Child Tracking and Activity Scheduling System

ABSTRACT

In recent times it has been observed that mostly both the parents are working and the child is either in the crèche or with a caretaker at home. In either case, the security of the child remains a concern as due to even small negligence there could be dangerous consequences. The concern is greater when the parents may not be at a reachable location. It is the responsibility of the government, people, and parents to ensure every child's safety and wellbeing. The smart city initiative in Sultanate of Oman emphasizes making the cities, health services, homes, etc., capable of providing a good and safe lifestyle to people by all means, particularly aided by technology. In line with this initiative, the authors have proposed an integrated smart system to track the location of the child remotely as well as to organize and keep a watch on the child's routine vocational, educational or recreational activities that contribute to the overall growth of the child – a task often too difficult for parents with over congested schedule to manage where forgetting a doctor's appointment for the child or preparing the child for the test is all too common. The system also allows the child to send SOS messages remotely to parents or guardians if he/she feels insecure or threatened such as in the case when left onboard a bus alone – a case all over the globe including Oman. Thus, this system could potentially save the lives of young children as well as mentally disabled or elderly. The system comprises hardware and software components. The hardware can be embedded in the shoes or worn as a wristband by the child while the application is an Android application that connects the system using a cloud-based database. The hardware component uses the internet to send location data to be recorded on the database or could use SMS instead to directly inform parents if the network is too weak.

Keywords – Child safety, tracking system, scheduling system, smart parenting, SOS message

Introduction

"Children are the future of every nation" is a popular saying around the globe. Although it is primarily the responsibility of parents and caregivers to keep the children safe, society and the government are equally responsible. In most nations, the lives of children today are much safer than they once were. However, that is not the case globally as there exists a few nations where the lives of children are being threatened. Excluding any threats from events such as wars and conflicts, poverty, famine, and diseases, children's lives are still at risk from kidnapping, child trafficking, accidents, and similar issues. While kidnapping and child trafficking are often found in underdeveloped countries and remote locations, the latter is a global case.

According to BBC (2021) and DW (2021), even as recent as March 2021, kidnapping has been a severe threat to many Nigerian school children where a total of 769 students have been abducted since December 2020 (Iyorah 2021). As per DW Documentary (2018), child trafficking is part of a large network of black markets in China. Since most people live in safer countries or places like Oman, child safety is often taken for granted. However, the threat to child safety is not merely in Nigeria and China, but that is simply a minuscule fraction of the reality oblivious to most of us. According to CDC (2020), every year nearly one billion children fall prey to violence all of whom are between the ages of 2 and 17. Among them, millions are prey to School-Related Gender-Based Violence (UNESCO 2019). According to International Labour Organisation (ILO), more than 150 million children and teenagers are prey to child labor around the globe, usually through trafficking and bondage (Al Jazeera English 2019). In India alone, this figure stands at more than 10 million who are between the ages of five and fourteen. Considering the global population of children, which is about two and a half billion, the figures are alarmingly high.

In addition to the above, a far more common threat to children is accidents. For example, in Oman alone within the past 12 months, motor vehicle accidents were the cause of extreme injury to 11.9% of all students and 12.6% of those between ages 13 and 15 (CDC 2016). Other than these, sometimes even simple events like a child being left accidentally in a school bus can be a reason for a child's death (Oman Observer 2019a). For example, in 2019 a four-year-old child was rushed to hospital in a dire situation after being accidentally stranded in a school bus for just a few hours (Oman Observer 2019).

Events like these often trigger fear, anxiety, and perhaps phobia among concerning parents and guardians. The situation is even more disturbing to parents who need to stay away from home due to work or for example when the school is too far from home and their child needs to travel alone. Parents and guardians living in countries where the threat to children is high might even hesitate to send their children to school or even to a neighboring shop. In certain cases, this fear might even discourage them to take up a type of job and force them to seek an alternate one.

This paper aims to address these problems so that parents can know when and where their child is at any given time thereby reducing the fear and anxiety about the child's safety and providing a means to protect him/her. In addition to that, it also aims to address another common problem. That is, parents and guardians who are for instance disabled or are often overwhelmed with work and other worrying matters fail to maintain their attention towards the child's need and hence fail to keep their child's life organized. Hence, for example, a child might therefore miss a doctor's appointment, the deadline to apply for a training program, prepare for an upcoming exam or fail to take part in a recreational activity. These problems are quite very common in the busier lifestyle of the current generation. Therefore, the goal is to provide a tool that addresses both these problems so that parents can be less stressed about their child. This tool is the "Child Tracking and Activity Scheduling System" – an IoT (Internet of Things) based system to track the child's real-time location using an Android mobile application. The mobile application can be used to view the location of the child as well as to schedule the daily activities of the child so that parents/guardians can keep track of what activity is done and what needs to be done.

