A Midterm Progress Report

On

IoT BASED SAFE SPHERE

Submitted in partial fulfillment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

COMPUTER SCIENCE AND ENGINEERING

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(JAN-MAY 2025)

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CHAPTER 1

INTRODUCTION

1.1 Women Safety Device

Women’s safety has become a pressing global concern due to the increasing incidents of harassment, assault, and other forms of violence. Despite various safety measures and legal frameworks in place, many women still face threats, especially in public places or while traveling alone. Traditional safety mechanisms, such as emergency helplines, self-defense techniques, and mobile applications, often fail in real-time crisis situations due to delayed response times or inaccessibility during distress. In such scenarios, technology-driven solutions can play a crucial role in enhancing women’s security. The rapid advancement of the Internet of Things (IoT) provides an opportunity to develop an intelligent safety device that ensures real-time monitoring, instant alerts, and automated distress responses to protect women in dangerous situations.

The IoT-based Safe Sphere for Women is a smart safety system designed to provide women with a wearable, real-time security solution that offers immediate assistance in emergency situations. This device integrates GPS tracking, biometric monitoring,and an SOS alert mechanism to provide a proactive and responsive safety system. Unlike traditional mobile safety apps that require manual activation, this device incorporates automatic distress detection through sensors that monitor changes in heart rate, motion, and surrounding environmental sounds. In case of a potential threat, the system automatically triggers an emergency alert to predefined contacts, law enforcement agencies, or nearby trusted individuals, ensuring a quicker and more efficient response. One of the key features of this device is its seamless integration with IoT technologies, enabling it to provide predictive safety measures. The system can detect abnormal behavior patterns, such as sudden acceleration (running), rapid heart rate spikes, or verbal distress signals, and send real-time alerts before a situation escalates.By leveraging IoT connectivity and real-time data processing, the Safe Sphere for Women provides a holistic security solution that bridges the gap between traditional safety measures and modern technology-driven solutions.

1.2 Problem Associated with Women Safety

Despite the availability of mobile safety applications and emergency helpline numbers, women in distress often face difficulties in seeking immediate help due to several limitations:

Panic and Restricted Movement: In high-stress situations, victims may experience panic and fear, making it difficult to manually access their phones or safety apps. Attackers may restrain movement, preventing the victim from pressing an SOS button or calling for help.

Unavailability of Network Services: Many mobile-based safety apps rely on internet connectivity to function, which may not be available in remote areas, basements, or enclosed spaces. Poor network signals can delay or prevent distress signals from reaching emergency contacts.

Delayed Response Time from Authorities: Even when an SOS alert is sent, authorities or emergency contacts may take time to receive, verify, and respond to the request. Response teams often lack real-time tracking, leading to delays in locating and assisting the victim.

Inefficient Real-Time Location Tracking: Traditional mobile-based GPS tracking may not work accurately indoors, in moving vehicles, or high-rise buildings.

_Lack of Automatic Distress Detection:_Most existing solutions require manual activation, which may not be possible during a sudden attack.

Limited Integration with Smart City Infrastructure: Current safety apps operate independently and are not integrated with police networks, surveillance systems, or emergency response units. A more effective system would leverage IoT and smart city technologies to instantly alert nearby security personnel and public safety systems.

1.3 Technology Used

Hardware Components

Hardware Device : Microcontroller (Arduino) – Acts as the brain of the device, processing sensor data and triggering alerts.

GPS Module (Neo-6M/SIM808) – Enables real-time tracking of the user's location.

GSM Module (SIM800/900A) – Sends emergency alerts via SMS or calls when there is no internet connectivity.

SOS/Panic Button – A manual trigger for instant alert activation.

Communication Technologies

Wireless Connectivity: Allows connection between the device and a user.

Wi-Fi (ESP8266/ESP32): Enables real-time data transmission when connected to a network. LoRa WAN (Long Range Wide Area Network) . Used for communication in areas with poor network connectivity.

IoT Communication Protocols: MQTT (Message Queuing Telemetry Transport) – A lightweight messaging protocol for real-time data transmission between the device and cloud servers. HTTP/HTTPS – Secure web-based communication for mobile applications and cloud storage.

Software Technologies

In an IoT-based women safety project, software plays a crucial role in managing communication, data processing, and real-time tracking. Various technologies and libraries are used to control hardware, enable wireless communication, and process GPS data efficiently. Some of the key software technologies used in this project include Arduino, WiFi.h, ESP-NOW, and TinyGPS++.

