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HYBRID LORA-WIFI GATEWAY DESIGN FOR SECURE COMMUNICATION IN ARMED FORCES

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ABSTRACT

The "LoRa-Based Soldier Security System Integrated with IoT" aims to enhance real-time monitoring and safety of soldiers in the field through advanced wireless communication and IoT technologies. The system comprises two key units: a Transmitter (Tx) and a Receiver (Rx). The Tx unit integrates vital sensors such as SpO2 and heartbeat sensors, a keypad emergency button, an LCD display, a buzzer, and a LoRa transmitter module. The Rx unit consists of a LoRa receiver module, an LCD display, a buzzer, and IoT integration for remote monitoring. Data from the sensors on the Tx side, including critical health parameters, are continuously monitored. If any parameter crosses predefined threshold values or the emergency button is pressed, an alert is triggered on both the Tx and Rx units via buzzers and LCD displays. Simultaneously, the alert is transmitted to an IoT server for real-time notification to higher authorities. The system employs an Arduino Uno on the Tx side for sensor data acquisition and an ESP32 on the Rx side for IoT communication. This project offers a reliable, low-power, and long-range communication solution, ensuring timely responses during critical situations and improving overall soldier safety and operational efficiency.

Keywords: LoRa Communication, Soldier Security System, ESP32, SpO_2 Sensor, Arduino Uno.

1. INTRODUCTION

An embedded system is a special-purpose computer system designed to perform one or a few dedicated functions, sometimes with realtime computing constraints. It is usually embedded as part of a complete device including hardware and mechanical parts. In contrast, a generalpurpose computer, such as a personal computer, can do many different tasks depending on programming. Embedded systems have become very important today asthey control many of the common devices we use. Since the embedded system is dedicated to specific tasks, design engineers can optimize it, reducing the size and cost of the product, or increasing the reliability and performance. Some embedded systems are massproduced, benefiting from economies of scale. Physically embedded systems range from portable devices such as digital watches and MP3 players, to large stationary installations like traffic lights, factory controllers, or the systems controlling nuclear power plants. Complexity varies from low, with a single microcontroller chip, to very high with multiple units, peripherals and networks mounted inside a large chassis orenclosure. In general, "embedded system" is not an exactly defined term, as many systems have some element of programmability. For example, Handheld computers share some elements with embedded systems — such as the operating systems and microprocessors which power them but are not truly embedded systems, because they allow different applications to be load and peripherals to be connected. An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is specifically designed for a particular kind of application device. Industrial machines, automobiles, medical equipment, cameras, household appliances, airplanes, vending machines, and toys (as well as the more obvious cellular phone and PDA) are among the myriad possible hosts of an embedded system. Embedded systems that are programmable are provided with a programming interface, and embedded systems programming is a specialized occupation. Certain operating systems or language platforms are tailored for the embedded market, such as Embedded Java and Windows XP Embedded. However, some low-end consumer products use very inexpensive

The soldier Health and Position Tracking System allows military to track the current GPS position of soldier and also checks the health status including body temperature and heartbeats of soldier. The System also consists extra feature with the help of that soldier can ask for help manually or send a distress signal to military if he is in need. The GPS modem sends the latitude and longitude position with link pattern with the help of that military can track the current position of the soldier. The system is very helpful for getting health status information of soldier and providing them instant help.

In this system, smart sensors are attached to the body of soldiers. As soon as any other soldier enters the enemy lines it is very difficult for the army base station to know about the location as well as the health status of all soldiers. The important and vital role is played by the soldiers. This system will be useful for soldiers, who involve in missions or in special operations. This personal server will provide the connectivity to the server at the base station using a wireless connection. There are many concerns regarding the safety of these soldiers. The M-health can be defined as mobile computing, medical sensors and communication technologies for health care. Each soldier also has a GSM (Global system for Mobile communication) module which enables the communication with the base station in case of injuries. In today's era enemy warfare is an important factor in any nation's security. The national security mainly depends on army (ground), navy (sea), air-force (air). In our project we have come up with an idea of tracking soldier as well as to give status of the soldier during the war. It is possible by M-Health. The defense department of country must be effective for the security of that country. This is implemented with a personal server for complete mobility. This system enables GPS (Global positioning systems) tracking of these soldiers.

A portable, wireless low cost tracking system w ith high reliability is the need of hour for the protection of valuable life of the soldiers on the battle fields. Further, soldiers can be guided for the correct directions during the operations using GPS. The army suffers a lot due to the unavailability of information of injuries to its personnel which may increase the death/ permanent disability toll. The armed forces when deployed in battlefield need to be monitored for better utilization of soldiers and using strategies to man oeuvre them to combat. It is observed that the causalities are caused due to injuries rather than the direct assaults in the battlefield. These number can be minimized if the real-time information is available at the control room about the health and location of the soldier. There are many issues regarding the safety of soldiers. The transmission ofthese parameters to the control room is carried out by the control room receives the position and orientation of soldier from GPS.

