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Article · August 2024

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Proceedings of the 7th International Conference on Inventive Computation Technologies (ICICT 2024)
Xplore Part Number : CFP24F70-ART ; ISBN : 979-8-3503-5929-9

Deep Learning based Channel Assignment with Load Balancing in MANET for Improved Performance

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2024 International Conference on Inventive Computation Technologies (ICICT) | 979-8-3503-5929-9/24/$31.00 ©2024 IEEE | DOI: 10.1109/ICICT60155.2024.10544447

***Abstract*— In Mobile Ad Hoc Networks (MANETs), the effective channel assignment is important for optimizing the performance of the network. The proposed system uses deep learning with CNN, RNN and LSTM for channel assignment with load balancing. The spatial parameters from the input data are obtained using CNN. This helps in analyzing the relationship between network nodes with communication patterns. The important features that help in channel assignment decisions are obtained through feeding the signal strength information to the CNN network. The sequential data in the network are handled using RNN networks. They help in analyzing the temporal dependencies in the channel assignment process. This helps in obtaining informed decisions based on communication links. LSTM networks are used for recollecting information regarding the previous channel assignments. This helps the system to learn from past circumstances and make better decisions with load balancing. The optimal channel assignments are based on the contemporary state of the network. This helps in reducing congestion with improved resource utilization. The proposed system are designed to adapt for real time variations in the network. This is done through considering various factors such as signal strength, interference and active nodes. Continuous improvement of decisions are obtained through feedback for improved performance of the network.**

Keywords*— Mobile Ad Hoc Networks, Channel assignment, Deep learning, Signal strength information, Communication links, Continuous improvement

I. INTRODUCTION

A Mobile Ad Hoc Network (MANET) is a self-configured, decentralized form of network that is connected wirelessly. They do not require any fixed infrastructure or centralized administration. They are designed based on their dynamic patterns in which the nodes enter and leave anytime without any limitations [1]–[3]. This leads to frequent changes in the network connectivity. These networks are largely used when the traditional infrastructure fails to perform in particular scenarios. They are largely used in military applications, disaster relief struggles and sensor networks . One of the important features of MANET involves the ability to function in a highly dynamic environment. This helps the system to become highly resilient and able to function in various circumstances [4], [5]. The communication system in MANETs is achieved using a multi-hop paradigm. Here the data packets may transfer to the intermediate nodes before reaching their destination. The decentralized techniques help the MANET to become the highly flexible and scalable network. There are various challenges in the MANET due to its dynamic conditions. Effective communication is done using the routing protocols due to the frequent mobility of nodes and the absence of infrastructure. Numerous routing algorithms are developed due to overcome the various challenges. The various algorithms used are namely proactive, reactive and hybrid protocols. The routing information of all nodes in the networks are achieved using proactive protocols such as Optimized Link State Routing (OLSR). The establishment of routes on demand is obtained using reactive protocols such as Ad Hoc On-Demand Distance Vector (AODV) [6], [7].

The important consideration in MANET involves the security and privacy. This is due to the dynamic nature of the network. The absence of centralized infrastructure makes them to highly vulnerable for numerous security threats. They include malicious nodes, eavesdropping, and denial-of-service attacks. To overcome various risks and challenges, numerous security mechanisms are developed and implemented [8]–[10]. They include authentication, data encryption and intrusion detection systems. They are designed to maintain the security of the dynamic network conditions. An important consideration in the design aspects of MANET involves the energy efficiency. Here various devices in the network operate at minimum battery conditions. The various protocols and algorithms used for the optimization of energy are Dynamic Source Routing (DSR) and Energy-Aware Routing (EAR). They play an important role in increasing the lifespan of the network with improved performance [11]–[13]. The integration of artificial intelligence plays an important role in improving the adaptability and reliability of MANET. The various challenges in the dynamic network are overcome using deep learning techniques with optimization algorithms. The important role of artificial intelligence in MANETs are optimization of routing protocols [14], [15]. Traditional and existing routing protocols in MANETs lead to various constraints in adapting to the dynamic environments. This results in suboptimal performance. The developed routing algorithms based on artificial intelligence help in analyzing historical data which helps to predict the dynamics of the network. They helps in adjusting the routing decisions based on real time environments. They helps in improving the overall efficiency of the data transmission with improved resilience of the network. AI helps in the efficient management of network resources in MANETs [16]–[18].

