**Chapter 1: Introduction**

**Section 1.1 Introduction**

Wi-Fi, one of the most widely used wireless technologies, covers over 4 million households worldwide to connect laptops, smart phones and even televisions, lights, and air-conditioners with the Internet.

LTE is a wireless communication standard developed for providing high-speed data transmission for mobile phones. It's uplink speed is up to 50 megabits per second (Mbps) and downlink speed is up to 100 Mbps. The user experience of many mobile services required fast data transmission (e.g. music and video streaming), are highly improved from the development of this technology.

For Wi-Fi services providers and communication operators providing LTE services, it is necessary to understand situations of the communication channels they are providing for the customers. There are various criteria to assess the performance of a communication channel, such as signal strength, connectivity, packet delay and packet lost,etc. Specially, signal strength, the signal power in the received end , is the most related feature to assess a communication channel. With the evaluation of the existing wireless network, these companies can decide the deployment of their Wi-Fi access points and signal towers and also conduct fault detection. This process is called Wireless Site Survey. Fundamentally, a sit survey process is to test chosen criteria in a working site. However as the performance of a channel varies significantly in different locations in the environment, the geographical information must be well recorded and associated with the evaluation data in the test.

Traditionally, there are three approaches proposed for conducting a site survey. However, they are highly labor-intensive and time-consuming. As for a large outdoor environment, these two constraints would become significantly restricted. As smartphone is one of the most common and easy-to-use platforms for most people, there are many site survey mobile applications offered in the market. They are suitable for the users requiring a fast, simple and automatic site survey. However, most them are not utilizing the GPS function embedded in most of the mobile phones nowadays. There are space to introduce more automation in the process of collecting and linking the location with the test data.

In this report, a new mobile application is proposed to accelerate and smoother the wireless site survey procedures in outdoor environment for the Wi-Fi services and communication companies. Smartphones will be used as a detection unit to generate the signal strength of a Wi-Fi/ LTE transmitter. The innovation of the project is to use the GPS function in the mobile phones to generate the geographical information automatically.

**Section 1.2: Literature Review**

In order to understand the performance of existing Wi-Fi and LTE network, various solutions have been proposed and can be categorized into four main aspects: predictive survey, passive survey, active survey and site survey mobile applications. We will briefly review these four fields.

The predictive survey functions by utilizing simulation software. Firstly, users need to create a virtual model of the site containing the information of material properties, which is very time-consuming. The attenuation properties of the materials will be assigned in the software. After finishing the model, users can place the transmitters and receivers in different locations in the model. By calculation with the associated algorithm, the prediction of signal strength, coverage area of a transmitter are generated. However, the accuracy heavily depends on the similarity between the model and the real environment and it takes a lot of time to improve the model.

A passive survey is an on-site listen-only survey and functions to measure transmitters’ signal strength, channels used and noise level. In this method, an adapter used to receive signals is settled in the facility to listen to, but not connect to, the transmitters. However, to finish the whole process, 3 to 4 engineers have to work together for a long period of time. It is labor-intensive and not suitable for fault detection which is requiring fast identification of the problems.

An active survey is also an on-site survey which provides more information than the passive survey. Instead of just listening to the transmitter, in active survey, a device is connected with the transmitter and receives messages from it. In this way, the active survey can provide extra information such as connectivity, throughput, round trip time, packet delay, packet lost, retransmission and other useful metrics. When users travel through the site, they can collect the data in different spots and finally produce a heat map. Similarly, by placing the transmitter in different places, users can find the location for the most robust coverage. However, the commercial software for this test is expensive as it cost up to 2000 US dollars. Also, the geographical data such as the floor plan of the building is not generated automatically by the system but has to be loaded into the computer by the user.

Site survey mobile applications are widely provided free in android and iOS systems. By using the embedded antennas in the phone, these applications can provide passive and active surveys with tolerable errors in a relatively small area. User can perform the whole test in relatively short time However, most of the applications are just able to collect the data from one point and are not able to associate with the location where the data is connected.

It is clear to see that the three commercial testing applications can provide accurate results of the signal strength of a site. however, they are very expensive and time consuming. On the other hand, site survey mobile applications are easy to use and are provided for free, but as there is a need for the floor plan of the site, there is improvement in this section. As such, we propose a new mobile application that can map the signal strength automatically with the geographical location where the strength data is collected.

