COMP4801 - Final Year Project

Blackbox System For The Elderly

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Abstract

The elderly in our society are prone to getting lost because of old age and even diseases like Alzheimer's. This can lead to serious and even fatal repercussions like dehydration, traffic accidents and falling prey to criminal activities. However, as smart phone technology permeates across different sections of society, there is an opportunity to provide a mobile solution that can help increase the security of the elderly in case they get lost. The "Blackbox System for the Elderly" is a mobile application that aims to accomplish exactly that. The application primarily provides a platform for family members and/or caretakers of the elderly to locate them and reach out to them easily in case they get lost. This report explains in details the problem that this project aims to solve. It also proceeds to discuss the features that are part of this application, how each of them was implemented and major decision points. It ends with discussing future plans for this application.

Acknowledgements

Table Of Contents

1. Introduction

Dementia describes a set of symptoms that include memory disorders, personality changes and impaired reasoning. According to WHO's report on dementia in 2015, nearly 47.5 million people in the world suffer from some form of dementia [1]. Every year nearly 7.7 million new cases of dementia are diagnosed [2]. It is a serious and possibly fatal disease being faced by people all over the world. The two earliest observed and most common symptoms of any form of dementia are memory loss and a failing sense of direction. Despite the huge boom in technology, unfortunately not much has been achieved to help patients with dementia. Consequences of poor memory can be as small as simply losing track of time, to more serious problems like not even recognising one's own family, in the advanced stages of the disease. Apart from dementia patients, many senior citizens across the globe also face the problem of declining memory due to the process of ageing.

The most common repercussion of poor memory is getting lost. In Hong Kong, according to a local telephone survey conducted by the government in 2007, nearly 30% people suffering from dementia (or their caregivers) had reported having being lost at least once [3]. Losing one's way can have serious and possibly fatal consequences. These include problems like, dehydration, starvation, falling prey to criminal activities and possible traffic accidents. However, it would be inhuman to stop the elderly from going out alone especially, if their condition is not very serious. There are GPS devices and nametags, that family members or caregivers make the elderly wear, to locate them in case they get lost. While these are useful, they often create a belittling and even humiliating feeling among the elderly. Many feel like they

are being equated with criminals, who are fitted with GPS trackers and ankle bracelets. Also, currently there are almost no mobile applications designed specifically for the elderly to increase their safety when they step out of their homes.

As can be seen, there is need for a solution designed to ensure the safety of the elderly on the go. Thus, I decided to build the Blackbox System for the Elderly. It is an application that can help family members locate the elderly easily in case they lose their way. It also provides additional features that can help the elderly reach their home or a place of safety in case they get lost. The application has been designed keeping in mind the specific requirements of the target customers i.e. the elderly.

This report discusses in detail the aim of this application, along with its features and flows. It then proceeds to explain in deep detail how every feature was implemented, the various technologies involved, critical decisions made and hurdles crossed during the process.

2. The Problem being Addressed

Consider a hypothetical senior citizen Lynda, who is 78 years of age and lives in Kwun Lung Lau, Kennedy Town, Hong Kong. Lynda is an active lady for her age who enjoys going on walks and meeting her locality friends. She even frequents the Smithfield Market and Cooked Food Centre, which is about 20 minutes away from her home, to purchase fruits and meat for her family. However, over the past couple of years, these seemingly simple acts have become slightly more difficult and dangerous for Lynda. This is because she was recently diagnosed with Alzheimer's, a form of dementia, which is a neurodegenerative disorder that negatively impacts her

cognitive abilities. The disease is still in a relatively early stage and manifests itself only in the form of sporadic bouts of memory loss, confusion and disorientation. As a result of this, Lynda has, on a couple of occasions, gotten lost while she was out or not known how to get back home. During these situations, she is also unable to clearly describe her current location to her family, as she feels extremely confused and scared. On one instance, she even forgot to call her family for help. While these incidents are extremely rare and will hopefully remain so in the near future, they have definitely instilled a sense of fear in her family members. At the same time, her family does not want to begin restricting her movement at such an early stage of the disease, especially considering how much she enjoys going out.

In an attempt to ensure Lynda's safety, her family has made her wear multiple GPS tracking devices. This is the most popular option being used to ensure the safety of senior citizens in Hong Kong today. However, she always discards them because they make her feel like a prisoner being tracked with an ankle bracelet. They are also easily visible to others, making others feel she isn't normal somehow and hence requires constant tracking. This makes her feel humiliated. Lynda's situation is similar to that of millions of senior citizens globally, who are still looking for a respectable solution that ensures their security without sacrificing their freedom and dignity.

3. Related Work

The current landscape for applications in the elderly-security and safety sphere can be shown succinctly using Figure 1. Each axis on the graph represents the three major focus points of this application i.e. GPS tracking, features to ensure greater safety like SOS calls, direction to police stations etc. and usability by senior citizens. Please note

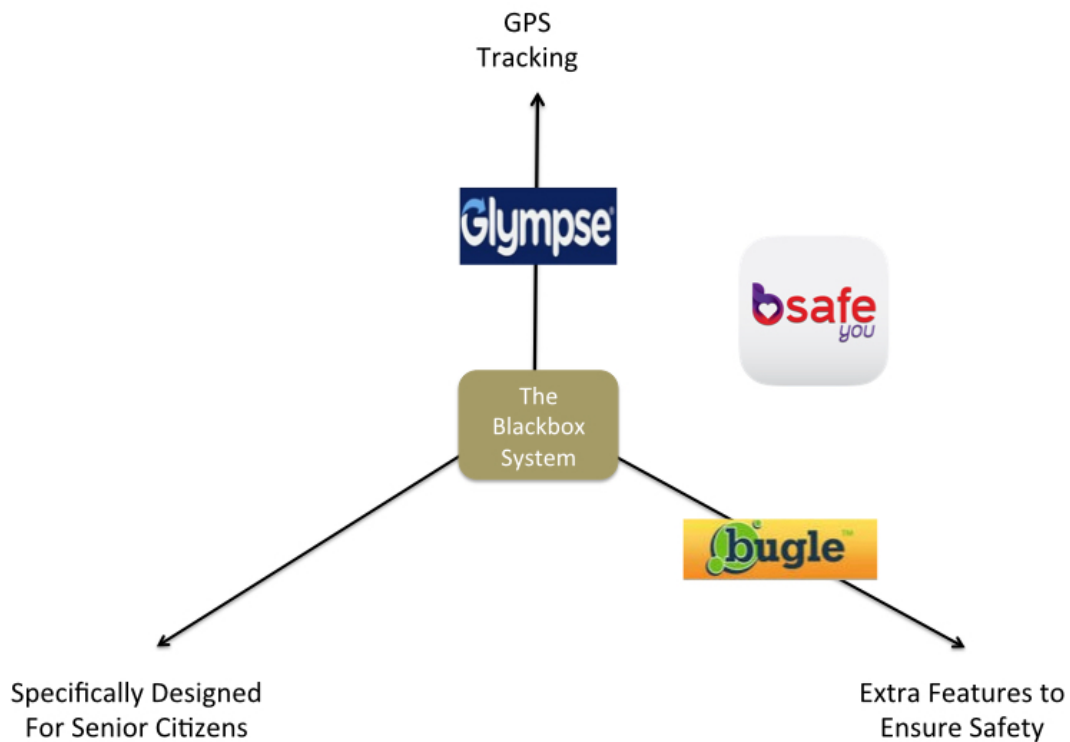that while there might be more competitors in the field, the graph only talks about the major competitors.

Figure 1: Scope of the Blackbox System and its competitors

Applications like *Glympse* focus only on GPS tracking, not on providing features that help increase the safety of the user. Applications like *Bugle* are on the other end of the spectrum, not providing GPS tracking and only providing safety features like setting off an alarm in case of any danger. Applications like *bsafe* provide both GPS tracking and SOS features to ensure safety however, none of the apps, including *bsafe*, take into account the requirements of the elderly. The elderly are not always as adept at using technology and hence their requirements must definitely be kept in mind while

designing the application. The Blackbox System is the only application that provides GPS tracking, SOS features to ensure safety of the elderly and is also designed to suit their requirements and allow maximum ease of use.

Physical tracking devices can also be considered as a part of the elderly-security and safety sphere. The most commonly used physical tracking device in Hong Kong is *Mobile Link (隨身寶)* (Figure 2). However, as mentioned previously in the case of Lynda (section 2), they make the elderly feel humiliated and like a prisoner who is made to wear an ankle bracelet.

Figure 2: Mobile Link: GPS Tracker for by the elderly

4. Application Implementation Process

As the can be seen from the previous section, an application like the Blackbox system

is almost vital to ensure the safety of the elderly. This section now goes on to describe in detail, the entire process of building this application

4.1 Timeline

Creating the Blackbox System has been much more than merely writing code. It has been a process that involved in-depth research and multiple interactions to best understand the requirements of the target users i.e. senior citizens, followed by designing the features and user interface of the application in accordance with their needs. The chart below gives a quick overview of the timeline of the application development.

