King Saud University
College of Computer and Information Sciences
Department of Information Technology
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‘Elfaa - إلفاء’

IT 497: Graduation Project Report
Product Release-2

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Elfaa (إلفاء)

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Abstract (English):

This project aims to solve the issue of losing children and allow parents to keep track of their children's whereabouts. This project proposes a system that adopts IoT technology along with a mobile application, which enables parents to monitor their child's location using an attractively designed wearable accessory. The Agile methodology was adopted for this project as it enables flexibility and encourages continuous development and testing throughout the software development process. The system alerts parents when their child exceeds the safe distance and provides a means of communication with security guards in case the child gets lost. The system also allows parents to customize the safe distance, add their child's information, and report missing children. Furthermore, Admins can view missing children reports, change the status of reports to "found" or "close," add/delete security guards, and manage security guards. Security guards can also view missing children reports and change the status of reports to "found". The project aims to provide a safe environment in crowded public places, ensuring ease and facilitation in finding lost children.

Abstract (Arabic):

يهدف هذا المشروع إلى حل مشكلة ضياع الأطفال والسماح للآباء بتتبع مكان أطفالهم، يقترح هذا المشروع نظامًا يعتمد على تقنية إنترنت الأشياء بالإضافة إلى تطبيق محمول والذي يمكّن الآباء من مراقبة موقع أطفالهم باستخدام ملحق قابل للارتداء مصمم بشكل جذاب. تم اعتماد منهجية (أجايل) لتطوير مشروع إلفاء، التي تتيح المرونة واستمرارية التطوير والاختبار طوال عملية تطوير المشروع. يتم تنبيه الآباء عن طريق التطبيق عندما يتجاوز طفلهم المسافة الآمنة التي تم تعريفها مسبقًا من قبلهم ويوفر وسيلة للتواصل مع حرّاس الأمن في حالة ضياع الطفل في المكان. يسمح النظام أيضًا للآباء بتخصيص المسافة الآمنة وإضافة معلومات أطفالهم والإبلاغ عن أطفالهم المفقودين. بالإضافة إلى ذلك، يمكن للمشرفين عرض تقارير الأطفال المفقودين، وتغيير حالة التقارير إلى "تم العثور عليه" أو "إغلاق"، وإضافة وحذف حَراس الأمن، ومراقبة حرّاس الأمن. يمكن لحرّاس الأمن أيضًا عرض تقارير الأطفال المفقودين وتغيير حالة التقارير إلى "تم العثور عليه". يهدف المشروع إلى توفير بيئة آمنة في الأماكن العامة المزدحمة، وضمان سهولة وتيسير العثور على الأطفال المفقودين.

Keywords: IoT, Mobile Application, Child Tracking, Safety, Security Guards, Smart Cities, Anti-Lost.

1 Introduction

When a child is lost this can be the start of losing him forever, the term 'Golden Hour' is often talked about in losing cases, and in respect of lost children time is of the essence. The first three hours are the most important time to find a lost child with the next most significant period being within 24 hours [1]. The problem of losing a child in a public place is common, it happens to everyone all over the world, where more than 8 million reports of missing children in the world annually [2]. Children can disappear in a second and their parents should find them as soon as possible to prevent the worst crimes like kidnapping, sexual harassment, or other accidents, besides the psychological damage which can be the worst [3]. For parents, losing a child experience can cause a variety of emotions that could trigger panic and anxiety [4], which makes it difficult for them to search for their child with focus and seek help. The usual scenario when a child is lost is to hear the security announcing the child's name and descriptions through loudspeakers hoping for the parents to come. While at that time, parents worried about whether their child left the place or not, which gate they left, or where is their exact location so they can find him. Moreover, when a lost child is found in a public place, people cannot know any information about him for different reasons; either the child cannot speak, has social anxiety, is too young, or any other reason so it will be a difficult job to return the child to their parents. Emerging digital technologies provided new solutions and made it possible to find efficient high-quality solutions for many different problems. However, in the case of losing a child, this technology still cannot be easily used by the public and is inaccessible to parents.

1.1 Goal

The goal of building *Elfaa (إلفاء)* system is to provide an environment where losing a child problem can be resolved efficiently. It helps the parents to be aware of their children's current location and to allows security guards to perform their job more effectively, in addition to assure that the public people can help when they encounter a lost child.

1.1.1 Objectives

- Enable the parents to track their children's location as well as allow parents to ensure a safe zone for their children.
- Reduce the time of finding a child by providing an easy way to reach their parents.
- Increase the society union by involving them to help the lost children and not leaving the job only for security guards.

- Streamline the procedure by providing the complete service online and using technology.
- Keep the parents' awareness continuously, by sharing the live location and sending them notifications.
- Facilitate the method of reporting a lost child.

1.2 Scope

This project is developed as an IoT-based android mobile application for parents to keep track of their child's whereabouts, security guards to receive lost children's reports, and an admin to create and manage security guards' accounts. On the other hand, the child will use the IoT tracking device that allows parents to track him. The platforms used to build the system are Visual Studio Code and Arduino IDE. The mobile application will have a QR code generator, and it will be connected by GPS/GSM sensors to receive location information. The system will be in the Arabic language. Therefore, the target users need to have good Arabic skills. *Elfaa (إلفاء)* application and tracking device require a stable Wi-Fi connection and strong cellular network (2G) to work effectively. *Elfaa (إلفاء)* application will be effective via using the full features in specific pre-defined zones at meanwhile it started in Riyadh, Saudi Arabia public places such as winter wonderland, boulevard world, boulevard city and King Saud University[1].

1.3 Project Vision Statement

For a parent,

Who needs to ensure their children's safety especially from being lost,

The *Elfaa (إلفاء)* is an IoT android mobile application with a wearable accessory.

That allows the parents to keep an eye on their children and find them when getting lost,

Unlike the other tracking system such as a smartwatch,

Our system precisely links the child with their parent using technology, alerting parents to keep them aware, inexpensive, and can be used as an accessory to be more appealing to children.

1.4 Development Methodology

Elfaa (إلفاء) system was developed using Agile software development methodology, which is an iterative approach to manage the project, by following an agile framework such as Scrum. At first, we

[1] **King Saud University was selected for testing.**

conducted a requirement elicitation process by publishing a questionnaire and interviewing parents and securities to understand their needs, while consulting IoT engineers about the best technologies we can use to implement a solution.

After gathering requirements, we ordered the hardware we need, and we planned the development phase and started working on the incremental agile approach. The agile approach allowed us to make changes and adapt to any challenges that occur during development. At the end of each sprint, we perform an acceptance testing and an integration testing to measure the performance.

We used Dart language and Flutter framework to build an Android mobile application, as well as c+ language to program the IoT tracking device. Also, we used Firebase real-time and Firestore NoSQL databases for storing and managing the system data. We used several tools during development, including Android Studio IDE and Arduino IDE for coding, GitHub for version control, and Jira software for project management.

1.5 Main Contribution

The project main contribution is to provide an Arabic system for the parents called *Elfaa (إلفاء)* to keep them aware of the child's location and find him easily. The main components of the system are an IoT android application that can be downloaded on a parent's mobile, and a children-friendly wearable accessory embedding the GPS and GSM sensors as shown in Figure 1.

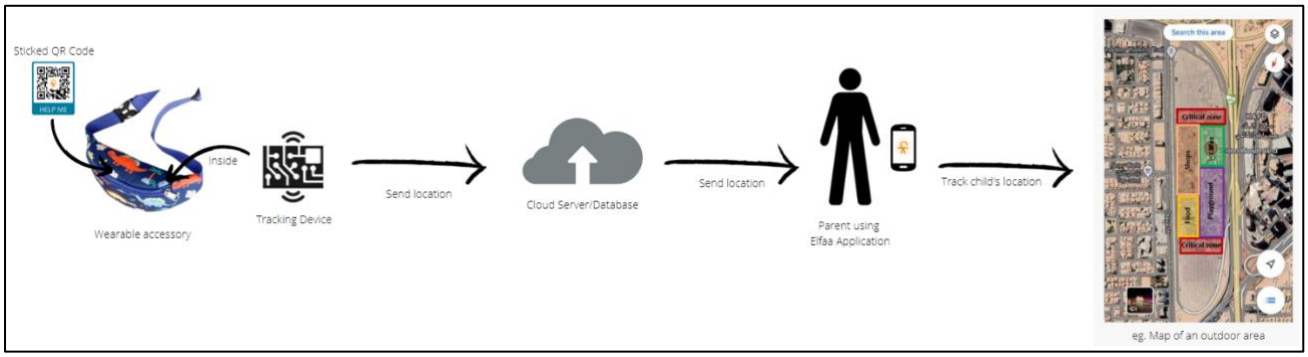


Figure 1: Proposed solution general idea

The IoT Android application will be programmed to contain three main interfaces for the parent, admin, and security guard. When the parent registers, he will get features that help him to feel assured most of the time. He can add a new child by filling in the child's information form and connecting him to *Elfaa (إلفاء)* tracking device. Then, generating a distinct QR code for him to be printed and attached to the tracking device. The GPS sensor will locate the child then the GSM sensor that is connected to the cellular network will send its data to the server so the client application can request and receive the data.

The security admin interface will allow him to create other security guards' accounts and manage them. The security guards can log in after the account is created by the admin. The main function of the previous two users is receiving parents' reports of their lost children.

The application will notify the parent every time his child enters a critical zone. Also, the parent will be able to set a safe distance in meters for his child so he will be notified when his child passes this distance. In case he loses his child, he can see his location and the utility zone name to track him. In addition, a parent can report that his child is lost. This report contains important information about the child to help the security guards find him.

We are going to design the wearable accessory to embed the GPS and GSM sensors and accommodate the printed QR code. The tracking device will reveal the child's live location to the parent using the mobile application and it will show the last location point in case it disconnected for any reason. The printed QR code will store the parent's contact information so that public people who find the child and want to help can contact the parent by only scanning it using the mobile camera.

Currently, there are different methods to track a child, like using security camera systems, mobile location, Apple Air Tag…etc. However, these solutions have their challenges. For instance, in the case of a security camera, it is time-consuming, must be checked manually, and needs special permission to access which cannot guarantee finding the child on time. On the other hand, in the case of mobile/watch location tracking devices, the child carrying a device may be exposed to theft, can be distracted more by these devices, is not work proactively to alert the parent if the child gets out of the specified allowed zone, and the most important thing, none of them are made especially for Arabic users.

This project will make a great difference in lost events for everyone. It will help parents take better care of their children. Also, the child will feel safer knowing that his parent is notified of his loss and can find him if he sits and waits. Public people can also contribute to helping the child by only scanning. Moreover, this solution will help the entertainment sector in Saudi Arabia in offering convenient family events that can attract families from all around the globe.

Throughout this document, the details of *Elfaa (إلفاء)* system will be described, starting with the background and literature review to understand the project and other existing systems. Then, the system design and development will describe the method for *Elfaa (إلفاء)* and present the system requirements. Followed by the product design which provides an understanding of how the system is

decomposed, and how the individual parts work together. Then, the data and interface designs are also shown. After that, system implementation is discussed, continued by the system evaluation to test the user acceptance, and analyze the results. At the end, the conclusion and future work for this system are provided.

2 Background

Nothing beats a pleasant family day out and trying several activities that a person can always enjoy with his family, from a quick stroll through the park to a hike through the woods. However, if there is one drawback of going to public places, it is unquestionably crowded places. A parent can quickly lose sight of his young children in the blink of an eye. Any parent would find it impossible to face the fear and suffering brought on by a child getting lost and the futile searches that follow. Sad to say, anyone could experience this.

Across the world, theme parks frequently experience lost children. One minute a parent walks with his child and then his child might go completely out of sight. They might have walked away into a crowd or been preoccupied with the wide variety of sights, sounds, and sensations that theme parks provide. For commercialized parks such as Disney World, an average of 11 children go lost each day. The average time they are lost from their family is around 30 minutes [5]. Anyone can imagine how these 30 minutes a family and the lost child can go through and feel.

In this section, relevant background needed to understand the proposed solution will be presented. The definition of IoT and its components are listed, in addition to the smart cities' definition and how it is related to the solution, GPS sensor, and how it works. Also, geofencing meaning is explained and the GSM definition is discussed. At the end, GoogleMaps API is explained and shows how it works.

2.1 Internet of Things (IoT)

The Internet of Things has emerged in recent years as one of the most significant 21st-century technologies [6]. Continuous communication between people, processes, and things is now feasible because of the potential to link everyday objects such as home appliances, autos, thermostats, and baby monitors to the internet via embedded devices Low-cost computing, the cloud, big data, analytics, and mobile technologies enable physical things to share and gather data with minimum human interaction. In today's hyper-connected environment, digital systems can record, monitor, and alter every contact between linked things, allowing the real and digital worlds to collaborate. [7].

IoT is supported by a large network, and various components work together to form a cohesive system. The devices operate autonomously based on data collected from linked sensors. The sophisticated IoT ecosystem is comprised of several participants in the entire process. Because it is expanding constantly, the IoT ecosystem is difficult to define. This ecosystem is made up of all the parts that go into connecting customers and companies to their devices. These might be hardware or

user interface components that are visible, or they could be network and storage components that are software and processing-related [8].

2.1.1 IoT Ecosystem Components

The key components that make up an ecosystem for the IoT are shown in Figure 2 below.

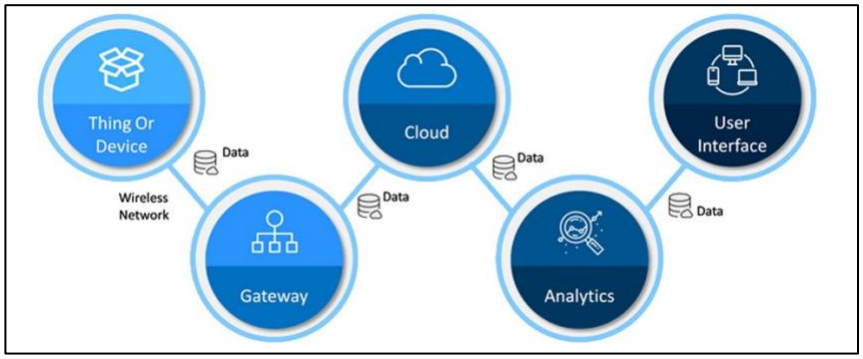


Figure 2: Components of the IoT [9].

1. Thing or Device Component

The first tier of an IoT ecosystem and the backbone of the whole IoT network. It consists of:

Sensors:

These work to gather small information from the environment.

Actuators:

Act while sensors sense, and initiate an action based on a signal or command they receive.

2. Gateway Component

Incoming and unprocessed data from the sensors must pass via IoT gateways in order to reach the cloud. To guarantee uninterrupted communication between all networked devices, gateways enforce network protocols.

3. Cloud Component

Once the collected data has been sent to the cloud, it must be processed. To connect the various parts of the IoT ecosystem, this high-performance facility is essential. It takes decisions and controls the data while storing it.

4. Analytics and Data Management Component

Data has great power and may significantly affect the quality of any product or business. IoT Analytics is used to examine huge amounts of analog data.

5. User Interface Component

The visible component that the IoT user may simply access and manage is the user interface [8].

2.2 Smart cities

Smart cities use data and digital technologies to make better decisions and enhance people's lives. More detailed real-time data enables agencies to monitor events as they occur, analyze how demand patterns are changing, and respond with faster and less expensive solutions. Saudi Arabia economy is recently growing with ambitious plans to turn its cities into smart cities [10]. Saudi officials intended to begin implementing the smart city project in 10 cities around the Kingdom in accordance with the Saudi Vision 2030 objectives. This program aimed to reach five Saudi cities by 2020: Makkah, androiddh, Jeddah, Al-Madinah, and Al-Ahsa. [11].

According to Argaam [12] from the Ministry of Municipal and Rural Affairs, Riyadh city rank moved up 23 places in the Institute for Management Development's (IMD) 2021 Smart City Index to rank 30th globally and 3rd regionally among a total of 118 cities worldwide [13].

The primary goal of a smart city is to maximize local operations, boost economic development, and improve citizen quality of life via the use of smart technology and data analysis. The value of technology is determined by how it is applied rather than how much technology is accessible. Children's safety is critical in a smart city since they are the future generation. From that perspective, different technologies can be utilized, as will be explained next.

2.2.1 GPS sensor

GPS Tracking sensor stands for Global Positioning System. It consists of a network of twenty-four satellites in rotation and devices on the ground that can show a person or object’s location on Earth with great precision. GPS Tracking tracks three separate data sets: positioning, navigation, and timing. This technology has been around for a long time. GPS was created for military use in the 1960s. In 1983, GPS became available for public use, and the technology has only grown from there. Today, it’s used for everything [14]. In order for GPS to work, it requires the use of many satellites orbiting the Earth. These satellites continually broadcast their locations and status above us. This is continually monitored by the GPS Master Control Station, as well as other tracking and monitoring stations here on the ground, to ensure accuracy and proper function. A GPS sensor device on Earth receives these

signals, interpreting each one's unique data. By mapping the locations of four or more satellites in relation to the tracking device, it can triangulate its exact position in three-dimensional space [14].

A GPS tracker sensor for children is a discrete tracking device that can fit in a pocket or backpack. Additionally, it enables real-time, exact child location tracking. Due to its many advantages and ease of use, it is becoming more and more commonly employed. A GPS tracker for children can also be used to keep an eye on children who have behavioral issues, autism, attention deficit disorder (ADD), or mental difficulties. Given the low cost of GPS tracking systems, parents can increase their children's safety with little outlay [15].

2.2.2 Geofencing

Geofencing is a type of location-based service in which an app or other software program uses radio frequency identification (RFID), Wi-Fi, GPS, or cellular data to trigger a targeted marketing action (such as a text, email, social media advertisement, app notification) when a mobile device or RFID tag enters or exits a virtual geographic boundary, known as a geofence. A simple example of geofencing is when a young woman walks near a Sephora retailer at the mall and receives an app notification that says: "Today only! Buy 1 lipstick, get 1 free!". When a user enters a geofence, you can send several types of alerts. Text messages, in-app notifications, and social media ads are the most common type [16]. The Google Maps APIs can be used to apply Geofencing, which is one of those clever bits of Google technology that helps you take the power of Google Maps and put it directly on your own site. It lets you add relevant content that is useful to your visitors and customize the look and feel of the map to fit with the style of your site [17].

2.2.3 GSM

GSM stands for Global System of Mobile communication. It is a digital mobile network that is widely used by mobile phone users using the time division multiple access (TDMA) technique. Furthermore, it is an open cellular technology that is used for transmitting data services operating at the 850MHz, 900MHz, 1800MHz, and 1900MHz frequency bands [18]. At present GSM is widely used around the world, having over 90% of the market share [19]. For this reason and considering that almost everyone owns a telephone nowadays, the option of using GSM signals to detect pedestrians is promising. The GSM module that will be used is a chip that establishes communication between a computing machine -cloud- and a GSM system.

2.3 Google Maps API

API stands for Application Programming Interface. In the context of APIs, the term application refers to software with a specific function. An interface can be viewed as a service contract between two applications as shown in Figure 3. This contract defines how the two communicate with each other via requests and responses. The API documentation contains information on how developers should construct these requests and responses [20].

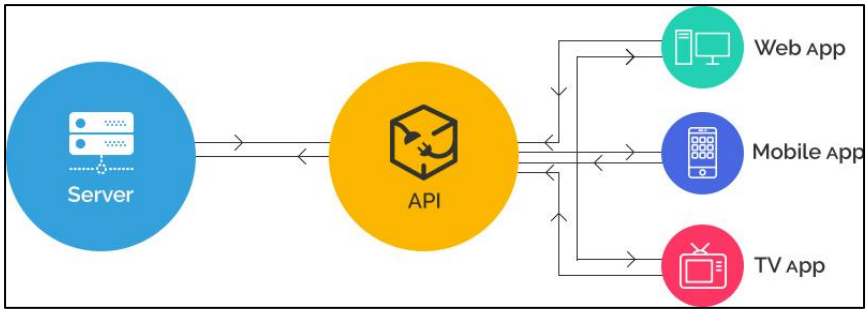


Figure 3 : How API works [21].

Google Maps APIs are prepackaged pieces of code that enable you to add maps quickly and simply to your websites or mobile applications and then extend the functionality of your programs. They allow you to transfer data between systems and are accessible for Android, iOS, and web browsers. [22]

3 Literature Review

This section presents a review of some of the existing systems that have been developed for finding lost people, some of these systems are proposed in research, while others are commercial products, The way these systems are applied will be presented, along with their purposes, and advantages and disadvantages. In the end, the systems will be compared, and the added value of the proposed solution will be highlighted.

3.1 Competitive Product Analysis

3.1.1 A Smart City Application Design for Efficiently Tracking Missing Person in Large Gatherings in Madinah Using Emerging IoT Technologies [23].

This paper serves the department of lost and found in Al-Masjid A-Nabawi. The users are vulnerable members of a group or a family, like children or the ones with certain diseases or disorders like Alzheimer's. The proposed system is a wearable bracelet that embeds a beacon that transmits a continuous radio signal repeatedly and securely to other devices.

As illustrated in Figure 4, when a family or a group submits a report containing the information of the lost person like his beacon ID, information is broadcasted to all security guards by displaying it on a list of lost people on the security guard mobile application. The security guards will scan the area looking for the lost person and whenever the application gets a signal from a nearby beacon with an ID that is in the list, the security guard will track this person in the crowd and when he finds him, he will use the IoT system to capture its beacon tag and ID to send it to the server for identifying and contacting his caretaker. The guard will also use the application features to report the found person. Then, the central office of the department of lost and found will contact the found person's caretakers to pick up the lost person.

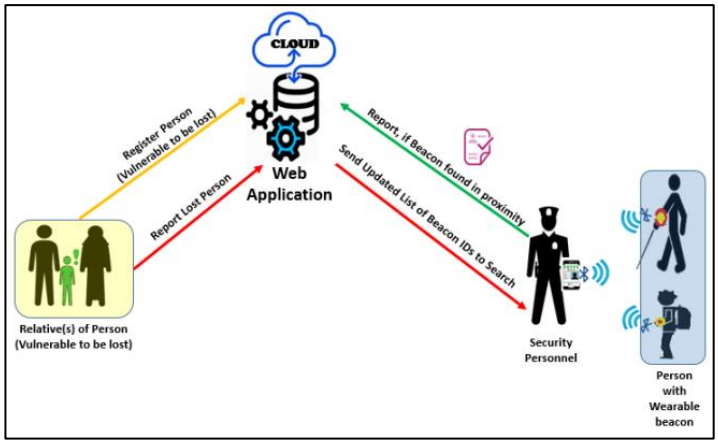


Figure 4: Illustration of the core methodology of the proposed system [23].

In case the reported lost person is not found in the average time, an enhanced search will be conducted by extending the perimeters of search space by including the surrounding areas. This system only allows the security guards to scan nearby beacons to find the lost person or child, leaving the caretakers without any information about the location of the lost member, or at least which zone he is in or what direction he went through. So, we need to give the caretakers some knowledge that is available to the security guards, especially when there are no security guards around to help.

3.1.2 Smart Patch: An IoT-based Anti-Child-Trafficking Solution [24].

This system helps to detect kidnapping incidents immediately. It continuously monitors and tracks the child so that any possible sign of kidnapping is detected and sent to the guard to take an action as soon as possible to prevent the kidnapping attempt.

This system embeds and conceals the sensors and the communicating parts in a smart patch attached to a shoe. As shown in Figure 5.(a), the system uses the shoe as an IoT node that can connect to a smartphone remotely. The shoes monitor the location of this child and provide options to generate alternated or manual emergency signals allowing a fast response from the guard.

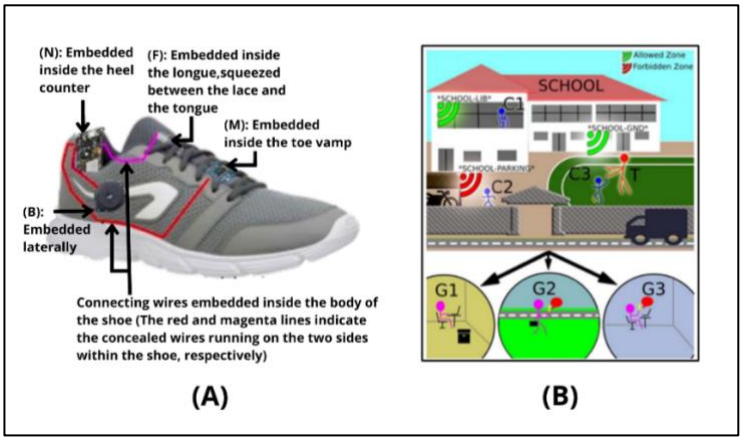


Figure 5: Smart patch: (a) Placement of the patch within the Smart Shoe. (b)The Smart Shoe system. [24]

The system shown in Figure 5.(b) continuously senses the zone in which the child is currently located and generates automated emergency responses to inform the guard when the child entered a forbidden zone or has gone too far from an allowed Wi-Fi network coverage area. Similar responses are generated if the shoe has been taken off by the child. This system fully depends on the help of the guard, by only sending the alert to him, leaving others, especially parents out of the picture, while a more general tracking-alerting system like would be better.

3.1.3 IoT Enabled Children Safety System [25].

This research proposes an IoT-based system, as presented in Figure 6, that allows schools, parents, and authorized people to track the movement of children during their transportation on the school bus. The proposed system equipped the school bus with GPS technology for tracking the bus and RFID technology to ensure children's presence on the bus by reading children's RFID cards using an Android application that interacts with a mobile RFID reader. The bus android application then processes the data and sends alerts or notifications to the parents or staff members.

