A Survey on Binary Tree-Based Approaches for Data Transmission in Mobile Ad Hoc Networks

Abstract

A thorough analysis of the current binary tree-based data distribution techniques in MANETs is the goal of this paper. MANET communication is highly dynamic, necessitating effective data transmission methods to improve network stability while also saving energy. Binary tree topologies work in tandem with routing and data aggregation to improve scalability, reduce latency, and increase energy economy. The paper investigates several binary tree algorithms that are appropriate for data and security structures, as well as routing techniques. Similar to previous MANETs, the network has three main issues: security threats, energy constraints, and mobility issues. Key features of modern algorithms are briefly discussed in the study, along with the benefits and drawbacks of tree-based systems. The study itself outlines the goals and directions for further investigation just to find the best network throughputs while staying within the constraints of dynamism's limited computing and energy resources.

Keywords: Binary Tree, Data Transmission, MANETs, Routing.

1. Introduction

Mobile Ad Hoc Networks MANET is a wireless communication infrastructure which has been of great importance due to its flexibility, scalability, and independence with wired infrastructure [1]. They are formed by mobile nodes which autonomously create routes to enable the connection of communications. Their uses are diverse crossing many areas such as in military operations, disaster management and vehicles where forming a prior defined network is usually impractical [2].

Data dissemination plays a cardinal role in MANETs due to features such as low bandwidth, dynamic, and energy-scarce in these networks [3]. In response to these issues, many algorithms and protocols have been developed to enhance routing and data dissemination. Of these, binary tree based approaches are widely used due to their well organized and hierarchical structure which may lead to improvement in efficiency and reduction of computational effort [4]. Using a binary tree approach is advantageous in order and method of nodes and their operations as well as in the efficiency of routing and delivery of data within the network despite possibly complex events.

Methods based on binary tree are most beneficial when implemented in hierarchical routing, resources and load control within the MANET [5]. These approaches mostly rely on the administrative hierarchy of the binary trees to simplify the routing and management of the trees and thus reducing the overhead normally attributed to conventional routing protocols [6]. For instance, the binary tree structure assists in splitting the network into smaller easily manageable subnetwork that assists in simplification of routing and increased scalability [7].

It is similarly noteworthy that inherent benefits of the binary tree-based methodologies translateto changes in the network. Due to the mobility of nodes in MANETs and constant addition and deletion of nodes to/from the network, binary tree-based protocols are aimed at being reparable without affecting their performance [8]. Furthermore, these methods may include schemes for conserving energy, which is a major concern for battery-powered mobile nodes [9]. As data transmission is made more direct and less repetitive by binary tree-based protocols, the overall functioning life of MANETs is also extended [10].

However, there are limitations to the use binary tree based methods when applied in real-life situations. The first one is the overhead used in managing the binary tree structure in highly dynamic systems [11]. High node mobility leads to the change of the tree structure often, which incurs significant cost and has influence on the network performance. Moreover, as the size of the networks becomes extremely large, further research is required to enable binary tree based system implementations to maintain the tree in such sizes [12].

This survey will focus on comparing binary tree-based approach for data transmission and its methodologies, applications, and drawbacks in MANETs. In doing so, this paper aims at trend analysis, performance evaluation, and directions for future work based on a review of prior research [13]. It will also assess how these new technologies, including machine learning and blockchain, can be incorporated with binary tree-based systems for improved operation in MANET contexts [14].

The subsequent sections of this paper explore the fundamentals of binary tree-based techniques in detail, their application in MANETs and the problems they solve. Besides, it assesses emergent progression and looks at the potential issue of how to establish effective, reliable, and adaptive protocols for transferring data in MANETs [15]. It is my intend to use this investigation as a reference for literature to researchers and practitioners interested in enhancing the design and application of user communication in mobile networks.

2.Theorical Background

Mobile Ad Hoc Networks (MANETs)

Mobile Ad Hoc Networks or MANETs are wireless mobile networks which of their nature do not comprise nonmoving base stations. MANET nodes are mobile and communicate directly with each other over multichip links, thereby creating temporary topologies [16]. This self-organizing capacity makes MANETs useful where conventional infrastructure cannot be provided, say in warfare, calamities, and vehicle ad-hoc networks [17].

