LoRa-Based Mesh Network for Off-Grid SMS-Style Communication in Emergency Situations

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Background:

Conventional Communication Networks – Incapacitated, or Unavailable

- Natural Disasters
- Technical Failures
- Warfare

Data at these times crucial for:

- Situational Analysis
- Strategic Planning
- Search and Rescue Operations
- General Communications

Proposed Solution:

- Off-Grid SMS-style Communication Network based on Low-Power Wide-Area Networks (LPWAN)

Image sources:

1. https://cnnphilippines.com/news/2020/11/12/Ulysses-weather-updates-.html
2. https://www.rappler.com/newsbreak/iq/list-deadly-landslides-philippines
3. http://fingfx.thomsonreuters.com/gfx/rngs/PHILIPPINES-ATTACK/010041F032X/index.html

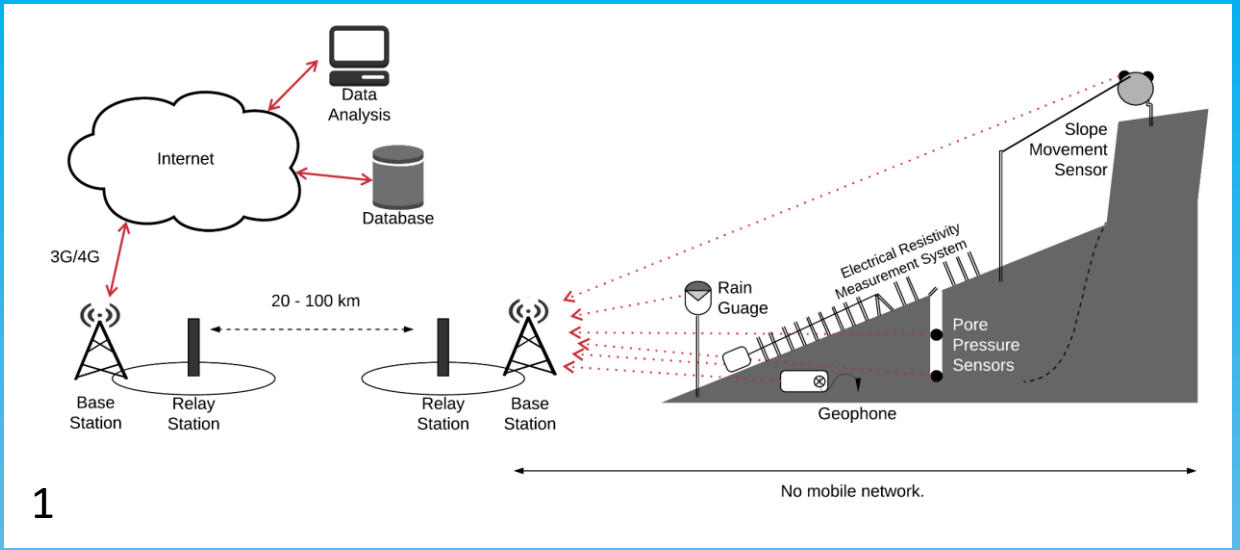
Relevant Technologies

LoRa-based Mesh Network

- Low-Power (can be powered off-grid)
- Long Range (can serve as relay as well as node)
- Frequency of Operation

Why SMS-style communication?

- Stems from LoRa technology limitations
- Data Rate
- Simple enough to convey crucial information



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Relevant Previous Works by Asean-IVO members:

1. Relay Station Network Based on Low-power Wide-area Network (LPWAN) Technologies for Disaster Management (Dr. Kanokvate Tungpimolrat (NECTEC), Other project members)

2. LoRa-based Mesh Network for Off-grid Emergency Communications (Khazmir Camille Valerie Macaraeg, Calvin Artemies Hilario, et al.)
   → uses ESP32+LoRa module and connects phone via Bluetooth Low Energy (BLE)


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SMS-style communication using BLE and Bluetooth Terminal as interface

Current Implementation

WiFi vs. BLE

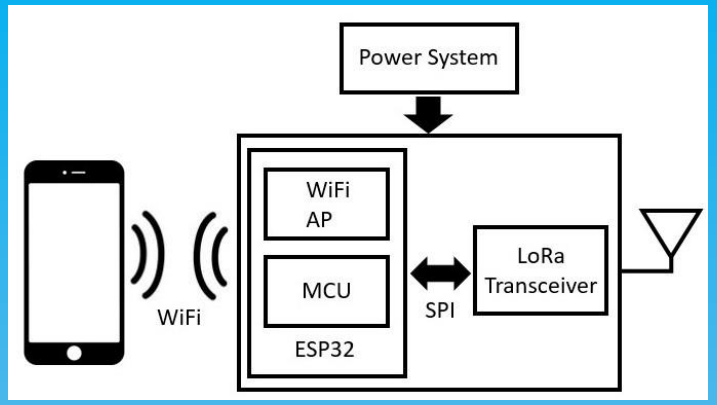
- Longer range
- Higher data rate
- Better capacity

