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Load Balancing Techniques in Multipath Energy-Consuming Routing Protocols for Wireless Ad hoc Networks in MANET: A Survey

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ABSTRACT

With the continuous advancement in technology, networking has evolved to adapt to recent trends. Mobile Ad hoc Networks (MANETs) have emerged as a technology that enables communication among a collection of mobile nodes without any central administering node. MANETs find applications in various areas, including communication and battlefields. However, MANETs face several challenges, such as load balancing, energy efficiency, packet loss, and connection failures. Among these challenges, routing in MANETs plays a critical role in defining network performance and connectivity capacity. Additionally, the energy consumption of mobile nodes, which are often battery-dependent and not easily rechargeable, poses a significant concern in MANETs. This paper explores different techniques aimed at addressing the issues of energy efficiency and load balancing in MANETs. Furthermore, a comparative analysis is provided to summarize the findings of the survey. The results of this study contribute to a better understanding of energy-efficient and load-balanced routing protocols in MANETs, facilitating the design and implementation of efficient networking solutions.

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INTRODUCTION

Mobile Ad hoc Networks (MANETs) are characterized by a group of independent mobile nodes (MNs) that rely on each other to establish communication in a wireless network. Unlike traditional networks, MANETs do not have a fixed infrastructure and instead operate in a self-configured manner. In this network, each MN is responsible for sending and receiving data to and from other nodes. When a node transmits data, it acts as a terminal node, while intermediate nodes function as routers, forwarding data from one node to another.

The basic architecture of a MANET[1] is illustrated in Figure 1. Due to the dynamic nature of MANETs, with nodes freely joining and leaving the network, there is no central control.

One of the key challenges in MANETs is the limited battery life of MNs, as they rely on battery power without the possibility of battery replacement[2]. Optimizing energy usage and managing power consumption is therefore crucial. MANETs enable connections between MNs at any location and time, and devices such as cell phones and PDAs typically have limited battery capacity.

To address the energy efficiency challenge, numerous protocols have been developed[3]. These energy-efficient protocols aim to minimize overall energy consumption in the network, thereby extending its lifetime. Energy-efficient protocols can be broadly classified into two types: Minimum Energy routing protocols and Maximum Network Lifetime routing protocols. Minimum Energy routing protocols focus on finding the most efficient route from the source to the destination node, considering energy consumption. On the other hand, Maximum Network Lifetime routing protocols aim to balance the remaining battery energy during the route selection process, ensuring the network operates efficiently over an extended period. Mobile nodes consume energy in various modes, including transmitting, receiving, idle/sleep, and the remaining energy.

In this paper, we explore the problem of energy efficiency and load balancing in MANETs. We investigate various techniques and protocols designed to optimize energy consumption and balance the workload among nodes. Additionally, we provide a comparative analysis to summarize the survey findings and identify areas that require further research and development. By understanding the energy-efficient and load-balancing aspects of MANETs, we can pave the way for designing more efficient and sustainable wireless networks.

Advantages of MANET:

- Easy and fast network establishment due to wireless connectivity.
- Network expansion from any location, providing flexibility.
- Increased reliability through multiple path routing.
- Dynamic network configuration, allowing nodes to join or leave without disrupting connectivity.

Applications of MANET:

MANET has a wide range of applications across various domains. Some of the key application scenarios are:

Sensor Network: MANET is used in home applications, health monitoring, weather monitoring, biological animal movement tracking, and more.

Entertainment: It finds application in organizations and campus settings, virtual classrooms, and wireless communications during meetings.

Emergency Services: MANET is utilized in search and rescue operations, disaster management, policing and firefighting, and supporting hospital management.

Tactical Networks: It is employed in military applications and the management of weapons in the battlefield.

Coverage Extension: MANET is used to extend the coverage and scalability of cellular networks and to connect the human body with the real world using the Internet of Things

(IoT).

Table 1: Applications of MANET

Application Scenario	Examples
Sensor Network	Home applications, Health Monitoring, Weather Monitoring, Biological Animal Movement, etc.
Entertainment	Organizations and campus settings, Virtual classrooms, Wireless communications during meetings.
Emergency Services	Search and rescue operations, Disaster Management, Policing and firefighting, In support of hospital management.
Tactical Networks	Military applications, Management of Weapons in battlefield.
Coverage Extension	Scalability procedure of cellular network access, Linking the human body with the real world by use of Internet of Things.

