Intelligent Tourist Safety and Rescue System Using Lora Mesh for Low/No Cellular Regions

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Abstract*—This paper proposes an Intelligent Tourist Safety and Rescue System on LoRa Mesh Communication for Low/No Cellular Regions to offer Effective communication and location information in emergency situations assistance in conventional ways is unavailable. Assist in places where tourists cannot be found in a conventional manner. There is no or limited cellular network coverage. The proposed system integrates IoT sensing, GPS-based Install location tracking, LoRa communication, mesh network, and community-assisted rescue mechanisms to enhance. The safety of the tourist in case of emergencies. The system is made up of Three complimentary stages: tourist safety supervision, emergency detection and warning transmission, and community-assisted rescue coordination. In Phase 1, the Tourist's location and safety conditions are monitored with sensor unit and GPS module control module based on ESP32. In The emergency alert, which was sent via an SOS, is considered Phase 2 An emergency alert that was sent using an SOS is considered Phase 2. mechanism is transmitted through multiple LoRa nodes The approach of using a multi-hop mesh communication was used to ensure that the communication message could be delivered to the end point even when direct communication is not possible. In Phase 3, the Emergency information is passed to neighbouring Make sure to enlist the help of community members and rescue personnel. Improved response and coordination. The proposed system is: The project's system design is based on ESP32 and LoRa technology for distributed design. Communication, central monitoring unit for. Getting and showing an emergency alert. Experimental evaluation can be carried out by analysing communication. Any of the following conditions can cause loss of packets: Packets can be lost whenever any of the following occurs: Low/No cellular service coverage areas. The proposed the framework is low power, long range and decentralized communication solution for tourist safety, emergency alerting and community assisted rescue with Effective implementation and application at remote tourist sites as the future validation.

***Index Terms*—Intelligent Tourist Safety, LoRa Mesh Communication, Community-Assisted Rescue, IoT, GPS, Emergency Alert, Low/No Cellular Regions, ESP32, Long-Range Communication**

I. INTRODUCTION

As a tourism industry continues to expand, adventure and travel to remote areas increase, so does the need for intelligent and the security of tourist facilities has become an issue. The traditional tourist safety systems are mostly based on cellular A network, internet or centralized cloud. Systems for emergency communication and location tracking. But these methods might not work in forests, mountains, trekking routes, rural tourist spots and other areas with weak or no cell reception. It requires a decentralised communication system which can provide emergency assistance without the need of traditional cellular networks. The system proposed here is comprised of three complementary phases. The implementation of the IoT enabled. The device is designed to keep track of tourists' safety. Monitoring the emergency and whereabouts of continuously. the user. In phase 2, in an emergency, in an emergency, an SOS alert and emergency information with corresponding location. The LoRa network is used to transmit it. The mesh the alert is passed on through the communication mechanism. If there is not a direct path, there will be a number of intermediate nodes communication link. In Phase 3 the emergency information is to be sent to the Emergency Response Centre. is shared with the community at large or with rescue personnel. This enables them to plan for assistance and to Be more effective in responding to the behavior of the tourist. The key This is a novel

contribution of this work, as it is integrating LoRa long-range mesh communication, real time location tracking, generation of an emergency alert and rescue by community members. To a consolidated decentralized safety system. The proposed the communication system is designed to communicate in low/no intensity. The images show “cellular coverage areas” that are relatively low powered. The conventional safety is based on cell consumption, whereas this is not the case. applications. The structure is the basis for Enhance emergency communication and rescue system coordination of remote tourist places. The practical field the deployment and validation of the network in large scale is It was felt that this would be left for future work.

II. LITERATURE REVIEW

Ensuring the safety of tourists and emergency communication; Traditional geographical position location and emergency broadcast services. This is mainly dependent on cellular networks, Wi-Fi, smart phones and cloud-based services for the systems. However, these techniques are not applicable in far off areas such as forests, mountains, trekking routes etc. there might not be any cellular infrastructure. This requires communication at low power and large distance technologies that can provide vital information in the case of an emergency. Lack of continuous cell to cell communication. To overcome the problems of cell-to-cell communication, enhance emergency communications in hard-to-reach areas,

Augustin et al. gave an extensive study of LoRa as a Low power, long range, wireless communication technology for IoT applications [1]. The study investigated the physical Layer properties of LoRa and presented the fact that it is a good candidate for applications that require long communication low energy use and great range of use. These features make LoRa made for tourist safety devices using a battery power source.

