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IoT-Enabled GPS Tracking System for Monitoring the Safety Concerns of School Students

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ABSTRACT

In today's world, reports of child abduction or attempted abduction are alarmingly frequent. With parents' hectic work schedules, children often travel to and from school alone, either by walking, biking, or taking school buses. This project proposes an Internet of Things (IoT) GPS tracking system to aid parents monitor their children's safety during these commutes. The system is designed for children between the ages of 4 and 10 and uses an Arduino Uno device placed in the child's school bag. This allows parents to track their child's real-time location movement through a mobile application. One of the key benefits of this system is the ability to monitor multiple children at the same time using the app. Otherwise, if the device remains stationary in an unusual location for a prolonged period, the system will automatically send an alert to the parents. This feature ensures that parents are promptly notified if their child's device is not moving as expected, potentially indicating a problem or emergency. The main objective of this proposed IoT solution is to give parents peace of mind and a way to take quick action if any worrying situations occur during their children's journeys to and from school. By leveraging advanced technology, this system will also authorize parents to stay connected and related to their children and respond swiftly to any potential threats to their safety.

1. Introduction

In the last twenty years, the problem of missing and exploited children has become a significant concern for the public [1,2]. In addition, the child's safety is crucial for their development and well-being. Ensuring their safety is a shared responsibility among parents, caregivers, and society [3]. The International Center for Missing and Exploited Children (ICMEC) defines a "missing child" as anyone

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under 18 years old whose location is unknown. The ICMEC classifies missing children's cases into different categories, such as family abductions, where a parent, family member, custodian, or agent unlawfully takes, keeps, or hides one or more children in violation of custody arrangements. Another category is the runaway child, where a minor leaves home voluntarily without their parent's permission or knowledge. The major concern of missing and exploited children is a critical societal problem that requires thorough investigation and the creation of preventive measures to protect this vulnerable group [4].

The effects of child exploitation and disappearances can be devastating, with potentially long-term psychological, emotional, and physical consequences for the victims and their families [5]. Furthermore, several studies [3-5] have shown that psychological injuries inflicted on individuals during childhood, resulting from such injurious events, can significantly impact personality development and potentially lead to personality disorders [6]. Children who go missing face a higher risk of harm, including physical and sexual abuse, human trafficking, and exposure to unsafe situations [7]. Furthermore, the emotional effect on families dealing with a missing child can be enormous, causing feelings of anxiety, guilt, and also trauma [8].

Combining the traditional efforts to tackle child exploitation and disappearances with the insights from the study on human trafficking and modern slavery in Indonesia, it becomes clear that a multi-faceted approach is necessary to effectively address this problem [9]. Law enforcement agencies, community organizations, and government initiatives have been focusing on raising awareness, improving response protocols, and providing support services [10]. However, the study highlights the need for a more comprehensive strategy that conceives the legal, sociological, and practical aspects of combating human trafficking and modern slavery [11]. Nevertheless, with the rapid development of technology, innovative solutions using emerging technologies, such as the Internet of Things (IoT) and Global Positioning System (GPS) tracking, have the potential to contribute to child safety and prevention efforts [12]. Positioning systems in preschool education research provide objective data on children's behavior, location, physical activity, and social interactions, offering new research possibilities [13].

This article explores the development and implementation of an IoT-enabled GPS tracking system designed to enhance the monitoring and safety of school-aged children during their commutes to and from educational institutions. The Internet of Things (IoT) technology has revolutionized the way GPS devices collect and transmit data, allowing them to connect seamlessly with other systems. This advancement has significantly improved the quality and functionality of modern tracking devices, enabling them to gather and transfer a wide range of vehicle data, such as fuel consumption, remote temperature, and driver identification. As more parents embrace technology in their daily lives, ensuring their children's safety has become a top priority. To address this concern, a school children's safety monitoring system (SCSM) using IoT GPS tracking has been developed to assist busy parents in monitoring their children's well-being as they travel between home and school.

This paper is structured as follows: Section 2 explores the existing literature on children's safety monitoring systems that utilize IoT GPS tracking technology. Section 3 delves into the research methodology employed in this study. Section 4 introduces the proposed solution, the School Children Safety Monitoring (SCSM) system. Lastly, Section 5 presents and analyzes the results obtained from the implementation of the proposed system.