This paper presents an architectural design of the system and how it can be developed. The following section of this paper looks into related works by other scholars. The rest of the paper then looks into the architecture of the system, methodology to develop the system, and enhancements that could be made in the future.

Related Work

Similar systems have been designed, proposed, or developed by several scholars and are available in literatures.

A system proposed and developed by Jisha et al. (2018) uses an Android application to track and monitor children. The application is to be installed on a smartphone and eliminates the need for further hardware. The system relies on the smartphone's built-in GPS and GPRS technology to provide the location of the bus. The system is used by four types of users. Firstly, the administrator manages all clients and activities. Secondly, a faculty marks the presence of children in the bus and monitors them. The third is the driver who drives the bus and turns on/off the transmission of the current location of the bus. The fourth type of user is the parents who uses the application to check the presence of their child on bus and the real-time location of the bus. The live location of the bus is recorded on Firebase and a Google Maps API is used by the application to display them. Data such as bus routes and attendances are also stored in the cloud to make them accessible to all users.

Wu et al. (2019) developed a system to track a child/elderly while indoor or outdoor. When indoor, the system (smartphone) uses Wi-Fi and iBeacon technology. For outdoors, GPS technology is used. The tracking mobile device sends the current location via SMS on receiving an SMS request. According to Wu et al., the primary advantage of this system is that it does not require internet access as it only sends location via SMS.

Dsouza et al. (2018) proposed a Child Security System that uses GPS and RFID technology. The authors believe that this system is an improvement to the currently available system. The GPS technology used here allows parents to obtain real-time location and enforce geofencing. Whereas, the RFID readers are placed in school and school buses so that the child can swipe his/her unique RFID card. In doing so, the reader instantly informs parents about their child such as when he/she enters the school. Simultaneously, this data is also recorded on a database owned by the school. Parents or guardians are informed about the location of the child via SMS. For the system to achieve this, it relies on two GSM modules – for GPS and RFID each. The tracking component carried by the child also contains a 'panic button' using which the child can immediately notify parents in case the child feels threatened.

The idea proposed by Mori et al. (2011) however is different compared to many and is based on tracking a group of children rather than an individual child. Mori et al. propose that every child must carry a computer such as a smartphone with WLAN capability. The computers of the children in a group then form a mesh network or cluster – an ad hoc network with multi-hop functionality. The cluster consists of a cluster head to look after all the other computers in the cluster. Security is enforced by the use of a PIN which is required to pair with other devices via Bluetooth. On the way to school, there exist several tags on different locations. When the group of children or the cluster arrives closer to the tag, the tag communicates with the cluster head and obtains all necessary information

about the children in the group. This information is then sent to a server where it is recorded and can be obtained to track the group of children. By placing several tags on the way to school, the location of the group and time the time they reached the tag can be easily tracked using this Autonomous Clustering technique. According to Mori et al., this system, therefore, provides the ability to manage many children efficiently. It is also easy to implement and add functions and is also suitable for children who travel to school by walking.

Madhuri, Gill, and Khan (2020) proposed the use of IoT cloud platforms, GPS technology, and Android mobile application to develop a child tracking system that is easy, cost-effective, and scalable. The system alerts the parents if the child crosses the defined safe zone. The authors believe that this feature of the system would help monitor children in mass gatherings. In that case, the authors suggested the use of a dedicated team to manage the system and provide the parents with an android application and a tracker for the child to wear.

System Architecture

The aim is to develop a system that allows parents/guardians to track the child's location in real-time as well as keep track of their child's routine activities/tasks. To achieve this, the system is composed of a hardware component and a software component. The hardware component is an Arduino-based system which is a tracker that the child is obliged to carry. The software herein is an Android-based mobile application used by the parents to view the location of the child and schedule tasks that the child must do. Figure 1 shows a high-level overview of the system.

