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Design and Implementation of a Low-Cost LORA-Based Bidirectional Transceiver for Emergency Messaging using Arduino Nano

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Abstract: In areas with poor or no mobile coverage, quick and reliable communication can save lives during emergencies. This paper presents a simple, battery-powered LoRa transceiver system built with two Arduino Nano boards, LoRa modules, spring antennas, Li-ion batteries, and six tactile switches. Each device lets the user send one of six predefined short messages (such as "ALERT" or "HELP") by pressing a button. The message appears on a small LCD screen and travels wirelessly to the paired unit, which also shows it on its own screen. The system works without internet or cellular networks and uses very little power. We describe the hardware, the code that runs it, how we put it together, and basic tests that showed it could send messages reliably over hundreds of meters in open areas. The design is cheap, easy to copy, and well suited for rural villages, hiking groups, or disaster zones.

Keywords: LoRa, Arduino Nano, emergency communication, predefined messages, low-power wireless, portable transceiver

1. INTRODUCTION

Mobile phones often fail when towers are damaged or when people move far from towns. In such cases, a small handheld device that works over long distances with almost no power can make a real difference. LoRa (Long Range) technology is made for exactly this: it sends small amounts of data over kilometers while using very little battery.

We built a pair of simple transceivers that let two people exchange short, ready-made messages by pressing buttons. No typing is needed, which is helpful when someone is stressed or injured. Each unit runs on a rechargeable Li-ion battery, fits in a small box, and costs less than many commercial walkie-talkies. The project shows how hobbyist parts can create a practical tool for real-world use.

2. LITERATURE REVIEW

Several researchers have explored LoRa for emergency communication because it offers long range and low power without needing existing infrastructure. Earlier work usually focused on sending sensor data or GPS locations, but a few systems added simple user inputs like buttons.

Table 1 compares selected previous studies with our system.

Table 1 Comparison of previous system with our system

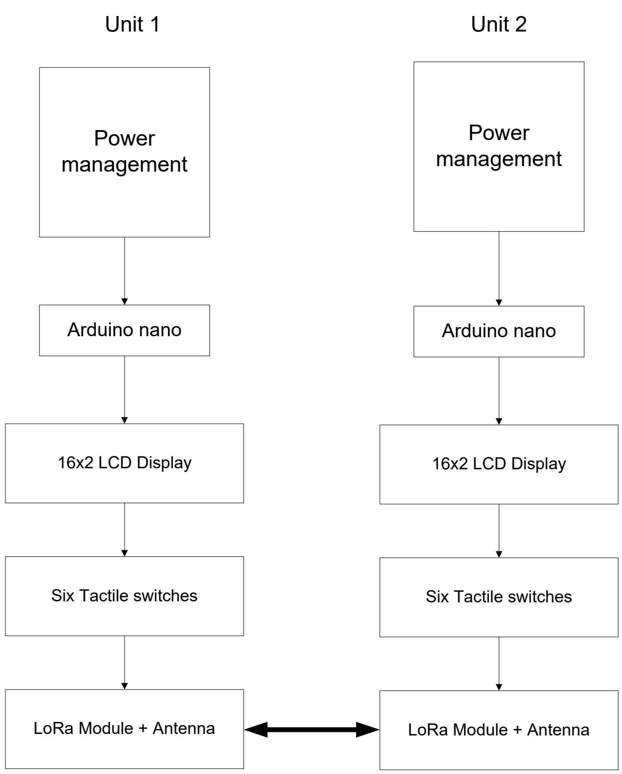
Reference	**Year**	**Main Focus**	**Hardware**	**Range (approx.)**	**User Interface**	**Limitations**
Kumar [1]	2025	Disaster response device	LoRa module, internal battery	Up to several km	Basic alert	No display, one-way in some tests
Srikanth et al. [2]	2025	Dead-zone emergency messaging	Arduino Uno, LoRa, push button	>1.5 km open	Predefined button + Bluetooth app	Larger size, needs GSM backup
Höchst et al. [3]	2020	Smartphone-to-smartphone LoRa	Custom firmware on phones	1–2 km	App-based	Requires phone, higher power
Centelles et al. [4]	2019	Earthquake response with LoRaWAN	LoRa nodes, predefined status messages	City-scale	Simple button or app	Needs gateway infrastructure
Bhattacherjee et al. [5]	2019	Public-safety alert	Arduino Pro Mini, LoRa, push button	1–3 km	Single emergency button	No LCD feedback, limited messages
Paul et al. [6]	2024	General emergency system	Arduino, LoRa	1–2 km	Basic alerts	No bidirectional display
Enam et al. [7]	2023	GPS + LoRa alert	Arduino Nano, GPS, LoRa	2–5 km	Panic button	Adds GPS cost and complexity
Villa et al. [8]	2025	Fall detection with LoRa	Accelerometer + LoRa	Indoor/outdoor	Automatic trigger	Not manual messaging
Our work	2026	Portable bidirectional transceiver	Arduino Nano x2, LoRa, 6 tactile switches, LCD, Li-ion	0.5–3 km (tested)	6 predefined messages + LCD	Short messages only, no GPS yet

Most earlier systems either sent sensor readings automatically or used a single panic button. Few offered six ready messages with instant visual feedback on both ends. Our design fills this gap by keeping everything simple, cheap, and truly handheld.