Adelantado et al. studied the benefits and challenges of LoRaWAN in large-scale IoT deployments [2]. Their work focused on the long-range and low power benefits of LoRaWAN and also mentioned the limitations in terms of network capacity, scalability and communication conditions. These results are relevant for the proposed tourist safety system, as terrain, node density and communication configuration can affect the reliability of emergency messages.

Bor et al. They studied the scalability of LoRa networks considering the effect of communication parameters and the number of nodes on the network performance [3]. Their results show that LoRa can be used for long distance communication with low energy requirements but network capacity becomes an important consideration as the number of communicating devices increases. They also suggested dynamic communication parameters and multiple sink nodes as ways to enhance scalability. This supports the need for careful node placement and network planning in large touristic areas.

Centenaro et al. surveyed low-power wide-area networking technologies and discussed their applicability to long-range IoT systems [4]. It demonstrated the suitability of LPWAN technologies for applications with distributed sensors, low data rates and power-constrained devices. These characteristics support the development of tourist safety systems. which require the transmission of emergency messages and location information over long distances.

Reynders et al. also studied the scalability and performance of LoRaWAN networks and the factors influencing the reliability of communications in dense IoT deployments [5]. Their work demonstrated the importance of network configuration node placement and communication parameters for reliable long-range connectivity. These results are relevant for the proposed system as strategically placed LoRa relay nodes may improve communication coverage in remote tourist locations.

Another important basis for the proposed system is the research on wireless mesh and multi-hop networks. In multi-hop architecture, messages can be forwarded by intermediate nodes if no direct link exists between a tourist device and the gateway. This method finds particular application in the case of forests and mountain areas where the terrain and obstacles may limit the direct communication range. Hence, the use of strategically positioned relay nodes can help extend

the coverage and provide alternative paths of communication.

Researches on IoT-based emergency monitoring have shown the effectiveness of integrating sensors, location information, wireless communication and centralized monitoring for emergency applications. Such systems can collect user or environmental information, detect abnormal conditions, and send emergency information to a monitoring platform. This forms the basis for the inclusion of GPS tracking and automated emergency alerts in the proposed tourist safety system.

GPS based tracking is also widely used for emergency localization as it allows the system to estimate the geographical location of a user without the need of cellular positioning. For the proposed system. GPS coordinates can be included in emergency packets, so that the monitoring platform or rescue team receives both the emergency type and the tourist's location.

The present works show the individual benefits of LoRa long-range communication, low-power IoT networking, GPS-based localization and multi-hop wireless communication. However, these technologies are often studied in isolation or for applications unrelated to tourist safety. The proposed system suggests consolidating these technologies into a single system especially for tourists operating in low/no cellular coverage zones with GPS-tracking, SOS messaging, geo-fence, emergency detection, multi-hop LoRa communication and community-assisted rescue coordination.

TABLE I. LITERATURE REVIEW AND RESEARCH GAP

ID / Year	Study & Technique	Relevance to Proposed System
[1] 2017	Adelantado et al. – Understanding the Limits of LoRaWAN – LoRaWAN performance and limitations	Relevance: Highlights the need for proper LoRa node placement and network design in tourist areas.
[2] 2016	Bor et al. – Do LoRa Low-Power Wide-Area Networks Scale? – LoRa scalability and node-density analysis	Relevance: Important for designing multiple relay/community nodes in the proposed LoRa network.
[3] 2020	IoT-Based Emergency Monitoring – IoT sensors, wireless communication and emergency alerts	Relevance: The proposed system addresses this limitation by using LoRa communication in low/no cellular regions.
[4] 2022	Community-Assisted Emergency Communication – Nearby users or community nodes participate in emergency communication	Relevance: Supports the proposed Community-Assisted Rescue Layer for faster local assistance.

III. PROPOSED SYSTEM

The proposed Intelligent Tourist Safety and Community-Assisted Rescue System is intended to offer reliable emergency communication, tourist monitoring and rescue coordination in remote tourist locations where cellular connectivity is weak or absent. The system incorporates ESP32, GPS tracking, sensors, LoRa mesh communication, emergency detection and a web-based monitoring platform to create a comprehensive safety ecosystem.