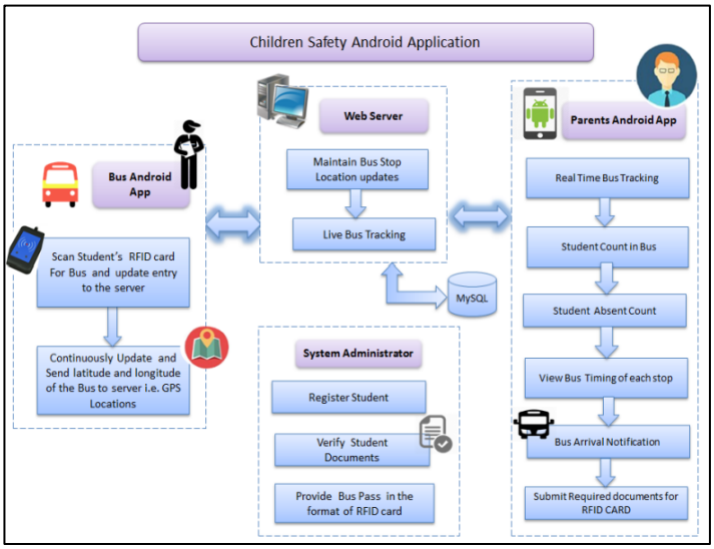


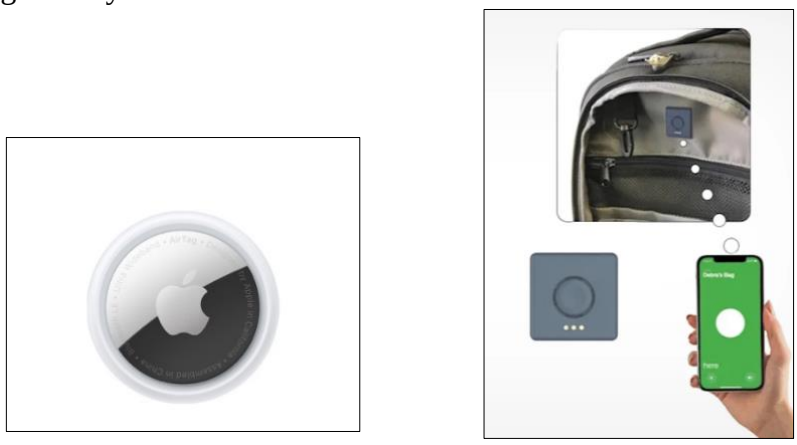
Figure 6: System Architecture [25].

This system enables parents to only track the school bus but when the child arrives, they cannot track him anymore, and in case they received an alert that their child is not on board, there is no way they can track the child out of the bus when it is useful if the parents can track their children anywhere.

3.1.4 Apple AirTag [26]

AirTag, shown in Figure 7.(a), is one way to track any moving object. It is possible to attach it to a child's backpack as shown in Figure 7.(b). Then, you can see it on your radar in the Find My app, where you can also track down your Apple devices and keep up with friends and family, but it cannot send any report to security guards in the same place. You can play a sound on the built-in speaker by going to the new items tab in the Find My app. If your AirTag is nearby, your iPhone can lead you straight to it with precision finding. You will see the distance to your AirTag and the direction to head in. The AirTag can send out a secure Bluetooth signal that can be detected by nearby devices in the Find My network. These devices send the location of the AirTag to iCloud then you can go to the Find My application and see it on a map. Finally, it was found that AirTag is not a complete system, and it

is only a tracker that can be put in any object, and only the user can track it. Moreover, the cost of AirTag is kind of high to buy.



(a) (b)

Figure 7: Apple AirTag: (a) Apple AirTag piece (b) Apple AirTag attached to a backpack [26].

3.1.5 Amber Alert GPS [27]

The Amber Alert GPS product shown in Figure 8 is a product that allows children to call a parent through a touch of a button via a 3G network. It also allows parents to call and track their children. There are multiple attachment accessories available, giving children and parents options for how to wear the device. With no screen, it does not allow internet access or texting. Parents can access their child's real-time whereabouts via an online portal or mobile phone app. Also, they can set up safe zones to get informational alerts, such as a child entering or leaving school, as well as SOS alerts, indicating your child may feel threatened or is not feeling well via voice call, text, and/or, email. Although the device provides many features, but the user cannot report his lost child to security guards through the system and the device is kind of big for a child to carry.

Figure 8: Amber Alert GPS product [27].

3.1.6 FiLIP [28]

Filip is a simple mobile device that children between 5 and 11 years old can wear on their wrists as shown in Figure 9. Moreover, up to five trusted contacts can communicate with the child using FiLIP, so children can talk directly to their grandparents and siblings too. With the FiLIP Companion App, parents & caregivers can manage their devices right from their smartphones. They can set up the devices' settings, add contacts, manage Safe Zones, send voice & text messages, monitor their location, and call them. However, Filip cannot report lost child to security guards through their application you will need to do it by yourself, it also has entertainment options which could distract children.

Figure 9: Filip as a wristwatch [28]

3.1.7 AngelSense [29]

To monitor the AngelSense, shown in Figure 10, Android or iOS devices or web browsers can be used. Only Guardians can make phone calls and listen to the device. Names can be assigned to frequently visited places to generate a narrative. Named places also persist as geofences and can be used to alert the user every time he/she enters or leaves a named place. Location accuracy is about a 100-foot radius, better outdoors than indoors. The AngelSense can also make calls and since it's designed for severely disabled people, it makes unusual types of calls. The phone can be called by app-designated guardians and uses caller ID to verify that the guardian is calling. It auto-answers after two rings, automatically in speaker mode. Because of some of its features and phone capabilities, it has a bigger size than the rest of the devices covered so far, has shorter battery life, and service plans are more expensive than some of the competitors.

Figure 10: AngelSense device [29]

3.1.8 Competitive Analysis Summary

As shown in Table 1, important features of tracker products have been summarized to find that there is a lack of technology that supports the Arabic language, and only one product in the literature that support Arabic. Moreover, alerting while in critical zones feature is also only provided by one product, and none of the systems covered so far have considered the feature that enables others (not a specific user) to find a child's parent phone number and help the child to find his parents. Moreover, the report to security guard feature was not targeted in 50% of the covered products and they only focused on alerting the caretaker. For utility zones' names, a few products have covered it but 90% of them are manually added by the user. Providing a friendly wearable device is very important when we target children but after testing the apps it was found that Amber Alert GPS and AngelSense products did not consider that.

Table 1: Features comparison

Product	Arabic language	Report to security guard	Utility zones' names	Public people can find the child's parent contact	Friendly-wearable device	Alert while in critical zones	Set a safe distance	Targeted users
Wearable beacon bracelet		✓			✓			Vulnerable people
Smart shoe		✓	✓		✓	✓		Children
School bus tracker		✓			✓			Children
Apple AirTag	✓				✓		✓	Objects
Amber Alert GPS			✓					Children
FiLIP			✓		✓			Children
AngelSense			✓					Disable children
ELFAA (إلفاء)	✓	✓	✓	✓	✓	✓	✓	Children

From what we have discussed so far, it can be concluded that *Elfaa (إلفاء)* system is an Arabic-friendly mobile/IoT application for children with more efficient aspects. Parents can report their lost child to a security guard, who can help them to find their child as fast as possible, which is a feature that most other systems do not support. *Elfaa (إلفاء)* system also helps the parents to know the exact location of their child, and the utility zone name related to a public place that GPS does not offer usually, e.g., the playground area, food area, and critical zones such as exit gates. The parents will also be notified when their child comes across it, in which none of the systems covered so far have this feature. The child will feel safer knowing that his parent is aware of his current location. In addition, *Elfaa (إلفاء)* system enables public people without restrictions to help the child by scanning his QR code and getting the child's parent contact information, which most other systems do not provide. Moreover, *Elfaa (إلفاء)* system provides a friendly wearable accessory device designed for children so that it is appealing for them to wear it when they go out. Finally, *Elfaa (إلفاء)* system will contribute further to the literature by allowing public people to help in finding a lost child by providing a QR code that is storing information to be scanned and contact the parents and provide the ability to set a safe distance that parent can be able to know if their children are far away from them.

4 System Design and Development

In this section, system description will be covered which includes the methodology used to develop Elfaa (إلفاء) system and it contains the users' section that describes the direct and indirect types of users of Elfaa (إلفاء) system, and their characteristics. Then, the requirements elicitation section illustrates the process of collecting the system's requirements, which includes the used method and its results and findings. After that, the use case diagram is presented showing how Elfaa (إلفاء) system interacts with actors.

4.1 Methodology

Elfaa (إلفاء) system was developed using Agile software development methodology, which is an iterative approach to manage the project, by following specific agile framework such as Scrum shown in Figure 1. The development process was divided into five small iterative sprints, while each sprint takes 3-4 weeks. At the beginning of a sprint, the developers formulate a plan to accomplish a specific objective by the end of the sprint. This involves breaking down the goal into smaller, manageable tasks that can be completed within the sprint timeframe., executing and evaluating a shippable product under a weekly supervision by the supervisor then present it at the end of each release to the stakeholders. This methodology helped the team to deliver value faster and with fewer issues through continuous evaluation of requirements, plans, learning, and results since agile process involves ongoing communication with stakeholders as well as continuous development at each sprint [30].

Scrum is a framework for Agile project management that is designed to help teams work together more efficiently and effectively. It provides a flexible approach to product development that emphasizes iterative development, continuous improvement, and a focus on delivering high-quality products that meet customer needs [31].

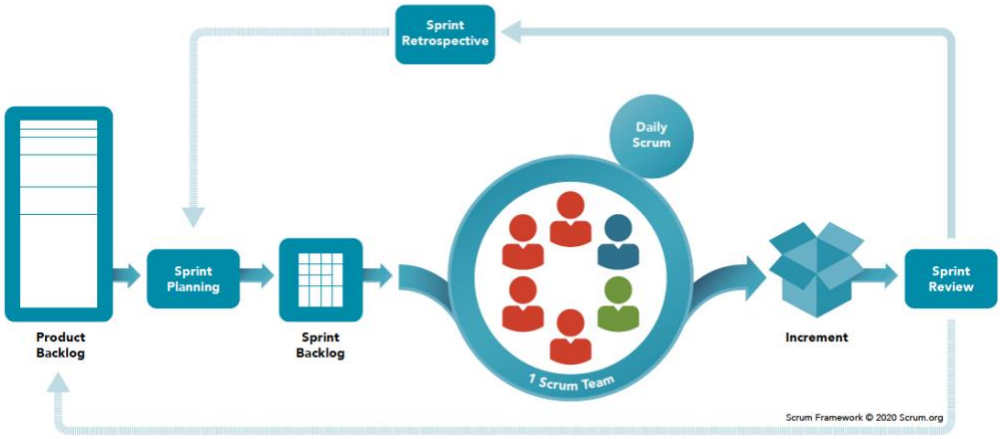


Figure 11: Scrum Framework [31].

Scrum framework consists of 5 events, 3 roles and 3 artifacts.

Scrum Events:

There are five Scrum events that occur within a Sprint, a time-boxed iteration of development work. The events are:

1. **Sprint Planning** - a time-boxed event where the Development Team plans the work for the upcoming Sprint.
2. **Daily Scrum** - a daily time-boxed event where the Development Team meets to discuss progress and plan for the next 24 hours.
3. **Sprint Review** - a time-boxed event where the Development Team demonstrates the completed work to stakeholders and receives feedback.
4. **Sprint Retrospective** - a time-boxed event where the Development Team reflects on the previous Sprint and identifies opportunities for improvement.
5. **Sprint** - the time-boxed period where the Development Team creates a potentially shippable product increment [32].

Scrum Roles:

The Scrum framework has three roles that ensure accountability and effective collaboration:

1. **Scrum Master** - responsible for ensuring that the Scrum framework is understood and followed, and for facilitating team collaboration and progress.

2. **Product Owner** - responsible for maximizing the value of the product and ensuring that the Product Backlog is prioritized and transparent.
3. **Development Team** - responsible for creating a potentially shippable product increment within each Sprint [33].

The following Table 2 presents *Elfaa (إلفاء) Scrum* team.

Table 2: Scrum Team

Scrum Team	
Product Owner:	Dr. Hebah ElGibreen
Developers:	Layan Alorayyidh Rahaf Alzahrani Danah Alturki Renad Altayyar
Scrum Master (SM):	Dr. Maha Alyahya
Stakeholders:	Examination committee

Scrum Artifacts:

The Scrum framework has three artifacts as shown in Figure 12 that provide transparency and opportunities for inspection and adaptation:

1. **Product Backlog** - a prioritized list of features and requirements for the product.
2. **Sprint Backlog** - a plan for the work that the Development Team will do during the upcoming Sprint.
3. **Increment** - the sum of all the completed Product Backlog items at the end of a Sprint [34].

Figure 12: Scrum Framework 3x5x3.

Scrum Agile process helped Elfaa (إلفاء) team to emphasize communication, collaboration, and transparency, as well as continuous improvement of the idea and a focus on delivering high-quality system that meet customer needs. The team works together closely to prioritize work, identify, and resolve issues, and adapt to changing requirements and feedback from stakeholders by conducting many meetings. The Product Owner was responsible for managing the Product Backlog and ensuring that the team is delivering value to the customer. On the other hand, the development Team was responsible for delivering a potentially shippable product increment at the end of each Sprint which allowed the team to quickly gather feedback from end users and respond much more quickly by reimplementing simple comments and considering any crucial comments as defects in Product Backlog (PB).

Elfaa (إلفاء) team used GitHub[2] to host the project's repository and upload the project code, libraries, and other resources files to it. This tool helps the team to push, pull the changes on their code to collaborate on the project. It also keeps track of the various changes made by other team members.

Also, the team used Jira[3] software as a management tool that provides a scum board which allowed us to manage the distribution tasks between the team members, organize and track our project, store the product backlog, document all the meetings' minutes with the supervisor, sprint reviews, and store any important documents.

[2] Elfaa Repository on GitHub: https://github.com/rahaf-alzahrani/2022-GP-3
[3] Elfaa Project on Jira: https://2022-1st-gp3.atlassian.net/jira/software/projects/GP/boards/1

4.2 System Requirements

4.2.1 System Users

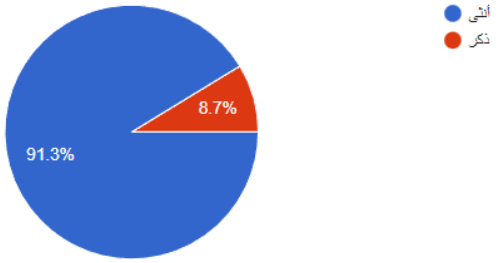
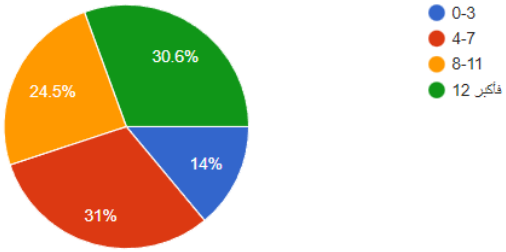
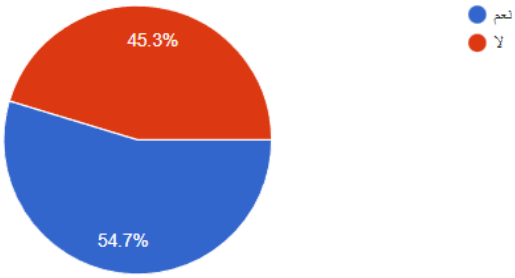
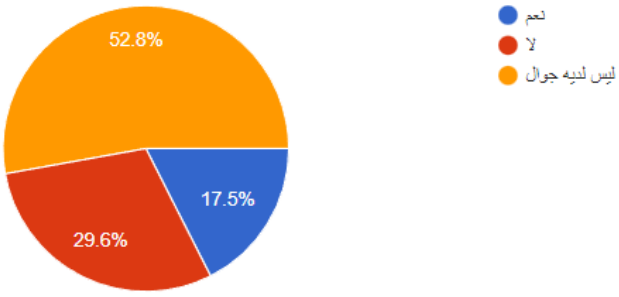
Elfaa (إلفاء) system targets **parents** who need to ensure their children's safety in outdoor public places. The parents can be adults of any age and educational background as long as they know how to use their mobile. Thus, it is preferred to have some technical background, to be able to use the application and track their children. **Admin** and **Security guards** are also users of the application, where an admin is considered the security guard supervisor, and they can be an adult of any age, and educational background, also should have some technical background to be able to access the system and an admin manage the security guards' accounts, while they both can handle children lost reports.

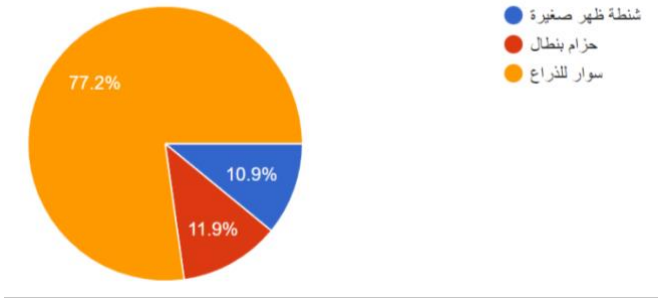
The indirect type of users are the **public people** and **children,** they do not need to have *Elfaa (إلفاء)* application on their mobiles but are indirectly affected by it. Public people can be adults of any age and educational background as long as they know how to use their mobile to scan a QR Code to contact a child's parents. Children are supposed to wear the accessory only, they can be of any age between 3-11 and they do not need any technical background.

4.2.2 Requirements Elicitation and Analysis

To elicit the users' requirements, a survey was conducted and distributed electronically to a sample of 570 who are parents and 189 non-parents but have a child at home; the details of the survey is reported in Appendix A. Starting with parents, illustrated in Table 3, responders' gender illustrates that 693 are female, while 66 are male, and the age of the sample children ranges from 1 month to 12 or older, were the targeted age (from 3 to 11) represents 69% approximately. Around 55% of the sample have lost their child before, while 82.4% of their children do not have mobile phones at all, or they do not carry them in public places. Tracking a lost child using GPS was chosen as the best way to find the child quickly by 48.2% of the sample. When it come to the accessory design, 77.2% of the sample preferred the tracking wearable device as a wristband, and when it comes to the feature of critical zones alerts and displaying utility zone names on the map, more than 98% of the sample find it is important and useful to have.

Table 3: Requirements Elicitation and Analysis for Parents

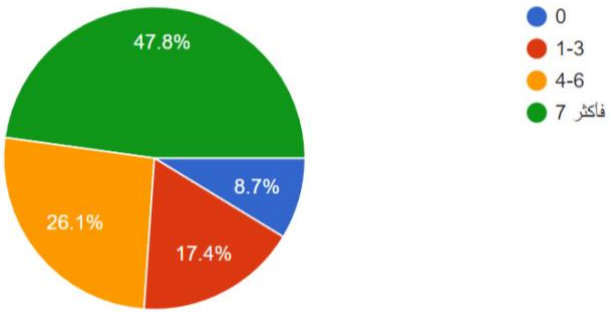
Parent/Have a child at home	
Question	Chart and results
Your gender: • Female • Male	
How old is your/ the child? • 0-3 • 4-7 • 8-11 • 12 or older	
Have you ever lost your child in a public place? • Yes • No	
Does your child carry his own mobile phone in public places? • Yes • No • Does not own a mobile phone	

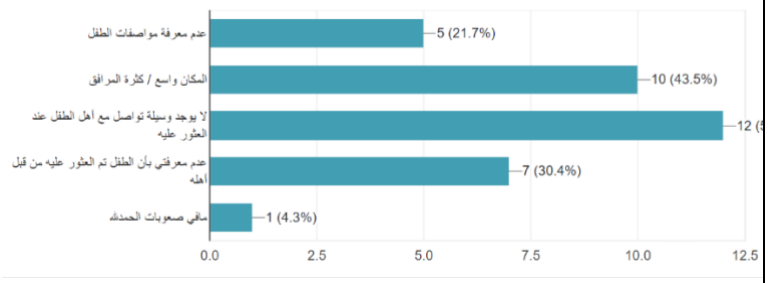
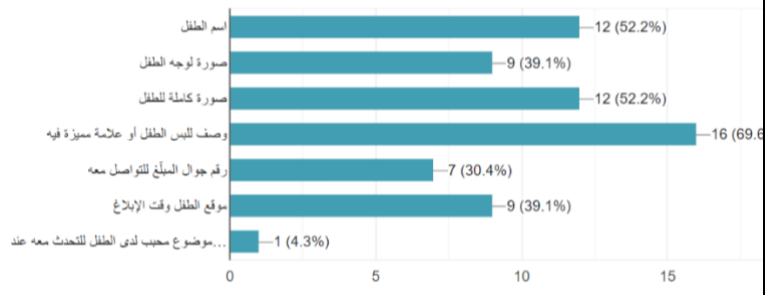
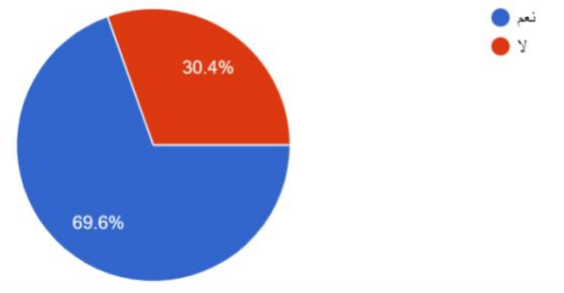
Parent/Have a child at home	
Question	Chart and results
How do you find your child when he is lost, usually? ● Calling his name loudly/using speakers ● Locate and track their location ● Notify the security guards to help you ● Walking and looking for him ● Other, …	
In your opinion, what is the fastest way to find a lost child? ● Calling his name loudly/using speakers ● Locate and track their location ● Notify the security guards to help you ● Walking and looking for him ● Other, …	
What do you think is the best accessory that will attract your child to wear it in public so that you can track their location? -The design of the accessory is suitable for both genders- ● Small backpack ● Belt ● Wristband	
Do you think it is important to receive an alert notification when a child passes one of the exits/critical zones (gates)?	

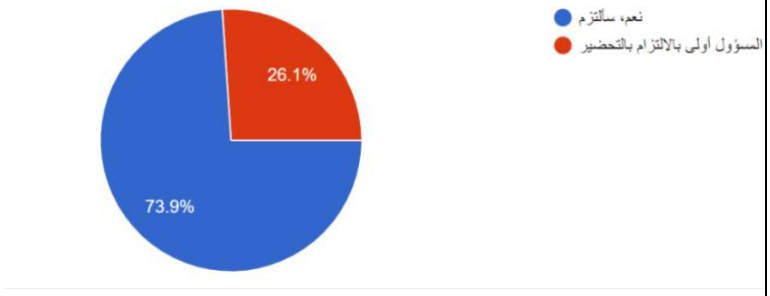
Parent/Have a child at home	
Question	Chart and results
• Yes • No • Other, …	
Do you think it would be useful to know the name of the zone/utility, such as amusements, restaurants, ... that your child is in when tracking their location? • Yes • No • Other, …	

In addition to parents, *Elfaa (إلفاء)* system also target security guards. Thus, another survey was conducted and distributed to 23 security guards who work in different public places to elicit their requirements. As shown in Table 4, 73.9% of the security guards sample encountered 4 to 7 or more lost children's cases per week. The sample is facing some difficulties when helping a parent to find his lost child, such as insufficient description/information about the lost child, the place is very wide, or they do not know if the child was found by his parents or not yet.

Table 4: Requirements Elicitation and Analysis for security guards

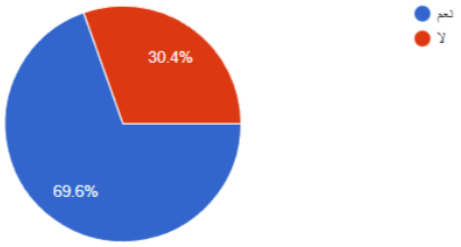
A security guard at a public place	
Question	Chart and results
On average, how many lost children do you face per week? • 0 • 1-3 • 4-6 • 7 or more	

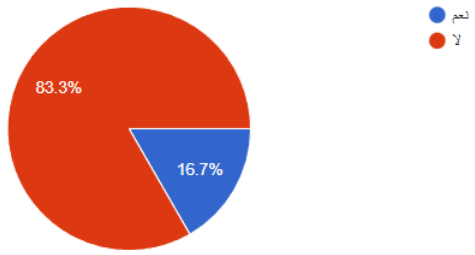
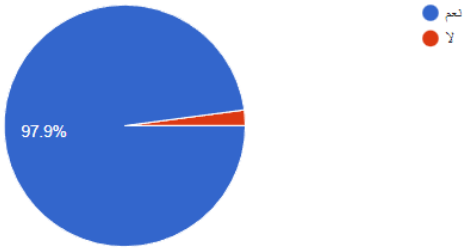
A security guard at a public place	
Question	Chart and results
What difficulties do you face when searching for a lost child? ● I do not know the child's characteristics ● The place is wide/utility variety ● I do not have a way to contact the child's parents when I found a lost child ● I go for searching, then I do not know if parents found their lost child or yet ● Other, …	
What information do you think is sufficient about the child and its parent when you are notified by a parent of a lost child? ● Child's name ● Child's face photo ● Child's general photo ● Description of child's clothes, or special mark ● Mobile phone number of the parent-reported ● A favorite topic for the child to talk about with him for anxiety-relieving	
Do you think it is annoying to be notified about a lost child when you are not at your work? ● Yes ● No	

A security guard at a public place	
Question	Chart and results
If you thought it is annoying at the previous question, will you commit to clock in yourself every day when you come to work via the application, or would you prefer it to be of the admin responsibilities? • Yes, I would commit • No, admin should do	

Finally, another survey was distributed to the public which are considered an indirect type of users of *Elfaa (إلفاء)* system. This was done to ensure the feasibility of interacting with this type of users in the system solution which will provide a QR code generator for the parents, so that public people willing to help lost child using their mobile phones directly to contact his parents. From Table 5, the sample included 192 persons who wanted help a lost child. Most of the sample support using a way that enables them to contact the lost child's parents by their mobile phones to reach them out, since 160 of the sample do not think there is an easy way to reach lost child's parents.

Table 5: Requirements Elicitation and Analysis for public people

Public People	
Question	Chart and results
Have you face a lost child before? • Yes • No	

Public People	
Question	Chart and results
From your point of view, is it easy to find out information that connects you to the parents of the lost child? • Yes • No	
Do you support having a way with the lost child that enables you to use your mobile to communicate directly and easily with his parents? • Yes • No	

In conclusion, the requirements elicitation goal was to gather and define clear user requirements based on the needs exported from the survey answers. Thus, the following important functions were determined to be important to implement since the potential users need it and interested on it:

- Build a GPS tracking sensor for children, to ease the finding process in case of loss.
- Alert parents when a child crosses a critical zone.
- Display utility zones' names for a parent while tracking the child.
- Notify the security guard of a lost child with sufficient information.
- Enable the security guard to log-in/log-out, so that he can log-out when he is not at work, then he will not receive any reports.
- Enable a parent to generate a QR code of his personal contact information, so that the public can get involved, and help lost children by scanning and contacting parents.

