ACADEMICIA

ISSN: 2249-7137 Vol. 11, Issue 10, October 2021 Impact Factor: SJIF 2021 = 7.492

ACADEMICIA
An International Multidisciplinary Research Journal
(Double Blind Refereed & Peer Reviewed Journal)

DOI: 10.5958/2249-7137.2021.02188.1

MOBILE AD-HOC NETWORK (MANET) ROUTING PROTOCOLS: A COMPARATIVE ANALYSIS

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ABSTRACT

Routing in a Mobile Ad-hoc Network (MANET) is a dynamic and difficult problem that has gotten a lot of attention from academics all over the world. To address this issue, a variety of routing classes have been developed, and the number continues to grow exponentially day by day. It's difficult to predict which protocols or routing classes would perform well in a variety of network situations, such as network volume and topology. We provide an overview of a vast number of current routing classes in this paper, with an emphasis on their uniqueness and usefulness. In addition, the judgment is based on the routing capability, and data is utilized to construct routing decisions. There is also a discussion of all of the routing protocols or classes. Furthermore, this research will aid academics in compiling a list of current classes and recommending which protocols would perform better in certain network situations.

KEYWORDS: *Ad-hoc Network, Delay, MANET, Mobile Ad-hoc Network, Routing protocol.*

1. INTRODUCTION

In the modern era, one of the most notable fields for study and growth of the wireless network is mobile ad-hoc networks (MANETs). As the MANET popularity grows, so does its use. In the wireless network, it has now become one of the most energetic and athletic communication areas. MANETs are self-configuring, decentralized networks with minimal infrastructure[1]. There are no requirements for these nodes to join the network or depart. Nodes may move around freely and often alter their connections with other devices or nodes. Because of the wireless networking environment, MANET offers a routable method for transferring packets from one node to another. Mobile Ad-Hoc networks are characterized by the absence of physical infrastructure and are highly dynamic[2]. Mobile Ad-Hoc Network's functionality uses routers to discover and maintain routes. Nodes in such networks may move and communicate with one other. MANET nodes function as both hosts and routers, forwarding packets to intermediate nodes, and have the unique ability to self-configure and self-club, allowing it to quickly create a new network. Because such networks are quick and simple to set up, they may be used in military applications, disaster recovery, and other situations when physical infrastructure is lacking.

MANETS are used for a variety of applications, ranging from commercial to private sector to military and emergency response. Business applications, military applications, emergency operations, home, office, educational applications, and wireless sensor networks are just a few of the significant MANET applications[3], [4]. The main problems with Ad-hoc routing protocols are the routing method to be employed, which is either unicast or multicast routing, dynamic network topology, which changes when mobile nodes travel from one BSS to another, and mobile node speed. Quality of Service (QoS) is another critical MANET performance characteristic for traffic flow management. Other issues with MANETs include frequency of updates or network overhead, scalability, and security. Routing based on mobile agents, energy efficient/power-aware routing, and secure routing.

Section 1 is an introduction to MANET, Section 2 is a literature review, Section 3 is a discussion of MANET features as well as a comparison of various routing protocols in MANET, and Section 4 is the conclusion.

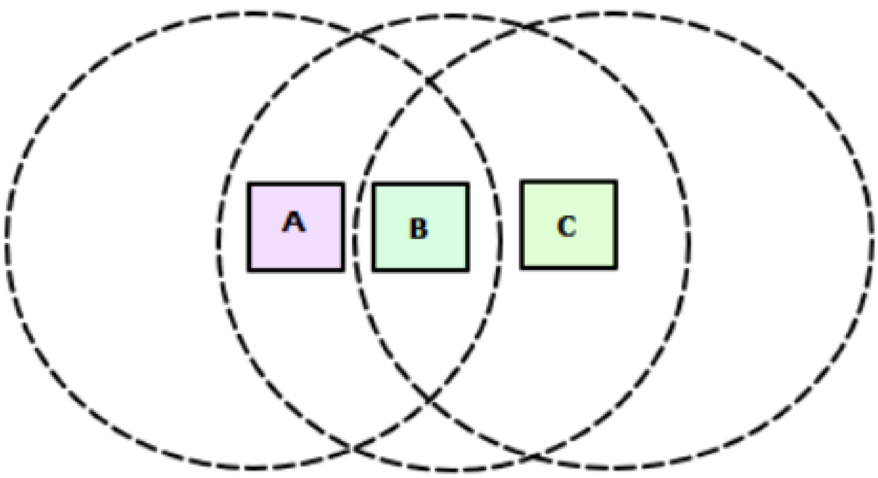

Fig. 1: A Mobile Ad-hoc Network (MANET)