2. LITERATUREREVIEW

The primary objective of this work is to develop a cost-effective and reliable system to enhance soldier health monitoring and security during wartime operations. Several researchers have contributed to this domain by integrating sensors, wireless communication, and IoT technologies. Initial approaches focused on monitoring vital physiological parameters such as body temperature, heart rate, and oxygen saturation levels using biomedical sensors [1]. These parameters are critical for assessing the real-time health condition of soldiers in extreme environments.

In addition to health monitoring, tracking the geographical location of soldiers using GPS technology has been widely implemented. Systems have been developed to continuously monitor and transmit location data to a base station, enabling efficient coordination and rescue operations [2]. Environmental factors such as atmospheric temperature and pressure are also monitored to provide a comprehensive understanding of the soldier's surroundings. The collected data is processed using IoT platforms such as Blynk and displayed through mobile applications, allowing real-time remote monitoring. Alerts are generated automatically when abnormal conditions are detected, ensuring timely intervention [3].

Various communication technologies such as ZigBee, GSM, and Wi-Fi have been utilized for transmitting sensor data. ZigBee-based wireless sensor networks have been widely adopted due to their low power consumption and reliability in short-range communication. GSM technology enables long-distance communication by sending real-time updates to control units or medical personnel [4]. Microcontrollers such as ATmega328P and AT89C51 have been commonly used for data acquisition and processing, while sensors like LM35, pulse rate sensors, and oxygen level detectors ensure continuous monitoring of soldier health.

Several studies have explored the integration of wireless sensor networks (WSNs) with cloud computing for efficient data storage and processing. These systems allow real-time data analysis and improve decision-making capabilities during military operations. IoT-based solutions further enhance system performance by enabling seamless communication between soldier units and base stations through cloud platforms [5]. Wireless Body Area Sensor Networks (WBASNs) have also been implemented to monitor multiple health parameters simultaneously, providing a more accurate assessment of a soldier's condition [6].

Advanced systems incorporate ARM processors and real-time monitoring techniques to track parameters such as ECG, temperature, and heart rate, along with GPS-based location tracking. Cloud-based storage and visualization tools, including Google Maps, have been used to display soldier positions and health data for control room monitoring [7]. Additionally, RF-based communication modules have been proposed to gather live battlefield data, offering an alternative to conventional communication systems [8].

Recent developments have focused on improving system efficiency, security, and portability. Raspberry Pi-based systems have been introduced for monitoring additional parameters such as respiration and movement. Security mechanisms such as One-Time Password (OTP) authentication have been proposed to ensure safe data transmission [9]. However, many existing systems still face challenges such as high cost, delayed response time, and bulky design.

2.1 Technology Overview

Accurate positioning systems are essential for military and emergency response applications. GPS-based positioning techniques are widely used to determine the real-time location and orientation of soldiers. Using Geographic Information System (GIS) principles, parameters such as distance, direction, and elevation between units can be calculated [10]. Data is transmitted wirelessly using RF transceivers, enabling effective coordination and situational awareness. GPS modules communicate through serial interfaces using standardized NMEA data formats, ensuring reliable data exchange.

2.2 Evaluation

The soldier tracking and health monitoring system represents a significant advancement in defense technology by integrating embedded systems, wireless communication, and IoT. It enhances operational efficiency by providing real-time health and location data, enabling timely decision-making and reducing casualties during missions. The implementation of mobile health (M-Health) concepts further strengthens the system by ensuring continuous monitoring and rapid response in critical situations. Overall, such systems contribute to improved soldier safety, efficient mission execution, and strengthened national security.

3. PROPOSED SYSTEM

The block diagram of GPS based soldier tracking and health indication system is shown in fig. it consist of two units soldier unit and base station unit. As it requires high speed communication it is intended to use Arduino controller which is based on with real-time emulation and embedded trace support, that combines the 2GB of embedded high speed Flash memory. Biosensors such as Body temperature and pulse rate are integrated to Raspberry Pi processor to monitor the health status. The GPS receiver is used to log the longitude and latitude of soldier, which is stored in microcontroller memory. GPS Receiver receives and compares the signal from orbiting GPS satellite to determine geographic position.

