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Self-Organization and Adaptation: Mechanisms and Algorithms for Resilience in Mobile Ad Hoc Networks

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ABSTRACT
MANET (Mobile Ad Hoc Network) technology has garnered increasing attention for real-world applications over the past decade. The dynamic and intermittent connectivity arising from node mobility presents a significant challenge to MANET operation, particularly in establishing end-to-end communication paths. Attacks targeting critical nodes can further degrade network services. In this study, we assess the network resilience of real-world traces under diverse malicious attacks. We had reviewed various attack strategy that adapts to different centrality metrics to gauge node significance based on network topological properties. Employing a resilience quantification approach, we evaluate the communication ability of various algorithmic across various network operational states. The resilience of robustness is scrutinized across different combinations of network parameters, while the resilience of application layer services under different routing protocols is compared across a spectrum of topological flow robustness states.
Keywords : Resilience, fault tolerance, MANETs, energy efficiency, management, centrality prediction, AODV Multipath Routing Protocol

I. INTRODUCTION

The landscape of wireless communication is continually shaped by the dynamic evolution of Mobile Ad Hoc Networks (MANETs). In contrast to conventional networks with fixed infrastructures, MANETs operate in a realm of spontaneity and adaptability, allowing nodes to form and reconfigure connections without the constraints of a predetermined network framework. This intrinsic flexibility positions MANETs as a crucial communication solution in scenarios where traditional infrastructures are impractical or nonexistent. However, the very dynamism that renders MANETs attractive introduces a complex array of challenges. Node mobility, resource limitations, and constantly changing network topologies create a dynamic environment that necessitates innovative solutions for resilience [1]. This exploration delves into the multifaceted strategies employed to enhance resilience in MANETs, emphasizing the intertwined concepts of self-organization and adaptation. By delving into the intricate mechanisms fortifying MANETs, this study aims to unravel the layers of complexity inherent in managing communication in a dynamic and unpredictable wireless landscape.At the core of

MANETs lies their dynamic nature, propelled by node mobility and the absence of a fixed infrastructure. This dynamism offers unprecedented possibilities for communication but also introduces challenges distinct from those encountered in traditional networks. Nodes can join or exit the network at any time, reshaping the network topology and communication paths dynamically. This dynamic nature necessitates adaptability not as a luxury but as an imperative aspect of MANET functionality [2].

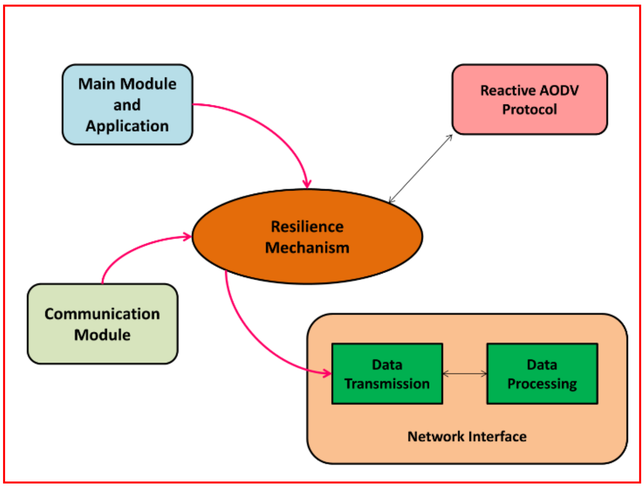

Figure 1. Depicts the Block Diagram of Algorithms for Resilience in Mobile Ad Hoc Networks

Resilience, in the context of MANETs, extends beyond mere survival. It encompasses the ability of the network to maintain functionality, performance, and connectivity despite challenges like node failures, link disruptions, or environmental changes. Achieving resilience becomes a multifaceted endeavor, demanding a holistic approach that considers various aspects of network design, protocols, and adaptive mechanisms.The forefront of resilience in MANETs features dynamic routing protocols designed to adapt to the ever-changing network topology. Reactive protocols, such as Ad Hoc On-Demand Distance Vector (AODV) and Dynamic Source Routing (DSR), exemplify adaptability by establishing routes on-demand, minimizing control overhead, and efficiently responding to dynamic communication paths.Resilience extends to the network's ability to autonomously detect and recover from disruptions. Self-healing mechanisms play a pivotal role, enabling nodes to continually monitor their neighbors' status. When link failures occur, local repair mechanisms swiftly reestablish connectivity without extensive global route rediscovery, ensuring robustness in the face of unpredictable changes [3].The dynamic nature of MANETs demands a focus on energy efficiency to ensure prolonged network operation. Adaptation in this context involves optimizing routing paths and dynamically managing individual node energy consumption. Adaptive power management and energy-aware routing strategies enable nodes to adjust power levels and route choices based on real-time considerations, preventing premature energy depletion and contributing to the network's overall sustainability.Efficient communication within a MANET is intricately linked to network topology. Adaptive topology control strategies, including dynamic transmission power control and adaptive clustering, enhance resilience by optimizing communication efficiency. Dynamic adjustment of transmission power levels minimizes interference, while adaptive clustering strategies reduce overhead, ensuring efficient data exchange in dynamic scenarios.In the pursuit of resilience, MANETs are integrating cognitive radio techniques, adding intelligence to communication nodes. Spectrum sensing and adaptation enable nodes to dynamically adjust to available spectrum bands, avoiding interference and optimizing communication in dynamic radio environments [4]. The cognitive capabilities introduced through these techniques mark a paradigm shift, allowing networks to intelligently navigate the complexities of the wireless spectrum.Integration of machine learning algorithms introduces predictive adaptation into MANETs. Predictive analytics, powered by machine learning, enables nodes to anticipate changes in network conditions. Reinforcement learning takes this a step further, allowing nodes to adapt behaviors based on feedback from the environment, proactively optimizing responses to diverse and dynamic scenarios.As we navigate through the various dimensions of enhancing resilience in MANETs, the overarching theme is one of multifaceted adaptability. Resilience is a synergistic integration of dynamic routing, self-healing, energy efficiency, adaptive topology control, cognitive capabilities, and intelligent learning through machine learning algorithms.