**Section 1.3: Objectives**

In this project, we will develop a mobile application to generate a signal strength heat map for a Wi-Fi/LTE channel over a region of interest. Further more, the architecture of the code is designed to be extensive in order to easily add more assessment tasks for the communication channels in the future.

**Section 2.1.1: Components List**

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| --- | --- |
| **Hardware** | **Functions** |
| LG Nexus 5  LG Nexus 4  Samsung Galaxy S4 | Testing the applications on different platforms |

Table(1) Hardware Components List

|  |  |
| --- | --- |
| **Software** | **Functions** |
| Android Studio | IDE for developing the application |
| Git Hub | Version Control and co-developing |
| Wi-Fi Analyzer | Wi-Fi Detection Accuracy Comparison |
| LTE Discovery | LTE Detection Accuracy Comparison |
| Google Map | Localization Accuracy Comparison |

Table(2) Hardware Components List

**Section 2.1.2: Budget**

|  |  |
| --- | --- |
| **Components** | **Cost (unit: HKD)** |
| LG Nexus 4 | Free, Provided by ECE department |
| LG Nexus 5 | Free, Provided by member |
| Samsung Galaxy S4 | Free, Provided by member |
| Android Studio | Free, Free Software |
| Git Hub | Free, Used the Free Features Provided |
| Wi-Fi Analyzer | Free Mobile Application |
| LTE Discovery | Free Mobile Application |
| Google Map | Free Mobile Application |

Table(3) Budget List

**Section 2.1.3: Project Description**



Figure (1) Work Flow

Figure (1) is the System Block Diagram showing the work flow of the application. When users enter the application, the LTE detection module starts detecting. The application keeps scanning the signal towers nearby in 500ms interval. Meanwhile, it creates a LTE list globally in the background and keep updating the table in each scanning. This mechanism is also applied to the Wi-Fi detection module, which creates a global static Wi-Fi list.

The Wi-Fi List Fragment and LTE List Fragment are the modules responsible for displaying the corresponding channel list. As for LTE, the LTE List Fragment displays the Physical Cell Identifier (PCI), Reference Signal Received Power (RSRP) and Arbitrary Strength Unit (ASU) Level of each signal tower. As for Wi-Fi, the Wi-Fi List Fragment will display the Service Set Identifier (SSID), Basic Service Set Identifier (BSSID) and the Received Signal Strength Indicator (RSSI) of each AP. With the gesture from the users, the Channels List Activity decides which list fragment to display. When users swipe to right, the two fragments will be exchanged interactively.

When users click on one of the items of the channels list, the channels list activity will pass the item's id with the control to the location activity. The Location Fragment will display a Google map that zoom in the user's location. With the item's id, location activity searches the information of that channel from the global static channel list. A circle plotted on the map is used to display the result.

Its location is the location of the user obtained from the GPS. Its color is decided by the signal strength of the channel on that location. When the users change his/her location, a new circle generated in the same manner. When users walk around the region of interest, the whole heat map is finished.

**Section 2.2: Project Tasks & Schedule**

|  |  |
| --- | --- |
| **Tasks** | **Schedule** |
| Build the Wi-Fi detection module | End of October 2015 |
| Build the localization module | Middle of December 2015 |
| Integrate the two module above &  Build the basic UI | Middle of January 2016 |
| Build the LTE detection module | End of February 2016 |
| Integrate the three module above | End of March 2016 |
| Improve the UI | End of April |

**Section 2.3: Technical Challenges**

The API provided by Android is NOT device independent. As reported from other developers, smart phones from Samsung are not providing the accessibility to the LTE cell information. There should be tests to find out the capable devices to run this application.

**Section 2.4: Report Outline**

There are six chapters following in this report.

In Chapter 1, we introduces the current site survey tools provided in the market and point out their features and disadvantages. We also propose our mobile application and display its working procedures.

In Chapter 2, the design of the Wi-Fi and LTE class are explained. The reasons of applying fragment to handling the detailed UI functions instead of relying directly on activity is given. We also discuss the benefit of using singleton of each channel list type. As there are several APIs providing the similar localization function, the advantages of using the Google Play Services API will be introduced.

In Chapter 3, we show the implementation details of the designs above. The related codes are shown and explained.

In Chapter 4, the application is run on three different devices. The results are verified separately.

In Chapter 5, the results of signal strength obtained from our application and another two popular site survey applications are compared to verify the detection accuracy.

In Chapter 6,