

# Exploiting Conventional MANET Routing in UAV's Based Environment

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**Abstract**— Nowadays, Unmanned Aerial Vehicles (UAVs), have indeed revolutionized various industries and opened up new possibilities. Additionally, a Flying Ad hoc Network (FANET), a group of UAVs can perform specific functions like delivering goods, assisting people after a disaster, monitoring the weather and environment, among others. FANET is another kind of ad-hoc mobile network. It is capable of connecting with its environment and other nodes to obtain critical information. It is particularly difficult to route across FANETs because of how mobility they are and how fast they may change layouts. Therefore, routing algorithms are crucial for improving the performance of ad-hoc networks. This article will analyse the performance of the AODV, DSDV, and TORA routing protocols in the FANET environment. The NS-2 simulator has been used for testing parameters such as jitter, throughput, End-to-End delay, and packet delivery ratio (PDR). The simulation results indicate that TORA outperforms AODV and DSDV routing protocols across all performance metrics except End-to-End Delay.

**Keywords**—Computer Networks, Routing Protocols, MANET, VANET, FANET, UAV

## I. INTRODUCTION

Unmanned Aerial Vehicles (UAVs), commonly known as drones, have brought about a paradigm shift across numerous industries, offering unmatched possibilities and innovations [1]. Advanced in drone technology have led to the emergence of smaller, autonomous drones that excel at executing complex tasks in a highly efficient, on-demand surveillance and life-threatening hazards, and actuation services, with the reduction of human involvement [2]. FANET is a distinct subset of wireless Ad hoc networks enables UAVs to communicate and coordinate their actions. The decentralized nature of FANET allows UAVs to operate in a self-organizing manner as shown in Fig. 1.

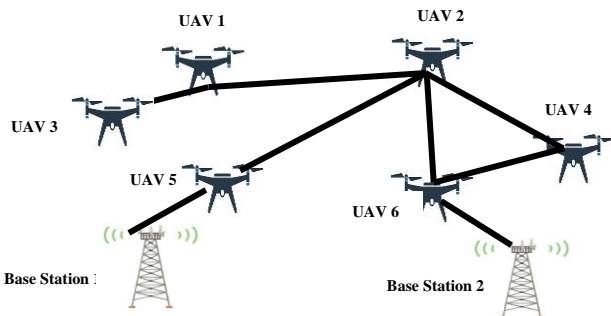


Fig. 1. FANET architecture [3]

Each UAV acts as a node and a router, forming direct wireless links with nearby UAVs to transmit and receive data [4]. FANET is a subset of both VANET and MANET as seen in Fig. 2.

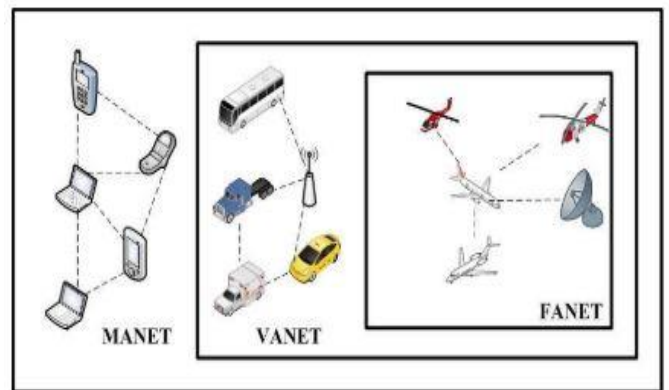


Fig. 2. The relationship among MANET, VANET and FANET [5]

FANET has similarities with existing ad hoc networks, but it also faces some unique design issues. The key distinction between FANET and other ad hoc networks is that FANET nodes have a substantially greater mobility degree than MANET or VANET nodes [5]. The topology of a FANET

network changes more often than that of a regular MANET or even VANET due to the rapid mobility of its nodes [6]. Table I presents a concise overview of the comparisons among FANET, VANET, and MANET regarding to certain criteria.

TABE I. COMPARATIVE ANALYSIS OF MANET, VANET, AND FANET

Parameters	MANETs	VANETs	FANETs
Node Density	Low	Medium	Very Low
Node velocity	Low	Medium	High
Power Consumption	Energy effective Consumption	Not needed	Need for mini-UAVs
Topology Change	Slow	Rapid	Rapid
Radio Propagation	Near to surface	Near to surface	High above the surface
Mobility model	Arbitrary	Steady	Mobility models for autonomous multi-UAV systems are typically predetermined, but exceptions apply.