MANET communication characteristics include but not limited to multichip communication, dynamic topology and restricted resource. These networks utilize collaborative routing since the intermediate nodes transmit data from the source to the destination [18]. This multichip strategy makes a connection possible even if nodes are far apart or immobilized by impervious barriers. However, this approach involves some issues such as the problem of delay, congestion and vulnerability problems.

Another impressive feature of MANETs is called dynamic topology. Because nodes are mobile, the network links are temporary and constantly need to be updated to keep a network connection. The current rigid routing protocols are incompatible with the dynamic nature of MANETs and suffer high overhead and slow convergence [19]. Thus, the specific routing protocols like Ad Hoc On-Demand Distance Vector (AODV) and Dynamic Source Routing (DSR) have been designed to address the need of the MANETs [20].

However, MANETs still have many difficulties, the principal of which is the constraint of resources. These networks comprise nodes and mostly dedicated a power supply from batteries, energy efficiency is an important factor in these systems. Further, high energy consumption due to repeated transmission and route discovery consumes the node resources and splits the network [21]. Moreover, as the communication in MANETs is conducted through a common wireless medium, certain problems exist, such as wire-tapping, physical jamming, unauthorized access, etc. [22]

In order to solve these problems, the researchers have paid special emphasis in designing the appropriate routing algorithms and data transmission strategies specific to MANETs. Hierarchical structures which employ a kind of binary tree for routing have been identified as a paradigm solution. These methods are intended to minimize routing's inefficiency, energy consumption, and to improve its scalability suitability for MANETs [23].

Moreover, the improvement of technology has enlarged the area of the usage of the MANETs. Connecting with smart objects and vehicle-to-vehicle/vehicle-to-infrastructure has created new research directions. For example, Mobile Ad hoc Networks (MANETs' subtypes, VANETs) have been employed for traffic flow optimization and increasing safety by using vehicle-to-vehicle communication [24].

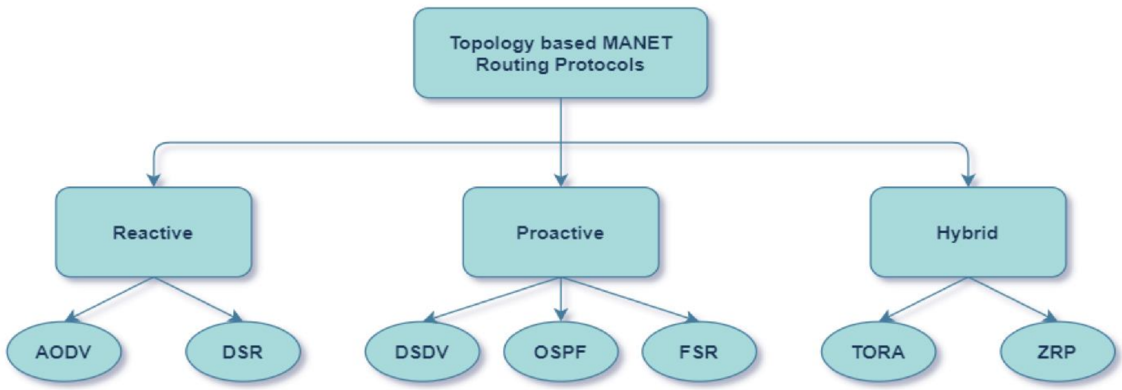


Figure 1: Topology-based MANET routing protocols.

Binary Tree Structures in Networking

Hierarchical data representation based binary tree structures are widely important for improving the representative networking frameworks. A binary tree takes nodes in a hierarchical structure where every parent node links to max of 2 subordinated nodes. Such structure of data organization and retrieval also makes it suitable in different networks application such as, Mobile Ad Hoc Networks (MANET) [25].

In networking, binary trees are used as a root for routing, data gathering and any failure tolerance in a network. Due to their structure nodes are arranged in hierarchical way, which makes complicated work straightforward. This helps in reducing the routing overhead since the nodes are expected to stick to these paths leaving minimal need to explore the network for routes. For example, Binary tree based protocols require less control packets for routing than flat routing that can make use of greater energy resources and favored networkography [26].

It can be easier to implement binary tree structures especially in MANETs since networks are dynamic and the topology constantly changes. These structures enable fast adjustments since changes can be made at the branch level instead of the network level. This localization enhances the ability the resistance of the network node mobility while guaranteeing that routing will remain effective even with continual shifts in topology [27].