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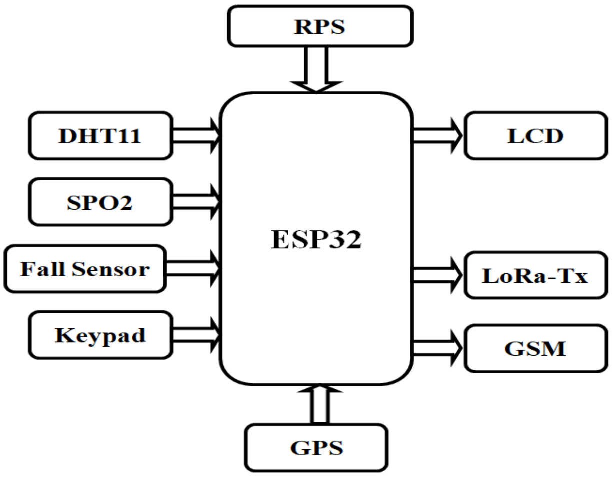

Fig. 1: ESP32-Based Health Monitoring Transmitter Block Diagram.

This image shows the block diagram of an ESP32-based health monitoring transmitter system. The ESP32 acts as the central controller interfacing with sensors such as DHT11 for temperature, SpO_2 sensor for oxygen levels, and a fall detection sensor for safety monitoring. A keypad is included for user input, while a GPS module provides location tracking. The system displays data on an LCD and transmits information using LoRa-Tx and GSM modules. A regulated power supply (RPS) ensures stable operation of all components.

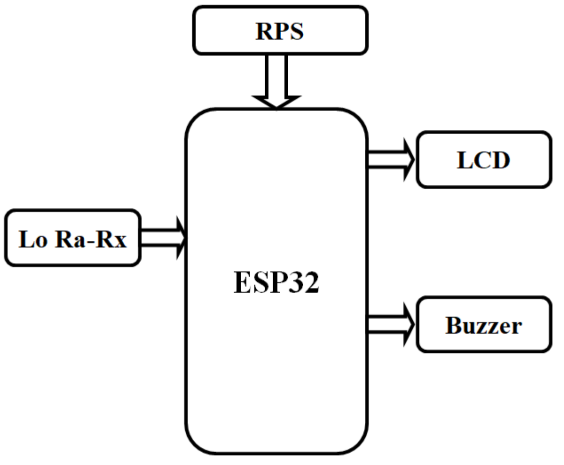

Fig. 2: Block diagram description

This is a block diagram referring soldier security using embedded electronics. Our project is characterized as five sections, which are RPS section, input section, output section, microprocessor section and programming section. A regulated power supply (RPS) is an embedded circuit, used to convert unregulated alternating current into a stable direct current by using a rectifier. The main function of this is to supply a constant voltage to a circuit that should be functioned in a particular power supply limit.Inour project we are supplying 5V to the raspberry pi board.

The input equipment of our project are temperature sensor which is DHT11. The DHT-11 Digital Temperature and Humidity Sensor is a basic, ultra low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air and spits out a digital signal on the data pin (no analog input pins needed). The input section also consists of heart beat sensor. Heartbeat sensor is designed to give digital output of heat beat when a finger is placed on it. When the heart beat detector is working, the beat LED flashes in unison with each

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heartbeat. This digital output can be connected to raspberry pie directly to measure the Beats Per Minute (BPM) rate. It works on the principle of light modulation by blood flow through finger at each pulse. The inputs temperature and heart beat are sent to the processor section. Our project output consists of LCD display which shows the latitude and longitude of a soldier's region which captured by the GPS receiver.The temperature and heartbeat are displayed on the LCD display in Celsius and heart beat per minute(bpm). The temperature, heartbeat and location of soldier is sent to the defense system through SMS. In this way live location, health of soldier is monitored. If the higher or lower temperature,heart beat is detected the buzzer is automatically activated. In this project we are using Raspberry Pi for processing the input and output. All the sensors (DHT11, heartbeat sensor), GSM module and GPS module, driver boards are connected to the Raspberry Pi. As we are using RaspberryPi we selected the embedded python as programming language. Generally embedded python consists several libraries which are useful for easy coding.

4. RESULTS

This section provides the visual validation of the prototype, illustrating the hardware integration and the real-time data flow from the soldier's wearable node to the remote monitoring interface. The experimental evaluation of the proposed system confirms the successful integration of physiological sensing, long-range communication, and automated cloud logging. The following subsections detail the physical implementation and the observed outputs.

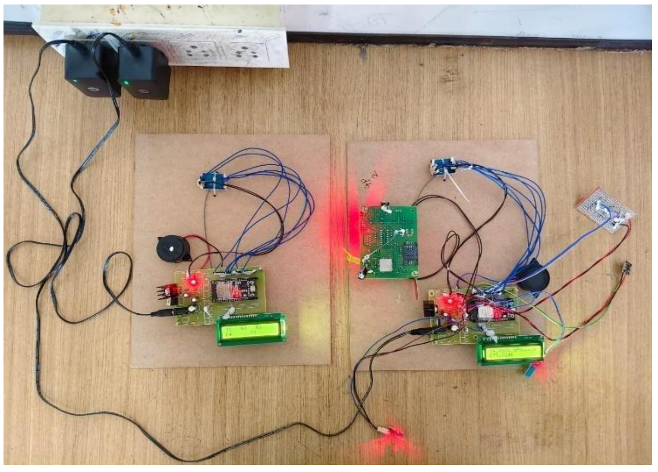

Fig. 3: Complete hardware setup of proposed system.