2. Literature Review

Personal safety devices are common and come in various forms [14]. However, there is a need for simple, effective systems and devices that allow a supervisory individual, such as a parent, to quickly locate a monitored individual, such as a child, when necessity[15]. Furthermore, if a safety issue arises, a signal must be sent to an operator to take appropriate action or act automatically. Tracking systems are used to monitor the locations of people or objects, whether they are moving or stationary, and periodically provide a sequence of location data to a monitoring system [16].

GPS technology allows for precise tracking of children's location and movement, providing objective data that can enhance the understanding of their behaviour, physical activity levels, and social interactions in the context of child safety monitoring systems. By leveraging the accuracy and reliability of GPS, researchers and developers can create more effective solutions to ensure the well-being of children, complementing traditional methods such as accelerometers and subjective observations [13].

In addition, the safety and well-being of children have become a pressing concern as reports of crimes against children continue to rise at an alarming rate. Parents, caregivers, and society are grappling with the urgent need to find effective solutions to protect children from various threats, both in the physical world and the digital realm [17]. In addition, increasing prevalence of child abduction, exploitation, and abuse has left communities feeling vulnerable and desperate for ways to keep their children safe [18]. The emotional toll on families dealing with a missing or harmed child is immeasurable, leading to profound trauma and long-lasting psychological scars. The impact of these crimes extends beyond the individual child, affecting entire families and communities, and undermining the very fabric of society.

One promising avenue is the use of advanced technology, such as GPS tracking devices and mobile applications, which can assist parents keep tabs on their children's whereabouts and alert them to any unusual or suspicious activities[19]. By leveraging the power of real-time data and instant communication, these tools can provide a vital lifeline for families, enabling them to respond quickly and effectively in the event of an emergency. However, more than technology is needed [20]. The parents also must focus on education and awareness campaigns to empower children with the knowledge and skills they need to recognize and report potential dangers [21]. This includes teaching them about stranger danger, online safety, and trusting their instincts when something doesn't feel right. By fostering open communication and creating a supportive environment where children feel heard and protected, we can help them build the resilience and confidence they need to navigate an increasingly complex and threatening world.

3. Methodology

The School Children Safety Monitoring (SCSM) prototype was developed using the prototyping model, which is a software development approach that involves creating, testing, and refining a prototype until it meets the desired requirements [22]. This methodology was chosen for the SCSM project because it provides a solid foundation for producing the final system or software.

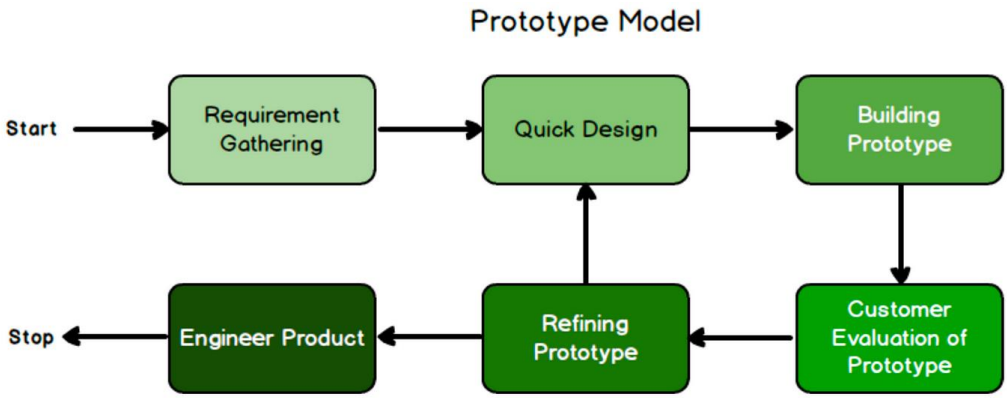

Fig.1. Prototyping model for GPS tracking system for monitoring the safety concerns of school students

The prototyping model depicted in Figure 1 is a tremendous way for developers to bring their ideas to life and get valuable feedback from users early on in the development process. With the School Children Safety Monitoring (SCSM) system, creating a prototype allows the development team to have a tangible representation of their vision, rather than just relying on written ideas or concepts that might be hard to picture.