Finalized set of features	**Sept '15**
Studied requirements of the elderly	**Mid Sept'15 – Beginning of Oct'15**
Designed UI and made wireframes	**Mid Oct'15**
Held Customer Focus Group	**24th October '15**
Built signup process	**Mid- End Oct'15**
Setup backend and database	**Nov - Dec'15**
Built location saving feature	
Built location viewing feature	

Built in-app map showing directions to home	**Jan '16 – Mid Feb '16**
Introduced turn by turn navigation	
Integrated Uber	
Built in-app maps showing closest hospital and police stations	**Mid Feb '16 – Mar '16**
Implemented Elderly's ID Page	
Implemented authorization to view Elderly's ID	
Implemented calls for SOS and police emergency	**Apr '16**
Redesigned UI & Performed Testing	

Figure 3: Application Development Timeline

4.2 Initial Research

Before the actual development of the application began, it was necessary to understand the user interface (UI) requirements of the elderly. This was particularly important, as the elderly are not always very comfortable using smartphone applications.

There are a lot of online resources available today that helped understand the problems faced by the elderly while using smartphone applications and possible ways to tackle them. For the purpose of this project, three main online resources were used. They were -

- Mobile Application Development For Senior Citizens by Jing Gao and Andy Koronios, School of Computer and Information Science, University of South Australia, Adelaide, Australia.

  (http://www.pacis-net.org/file/2010/S05-03.pdf)

- Tips to Design Innovative Digital Products for Senior Citizens, Vol. 1 and 2. (http://mobisoftinfotech.com/resources/blog/tips-design-innovative-digital-products-senior-citizens/)

- Designing For The Elderly: Ways Older People Use Digital Technology Differently   by   Olie   Campbell. (http://www.smashingmagazine.com/2015/02/designing-digital-technology-for-the- elderly/)

4.2.1 Findings from Initial Research

Using the above-mentioned resources, the following conclusions were drawn-

- The elderly often have weaker eyesight; hence the text on the screen must be big and well spaced out.

- Similarly, buttons in the application must also be big in size.

- Text should also be left aligned because it is easier to read as compared to other alignment formats.

- There should not be too many tasks on one page as that tends to create confusion and it is often considered difficult.

- Voice instructions are preferred on every screen for guidance.

- Minimum text input should be there, as the elderly often find it hard to type on the small keyboards that phones have.

- It is preferable to not have usernames and passwords as the elderly have a tendency to forget them.

- If a task requires the users to remember what they entered previously, avoid splitting it across different screens, as they might forget what they had entered previously.

- Avoid animations and keep the user interface as simple as possible, with basic colours.

4.3 Customer Focus Group

The online resources provided a lot of insight into the considerations that need to be kept in mind while building an application for the elderly. The purpose of this customer focus group was to validate the conclusions drawn from the online research and to gain first hand knowledge about how the elderly use smartphone applications. This survey was conducted at Chi Sun College, JCSV III, HKU on 24th October 2015, where close to 20 senior citizens from Kwun Lung Lau, Kennedy Town come twice a month to learn how to use smartphones and smartphone applications.

4.3.1 Approach

For the purpose of this survey three practices were adopted. First, the elderly's interactions with their smart phones were observed from a distance. Second, they were asked a set of questions that had been prepared previously. These survey questions were asked orally in the form of an interview. The interview included questions like which phones they used and what problems they faced with commonly used mobile applications like WhatsApp etc. These questions were basically meant to

understand the kind of difficulties they faced while using their phones and applications. Finally, they were shown three screens of the application. They were allowed to use the application for sometime and feedback was taken from them on two main criteria - comfort of use and understandability. A complete list of the survey questions and the application screens used can be viewed in sections 1 and 2 of the Appendix.

4.3.2 Findings from Customer Focus Group

The survey's findings were in line with those of the online research. All the elderly except one used Android phones. However, it was clear that their phones have relatively older Android versions (usually Android OS 4.0), as they do not change their phones often. Thus, it heightened the need for the application to be functional on lower Android versions as well. The second point that became apparent was that the elderly prefer phones with bigger screens. With weaker eyesight, it helps them see the contents on the phone better. Therefore, the user interface must be built for bigger screen sizes as well, in addition to the standard screen sizes.

Most of the elderly, especially those who were slightly older in age, clearly did not prefer typing text. Even while using WhatsApp they preferred to send voice messages. When asked about applications like WhatsApp, almost all of them said that they found them a bit confusing. This was especially because they thought that there was a lot happening on each screen and the text on the screen wasn't very big.

The idea of having instructions on each screen was very popular. However, they were not too keen on having voice instructions. This is because, they felt that the sound

from the phone wasn't always loud enough to clearly hear and understand. The idea of having passwords or anything similar was widely unacceptable. All of them unanimously said that they found remembering passwords difficult. They also said that they found it much easier to use any application if it was in their native language i.e. Cantonese.

The family members of many of the elderly had tried to make them use a safety device. However, as mentioned previously in section 3, they found the idea of using this tracking device demeaning, and they had gotten rid of it. They liked the idea of the Blackbox system however, they did not like certain words used in the application like "follower" (used initially to refer to the family members), as it reminded them of the tracking device.

4.4 Changes Made Post Mid-Term Evaluation

Two major changes were made to the original development plan post the mid-term evaluation. The first was a suggestion made by the second examiner Dr. Ronald H.Y. Chung. He pointed out that the elderly ID page (section 5.1.6) could be accessed by anyone having the phone. This could lead to the elderly's personal information potentially falling into the wrong hands. This was a very valid point and needed to be addressed. He suggested using a video call in the SOS (section 5.1.5) to contact the elderly's family member who could then authorize the third person to view the elderly's personal information. Upon closer examination, it was concluded that a video call might not be the best possible method. This was because a video call would require an Internet connection and one major purpose of the SOS button is to allow the elderly to contact their family member in case they are lost and have no Internet.

However, the safety of the elderly's personal information was still a major concern. Thus to solve this, it was decided to password protect the elderly's ID page. The password would be the same as the common password provided to the family members at the time of sign up (section 5.1.1) So clicking the SOS button places a regular call to the elderly's emergency contact. Once they are satisfied of the authenticity of the person calling, they can provide the password, which will then unlock the ID page.

The second change was to not implement one feature of the application that had been decided in the beginning. It was a feature that would notify the elderly's family members when the elderly's phone battery was low. While this feature was extremely useful, it would also put a huge load on the phone's battery, as the application would have to constantly listen for a situation when the battery of the phone would be low. Therefore the plan to implement this feature was dropped.
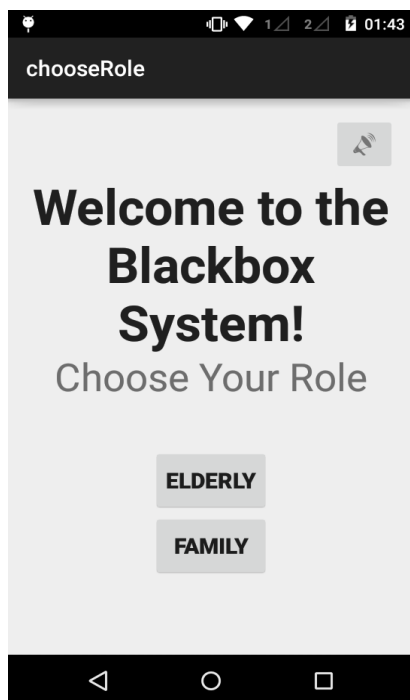
4.5 Testing

My advisor, Dr T.W.Chim, and I did implementation testing for the application. Our tests looked at whether the application performed as expected and noted bugs, if any. The process involved going through each flow of the application. The application performed as expected in both our tests. There was only a small glitch that the application would become quite slow at times. This happens because the server of the application is being hosted on the lowest tier of Google App Engine, which is free. As a result, when the number of calls to the server increases a lot (as it did during testing) the application tends to slow down. This glitch can easily be solved by upgrading Google App Engine to next highest tier.

5. Solution

In order to ensure that Lynda and her family feel safe while she is on the go, it is necessary to provide Lynda's family with accurate information regarding her location and also empower Lynda with tools that can help her reach safety, in case she does get lost. I developed The Blackbox System for the Elderly precisely to provide these services. The Blackbox System is an Android application that routinely saves the location of the elderly (or any other person with poor or deteriorating memory) in a database, making it accessible to family members and/or caretakers upon authentication. It also provides methods for the elderly to reach a place of safety like home or a hospital or police station in case they get lost alone.

5.1 Flows and Features in Detail For The Elderly

To better understand how Lynda can sign up for and use the application to increase her security while on the go, following sections describe the application flows for the elderly.