1. Arduino

Arduino is an open-source microcontroller platform that provides a simple yet powerful way to develop IoT-based projects. It includes both hardware (Arduino boards) and software (Arduino IDE and libraries), making it easier to interface with various sensors, communication modules, and external devices.

In an IoT-based women safety project, Arduino is used as the central control unit, responsible for handling inputs from sensors (such as an SOS button or motion detector), processing GPS data, and managing wireless communication. It interacts with components like GSM modules, Wi-Fi modules, and GPS receivers to send alerts and share location data. The Arduino IDE is used to write and upload code to microcontrollers like Arduino Uno, ESP8266, or ESP32.

Some key features of Arduino in this project:

- Collects sensor data (SOS button, etc.)
- Reads GPS coordinates from a GPS module.
- Controls communication modules (Wi-Fi, GSM, ESP-NOW.)
- Processes emergency alerts and location sharing.

Since Arduino is lightweight and efficient, it is ideal for low-power IoT applications like a portable women safety device.

2. WiFi.h

The WiFi.h library is essential for enabling Wi-Fi communication in ESP8266 and ESP32-based IoT projects. It allows the microcontroller to connect to Wi-Fi networks, send and receive data over the internet, and interact with cloud services.

In an IoT-based safety project, WiFi.h plays a critical role in:

Sending real-time alerts over the internet via cloud-based messaging services.

Enabling live GPS tracking by sending location data.

For example, when an SOS button is pressed, the ESP32 uses WiFi.h to connect to a Wi-Fi network and send an alert (including GPS coordinates) to predefined emergency contacts. If the network is unavailable, alternative communication protocols like GSM or ESP-NOW can be used as backups.

3. ESP-NOW

ESP-NOW is a low-power, peer-to-peer wireless communication protocol developed by Espressif (the company behind ESP32 and ESP8266). Unlike Wi-Fi, ESP-NOW does not require an internet connection or a route; instead, it allows direct communication between ESP devices.

In an IoT-based women safety project, ESP-NOW can be used in situations where Wi-Fi or GSM networks are unavailable. It allows multiple ESP32/ESP8266 devices to communicate directly, making it ideal for:

- Offline emergency alert systems, where one device can send an SOS signal to another device without internet access.
- Low-power communication, ensuring that the device remains operational for long periods on battery power.

- Short-range connectivity, useful for local networks within a safety zone(e.g., alerting family members).

ESP-NOW is highly efficient for real-time emergency communication in areas with poor network connectivity, ensuring that alerts can still be transmitted without relying on Wi-Fi or GSM.

4. TinyGPS

TinyGPS is a powerful and lightweight C++ library used to parse and process GPS data from serial-based GPS modules like NEO-6M and u-blox. It extracts critical location data, such as latitude, longitude, altitude, speed, and time, from raw GPS signals received via the UART (serial) interface.

In an IoT-based women safety project, TinyGPS++ is used to:

- Extract real-time GPS coordinates from the GPS module.
- Convert raw GPS data into readable format for tracking.
- Filter and improve accuracy of location updates.
- Format GPS data before sending it over GSM, Wi-Fi, or ESP-NOW.

For example, when an emergency occurs, the microcontroller reads GPS data using TinyGPS++, processes it, and then sends it via Wi-Fi or GSM to emergency contacts. TinyGPS++ ensures that the location data is accurate and reliable, which is critical for real-time tracking and fast response.

Conclusion

In an IoT-based women safety project, these software technologies work together to enable real-time emergency communication and tracking. Arduino serves as the main processing unit, handling sensor inputs and decision-making. WiFi.h provides internet connectivity for cloud-based alerts and tracking, while ESP-NOW ensures communication in offline scenarios. TinyGPS++ processes and formats GPS data, ensuring accurate location tracking. By integrating these technologies, the system becomes efficient, reliable, and responsive, making it an effective safety solution.

1.4 The Project: IoT Based Safe Sphere

Women's safety has become a serious concern worldwide, with increasing incidents of harassment, assault, and violence occurring daily. Traditional safety measures such as self-defense techniques, emergency helpline numbers, mobile applications, and location-sharing services are often ineffective in high-risk situations. Victims may be unable to manually call for help due to panic, physical restraint, or network unavailability.

