Child Detector Android Application using Bluetooth Low Energy (BLE) Beacon Technology

Steven Valentino E. Arellano, Kierven R. de Mesa, Lawrence Alexis P. Desuasido

Abstract: The Child Detector Android Application through Smartphone Using Bluetooth Low Energy (BLE) Beacon Technology was developed to prevent the child from getting lost. The researcher mainly utilized beacon and Android application in developing the system. Smartphone with installed application will detect and display the distance of the child, and it will also alert whether the child is going far from the user. The beacon is detected through smartphone's Bluetooth within 30-meter range proximity, while it is attached to the child. The objective of this study was to determine the effectiveness of the system and satisfaction level of the users. This was tested to Grade One students of one of the private schools in the Philippines were the parents, teachers, and school administrators served as respondents to the conducted survey. Obtained results indicated that the Android application were effective for child detection. Overall, this would be a new security Android application for children.

Index Terms: Android Application, Bluetooth Low Energy, Beacon

I. INTRODUCTION

Nowadays, parents wanted to secure that their children are in safe place especially those who are in kindergarten up to elementary levels. Schools are the one responsible for the security of the students while inside the campus premises. There are some instances of unexpected curiosity and enjoyment from the children exploring their surroundings and accidentally got lost outside the school premises and other places such as shopping malls, parks, and other places. However, the parents are having hard time searching and they want to find some possible solution to secure their children and prevent from getting lost when they are not around.

Most of the people now are using smartphones and tablet personal computers (PC) with the latest Android Operating System (OS) mobile applications that can be easily downloaded through Internet. Android applications were easy to set-up for coding, and which are now use as transmitter and receiver of signals from any devices particularly Bluetooth with Low Energy (BLE) devices through API (Application Program Interface) of Android OS

in performing different operations to produce an output data depending on the application or given instructions. BLE has a smart native support to develop an easy application for smartphones, beacon technology, social economy and cloud computing connectivity [1]. Beacons are low-cost devices with built-in battery that allow more precise location within a limit range depending on its signal proximity, than Wi-Fi vicinity range and GPS. The BLE serves as transmission of small amounts of data for beacons resulting of using it frequently in an enclosed site, though it can also be used for outdoor activities [2]. Likewise, the use of beacons such as Indoor Positioning System (IPS) in schools and colleges; locate people, places, and objects within particular sets of range; which is more widely used Bluetooth technology detection device today [3]. Furthermore, most of smartphones today have built-in tracker system application using GPS that detects the location of the other person's smartphone not the person itself. In some schools, students were not allowed to bring smartphones to secure their safety from thefts. The said tracker application will only be functional with the use of mobile data, and Wi-Fi connection; whereas beacon is small, and easier to attach to the person because it will detect and paired to the smartphone through its Bluetooth and it will now be functional, and the user will easily determine the distance of the person being detected. This study was purposely developed to prevent and eliminate the cases of child from getting lost in schools and other places. The system could be a support for parents, guardians, teachers, and different schools for the security of their children and students. This study could also be used as reference by the Android application and Bluetooth Smart technology developers to develop a multifunctional mobile application and devices that will be more accessible, helpful, and independent.

A. Conceptual Model

Fig. 1. The Conceptual Model of the Study.

Fig. 1 showed the conceptual model of the study, the beacon device will broadcast its Universally Unique Identifier (UUID) to detect by the smartphone when it is located in its signal proximity. The developed Android application will first check if the signal of beacon device is detected, it will automatically display a push notification to the smartphone with the said application. When the beacon device is ready to use,

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it will display where the child with beacon device is located. The application will either send a notification to the user when the beacon device is going far within the signal proximity of beacon, and it will send another notification that will alert the user when the beacon signal is being detected along its proximity. It will display the distance of the location where the beacon device is located when beacon signal is starting to detect by the smartphone.

B. Statement of the Problem

This study was developed to be used by the parents, guardians, teachers and school administrators to prevent and eliminate the cases of child from getting lost in schools and other places. This study specifically sought answers to the following problems:

1. What are the benefits of using smartphone for the parents, teachers and school administrators?
2. What is the rate of effectiveness in detecting the location of the child using the developed system?
3. What is the level of satisfaction in detecting the location of the child in using the developed system?