4.2.3 User Interactions

Elfaa (إلفاء) system will include the use cases presented in Figure 13.

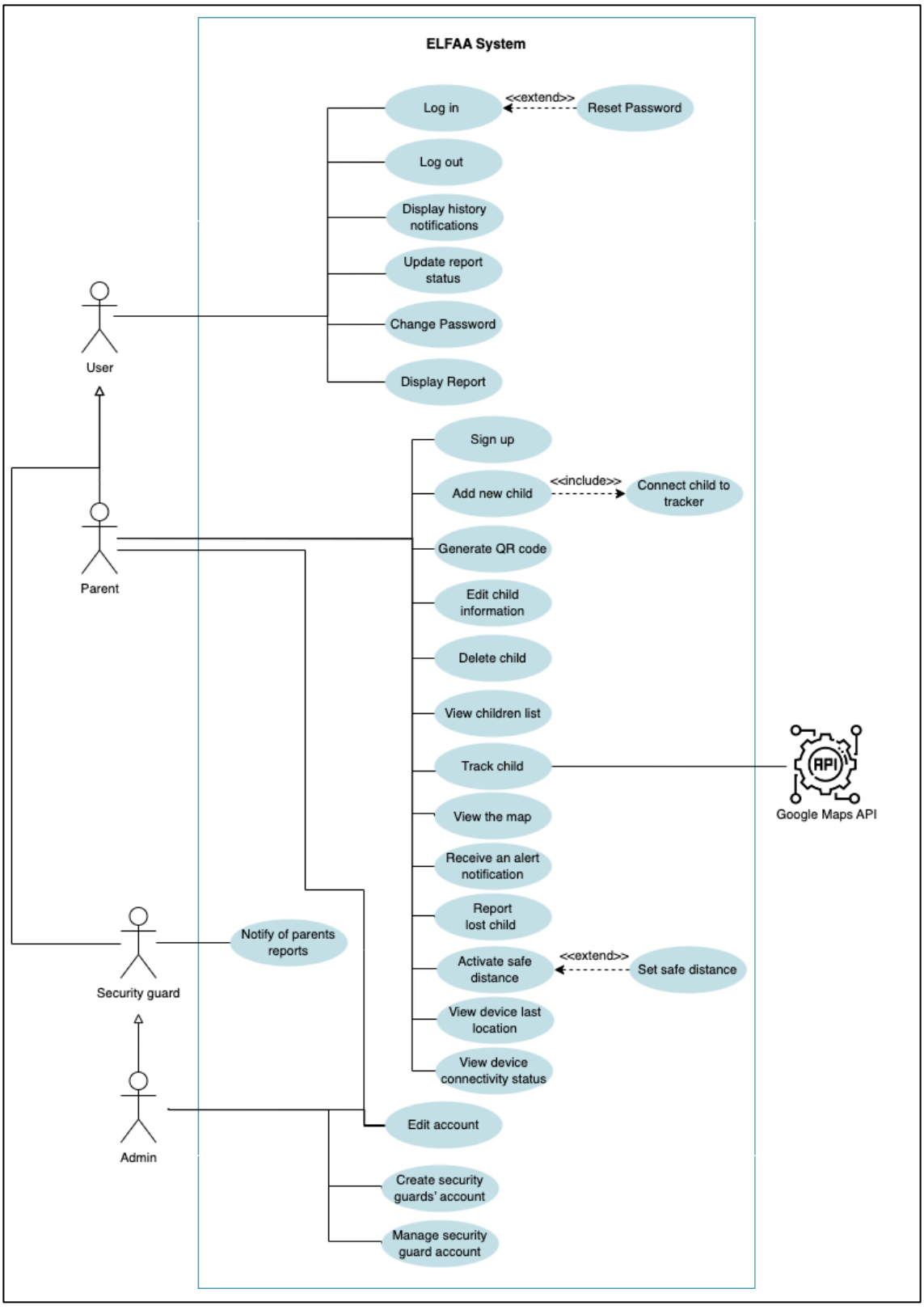


Figure 13: Use Case Diagram of Elfaa (إلفاء) system

4.2.4 Roadmap and Product Backlog

- Product Roadmap

In this section, the roadmap of the project is illustrated as a visual diagram in Figure 14, as it has two releases with its dates divided into five sprints.

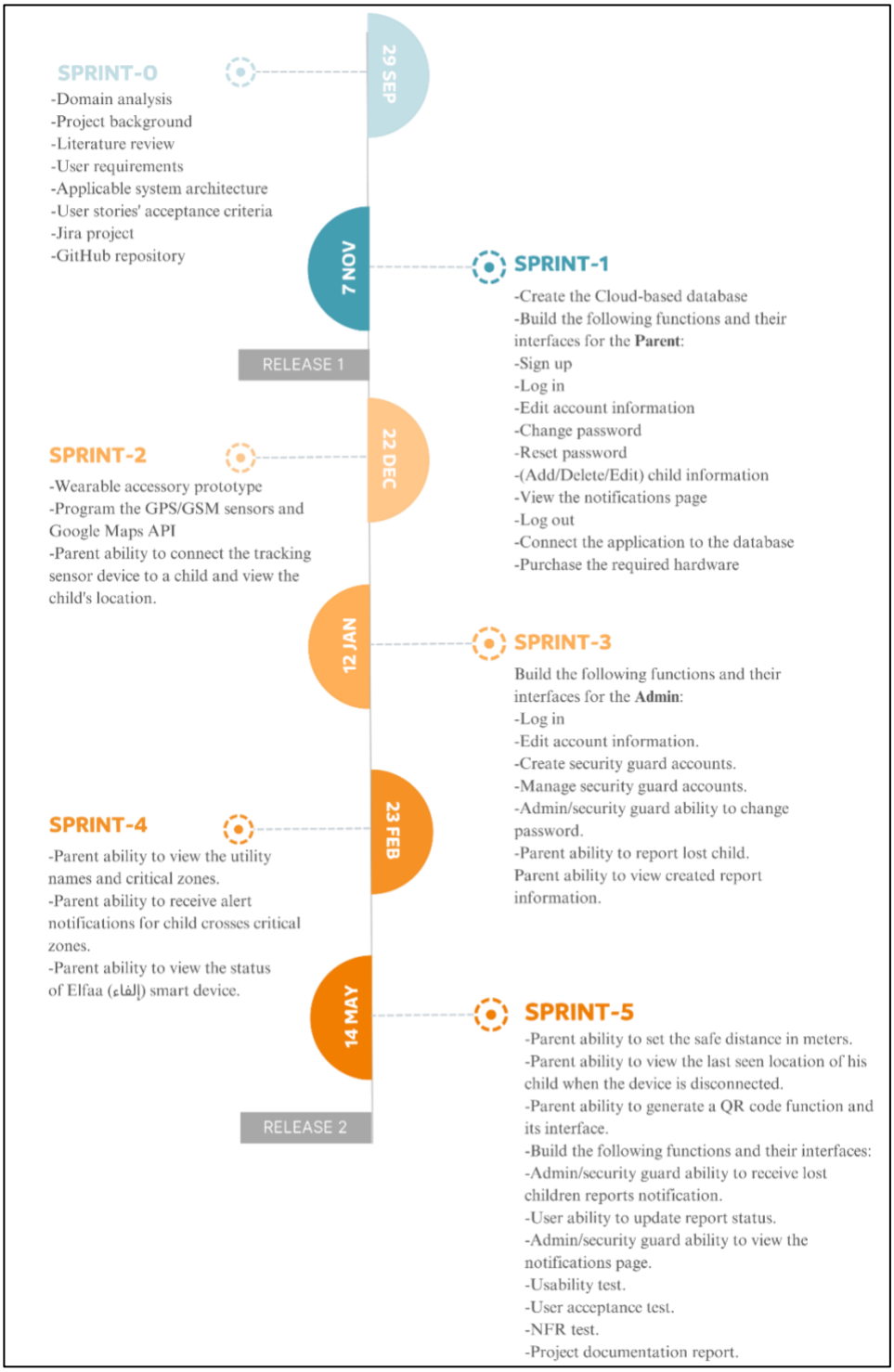


Figure 14: Roadmap of Elfaa (إلفاء)

- Product Backlog

In this section, the PBIs are illustrated, their sizes, types, acceptance criteria, and the highest priority user stories at the top of the Product Backlog Table as below in Table 6.

Table 6: Product Backlog

ID	PBI (User story)	Size	Type	Status	Acceptance Criteria
1	As a parent, I want to be able to sign up, so that I can access the system.	3	Feature	Done	1-As a parent, if I open the registration page, I should fill the fields of the form with the required information then I should receive an email verification link and can log-in to my account. 2-As a parent, if I go to the sign-up page and fill the required information, then I should receive an email verification link.
2	As a user, I want to be able to log-in, so that my information can only be accessed by me.	3	Feature	Done	As a user, if I open the log-in page I should fill the fields of the form with the valid required information, then I can view and manage my account.
3	As a user, I want to be able to log out, so that I prevent unauthorized actions on my current login session.	2	Feature	Done	As a logged-in user, if I click on the log-out button, then I should be redirected to the onboarding page.
4	As a parent, I want to be able to add a new child, so that I can manage him.	5	Feature	Done	As a parent, if I need to add a new child I should fill the fields of the form with the valid required information of the child, then I should be able to connect the tracker sensor to my added child.

ID	PBI (User story)	Size	Type	Status	Acceptance Criteria
5	As a parent, I want to be able to view list of my children, so that I can revise them when needed.	3	Feature	Done	As a parent, if I want to view list of my children, I should open the home page and find the list of my added children, then I can make sure they are added correctly and be able to manage them easily.
6	As a user, I want to be able to change my password, so that my account can be more secure.	3	Feature	Done	As a user, if I want to change my password, I should fill the form fields with valid information, then I should be told that my password changed successfully, and I signed out.
7	As a user, I want to be able to reset my password so that, I can get back into the application if I forget my password.	3	Feature	Done	As a user, if I want to reset my password, I should fill the email field with the valid required information, then I should receive an email with a link that asks me to reset my password.
8	As a parent, I want to be able to edit my child's information, so that I can make his information up to date.	4	Feature	Done	As a parent, if I want to edit a child's information, I can view the current information so that I can edit any field, then the edited fields should be updated.
9	As a parent, I want to be able to delete my child, so that I can stop managing him.	4	Feature	Done	As a parent, if I want to delete a child, I should select one among the children list, then the child should disappear from my home page.
10	As a user, I want to be able to display all the history notifications,	5	Feature	Done	As a user, If I want to revise my previous notifications, then I can view all my previous notifications on one page.

ID	PBI (User story)	Size	Type	Status	Acceptance Criteria
	so that I can revise my previous notifications when needed.				
11	As a user, I want to be able to display a report information, so that I can get to know all details about the lost child.	4	Feature	Done	As a user, If I want to view a report, then I should be able to display the report with all its detailed information (name, age, height, image, location, status, parent's information, and admin office phoneNo).
12	As an admin, I want to be able to create security guards' accounts, so that I guarantee they are authorized security guards.	4	Feature	Done	1- As an admin, if I need to create a security guard account, I should fill the fields of the form with the required information, then the account should appear to me. 2- As an admin, if I created a new security guard account, then he/she can log-in with the created credentials successfully.
13	As an admin, I want to be able to manage security guards' accounts, so that I guarantee their accounts are managed only by me.	4	Feature	Done	As an admin, if I created a security guard account and I requested to manage it, then I should have options that enable me to edit or delete the account.
14	As an admin/parent, I want to edit my account's information,	4	Feature	Done	As an admin/parent, if I want to edit my account's information, I can view the current information so that I can edit any

ID	PBI (User story)	Size	Type	Status	Acceptance Criteria
	so that I can ensure its up to date.				field, then the edited fields should be updated.
15	When the tracking sensor passes 10 seconds, it will send the location's coordination to the cloud continuously.	4	Feature	Done	As *Elfaa (إلفاء)* system, if the tracking sensor is available and equipped by the child, then the location will be updated in the system continuously each 10 seconds.
16	As a parent, I want to be able to view the map, so that I can track my child's location.	5	Feature	Done	As a parent, if I want to know my child's location, I should view the map, then the utility zone name and the exact location should appear clearly.
17	As a parent, I want to be able to report my lost child to the security guards, so that they can help me find him.	5	Feature	Done	As a parent, if I lost my child and need security guards to help me find him, I can report the lost child, then the security guards will receive the report.
18	As an admin/security guard, I want to be notified about a lost child report, so that I can look for him.	4	Feature	Done	As an admin/security guard, if parents report a lost child, then I should be alerted application is closed and able to view the report's content.
19	As a user, I want to update the lost child report status, so that	4	Feature	Done	As a user, if a parent reported a lost child, then I can change the status of the report when it changed.

ID	PBI (User story)	Size	Type	Status	Acceptance Criteria
	report management becomes easier.				
20	As a parent, I want to be able to receive an alert notification, so that I can be aware if my child entered a critical zone.	5	Feature	Done	As a parent, if my child entered a critical zone and I do not have the application open, or my phone is locked then a notification banner should appear.
21	As a parent, I want to be able to generate a QR code of my contact information, so that I can be reachable to the public people.	4	Feature	Done	As a parent, if I ask to generate a QR code of my contact information, then a QR code should appear.
22	As a parent, I want to be able to view the status of *Elfaa (إلفاء)* tracking device, so that I can make sure it is working.	3	Feature	Done	As a parent, if I go to the homepage and see the map of my children's' locations then I should see the status of the device connectivity showing if it is connected or disconnected.
23	As a parent, I want to be able to activate receiving an alert when any of my children exceeds the safe distance, so that I	5	Feature	Done	As a parent, if I activated the safe distance option and any of my children is out of a specified safe distance, then I should receive an alert message that appears on the notifications page either if the application is closed or opened.

ID	PBI (User story)	Size	Type	Status	Acceptance Criteria
	pay more attention of my child.				
24	As a parent, I want to be able to set the safe distance in meters for my children, so that I can be able to know if they are far away from me.	5	Feature	Done	As a parent, if I want to change the safe distance from the default distance (6 meters [35]) for my children, then it should be set up after I confirm it from the confirmation message.
25	As a parent, I want to be able to view the last seen location of my child when the device is disconnected, so that I have a clue of his last location.	4	Feature	Done	As a parent, if I am on the view child page or in the homepage and the device status was disconnected, then I should see my last seen location of my child.
26	As a parent, I want *Elfaa (إلفاء)* tracking device to be available when there is a cellular network around, so that I can receive my child's location.	NA	Feature	Done	-
27	As a user, I want *Elfaa (إلفاء)* application to be available all days except five hours for maintenance every	NA	Feature	Done	-

ID	PBI (User story)	Size	Type	Status	Acceptance Criteria
	two weeks, so that I can access it any time unless it's maintenance time.				
28	As a user, I want to log-in within less than 20 seconds.	NA	Feature	Done	-
29	As a user, I want the mobile interface to be simple and easy to understand, so that I can know how to use it properly in less than 10 minutes.	NA	Feature	Done	-
30	As a user, I want the system response to my request in less than 10 seconds, so that I can use it effectively with full attention.	NA	Feature	Done	-

4.3 System Design

4.3.1 Architectural Diagram

Elfaa (إلفاء) System utilizes the IoT architecture as shown in Figure 15 to manage and support IoT devices in the application. There are four layers presented that can be divided into sensing, network, data processing, and application layers. In addition to the third-party layer for the google maps API that is going to be used in *Elfaa (إلفاء)* system, these layers support IoT devices through data collection and processing. This architecture goes beyond the OSI model to include the transformation of data into usable information.

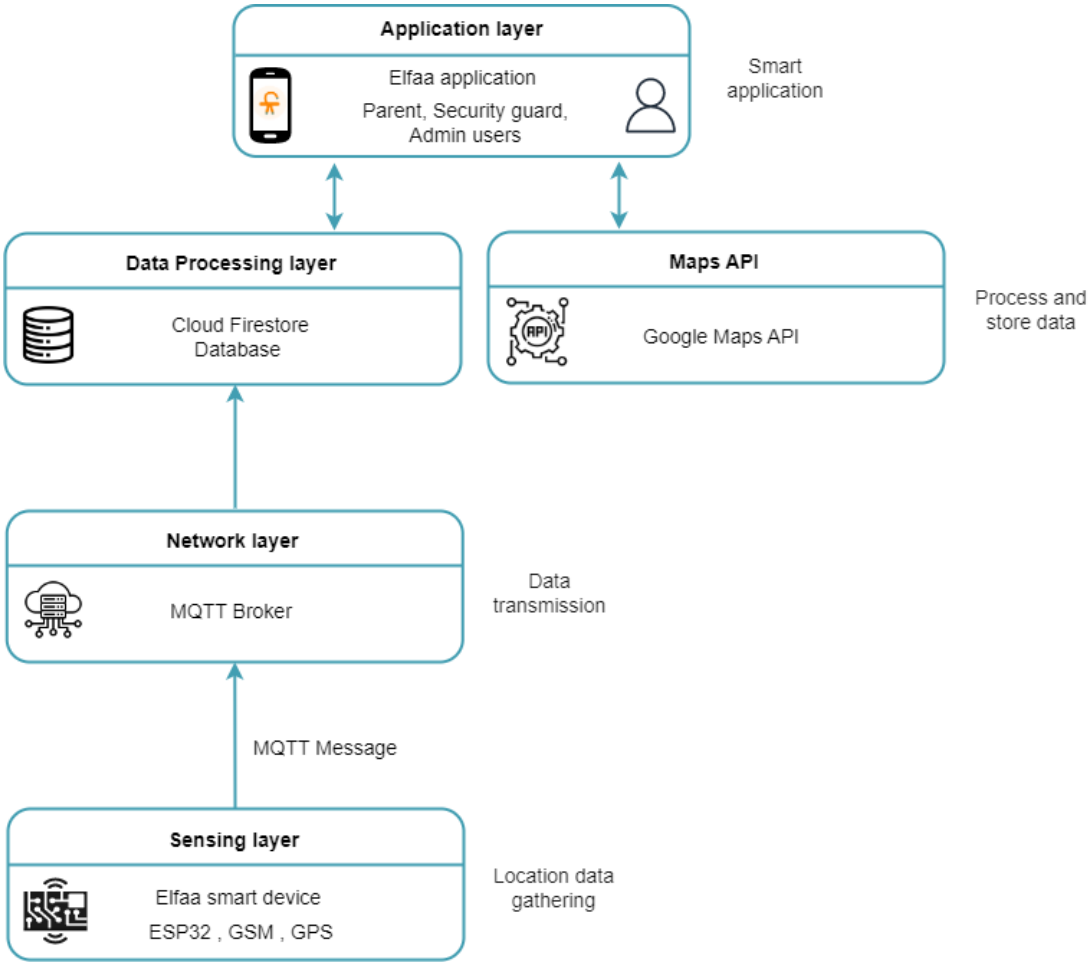


Figure 15: System Architecture of Elfaa (إلفاء) system

Starting from the lowest layer, *Elfaa (إلفاء)* tracking device which consist of ESP32, GSM and GPS is presented in the sensing layer as it is gathering the location coordinate and emits data over a cellular network via MQTT Message. The network layer consists of MQTT broker where it is responsible for transmitting the location data to the cloud Firestore database as it is the processing unit in the IoT ecosystem, where the data is analyzed and pre-processed. The Google Maps API will make use of the received data to view the map with the required information. Lastly, the application layer includes Elfaa (إلفاء) smart application and the users of the application since the main function of the parent is to track his child, while the security guard can receive the lost children reports and the admin will manage the security guards accounts and information.

4.3.2 Class Diagram

The class diagram of *Elfaa (إلفاء)* system is presented in Figure 16.

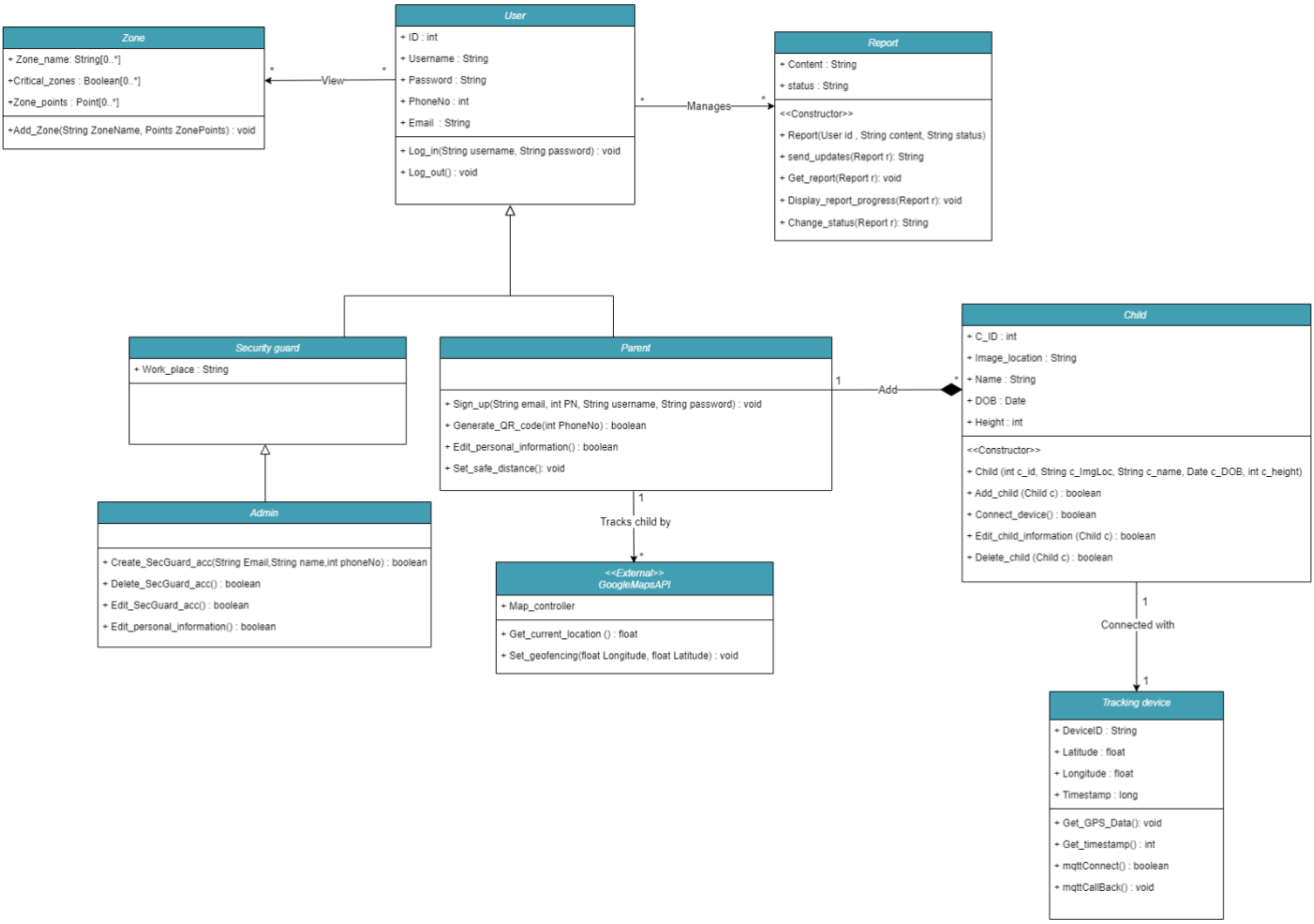
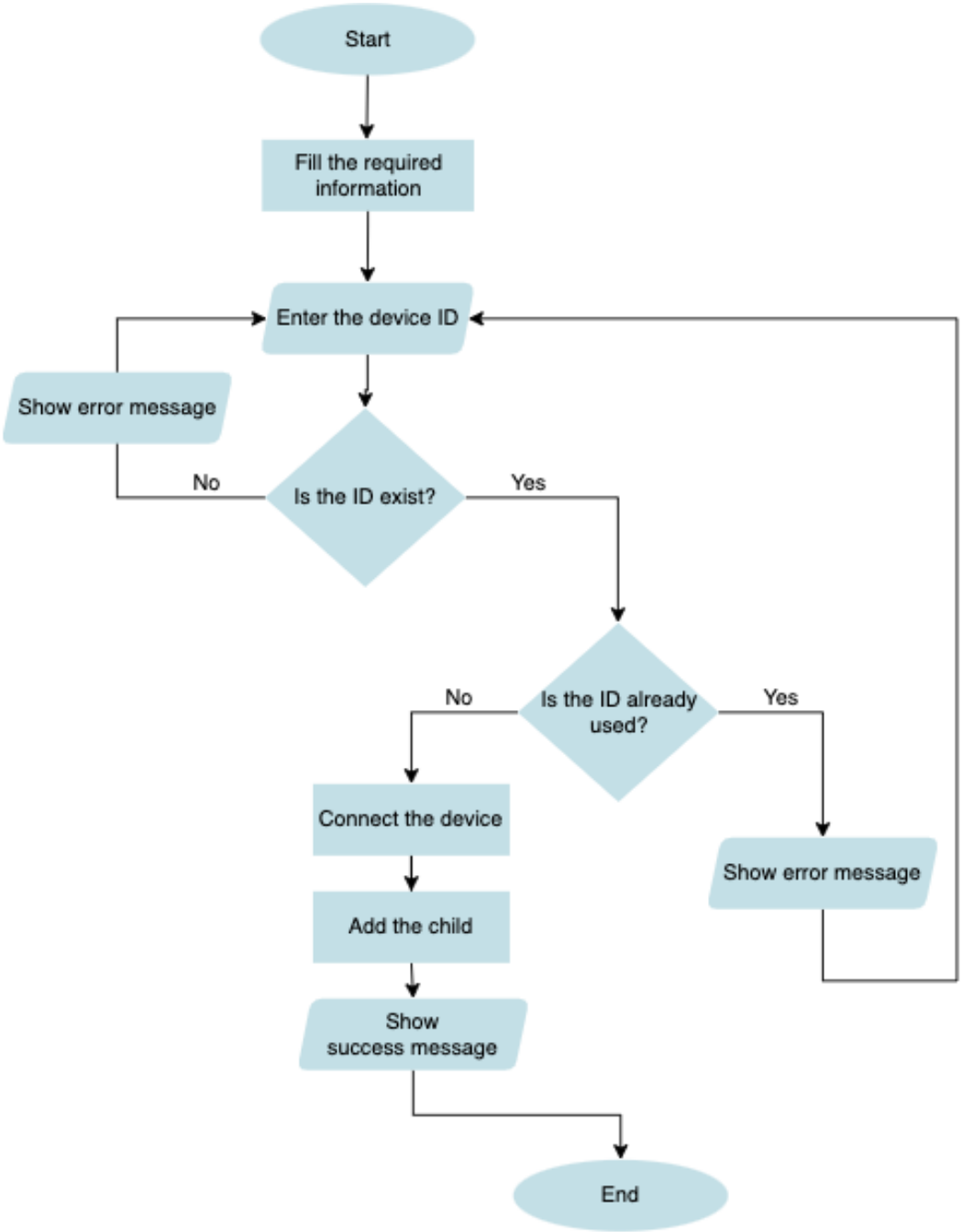