2. LITRATURE REVIEW

The present concept in the area has been evaluated using several pieces of important literature in the subject of MANET routing protocols. Maghsoudlou et al. investigated unlike face routing algorithms, dissimilar face routing strategies, and greedy routing algorithms in the context of the MANET geographical routing protocol[5]. The geographic routing protocols, according to the authors, are based on greedy forwarding, in which data is delivered to the target's closest node, although the data may be tainted at times. If there isn't an immigrant node in close proximity to the target. The authors also suggested ways to enhance recovery strategies, concluding that the most frequent method for recovering from the void state is the faced routing algorithm, which employs planner graphs.

AODV, DSR (reactive), and DSDV (proactive) routing protocols were evaluated by Arora et al[6]. These are calculated using the Packet Delivery Ratio, a typical end-to-end latency under various mobility models with variable mobile speeds. These routing methods are efficient and quantifiable. Network Simulator-2 (NS-2) is used for simulation. When it comes to mobility, AODV outperforms DSR and DSDV. AODV has a high packet delivery ratio in both random walk and random direction. However, the AODV protocol had a very long end-to-end latency. As a result, DSR outperforms AODV and DSDV in both the random walk and random direction mobility models.

In this paper, Khan J. et al. not only review the efficiency of ad-hoc routing protocols in order to determine their accuracy, effectiveness, traffic load, and end-to-end delay in an energetic intermediate nodes scenario, but they also use the OPNET simulator to test the AODV and DSR routing classes[7]. Instead of separate presentations of both AODV and DSR routing classes and also in intermediate nodes data transport rate from source to target, the author proposes using the Opnet simulator to observe performance with respect to different parameters that changes mobility models have a significant effect on the overall performance of both AODV and DSR routing class could be the most excellent solution in MANET.

Sllameet al. used the simulation program OPNET modeler 14.5, to compare MANET routing protocols such as GRP, AODV, OLSR, and DSR on the basis of end-to-end latency, network load, retransmission attempts, and throughput[8]. The authors discovered that AODV and DSR work better than other protocols. When AODV and DSR are compared to other protocols, the throughput of AODV and DSR is higher, and the latency of AODV is lower.

Menon et al. looked at how various geographic routing methods performed in high mobility situations[9]. The performance of various geographic routing protocols was compared using performance measures, and the advantages and demerits of these protocols were stated using these performance criteria. The various parameters involved in designing and selecting a routing protocol were addressed by the authors.

Using the simulation tool NS2, Aggarwal et al. compared different geographic routing protocols such as Location-aided routing, Greedy perimeter stateless routing, and Energy-aware geographic routing on performance metrics such as system lifetime, end-to-end delay, packet delivery ratio, and energy utilization[10]. When the topology varies dynamically and mobility is high, the authors found that geographic routing provides a higher packet delivery ratio, better energy usage, and longer network lifespan than other protocols.

3. DISCUSSION

3.1. Characteristics of MANETs:

Because of the many network constraints, designing a routing protocol for MANET is difficult. MANET has had to deal with a variety of network resource constraints, including as energy, bandwidth, processing, and storage. The following are the major elements of difficulties in sensor networks.

3.1.1. Dynamic Topology:

The topology of the network changes unexpectedly since nodes are free to migrate in any direction.

3.1.2. Limited Bandwidth:

Wireless network bandwidth is often lower than that accessible on wired networks. Due to different disturbances and fading effects, the throughput of these networks is usually poor.

3.1.3. Energy Constrained Operation:

The nodes are battery-powered gadgets that may be carried around. This is the MANET's most significant design factor.

3.1.4. Security:

Threats are more common on wireless networks than on wired networks. The heightened risk of different security threats such as eavesdropping and Denial of Service (DoS) must be properly managed. MANET performance is determined by the routing protocol and the node's battery usage. Various quality of service characteristics, such as bandwidth delay, jitter, and throughput, have an impact on performance. Because the bandwidth supplied to the nodes at one moment in time becomes unavailable if the nodes migrate from one location to another, dynamic topology routing is a significant challenge for these networks. Routing also has an impact on the performance of these networks. As a result, an effective routing protocol must be designed to address all of these issues. On the basis of route discovery, MANET routing protocols are divided into three categories: (i) reactive, also referred to as on-demand routing protocol, (ii) proactive, also referred to as table driven protocol, and (iii) hybrid protocol. Routing protocols are further classified as flat-based, hierarchical-based, or location-based on the basis of network structure. All nodes in a flat-based protocol are equal, which means they all perform the same function in the network. Various nodes perform different functions in hierarchical protocols, and different cluster leaders are selected among cluster members. Nodes in a location-based protocol depend on and communicate with each other using location information.