The IoT-Based Safe Sphere is an innovative smart wearable device that leverages the power of Internet of Things (IoT), Artificial Intelligence (AI), GPS tracking, and biometric sensors to ensure women's safety. This system is designed to detect distress automatically, send real-time alerts to emergency contacts and law enforcement, and provide live tracking of the victim's location. The Safe Sphere acts as a personal security system, significantly reducing response time and increasing the chances of timely intervention.

Key Aspects of the IoT-Based Safe Sphere Project.

Instant Emergency Alerts : Sends SOS messages, and notifications to predefined contacts, police, and nearby users.

Communication Channels:Works with Wi-Fi, GSM to ensure alerts are sent even in low-network areas.

Community Assistance Network : Alerts nearby registered users within the Safe Sphere network to provide immediate help.

1.5 Objectives

The objectives of this IOT based safe sphere are:

1. To create a compact hardware system equipped with GPS and communication modules to enable women to send real-time alerts during emergencies.

The primary goal of this project is to develop a small, portable, and power-efficient hardware system that allows women to send emergency alerts instantly during critical situations. To achieve this, the device will integrate GPS and communication modules, ensuring real-time location tracking and alert transmission. The GPS module, such as NEO-6M or u-blox, will continuously fetch the user's geographical coordinates with high accuracy. This is crucial for tracking movement and providing precise location data in emergencies. In addition to GPS, the system will include a communication module, such as GSM (SIM800L, SIM900), Wi-Fi (ESP8266, ESP32), or LoRa, to establish a reliable connection for sending alerts. GSM modules will enable SMS or voice call alerts, while Wi-Fi and LoRa can provide cloud-based notifications for internet-based tracking. A microcontroller, like ESP32, Arduino, or Raspberry Pi, will serve as the processing unit, coordinating data from the GPS and communication modules. It will handle user inputs, manage power consumption, and trigger emergency alerts when needed. A crucial aspect of this system is the SOS activation mechanism, which can be either a physical button or sensor-based triggers such as fall detection (accelerometer/gyroscope) or voice activation. This ensures multiple ways of activating the distress signal, making the device adaptable to different emergency scenarios. By combining these elements, the hardware system ensures instant communication and real-time location tracking, significantly improving safety by connecting the user with emergency contacts and authorities.

2. To implement a screen within the system to display real-time alert messages, providing immidiate visual feedback during critical situations.

To enhance user interaction and usability, the system will include a display screen that provides immediate visual feedback during emergency situations. This feature is critical, as it reassures the user that the distress signal has been successfully triggered and helps them stay informed about the device's status. The screen can be an OLED, LCD, or e-paper display, depending on power efficiency and visibility requirements. OLED screens are preferred for their low power consumption and high contrast, making them ideal for portable battery-powered devices. The screen will serve multiple purposes. First, it will display alert messages confirming that the emergency signal has been sent, reducing panic and uncertainty. Second, it will show system status indicators such as battery level, network signal strength, and GPS connectivity to ensure the device is functioning correctly. Third, it can provide instructions or feedback messages, guiding the user on what steps to take during an emergency. For example, if the device detects that the message failed to send, it can prompt the user to move to an area with better network coverage.

This feature plays a crucial role in making the system more user-friendly and intuitive, as real-time feedback ensures the user knows their request for help has been acknowledged. The presence of a screen also makes the device more reliable, as users can verify whether the system is active and functioning properly. In emergency situations, quick and clear communication is essential, and a display screen enhances this aspect by providing real-time updates and confirmations.

3. To develop a platform, for live location sharing with emergency contacts and authorities.

One of the most important aspects of this project is the development of a real-time location-sharing platform that allows trusted contacts and law enforcement authorities to track the user's movement during an emergency. This platform will act as a centralized monitoring system, ensuring that help reaches the user as quickly as possible. The core functionality of this system involves continuously updating the user's location and sharing it through SMS.The system will be built using services such as Arduino, which will securely handle the storage and transmission of GPS coordinates.

The alert system will also have notifications, meaning that as soon as the SOS button is pressed, the system will send SMS alerts containing the user's live GPS coordinates. The platform can also be designed to automatically contact law enforcement in case of an emergency, providing them with continuous location updates until the user is safe. Additionally, an auto-tracking mode can be enabled, where the system shares location updates at regular intervals, allowing emergency responders to track movements in real-time.By integrating a live tracking platform, the project ensures that the emergency response is fast, accurate, and reliable. Instead of relying on delayed or manual location updates, authorities and emergency contacts will have real-time access to the user's position, significantly improving the chances of timely intervention and assistance.

