A Comparative Study of MANET Routing Protocols Performance

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***Abstract*: Wireless networks that function without any infrastructure are known as mobile ad hoc networks, or MANETs. Instead of a central access point, the nodes that create the network handle routing in these MANETs. The network is unpredictable because these nodes move frequently and at different speeds. Because the nodes of MANETs are battery-powered, they too run on a finite amount of energy. Because of this, an effective routing protocol that takes into account the nodes' energy consumption and mobility must be employed. Four routing protocols—DSDV (Destination Sequenced Distance Vector), AODV (Ad hoc On Demand Distance Vector), DSR (Dynamic Source Routing), and OLSR (Optimised Link State Routing)—are compared and examined in this article under diverse circumstances. Network Simulator 3 was used to mimic the protocols (NS3). Both the average receives rate and the average number of packets received were found to be higher for AODV. It was found that DSR used the greatest energy. The least amount of energy was discovered to be used by DSDV, which also had the lowest average number of packets received and packet receive rate.**

Keywords: performance, routing, MANET, AODV, DSDV, DSR, OLSR, and NS3.

I. INTRODUCTION

A collection of mobile wireless nodes forms Mobile Ad Hoc Networks, or MANETs. Information is dynamically shared between the nodes in these networks. A MANET can communicate without the use of any infrastructure. Their applications are diverse and include traffic management for automobiles as well as military sensors used to identify potentially dangerous objects [1]. Due to the numerous difficulties that arise while transferring data from one node to another, routing in MANETs is a field that is extensively studied. An issue that arises is the quantity of energy that nodes located inside the network use. Because MANET nodes run on batteries, they have a limited lifespan.

The amount of energy that the batteries can produce determines how well the nodes work. In the event that the node uses a lot of energy, the batteries will eventually run out of power, which will cause the node to fail [2]. The performance of MANETs in terms of node mobility is another problem. In an actual situation, the nodes move at different speeds. R. SkaggsSchellenberg et al. claim that nodes travelling at slower speeds may depict people strolling, while nodes travelling faster may depict people driving[3]. This paper's goal is to examine and contrast the MANET routing technologies' respective performances. Understanding each protocol's benefits and drawbacks will help you select the best one for the use for which it was designed. Four MANET routing protocols—OLSR, DSDV, AODV, and DSR—are covered in the sections that follow. The simulation parameter tests these protocols. Afterwards, graphs are used to examine and display the simulation results. The protocol that works well in each case is also highlighted by the examination of the data.

II. ROUTING PROTOCOLS

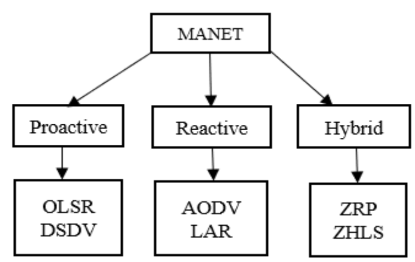

Fig.1. MANET Routing Protocol Types

As illustrated in Fig. 1, MANET routing protocols fall into three categories: proactive, reactive, and hybrid. This article compares and simulates the performance of two reactive routing protocols (AODV and DSR) and two proactive routing protocols (OLSR and DSDV). Network node routing information can be stored thanks to proactive routing protocols. By sharing routing data across the nodes, they add new routes and update old ones on a regular basis. Reactive routing systems, on the other hand, only create routes when necessary. Not every node in the network has a route maintained by the nodes utilising these protocols. Additionally, they don't update their routing tables very often [4].

A. *Proactive Routing Protocol*

The link state routing technique is optimised by the proactive routing protocol known as OLSR. By using Multi Point Relays (MPRs), which are nodes chosen for delivering control packets, this protocol lowers overheads. As a result, there are fewer retransmissions needed to broadcast the message. HELLO and Topology Control (TC) messages are used by OLSR. Every node communicates with every other node on a regular basis to find out who their neighbours are. They are also employed in the MPR node selection process. The paths to the destination nodes in the network are kept up to date by the TC messages [5].

This protocol's utilisation of MPR nodes makes it appropriate for extremely dense networks [6].A table-driven routing protocol is called DSDV. It tracks the routes to potential destinations using routing tables. Additionally, these tables are shared by nearby nodes. The Bellman Ford routing method is used by DSDV. The shortest path between two nodes is determined using it [4]. To avoid redundancy, a sequence number is assigned to each entry in the routing table. With the greatest sequence number is the node that was most recently used. By using this technique, network loops are prevented. The nodes communicate with the rest of the network on a regular basis regarding where they are. The destination address, hop count, and sequence number of the received data are assigned to new routes. Every node in the network stores information about the next hop [7]. DSDV is applicable to networks with fewer nodes. Even when the network is idle, resources are still consumed by the routing tables' recurring changes. Moreover, DSDV is unable to adjust to extremely dynamic networks [5].

