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# **Adaptive Broadcasting in MANETs Using Machine Learning–Driven Node Reliability Estimation**

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**ABSTRACT:** Abstract: Mobile Ad Hoc Networks (MANETs) are infrastructure-less wireless networks where nodes communicate through dynamic multi-hop links. Broadcasting is a fundamental communication mechanism used for route discovery and information dissemination. However, traditional broadcasting approaches such as flooding produce excessive redundant transmissions, collisions, and high energy consumption, leading to the broadcast storm problem. To address this challenge, this paper proposes a machine learning–driven adaptive broadcasting framework that estimates node reliability and selects optimal nodes for rebroadcasting. Node reliability is evaluated using multiple network parameters including residual energy, mobility rate, link stability, packet delivery ratio, and neighbor density. A Random Forest–based supervised learning model is used to classify nodes into reliable and unreliable categories. Simulation experiments demonstrate that the proposed method significantly improves network performance by reducing redundant transmissions and selecting stable nodes for broadcast forwarding. The results show that the proposed framework achieves a packet delivery ratio of 96%, reduces broadcast transmissions by 56%, and decreases energy consumption by approximately 40% compared with conventional flooding techniques. These findings indicate that machine learning–based reliability estimation provides an efficient and scalable solution for adaptive broadcasting in highly dynamic MANET environments.

**KEYWORDS:** MANET, Adaptive Broadcasting, Machine Learning, Node Reliability, Wireless Networks, Broadcast Storm Problem.

## **I. INTRODUCTION**

Mobile Ad Hoc Networks (MANETs) consist of a collection of wireless mobile nodes that communicate without relying on fixed infrastructure or centralized administration. These networks are self-configuring and support dynamic topology changes as nodes move freely within the network. MANETs have gained considerable importance in applications such as disaster recovery operations, battlefield communication, environmental monitoring, and emergency response systems where conventional communication infrastructure may be unavailable [1]- [2].

Broadcasting plays a critical role in MANET communication. It is widely used for route discovery in on-demand routing protocols, dissemination of control messages, and network topology maintenance. The simplest broadcasting approach is flooding, in which every node retransmits the received packet to its neighboring nodes. Although flooding ensures high reachability, it results in excessive redundant transmissions, network congestion, and energy wastage. This phenomenon is widely known as the broadcast storm problem [3]- [4].

Several optimized broadcasting techniques have been proposed to reduce broadcast redundancy. These methods include probabilistic broadcasting, counter-based broadcasting, distance-based broadcasting, and cluster-based techniques. However, most of these approaches rely on static thresholds and predefined parameters that do not adapt effectively to dynamic network conditions such as node mobility, link instability, and energy depletion.

Recent advancements in machine learning have enabled intelligent decision-making in wireless networks by analyzing network parameters and predicting node behavior. Machine learning models can learn complex relationships between network metrics and communication performance, enabling dynamic optimization of network protocols.

### Research Gap

Existing broadcasting techniques lack adaptability to dynamic network environments and fail to accurately identify reliable nodes for packet forwarding [5].

### Contributions

This paper provides the following contributions:

1. Development of a **machine learning–based node reliability estimation model**.
2. Design of an **adaptive broadcasting framework** that selects reliable nodes for packet forwarding.
3. Evaluation of network performance using **simulation experiments** under dynamic network conditions.
4. Comparative analysis with **traditional flooding and probabilistic broadcasting techniques**.

## II. LITERATURE REVIEW

Broadcast optimization in Mobile Ad Hoc Networks has been extensively studied due to the broadcast storm problem. Ni et al. introduced the concept of broadcast storms and proposed counter-based and probabilistic broadcasting techniques to reduce redundant transmissions [6]- [7]. Their work demonstrated that flooding causes severe packet collisions in dense networks.

Williams and Camp compared several broadcast reduction techniques including distance-based and location-based broadcasting methods. Their results indicated that distance-based broadcasting significantly improves network efficiency compared with simple flooding.