A resource optimization is another significant use of binary trees. MANETs are characterized by a problem of energy efficiency since nodes have limited batteries. The ability of binary trees is also to distribute the communication load to the nodes equally so that no particular node is getting drained of energy. Further, they allow data gathering to be centralized by collecting data from multiple nodes in a higher level of tree while minimizing the size of data moved around [28].

The effectiveness of structures based on binary tree for implementing fault tolerance is another advantage of the discussed systems. In large scale networks, node failures are unavoidable. Fault tolerance is provided in a binary trees since the data is usually routed in the tree hierarchy. New binary tree structures have been introduced into the DSR and OLSR algorithms to enhance their resistance to node failure [29].

The application of networking also benefits through AI and ML as the emerging technology that supports the value of binary trees. By utilizing AI technology, it is possible to anticipate the shifts in the network's structure, as well as adjust the binary tree model proactively. This predictive capability reduces interferences and improves performance of the total network. Continuously, the communication loads of nodes in the binary tree can also be optimized in ML models so as to achieve the most efficient network configuration [30].

Nevertheless, binary tree structures have certain demerits, and these are explained below. Their hierarchical design may create bottlenecks at higher level of hierarchy where parent node receives heavy traffic. Addressing this issue involves incorporating load balancing features together with increasing node capability at key points. Furthermore, dynamic environment setup the initial formation of a binary tree to can involve high computation cost in terms of time for constructing and maintaining the tree [31].

Binary Tree-Based Approaches for MANETs

Binary tree based techniques for MANETs are also fascinating because of its effective routing and management [32]. MANETs are ad hoc distributed wireless networks in which each node is a host as well as a relay point. Such characteristics of MANETs make them difficult to handle especially in the areas of scalability, security and routing. One among them is that the node is grouped into hierarchical levels using binary tree structure which in turn minimizes the number of nodes between the source and the destination [33]. Depending on the need of an application, trees in MANETs can be either dynamic or static trees, and dynamic trees may provide more flexibility when it comes to node mobility. All these tree structures can be used in the development of optimized multicast and broadcast communication methods [34]. Examples include how in multicast routing, use of binary trees reduces the amount of data transmitted thereby cutting down on the amount of load placed on the network. Further, based on the binary trees, routing algorithms improve the route discovery process by building idealistic routes helpful in environments where route stability is crucial. In addition, the binary trees mentioned above help to lessen the overhead resulting from the flooding techniques always incorporated in MANET traditional routing algorithms [35]. Another major advantage of the use of binary trees is on the scalability of the algorithms used. However, as the size of the network increases, binary tree algorithms mitigate this shortcoming by partitioning the network into manageable subtrees hence enhancing performance and reducing traffic. A number of studies have demonstrated that binary tree protocols are superior to conventional routing protocols in regards to latency, energy consumption, and packet delivery rate [36]. For instance, routing structures based on binary trees help link the data packets evenly across the system to decrease the possibility of crowding in any section of the network. Further, these protocols can be integrated with other optimism strategies including clustering or load balancing to improve the performance of MANETs in general [37]. Nonetheless, some issues like the node mobility and the tree management in a highly mobile network still pose as challenges that limit the deployment of binary tree solution. Nevertheless, the studies are still ongoing, seeking to enhance the robustness and flexibility of binary tree structures in relation to MANETs [38].