C. Scope and Delimitation

BLE beacon, Android OS smartp hone with Bluetooth 4.1 or above, and along with the said application was mainly utilized in the system. The lower Android versions, Android 4.1.2 to 4.3.1 (API 16 to 18) Jelly Bean version and below can run the application but with minimal changes in terms of its GUI. The user's smartphone must turn on their Bluetooth, compatible with version 4.1 or above, and the distance of the user's smartphone from the attached beacon has to be considered as delimitation of this study.

The beacon is attached to the child's ID card lace because it is a must for a student to wear it while inside the school premises. The developed application will prompt the user whether the child is 10, 15, 20, 25, and 30 meters away from the smartphone. The signal proximity could be greater than or less than 30 meters depending on the signal proximity of the beacon that will going to use by the upcoming user of the system. Each beacon used could be functional approximately 30 meters otherwise any devices that are not within the range of the beacon signal will not function. Only 2 running beacons can be detected at the same time, otherwise the application will not function properly.

The said application has an inventory management through database that will store, save, search, and delete the time and date of detection of the beacon. Other possible interruption should be considered as delimitation such as Bluetooth signal and power disruptions. This was study focused on locating the child with BLE beacon within the school premises, and to prevents the child from getting lost for safety measures. This could also be used outside the school by the parents or guardian in commercial establishments and recreational venues. Lastly, this study is for Android smartphone only otherwise this application will not be functional.

II. LITERATURE REVIEW

Android is an open source mobile operating system, which is now the most popular platform among the smartphone users because of its efficiency and effectiveness compared to the other platform operating systems. It can also be used as E-learning or M-learning tools and other uses to be more beneficial for the users [4],[5].

On the other parts of this research, it also focuses on using BLE beacons and smartphones because of the application that the researcher developed. Each beacon has a BLE transmitter and It broadcast small radio signal over the air having unique location-specific data. Modern smartphones constantly scan for these signals. If signals enter its proximity an associated application responds with the desired action [6],[7]. Applications can also push to the cloud user data and have its own database using SQL (Standard Query Language) [8]. Personalized contents are displayed as a notification or directly in the application, and nearby screens can also respond with relevant information [7].

During the development of this study, the researchers identified gaps were no local studies conducted on combining the used of beacon technology and Android application in terms of detection or tracking system; and no studies conducted on combining the used of beacon, Bluetooth Low Energy with higher signal proximity (version 4.1 and above) and the latest Android version in terms of detection or tracking system. effective broadcasting ranges of Bluetooth signal implemented by the researcher are useful on dealing with the present study through the information gathered from other broadcasting device besides from Bluetooth 4.1. Using higher signal proximity of beacons, and Android 8.0 and above versions of OS will also beneficial to this study and will obtain an outstanding result in terms of accuracy and effectiveness. On this study, aiding the normal searching for the lost child showed the effectiveness of this study. Based on the literature review, it provided a roadmap to have a modification, and further research on Android application using the BLE beacons more productive.

III. METHODOLOGY

A. Research Design

Descriptive method was used as research design in which it describes currently existing conditions so that these could be modified later on as a result of the research.

B. Systems Development Model

Prototyping model was utilized in developing the system and an interactive process, which is part of the analysis phase of the systems development life cycle model. It was also used for direct implementation of the output phase of the system to gather feedback from the users within the area of study.

C. Population of the Study

The population of this study were composed of 15 parents, 15 teachers, and 5 school administrators of Canossa School Santa Rosa, which served as the locale of this study. Purposive type of sampling was used because the sources of data were limited and this study was tested to Grade One students only.

Canossa School is a Filipino Catholic educational institution in the City of Santa Rosa, Laguna, opened its door on June 14, 1954, they completed the first group of Canossian Sisters in the Philippines.

The school was named in honor of their foundress, St. Magdalene of Canossa whose main goal in the educational and pastoral work as to fulfil the mission, "to make Christ known that He may be loved". The administrators, teachers and staff of Canossa School work hand in hand to draw out to the utmost the abilities and qualities of each student.

D. Data Collection Method

Closed-ended questionnaires with 5-point Likert scale and system evaluation through testing served as research instruments and data collection method to determine the rate of effectiveness of the developed system. Questionnaires for validation, and approval to the principal of the said school. The said instruments were validated by the research coordinator including the maintaining, reviewing and authenticating of all data gathered through statistical treatments such as weighted mean and percentage.

