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Mobile Ad-hoc Network: Routing discussion and Challenges

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Abstract. *The last decade has witnessed an ever-growing user demands for a better quality of services. This has led to the rapid evolution and advancements in wireless communication technologies in an attempt to produce a standard that satisfies the users' demands. In the mobile ad hoc network (MANET), mobile users are obliged to implement the routing of the actual data due to the lack of infrastructure in this type of network. When the destination is outside of the radio range of the source, each mobile of the network serves as a relay by retransmitting the data to another mobile unit until the destination is reached. MANET has more security flaws than quality of service (QoS). In this paper we present the comparative study for mobile ad-hoc network applications based on different techniques and, present some issues or challenges as we find in literature survey work.*

Keywords: MANET, Optimization, QoS, RREQ, RREP.

Introduction

In a Mobile Ad-hoc Network (MANET), nodes are equipped with radio transmitters and receivers, enabling wireless bidirectional communication. Although MANET allows for convenient data transmission, one of its primary limitations is that the transmission range is often restricted compared to previous methods, complicating data exchange amidst numerous nodes. A significant challenge in Wi-Fi Ad-hoc networks arises from the reliance on battery-powered portable nodes, which frequently exhibit underperformance, making battery replacement or recharging time-consuming. Characterized as a multi-hop network, MANET allows source nodes to communicate with destination nodes via intermediary nodes when they are beyond direct communication range. It emerges as a promising technology for establishing temporary connections in scenarios that lack pre-existing infrastructure, such as emergency situations, disaster recovery, and military applications [12]. However, a critical issue is that link breakages can disrupt established connections, complicating communication. Many MANET protocols utilize reactive path construction through flooding the network with route request (RREQ) packets. This flooding, while establishing connections, incurs high control overhead, resulting in performance degradation. Therefore, it is important to selectively manage flooding operations to enhance network efficiency by controlling the dissemination of RREQ packets among mobile nodes.

Node mobility can induce rapid changes in topology, leading to frequent link breakages that contribute to additional overhead and disruptions in ongoing connections. These disruptions significantly influence network performance, causing delays and increased control overhead, thereby reducing the packet delivery ratio. Consequently, there is a heightened need for effective link failure prediction strategies.

Another pressing concern in the context of MANETs is energy consumption, as nodes typically exhibit varying levels of battery power, bandwidth, and transmission range [11]. Mobile nodes forward packets to adjacent nodes, expending battery energy in a multi-hop routing environment, necessitating mechanisms to budget energy usage effectively. The goal is to minimize overall energy consumption during packet delivery through methods that balance energy usage across nodes while considering factors like cost per packet and time to potential network partition. Existing routing algorithms are tasked with selecting paths that ensure minimum energy consumption by optimizing energy distribution across the network.

Literature Review

Mobile ad hoc networks (MANETs) are dynamic, self-organizing networks that lack fixed infrastructure, making them suitable for various applications such as emergency communications, military operations, and outdoor events. The inherent mobility of nodes leads to frequent and unpredictable topology changes, which increase the overhead for topology maintenance as mobility information must be disseminated throughout the network. Researchers have proposed numerous cluster-based algorithms designed to minimize routing table sizes, thus addressing the challenges of topology maintenance.

