A Mobile Application for Preventing Telephone Deception

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1. Abstract

The pecuniary loss of telephone deception has been rising since 2014. Thus, this project is to develop an Android app with a view to safeguarding Hong Kong people's assets. Regarding features, it executes call screening by querying the Firebase Realtime Database and web-scraping JunkCall HK. Then, it displays the caller information before users accept the call. Moreover, it analyzes phone conservation through real-time speech-to-text. It also provides a simplified UI for the elderly. Several challenges are identified, such as privacy and lacking database record. This project is currently on track. UI for normal users, Firebase Realtime Database setup, news display, phone number query and report are completed. Research on UI for the elderly has been conducted. The phototype of web scraper was built and tested. The next phrase will be phone call screening and UI for the elderly.
2. Acknowledgement

I would like to express my deepest appreciation to Dr. T.W. Chim for supervising my final year project and providing lots of guidance.
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<tr>
<td>API</td>
<td>Application Programming Interface</td>
</tr>
<tr>
<td>IDE</td>
<td>Integrated Development Environment</td>
</tr>
<tr>
<td>MVVM</td>
<td>Model – View – View Model</td>
</tr>
<tr>
<td>UI</td>
<td>User Interface</td>
</tr>
<tr>
<td>UX</td>
<td>User Experience</td>
</tr>
</tbody>
</table>
1. Introduction

1.1. Background

1.1.1 Types of Telephone deception in Hong Kong

In general, scammers fabricate reasons and identities to defraud victims’ money and personal information. The two major types of phone frauds in Hong Kong are “Pretend Officials” and “Guess Who” [1]. In the first case, scammers claim to work for the government and accuse victims of a crime [2]. For instance, they impersonate Mainland public security officers and deceive victims into providing crucial personal information to prove innocence, such as bank account details [2]. In the second case, the scammer asks the victim to guess his/her identity [3]. If the victims reply with a name, the scammer will impersonate and state they had committed crimes in Mainland China [3]. Lastly, they deceive victims into transferring money to them [3].

1.1.2 Current Situation of Telephone Deception in Hong Kong

In figure 1.1, the number of telephone deception was 152, which increased by around 1.6 times. The monetary loss was 41.29 million HKD, which increased by roughly HK$ 6 million. In comparison with other types of frauds, the monetary loss of telephone deception is second-to-last. However, the number of cases is the second highest. By observing the past eight years, the problem of telephone deception is more apparent to the eye.

Figure 1.1 Year-to-year comparison in topical scams' figures in Hong Kong [4]

The x-axis and y-axis represent the number of cases and types of frauds respectively. This graph displays the number of cases and monetary loss difference of each fraud between June 2021 and June 2022. The dark grey and light grey bar represent the number of cases and monetary loss in June 2021 respectively. The blue and red bar represent the number of cases and monetary loss in June 2022 respectively.
The number of cases has fluctuated during the past eight years (see figure 1.2). Although it is decreasing overall, the pecuniary loss has escalated sharply since 2018 and reached 810 million HKD (see figure 1.3). Thus, telephone deception is still a pressing problem in Hong Kong.

Figure 1.2 The number of telephone deception in Hong Kong [5-12]
The x-axis and y-axis represent the number of cases and year respectively. This graph display how the number of telephone deception in Hong Kong changed from 2014 to 2021.

Figure 1.3 The pecuniary loss of telephone deception in Hong Kong [5-12]
The x-axis and y-axis represent the number of cases and year respectively. This graph display how the pecuniary loss of telephone deception in Hong Kong changed from 2014 to 2021.
1.1.3 Existing Mobile App

The top three phone call filter apps are Call Defender (小熊來電), Headuck Call Blocker (小鴨幹線) and Jima Caller ID (芝麻來電) in Hong Kong [13]. They have more than four pages and each page contains different components. Consequently, it requires a longer time to be familiar with apps, which is problematic for the elderly. Furthermore, Call Defender has advertisements, which can worsen the user experience. They also lack conversation analysis and a monitoring feature.

1.2. Project Overview

This project is to develop an Android app (Call Guardian) with a view to safeguarding Hong Kong people asset and ameliorating existing apps. This app has four major features. First, it executes call screening on unknown phone numbers by querying Firebase Realtime Database or JunkCall HK. The app will further send an SMS message to notify user trusted person(s). Second, it analyzes phone conservation through speech-to-text mechanism and detects any suspicious wordings. Third, it displays the latest news about phone frauds. Fourth, there are two apps with different UI for normal and elderly users respectively.