Layer 1 – Sensing and Data Acquisition of Tourist

This layer collects the relevant data from the tourist and the environment. The main controller is an ESP32 based tourist safety device. A GPS module is used to get the real-time position of the tourist. Other sensors can also be incorporated to record variables such as temperature, motion or other given environmental conditions. There's also an SOS button, by which the tourist can initiate an emergency call by himself. On this layer, the data is preprocessed and the emergency identification is completed.

Layer 2 – Preprocessing of Data and Emergency Identification

Data from the sensors and GPS module is handled by ESP32 prior to sending it. The data is filtered out and the tourist's emergency and location are sent for communication. Emergency conditions are detected either from the SOS input or pre-defined safety conditions. After detecting an emergency, an alert packet is generated with the necessary information like tourist id, GPS coordinates, emergency status and time

Layer 3 – LoRa Mesh Communication Layer
This information, after being processed, is transmitted via LoRa communication. In the tourist area some LoRa enabled nodes are spread and are working as relay nodes. The intermediate nodes relay the emergency packet to the next node that can be reached. This multi-hop mesh communication provides enhanced communication coverage and can send emergency information to the rescue station even when there is no cell reception.

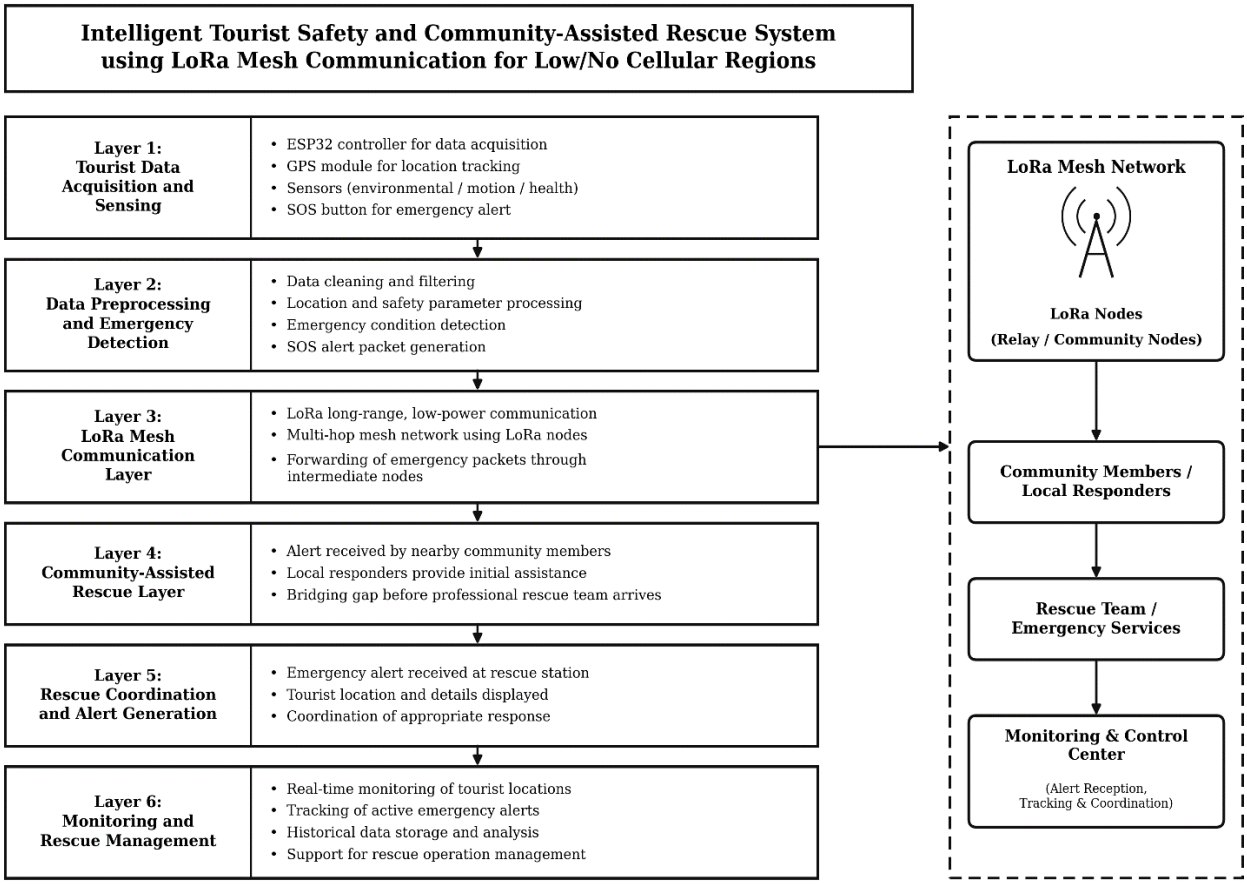


Fig. 1. Proposed Intelligent Tourist Safety and Community-Assisted Rescue System using LoRa Mesh Communication

Layer 4 – Community Assisted Rescue Layer (CARL)
If an emergency alert is received by a near node, the information will be available to any authorised local emergency responders or community members. When the alert is received, the location of the tourist and details of the emergency are included, enabling neighbouring individuals to render first aid, if appropriate.
Engaging the community helps shorten the response time between the emergency and when the professional rescue teams arrive

Layer 5 – Rescue Coordination and Notification