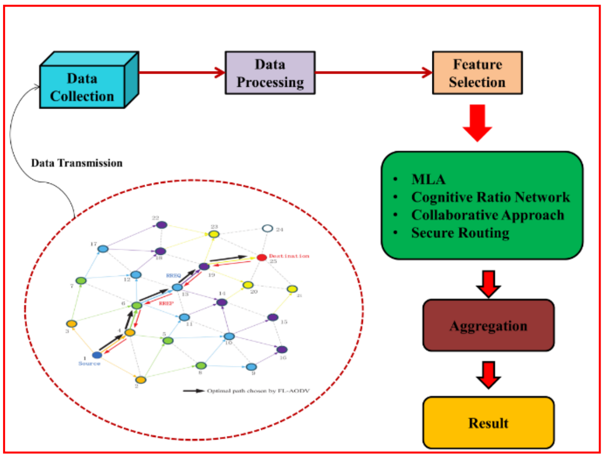

Figure 2: Process for proposed model

This journey toward building networks that thrive in dynamic and unpredictable environments will be further explored in the subsequent sections, unraveling the intricacies of mechanisms contributing to the resilience of MANETs [5]. The inherent challenges of MANETs, including node mobility, limited resources, and dynamically changing network topologies, demand robust mechanisms for self-organization and adaptation. The ability of a MANET to autonomously reconfigure itself in response to environmental changes and uncertainties is vital for ensuring reliable communication and optimal performance. This introduction delves into the mechanisms and algorithms that drive self-organization and adaptation in MANETs, aiming to enhance the network's resilience in the face of uncertainties. As we explore these dynamic solutions, we uncover the innovative approaches that researchers and engineers employ to address the intricate challenges posed by the ever-changing nature of mobile ad hoc networks. From dynamic routing protocols and self-healing mechanisms to energy-efficient algorithms and adaptive topology control, the quest for resilient MANETs involves a multidisciplinary exploration of computer science, networking, and artificial intelligence. The incorporation of machine learning and cognitive radio techniques further pushes the boundaries, introducing intelligent decision-making and spectrum-aware adaptation [6].

II. REVIEW OF LITERATURE

In the [7], author introduces an approach to quantifying resilience in mobile ad hoc networks (MANETs) by proposing metrics such as Mean Time Between Failures (MTBF) and Mean Time to Recovery (MTTR) to assess the availability and adaptability of the network during disruptions. In the [8], author focuses on the resilience measurement of MANETs, incorporating human walk patterns to simulate realistic scenarios and introducing innovative metrics to enhance the understanding of network resilience under dynamic conditions. In the [9], author a multipath resilience routing technique is proposed to enhance fault tolerance in mobile ad hoc networks. This technique aims to improve network reliability by dynamically adapting routing paths, mitigating the impact of node failures. In the [10], author centers on energy-aware management in ad hoc networks, introducing stable topology management techniques to optimize energy consumption, stabilize the network, and improve overall performance. In the [11], author provides a comprehensive review of imperatives and challenges in mobile ad hoc networking, discussing key aspects such as scalability, security, and efficiency, offering insights into the fundamental issues in MANETs. In the [12], author, which focuses on dynamic human contact networks, the authors explore centrality prediction by analyzing patterns of human interactions to predict central nodes in the network, providing valuable insights into its dynamic nature. In the [13], author delves into the realm of time-varying graphs and dynamic networks, discussing concepts such as connectivity preservation and critical node/link identification, offering a deeper understanding of dynamic network structures. In the [14], author, centered on energy conservation, introduces an Ad Hoc On-Demand Distance Vector (AODV) Multipath Routing Protocol to optimize energy usage in ad hoc networks, contributing to increased efficiency and extended network lifetime. In the [15], author, a survey, provides an extensive overview of sensor networks, covering topics such as routing, security, and energy efficiency, offering a comprehensive understanding of the challenges and advancements in the field.

