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"SahayaNet: An IoT-Based Women Safety System Using BLE and Real-Time Location Tracking"

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Abstract -The alarming rise in crimes against women demands urgent, dependable, and discreet safety measures. This paper introduces SahayaNet, an innovative IoT-based safety system engineered to provide immediate emergency assistance.SahayaNet operates through two core components: a small, low-power wearable device built on the ESP32-C3 microcontroller with Bluetooth Low Energy (BLE), and a dedicated cross-platform mobile application developed using Flutter. When activated, the wearable instantly triggers an SOS alert, communicating with the mobile app. The app rapidly uploads the user's real-time location to Firebase Firestore and alerts both trusted personal contacts and nearby users in the vicinity using GeoFlutterFire for efficient community outreach.Designed for low power consumption, modularity, and easy implementation using open-source tools, SahayaNet offers a reliable, swift, and scalable solution to enhance women's safety through the power of connected technology.

Keywords: women safety, IoT technology, wearable device, Bluetooth Low Energy, cross-platform mobile application, real-time location tracking, emergency assistance system.

1.Introduction

The landscape of modern cybersecurity is unforgiving, and unfortunately, small businesses now find themselves on the front lines, bearing a disproportionate share of cyberattacks. While large enterprises have the capital and dedicated security teams to deploy sophisticated defenses, small businesses face a fundamental dilemma: they desperately need robust protection but are often priced out of the market.

Traditional Web Application Firewalls (WAFs), designed for enterprise environments, are often prohibitively expensive—costing between $50,000 to $500,000 annually—and require specialized technical expertise that small teams rarely possess. This creates a critical security gap where 43% of cyberattacks specifically target small businesses, yet these organizations cannot afford enterprise-grade protection.

The existing solutions offer a frustrating choice: either adopt expensive enterprise platforms that shatter their budget or settle for inadequate free options plagued by high false positive rates (up to 30–40%). Moreover, existing WAFs often rely solely on rule-based detection, which constantly lags behind the creativity of attackers, failing to adapt to evolving threats and requiring constant, manual updates. Adding to the frustration, these older systems typically suffer from slow response times (100–500 milliseconds), which can noticeably degrade user experience and performance.

Advancements in the Internet of Things (IoT) and wearable technology have opened new possibilities for designing automated and responsive safety systems. IoT allows seamless interconnection between physical devices, sensors, and cloud-based applications, enabling real-time data sharing and decision-making. In particular, Bluetooth Low Energy (BLE) has emerged as a powerful technology for short-range, low-power wireless communication, making it ideal for wearable safety devices. By integrating BLE-enabled devices with cloud infrastructure and mobile applications, it becomes possible to create a reliable and scalable safety ecosystem capable of instant communication and location tracking during emergencies.

The proposed system, SahayaNet, leverages these technologies to create an intelligent, fast, and user-friendly IoT-based women safety solution. SahayaNet comprises a BLE-enabled wearable device, built using the ESP32-C3 microcontroller, that can trigger an SOS signal with a single press of a button. Once activated, the device communicates with the user's smartphone application, developed using Flutter, through BLE. The mobile app then immediately shares the victim's real-time GPS location with trusted contacts and nearby users, utilizing Firebase Firestore as the cloud database. To enhance community participation and support, GeoFlutterFire is integrated for spatial queries, allowing the system to detect and notify nearby users who may assist the victim. This approach ensures faster response times by involving both personal and community-level responders

2.Literature Survey

Recent advancements in the Internet of Things (IoT) and wireless communication have motivated researchers to design innovative solutions for women's safety. Several studies have focused on integrating wearable devices, GPS, and mobile communication to enhance emergency response mechanisms.

S. Patel and R. Nair (2022) developed a *Smart Wearable Safety Device using BLE Technology*, designed for short-range communication through Bluetooth Low Energy. The system consists of a wristband connected to a mobile application capable of sending distress alerts within a limited range. It demonstrated effective energy efficiency and minimal delay but lacked long-distance alerting and cloud-based tracking, restricting its use to localized scenarios.

K. Mehta et al. (2023) introduced an *AI-Assisted Women Safety System* that combines IoT sensors with machine learning algorithms to predict distress situations based on motion and sound analysis. The system could autonomously send alerts when abnormal behavior was detected, improving responsiveness in emergency situations. However, its high processing and data requirements increased hardware costs, limiting its implementation for low-power wearable devices.