One of the coolest things about using the prototyping model is that it lets developers catch any potential problems or missing features early on before they become bigger issues down the road. It's like having a crystal ball that shows you the future, so you can make changes and improvements before it's too late. This hands-on approach is a game-changer because it reduces the risk of costly mistakes or delays that could derail the entire project. Furthermore, the prototyping model encourages active user involvement throughout the development cycle. By allowing users to test and provide feedback on the prototype, developers can ensure that the final system meets the users' expectations and requirements.

This collaborative approach helps to build trust and confidence in the system, as users feel that their input is valued and incorporated into the final product. In other words, in the case of the SCSM project, using the prototyping model allowed the development team to create a functional prototype of the safety monitoring system, which could be tested by parents, school administrators, and other stakeholders. Through multiple iterations of testing and refinement, the prototype was improved until it reached a level of functionality and usability that was deemed acceptable by the users. In addition, by following the prototyping model, the SCSM project not only created a working prototype but also established a strong foundation for the development of the final system. The insights gained from user feedback and the lessons learned during the prototyping process can be applied to the subsequent stages of development, ensuring that the final SCSM system is robust, user-friendly, and effective in promoting the safety of school children.

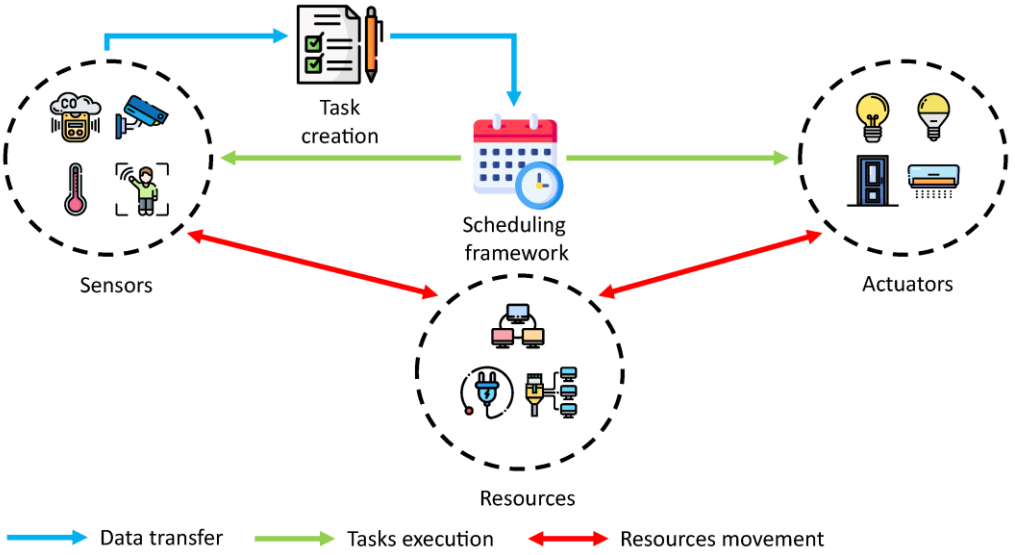

Fig. 2. An overview of the smart office system [23]

The main reason why this scheduling framework is particularly suitable for the SCSM system is that it allows for efficient and timely processing of the large amount of data generated by the sensors depicted in Figure 2. In a system designed to ensure the safety of children, any potential threats or anomalies must be detected and addressed promptly. Therefore, by employing a scheduling framework that prioritizes tasks based on their urgency and optimally allocates resources, the SCSM system can respond to emergencies in real-time, minimizing the risk to children's safety [24]. Moreover, the framework's ability to handle a high volume of tasks ensures that the system remains responsive and effective even during peak hours when many children are commuting to and from school. In summary, the scheduling framework presented in the figure is well-suited for the SCSM system as it enables the efficient processing of sensor data, timely execution of critical tasks, and prompt activation of appropriate safety measures, ultimately contributing to the overall goal of ensuring the well-being of school children.

4. Proposed Work

This section outlines the design and development process of the School Children's Safety Monitoring System using IoT GPS Tracking (SCSM). The project utilizes Arduino Uno and U-Blox NEO-6M GPS Module to create the GPS Tracker. Arduino Uno is a low-cost, high-quality hardware platform that enables the GPS Tracker to be monitored through a mobile application. The Arduino Create environment was used for writing code and configuring the board.

