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مجلة علمية محكمة تصدر عن كلية التربية

بجامعة المرقب

العدد السادس والعشرين
يناير 2025م

- المجلة ترحب بما يرد عليها من أبحاث وعلى استعداد لنشرها بعد التحكيم .
- المجلة تحترم كل الاحترام آراء المحكمين وتعمل بمقتضاها .
- كافة الآراء والأفكار المنشورة تعبر عن آراء أصحابها ولا تتحمل المجلة تبعاتها .
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- البحوث المقدمة للنشر لا ترد لأصحابها نشرت أو لم تنشر .

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Simulation and Comparison of Control Messages Effect on AODV and DSR Protocols in Mobile Ad-hoc Networks

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Abstract— a Mobile Ad-hoc NETwork (MANET) is a set of portable wireless devices forming a temporary wireless network without utilize of any supplementary infrastructure and there is no centralized management. In MANET’s routing protocols, one of the most important key challenges is the flooding process of control packets and its influences on the performance in the network. In this paper, we present a simulation study evaluating the performance of on-demand routing protocols, specifically Dynamic Source Routing (DSR) and Ad hoc On-Demand Distance Vector (AODV), under varying conditions. By altering the number of source nodes (traffic load), pause time of nodes (speed), and the number of nodes (network size), we aimed to understand the impact of control messages on the protocols' performance. Our results indicate that DSR exhibits better scalability, with control packets stabilizing or decreasing slightly as the network size grows. Conversely, AODV shows a sharp and exponential increase in control packets with more nodes, suggesting higher control overhead and reduced scalability in larger networks. Both protocols display inconsistent variations in control packets with changes in the number of source nodes, likely due to route maintenance and discovery mechanisms. While DSR demonstrates a controlled and predictable increase in control packets, making it more efficient for larger networks, it may require optimized settings for fluctuating node densities. In contrast, AODV is efficient for small to medium-sized networks but faces higher control overhead in very large networks, necessitating careful management to prevent congestion and excessive control messaging. The preference between DSR and AODV is determined by particular network requirements, with each protocol having its strengths and weaknesses, and their performance varying based on network size and conditions. Simulations of DSR and AODV protocols to analyse and study its performance were implemented in Global Mobile Simulator.

Key words**:** MANET, On-demand protocols, AODV, DSR, control messages.

1. Introduction

A mobile ad-hoc network (MANET) is a type of wireless network characterized by its mobility and lack of infrastructure. MANETs are formed dynamically by wireless mobile nodes that move randomly without the need for any support station or access point. In a MANET, each mobile node can function both as a host and a router simultaneously, allowing for free movement and self-organization in an arbitrary manner, resulting in a dynamic network topology [Al-Shora et al., 2018; Khudayer et al., 2020].

To maintain connectivity, each node in a MANET acts as a router, sharing the task of routing data across the network [Hajlaoui et al., 2015]. There are three methods for establishing routes between source nodes and their destinations in MANETs: proactive (table-based) routing, reactive (on-demand) routing, and hybrid routing [Malwe et al., 2022]. However, most routing protocols in MANETs can be categorized into two types [ahmed et al., 2024]: reactive and proactive. Reactive routing protocols include: the Dynamic Source Routing (DSR) protocol and the Ad hoc On-Demand Distance Vector (AODV) routing protocol [Saima et al., 2016; Priyaganga and Madhumita, 2016]. Proactive routing protocols include the Destination-Sequenced Distance Vector (DSDV) routing protocol and the Wireless Routing Protocol (WRP). Generally, reactive routing protocols must swiftly adapt to topology changes to maintain the routes between the source node and its intended destination. Typically, routing protocols use various control messages (packets) to ensure the delivery of data packets from the source to the intended destination within the network [Clausen et al., 2018; Khudayer et al., 2020].

Reactive (On-demand) routing protocols, for instance: DSR and AODV, establish routes to intended destinations dynamically through their specific route discovery processes. The key control messages in the route discovery and maintenance operations of these protocols are Route Request (RREQ), Route Reply (RREP), and Route Error (RERR) messages. These messages play a crucial role in the data transmission process within MANETs [Mann et al., 2005; Zhang et al., 2011; Soundarya et al., 2021]. In addition, studying the previously mentioned features of control messages presents significant challenges. These control messages are influenced by various factors, such as mobility, network size, and offered load. This article provides a detailed analysis of the control messages generated during the routing process in the DSR protocol.