This layer processes and receives the emergency alerts at the rescue/monitoring station. The system manages to identify the location of the tourist, and the emergency information can be displayed to the rescue team in charge. The severity and type of emergency may determine the type of alert generated. The GPS and communication status received allows the rescue team to coordinate the appropriate response

Layer 6 – Management of Monitoring and Rescue
Monitoring interface is the final layer to verify the tourist places, active alerts, communication and rescue information.
The system can provide historical analysis of emergency events and communication activities. The dashboard enables the rescue team to see the alerts received and the status of emergency response.

IV. EXPERIMENTAL SETUP

A. Software And Hardware Configuration

The proposed system is a tourist safety and emergency communication system using ESP32 microcontroller, GPS module, LoRa transmitter and receiver and safety sensors. The ESP32 handles the local data collection, emergency detection, GPS processing and control of communications. The LoRa modules support long range communication between the tourist device and relay/community nodes and the gateway. The software system consists of the ESP32 firmware, LoRa communication logic, backend server, databases and monitoring dashboard. The backend can handle tourist data, GPS coordinates, emergency alerts, geo-fence events and device status. The database is used to record the profile of tourist, their location history, emergency record and rescue status. The proposed deployment consists of a single tourist node, multiple LoRa relay/community nodes, a LoRa gateway and a rescue monitoring station.

B. Data Acquisition and Preprocessing

Phase 1 – Gathering Tourist Safety Info

The tourist safety device is made up of ESP32, GPS module, LoRa transceiver and SOS button. Other types of sensors, such as MPU6050, can be used to watch for unusual activities or a fall.

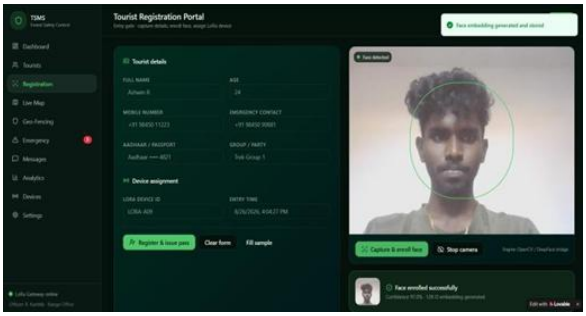


Fig. 2. Gathering Tourist Safety Info using face recognition pattern

The ESP32 gathers:

1. Tourist ID Latitude
2. Long.
3. Timestamp Emergency condition
4. Sensor data
5. Battery condition
6. Status of device

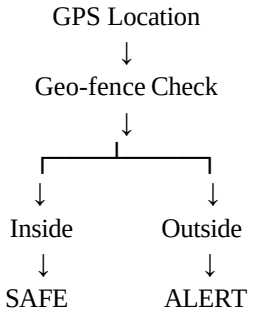
The data collected is checked for invalid or incomplete values before processing for transmission.

Phase 2 – Detection of Emergencies and Geo-Fence Monitoring

The system also constantly tracks the location and safety status of the tourist. The GPS position is compared with the defined geo-fence boundary.