Table 1. Summarizes the Comparative Study of Various Author

Author & Year	Area	Methodology	Key Findings	Challenges	Pros	Cons	Application
Jabbar, H. Narra and J. P. G. Sterbenz (2011)	MANET Resilience Quantification	Metrics (MTBF, MTTR)	Proposal of resilience metrics for MANETs, including Mean Time Between Failures (MTBF) and Mean Time to Recovery (MTTR), to assess availability and adaptability.	- Limited scalability of proposed metrics	- Quantifiable metrics for resilience	- Limited scalability	MANETs
Zhang and J. P. G. Sterbenz (2015)	MANET Resilience Measurement	Simulation with Human Walk Patterns	Incorporation of human walk patterns in MANET simulations, introducing innovative metrics to enhance the	- Realistic scenario creation	- Realistic modeling of network scenarios	- Increased computational complexity	MANETs

			understanding of network resilience under dynamic conditions.				
S. Balaji and Y. H. Robinson (2018)	Fault Tolerance in MANETs	Multipath Resilience Routing	Proposal of a multipath resilience routing technique to enhance fault tolerance in MANETs, dynamically adapting routing paths to mitigate the impact of node failures.	- Dynamic adaptation introduces complexity	- Enhanced fault tolerance in routing	- Increased routing overhead	MANETs
L Bao and JJ Garcia-Luna-Aceves (2010)	Energy-Aware Topology Management	Stable Topology Management	Introduction of stable energy-aware topology management in ad hoc networks, optimizing energy consumption, stabilizing the network, and improving	- Trade-off between stability and energy optimization	- Optimized energy consumption	- Potential impact on network stability	Ad hoc Networks

			overall performance.				
Chlamtac, M. Conti and J. J.-N. Liu (2010.)	MANET Imperatives and Challenges	Literature Review	Comprehensive review of imperatives and challenges in mobile ad hoc networking, covering scalability, security, and efficiency, providing insights into fundamental issues.	- Diverse challenges in MANETs	- In-depth understanding of MANET issues	- Lacks specific empirical data	MANETs
H. Kim, J. Tang, R. Anderson and C. Mascolo (2012)	Dynamic Human Contact Networks	Centrality Prediction	Exploration of centrality prediction in dynamic human contact networks, analyzing patterns of human interactions to predict central nodes in the network.	- Predicting centrality in dynamic networks	- Valuable insights into dynamic network	- Limited to human contact networks	Social Networks

Casteigts, P. Flocchini, W. Quattrociocchi and N. Santoro (2012)	Time-Varying Graphs and Dynamic Networks	Graph Theory Algorithms	Investigation into time-varying graphs and dynamic networks, discussing connectivity preservation, and critical node/link identification.	- Dynamic network structures	- Deeper understanding of dynamic networks	- May have higher computational cost	Dynamic Networks
Smail, Z Mekkakia, B Messabih, R Mekki and B Cousin (2014)	Energy Conservation in AODV Multipath Routing	AODV Multipath Routing	Introduction of an AODV Multipath Routing Protocol for energy conservation in ad hoc networks, aiming to optimize energy usage and extend network lifetime.	- Balancing energy optimization and network stability	- Enhanced energy efficiency	- Potential overhead in routing updates	Ad hoc Networks
IF Akyildiz, W Su, Y Sankarasubramaniam and E Cayirci (2009)	Sensor Networks	Literature Review	An extensive survey on sensor networks, covering topics such as routing, security,	- Diverse challenges in sensor networks	- Overview of challenges and advancements	- Lacks specific empirical data	Sensor Networks

			and energy efficiency, offering a comprehensive understanding of challenges and advancements.				
N. Aschenbruck, A. Munjal and T. Camp (2011)	Mobility Modeling in Multi-hop Wireless Networks	Trace-Based Modeling	Focus on trace-based mobility modeling for multi-hop wireless networks, utilizing real-world mobility traces for more realistic network evaluation.	- Dependency on the availability of realistic mobility traces	- Realistic modeling for network evaluation	- Limited to scenarios with available traces	Wireless Networks

This Review focusing on mobility modeling for multi-hop wireless networks, introduces a trace-based approach, utilizing real-world mobility traces to create more realistic models for the evaluation of multi-hop wireless communication.

III. NETWORK RESILIENCE QUANTIFICATION

Quantifying network resilience involves a multifaceted approach encompassing various metrics and evaluation techniques. One crucial aspect is the network's availability, gauged by metrics such as Mean Time Between Failures (MTBF) and Mean Time to Recovery (MTTR). Monitoring tools and controlled failure injection experiments are commonly employed for evaluation. Adaptability, another key dimension, assesses the network's capacity to adjust to dynamic conditions and reconfigure autonomously. Dynamic reconfiguration speed and autonomous re-routing capabilities serve as metrics, with simulation tools like NS-3 and OPNET facilitating evaluation.Redundancy, an essential factor, involves metrics such as the redundancy ratio (backup links/nodes) and analysis of node/link disjointedness. Evaluation tools include redundancy analysis tools and fault tree analysis.

Resilience index, a composite metric, combines various factors like availability and adaptability, with resilience assessment frameworks and Bayesian networks being common evaluation tools. Topology robustness focuses on maintaining connectivity under failure scenarios, utilizing metrics like connectivity preservation and identification of critical nodes/links. Graph theory algorithms and vulnerability assessment tools aid in evaluation.Response time metrics, including the time to detect and respond to failures, alongside network convergence time, are pivotal in assessing a network's recovery speed. Real-time monitoring, as well as simulation and modeling, are instrumental evaluation techniques. Lastly, evaluating the security posture involves metrics like the number of successfully thwarted attacks and security incident response time. Intrusion detection systems (IDS) and penetration testing tools play crucial roles in assessing and enhancing the network's security resilience. Collectively, these metrics and evaluation techniques provide a comprehensive framework for quantifying network resilience, considering diverse dimensions critical for robust and adaptive network performance.