2. Related Work

Karthikeyan et al. (2013) analyzed the impact of broadcast mechanisms in both proactive (DSDV) and reactive (DSR and AODV) routing protocols on network performance, considering factors like broadcast overhead, network load, MAC load, and throughput. Their study concluded that broadcast or flooding algorithms lead to significant overhead issues in protocol design. The authors suggest that researchers should develop new broadcasting techniques to enhance the performance of routing protocols in MANETs.

In their 1999 work, Ni et al. categorize broadcast algorithms into two types: deterministic and probabilistic. In a broadcast protocol with deterministic characteristics, relay nodes are chosen in a way that ensures the entire network is covered. When a node gets a broadcast message, it deterministically decides whether to forward it. The IETF's internet draft uses flooding as a straightforward method for propagating and multicasting in Ad-Hoc networks, particularly those with low node densities and high mobility.

Karthikeyan et al. (2009) conducted a study comparing the performance of different broadcasting methods in MANETs. In the straightforward flooding method, a source node transmits an acknowledgment packet to all its neighboring nodes. Each neighbor then retransmits the packet the first time they receive it. This process repeats until all reachable mobile nodes in the MANET have received and rebroadcast the packet once. This method, however, often uses up important network resources such as bandwidth and node power because of redundant packet retransmissions. These redundant retransmissions result in high contention and collision within the network, a problem referred to as the re-propagate storm problem. This issue can potentially cause the network to fail entirely.

Natesapillai et al. (2010) evaluated the performance of density-based flooding, comparing its metrics with those of single-source broadcasting techniques like the uncomplicated flooding algorithm and the probability flooding algorithm. This approach ensures packet delivery from a source to every network nodes while reducing routing load, power expenditure, and packets collision compared to the other two methods. The study concludes that uncomplicated flooding necessitates each node to re-propagate all messages. In contrast, probability-based methods use basic knowledge of the MANET configuration to assign a probability for a node to re-propagate. In density-based flooding, each node decides its re-propagate probability or whether to forward a message based on both its own neighbor density and the previous node's neighbor density. This indicates that every node has the responsibility to either pass along or discard a received message.

Kumar and Mehfuz (2016) proposed a method that determines the probability of RREQ broadcasts based on the output from fuzzy controllers, which take into account node density, remaining energy, and available bandwidth. Their Particle Swarm Optimization Probabilistic Broadcasting (PSOPB) method surpasses other AI-based probabilistic broadcasting techniques such as the elitist simulated binary evolutionary algorithm (ESBEA), the multi-objective problem with Pareto front solution (MOP_PF), and the proficient fuzzy logic-based random propagating. Additionally, PSOPB accomplishes improved results evaluated to these methods. This technique can also be applied with other parameters like node velocity and can be utilized in the path discovery stage to analyze its effectiveness in mitigating the broadcasting storm dilemma while enhancing link stability.

In work by [OM Saleh, 2023], a comprehensive simulation based performance study and analysis is executed on the control packets (specifically route request, route reply and route error packets) along with its influences on the performance of DSR routing protocol. Basically, the control packets of DSR protocol has studied using different simulation scenarios and by analysing their influences with regard to, size of MANET, number of source nodes and mobility of nodes in MANET. However, the simulation outcomes prove that the quantity of control packets of DSR routing protocol is influenced by mobility of nodes more than no. of source nodes (the offered load) and no. of nodes (MANET size) in the network. It has concluded that DSR protocol is functioning excellent with respect to its control packets in three MANET environments: high offered load networks, low mobility networks and high density networks.

3. An Overview On-Demand Routing Protocols

On-Demand routing protocols form another category in routing strategies [ahmed et al., 2024]. In these protocols, the path is established only when sender nodes intend to send data to the receiver. The source propagates a Route REQuest packet throughout the network. Nodes that receive this packet, except for the destination node, will rebroadcast it to their neighboring nodes. This continues until the destination is reached. When the target (destination) node, or a middle node with a known path to the target, receives a path request message, it replies to the sender node. Whenever a source node needs to transmit data packets to a target, it inundates the MANET with route request packets. The target responds with a route reply message in a unicast manner, after which the source sends the data packet to the destination. Examples of on-demand routing protocols include: DSR, AODV, and TORA (Temporally Ordered Routing Algorithm) protocols [Sayedahmed et al., 2021].