You can generate an emergency by:

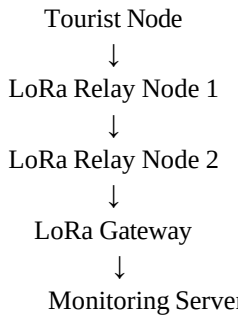
1. SOS handbook
2. Autumn / Abnormal Motion Detection
3. Geo-fence breach
4. Battery low
5. Device communication error



If an emergency occurs, the ESP32 creates an emergency packet containing the Tourist ID, GPS coordinates, type of emergency, timestamp and packet ID.

Phase 3 – LoRa Mesh Communication

The emergency information is sent over the LoRa mesh network.



If tourist node is not directly connected to the gateway, then intermediate nodes relay the packets to the gateway. Relying on the packet ID, each relay node can identify whether the relay packet has been already forwarded; relying on the hop count, each relay node can count the number of intermediate nodes the relay packet has passed through.

C. FEATURE AND MESSAGE ENGINEERING

The information that will be passed around via the

tourist device is organized into significant communication areas: Tourist ID, GPS latitude, GPS longitude, Timestamp, Emergency Type, Battery Status, Node ID, Hop Count and Packet Status. GPS coordinates designate where the tourist is and the time stamp reflects when it happened.

The number of LoRa relay nodes that relay the emergency message is determined by the hop count. To identify duplicate messages and to enhance reliable message handling in the mesh network, packet IDs are used to identify messages. One can watch the values of the sensors for safety using threshold conditions. If an abnormal condition is detected, the system will set up the related emergency status and send the related alarm.

D. System Implementation Configuration

The tourist node is implemented on ESP32, where GPS information and sensor information are collected, emergency messages are generated etc.

The tourist node and relay nodes communicate each other by using the LoRa communication layer, which offers long-distance communication.

More relay nodes can be deployed at appropriate places to boost the coverage in forests, hills and trekking routes. If there is an Internet connection, the gateway receives the LoRa emergency packets and sends them to the back-end.

The backend is:

1. Inspecting tourists
2. Data verification
3. Geo-fence validation
4. Emergency processing
5. Creating Alerts
6. Database storage
7. Rescue status administration

The web dashboard shows:

1. Touristic sites
2. Live/Last known status
3. Geo-fence Breaches
4. Emergency alerts
5. Device state
6. Rescue team updates
7. Location history.

E. Performance Evaluation

The following parameters can be used to evaluate the system:

1. LoRa Communication Distance

Calculate the maximum transmission distance for an emergency packet successfully sent

2. Packet Delivery Ratio (PDR)

Calculate the percentage of packets that the gateway received successfully.

PDR= Packets Sent / Packets Received × 100

3. Performance of Multi-Hop

Compare:

Direct LoRa Tourist -> Gateway with:

Multi-Hop LoRa Tourist → Relay → Relay → Gateway

This indicates whether relay nodes can improve communication coverage.

4. GPS precision

Calculate difference between GPS location and reference position, and show the difference. The precision of GPS location is measured by calculating the gap between the known and calculated locations. Log the error with different environmental and signal conditions. Test consistency and reliability of the GPS based positioning system.

5. Response Time in Emergency

Measure.

Emergency detected

↓

Alert received

↓

Rescue team notified

6. Current consumption

Measure the power consumption of the tourist device in:

1. Periodic surveillance
2. GPS working
3. LoRa transmission
4. Emergency broadcast

7. Geo-Fence Precision

Verify that the system detects correctly: Inside boundary = SAFE

Boundary outside = GEOFENCE ALERT

V. RESULT AND DISCUSSION

A. Phase 1 – GPS Tracking and Tourist Safety Monitoring System

In Phase 1, the tourist safety device based on ESP32 was designed to continuously acquire the location and safety-related information of the tourist. The GPS module provides the information regarding the latitude, longitude and the time stamp. The ESP32 processes the data acquired and monitors the status of the tourist device. There is an SOS mechanism provision so that the tourist may establish an emergency situation manually.

The information collected includes Tourist ID, latitude, longitude, timestamp, emergency status, battery status, sensor status and device status. The data acquired is validated before transmission, discarding invalid or incomplete GPS readings.

The performance of the GPS tracking can be assessed by comparing the GPS reported position with a known reference position. The position error can be calculated as the geographical distance between the two positions. Measurements could be performed in several locations and under different environmental conditions, such as open areas, forests, valleys and partially obstructed locations.

