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A Machine Learning-based Secured and Energy-efficient Data Transmission in Mobile Ad-Hoc Networks (MANET)

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Abstract

Mobile hoc networks (MANET) are wireless networks of mobile devices that set up Data Transmission (DT) links independently without a fixed framework. Because topology changes constantly, MANET lines are often interrupted and out of balance. So, making sure that DT works well and reliably while also making good use of network resources is a problematic issue that MANET needs to solve. The suggested solution is to create a DT method to deal with these issues. This method aims to improve DT by sending data as quickly as possible while using as little time. As learning examples, the suggested method uses a range of mobile gadgets. Support Vector Machine (SVM) classes are trained to be weak groups. Supervised SVM can sort the surrounding nodes into groups with better link quality and lower energy use. The results of weak learners are combined to create a robust classifier, which guarantees that the data transfer works well. An experimental test checks the amount of power used, the packet transfer rate, the time it takes, and the output. The number of mobile nodes and data packages will be changed during the analysis.

Keywords: Energy Efficiency, Mobile Ad-Hoc Networks, Machine Learning, Data Transmission.

1 Introduction to Energy-Efficiency Mobile Ad-Hoc Networks

The main goal of current Energy Efficiency (EE) techniques is to lower energy use by using a route method (Mahi et al., 2021). Route optimization is a systematic way to reduce the number of hops so that the cost of sending is low, speed is high, and message delivery times are short. Mobile Ad hoc Networks (MANET) are made up of many mobile devices that join each other temporarily without using stable infrastructure (Srilakshmi et al., 2022). They are decentralized and self-organizing networks. The

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system's organization is changing because each node moves around in different ways that don't follow a set plan. Node movement and limited resources are critical factors affecting how well a MANET works (Sirmollo & Bitew, 2021). The stability of the link depends on how mobile the nodes are. To improve the reliability of data transfer in MANET, developing an excellent route method is necessary (Kimura & Premachandra, 2016).

MANETs are widely used in many areas and situations, including the Internet of Things (IoT), cluster settings, and joint networks (Giji et al., 2023). This is because they can be set up quickly, as mobile nodes are powered by batteries when not in use. The energy levels of nodes are limited, and connection range issues mean that data can't be sent instantly from nodes that are sending it to nodes that are receiving it (Manipriya et al., 2020). To fix these issues, Data Transmission (DT) makes transmissions faster and ensures that they work with limited energy resources so that Malaysian consumers can change (Raman & Ramachandaran, 2023).

A communication paradigm named Heterogeneous Secured reflection-inducing state was introduced in (Raman et al., 2023) to satisfy customer experience in the airline business. By accurately predicting malfunctioning nodes, the research achieved a greater rate of successful packet delivery while minimizing the duration it requires for packets to reach their target (Harang & Hyun, 2024). Another routing system, which relies on a service-oriented structure, was developed in (Chen et al., 2021). This protocol is cluster-based and takes into account both mobility and energy considerations.

To reduce energy use, a novel approach using an evolutionary method rooted in an imperialist competitive strategy was suggested in (Karakatič, 2021). A technique for DT reliably with a higher transmission rate was presented in (Zhou et al., 2021). In (Chen et al., 2021), a structure-free data collection approach was created to reduce overhead, notwithstanding the high transmission rate and power consumption (Chen et al., 2021). The increased mobility and constantly changing network structure in the MANET lead to more significant latency and decreased packet transmission ratio (Vijayan et al., 2022). To tackle this problem, a fuzzy rule solution has been suggested in (Vargheese et al., 2023) to reduce the propagation time.

While MANETs exhibit high flexibility in ad-hoc scenarios, nodes are susceptible to DT risks and failures (Trivedi et al., 2023). DT often fails because of the reliance on intermediary relay nodes. Researchers developed a strategic rendezvous model to tackle the issue of unpredictability in mobility and guarantee prompt delivery of data packets (Serhani et al., 2020). An EE-based DT approach that utilizes the Firefly optimization method was suggested in (Goyal et al., 2021). This method contributes to enhancing the lifespan and coverage of the system. A sophisticated DT technology was developed in (Cai & Wu, 2023). A DT system utilizes a multi-perceived area to optimize asset usage and improve the effectiveness of data transfer in the logistics industry (Prashanth et al., 2024).