P. Deshmukh and V. Kulkarni (2023) presented an *IoT-Based Personal Safety Device with Real-Time Tracking* using GPS and Wi-Fi modules for continuous location sharing through a smartphone application. The proposed model successfully reduced manual intervention by automating SOS activation. Despite its accuracy, it relied heavily on Wi-Fi and mobile data, resulting in increased latency and poor performance in areas with weak network connectivity.

R. Singh et al. (2024) proposed a *Cloud-Integrated Emergency Response System for Women Safety* that utilized Firebase for storing live location updates and sending push notifications to predefined contacts. The study demonstrated efficient data handling and low-latency cloud alerts. However, since the system operated exclusively through online services, it failed to provide support during internet disruptions, highlighting the need for offline fallback mechanisms.

M. Thomas and S. George (2024) developed a *BLE-Enabled Smart Band for Women Safety* where a BLE module in a wearable device communicated with a mobile app to send instant SOS messages. The design achieved response times under one second and provided accurate location tracking within a 10-meter radius. Its limitations included a short communication range (limited to approximately 50 meters) and dependency on the paired smartphone's Bluetooth status.

T. Banerjee et al. (2025) designed an *IoT-Based Community Safety Framework* that combined GPS, cloud storage, and geolocation APIs to identify and alert nearby registered users during an emergency. The system emphasized community-driven safety networks and real-time information sharing. Despite its effectiveness in urban tests, it required a significant user base for meaningful results and suffered from privacy concerns in data sharing.

N. Kaur and A. Verma (2025) proposed a *Hybrid IoT–Cloud Women Safety Device* that integrates BLE, GPS, and Firebase for multi-layered emergency communication. The device supported both real-time online alerts and offline SMS fallback to ensure message delivery during poor connectivity. It achieved reliable, fast, and scalable performance across varied environments. However, the hardware design involved multiple communication modules, increasing the overall cost of implementation.

3. Material And Methodology

Materials :

The proposed *SahayaNet* system integrates hardware and software components to ensure fast, reliable, and real-time communication between the wearable device, smartphone application, and cloud database.

Xiao ESP32-C3 Microcontroller: The core component of the system, the ESP32-C3, is a low-power, RISC-V–based microcontroller that supports Bluetooth Low Energy (BLE) communication. It handles SOS button input and transmits alerts to the smartphone app through BLE.

Push Button / SOS Trigger: A tactile push button is attached to the ESP32-C3 to allow the user to manually activate the SOS alert instantly in distress situations.

Power Source (Li-ion Battery): A rechargeable 3.7 V lithium-ion battery powers the wearable, ensuring portability and continuous operation for several hours.

Smartphone (Android / iOS): Acts as the interface between the wearable device and the cloud, receiving BLE data and forwarding it to Firebase servers.

Connectivity Modules: The built-in Wi-Fi and BLE modules of the ESP32-C3 ensure seamless data transfer while minimizing energy consumption.

Software Components :

Flutter Framework: Used for developing a cross-platform mobile application (Android/iOS) with an intuitive user interface for SOS activation, live tracking, and alert notifications.

Firebase Firestore: A real-time NoSQL cloud database that stores user profiles, live coordinates, and emergency status updates.

GeoFlutterFire Library: Enables spatial queries in Firestore, allowing detection and notification of users within a specific radius from the victim.

PROPOSED ARCHITECTURE SYSTEM:

Fig. 1: Architecture Diagram

The proposed architecture of SahayaNet, an IoT-based women safety system, is designed with an integrated three-layer structure consisting of the hardware layer, mobile application layer, and cloud layer, working together to provide instant alerts and real-time location tracking during emergencies. The hardware layer comprises a BLE-enabled wearable device built using the ESP32-C3 microcontroller, equipped with an SOS button and a rechargeable battery. In a distress situation, when the SOS button is pressed, the device communicates with the user's smartphone via Bluetooth Low Energy (BLE), sending an emergency trigger signal.