Hardware Prototype Integration

The complete hardware setup consists of two distinct units mounted on a common testing platform. The Transmitter Section functions as the field unit, integrating the ESP32 with the MAX30102 and DHT11 sensors. The Receiver/Gateway Section utilizes a high-gain LoRa antenna to intercept sub-GHz signals, which are then processed and forwarded to the cloud via the onboard Wi-Fi chip.

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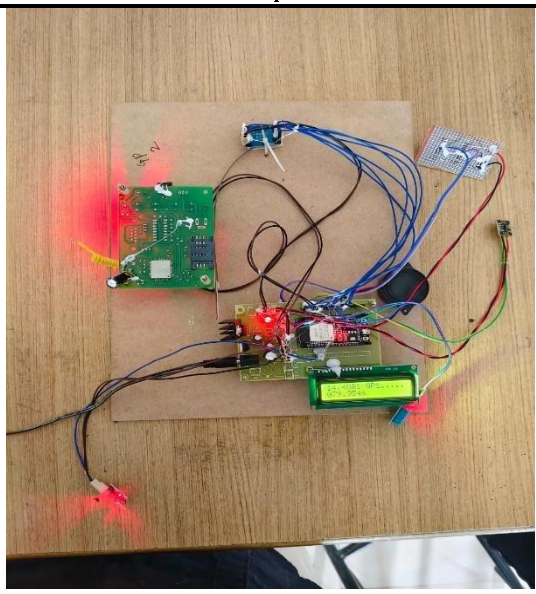

Fig. 4: Transmitter unit

Real-Time Monitoring and LCD Interface

During active operation, the local LCD on the soldier node provides immediate feedback on environmental conditions. As shown in the prototype testing, the system accurately captured a temperature of 32°C and humidity of 82%, alongside the calculated vitals. The secondary unit (Receiver) successfully parsed the NMEA strings from the GPS module, displaying the precise coordinates required for asset tracking.

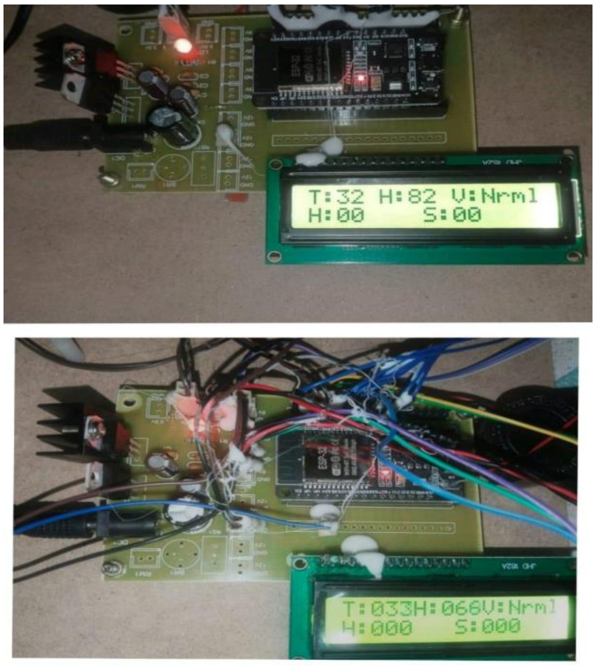

Fig. 5: Real-time monitoring of LCD interface.

5. CONCLUSION

Security and safety for soldiers: GPS tracks position of soldier anywhere on globe and also health system monitors soldiers vital health parameters Which provides security and safety for soldiers. Modules used are smaller in size and also lightweight so that they can be carried around. So in this way concept of tracking and navigation system is very useful for soldiers when they are on military field during war. And also for base station so that they can get real-time view of soldier's on field displayed on PC. From above proposed system, we can conclude that we are able to send data which is sensed from remote soldier to army control room using GSM. The system is completely integrated and can track the location of soldier at anytime from anywhere on the earth using GPS receiver. This system helps to monitor health parameters of soldier using heart beat sensor to measure heart beats and temperature sensor to measure body temperature of soldier. This system helps the soldier to get help from army base station and/or from another fellow soldier in panic situation. This system provides the location information and health parameters of soldier in real time to the army control room. Security and safety for soldiers: GPS tracks position of soldier anywhere on globe and also health system monitors soldier vital health parameters Which provides security and safety for soldiers.

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