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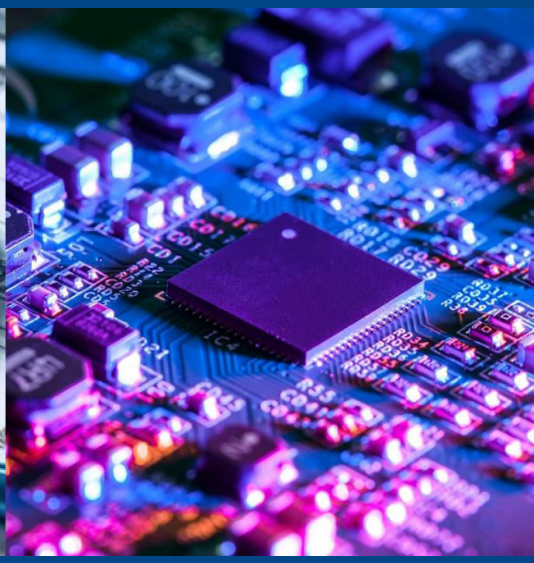

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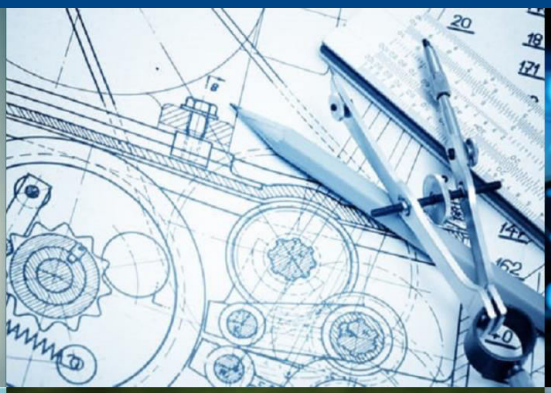

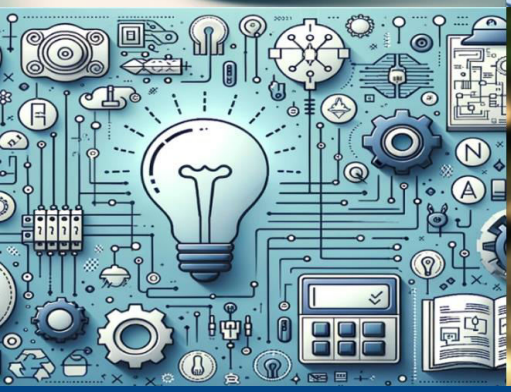

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Jamming-Aware Traffic Allocation for Multi-Path Routing

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ABSTRACT: Reliable data communication in wireless networks is a challenging task, especially in the presence of jamming and interference. This project presents a system that enables secure message and file transfer between two laptops using IP address-based communication. To improve reliability, the network is designed with multiple routers and sub-routers, creating several alternative paths for data transmission.During communication, data packets are sent from one system to another through the available routing paths. If a particular path is affected by jamming or interference, the system detects the issue and prevents data loss. Instead of continuing through the disrupted route, the data is automatically redirected through an alternative path that is free from interference.This dynamic path selection is achieved through a multipath routing mechanism, where each route is continuously monitored based on its performance and stability. The routers and sub-routers work together to identify the most efficient and reliable path for communication. As a result, even in the presence of network disturbances, the system ensures uninterrupted data transfer.The proposed approach significantly reduces packet loss, improves transmission efficiency, and maintains stable communication between devices. This method is particularly useful in environments where network reliability is critical. Overall, the system demonstrates an effective solution for jamming-aware traffic allocation using multiple routing paths.

KEYWORDS: MANET, Jamming Attack, Multiple-Path Routing, Portfolio Selection, Deep Q-Network (DQN), Traffic Allocation, Reinforcement Learning, Channel Allocation, Anti-Jamming, Wireless Security.

I. INTRODUCTION

Wireless communication networks have become an essential part of modern life, supporting applications ranging from emergency rescue operations to military communications and civilian IoT deployments. Among these, Mobile Ad-hoc Networks (MANET) play a critical role due to their self-configuring and infrastructure-free nature. However, the open and shared medium of wireless communication makes MANETs extremely susceptible to various forms of interference, particularly intentional jamming attacks.

A jammer is a malicious entity that deliberately transmits radio frequency signals on the communication channel to disrupt legitimate data transmission. Unlike passive eavesdroppers, jammers actively degrade the quality of communication, leading to increased packet loss, reduced throughput, and even complete denial of service. In dynamic environments where nodes move frequently and channel conditions change rapidly, the effect of jamming becomes even more severe.