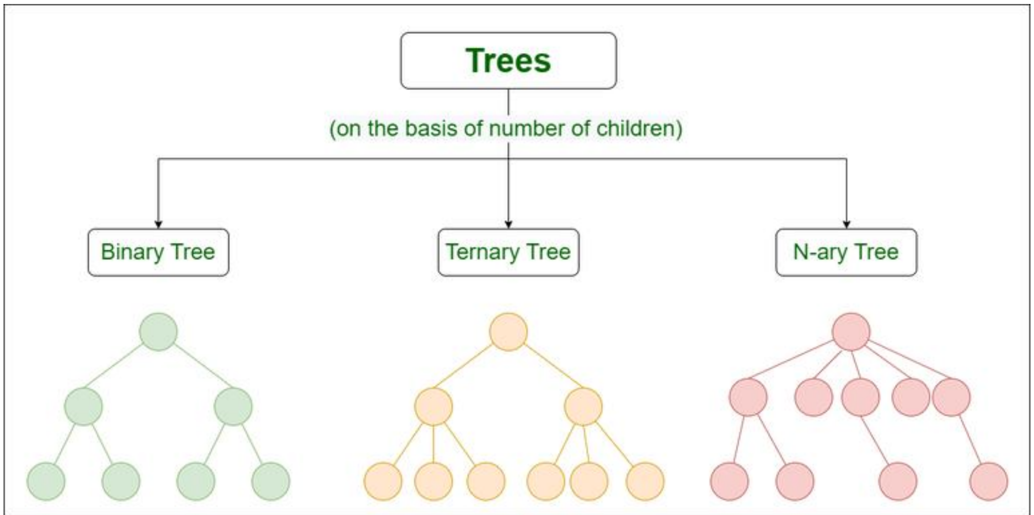


Figure 2: Shows Types of Tree in Data Structure

3. Literature Review

Bathla et al claimed in 2021 Wireless sensor network (WSN) is one of the emerging field in networking due to new changes that evolved in the twenty first century. The major benefits of using WSN using sensor nodes include the following, it is inexpensive, easily expandable, economically reliable and reliable. The constraint that is associated with the sensor nodes can be summed up with the following [energy] The fixed and limited power supply as well as durability, storage and computational facilities, which makes energy a broader issue in deploying sensor nodes to avoid quick power drain. This paper presents a new deployment strategy for wiring the sensor nodes in a manner of a 4-sided virtual full binary tree network. Therefore, in the proposed scheme, data is expected to get to the resource opulent Base Station (BS) ```Hops" equal to the height of the tree. In addition, it will enhance the stability of the network and will also improve the average values of the network about 82.78 % in the range of 49- 98% to implement the existing scheme of the network life time based up on different scenarios. Proposed scheme provides very good performance in terms of variable nodes and variation in the size of the area to be covered by WSN [39].

Lin et al. (2020) established that mobile network performance will improve when data paths receive optimal optimization. The research presented hierarchical routing frameworks such as binary trees that helped maximize network performance by trimming delay times and lowering energy use. Research findings demonstrated that optimization techniques achieve efficiencies while extending network life duration while ensuring dependable communication systems operate successfully in dynamic mobile settings. The analysis included node mobility problems because they create recurring disruptions to data paths. Optimized hierarchical data paths deployed in mobile networks produce both stable network operation alongside efficient resource utilization.

According to Patel et al. (2021) binary tree protocols need scalable methods for large networks to sustain their performance in expanding applications. Protocol performance benefits come from better load distribution capabilities alongside decreased latency effects achieved through adaptive system adaptions. The research team recognized performance consistency challenges grow when networks scale up. Researchers developed an approach to boost scalability and support reliable data transmission in extended networks which delivered performance gains for multiple operational conditions.

The paper, In 2021 Rani et al., demonstrates that the work brings a new security perspective for a Mobile Ad-Hoc Network (MANET)-based IoT model based on the idea of artificial intelligence. The Black Hole Attack (BHA) is seen as one of the most affecting threat in the MANET in which the attacker node has the ability to drop all the traffic of data and therefore the performance of the network is affected. It therefore requires the development of an algorithm that could shield the network from the BHA node. This article presents Ad-hoc On-Demand Distance Vector (AODV), an updated routing protocol which is developed using the reconnaissance of Artificial Bee Colony (ABC), Artificial Neural Network (ANN) and the Support Vector Machine (SVM). The enhancement is modelled by integrating the SVM with ANN as the novelty of the work for detecting attackers inside the identified route of the AODV mechanism. Here, the model is trained using ANN but the identification of training data set is accomplished using the ABC fitness function, then classification is made using SVM. ABC's function is to ensure it offers a more appropriate channel through which to send the data than the original path from the source-node to the final destination node. The optimized route suggested by ABC is then used together with the properties of the node to the SVM models. In this connection using the properties the ANN decides if the node is a normal node or an attacker node. Simulation analysis done in MATLAB demonstrates that the proposed work has better PDR, throughput and delay compared to IS-201 implementation. To justify the efficiency of the proposed system, a comparison is conducted with Decision Tree and Random Forest methods to realize that the use of SVM with ANN is a helpful addition for the identification of BHA attackers in the MANET-based IoT networks [40].