Actual observation of the activities of students, and the tasks and duties of security personnel of the school took place whereas system testing also done to test and verify its effectiveness and satisfaction rates to the parents, teachers, and school administrators. The respondents grouped into three in testing the Android application because there are only three available beacons. Consultations from university instructors, colleagues and professionals in the field of Statistics and Android application development also took place in order to acquire information in developing this study. Obtained results provided valuable information to the performance deficiencies under consideration and lead to the good performance and quality of the system.

IV. SYSTEM DEVELOPMENT

A. System Requirements

TABLE I. SYSTEM REQUIREMENTS

System Requirements	Characteristic Properties
Programming Language(s) Used:	Android Studio IDE Java
Database(s) Used:	SQLite
Input Data/Device(s):	Bluetooth Signal BLE Beacon Signal
Output Device(s):	Android Smartphone
Working Voltage:	Built-in Battery (Beacon)
Beacon(s) Used:	Apple iBeacon

B. System Specifications

TABLE II. BEACON, ANDROID APPLICATION AND SMARTPHONE SPECIFICATIONS

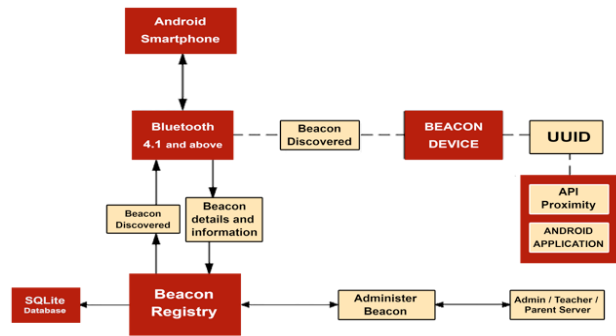| System Requirements		Characteristic Properties
Exterior Dimension:		33mm in diameter
Height:		5mm
Bluetooth Range:		≤ 30m
Power Source:		CR2016 – 3V
Operating System:	Recommended	Android 7.1.1 (Nougat)
	Minimum	Android 4.4.4 (KitKat)
RAM:	Recommended	1GB to 2GB
Internal Memory:	Recommended	4GB to 8GB
Bluetooth:	Recommended	4.0 to 4.1

C. System Block Diagram

Fig. 2. System Block Diagram

Fig. 2 showed the system block diagram, the user will start with the Android application installed to the smartphone; it will detect any signal approaching from the beacons attached on a specific area. Once matched with the UUID, the smartphone will receive a push notification and messages once a beacon has been detected. The notification will display in two ways: first, the smartphone detects the beacon, which is going far away from the user; the other one, the smartphone detects the beacon, which is going near to the user and will detects the exact location of it. The Android application will be having its own database using SQLite to save the UUID, date and time of each beacon being detected by the said application.
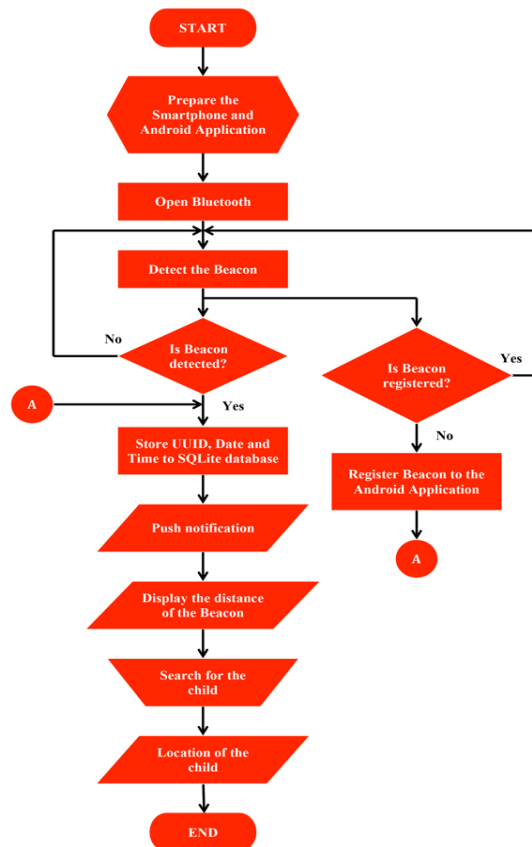
D. System Flowchart

