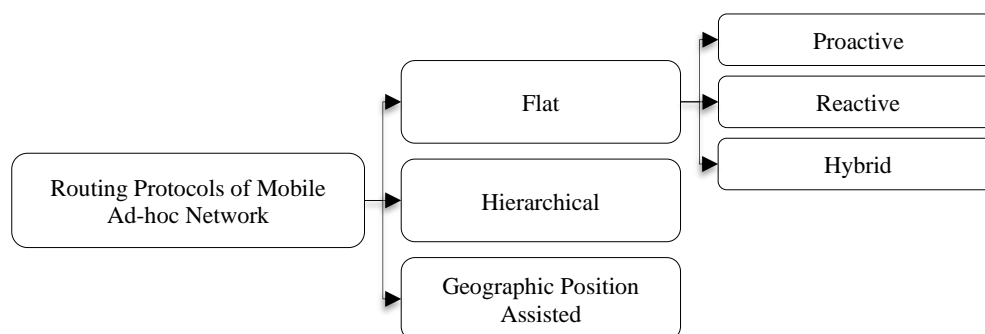


Figure 2. The types of routing protocols in MANET

Several uses of MANETs such as emergency, search and rescue, information sharing, advertising, navigation, and shopping. The self-configuring and dynamic characteristics of MANETs makes it proper and essential for disaster communications [21, 22]. While there is a terrorist attack or a natural disaster, quick action and response are important. Usually, the communication network is disturbed when there are such sudden and unexpected mishaps. Consequently, this eventually makes response and coordinated help

cumbersome and unfavorable. Accurate, quick, and speedy response is very important for effective rescue during manmade or natural calamities. MANET is an independent system of mobile nodes wirelessly connected. The nodes are free to move arbitrarily, so, the topologies of these networks are changing dynamically. MANETs have various characteristics that create a reliable and efficient network for communication in a critical situation. MANET consider as one of the most exciting research areas and it has gotten enormous interest from the researchers [23]. This paper gives a relative examination to the most mainstream routing conventions in MANET environments namely, DSDV, AODV and ad-hoc on-request multipath distance vector (AOMDV).

Chen *et al.* [24] came up with a crossbreed or hybrid-network prototype in which a gathering of near-by cells serviced by a cellular base station is examined. Due to the catastrophe, however, some of the base stations get ruined and their cells are considered as dead cells as there is no cellular network inclusion. This can also occur because of deteriorating of connection availability, some portable/mobile nodes inside the cell are unable to get a signal. To solve these issues a hybrid prototype is suggested which a combination of cellular and ad-hoc systems. Nodes are straightforwardly associated with cellular systems provided that they are in the range of the operational base station and provided that when there is no cellular coverage, nodes are operating in ad-hoc system mode and in communication with their neighbor. A node that is working in cellular condition fills in as a gateway, ready to send packets originating from neighbors working in an ad-hoc fashion. A node operating in an ad-hoc system attempts to provide a route to an operational base station utilizing a multi-hopping approach. When a node has a pathway to a minimum of one base station, it creates a passage and sends information to that base station. Whenever there is traffic clog in that base station, the node marks that base station as "occupied (busy)" for certain interim or period and again looks for the active base station. The constraints and problems with this methodology are it lacks awareness in regards to accessible correspondence framework and power assets of nodes. A lot of transmissions are passing in and out of a node irrespective of whether it is transmitting or not. There is a likelihood of system segmentation. There might be conceivable because of the catastrophe where there is no active base station and in such an event, this model totally comes up short.

Zasad *et al.* [25] used the OPNET simulation tool to evaluate the performance of TORA, LDR and ZRP on non-real time implementation (such as HTTP and FTP) traffic. They used 4 performance evaluation parameters (packet delivery fraction, normalized routing load, execution, and end-to-end delay) to study how the above-mentioned routing protocol performed between 10 to 50 nodes and the simulation time was 150 secs. It was discovered that DSR performance was very low for non-real time applications for all the four-performance matrix while OLSR was considered as the most stable routing protocol.