The main aim of this study is to evaluate the efficiency of conventional Ad-Hoc Network routing protocols under different FANET mobility models. We performed extensive simulation experiments to assess the effectiveness of FANET utilizing several mobility models and routing protocols, such as Destination Sequenced Distance Vector (DSDV), Temporally Ordered Routing Algorithm (TORA), and Ad-hoc On-Demand Vector (AODV).

## II. RELATED STUDY

The routing protocol selects an optimal path for packets to reach their intended destination by traversing various nodes in a network. The performance of FANETs is closely linked to the effectiveness of routing protocols. The effectiveness of a FANET is determined by several parameters, such as the time it takes to converge following topology changes, the amount of bandwidth overhead needed for optimal routing, and the power consumption [3]. Numerous algorithms and methods have been suggested for FANET routing protocols in recent years, with much of the research concentrating on their design [7]–[9]. Kuldeep Singh and Anil Kumar Verma, examine several network factors related to nodes that are highly mobile and compare the OLSR, DSDV, and AODV protocols. The research concluded that OLSR outperformed AODV and DSDV in terms of routing protocol performance. Therefore, the OLSR routing protocol should be considered for use as the routing protocol in FANET [10].

Perkins C. et al. performed a comparative investigation of two on-demand routing systems created for ad hoc networks. The research analysed the distributed MAC load, packet delivery ratio, standardised routing burden, and average data packet delay of the DSR and AODV protocols [11].

A three-dimensional FANET environment is examined in [12] relation to the OLSR and AODV routing protocols. The outcomes demonstrate that OLSR exhibits superior performance over AODV across multiple FANET network

scenarios, including those characterised by fluctuating node velocities and a growing node count, as determined by a simulation employing a three-dimensional model of the networks.

## III. BACKGROUND

One of the major tasks in FANET is to search for the route or the route group among the network nodes. FANET routing protocols require different requirements from traditional ad hoc networks, such as low node density, high mobility, and frequent topology changes. Moreover, such route parameters as connectivity, route length and transit nodes share, influence the traffic performance in the network. It is difficult to design a FANET routing protocol by considering these characteristics. Therefore, the researchers have classified FANET routing protocols into several categories, for example reactive (AODV), proactive (DSDV), and hybrid (TORA) routing protocols.

### A. Ad hoc. On-demand Distance Vector (AODV)

AODV as shown in Fig. 3, is a routing protocol that is characterised by its dynamic and reactive nature. Route establishment in AODV occurs only when there is a need for a new route [13]. AODV supports the routing of unicast, broadcast, and multicast traffic. AODV exhibits rapid responsiveness to alterations in the network topology and selectively updates just the hosts that might potentially be impacted by these changes via the use of the RREQ message. This sequence number enables the selection of the most recent route each time a route is searched [14].

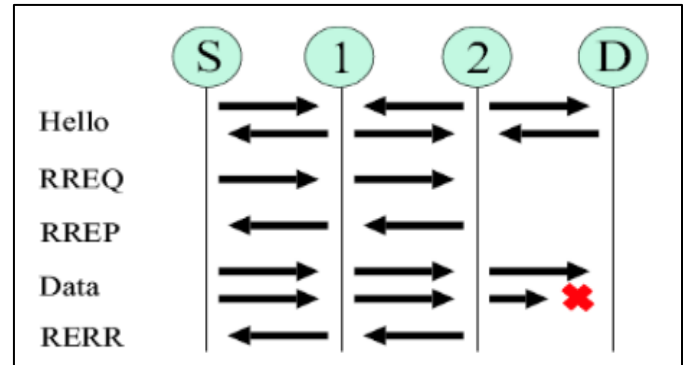


Fig. 3. Routing process in AODV [15]

### B. Destination Sequenced Distance Vector (DSDV)

DSDV is a common proactive protocol that modifies Distance Vector Routing. It was created to address the constraints of Distance Vector Routing by including two factors in routes: Sequence Number and Damping [16]. In DSDV, each node must identify everything about the other nodes in the network. Fig. 4 depicts the routing table, which consists of three parameters: destination, distance, and next hop. It is regularly updated about the complete network with a sequence number to minimize routing loops and network congestion when there is a change in topology. At regular

intervals, each node sends its routing table to surrounding nodes, and the parameters are recalculated by the other nodes [17].