5.1.1 Sign Up Form

To begin using the application, the elderly must first register for the application. Upon installation when the application opens for the first time, a screen is displayed, as seen in Figure 4, which asks the user to choose a role – Elderly or Family. Lynda can select the option "Elderly". The next few screens (as shown

Figure 4: First Screen of Sign Up Flow- Choose Role

in figure 5) ask Lynda to enter the following information –

- Full Name,

- Phone Number

- Address

- Emergency Phone Number. The emergency phone number basically refers to the number that is called by the application in case of an emergency.
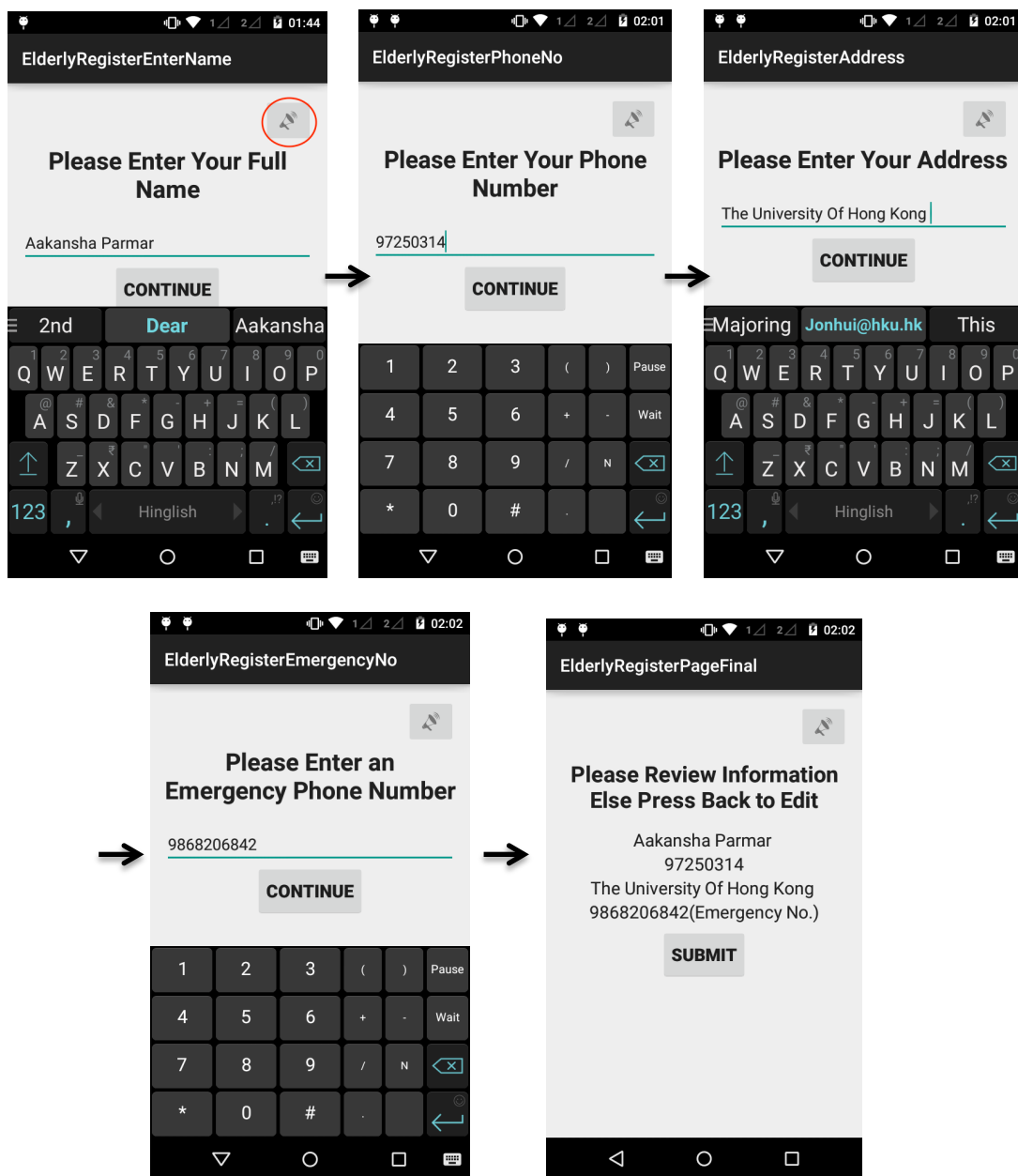

Figure 5: Sign Up Flow For The Elderly

The number of details that the elderly is expected to enter is kept to a minimum as it has been concluded from the Customer Focus Group held in October 2015, (section 4.3.2) that the elderly find it difficult to type on the small keyboards in smartphones. However as all the information is necessary for the correct functioning of the application, none of the input fields can be left blank.

The user interface (UI) of the application has been designed such that the user enters only one input per screen. While this does make the sign up process seem longer and more cumbersome, the customer discovery focus group clearly showed that the elderly find it very difficult to move the pointer from one input field to another. Thus, this method along with displaying the keyboard automatically when the screen opens, can ensure greater clarity for the user. In case there is any confusion regarding what to do or enter on each screen, there is a small loudspeaker icon on the top right corner of each screen (see red circle on first screen in Figure 5), which has voice instructions to help the user.
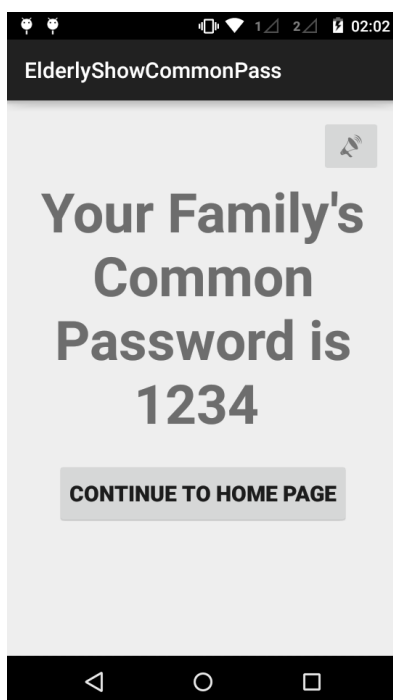
After entering all her details, Lynda can review ther information she entered (final screen in Figure 5) and finally submit it. Once submitted, she will be shown a screen with a common password (Figure 6) that will be used to authenticate her family members before they are allowed to view her location. Lynda can click the button at the bottom of the page to then view the home screen of the application.

Figure 6: Screen Displaying Common Password

5.1.2 Elderly Home Screen

The home screen of the elderly side of the application has three major tabs (Figure 7):

- Get Home!

- Hospital and Police

- SOS

The three tabs, as the names suggest, provide help for the elderly to reach home, to reach the closest hospital or police station and to call for help in case of an emergency.
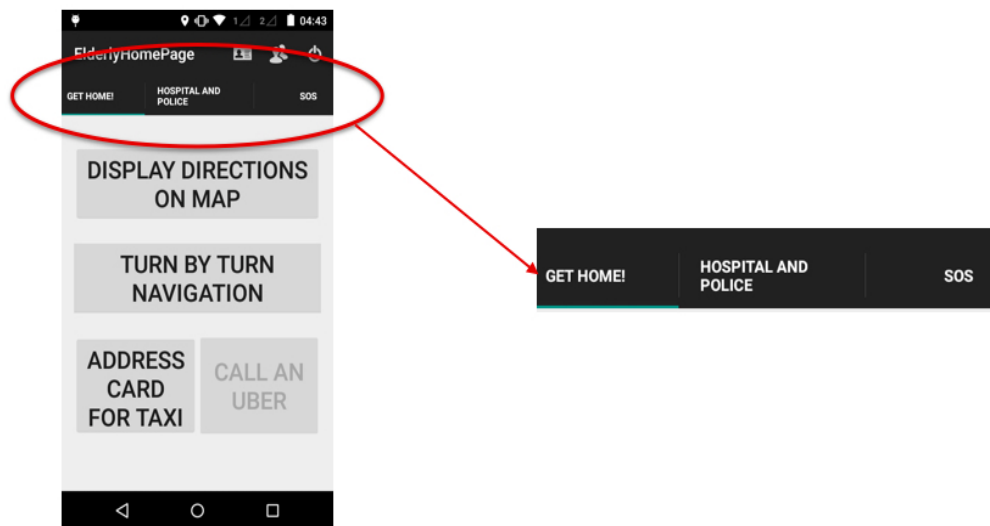

Figure 7: Navigation Tabs on Elderly Home Page

5.1.3 Get Home!

The first tab on the home screen of the elderly side of the application is titled "Get Home!". It contains 4 buttons (Figure 8):

- Display Directions On Map
- Turn By Turn Navigation
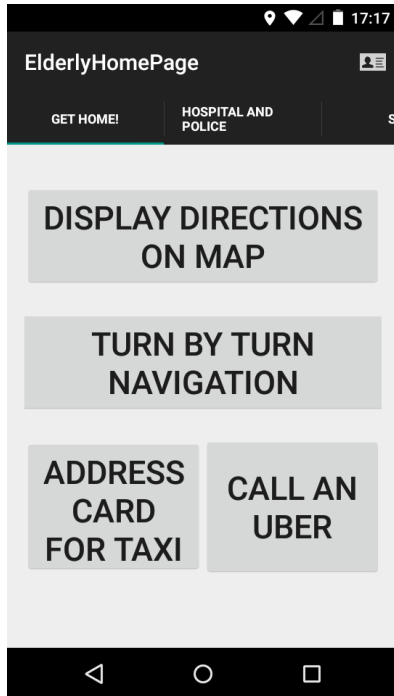
- Call An Uber

- Address Card for Taxi

Figure 8: Get Home! Screen   **Figure 9: Directions to Home**

5.1.3.1 Display Directions On Map

If Lynda gets lost and is unable to remember how to get home, one possible option for her is to click on the button "Display Directions On Map" which will open a map (Figure 9) showing the most optimized route to walk from her current location to her home address, which she entered at the time of registration. The blue marker on the map represents her current location and the green marker represents her destination i.e. her home. There is also a light blue dot on the map which tracks her movement in real time, telling her if she is going in the right direction or not. The map also allows for Lynda to zoom in and zoom out as per her preference.