The mobile application layer, developed using Flutter, acts as the central communication interface. Once the BLE signal is received, the mobile app immediately fetches the user's real-time GPS location and transmits it to the cloud database. It also notifies trusted contacts through SMS or app notifications and simultaneously uses GeoFlutterFire to identify and alert nearby users who can provide immediate assistance. The cloud layer, powered by Firebase Firestore, stores and synchronizes all emergency data in real time, ensuring that location updates and alerts are instantly accessible across devices.

The working of SahayaNet begins with the wearable device remaining in standby mode, continuously paired with the smartphone. On pressing the SOS button, an emergency alert is triggered, initiating BLE communication with the app. The app captures the victim's GPS coordinates, uploads them to the Firebase cloud, and disseminates alerts to both personal contacts and nearby community responders. The victim's location continues to update periodically until the emergency is resolved. This architecture ensures low latency, scalability, and real-time response, enabling both individual and community-level safety intervention effectively.

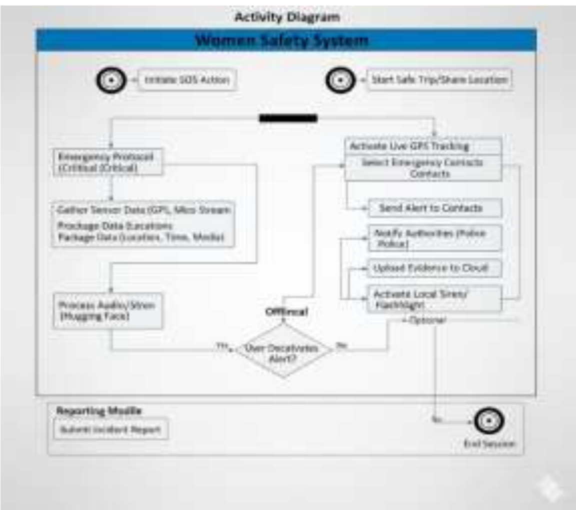

Fig. 2: Activity Diagram

4. Future Scope

The future of SahayaNet—an IoT-based women's safety system—holds immense promise, with numerous opportunities for technological growth and practical implementation. Looking ahead, the system can be significantly enhanced by incorporating artificial intelligence (AI) and machine learning (ML). These technologies could enable the automatic detection of unusual motion patterns, distress in voice, or sudden spikes in heart rate, allowing the system to identify potential threats even before the SOS button is activated.

To improve the accuracy of emergency detection, future iterations could integrate advanced sensors such as accelerometers, gyroscopes, and biometric monitors. Leveraging 5G connectivity and edge computing would also help minimize latency, ensuring rapid data transmission and real-time responsiveness—even in high-traffic network areas.

Beyond core safety features, SahayaNet can evolve to include multi-language voice support, gesture-based panic alerts, and AI-powered route prediction that warns users about potentially unsafe areas using live crime data. Tighter integration with local law enforcement systems and public safety networks could further enhance emergency response and tracking capabilities.

Scalability is another key advantage. The system's architecture could be extended to support community-wide safety networks across urban neighborhoods, campuses, or public spaces—fostering a collective approach to safety through crowd-sourced alerts. Additionally, advancements in wearable technology and low-power IoT chips will likely lead to smaller, more comfortable, and energy-efficient devices, enabling longer battery life and continuous operation.

In essence, SahayaNet has the potential to grow into a smart, responsive, and comprehensive safety ecosystem—one that offers women faster, more intelligent, and more dependable protection in real-world scenarios.

5. Conclusion

To sum up, SahayaNet offers a smart, affordable, and practical solution to the growing safety concerns faced by women today. By combining Bluetooth Low Energy (BLE), GPS, and cloud-based technologies within a Flutter mobile app backed by Firebase Firestore, the system enables quick communication, live location tracking, and instant emergency alerts.

Unlike older systems that depend solely on GSM networks or manual updates, SahayaNet takes advantage of IoT connectivity and community involvement to deliver faster response times and wider coverage. The use of the compact and budget-friendly ESP32-C3 microcontroller also makes the wearable device easy to deploy, even for smaller user groups.

Overall, SahayaNet shows how modern IoT innovations can be used to strengthen personal safety, promote community support, and build a dependable protection network for women. With ongoing research and the integration of AI, advanced sensors, and real-time analytics, the system has the potential to grow into a smart, scalable safety platform with global reach.

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