Figure 16: Class Diagram of Elfaa (إلفاء) system

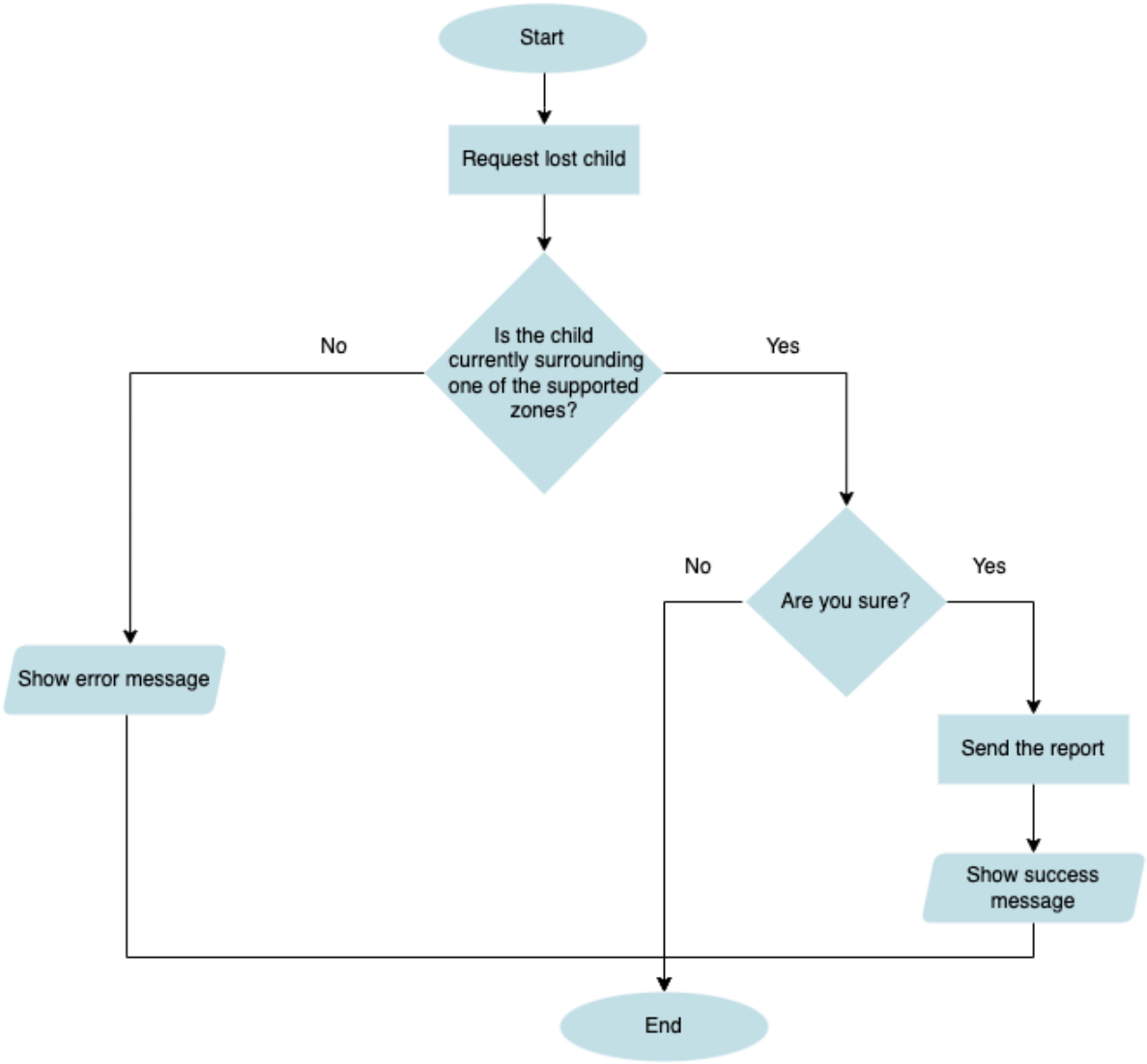
4.3.3 Component Level Design

In this section, we provide the flowcharts for the main component in *Elfaa (إلفاء)* system.

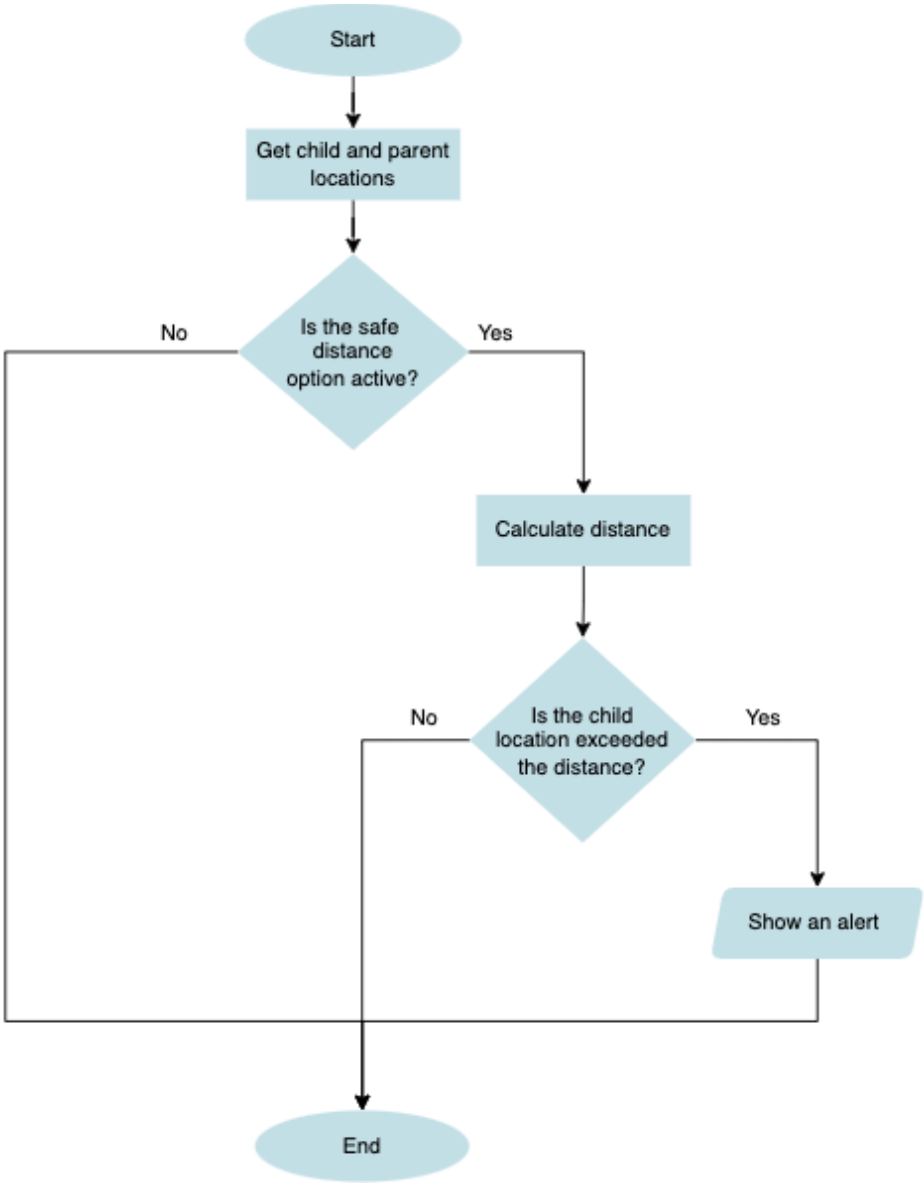
- Add New Child



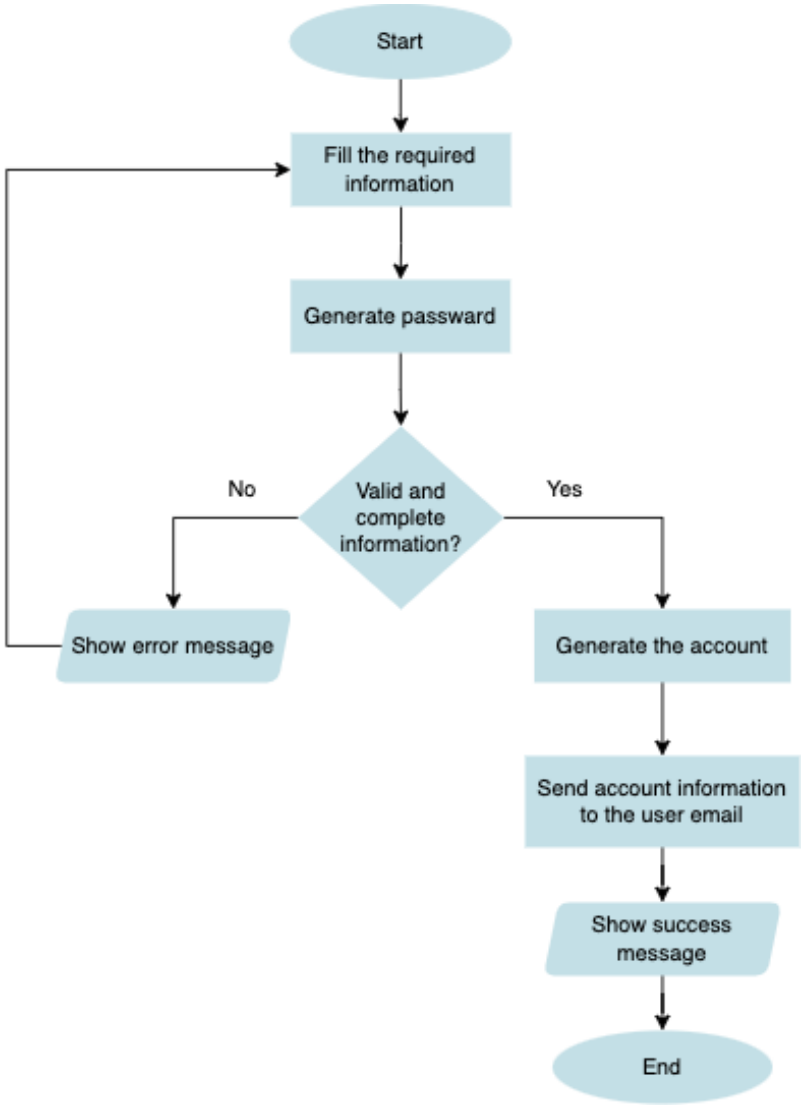
- Report Lost Child



- Safe Distance Alert



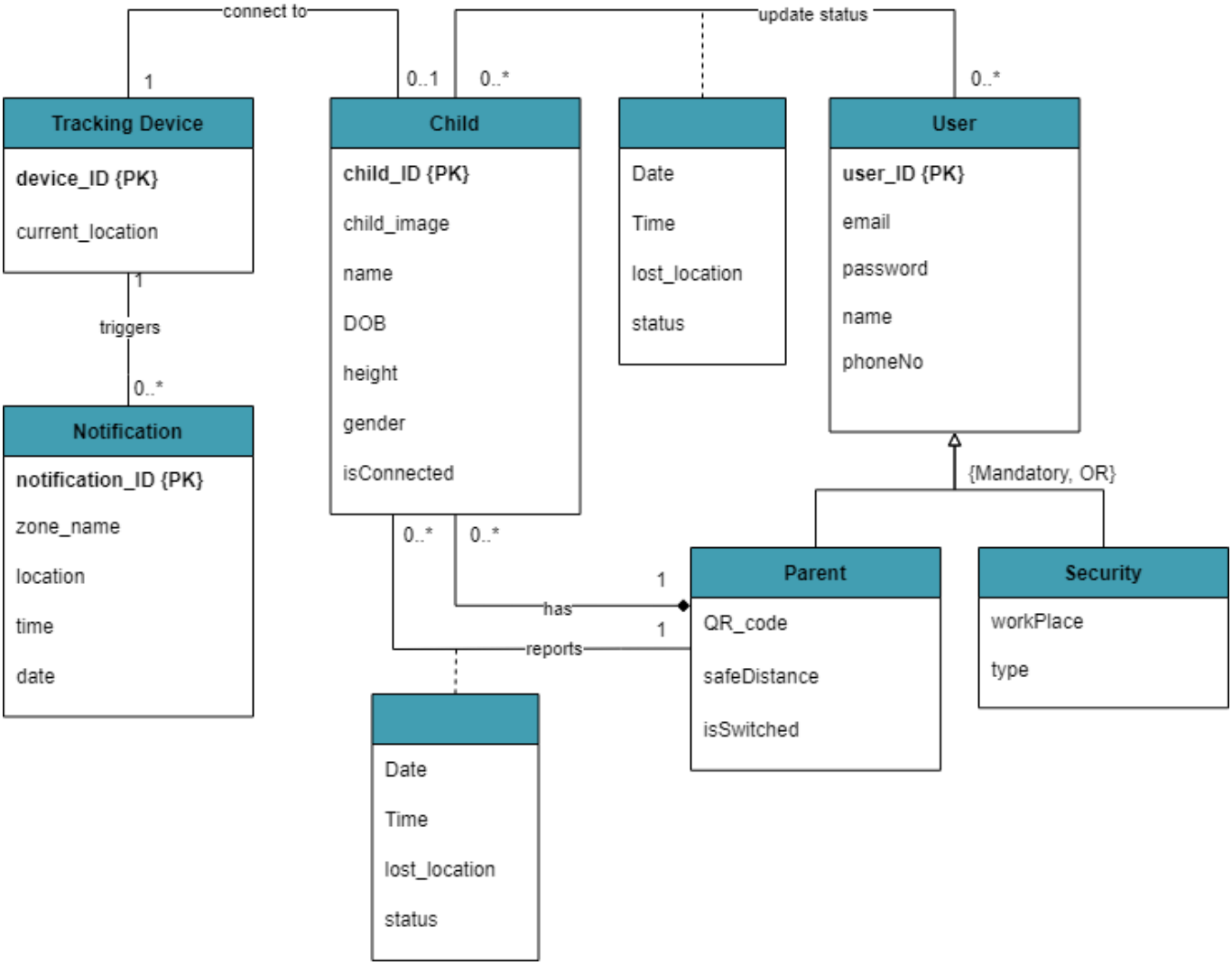
- Create Accounts for Security Guards (Admin)



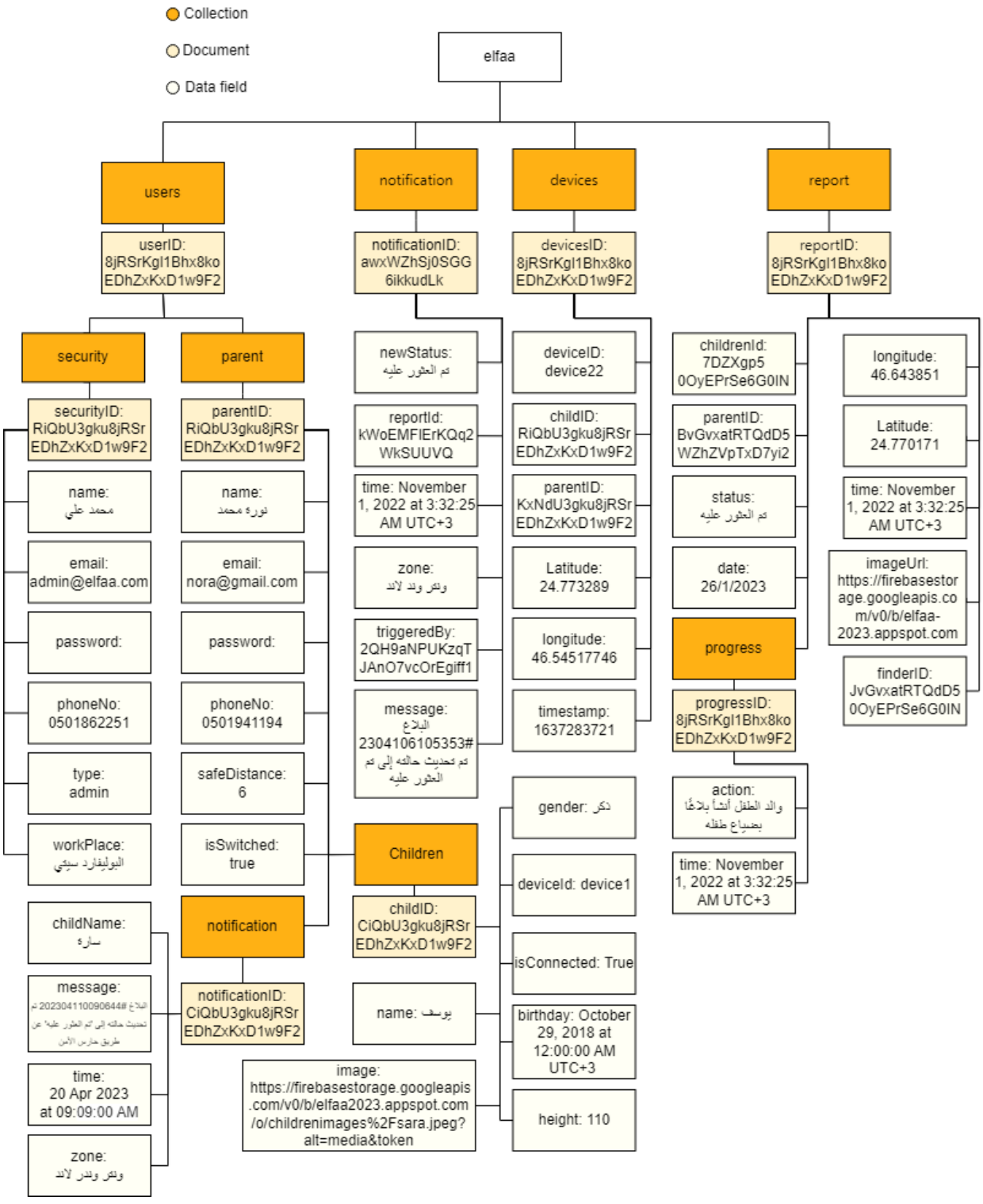
4.4 Data Design

4.4.1 Data Models

- ER diagram.



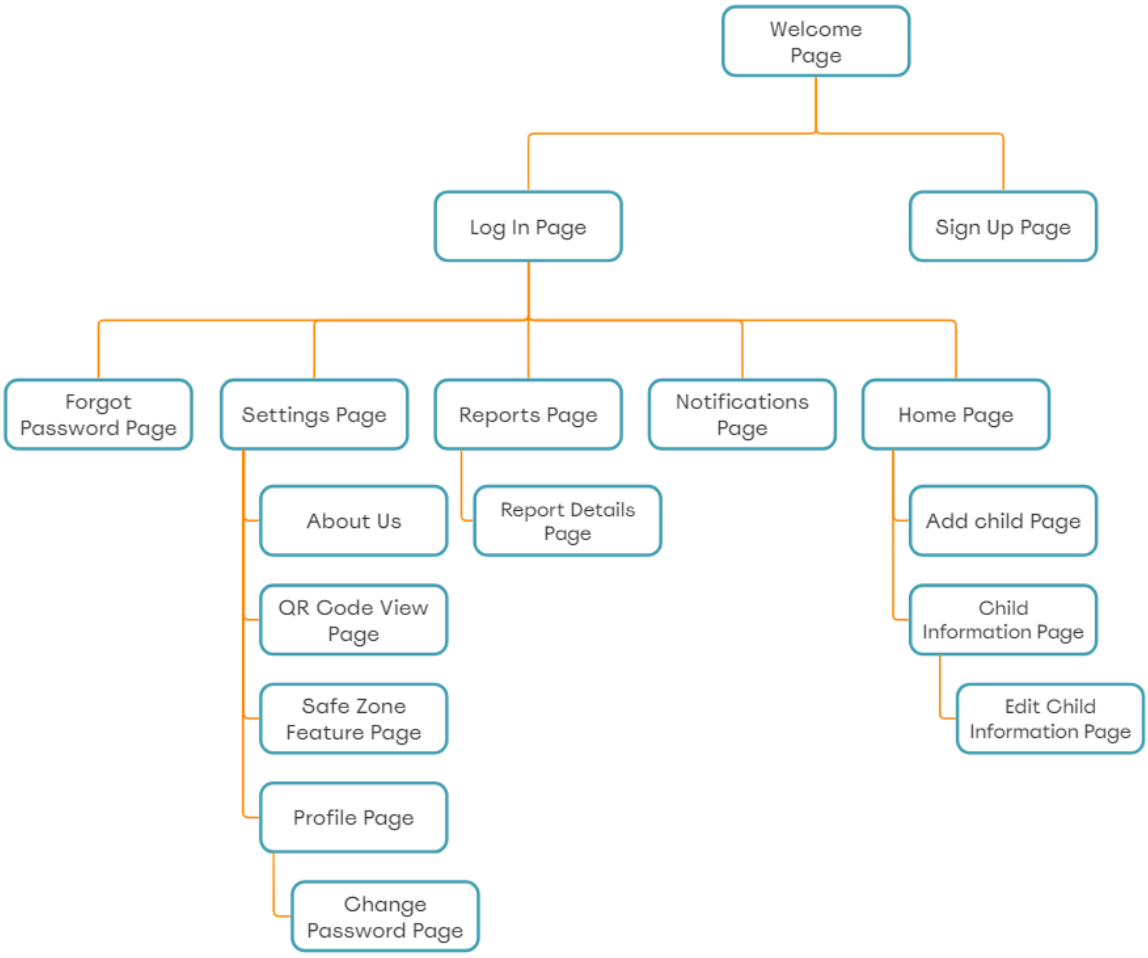
- Non-relational data model



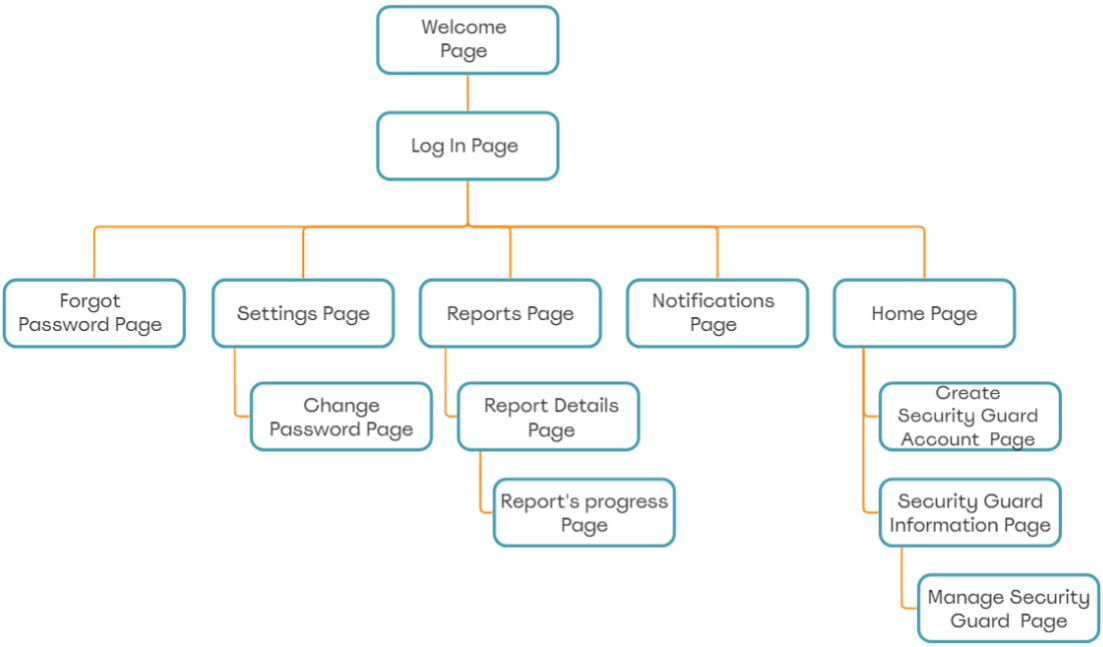
4.5 Interface Design

This section shows *Elfaa (إلفاء)* application structure using a site map for the parent, admin, and security guard views. Then, UX guidelines incorporated while designing *Elfaa (إلفاء)* application interface will be highlighted.

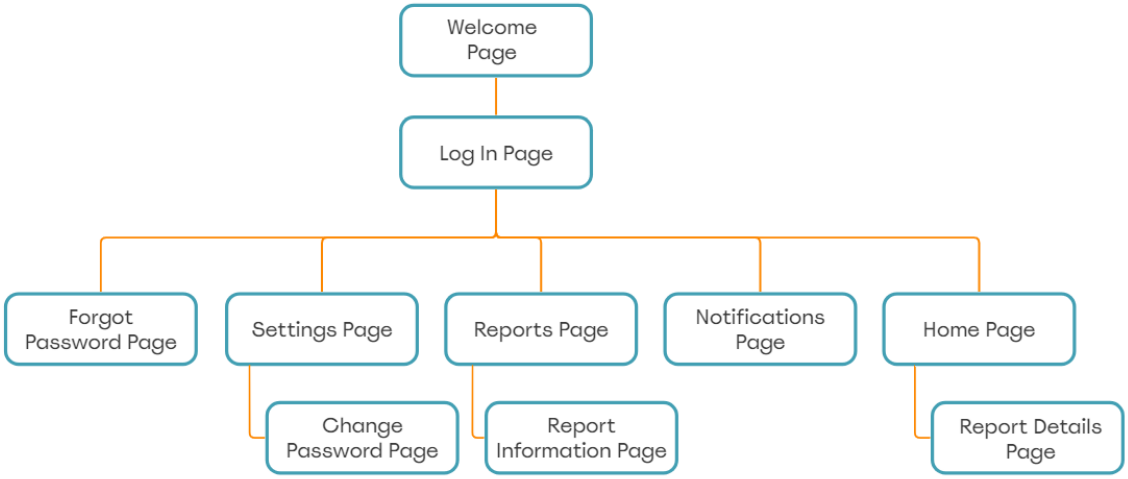
- Parent site map



- Admin site map:



- Security Guard site map:



- UX guidelines:

1. **Simple Forms** where the user can provide their input with ease. Using form controls where typing the text is minimum and selection options is used instead. For example, in “add child” function, date picker is used instead of writing the date of birth of the child manually.