3.2. Routing Protocols for MANET:

Routing is the process of moving data from a source point to a destination point inside a network. At least one intermediary node in the network is contacted throughout this procedure. The concept of routing essentially entails two activities: first, finding the best feasible routing routes, and second, moving data across a network. There are two kinds of routing: static routing and dynamic routing. The term "static routing" refers to a manual routing strategy. The administrator maintains a routing table in static routing. The state is the most important factor in dynamic routing. Dynamic routing is available in mobile ad hoc networks. As illustrated in Fig. 2, these procedures may be classified into three categories: proactive, reactive, and hybrid. This categorization of routing protocols is based on their route discovery techniques, such as hop count, link status, and QoS. In the hop count approach, each node's routing table includes information about the next hop to the destination. While link state routing protocols maintain a routing table for absolute topology, which is built up by determining the shortest route of link costs, link state routing protocols preserve a routing table for relative topology. QoS routing is the process of choosing the route that a flow's packets will take depending on its QoS criteria, such as bandwidth, latency, and so on.

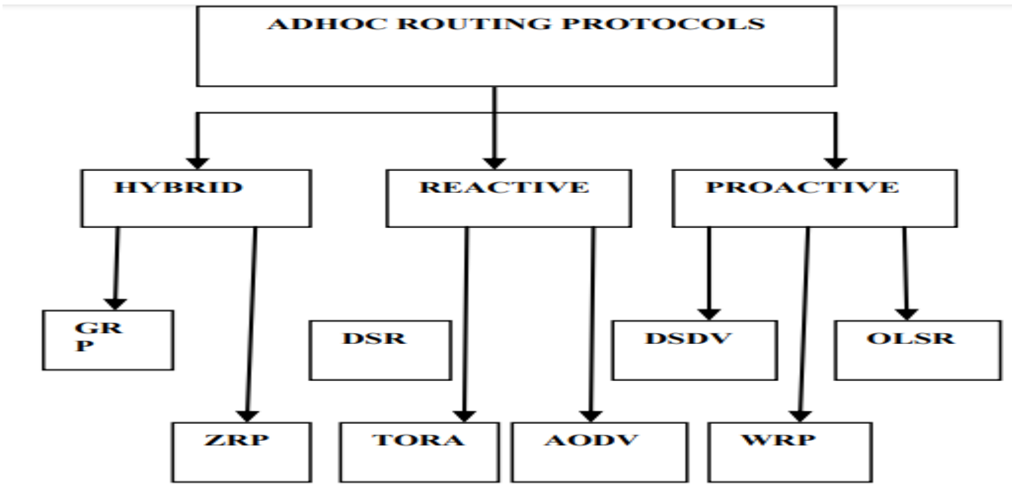

Fig. 2: Illustrates Routing Protocols in MANET

3.2.1. Proactive Routing Protocol:

Each ad hoc node in table-driven routing protocols has a topology table that includes the most up-to-date information about network node interactions. The proactive protocols are also known as table-driven since this table is constantly updated. Each node maintains one or more routing tables, which are regularly exchanged in order to communicate topological information with other nodes and keep a consistent network picture. A transmission will occur without delay if a route has already been established before traffic arrives. Otherwise, traffic packets should wait until the node gets routing information for their destination. Wireless Routing Protocol (WRP), Destination-Sequenced Distance Vector (DSDV), and Optimized Link State Routing (OLSR) are just a few of the proactive routing technologies available.

- *Destination-Sequenced Distance Vector (DSDV):*

Perkins and Bhagwat designed the DSDV protocol, which is a proactive routing class. The DSDV routing class stands for Destination-Sequenced Distance Vector. The Routing Protocol Class is based on the Bellman-Ford Routing Algorithm's concept, but with significant enhancements such as making it loop-free. Due to issues such as count to infinity and bouncing outcomes, the distance vector routing class is less resilient than the link state routing class. Each system maintains a routing-related database that contains entries for all of the network's policies. To maintain the routing table completely rearranged at all times, each device sends various routing communications to its neighbours on a regular basis. When a neighbour device gets the sender's broadcasted different routing message and knows the device's current relation cost, it compares this value to the associated value stored in its routing database.