During this phase, the user-friendly interfaces for the SCSM mobile application were designed. The mobile application was developed using Android Studio, a powerful and feature-rich integrated development environment (IDE) for creating Android apps. Before proceeding with the actual user interface (UI) development, a mock UI was created using various design tools such as Canva, Adobe Photoshop, and Adobe Illustrator. These tools allowed for the creation of visually appealing and intuitive UI designs, ensuring a seamless user experience. The Arduino Uno is an open-source hardware and software development platform that offers a wide range of possibilities for creating interactive projects. The combination of Arduino boards, the Arduino programming language, and the Arduino software for development made the creation of the SCSM IoT GPS Tracker possible. The

Arduino ecosystem provides a user-friendly environment for writing code, uploading it to the board, and testing the functionality of the GPS Tracker.

The U-Blox NEO-6M GPS Module was chosen for this project due to its ease of use and user-friendly nature. This module is a highly reliable and accurate GPS receiver that can provide precise location data, making it an ideal choice for the SCSM system. The NEO-6M module communicates with the Arduino Uno board, allowing the GPS Tracker to determine its location and transmit the data to the mobile application for real-time monitoring. By leveraging the capabilities of Arduino Uno, the NEO-6M GPS Module, and the carefully designed mobile application, the SCSM system provides a comprehensive solution for ensuring the safety of school children. The combination of hardware and software components enables parents and school authorities to track the location of children in real time, receive alerts in case of any deviations from the expected route, and take prompt action if necessary. The user-friendly interfaces of the mobile application ensure that users can easily navigate and interact with the system, making it accessible to a wide range of users, regardless of their technical expertise.

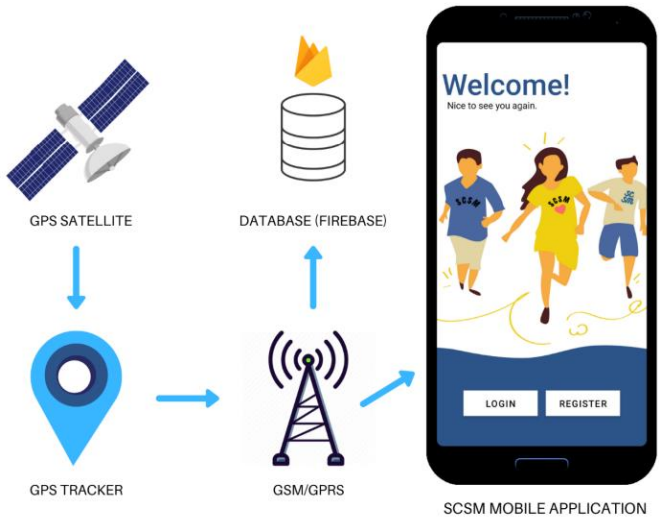

Fig.3. Proposed framework and overall architecture

5. Results and Discussion

As part of the study, a questionnaire was distributed to parents and caregivers of school children aged 4 to 10 years old to gather valuable insights into the usability of the School Children Safety Monitoring (SCSM) system. The questionnaire was conveniently shared via Google Form, allowing respondents to easily access and complete the survey at their own pace. The Likert scale, a widely used and reliable measurement tool, was employed to assess the respondents' opinions and experiences with the SCSM system. This scale typically presents a series of statements or questions, asking participants to indicate their level of agreement or disagreement on a five-point or seven-point scale, ranging from "strongly disagree" to "strongly agree."