1.6 The following steps are plannned to accomplish the project goals:

1. Research & Problem Analysis – Identify safety gaps and define key requirements for an IoT-based security system.

2. System Design & Hardware Selection – Choose suitable sensors, communication modules, and finalize communication protocols (Wi-Fi, GSM, LoRaWAN) for real-time data transmission.

3. Software Development & AI Integration – Set up a cloud-based server to store emergency data and integrate with law enforcement..

4. System Integration & Testing – Combine hardware and software, conduct real-world testing, and optimize performance.

5. Deployment & User Training – Distribute devices, conduct awareness programs, and gather user feedback.

6. Scaling & Smart City Integration – Expand network coverage, integrate with law enforcement, and enhance features using smart technologies.

CHAPTER 2

SYSTEM REQUIREMENTS

2.1 Software Requirements

Programming Arduino boards (Uno, Mega, Nano), ESP8266, ESP32: The Arduino family of microcontrollers (Uno, Mega, Nano) and the ESP8266/ESP32 Wi-Fi-enabled microcontrollers are widely used in IoT applications due to their simplicity, flexibility, and extensive community support. Arduino Uno, Mega, and Nano are based on ATmega microcontrollers, offering easy integration with various sensors and modules, making them ideal for simple IoT and embedded applications. Programming these boards is done using the Arduino IDE, where developers write code in C/C++ and upload it via USB. The Arduino Mega is suitable for projects requiring more I/O pins and memory, while the Arduino Nano is compact and ideal for wearable devices like the IoT-Based Safe Sphere for Women. These boards support various communication protocols like I2C, SPI, and UART, enabling seamless sensor interfacing.

Large community support and built-in libraries for GPS, GSM, Wi-Fi, Bluetooth, and sensors: One of the key advantages of using Arduino and ESP microcontrollers is their large community support and extensive built-in libraries for various communication and sensing modules. These libraries simplify the integration of essential components like GPS, GSM, Wi-Fi, Bluetooth, and various sensors, enabling faster development and debugging. For instance, the TinyGPS++ library helps process GPS data efficiently, while the Adafruit FONA library facilitates communication with GSM modules for emergency alerts via SMS or calls. Similarly, WiFi.h and ESP8266WiFi.h provide easy-to-use functions for connecting ESP-based microcontrollers to the internet, enabling real-time location sharing and cloud-based monitoring. The Bluetooth Serial library in ESP32 allows seamless pairing with mobile applications, enhancing user interaction. Additionally, libraries for motion sensors (MPU6050), With a vast developer community, these libraries are continuously updated, ensuring compatibility, security, and innovation in IoT-based safety solutions.

2.2 Hardware Requirements

GPS module for real-time tracking:

The GPS module is a crucial component of the IoT-Based Safe Sphere for Women, enabling real-time tracking during emergencies. It continuously captures the user's latitude and longitude coordinates and transmits them to a cloud platform or emergency contacts using GSM, Wi-Fi, or Bluetooth communication. Modules like Neo-6M, u-blox, or SIM808 (GPS + GSM) ensure accurate location tracking, even in remote areas. When a distress situation is detected—either through biometric sensors (heart rate, motion detection) or a manual SOS trigger—the device instantly sends the victim’s live location to pre-registered contacts and law enforcement agencies. This real-time tracking ensures a faster response time, allowing authorities or trusted individuals to locate and assist the person in danger. Additionally, geo-fencing features can be implemented to detect if the user moves outside a safe zone, triggering an automatic alert. By integrating GPS with cloud storage, the Safe Sphere can continuously monitor movement patterns and help predict or prevent potential threats, making it a proactive and effective women's safety solution.

Microcontroller:

The microcontroller or microprocessor is the heart of the IoT-Based Safe Sphere for Women, as it is responsible for processing inputs from various sensors, executing decision-making algorithms, and controlling the overall operation of the device. These components are chosen based on their capability to handle the complexity of real-time distress detection, GPS tracking, communication protocols, and sensor data processing.

Communication modules for sending alerts:

Power supply and rechargeable batteries for portable usage.