According to Li et al. (2022) binary tree-based approaches deliver substantial routing efficiency improvements for MANETs. The key advantages from these methods are controlled transmission routes together with minimized data transfer times and adjustable systems. Fundamental constraints within MANETs stem from their dynamic nature which leads to decentralization that complicates routing operations. The research explores methods to combine binary tree frameworks and machine learning approaches to solve MANET data transmission constraints thus delivering better data transmission reliability and efficiency.

Gopikrishnan et al., (2018) we mentioned in your paper that energy efficient data aggregation, is a key solution to improve the lifetime of WSN since the nodes to the network are always power by batteries and placed in harsh environments. This paper presents a brief discussion on a two-hop data aggregation tree construction with emphasis made on the usage of binary search tree to minimize the overall energy consumption of the sensor nodes in wireless sensor networks. A novel adaptive and hybrid routing algorithm for simultaneous data aggregation and taking advantage of data correlation between nodes by adopting the two-hop data aggregation tree architecture is presented. Depending on the shortest response time for the broadcasting request, the routes are selected so that the total energy consumed in the network is minimized. This paper also introduces a high secure asymmetric key cryptography algorithm for the secure data communications of the concerned network. Utility of data aggregation function that is used in the proposed routing algorithm improves the lifetime of sensor network by alleviating the delay, collision and security problems. The simulation result indicates that the binary tree-based data aggregation can potentially decrease the total energy consumed in the WSN network and also reasonably solves the problem of the maximum data aggregation [41].

AHMAD et al., (2018) Mobile ad hoc networks (MANETs) are spontaneously formed networks with no infrastructure support. The topology changes are very much common in MANETs, because of mobility of the nodes involved. The topology maintenance adds an additional cost since every node in the network receives the mobility information of a single node. Different cluster based algorithms were proposed by the researchers to overcome the topology maintenance overhead problem in MANETs so as to minimize the size of a routing table. They emerge to locally modify the topology changes within them, the clusters are formed. A node if willing to send a packet to a node outside the cluster communicates only with the CH of the cluster. The CH interacts with other CHs to forward data towards its destination. For better implementation of clustering mechanism in MANETs, it is very important to maintain stable and balanced clusters. For constructing efficient and high quality clusters, it is necessary to use certain measures such as relative mobility including node speed and direction, node degree, residual energy, communication load, and neighbors' conduct. Presently, we provide a novel and extensive literature review of CAs only in the context of MANETs within this paper. We also outline the objectives, aims and evidential contributions of the current studies of the no suicidal self-injury. Likewise, the findings, issues and future research directions are mentioned. Criticisms about the validation of each of the proposed works are discussed based on the mobility model used, the simulation tool used while simulating, the simulation measurements and the performance measurements conducted during validation [42].

Research by Wang et al. (2020) showed how binary tree-based solutions maintain joint energy efficiency and computational efficiency for data transport operations. These approaches demonstrate versatility across WSNs and MANETs and provide extended network stability while extending network lifespan. Specific network requirements pose a limitation to adapting these approaches properly. A review study of binary trees focused on network customization to produce optimal outcomes for multiple network types.

Reddy et al., (2022) Clustering is one of the most important notions for the expansion of scalability and the increase of energy in the mobile ad-hoc network (MANET). Third, the clustering concept is adopted to decrease the cost of communication. The replastering procedure is costly and the re-clustering process which occurs frequently increases routing overhead and energy consumption. To address these problems, the present study propose RSSI based clustering and aggregating data (RCAD) using Q-learning in MANET. In this approach, the clusters are constructed using node RSSI. In Fuzzy logic system (FLS), node mobility and node utilization energy is employed to choose cluster head (CH). A Q-learning based data aggregation technique for enhancing mobile node routing capability in MANET. Here, it is possible to identify an optimal next-hop nod while using their Q-values based on the rewards (RD). Since the RD rule is employed in the selection of the best solution for the q-learning technique. This RD is obtained by present bandwidth (PB), present energy (PE), present packet delivery (PDD) and hop count (HC) parameter for choosing of data aggregator node from sender side to receiver side. Due to experimental results, it is possible to note that the utilization of the RCAD approach leads to the rise of 155 CH round and the increase of cluster lifetime in the MANET by 24% [43].