The positioning error can be written as:

Positioning Error = Distance (GPS-reported Position, Reference Position)

Then the mean positioning error is calculated by:

Mean Error = Sum of Position Errors Number of Measurements

The mean error is the total sum of the errors of all the positions Divided into the number of measurements. Results allow to assess consistency and reliability of localisation of tourists using their GPS. The lower the more accurate the location, the less the positioning error will be, the nearer the rescue team is to the disaster, the higher the degree of shock. useful the disaster information can be obtained.

Table II. GPS POSITIONING EVALUATION

Parameter	Evaluation Method
Reference Position	Known geographical coordinate
GPS Position	Coordinate obtained from GPS module
Positioning Error	Distance between reference and GPS position

The GPS information forms an important component of the proposed system because emergency alerts without reliable location information may not be sufficient for effective rescue coordination.

B. Phase 2 — Emergency Detection and Geo-Fence Monitoring

Phase 2 evaluates the ability of the proposed system to identify emergency conditions and generate appropriate alerts. The ESP32 continuously monitors the SOS input, GPS position, battery condition and optional safety sensors. An emergency can be generated through an SOS button, abnormal motion or fall detection, geo-fence violation, low battery condition or device communication failure. The geo-fencing mechanism compares the current GPS coordinates with a predefined safe geographical boundary. When the tourist remains inside the defined boundary, the system maintains a safe status. When the tourist moves outside the permitted region, a geo-fence alert is generated.

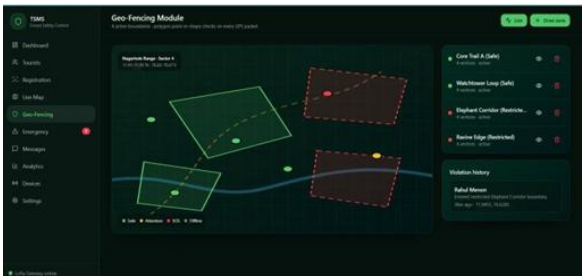


Fig. 3. Geo-Fence Monitoring

The basic operation can be represented as:

GPS Location → Geo-Fence Check → Boundary Comparison → Safety Status

If:

Position ∈ Geo-Fence → SAFE

And

Position ∉ Geo-Fence → GEO-FENCE ALERT

The system can record the time at which the boundary violation occurs and include the latest GPS coordinates in the generated alert.

Table III. EMERGENCY DETECTION EVALUATION

Emergency Condition	Expected System Response
SOS button pressed	Immediate emergency alert
Abnormal motion/fall	Emergency alert
Geo-fence violation	Geo-fence alert

The emergency detection mechanism offers multiple ways of detecting unsafe situations, rather than just manual SOS activation. This increases the general safety property of the proposed structure.

C. Phase 3 — LoRa Communication and Multi-Hop Emergency Transmission

In phase 3, the communication function of LoRa network is tested. The emergency packet is sent by the tourist node using LoRa. If the gateway is unable to reach the target, intermediate LoRa relay nodes relay the packet towards the gateway. The communication path can be depicted as: The main point is how a tourist node can send data to a monitoring server via LoRa relay nodes (1 and 2) and LoRa gateway.Here is the main point: How a tourist node can send data to a monitoring server through LoRa relay nodes (1, 2) and LoRa gateway. The emergency packet contains information such as Tourist ID, GPS latitude, GPS longitude, emergency type, timestamp, packet ID, node ID, battery status and hop count. The hop count is added to by intermediate relay nodes when the packet is forwarded. The packet ID is necessary to help identify duplicate packets and avoid duplicate forwarding. We can measure the performance of the communication network by Packet Delivery Ratio (PDR), communication distance, packet latency and packet hop count.

The packet delivery ratio is equal to:
PDR (%) = Number of Successfully Received Packets / Number of Transmitted Packets × 100
A higher PDR indicates more reliable emergency communication.

Table IV. LoRa COMMUNICATION PERFORMANCE PARAMETERS

Parameter	Measurement
Transmission Distance	Maximum successful communication distance
Packets Transmitted	Total emergency/test packets sent
Packets Received	Packets successfully received
Packet Delivery Ratio	Successful packets / transmitted packets
Packet Latency	Time required for packet delivery
Hop Count	Number of relay nodes used

Multi-hop is especially relevant for forests, mountains and trekking routes, due to physical obstacles and terrain that might obstruct direct communication between the tourist device and the gateway.

