Improving Stability and Efficiency in MANETs: A Multi-Criteria Approach for Optimal Multipoint Relay Selection

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ABSTRACT

Mobile ad hoc networks (MANETs) were self-sufficient networks made up of several nodes on the move that could connect electronically without the aid of any kind of pre-existing equipment. Because such networks function in extremely unpredictable situations, their capacity to ensure. Mobile area networks, or MANETs, constitute distributed networks with nodes that roam. Energy is a crucial resource because MANET nodes are battery-operated. In OLSR, MPRs are separate nodes to which various nodes decide to send information and manage traffic. As a result, MPR nodes may consume a significant amount of power. Providing Quality of Service (QoS) is a significant research challenge since those networks are susceptible to volatility brought on by wireless communication nor movement. Therefore, when creating routing techniques for MANETs, it is essential to use circuits and mediation facilities that provide assurance, safety, and longer network lives. In order to address the issues of node mobility, energy limitations, and security flaws, this study suggests an advanced algorithm for choosing complicated messengers (MPRs) in MANETs. The suggested method improves networking strength, availability, and endurance by using a multicriteria-weighted methodology that evaluates the dependability, energy consumption, and range of portable nodes. The enhanced technique is tested in NS5 simulations using its Random Waypoint as well as ManhattanGrid motion models. According to the results, the improved algorithm performs better than the conventional OLSR, especially when it comes to throughput, messages distribution, and latency decreases for changeable network situations.

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1. INTRODUCTION

Over the past decade there has been a steady rise in user requests for higher-quality services. The emergence of ad hoc wireless networks in recent years has allowed for greater connectivity than many people had previously thought was possible. Recent advances have led to the development of a number of cutting-edge technologies that make wireless communications accessible to us [1]. Ongoing research efforts involving the application of mobile and radio waves have resulted in the development of numerous technological solutions that facilitate the setting up and use of wireless innovations in areas affected by disasters of any kind [3]. It is admirable to use wireless networks to aid the search efforts with areas affected by a disaster, but doing so may be challenging, especially if traditional and centrally located telecommunications infrastructure, such as the interaction tower or central station, is damaged during the disaster [4].

When developing a system for MPR selection, energy is an essential parameter that needs to be considered for two main reasons: First off, MPR nodes require more energy than non-MPR nodes because they have to relay information and handle transport for the sake of the sites (MPR, which is selector) that chose to utilize MPR [5]. Second, the energy resources accessible to battery-powered nodes in MANETs are restricted. Nodes frequently misbehave to conserve electricity by rejecting messages from a sending cluster under the guise of transmitting them since energy is limited and energy usage is high. The sender node loses energy as a result [6].