The current methods employed for DT in MANET have inherent limitations, including:

- The analysis did not account for the power use during DT.
- The study did not prioritize the simultaneous DT rate and time assessment.

A novel approach has been devised and thoroughly elucidated to address the limitations of current data distribution systems.

2 Proposed Energy Efficiency-based Data Transmission in MANET

The proposed approach addresses the issue of power consumption and DT in MANET. It utilizes group learning, specifically boosting weaker learners, to provide computationally effective information

transmission. The Supervised Support Vector Machine (SVM) determines the mobile devices in MANET based on adjacent devices with superior link quality and lower power usage. This model helps to minimize energy consumption throughout DT across massive and highly dense networks. The feeble learners are amalgamated using the Brown-Boosting (BB) algorithm, generating robust classification outcomes for effective DT via the Enhanced BB-based DT framework.

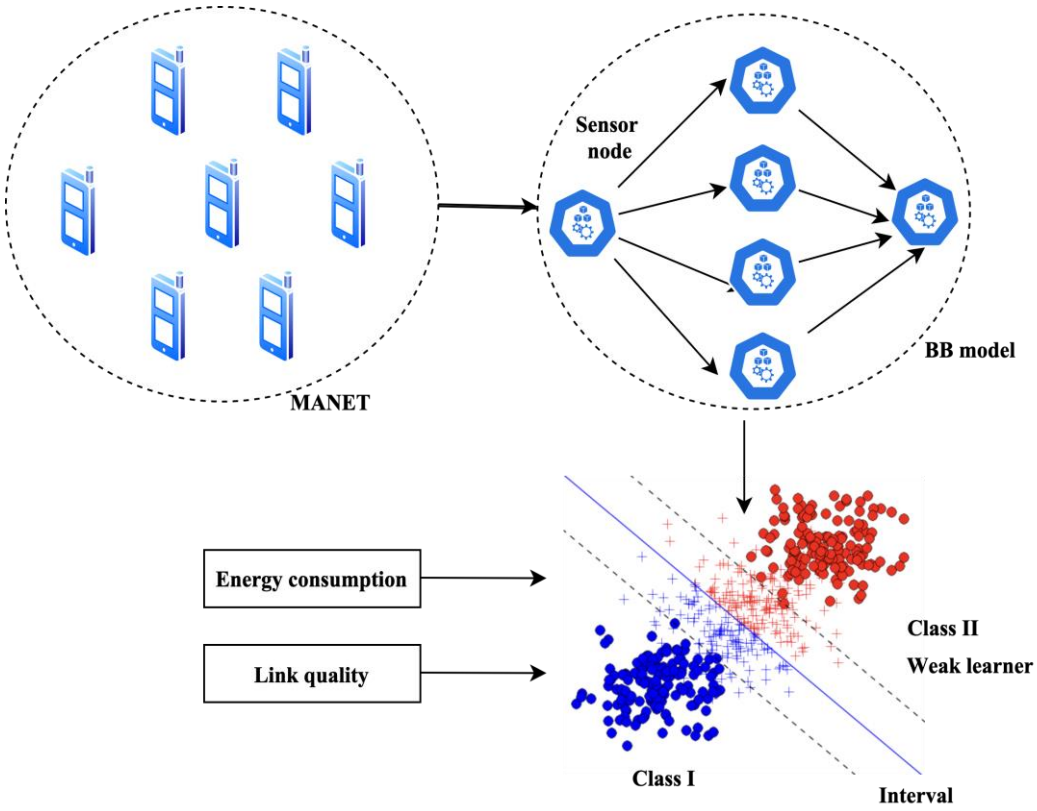

Figure 1: Architecture of the Supervised SVM Model

Different mobile nodes are used as examples of the training information in the suggested method. This shows how to build a system known as the Supervised SVM method. For the best data sharing in Small and Medium Enterprises (Khalife et al., 2024), the model tries to find mobile nodes with the best link quality and the most minor energy use. Figure 1 shows how the Supervised SVM algorithm is put together. Because network conditions change constantly, supervised SVM provides good DT in MANET. The suggested DT paradigm uses data from nearby devices, like how well they link and how much power they use, to respond to changing layouts and other factors.