The various parameters such as resource allocation, bandwidth utilization and power management require various adaptive strategies due to its dynamic conditions. The deep learning techniques help in optimizing the allocation of resources to obtain efficient utilization and reduce bottlenecks.The robust intrusion detection system is obtained using the optimization algorithms. To obtain efficient functioning of the network, various preventive mechanisms are obtained. They help in the continuous monitoring of the network behaviour with the identification of anomalies. This optimization algorithm helps in extracting information from attack patterns to improve the ability in the detection of unknown threats that can able to fix security challenges. The optimization algorithm provides advanced decision-making and self-organization structure [19], [20]. They help the nodes to perform intelligent decision-making skills based on the obtained information. They integrate with the neighbouring nodes which helps in the optimization of the network performance. The frequent joining and leaving of the nodes in the network are due to the aid of self-adaptive capability. The data flow and connectivity are obtained using the dynamic approach. Thus the integration of artificial intelligence in MANET helps in obtaining improved efficiency and resilience in the performance of the network.

II. TRADITIONAL METHODOLOGY

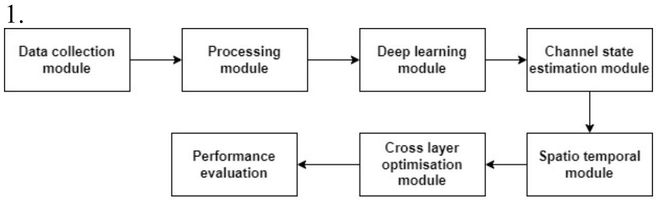
While existing strategies for channel mission in Mobile Ad Hoc Networks (MANETs) have typically relied traditional routing protocols, this study proposes a new deep learning-primarily based method. More precisely, conventional methods often use proactive protocols such as Optimised Link State Routing (OLSR) or reactive protocols like Ad Hoc On-Demand Distance Vector (AODV) to establish and sustain routes inside the network. Although these traditional methods have played a fundamental role in MANET research, they provide challenges in adjusting to the ever-changing and unexpected conditions of MANET settings. Proactive protocols safeguard routing data for all nodes inside the network, leading to increased overhead, particularly in scenarios with high levels of mobility. Reactive protocols, on the other hand, start the process of course discovery when needed, reducing certain concerns about excessive workload but causing delays during the establishment of the course sequence.

In addition, established methods may also likewise fail to efficaciously adapt to shifting network occasions, significantly in scenarios suggested by fluctuation topologies, node mobility, and dynamic website traffic patterns. The fundamental issues of those tactics demand the requirement for additional state-of-the-art and adaptable therapies, which stimulates the look at of deep learning approaches in this test. The advised strategy employs CNNs, RNNs, and LSTM networks to triumph over those problems with the help of means of delivering a dynamic and context-aware channel allocation technique. This has been proven by employing full-size complaint in a simulated MANET environment.

III. PROPOSED SYSTEM

The device advised within the ability research supplies an innovative method for controlling tasks in Mobile Ad Hoc Networks (MANETs) by applying superior deep learning approaches. By the utilisation of Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), and Long Short-Term Memory (LSTM) networks, the model makes use of the spatial and temporal qualities of network recordings to boost flexibility and performance. The CNNs analyse geographical qualities generated from signal strength data, permitting insightful options on channel assignments with the aid of comprehending the difficult interconnections involving community nodes. RNNs are utilised to govern sequential information, appropriately taking photos temporal relationships in the channel undertaking system. The usage of LSTM networks similarly increases the system's abilties by using saved knowledge from previous channel assignments, permitting the version to analyse from historical records and make intelligent judgements with a concentrate on load balancing.

This new response is getting beyond the constraints of conventional techniques, which may also struggle to change to the dynamic circumstances inherent in MANETs. The presented technique is designed to handle the demanding circumstances produced with the assistance of applying modifying topologies, node mobility, and fluctuating visitors types, giving an extra bendy and durable reply. Through huge opinions in a simulated MANET surroundings, the gadget exhibits greater usual performance in terms of throughput, latency, dependability, and load balancing performance instead of baseline designs and standard ways. The suggested technology serves as a testimonial to the potential of deep learning to change channel project techniques in MANETs, opening the way for extra flexible and strong wireless discussion networks. The architecture of the proposed system is shown in figure 1.



IV. IMPROVED PERFORMANCE IN MANET USING DEEP LEARNING

The total performance of the network is boosted the usage of deep acquiring knowledge of techniques using optimization algorithms. This involves multiple layers as mentioned below.