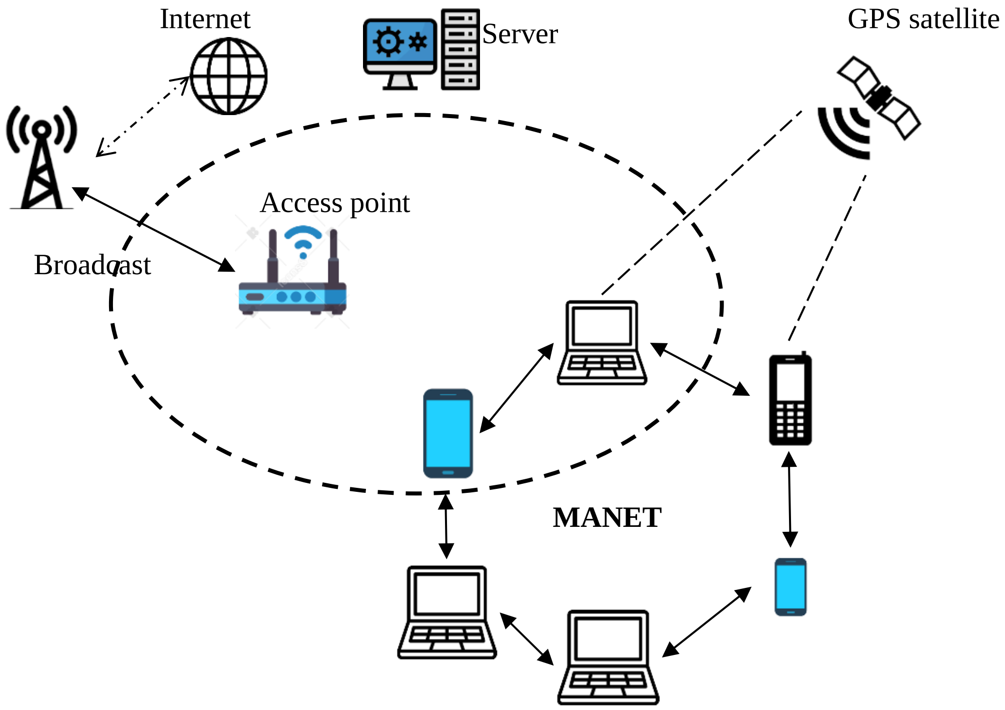

Figure 1. The Basic architecture of MANET

The architecture of MANAET, which houses the entire system network, is shown in Figure 1. By linking devices via various networks, these technologies facilitate Internet of Things (IoT) applications [7]. IoT integration with MANETs and WSNs improves localized data transfer, lowers implementation costs, and increases mobility in smart settings. Because MANETs are distributed networks with frequent topology changes, routing is still a major difficulty. Multipoint relays (MPRs) are used by routing protocols like OLSR to efficiently control traffic and increase routing. The MPR selection method of the Optimized Link OLSR is crucial for reducing control traffic [8]. However, important elements including node movement, energy consumption, and dependability are frequently overlooked by the existing MPR selection algorithms. In rapidly changing and restricted in resources contexts, this results in higher channel overhead costs, worse network performance, and frequent MPR adjustments.

[9] To increase the dependability and stability of some MPRs, our proposed method integrates faith metrics, power, and mobility statistics, in contrast to previous research that focused on a single criterion (like energy or mobility). This approach reduces cost and improves the efficiency of networks in general, particularly in high-mobility scenarios, by significantly lowering the quantity of magnetic resonance imaging re-affiliations. Additionally, our method improves network security by integrating trust metrics, which results in more dependable communication, particularly in settings where hostile activity is common [10]. Flexibility to high-mobility settings, guaranteeing dependable data transmission even in the face of frequent topological shifts. Enhance safety in networks and strengthen defenses from intrusions by utilizing trust indicators. The efficacy of the multicriteria-weighted MPR technology decision method is supported by extensive modeling findings. These are the results that the proposed system generates [11].

2. LITERATURE REVIEW

Abdellaoui et al. [12] introduced Enhancing Stability and Efficiency in Mobile Ad Hoc Networks (MANETs). Mobile ad hoc networks (MANETs) were self-sufficient networks made up of several nodes on the move that could connect electronically without the aid of any kind of pre-existing equipment. Because such networks function in extremely unpredictable situations, their capacity to ensure. Mobile area networks, or MANETs, constitute distributed networks with nodes that roam. Energy is a crucial resource because MANET nodes are battery-operated. In OLSR, MPRs are separate nodes to which various nodes decide to send information and manage traffic. As a result, MPR nodes may consume a significant amount of power. Providing Quality of Service (QoS) is a significant research challenge since those networks are susceptible to volatility brought on by wireless communication nor movement. In order to address the issues of node mobility, energy limitations, and security flaws, this study suggests an advanced algorithm for choosing complicated relays (MPRs) in MANETs. The suggested method improves networking strength, availability, and endurance by using a multicriteria-weighted methodology that evaluates the dependability, power consumption, and range of portable nodes. The enhanced technique is tested in NS5 simulations using its Random Waypoint as well as ManhattanGrid motion models. As a result, communication becomes more dependable and effective, making it a strong option for MANET systems that are extremely dynamic.