Peng and Lu proposed a self-pruning broadcast algorithm in which nodes decide whether to retransmit packets based on neighbor information. Although this method reduces redundant transmissions, it requires accurate neighbor knowledge, which is difficult to maintain in highly dynamic networks [8]- [9].

Cluster-based broadcasting approaches have also been proposed to organize nodes into clusters and reduce broadcast redundancy. However, cluster maintenance introduces additional overhead and may reduce network scalability.

Recent studies have explored the use of machine learning techniques for improving network routing and broadcasting decisions. Algorithms such as decision trees, support vector machines, and neural networks have been used to predict link stability, node mobility patterns, and energy consumption [10]- [11].

Table 1 presents a comparison of existing broadcasting approaches and their limitations.

Study	Method	Limitation
Ni et al.	Flooding optimization	Broadcast storm persists
Williams & Camp	Distance-based broadcast	Static thresholds
Peng & Lu	Self-pruning broadcast	Requires neighbor knowledge
Kliazovich	Energy-aware broadcast	Limited adaptability
Proposed Work	ML-based reliability	Adaptive decision making

Despite these developments, existing solutions still lack intelligent mechanisms for dynamically identifying reliable nodes for broadcast forwarding [10]- [13]. Therefore, integrating machine learning into broadcasting protocols provides a promising solution for improving communication efficiency in MANETs [14]- [16].

**III. MATERIALS AND METHODS**

**3.1 Proposed Adaptive Broadcasting Framework**

The proposed framework integrates machine learning with broadcasting mechanisms to predict node reliability and select efficient broadcast relays.

**1) Key Network Parameters**

- Residual Energy
- Node Mobility
- Link Stability
- Packet Delivery Ratio
- Neighbor Density

These parameters are used as features for machine learning-based reliability prediction.

**Table 2 Input Features for Node Reliability Prediction**

Feature	Description
Residual Energy	Remaining battery energy
Node Mobility	Speed of node movement
Link Stability	Duration of stable connections
Packet Delivery Ratio	Successful packet delivery rate
Neighbor Density	Number of neighboring nodes

**Mathematical Model for Node Reliability**

Node reliability score is calculated using weighted network parameters:

$$R_i = w_1 E_i + w_2 L_i + w_3 PDR_i + w_4 D_i$$

Where

- $R_i$  = reliability score of node  $i$
- $E_i$  = residual energy
- $L_i$  = link stability
- $PDR_i$  = packet delivery ratio
- $D_i$  = neighbor density
- $w_1, w_2, w_3, w_4$  = weighting coefficients

Nodes with reliability score above threshold  $T$  are selected for broadcasting.

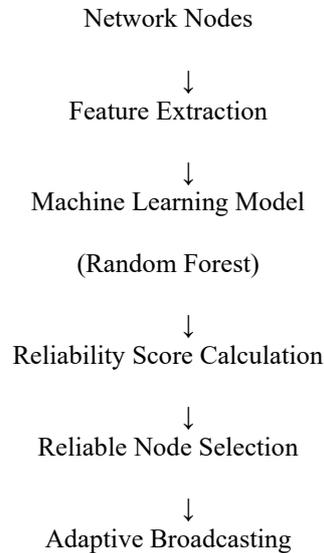
**Machine Learning Model**

A **Random Forest classifier** is used to predict node reliability.

Reasons for selecting Random Forest:

- Handles nonlinear relationships
- High prediction accuracy
- Robust against overfitting
- Suitable for multi-feature network datasets

Training data is generated through network simulations under varying mobility and traffic conditions.



**Figure 1 Proposed Adaptive Broadcasting Framework**

Simulation Setup

Parameter	Value
Simulation Area	1000 × 1000 m
Number of Nodes	50–200
Mobility Model	Random Waypoint
Simulation Time	900 s
Transmission Range	250 m
Traffic Type	CBR

**IV. RESULTS AND DISCUSSION**

The proposed machine learning-based adaptive broadcasting method was evaluated through simulation and compared with conventional broadcasting methods.