2. **Consistency** where all pages in *Elfaa (إلفاء)* use the same "consistent" interface components and style, as in background, colors, fonts, and buttons.
3. **Error prevention** by presenting users with a confirmation option before they commit to actions as delete or edit and eliminate error-prone conditions such as in the phone number entry, numeric keyboard is used.
4. **Recognition rather than recall** is to help the user's when filling information, especially if he was distracted, hints are always available in *Elfaa (إلفاء)* application and not disappear as soon as the user start to fill a text. Moreover, advanced options allowing the user to view the password he is writing is available to reduce the need to memorize as much as possible.
5. **Help users recognize, diagnose, and recover from errors** where error messages are expressed in simple textual language (no error codes, or technical jargons), precisely indicating the problem using traditional error messages in red text, and telling users what went wrong in language they understand.

4.6 Implementation

In this section, *Elfaa (إلفاء)* team discuss the implementation difficulties they faced, present the used software and hardware tools, report and explain the implementation aspects in detail, and provide the associated GitHub repository at the end.

4.6.1 Implementation difficulties

During the development for *Elfaa (إلفاء)* system, we encountered different complications and challenges, including the following:

- Reset password function

As a security measure, we have developed a multi-step page where the user enters his email address then receives an OTP, and the last step was supposed to make him able to reset his password under the password constraints of *Elfaa (إلفاء)* application. However, it was not possible to implement this solution because the user is logged out from his account and, thus, he could not set his password. Therefore, we did our research to find that Firebase provides a variety of hosted backend services. As a result, we have used the reset password authentication function that is provided from the Firebase backend, and we have successfully solved this problem.

- Dealing with firebase storage images

We couldn't upload images to firebase storage because of the default firebase security rules, so we edited these rules to accept files. Even more, we found that uploading takes some time and the user may click on the button more than once resulting in adding the child multiple times to the database. Thus, we added a timer set with a spinning circular waiting icon in addition to a boolean flag to disable the button while waiting. After that we faced another challenge, getting back the download URL which takes some time depending on the size of image file, so we solved this problem by fetching child data only once at the home page then sending the information as a parameter to other pages constructors, reducing the number of fetches and enhancing the overall application performance.

- Admin privileges

When building the client-side application using Flutter application with Firebase, there was no SDK that gives a certain user the privilege to edit credentials or delete other users' accounts. Therefore, we used Firebase_core plugin that we already used in the main() method of our application to initialize another Firebase session with the user that the admin wants to edit/delete as its current user. Then, the admin will be able to perform edit/delete actions to the other user account in isolation of the admin's main session.

- QR Code

In Flutter, there is no library to export QR codes that are generated from QR image widget. Therefore, we used a screenshot library that provides a way to capture the widget QR code and save them as an image file.

- Tracking device components' integration

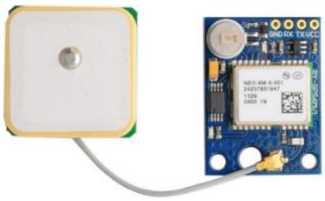
During the implementation of the tracking device using the main components ESP32, GSM SIM800L, and GPS NEO-6M, we encountered difficulties integrating the different modules. To overcome this, we tested each module individually and verified its functionality before connecting them to the ESP32. We then used compatible libraries for all the modules and modified the code to ensure they could work together seamlessly. This involved combining the functions of different libraries and reconciling conflicts between them.

4.7 Hardware tools

The main goal of *Elfaa (إلفاء)* application is to help parents be aware of their child location. To achieve that, *Elfaa (إلفاء)* team decided to build their own tracking device using different hardware

components. Table 7 below shows the required hardware components that used to build *Elfaa (إلفاء)* tracking device.

Table 7: Hardware tools

Hardware Component	Name and Usage Description
	**ESP32** - low-cost, low-power system on a chip microcontroller, used as MQTT client to send location data received form the GPS sensor via the internet provided by the GSM to the MQTT Server.
	**NEO-6M GPS Chip** – used to receive time and position updates from the satellite, works in outdoor.
	**GSM SIM800L** - GSM/GPRS module is a miniature GSM modem, used in this project to provide the tracking device a connection to the Internet via GPRS, it should hold a micro sim card – STC SIM card is supported.
	**Lithium Ion Battery** – chosen based on its size and weight, it is light weight battery lasts between 3-5 hours on a full charge, used to support the tracking device with power.
	**TP4056 1A Li-ion lithium Battery Charging Module –** used to charge the battery by using micro-USB cable.
	**Slide switch** - used to control current flow from the battery, to give the user the ability to save battery in case of he does not need to use the tracking device.

Hardware Component	Name and Usage Description
	**Boost converter** – used to convert the voltage coming from the battery which is from 3.7v ~ 4.2 to 5v, since some modules needed 5v.
	**10K-ohm resistor, and 510-ohm resistor –** used as a voltage divider for the GSM to lower the voltage level of the esp32 signal.
	**Jumper wires** - used in the circuit to connect two points together and make connections between the different tracking device components.

4.7.1 Software tools

Table 8: Software tools

Software Type	Version
Dart SDK	2.13.1
Flutter	3.3.4
Visual studio Code	1.67
Android Studio	2021.3.1
GitHub	2.9.3
Firebase	11.14.1
Arduino IDE	1.8.3
Linode VPS	1.89.1
PyCharm	2022.3
Fusion 360	2.0.13162

4.7.2 Hardware implementation

Elfaa (إلفاء) tracking device is based on assembling many hardware components to build it. It uses a GPS module, a GSM module with GPRS internet connectivity, and an ESP32 microcontroller as the main components. The GPS module sends location and time data to the ESP32, which runs C++ code that communicates with the GPS and GSM modules and sends data to a broker server using the MQTT protocol. To connect to the broker server that is hosted on the Linode cloud platform, the ESP32 uses the GPRS connectivity provided by the GSM module, allowing it to transmit data using the MQTT protocol over the internet.

- Tracking device code: connect the client to the broker.

Function	Connect to MQTT protocol
Description	This code fragment written in C++ using Arduino IDE, defines MQTT-related variables such as the broker IP address, authentication credentials, and communication topic for the MQTT client. Additionally, it defines two functions, mqttCallback and mqttConnect, for handling incoming messages and connecting to the broker, respectively.

```
// Set the MQTT broker details
const char* broker = "139.177.191.224";
const char* mqttUsername = "elfaa";
const char* mqttPassword = "123456";

// Set the MQTT topics to be used
const char* topicPubGpsData = "esp32/gsm_gps/device";
const char* topicSubLed = "esp32/gsm";
```

```
// Function to handle incoming MQTT messages
void mqttCallback(char* topic, byte* message, unsigned int len) {
  Serial.print("Message arrived on topic: ");
  Serial.print(topic);
  Serial.print(". Message: ");
  String messageTemp;

  for (int i = 0; i < len; i++) {
    Serial.print((char)message[i]);
    messageTemp += (char)message[i];
  }
  Serial.println();
}

// Function to connect to the MQTT broker
boolean mqttConnect() {
  SerialMon.print("Connecting to ");
  SerialMon.print(broker);

  boolean status = mqtt.connect("GsmClientN", mqttUsername, mqttPassword);

  if (status == false) {
    SerialMon.println(" fail");
    ESP.restart();
    return false;
  }
  SerialMon.println(" success");
  mqtt.subscribe(topicSubLed);
  return mqtt.connected();
}
```

On the server, a Python script is uploaded to receive the location and time data from the tracking device. The Python script uses the Firebase API to authenticate and send the data to the Firebase real-time database. The location and time data sent by the tracking device is stored in the database and can be accessed and displayed in real-time through the developed Android mobile application "Elfaa" which is connected to the Cloud Firestore Database.

- Broker script: send child's location data to Real-Time Firebase database.

The python script below is hosted on a VPS to send the location data to Firebase. We used several imports to enable this Python script to interact with an MQTT broker and a Firebase Realtime Database. The logging module was imported to allow logging of debugging information and error messages. The firebase_admin module was imported to facilitate interaction with the Firebase Realtime Database, and the credentials module was used to authenticate the client when connecting to

the database. The db module was imported to create a reference to the Firebase Realtime Database, and the json module was used to decode the JSON messages received from the MQTT broker. Finally, the paho.mqtt.client module was imported to create an MQTT client.

We also created three functions to handle various events that might occur while the client is running. The on_connect function is called when the client successfully connects to the MQTT broker. The on_subscribe function is called when the client successfully subscribes to a topic. The on_message function is called when the client receives a message on the subscribed topic. The on_message function extracts certain fields (deviceID, lat, lng, and timestamp) from the received message and writes them to the Firebase Realtime Database under the /devices path with the deviceID as the key.

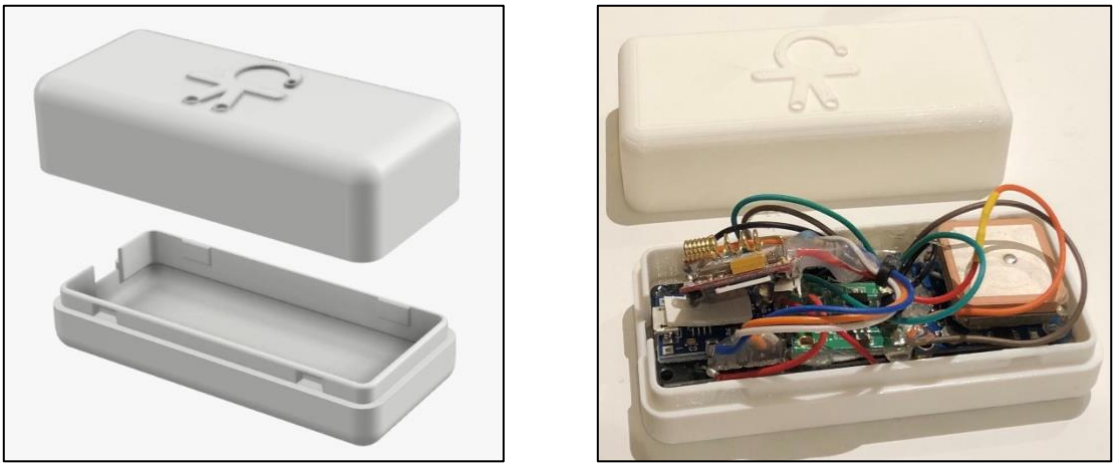
Send_to_Firebase.py
Python Script

```
# Import important libraries
import logging
import firebase_admin
from firebase_admin import credentials
from firebase_admin import db
import json
from mqtt_config import *
import paho.mqtt.client as mqtt


# Configure the logger to write to a file
logging.basicConfig(filename="send_to_firebase.log", format="%(asctime)s %(message)s", filemode='w')
logger = logging.getLogger()
logger.setLevel(logging.DEBUG)


# Load the firebase admin credentials
cred = credentials.Certificate('elfaa-2023-firebase-adminsdk-qvq55-a3ee83af25.json')


# Initialize the firebase admin app with the credentials and database URL
default_app = firebase_admin.initialize_app(cred, {'databaseURL': "https://elfaa-2023-default-rtdb.asia-southeast1.firebasedatabase.app"})
```

```
# Callback function for when the mqtt client connects to the broker
def on_connect(client, userdata, flags, rc):
    result_from_connect = mqtt.connack_string(rc)
    print("Result from connect: {}".format(result_from_connect))
    logger.debug("Result from connect: {}".format(result_from_connect))
    client.subscribe(mqtt_sub_topic)

# Callback function for when the mqtt client subscribes to a topic
def on_subscribe(client, userdata, mid, granted_qos):
    print("I've subscribe with QoS: {}".format(granted_qos[0]))
    logger.debug("I've subscribe with QoS: {}".format(granted_qos[0]))

# Callback function for when the mqtt client receives a message
def on_message(client, userdata, msg):
    topic = msg.topic
    m_decode = str(msg.payload.decode("utf-8", "ignore"))
    try:
        # Parse the message as json
        message_json = json.loads(m_decode)
        print("Message Received: ")
        print(message_json)
        logger.debug("Message Received: ")
        logger.debug(message_json)

        # Extract the data from the message
        deviceID = message_json["deviceID"]
        lat = message_json["lat"]
        lng = message_json["lng"]
        timestamp = message_json["timestamp"]
```

```
        # Log the extracted data
        print("\n DeviceID: {}\n lat: {}\n lng: {}\n timestamp: {}\n".format(deviceID, lat, lng, timestamp))
        logger.debug("\n DeviceID: {}\n lat: {}\n lng: {}\n timestamp: {}\n".format(deviceID, lat, lng, timestamp))


        # Set the message_json to the firebase realtime database
        path = "/{}".format(deviceID)
        ref = db.reference("devices").child(deviceID)
        ref.set(message_json)
    except:
        print("Error message format")


# Main function
if __name__ == "__main__":
    client = mqtt.Client()
    client.on_connect = on_connect
    client.on_subscribe = on_subscribe
    client.on_message = on_message
    client.username_pw_set(mqtt_username, mqtt_password)
    client.connect(host=mqtt_server_host, port=mqtt_server_port, keepalive=mqtt_keepalive)
    client.loop_forever()
```

Ultimately, *Elfaa (إلفاء)* team designed a 3D container for the tracking device using Fusion 360 software that contains all the hardware components to prevent damages, Figure 17 below illustrates how it looks. This tracking device uses a combination of hardware components and cloud-based software services to provide real-time location tracking and data storage. The GPS module and GSM module with GPRS internet connectivity allow the device to transmit location and time data to the server, while the Linode cloud platform and Firebase real-time database provide a secure and scalable solution for storing and accessing the data.



(a) (b)

Figure 17: 3D Box Design & 3D Printed Box

4.7.3 Software implementation

Elfaa (إلفاء) system was implemented in Visual Studio code environment using Flutter UI framework and Dart as a programming language. The reason we have chosen Dart as a programming language is because Flutter applications usually use Dart programming language for creating mobile applications and it is easy to find a lot of resources that help in the implementation. To use Flutter, we initially downloaded the Flutter SDK depending on the operating system, then extracted the file and added the Flutter tool path then run Flutter doctor command to see if there are any dependencies, we need to install to complete the setup.

To test the application interfaces and function, we used an Android virtual device provided by Android Studio and a Samsung mobile. In addition, we used GitHub to upload the code online so that we can easily share the changes and updates between the group and keep track revision like who changed what, when, and where those files are stored. To use GitHub, first we install Git then we create a repository that will store everything files, images, etc…, then we started making and committing changes to the repository.

Firebase was also used for the database in Elfaa (إلفاء) application to make the application rich, and collaborative by allowing secure access to the database directly from client-side code. The database is a "NoSQL" database and as such has different optimizations and functionality compared to a relational database. Also, "NoSQL" is used for Fast-paced Agile development and when there is a huge volume of data.

Elfaa (إلفاء) application provides different functionalities that were developed and tested that listed below:

- Change and reset password

One of the important functionalities is the change and reset password. When it comes to reset, when you are logged out from your account, and you have forgotten your password you can just reset your password through the following authentication function.

Function	sendPasswordResetEmail()
Description	This function is called by the user when he fills the required email address. First, it will check if the email address existed in the authentication table, then the user will successfully receive an email that asks him to reset his password.

```
Future resetPassword() async {
   try {
     await FirebaseAuth.instance.sendPasswordResetEmail(email: email.text);
     Fluttertoast.showToast(
         msg:
             "تم إرسال البريد الإلكتروني الخاص بإعادة تعيين كلمة المرور بنجاح",
         toastLength: Toast.LENGTH_SHORT,
         gravity: ToastGravity.BOTTOM,
         timeInSecForIosWeb: 7,
         backgroundColor: Colors.lightGreen,
         fontSize: 16.0,
         textColor: Colors.white);
   } catch (e) {
     Fluttertoast.showToast(
         msg: " البريد الإلكتروني غير موجود ",
         toastLength: Toast.LENGTH_SHORT,
         backgroundColor: Colors.red,
         fontSize: 16.0,
         textColor: Colors.black);
   }
 }
```

Besides that, the change password function is when the user is logged in. Users can change their password for security reasons in case someone knew your password.

Function	updatePassword()
Description	This function is called by the user, when he fills the required three fields (current password, new, and confirmed), with valid new password following the specified criteria for a strong password. It first authenticates the logged-in user to check if the entered current password is identical to the one in the database, then it checks if the new password is identical to the one after it (confirmed password), it will accept the changing of the password and reauthenticates the user with his new password and signed him out with a direction to the log in page.

```
Future<void> updatePassword() async {
    final user = await FirebaseAuth.instance.currentUser;
    final credential = EmailAuthProvider.credential(
        email: user!.email.toString(), password: _old.toString());
    user.reauthenticateWithCredential(credential).then((value) {
      if (_new == _confirmed) {
        user.updatePassword(_new.toString()).then((value) {
          Fluttertoast.showToast(
              msg: "تم تغيير كلمة المرور بنجاح",
              toastLength: Toast.LENGTH_SHORT,
              gravity: ToastGravity.BOTTOM,
              timeInSecForIosWeb: 1,
              backgroundColor: Colors.green,
              textColor: Colors.white,
              fontSize: 16.0);

          FirebaseAuth.instance.signOut();
          Navigator.pushReplacement(
              context,
              MaterialPageRoute(
                  builder: (context) => SignInScreen(type: "parent")));
        }).catchError((error) {
          Fluttertoast.showToast(
              msg: "حدث خطأ ما",
              toastLength: Toast.LENGTH_SHORT,
              gravity: ToastGravity.BOTTOM,
              timeInSecForIosWeb: 1,
              backgroundColor: Colors.red,
              textColor: Colors.white,
              fontSize: 16.0);
        });
      } else {
        Fluttertoast.showToast(
            msg: "كلمة المرور غير متطابقة",
```

```
            toastLength: Toast.LENGTH_SHORT,
            gravity: ToastGravity.BOTTOM,
            timeInSecForIosWeb: 1,
            backgroundColor: Colors.red,
            textColor: Colors.white,
            fontSize: 16.0);
      }
    }).catchError((error) {
      Fluttertoast.showToast(
          msg: "كلمة المرور القديمة غير صحيحة",
          toastLength: Toast.LENGTH_SHORT,
          gravity: ToastGravity.BOTTOM,
          timeInSecForIosWeb: 1,
          backgroundColor: Colors.red,
          textColor: Colors.white,
          fontSize: 16.0);
    });
  }
```

- Display Map Functions

This function allows parents to see the map using Google Maps API to view their children's location and all zones with their name and icon including the critical zones. After asking the parent permission to access his location the getMyCurrentLocation() method will get his exact location with high accuracy and then we can call buildMap() method to display the map.

Function	getMyCurrentLocation()
Description	This function is called to get the user's current location to view it in the map by calling getCurrentLocation() from class Location_helper to ask the user to open the GPS in his phone. The first three lines that we add in the AndroidManifest will enable to do so.

AndroidManifest.xml:

```
<uses-permission android:name="android.permission.ACCESS_FINE_LOCATION" />
<uses-permission android:name="android.permission.ACCESS_BACKGROUND_LOCATION"/>
<uses-permission android:name="android.permission.ACCESS_COARSE_LOCATION" />
```

Home_page.dart , veiwChild.dart:

```
Future<void> getMyCurrentLocation() async {
  //ask for permission
  await Geolocator.requestPermission();
```

```
  //update parent location
  position = await Geolocator.getLastKnownPosition().whenComplete(() {
    if (mounted) {
      setState(() {});
    }
  });
}
```

Location_helper.dart:

```
import 'package:geolocator/geolocator.dart';

class Location_Helper {
 //get Current Location of the parent
 static Future<Position> getCurrentLocation() async {
  //check if the location service is enabled
  bool isEnabled = await Geolocator.isLocationServiceEnabled();
  //if not ask for permission
  if (!isEnabled) {
    await Geolocator.requestPermission();
  }
//return the location with high accuracy
  return await Geolocator.getCurrentPosition(
      desiredAccuracy: LocationAccuracy.high);}}
```

Function	buildMap()
Description	This function is called to build the map on the home page and also in the view child page so that parents can see their child's location besides parents' location.

```
 Widget buildMap() {
  zoneList.addZonetoMap();
//make use of GoogleMap API
  return GoogleMap(
    //look of the map
```

```
    mapType: MapType.normal,
    myLocationEnabled: true,
    //zoom in and zoom out
    zoomControlsEnabled: true,
    //show all marks we have defind
    markers: Set<Marker>.of(zoneList.markers + markersMap.values.toList()),
    //relocate the camera
    myLocationButtonEnabled: true,
    //show my current location
    initialCameraPosition: _myCurrentLocationCameraPosition,
    onMapCreated: (GoogleMapController controller) {
      setState(() {
        _mapcontroller.complete(controller);
      });
    },
    //show children on the map
    circles: Set.of((circle != null)
        ? [circle] + circlesMap.values.toList()
        : circlesMap.values.toList()),
        //show our defind zones
    polygons: zoneList.polygons,
  );
}
```

- Display Zones Functions

After building the map now we are going to put the critical zones on the map. There is a class called zones which has all the zones coordination, name, image, color, and whether it is a critical zone or not then addZonesName() method will organize the zones in an array and then use it to display each child zone. For addZonetoMap() method, it will add all zones on the map by specifying each zone's points and color.

Function	addZonesName()

Description	This function is called to organize the zones in an array with the zone name, points, and whether it is a critical zone or not[4].

```
addZonesName() async {
  //creat lisit whith all points of each zone we have to know the child zone later
  List<List<Point>> zonePoints = [
    nafoorah_,
    garden_,
    gate1Bole_
  ];
  //store info of each zone it's name and points and critical or not
  for (int i = 0; i < zoneName.length; i++) {
    zoneNames.add({
      'name': zoneName[i],
      'points': zonePoints[i],
      'criticalZones': criticalZones[i]
    });
  }
}
```

Function	addZonetoMap()
Description	This function is called to show the zones on the map by specifying each zone's points and color [5].

```
addZonetoMap() async {
  //store all coordanations for all zones we have with the color to show it on the map
  //winter wender land
  // boulevard
  polygons.add(
    Polygon(
      polygonId: PolygonId("30"),
```

[4] We add only 3 zones from boulevard zone as example.
[5] We show here only some of boulevard zones as example.

```
      points: nafoorah,
      fillColor: ui.Color.fromARGB(255, 0, 94, 255).withOpacity(0.2),
      strokeColor: ui.Color.fromARGB(255, 0, 94, 255),
      strokeWidth: 2,
    ),
  );
  polygons.add(
    Polygon(
      polygonId: PolygonId("31"),
      points: garden,
      fillColor: ui.Color.fromARGB(255, 7, 185, 22).withOpacity(0.2),
      strokeColor: ui.Color.fromARGB(255, 7, 185, 22),
      strokeWidth: 2,
    ),
  );
   polygons.add(
    Polygon(
      polygonId: PolygonId("36"),
      points: gate1Bole,
      fillColor: ui.Color.fromARGB(255, 255, 0, 0).withOpacity(0.6),
      strokeColor: ui.Color.fromARGB(255, 255, 0, 0),
      strokeWidth: 2,
    ),
  );
  // boulevard
}
```

Function	LoadData()
Description	This function is called to show the marker with the zone name as a title on the map.

```
LoadData() async {
  //load all image we have for the map
  for (int i = 0; i < images.length; i++) {
    final Uint8List markerIcon = await getBytesFromAssets(images[i], 50);
    //add it to markers to be able to show it on the map
    markers.add(
      //pass all nececcery data
      Marker(
        markerId: MarkerId(i.toString()),
        position: latLang[i],
        icon: BitmapDescriptor.fromBytes(markerIcon),
        infoWindow: InfoWindow(
          title: zoneName[i],
        )));
  }
}
```

- Send Notifications Function

To send notifications for parents even when the application is closed, we had to use and activate background service in the user device using initializeService() method so that we be able to check the location of the parent and the child all the time. We assigned two tasks for the background using backgroundTask() method. The first one is to check if the child enters a critical zone using checkZone() method and the second one using check_range() method to check if the child exceeds the safe distance. Then both of them are going to call showNotification() method and send the notification details as parameters when they need to send a notification .