- *Optimized Link State Routing (OLSR):*

OLSR is a proactive class that uses multipoint relaying, a competent link state packet forwarding system. The clean link state routing class is optimized. Optimizations may be accomplished in two ways: first, by decreasing the amount of control packets, and second, by tumbling the number of associations utilized for promoting link state messages. As you may know, each node maintains the network's topology information by regularly replacing link state communication among the other nodes. The three processes that make up the OLSR routing class are neighbour sensing, capable flooding, and calculating an optimal route utilizing a variety of shortest-path algorithms. Neighbour sensing is the assessment of changes in the node's immediate vicinity. Using this topological knowledge, each node determines the optimal route to every known destination and records it in a routing table. The most constructive route is then calculated using the shortest path method. When data broadcasting starts, routes to all destinations are immediately accessible and stay so for a certain amount of time until the information is finished.

- *Wireless Routing Protocol (WRP):*

The Wireless Routing Protocol is a table-based protocol that replaces the Bellman-Ford Algorithm's assets. It belongs to the DSDV class. The primary goal is to preserve routing information about the quickest route to each destination among a variety of nodes in the network. WRP (Wireless Routing Protocols) is a class of loop-free routing protocols. WRP is a path-searching method that avoids the count-to-infinity catastrophe by requiring each node to do consistency checks on all of its neighbours' precursor information. Each node in the network has a set of four tables that provide more detailed information. The distance table (DT), routing table (RT), link-cost table (LCT), and message retransmission list (MRL) tables are the ones to look at. In the event that a connection between two nodes fails, the nodes start new communications to their neighbours. With one notable exception, WRP belongs to the class of path-finding algorithms. It overcomes the count-to-infinity problem by requiring each node to perform consistency checks on all of its neighbours' precursor information. This eliminates looping situations and allows for faster route convergence in the event of a connection breakdown.

3.2.2. Reactive Protocols:

On-demand routing protocols do not always replace routing information, but instead rely on flooding to acquire data when it is necessary for a node to transmit a data packet. A route request is broadcast to all nodes in the network by the host node that needs to broadcast packets to a network destination. Before sending packets, the host node will wait for the network nodes to respond with a route to the destination. During the route finding process, they construct a route. Route request packets are flooded across the network, beginning with the source's near neighbours. The route discovery procedure is completed after a route is created or several paths for the destination are discovered. A route maintenance procedure ensures that the route remains stable for the duration that it is required from the source. DSR, AODV, and TORA, for example, are examples of source-initiated routing protocols.

- *Ad hoc on-demand Distance Vector (AODV):*

The AODV routing class is a key component of the Reactive protocol, and it constructs routes using a route request/route reply query sequence. A source node sends a route request (RREQ) packet to the network when it seeks a route to a destination for which it does not already have a path. Nodes receiving this packet update their information for the source node and create backward references in their route tables to the original node. The RREQ contains the most recent series number for the target for which the source node is alert in addition to the source node's IP address, current series number, and broadcast ID. If a node receiving the RREQ is either the target or has a route to the destination with an equivalent series number higher than or equal to the one limited in the RREQ, it may send a route reply (RREP). It unicasts an RREP back to the source node if this is the case; otherwise, it retransmits the RREQ. Nodes save the source node IP address of the RREQ and broadcast the ID of a better route. If they get an RREQ that they have previously completed, they reject it and do not continue with it. The route will be maintained as long as it remains active. A route is considered energetic if data packets are moving from source to destination at some point along the route. The connections will time out and eventually be removed from intermediate node routing tables once the source node stops transferring data packets. If the source node still wants a route after getting the RERR, it may restart route discovery.

- *Temporally Ordered Routing Algorithm (TORA):*

The routing class Temporally-Ordered Routing Algorithm (TORA). Park and Corson came up with the idea. The Temporarily Ordered Routing Algorithm (TORA) is a kind of discrete routing algorithm that is genuinely adaptive and loop-free. It is based on the notion of connection turnaround. It explains the pathways either upstream or downstream using directed acyclic graphs (DAG). To provide this capability, TORA requires node synchronization, which limits the protocol's functionality. TORA routing class is a fairly complicated protocol, but its primary feature of broadcasting manage messages just around the point of crash when a connection stoppage occurs makes it distinctive and essential. When a link fails in the evaluation, all other protocols must re-initiate route detection, but TORA would be able to patch itself up around the point of failure. TORA can scale to larger networks thanks to this feature, although it has a greater overhead for smaller networks. TORA is responsible for four essential operations: route creation, preservation, removal, and optimization. Because every node must have a height, any node that does not has one is considered a deleted node, and its height is null. To improve the connecting structure, nodes are sometimes given additional heights. This is referred to as route optimization.