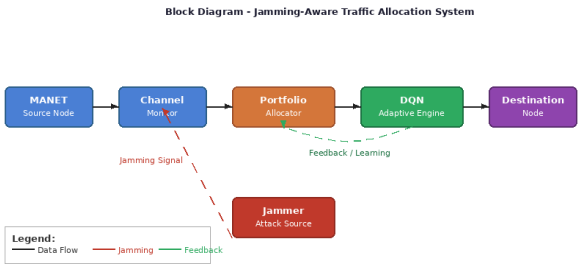

Fig 1 : Block Diagram

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Traditional anti-jamming techniques such as frequency hopping and spread spectrum, while effective to some extent, do not account for intelligent or adaptive jammers that can follow frequency patterns over time. There is, therefore, a strong need for smarter, learning-based approaches that can observe jamming behavior and proactively avoid disrupted channels.

In this work, we consider a MANET scenario where a jammer intermittently occupies one or more communication channels, forcing the transmitter to allocate traffic dynamically across multiple available paths. We draw inspiration from financial portfolio theory, which provides a well-established mathematical framework for distributing investment across risky assets to maximize return while minimizing risk. By modeling each routing path as an asset with associated jamming risk and reliability, we apply portfolio optimization to determine the optimal traffic allocation across paths.

Furthermore, to enable the system to adapt to changing jamming patterns without requiring explicit knowledge of the jammer's strategy, we incorporate a Deep Q-Network (DQN) based reinforcement learning module. The DQN agent observes the state of each channel over time and learns to generate transmission decisions that minimize the probability of interference while maximizing successful data delivery.

The rest of this paper is organized as follows. Section II presents the related literature. Section III describes the existing systems and their limitations. Section IV details the proposed system architecture. Section V explains the methodology. Section VI presents the simulation results and discussion. Section VII concludes the paper followed by references.

II. LITERATURE REVIEW

In modern wireless communication systems, ensuring reliable data transmission under interference and jamming is a major challenge. Traditional routing techniques focus mainly on shortest path selection and load balancing but lack adaptability to handle dynamic jamming attacks effectively. Several research efforts have addressed anti-jamming communication and multi-path routing separately. For example, Wang et al. proposed a game-theoretic model for anti-jamming communication, while Li and Han introduced a Q-learning-based approach to adapt to jamming patterns; however, these methods face limitations such as static assumptions and scalability issues. Other approaches, including frequency agility, adaptive power control, and multi-path routing, improve performance but do not fully address intelligent jamming mitigation. Advanced techniques like reinforcement learning and resource optimization offer adaptability but are often limited to specific scenarios. As a result, existing systems provide only partial solutions and lack an integrated framework for dynamic routing under jamming conditions. To overcome this, the proposed system introduces a multi-path routing framework with jamming simulation, combining data splitting, sequence-based transmission, and intelligent rerouting through sub-routers. It also includes a real-time visualization interface to monitor packet flow, delays, and losses, making it effective for understanding network resilience and improving reliable communication.

Relevance to current Research

This project contributes to the field of computer networks by integrating multi-path routing, jamming simulation, and sequence-based data reconstruction into a single system, enabling intelligent routing decisions under adverse network conditions. Implemented using Java socket programming with a GUI-based interface, the system allows users to visualize packet transmission, delays, losses, and rerouting in real time. By simulating challenges such as packet loss, delay, corruption, and connection failure, it enhances understanding of network resilience and fault tolerance. Additionally, the use of sub-routers for alternative path selection improves reliability and ensures continuous data transmission, making the system relevant for applications in wireless communication, distributed systems, and network security.

Summary Table: Related Work

No	Paper / Technique	Authors	Key Points	Relevance to Current Work
1	Game Theory Anti-Jamming	Wang et al.	Models jammer vs transmitter as game	Provides theoretical base
2	Q-Learning Channel Selection	Li & Han	Learns jamming patterns	Adaptive routing concept

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No	Paper / Technique	Authors	Key Points	Relevance to Current Work
3	Frequency Agility	Slater et al.	Uses dynamic frequency switching	Handles basic jamming
4	Multi-path Routing	Liu et al.	Improves fault tolerance	Base for path splitting
5	Portfolio Optimization	Xiao et al.	Resource allocation strategy	Channel selection idea

III. METHODOLOGY OF PROPOSED SURVEY

The proposed system methodology consists of four main stages: channel monitoring, jamming probability estimation, traffic allocation, and adaptive refinement. Initially, the system collects real-time metrics such as RSSI, packet delivery ratio (PDR), and jamming status for each routing path using a sliding window to track recent network conditions. Based on this data, it estimates the jamming probability and calculates the reliability of each path. These values are then used in a portfolio-based optimization approach to distribute traffic efficiently by assigning higher weights to more reliable and less jammed paths. Finally, a DQN-based adaptive module refines the allocation by analyzing network conditions and applying a reward-based learning strategy, ensuring improved performance, reduced jamming impact, and efficient data transmission under dynamic network environments.

MODULES

The system is organized into eight main modules, each handling a specific function of the application. The modules are described as follows:

1. **Client Module**

Sends data by splitting it into multiple parts with sequence numbers.

