Towards Disaster-Resilient Wireless Networks: A Simulation-Based Study

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***Abstract*—Disaster-resilient networks (DRNs) are critical for maintaining communication in emergency scenarios where infrastructure is damaged. This paper investigates the design and performance of DRNs using wireless ad hoc networks and routing protocols such as AODV. Through simulation in OMNeT++, we analyze network performance under node failures and high mobility, mimicking post-disaster conditions. Results show that proactive optimization of routing and resource allocation can significantly enhance network resilience, ensuring robust communication during emergencies.**

Keywords Disaster-Resilient Networks, Wireless Ad Hoc Networks, AODV, OMNeT++, Simulation.

INTRODUCTION

The increasing frequency of natural disasters underscores the need for resilient communication networks. Traditional networks often fail during disasters due to infrastructure damage, leaving communities and response teams isolated. Disaster-Resilient Networks (DRNs) leverage wireless and ad hoc technologies to provide critical communication under adverse conditions. This study focuses on evaluating the performance of DRNs using OMNeT++ simulations, with emphasis on dynamic routing and node failures.

DRNs face challenges such as high node mobility, limited power, and network partitioning. This study aims to address these issues by simulating DRNs under various failure scenarios and optimizing routing protocols to enhance resilience and efficiency.

RELATED WORK

Disaster-Resilient Networks DRNs ensure communication during disasters through decentralized, self-healing networks. These networks rely on wireless technologies and protocols optimized for resilience and scalability. By dynamically adjusting to changing topologies, DRNs can maintain connectivity in highly volatile environments.

Routing Protocols for DRNs Ad hoc On-Demand Distance Vector (AODV) is a reactive routing protocol suited for dynamic topologies, making it ideal for DRNs. Unlike proactive protocols, AODV establishes routes on demand, minimizing overhead in unstable networks. Proactive protocols like OLSR, while efficient in stable networks, struggle in high-mobility scenarios.

Existing Work Previous studies have explored DRNs using different wireless technologies, focusing on specific disaster scenarios. However, limited research exists on using OMNeT++ for large-scale DRN simulation under varied failure conditions. Recent works highlight the need for adaptive protocols that balance resilience, latency, and energy efficiency.

METHODOLOGY

I. NETWORK SIMULATION ENVIRONMENT

Simulations were conducted using OMNeT++ with INET framework extensions. The network consists of wireless nodes using AODV routing. The scenarios include node mobility, failures, and high traffic, mimicking post-disaster conditions.

II. SIMULATION PARAMETERS

- **Network Size:** 50 nodes
- **Simulation Area:** 1000m x 1000m
- **Traffic:** Constant Bit Rate (CBR) UDP flows
- **Node Mobility:** Random waypoint model
- **Node Failure:** 20
- **Simulation Duration:** 300 seconds

III. METRICS

- **Packet Delivery Ratio (PDR):**Measures successful packet delivery.
- **End-to-End Delay:** Measures communication delay.m
- **Routing Overhead:** Evaluates protocol efficiency.
- **Node Mobility:** Random waypoint model
- **Energy Consumption:**Assesses network sustainability.

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Results and Discussion

A. Packet Delivery Ratio

PDR decreased with increased node failures but remained above 70% for the AODV protocol due to its reactive routing mechanism. Enhanced routing optimizations further improved PDR by 10%. Comparative analysis with OLSR showed that AODV outperformed in high-mobility scenarios.

B. End-to-End Delay

The delay increased under high mobility and failures due to route rediscovery. However, the delay was within acceptable limits (below 200ms), enabling effective communication for most scenarios. Proactive protocols exhibited lower delays but were less resilient to failures.

C. Routing Overhead

AODV's overhead increased linearly with node mobility, highlighting a trade-off between resilience and efficiency. Future work could optimize overhead by integrating machine learning-based prediction models. Energy-efficient modifications to AODV could further enhance performance.

D. Energy Consumption

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E. Conclusion and Future Work

This study demonstrates the potential of DRNs using AODV and OMNeT++ for disaster scenarios. The findings underscore the importance of routing optimization in enhancing network resilience. Future work will explore AI-driven adaptive routing and hybrid wireless technologies to further improve DRN performance. Additionally, integrating blockchain for secure communication and employing UAVs for rapid deployment can be explored.

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