An Integrated Secure Communication System for Modern Soldier Connectivity using Sentinel Command Network

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***Abstract*— The Sentinal Command Network (SCN) is wearable communication device is made to use in difficult environment such as defence, disaster management, mountain areas etc. In such places, where normal communication like mobile network is not available at all. The system uses LoRa technology to provide long range communication with low power use. A simple input method like Morse code used, where user can send messages using symbol like (*) and (/). This allows user silent communication in sensitive situations.**
A central hub is included in the system to improve the connectivity of device. If two devices are not in range the message is send to the hub then it forward to the destination device. The device also contains the GPS tracking and health monitoring system. The control center receives all data and displays it for monitoring. Overall, the system provides a communication solution.

***Index Terms*— LoRa, Morse Code Communication, Wearable Devices, GPS Tracking, Health Monitoring, ESP32, Wireless Communication, Relay Network, Control Center, IoT.**

I. INTRODUCTION

Communication is important in area like the defence, rescue areas, and remote field work. In many places, network is not available, especially in mountains or border areas. Because maintaining the communication between member becomes difficult. Another issue is, in some areas voice communication is not safe or practical. It reveals the position of user. Sometimes not clearly hear due to background noise. So silent communication is needed. To solve this problem, we design the system called SCN. It is wearable device allow user to send message in symbol. This makes easy to use in stressful conditions.

The device used the LoRa for long range communication with a central hub. If device is not in range central hub is used to forward the message. This help to communicate in difficult areas. GPS tracking and the health monitoring is also included. This helps the control center to monitor user location and present condition of user in real time. This device is made by analysis of real-world problem and normal communication device failure.

II. METHODOLOGY

- User inputs Morse code using the buttons.
- ESP-32 converts the inputs into the digital message.
- Data packets are created (ID + message + GPS + Health Data).
- LoRa used to transmit the data.
- If device is out of range, central hub used to froward message.
- Control center is used to monitor all the activities.

III. BLOCK DIAGRAM

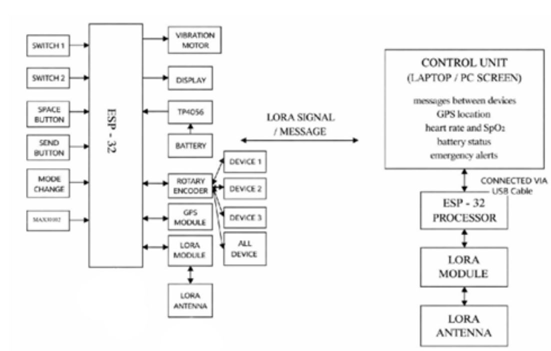


Fig. 1 shows the block diagram of the proposed system.

The working of the system as follows:

- The soldier enters the data using buttons that are based on the symbol language * /, which is used in silent communication.
- Sensors such as MAX30102 are used to monitor the health of the soldiers, such as heart rate and SpO2.
- The GPS module is used to get the real-time location of the soldiers.
- The ESP-32 module is used to process all the input and sensor data.
- The data is transmitted over long distances using the LoRa module.
- The data is received using a LoRa receiver module in the control unit.
- The data is decoded and displayed on a PC interface.
- The data is also uploaded to the cloud at the same time.
- An alarm is triggered in case of abnormal conditions.
- The Central is used to fill the gap between the communication.

The block diagram is of Sentinel Command Network the Soldier Unit and the Control Unit, connected through LoRa communication and integrated with cloud storage.

IV. PROPOSED SYSTEM

The system has three main components:

1. Wearable Device

- Each wearable device has:
- ESP32 microcontroller
- LoRa module
- GPS module
- MAX30102 sensor
- OLED display
- buttons to input Morse code
- rotary encoder to select the device
- vibration motor to alert
- Morse Code Communication

The system has:

- "*" represents dot
- "/" represents dash

Example:
SOS represents * * * / / / * * *

The user can input Morse code using buttons, and then ESP32 will transmit the encoded message.

2. Central Hub

The role of the hub as a relay node includes:

- receiving messages from devices
- forwarding messages to the target device
- extension of communication range
- ensuring communication in obstructed environments

Example:
Device A → Hub → Device B

3. Control Center

The control center includes:

- ESP32 with LoRa
- Laptop Dashboard
- Functionality:
- Monitoring of all devices
- Display of messages
- Visualization of GPS tracking
- Health monitoring
- Cloud data storage

Table 1: System comparison.
The table 1 show the comparison between existing device proposed SCN device.