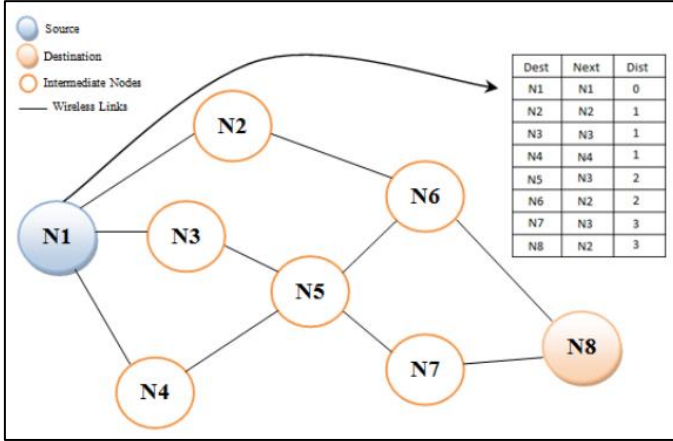


Fig. 4. Overview of DSDV routing protocol [18]

### C. Temporally Orderd Rouing Algorithm (TORA)

TORA is a Link Reversal Routing variant that Park and Corson initially developed. The objective is to uphold a directed graph devoid of any cycles that would otherwise arrive at a destination. Four essential operations are performed by TORA: creating, preserving, eradicating, and optimizing routes [19]. The TORA algorithm as shown in Fig. 5, constructs a cyclic graph to guide the flow of packets and guarantee their accessibility to all nodes. In order to generate directed graphs, the node will transmit query packets. The query packet will be dropped if the receiving node lacks a downward link to the destination. However, in the event that a node does possess a downward link, it will transmit a reply payload that updates the receiving node's height. However, in order for the height to be updated, it must be greater than the replied packet or other packets [20].

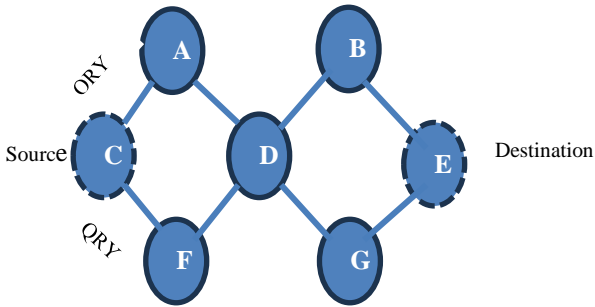


Fig. 5. TORA routing protocol [21]

## IV. METHODOLOGY

### A. The Simulation environment Description

This study investigates three traditional ad-hoc routing protocols within the framework of FANET scenarios, utilizing the NS-2 simulator, a tool that is highly regarded among

research organizations. NS-2 is a comprehensive suite of tools that have been designed to faithfully simulate the operation of networks. It is designed to simulate IP networks at a packet-level using a discrete event network simulator developed by UC Berkeley. Both wire and wireless networks can be simulated using NS-2. Over the past few years, simulations have become increasingly popular for analysing wireless networks. A wide range of metrics have been employed to evaluate the efficacy of routing protocols in the context of diverse node counts and degrees of mobility. Table II provides comprehensive information on the simulation settings.

TABLE II. SIMULATION PARAMETERS

Parameter	Value
Network Simulator	NS2
Protocols	AODV, DSDV, and TORA
Traffic Type	CBR
Simulation Time	1800 S
Number of Nodes	50, 100, 150, 200
Channel Type	Wireless
Simulation Area size	1000 x 1000 m
Data Packet Size	256 bytes
UAV speed	0-40 m/s
Propagation model	Two ray ground
Mobility Model	Random Way Point
Performance Measures	throughput, packet delivery ratio (PDR), end-to-end delay, and jitter

### B. Performance Evaluation Parameters and metrics

Mobility models show the movement of UAV from one location to another location with varying velocity and direction over a specific amount of time. The main challenge in FANET is the varying speed and height of flying UAV, which causes the packets to be delayed, failed to be received, or dropped. Therefore, to overcome this challenge, the performance of FANET must be evaluated using different mobility models with realistic scenarios that are used in real-life missions. In this paper Random Way Point mobility model (RWP) has been used in all simulation scenarios. In RWP, a mobile node begins transmission by waiting in a location for some period time. Once this period finishes, the mobile nodes select a random position in the defined simulation area and a speed from a certain range of minimum speed uniformly and maximum speed. Then mobile nodes move in the direction of the newly selected location in the defined area at the selected speed. This procedure is repeated another time, as a node pauses for a uniformly distributed random time before it starts another movement.