1.3. Objectives

The objectives of this project:

- To raise users’ alertness when receiving an unknown phone call
- To simplify phone number information checking
- To protect users who are vulnerable to phone scams, such as the elderly
- To educate users what to do when receiving an unknown phone call
- To provide latest news about telephone deception, such as the content and type
- To provide a simple and straightforward UI for users

1.4. Report Outline

This report has five remaining chapters. Chapter 2 explains approaches and designs for implementing this app. Chapter 3 reports current progress of the app. Chapter 4 discusses encountered challenges or difficulty. Chapter 5 outlines the future plan. Chapter 6 summarizes this interim report.
2. **Methodology**

This chapter explains the implementation of Call Guardian, such as IDE, UI and database. In addition, it discusses the reasons for choosing specific techniques or approaches.

2.1. **IDE and Language**

Android Studio is used for the app development, which is the official IDE for Android development. Kotlin is used for the frontend development. In comparison with Java, it is more modern and recommended by Google [14]. Furthermore, Kotlin coroutine is good for managing and executing long-running tasks, such as web scraping [14]. XML is used for building the UI.

2.2. **App Architecture**

MVVM is adopted for this app. Model holds the app data. View is the app UI. View model acts as a bridge between view and model to transform data from model and expose it to view [15]. Then, views can observe those data and update UI elements if there are changes. This separation enhances the app’s understandability, extensibility and testability.

![Figure 2.1 App Architecture Diagram](image)

The UI layer is responsible for displaying data on the screen. View model holds those data and provides it to the UI. Those data come from the data layer. Repository manages the read and write operation of data from Firebase Realtime Database and web scraping from JunkCall HK. Then, it exposes data to UI layer.
2.3. UI and UX

Figma is used for UI design, which is a free web application for designing app UI and UX [16]. This app has three main fragments, namely News, Query and Report. Bottom navigation bars are implemented for navigating between them (see figure 2.2). Each destination (fragment) is represented by an icon and a text label, which help users find their desired destination quickly. It is also ergonomic, because users can easily press the destination with their thumbs when holding the phone.

![Figure 2.2 Bottom Navigation Bar](image)
It contains three destinations – 最新資訊 (news), 查詢 (query) and 舉報 (report). Current destination is purple.

Besides, there are two more fragments, namely Article and DisplayReport. The top app bar’s back button and navigation bar let users navigate back to the previous fragment. The top app bar displays the current fragment name as title. Moreover, it provides relevant functions based on the current fragment (see figure 2.3).

![Figure 2.3 Top App Bar](image)
This is the top app bar of Article fragment, which has a back button, a title (文章), open in browser, share and save button.

In elderly mode, font size and UI components are bigger to cater for the elderly weakened vision. Font size is at least 16 px [17, 18]. The line spacing is 1.5 [19]. Furthermore, the color contrast between text and background is no less than 4.5:1 [19]. Apart from text, clickable components are at least 11 mm diagonally long and 2 mm aways of other components [20].
2.4. Web Scraping

Skrape{it} is used for web scraping and data parsing, which is a Kotlin-based web scraping library [21]. The HKJunkCall database is no longer open to the public. Therefore, web scraping is chosen for retrieving phone number information. JunkCall HK is simpler than the HKJunkCall webpage in terms of structure and number of elements. Hence, it reduces web scraping time cost. Since Firebase Realtime Database lacks records, the app relies on JunkCall HK for obtaining information about phone numbers.

https://www.junk-call.com/hk/{phone_no}

2.5. Phone Call Screening

It is a real-time mechanism which displays the caller information before accepting the call [22]. When a user receives an unknown phone call, this app will conduct caller identification by querying the database and JunkCall HK with the given phone number. Next, it will display the caller information. However, this app relies on JunkCall HK as mentioned in 2.3. Internet connection is required to do the call screening.