Bhat *et al.* [26] conducted a simulation on hybrid, proactive and reactive routing protocols (AODV, DSR and LAR, ZRP and OLSR) and compared their analysis using Qual net 5.0.2 simulator for mobile and stationary mode between 25-250 connection using above mentioned performance matrix. For Stationary mode, it was discovered that all AODV, DSR, LAR performed far better than OLSR, while ZRP performance was below average. For Mobile mode, using a scale of preference to indicate their performance LAR, AODV, DSR, out-performed OLSR and ZRP respectively. When the number of nodes was 50, all routing protocols mentioned except ZRP performance was above 95%. They concluded that DSR and AODV will perform better for applications that are not susceptible to jitter, and throughput on the average while OLSR will suit a large and dense environment with random and sporadic changes between nodes.

Zafar *et al.* [27] analyzed and compared throughput and delay in AODV, DSDV and DSR in a MANET using NS-2 simulator. They discovered that as the network topology and speed of the mobility are increased, DSR outperformed AODV and DSDV performed the least. This indicates that when a MANET system has many nodes it is preferred to use DSR.

2. MATERIAL AND METHOD

This section discussed the environment of the simulation for three routing protocols. The experimental aim is to tests and evaluate the performance of these protocols underneath specific scenarios such, search and rescue missions. The main steps used to simulate the scenario are shown in Figure 3. The simulation model comprises five main modules. First, Module A was employed to build the MANET environment. This module illustrates the characteristics of MANET, such as simulation time, number of nodes, network size, node speed, and so on. Module B used to implement the three routing protocols. The simulation time scenario with several parameters was included in Module C to evaluate the performance of the three routing protocols. In module D, the performance metrics of packet delivery ratio (PDR), throughput (TP), end-to-end delay (E2E delay), and packet loss ratios (PLR) were used to assess the performance of the protocols. Finally, a results visualization graphical module is included to view the results and related analysis.

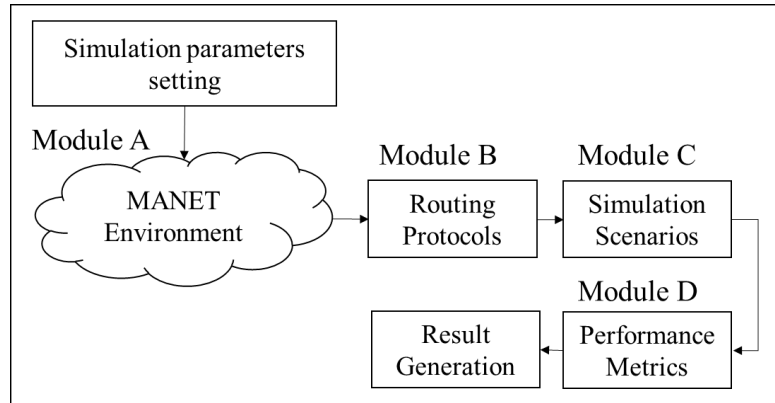


Figure 3. Simulation model design

The search and rescue missions require time and high-speed mobility as well as continuous communication between rescuers. The setting of the parameters for the simulation was adapted from search and rescue missions [28-32]. Table 1 shows all the simulation parameters/metrics.

Table 1. Simulation setting

Parameter	Value	Unit
Area	1000	m ²
Queue size	50	Packet
Mobility Model	Random Way Point	-
Packet Size	512	Byte
Transmission Range	250	Meter
Protocol	AODV, AOMDV, DSDV	-
No. of nodes	50	Node
Node speed	1	m/s
Simulation time	(600-3400)	Second
Traffic type	CBR/UDP	-

This section evaluates the quality of three routing protocols under the simulation time scenario. The simulation time altered as (600-3400) second. The performance of the protocols is measured based on TP, PDR, PLR, and E2E delay.

Throughput (TP): The number of bits that the destination has effectively gotten. Communicated in kilobits every second (Kbps) [2-3]. TP computes a routing protocol's productivity or proficiency in destination getting information packets. Throughput is determined as below:

$$TP = \frac{\text{No. of bytes received} \times 8}{\text{Simulation time}} \times 1000 \text{ kbps} \quad (1)$$

Packet Delivery Ratio (PDR): This implies the proportion of the data packets that were conveyed to the destination node to the ones that were produced by the source [7]. This measurement depicts a routing protocol's quality in its conveyance from source to destination. The greater the proportion, the better is the execution of the routing protocol. PDR is determined in this way:

$$PDR = \frac{\text{No. of packet received}}{\text{No. of packets sent}} \times 100\% \quad (2)$$