Araujoet al. [13] presented enhancing proactive routing in ad hoc wireless networks using an adaptive framework and several criteria. Given that these networks are vulnerable to instability caused by wireless media and mobility, delivering Quality of Service (QoS) represents a major research problem. When addressing the routing problem, the protocol must take into account two or more QoS criteria, depending on the application. By taking into account important network quality metrics, this research suggests an adaptive and multicriteria framework for proactive routing that can produce viable compromise solutions. Two novel approaches—one based on the compromise method (econstraint) and the other on the weighted sum method—are put forth and contrasted with the conventional weighted sum approach. In almost every quality metric, the suggested approaches outperformed the conventional weighted sum approach, based upon the results in the static scenario. It implies that suggested tactics, such as the ND-DEMO algorithm and the multicriteria utility function, were highly successful. Sometimes, especially when the bandwidth was equal to 11 kbps or 202kbps in terms of PLR, which remains Capacity, and NRL parameters, the conventional weighted sum approach outperformed alternative methods.

Tilwari et al. [14] proposed Mobile ad hoc networks use MCLMR, a multicriteria oriented multipath routing system. In Mobile Ad hoc Networks (MANETs), establishing a dependable transmissions path connecting the origin including the target node pair depends on a number of critical aspects, including node mobility, traffic congestion, and the evaluation of the intermediary nodes' link quality. In order to find the best path for MANETs, this study suggests Mobility Congestion establishing and Communication Quality Sensitive Multipath Routing (MCLMR), a routing technique that takes into account the mobility of the nodes, the size of the contention window, and the probable link quality rating of the intermediate nodes. Additionally, the MCLMR employs the TOPSIS scheme, a multicriteria decision-making method that assigns intermediary nodes extra weight according on their contention window size and accessibility status quality of connection ratings. Additionally, to lessen the impact of the directive message storm, the suggested approach uses the ETX (Expected The amount of Transmissions) measure. When analyzing the MCLMR scheme compared with the MP-OLSRv2 routing method at a node that travels 60 m/s, the simulation results show a substantial decrease in both the container ratio of loss and overall delay, at 25.59 percent and 12.38 percentage, respectively. Therefore, even under high-speed node circumstances, the MCLMR transportation system is dependable for data transport.

Jabbar et al. [15] suggested Mobility and resources For load balancing while route stability in MANETs, use a mindful multipath routing system. The most important characteristics of mobile ad hoc networks (MANETs) are node motion and restricted energy resources. The network's topology is subject to unforeseen changes due to node mobility, which impacts the stability of linked pathways. Furthermore, it results in unnecessary overhead traffic, which raises energy consumption and impairs routing protocol performance. Based on MP-OL SRv2, we presented the Multipath Battery and Mobility-Aware routing strategy (MBMA-OL SR) in this study. The study specifically uses a Multi-Criteria Nodal Rank (MCNR) evaluation that takes node performance and remaining battery power into account. To assess the balance involving conservation of energy and QoS over the route computation in the proposed scheme, it is also highly recommended to study the proposed MCNR using supplementary QoS measures from different layers. This is due to the fact that link metrics are still a very broad topic, and taking into account different QoS metrics to gauge link quality will lead to fresh approaches that can accommodate a wider range of scenarios and satisfy the needs of different applications.

Anand et al. [16] developed Multipoint relay selection in mobile ad hoc networks that is both secure and energy efficient. Due to the battery-powered nature of MANET nodes, energy is a vital resource. The remaining nodes choose special nodes known as MPRs to pass along their data and regulate traffic in OLSR, which may result in MPR nodes using a lot of energy. Therefore, to guarantee a longer network lifetime, it is essential to use an energy-efficient MPR selection mechanism. Misbehaving MPR nodes, on the other hand, typically discard packets from other nodes rather than forwarding them in order to save energy. An energy-efficient preserved MPR selection (ES-MPR) method that considers power and safety metrics for MPR selections is presented in this study. It determines the "Composite Eligibility Index" of nodes (based on being disruptive chances, Strength Factor, Having stability Index, Hello Loss Ratio, and Forwarding Behavior) in order to supply different choosing elements for Inundation and Forwarding MPRs. It adds it to the commitment value, which is calculated by utilizing Queue Occupancy, Accessible Capacity, and Longevity. Using NS-2, the effectiveness of ES-MPR is assessed by contrasting it with the currently employed MPR selection methods.