2.6. Phone Conversation Analysis

After the speech-to-text conversion, this app will identify any suspicious keywords, such as claiming to be a government officer. It will warn users if it is suspicious. One possible method is Speech Recognizer, which enables the app access to the Android built-in speech recognition service [23]. Another approach is conversation recording and transcription. Google speech-to-text API transcribes mp3 files and returns a text file back to the app [24]. The first method is free and already available on Android devices. Furthermore, it can be executed without the Internet connection if users downloaded the offline speech recognition package. Hence, the first method is better.
2.7. Backend and database

The Firebase Realtime Database is used for storing users' reports and news about telephone deception. It is a cloud database and stores data as JSON [25]. Furthermore, data is synchronized in real time, which means users automatically receive new phone number reports and news [25]. News is input by the developer, while reports are input by users or developers. There are two paths for reading and writing data: news and report.

There are two entity sets, news and report. Figure 2.4 illustrates attributes of news and report respectively. All attributes are string except for timestamp being long. Firebase Realtime Database only supports string, long, double, Boolean, map and list, so datetime object cannot be used. Although time can be saved as string, records cannot be sorted chronologically by using orderByChild(). Therefore, timestamp is chosen for storing datetime, which counts the number of seconds that have elapsed since 00:00:00 UTC on 1 January 1970.

![Figure 2.4 Entity Diagram](image)

The primary keys of news and report are id and phone_no respectively. All attributes are string except for timestamp being long.
3. Progress

This chapter outlines completed parts of the app. It introduces UI and functions of News, Query, Report, Article and DisplayReport fragments in chapter 3.1 to 3.5 respectively.

3.1. News Fragment

This fragment displays a list of news, which is fetched from the Firebase Realtime Database (see figure 3.1). The onDataChange() function in ValueEventListener will be triggered if data is changed at news. Each news article can be saved or shared through various social apps, such as WhatsApp, Instagram, Gmail etc. The save feature has not been completed yet.

![Figure 3.1 News Fragment](image)
3.2. Query Fragment

This fragment has a text field for reading phone numbers (see figure 3.2). It is set to read phone numbers only, so it can reduce typing errors and simplify data validation. After the button is clicked, the app will navigate to DisplayReport fragment. It will first search record in the Firebase Realtime Database. If there is no record, it will get record from JunkCall HK by web scraping.

![Query Fragment](image)

Figure 3.2 Query Fragment
3.3. Report Fragment

This fragment has four text fields for reading phone number, type, caller and description (see figure 3.3). Type is predefined: 不明來電 (unknown call), 財務借貸 (loan), 推銷 (sell), 詐騙 (scam) and 滋擾 (nuisance). Users choose one of them from the dropdown menu. Description has a word limit of 100. All fields are mandatory except for caller. If the required text fields are not completed, errors will pop up to remind users.

Figure 3.3 Report Fragment
3.4. Article Fragment

This fragment displays the content of a news article, namely title, data, image, fraud description and advice for handling it (see figure 3.4). The top app bar provides three different actions on the right side: open in browser, save and share. It also has a navigate back button on the left side for returning to News fragment.

Figure 3.4 Article Fragment
3.5. Display Report Fragment

This fragment displays reports of the phone number queried in Query fragment (see figure 3.5). Each report contains type, date, caller and description. The top app bar provides an open in browser action for visiting the JunkCall HK page of that phone number. It also provides a navigate back button on the left side for returning to Query fragment.

![Image of report display fragment](image_url)

Figure 3.5 Report Display Fragment
4. Challenges

The feasibility of running Speech Recognizer in the background during phone conversation is still under testing. It is uncertain whether it can read callee’s and caller’s speech during phone conversation. The current solutions are studying official documents about Speech Recognizer and discussing with experienced developers in online platforms. If it is indeed unfeasible, alternatives will be used, such as Google Speech-to-Text API.

Besides, the Firebase Realtime database lacks phone number reports. Call screening and phone number query will primarily rely on web-scraping JunkCall HK, which requires Internet connection. One solution is automatically updating the database when the app accesses JunkCall HK. When a user checks a report of a phone number from JunkCall HK, the app will automatically upload it to the database. The database will store it if it does not exist. In the long term, the database will rely less on JunkCall HK. Phone number query and call screening can be executed without Internet Connection, since Firebase Realtime Database supports offline caching.