B. *Reactive Routing Protocol*

AODV is a reactive routing protocol where the routes between nodes are established through Route Request or 'RREQ' and Route Reply or 'RREP' messages. The AODV protocol is implemented in two stages. The route finding step is the first action item. The RREQ messages are sent to nearby nodes in this step when a node has data to send to another node. The latest sequence number known to the destination node is contained in the RREQs. After receiving the RREQ message, every node builds a backward path to reach the source node. The number of hops and the most recent sequence number that the source node is aware of are included in the RREP message that is sent by the destination node once it receives the message [5]. Every intermediate node verifies if the packet that was sent was meant for them. That node is the destination node if it is. The RREP packet is then produced by this node. [1].

The route maintenance phase is the following procedure. When the route is active, a Route Error (RRER) message is generated and forwarded to the source node in the event of a link breakdown. The source node is notified by this message that the destination cannot be reached. After then, the route finding procedure is restarted. AODV requires fewer overheads and can be used for both unicast and multicast routing. However, because network traffic is reactive, RREQ and RREP packets may cause issues [6].Another reactive routing technology that uses source routing as its foundation is DSR. The transmitted packet in source routing needs to contain the entire address from the source to the destination [7].

The protocol operates in two stages, similar to AODV: route discovery and route maintenance. The source node initially searches its cache for the destination's route. It transmits the RREQ message if the route is absent. The RREQ has a list of every node it has passed through. An intermediary node examines this record to determine whether the message has previously been recorded there in order to avoid network loops. The RREQ message will be dropped if the node has already received it [1]. An RREP message is delivered back to the source node once the message has arrived at its destination. An RRER message is generated and the route discovery process is restarted in the event of a link breakdown, such as in AODV [6].

III. MANET APPLICATIONS

Mobile Ad hoc Networks (MANETs) are flexible and decentralised networks with applications in many different sectors. When fixed infrastructure is either unavailable or corrupted, soldiers can interact and share information in dynamic and dangerous surroundings thanks to MANETs in combat circumstances. MANETs are useful for disaster relief efforts because they allow victims and rescue teams to communicate in places where communication infrastructure is either nonexistent or destroyed. Vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication is made possible by MANETs in vehicular networks, which improve traffic management and road safety. They are also used in sensor networks, which are made up of nodes that assemble and disband on their own to gather and transmit data in hostile or isolated locations.

In smart cities, MANETs are used for effective management and monitoring of the urban infrastructure, such as energy distribution, environmental monitoring, and transportation. Additionally, MANETs facilitate cooperative applications that let users share resources and work together without the need for established infrastructure in conferences, exhibitions, and schools. Within the healthcare industry, MANETs facilitate the establishment of transient networks to facilitate communication between medical staff and the transfer of patient information in case of emergencies or at remote locations. In IoT (Internet of Things) contexts, where devices connect wirelessly without depending on centralized infrastructure, MANETs are especially useful for applications like industrial automation and smart homes.

IV. SIMULATION ENVIRONMENT

A controlled experimental setup has been used to run the simulation and obtain the required results.

A. Virtual Environment

To run the simulation environment, Ubuntu OS is used. Ubuntu virtual environment in VMware provides users with a flexible and efficient way to run Ubuntu Linux on their systems without needing dedicated hardware. This setup enables developers, system administrators, and enthusiasts to test software, experiment with configurations, and deploy applications in a controlled environment. It is one of the preferred Linux environments to run the NS-3 network simulation tool.

B. Simulation Tool

NS-3 (Network Simulator 3) is a widely used discrete-event network simulator designed to model network systems and protocols accurately. It provides a robust platform for simulating complex networking scenarios, offering a rich set of features for research, development, and education. NS-3 supports various network technologies and protocols, including IPv4, IPv6, TCP, UDP, Wi-Fi, LTE, and more. With its modular architecture and extensive documentation, NS-3 facilitates experimentation and analysis in networking research, enabling users to evaluate performance, conduct simulations, and validate algorithms in diverse networking environments.

V. SIMULATION METRICS

Throughput: Throughput is a measure of the rate of successful message delivery over a communication channel. It is calculated in kilobits per second (kbps) and represents the amount of data received per second.

Packet Reception: This metric provides insight into the reliability of message delivery in the network. Each time a packet is received by a node, information about the packet reception event is logged, including the timestamp, node ID, and sender address.

Transmission Power: Transmission power refers to the strength of the signal transmitted by wireless devices. In the code, the transmission power is set to a specific value (e.g., 7.5 dBm).

VI. RESULTS

Below are the graphical interpretations of the obtained results using Python libraries like Matplotlib and Gnuplot. After running the simulation code of each protocol, we obtain the following files.

A. Throughput Results

The calculated throughput, along with other relevant information such as the simulation time (every 1 second), the number of packets received, the number of sink nodes, the routing protocol used, and the transmission power, is written to a CSV file.

B. Flowmon File

The .flowmon file contains details about flow-level statistics collected during the simulation. Flow-level statistics typically include information about packet flows between nodes in the network like Delay, Jitter, Packet Loss, etc.

C. Mobility Tracing

The .mob file contains information about the mobility of nodes within the network during the simulation. It records the movement patterns, positions, and velocities of each node over time. This information can be visualized using network simulation tools.

The results from these files are utilized to perform graphical analysis both on throughput and flow-level statistics.