1. Network facts series and processing

The procedure of statistics collecting for channel mission in MANETs comprises the gathering of information relating network structure, visitors styles and node characteristics. The topological information is crucial for interpreting the spatial relationship of nodes. This also includes the identification of nearby nodes and their connection matrix. The upgradation of topology information is performed via Dynamic Source Routing (DSR) or Ad Hoc On-Demand Distance Vector (AODV). They are crucial for getting educated decisions about channel assignments. They support within the estimate of ability interference assets and varied options for load balancing. The communication among the nodes are chosen utilising traffic patterns inside the MANET. This comprise of information transmission fees, size of the packet and frequency of communication. The dynamic aspect of the network is motivated by method of examining the mobility pattern of nodes. Data collecting procedures comprise the deployment of multiple tracking devices. Node characteristics serve a crucial role in load balancing. This incorporates computational abilties and strength levels. The channel assignments are done using thinking about distinct aspects involving node processing power and battery state of pricing. The strong exploitation of the information is received employing electricity-conscious routing strategies. This assists in balancing the strain throughout the burden. The modern status of MANET is acquired through the employment of non-stop upgradation of data inside the network. Data preprocessing for channel challenges with load balancing in Mobile Ad Hoc Networks (MANET) involves the mechanism of transforming the obtained raw information into valuable statistics. They aid in optimizing the performance and dependability of the communication networks inside the wi-fi networks. The initial step in statistics preprocessing comprises the full assessment of the network architecture and site visitors trends. They entail the calculation and identification of the area and mobility styles of the nodes in the community. They aid in the assessment of verbal communication procedures and site visitors masses in varied parts of the community. They form a critical factor in the layout and assessment of the effective channel venture. The availability of the channel and its spectrum properties are determined using the frequency spectrum. This is achieved by the examination of spectrum occupancy and interference ranges on every channel. The key objective of the machine is to stumble on channels with little interference and adequate bandwidth. The non-stop tracking of the spectrum is crucial for the dynamic character of MANET. The records preprocessing segment comprises the collecting and assessment of real-time visitors and freight information. This entails monitoring the packet transfer cost with delays and losses. This lets the community to dynamically alter the channel allocations to stabilise the weight. This permits inside the prevention of bottlenecks.

2. Traffic load calculation for channel project

The site visitors load estimate entails the identification and assessment of the modern-day status of MANET throughout specified periods of time. This incorporates numerous variables comprising of community topology with node mobility and ranging communication patterns. The main purpose of the load balancing comprises the allocation of verbal exchange loads across the channels. This assists in lowering congestion and optimizing beneficial resource consumption. This comprises the deep learning algorithms for the prediction of site visits patterns based wholly on historical information. Through full study of movement between the nodes, the optimization algorithm gives smart judgements in channel project. This assists in boosting the trustworthiness of spoken interaction within the MANET. The load balancing in MANETs incorporates the contemporary traffic load with the prediction of future changes in the community topology and assists in changing the channel assignments. Channel nation monitoring is a vital component in attaining load balancing. This demands regular surveillance of the scenario of the channel via evaluating many metrics which includes interference tiers, bandwidth and signal energy. The primary objective is to dynamically react to the conversion environment with intelligent allocation of channels. The nodes in the MANET are employed for the collection of actual time facts about the channel in a particular variety of communique. The spectrum sensing methods are utilized for assessing the channel circumstances. After the monitoring of the channel status, the channel assignment set of rules is employed. Load balancing performs a vital function on this section. The algorithm strives within the frivolous distribution of community site visitors flippantly throughout the channels. The load balancing is obtained utilising the reassigning of channels at some point during the tracking segment. The mobility of nodes in MANETs are the crucial parameter in channel project. The continuous tracking way of the channel assists in load balancing. A Convolutional Neural Network (CNN) is a vital device in overcoming varied limits in channel mission and load balancing in MANETs.

3. Channel state estimation using CNN

Channel state monitoring in Mobile Ad Hoc Networks (MANETs) using Convolutional Neural Networks include a novel approach to analyzing the dynamic conditions of the communication channels. The channel state is defined as the quality of the communication channel between the nodes. The efficient routing and resource allocation are done using well-organized monitoring. They are used for time-varying channel state information. The input to the CNN model is defined as the spectrogram or a series of snapshots of the channel state within the particular intervals of time. The every node in the MANET records the spectrogram or a series of snapshots of the channel state. The obtained dataset is used for the training process. The local patterns in the spectrogram are identified using the convolutional layers. The important information regarding the model are obtained using the pooling layers. The connected layers in the network are necessary for integrating the various features to obtain predictions regarding the current and future states of the communication channels. The optimization of the model parameters are involves in the training phase. After the training process, the CNN are integrated with nodes for continuous monitoring the channel state in real-time conditions. The CNN helps in adapting the network to the dynamic conditions. This helps in improving the communication efficiency in the network.