Configuration:

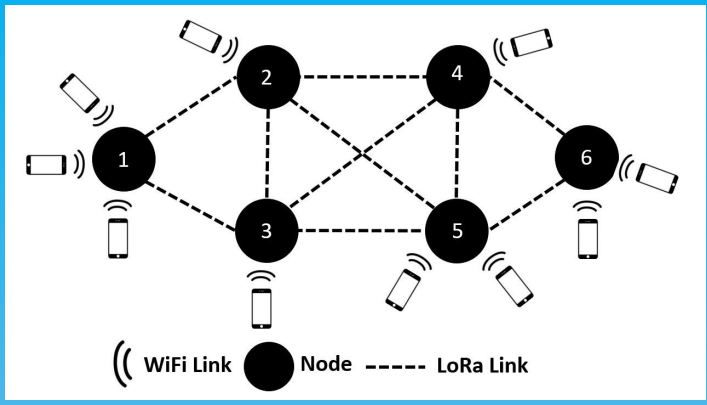
- **Node:** ESP32 + RFM95 LoRa
- Mesh configuration (each node can function as a relay)

LoRa Messenger App[1]:

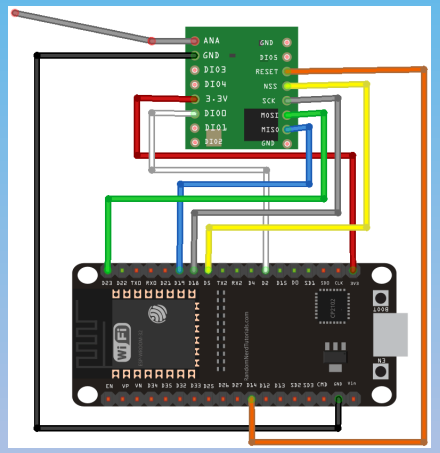
- Open source
- Reconfigurable LoRa band, SF, Tx Power, Node name, Recipient, and other parameters for SMS-style comms
- Nearby active nodes are discoverable with RSSI, and possible no. of hops to reach
- Intuitive chatbox interface



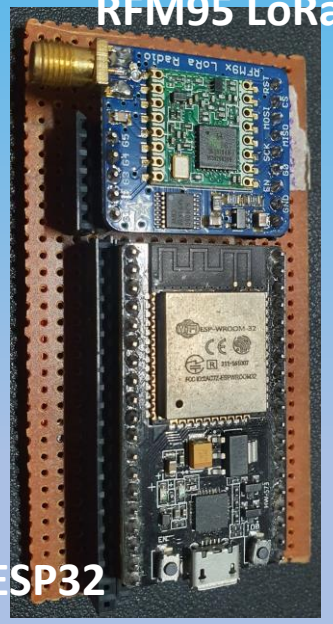
LoRa node to smartphone connectivity

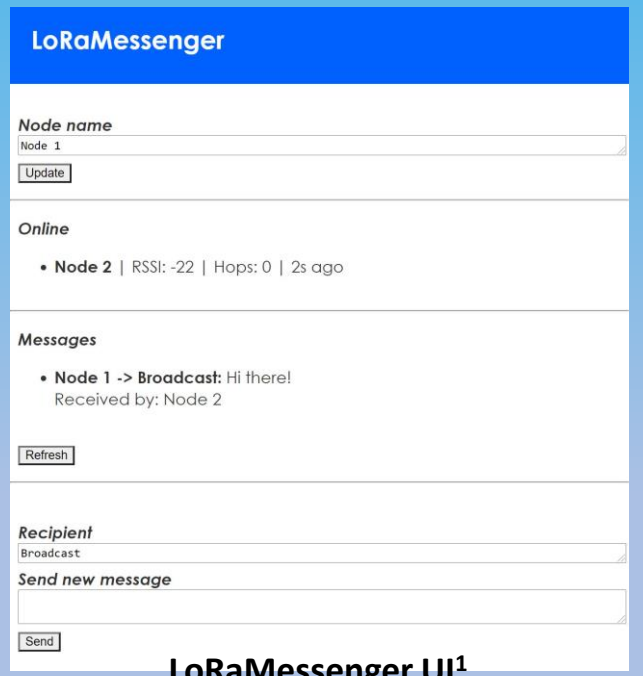


Mesh Network Configuration



LoRa node wiring diagram





LoRaMessenger UI[1]