Reactive routing protocols eliminate the need for constant information upkeep and reduce routing overhead by maintaining only updated paths. Communication among the source and target requires a route discovery process and adherence to maintenance rules until the route becomes invalid or unnecessary [Abdelhakim and Mohamed, 2023]. In these protocols, the source node floods the network with a route request packet (RREQ) to determine a path to the target on demand. A common drawback of such protocols is the higher delay associated with new route discoveries. Specifically, AODV protocol faces issues like a huge number of control packets created during link failures, high network bandwidth consumption, and decreased Quality of Service (QoS) with increased network density [Ebadinezhad, 2021]. The DSR protocol also has drawbacks, including lack of scalability, long times to obtain routing information, and out of date routes in the route cache. Consequently, reactive routing protocols are generally better suited for medium-sized networks [Sayedahmed et al., 2021].

3. 1. Dynamic Source Routing (DSR) Protocol

Basically, DSR is a reactive (on-demand) routing protocol for MANETs [Khudayer et al., 2020] [ahmed et al., 2024]. In DSR, nodes do not maintain the network topology due to the portability of the nodes. When a node wants to send a data packet, it first executes a route discovery procedure to find the destination node. Once the route is discovered [Saleh et al., 2013], it starts sending data packets through this route to the destination. Each intermediate node on the source route is responsible for delivering the transmitted data packets to the next node towards the destination. If a link in the discovered route fails, the intermediate nodes must perform route maintenance procedures to salvage the data packets during transmission. Generally, MANET routing protocols, for instance DSR, rely on control packets to execute all routing processes in the network [Priya, 2014[Singh, et al., 2023].

Control Packets of DSR Protocol

In MANETs, the DSR protocol involves three primary phases: Route Discovery, Data Forwarding, and Route Maintenance [ahmed et al., 2024]. Each routing protocol uses control messages (packets) to establish efficient routes among the source and the intended destination nodes. Specifically, in reactive protocols like DSR, there are three key types of control messages for route discovery and maintenance: Route Request (RREQ) packet, Route Reply (RREP) packet and Route Error (RERR) packet. Basically, to transmit data packetes in a network, the routing system must identify one or more routes from the source node to the destination node and detect any faults in the selected route. In the route discovery method of the DSR protocol, source nodes initiate the route discovery procedure if they lack a route to the desired destination in their route caches [khan et al., 2024] [Zarzoor, 2021; Satyanarayana et al., 2021]. The route discovery procedure primarily involves two types of control packetes: RREQ packet and RREP packet. If a source node desires to transmit data packets to the destination but the source route is unavailable, it broadcasts RREQ packetes to its neighboring nodes [Alani et al., 2020]. Neighbor nodes that receive an RREQ packet must rebroadcast it to their neighbors unless they are the destination node or have a cached route to the destination. Any intermediate node that receives the same RREQ packet will not rebroadcast it again. The RREQ packet contains a list of all intermediate nodes it has passed through, including the source node. When a mobile node obtains a new RREQ packet, it immediately stores a recent route to the original source node (called the source route) and verifies the intermediate nodes in the route. If a new source route does not already exist, it will be saved in the route cache for any intermediate nodes [Saleh et al., 2013]. On the other hand, the route maintenance method in DSR nodes employs procedures to maintain its source routes to the intended destinations and to salvage transmitted data packets in the active source routes. The route maintenance method includes a crucial procedure, the RERR control packet process, to notify the source and other nodes that the used route is disconnected. When the source node needs to transmit a data packet to the destination, it uses cached routes. Every node transmitting the data packet must confirm that it has reached the next intermediate node. In the case of a link failure, the affected node sends a RERR packet back to the source node and its neighboring nodes and initiates the route maintenance procedure to salvage the transmitted data packets [Soundarya et al., 2021]. Each node receiving a RERR packet must delete all cached routes affected by the detected failure link. Subsequently, it will check its route cache for an alternative route or initiate a new route discovery procedure to transmit the remaining data packets [Bansal , 2023][Ahmed et al., 2022].