The literature presents multiple solutions aimed at maintaining security and efficiency in MANETs. One proposed method involves using the Bacteria for Aging Optimization Algorithm (BFOA) for energy-efficient, trust-based routing [1]. Security vulnerabilities in MANETs can lead to potential attacks, necessitating advanced intrusion detection systems to safeguard against breaches. The article also highlights a hybrid routing strategy, known as Genetic Algorithm with Hill Climbing (GAHC), which aims to enhance fault tolerance through multipath routing—a method advantageous in scenarios with high node mobility and connection instability [2]. Within vehicle ad-hoc networks (VANETs), which fall under the MANET category, dynamic routing protocols face challenges related to route failure and high bandwidth demands. Additionally, bio-inspired algorithms such as the Elephant Herding Optimization (EHO) are utilized to tackle energy consumption in routing [3]. The need for robust mechanisms to identify and mitigate threats is emphasized, including the introduction of secure neighbor selection techniques based on recurrent learning models. These models assess node behaviors across multiple communication hops, facilitating the establishment of secure, reliable transmission paths. Suggestions for improving on-demand source routing include implementing zone-based discovery mechanisms and link failure predictions to combat frequent topology changes. Energy efficiency remains a core concern; protocols like Ad Hoc On-Demand Multipath Distance Vector (AOMDV) have been adapted to incorporate bio-inspired methods to optimize node energy during path discovery. Trust-based routing mechanisms that leverage node performance metrics have been explored, though challenges remain in accurately representing certain performance metrics quantitatively [4].

Mobile ad hoc networks (MANETs) are self-organizing systems characterized by frequent changes in topology due to the mobility of nodes, which creates overhead challenges in maintaining updated routing information. To mitigate this issue, researchers have developed various cluster-based algorithms that help reduce the size of routing tables. These algorithms group nodes into clusters, allowing for localized management of topology changes; external communications are facilitated through a designated cluster head (CH) [5]. In this context, a new local flooding-based on-demand routing protocol is proposed, aimed at minimizing flooding overhead while ensuring efficient communication paths between source and destination nodes. This protocol leverages overhearing to identify one-hop neighbors along the optimal route, enabling periodic local flooding initiated by the destination node for updated routing information. This strategic flooding approach significantly lowers the network overhead and provides seamless rerouting when existing paths become disconnected or outdated [6]. Furthermore, MANETs necessitate reliable routing strategies that accommodate the dynamic and decentralized nature of the network, especially given that they lack centralized administration. The proposed protocol's goal is to determine the least-cost routing of packets while ensuring survivability against potential node or arc failures, which is critical for maintaining uninterrupted communication. Additionally, the performance and security of wireless ad-hoc networks (WANETs) are paramount, particularly since they are vulnerable to packet drop attacks owing to their decentralized nature [7]. In such scenarios, nodes may exhibit untrustworthy behavior by failing to forward messages to subsequent nodes, leading to network disruption. A scheme is introduced to counter selective drop attacks, focusing on identifying and isolating malicious nodes to safeguard the integrity and performance of the network. This resistive to selective drop attack (RSDA) scheme aims to enhance network security against these threats while maintaining service availability and performance [8].

Overall, the collective research underscores the complexities of managing the inherent dynamism of MANETs while ensuring secure, efficient data transmission through adaptive and innovative routing strategies that address energy consumption, reliability, and security in a collaborative framework.

Challenges in MANET Routing

Despite the numerous advantages of Mobile Ad Hoc Networks (MANET) such as self-configuration, easy deployment, and node mobility, they face significant limitations including reliance on portable batteries, limited bandwidth, and restricted processing resources. The main challenge lies in routing packets through a dynamic and rapidly changing topology without a central control unit, necessitating reliable paths through intermediate nodes [9]. The mobility of nodes and their limited power contribute to link breakages and network partitions, complicating connectivity. In disaster scenarios, the variables affecting routing protocols include node mobility patterns, velocity, number, and wireless capabilities, alongside environmental obstacles, disaster types, and weather conditions. While MANET is flexible and can support consistent data transfer, its low transmission capacity limits radio coverage, requiring nodes to rely on others for communication. Nodes, often handheld devices with minimal resources, can join or leave the network dynamically, which introduces security challenges. The changing behaviors of nodes over time highlight the necessity of addressing security issues while ensuring careful communication and engagement among nodes [10].