Boost Converter :

A boost converter is a DC-DC power converter used to step up the voltage from a lower level to a higher level. In an IoT-based women safety device, the boost converter ensures that low-voltage power sources (such as batteries) can provide the necessary voltage to different components, including GPS modules, GSM modules, and microcontrollers.

- Ensures consistent power supply to IoT modules.
- Enhances battery life by optimizing power usage.
- Essential for devices running on small, portable batteries like Li-ion or Li-Po.

Level Converter :

IoT devices often involve communication between components operating at different voltage levels. A level converter is used to shift voltage levels safely between microcontrollers, sensors, and communication modules.

- Converts 3.3V (ESP8266, ESP32, or sensors) to 5V (Arduino, GSM, GPS modules) and vice versa.
- Prevents damage to sensitive components due to voltage mismatches.
- Ensures stable and accurate data transmission between modules.

Antenna:

An antenna is an essential component for wireless communication in an IoT-based women safety system, where real-time alerts and location tracking are critical. The antenna is used for:

- Enhancing signal strength for GSM/GPS modules to ensure reliable tracking and communication.
- Enabling Wi-Fi or LoRa-based connectivity for real-time data transmission to cloud servers or mobile applications.
- Improving range and accuracy of location-based services, especially in emergency situations.

Circuit Charging System

Since IoT-based safety devices are designed for portability, a circuit charging system is required to manage power efficiently. This system includes:

Battery Management System (BMS): Ensures safe charging and prevents overcharging/discharging of the battery.

Conclusion

These hardware components play a crucial role in ensuring the efficiency, reliability, and portability of an IoT-based women safety device. The boost converter and circuit charging system help manage power efficiently, the level converter ensures proper communication between different voltage components, and the antenna enables real-time communication for emergency alerts. Integrating these components optimally enhances the effectiveness of the safety system.

CHAPTER 3

SOFTWARE REQUIREMENTS ANALYSIS

1. Problem Definition

Women's safety remains a critical concern, especially in unsafe environments. Many women face threats such as harassment, stalking, and assault, often with no immediate way to seek help. Traditional safety measures like phone calls or messages may not be practical in emergencies.

Challenges:

Difficulty in contacting emergency contacts during distress.

Lack of real-time location tracking for immediate help.

Proposed Solution:

An IoT-based women safety system that enables users to send an SOS alert to predefined contacts and law enforcement with real-time GPS tracking. The system will consist of an IoT device and a arduino-based system for alert processing and data management.

2. System Modules and Their Functionalities

1. User Module

Functionality:

Enables the configuration of emergency contacts.

Provides a simple interface to trigger an SOS alert.

2. IoT Device Module

Functionality:

A device with a button to trigger an alert.

Sends the user's location. .

3. Alert Processing Module (Backend System)

Functionality:

Receives distress signals from the IoT device.

Sends real-time notifications(SMS) to guardians.

4. Emergency Notification Module

Functionality:

Sends an SOS alert message with to predefined contacts.

Summary

This IoT-based women safety system ensures immediate response in emergencies through real-time tracking, quick alerts, and monitoring. The structured modules enhance security by enabling instant distress signals, live tracking, and automated emergency communication with minimal effort from the user.

CHAPTER 4

SOFTWARE DESIGN

Gantt Chart (Project Timeline Management)

It helps track progress, allocate resources efficiently, and ensure timely completion of the project.

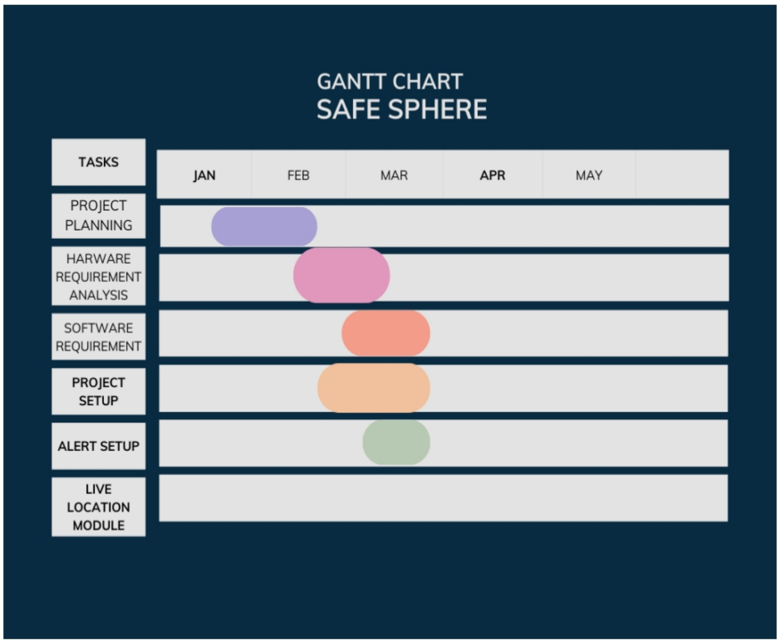
Flowchart (Process Visualization)