In particular, DSR protocol uses route discovery and maintenance procedures to ensure data packets are delivered to their targets [Singh, et al., 2023]. Source nodes exchange control packets (RREQ, RREP, and RERR) with their neighboured nodes to complete their data transmission tasks. However, certain situations can lead to control packet storms in the network. Flooding the network with control packets increases control overhead, and reduces MANET performance. Additionally, the DSR protocol faces other significant concerns, for instance poor scalability and increased data packet collisions, due to the excessive use of control packets inside the network [Bansal , 2023] [Dusia et al., 2019].

3.2. Ad-Hoc On-demand Distance Vector (**AODV**) Routing **Protocol**

The AODV protocol fundamentally comprises four types of control messages used to discover and maintain routes between source and destination nodes in MANET. In its route discovery procedure, the AODV protocol employs three types of control messages: route request (RREQ) and route reply (RREP) messages. The fourth type of control message, route error (RERR) message, is used in the route maintenance procedure. These control messages will be detailed in the following subsections [Eltahlawy et al.,2024] [khan et al., 2024].

3.2.1. Control Messages in AODV Route Discovery Procedure

A) Routing Request (RRQ) Message

Practically, when a source does not have a route to the desired destination in routing table, it propagates a RREQ message to all neighboring nodes (or any intermediate node in case of no routing information) [Khan et al., 2024]. Each node maintains two counters: a node sequence and a propagate ID. The RREQ message includes six fields: source node address, source node sequence, propagate ID, destination node address, destination node sequence, and hop count. The combination of source node address and propagate ID uniquely identifies an RREQ message, and the propagate ID increases each time the source node propagates a recent RREQ message [Saleh, 2024]. Each neighboring node either responds to the RREQ message by sending a RREP message back to the source node or by increasing the hop count and re-propagating the RREQ message to neighbour nodes. When an intermediate node obtains an RREQ message, it checks if it has a suitable route to the destination. If it does, it creates a new RREP message. The route table entry for the destination must have a sequence number at least as large as the one specified in the RREQ message. If a middle node has previously received an RREQ message with the same propagate ID and source node address, it cancels the redundant RREQ message. The destination sequence number is used to find the freshest route and ensure loop freedom in the discovered route [Eltahlawy et al.,2024].

B) Routing Reply (RRP) Message

Practically, when a destination or middle node receives an RREQ message and has a route to the desired destination in the routing table, it creates an RREP message and sends it reverse to the original source node. The RREP message contains five fields: Source Node Address, Destination Node Address, Destination Node Sequence, Hop Count, and Live Time. RREP messages are used by intermediate or destination nodes to respond to an RREQ message in unicast mode. The purpose of unicast mode is that all intermediate nodes forwarding any RREQ message cache a reverse route to the original source node [Eltahlawy et al.,2024].

In the setting of RREP message, the hop count field is set according to the node’s distance from the destination node. If the destination node itself generates a RREP message, the hop count value is set to 0. Once the RREP message is generated, the destination node and intermediate nodes begin to unicast it to the subsequently hop toward the source node. The reverse route included in the RREQ is utilized to transmit the RREP message back to the source. Upon receiving the RREP message, an intermediate node creates a forward route entry for the destination, utilizing the node from which it received the RREP message as the subsequently hop towards the destination. The hop count in the message corresponds to the hop count for that route, increased by one hop. This forward route entry for the destination node will be used if the source node selects this route for sending data messages to the destination [Saleh, 2024].

C) Routing Hello (HELLO) Message

In practice, the AODV protocol uses hello (HLO) messages to discover and monitor route links to neighboured nodes in MANET [Bansal , 2023] [khan et al., 2024]. AODV nodes identify their neighbors using local broadcasts that rely on periodic HLO messages to ensure the routing process. Neighboring nodes are those that can immediately communicate with each other through these periodic control messages. Essentially, the AODV protocol uses HLO messages to inform neighboring nodes that the connection is still active. During the route discovery process, as soon as a node receives an HLO message, it immediately refreshes the lifetime of the neighbor information in the routes table. Additionally, HLO messages can help maintain local links in the network. However, using HLO messages is not always necessary [saleh, 2024]. For example, an AODV mobile node observes for the re-sending of data packets to ensure the subsequently hop is within its coverage range. If the mobile node fails to detect resending, it may use other methods, including responding to HLO messages.