3. PROPOSED METHODOLOGY

Unpredictable node mobility, scarce energy resources, and security flaws are fundamental problems with MANETs. Because nodes migrate, join, or depart regularly, these dynamic networks have a difficult time sustaining dependable communication and network performance. We suggest a sophisticated multicriteria stability method that evaluates and improves node stability to overcome these problems. To choose MPRs more effectively and steadily, this process takes into account important variables including mobility of nodes, energy accessibility, and protection characteristics. Our method reduces the intrinsic instability of MANETs by methodically assessing these parameters, which improves network dependability and resilience.

A table-driven networking protocol designed especially for MANETs is called the OLSR protocol. It provides high efficiency and streamlines routing logic. By sending greetings to their fellow 1-hop neighbors, nodes in OLSR choose a group of MPRs. Only MPRs generate link-state information and forward topological information. OLSR works particularly well in dense and sizable networks. Technologies that improve this selection process must be investigated because choosing the minimal collection of MPRs presents difficulties.

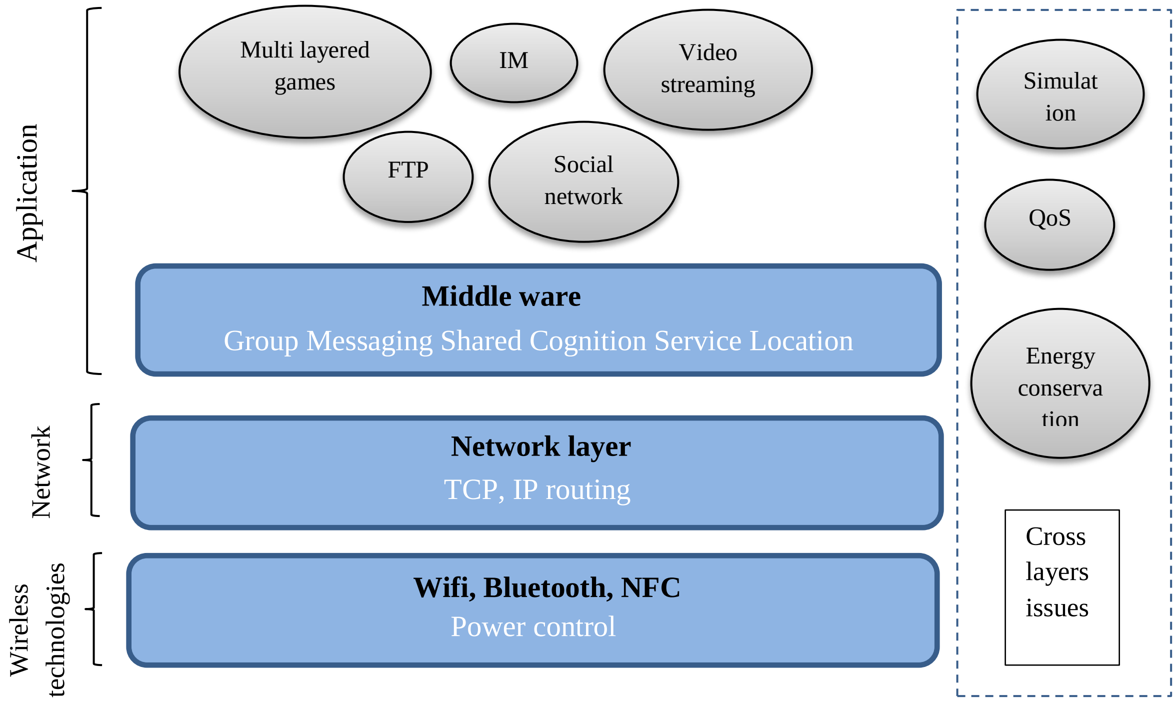

Figure 2. The Architecture of the suggested system

The MANET framework's architectural view is displayed in Figure 2. The Composite Eligibility Index (CEI), a new idea introduced by ES-MPR, assesses a node's suitability for selection as MPR. The MPR selection node determines the CEI based on reliability and safety concerns, whereas the node itself calculates and disseminates willingness. A key component of MPR selection in ES-MPR, the "Selection Parameter," is determined by combining CEI with a node's received willingness. Every node in ES-MPR calculates its capacity number (both WF(u) and WR(u)) using the following metrics: Queue Occupancy Metric (MQO), Available Bandwidth Metric (MAB), and Longevity Metric (MLT). A node u's lifespan is determined by its remaining power and drain velocity at time "t." It is expressed as follows:

