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Routing Protocols Terminology and Challenges in MANETs

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ABSTRACT:

Mobile ad hoc networks (MANETs) are dynamic and self-configuring networks that do not rely on a fixed infrastructure. Routing protocols play a crucial role in establishing efficient communication paths in MANETs. This paper explores the terminology and challenges associated with routing protocols in MANETs. Various routing protocols, such as AODV, DSR, and OLSR, are discussed along with their advantages and limitations. The unique characteristics of MANETs, such as node mobility, limited battery power, and dynamic network topology, present significant challenges for routing protocol design and implementation. This paper aims to provide a comprehensive understanding of the terminology and challenges surrounding routing protocols in MANETs to aid researchers and practitioners in developing more robust and efficient solutions for mobile ad hoc networks.

Keywords: MANETs, Static & Dynamic Routing, Routing Procedures, Ad-hoc Network.

1. INTRODUCTİON

In the 1970s, the concept of Mobile Ad-hoc Networks (MANETs) originated primarily for military purposes, providing agile and adaptable communication networks in dynamic battlefield scenarios. Over time, the efficiency and versatility of MANETs have caught the attention of experts in various fields beyond the military. Today, MANETs are widely recognized and utilized across industries, including computing, education, meetings, conferences, emergency situations, disaster relief, and automated processes in challenging environments where building traditional infrastructure is difficult or costly.

MANETs, as depicted in Figure 1, are decentralized wireless networks comprising mobile nodes that interact and communicate through wireless links without the need for centralized supervision. This self-organizing nature allows for flexible and efficient network setups, making them ideal for diverse applications across different sectors [1].

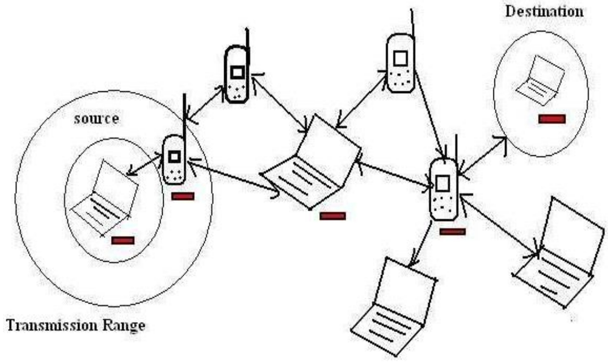

Figure. 1 Mobile Ad-hoc Network

In MANETs, communication occurs without the need for underlying infrastructure. Nodes within a specific communication range can exchange information packets directly or through multi-hop relay, forwarding data packets through other nodes if the destination node is out of the direct communication range of the source nodes. This dynamic and adaptable relay mechanism enables effective data transmission in scenarios where direct communication paths are unavailable. [2]. The distinctive attributes and specific challenges inherent in Mobile Ad-hoc Networks (MANETs) present significant obstacles in achieving efficient routing and necessitate the development of new protocols or enhancements to existing routing algorithms to operate effectively in the complex and dynamic environment of MANETs. These challenges require innovative solutions that can address the inherent complexities and uncertainties of routing in MANETs to ensure reliable and efficient communication across the network. [3].

2. Protocols Taxonomy in MANETs

Routing involves the process of transferring information from a message source to a designated destination host. In networking, routing protocols establish effective communication paths among various available options for transmitting information packets. The routing practices within Mobile Ad-hoc Networks (MANETs) can typically be classified into two main categories: static routing protocols and dynamic routing protocols. Static routing entails predetermined paths for data transmission, while dynamic routing protocols dynamically adjust communication paths based on real-time network conditions and node movements within the MANET environment. This distinct routing behaviour's cater to the diverse requirements and challenges encountered in MANETs, ensuring efficient data transfer across the network. [4-6].