The flowchart represents the logical workflow of the system, from detecting an emergency to sending alerts and tracking location.

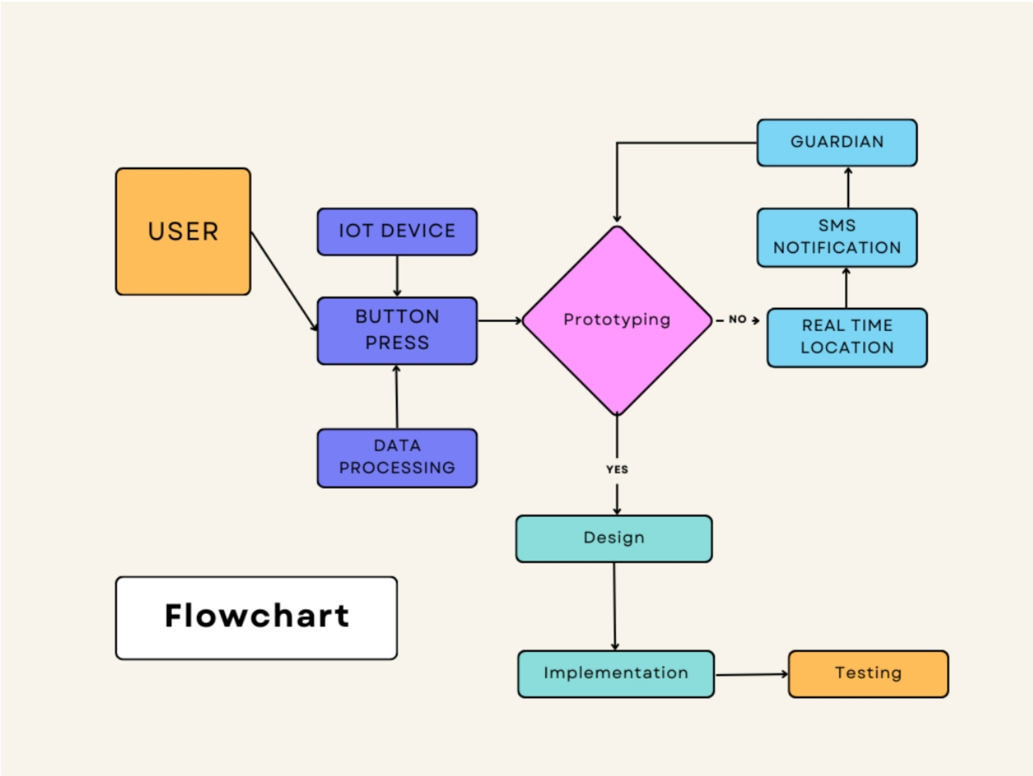
ER Diagram (Database Design)

It defines relationships between entities like User, GPS Data, Alert Logs, and Emergency Contacts, ensuring efficient data management.

