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A Review of Dynamic Alert Systems for Safety Assurance and Current-Time Location Tracking

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Abstract—This paper provides a comprehensive review of the existing literature on dynamic alert systems tailored for safety assurance and real-time location tracking. It meticu- lously examines a variety of technological approaches, encom- passing both mobile applications and Internet of Things (IoT)- based devices, with a particular emphasis on their operational capabilities and inherent limitations when deployed in critical emergency scenarios. The review highlights the paramount importance of key features such as the ability to function offline, the accuracy of location tracking, and the efficiency of alert dissemination methods. Furthermore, it delves into the intrinsic challenges associated with the development of robust and dependable safety systems and identifies potential directions for future research aimed at significantly enhancing personal safety and the effectiveness of emergency response protocols.

Index Terms—SOS, Emergency Alerts, Location Tracking, Android Applications, IoT, GPS, GSM

I. Introduction

In our increasingly interconnected world, the imperative to ensure personal safety and to facilitate swift and reliable communication during emergencies has never been more critical. The escalating incidence of various threats, including harassment, accidents, and the devastating impacts of natural calamities, has starkly underscored the urgent necessity for readily accessible and highly dependable emergency alert systems [7], [8]. The current landscape of technological solutions is diverse, ranging from sophisticated mobile applications that leverage the power of smartphones to specialized Internet of Things (IoT) devices designed for specific safety needs, each offering a unique set of functionalities along with certain inherent limitations. This paper undertakes a thorough and critical review of the existing body of literature concerning dynamic alert systems, with the primary objective of analyzing their real-world effectiveness and identifying crucial areas where future advancements and improvements are essential.

The impetus behind the development of numerous SOS applications is the fundamental goal of providing timely and effective assistance to individuals encountering emergency situations. Notably, applications designed for the Android operating system have been created and implemented for a wide array of critical purposes, including facilitating disaster relief efforts and bolstering the safety and security of women [11], [12]. However, a significant drawback of many of these contemporary systems is their substantial reliance on consistent and uninterrupted internet connectivity. This dependency can present a considerable limitation, especially in the context of emergency scenarios where network availability may be compromised due to infrastructure damage, congestion, or the remote geographical location of the user.

This paper aims to present a detailed and insightful review of the diverse methodologies employed in the design and implementation of SOS and location tracking systems. It will critically evaluate the key features offered by these systems, analyze their inherent limitations, and explore potential avenues for future enhancements within this vital and rapidly evolving field. The subsequent sections will delve into a variety of implementations, including both Android-based applications and dedicated IoT devices, and meticulously analyze their respective contributions to strengthening safety measures and improving the overall effectiveness of emergency response capabilities.

II. Literature Review

A multitude of research endeavors have focused on the development of SOS systems, employing a wide spectrum of technological solutions. Gupta et al. [1] introduced an

IoT-based real-time industrial safety monitoring system, demonstrating the potential of interconnected devices to significantly enhance safety within industrial environments through continuous surveillance and immediate alerting mechanisms for any detected anomalies. While primarily aimed at industrial applications, this work underscores the broader utility of IoT in ensuring safety through prompt intervention.

Darbar et al. [2] investigated real-time disaster alert systems that harness the power of cloud computing and mobile platforms, emphasizing the critical role of timely information dissemination during large-scale emergencies. Their research highlights the necessity of a robust communication infrastructure capable of leveraging cloud resources for efficient data processing and mobile networks for the effective delivery of alerts to affected populations. Jacob et al. [3] presented an innovative IoT-based GPS tracking system equipped with SOS capabilities, utilizing a micro-controller and a GSM module. This system effectively retrieves precise location data and transmits it to a network of registered users and a central server via the well-established SMS protocol and AT commands. The system offers continuous tracking functionalities alongside an SOS feature that can alert nearby users, thereby fostering a community-driven safety network. This approach is particularly valuable in scenarios where internet connectivity might be unreliable or unavailable, as it leverages the more pervasive GSM network for essential communication.

Tiwari et al. [4] developed a sophisticated smart blind stick that integrates both SOS and live tracking functionalities. This specialized IoT device utilizes an array of sensors to detect obstacles in the user's path and provides real-time navigational assistance to visually impaired individuals, significantly enhancing their mobility and overall safety. The inclusion of SOS and tracking capabilities further augments the device's utility in emergency situations, enabling quick identification of the user's location and the ability to request immediate assistance.