The paper is structured into sections that cover key aspects of energy efficiency and load balancing in MANETs. Section II discusses routing protocols, Section III focuses on energy-efficient routing protocols, Section IV explores load balancing, and Section V presents a survey of existing techniques in energy efficiency and load balancing. The organization of the paper ensures a comprehensive understanding of the topic and identifies research gaps and challenges in achieving efficient energy utilization and load balancing in MANETs.

ROUTING PROTOCOLS

Routing protocols play a crucial role in selecting the optimal route for data transmission in various networks, including MANET, Internet, and VANET. In MANET, routing becomes particularly challenging due to the dynamic nature of mobile nodes (MNs) and the frequent changes in network topology caused by their movement. Therefore, routing protocols need to adapt dynamically, ensuring energy efficiency, load balancing, and maintaining connectivity for effective communication among MNs. Routing protocols can be broadly categorized into three types based on their working approaches: table-driven routing protocols, on-demand routing protocols, and hybrid routing protocols.

A. Table-driven routing protocols, also known as proactive routing protocols, continuously update their routing tables in response to any topological changes in the network. These protocols maintain routing tables containing data about every node in the network, which is used for routing. The routing tables are also updated by neighboring nodes, ensuring accurate and up-to-date routing information. Examples of table-driven routing protocols include DSDV, WRP, and STAR.

B. On-demand routing protocols, also known as reactive routing protocols, dynamically establish routes based on the system's requirements. These protocols involve two main steps: route discovery and route maintenance. In the route discovery step, route-request packets (RREQ) are initiated from the source node and propagated through intermediate nodes. Upon reaching the destination, a route-reply packet (RREP) is sent back to the source node through the intermediate nodes. Examples of on-demand routing protocols include DSR and AODV.

C. Hybrid routing protocols combine elements of both proactive and reactive protocols to leverage their advantages. These protocols aim to reduce traffic overhead through proactive mechanisms while minimizing route discovery delay through reactive mechanisms. Examples of hybrid routing protocols include ZRP and BGP.

Fig.1 Classification of Routing Protocols

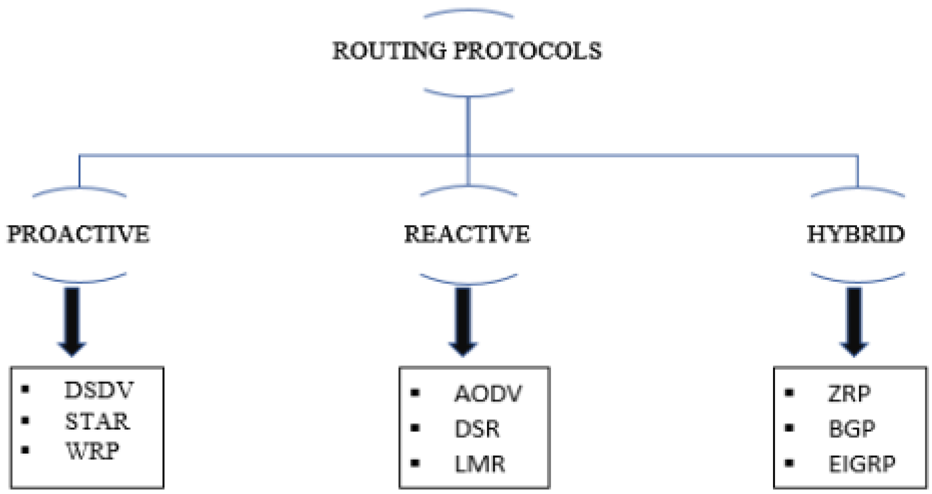


Figure 1 illustrates the classification of various routing protocols. It is essential to choose the appropriate routing protocol based on the specific requirements and characteristics of the MANET scenario.

In summary, routing protocols in MANETs play a critical role in establishing efficient routes for data transmission. Table-driven protocols ensure constant updates to routing tables, while on-demand protocols dynamically establish routes based on system requirements. Hybrid protocols combine the benefits of both proactive and reactive approaches. The choice of routing protocol depends on factors such as energy efficiency, load balancing, and the need for route discovery delay reduction.