$$M_{LT} = \frac{LT_t}{LT_{max}} \qquad (1)$$

"LT_{max}" will be the node's maximum value. The available bandwidth metric, which is used to calculate willingness, is as follows:

$$M_{AB} = \frac{BW}{BW_{max}} \qquad (2)$$

The node's maximum bandwidth value will be "BW_{max}". Using Hello messages, the The OLSR algorithm protocol disperses the registration of a group of MPRs and establishes 2-jump companions. There is constantly a path through all of a node's 2-hop neighbors when it is chosen as an MPR. Massive and packed networks are best suited for OLSR, which provides the optimal pathways in terms of hop count.

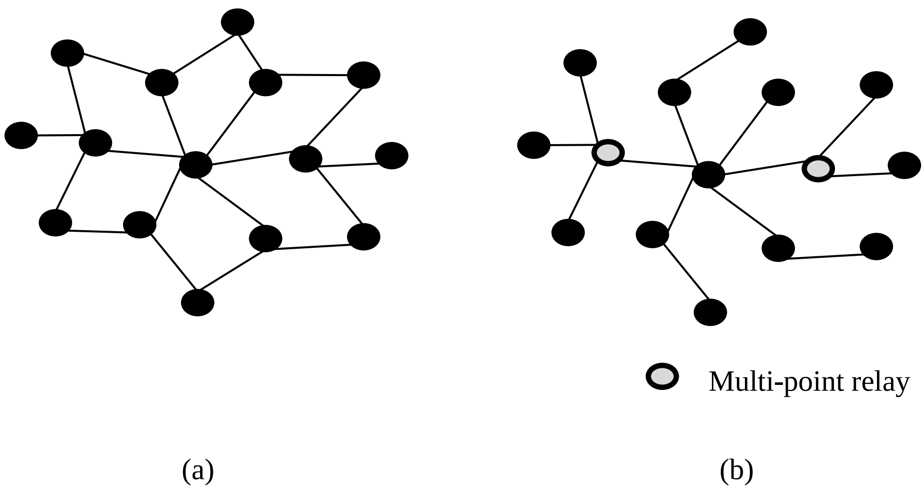

Figure 3. Multipoint relay illustration

The multipoint relay idea, which minimizes overlapping transmissions in the network to optimize data transmission, is depicted in Figure 3. We created Multicriteria Weighted MPR (MCWMPR), a multicriteria instability system for appropriate MPR decisions within the OLSR protocol, building on previous research. MCWMPR assesses the energy levels, trustworthiness, and mobility patterns among nodes. Similar transportation, high speed, and reciprocal confidence increase the likelihood that nodes will continue to form strong bonds and remain unified over time. The following formula can be used to calculate the changes in a node's x- and y-coordinates, ΔxA and ΔyA, at each time interval ΔA. A node's current and prior positions are separated by the Euclidean distance Y, which is computed as

$$Y = \sqrt{(\Delta xA)^2 - (\Delta yA)^2} \qquad (3)$$

This computation aids in figuring out the nodes' mobility pattern, which is essential to the suggested multicriteria MPR selection method. The definition of a node's direction (θ) is

$$\vartheta_i = \begin{cases} \delta.\,sin(\Delta yA_i) \\ \frac{\pi}{2}.\,sin(\Delta xA_i) \\ \mu - \sigma.\,sin(\Delta xA_i) \end{cases} \qquad (4)$$