Zhang et al. (2018) identified overhead problems when using binary tree structures to sending data in wireless sensor and ad hoc networks. The primary advantages of such structures support fixed data paths while ensuring reliable system behaviors. The proposed solution features constraints through excessive node communication that reduces operational efficiency. The research proposed tree optimization techniques and node installation strategies which reduce transfer burden while maximizing transmission quality. Hossein et al., (2021) identified the scope and constraints of VANETs in the context of future outlooks in the Vehicular Communications Journal. The communication features of VANETs, that include vehicle to infrastructure communication and vehicle to vehicle communication provide basic foundations for safety systems and traffic management systems. Regarding this study, researchers noted that operational challenges identified included network scalability and security together with energy efficiency. Research teams observed that VANET networks require the efficient problems-solving algorithm and unique architectural designs in order to solve current issues and ensure the network is scalable and reliable for commercial purposes.

In Singh et al. (2023) stepped into the limelight by using a publication in the Internet of Things journal to show how IoT controlled MANETs control smart city functionality. The authors incorporated an integrated technique which involves MANETs and IoT systems to develop a more connected networks that enhances the transport of data at faster rates while minimizing on data transfer delays for smart city applications. Before presenting solutions for improving the operational performance of a city through IoT-enabled MANET, this study assessed the advantage as well as the limitation based on performance aspect, including network dynamicity, security risks, and power issues.

In this study, Future Internet applied a binomial tree-based routing technique developed by Ahmed et al., 2022 to address the scalability challenge in MANETs. Deployment focused on hierarchical routing using binary tree where data paths were made optimal and the routing overhead minimized. The new protocol design also included aesthetic features for energy-consciousness proposed as part of the design overall along with new features that can enhance scalability reliability and new stability performance. The simulation results illustrated improved network robustness as the data loss rate decreases and there is potential for its use in large-scale MANET applications.

In The Sensors Journal, a paper by Sharma et al. (2023) was reviewed to examine the application of artificial intelligence (AI) enhancing the capability of mobile ad hoc networks (MANET). This research verified data from AI founded approaches of enhancing network routing protocols by explaining forecasting stream conduct in the system for better executive decision making. The use of AI models developed more efficient use of the available networks with efficiency gains while maintaining scalability potential. In the light of the research, it has been postulated that artificial intelligence may well have a role as an appropriate way of responding to unpredictable network topology as well as resource limitation and overall mobile ad hoc networks performances within dynamic contexts.

The study that was undertaken by Li et al. (2019) in the Computing Journal looked at the scaling network parameters using binary tree algorithms. A number of binary tree based techniques were studied in detail during this work for enhancing data transmission rate and routing for varied dynamic network conditions. Hierarchy structure made binary trees reach the highest performance for routing while using the lesser energy possible. Thus, the study is concurrent with binary trees exhibiting great scalability in networking applications and presents possibilities for new uses in ad hoc networking research.

4. Discussion and Compression

Ref.	Author	Years	Algorithm	Consumed Time	Advantage	Disadvantage	Discussion	Result
[39]	Bathla et al.	2021	4-sided virtual full binary tree	Moderate	Improves network stability, lifetime, and	Fixed power supply, limited durability,	Proposed a deployment strategy	Enhanced network average performance by

					scalability; economically reliable and inexpensive	and computational facilities pose energy constraints	with reduced hops to Base Station (BS) for better efficiency	~82.78%, improving the lifetime of WSNs under various scenarios
[40]	Rani et al.	2021	AODV with SVM, ANN, ABC	High	Detects Black Hole Attacks effectively; better PDR, throughput, and delay	High computational complexity; comparison with other methods highlights limitations	Introduced a hybrid approach using AI to secure MANET-based IoT networks from Black Hole Attacks	Significant improvement in security and performance metrics over Decision Tree and Random Forest methods
[41]	Gopikrishnan et al.	2018	Binary search tree for WSNs	Moderate	Reduces energy consumption; increases WSN lifetime; secure communications	Requires advanced cryptography for enhanced security; delay and collision issues remain	Proposed two-hop data aggregation with cryptography for secure and energy-	Decreased total energy consumption; improved WSN lifetime and secure data