3.2.2. Control Messages in AODV Route Maintenance Procedure

The AODV route maintenance system mainly uses one type of control message: RERR message [khan et al., 2024], [Eltahlawy et al.,2024]. This message is crucial for repairing affected active routes in a MANET. Once a route is discovered, it is maintained only when necessary. During communication, all mobile nodes monitor their neighboring nodes. If a node in an active route experiences a link failure, an RERR message is generated and propagated to inform neighboring nodes on both sides of the failed link. The RERR message lists all destination nodes that are currently inaccessible due to the link failure [Bansal , 2023]. The RERR message, marked with an infinite metric, is then sent through the reverse route to the original source of the data packet. Upon receiving an RERR message, the source and neighboured nodes delete all broken routes to the destination from their route tables. The source node then attempts to maintain the route if possible or re-run a recent route discovery process [Eltahlawy et al.,2024]. However, the AODV protocol faces significant issues due to the excessive use of control messages (RERR, RREP, and RREQ). The flooding of RERR messages, in particular, contributes to control-message storms, leading to increased control overhead and delays in MANET networks [Saleh, 2024] [Singh, et al., 2023].

5. Research Methodology

5.1. Simulation Environment

In this work, our simulations of MANET are executed using the GloMoSim (Global Mobile Simulator) simulator. The nodes within the simulation area follow the widely-recognized Random Waypoint Mobility (RWM) model. Each scenario runs for 900 seconds, with the simulated MANET region being a 2200 m x 600 m rectangle. In all simulations, the MAC layer protocol used is IEEE 802.11, and the network layer protocol is the Internet Protocol (IP). The Constant Bit Rate (CBR) traffic sources provide a steady stream of 512-byte data packets [Al-Refai, 2020] [Saleh, 2024]. The simulation parameters for our experiments are detailed in Table 1.

Parameters	Values
Simulation Area	2200m X 600m
Simulation Time	900 second
Size of Network	40, 50 or 60 nodes
Node Speed	From 0 to10 meter per second

Mobility Model	RWP Model
Traffic Model	CBR Model (4 packets/sec.)
Routing Protocol	DSR / AODV
Pause Time	0, 300, 600 or 900 sec.
Number of Sources	5, 8, 10 or 15 sources
Bandwidth	2 Mbps
Packet Size	512 Byte

Table 1: Simulation Values and Parameters

5.2. Performance metrics

In our simulation tests of both DSR and AODV, we have selected the number of control messages as performance metrics with respect to pause time period, number of nodes and number of source nodes in order to investigate and analysis the control messages of standard AODV and DSR protocols, where the presented quantitative metrics must be based on the equivalent MANET characteristics, for instance: dimension of simulated region, bandwidth, traffic variety, energy resources, etc. [Saleh, 2024] [OM Saleh, 2023].

6. Simulation Experiments and Results

Practically, we investigate various simulation scenarios in our experiments, with MANET nodes distributed across the simulation region. These scenarios involve:

- Varying the number of sources (traffic load)
- Varying the pause time of nodes (speed)
- Varying the number of nodes (network size)

This helps us to understand the impact of control messages on the performance of both DSR and AODV routing protocols. These two on-demand routing protocols are evaluated under diverse conditions using these different simulation scenarios.

In this simulation study, three simulation scenarios have been run with respect to three parameters (i.e. number of source nodes, pause time of mobile nodes and number of MANET’s nodes), while every simulation scenario has been simulated for 900 sec.. In the 1st simulation scenario, varying number of MANET’s nodes (network size) is varied from 40 nodes to 60 nodes. In the 2nd simulation scenario, varying number of source nodes (offered load) is varied from 5 sources to 12 sources. In the 3rd simulation scenario, varying pause time of mobile nodes (mobility) is varied from 0 sec. to 900 sec.. In next subsection, the simulation scenarios and their results are explained.

6.1. Scenario 1: Effect of Varying Number of Nodes

This simulation scenario changes the number of nodes (size of network) in the MANET. This scenario intends to explain the impact of number of nodes on the number of control messages. Practically, the simulation scenario is executed for 40, 50 and 60 as number of mobile nodes in the MANET. Table 2 explains the simulation parameters which vary from the standard parameters that provided previously in Table 1.