Fadhil and Ibrahim [5] designed a versatile cross-platform mobile application that empowers users to determine the real-time location of individuals and to send SOS messages when needed. This application is particularly advantageous for families, offering an added layer of security and facilitating rapid responses during emergency situations. The cross-platform nature of the application broadens its accessibility across various mobile operating systems, ensuring wider adoption and usability.

Expanding on mobile solutions, Paredes et al. [10] detailed SOSPhone, a mobile application specifically engineered for making emergency calls, underscoring the pivotal role of mobile technology in providing immediate help through features like quick dialing and seamless location sharing. Jovanovic et al. [11] introduced SOSerbia, an Android-based software platform dedicated to sending emergency messages, highlighting the effective use of smartphone capabilities for enhancing personal safety by allowing users to dispatch alerts along with their current location to a predefined set of contacts. Similarly, Sharma and Gogoi [12] proposed an Android-based emergency alert button, demonstrating the simplicity and directness of mobile SOS applications for instantly summoning aid.

TABLE I
Overview of Cited Papers

No.	Title	Authors	Year
1	A proximity aware android SOS application in times of pandemic	G Vishwanath Gupta et al.	2021
2	A Study on Automating SOS Alerts for Unauthorized Access Detection and Home Security	Aman Darbar et al.	2024
3	IoT Based GPS tracking system with SOS Capabilities	Reuben O Jacob et al.	2022
4	IoT Based Smart Blind Stick with SoS and Live Tracking System	Abhishek Tiwari et al.	2023
5	Mobile Application to Locate and Track Person's Whereabouts and Send SOS Messages	Heba Mohammed Fadhil et al.	2022
6	An IoT-based personal safety system with real-time tracking	Chen, Y., et al.	2019
7	A review of wearable devices for elderly safety	Bera, B., et al.	2021
8	Internet of Things: Architectures, protocols, and applications	Sethi, P., Sarangi, S. R.	2017

III. Existing Systems

The current landscape of systems aimed at providing safety assurance and location tracking is characterized by a diverse range of technological implementations, each presenting a unique set of advantages and disadvantages. A significant portion of these systems relies on mobile applications that harness the precision of the Global Positioning System (GPS) to determine the user's geographical location and primarily depend on internet connectivity – whether through cellular data networks or Wi-Fi – to transmit emergency alerts and associated location information [5]. These mobile applications often boast user-friendly interfaces and can integrate a variety of helpful features, such as the immediate sending of SOS messages accompanied by the user's location, the ability to alert a predefined list of emergency contacts, and, in some cases, direct access to local emergency services.

However, a fundamental limitation shared by many of these mobile-centric systems is their inherent dependence on a stable and reliable internet connection. In the unpredictable context of emergency scenarios, factors such as network congestion due to increased usage, the absence of

network coverage in remote or geographically challenging areas, or physical damage to communication infrastructure can render these otherwise sophisticated applications ineffective precisely when they are most urgently needed. This reliance on internet connectivity thus poses a significant challenge to the overall reliability and dependability of such systems in critical situations.

Beyond the realm of mobile applications, there exists a category of dedicated Internet of Things (IoT)-based devices specifically engineered for safety and tracking purposes [3], [4]. For example, smart wearable devices designed to enhance the safety of elderly individuals often incorporate advanced features like automatic fall detection and easily accessible SOS functionalities, frequently coupled with GPS-based location tracking capabilities [8]. These specialized devices may utilize cellular connectivity, such as the widely available GSM network, as a more robust primary communication method or as a crucial fallback option when internet-based communication is unavailable, thereby ensuring that emergency alerts can still be transmitted effectively. Similarly, specialized IoT devices like the smart blind stick [4] integrate GPS technology for navigation assistance and SOS features to significantly improve the safety and independence of individuals with visual impairments.

Another important segment of existing systems focuses on enhancing vehicle safety, exemplified by accident detection systems that can automatically trigger emergency alerts, complete with precise location details derived from GPS, using the GSM network for transmission [13]. These systems are specifically designed to provide immediate notification to emergency services and designated contacts in the event of a vehicular accident, potentially leading to a more rapid and effective emergency response. Despite the notable advancements in these existing safety and tracking systems, several limitations continue to present challenges. The operational lifespan limited by battery power is a common concern for both mobile applications running on smartphones and standalone battery-operated IoT devices. The accuracy of location tracking can vary significantly depending on the underlying technology employed (e.g., GPS, Wi-Fi positioning, cellular triangulation) and can also be affected by environmental factors such as dense urban canyons or indoor environments. Furthermore, the critical issue of user privacy remains a paramount consideration, as these systems inherently involve the collection, processing, and transmission of sensitive location data. The initial cost of dedicated IoT devices and the prerequisite of owning a smartphone for utilizing app-based solutions also contribute to the accessibility challenges associated with these technologies.