Function	initializeService()
Description	This function will activate background services when the user open the application.
`Future<void> initializeService() async {` `final service = FlutterBackgroundService();`	

```
  await service.configure(
    androidConfiguration: AndroidConfiguration(
      // this will be executed when app is in foreground or background in separated isolate
      onStart: onStart,
      // auto start service
      autoStart: true,
      isForegroundMode: true,
    ),
    iosConfiguration: IosConfiguration(
      autoStart: true,
        // these will be executed when app is in foreground or background in separated isolate
      onForeground: onStart,
      onBackground: onIosBackground,
    ),
  );
  service.startService();
}
```

Function	backgroundTask()
Description	This function will fetch all necessary information for critical zone and safe distance functions to work like parent and child locations and then sending this information as parameters when calling them.

```
Future<void> backgroundTask() async {
  final parent = await FirebaseFirestore.instance
      .collection("users")
      .doc(FirebaseAuth.instance.currentUser!.uid)
      .get();
      //get all nececcery varuabels
  bool? isSwitched = parent.data()!['isSwitched'];
  int? safeDistance = int.parse(parent.data()!['safeDistance']);
```

```
final childrens = await FirebaseFirestore.instance
    .collection("users")
    .doc(FirebaseAuth.instance.currentUser!.uid)
    .collection('children')
    .orderBy('birthday', descending: true)
    .get();
    //get all children location
List<String> childDocIds =
    childrens.docs.map<String>((e) => e.data()["deviceId"]).toList();
Map<String, String> childrenNames = {};
Map<String, bool> isHeWithme = {};
Map<String, String> childrenImages = {};
for (var childDoc in childrens.docs) {
  childrenNames[childDoc.data()["deviceId"]] = childDoc.data()["name"];
  childrenImages[childDoc.data()["deviceId"]] = childDoc.data()["image"];
  isHeWithme[childDoc.data()["deviceId"]] = false;
}
//read all zones
zones zoneList = zones();
zoneList.LoadData();
DatabaseReference _databaseReference =
    FirebaseDatabase.instance.ref().child('devices');
_databaseReference.onValue.listen((event) {
  for (var child in event.snapshot.children) {
    if (!(childDocIds.contains(child.key!))) {
      continue;
    }
    Map data = child.value as Map;
// call function and send all neccecry parameters
    checkZone(data, zoneList, child.key!, childrenNames, childrenImages);
    check_range(LatLng(data['lat'], data['long']), isSwitched, safeDistance,
        childrenNames, isHeWithme, child.key!, childrenImages);
  }
```

```
  });
}
```

Function	checkZone(Map data,zones zoneList,String deviceId,Map<String, String> childrenNames, Map<String, String> childrenImages)
Description	This function receives the child's location and zones list then walks through all zones and checks if the child is in one of the critical zones. If yes it will send the notification details to showNotification() method then save the notification details to be able to show it on the notification history page.

```
Future checkZone(
    Map data,
    zones zoneList,
    String deviceId,
    Map<String, String> childrenNames,
    Map<String, String> childrenImages) async {
  //store the zone that the child is in now
  var theZoneName = "";
  //store the last zone the child was in
  var lastCriticalZone = "";
  //defult location in case the location is null
  List<Point> theZone = [
    Point(x: 24.729121, y: 46.631753),
  ];
  //call the function to bring all zones
  zoneList.addZonesName();
  //child location
  final Point point = Point(x: data['lat'], y: data['long']);
  //check if the location has changed to ensure that we send the notification only onec
  if (!Poly.isPointInPolygon(point, theZone)) lastCriticalZone = "";
```

```
//find the zone that he is in right now and wither it is critical or not
for (int i = 0; i < zoneList.zoneName.length; i++) {
  if (Poly.isPointInPolygon(point, zoneList.zoneNames[i]['points'])) {
    theZoneName = zoneList.zoneNames[i]['name'];
    if (zoneList.zoneNames[i]['criticalZones'] &&
        lastCriticalZone != theZoneName) {
      lastCriticalZone = theZoneName;
      theZone = zoneList.zoneNames[i]['points'];
      //send notification in case it is critical
      showNotification(
          title: "تحذير",
          body: "انتبه طفلك" +
              ' ${childrenNames[deviceId]} ' +
              "دخل منطقة محظورة " +
                  "\"${zoneList.zoneNames[i]['name']}\"",
          payload: '${childrenImages[deviceId]}');
      final note = UserNotification2(
        message: "\"" +
            "انتبه طفلك" +
            ' ${childrenNames[deviceId]} ' +
            "دخل منطقة محظورة " +
                "\"${zoneList.zoneNames[i]['name']}",
        zone: zoneList.zoneNames[i]['name'],
        time: DateTime.now(),
      );
      writeNote(note);
    }
  }
}
```

Function	check_range(myChildLocation,isSwitched,safeDistance,Map<String, String> childrenNames,Map<String, bool> isHeWithme,String deviceId, Map<String, String> childrenImages)
Description	This function receives the parent and child location and isSwitched to make sure that the parent has activate this function or not and isHeWithme parameter is to ensure that the notification will be sends only one time until the child come back and exceeds the distance again, then using the parent and child location this function will checks the range between the parent and child to see if it exceeds the distance that the parent has specified (or the default which is 6 meters) or not it will send the notification details to showNotification() method then save the notification details to be able to show it on the notification history page.

```
Future<void> check_range(
  myChildLocation,
  isSwitched,
  safeDistance,
  Map<String, String> childrenNames,
  Map<String, bool> isHeWithme,
  String deviceId,
  Map<String, String> childrenImages) async {
Position? position = await Geolocator.getLastKnownPosition();
LatLng myLocation = LatLng(position!.latitude, position.longitude);
double dist = Geolocator.distanceBetween(myChildLocation.latitude,
    myChildLocation.longitude, myLocation.latitude, myLocation.longitude);
    // make sure that parent has activate safe distance function
if (isSwitched ?? false) {
  //callculate distance between parent and child and the defuilt distance is 6
  num allowedDis = dist.toInt() - (safeDistance ?? 6);
  //see if the child exeedes the safe distance to snd notification
  //isHeWithme is to check if child exeeds for first time since the last one or not
  if ((safeDistance ?? 6) < dist && !isHeWithme[deviceId]!) {
    showNotification(
```

```
        title: "تحذير",
        body: "انتبه طفلك" +
            ' ${childrenNames[deviceId]} ' +
            " تجاوز المسافة المسموحة بـ " +
            "$allowedDis" +
            " متر",
        payload: '${childrenImages[deviceId]}');

    final note1 = UserNotification2(
      message: "انتبه طفلك" +
          ' ${childrenNames[deviceId]} ' +
          " تجاوز المسافة المسموحة بـ " +
          "$allowedDis" +
          " متر",
      zone: "",
      time: DateTime.now(),
    );
    await writeNote(note1);
    //he is with his parent now
    isHeWithme[deviceId] = true;
  } else if ((safeDistance ?? 6) >= dist) {
    //he exceed the safe distance again
    isHeWithme[deviceId] = false;
  }
 }
}
```

Function	showNotification({required String title, required String body,required String payload})
Description	This function receives the notification details and then show it to the user.

```
showNotification(
```

```
  {required String title,
  required String body,
  required String payload}) async {
final FlutterLocalNotificationsPlugin flutterLocalNotificationsPlugin =
    FlutterLocalNotificationsPlugin();
// call the initialize method of the FlutterLocalNotificationsPlugin class to initialize the plugin
await flutterLocalNotificationsPlugin.initialize(const InitializationSettings(
    android: AndroidInitializationSettings('app_icon'),
    iOS: DarwinInitializationSettings()));
// define notificaiton channel & setting
const AndroidNotificationChannel channel = AndroidNotificationChannel(
  'channel_id', // id
  'channel_name', // title
  description:
      'This channel is used for important notifications.',
  importance: Importance.high,
);
await flutterLocalNotificationsPlugin
    .resolvePlatformSpecificImplementation<
        AndroidFlutterLocalNotificationsPlugin>()
    ?.createNotificationChannel(channel);
// display notification
const AndroidNotificationDetails androidPlatformChannelSpecifics =
    AndroidNotificationDetails(
  'your channel id', // channel id
  'your channel name', // channel name
  channelDescription: 'your channel description', // channel description
  importance: Importance.max,
  priority: Priority.high,
);
const NotificationDetails platformChannelSpecifics =
    NotificationDetails(android: androidPlatformChannelSpecifics);
await flutterLocalNotificationsPlugin
```

```
    .show(0, title, body, platformChannelSpecifics, payload: payload);
}
```

- Check devices connectivity

In addition, the system also shows the devices connectivity so that parents know if their child's device is active or not, as explained below.

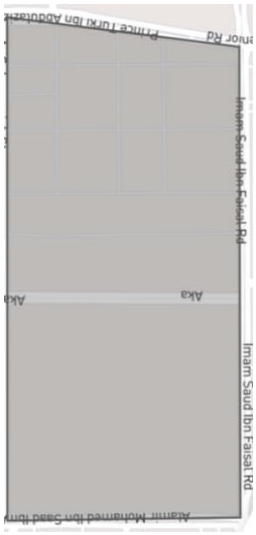
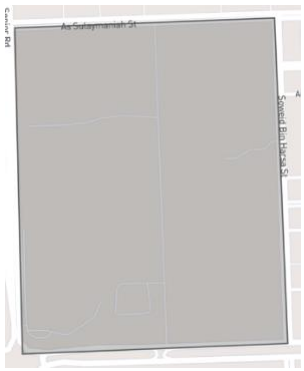
Function	checkTimer ()
Description	This function creates a timer that executes a code block periodically every 15 seconds. The code block checks for certain devices that are offline and have not been updated within a certain time limit (specified by the "updateSeconds" variable). It then updates the connectivity status of these devices on Firebase Realtime Database by calling the "updateKeysConnectivityOnFirebaseRealtime" function with the list of offline device keys as its argument. The function uses asynchronous programming with the "async" and "await" keywords to handle the asynchronous nature of the timer and database operations. Finally, the function prints the list of offline device keys to the console for debugging purposes.

```
// check if the device is connected or not
  checkTimer() {
Timer.periodic(Duration(seconds: 1), (t) async {
      List<String> offDevicesKeys = devicesTimer.keys.where((element) =>
((DateTime.now().difference(devicesTimer[element]!).inSeconds.abs() >=
                  updateSeconds) &&
              (isDevicesConnected[element] == true))).toList();
      List<String> onDevicesKeys = devicesTimer.keys.where((element) =>
((DateTime.now().difference(devicesTimer[element]!).inSeconds.abs() <
                  updateSeconds) &&
              (isDevicesConnected[element] == false)))
          .toList();
      await updateKeysConnectivityOnFirebaseRealtime(
          onDevicesKeys, offDevicesKeys);
    });
  }
```

- Report Lost Child Function

The parent can report the loss of his child if the child location already in one of the four supported zones, which are defined in the code and illustrated below in Table 9, the following functions will show how the report can be done and sent to the security guards and admin of the zone the child is in.

Table 9: Elfaa (إلفاء) Supported Zones

Supported Zones			
Winter Wonderland	Boulevard World	Boulevard City	King Saud University
			

Function	getZone(double lat, double long)
Description	This function determines the name of a zone based on input latitude and longitude coordinates. It defines four zones, each with a set of coordinates, and stores the names and coordinates of these zones in separate lists. It then loops through the zone names and points to add each zone's name and points to a list as a dictionary.

```
// This function takes in a latitude and longitude and returns the name
// of the zone that the coordinates fall within.
Future<String> getZone(double lat, double long) async {
  String zone = "";   // Empty string to hold the zone name.
  List<String> zoneName = [ // Names of the zones.
    "ونتر وندر لاند",
    "البوليفارد وورلد",
    "البوليفارد سيتي",
    "جامعة الملك سعود",
  ];
  // Define the coordinates for the Winter Wonderland zone.
```

```
List<Point> WWZone = [
  Point(x: 24.777069, y: 46.642839),
  Point(x: 24.777002, y: 46.642543),
  Point(x: 24.773998, y: 46.641062),
  Point(x: 24.766823, y: 46.644716),
  Point(x: 24.764514, y: 46.646123),
  Point(x: 24.763594, y: 46.647654),
  Point(x: 24.763236, y: 46.649506),
  Point(x: 24.763482, y: 46.649679),
  Point(x: 24.777069, y: 46.642839),
];
// Define the coordinates for the Boulevard World zone.
List<Point> BWZone = [
  Point(x: 24.786058, y: 46.612625),
  Point(x: 24.779068, y: 46.595940),
  Point(x: 24.771164, y: 46.598656),
  Point(x: 24.778611, y: 46.616516),
  Point(x: 24.786058, y: 46.612625),
];
// Define the coordinates for the Boulevard City zone.
List<Point> BCZone = [
  Point(x: 24.771093, y: 46.599036),
  Point(x: 24.762468, y: 46.603287),
  Point(x: 24.765717, y: 46.610942),
  Point(x: 24.774263, y: 46.606540),
  Point(x: 24.771093, y: 46.599036),
];
// Define the coordinates for the King Saud University zone.
List<Point> KSUZone = [
  Point(x: 24.735046, y: 46.633437),
  Point(x: 24.733364, y: 46.631042),
  Point(x: 24.731569, y: 46.629427),
  Point(x: 24.728104, y: 46.630401),
  Point(x: 24.726259, y: 46.630318),
  Point(x: 24.723819, y: 46.632184),
  Point(x: 24.721771, y: 46.636193),
  Point(x: 24.720658, y: 46.637139),
  Point(x: 24.719090, y: 46.637056),
  Point(x: 24.725715, y: 46.643820),
  Point(x: 24.728092, y: 46.641816),
  Point(x: 24.729736, y: 46.639895),
  Point(x: 24.735046, y: 46.633437),
];
// Empty list to store the names of the different zones
List zoneNames = [];
// List of lists, where each inner list represents the points that define a zone
List<List<Point>> zonePoints = [WWZone, BWZone, BCZone, KSUZone];
```

```
  // Loop through the zoneName list and add each zone's name
  //and points to the zoneNames list as a dictionary
  for (int i = 0; i < zoneName.length; i++) {
    zoneNames.add({
      'name': zoneName[i],
      'points': zonePoints[i],
    });
  }
  // Create a new Point object using the latitude and longitude values
  final Point point = Point(x: lat, y: long);

  for (int i = 0; i < zoneNames.length; i++) {
    if (Poly.isPointInPolygon(point, zoneNames[i]['points'])) {
      // If the point is within the polygon, set the zone variable
      //to the current zone's name
      zone = zoneNames[i]['name'];
    }
  }
  // Return the name of the zone that the point is in
  return zone;
}
```

Function	createReportToFirebase(childrenList child)
Description	This function creates a report for a child object in Firebase. It retrieves the child's information, including the device ID, location, and zone, and creates a new report object with this information after checking his location if it is in one of the supported zones. It then saves the report to Cloud Firestore and adds a progress log to the report's progress collection. Finally, it sends a push notification to notify users of the new report. If any errors occur during this process, an exception is thrown.

```
// This function takes a child object and creates a report for it in Firebase
Future<String> createReportToFirebase(childrenList child) async {
  String childrenId = child.childID!;
  String childImage = child.childImagePath!;
  String childName = child.childName!;

  try {
    // Get the device with the same ID as the child's
    DatabaseReference ref = FirebaseDatabase.instance.ref("devices");
    ref = ref.child("${child.deviceId}");
```

```
    // Get the device's location from the database
    DataSnapshot temp = await ref.get();
    Map data = temp.value as Map;

    // Get the device's latitude and longitude
    final lat = data["lat"] as double;
    final long = data["long"] as double;

    // Get the zone name of the device's location
    final zone = await getZone(lat, long);

    if (zone.isEmpty) {
      Fluttertoast.showToast(
          msg:
              "نعتذر منك! طفلك في منطقة غير مدعومة من قبل تطبيق إلفاء لخدمة البلاغات إلى حرّاس الأمن",
          toastLength: Toast.LENGTH_LONG,
          gravity: ToastGravity.BOTTOM,
          timeInSecForIosWeb: 10,
          backgroundColor: Color(0xFF9C0000),
          textColor: Colors.white,
          fontSize: 16.0);
      return "";
    }

    // Get the current user's ID from Firebase Authentication
    FirebaseAuth _auth = FirebaseAuth.instance;

    // Create a new document in the "report" collection in Cloud Firestore
    final docChild = FirebaseFirestore.instance.collection('report').doc();
    User? user = _auth.currentUser;

    // Get the parent-child document from the current user's children collection
in Cloud Firestore
    final parentChild = FirebaseFirestore.instance
        .collection('users')
        .doc(user!.uid)
        .collection('children')
        .doc(childrenId);

    // Create a new Report object
    Report report = Report(time: DateTime.now());
    report.parentID = user.uid;
    report.id = docChild.id;
    report.status = "ضائع";
    report.childrenId = childrenId;
    report.imageUrl = childImage;
```

```
    report.childName = childName;
    DateTime now = DateTime.now();
    report.date = "${now.day}/${now.month}/${now.year}";
    report.time = DateTime.now();
    report.lat = lat.toString();
    report.long = long.toString();
    report.zone = zone;
    report.finderID = "";

    // Save the report to Cloud Firestore
    await docChild.set(report.toMap());

    final parent = await FirebaseFirestore.instance
        .collection('users')
        .doc(user.uid)
        .get();

    // Add a progress log to the report's progress collection for the admin use
    await docChild.collection('progress').add({
      "action": "والد الطفل أنشأ بلاغًا بضياع طفله",
      "time": Timestamp.now()
    });

    // Send a push notification
    await NotificationService()
        .sendNotifications(title: "بلاغ جديد!", notification: {
      "message":
          "البلاغ #${DateFormat("yyyyMMDDhhmmss").format(report.time)} تم إنشاءه للتوّ",
      "newStatus": "ضائع",
      "reportId": report.id,
      "triggeredBy": user.uid,
      "zone": zone,
      "time": Timestamp.now()
    });

    await parentChild.update({"status": true});

    return "Success";
  } catch (e) {
    throw e;
  }
}
```

- Generate QR

This function allows the parent to have a QR code with his/her number and a banner says " اتصل بعائلتي".

Function	GenerateQR ()
Description	The QrImage widget displays a QR code that contains the phone number (widget.phoneNo) as data. The QR code also has an embedded image of *Elfaa (إلفاء)* logo and customized styles. The Directionality widget is used to set the text direction of the call-to-action button to right-to-left. A banner with a customized decoration includes a text that says "اتصل بعائلتي".

```
// This function generates a scrollable widget that displays the QR code and a
text box.
SingleChildScrollView GenerateQR() {
  return SingleChildScrollView(
    child: Column(
      children: [
        Container(
          margin: EdgeInsets.only(top: 40),
          // Add a QR code image widget to the container
          child: QrImage(
            // Set the phone number to be encoded in the QR code
            data: ("${widget.phoneNo}"),
            errorCorrectionLevel: 2,
            size: 300,
            foregroundColor: kPrimaryColor,
            backgroundColor: kLightColor,
            // Set Elfaa logo to be an embedded image on the QR code
            embeddedImage: AssetImage('assets/images/logo1.png'),
            embeddedImageStyle: QrEmbeddedImageStyle(size: Size(80, 80)),
          ),
        ),
        // Add a text box to the column
        Directionality(
          // Specify the text direction (Arabic)
          textDirection: TextDirection.rtl,
          child: Container(
            decoration: BoxDecoration(
              color: kPrimaryColor,
              border: Border(
                left: BorderSide(
                  color: kPrimaryColor,
                  width: 5.0,
                ),
```

```
            right: BorderSide(
              color: kPrimaryColor,
              width: 5.0,
            ),
            bottom: BorderSide(
              color: kPrimaryColor,
              width: 5.0,
            ),
          ),
        ),
        alignment: Alignment.center,
        height: 43,
        width: 300,
        child: Text(
          // Set the meesage to be displayed under the QR
          "اتصل بعائلتي",
          style: TextStyle(
            fontSize: 25,
            color: kLightColor,
            fontWeight: FontWeight.bold,
          ),
        ), ), ), ], ),);}
```

- Save QR Image

This function allows the parent to save the QR code on their phones to be printed and attached to the child`s tracking device.

Function	saveImage ()
Description	This function captures a screenshot of a widget and saves it as an image file. The code first calls the captureFromWidget() method on a controller object, passing in the widget GenerateQR() as an argument. This method captures a screenshot of the widget and returns it as an Image object. Next, the code calls a function called savelmage() and passes the captured image as an argument. This function first requests permission to access the device's storage using the `request()` method of the `Permission` class from the `permission_handler` plugin. Then, the function generates a unique file name for the image. Then the function calls the `saveImage()` method of the `ImageGallerySaver` plugin, passing in the `bytes` of the image and the `name` of the file as arguments. This method saves the image file to the device's storage and returns the file path of the saved image.

```dart
// When the user presses a button, capture an image of the QR code and save it to a file
onPressed: () async {
  // Capture an image of the QR code widget
  final image =
      await controller.captureFromWidget(GenerateQR());
  if (image == null) return;
  // Save the image to a file
  await savelmage(image);
  // Display a toast message to indicate that the image was saved successfully
  Fluttertoast.showToast(
    msg: "تم حفظ الرمز في الملفات بنجاح",
    toastLength: Toast.LENGTH_SHORT,
    gravity: ToastGravity.BOTTOM,
    timeInSecForIosWeb: 5,
    backgroundColor: Colors.lightGreen,
    textColor: Colors.black,
    fontSize: 16.0,
  );
}
// Save an image to the device's gallery
Future<String> savelmage(Uint8List bytes) async {
  // Request permission to access storage if it hasn't been granted yet
  await [Permission.storage].request();
  // Generate a timestamp to use as part of the filename
  final time = DateTime.now()
      .toIso8601String()
      .replaceAll('.', '-')
      .replaceAll(':', '-');
  // Construct the filename with Elfaa and the timestamp
  final name = 'elfaaQR_$time';
  // Save the image to the device's gallery using ImageGallerySaver
  final result = await ImageGallerySaver.saveImage(bytes, name: name);
  // Return the filepath of the saved image
  return result['filePath'];
}
```

- Managing Security Guard Functions

Create New Security Guard Account: This function allows the admin to create new security guard accounts, by filling their requested information excluding workplace since it inherited from the admin, and the password will be generated randomly by a click.

Function	CreateNewSecurity ()
Description	This function first checks if all the fields in the form are valid by calling the validate() method on the current state of the form. If the fields are valid, the method then proceeds to create a new user in the authentication table by calling the createUserAuthTable() function with the email and password entered by the user. After creating the user, the method adds the user details to the database by calling the addUserDetails() function with the user's name, email, phone number, workplace, and the user ID obtained from the authentication table. The method then sends an email to the user with their login credentials by calling the sendEmail() function. Finally, a success message is displayed using the Fluttertoast.showToast() method and the user is navigated to a new screen using the Navigator.push() method. If an error occurs during the user creation process, an error message is displayed using the Fluttertoast.showToast() method.

```
// Create a new security guard account
Future<void> CreateNewSecurity(BuildContext context) async {
  // Validate the form fields
  if (_formKey.currentState!.validate()) {
    try {
      // Create a new user account with the given email and password
      await createUserAuthTable(email.text, pass.text);
      print("User ID on create::: $userID");
      // Add user details to the firestore database
      addUserDetails(
          name.text.trim(),
          email.text.trim(),
          phoneNo.text.trim(),
          userID,
          workPlace.text.trim());
      // Send a confirmation email to the user's email address containing the
password
      sendEmail(email.text.trim(), pass.text.toString());
      // Display a success message to the user
      Fluttertoast.showToast(
          msg: "تم إنشاء حساب حارس الأمن بنجاح",
          toastLength: Toast.LENGTH_SHORT,
          gravity: ToastGravity.BOTTOM,
          timeInSecForIosWeb: 3,
          backgroundColor: Colors.lightGreen,
          fontSize: 16.0,
          textColor: Colors.black);
```

```
// Navigate to the home page
      Navigator.push(
        context,
        MaterialPageRoute(
          builder: (context) => NavPage(
            code: 1,
          ),
        ),
      );
    }
catch (e)
{
      // If an error occurs, display an error message to the user
      Fluttertoast.showToast(
          msg: "البريد الإلكتروني مستخدم بالفعل",
          toastLength: Toast.LENGTH_SHORT,
          backgroundColor: Colors.red,
          fontSize: 16.0,
          textColor: Colors.black);
    }
  }
}
```

- Edit Security Guard Information

This function allows the admin to edit the information of a security guard in the Firestore database and reset the email associated with a security guard`s in Firebase authentication table.

Function	editSecInfo ()
Description	This function first updates the security guard's information in the Firestore database by calling the update() method on the DocumentReference object of the security guard with the new values for the name, phone number, and email. The function uses the then() method to wait for the update() method to complete before calling the resetEmail() function. After updating the information, the function calls the resetEmail() function which first initializes a temporary Firebase app using the Firebase.initializeApp(). Next, it creates a new instance of FirebaseAuth using the temporary app, and signs in the current user using their email address and password. After signing in, the function gets the current user's FirebaseUser object and updates the user's email address with the new email using the updateEmail() method and returns a success message of "Success".

```
// This function updates the security guard information
Future<void> editSecInfo(
  TextEditingController _secName,
  TextEditingController _phoneNo,
  TextEditingController _email,
  Future<String> resetEmail(String newEmail)) async {

    // Update the security guard information in the Firestore database
    await FirebaseFirestore.instance
      .collection('users')
      .doc(widget.secID)
      .update({
        // Set the new security guard name
        'name': _secName.text,
        // Set the new security guard phone number
        'phoneNo': _phoneNo.text,
        // Set the new security guard email
        'email': _email.text
      })
      .then((value) {
        // After successfully updating the security guard information, reset the
email
        resetEmail(_email.text.toString()).then((value) {});
      });
  }
// Resets the email of a user in Firebase Authentication Table
Future<String> resetEmail(String newEmail) async {
  try {
    // Initializes a temporary Firebase app to perform the password reset
operation
    FirebaseApp tempApp = await Firebase.initializeApp(
        name: 'temporaryApp', options: Firebase.app().options);

    // Gets the temporary Firebase authentication instance for the app
    FirebaseAuth tempInstance = FirebaseAuth.instanceFor(app: tempApp);

    // Signs in with the security user email and password
    await tempInstance.signInWithEmailAndPassword(
        email: widget.email, password: widget.password);

    // Gets the current user from the temporary authentication instance
    final firebaseUser = await tempInstance.currentUser!;

    // Checks if the user is not null
    if (tempInstance.currentUser != null) {
      // Updates the user's email with the new email
      await firebaseUser.updateEmail(newEmail);
```

```
      return "Success";
    } else {
      return "Could not get user";
    }
  } on FirebaseException catch (e) {
    print(e.message.toString() + "this msg");
    return e.message.toString();
  }
}
```

- Delete Security Guard Information

This function allows the admin to delete a security guard user from both Firebase Authentication and Firestore database.

Function	deleteSecurity ()
Description	This function first initializes a temporary Firebase app using the Firebase.initializeApp() method with a unique name and the options of the current default Firebase app. Next, it creates a new instance of FirebaseAuth using the temporary app, and signs in the current user using their email address and password. After signing in, the function gets the current user's FirebaseUser object and checks that it is not null. If the user object is not null, it deletes the user's account from Firebase Authentication using the delete() method. Then, it deletes the user's information from the Firestore database using the delete() method on the DocumentReference object of the security guard. If the user object is null, the function returns an error message of "هناك مشكلة بالحذف". If an error occurs during the function execution, such as if the user is not authenticated, the function catches the error using a FirebaseException and returns the error message as a string.

```
// Delete security guard function
Future<String> deleteSecurity() async {
  try {
    // Initialize temporary Firebase app
    FirebaseApp tempApp = await Firebase.initializeApp(
        name: 'temporaryApp', options: Firebase.app().options);

    // Get instance of Firebase auth for the temporary app
    FirebaseAuth tempInstance = FirebaseAuth.instanceFor(app: tempApp);

    // Sign in with the email and password of the security guard
```

```
    await tempInstance.signInWithEmailAndPassword(
        email: widget.email, password: widget.password);

    // Get the security user
    final firebaseUser = await tempInstance.currentUser!;

    // Check if  user exists
    if (tempInstance.currentUser != null) {
      // Delete the user's account
      await firebaseUser.delete();

      // Delete the user's document from Firestore
      await FirebaseFirestore.instance
          .collection('users')
          .doc(widget.secID.toString())
          .delete();

      return "Success";
    } else {
      // Return error message if current user doesn't exist
      print(tempInstance.currentUser);
      return "هناك مشكلة بالحذف";
    }
  } on FirebaseException catch (e) {
    // Return error message if an exception occurs
    return e.message.toString();
  }
}
```

4.7.4 GitHub repository

GitHub Link: **GitHub - Elfaa project**

5 System Evaluation

In this section, the evaluation of *Elfaa (إلفاء)* mobile application for the final release will be presented. First, the user acceptance test is introduced followed by the NFR testing and its results, then the discussion of both UAT and NFT testing results is provided.