Parameter	Value
Number of nodes	40; 50 or 60 nodes
Speed of nodes	0-10 m/s
Pause time	900 sec.
Number of sources	10 source nodes
Routing Protocol	DSR / AODV

Table 2: The effected parameters of simulation scenario 1

In simulation scenario 1, the total numbers of control messages successfully broadcast in MANET network are illustrated in Table 3, whereas three environments executed using varying number of nodes. Consequently, the simulation result was collected and illustrated in Fig. 1.

Control Messages vs. Varying Number of Nodes		Number of Nodes		
		40	50	60
NO. of Control Messages	DSR Control Messages	9833	21214	19678
	AODV Control Messages	27117	41693	223211

Table 3. Varying Number of Nodes VS. Control Messages

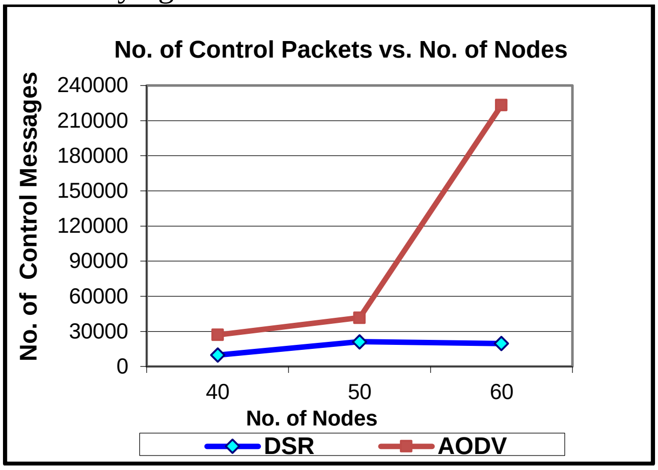

Fig. 1: Shows the no. of control packets VS. no. of nodes

Basically, Fig.1 shows that as the number of MANET's nodes raises, the control overhead for both DSR and AODV protocols varies significantly. The AODV protocol seems to have a much higher control overhead compared to the DSR protocol, especially as the number of MANT's nodes raises.

To analyze the impact of the number of nodes in a MANET on the number of control packets for DSR and AODV based on the data you provided. Practically in DSR protocol, when the number of mobile nodes rises from 40 to 50, there is a significant boost in control packets from 9833 to 21214. However, when the number of mobile nodes rises further from 50 to 60, the number of control packets slightly decreases from 21214 to 19678. The initial increase in control packets might be due to the higher overhead required to preserve routing information as the network grows, but the decrease suggests that DSR becomes more efficient or stabilizes after a certain threshold.

Conversely**,** AODV protocol exhibits a much sharper boost in the number of control packets as the number of mobile nodes raises. Whilst the number of mobile nodes changes from 40 to 50 nodes, the number of control packets boosts significantly from 27117 to 41693. However, the number of nodes changes From 50 to 60 nodes, there is an exponential increase, with the number of control packets soaring to 223211. This pattern indicates that AODV has a much higher control overhead compared to DSR as the network size grows, possibly due to its route discovery and maintenance processes becoming more complex with more nodes.

As an analyses of scenario 1, DSR shows a more controlled and predictable boost in the no. of control packets with the raise in the no. of mobile nodes. This suggests that DSR might be more scalable for larger networks. In contrast, AODV shows a dramatic increase in control packets, which could imply higher overhead and less scalability in very large networks.

6.1.1. Scenario 2: Effect of Varying Number of Source Nodes

This simulation scenario changes the number of source nodes (Offered Load), since it aims to explain the impact of number of source nodes on the number of control messages in the MANET. Practically, the simulation scenarios are executed for 5, 8, 10 and 12 mobile source nodes. Table 4 explains the parameters of the simulation experiment (1) which vary from the standard parameters that provided previously in Table 1.

Parameter	Value
Pause time	900s
Number of nodes	50 nodes
Speed of nodes	0-10 m/s
Number of sources	5, 8, 10 and 12 sources
Routing Protocol	DSR / AODV

Table 4: shows the effected parameters of simulation experiment 1

In this simulation scenario, four environments executed using varying number of sources. Consequently, the simulation result was collected and illustrated in Fig. 2, whereas the total numbers of control messages successfully broadcast in MANET network are illustrated in Table 5.