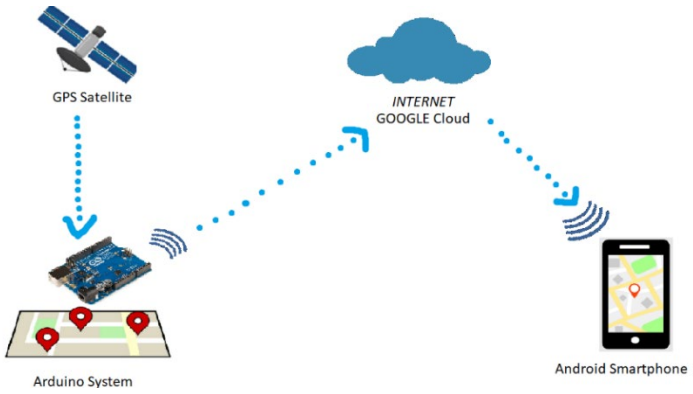

Figure 1. High-level overview of the system

The Hardware Component – Arduino Based System

The main hardware is the Arduino Uno R3 to which various modules are attached. The components attached are:

- SIM Module – The SIM module must have GPS functionality, send/receive SMS, allow internet access, and support HTTPS protocol. This module will obtain the real-time location of the tracker using GPS and send them to Firebase (online database) via internet where it will be recorded. HTTPS protocol support is essential as Firebase does not accept HTTP requests for security concerns. SMS functionality allows the system to operate if internet access is unavailable/weak. Parents can request the system via SMS to send the location of the tracker. On receiving the request, the system replies with the current location of the tracker via SMS.
- Button Module – the button allows the child to send SOS message to parents in case he/she feels insecure or threatened. The button is to be built onto the tracker. On pressing, an alert message with current location is immediately sent to parents via SMS. Additionally, if the internet is available, the message is recorded on Firebase for future reference and the Android application instantly alerts the parents using a warning tone.

The Software Component – Android Mobile Application

The software provides the primary interface for interacting with the system. The Android application uses a username and password to verify users. The application can do so as it is connected to Firebase. The application consists of the following features.

- Options to independently create, schedule, and manage daily tasks for every child
- Option to add multiple child tracker (using unique tracker ID for each tracker) for different children
- Display real-time location for each tracker (child) on a map using Google Maps API and provide navigation
- Allow geo-fencing to set safe zones so that the application can issue warnings if the child moves out of it
- Provide access to the past location of the tracker (history)
- Set notifications to receive notifications when the tracker (child) reaches a particular destination (e.g. home)
- Receive alert notification when the child sends an SOS message and record them to view them later
- Option to send SMS to Arduino tracking system requesting to send current location via SMS
- Display System Access Log (to know who has accessed the system)

The Firebase

All data from both hardware and software components are stored online on Firebase. To visualize the data, an Entity Relational Diagram is shown in figure 2. However, it is very important to note that Firebase is a real-time NoSQL database and does not support relational databases. Figure 2 is just for reference only. The Users in the diagram are parents/guardians. There could be multiple users keeping track of the same child, such as the mother and father. As a tracker belongs to only one child, the Trackers entity represents a single child. The Tasks scheduled by parents belong to a single child. That is, a parent can have multiple children and every child can have a different set of tasks, location data, and SOS messages log. The System Access Log records every user who logs into the system. For security concerns, Access Log is read-only and gets deleted automatically after a set duration such as six months.

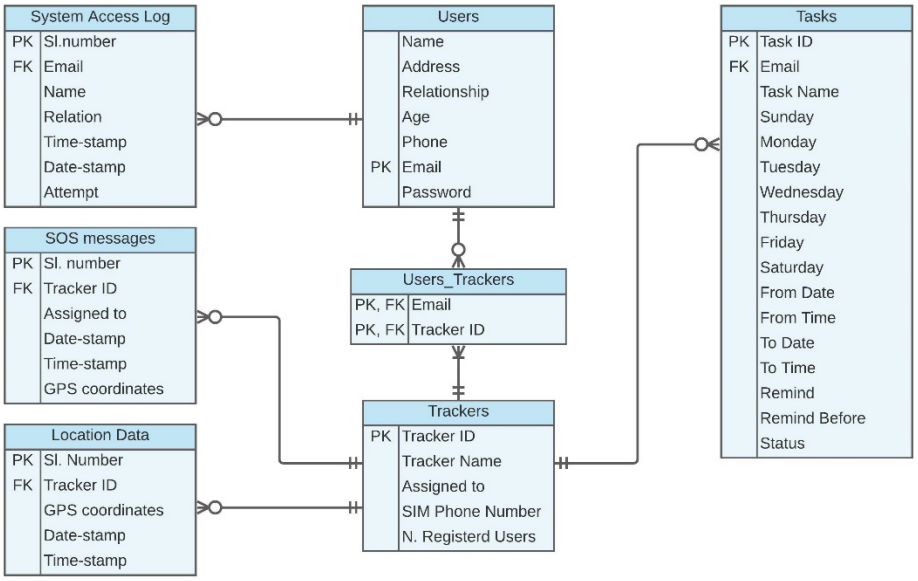

Figure 2. Entity Relational Diagram of the system.