ENERGY EFFICIENT ROUTING PROTOCOLS

The primary objective of energy-efficient routing protocols is to prolong the network lifetime by utilizing optimal routes between node pairs [3]. This goal is achieved by reducing both the active and inactive modes of communication for mobile nodes (MNs). Several approaches are employed for optimizing energy consumption in both types of communication.

Transmission Control Approach: This approach focuses on two key parameters: transmitting power and communication energy. Minimum Energy Broadcasting is used to adjust the radio power of each node during active communication to the destination node. By employing multi-hop transmission from the source node to other nodes, the network can consume minimal energy [3]. Flooding is a commonly used technique for broadcasting messages within the network.

Load Distribution Approach: This approach aims to optimize active power usage by achieving a balanced distribution of energy among different nodes. By adopting suitable routing paths, this approach maximizes the network lifetime by ensuring that energy consumption is evenly distributed across the network [3].

Battery-cost Lifetime-aware Routing: This approach operates in two different ways. Firstly, it minimizes the number of nodes required for routing, reducing energy expenditure and optimizing network resources. Secondly, it takes into consideration the residual battery power at different nodes and assigns routes with a hierarchy of low residual power, thus ensuring efficient energy utilization and extending network lifetime [3].

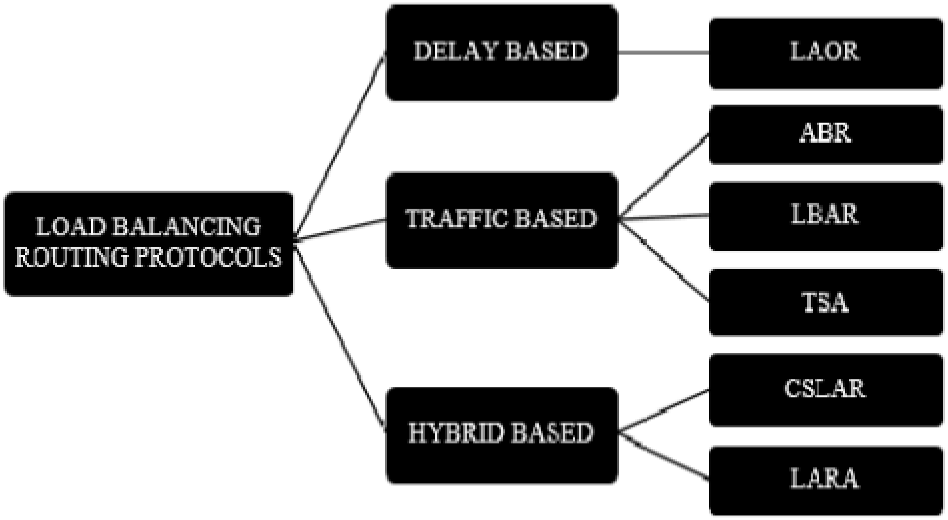
By implementing these energy-efficient routing techniques, MANETs can effectively manage energy resources and prolong the overall network lifetime. These approaches address the critical challenge of energy consumption in MANETs and contribute to enhancing the efficiency and sustainability of wireless communication.

LOAD BALANCING

Load balancing plays a crucial role in maximizing the utilization of network resources and reducing traffic congestion in MANETs[4]. It involves managing the distribution of traffic among multiple routes based on network traffic measurements. Load balancing is particularly critical for time-dependent applications that require high performance and efficient resource allocation.

Over the years, numerous approaches have been proposed to address load balancing in MANETs. Many of these approaches employ on-demand routing combined with route discovery mechanisms. Figure 2 illustrates the classification of load balancing protocols, which can be categorized as follows[5]:

Fig. 2 Classification of Load Balancing Protocols



a. Delay-Based Approach: This approach achieves load balancing by avoiding nodes with high delay. By diverting traffic away from high-delay nodes, the overall network performance can be improved. A commonly used protocol in this category is LAOR.

b. Traffic-Based Approach: In this approach, load balancing is achieved by evenly distributing the traffic load across the network. The goal is to prevent certain nodes from being overloaded while others remain underutilized. Examples of protocols in this category include ABR, LBAR, and TSA.

c. Hybrid-Based Approach: The hybrid approach combines both traffic and delay-based techniques to achieve load balancing. By considering both the traffic load and delay metrics, this approach aims to optimize the distribution of traffic and improve overall network performance. Common examples of protocols in this category include CSLAR and LARA.