Control Messages vs. Varying Number of Source Nodes		Number of Source Nodes			
		5	8	10	12
NO. of Control Messages	DSR Control Messages	17342	14684	27144	18768
	AODV Control Messages	96584	78760	51242	89381

Table 5: shows varying no. of source nodes VS. no. of control messages

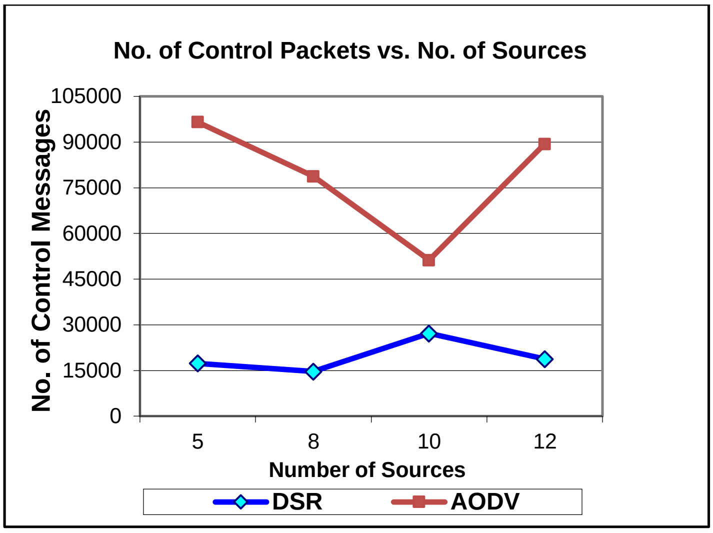

Fig. 2: Shows the no. of control packets VS. no. of sources

In simulation scenario 2, the impact of the number of source nodes on number of control packets for DSR and AODV protocols based on the data has provided in Table 3.

For the DSR protocol, with 5 source nodes, number of control packets is 17342, which decreases to 14684 with 8 source nodes, then significantly increases to 27144 with 10 source nodes, and drops to 18768 with 12 source nodes. This inconsistency in number of control packets could be due to the route maintenance and discovery mechanisms of DSR in dissimilar network sizes.

Conversely, for AODV protocol, with 5 sources, the number of control packets is 96584, which decreases to 78760 with 8 source nodes, further decreases to 51242 with 10 source nodes, and then increases to 89381 with 12 source nodes. The downward trend from 5 to 10 source nodes suggests that fewer control messages are needed as the network grows, but the significant increase at 12 nodes indicates potential congestion and increased route requests in a more congested network. In terms of scalability and efficiency, DSR shows an inconsistent pattern in the no. of control packets, which might reflect the challenges in route discovery and maintenance in varying network sizes. AODV initially shows a more consistent decrease in control packets, suggesting it might handle smaller to medium-sized networks more efficiently, but the increase at 12 nodes indicates that network congestion and control overhead can spike in larger networks. For network administrators, optimizing protocol settings or considering hybrid approaches may be necessary for DSR in networks with fluctuating node densities. For AODV, while the protocol scales well initially, careful management is needed as the network grows beyond a certain size to prevent congestion and excessive control messaging.

6.1.3. Scenario 3: Effect of Pause time of Mobile Nodes

This simulation scenario changes the pause time of mobile nodes (speed), since it aims to explain the influence of the pause time of mobile nodes on number of control messages in MANET. Practically, the simulation scenarios are accomplished for 0, 300, 600 and 900 sec. on DSR and AODV separately. Table 6 explains the parameters of the simulation experiment (1) which vary from the standard parameters that provided previously in Table 1.

Parameter	Value
Pause time	0; 300; 600 or 900 sec
Number of nodes	50 nodes
Speed of nodes	0-10 m/s
Number of sources	10 sources
Routing Protocol	DSR / AODV

Table 6: shows the effected parameters of simulation experiment 1

In simulation scenario 3, four environments executed using varying no. of sources. Consequently, the simulation result was collected and illustrated in Fig. 3, whereas the total numbers of control messages successfully broadcast in MANET network are illustrated in Table 7.

