Node V1 & Node V1 OS - Technical Breakdown

1. Introduction to Node V1

Node V1 is a portable, rugged, and modular communication terminal engineered for resilient mesh networking across diverse radio types. It supports flexible deployment in adverse field conditions, enabling private, secure, and infrastructure-independent communication. Applications include emergency response, tactical operations, wilderness expeditions, and off-grid team coordination.

- **Form Factor:** Compact handheld enclosure, weather-resistant, field-ready
- **Core Objective:** Enable decentralized, encrypted communication via mesh and hybrid radios
- **Modes of Operation:**
    - Direct P2P radio communication
    - Multi-hop mesh relaying
    - Hybrid LTE or satellite fallback when available
- **Operating System:** Node V1 OS (custom modular firmware)

2. Hardware Architecture

- **Microcontroller Unit (MCU):**
    - **Model:** ESP32-S3-WROOM-1U-N16R8
    - **Specs:** Dual-core 240 MHz, 8MB SRAM, 16MB Flash
    - **Interfaces:** Wi-Fi, Bluetooth LE, USB OTG
- **Display:**
    - **Model:** Waveshare 1.69” IPS LCD
    - **Resolution:** 240x280 pixels
    - **Driver:** ST7789 (LVGL-compatible)
    - **Interface:** SPI
    - **Orientation:** Landscape, flipped
- **Radio Modules:**
    1. **Wi-Fi/BLE:** Integrated into ESP32-S3
    2. **LoRa:** E22-900M30S
        - Power: 30 dBm (1W)
        - Frequency: 915 MHz
        - Semtech-compatible for custom and standard mesh protocols
    3. **Cellular/Satellite:** Quectel BG770A-SN
        - LTE Cat-M1, NB-IoT, fallback SMS over satellite
        - UART interface with AT command support
        - SIM slot (externally accessible)
        - Emnify M2M platform compatibility

- **GPS Module:**
    - **Model:** Antenova M20048-1
    - **Protocol:** NMEA 0183
    - **Interface:** UART
    - **Functionality:** Real-time tracking, breadcrumb trails, speed/time
- **Power and I/O:**
    - 3.7V Li-ion battery
    - USB-C charging and data access
    - SPI NOR flash storage
    - Button array: D-pad, select, back, and menu buttons
    - Optional secure element for cryptographic keys

3. Node V1 OS – Firmware Overview

Node V1 OS is a modular C/C++ firmware with a layered architecture designed for radio abstraction, encryption, persistence, and extensibility.

- **UI Layer (LVGL):**
    - Tabs: Map, Nodes, Messages, Radios, Teams, Settings
    - Top bar: Clock, signal strength, active radio icon
- **Radio Abstraction Layer:**
    - Dynamic detection/switching of radio modules
    - Manual override or automated fallback based on RSSI, SNR, and latency
    - Unified packet format for cross-radio compatibility
- **GPS & Mapping:**
    - NMEA parser for Antenova M20048-1
    - Filters GPRMC/GPGGA messages
    - Breadcrumb visualization with peer overlay on maps
- **Messaging Engine:**
    - End-to-end encrypted peer-to-peer communication
    - Message queuing, TTL, hop control
    - Offline cache and retry on failure
- **Persistence Manager:**
    - Flash-based JSON structure with CRC validation
    - Stores: callsign, avatar, team memberships, trusted peers, preferences, and last GPS lock
- **Security:**
    - AES-GCM encryption + X25519 key exchange (planned)
    - Replay protection using nonces
    - Optional use of secure hardware for key storage
- **Device Services:**

    - Power state management
    - GPS logging in background
    - Screen dimming logic
    - USB file transfer support (planned)
4. Companion iOS App

Designed as a graphical control panel and communication hub, the Node V1 iOS app mirrors the on-device interface and adds advanced functionality.

- **Connectivity:**
    - BLE pairing with encrypted session keys
    - Synchronizes settings, logs, messages
- **Features:**
    - Real-time live map with node positions
    - Full chat/message history
    - Group/team management and broadcast tools
    - GPS trail visualization
    - OTA firmware push and monitoring
    - Backup/export tools for logs, profiles, and locations
- **UI Design:**
    - Same tab layout as firmware for ease of transition
    - Themes, dark/light mode, offline support
- **Security:**
    - Session-based pairing with handshake
    - App-lock with FaceID/TouchID support

5. Future Plans

- Android companion app with full feature parity
- Cross-device bridges: (Node <-> Phone <-> Internet)
- Mesh routing enhancements (AODV/Gossip-style protocols)
- File/image sharing over mesh radio
- Guaranteed delivery via satellite fallback
- Encrypted team channels and status beacons
- Remote provisioning via QR codes or app interface

Hardware v2 Concepts: - Integrated touchscreen - Solar-assisted charging - Modular plug-and-play radio expansion