These load balancing techniques enhance the efficiency of MANETs by effectively managing network traffic and ensuring the equitable utilization of network resources. By distributing the traffic load across multiple routes, congestion can be minimized, and the overall network performance can be significantly improved.

LITERATURE SURVEY

The paper[4] proposes an energy-efficient load balancing approach for the AOMDV routing protocol in mobile Ad-hoc networks (MANETs). It aims to distribute energy consumption evenly among nodes, thereby extending the network's lifetime and improving overall performance. The approach involves load estimation based on energy levels and selecting routes with lower energy consumption. Simulations show that the proposed technique significantly improves network lifetime, reduces energy consumption, and enhances performance compared to traditional AOMDV routing.

The paper[6] proposes a new load-balanced multi-path dynamic source routing (DSR) protocol for Mobile Ad-Hoc Networks (MANETs). The protocol aims to improve the performance of routing by distributing the traffic load evenly across multiple paths. It addresses the challenge of load balancing in MANETs to optimize resource utilization and reduce congestion. By utilizing multiple paths dynamically, the protocol enhances the efficiency of data transmission and improves the overall network performance. The proposed protocol offers a promising solution for load balancing in MANETs, contributing to the advancement of mobile communication technologies.

The paper[7] introduces a routing protocol for wireless ad hoc networks that focuses on load balancing to enhance network performance. It proposes mechanisms for load estimation, path selection, traffic distribution, and dynamic routing table updates. Through simulations, the protocol demonstrates improved network performance, increased throughput, reduced congestion, and better load balancing compared to existing protocols. The findings highlight the importance of load balancing in optimizing resource utilization and network efficiency in wireless ad hoc networks.

The paper[8] proposes an energy-efficient load balancing approach to enhance the performance of the Ad hoc On-Demand Multipath Distance Vector (AOMDV) routing protocol in Mobile Ad hoc Networks (MANETs). The objective is to distribute network traffic evenly across multiple paths while considering energy constraints. The approach incorporates energy estimation, load balancing algorithm, path selection, and dynamic routing table updates. The performance evaluation considers metrics such as throughput, end-to-end delay, and energy consumption. Using NS-2 simulator, the approach demonstrates improved energy efficiency, enhanced network performance, and balanced traffic distribution compared to traditional AOMDV routing.

The paper[9] presents an advanced load balancing, congestion control, and multipath routing scheme for MANETs. The objective is to improve network performance by efficiently managing traffic and avoiding congestion. The proposed approach combines load balancing techniques, congestion control mechanisms, and multipath routing algorithms. Additionally, it incorporates Random Early Detection (RED) to prevent congestion and utilizes Fractional Order Particle Swarm Optimization (FOPSO) for optimizing the routing paths. The performance of the scheme is evaluated through simulations, considering metrics such as throughput, delay, and packet delivery ratio. The results demonstrate that the proposed approach effectively achieves load balancing, congestion control, and improves the overall performance of MANETs.

The paper[10] introduces an improved version of the Ad hoc On-demand Multipath Distance Vector (AOMDV) routing protocol for ad hoc networks. The objective is to enhance the routing efficiency by incorporating load balancing mechanisms while considering energy constraints. The proposed protocol aims to distribute traffic evenly across multiple paths, thereby reducing congestion and prolonging network lifetime. It achieves this through load balancing algorithms and energy-aware routing decisions. The performance of the protocol is evaluated using simulations, considering metrics such as throughput, end-to-end delay, and energy consumption. The results show that the improved AOMDV protocol effectively balances the network load, improves routing efficiency, and prolongs the network lifetime by considering energy constraints.

The paper[11] presents a multipath routing protocol for ad hoc networks based on the Ad hoc On-demand Multipath Distance Vector (AOMDV) protocol. The objective is to achieve load balancing and energy efficiency in the network. The proposed protocol incorporates load balancing mechanisms to distribute traffic across multiple paths, thereby reducing congestion and improving network performance. It also takes into account energy constraints by considering the residual energy of nodes when selecting routes. The performance of the protocol is evaluated through simulations, measuring metrics such as packet delivery ratio, end-to-end delay, and energy consumption. The results demonstrate that the proposed protocol effectively achieves load balancing, enhances energy efficiency, and improves the overall performance of the ad hoc network.