Fig. 3. System Flowchart

Fig. 3 showed the system flow starts from turning on the smartphone's Bluetooth and Android application, followed by the registration and detection of beacon's UUID. It will store, save, update and delete the date and time of upcoming and outgoing beacon's detection through SQLite database of the Android application. The push notification will prompt upon detection of the beacon, while the application will display the distance of the beacon from the smartphone, and then manual searching for the location of the child takes place. The Android application will serve as guide to easily detect and locate the child with beacon.

E. System Structural and Hardware Designs

Fig. 4. i Beacon Device powered by Bluetooth Low Energy 4.1.
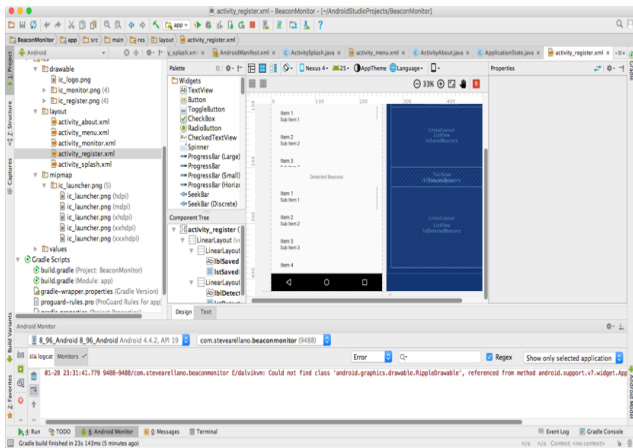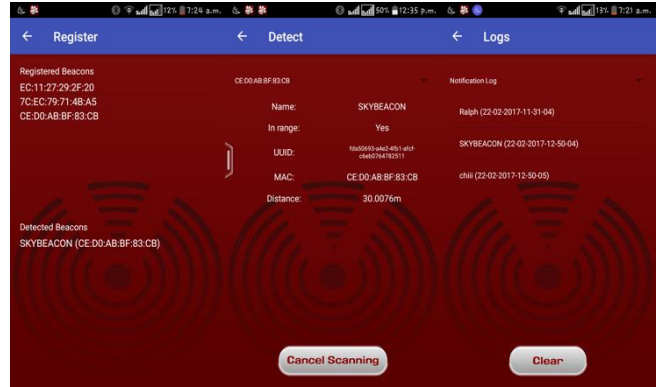
F. System Software Design

Fig. 5. Android Studio Integrated Development Environment.

Android Studio is an official integrated development environment (IDE) in developing the interface of the application up to its functions and features, while SQLite was used for database storage.
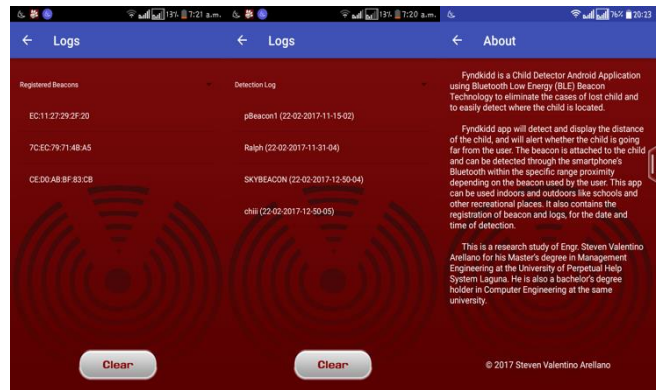
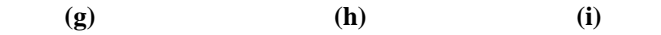### G. System Implementation

| **(a)** | **(b)** | **(c)** |

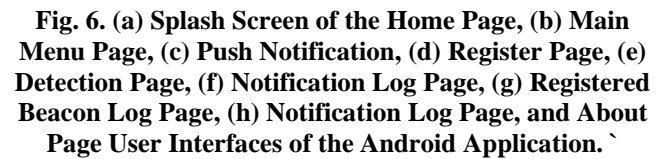| **(d)** | **(e)** | **(f)** |

| **(g)** | **(h)** | **(i)** |

Fig. 6. (a) Splash Screen of the Home Page, (b) Main Menu Page, (c) Push Notification, (d) Register Page, (e) Detection Page, (f) Notification Log Page, (g) Registered Beacon Log Page, (h) Notification Log Page, and About Page User Interfaces of the Android Application. `