5.1.3.2 Turn By Turn Navigation

There are two possible cases when the "Display Directions On Map" may not be completely useful for Lynda. The first possible situation is that she is way too far from her home to walk back or is in a car, and needs to drive or be driven back. The second possible case is that she may find it difficult to follow the map and reach home because she might be confused or the route might just be complicated. In these situations, there needs to be a more detailed form of instruction to help Lynda find her way back home. This form of instruction is referred to as Turn-by-Turn Navigation.
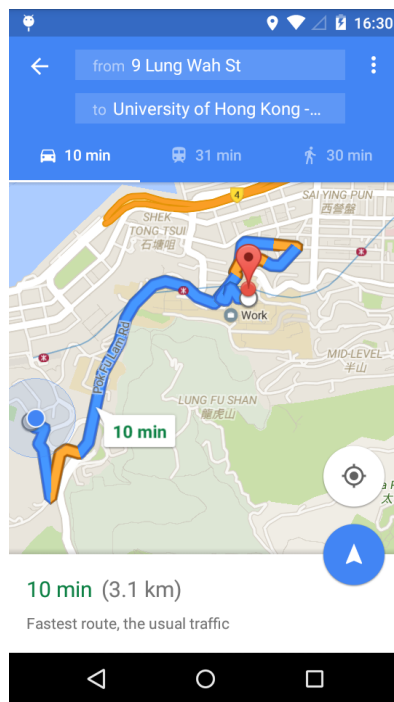

Figure 10: Google Maps Opened from application

Turn-By-Turn Navigation refers to a feature, which displays the directions to a specific destination in an audio or textual form. Google provides the most accurate

turn-by-turn navigation. However, there is no way to build that feature of Google Maps into a separate android application. Hence, clicking on the "Turn-By-Turn Navigation" button opens the turn-by-turn navigation feature in the official Google Maps Android Application (Figure 10) that is by default installed in every Android based smartphone. The complete, detailed reasoning behind using a third party application for implementing this feature has been given in section 5.4.4.

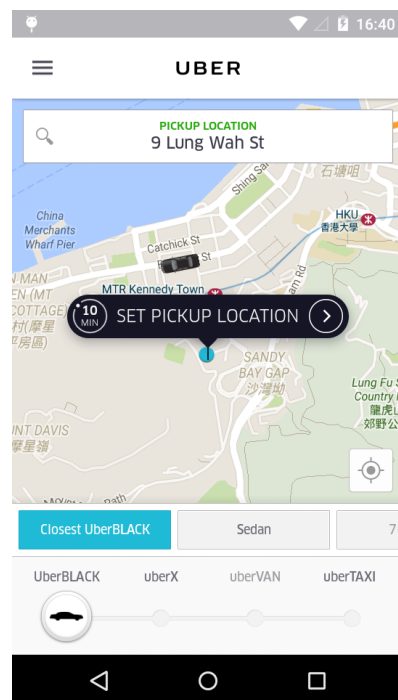**Figure 11: Uber Page opened on clicking Call an Uber button**

5.1.3.3 Call an Uber

Memory deterioration can also often cause disorientation and extreme confusion. This might make it difficult for Lynda to navigate back to her home on her own or even explain her home address to someone else like a taxi driver. In such a situation she can click on the "Call an Uber" button. A screen similar to Figure 11 opens up in the

Uber application, with the pick up location automatically set to her current location and the destination set as her home address that she entered at the time of registration. This saves her the trouble of having to navigate through the Uber application and entering all the above information, something that can be challenging to do in a state of confusion.

The application uses Uber as its taxi service of choice because of its reputation and also because of the extremely simple framework provided by Uber to launch it from a separate application with all relevant details already entered. Other mobile-based taxi services can also be integrated into the application in the future. Such an integration can also become a part of the application's business model in the future with Blackbox System getting a small percentage of commission from every ride taken through its application.
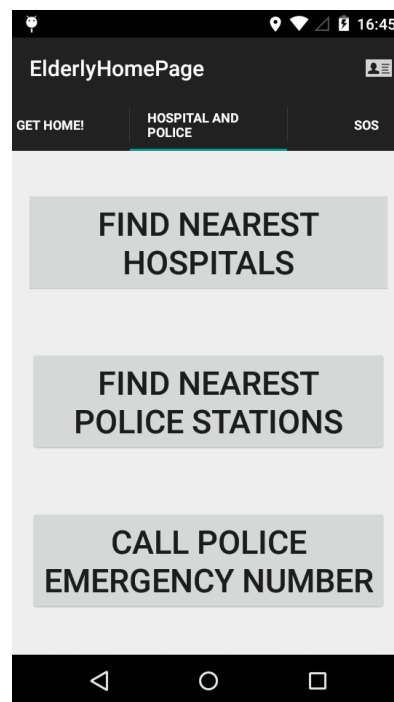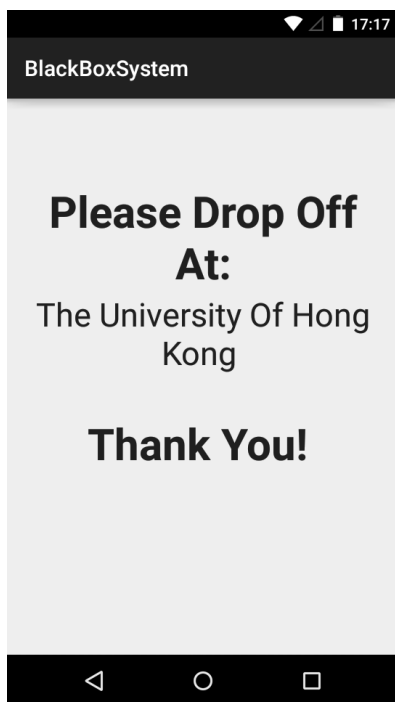

Figure 12: Address Card Screen   Figure 13: Hospital and Police Screen

5.1.3.4 Address Card for Taxi

The address card is a page that displays Lynda's address. It can be used to show regular taxi drivers where she has to be dropped, in case she forgets her address (Figure 12).

5.1.4 Hospital and Police

The second tab on the Elderly Home Page is titled Hospital and Police. Hospitals and Police stations are often places where help can be found. In case Lynda is unable to reach home safely on her own, this page will provide her with ways to reach a place of safety or contact an authority for help. The screen has three buttons (Figure 13):

- Find Nearest Hospitals

- Find Nearest Police Stations

- Call Police Emergency Number

Figure 14: Closest Hospitals Screen

Figure 15: Closest Police Stations Screen

25

5.1.4.1 Find Nearest Hospitals

Clicking on the "Find Nearest Hospitals" button will display a map with each red marker showing a hospital within a 1000 metres radius (Figure 14). The map also displays the route to the closest hospital in the area (red line segment drawn on map in Figure 14)

5.1.4.2 Find Nearest Police Stations

Clicking the "Find Nearest Police Stations" button yields similar results to those obtained from clicking the "Find Nearest Hospitals" button (section 5.1.4.1). It opens a map displaying the closest police stations in a 1000 metres radius (Figure 15). The map also displays the route to the closest police station in the area (red line segment drawn on map in Figure 15)

5.1.4.3 Call Emergency Hotline

In case there is no hospital or police station close to where Lynda is currently or she is unable to find her way back to the aforementioned destinations, the application also provides a button titled "Call Police Emergency Number" which places a regular call to the number 999, which is the emergency hotline for both hospitals and police in Hong Kong.

5.1.5 SOS

In case Lynda is unable to get reach home on her own, or reach a hospital or police station, or for some reason is unable to access the Internet through her phone, she can use the SOS feature. On clicking the SOS button (Figure 16), a call will be placed to

the emergency contact number that Lynda had entered at the time of registration. This way she does not even need to remember the name or phone number of her family member or caretaker, which can be difficult for someone with poor memory.
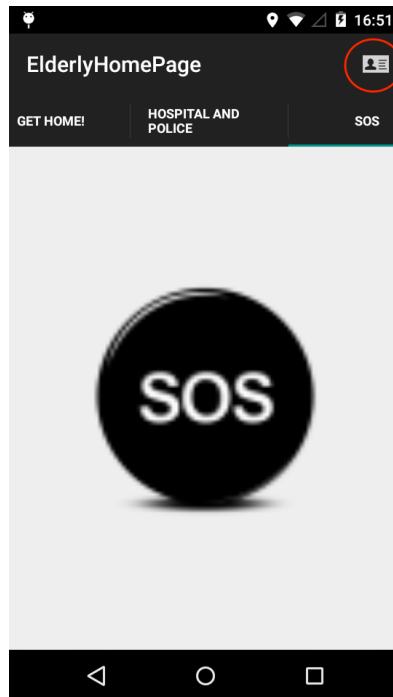
Figure 16: SOS Button Screen and ID Page Button

5.1.6 ID Page

Consider a case when Lynda has probably lost her way and needs to reach home. She decides to approach someone on the road to help her get back. However, due to her poor memory she is unable to provide any information about herself, thus making it difficult for someone to help her out. In such a situation the person whom she asks for help can click on the ID page button on the top right corner of the home page of the elderly's application side (Red circle in Figure 16).