Table 2. Comparative Study of Network Resilience Quantization

Aspect	Description	Metrics/Indicators	Evaluation Techniques/Tools
Availability	The ability of the network to remain operational and provide services during disruptions.	- Mean Time Between Failures (MTBF)	- Network monitoring tools
Adaptability	The network's capacity to adjust to changing conditions, configurations, or requirements.	- Dynamic reconfiguration speed	- Simulation tools (e.g., NS-3, OPNET)
Redundancy	The existence of backup resources or paths to ensure continuity in case of failures.	- Redundancy ratio (backup links/nodes)	- Redundancy analysis tools
Resilience Index	An overall metric that combines multiple aspects of resilience into a single measure.	- Composite resilience index	- Resilience assessment frameworks
Topology Robustness	The network's ability to maintain connectivity under different failure scenarios.	- Connectivity preservation under random failures	- Graph theory algorithms (e.g., connectivity analysis)
Response Time	The time it takes for the network to recover or adapt after a disruption.	- Time to detect and respond to failures	- Real-time monitoring and analysis
Security Posture	The network's resistance to malicious attacks and its ability to maintain security.	- Number of successfully thwarted attacks	- Intrusion detection systems (IDS)

IV. ALGORITHIM RESILIENCE IN MOBILE AD HOC NETWORKS (MANETS)

Several algorithms and mechanisms have been proposed to enhance resilience in Mobile Ad Hoc Networks (MANETs). These algorithms aim to improve the network's ability to adapt, recover, and maintain functionality in the presence of various disruptions. Here are some notable algorithms for resilience in MANETs:

A. Dynamic Source Routing (DSR):

Description: DSR is a reactive routing protocol that dynamically establishes routes based on on-demand route discovery. It adapts to changes in network topology by initiating route discovery when needed.
Resilience Features: DSR enhances resilience by re-establishing routes in real-time, making it suitable for dynamic and changing MANET environments.

B. Ad Hoc On-Demand Distance Vector (AODV):

Description: AODV is another reactive routing protocol that creates routes on-demand. It adapts to changes in the network by initiating route discovery when there is a need for communication.
Resilience Features: AODV improves resilience by reducing control overhead and adapting to dynamic network conditions.

C. Secure and Efficient Adaptive Distance Vector Routing Protocol (SEAD):

SEAD is a proactive routing protocol designed to provide secure and efficient routing in MANETs. It uses a combination of distance-vector and link-state routing concepts.
Resilience Features: SEAD enhances resilience by incorporating security measures, making the network less susceptible to malicious attacks.

D. Watchdog and Path rater:

Description: Watchdog and Path rater are intrusion detection mechanisms designed to identify misbehaving nodes and assess the reliability of discovered routes.
Resilience Features: These algorithms contribute to network resilience by detecting and isolating malicious nodes and unreliable routes.

E. Energy-Aware Routing (EAR):

Description: EAR algorithms focus on optimizing energy consumption in MANETs by considering the energy levels of nodes in route selection.
Resilience Features: EAR enhances network resilience by promoting energy-efficient routing, leading to prolonged network lifetime and reduced risk of premature node depletion.

F. Neighbor-Centric Topology Control (NCTC):

Description: NCTC is a topology control algorithm that adapts to the changing network environment by dynamically adjusting transmission power based on the density and mobility of neighboring nodes.
Resilience Features: NCTC improves resilience by optimizing communication range, reducing interference, and adapting to dynamic topologies.

G. Cluster-Based Routing Protocol (CBRP):

Description: CBRP organizes nodes into clusters, reducing the complexity of routing and improving efficiency. It adapts to changes by dynamically forming and adjusting clusters.

Resilience Features: CBRP enhances resilience by providing a hierarchical structure that adapts to changing network conditions and reduces the impact of node failures.

H. Dynamic MANET On-Demand (DYMO):

Description: DYMO is an on-demand routing protocol designed for highly dynamic ad hoc networks. It adapts to changes in topology by initiating route discovery as needed.

Resilience Features: DYMO improves resilience by efficiently managing routes in dynamically changing scenarios, reducing latency in route discovery.

I. Game-Theoretic Approaches:

Description: Game theory-based algorithms model the interactions among nodes in a MANET as strategic games, enabling nodes to adapt their behaviors based on the expected payoffs in the network.

Resilience Features: Game-theoretic approaches enhance resilience by providing nodes with adaptive strategies to cope with dynamic and uncertain conditions.

V. MECHANISM OF RESILIENCE IN MOBILE AD HOC NETWORKS (MANETS)

Resilience mechanisms in Mobile Ad Hoc Networks (MANETs) are designed to enhance the network's ability to adapt, recover, and maintain functionality in the face of dynamic changes, disruptions, and potential attacks. Here are several mechanisms employed to improve resilience in MANETs:

A. Dynamic Routing Protocols

Description: Dynamic routing protocols, such as Ad Hoc On-Demand Distance Vector (AODV) and Dynamic Source Routing (DSR), establish and maintain routes based on real-time network conditions.

Resilience Features: Adaptability to changing topologies, quick route discovery, and reconfiguration in response to node mobility or failures.

B. Self-Healing Mechanisms:

Description: Self-healing mechanisms allow nodes to autonomously detect and recover from failures or disruptions.

Resilience Features: Automatic detection of link or node failures and the ability to locally repair or re-establish connectivity without central coordination.