Packet Loss Ratio (PLR): This comprises the proportion of the distinction between the quantity of data packets transmitted and the quantity of data packets/bundles gotten [17]. For a situation where a router gets a packet while taking care of another, the gotten packet must be stored in the input buffer until its opportunity arrives. A router input buffer is limited in size. PLR is determined as follows:

$$PLR (\%) = \frac{\text{No. of packets sent} - \text{No. of the packet received}}{\text{No. of packet sent}} \times 100 \quad (3)$$

End-to-End Delay (E2E delay): alludes to the meantime expended by data packets in completely transmitting messages over the system from source to destination [18]. This incorporates a wide range of delay types, such as lining at interface queue; propagation and transfer times; MAC retransmission delays;

and buffering during the path-way disclosure inactivity. Expressed as follows is the equation to compute the E2E delay:

$$E2E\ delay = \frac{\sum_{i=1}^n (Ri - Si)}{n} \quad (4)$$

3. RESULTS AND DISCUSSION

The outcomes subsequent to conducting simulations obviously exhibit the differences in throughput for AOMDV, DSDV, and AODV. These protocols have distinctive throughput/ performance while expanding the simulation time. Figure 4 depicts the differences in throughput for AOMDV, DSDV, and AODV. At the point when there is an increase in simulation time (600-3400) second, the AOMDV routing protocol shows better execution over both DSDV and AODV in terms of throughput. The route separation and reliability are beneficial to the AOMDV routing protocol to limit the loss of packets and increase the throughput.

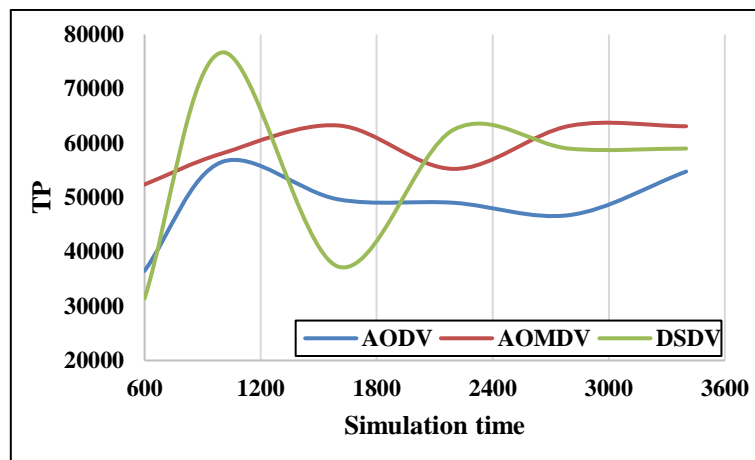


Figure 4. The TP results

Figure 5 indicates the changes in PDR for AOMDV, DSDV, and AODV. The impact of changing the simulation time of the routing protocols is depicted in Figure 5. Simulation time is varied as (600-3400) seconds. At the point when there is an increment in simulation time, there is an increment in PDR. The AOMDV protocol has better execution as far as PDR is concerned compared to both DSDV and AODV protocols. The outcomes unmistakably show that the AOMDV protocol has better execution due to the solid and short pathway it chooses to move the information traffic, which results in diminished loss of packets.