Clicking on the button will open an authentication page requesting a password (Figure

17). The ID page contains a lot of personal information regarding the elderly that needs to be safeguarded. For this reason the ID page is password protected. To unlock the page, the person must call the elderly's emergency contact by clicking on the SOS button. The contact (family member or caretaker) can then provide the common password, which is obtained at the time of elderly registration (section 5.1.1, Figure 6). Upon receiving the password, the person can enter it, view the personal particulars of the elderly (Figure 18) and then help them reach home safely.
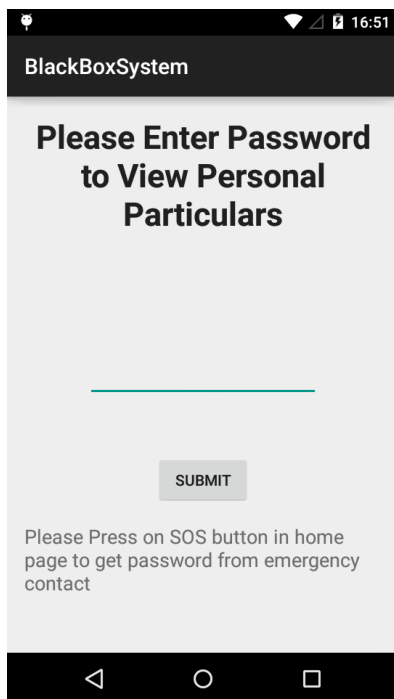
Figure 17: ID Page Verification Screen
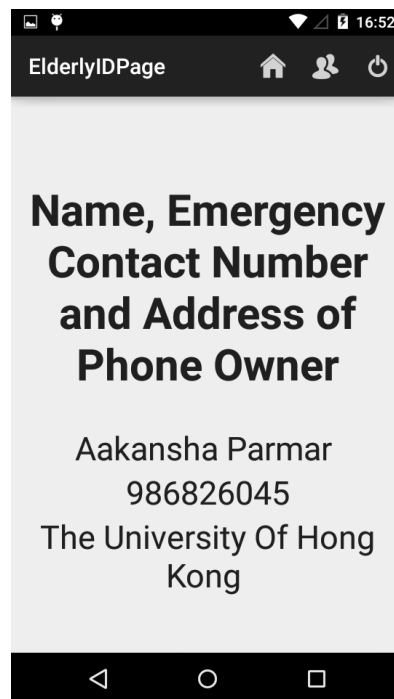
Figure 18: ID Page Screen

5.1.7 Location Saving

Sections 5.1.1 to 5.1.6 describe in great detail the features that can be used by Lynda to reach safety, in case she gets lost. In addition to these features, there is a very important service that the application provides i.e. continuously saving the location of

the elderly into a database every 10 minutes. The family members or caretakers can then view this location on their phones and find Lynda more easily if she is lost.

5.2 Flows and Features in Detail For The Family

The following sections focus on how Lynda's family members, for example her son Tony, can use the Blackbox System application to locate Lynda.

Figure 19: Sign Up Flow For Family Members

5.2.1 Sign Up Form

The application requires each family member of the elderly to also register before using the application. Hence, after installing the application on his phone, Tony is asked to choose his role i.e. Elderly or Family (Figure 4). After clicking on the Family button, he is then required to enter the following personal particulars into the application (some of these are shown in Figure 19)–
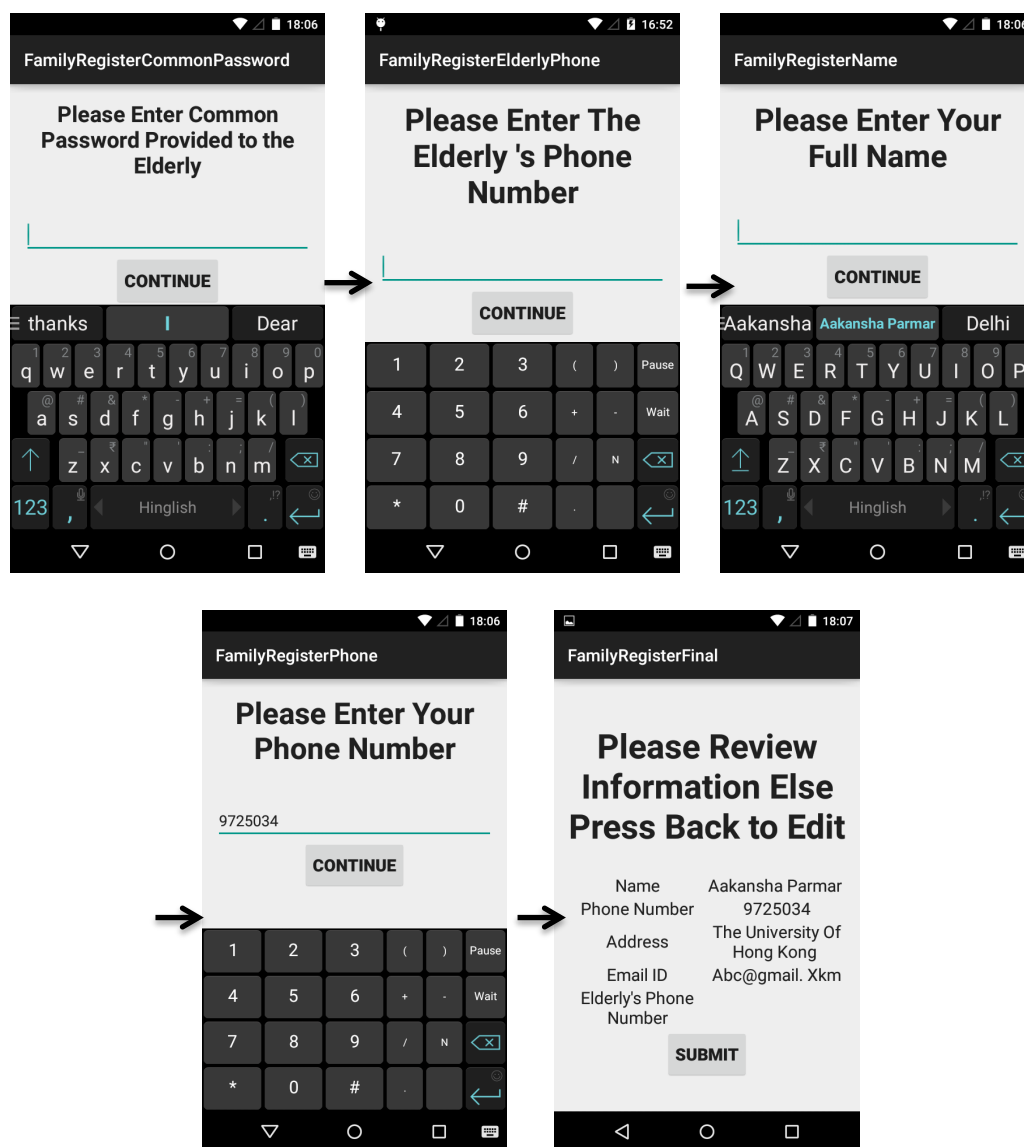
- Elderly's Phone Number

- Full Name

- Family Member's Phone Number

- Address

- Email ID

- Common Password Provided to the Elderly at the time of registration (Refer to section 5.1.1, Figure 6).

Each input is compulsory for the functioning of the application and cannot be left blank. Also, to improve the security of the application and to avoid any unauthorized access to the elderly's location, only those people who have a valid elderly's phone number and password combination will be allowed to register for the application. Once all the information has been reviewed by the family member (last screen of Figure 19) and consequently verified in the backend, he or she may proceed to view the elderly's location on the application.

5.2.2 View Elderly's Location

As mentioned in section 5.1.7, the application on the elderly's side saves the elderly's

location into a database. When Tony opens the application after registration, he is immediately greeted with a map (Figure 20), which shows him his mother's last known location, thus allowing him to find her in case she gets lost. At the bottom of the screen he can also see the geographic coordinates (latitude + longitude) of his mother's last known location (not visible in Figure 20).

Figure 20: View Elderly's Location Screen

5.3 Implementation Details

The Blackbox System for the Elderly is an application built to run on the Android operating system. The application's backend is being run on Google App Engine (GAE) and uses Google Cloud SQL, a MYSQL database in Google's cloud, to store all the application's data. The connection between the Android client and the App Engine mobile backend is done using Google Cloud Endpoints (GCE). GCE enables generation of application program interfaces (APIs) and client libraries from the

backend, thereby simplifying client access to data from other applications (in this case, Google Cloud SQL) [4]. GCE also enables the extension of the same API to iOS and web, thereby providing the flexibility to easily expand to other platforms in the future (as seen in Figure 21). Multiple Google APIs, like Google Maps API and Google Places API, have been used to implement the features of this application. These have been discussed in detail in the coming sections.
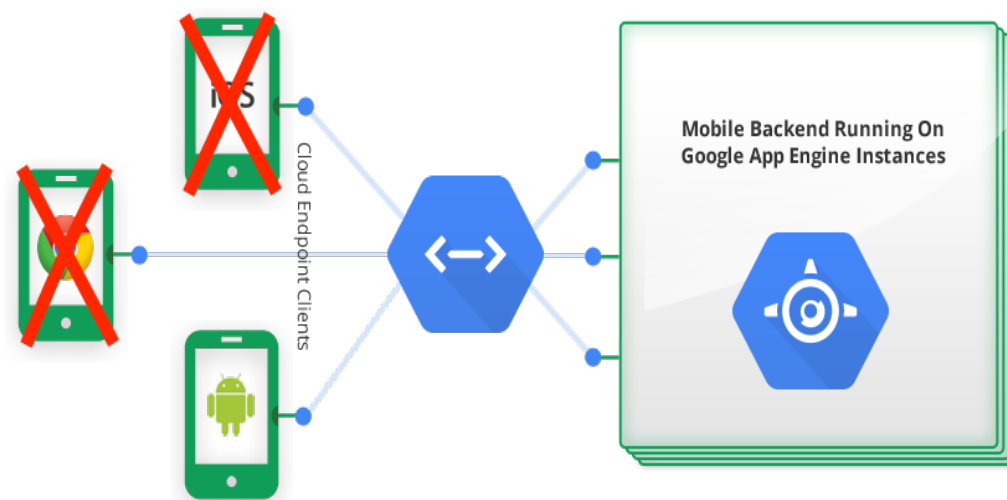
Figure 21: System Design Overview [4]

The Application has been built on the Android Studio platform. It contains nearly 42000 lines of code, not including auto-generated libraries, comments and blank lines. These include ~10,000 lines of Java and (for Android client and GAE backend) and ~32,000 lines of XML (for user interface and string values). The Google Cloud SQL has 3 SQL tables. The entire source code of the application can be viewed here - https://github.com/aakanshaparmar/BlackBoxSystem.