The terminology of static routing requires manual configuration efforts to input routing information into the routing table. Extensive research has highlighted that this manual approach is not ideal for MANETs due to the need for ongoing administrative efforts to manually update routing tables when network changes occur, such as router join or detachments. Dynamic routing protocols address the limitations of static routing by automatically updating routing table information without manual intervention. In dynamic routing, each routing device periodically broadcasts its presence in the network through information packets, allowing other devices to stay updated on network changes, including the addition or removal of routing devices. Since the inception of MANETs, researchers have proposed numerous routing protocols to enhance network efficiency and adaptability in dynamic environments. [6,7]. An effort can bebroadly categories under three foremost type (Fig. 2).

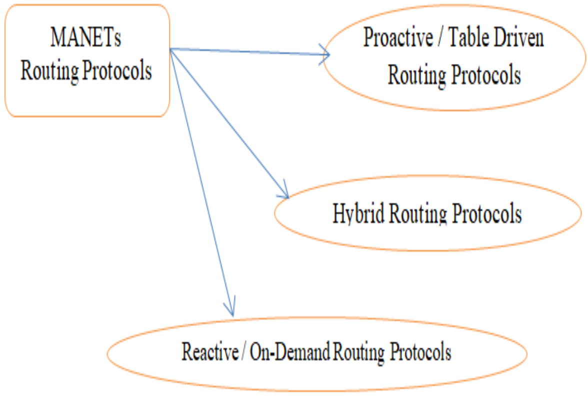

Figure. 2 Routing Protocol Classes in MANET

Proactive Technique: The proactive routing technique, also known as table-driven routing, involves storing information about all connected hosts in the network within a table. This method maintains routes to all destinations and ensures that any changes are communicated to other hosts. Nodes need to periodically send control messages to update route information accurately. However, the drawback of this approach is its high consumption of network bandwidth. Examples of proactive routing protocols include DSDV, OLSR, FSR, STAR and WRP. These protocols aim to efficiently manage routing information and maintain network connectivity in proactive routing environments.

Reactive Technique: In response to the challenges posed by proactive routing protocols, a different class of protocol known as reactive or on-demand routing protocols was developed. This approach establishes communication links between nodes only when a host in the network requires a path to transmit information. By implementing this on-demand strategy, the protocol minimizes network bandwidth consumption, thereby improving the efficiency of network routing processes. Routing protocols such as AODV, DSR and are examples of protocols that belong to this category, offering flexible and efficient routing solutions in dynamic network environments.

Hybrid Routing Protocol: The hybrid routing protocol combines features of both reactive and proactive routing protocols, aiming to optimize network performance by minimizing overhead and delays in route discovery processes. This approach divides network hosts into distinct zones to enhance routing efficiency and network reliability. The Zone Routing Protocol (ZRP) exemplifies this hybrid approach, offering a synthesis of reactive and proactive elements to address the diverse requirements of dynamic network environments efficiently.

Table1. Proactive Vs Reactive Vs Hybrid Routing Protocol [5]

S. No.	Proactive Protocols	Reactive Protocols	Hybrid Protocols
1.	A Table-Driven Steering Scheme is a type of routing protocol where each host in the network maintains one or more tables to store routing information.	On-demand routing scheme. Do not maintain routing info in-fact they send info in an on demand.	Combine Functionality, Table Driven & on- demand routing scheme.
2.	Minimum Delay	Higher Delay against to proactive steering practices.	Balanced Delay.
3.	In a no flooding scenario, the scheme's ability to maintain real-time routing information in tables allows for rapid identification of nodes present in the network.	Perform flooding process during route searching practices.	As hybrid routing protocols incorporate properties of both proactive and reactive approaches, they do not rely on flooding to disseminate information throughout the network.
4.	Need higher bandwidth requirement.	Need lower bandwidth requirement.	Need medium bandwidth requirement.
5.	Low latency in data transmission refers to the minimal time taken by data packets to travel from one point to another within a network.	High latency in data transmission signifies an increased duration for data packets to travel from one destination to another within a network.	The combination of low internal latency and high external latency in this protocol stems from its ability to exhibit characteristics of both proactive and reactive routing approaches
6.	Routing Overhead in proactive routing protocols refers to the phenomenon where routing packets and data packets compete for the same available bandwidth, leading to an increase in overall network traffic.	In reactive routing protocols, the Routing Overhead, which occurs when both routing packets and data packets contend for the same bandwidth, is typically low.	Routing Overhead, defined as the situation where routing packets and data packets share the same bandwidth, resulting in route overhead, is typically considered medium in hybrid routing protocols.

