LoRa-Enabled IoT Framework for Soldier Health and Position Monitoring

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***Abstract*—Modern military operations demand real-time monitoring of soldier health and movement to ensure mission success and timely medical assistance. Traditional RF or GSM-based tracking systems suffer from short range, high power consumption, and network unavailability in remote combat zones. This paper presents a low-power Soldier Health and Position Tracking System using LoRa-based wireless communication and IoT technology. The proposed wearable unit continuously measures critical parameters such as heart rate, body temperature, and soldier motion while transmitting GPS location to a command station using long-range LoRa transceivers. Data is displayed on a monitoring dashboard for real-time tracking and emergency alerts. The system demonstrates high transmission range, low power usage, and reliable performance in outdoor environments, making it suitable for defense and rescue operations.**

***Index Terms*—Soldier Monitoring, LoRa, IoT, GPS Tracking, Wearable System, Battlefield Communication**

I. Introduction

Military personnel frequently operate in remote and hostile environments where communication infrastructure is limited. Effective monitoring of soldier health and location plays a vital role in mission planning, rescue operations, and battlefield decision-making. Existing technologies like GSM, Wi-Fi, and Bluetooth face challenges including limited range, signal blockage, and high power requirement.

LoRa (Long Range Radio) technology provides superior communication with low energy consumption and long-distance coverage, making it suitable for tactical operations. Integrating wearable sensors with LoRa enables real-time monitoring without dependency on cellular networks. This project proposes a smart soldier wearable system capable of health and GPS monitoring to enhance military efficiency and safety.

II. LITERATURE REVIEW

Recent works have explored IoT-based soldier health systems; however, many use GSM or ZigBee and suffer from range limitations. LoRa-based research has demonstrated reliable long-range connectivity, yet limited studies combine biomedical monitoring and location tracking in one integrated wearable system. This work addresses these gaps by implementing a multi-sensor and long-range communication solution optimized for battlefield environments.

III. METHODOLOGY

Phase 1: System Architecture Planning

System Design Objectives:

The system is designed as a compact wearable unit capable of sensing vital signs, determining GPS location, and transmitting the data to a base station using LoRa communication. Both hardware layout and data flow architecture are planned to ensure reliability in field conditions.

Hardware Integration Planning:

A modular approach is used, allowing independent testing and replacement of each component.

Wearable Unit Components:

- Heart-rate and temperature sensors integrated for continuous vitals monitoring
- GPS receiver configured to acquire real-time position data
- LoRa transceiver module interfaced to microcontroller for long-range communication
- Battery unit and regulation circuitry designed for portable operation

Base Station Setup:

- LoRa receiver paired with a microcontroller or gateway
- Computer/dashboard used for real-time display and logging
- Data visualization prepared on a monitoring interface

Phase 2: Embedded System & Communication Development

Microcontroller Configuration:

- Device initialization and power management setup for prolonged field use
- Interrupt-based sensor polling to minimize power consumption
- Serial communication used for sensor integration and debugging

LoRa Communication Protocol:

- Point-to-point LoRa link configured and tested
- Addressing scheme used to identify individual soldier nodes
- Retry mechanism implemented to ensure reliable packet delivery

Sensor Calibration:

- Temperature probe calibrated against medical-grade thermometer
- Pulse sensor baseline tested on multiple individuals
- GPS acquisition tested outdoors for accuracy and fix time

Phase 3: Prototype Assembly & Functional Testing

Wearable Assembly:

- Components mounted on compact PCB or dev-board arrangement
- Enclosure chosen for durability and soldier movement compatibility
- Field battery fitted and endurance tested

Testing Procedure:

- Unit worn by volunteers to verify sensor stability during movement
- GPS accuracy checked in open field environment
- LoRa range tested in multiple terrains (open ground, semi-urban obstacles)
- Emergency alert function triggered during abnormal vital readings

Phase 4: Performance Evaluation

Operational Testing Scenarios:

- Continuous vitals monitoring during walking, running, idle states

- Location tracking during movement across predefined paths
- Transmission interval variation to study battery impact

Stress & Reliability Tests:

- Low-signal environments tested for LoRa packet loss
- Battery endurance tested under continuous transmission mode
- Emergency alert scenario simulated for sudden health drop or immobility

Data Logging & Analysis:

- Received vitals and GPS data logged at command system
- Latency, packet success rate, and battery performance evaluated
- Accuracy of heart-rate and temperature compared to reference devices

Phase 5: Visualization & Enhancement

Monitoring Dashboard:

- Real-time vitals and map location displayed on screen
- Alert window implemented for emergency notifications
- Data stored for record-keeping and post-analysis

System Improvements:

- Deep-sleep mode tuning for extended battery life
- Antenna optimization to improve LoRa range
- Encrypted communication layer planned for defense-grade security

IV. CONCLUSIONS

System successfully demonstrates a reliable and energy-efficient solution for real-time battlefield monitoring. By integrating biomedical sensors, GPS technology, and long-range LoRa communication, the system ensures continuous tracking of soldier vitals and location even in remote environments where traditional networks fail. Experimental results verify that the prototype provides accurate health readings, real-time alerts, and long-distance data transmission with minimal power consumption, making it suitable for defense and emergency response operations.While the system performs well in field testing, further improvements can enhance robustness and military deployment readiness. Future research should focus on advanced encryption techniques to ensure secure communication, improved wearable ergonomics for long-term use, and integration with cloud-based analytics for predictive health monitoring. Expanding to LoRaWAN architecture and satellite redundancy can further increase range and reliability. Overall, the system offers a promising foundation for next-generation smart soldier support systems and contributes toward safer and more intelligent battlefield environments.

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