Feature	Existing Systems	Proposed SCN System
Communication	LoRa / GSM only	LoRa + Hub + Control Center
Silent Messaging	Not available	Morse Code (* /)
GPS Tracking	Available (limited)	Real-time tracking
Health Monitoring	Available (separate)	Integrated
Multi-device Communication	Limited	Fully supported
Relay Communication	Not available	Hub-based relay
Cloud Storage	Limited	Enabled

V. RESULTS / EXPECTED OUTPUT

The system is expected to provide the:

- Communication range of 1–3 km
- Reliable message transmission using LoRa
- Silent communication using Morse code

- Real-time GPS tracking of devices
- Continuous monitoring of heart rate and SpO_2
- Relay communication in obstructed environments
- Relay communication using the hub.

A. Example Output:

Device: D02
Message: */**
Location: 18.5204, 73.8567
Heart Rate: 80 bpm
SpO2: 97%
Status: SAFE

B. Result Explanation:

Table 2: System Specification
Table 2 shows the expected performance of device. It includes it range and Monitoring capability.

Parameter	Value
Communication Range	7–10 km
Communication Type	LoRa
Input Method	Morse Code (* /)
GPS Accuracy	±5 meters
Heart Rate Range	60–100 bpm
SpO_2 Range	95–100%
Battery Backup	4–6 hours
Devices Supported	Up to 20 nodes
Network Type	Hybrid (Star + Relay)

Fig. 2 Communication Technology Distribution.
Fig. 2 shows the LoRa is the main communication technology used due the long range and use the less power.

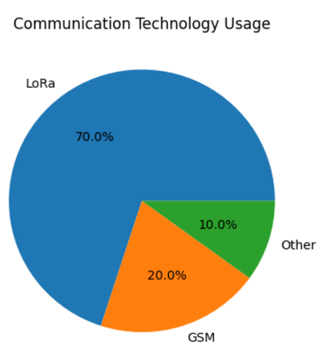
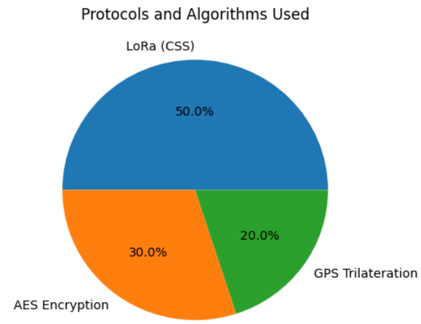


Fig.3 Protocol and the Algorithm
Fig.3 shows the protocol used in system including LoRa, encryption, and GPS tracking.



VI. LITERATURE REVIEW

1. LoRa – Based Communication System:

Several studies have explored the use of LoRa technology for long-range, low-power communication in IoT applications. Research has shown that LoRa enables reliable data transmission over large distances with minimal energy use, making it suitable for remote and defense environments [4], [10], [23]. Studies like "A Study of LoRa: Long Range & Low Power Networks for the Internet of Things" [4] and "On the LoRa Modulation for IoT" [31] highlight LoRa's efficiency regarding spectral use and resistance to interference. Performance-oriented studies, including "LPWAN at Sea" [10] and "Understanding the Limits of LoRaWAN" [23], demonstrate that LoRa can achieve communication ranges of several kilometers even in tough environmental conditions. However, most existing studies mainly focus on communication performance and do not incorporate wearable systems or user-to-user communication features.

2. Multi-Node and Relay-Based Communication Systems:

Multiple research works have focused on improving communication reliability through multi-node and relay-based architectures. Systems like "Design of Real-Time Data Acquisition with Multi-Node Embedded Systems" [9] and "LoRa-Based Multi-Node Monitoring Systems" [6] showcase centralized monitoring with distributed sensor nodes. Studies such as "Two-Hop Relaying LoRa Systems" [19], "Multi-Hop and Mesh for LoRa Networks" [13], and

"Reliability Improvement using ARQ and Relay Nodes" [14] demonstrate that relay-based communication greatly improves communication range and packet delivery performance. Additionally, delay-tolerant networking methods allow communication in disconnected environments by using store-and-forward mechanisms [11]. Despite these advancements, existing systems generally lack wearable interfaces, silent communication techniques, and integrated health-monitoring features.