C. Energy-Efficient Strategies:

Description: Strategies such as adaptive power management and energy-aware routing optimize the use of energy resources in MANETs.

Resilience Features: Prolonged network lifetime by dynamically adjusting power levels and optimizing energy consumption to prevent premature node depletion.

D. **Adaptive Topology Control:**

Description: Adaptive topology control mechanisms dynamically manage communication by adjusting transmission power levels, reducing interference, and optimizing data exchange.

Resilience Features: Efficient communication in dynamic scenarios, reduced interference, and improved overall network performance.

E. **Cognitive Radio Networks:**

Description: Cognitive radio techniques enable nodes to intelligently adapt to available spectrum bands, avoiding interference and optimizing communication in dynamic radio environments.

Resilience Features: Intelligent spectrum adaptation, improved communication reliability in the presence of varying radio conditions.

F. **Machine Learning Algorithms:**

Description: Integration of machine learning algorithms enables predictive adaptation based on historical network behavior, facilitating proactive responses.

Resilience Features: Predictive analytics for anticipating changes, reinforcement learning for adaptive behavior, and improved network response to diverse scenarios.

G. **Secure Routing Protocols:**

Description: Secure routing protocols incorporate cryptographic techniques and authentication mechanisms to resist malicious attacks and ensure data integrity.

Resilience Features: Improved resistance against routing attacks, enhanced security posture, and prevention of unauthorized access.

H. **Intrusion Detection Systems (IDS):**

Description: IDS monitors network activity for signs of malicious behavior or anomalies and triggers alerts or countermeasures.

Resilience Features: Early detection and mitigation of security threats, enhancing the network's ability to withstand attacks.

I. **Collaborative Approaches:**

Description: Collaborative mechanisms involve nodes working together to share information, detect anomalies, and collectively respond to disruptions.

Resilience Features: Improved situational awareness, cooperative problem-solving, and collective defense against network challenges.

J. **QoS-Aware Routing:**

Description: Quality of Service (QoS)-aware routing mechanisms consider parameters such as latency, bandwidth, and reliability to optimize communication paths.

Resilience Features: Improved service quality, adaptive routing based on real-time QoS metrics, and efficient utilization of network resources.

K. **Cross-Layer Design:**

Description: Cross-layer communication allows different layers of the network protocol stack to exchange information, enabling more informed decision-making.

Resilience Features: Enhanced adaptability by considering information from multiple layers, leading to more robust and context-aware network behavior.

Table 3. Mechanism of Resilience in Mobile Ad Hoc Networks (Manets)

Mechanism	Description	Resilience Features	Use Cases/Considerations	References/Tools
Dynamic Routing Protocols	Establish and maintain routes based on real-time network conditions.	- Adaptability to changing topologies - Quick route discovery and reconfiguration	- Dynamic environments with frequent topology changes	AODV, DSR, OLSR
Self-Healing Mechanisms	Nodes autonomously detect and recover from failures or disruptions.	- Automatic detection and local repair	- Reducing reliance on central coordination	Self-healing algorithms
Energy-Efficient Strategies	Adaptive power management and energy-aware routing to optimize energy resources.	- Prolonged network lifetime	- MANETs with resource-constrained nodes	Energy-aware routing protocols
Adaptive Topology Control	Dynamically manage communication by adjusting transmission power and optimizing data exchange.	- Efficient communication in dynamic scenarios - Reduced interference	- Networks with varying topologies and interference	Adaptive topology control algorithms
Cognitive Radio Networks	Nodes intelligently adapt to available spectrum bands to avoid interference and optimize communication.	- Intelligent spectrum adaptation	- Dynamic radio environments with varying spectrum conditions	Cognitive radio protocols
Machine Learning Algorithms	Integration of machine learning for predictive adaptation based on historical network behavior.	- Predictive analytics for anticipating changes - Reinforcement learning for adaptive behavior	- Networks with dynamic and evolving conditions	Machine learning frameworks

Secure Routing Protocols	Incorporate cryptographic techniques and authentication mechanisms to resist malicious attacks.	- Improved resistance against routing attacks - Enhanced data integrity	- Networks prone to security threats and attacks	Secure routing protocols
Intrusion Detection Systems (IDS)	Monitor network activity for signs of malicious behavior, triggering alerts or countermeasures.	- Early detection and mitigation of security threats	- Networks with potential security vulnerabilities	IDS tools, anomaly detection systems
Collaborative Approaches	Nodes work together to share information, detect anomalies, and collectively respond to disruptions.	- Improved situational awareness - Cooperative problem-solving	- Collaborative networks where nodes can cooperate	Collaborative defense mechanisms
QoS-Aware Routing	Consider QoS parameters to optimize communication paths, including latency, bandwidth, and reliability.	- Improved service quality - Adaptive routing based on real-time QoS metrics	- Applications with specific QoS requirements	QoS-aware routing protocols
Cross-Layer Design	Enable communication between different layers of the protocol stack for more informed decision-making.	- Enhanced adaptability by considering information from multiple layers	- Situations where cross-layer communication can provide benefits	Cross-layer communication protocols

VI. Simulation-Based Data Generation

The simulation environment for evaluating the various routing protocols in Mobile Ad Hoc Networks (MANETs), we have used the OMNeT++ with following settings to collect and analyze the protocol under scope:

a. **Network Topology and Area:**
   - Area Size: A simulation area of 1000m x 1000m is defined to provide ample space for node movement and interaction.
   - Node Distribution: Initially, 150 nodes are randomly distributed across the simulation area to mimic a dense network scenario, such as sensors in a large agricultural field or devices in an urban setting.

b. Node Mobility Model:

Model Choice: The Random Waypoint (RWP) model is selected for its simplicity.