1) BB-based DT Model

In MANET, ensemble categorization takes a bunch of weak categorization methods and combines them to make strong categorization models. This makes DT work well. To address the problems related to DT, this study uses BB categorization to combine weak learners and ultimately generate strong students. The BB categorization method involves developing a set of separate classifications with varying weights and knowledge management to analyze firm performance (Subrahmanyam et al., 2024). These weights are adjusted to optimize the performance of the classifications in adapting to new information. Ensemble classifications outperform single classifications significantly in this scenario.

Initially, a group of mobile nodes prepared to transmit information is gathered from the system. The BB-based DT concept utilizes categorization techniques to determine whether the individual mobile node is responsible for transmitting data. The classification-based DT method is improved since it delivers data using continuously changing topologies and traffic in mobile terminals.

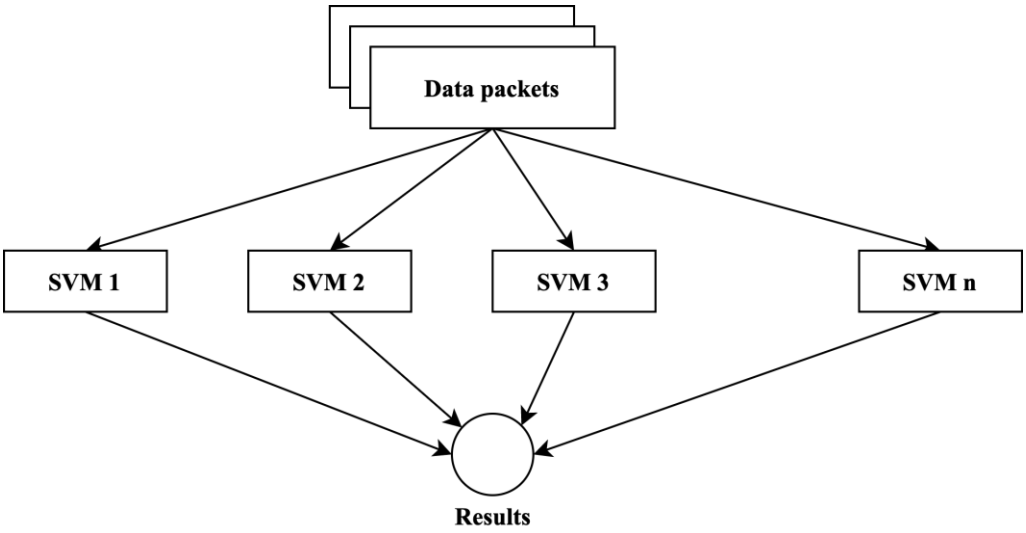

Figure 2: Data Transmission Model Using SVM

The BB-based DT mechanism is a boosting strategy that generates binary outcomes. The traditional methodology could not quickly identify mobile nodes with excellent DT rates. The BB-based DT combines weak hypotheses or weak learners to create a final robust classification to improve the pace at which data is delivered. The proposed method utilizes an SVM classification as a weaker group, whereas the BB classification merges many weaker groups to provide a robust classification. Figure 2 illustrates the procedure of BB-based DT.

The proposed technique uses ensemble categorization to improve the DT rate in a short amount of time. Here, the BB classification delivers data using the underlying classification algorithm, Supervised SVM. This method involves the execution of four distinct operations. Initially, the loss function for the output of category 2 (i.e., the outputs of the weaker mobile node learners) is acquired. The starting weight for every weaker mobile node learner is developed. The corresponding data packets undergo weight standardization. A robust learner output is achieved, and a categorization is formed about whether data is sent. Using an ensemble categorization technique improves the rate at which data is sent, and the time it takes to deliver, thereby effectively contributing to the target.

3 Simulation Outcomes

The suggested DT technique's efficiency is assessed using NS-2 (version 2.34) with varying test case numbers. The evaluation is based on various variables. To conduct the simulation, 600 movable nodes are positioned inside a square region of 1200×1200 m^2, with each node capable of moving at speeds ranging from 0 to 25 m/s. The Random Waypoint is a node mobility approach, while the Dynamic Source Routing (DSR) algorithm executes EE-based DT routing.