The paper[12] presents a modified energy-constrained protocol based on the Ad hoc On-demand Multipath Distance Vector (AOMDV) routing protocol for mobile ad hoc networks. The objective of the protocol is to enhance energy efficiency and prolong network lifetime. The proposed protocol incorporates energy constraints by considering the remaining energy levels of nodes in route selection. It aims to balance energy consumption among nodes and avoid energy depletion in specific nodes. The performance of the protocol is evaluated through simulations, considering metrics such as network lifetime, energy consumption, and packet delivery ratio. The results show that the modified energy-constrained protocol improves energy efficiency, extends network lifetime, and maintains satisfactory packet delivery performance compared to traditional AOMDV protocols.

The paper[13] proposes a multipath routing protocol that aims to achieve load balancing and Quality of Service (QoS) in ad hoc networks. The objective of the protocol is to distribute network traffic evenly across multiple paths, thereby improving network performance and resource utilization. The methodology includes load balancing mechanisms and QoS considerations in the path selection process. The protocol is evaluated using performance metrics such as throughput, delay, and packet delivery ratio. The results show that the proposed protocol achieves load balancing, improves network performance, and ensures QoS requirements are met in ad hoc networks.

The paper[14] aims to improve load balancing and energy efficiency in ad hoc networks. It achieves this by considering both the residual energy of nodes and load balancing factors during route selection. The protocol dynamically balances the traffic load across multiple paths while ensuring that energy-constrained nodes are not excessively utilized. Through simulations, the LBMMRE-AOMDV protocol demonstrates improved load balancing, enhanced network performance, and prolonged network lifetime compared to traditional AOMDV protocols.

The paper[15] proposes a method to improve the performance of the AOMDV routing protocol in mobile Ad-hoc networks by incorporating traffic-aware load balancing. It introduces a mechanism that monitors traffic load and dynamically adjusts routing decisions based on current network conditions. The proposed approach redistributes traffic across multiple paths to alleviate congestion and enhance network performance. Simulations show that it significantly improves throughput, reduces packet loss, and enhances network stability compared to traditional AOMDV routing.

The paper[16] proposes an energy-aware approach for the AOMDV routing protocol in MANETs. It considers the queue length of nodes as a constraint to optimize energy consumption and improve network efficiency. The approach involves energy estimation and routing based on constrained queue length. It selects routes with unconstrained queue lengths to promote efficient energy usage. Simulations show that the proposed approach significantly improves energy consumption, network efficiency, and node lifespan in MANETs.

The paper[17] proposes a routing protocol called ZBLE that combines zone-based leader election and energy constraints with the AOMDV protocol in MANETs. ZBLE divides the network into zones and selects leaders based on energy levels. It routes traffic through energy-efficient paths to improve network performance and extend the network's lifespan. Simulations show that ZBLE outperforms traditional AOMDV protocols in terms of energy consumption, network performance, and lifespan.

The paper[18] proposes an energy-efficient load balancing approach for multipath routing protocols in ad hoc networks. It aims to distribute energy consumption evenly across paths to prevent early battery depletion and performance degradation. The approach involves load estimation based on energy levels and dynamically adjusting routing decisions to balance energy load. Simulations show that the proposed technique improves energy consumption balance, prolongs network lifetime, and enhances overall performance compared to traditional multipath routing protocols.

The paper[19] introduces an on-demand load balancing multi-path routing protocol for differentiated services in MWSNs. It addresses the challenges of load balancing and QoS differentiation by dynamically balancing the load among paths and allocating resources based on application requirements. Simulations demonstrate improved load balancing, QoS differentiation, and overall network performance.

The paper[20] proposes a routing protocol called ZBLE, which stands for Zone-Based Efficient Energy Multipath Protocol, for routing in mobile Ad Hoc networks. ZBLE utilizes zones to improve energy efficiency and incorporates multipath routing. It aims to optimize energy consumption by efficiently selecting paths within different zones. The protocol provides improved energy efficiency and routing performance in mobile Ad Hoc networks.