5.1 User Acceptance Testing

Elfaa (إلفاء) was tested after the implementation has been completed. The user acceptance test (UAT) was performed to check if the system fulfills the user requirements and can be used by the end users. To evaluate *Elfaa (إلفاء)* application, 61 of the target users (parents and admins and security guards) were chosen to participate after their agreement on participating and testing *Elfaa (إلفاء)* mobile application. The UAT for all the participants was held individually with one of the team members in a quiet room using their mobile phone, or the emulator for who did not have an android mobile phone and for parents *Elfaa (إلفاء)* device was used to test all functions. The evaluator started by giving the participant an overview of the project idea and the system features. Then, the participant was asked to test and explore the application without intervention. After testing all functions, the participant was asked to answer a questionnaire given in Appendix B. The results will be discussed in the following subsections.

5.1.1 Demographics of Participants

The number of participants who test the application is 61 users. Twenty of the participants were parents, 21 were admins, and 20 were security guards. When it comes to the participants' demographics, as shown in Table 10, the sample have different ages, starting from 15 to 48 years old or older, but most of them were between 15 and 25 years old and between 37 and 74 years old. They were all Saudi, and 39 of them were females, while 22 were males. When it comes to their technical background, most of the participants had a high to medium background in technology.

Table 10: Participants' Demographics

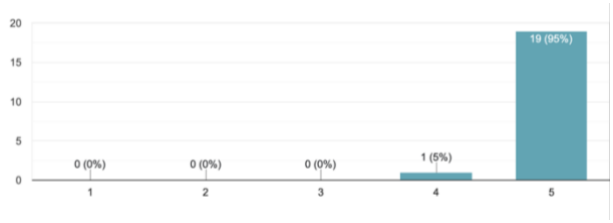
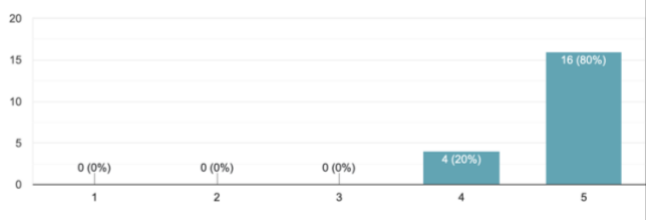
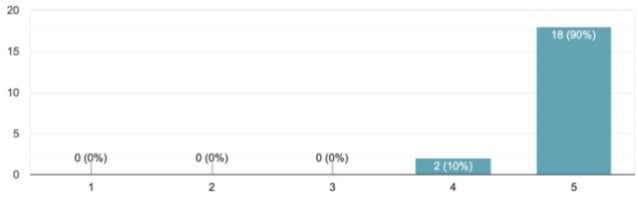
Variable	Value	N = 61	Percentage %
User Type	Parent	20	32.8%
	Admin	21	35%
	Security Guard	20	32.8%
	15-25	20	32.8%

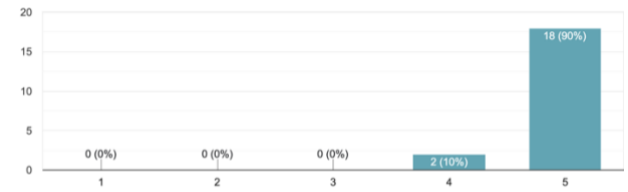
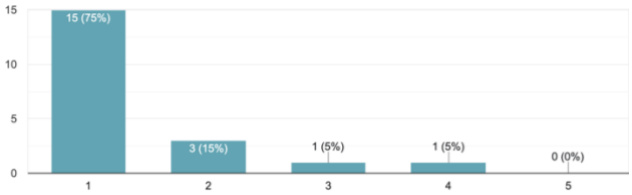
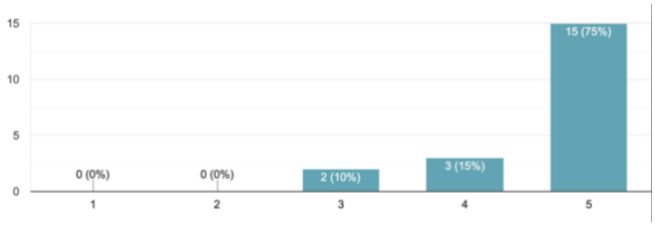
Variable	Value	N = 61	Percentage %
Age	26-36	17	27.9%
	37-47	20	32.8%
	48 or older	4	6.6%
Gender	Female	39	63.9%
	Male	22	36.1%
Nationality	Saudi Arabia	61	100%
	Others	0	0%
Technical Background	High	35	57.4%
	Medium	19	31.1%
	Low	7	11.5%

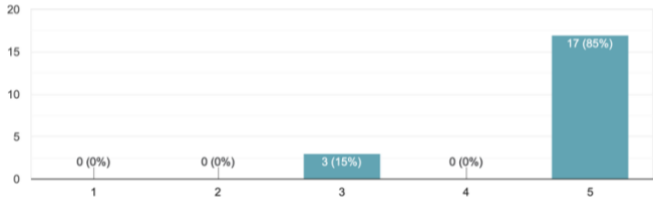
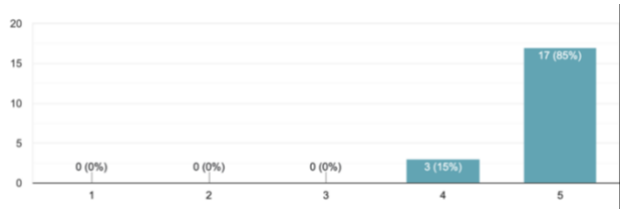
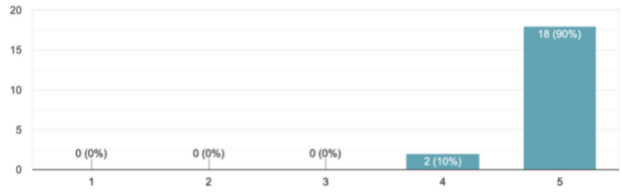
5.1.2 Questionnaire/Interview Results

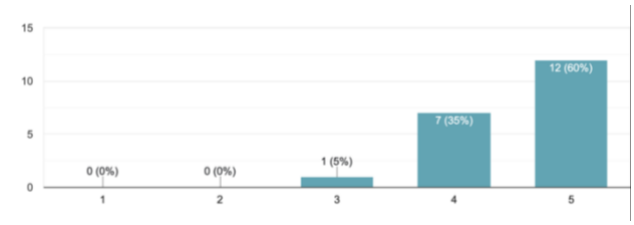
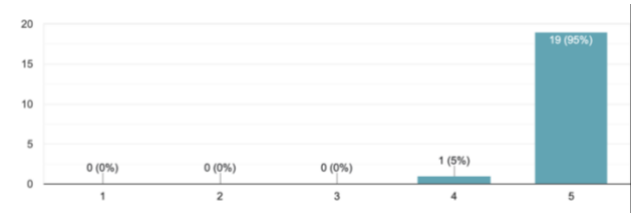
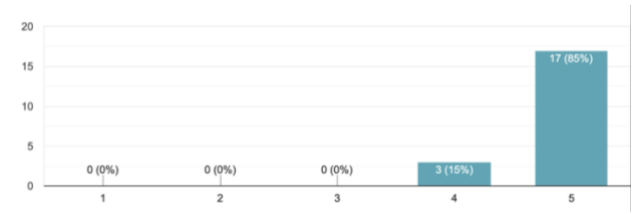
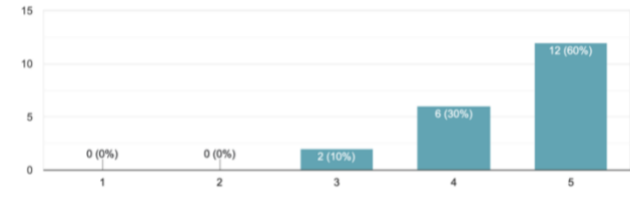
After completing the test session with each participant, they were asked to provide feedback on the application and propose improvement if they see fit from different scale questions (from 1-5) where 5 means strongly agree and 1 strongly disagree, as illustrated in Appendix B in detail. Starting with parents, as shown in Table 11, it was found that the general feedback of parents is satisfactory and highly positive. When adding a new child process, 75% of participants see that it is an easy process and does not take a long time. When it comes to link the device to the child, report lost child, view report details, receive notifications, create QR code, view zones on the map and view notifications history functions we see that more than 80% strongly agreed that they were clear and straightforward, but it is more than 60% for activate the safe distance, view child location view device connectivity status functions.

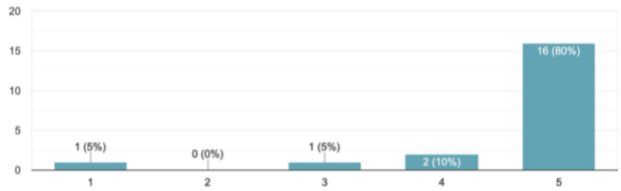
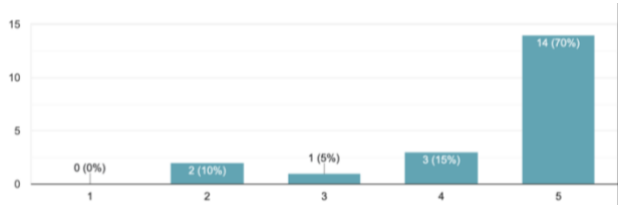
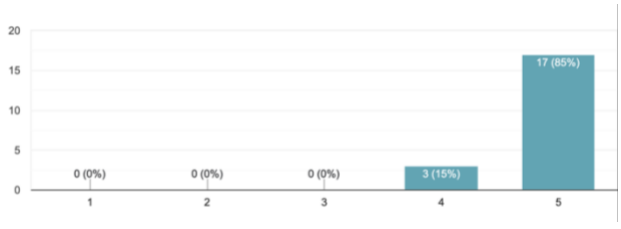
Table 11: User Testing Questionnaire (parent)

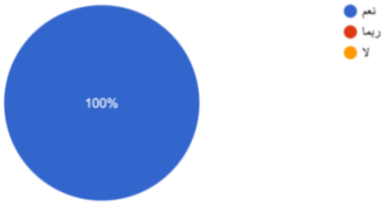
Parent	
Question	Chart and results
How would you rate your experience with *Elfaa (إلفاء)* application? ● Great ● Excellent ● Good ● Bad ● Very bad	
The application is convenient and easy to use for parents. ● Strongly agree ● Agree ● Neutral ● Disagree ● Strongly disagree	
The design of the application interfaces and the colors used are appropriate, consistent, and do not annoy the eyes. ● Strongly agree ● Agree ● Neutral ● Disagree ● Strongly disagree	

The error messages that appear to me are clear and helped me to understand what was required. • Strongly agree • Agree • Neutral • Disagree • Strongly disagree	
I think the icons used in the application are ambiguous and unfamiliar. • Strongly agree • Agree • Neutral • Disagree • Strongly disagree	
I have found that the add child function process takes a long time to be completed. • Strongly agree • Agree • Neutral • Disagree • Strongly disagree	

The process of knowing the tracker serial number and linking it to the child was straightforward. ● Strongly agree ● Agree ● Neutral ● Disagree ● Strongly disagree	
I see that the process of creating a report of a lost child and accessing the details of the report and his condition is clear and easy. ● Strongly agree ● Agree ● Neutral ● Disagree ● Strongly disagree	
I think it is important to be notified whenever the status of my lost child report changes. ● Strongly agree ● Agree ● Neutral ● Disagree ● Strongly disagree	

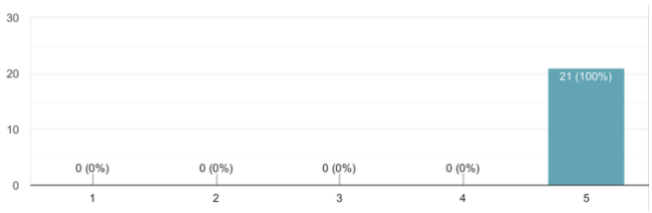
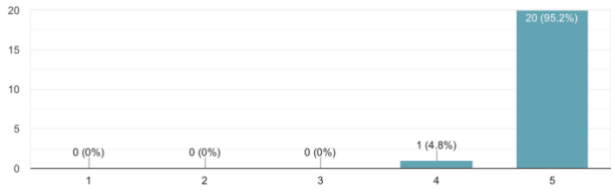
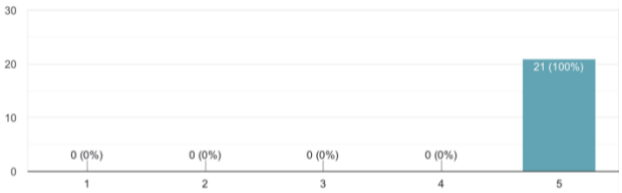
It was easy to activate the safe distance feature and learn how to use it. ● Strongly agree ● Agree ● Neutral ● Disagree ● Strongly disagree	
The purpose of a QR code is clear. ● Strongly agree ● Agree ● Neutral ● Disagree ● Strongly disagree	
It was easy to find the QR code after saving it. ● Strongly agree ● Agree ● Neutral ● Disagree ● Strongly disagree	
Knowing when the tracker disconnected, and the last location was obvious to me.	

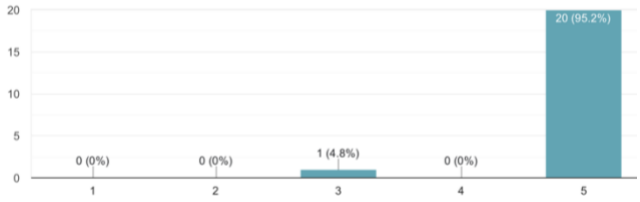
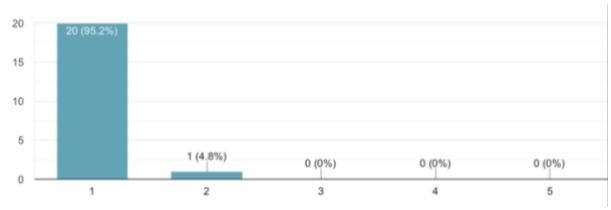
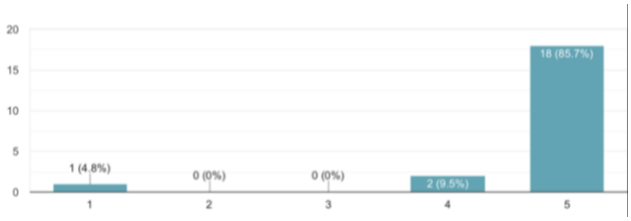
• Strongly agree • Agree • Neutral • Disagree • Strongly disagree	
When viewing the map in the application, the boundaries and names of the zones are clear. • Strongly agree • Agree • Neutral • Disagree • Strongly disagree	
When viewing the map, my child's location was clear. • Strongly agree • Agree • Neutral • Disagree • Strongly disagree	
The history of notification had clear icons and information.	

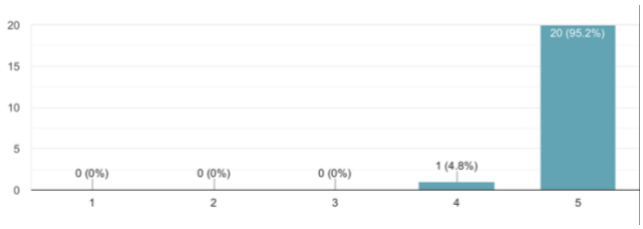
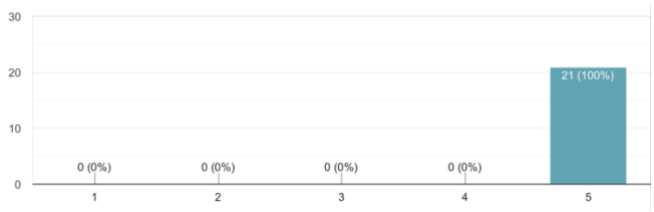
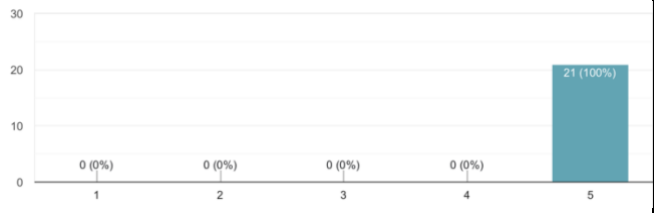
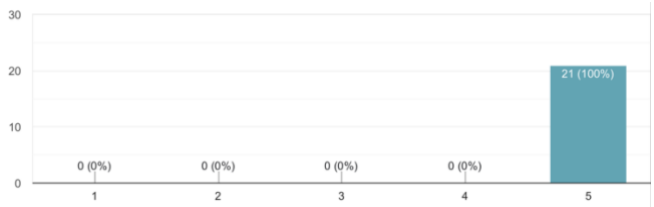
• Strongly agree • Agree • Neutral • Disagree • Strongly disagree	
What difficulties did you encounter while using the application?	The responses are in Appendix B.
Do you have any suggestions to improve the application?	
Are you likely to use *Elfaa (إلفاء)* application in the future? • Yes • Maybe • No	

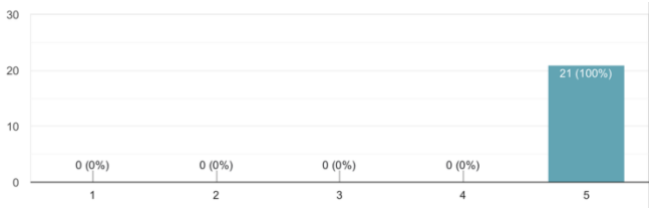
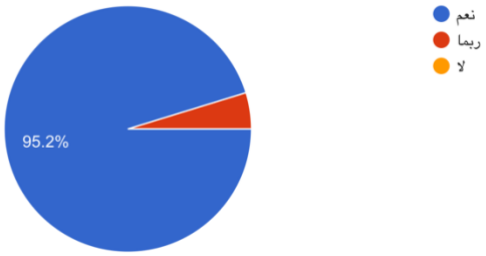
When it comes to admins, as shown in Table 12, their feedback was even more positive than parents and they showed their interest in the system due to their continuous struggle with too many lost child cases that is caused especially in crowded places. When it comes to create, edit, and delete security guard accounts more than 95.2% strongly agree that they were clear and straightforward. Moreover, 85.7% of participants think that specifying the account type when logging in does not threaten the security of the company's information. In addition, all of them strongly agreed that the history of notifications had clear information and the process of accessing the report and changing its status to "Found" or "Closed" was straightforward.

Table 12: User Testing Questionnaire (admin)

Admin	
Question	Chart and results
How would you rate your experience with *Elfaa (إلفاء)* application? ● Great ● Excellent ● Good ● Bad ● Very bad	
The application is convenient and easy to use by admins. ● Strongly agree ● Agree ● Neutral ● Disagree ● Strongly disagree	
The design of the application interfaces and the colors used are appropriate, consistent, and do not annoy the eyes. ● Strongly agree ● Agree ● Neutral ● Disagree ● Strongly disagree	

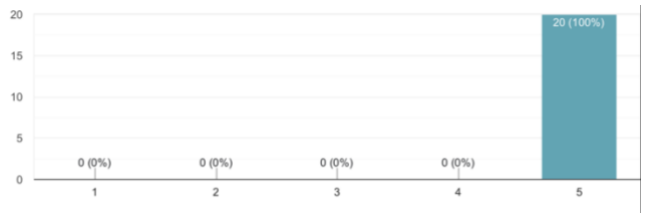
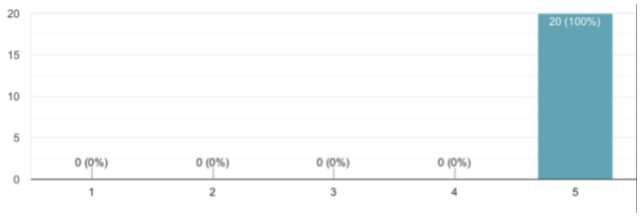
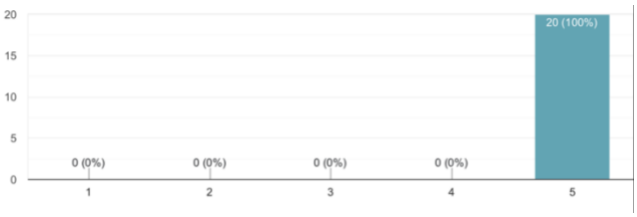
The error messages that appear to me are clear and helped me to understand what was required. ● Strongly agree ● Agree ● Neutral ● Disagree ● Strongly disagree	
I think the icons used in the application are ambiguous and unfamiliar. ● 5. Strongly agree ● 4. Agree ● 3. Neutral ● 2. Disagree ● 1. Strongly disagree	
I think that specifying the account type when logging in does not threaten the security of the company's information. ● Strongly agree ● Agree ● Neutral ● Disagree ● Strongly disagree	

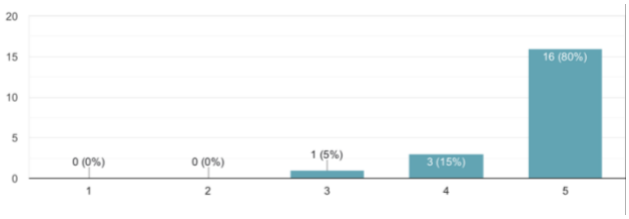
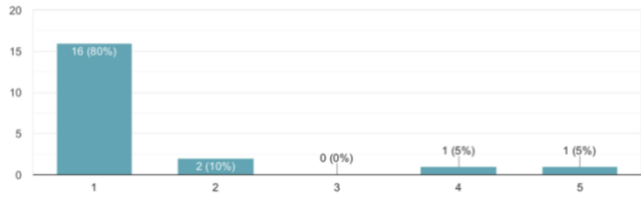
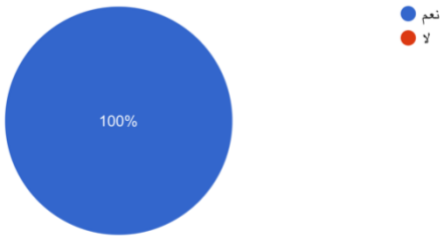
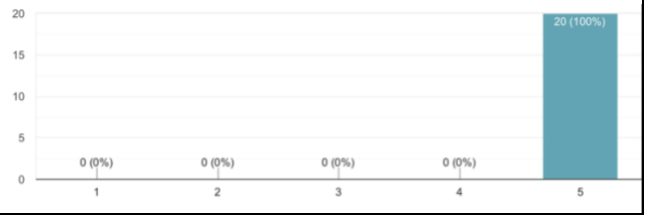
The steps to create an account for security guards are straightforward. ● Strongly agree ● Agree ● Neutral ● Disagree ● Strongly disagree	
I was able to easily modify the security guard's information. ● Strongly agree ● Agree ● Neutral ● Disagree ● Strongly disagree	
Deleting the security guard account from the system was easy and efficient. ● Strongly agree ● Agree ● Neutral ● Disagree ● Strongly disagree	
The history of notifications had clear information.	

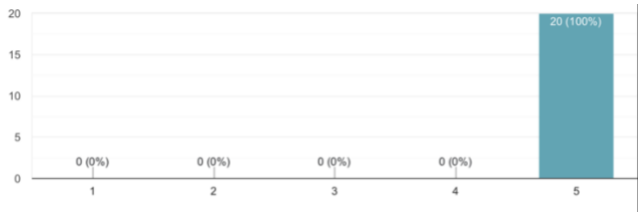
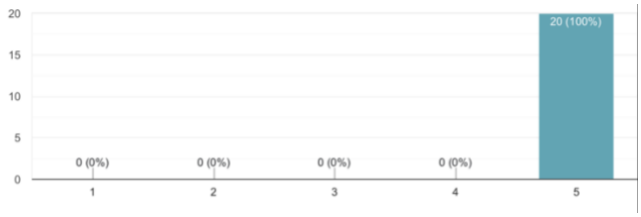
• Strongly agree • Agree • Neutral • Disagree • Strongly disagree	
The process of accessing the report and changing its status to "Found" or "Closed" was straightforward. • Strongly agree • Agree • Neutral • Disagree • Strongly disagree	
What difficulties did you encounter while using the application?	The responses are in Appendix B.
Do you have any suggestions to improve the application?	
Are you likely to use *Elfaa (إلفاء)* application in the future? • Yes • Maybe • No	

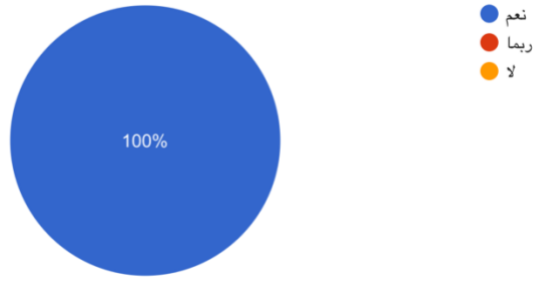
For security guards, as shown in Table 13, all of them were able to log in to his account for the first time and change the password easily. In addition, all the security guards strongly agreed that the history of notifications had clear information and the process of accessing the report and changing its status to "Found" was straightforward.

Table 13: User Testing Questionnaire (security guard)

Security guards	
Question	Chart and results
How would you rate your experience with *Elfaa (إلفاء)* application? ● Great ● Excellent ● Good ● Bad ● Very bad	
The application is convenient and easy to use by security guards. ● Strongly agree ● Agree ● Neutral ● Disagree ● Strongly disagree	
The design of the application interfaces and the colors used are appropriate, consistent, and do not annoy the eyes. ● Strongly agree ● Agree ● Neutral ● Disagree ● Strongly disagree	

The error messages that appear to me are clear and helped me to understand what was required. ● Strongly agree ● Agree ● Neutral ● Disagree ● Strongly disagree	
I think the icons used in the application are ambiguous and unfamiliar. ● Strongly agree ● Agree ● Neutral ● Disagree ● Strongly disagree	
I was able to log into my account for the first time easily. ● Yes ● No	
I was able to change my account password easily.	

