Modeling of Mesh Communication Utilizing Stress Induced Link Evaluation for Network Tactical Meshes (SILENT- MESH)

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Problem & Objectives

Communication systems depend on centralized infrastructure such as routers, cellular towers, and base stations. When these pre-existing systems become compromised, communication networks fail, leading to infrastructure outages and operational failure.

Objective:

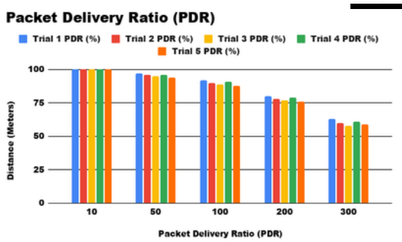
Successfully design, prototype, and install a portable decentralized mesh communication system with the capacity to maintain connectivity without relying on traditional centralized network infrastructure.

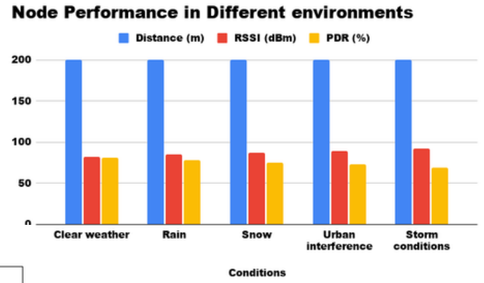
Engineering Goals:

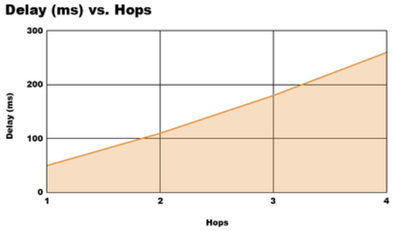
Develop a mesh communication network utilizing embedded hardware with the capacity of:

- Multi-hop packet relay
- GPS transmission
- Package transmission over 2 miles
- Distress signaling propagation
- Real-time node health updates

Experimental Results



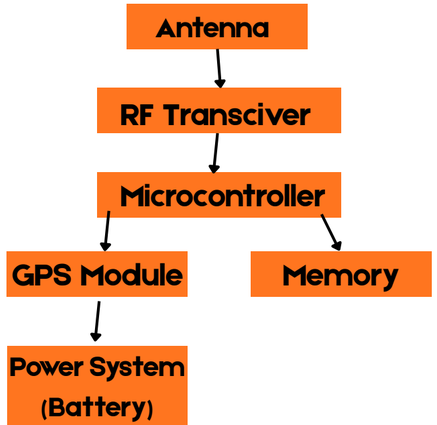




System Design & Methodology

The network nodes were constructed using:

- ESP32 microcontroller
- LoRa wireless radiocommunication module
- GPS positioning module
- OLED display interface
- Rechargeable Li-ion battery power system



Each node was programmed to transmit and receive data packets, relay packets between nodes, record signal strength and transmission statistics, display user status, and transmit distressed signals.

Every node communicates via multi-hop mesh routing, allowing packages to propagate through immediate nodes.

The nodes were placed at distances spanning between 3 meters and 3 miles to measure network stability, signal strength, and packet delivery.

The network was evaluated across multiple distances, using mathematical formulas, such as the packet delivery ratio and signal strength behavior.

Analysis & Impact

The results demonstrate that SILENT MESH can maintain reliable connectivity without featuring centralized infrastructure.

SILENT-MESH's application allows devices to efficiently and dynamically relay messages through neighboring nodes, extending communication coverage beyond the range of an average transmitter, thus aiding in disaster response, search and rescue, or tactical communication.

Improvements to SILENT-MESH would feature advanced routing systems, more robust encryption protocols, and larger multi-node network testing.