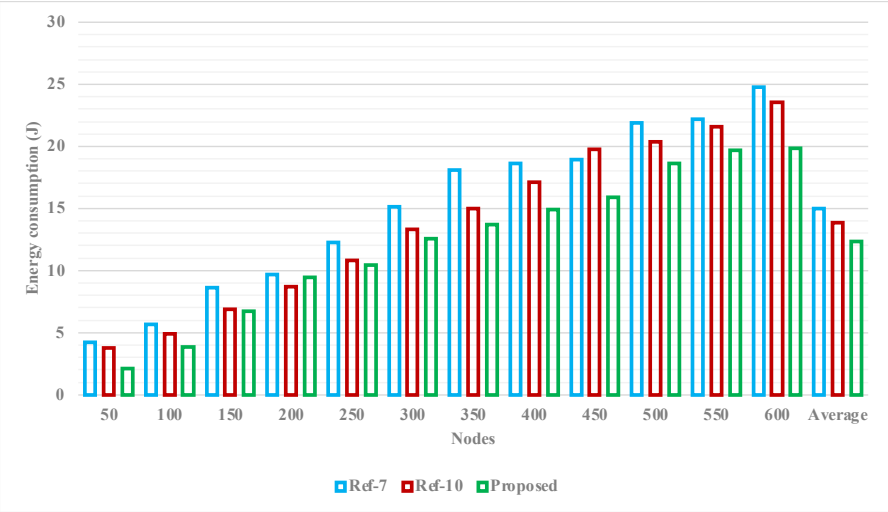

Figure 3: Energy Consumption Analysis

Figure 3 depicts the energy use while simulating different quantities of mobile nodes, ranging from 50 to 500. This research aims to provide a way for EE-based DT to be enhanced. The mean energy usage is a crucial parameter for assessing the suggested procedure. The proposed approach has a markedly lower mean energy usage than other methods. This approach selects the nearest node for DT depending on the quality of the connection and the pace at which energy is being depleted. Thus, the proposed approach is reported to significantly reduce energy usage, with a decrease of 26% comparable to Ref-[7] and 43% similar to Ref-[10].

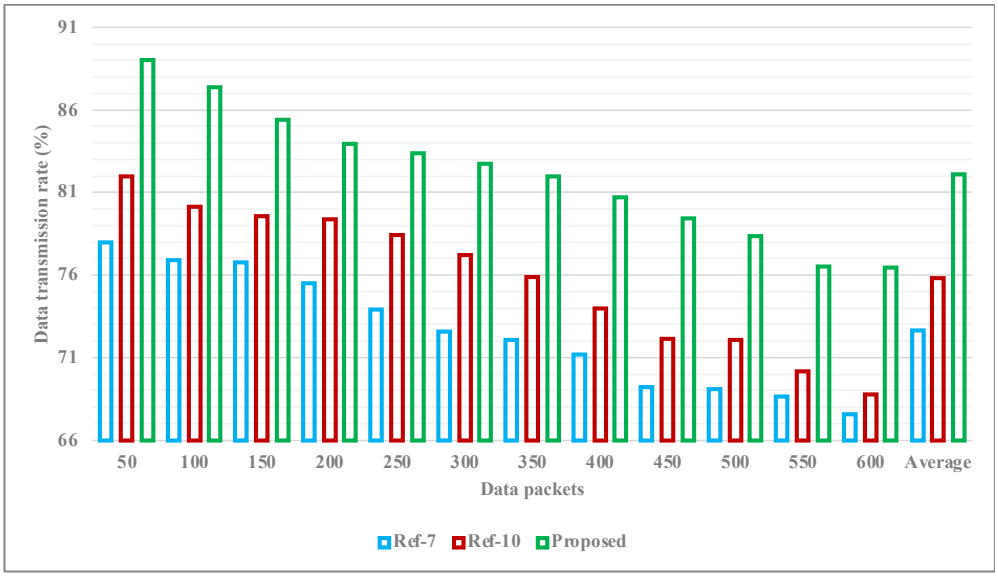

Figure 4: Data Transmission Rate Analysis

Figure 4 illustrates the DT rate of the proposed method compared to Ref-[7] and Ref-[10]. Several transmission schemes need better DT speeds due to the energy computation performed at each cycle. The proliferation of data packets and their expanding size leads to a decline in the pace at which data is delivered. The proposed approach achieves higher than the DT techniques mentioned in Ref-[7] and Ref-[10]. The proposed approach significantly increased the DT rate by 6% compared to Ref-[7] and 9% compared to Ref-[10].