5.3.1 Android Client

The Android Client primarily consists of application screens, called activities, which are discussed in sections 5.1 and 5.2. Each activity consists of three components –

- A layout XML file, which describes the layout of each activity along with the elements (like buttons, textviews etc) placed on it.

- A menu XML file, which describes the buttons, text and other elements on the top menu bar of each activity.

- A Java file that basically describes how the activity behaves and also connects it to the backend when required.

In addition to the aforementioned files, there is also a strings.xml file, which stores all the textual information that is displayed on the screen. Each constant string used in the application is stored in the following format –

<string name="chooseRole">Choose Your Role</string>

The above line of code means that the text "Choose Your Role" is identified across the application using the key "chooseRole". This key is then used in different XML files in the following format –

<TextView

android:layout_width="wrap_content"

android:layout_height="wrap_content"

android:text="@string/chooseRole"

android:id="@+id/role"

android:textSize="35dp"

android:layout_centerVertical="true"

android:layout_centerHorizontal="true" />

When the above piece of code is executed, the "chooseRole" key is replaced by the value attached to it i.e. "Choose Your Role". This facilitates easily using and changing the same text in multiple places across the application. It also allows for conveniently adding more languages, which is a future goal of this particular application. The same string can be stored with the same key in a different language (like Hindi) in the following format –

<string name="chooseRole"> अपनी भूमिका का चयन करें </string>

The application will then automatically change its language depending on the device's language specifications.

There is also the AndroidManifest.xml file which contains all information necessary to run the application like package name, list of all activities, permissions required etc. Finally, the mipmap and drawable directories in the Android Client store all icons and images used in the application. Each icon is stored with five resolutions i.e. mdpi, hdpi, xhdpi, xxhdpi and xxxhdpi, where dpi stands for dots per inch. The lowest resolution is mdpi and highest is xxxhdpi. This ensures that different Android devices can display images and icons with ideal resolutions, depending on their specifications.

5.3.2 Google App Engine Backend and Google Cloud Endpoints

As mentioned previously, the backend of the application is implemented using Google App Engine. Google App Engine is a platform as a service (PaaS) model, which provides a secure environment to conveniently deploy web as well as mobile applications. It allows automatic scaling based on the incoming traffic as well as traffic splitting, which means that requests for an application are split across multiple servers depending on traffic [5].

It has multiple language options for the App Engine environment and for the purpose of this project the standard Java environment is being used. The App Engine has a free quota of 1 GB daily for incoming and outgoing traffic, which is adequate for the current scale of the application.

Google Cloud Endpoints (GCE) is a feature of Google App Engine that allows the application to easily connect to the App Engine. It creates an API for the backend that can be used by the Android Client.

Consider the case of elderly registration, where input entered by the user must be saved in the database hosted on Google App Engine using GCE. It is done in the following way -

- First an entity class is created with all the relevant fields as private member variables. The class also has public getter and setter functions, to obtain and set the values of each field. The entity class for elderly registration is called "ElderlyRegistration" and is defined as –

    public class ElderlyRegistration {

```
        private String fullName;

        private String phoneNo;

        private String eID;

        private int commonPass;

        ...

        public String getFullName() {       return fullName;    }

        public String getPhoneNo() {       return phoneNo;    }

        ...

        public void setFullName(String name){  fullName = name;}

        public void setPhoneNo(String num) {    phoneNo = num;  }

    }
```

- Once the entity class is created, a backend API can be generated by right clicking on the Entity class in Android Studio and selecting "Generate Cloud Endpoint from Java Class".

- Once this backend API gets generated it creates a RESTful service (Representational State Transfer) which enables using HTTP to perform basic CRUD (Create-Read-Update-Delete) operations on the data in the Google App Engine [6].

- An AsyncTask (asynchronous task) is then created in the Android client that connects to the backend API asynchronously. This allows performing background operations and publishing results on the UI thread as it continues to run separately. Once the connection is made, the Android client can perform the CRUD operations.

GCE is completely platform agnostic. Hence, in the future if the application is expanded to other platforms like iOS and web, the same entity classes and APIs created for this Android application can be used by other platforms to connect to Google App Engine as well. This project in total has three entity classes –

- "ElderlyRegistration" to save personal particulars of the elderly into the database.

- "FamilyRegistration" to save personal particulars of the family members into the database as well as to authenticate them

- "ElderlyLocationInfo" to save the location of the elderly into the database as well as to retrieve it and display it to the family members.

5.3.3 Google Cloud SQL

The database for the application is built using MySQL and is hosted on Google's Cloud via Google Cloud SQL. The SQL instance is called "blackboxsystemsqlinstance" and runs on the lowest tier i.e. D0. The D0 tier provides a RAM of 0.125 GB with a maximum storage of 500 GB. The pricing plan is usage based. The relational database is called "bbsystemDB" and it contains the following SQL tables –

- *elderlyInfo* table, used to store the personal particulars of the elderly. It contains the following columns – *fullName, phoneNo, address, eID, commonPass* and *emergencyPhoneNo*. The *eID* column is the primary key of this table and represents a unique id number used to identify each elderly user. The *eID* is generated by concatenating the letter 'e' (representing the elderly) with the elderly's phone number. For example if Lynda's phone number is

123456, then her eID will be "e123456". The *commonPass* column is the common password that is used to authenticate all family members of an elderly before they can view the elderly's location.

- *familyInfo* table used to store the personal particulars of the family members of the elderly. It consists of the following columns - *fullName, phoneNo, address, eID, emailID, fID* and *commonPass*. In the above table *fID* is the primary key and is used to uniquely identify each family member of the elderly. It is generated by concatenating the *eID* of the respective elderly with the letter "f" and the family member's phone number. For example the fID of Lynda's son Tony, whose phone number is 654321, will be "e123456f654321". *eID* in this table will be a reference key which references *elderlyInfo's* column with the same name.

- *elderlyLocInfo* table is used to store the location of the elderly which can be accessed by the family members. It contains the following columns – *latitude, longitude, locID, eID and locDate*. Here *locID* is the primary key and is generated by concatenating the *eID* of the elderly with the date and time at which it was stored. *eID* is the reference key which references *elderlyInfo's* column with the same name. *locDate* is a date type column which stores the date and time at which the location was stored. For each elderly user only the ten latest locations are stored, rest are all deleted.

5.3.4 Google Play Services

Google Play Services contains client libraries that allow access to services that Google provides through APIs. This application uses a few such APIs provided by

Google like Google Maps API and Google Directions API.
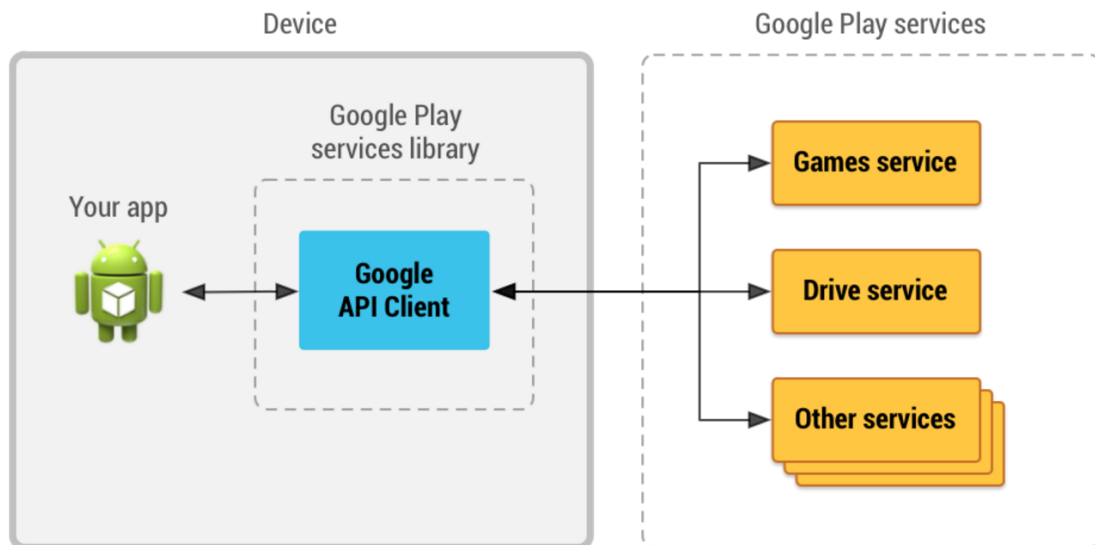
**Figure 22: Way to connect Android Application to Google Play Services
using Google API Client [7]**

Before using the APIs, proper authentication must be obtained. To do this the
application must be registered with Google. Google then provides an Android and a
Server key that must be included in the AndroidManifest.xml file that was discussed
in section 5.3.1. To use the APIs a Google API Client must be declared in the Android
Client, in the following manner –

mGoogleApiClient = new GoogleApiClient.Builder(this)

.addConnectionCallbacks(this)

.addOnConnectionFailedListener(this)

.addApi(LocationServices.API)

.addApi(AppIndex.API)

.build();

The Google API Client then provides an interface to connect to and interact with different Google Play Services (Figure 22). Multiple APIs can be added to the Google API Client using the ".addApi( )" function. The following sections describe in detail the different APIs of Google Play Services that have been used in this application.