Methodology

Several methodologies can be used to develop this system. Nevertheless, the iterative methodology can be used to develop the system. This methodology involves building the entire application incrementally. That is, the hardware component and the software component will be built incrementally adding new functionality each time based on outcomes from the testing phase and feedback. This way, every increment cycles through a set of phases every time until the final system is fully complete. This methodology provides the flexibility of making corrections to the system in case of encountering any issues. Additionally, there is also flexibility in adding a few new features later.

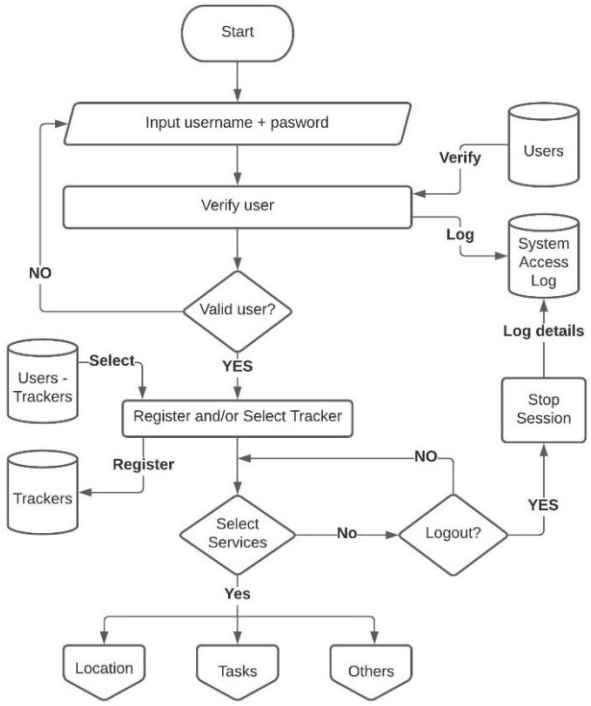

Figure 3. Home page of the application

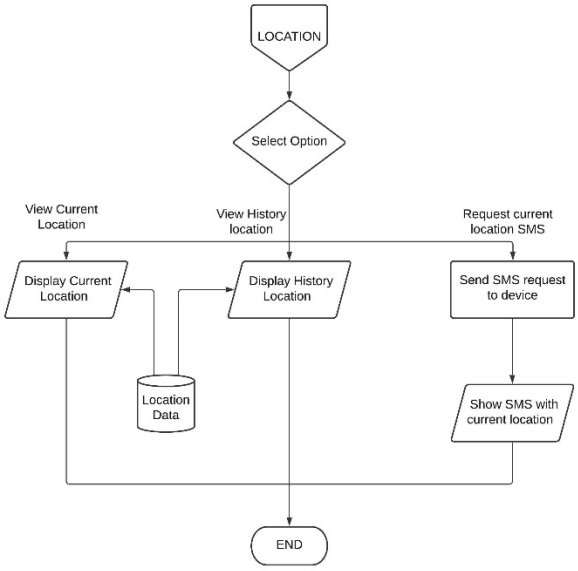

Figure 4. Location Page

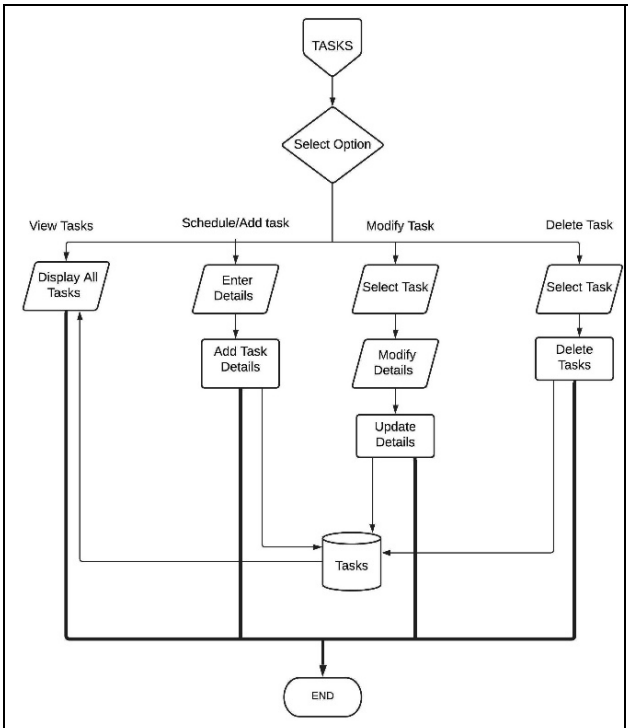

Figure 5. Tasks Page

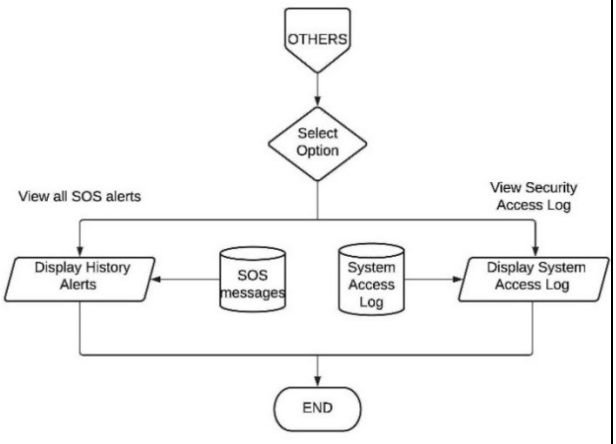

Figure 6. Others page

For developing this system, firstly the hardware component of the system can be built. In the first iteration, the SIM module can be connected to Arduino and tested with AT commands to check for connectivity. By using appropriate AT commands, the GPS coordinates and time can be obtained from the SIM module. This can then be sent to Firebase using an HTTPS POST request. In the meantime, Firebase must also be configured to receive the data in the right way. An important point to note is that Firebase must be able to uniquely identify the Arduino tracker.
In the following iterations, the button module can be attached to Arduino to allow the child to send an SOS message. By uploading a proper program to Arduino, Arduino should be able to send SMS via SIM module with current GPS coordinates to a specific phone number (parent's smartphone). The program should also ensure that the SOS message is recorded on Firebase as well. The SIM module must also detect SMS requests from specific phone numbers so that it can send an SMS with current GPS coordinates.

After building the hardware component and Firebase, the software component of the system can be developed. For simplicity, one could consider developing the Android mobile application using Flutter and Dart with the help of Android IDE, although there is no such restriction. Similar to developing hardware, the iterative model can be considered again. The mobile application should first verify the users using data stored on Firebase and provide the option to register their children (tracker) using a unique identification number/string (refer to figure 3). The application should then provide multiple services, i.e. location, tasks, and others (refer to figure 4, 5, and 6).

Future work