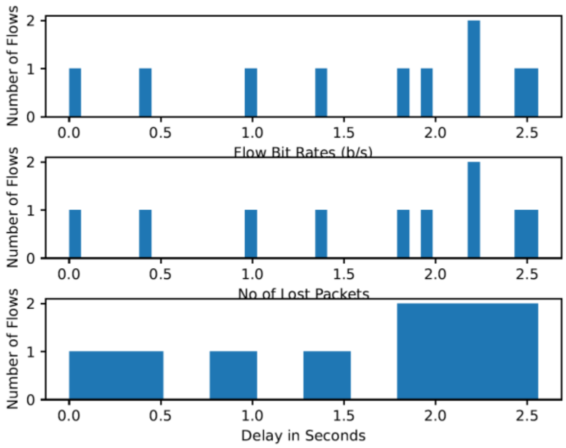

Fig.6.1. AODV

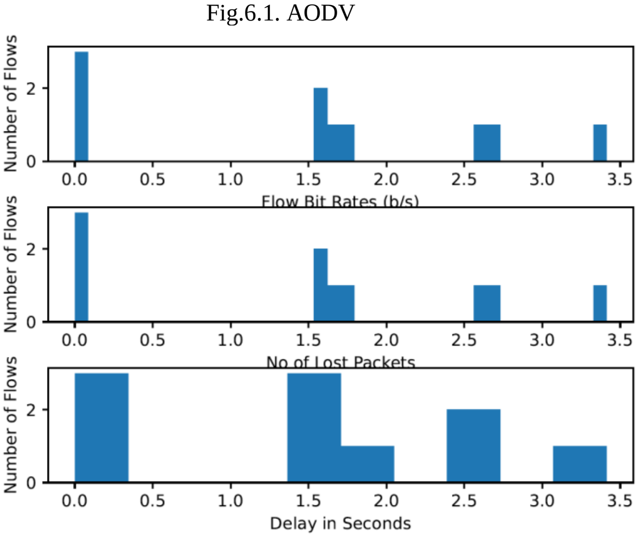

Fig.6.2. OLSR

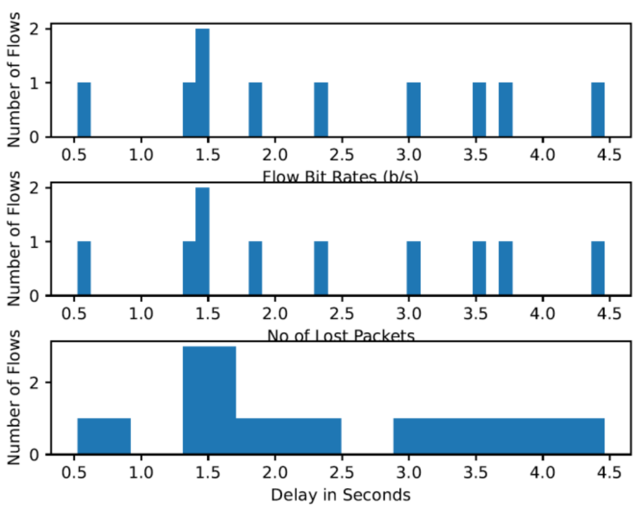

Fig.6.3. DSDV

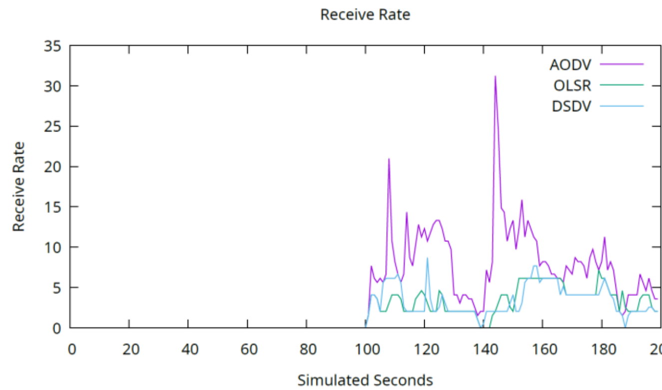

Fig.6.4. Combined Receive Rate Analysis

EVALUATION METRIC	AODV	OLSR	DSDV
Average Throughput (kbps)	Highest	Lowest	Lower than AODV
Packet Loss	1%-5%	0.5%-3%	1%-5%
Delay (in seconds)	0.1-0.5	0.05-0.3	0.1-0.5
Transmission Power (in dBm)	Set to 7.5 dBm	Set to 7.5 dBm	Set to 7.5 dBm

Table.6.1. Performance Comparison of MANET Routing Protocols

VII. CONCLUSION

From the insights from the obtained graphs, it is concluded that AODV, with its reactive approach, demonstrates agility in dynamic environments but may incur higher routing overhead during route discovery. OLSR, being proactive, offers lower latency and stable routes but may suffer from increased overhead in large-scale deployments. DSDV, although less commonly used, provides stability in relatively static networks but may struggle with rapid topology changes. Factors such as node mobility, network size, traffic patterns, and application demands play a critical role in protocol selection.

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