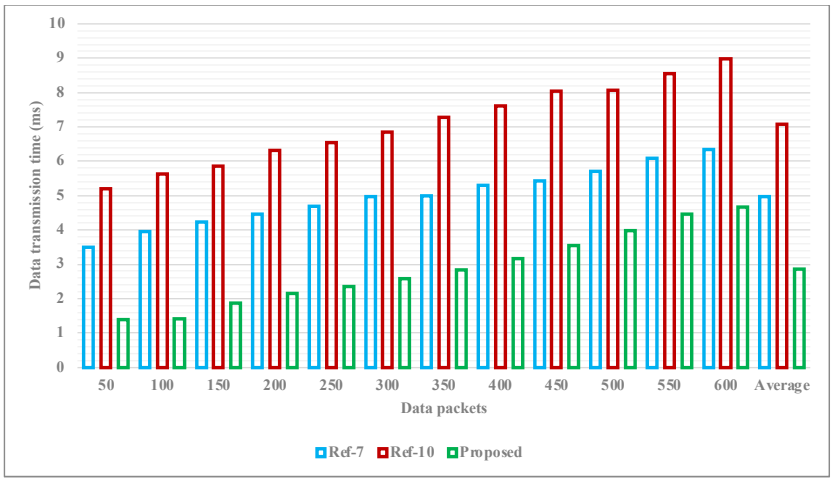

Figure 5: Data Transmission Rate Analysis

Figure 5 illustrates the time the suggested technique takes to transmit data compared to two alternative methods referenced as Ref-[7] and Ref-[10]—the data packets used in the comparison range from 50 to 600. DT time refers to the time spent transmitting data packets from the source to the destination. An optimal MANET system should provide minimal DT time regardless of the number of nodes and packets sent. The proposed approach yielded a transmission time of 1.23 ms for 50 data packets, whereas Ref-[7] and Ref-[10] resulted in delivery times of 3.52 ms and 5.21 ms, respectively.

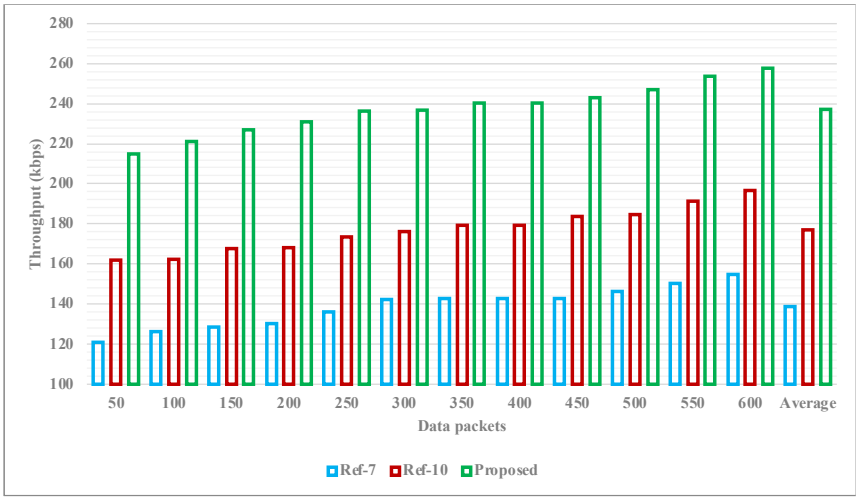

Figure 6: Throughput Analysis

Figure 6 displays the throughput outcomes depending on the quantity of data packets ranging from 50 to 600B. The findings indicate that the performance is much higher than the previous approaches. Based on the observed findings, the proposed approach demonstrates a higher data packet delivery rate within a particular time frame than the current techniques. The findings indicate that the proposed approach enhances performance while sending packets from the origin to the target. Through this approach, the prospective loss process is assessed for every individual class. Next, the weight is set for each weaker group. The weight standardization process is performed on the specific messages. The influential group produces output attained from the origin and transmitted to the destination while simultaneously consolidating the outcomes of the weaker learners. The proposed approach increases the mean comparison findings for throughput by 12% and 27% compared to Ref-[7] and Ref-[10].