Parameters:

- Minimum speed is set to 0 m/s to allow for stationary periods, reflecting nodes that might temporarily stop moving.
- Maximum speed is set to 20 m/s to simulate fast-moving nodes, such as drones or vehicles.
- Pause times between movements range from 0 to 30 seconds, allowing nodes to halt at certain points before changing direction or speed, adding realism to the mobility pattern.

c. Communication Model:

- Transmission Range: Each node has a transmission range of 250m, which is typical for outdoor MANET applications using standard Wi-Fi.
- Bandwidth: The network bandwidth is set to 2 Mbps, reflecting a common throughput for Wi-Fi connections in a congested network environment.
- Packet Size: Data packets are 512 bytes, a size that balances the need for realistic payload sizes with the necessity to avoid excessive network congestion.

d. Traffic Patterns:

- Source-destination pairs are randomly chosen with a new pair selected every 100 seconds to simulate varying communication patterns.
- Data rates for sending packets from sources to destinations are set at one packet per second, representing a moderate load on the network.

e. Simulation Duration and Repetitions:

- Duration: Each simulation run is set for 600 seconds (10 minutes) to allow enough time for network dynamics to unfold and stabilize.
- Repetitions: To ensure statistical relevance, each simulation setup is repeated 30 times with different random seed values, allowing for the aggregation of results to minimize the impact of outliers.

VII. OBSERVATION & DISCUSSION

A. Evaluation of Algorithim

i. Evaluationof Performance, Efficiency&Scalability

Table 4. Evaluation of Performance, Efficiency & Scalability

Routing Protocol	Performance (%)	Efficiency (%)	Scalability (%)
AODV	80	70	60
DSR	85	60	50
OLSR	90	80	85
ZRP	75	70	90
TORA	80	50	65
ABR	85	75	70
FSR	80	85	90

DYMO	85	80	75
LAR	80	65	70
CBRP	85	85	85

In evaluating various routing protocols for Mobile Ad Hoc Networks (MANETs), performance, efficiency, and scalability are crucial metrics. The Ad Hoc On-Demand Distance Vector (AODV) protocol exhibits a performance rating of 80%, suggesting a reliable operational performance. However, it shows a moderate efficiency of 70%, indicating room for improvement in resource utilization. Scalability is rated at 60%, signaling potential challenges in expanding network size.