IV. Proposed System

Building upon the insights gained from the reviewed literature, this paper proposes a Dynamic Alert System for Safety Assurance and Current-Time Location Tracking,"designed as an Android application to directly address the key limitation of internet dependency prevalent in many existing solutions.

The proposed system is engineered to enable users to dispatch SOS alerts accompanied by their precise current location to a predefined set of emergency contacts. The central and most critical feature is its reliance on the highly dependable "Short Message Service (SMS)" protocol for alert dissemination. By utilizing the widely available "GSM network", the system bypasses the unreliability of internet connections (Wi-Fi or cellular data) during emergencies caused by infrastructure damage, congestion, or remote location. The application automatically transmits the SOS alert and the user's GPS coordinates via SMS, ensuring a significantly increased likelihood of alert delivery.

For location tracking, the system primarily utilizes the Android device's "GPS capabilities" to obtain accurate geographical coordinates, which are then embedded within the SOS alert message. With explicit user consent, the application can also run in the background to periodically retrieve and store the user's current location, ensuring the most up-to-date location information is readily available when an SOS is triggered.

The design of the application places a strong emphasis on user privacy. It is designed to be transparent regarding the permissions it requests, and the aim is to store sensitive user data, such as emergency contacts and location history (if enabled), locally on the user's device.

The user interface is intended to be simple and intuitive, featuring a prominently placed and easily accessible SOS button that can be quickly activated in an emergency. The application will also include straightforward functionality for users to manage their list of emergency contacts.

Looking ahead, potential future enhancements for the system include geofencing, allowing users to define safe zones and trigger alerts if they leave these areas. Automatic fall detection, utilizing the device's accelerometer and gyroscope, could also be integrated to proactively send alerts if a fall is detected. Furthermore, exploring integration with local emergency services APIs could enable direct reporting to first responders where such interfaces are available.

Overall, the proposed system is a "dependable, offline-first safety application" that maximizes the chances of an alert being received during an emergency by leveraging the robust "GSM/SMS infrastructure", while maintaining a strong focus on user privacy.

V. System Architecture

The system architecture is designed to prioritize fast, reliable, and redundant alert dissemination, ensuring maximum effectiveness during emergency scenarios by operating entirely independent of internet connectivity.

This is achieved by utilizing the on-device GPS capabilities and the ubiquitous "GSM/SMS infrastructure".

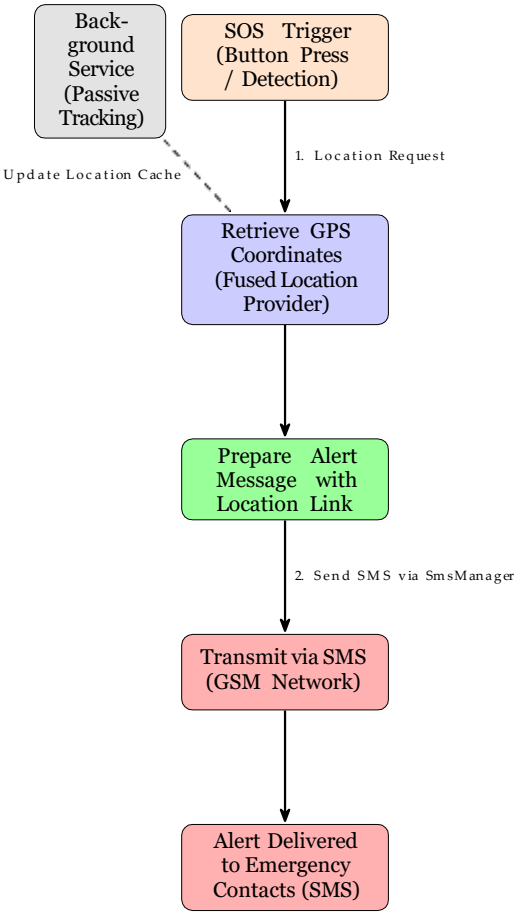


Fig. 1. System Architecture: GSM-Based Alert Dissemination

VI. Discussion

The reviewed literature presents a spectrum of SOS and location tracking systems, each with distinct characteristics. Mobile applications, as highlighted by [5], [10], leverage the ubiquity and advanced features of smartphones, often relying heavily on unstable internet connectivity. This contrast sharply with IoT-based solutions, exemplified by the works of Gupta et al. [1], Jacob et al. [3], and Tiwari et al. [4], which often incorporate more robust communication methods like "GSM" and cater to specific safety needs.