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[1] https://github.com/TheNico14/LoRaMessenger

Lab Testing / Node Setup

Off-Grid capability setup:

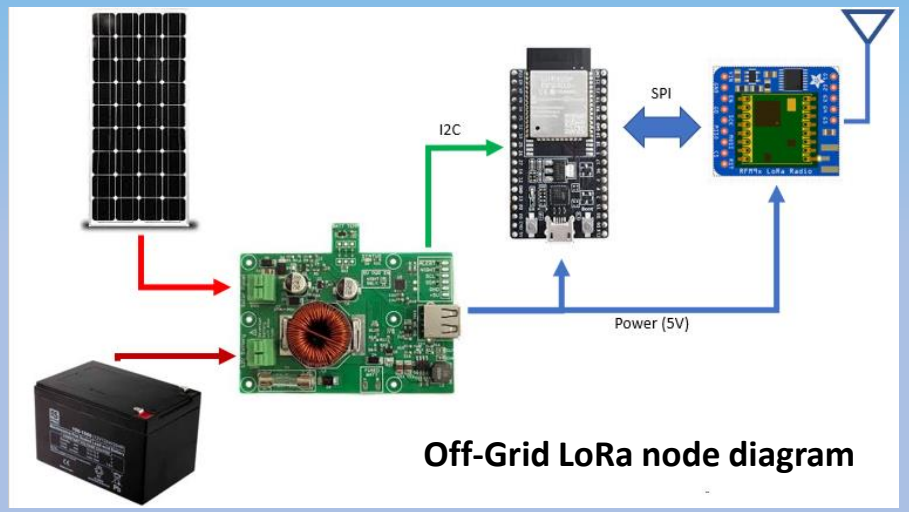
- ESP32+RFM95 LoRa module powered by Photovoltaic source with MPPT solar charger and battery placed inside an enclosure box and mounted on a pole.

- Lab test consisted of testing capability for phone connection to LoRa node via WiFi AP provided by ESP32, active nodes discovery, setting of node name and recipient/broadcast mode, basic send/receive functions, power supply

- Test done to test capabilities in an urban setting using 23dBm Tx power, SF 7, 868MHz LoRa band frequency

Inside of controller box

LoRa-based main node



Off-Grid LoRa node diagram

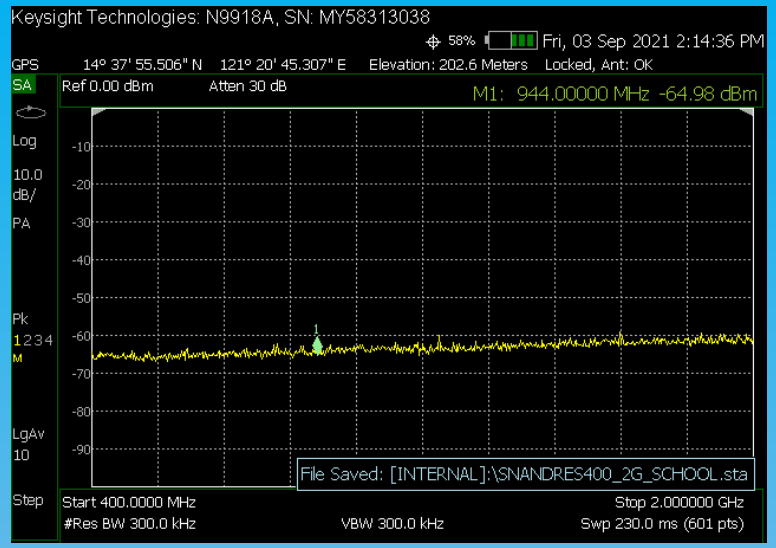
Field Testing

- Same tests were performed on a rural setting in a province in the Philippines where no connectivity is present with the LoRa node 23dBm Tx power, SF 7, 868MHz LoRa band frequency.