2. **Router Module (A, B, C)**

Receives data from client and forwards it through different network paths.

3. **Sub-Router Module (A1, A2, B1, B2, C1, C2)**

Acts as backup paths when jamming or congestion occurs.

4. **Jamming Simulator Module**

Simulates network issues like packet loss, delay, corruption, and failure.

5. **Data Transmission Module**

Handles sending and receiving of data packets between nodes.

6. **Sequence Management Module**

Maintains order of packets for correct data reconstruction.

7. **Server Module**

Receives all parts, reassembles data, and processes output.

8. **GUI Monitoring Module**

Displays real-time packet flow, status, delays, and errors.

IV. SYSTEM ARCHITECTURE

The system architecture of the proposed project is designed based on a multi-path routing model with integrated jamming simulation and layered communication structure. The architecture consists of a client, multiple routers (A, B, C), sub-routers (A1, A2, B1, B2, C1, C2), and a central server. The client initiates data transmission by splitting data into multiple parts and assigning sequence numbers, which are then sent through different routers simultaneously. Each router forwards the data to the server directly under normal conditions, but when jamming or network congestion is detected, the data is rerouted through corresponding sub-routers to ensure continuity. The system also includes a jamming simulator module that introduces conditions such as packet loss, delay, corruption, and connection failure to test network resilience. Finally, the server receives all data parts, reassembles them in the correct order using sequence numbers, and processes the output. This architecture ensures reliable, fault-tolerant, and efficient data transmission even under adverse network conditions.

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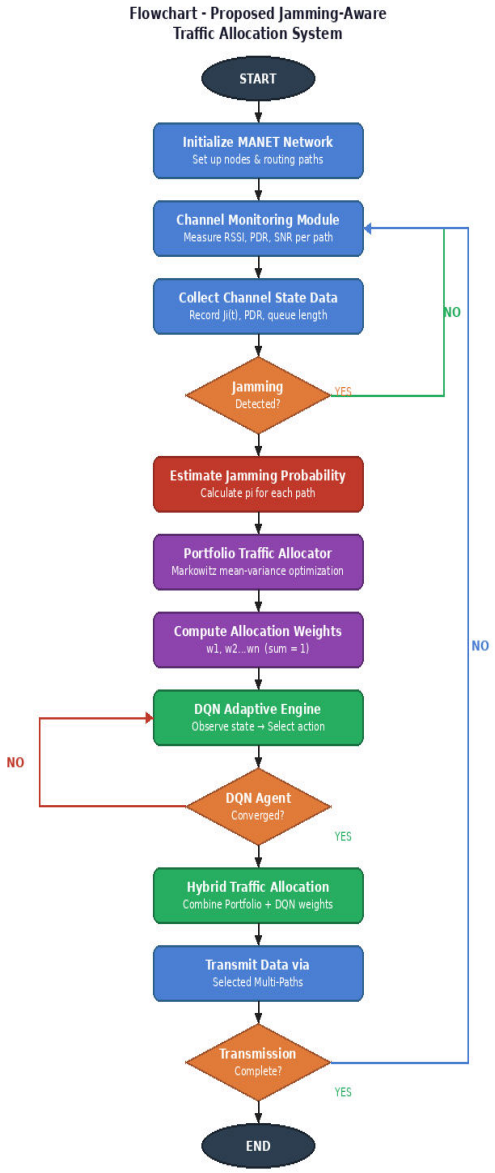

Fig 1 Work Flow

V. CONCLUSION AND FUTURE WORK

The proposed system successfully demonstrates a reliable and efficient approach for data transmission in the presence of network disturbances such as jamming, delay, and packet loss. By integrating multi-path routing, jamming simulation, and sequence-based data reconstruction, the system overcomes the limitations of traditional single-path routing techniques. The use of multiple routers and sub-routers enables dynamic rerouting of data whenever a network path is affected, thereby improving fault tolerance and ensuring continuous communication between the client and server. Furthermore, the implementation using Java socket programming and a GUI-based monitoring system provides real-time visualization of packet flow, helping users better understand network behavior. Overall, the system enhances reliability, flexibility, and robustness, making it highly suitable for applications in wireless communication, distributed systems, and network security research, while also serving as an effective educational tool.

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Future enhancements can further improve the performance and scalability of the system. The integration of intelligent routing techniques such as machine learning or artificial intelligence can enable automatic prediction and avoidance of jamming conditions. The system can be extended to support large-scale real-time environments like cloud computing and Internet of Things (IoT) networks. Incorporating advanced security features such as encryption can strengthen data protection, while adding realistic network parameters like mobility, dynamic topology, and bandwidth variation can improve simulation accuracy. Additionally, developing a web-based or mobile interface for remote monitoring and including performance metrics such as throughput, latency, and packet delivery ratio will provide deeper insights and help optimize the system for real-world applications.

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