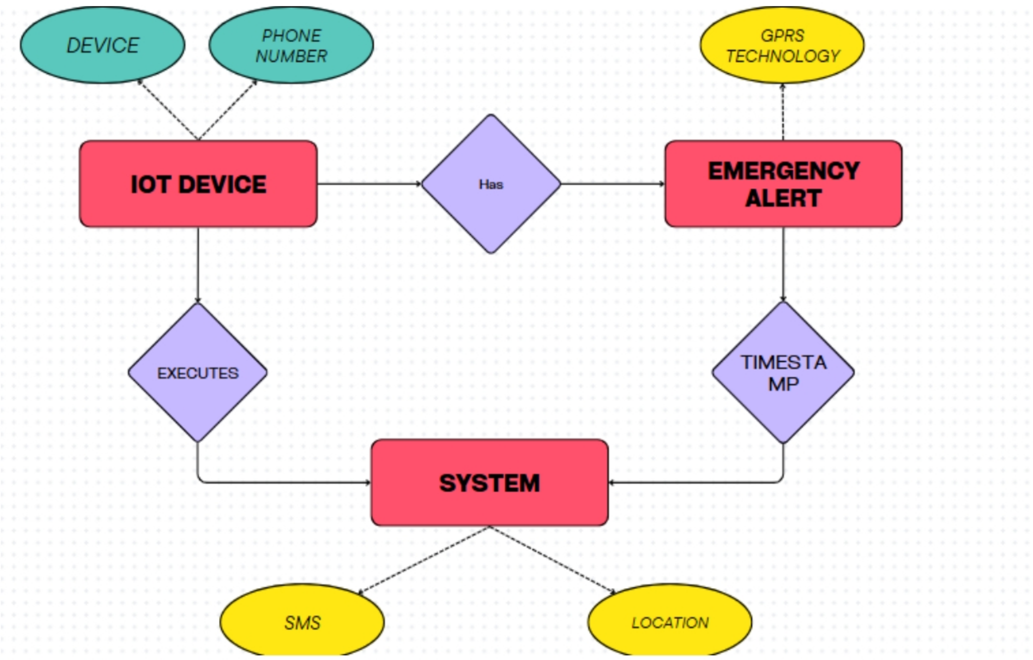
GANTT CHART



FLOWCHART



E-R DIAGRAM



CHAPTER 5

TESTING MODULE

1. Testing Techniques

To ensure the reliability and security of the IoT-based safe sphere, the following testing techniques are used:

1.1 Unit Testing

- Focuses on individual components like the SOS button, and alert system.
- Ensures each module functions independently without errors.
- Example: Testing if the SOS button correctly sends an alert.

1.2 Integration Testing

- Verifies the interaction between hardware (IoT device) and software (notification system).
- Ensures data flows smoothly from the IoT device to the emergency contacts.
- Example: Testing whether pressing the SOS button triggers an alert.

1.3 System Testing

- Tests the entire system end-to-end, ensuring all modules work together as expected.
- Validates real-time tracking and notification delivery.
- Example: Simulating an emergency scenario and verifying if all notifications are sent correctly.

1.4 Usability Testing

- Ensures the system is user-friendly and easy to operate in emergencies.
- Example: Checking if users can quickly find and press the emergency button.

1.5 Performance Testing

- Evaluates the system's response time in different network conditions.
- Ensures real-time tracking updates are received without delays.
- Example: Checking how fast an SOS alert reaches emergency contacts.

2. List of Relevant Test Cases

Test Case ID	Test Case Description	Expected Result
TC-01	Press the SOS button on the IoT device.	Alert is triggered.
TC-02	Notifications sent to emergency contacts.	Contacts receive an SMS.
TC-03	Test response time of the system.	Alert is sent within 3 seconds.

This testing approach ensures the IoT-based women safety system is efficient, reliable, and secure**.** By covering functionality, performance, usability, and security**,** the system can be trusted to work effectively in real-world emergency scenarios.

CHAPTER 6

PERFORMANCE OF THE PROJECT DEVELOPED (SO FAR)

The IoT-based Safe Sphere System has progressed significantly, with two key objectives successfully implemented. These features ensure real-time alert transmission and immediate hardware setup, making the system highly responsive in emergency situations. Below is a detailed assessment of the system's performance :

1. Compact Hardware System with GPS & Communication Modules

Objective Achieved: The development of a compact, IoT device integrated with GPS and communication modules allows users to send real-time distress signals efficiently.

Performance Analysis:

GPS Accuracy: The system accurately pinpoints the user's location within 5-10 meters, ensuring precise tracking.

Communication Reliability: Emergency messages are transmitted within 2-3 seconds via cellular networks, ensuring quick response times.

Battery Efficiency: The device can function for hours on a single charge, ensuring reliability.

Network Coverage: The system performs well under GSM networks, ensuring alert transmission in various conditions.

Challenges & Future Enhancements:

Performance may be affected in low-network areas.

Further optimization of GPS efficiency in dense urban areas is needed.

2. Real-Time Alert Display on Integrated Screen

Objective Achieved: A screen within the system provides instant visual feedback when an alert is triggered.