- *Dynamic Source Routing (DSR):*

DSR is one of the most pure instances of an on-demand routing system based on the source routing idea. It was created with multi-hop ad hoc networks of mobile nodes in mind. It enables the network to self-organize and configure itself without the requirement for any existing network infrastructure or management. DSR, unlike AODV, does not send frequent routing messages, reducing network bandwidth overhead, conserving battery life, and avoiding massive routing changes. Instead, DSR requires MAC layer assistance to detect connection failure. Route Discovery and Route Maintenance are two methods in DSR that operate together to enable nodes to find and maintain source routes to arbitrary destinations in the network. By virtue of source routing, DSR has a distinct benefit. Routing loops, whether short or long-lived, cannot develop since they can be identified and removed instantly because the route is part of the packet itself. This feature allows for a number of helpful protocol improvements. The shortest route is not guaranteed by either AODV or DSR. The first route may be the shortest if the destination can only respond to route requests and the source node is always the route request initiator.

3.2.3. Hybrid Routing Protocol:

The hybrid routing protocol is divided into two types. The first is a proactive class, while the second is a reactive class. Proactive and reactive routing methods are combined in hybrid routing systems. Both proactive and reactive routing methods have benefitted from hybrid routing protocols. Because the first nodes contain tables, it acts like a proactive routing protocol. When nodes realize they don't have any routes to target, they begin route discovery and operate as reactive routing protocols. ZRP is the hybrid protocol. Zone Routing Protocol is a protocol that combines the advantages of both methods (ZRP). Each node in ZRP has a zone surrounding it that contains all of its neighbours. If the destination node's location is inside the source's zone, proactive routing is used; otherwise, reactive routing is used.

- *Zone Routing Protocol (ZRP):*

Zone routing class was proposed by Haas and Pearlman. ZRP It's a hybrid routing class for mobile ad hoc networks that divides nodes into smaller networks (zones). It has the characteristics of both on-demand and proactive routing classes. Proactive Networks limit nodes into sub-networks within each zone (zones). It combines the benefits of reactive and on-demand routing methods. Within each zone, the proactive routing class is changed to improve communication in areas where neighbours are present. To minimize needless communication, the inter-zone interaction employs on-demand routing classes. According on the distance between mobile nodes, the network is divided into routing zones. Given a hop distance d and a node N, all nodes within a communication hop distance of at least d from N are included in N's routing zone. N's peripheral nodes are the nodes in its routing zone that are precisely d hops distant from N. One of the most difficult aspects of zone routing is determining the zone's size. Independent Zone Routing (IZR), a superior zone routing system that allows adaptive and flexible reconfiguration of the zone's decreased size, is presented. Furthermore, the IZR class's adaptive nature improves the ad hoc network's scalability. Each node is seldom interested in updating the zone's routing information. Additionally, each node does some limited route optimization, which includes the following actions: removing unnecessary routes, shortening routes, and detecting connection failures.

3.3. Comparison:

Comparison of Routing Protocols in MANET are illustrated in Table 1 below.

TABLE 1: COMPARISON OF ROUTING PROTOCOLS IN MANET

Parameter	DSDV	WRP	OLSR	AODV	DSR	TORA
Routing structure	FLAT	FLAT	FLAT	FLAT	FLAT	FLAT
Routing overhead	HIGH	HIGH	LOW	HIGH	HIGH	HIGH
Caching overhead	MEDIUM	HIGH	HIGH	LOW	HIGH	HIGH
Throughput	LOW	LOW	HIGH	HIGH	LOW	LOW
Loop Free	YES	YES	LOW	YES	YES	YES

4. CONCLUSION

This article explained how to classify various routing systems based on their routing approach. Some key features of the three routing methods, such as reactive, proactive, and hybrid protocols, were addressed. There are a few distinctions between them, as seen in Table 1. In this article, an attempt has been made to focus on a comparison of DSDV, AODV, DSR, TORA, OLSR, WRP, and DSDV. Furthermore, since a single routing protocol cannot perform optimally in all circumstances, routing protocol selection should be based on the needs of the particular application. Our future research effort will concentrate on proposing an extension of current conventional routing protocols that will be superior in terms of security, throughput, efficient resource usage, and service quality.

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