4 Conclusion and Discussions

The current emphasis of study in the burgeoning subject of minimizing energy usage and maximizing DT in wireless networks like MANET is ensemble algorithms and their potentialities. The significant decrease in energy consumption in MANET leads to the general sustainability of the system and communication model. This work introduces a novel approach to enhance the DT rate while minimizing power consumption and duration. This technique considers the energy-depleting rate of mobile devices and the changes in topologies. Neighboring nodes are detected by evaluating the link quality and degradation rate. This process categorizes robust mobile devices as relay nodes, which help transmit data from the origin to the target. This approach enhances DT efficiency and reduces the time required. An experiment was done to analyze the performance of the suggested technique with two other methods employing a network simulator (NS-2). The proposed approach performs better than the other methods regarding power consumption, data packet transmission rates, transmission time, and throughput. An intriguing area for future research would be identifying the most effective classifications to be used in an ensemble to improve the total precision of DT. While SVM uses neighbor node learning to handle the multi-class issue, it often leads to extended training time. Deep learning techniques enhance focus and mitigate this prolonged training duration.

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Authors Biography

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Salim Saleh Said Al Khadouri, is a Project Manager at Omantel with over 13 years of experience in telecommunications, specializing in project delivery, vendor management, and technical troubleshooting. He is also pursuing a PhD in Management at INTI International University, Malaysia, researching the impact of AI on customer service at Omantel. Salim holds an MBA in IT from Middle East College and has received accolades, including the Omantel Stars Academy award for customer experience. His expertise and leadership are key to his success in the industry.

Dr. Anantha Raj A. Arokiasamy, known as Dr. Alex, is an Associate Professor at INTI International University's Faculty of Business and Communications, with over 20 years in academic and professional roles. He holds degrees from the University of Hertfordshire, University of Wolverhampton, and an MBA from the University of the West of England. His Ph.D. in Educational Management and Leadership from the University of Science Malaysia focused on integrating leadership principles into educational management. Dr. Alex has authored several books and published over 80 academic papers on topics such as organizational culture, leadership development, and strategic planning, influencing global educational policies and initiatives.

Dr. Stephen Antoni Louis, is a distinguished academician and corporate professional with over 25 years of experience in both sectors. He is currently the Director of the MBA program at Knowledge Institute of Technology, Salem. Dr. Stephen holds multiple qualifications, including a Ph.D., MBA, M.A, M.Phil and certifications such as a Six Sigma Green Belt from Benchmark, Australia. He has served in various leading institutions and played pivotal roles in academic and industry bodies like the Confederation of Indian Industry (CII) and Madras Management Association (MMA). Dr. Stephen is also an approved research supervisor for Anna University, Chennai, and active mentors Ph.D. scholars in HR, Marketing, and Finance. His expertise spans institution building, change management, and consultancy, with a strong focus on education and skill development was Recipient of Organisational Citizenship Behaviour (OCB) Award for Voluntary Commitment in the Educational Institution.

Dr. Arasu Raman, is a senior lecturer in Marketing and Management at INTI International University, holding a Ph.D. in Business Administration with a specialization in Marketing. His international educational background includes degrees from institutions in New Zealand, Australia, and the Philippines, which contribute to his global perspective. With over 27 years of teaching experience, he is certified as a Professional Trained Teacher by the University of Hertfordshire and in Case Teaching by Harvard Business School. Dr. Arasu has published 26 research articles in prestigious journals on topics such as entrepreneurship, digital marketing, and marketing information systems, including Scopus and WOS listed journals. As the university's sole entrepreneurial scientist and an active industry consultant, he is renowned for his innovative curricula and extensive international teaching experience. Dr. Arasu is honoured for his excellence in teaching, research leadership, and collaboration with major multinational companies.