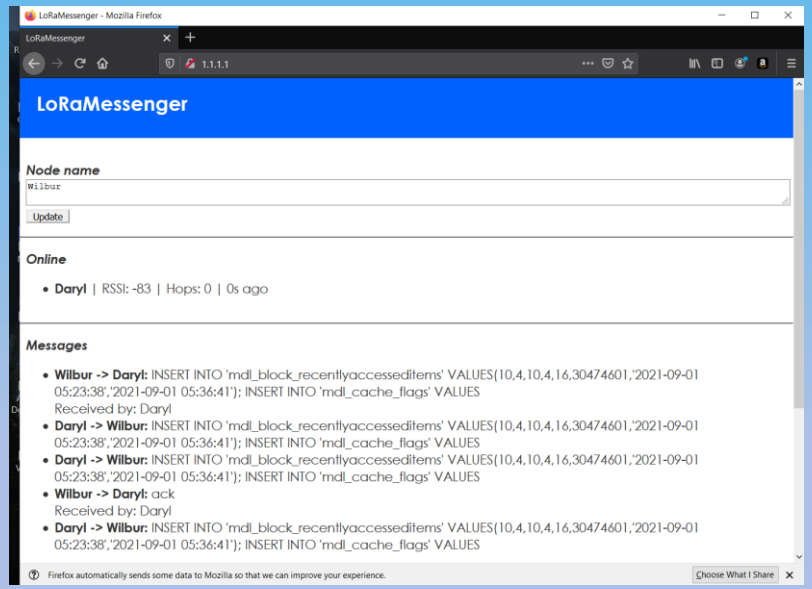
- To keep mobility easier, power banks were used in place of photovoltaic power supply.

Some Observations:

- The number of characters successfully sent decreases as node-to-node distance increases
- Foliage seems to have great effect on send/receive success
- Mesh configuration may help with issues



Tanay, Rizal, Philippines Spectrum Measurement



LoRaMessenger Chatbox UI

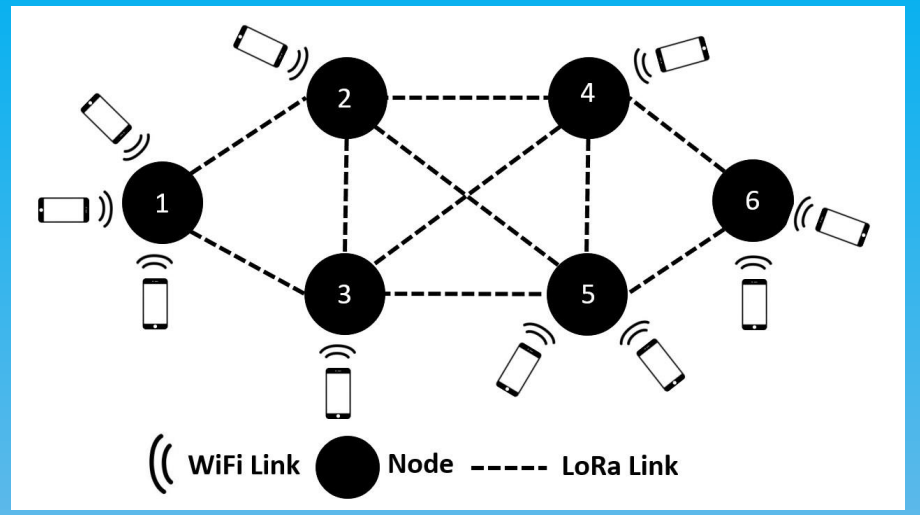
Geographical snapshot of San Andres, Tanay, Rizal, Philippines

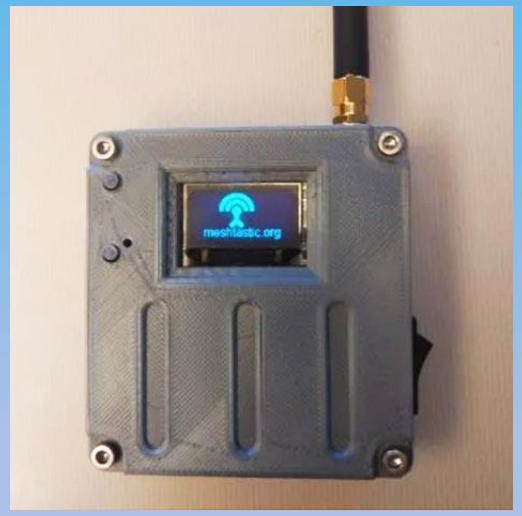
Future Plans

- Explore mesh configuration
- Study routing algorithm used and explore optimizations or implementation of new algorithm altogether
- Stress test on operation of both node-to-node and mesh operation (power, environmental conditions, PDR as number of nodes increases, etc.)
- Potential work to create personalized version of nodes similar to open-source projects like Meshtastic[1] and Disaster-Radio[2]

→ involves incorporation of other essential modules like GPS

→ Essential for rescue operation in times of disaster





https://meshtastic.letstalkthis.com/

https://hackaday.com/2020/07/30/join-your-own-private-lora-mesh-network/

[1] https://github.com/meshtastic
[2] https://github.com/sudomesh/disaster-radio

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Thank you!

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