Considering its speed (V), which is a combination of motion and acceleration, the rate of acceleration (B) from a particular node over time ΔT is computed as:

$$B = \frac{\Delta v}{D} \qquad (5)$$

Secure communication requires trust. Two nodes' trust measure, $TM_{(i,j,l)}$, is computed as

$$TM_{(i,j,l)} = \frac{PM_{(i,j,l)}}{PS_{(i,j,l)}} \qquad (6)$$

Lastly, a node's multicriteria-weighted MPR (MCWMPR) is determined as

$$MCW_{MPR(i,j,l)} = W1.\frac{1}{n}\sum_{j=1}^{n} TM_{(i,j,l)} + W2.\frac{1}{n}\sum_{j=1}^{n} SD + W3.\frac{1}{n}\sum_{j=1}^{n} TM_{(i,j,l)} \qquad (7)$$

For computation, the full MCWMPR formula is given in Equation 7. Node I with a reduced MCWMPR value is more dependable, has a larger buddy set, shows similar migration patterns to its fellow citizens, and has high energy levels, all of which contribute to network stability. Acceleration, orientation, velocity, power, and protection are all closely related. Consequently, an element with a relatively low MCWMPR value could possess an MPR, which can improve stability and enhance security, reachability, and communication quality. Because of this, the routing is appropriate for highly mobile scenarios.

4. RESULT AND DISCUSSION

The NS3 simulator, which is based on both the RandomWaypoint and ManhattanGrid movement models for MANETs, is used in a C++ environment to assess the effectiveness of routing protocols. The effectiveness of different MCW_OLSR and OLSR scenarios is compared by the authors. The simulation runs for one hundred seconds. In a 1000 m by 1500 m area, identical mobile nodes with the numbers 15, 20, 35, 50, 55, 70, 75, 90, 95, and 110 are grouped. The findings of the simulation are discussed using a graph analysis. The following graphs illustrate the effects of total node count on throughput delay and packet delivery percentage (PDR). OLSR in terms DSDV and SR_OLSR are not as effective as MCW_OLSR, especially in networks with more nodes. These findings illustrate how well MCW_OLSR performs in dense network conditions.

MCW_OLSR performs better than OLSR DSDV and SR_OLSR, especially in networks with more nodes. The success of MCW_OLSR in scenarios involving dense networks is demonstrated by these results. Figure 4 displays the duration of the data packets' journey from their source to their destination. With the best connectivity possible, this approach guarantees that paths stay genuine and safe. This enhancement implies that the method has a clear benefit in communication and broadcasting, particularly when there are more mobile nodes.

ManhattanGrid Resutls

The multicriteria-weighted MPR method cuts down on latency. MCW_OLSR has a lower delay than OLSR DSDV and SR_OLSR as shown in Figure 5. This improvement shows how useful the recommended approach is in busy and dynamic environments.