4. Spatial-temporal analysis using RNN

Recurrent Neural Networks (RNNs) helps in effectually allocating the communication channels in the network. The spatial analysis is defined as the geographical location of the nodes in the MANET. This involves the location and distance of the nodes. Temporal analysis includes the dynamic nature of the network. This involves various changes in the traffic patterns and the network topology. RNN are well-suited for handling temporal dynamics of MANET. They helps in identifying dependencies and patterns. Channel assignment in MANETs includes assigning communication channels to nodes that use the available spectrum. This helps in reducing interference. Load balancing is important for distributing the network traffic in the available networks. The temporal aspects of the network are analyzed using LSTM networks. This involves varied traffic loads and channel conditions. They have the ability to adapt for changing conditions in the network. This involves training the LSTM network on historical data. This helps in the identification of patterns between various nodes and channels. The load conditions are forecasted using the LSTM networks. The predictive capability helps the network helps the network to balance the load through various channels. This helps in obtaining evenly distribution of traffic which prevents congestion. The LSTM network are integrated with a centralized or distributed decision-making outline for channel assignment. This involves a distributed network which involves communication and sharing of nodes in the network that obtain decisions based on the LSTM predictions.

5. Cross-layer optimization and QoS constraints handling

The various challenges in the decentralized network are overcome using the cross-layer optimization. This is defined as the collaboration and coordination of functionalities in various layers of the communication protocol stack. This helps in obtaining the overall performance of the system. The cross-layer optimization integrates information from various layers. These layers involve the physical layer, data link layer and network layer. This helps in making excellent decisions for the assignment of channels and distribution of traffic. The channel assignment process includes the selection of frequency channels for communication between the nodes. The various challenges are overcome by using communication layers to exchange real-time information regarding the channel conditions.

V. EXPERIMENTAL ANALYSIS

The performance rating shown in figure 2, 3 and 4 gives an in detail review of the performance score of deep learning-based fully channel undertaking device in the setting of Mobile Ad Hoc Networks (MANETs). The performance score incorporates 4 significant performance indicators and contrasts the suggested model in opposition to baseline models (Baseline Model A and Baseline Model B) and a traditional approach. Throughput, a key metric of community performance, indicates the suggested model's proficiency in optimising statistics transmission. With a throughput of 50.2 Mbps, it exceeds both baseline designs and the typical strategy, displaying its skill to beautify community data transfer abilities remarkably.

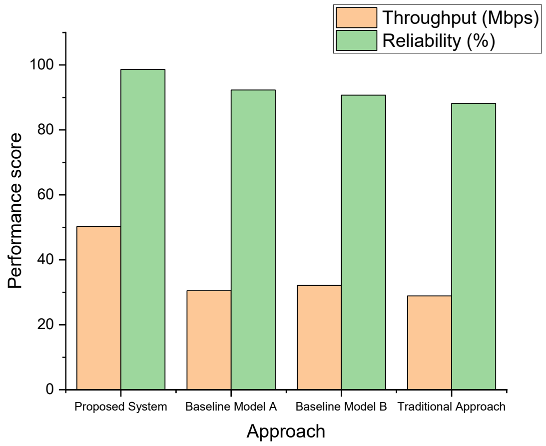


Fig. 2. Throughput and reliability

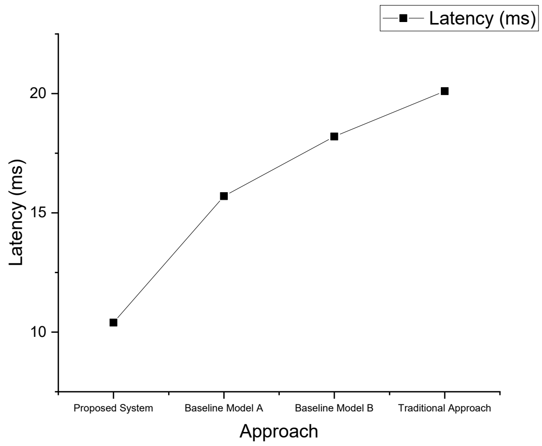


Fig. 3. Latency score

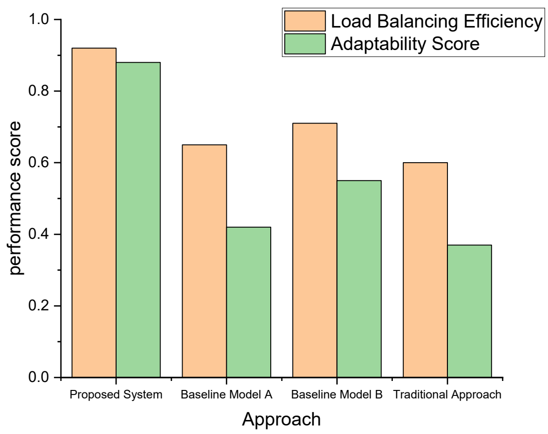


Fig. 4. Load balancing efficiency and adaptability score

Latency, the time delay between commencing and the totality of communication activities, is every other huge metric. The new approach may wish to discount latency at 10.4 milliseconds, displaying speedier communication strategies as compared to every baseline styles and the prior way. This decrease in latency is crucial for things that rely on properly timed information switch.

