# Lora Based Emergency Control and Health Monitoring System

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***Abstract*—This paper presents a peer-to-peer emergency communication system that sends and receives emergency alerts without relying on mobile networks or the Internet. The system uses ESP32 controllers and LoRa modules to establish long-range two-way communication between a transmitter and a receiver, with a target range of approximately 10 km depending on the environment and antenna used. The transmitter monitors the user's live status and surrounding conditions using a DHT11 temperature and humidity sensor, an MQ-series air-quality/gas/smoke sensor, an optional GPS module and a smart wristband for heartbeat monitoring. An alert can be raised manually through an emergency button or automatically when an abnormal condition is detected or the user fails to respond to a periodic safety reminder. A continuous 5-second button press on the receiver is required before a reverse alert is sent, which reduces accidental activation. The system is intended for disaster management, remote-area safety, trekking and rescue operations**

***Index Terms*—LoRa, ESP32, emergency communication, offline communication, peer-to-peer, heartbeat monitoring, disaster management.**

## I. INTRODUCTION

During disasters, in remote areas and on trekking routes, mobile networks and the Internet are often unavailable, overloaded or damaged, which makes it difficult for a person in danger to call for help [1]. Low-power wide-area network (LPWAN) technologies, and LoRa in particular, offer long range and low power consumption, and have been studied for disaster management and search and rescue [2], [6].

This paper presents a peer-to-peer emergency communication system based on ESP32 controllers and LoRa modules that works completely offline. The transmitter continuously monitors the user's status, heartbeat and environmental conditions and can send an alert automatically or manually. The receiver can also send an alert back, giving two-way communication.

## II. RELATED WORK

Pervez et al. surveyed wireless technologies for emergency response and showed that infrastructure-dependent systems fail when the underlying network is damaged or overloaded [1]. Manuel et al. proposed a LoRa-based disaster management system in which victims, a base station and search-and-rescue robots communicate over LoRa, and reported field-test results [2]. Nevatia et al. combined LoRa localization with radar-based obstacle detection and D* Lite pathfinding for infrastructure-free forest navigation [3]. Girolami et al. collected LoRa propagation data with a buried transmitter in avalanche scenarios and found the channel quality to be high even at a depth of 1 m in wet snow [6]. Shehni et al. analysed the fundamental limits of LoRa-based localization and reported that meter-level accuracy is promising [7], while Zadorozhny et al. flight-tested LoRa modulation from a CubeSat in low-Earth orbit [8]. Poke and Uludag evaluated a LoRa mesh network for emergency communication and noted that the protocol implementation still needed improvement [9]. Other emergency-network approaches include UAV base stations [4] and drone-based optical camera communication [5]. Compared with these works, the proposed system is a low-cost, portable personal unit that combines two-way LoRa messaging with health and environment monitoring.

## III. WIRELESS EMERGENCY RESPONSE AND HEALTH MONITORING

Pervez et al. review wireless technologies used in emergency response, including cellular systems, ad-hoc mesh networks, and hybrid arrangements combining terrestrial and satellite links [1]. Their survey describes systems designed for multimedia exchange and coordination between response agencies, as well as systems intended to deliver patient information to medical personnel. Examples discussed include DUMBONET and DistressNet for incident-site communication, and patient-monitoring systems such as WIISARD, ARTEMIS, MEDiSN, and related approaches [1]. The key lesson is architectural: emergency communications involve several traffic types, from compact vital-sign readings and distress alerts to high-bandwidth images and video. LoRa is better aligned with low-volume telemetry and alerts than with multimedia transfer.

Health-monitoring applications also impose different requirements from ordinary sensor networks. Periodic health readings can tolerate some delay depending on the application, whereas a critical alert may require immediate prioritization and a clear indication of whether it was delivered. A system that collects physiological measurements but does not manage stale readings, missing packets, or alert acknowledgement may provide incomplete situational awareness. The literature therefore supports separating routine telemetry from urgent events and designing explicit rules for alert priority and escalation.

## IV. LoRa-BASED EMERGENCY COMMUNICATION

Research on LoRa-based emergency communication addresses the possibility of transmitting messages without relying on functioning mobile infrastructure. Macaraeg et al. investigate a LoRa-based mesh network for off-grid emergency communications [2]. This line of work is important because it treats communication resilience as a network-level problem, not simply a matter of selecting a long-range radio. In an off-grid setting, nodes may need to relay messages, and system performance depends on topology, routing behavior, energy availability, and the ability to recover from missed transmissions.

Sciullo et al. present LOCATE, a LoRa-based mobile emergency-management system, examining its design and performance for emergency scenarios [3]. Such systems show how LoRa can serve as a communications layer for mobile users and emergency-management applications. Nevertheless, the narrow data capacity of LoRa means that payloads should be concise and transmission frequency must be selected carefully. A design that sends every sensor sample at a high rate may increase channel contention and energy use, potentially reducing the reliability of the most important emergency messages.