3. Wearable Health Monitoring Systems:
Wearable IoT systems have been widely studied for monitoring physiological parameters. Research like "Wearable IoT Enabled Real-Time Health Monitoring System" [5] and "Smart Sensor Systems for Wearable Electronic Devices" [26] shows continuous monitoring of heart rate and SpO_2 using biomedical sensors like MAX30102. Similarly, "IoT-Based Real-Time Multi-Node Health Monitoring System using ESP32 and Biomedical Sensors" [27] highlights efficient real-time monitoring with embedded systems. While these systems work well for healthcare applications, they mainly depend on short-range communication or cloud-based connectivity. They do not make use of long-range communication technologies like LoRa for deployment in remote areas.

4. GPS-Based Tracking Systems:
There are many studies for location tracking using GPS integrated with wireless communication systems. Research such as "Location Tracking using LoRa" [2] and "Real-Time Extensive Livestock Monitoring Using LPWAN Smart Wearable and Infrastructure" [7] shows real-time tracking in long distance. Such systems are particularly useful in defense, surveillance and remote monitoring applications. However, they do not provide direct communication between users and do not have a relay-based/hybrid network architecture for long-distance connectivity.

5. Network Topologies (Star, Mesh, Hybrid):
The network topology is important for communication efficiency and reliability. Typically, star topology is used in traditional LoRaWAN systems, owing to its simplicity and low power consumption [33]. However, research including "LoRaWAN Mesh Networks: A Review and Classification of Multihop Communication" [20] and "Hybrid Star-Mesh Topology for LoRaWAN" [35] proves that network coverage, scalability, and fault tolerance are improved by using mesh and hybrid topologies. Comparative studies demonstrate that mesh networks offer better reliability, and hybrid networks combine the advantages of both star and mesh architectures [37]. However, existing works do not incorporate such topologies into wearable communication systems with real time messaging and monitoring capabilities.

6. Energy Efficiency and Battery Systems:
Energy consumption plays a significant role for wearable and IoT systems. Studies such as "An Energy-Efficient LoRa Multi-Hop Protocol through Preamble Sampling" [21] and "Battery Storage Integration for Power Quality Improvement" [30] highlight techniques to reduce power consumption and extend battery life. These works indicate that the efficiency of the system can be significantly improved by the optimized communication protocols and power management strategies. However, such approaches do not cater to wearable communication systems that integrate sensing, tracking and messaging functionalities into a single platform.

7. Security and Communication Protocols:
Secure communication is an important problem in defense and emergency applications. The security of wireless communication has been studied by using encryption techniques like AES and DES to make wireless data transmission secure [12]. Furthermore, protocols such as RTPL (Real-Time LoRa Protocol) improve communication performance by minimizing latency and packet collisions in LoRa networks [15]. Multi-hop LoRa protocols also contribute to reliable and secure communication in dynamic network environments [16]. These methods increase security and efficiency in communication, but most existing systems do not combine lightweight security mechanisms with wearable communication devices or hybrid relay-based network architectures.

VII. RESEARCH GAP:

Existing studies [3], [13], [20] study LoRa communication, wearable monitoring, GPS tracking, relay networking and security mechanisms in isolation. But the integrated wearable communication framework using long-range LoRa communication, silent Morse-code messaging, GPS tracking, health monitoring, relay-based communication and centralized control for defense applications is still under-explored. The proposed Sentinel Command Network (SCN) aims to fill this research gap by integrating all these functionalities into one communication system for remote and critical locations.

VIII. CONCLUSION

The SCN provides a solution for communication in critical environments. It combines of LoRa communication, Morse code messaging, GPS tracking, and health Monitoring in single system.
The use of central hub is to improve communication by allowing message relay when they are out of range. The system ensures silent communication, making it suitable for defence and emergency application.

IX. FUTURE SCOPE

The proposed system can be further enhanced in the following ways:

- Mesh networking implementation
- Advanced encryption methods
- AI for health analysis
- Mobile application for monitoring
- Miniaturization of wearable device
- Satellite communication integration

X. CONFLICT OF INTEREST STATEMENT

The authors have no conflict of interest to disclose.

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