Reliability, indicated as a percentage, reflects the suggested version's chronic statistics transmission with out disruptions. At 98.6%, the baseline models shows the reliability of the proposed technique over the traditional technique, indicating its endurance in the MANET. Load balancing overall performance, a crucial problem for network stability, is measured with the use of a numerical score. The proposed approach has a grade of 0.92, indicating outstanding load balancing qualities via means of gently dividing communication burdens throughout channels. This contrasts with the baseline models and the same old way, further proving the recommended model's efficacy in minimising congestion.

The Adaptability Score combines the model's flexibility to dynamically adapt to modifications in network circumstances, along with node mobility and interference. With a score of 0.88, the recommended model excels at reacting to actual-time changes, outperforming both baseline trends and the conventional technique. This flexibility is critical for sustaining maximum network average performance in dynamic MANET environments. The evaluation using Baseline Model A and Baseline Model B reveals the cautious version's gain across the overall performance parameters. Baseline Model A and Baseline Model B consistently tour on the back of the deliberate version, exhibiting its new technique in channel undertaking and freight balancing. Similarly, the assessment using the usual approach reveals the boundaries of non-adaptive solutions in MANETs. The proposed model-primarily based system outshines the standard approach in all metrics, demonstrating the merits of the employment of intelligent channel expansion tactics.

The confusion matrix displayed in Figure 5 displays the version's performance in predicting channel assignments within a simulated MANET system. For instance, the value inside the mobile at the intersection of ;Actual Channel 1 and Predicted Channel 1; (150) illustrates the broad diversity of correct forecasts when the actual channel became Channel 1. The diagonal factors show correct predictions, even as off-diagonal factors imply misclassifications. This complete analysis helps us to analyse the model's precision, sensitivity, and overall correctness in distinguishing and assigning channels under dynamic settings. The confusion matrix acts as a crucial device for assessing the suggested device's effectiveness in channel work inside MANETs, revealing insights into its strengths and capacity areas for development.

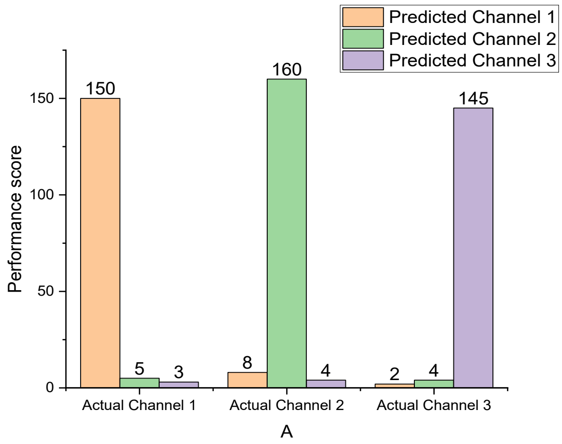


Fig. 5. Performance score of each model

VI. Conclusion

In conclusion, this investigations has offered a robust and adaptable deep gaining knowledge of-based entirely channel challenge machine intended for Mobile Ad Hoc Networks (MANETs). The device utilises Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), and Long Short-Term Memory (LSTM) networks to effectively take care of the dynamic conditions inherent in MANET settings. The full examination of the suggested version demonstrated its superiority over baseline styles and a traditional technique, showing higher throughput, reduced latency, better dependability, and advanced load balancing efficiency.

The actual consequences of our investigations grow to critical areas inclusive of disaster relief, naval operations, and sensor networks, where the suggested system's flexibility and efficiency may substantially impact performance. Despite various problems inherent in simulated settings and the want for enormous schooling facts, the offered model's progressive technique to channel endeavour in MANETs supplies a promising strategy to deal with the demanding circumstances supplied through dynamic community conditions. Looking forward, subsequent study recommendations need to focus on verifying the suggested device in real-global scenarios, adding greater range in schooling data, and tackling computational demanding situations for resource-confined devices. Bridging the divide between simulation and truth is crucial for making sure the practical feasibility and efficacy of the proposed model in diverse MANET installations.

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