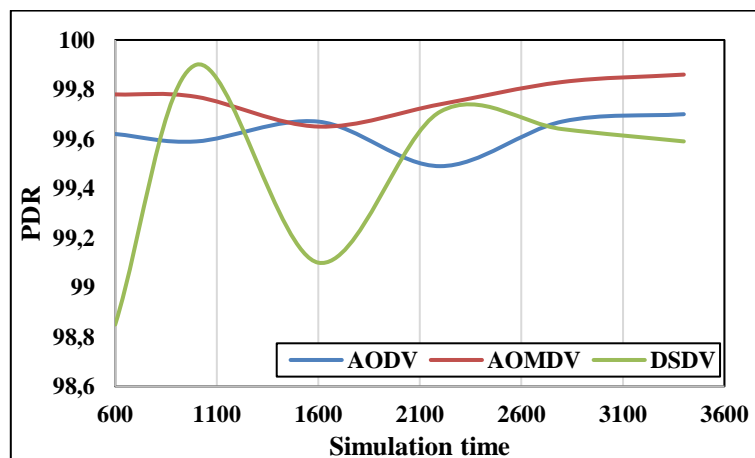


Figure 5. The PDR results

Figure 6 shows the PLR for AOMDV, DSDV, and AODV while changing the simulation time as (600-3400) seconds. As the simulation time increases, a corresponding increase occurs in PLR. The AOMDV routing protocol beat both DSDV and AODV in light of the fact that the source node chooses several shortest and reliable paths that limit the time required for a packet to transverse the system. Figure 7 shows the E2E for AOMDV, DSDV, and AODV while varying the simulation time as (600-3400) seconds, while incrementing the simulation time, the E2E likewise shows considerable increments. Due to the quantity of exhausting nodes increments, this also increases the connection failure likelihood. The DSDV routing protocol outperforms both AOMDV and AODV on the grounds that it utilizes the proactive system. This mechanism diminishes the time it takes to locate an optional way from source to the destination just as the source node chooses the shortest path which limits the time taken for a packet to transverse the system.

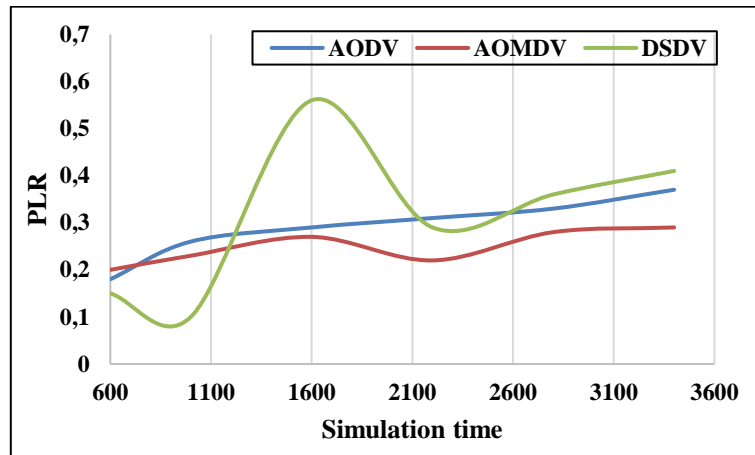


Figure 6. The PLR results

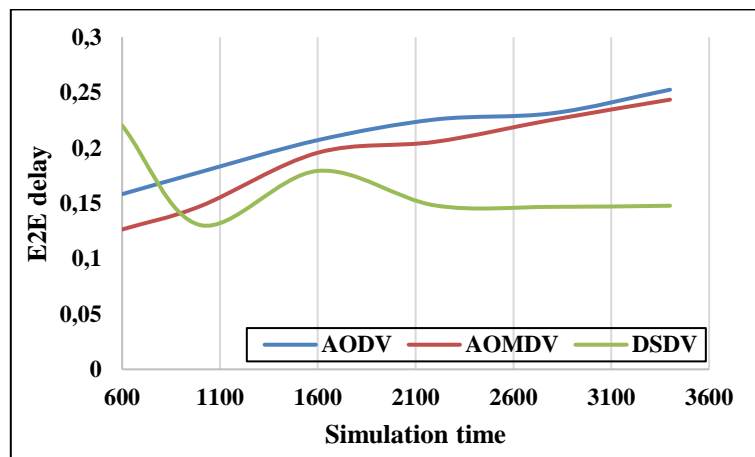


Figure 7. The E2E delay results

The overall results show the most appropriate protocol in the environment of time-critical events of search and rescue missions is the AOMDV routing protocol. The findings show the simulation time scenario has a diverse influence on the behavior of these routing protocols in this environment. However, it dramatically raises the likelihood of altering the network topology, which dramatically leads to link failure.

4. CONCLUSION

The significant knowledge we gained from various catastrophic events is that cellular systems were defenseless and susceptible, and the loss of correspondence framework may have a disastrous outcome or consequences. MANETs have various attributes which makes it a proficient and robust system

for correspondence in a critical situation. The topology of these remote/wireless connections varies progressively as the associated nodes are allowed to move discretionarily. Various kinds of routing protocols in MANET are proposed. This paper gives a similar or comparative evaluation to three types of routing protocols: ad-hoc on-demand multipath distance vector (AOMDV), DSDV and AODV. The outcome shows the AOMDV is better as far as TP, PDR, and PLR are concerned. However, the DSDV outperforms in terms of E2E delay.

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