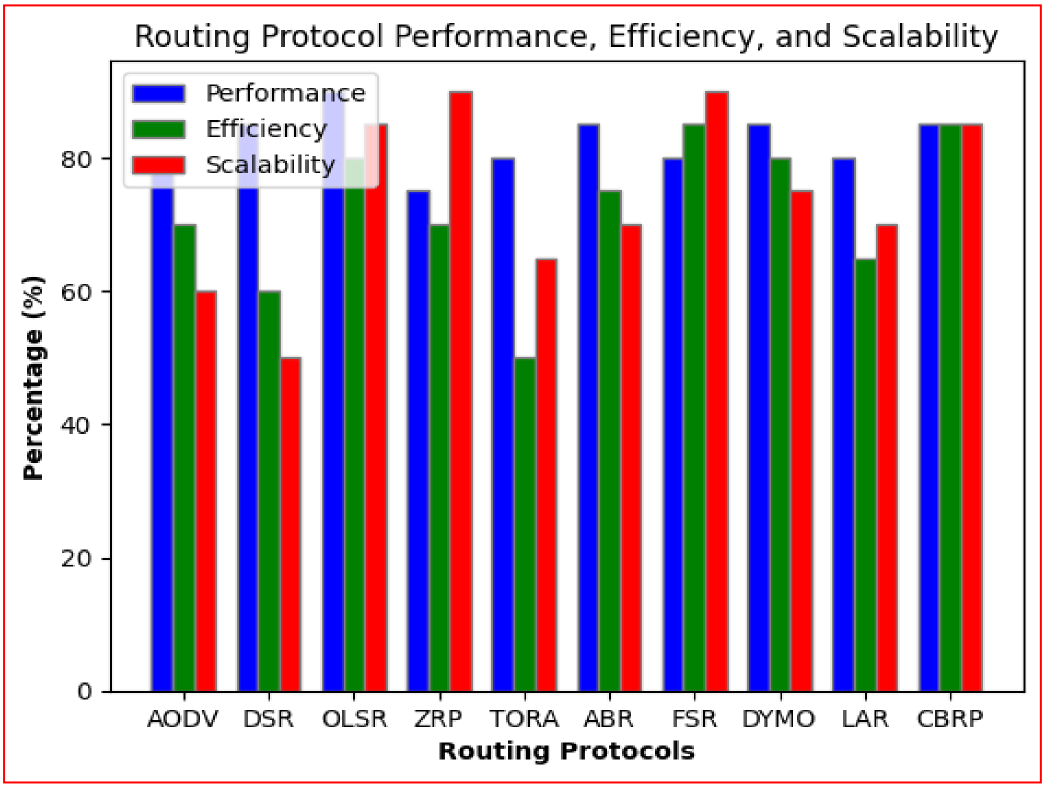

Figure 3. Depicts the Performance Analysis of Algorithim

A. Performance Evaluation of mechanisms for resilience in MANET

Evaluation of Scalability & Reliability of Various Mechanism

Table 6. Evaluation of Scalability & Reliability of Various Mechanism

Resilience Mechanism	**Scalability (%)**	**Reliability (%)**
Dynamic Routing Protocols	70	75
Self-Healing Mechanisms	80	80
Energy-Efficient Strategies	85	75
Adaptive Topology Control	85	85
Cognitive Radio Networks	85	80
Machine Learning Algorithms	90	80
Secure Routing Protocols	75	85
Intrusion Detection Systems	80	80

Collaborative Approaches	90	80
QoS-Aware Routing	80	85
Cross-Layer Design	85	80

In the assessment of resilience mechanisms for Mobile Ad Hoc Networks (MANETs), scalability and reliability play pivotal roles. Dynamic Routing Protocols, with a scalability rating of 70%, exhibit a moderate capability to handle network growth, while achieving a commendable reliability rating of 75%, indicating a reliable approach to data delivery under dynamic conditions.

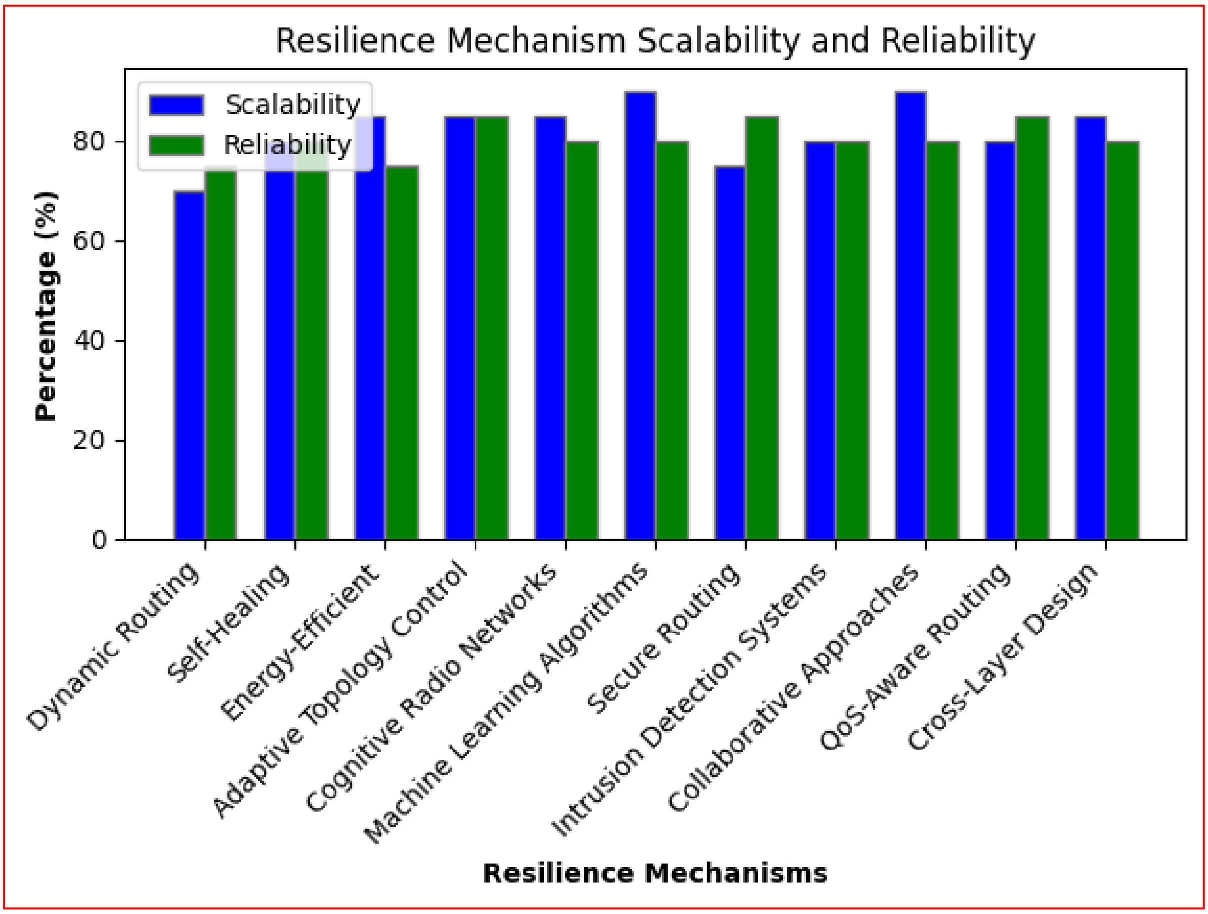

Figure 4. Depicts the Performance Evaluation of mechanisms for resilience in MANET

VIII. Conclusion

The assessed Mobile Ad Hoc Network (MANET) resilience by utilizing real-world mobility traces derived from human walking patterns, considering various centrality-based attack strategies. Our evaluation leveraged authentic mobility traces gathered in diverse settings such as campuses, local fairs, and theme parks, providing a realistic validation of our proposed attack models. Resilience, defined as robustness, was measured in terms of service degradation in response to network challenges that deviate from the normal operation of the network. To address resilience optimization, our analysis was structured into two layers. The first layer focused on topological flow robustness, serving as the metric for service state evaluation. This metric reflected connectivity conditions through different network parameters. In the assessment of routing protocol impacts on Packet Delivery Ratio (PDR) and delay, topological flow robustness was employed as the operational state metric. Despite the dynamic nature and variances in different network graphs, none of the centrality metrics individually offered a consistently accurate indication of node significance.