The objectives of the conducted simulations are to analyse the AODV, DSDV, and TORA routing protocols for FANET and take the necessary measurements, to detect potential drawbacks, to evaluate the performance and efficiency of multiple routing protocols, and to assess the impact of some changes or modifications to the performance. The performance measures listed below are used to compare the performance of different routing protocols.

1) *Throughput*: It measures the number of successfully delivered packets from source to target nodes in a specified

period of time. It can be improved as node density increases [22].

2) *Packet Delivery Ratio (PDR)*: It refer to how many packets from the source have been received at the destination [23].

3) *End-to-End Delay*: This term refers to an estimation of how long it typically takes for data to be sent over a network. This calculation is based on delays that may occur during the transmission process [24].

4) *Jitter*: The time interval between data packets received within a network is denoted by this value. For optimal efficacy, packet arrival times ought to fluctuate negligibly [25].

**V. RESULTS AND DISCUSSION**

In this paper, the primary objective is to examine how various routing protocols perform under a random waypoint mobility model for FANET, including AODV, DSDV, and TORA routing protocols. Using the network simulator NS2, a variety of metrics have been used to evaluate the performance of the protocols mentioned above in different mobility scenarios and CBR connections. The results of these metrics will be presented in detail as follows.

*A. Throughput*

The simulation results in Fig. 6 presents the analysis of routing protocols (AODV, DSDV, and TORA) under different size of nodes. The findings show that TORA had the best throughput and that the value stayed nearly constant when the node density was raised. With small size network, AODV has outperform DSDV. In contrast, DSDV exhibits a significantly higher throughput than AODV as node density increased.

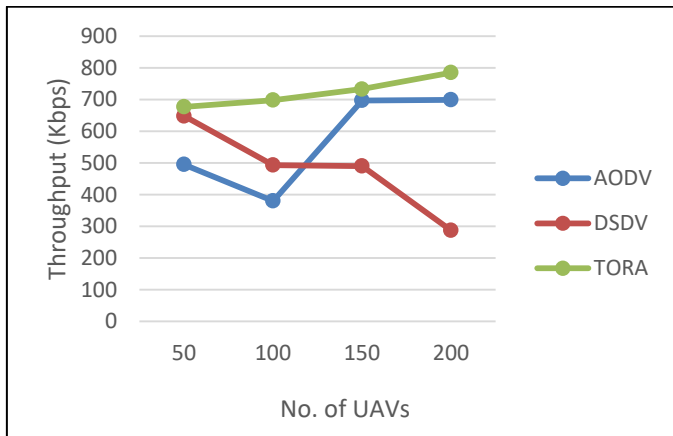


Fig. 6. Throughput versus No. UAVs

*B. Packet Delivery Ratio (PDR)*

Fig. 7 presents the results of experiments of the average PDR for three routing protocols for various nodes. The AODV show good performance when the number of nodes is less, however, its performance declines drastically with an increased number of nodes in the network. For DSDV, the results indicate that the number of nodes has an impact on the average PDR. For example, with 100 and 200 nodes, the average PDR

for AODV and DSDV is 20% and 58% respectively. In all experiments, TORA showed the highest PDR reflecting better performance.