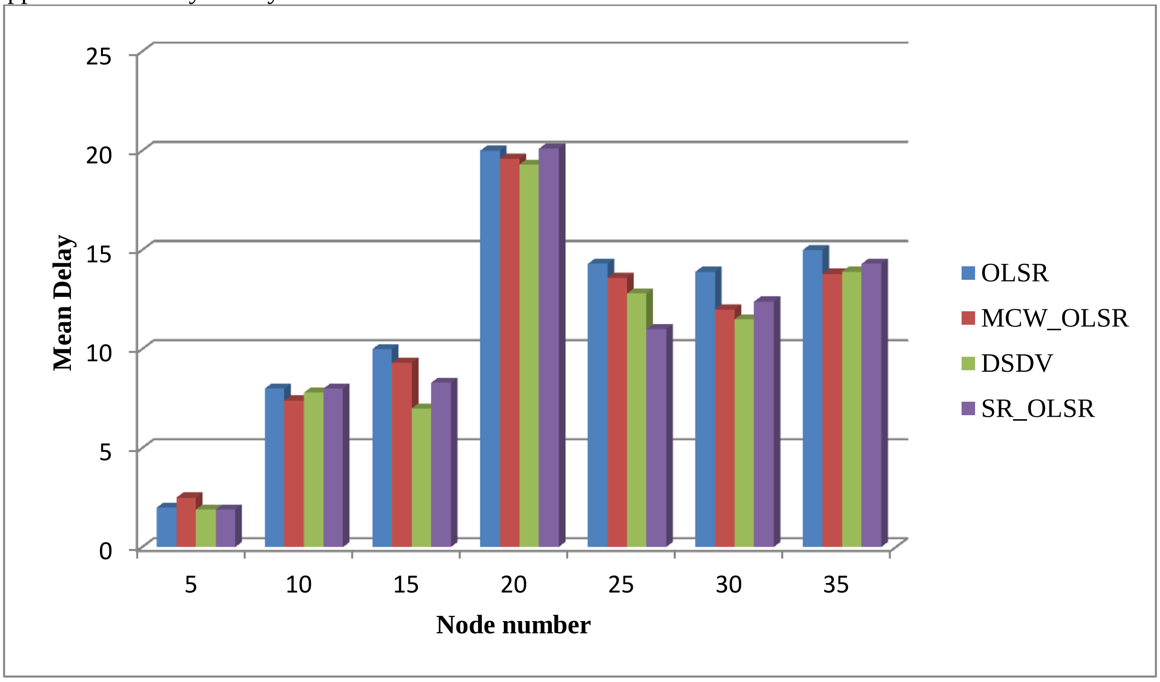

Figure 4. Comparison of Mean Delay

Figure 4 illustrates how long it takes for packets of information to get from starting point to their conclusion. According to the data, MCW_OLSR provides a less significant delay than OLSR DSDV and SR_OLSR. Increased node stability, security, and lifetime—which guarantee reliable connections with neighboring nodes—are the source of this improvement. MPR that is weighted by multiple criteria reduces latency. Compared to OLSR DSDV and SR_OLSR, MCW_OLSR shows a reduced delay.

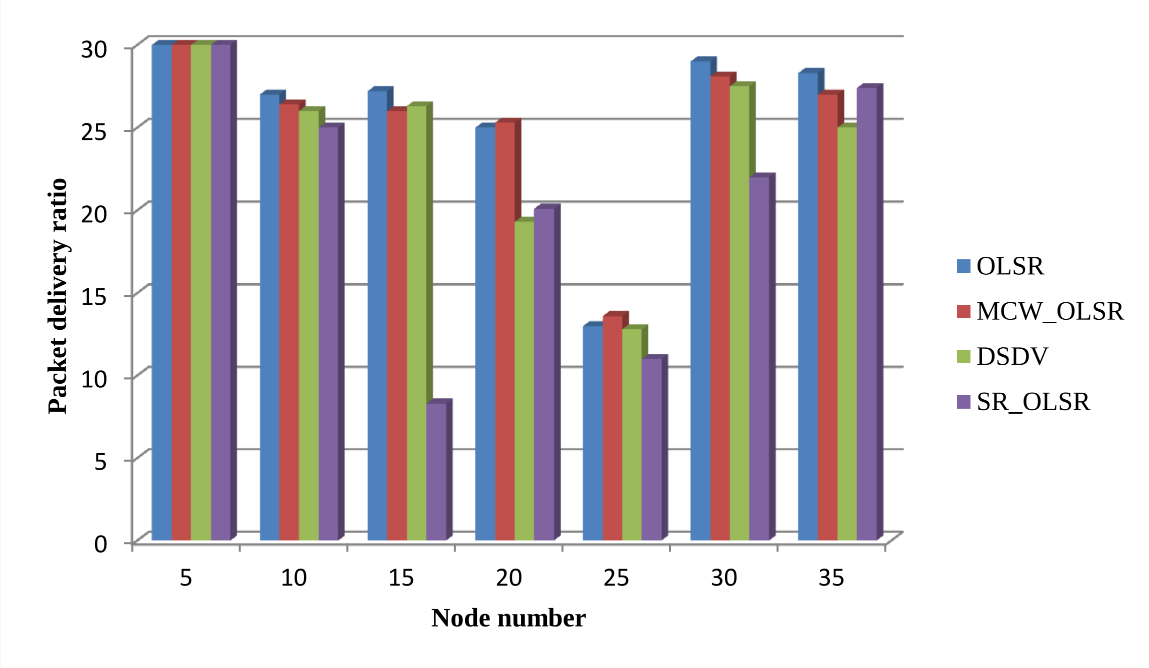

Figure 5. Comparison of Packet delivery ratio

The packets that were successfully broadcast by each protocol are compared in Figure 5. MCW_OLSR outperforms OLSR, DSDV, and SR_OLSR in terms of packet distribution. This demonstrates how well the suggested strategy works concerning PDR.