D. Direct Communication versus Multi-Hop Communication

Considering the proposed mesh architecture, a direct LoRa communication can be compared with multi-hop architecture.
With the direct configuration:
Tourist Node → Gateway

In the multi-hop mode:
Tourist Node-> Relay 1-> Relay 2-> Gateway
Communication distance, packet delivery ratio, latency and reliability are the two configurations that can be used to evaluate the two configurations.

Table V. DIRECT AND MULTI-HOP COMMUNICATION COMPARISON

Parameter	Direct LoRa	Multi-Hop LoRa
Communication Path	Tourist → Gateway	Tourist → Relay → Gateway
Coverage	Limited by direct link	Extended using relay nodes
Number of Hops	0	≥1

The multi-hop approach is to improve the communication coverage as the packet is not required to be transmitted directly from the tourist node to the gateway. Each extra hop, however, can add forwarding delay, and needs to be routed and handled the duplicate packets. Therefore, node placement and routing is important to guarantee reliable communication.

E . Packet Delivery Ratio, Communication Reliability

The trustworthiness of emergency communication is checked by Sending a predefined amount of test packets between tourist node, relay node and gateway. For instance, packets can be sent a wide range of distances and number of hops. The gateway keeps count of the number of packets successfully received. The PDR is calculated using: The So, the number of packets transmitted is divided by the number of... packets received. The experiment can be repeated in various environments such as open field, partially obscured field, forest and hilly regions. There are

many parameters that can affect the distance, including obstacles, interference, node placement, and communication parameters. can cause a decrease in PDR. Thus, the roots of the equation found are can be utilized to determine the best sites of the relay nodes for deployment in tourist zones in the tourist zones. F. Emergency Alert Latency The important parameter is the response time in an emergency, which is: Effective communication will be impaired by the delayed communication. rescue operations. The time taken for the emergency situation to occur is the emergency latency.

The following is an approximation of:
Emergency Latency = (Alert Received Time - Emergency) Detection Time

If multiple relay nodes are used, the latency can get higher as the number of relay hops increases as the packet has to be delivered to every relay and processed and re-transmitted to the next. Thus, latency should be evaluated in the direct, one-hop, two-hop and more hop communication scenarios.

F. Geo-Fence Accuracy and Safety Monitoring
In addition to the normal features of the H. Geo-Fence, this feature monitors accuracy and safety. The geo-fencing mechanism is tested by travelling the tourist device through the set safe and restricted boundaries. The system should be able to accurately determine if the tourist is within or outside the area defined by the geographical region.

Table VI. GEO-FENCE VALIDATION

Tourist Position	Expected Result
Inside safe region	SAFE
Near boundary	Boundary evaluation
Outside safe region	GEO-FENCE ALERT

Repeat testing can also be carried out at the outer edges of the geo-fence since the GPS measurement can vary from test to test, causing the measurement location to slightly cross the delineated boundary.

G. Database and Monitoring Dashboard Evaluation
In an emergency, the monitoring system is able to receive the emergency information from the gateway and the emergency information is saved in the back-end database.

Can be stored on the database:

- Tourist ID
- Latest GPS location
- Location history
- Emergency type
- Emergency timestamp
- Battery status
- Device status
- Communication status
- Hop count
- Rescue status

The monitoring dashboard offers a one-stop view for rescue personnel of active and past emergency events. The dashboard allows to show Tourist Location, Emergency Status, Emergency Type, Communication Status, Rescue Status are recorded. The system can classify alerts according to their severity, and keep an emergency history for further investigation.