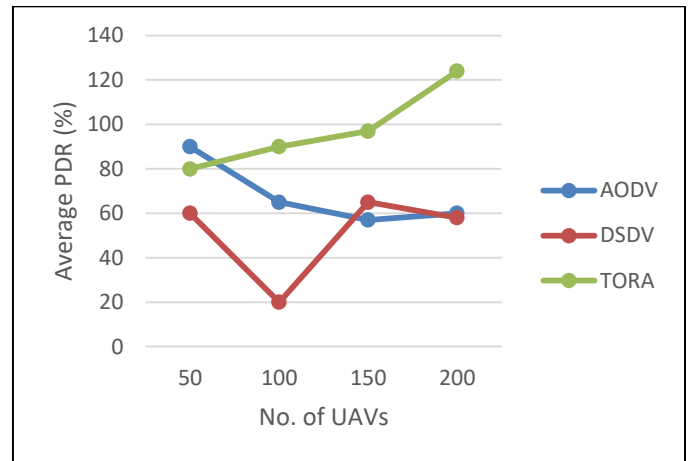


Fig. 7. PDR versus No. UAVs

*C. End-To-End Delay*

The simulation findings in Fig. 8 show that AODV has the highest end-to-end latency, followed by TORA, with DSDV having the lowest and most consistent end-to-end delay in mobility. AODV has the largest latency among DSDV and TORA when the number of nodes is increased, attributed to a rise in broken routes and additional transmission of control messages specific to AODV.

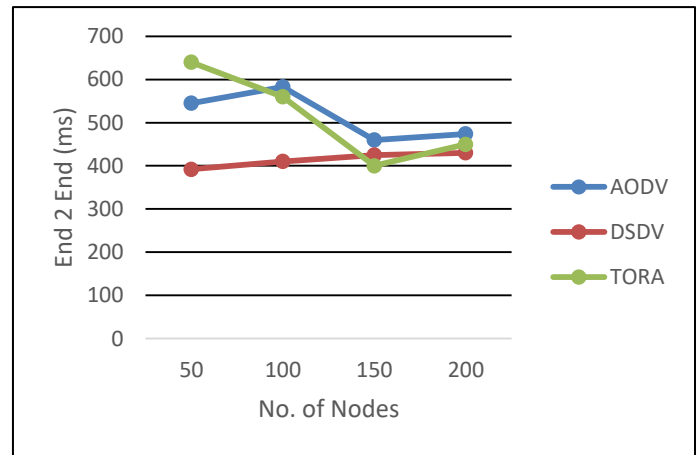


Fig. 8. End-To-End Delay versus No. UAVs

*D. Jitter*

The simulation results obtained from Fig. 9, DSDV performed better than the other two protocols with regard to jitter as the node density grew. AODV's jitter was minimal, but TORA's became more noticeable as the number of nodes increased.

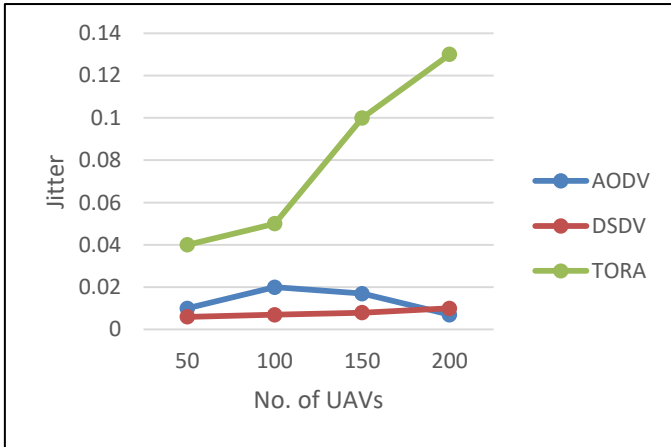


Fig. 9. Jitter versus No. UAVs

## VI. CONCLUSION

Within the context of the FANET environment, this research investigated and analyzed three different ad hoc routing protocols: AODV, DSDV, and TORA. To assess the efficacy of the three distinct routing protocols, various metrics were employed, including jitter, Packet Delivery Ratio (PDR), and throughput. According to the results of the simulation, TORA has superior performance over AODV and DSDV routing protocols in terms of all metrics, with the exception of End-to-End Delay. The study explores the UAV Ad-hoc network, consisting of multiple drones connected internally and a backbone drone that acts as a gateway for data communication. This topology expands communication range but requires consistent mobility patterns for all connected UAVs in a FANET. It is suitable for small-sized FANETs, but a single drone acting as a gateway can lead to a single point of failure and rapid battery drain. Therefore, a more efficient and reliable approach is needed. Additional research might be conducted in the future to investigate the other FANET-based protocols under other mobility models and different kinds of traffic with other performance parameters.

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