Pham et al. evaluate a mesh network based on LoRa technology [4]. The wider mesh-network literature indicates that multihop communication may extend reach beyond a single radio link, but it also introduces additional failure points and protocol overhead. Emergency networks must account for message duplication, routing loops, relay-node outages, and congestion when many devices report simultaneously. For safety-related messages, acknowledgement and retransmission policies are particularly important; repeated transmissions must also be rate-limited so they do not congest the channel.

## V. SEARCH-AND-RESCUE SYSTEMS AND PROPAGATION

Manuel et al. describe the Titan disaster-management system, which uses LoRa devices to connect victims, a base station, and search-and-rescue robots when conventional networks may be unavailable [5]. The system combines communication with coordination and robot navigation. Its evaluation demonstrates the relevance of LoRa to sending location information and coordinating actions in an outdoor rescue setting. The authors also note a fundamental limitation: the LoRa communication channel cannot support live video streaming, so the information exchanged must be matched to the available capacity [5]. This reinforces the suitability of LoRa for compact messages, location reports, and status data rather than continuous rich media.

Girolami et al. provide an experimental dataset for search-and-rescue operations in avalanche scenarios, focusing on LoRa radio
propagation through snow and the relevance of propagation characterization to rescue use cases [6]. Their work highlights that range and link quality are

context-dependent. Body position, antenna orientation, terrain, snow, obstacles, and environmental conditions can affect signal strength and packet reception. Therefore, range figures reported for one deployment should not be treated as guaranteed coverage for another. Field testing in the intended environment is necessary before making claims about reliability or operational range.

Research on LoRa localization further suggests that communication coverage and accurate positioning are distinct capabilities.

Received-signal-strength methods are affected by environmental variability, while time-based techniques may require synchronized timing and suitable infrastructure. For an emergency-control system, GPS may provide location where available, but location information should be identified as unavailable or uncertain when a reliable fix cannot be obtained. LoRa connectivity alone should not be presented as proof of precise location.

## VI. RESEARCH GAPS AND DESIGN IMPLICATIONS

The reviewed studies point to several gaps relevant to the combined theme of emergency control and health monitoring.

Integrated handling of health data and emergency events: Emergency communication and patient monitoring are often described as distinct functions. A unified framework should define how routine readings, threshold violations, manual distress calls, and responder acknowledgements share the channel.

Reliability and acknowledgement: Emergency messages should include identifiers, timestamps or sequence numbers, and message types. Delivery acknowledgement and controlled retransmission can reduce silent loss, while the interface should indicate when delivery cannot be confirmed.

Priority and congestion management: Critical alerts should be prioritized over periodic telemetry. Reporting intervals and retry limits should be designed to avoid synchronized transmissions from many devices.

Energy and continuity: Power-aware sampling, radio sleep modes, battery-status reporting, and backup power matter when systems must operate for extended periods without charging.

Validation under realistic conditions: Tests should report packet-delivery ratio, end-to-end alert latency, effective range, power consumption, and behavior with obstacles or multiple nodes. A single maximum-range result is insufficient to establish dependable emergency performance.

Security and privacy: Health data and emergency messages can be sensitive. Authentication, integrity protection, and appropriate access control should be considered without making the system too complex for constrained devices.

Clear operating boundaries: LoRa should be treated as a communications aid, not as a substitute for professional medical equipment

or a guaranteed emergency service. The system should communicate stale or missing readings and should not imply that a health condition has been diagnosed.

## VII. DISCUSSION

Across the reviewed literature, LoRa is most compelling when the information payload is small, the desired communication distance is relatively long, and low power consumption is important. These properties align with periodic vital-sign summaries, emergency identifiers, concise location information, and acknowledgement messages. The same literature cautions against assuming that LoRa is inherently reliable in every environment or that a long-range link can carry arbitrary data. Emergency-control designs should therefore be judged by end-to-end behavior—including the sensor, controller, radio link, receiving interface, and human response—not by radio range alone.

For health monitoring, the communication system should preserve the meaning and timing of measurements. Readings need units, timestamps, and a clear indication of missing data. Threshold-based alerts should be described as screening or notification logic unless clinically validated. For emergency control, a manual trigger can complement automated monitoring, but false triggers, missed messages, accidental acknowledgement, and battery depletion must be addressed. The literature supports these as system-design requirements; it does not by itself establish the performance of any new integrated implementation.

ACKNOWLEDGMENT

We express our sincere gratitude to our guide, Lekshmi Raj D, Assistant Professor, Department of Electrical and Electronics Engineering, UKF College of Engineering and Technology, for her valuable guidance, encouragement, and continuous support throughout the completion of this project. We would like to thank the faculty members of the Department of Electrical and Electronics Engineering, UKF College of Engineering and Technology, for providing us with the necessary resources and technical assistance during the project work.

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