Power Aware Based Routing Algorithms

Existing power-aware routing algorithms in classical Mobile Ad-Hoc Networks (MANETs) can be categorized into activity-based and connectivity-based routing. Activity-based algorithms focus on data transmission solutions among network nodes, while connectivity-based algorithms handle the maintenance of transmission connectivity. Connectivity-based methods are further divided into Passive Energy Saving Protocols, like the Geographic Adaptive Fidelity (GAF) protocol, which organizes the network into virtual grids to maintain vital nodes in an active state while conserving energy by putting other nodes to sleep. Topology control protocols, such as Local Information No Topology (LINT) and Local Information Link-State Topology (LILT), use local information to adjust transmission signals based on high (dh) and low (dl) threshold neighbors, although LINT cannot recognize network partitions.

On the other hand, activity-based algorithms are categorized into two: transmission power control and maximizing network lifetime. Transmission power control protocols, including Minimum Total Transmission Power Routing (MTPR) and Minimum Power Routing (MPR), aim to select routes that minimize energy consumption. Maximizing network lifetime protocols, such as the Min-sum Battery Cost Routing (MBCR) protocol, balance power resource consumption to prolong node lifespan, utilizing path residual energy as a cost metric. However, one limitation of the MBCR protocol is its path selection process, which may favor longer paths with nodes that have low remaining energy.

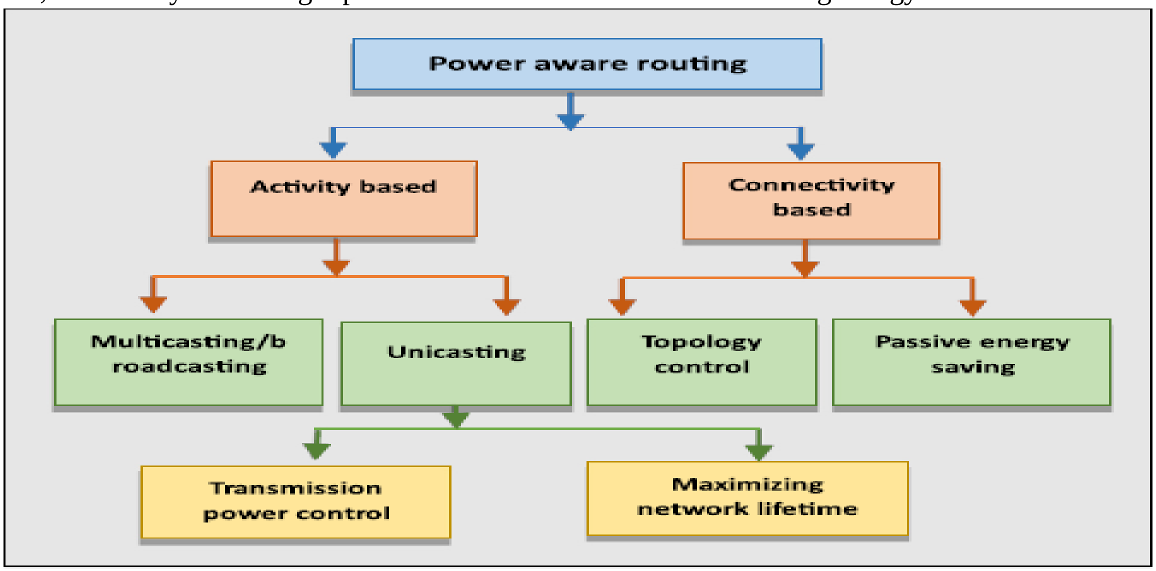

Figure 1: Existing power aware routing algorithms [10].

Conclusion

In recent years, wireless communication technologies and mobile devices, such as laptops and smartphones, have enabled network access anywhere without the need for infrastructure. This has led to the development of Mobile Ad-hoc Networks (MANETs), which can be formed without fixed infrastructure and are utilized in various applications including disaster recovery, traffic control, security, and distributed collaborative computing. In these networks, routes are typically multi-hop, with communication occurring via packet radios. The research work, reviews literature on MANETs, examining various techniques across different applications while identifying existing challenges. It also proposes the use of optimization techniques to address these issues in future work.

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