Other useful studies looked at LoRa for forest fire monitoring [9], soldier tracking [10], microgrid data transfer [11], and wearable health alerts [12], confirming that LoRa works well in remote or obstructed areas. Reviews of LoRaWAN applications [13] also highlight its popularity with Arduino boards because of low cost and easy programming.

3. SYSTEM DESIGN AND METHODOLOGY

3.1 Hardware Components



The block diagram of the system is shown in the figure below.

Figure 1 Block diagram of the system

Each transceiver uses:

a) Arduino Nano: Small, cheap microcontroller that runs the code and controls everything.
b) LoRa module (SX1276/1278 compatible): Handles the wireless link at 433 MHz (legal in India).
c) Spring antenna: Low-cost helical antenna soldered directly to the module for portability.
d) Li-ion battery (18650 or similar with protection circuit): Powers the unit for many hours of standby use.
e) Six tactile switches: Connected to digital pins with internal pull-ups; pressing one sends its message.
f) 16x2 LCD with I2C: Shows “Sent: MESSAGE” or “Received: MESSAGE” clearly.

3.2 Software Implementation

The code (written in Arduino IDE) as shown in the figure below .

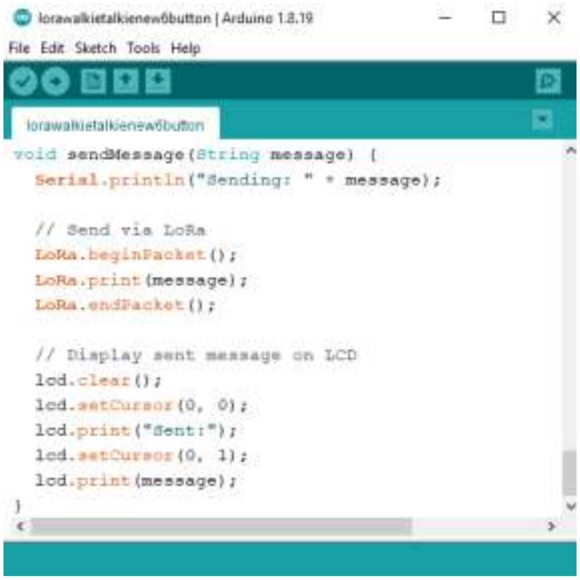


Figure 2 Arduino IDE with developed code

It does three things:

- Watches the six buttons.
- Sends the matching predefined message when a button is pressed.
- Listens for incoming packets and shows them on the LCD.

Key parts of the code include:

- LoRa library initialization at 433 MHz.
- Button pins set with INPUT_PULLUP (no extra resistors needed).
- A simple sendMessage() function that starts a packet, prints the text, and ends the packet.
- In the main loop, it checks each button and also calls LoRa.parsePacket() to receive.

The six messages are stored as strings: “Message 1: ALERT”, “Message 2: HELP”, and so on. When a message arrives, the LCD clears and shows “Received:” on the first line and the text on the second. Serial output helps with debugging. The 500 ms delay after sending prevents accidental repeated presses.

The same code runs on both devices, making the pair fully symmetric.

4. PROTOTYPE DEVELOPMENT

We assembled each unit on a small perfboard. The LoRa module connects via SPI pins, the LCD via I2C (SDA and SCL), and buttons go straight to digital pins 3–8. A simple 3.7 V to 5 V boost converter keeps the Nano and LCD happy when the battery voltage drops. The developed prototype is shown in the figure below.

Figure 3 Developed prototype

We enclosed the prototypes in 3D-printed or plastic boxes with a small window for the LCD and holes for the antenna and buttons. A power switch and charging port were added for daily use.

5. TESTING AND RESULTS

We tested the pair in open fields near Gwalior. With the spring antennas at about 1–2 meters height:

- Reliable communication reached roughly 200–600 meters line-of-sight.
- At 2–3 km the signal was still readable but weaker (RSSI around –110 dBm).
- Inside buildings or with trees, range dropped to 300–500 meters, which is still useful.
- Battery life in standby exceeded 24 hours; sending messages used almost no extra power.

The LCD gave instant confirmation that the message was sent or received. No messages were lost in clear conditions when buttons were pressed one at a time. The code's RSSI print helped us see signal strength during tests.

6. DISCUSSION

The main strengths are simplicity and low cost. Anyone with basic soldering skills can copy the design. Predefined messages reduce mistakes during panic and keep data packets small, which helps range and battery life.

Compared with commercial LoRa devices or satellite messengers, our system is far cheaper and needs no subscription. It does not replace phones but works when phones cannot.

Limitations include the fixed six messages and the lack of GPS location. Future versions could add more buttons, changeable messages via a menu, or a small GPS module to send coordinates with alerts. Mesh networking (letting one unit forward messages to others) would extend coverage even further.

7. CONCLUSION

We have shown that two Arduino Nano boards, LoRa modules, and a handful of everyday parts can create a practical emergency communicator. The system is easy to build, runs on rechargeable batteries, and needs no network infrastructure. It offers a useful tool for hikers, farmers, rescue teams, or anyone living in areas with weak mobile signals. By sharing the full code and component list, we hope others will build, improve, and test similar devices in their own regions.

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