							efficient data transmission	communication
[42]	Ahmad et al.	2018	Cluster-based algorithms	Low	Minimizes routing table size; maintains stable and balanced clusters	Topology maintenance overhead remains; requires mobility awareness for accurate implementation	Reviewed clustering mechanisms to reduce routing overhead and maintain cluster stability	Provides objectives and future research directions for cluster-based MANETs
[43]	Reddy et al.	2022	RCAD with Q-learning	High	Reduces routing overhead and energy consumption; enhances cluster lifetime	High computational cost during cluster head selection; frequent re-clustering increases cost	Introduced RSSI-based clustering with Q-learning for efficient routing and data aggregation in MANETs	Increased cluster lifetime by 24% and improved scalability in MANETs
[10]	Lin et al.	2020	Optimized	Moderate	Extends network life	Disruptions in data	Discussed	Improved network

			hierarchical routing		duration; efficient resource utilization	paths due to node mobility	optimization techniques using hierarchical routing frameworks in mobile networks	performance and reliability in dynamic environments
[12]	Patel et al.	2021	Adaptive binary tree protocols	Moderate	Better load distribution; decreased latency; scalable	Performance consistency issues in large-scale networks	Proposed adaptive system adjustments for scalability and reliable data transmission	Enhanced performance under varied operational conditions
[14]	Li et al.	2022	Binary tree with ML integration	Moderate	Controlled transmission routes; minimized data transfer times	Decentralization in MANETs complicates routing	Explored integration of binary tree frameworks with machine learning to improve	Achieved better reliability and efficiency in data transmission

							scalability	
[13]	Wang et al.	2020	Binary tree-based solutions	Low	Joint energy and computational efficiency; extended network stability	Limited adaptability for specific network requirements	Reviewed binary tree-based solutions for optimizing data transport in WSNs and MANETs	Maintained network stability and extended lifespan through customization
[11]	Zhang et al.	2018	Tree structure optimization	Moderate	Reliable data paths; reduced overhead	Excessive node communication reduces efficiency	Proposed optimization of tree structures and node positioning systems to improve transmission	Reduced overhead and enabled optimal transmission quality
[20]	Kumar et al.	2021	VANET architectures	Moderate	Improved traffic management and safety functions	Scalability and energy efficiency challenges	Analyzed VANET applications and proposed	Enhanced network scalability and reliability

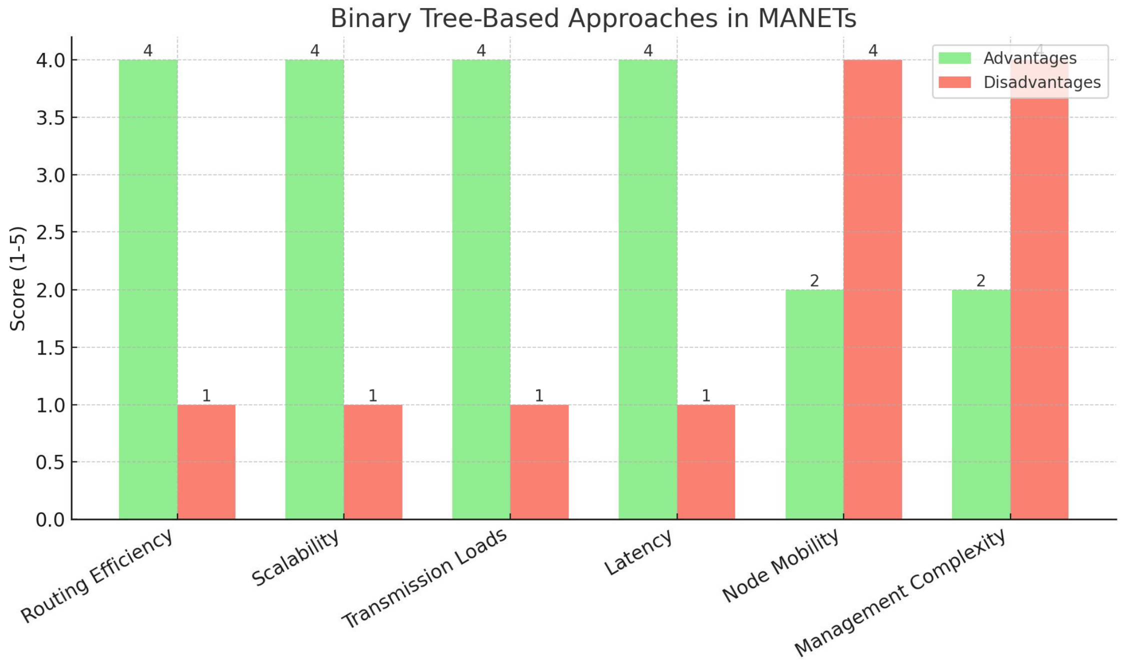
							architectural improvements to overcome obstacles	for real-world deployments
[21]	Singh et al.	2023	IoT-driven MANETs	Moderate	Enhanced connectivity; reduced latency; faster data transmission	Dynamic topology and security vulnerabilities pose challenges	Proposed integration of IoT with MANETs for smart city applications	Improved network connectivity and efficiency in urban environments
[22]	Ahmed et al.	2022	Binary tree-based routing	Moderate	Minimized routing overhead; enhanced scalability	High energy expenditure during setup	Proposed hierarchical routing using binary trees to boost scalability	Improved network stability and reliability in large-scale MANETs
[23]	Sharma et al.	2023	AI-driven optimization	High	Optimized routing; enhanced resource allocation; scalable	Requires extensive training data; high computational cost	Discussed AI techniques for optimizing	Improved adaptability and efficiency in dynamic