The hardware component presented here is rather bulky and not very portable. This prototype can however be customized to hold only the necessary electronic components in a much smaller form factor such that it can be easily embedded in wearables such as smartwatches or shoes. That would make the child comfortable in carrying the tracker.

Likewise, the Android mobile application can be further enhanced and expanded to allow the parent to not only schedule tasks and organize their children's daily lives, but also to help them in giving good parenting care particularly among new parents. That is, for example, the application could include features to help parents who lack knowledge and experience and don't know the right way to take care of their children. A few of the features that could be embedded in the application are:

- Parenting manual to help parents get general information about parenting such as how to understand a child's mental state or how to treat common diseases.
- Valuable information such as the address of nearby pediatrician or school
- Feature to seek advice/help directly from verified experts around the globe.
- Show information about any recent research in parenting that could help parents
- Provide a platform for communities to discuss parenting matters such as by hosting discussion forums

Recommendations

This paper provides an architectural design of a "Child Tracking and Activity Scheduling System". The system hopes to relieve the anxiety parents face due to concerns about their child's safety by acting as a tool to help parents view the real-time location of their child and alert them if their child crosses their defined safe zone. In addition to that, it also allows the child to immediately alert his/her parents in case he/she feels threatened. Last but not least, the application developed for this system addresses very common issues parents face due to their over congested schedule – failing to give the attention their child needs. Hence, the application allows parents to organize and schedule their child's daily activities thus ensuring that none are missed and the child's daily routine is well organized. It can be stated that, since elderly or disabled people are equally vulnerable, the system should be able to help them as well.

The tool at this stage is simply a prototype and rather bulky for the child to carry around. However, by removing excessive electronic components in this prototype, a system with a much smaller form factor can be developed such that it can be easily embedded in wearables such as smartwatches or shoes. The application can be expanded as well to incorporate a much wider field of parenting. That is, by having additional features such as a parenting manual embedded into the application, parents can get wider support in parenting their children.

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