5.3.4.1 Google Maps Android API and Google Maps Geocoding API

A lot of screens of this application involve displaying maps. A map is displayed when Lynda attempts to view the directions to her home, to the closest hospital and the closest police station. It is also displayed when Lynda's son Tony opens the application to view his mother's last known location.

The Google Maps API automatically handles access to Google Maps servers, data downloading, map display, and response to map gestures [8]. A basic map gets displayed in the Android client by introducing the following code into the respective XML files –

> *<fragment*
>
> *android:id="@+id/map"*
>
> *android:layout_width="wrap_content"*
>
> *android:layout_height="wrap_content"*
>
> *class="com.google.android.gms.maps.SupportMapFragment"/>*

On top of this basic map, one can then add markers, polylines etc. depending on the

application's requirements (Discussed in future sections).

When Lynda registers for the application, she enters her address. Her address is displayed on the map when she is seeing the directions to her home. However the address she entered is in words, and it needs to be converted into geographical coordinates (latitude and longitude) so that it can be displayed on the map. This conversion from textual address to latitude-longitude (lat-long) form is done using the Google Maps Geocoding API. Suppose Lynda's Address is The University of Hong Kong. To convert this address into lat-long form, an HTTP Request is sent using the URL –

http://maps.google.com/maps/api/geocode/json?address=The University of Hong Kong&sensor=false

The above URL returns a JSON object, with all possible results matching the above address. The JSON object looks similar to the one displayed below.

{   "results" : [

*   {*

*   "address_components" : [*

*   {*

*   "long_name" : "University of Hong Kong - Loke Yew Hall",*

*   …*

*   "formatted_address" : "The University of Hong Kong Main Building, Pok Fu Lam Rd, Lung Fu Shan, Hong Kong",*

"geometry" : {

"bounds" : {

"northeast" : {

"lat" : 22.284384,

"lng" :114.138246   }

The JSON object received is then parsed to retrieve the latitude and longitude values, which are referred to as "lat" and "lng" under "geometry". This latitude and longitude value is then added as a marker to the map that, as mentioned previously, has already been displayed using Google Maps API. It must be noted that this entire process is carried out as an asynchronous task i.e. it runs on a background thread and its results are then displayed on the main UI thread.

5.3.4.2 Google Maps Directions API

The application displays directions in the three following features –

- Displaying directions from the elderly's current location to their home.

- Displaying closest hospitals and the directions to the closest of them all.

- Displaying closest police stations and the directions to the closest of them all.

To display the directions between two points and HTTP request is created. The URL for the HTTP request is can be as follows-

https://maps.googleapis.com/maps/api/directions/json?origin=22.284384,114.1382&

destination=22.279187,114.128739&sensore=false&mode=walking&key=API_KEY

The above URL allows setting the origin, destination as well as mode of transport. In

this application the mode of transport has been set to walking. The HTTP request returns a JSON object with a set of geographical points known as waypoints that lie in between the origin and destination. Once the JSON object is received, PathJSONParser.java file parses through the JSON object and extracts the waypoints between the origin and destination. These waypoints are then used to create a polyline. A polyline refers to a line segment on a map that can be built with an array of lat-long values. This polyline is finally displayed on the map, that was generated using Google Maps API and represents the route from the origin to destination.

5.3.4.3 Google Places API

Google Places API is used in the application to display the closest hospitals and police stations. Like previously mentioned APIs, this API too retrieves information using an HTTP request with a URL of the form –

https://maps.googleapis.com/maps/api/place/nearbysearch/json?location=22.279187 0,114.1287390&radius=1000&type=hospital&key=API_KEY

This application only retrieves hospitals and police stations in the 1000 metres radius. The URL returns a JSON object with a list of hospitals or police stations in the 1000 metres radius. PlaceJSONParser.java then parses through the JSON object to retrieve the lat-long values of these places. Once the lat-long values are obtained, these hospitals or police stations are displayed as markers, on the map that has been displayed on the screen. A marker is essentially an icon used to represent a place on a map.

5.3.4.4 Receiving Location Updates

A fused location provider API is used to obtain the current location of the elderly. This API automatically provides the most accurate location either from the mobile network or the phone's GPS, whichever is best suited for the phone's hardware. The fused location provider API is also able to update the location after a specific time interval or on location change. In this application the location is updated every ten minutes. Once the Google API Client (section 5.3.4) has been declared, a new location request is created. The time interval for updates and level of accuracy is also specified. Once the connection is made, the Android Client asynchronously requests for the location of the user every ten minutes. The location is received in the lat-long form and is then stored in the database using Google Cloud Endpoints (sections 5.3.2).

5.3.5 Background Application

The location saving feature (section 5.1.7) of the application is a long running process that does not interact with the user interface of the application. For this reason it is implemented as a Service. A Service is an application component that can perform long-running operations in the background and does not provide a user interface [9]. This component continues to run even if the user switches to another application. As a result the application doesn't need to stay on all the time, thus reducing the phone's battery consumption.

5.4 Technical Decisions Made

The process of application development involved taking a number of important decisions on a large number of issues ranging from UI designs to which server to use.

The rationale behind some major decisions made during this project have been explained in the following sections.

5.4.1 Choice of Mobile Platform

As mentioned previously this application has been built for Android. This is because it is the most popular smartphone operating system today, with nearly 78% share of all users globally (as per 2014 records in Business Insider) [10]. In addition, its open source nature has allowed for many companies to release cheap Android phones that are affordable by majority of the population, irrespective of their economic background. In many countries including India one can buy an Android phone for as low as HK$195 (as seen on Indian e-commerce websites). Therefore, using Android will ensure maximum user reachability. This is vital to ensure that anyone who needs the application can use it, irrespective of their financial background.

The application will also be built adaptable to maximum possible Android versions. This is in line with the project's maximum user reachability principle. Currently, the proposed minimum supported Android version is 4.0 (Ice cream Sandwich), API level 14. This is because, all versions below 4.0 are known to have a low market share of 0.4% or less individually [11]. In the future however, if it is possible to use lower API levels to support the application efficiently, without much need for, lowering the API level will also be considered.

5.4.2 Using Google App Engine

For the mobile backend of the Blackbox System, two options were considered

- Amazon Web Services (AWS) Mobile Services, the AWS SDK for Android, which is an open- source development kit, distributed under an Apache Open Source license. It is based on the Backend as a Service (BaaS) model that allows the developer to access Amazon's extensive cloud infrastructure and hence has a much higher level of abstraction [12].

- GAE, which is a PaaS model that provides access to Google's cloud and infrastructure.

The main reasons behind choosing GAE was that it means lesser abstraction than AWS and also because it provides the Google Cloud Endpoints feature which helps create a platform agnostic backend code (discussed in section 5.3.2).

5.4.3 User Interface Decisions

As mentioned previously, this application has been built for the elderly. Therefore, while designing the user interface of the application the following decisions were made to ensure maximum ease of use by the elderly –

- While accepting inputs there would be only one text field per screen and the keyboard would automatically be displayed. (For example in the sign up process). This would make the process seem longer and more tiresome, however, it would make it much easier to use for someone who is not very well acquainted with smartphones.

- Any textual information in the application would be as big as possible. This was done to ensure that senior citizens with weaker eyesight would not find it difficult to read information displayed in the application.

- The colours in the application have been made very basic i.e. currently it is a black and grey colour scheme and in the future it will be a white and blue colour scheme. Also, any fancy UI designs like swiping pages, sidebars etc. have been avoided. While this might slightly reduce the aesthetic value of the application, it will definitely make it more user friendly for the elderly because as mentioned in section 4.2.1, the elderly find bright colours and complicated UIs confusing and difficult to use.

5.4.4 Introducing Turn-By-Turn Navigation

The application has a feature that displays the shortest route from the elderly's current location to their home on a map (section 5.1.3.1). However, during the development process a decision was made to add another option, which was turn-by-turn navigation. Turn-by-turn navigation basically means supplementing the directions on the map with audio or textual instructions or both. It was realized that this feature could be extremely helpful for some elderly who might find it difficult to follow the map on the phone. However, one problem faced was that Google does not allow adding turn-by-turn navigation to any third party application (like the Blackbox System), due to possible copyright infringement. There is also no other library, which can provide equally accurate information as Google. Therefore, it was decided that to provide the turn-by-turn navigation feature, the official Google Maps Android Application would be launched from the Blackbox System application with all the data automatically entered (section 5.1.3.2).