IX. REFERENCES

[1]. Jabbar, H. Narra and J. P. G. Sterbenz (2011) 'An approach to quantifying resilience in mobile ad hoc networks', Proceedings of the 8th IEEE International Workshop on the Design of Reliable Communication Networks (DRCN), pp. 140-147, October.

[2]. Zhang and J. P. G. Sterbenz (2015) 'Measuring the resilience of mobile ad hoc networks with human walk patterns,' 2015 7th International Workshop on Reliable Networks Design and Modeling (RNDM), Munich, Germany, pp. 161-168. DOI: 10.1109/RNDM.2015.7325224.

[3]. S. Balaji and Y. H. Robinson (2018) 'Development of Multipath Resilience Routing Technique to Improve the Fault Tolerance in Mobile Ad-Hoc Networks,' 2018 International Conference on Inventive Research in Computing Applications (ICIRCA), Coimbatore, India, pp. 743-747.

[4]. L. Bao and JJ Garcia-Luna-Aceves (2010) 'Stable energy-aware topology management in ad hoc networks', Proceedings of Ad Hoc Networks, vol. 8, no. 3, pp. 313-327.

[5]. Chlamtac, M. Conti and J. J.-N. Liu (2011) 'Mobile ad hoc networking: imperatives and challenges', Ad Hoc Networks, vol. 1, no. 1, pp. 13-64.

[6]. H. Kim, J. Tang, R. Anderson and C. Mascolo (2012) 'Centrality prediction in dynamic human contact networks', Computer Networks, vol. 56, no. 3, pp. 983-996.

[7]. Casteigts, P. Flocchini, W. Quattrociocchi and N. Santoro (2012) 'Time-varying graphs and dynamic networks', International Journal of Parallel Emergent and Distributed Systems, vol. 27, no. 5, pp. 387-408.

[8]. IF Akyildiz, W Su, Y Sankarasubramaniam and E Cayirci (2009) 'A Survey on Sensor Networks', IEEE Comm. Magazine, vol. 40, no. 8, pp. 102-114.

[9]. N. Aschenbruck, A. Munjal and T. Camp (2011) 'Trace-based mobility modeling for multi-hop wireless networks', Comput. Commun., vol. 34, pp. 704-714, May.

[10]. H. Deng, W. Li and D. Agrawal (2019) 'Routing security in wireless ad hoc networks', Communications Magazine IEEE, vol. 40, pp. 70-75, Oct.

[11]. Zhang and J. P. G. Sterbenz (2014) 'Analysis of Critical Node Attacks in Mobile Ad Hoc Networks', Proceedings of the 6th IEEE/IFIP International Workshop on Reliable Networks Design and Modeling (RNDM), pp. 171-178, November.

[12]. Zhang, S. A. Gogi, D. S. Broyles, E. K. Çetinkaya and J. P. Sterbenz (2012) 'Modelling Attacks and Challenges to Wireless Networks', Proceedings of the 4th IEEE/IFIP International Workshop on Reliable Networks Design and Modeling (RNDM), pp. 806-812, October.

[13]. S Chen and K Nahrstedt (2009) 'Distributed quality-of-service routing in ad-hoc networks', IEEE J Sel Areas Commun, vol. 17, no. 8, pp. 1488-1505.

[14]. K Mahesh, Samir R Marina and R Das (200) 'Ad Hoc On demand Multipath distance vector routing', IEEE Trans, vol. 19, no. 4, pp. 74-86.

[15]. J. P. Rohrer, A. Jabbar and J. P. Sterbenz (2014) 'Path Diversification for Future Internet End-to-End Resilience and Survivability', Springer Telecommunication Systems, vol. 56, pp. 49-67, May.

[16]. H. Yang, H. Luo, F. Ye, S. Lu and L. Zhang (2004) 'Security in mobile ad hoc networks: challenges and solutions', IEEE Wireless Communications, vol. 11, no. 1, pp. 38-47.

[17]. J. P. G. Sterbenz, D. Hutchison, E. K. Çetinkaya, A. Jabbar, J. P. Rohrer, M. Schöller, et al. (2010)

'Resilience and survivability in communication networks: Strategies principles and survey of disciplines', Computer Networks, vol. 54, no. 8, pp. 1245-1265.

[18]. A. Jamaković and P. Van Mieghem (2008) 'On the Robustness of Complex Networks by Using the Algebraic Connectivity', Proceedings of the 7th International IFIP Networking Conference, pp. 183-194, May.

[19]. J. P. Rohrer, A. Jabbar and J. P. G. Sterbenz (2009) 'Path Diversification: A Multipath Resilience Mechanism', Proceedings of the IEEE 7th International Workshop on the Design of Reliable Communication Networks (DRCN), pp. 343-351, October.

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