The paper[21] introduces ZBLE, an energy-efficient zone-based leader election multipath routing protocol for MANETs. ZBLE focuses on energy efficiency by selecting leaders within different zones and utilizing multipath routing. The protocol aims to improve energy consumption and routing performance in MANETs.

The paper[22] addresses efficient traffic management in mobile ad hoc networks (MANETs) through congestion control and load balancing. It proposes techniques to mitigate congestion and balance the network load for improved performance. The focus is on optimizing traffic management in MANETs to enhance efficiency and reduce network congestion.

The paper[23] presents a design and analysis of an energy-efficient load balancing and bandwidth-aware adaptive multipath N-channel routing approach in MANETs. The proposed approach aims to balance the energy consumption among nodes and optimize bandwidth utilization by dynamically adapting multipath routing. It offers an efficient solution to improve energy efficiency, load balancing, and bandwidth utilization in MANETs.

The paper [24]focuses on optimized tuning of parameters for the LOADng routing protocol in the context of the Internet of Things (IoT). It aims to enhance the performance of LOADng by finding the optimal configuration of its parameters. The study focuses on improving the routing protocol's efficiency and effectiveness in IoT environments through parameter optimization.

Based on the survey conducted, Table 2 presents a comparative analysis of various algorithms developed to improve energy efficiency and load balancing in ad hoc networks.

The table showcases different performance metrics used to evaluate the algorithms. Among the discussed approaches, it is found that EELB-AOMDV[18] stands out as the most effective approach for achieving energy efficiency and load balancing. This approach utilizes a multi-path routing strategy and has been compared with different versions of AOMDV, demonstrating superior performance in terms of energy efficiency and load balancing.

TABLE II Comparative Analysis of Energy Efficiency and Load Balancing

Papers	Objective	Protocol	Methodology	Performance metric	Simulator Used	Result
[6]	Develop a load balanced multi-path dynamic source routing protocol for mobile ad-hoc networks	Load Balanced Multi-Path Dynamic Source Routing Protocol	Load estimation, path selection, traffic distribution, routing updates	Throughput, End-to-End Delay, Packet Delivery Ratio	NS-3	Improved load balancing, increased throughput, reduced end-to-end delay, enhanced packet delivery ratio
[7]	Develop a routing protocol for wireless ad hoc networks that achieves load balancing and improves network performance	Load Balancing Routing Protocol	Load estimation, path selection, traffic distribution, dynamic routing table updates	Throughput, End-to-End Delay, Packet Delivery Ratio, Load Balancing	NS-2	Improved network performance, increased throughput, reduced congestion, and better load balancing
[8]	Develop a multipath energy-conserving routing protocol to improve the lifetime of wireless ad hoc networks	Multipath Energy-Conserving Routing Protocol	Energy-aware path selection, load balancing, packet forwarding	Network lifetime, Energy consumption , Packet delivery ratio	NS-2	Increased network lifetime, reduced energy consumption, improved packet delivery ratio
[9]	Develop an advanced load balancing, congestion control, and multipath routing protocol in MANETs using Fractional order Particle Swarm Optimization (FOPSO)	Load balancing Congestion control Multipath routing with Random Early Detection using FOPSO	Fractional order Particle Swarm Optimization, Random Early Detection, Load balancing, Congestion control	Throughput, Packet loss, Delay, Network load, Load balancing index	NS-3	Improved load balancing, reduced congestion, increased throughput, minimized packet loss and delay
[10]	Develop an improved AOMDV routing protocol with load balancing and energy constraining for ad hoc networks	AOMDV (Ad hoc On-Demand Multipath Distance Vector)	Load balancing, Energy constraining, Path selection, Dynamic routing table updates	Throughput, End-to-end delay, Packet delivery ratio, Load balancing index	NS-2	Enhanced load balancing, improved energy efficiency, increased network performance