5. Future Plan

Table 7.2 in appendices illustrates the project schedule. The next major tasks will be call screening and UI for the elderly users. Web scraping will be implemented to support call screening and act as a second source of phone number report. After that, an SMS warning function and a setting page will be implemented. Finally, conversation analysis will be implemented. If Speech Recognizer is not feasible, other approaches will be used. App features will be completed in March. Then, testing, debug and optimization will be conducted. Last but not least, deliverable of phrase 3 will be prepared.
6. Conclusion

Despite the overall decline of telephone deception, it is still imperative to tackle telephone deception actively. The downsides of existing apps are complex UI and lacking conversation analysis. Therefore, this project aims to develop a better app with better UI, UX and phone conversation analysis. Regarding the current progress, this project is currently on track. UI for normal users, news display, phone number query and report were completed. Although several problems and difficulties were encountered, different solutions were planned and expected to overcome them. Therefore, the first stage of this project is satisfactory. The next major tasks will be calling screening and UI for elderly users.
7. References


# 8. Appendices

<table>
<thead>
<tr>
<th>Description</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Technically Difficulty</strong></td>
<td>Give warning instead of blocking</td>
</tr>
<tr>
<td>Distinguishing phone calls between</td>
<td>Query trusted website to get caller information</td>
</tr>
<tr>
<td>real organization and scammers.</td>
<td>Analyze conversation to determine whether it is suspicious</td>
</tr>
<tr>
<td>They may share the same phone number pattern, such as start with 3</td>
<td></td>
</tr>
<tr>
<td><strong>Technically Difficulty</strong></td>
<td>Study related documentation</td>
</tr>
<tr>
<td>Running Speech Recognizer in the</td>
<td>Find any workable solutions online</td>
</tr>
<tr>
<td>background during phone call</td>
<td>Test Speech Recognizer during phone call at the early stage</td>
</tr>
<tr>
<td><strong>Privacy Problem</strong></td>
<td>Seek consent from users when they use the app initially</td>
</tr>
<tr>
<td>Accessing sensitive data such as</td>
<td>Don’t upload any call logs and phone conversations</td>
</tr>
<tr>
<td>user phone call logs and content of</td>
<td>Allow users to enable phone conversation analysis on unknown</td>
</tr>
<tr>
<td>phone conversation</td>
<td>callers only</td>
</tr>
<tr>
<td><strong>Database Problem</strong></td>
<td>Update the database when users check phone numbers which only exist in JunkCall HK</td>
</tr>
<tr>
<td>Lacking phone number records in the</td>
<td></td>
</tr>
<tr>
<td>Firebase Realtime Database</td>
<td></td>
</tr>
</tbody>
</table>

**Table 8.1 Problem, Difficulty and Solution**

This table not only describes difficulties and problems encountered, but also includes the corresponding solutions.
<table>
<thead>
<tr>
<th>Date</th>
<th>Milestone</th>
</tr>
</thead>
</table>
| Sep 2022 | **Deliverables of Phrase 1:**  
• Detailed Project Plan  
• Project Web Page  
**Research:**  
• Strength and weakness of existing apps  
• Privacy and legal problem  
• Web scraping |
| Oct 2022 | **Research:**  
• Speech Recognizer during phone call  
• Guideline of designing UI and UX  
**Implementation:**  
• UI and UX design |
| Nov 2022 | **Research:**  
• Firebase Realtime database  
**Implementation:**  
• Database design and setup |
| Dec 2022 | **Research:**  
• Pop-up warning when received suspicious phone call  
• Background task for validating phone number  
**Implementation:**  
• Function of displaying news about telephone deception  
• Function of querying phone number report  
• Function of reporting phone number |
| Jan 2023 | **Deliverables of Phase 2:**  
• Preliminary implementation  
• Detailed interim report  
• First presentation  
**Implementation:**  
• Call screening  
• Web scraping  
• Elderly mode |
| Feb 2023 | **Implementation:**  
• Function of sending SMS to users' trusted people  
• Conversation analysis |
| Mar 2023 | **Implementation:**  
• Testing of the app  
• Debugging  
• Optimization |
| Apr 2023 | **Deliverables of Phase 3:**  
• Finalized tested implementation  
• Final report  
• Final presentation |

**Table 8.2 Project Schedule**

This table illustrates this project schedule from September 2022 to April 2023. It includes the tasks of each month, mainly research or implementation.