• Strongly agree • Agree • Neutral • Disagree • Strongly disagree	
The history of notifications had clear information. • Strongly agree • Agree • Neutral • Disagree • Strongly disagree	
The process of accessing the report and changing its status to "Found" was straightforward. • Strongly agree • Agree • Neutral • Disagree • Strongly disagree	
What difficulties did you encounter while using the application?	The responses are in Appendix B.
Do you have any suggestions to improve the application?	

Are you likely to use *Elfaa (إلفاء)* application in the future? • Yes • Maybe • No	

From Table 11, Table 12 and Table 13, it can be concluded that most of the participants had good experience with *Elfaa (إلفاء)* application, also most of them agreed that the application is convenient and easy to use. We can see that of all users, more than 90% strongly agreed that the application user interfaces design and colors are consistent, and more than 80% strongly agreed that the error messages are clear and helped them to understand the requirements. When it comes to the icons used in the application, 80% of the participants think that the used icons are familiar and not ambiguous for them, and more than 95.2% are likely to use *Elfaa (إلفاء)* application in the future.

5.2 Quality Attributes (NFR testing)

In order to ensure that our system meets the non-functional requirements, we conducted NFR testing to evaluate the system's availability, performance, and usability. Table 14 below provides a summary of our NFR testing results for each user story, along with the quality attribute and measure we used for each. Additionally, we have included the test scenarios we used to test each non-functional requirement.

Table 14: NFR Testing

User story	Quality Attribute	Measure	Results
As a parent, I want *Elfaa (إلفاء)* tracking device to be available and running when there is a	Availability How often is *Elfaa (إلفاء)* tracking device available when there is a	The percentage of time *Elfaa (إلفاء)* tracking device is available when there is	Test scenario: 1- A group of users was selected (10 parents), who participated in the UAT. 2- Turned *Elfaa (إلفاء)* tracking device on, in an area with a good cellular network signal.

cellular network around, so that I can receive my child's location.	cellular network around?	a cellular network around.	3- Gave the parents the device to test it and connect it to their child. 4- Continuously monitored the device's availability over a period of time (~15 min) for each user. The test is done in different locations with varying 2G network signal strengths. Results: *Elfaa (إلفاء)* tracking device was available 50% (5 0f 10 users did not encounter signal absence) of the time when there was a cellular network around. The other 50% faced connectivity problems due to the fact that 2G network was not strong in their area.
As a user, I want *Elfaa (إلفاء)* application to be available all days except five hours for maintenance every two weeks, so that I can access it any time unless it's	Availability How often is *Elfaa (إلفاء)* application available for users to access, accounting for scheduled maintenance windows?	The percentage of time *Elfaa (إلفاء)* application is available, accounting for scheduled maintenance windows.	Test scenario: 1- A group of users was selected (30 users), around half of the users who participated in the UAT. 2- During their testing sessions, we calculate the percentage of time the application is available. Results: *Elfaa (إلفاء)* application was available 100% of the time, since the testing was done out of scheduled maintenance windows.

maintenance time.			
As a user, I want to log-in within less than 20 seconds.	Performance What is the time it takes for the user to log in to *Elfaa (إلفاء)* system?	The time it takes for the user to log in to *Elfaa (إلفاء)* system system.	Test scenario: 1- A group of users was selected (30 users), half of the users who participated in the UAT. 2- The users provided login credentials and instructions on how to access the system. 3- The users asked to log in to the system, and we used a stopwatch timer to record how long it takes them to complete the process. Results: Minimum time to log in: 9 seconds. Maximum time to log in: 30 seconds. Average time to log in: 18 seconds.
As a user, I want *Elfaa (إلفاء)* mobile interface to be simple and easy to understand, so that I can know how to use it properly in less than 10 minutes.	Usability What is the time it takes for the user to understand how to use *Elfaa (إلفاء)* mobile interface?	The time it takes for the user to understand how to use *Elfaa (إلفاء)* mobile interface.	Test scenario: 1- A group of users was selected (9 users), 3 of each user type (parent, admin, security guard), each has a different level of technical background. 2- Introduced the test and explained the purpose of the test to the users. 3- Provided the users with the mobile device and the list of different tasks relevant to his type, to complete.

			4- Instructed the users to complete each task using the mobile interface and timed how long it took for them to understand how to perform the task. 5- Recorded the time taken for each user to complete each task. Results: - Minimum time: 4 minutes. - Maximum time: 9.5 minutes. - Average time: 7 minutes.
As a user, I want *Elfaa (إلفاء)* system response to my request in less than 10 seconds, so that I can use it effectively with full attention.	Performance What is the time it takes for the system to respond to the user's request?	The time it takes for *Elfaa (إلفاء)* system to respond to the user's request.	Test scenario: 1- A group of users was selected (30 users), half of the users who participated in the UAT. 2- Provided the users with access to the system and a list of requests (add, delete, edit, etc…) to make. 3- Asked the users to make each request and time how long it takes for the system to respond. Results: - Minimum response time: 1.5 seconds - Maximum response time: 5 seconds - Average response time: 3 seconds

5.3 Discussion

The UAT and NFR tests were conducted with respect to parents, admins and security guards' views, and the results were satisfactory for them as expected users. Most of the participants had good experience with *Elfaa (إلفاء)* application, also most of them agreed that the application is convenient and easy to use and matched their expectations. From the evaluator's observation during the test, and the answers of the questionary that are shown before, most of the participants show an interest in using *Elfaa (إلفاء)* application in the future.

The users were also asked some questions about the application and how it can be improved, they provided us with some future work that will increase the value of the application and will make them happier, for instance, provides the ability to move in the map that on the home page by gesture, the ability to specify each child's safe distance in case they have more than one child, the ability to communicate with the child using *Elfaa (إلفاء)* device, include an attendance system in the application and support IOS.

The improvement suggestions that we get from users, like providing the ability to move in the map that is on the home page by gesture, are ones that we have handled, but others will be proposed as future work since we could not be able to do them within the specified project duration.

During the NFR test, it was discovered that *Elfaa (إلفاء)* tracking device meets the availability requirement set by the user story only when there is a 2G coverage. For the availability of Elfaa (إلفاء) application, it was available 100% of the time during the testing period since the testing was done during a duration that did not contain any scheduled maintenance windows. However, the application's availability may vary when maintenance windows is scheduled every two weeks for five hours. The test scenario and results indicate that the application's availability meets the user story's requirement. In addition, the system meets the performance requirement set by the user story, users can log in to the system within the specified time frame, which ensures a fast and efficient login process. The app interfaces met the usability requirement set by the user story, so users were able to understand how to use the app quickly and efficiently, which ensured a good user experience. Finally, the system meets the performance requirement for the response time, since the average response time is 3 seconds which is acceptable for the users based on a research says if a request or a page takes more than three seconds to response, 53% of mobile site visitors will leave which can be also the same for an application based on its intended use [36].

6 Conclusions and Future Work

In conclusion, *Elfaa (إلفاء)* system is a cutting-edge Arabic-friendly IoT mobile application that has been designed with the aim of supporting the Kingdom Vision 2030 by enhancing the use of technology and smart cities. With its advanced features, *Elfaa (إلفاء)* offers an array of benefits, including providing parents with the ability to monitor their child's whereabouts, enabling security guards to receive lost children's reports, and allowing administrators to create and manage security guard accounts with ease.

Elfaa (إلفاء) system is poised to make a significant impact on society by providing a practical and innovative solution that promotes safety and security for families and communities. As technology continues to advance, it is crucial to harness its power to create solutions that make life safer and more efficient. *Elfaa (إلفاء)* system is an excellent example of this, and we believe that it has the potential to revolutionize the way that people interact with technology in the Arab world.

Overall, *Elfaa (إلفاء)* system represents a remarkable achievement in the field of mobile application development, and we are confident that it will continue to make significant contributions to the Kingdom's vision of creating smarter, safer, and more connected cities.

- Global and local impact

Elfaa (إلفاء) system help to reduce the worst crimes that could happen to the child like kidnapping, sexual harassment, or other accidents, besides the psychological damage which can be the worst. *Elfaa (إلفاء)* system can help to save time, money, resources and efforts to the government and police force in addition to helping to provide a safe environment for children.

- Problems and challenges encountered during software development

As mentioned, in section 4.6.1, we have encountered many challenges during the development of the application and the hardware. The most difficult aspect was determining the best and most suitable hardware components for the project, and we struggled to build a small tracking device for our project. It was challenging to find the right hardware components that could fit in a small enclosure. We researched and selected smaller components, but we still faced design complexity issues that made the device larger than we had hoped. Additionally, power consumption was a factor that we had difficulty managing. Our attempts to reduce power consumption were not successful, and we ended up needing a larger battery, which added to the size of the device.

- Limitations of the system

There are several potential limitations of our system, including accuracy, range, power consumption, and compatibility. We have found that depending on the technology and methodology used, our system may not be able to provide precise location information, which could limit its usefulness in certain applications, in addition to that it only provides location data in outdoor. Additionally, our system has a limited range in areas with poor 2G signal or coverage. Power consumption has also been a concern for us, as our system requires constant transmission or reception of data, which can drain the battery quickly and limit the device's operational time. However, the system is suitable enough as a prototype and proof of concept to solve the targeted problem and we are currently pitching it to potential sponsors including the Digital Innovation Unit of the KSU Entrepreneurship Institute; in which it received good feedback, and they praised the maturity of the solution. Thus, we are working to the future to address these limitations and determine the best solutions to ensure that our system is effective and usable for our intended application.

- The main contribution of the project

As individuals of society, it is our responsibility to contribute to the discovery and advancement of new knowledge and technologies to enhance human well-being and make the world a better place to live. In pursuit of this, we have designed and worked on unique ideas and products to contribute to solving social issues, such as child safety, using new technology such as IoT systems.

Our contributions extend beyond product design. We have also participated in an academic conference, the 14th Annual Undergraduate Research Conference on Applied Computing (URC 2022) and presented posters to share our research findings and innovative solutions with others. Additionally, we have worked closely with the innovation center at KSU to refine our ideas and bring them to market.

Through our efforts, we hope to make a meaningful impact on society and contribute to creating a safer and better world for all.

- Future work

Elfaa (إلفاء) has several future plans for adding more features and enhancements to the system hardware and software. These include:

- Getting sponsors to improve the technology used for providing the tracking device with internet access in a more efficient and effective way than the GSM that uses 2G, to improve the speed and reliability of the system.

- Reducing battery consumption and increasing the tracking device's operational time, which could be achieved by improving power management and optimizing the device's hardware components. Also, showing the battery measurement accurately to the parent for each child device in the application.
- Designing a smaller tracking device by working with a manufacturer to improve the device's form factor and overall usability.
- Adding the ability to inform parents if their child has taken off the device or if it is still on the child, which could improve the security and safety of the system.
- Implementing a dynamic QR code that does not require parents to print a new code for each contact phone number change, but instead can be scanned and modified easily.
- Improving the organization of security guards and their admins to find a suitable way to send notifications only to active employees, not all registered ones.

In addition to these enhancements, *Elfaa (إلفاء)* also plans to support different languages to cater to different nationalities and languages, enable public people to report found children using *Elfaa (إلفاء)* application. Parents with multiple children will also be able to specify each child's safe distance separately. Finally, a playback function in the map might be added to check and follow the previous places where the child was located, which could provide parents with additional peace of mind and security.

7 Acknowledgements

We would like to express our deepest gratitude to all those who have supported us throughout the course of this project.

Firstly, we extend our heartfelt thanks to our supervisor, Dr. Hebah ElGibreen, for her invaluable guidance, support, and encouragement. Her expertise, feedback, and constructive criticism have been instrumental in shaping our research and helping us achieve our academic goals. We are extremely grateful for her unwavering dedication to our project.

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Lastly, we would like to express our heartfelt appreciation to our families for their unwavering support, love, and encouragement. Their support and encouragement have been crucial in enabling us to pursue our academic goals and achieve success. We are truly grateful for their love and unwavering support.

We are incredibly fortunate to have had such an outstanding support network, and we are truly grateful to everyone who has contributed to our project's completion.

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9 Appendix

9.1 Appendix A: Survey

استبانة لتطوير مشروع **إلفاء**:

إلفاء هو فكرة مشروع تخرج طالبات من قسم تقنية المعلومات بجامعة الملك سعود
تطبيق **إلفاء** يستخدم تقنيات إنترنت الأشياء للمساهمة في بناء حل يعمل في المدن الذكية لتوفير بيئة آمنة في الأماكن العامة أو المزدحمة، يستهدف **الآباء** عن طريق استعمالهم للتطبيق وربط جهاز التتبع بطفلهم الذي يحمله الطفل كإكسسوار مصمم بشكل جذاب. ويمكن للناس العامّة المساهمة في مساعدة طفل ضائع بكل سهولة ويسر عن طريق توفير وسيلة تواصل مع أهل الطفل..
أيضًا، يوفّر هذا الحل إمكانية للأب/الأم أن يراقب موقع طفله في أي وقت ضمن النطاق المحدد للمكان، ومعرفة ما إذا كان ضمن النطاق المسموح أم لا عن طريق إشعار تنبيهي يصله، وإن كان قد أضاعه ووجد أن مكانه بعيدٌ عنه فيمكنه إبلاغ حراس الأمن عن طريق التطبيق لمساعدته في إيجاده سريعًا؛ كما أن هذا الحل يساهم في جزء من عمل حارس الأمن في مكان عام وإشراكه في البحث عن الأطفال الضائعين بما يضمن اليسر والتسهيل..

قسم 1

هل أنت:

- أم/أب
- لديك طفل في المنزل
- حارس أمن في مكان عام
- تودّ مساعدة طفل ضائع

قسم 2

أم/أب | لديك طفل في المنزل

من فضلك، ما هو جنسك؟

- أنثى
- ذكر

كم عمر طفلك؟

- 3-0
- 7-4
- 11-8
- 12 فأكبر

هل سبق وحصل لك أنّ طفلك ضاع في مكان عام؟

- نعم
- لا

هل يحمل طفلك جواله الخاص به في الأماكن العامة؟

- نعم
- لا
- ليس لديه جوال

في الوضع الحالي، كيف تجد طفلك عندما يضيع منك؟

- مناداته بصوت عالٍ / باستخدام مكبرات الصوت
- تحديد موقعه وتتبعه
- تبليغ حراس الأمن لمساعدتك
- المشي والبحث عنه
- غير ذلك...

من وجهة نظرك، ما هي الطريقة الأسرع للعثور على طفل ضائع؟

- مناداته بصوت عالٍ / باستخدام مكبرات الصوت
- تحديد موقعه وتتبعه
- تبليغ حراس الأمن لمساعدتك
- المشي والبحث عنه
- غير ذلك...

برأيك ما هو الاكسسوار الذي سيجذب طفلك لارتدائه في الأماكن العامة حتى تتمكن/ين من تتبع موقعه؟

-تصميم الاكسسوار مناسب للجنسين-

- شنطة ظهر صغيرة
- حزام بنطال
- سوار للذراع

هل ترى/ين أنه من المهم أن يصلك إشعار تنبيه عندما يعبر الطفل أحد مناطق الخروج (البوابات)؟

- نعم
- لا
- غير ذلك...

هل تعتقد أنه من المفيد معرفة اسم المنطقة/المرفق، مثل: ملاهي، مطاعم،... التي يتواجد فيها طفلك عند مراقبة موقعه؟

- نعم
- لا

- غير ذلك...

قسم 3

حارس أمن في مكان عام

كم متوسط حالات ضياع الأطفال التي تواجهها أسبوعيًا؟

- 0
- 3-1
- 6-4
- 7 فأكثر

ما هي الصعوبات التي واجهتها عند بحثك عن طفل ضائع؟

- عدم معرفة مواصفات الطفل
- المكان واسع / كثرة المرافق
- لا يوجد وسيلة تواصل مع أهل الطفل عند العثور عليه
- عدم معرفتي بأن الطفل تم العثور عليه من قبل أهله

ما هي المعلومات التي تعتقد أنها كافية عن الطفل ووالده عند إشعارك بإبلاغ من والد عن طفله الضائع؟

- اسم الطفل
- صورة لوجه الطفل
- صورة كاملة للطفل
- وصف للبس الطفل أو علامة مميزة فيه
- رقم جوال المبلّغ للتواصل معه
- موقع الطفل وقت الإبلاغ
- موضوع محبب لدى الطفل للتحدث معه عند العثور عليه قبل وصول والده لتخفيف القلق والتوتر عنه

هل تعتقد أنه من المزعج أن يصلك إبلاغ عن طفل ضائع وأنت لست حاضر/مداوم في ذلك الوقت؟

- نعم
- لا

إذا كنت تعتقد في السؤال السابق أنه أمر مزعج،

هل ستلتزم بتحضير نفسك يوميًا عند حضورك لعملك عن طريق التطبيق، أم تفضل أن يلتزم بالتحضير شخص واحد مسؤول فقط؟

- نعم، سألتزم
- لا، أعتقد أن المسؤول أولى بالالتزام بالتحضير

قسم 4

تودّ مساعدة طفل ضائع

هل سبق وصادفت طفل ضائع؟

- نعم
- لا

من وجهة نظرك، هل من السهل معرفة معلومة توصلك إلى أهل الطفل الضائع؟

- نعم
- لا

هل تدعم وجود وسيلة مع الطفل الضائع تمكنك من استخدام هاتفك للتواصل مباشرة بسهولة مع أهله؟

- نعم
- لا

9.2 Appendix B: Release-2 User Acceptance Testing Questionnaire

قسم 1

هل توافق على أن تكون ضمن عيّنة اختبار تجربة المستخدم لتطبيق إلفاء للإطلاق الثاني؟

- أوافق
- لا أوافق

قسم 2

معلومات عامة عن المستخدم

أنت:

- أم/أب
- مشرف أمن
- حارس أمن

العمر:

- 15-25
- 26-36
- 37-47
- 48 أو أكبر

الجنس:

- أنثى
- ذكر

الجنسية:

- السعودية
- أخرى ...

الخلفية التقنية:

- ممتازة
- متوسطة
- منخفضة

قسم 3

(عند اختيار خيار أم/أب يتم الانتقال إلى هذا القسم)

تقييم تجربة المستخدم للإطلاق الأول

(التقييم بمقياس خطّي لهذه الاسئلة 1-5)

كيف تقيّم تجربتك لتطبيق إلفاء؟

- سيئة
- ممتازة

التطبيق مناسب وسهل الاستخدام ليُستعمل من قبل الأمهات والآباء.

- لا أوافق مطلقًا
- أوافق بشدة

تصميم واجهات التطبيق والألوان المستخدمة مناسبة ومتناسقة ولا تؤذي العين.

- لا أوافق مطلقًا
- أوافق بشدة

وجدت رسائل الخطأ التي تظهر لي واضحة وساعدتني على فهم المطلوب.

- لا أوافق مطلقًا
- أوافق بشدة

أعتقد أن الأيقونات المستخدمة في التطبيق مبهمة وغير معتاد عليها.

- لا أوافق مطلقًا
- أوافق بشدة

وجدت عملية إضافة الطفل تستغرق وقتًا طويلًا لإتمامها.

- لا أوافق مطلقًا
- أوافق بشدة

كانت عملية معرفة الرقم التسلسلي لجهاز التتبع وربطه بالطفل واضحة.

- لا أوافق مطلقًا
- أوافق بشدة

وجدت عملية إنشاء البلاغ بضياع الطفل والوصول لتفاصيل البلاغ وحالته واضحة ويسيرة.

- لا أوافق مطلقًا
- أوافق بشدة

أعتقد أنه من الضروري أن يصلني إشعارًا كلما تغيرت حالة البلاغ الخاص بضياع طفلي.

- لا أوافق مطلقًا

- أوافق بشدة

كان من السهل تفعيل خاصية المسافة الآمنة ومعرفة فائدتها.

- لا أوافق مطلقًا
- أوافق بشدة

الهدف من وجود رمز الاستجابة السريعة واضحًا.

- لا أوافق مطلقًا
- أوافق بشدة

كان من السهل إيجاد رمز الاستجابة السريعة بعد حفظه.

- لا أوافق مطلقًا
- أوافق بشدة

معرفة حالة انقطاع اتصال جهاز التتبع وآخر موقع كانت واضحةً بالنسبة لي.

- لا أوافق مطلقًا
- أوافق بشدة

عند استعراض الخريطة في التطبيق كانت حدود المناطق وأسمائها واضحة.

- لا أوافق مطلقًا
- أوافق بشدة

عند استعراض الخريطة كان موقع طفلي واضحا.

- لا أوافق مطلقًا
- أوافق بشدة

كان سجل التنبيهات يحتوي على معلومات واضحة من أيقونات ونصوص.

- لا أوافق مطلقًا
- أوافق بشدة

ما هي الصعوبات التي واجهتها أثناء استخدام التطبيق؟

لا يوجد

لا يوجد

لاشي

لا توجد صعوبات

لا يوجد اتوقع

عدم تحرك الخريطة + عند إضافة صورة الطفل يتم تكرار عملية التسجيل + الخروج من الحساب بشكل مفاجئ

لا كل شي جميل جداً

لم استطع تحريك الخريطة بسهولة في الصفحة الرئيسية

هل لديك أي اقتراحات لتطوير التطبيق؟

تحديد المسافة الآمنة لكل طفل على حده

القدرة على التواصل بالصوت مع الطفل من خلال الجهاز

لا

تطبيق متكامل

في زمن اخر

تطوير سلاسة التطبيق

نعم لدي الاقتراح كالاتي : بعد انشاء الحساب التوجه للصفحة الرئيسية بدون التأكيد على الرمز السري

اضافة تعليمات عند بداية دخول التطبيق

دعم الIOS

هل من الممكن أن تستعمل تطبيق إلفاء في المستقبل؟

- نعم
- ربما
- لا

قسم 4

(عند اختيار خيار مشرف أمن يتم الانتقال إلى هذا القسم)

تقييم تجربة المستخدم للإطلاق الأول

(التقييم بمقياس خطّي لهذه الاسئلة 1-5)

كيف تقيّم تجربتك لتطبيق إلفاء؟

- سيئة
- ممتازة

التطبيق مناسب وسهل الاستخدام ليُستعمل من قِبل مشرف الأمن.

- لا أوافق مطلقًا
- أوافق بشدة

تصميم واجهات التطبيق والألوان المستخدمة مناسبة ومتناسقة ولا تؤذي العين.

- لا أوافق مطلقًا
- أوافق بشدة

وجدت رسائل الخطأ التي تظهر لي واضحة وساعدتني على فهم المطلوب.

- لا أوافق مطلقًا
- أوافق بشدة

أعتقد أن الأيقونات المستخدمة في التطبيق مبهمة وغير معتاد عليها.

- لا أوافق مطلقًا
- أوافق بشدة

أرى أن تحديد نوع الحساب عند تسجيل الدخول لا يهدد أمن معلومات المنشأة.

- لا أوافق مطلقًا
- أوافق بشدة

خطوات إنشاء الحساب لحراس الأمن واضحة ومباشرة.

- لا أوافق مطلقًا
- أوافق بشدة

استطعت تعديل معلومات حارس الأمن بشكل سهل.

- لا أوافق مطلقًا
- أوافق بشدة

كان حذف حساب حارس الأمن من النظام سهل وفعّال.

- لا أوافق مطلقًا

- أوافق بشدة

كان سجل التنبيهات يحتوي على معلومات واضحة.

- لا أوافق مطلقًا
- أوافق بشدة

عملية الوصول إلى البلاغ وتغيير حالته إلى "تم العثور عليه" أو "مغلق" كانت سهلة ومباشرة.

- لا أوافق مطلقًا
- أوافق بشدة

ما هي الصعوبات التي واجهتها أثناء استخدام التطبيق؟

لا يوجد اي صعوبات

لايوجد

هل لديك أي اقتراحات لتطوير التطبيق؟

يحتاج التطبيق خانة تسجيل صوت .

أن يكون هناك نظام تحضير بالتطبيق لكي يسهل علينا العمل كذلك لكي لاتصل إشعارات البلاغ لمن لم يداوم

هل من الممكن أن تستعمل تطبيق إلفاء في المستقبل؟

- نعم
- ربما
- لا

قسم 5

(عند اختيار خيار حارس أمن يتم الانتقال إلى هذا القسم)

تقييم تجربة المستخدم للإطلاق الأول

(التقييم بمقياس خطّي لهذه الاسئلة 5-1)

كيف تقيّم تجربتك لتطبيق إلفاء؟

- سيئة
- ممتازة

التطبيق مناسب وسهل الاستخدام ليُستعمل من قبل حارس الأمن.

- لا أوافق مطلقًا
- أوافق بشدة

تصميم واجهات التطبيق والألوان المستخدمة مناسبة ومتناسقة ولا تؤذي العين.

- لا أوافق مطلقًا
- أوافق بشدة

وجدت رسائل الخطأ التي تظهر لي واضحة وساعدتني على فهم المطلوب.

- لا أوافق مطلقًا
- أوافق بشدة

أعتقد أن الأيقونات المستخدمة في التطبيق مبهمة وغير معتاد عليها.

- لا أوافق مطلقًا
- أوافق بشدة

تمكنت من تسجيل الدخول في حسابي لأول مرة بسهولة.

- نعم
- لا

استطعت تغيير كلمة المرور الخاصة بحسابي بسهولة.

- لا أوافق مطلقًا
- أوافق بشدة

كان سجل التنبيهات يحتوي على معلومات واضحة.

- لا أوافق مطلقًا
- أوافق بشدة

عملية الوصول إلى البلاغ وتغيير حالته إلى "تم العثور عليه" كانت سهلة ومباشرة.

- لا أوافق مطلقًا
- أوافق بشدة

ما هي الصعوبات التي واجهتها أثناء استخدام التطبيق؟

ما قدرت اكبر صورة الطفل الضايع في البلاغ
مافي صعوبات
لايوجد
Nothing

هل لديك أي اقتراحات لتطوير التطبيق؟

لا هذا احسن شيء
لايوجد
اتمنى يتطبق باسرع وقت لاننا نتعب جدًا بموضوع التواصل بجهاز اللاسلكي الخاص بحرّاس الامن
لابد من وجود التطبيق لسهوله العثور ع المفقود كذلك ان وجد اضافه للمفقودات الشخصيه
لا يوجد
اريد ان احمل التطبيق في جهازي الايفون

هل من الممكن أن تستعمل تطبيق إلفاء في المستقبل؟

- نعم
- ربما
- لا