[11]	Develop a multipath routing protocol with load balancing and energy constraining based on AOMDV in ad hoc networks	AOMDV with load balancing and energy constraining	Load balancing, Energy constraining, Path selection, Dynamic routing table updates	Throughput, End-to-end delay, Packet delivery ratio, Energy consumption , Load balancing index	NS-2	Improved load balancing, enhanced energy efficiency, increased network performance
[12]	Enhance energy efficiency and prolong network lifetime	A modified energy-constra ined protocol based on AOMDV	Incorporates energy constraints in route selection	Network lifetime, energy consumption , packet delivery ratio	NS-2 simulator	Improved energy efficiency, extended network lifetime, satisfactory packet delivery performance compared to traditional AOMDV protocols.
[13]	To achieve load balancing and QoS in ad hoc networks	Multipath routing protocol with load balancing and QoS considerations	Incorporates load balancing mechanisms and QoS considerations in path selection	Throughput, delay, packet delivery ratio	NS-3	The proposed protocol achieves load balancing, improves network performance, and ensures QoS requirements are met in ad hoc networks.
[14]	Improve load balancing and energy efficiency in ad hoc networks	LBMMRE-A OMDV	Consider residual energy and load balancing factors for route selection	Load balancing, energy efficiency	NS-2	Improved load balancing, enhanced network performance, prolonged network lifetime compared to traditional AOMDV protocols
[15]	Improve load balancing and network performance in AOMDV routing	AOMDV	Incorporates traffic-aware load balancing approach	Load balancing, network performance	NS-2	Improved load balancing, reduced congestion, and enhanced network performance compared to traditional AOMDV protocols.
[4]	Enhance energy efficiency and load balancing in AOMDV routing	AOMDV	Introduces an energy-efficien t load balancing mechanism	Energy efficiency, load balancing	NS-2	Improved energy efficiency, enhanced load balancing, and prolonged network lifetime compared to traditional AOMDV routing protocols.
[16]	Improve energy efficiency in AOMDV routing	AOMDV	Incorporates constrained queue length approach	Energy efficiency, packet delivery ratio	NS-2	Improved energy efficiency, reduced packet loss, and enhanced network performance compared to traditional AOMDV routing protocols.
[17]	Improve energy efficiency and network lifetime	AOMDV	Zone-based leader election and energy constraints	Energy efficiency, network lifetime, packet delivery ratio	NS-2	Improved energy efficiency, extended network lifetime, and enhanced packet delivery performance compared to traditional AOMDV routing protocols.
[18]	Improve energy efficiency and load balancing	Multipath routing protocol with load balancing	Energy-aware load balancing and routing	Energy efficiency, load balancing, network performance	NS-2	Enhanced energy efficiency, improved load balancing, and enhanced network performance compared to traditional multipath routing protocols.

[19]	Achieve load balancing and differentiated services	Load balancing multi-path routing protocol	On-demand routing, load balancing mechanisms	Load balancing, service differentiation, network performance	NS-2	Improved load balancing, enhanced service differentiation, and improved network performance compared to existing protocols.
[20]	Improve energy efficiency and routing performance	ZBLE protocol	Zone-based routing, energy management	Energy efficiency, routing performance	NS-2	Improved energy efficiency, enhanced routing performance, and extended network lifetime compared to traditional routing protocols in mobile ad hoc networks.
[21]	Enhance energy efficiency and routing performance	ZBLE protocol	Zone-based routing, leader election	Energy efficiency, routing performance	NS-2	Improved energy efficiency, enhanced routing performance, and extended network lifetime compared to traditional MANET routing protocols.
[22]	Improve congestion control and load balancing	Not specified	Congestion control, load balancing	Congestion level, load distribution	NS2	Improved congestion control, balanced load distribution, and enhanced network performance in terms of throughput and delay in mobile ad hoc networks.
[23]	Improve energy efficiency, load balancing, and bandwidth utilization	Not specified	\Adaptive multipath N-channel routing	Energy consumption , load distribution, bandwidth utilization	NS2	Improved energy efficiency, load balancing, and bandwidth utilization in MANETs.
[24]	Optimize the performance of LOADng routing protocol for IoT	LOADng routing protocol	Parameter tuning, optimization	Network throughput, packet delivery ratio, end-to-end delay	NS2	Improved performance of LOADng routing protocol in IoT networks through optimized parameter tuning.

Conclusion

Energy efficiency and load balancing pose significant challenges in mobile ad hoc networks. Researchers have made extensive efforts to develop algorithms to tackle these issues. This paper provides a brief survey of existing energy efficiency and load balancing approaches. However, further advancements are required in this area, including the exploration of new protocols that incorporate innovative metrics. These protocols should aim to enhance energy efficiency, achieve effective load balancing, and ultimately extend the network's overall lifespan.

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