5.4.5 Multi Language Support.

The customer focus group (section 4.3) discovered that the elderly are most comfortable using an application in their local language. Therefore for this reason, allowing multi language support on the application has been extremely important. While no other language was actually implemented due to paucity of time, the application has been built to ensure that adding another language will be easy.

No textual information in the application has been hard coded. All of them have been stored in the form of key-value pairs, where referencing the key will return the actual text to be displayed. As a result when new languages like Chinese or Hindi are added, one can just add one more value for the text to the same key. Thus if the phone's default language is Hindi then while displaying any text in the application it will extract the Hindi value from the key instead of the English value (Example given in section 5.3.1).

6. Difficulties Encountered

During the application development process the following difficulties were encountered –

- **Deciding frequency at which the elderly's location will be saved**

  At the beginning of the project, it was decided that the frequency of location saving will be based on the user's speed. However, during the online research and customer focus group, it was revealed that the elderly have relatively older phones. These phones may not be able to recognise the movement of the user and hence may not be able to support this feature. Therefore, instead of basing the frequency off the user's speed, a fixed frequency of ten minutes was decided upon.

- **Ensuring efficiency**

An important aspect of this application is the need for efficiency. The application is a background application i.e. it will be running continuously on the phone to save the location of the elderly. Such an application can immensely drain a phone's battery and increase its data usage. While newer phones might still function normally despite the load on their battery, the performance of older phones may definitely suffer. In the customer focus group conducted as part of this project, it was seen that most senior citizens have older phones, thus this definitely became an important consideration. Too much data usage could also be extremely costly for the user. As discussed in the previous point, there was also the problem that the frequency of saving the location could not be varied with the speed of the user (which would have been the ideal situation). Therefore, to optimize battery and data usage the frequency for saving the location was made ten minutes, which isn't so frequent that it majorly impacts the battery and neither is it so less that it reduces the accuracy of the location saving and viewing feature.

- **Ensuring security**

The last and possibly most important difficulty faced was ensuring maximum security. GPS tracking has always been under scrutiny for creating a huge security and privacy risk. A person's location and movement details are private and must not get misused. There is also a lot personal information about the elderly that is stored on the application. Thus, it needed to be ensured that these pieces of information would remain secure both in the

application as well as in the database. Google Cloud SQL automatically encrypts all data in the databases, thus adding a very strong layer of security. On the application side, the elderly's location and well as personal information were all password protected by a random combination of numbers that would be provided upon registration (Detailed explanation available in section 5.1.1). A family member is not even allowed to register for the application unless and until he enters the password, which can authenticate his identity.

7. Future Work

While a lot of progress has been made this academic year, there are some features that must be added to the application in the future to make is more comprehensive and useful to senior citizens with memory problems. These features include-

- Making the application available in multiple languages.

- Adding an extra layer of security to the verification process used while viewing the elderly's personal information (section 5.1.6). This can be in the form of having to take a picture and sending it to the family member before placing the SOS call. This can assist the family member in visually verifying the person attempting to view the elderly's personal information, thus further increasing the security of the application.

- For patients with severe memory problems, the application should be able to raise an alert if they stray too much from a pre-defined path. While this is an extremely restrictive feature, it can be essential for people with early stage dementia who do go out alone.

8. Conclusion

Diseases like Alzheimer's pose a very real threat to the safety of senior citizens in our society. The Blackbox System is an attempt to use ever-growing technology to increase their safety.

The application routinely stores the location of the elderly into a database. This location can then be used by the elderly's family to locate them. There are also additional features that can help the elderly reach home safely in case they do get lost alone. The Blackbox System is an important step in the direction of providing safety to the elderly without making them feel handicapped in anyway and in ensuring their independence.

The application has been developed keeping the target user's requirements and preferences in mind. It will have multi language support and can run on relatively older Android smartphones as well. The application's user interface design is also optimized for use by the elderly, who might not be very familiar with smartphone technology. All these features have been developed after extensive online research and a customer focus group held on 24th October 2015.

While majority of the application has been developed this past academic year, there are still some features that should be added in the future to ensure even greater safety for the elderly. The response from the potential users of the application has been overwhelmingly positive as they too realize the importance of having such a tool that can ensure their safety on the go.

Works Cited

[1] World Health Organization. Mental health and older adults (2015).

http://www.who.int/mediacentre/factsheets/fs381/en/. Retrieved on 14th April 2016.

[2] World Health Organization. 10 Facts On Dementia (2015).

http://www.who.int/features/factfiles/dementia/dementia_facts/en/. Retrieved on 14th

April 2016.

[3] The Government Of Hong Kong. How to handle the problem of getting lost in

elders with dementia? (2015).

http://www.info.gov.hk/elderly/english/health_elderly/eng/lost_in_elders_with_deme

ntia.htm. Retrieved on 14th Apr

il 2016.

[4] Google Cloud Endpoints Overview (2015).

https://cloud.google.com/appengine/docs/java/endpoints/. Retrieved on 15th April

2016.

[5] Google App Engine Docs (2016)

 https://cloud.google.com/appengine/docs. Retrieved on 15th April 2016.

[6] Cloud Endpoints (2016).

https://cloud.google.com/endpoints/. Retrieved on 16th April 2016.

[7] Accessing Google APIs (2016).

https://developers.google.com/android/guides/api-client. Retrieved on 16th April 2016.

[8] Introduction to the Google Maps Android API (2016).

https://developers.google.com/maps/documentation/android-api/intro. Retrieved on 16th April 2016.

[9] Services (2016). http://developer.android.com/guide/components/services.html. Retrieved on 16th April 2016.

[10] Jim Edwards, Business Insider. The iPhone 6 Had Better Be Amazing And Cheap, Because Apple Is Losing The War To Android (2014). http://www.businessinsider.com/iphone-v-android-market-share-2014-5. Retrieved on 16th April 2016.

[11] Vaughn Highfield. What's the most popular version of Android? (2015). http://www.alphr.com/smartphones/1000324/whats-the-most-popular-version-of-android. Retrieved on 16th April 2016.
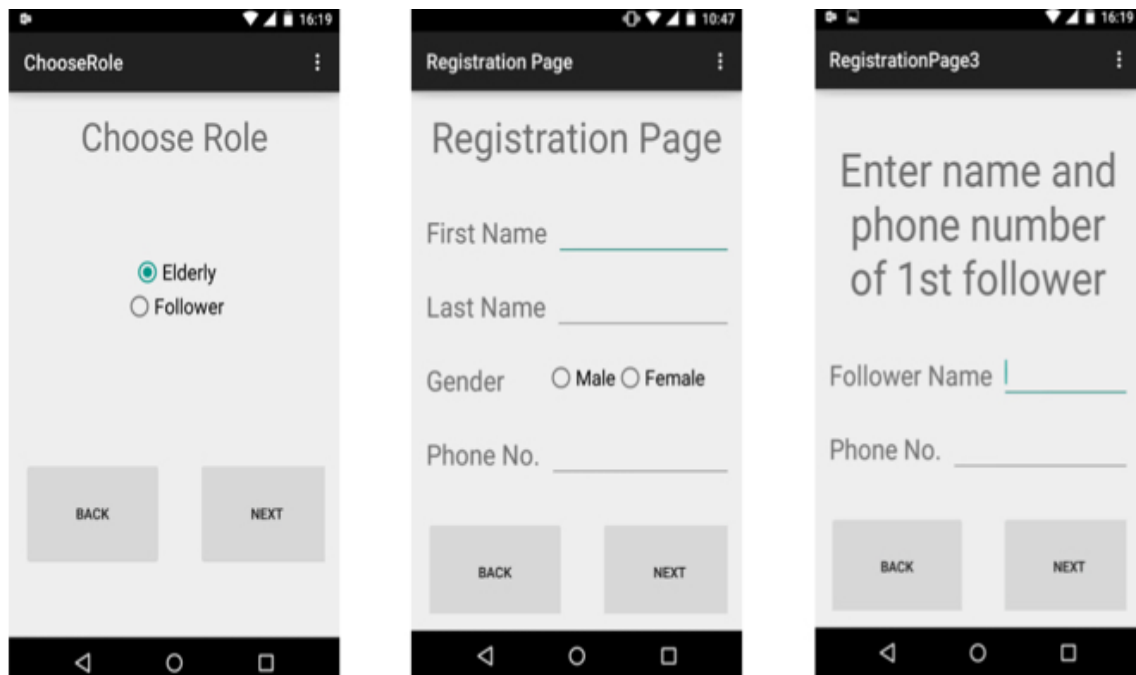
[12] AWS Mobile SDK for Android (2015). http://docs.aws.amazon.com/mobile/sdkforandroid/developerguide/. Retrieved on 17th April 2016.

Appendix

1. Complete List of Customer Focus Group Questions

• Which phone do you use?

• If Android, which one is it ?

• Are you comfortable typing out text on the phone?

• What do you think about applicatios like WhatsApp (The major app all of them used)

• Would you like it if applications you used had voice/text instructions?

• Are you comfortable having passwords?

• Are you using any application to ensure your safety when you go out?

• What do you think about an application like the Blackbox system?

2. App Screens Shown During Customer focus Group

3. Pictures from Customer focus Group

3. Pictures from Customer focus Group