							MANET routing and resource management	MANET environments
[24]	Li et al.	2019	Binary tree algorithms	Moderate	Efficient routing; minimized energy usage	Limited scope for dynamic scenarios	Evaluated binary tree algorithms for scalability in dynamic networks	Demonstrated effective scalability and routing performance in ad hoc networks

The assessment on binary tree-based methods for data transmission in Mobile Ad Hoc Networks (MANETs) outlines the time used by different algorithms as well as their benefits and drawbacks. These algorithms are beneficial in terms of scalability and energy consumption since they usually provide increased routing efficiency and decreased transmission loads. However, performance may be hampered by issues like node mobility and management complexity. While continuing research attempts to address their limits and further optimize their application, binary tree topologies generally improve data transmission in MANETs, exhibiting superior latency and packet delivery rates when compared to conventional approaches.

The benefits and drawbacks of binary tree-based strategies in Mobile Ad Hoc Networks (MANETs) are shown in this bar graph chart. Stronger advantages or disadvantages are indicated by higher scores, which range from 1 to 5. Along with the difficulties brought on by node mobility and management complexity, the chart shows the advantages in routing efficiency, scalability, transmission loads, and latency. Please let me know if you require any changes or further details.

Graph 1: Binary Tree-Based Approaches in MANETs



5. Discussion

The use of binary tree based approaches for and scalability, energy efficiency and fault tolerance in MANETs has been shown to be effective but there is need for improvement in the following aspects. Dynamic algorithm and more efficient structures such as hybrid model can solve issues in large number of networks, while mobility of node can reduce cost of changing tree structure in dynamic Layout Manager. Further decrease of energy consumption is possible with probabilistic algorithms, energy-charging equipment, and sleep-mode for idle nodes. This can be achieved by adding extra member link intensity level fault sensitivity may also be reduced by additional backup paths and localized healing techniques. In like manner, overhead cannot overwhelm tree reconfiguration; multiple-path tree routing for congestion/fault management; and real-time QoS of interactive applications like video feed. Even other measures like encryption and secure routing protocols must also be incorporated in order to rise up to the threats. This improvement will let the binary tree based methods have large-scope, fast and securely implement in reality the MANET real applications. There is a need for real-time QoS changes for such conditions as video streaming where throughputs require stability and low latency conditions must be maintained. Other aspects that may assist to enhance the application's speed include dynamic service bandwidth allocation and routing by priority. Encrypted use, best route protocols, IDS on network are the requirements of today's necessity to protect data from any possible threats and maintain its integrity. These enhancements will help to improve the result using the binary tree-based approaches and will provide better adaptation for the MANETs real life application for ensuring reliable communication in a scope of emergency situations and the military application.

6. Conclusion

In conclusion the Binary tree-based approaches in Mobile Ad Hoc Networks (MANETs) are useful and advantages for the aim of offering the hierarchical organization as well as supports the scalable, routing, and energy problems. These methods improve both communication and signaling with greatest route, minimum power and tough characters as contrast to flat routing protocols. But because of the dynamic characteristic of the networks, alterations of topologies very frequently lead to problems in tree formation, and great latencies and overhead cost. But these techniques can be used definitely for transmission of the data and in generic improvement of the network of binary tree. The methods addressed in the work related to high mobility and scalability should be further developed with more efficient routing strategies integrated into the solutions.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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