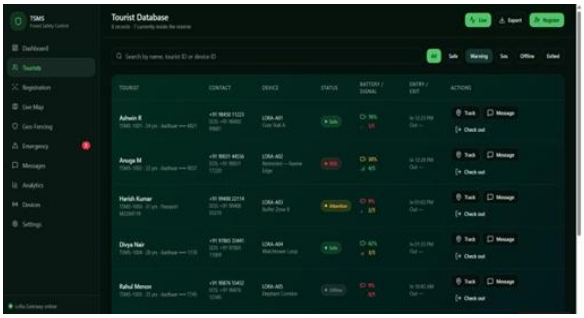


Fig. 4. Database and Monitoring Dashboard

H. Cross-Phase Discussion
The three main stages of the proposed system complement each other to create an integrated tourist safety and emergency communication system.
Phase 1 is the tourist monitoring and GPS tracking of their location. The ESP32 gathers the tourist's location and safety data and sends it to the next stage for processing.
Phase 2 deals with emergency detection and geo-fence monitoring. The system detects SOS activation, abnormal conditions, geo-fence violations and more, and generates emergency packets accordingly.
Phase 3 is about emergency communications and rescue co-ordination. In the absence of a direct radio communication link, the LoRa mesh network forwards packets of emergency information through intermediate nodes. Then the gateway passes the data received to the monitoring platform for rescue to find the tourist and his status of emergency.

The main advantage of the proposed architecture is that the information about the emergency can be broadcasted from the decentralized LoRa network without the tourist node having a continuous cellular connection. Relay nodes can serve to extend the effective communication area, and GPS can provide the location information data needed for rescue. Actual system performance will be affected by terrain, the LoRa settings, location of nodes, GPS reception, interference, density and battery life. Therefore, it is important to perform field tests in forests, mountains and other representative tourist spots to test the proposed architecture in real operation.

VI. CONCLUSION AND FUTURE SCOPE

The study suggested an Intelligent Tourist Safety and Community-Assisted Rescue System for low/no cellular regions based on LoRa Mesh Communication to provide a reliable emergency communication and location-based assistance in remote tourist areas. The proposed safety architecture combines safety monitoring with ESP32, location tracking with GPS, geo-fencing, emergency detection, communication with LoRa, multi-hop mesh networking, and community-assisted rescue coordination.

The proposed system is developed to monitor continuously the tourist's location and safety status by using an ESP32 based sensing unit. If a safety condition is detected or an SOS signal is sent, an emergency packet will be sent in the case of emergency, containing the Tourist ID, GPS location, type of emergency, time, battery level, packet ID and hop count. The emergency packet is then able to be relayed via several nodes of the LoRa network so that the communication can be carried on even if the tourist node cannot reach the gateway directly. One of the key benefits of having a multi-hop LoRa architecture is that they enable for remote tourist areas, like forests, mountains, trekking paths, etc. where traditional mobile networks can be weak or nonexistent. This relaying of emergency information to the gateway by these intermediate nodes can, in turn, increase the effective communication range. It also contains packet identifiers and hop count information, which help controlled forwarding and the elimination of needless duplicate packets. Additionally, the suggested system includes the geo-fence monitoring and GPS-based localisation to enhance the safety of tourists. The location reported by the GPS can be matched against a safe area and violations of the safe area can be detected. If an emergency occurs, the tourist's geographical coordinates can be sent with the alert so rescue personnel or members of the community can get an approximate idea of the tourist's location and provide assistance.

The proposed Community-Assisted Rescue Layer is an alternative method of emergency response. The emergency information can be used to give initial help before professional rescue personnel arrive when an emergency alert is received at a neighbouring community or an authorised responder node. The proposed distributed approach is hoped to help minimize the time from emergency to the commencement of rescue operations.

For the experimental evaluation of the proposed framework, various parameters including LoRa communication range, Packet Delivery Ratio (PDR), RSSI, SNR, multi-hop performance, emergency latency, GPS positioning error, geo-fence accuracy, power consumption and community response time can be used. All these parameters represent a complete set which is used to determine the reliability, coverage, and practicality of the proposed system.

Future work:

Future work will be on real time field deployment and validation of the proposed system in forests, hills and trekking routes. Multiple LoRa relay nodes and gateways will be deployed to test the range of communication between nodes, packet delivery ratio, latency, RSSI, SNR, and the multi-hop reliability in various environments.

Improvements to the system include fall-detection sensors, AI-based emergency detection, low-power modes and enhanced GPS accuracy. The monitoring dashboard can also be supplemented with real-time maps and tourist tracking, as well as coordination of rescue teams.

Last but not least, the proposed tourist safety system based on LoRa mesh will be tested for extended periods of time using several tourist and relay nodes to gauge the scalability, reliability and robustness of the system.

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