1. Synopsis

This project entails the development of a decentralized, long-range communication network independent of cellular infrastructure or the internet. Utilizing **LoRa (Long Range)** modulation technology, the system consists of multiple handheld "nodes" capable of transmitting encrypted text messages and GPS coordinates over distances of 5-10 kilometers. The devices employ a **Mesh Topology**, meaning if Node A cannot reach Node C directly, the message automatically "hops" through Node B. This mimics military-grade tactical communication systems used in environments where traditional infrastructure has failed.

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2. Technical Report

2.1 Problem Statement and Societal Necessity In the immediate aftermath of natural disasters (earthquakes, floods, hurricanes) or during civil unrest, cellular towers and internet backbones are often the first infrastructure to fail. This communication blackout impedes rescue operations and leaves civilians isolated. There is a critical societal need for a "Zero-Infrastructure" communication system that is low-cost, energy-efficient, and instantly deployable to coordinate rescue efforts and locate survivors.

2.2 Key Features

- **Long-Range Modulation:** Utilizes the SX1278 transceiver (LoRa) to achieve link budgets capable of penetrating urban debris or spanning rural valleys.
- **Mesh Networking Protocol:** Implements a "Flood-Fill" or "Packet Forwarding" algorithm. Every device acts as a repeater, extending the network's effective range exponentially as more users join.
- **Geospatial Tracking:** Integrated GPS modules append precise latitude/longitude data to every distress signal.
- **Low Power Consumption:** Designed to operate for days on a standard 18650 Li-Ion cell using Deep Sleep wake-on-radio interrupts.

2.3 Innovation and Differentiation Standard student projects use Wi-Fi (range < 100m) or Bluetooth. This project distinguishes itself by using **Sub-GHz RF bands** (433MHz/868MHz/915MHz), demonstrating knowledge of RF propagation and antenna theory. Furthermore, implementing a **Mesh Routing layer** on top of the physical layer shows advanced software engineering capabilities, moving beyond simple "client-server" models to "peer-to-peer" distributed systems.

2.4 Cost Analysis and Feasibility

- **ESP32 Microcontroller:** $6.00
- **SX1278 LoRa Module (Ra-02):** $5.00
- **NEO-6M GPS Module:** $4.00
- **0.96" OLED Display:** $3.00
- **Li-Ion Battery + Charging Circuit:** $5.00
- **Total Unit Cost:** ~23.00$ per node. This is significantly cheaper than satellite phones (dollar 1000+), making it feasible for mass distribution by NGOs or government agencies.

2.5 Business Model

- **B2G (Business to Government):** Selling stockpiles of these devices to FEMA or National Disaster Response Force (NDRF) for emergency deployment.
- **Adventure Tourism:** Marketing a consumer version for hikers and mountaineers entering areas with no cell service.

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3. Hardware Interfacing and Pin Mapping

Component List:

1. **Microcontroller:** ESP32 Development Board
2. **RF Transceiver:** Ai-Thinker Ra-02 (SX1278) 433MHz LoRa Module
3. **Positioning:** NEO-6M GPS Module
4. **Interface:** 0.96 inch I2C OLED Display (SSD1306)
5. **Antenna:** 433MHz Spring Antenna (Critical for range)

Note: The GPS TX pin connects to ESP32 RX pin, and GPS RX connects to ESP32 TX. This is a UART Cross-connection.