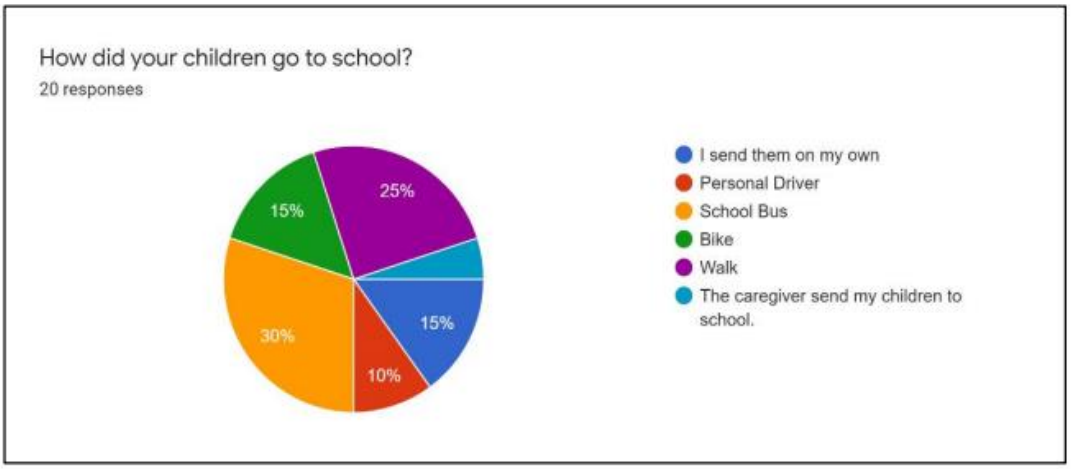

Fig.3. The respondents' children's ways to go to school

The overwhelming majority of children expressing a desire to learn suggests that the surveyed population places a high value on education and considers it as a means for personal growth and development. The relatively small percentages for other reasons, such as parental influence or free meals, indicate that while these factors play a role in school attendance, they are not the primary drivers for most children. The presence of a segment staging children who do not like going to school highlights the need for educators and school systems to focus on creating engaging, inclusive, and supportive learning environments that cater to the diverse needs and preferences of students.

In conclusion, Figure 3 furnishes a snapshot of the primary reasons why children go to school, with a strong emphasis on the desire to learn. However, it also reveals the presence of other motivating factors and challenges that should be considered when designing educational policies and practices to ensure that all children have access to a high-quality, engaging, and supportive learning environment.

6. Conclusion

The development of the School Children Safety Monitoring (SCSM) system represents a significant step forward in addressing the critical issue of child safety, particularly for those aged 4 to 10 years old. The system's potential for commercialization is evident, as it offers a practical and effective solution to the growing concerns of parents and caregivers who want to ensure the well-being of their children during their daily commutes to and from school. Furthermore, the positive feedback received from the target users through the questionnaire highlights the SCSM system's ability to enhance the feeling of security among parents and caregivers. This increased sense of security is crucial, as it can help alleviate the anxiety and stress that many parents experience when their children are out of their sight. By providing real-time information on the location and status of their children, the SCSM system empowers parents to take a more active role in ensuring their children's safety. Moreover, the development of the SCSM system has the potential to foster a stronger emotional connection between parents and their children. When children feel that their parents are actively involved in protecting their safety, it can lead to increased trust, communication, and overall relationship quality. This emotional bond is essential for the healthy development of children and can have a lasting positive impact on their lives.

However, it is important to recognize that the SCSM system is not a standalone solution to the complex issue of child safety. To achieve the final objective of creating a safe and secure environment for school children, both parents and children must take responsibility and actively participate in the process. The SCSM system should be viewed as a tool that complements and enhances the existing safety measures and practices, rather than replacing them entirely. Parents and caregivers must continue to educate their children about personal safety, stranger danger, and the importance of following established rules and guidelines. They should also maintain open lines of communication with their children, encouraging them to share any concerns or incidents that may occur during their daily routines. By fostering a culture of safety awareness and proactive communication, parents can help their children develop the skills and confidence needed to navigate potential risks and challenges.

Similarly, children must be empowered to take an active role in their safety. This can be achieved through age-appropriate education and training programs that teach children how to identify and respond to potentially dangerous situations. By equipping children with the knowledge and tools to protect themselves, we can help them build resilience and self-confidence, which are essential for their overall well-being and success in life. In conclusion, the development of the SCSM system represents a significant milestone in the ongoing effort to ensure the safety and well-being of school children aged 4 to 10 years old. While the system has the potential to provide a valuable tool for parents and caregivers, it is crucial to recognize that child safety is a shared responsibility that requires the active participation and commitment of all stakeholders. By combining the use of innovative technology with a comprehensive approach to safety education and awareness, we can create a safer and more secure environment for our children, both now and in the future.

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