3. Related Efforts

In a study referenced as [7], researchers examined the performance of traditional routing schemes within Mobile Ad Hoc Networks (MANETs). Through a series of simulations using various parameters, the authors specifically compared the performance of the AODV routing scheme with other existing algorithms. The results of the simulations pointed towards the superior and more suitable nature of the AODV routing algorithm for MANETs. However, the study also highlighted certain drawbacks of the AODV routing scheme, such as high overhead, significant energy consumption in large networks, and the use of a flooding process necessitating modifications [8]. A novel approach called QAS-AODV was proposed in [9] to address energy consumption issues. This method focuses on selecting an alternate node promptly, ensuring neighbor connections with higher energy-level nodes, and leveraging these nodes for packet forwarding. It also prioritizes network connectivity and maintains node energy levels above certain thresholds to reduce packet loss. The success of this method was supported by assessment results. Furthermore, in [10], an enhanced version of the AODV routing protocol was introduced to achieve greater efficiency. This approach, based on hop AODV, node mobility speed, and communication state, alters the route discovery and selection process of the AODV protocol based on the number of hops and utilizes low-speed nodes for forwarding RREQ packages within the network. The system also leverages data packets from neighboring nodes to monitor, control, and maintain link quality. Experimental results demonstrated the advantages of this approach over traditional AODV routing algorithms in terms of improved packet transmission rates, reduced control overhead, and minimized end-to-end delays.

Numerous researchers have proposed various algorithms aimed at enhancing the efficiency of routing protocols [11-18]. These solutions typically focus on improving routing performance under different constraints, with a predominant emphasis on discovering and maintaining accurate route information. However, many of these proposed approaches rely on backbone routing paths that can increase overhead and consume significant bandwidth and node power during communication. Additionally, the diverse terrains encountered in the highly dynamic environment of Mobile Ad Hoc Networks (MANETs) present unique challenges to effective routing. As such, ongoing efforts to optimize routing protocols in MANETs must carefully consider these factors to achieve optimal performance.

4. Unified Problems with Attainable Routing Protocols of MANETs

The constantly changing network topology in Mobile Ad-hoc Networks (MANETs) presents significant challenges for researchers in developing efficient routing algorithms. Some of the prominent issues in MANETs routing protocols include the following challenges and limitations:

1. The dynamic nature of MANETs leads to frequent reshaping of the network topology, posing challenges for the implementation of effective routing algorithms.
2. Common issues include difficulties in maintaining stable communication paths, managing bandwidth effectively, and overcoming routing inefficiencies due to the ever-changing network structure.
3. Researchers face the challenge of adapting routing protocols to the high mobility and connectivity fluctuations inherent in MANETs, requiring innovative solutions to address these complexities.
4. Many steering procedures are only effective in networks with a low number of hosts.
5. Common practices involve flooding processes to establish communication paths between nodes, resulting in high bandwidth consumption and prolonged end-to-end delays.
6. Proactive schemes are often hindered by limited routing information availability.
7. Reactive routing techniques can struggle to establish comprehensive paths between hosts due to frequent network partition occurrences.
8. Flooding methods are commonly used to establish links between network hosts, leading to significant bandwidth usage and delays.

9. Scalability can be an issue, as networks may transition quickly from sparse to dense configurations.

5. Conclusion

The research paper analyzed the features and challenges of routing algorithms specific to Mobile Ad-hoc Networks (MANETs). MANETs are a dynamic form of wireless communication networks where the network topology changes rapidly. Challenges such as maintaining link stability and routing efficiency arise due to the mobility and battery power constraints of mobile hosts in MANETs. Despite numerous routing approaches proposed over the years to address these challenges, researchers continue to introduce new algorithms to tackle the issues in this complex and ever-changing wireless communication environment. However, each algorithm has its own limitations, leaving room for further research and innovation in overcoming the high research challenges present in this field.

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