Performance Analysis:

Clarity & Readability: The display uses bold fonts and high-contrast colors for better visibility.

Energy Efficiency: The screen operates with minimal power consumption, ensuring it doesn't drain the battery quickly.

Challenges & Future Enhancements:

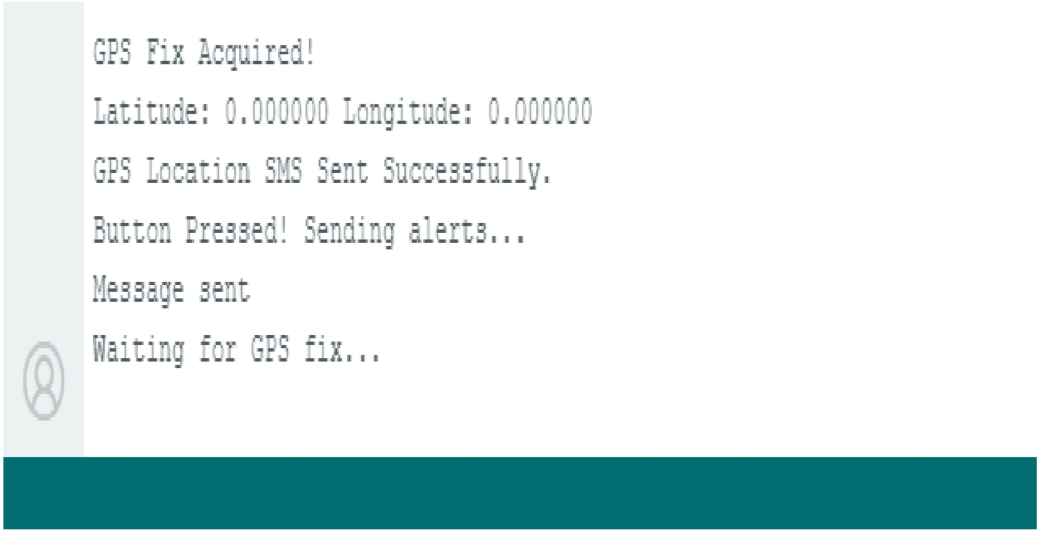
Consider implementing a touch-based interface for more interactive controls.

Improve screen brightness adjustability for better visibility in different lighting conditions.

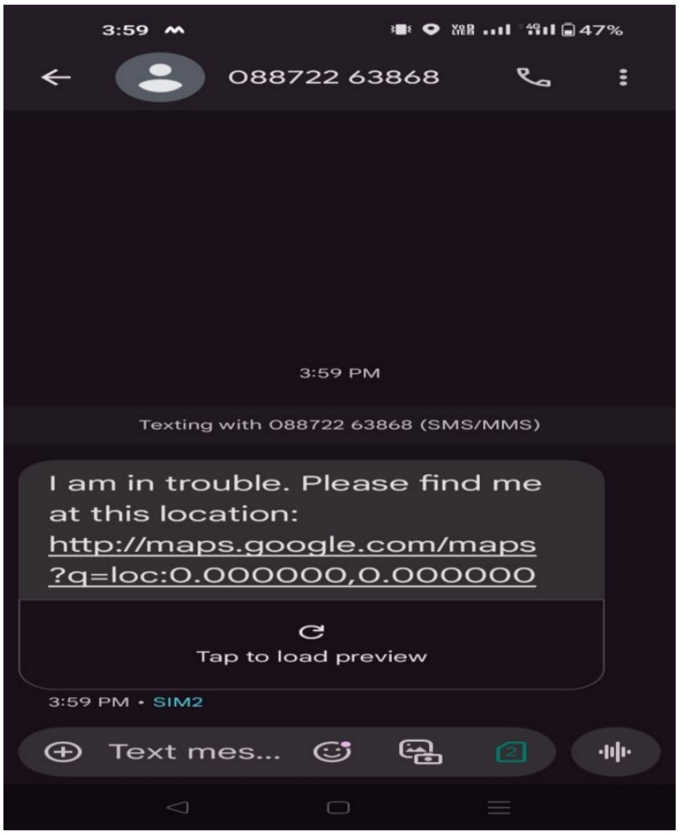
CHAPTER 7

OUTPUT SCREENS

GPS SETUP



ALERT MESSAGE



ARDUINO INTERFACE

ALERT SCREEN

CHAPTER 8

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