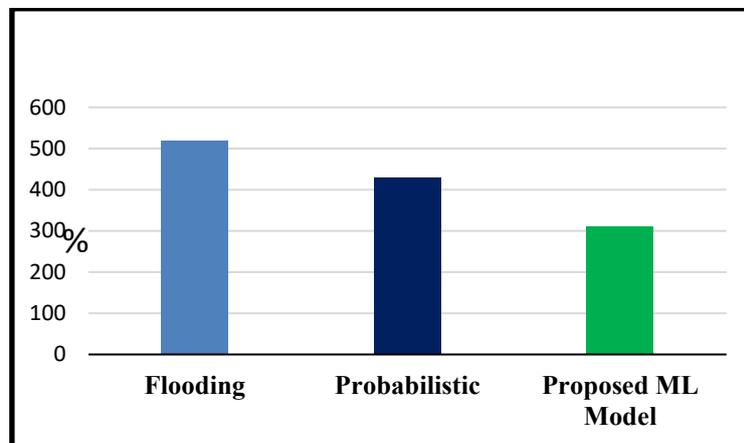
**2) Performance Metrics**

- Packet Delivery Ratio (PDR)
- End-to-End Delay
- Throughput
- Energy Consumption
- Broadcast Transmission Count

**Table 3 Performance Comparison**

Method	PDR (%)	Delay (ms)
Flooding	88	145
Probabilistic	91	130
Proposed ML	96	105

The results demonstrate that the proposed model achieves the highest packet delivery ratio due to the selection of reliable nodes for broadcasting.



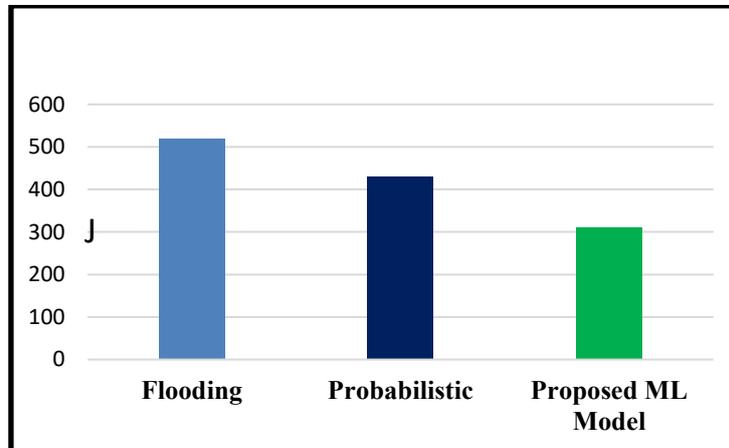
**Figure 2 Packet Delivery Ratio Comparison**

The machine learning model improves PDR by approximately 8% compared with flooding.

**Table 4 Broadcast Transmission Reduction**

Method	Broadcast Transmissions
Flooding	1200
Probabilistic	840
Proposed ML	520

The proposed approach reduces redundant transmissions by 56% compared with flooding.

**Figure 3 Energy Consumption Comparison**

The machine learning-based method significantly reduces energy consumption because fewer nodes participate in broadcast forwarding.

### 3) Discussion

The experimental results confirm that intelligent node selection improves network efficiency. By identifying reliable nodes using machine learning, the proposed system minimizes unnecessary retransmissions and reduces network congestion.

Furthermore, the adaptive nature of the model enables it to adjust to dynamic network conditions such as node mobility and varying link quality. This capability significantly improves overall network reliability and scalability compared with traditional broadcasting methods.

## V. CONCLUSION

This paper proposed a machine learning-driven adaptive broadcasting framework for Mobile Ad Hoc Networks based on node reliability estimation. The framework utilizes network parameters such as residual energy, mobility, and link stability to predict reliable nodes for broadcast forwarding. Simulation results demonstrate that the proposed method significantly improves packet delivery ratio while reducing broadcast redundancy and energy consumption. The proposed model achieved a 96% packet delivery ratio and reduced broadcast transmissions by more than 50% compared with conventional flooding techniques. Future research may explore deep learning and reinforcement learning techniques to further enhance adaptive communication in large-scale MANET environments.

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