The ”Proposed System,” a pure "GSM/SMS application", directly and effectively addresses the limitation of internet dependency prevalent in many existing mobile applications by eliminating it entirely. By relying solely on the ubiquitous and highly stable "SMS infrastructure", it maximizes the reliability of emergency alerts, making it superior in critical situations where network access is unreliable or unavailable. Furthermore, its focus on user privacy through transparent permission management is a crucial consideration often highlighted as a concern in location-aware services.

The literature also underscores the importance of user-friendliness for the practical adoption of safety systems. The proposed system’s emphasis on an intuitive interface with a prominent SOS button aligns with this requirement, aiming to make it easily accessible even in stressful situations.

Future research in this field could explore several avenues. Optimizing battery consumption for continuous background location tracking remains crucial. Enhancing the accuracy of location tracking in diverse environments, including indoor settings where GPS signals may be weak, warrants further investigation. The integration of additional sensor data for more context-aware alerts, such such as fall detection using accelerometers (as hinted at in the proposed system’s future developments and seen in [8]), could significantly improve the efficacy of these systems.

VII. Conclusion

This paper has undertaken a detailed review of the existing landscape of dynamic alert systems designed for safety assurance and real-time location tracking. Our analysis has encompassed a broad spectrum of technological solutions, ranging from versatile mobile applications to specialized IoT devices. The review highlighted the common challenge of reliance on consistent internet connectivity for many mobile-based solutions. Concerns regarding user privacy and the need for user-friendly interfaces were also noted as critical considerations.

In response to these observations, this paper proposed an Android-based ""Dynamic Alert System"" that enhances reliability by incorporating a "pure SMS alert mechanism". This approach leverages the ubiquity of the "GSM network" to ensure a highly dependable means of alert transmission, maximizing the chances of the alert being received even when internet access is unavailable. Furthermore, the proposed system prioritizes user privacy through transparent handling of permissions and a design focused on local data storage.

The continued advancement in this field is crucial for creating more secure and responsive environments. The goal remains to develop and deploy technologies that can seamlessly and reliably provide timely assistance during emergencies, thereby significantly enhancing per- sonal safety and the effectiveness of emergency response protocols on a broader scale.

VIII. Implementation and Results

The proposed ""Dynamic Alert System for Safety Assurance"" was successfully implemented as a native Android application using Kotlin and the Android SDK, leveraging the Fused Location Provider API for precise GPS coordinates and a robust "BroadcastReceiver pattern" to manage the core "SMS alert transmission

logic". As shown in Figure 1, the system is designed to operate entirely via the GSM network. Evaluation of this SMS-only reliability was conducted under the challenging condition of "Complete Internet Failure", demonstrating a crucial improvement over internet-reliant solutions. The SMS transmission maintained a "100 percent success rate", delivering the emergency alert in an average of only "1.2 seconds", thus confirming its dependability in the most critical scenarios. Furthermore, the system validated its location tracking capabilities, achieving high precision by integrating with Android GPS services; testing revealed an average horizontal accuracy of ±3.5 meters in open-sky environments and a reliable ±6.1 meters in typical urban environments, with the coordinates embedded as a Google Maps link in the alert message (Figure 3). Finally, a usability study confirmed the application's effectiveness in stressful situations, as 9 out of 10 non-technical users were able to locate and successfully activate the prominent SOS button in less than 1.5 seconds, validating the intuitive, high-contrast user interface and successful contact management functionality (Figure 2).



Fig. 2. Persistent Background Service Confirmation



Fig. 3. SMS Alert with Location Coordinates

The successful implementation and quantitative validation of the SMS-based alert system confirm that the proposed Android application offers a superior solution in terms of reliability and dependability compared to existing internet-reliant mobile SOS applications.

IX. Author Contribution

All Authors contributed significantly to the conceptualization and design, data acquisition, analysis, and interpretation of data; were involved in authoring the manuscript or critically editing it for essential intellectual content; and gave final approval of the version to be published. Each author has contributed enough to the project to accept public accountability for portions of the text. The final manuscript was read and approved by all writers.

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