Control Messages vs. Varying of Pause Time		Pause Time of Nodes			
		0	300	600	900
NO. of Control Messages	DSR Control Messages	27144	21214	16005	14634
	AODV Control Messages	51242	41693	37513	34273

Table 7: shows Varying Pause Time of Nodes VS. Control Messages

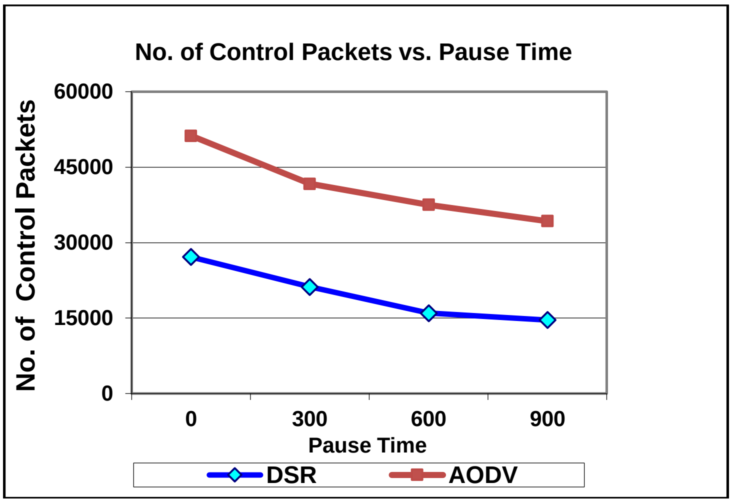

Fig. 3: Shows the no. of control packets VS. Pause time of nodes

In simulation scenario 2, the impact of varying pause time of nodes on the control packets for DSR and AODV protocols based on the data has provided in Table 3.

For the DSR protocol, with 0 seconds pause time, no. of control packets is 27144, which decreases to 21214 at 300 seconds, further decreases to 16005 at 600 seconds, and reaches its lowest at 14634 at 900 seconds. This consistent decrease suggests that with longer pause times, meaning nodes are relatively stationary for longer durations; there is less need for route discoveries and maintenance, leading to fewer control messages.

For the AODV protocol, with 0 seconds pause time, no. of control packets is 51242, which decreases to 41693 at 300 seconds, further decreases to 37513 at 600 seconds, and reaches its lowest at 34273 at 900 seconds. Similar to DSR, AODV also benefits from longer node pause times, resulting in fewer route requests and error messages, hence fewer control packets. In terms of impact, an increase in pause time leads to a decrease in the no. of control packets for both protocols, as longer pause times mean nodes move less frequently, reducing the frequency of route breakages and the need for route discoveries. The reduction in control packets is more significant in DSR initially, but both protocols show similar trends of reduced overhead with increased pause time. Regarding efficiency and performance, the consistent decrease in control packets with increased pause time highlights DSR's efficiency in more stable networks with less mobility, while AODV also benefits from reduced node mobility, showing fewer control packets as pause times increase. AODV's adaptability to changing network conditions is evident in how it manages control traffic efficiently with varying pause times. Both DSR and AODV show improved performance and reduced control packet overhead with increased pause times, operating more efficiently in scenarios with higher node stability (longer pause times) and reducing the burden on network resources. Analyzing the graph, DSR shows a significant decrease in control packets as pause time increases, indicating that less mobility leads to fewer control messages being generated, while AODV also shows a decrease in control packets with longer pause times, though the overall no. of control packets remains higher than that of DSR.

7. Conclusion

In this research work, our simulation study evaluated the performance of on-demand routing protocols (specifically DSR and AODV) under different conditions by altering the number of source nodes (traffic load), pause time of nodes (speed), and the number of nodes (network size) to understand the impact of control messages on the protocols' performance. For the DSR protocol, control packets initially increased with network size, but stabilized or decreased slightly, indicating better scalability. In contrast, the AODV protocol showed a sharp and exponential increase in control packets with more nodes, suggesting higher control overhead and less scalability in larger networks. Additionally, for both protocols, the number of control packets varied inconsistently with changes in the number of source nodes, likely due to route maintenance and discovery mechanisms. While DSR demonstrated a controlled and predictable increase in control packets, making it more efficient for larger networks, it may require optimized settings for fluctuating node densities. On the other hand, AODV was efficient for small to medium-sized networks but faced higher control overhead in very large networks, requiring careful management to prevent congestion and excessive control messaging. Overall, the choice between DSR and AODV depends on specific network requirements, with both protocols having their strengths and weaknesses, and their performance varying based on network size and conditions. DSR is generally more suitable for larger networks due to its lower and more stable control overhead.

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