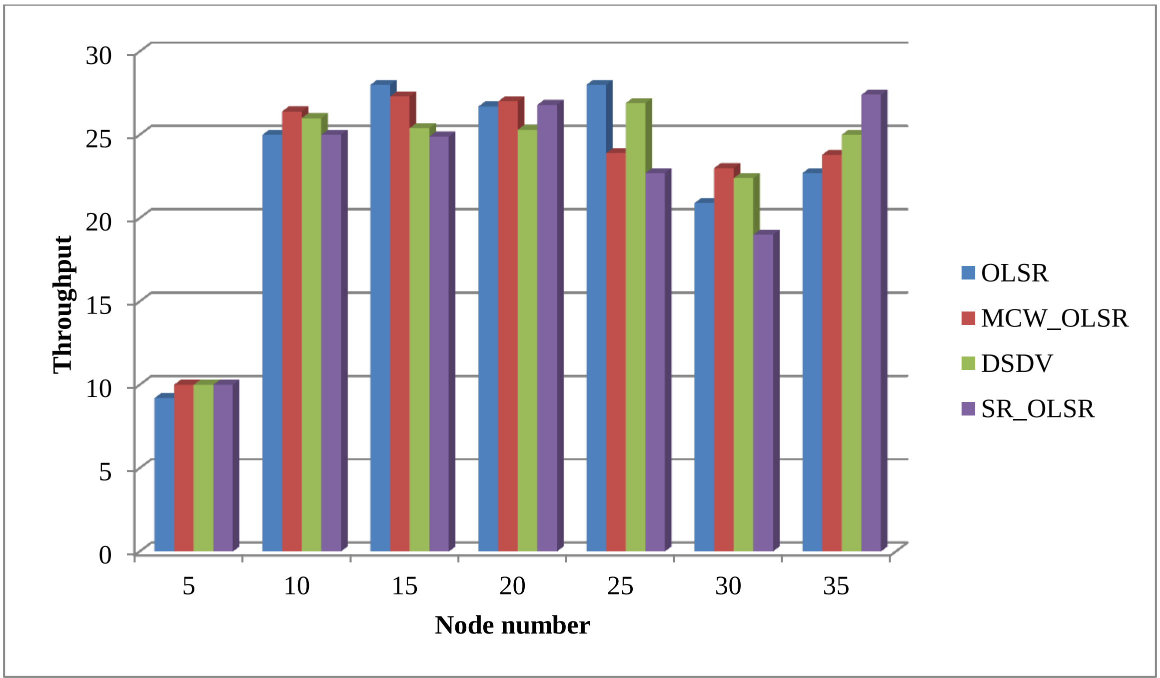

Figure 6. Comparison of Throughput

The effect of node count on throughput is seen in Figure 6. In comparison to OLSR, DSDV, and SR_OLSR, MCW_OLSR exhibits a noticeable increase in throughput by maximizing the selection of MPRs.

5. CONCLUSION

Nodes in OLSR choose Multipoint Relays (MPRs) to transmit their control and data traffic throughout the network. Energy and QoS measures, including residual energy, connection stability, longevity, etc., constitute the foundation of current MPR selection algorithms. By addressing the main issues of mobility, energy limitations, and security flaws in MANETs, this strategy enhances the accessibility, protection, and endurance of the network. However because these systems don't consider any security metrics, they might not work well in a hostile environment. The MCW_OLSR protocol was thoroughly compared to three SOTA baselines: the original OLSR, DSDV, and SR_OLSR protocols. The outcomes show that, especially in dynamic and crowded network situations, our multicriteria-weighted MPR decision algorithm continuously performs better than existing conventional protocols. Compared to the RandomWaypoint and ManhattanGrid transportation models, MCW_OLSR showed notable gains in terms of fewer missed packets, reduced delay, reduced jitter, enhanced PLR, enhanced PDR, and optimized total bandwidth. As a result, communication becomes more dependable and effective, making it a strong option for MANET systems that are extremely dynamic.

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