V. RESULTS AND DISCUSSION

TABLE III. BENEFITS OF USING SMARTPHONES ACCORDING TO THE RESPONDENTS

Benefits	Parents	Teachers	School Administrators
Communication	1.5	3	1
Entertainment	4	4	4
Internet / Wi-Fi Access	1.5	2	2.5
Portability	3	1	2.5

Table III showed that the gathered data through multiple responses were arranged by ranking from most to least benefits. Most of the parents said that the communication and having an Internet and Wi-Fi access were the most beneficial aspect followed by its portability and for entertainment. The teachers said that portability was the most benefit aspect in using smartphone followed by its Internet and Wi-Fi access, and for communication purposes. Finally, communication came first, followed by Internet or Wi-Fi access, and portability of smartphones for the school administrators.

TABLE IV. LIKERT SCALE RATING EQUIVALENT OF THE RATE OF EFFECTIVENESS OF THE DEVELOPED SYSTEM

Numerical Value	Mean Value	Interpretation
5	4.50 – 5.00	Very Effective
4	3.50 – 4.49	Effective
3	2.50 – 3.49	Fairly Effective
2	1.50 – 2.49	Ineffective
1	1.00 – 1.49	Very Ineffective

TABLE V. RATE OF EFFECTIVENESS OF THE DEVELOPED SYSTEM

Distance (meters)	Parents	Teachers	School Administrators	Weighted Mean
10m	5.00	5.00	5.00	5.00
15m	5.00	5.00	5.00	5.00
20m	4.80	4.80	4.60	4.73
25m	3.53	3.93	4.40	3.95
30m	3.13	3.40	3.80	3.44
			Mean	4.42

The developed system was effective and can precisely detects the child with beacon as shown in Table V. Results of the system testing were based on the computed weighted mean of gathered data using the Likert scale for interpretation as shown in Table IV. Obtained results signifies that detecting the child with beacon from 10m, 15m, and 20m away to the user using the developed system was very effective because it can detect for less than a minute. Likewise, detecting the child with beacon from 25m and 30m distance signifies that the system was effective because it can detect for 1 to 2 minutes. Based on computed weighted mean, the overall developed system was effective in child detection.

TABLE VI. LIKERT SCALE RATING EQUIVALENT OF THE LEVEL OF SATISFACTION OF THE DEVELOPED SYSTEM

Numerical Value	Mean Value	Interpretation
5	4.50 – 5.00	Very Satisfied
4	3.50 – 4.49	Satisfied
3	2.50 – 3.49	Fairly Satisfied
2	1.50 – 2.49	Unsatisfied
1	1.00 – 1.49	Very Unsatisfied

TABLE VII. LEVEL OF SATISFACTION OF THE RESPONDENTS TO THE DEVELOPED SYSTEM

Respondents	Weighted Mean	Interpretation
Parents	4.53	Very Satisfied
Teachers	4.47	Very Satisfied
School Administrators	3.60	Satisfied
Mean	4.20	Satisfied

Table VII showed the level of satisfaction in detecting the child using the developed Android application and had a satisfactory rating based on the average weighted mean according to the respondents using the Likert scale for interpretation as shown in Table VI.

VI. CONCLUSION

Internet is currently use as a way of communication through different social networking sites and other different applications available on the worldwide web, which led into higher level of social communication. Hence, Internet could access and serve as communication not only for people but also to several industries through Internet of Things (IoT), Internet of Everything (IoE), cloud-computing, and artificial intelligence (AI) mobile applications, which are the current existing technologies today and as well as beneficial features of using smartphone. As the technologies become smaller, it became more useful and meaningful for people and had a great response in making the life more relevant and dynamic.

In terms of the rate of effectiveness of the developed system, since the beacon was 10 to 30m away from the smartphone, the user can detect the distance of the beacon, but it is dependent on its signal proximity. The longer distance away from the beacon is the longer time of detection of the Android application. Furthermore, smartphone also took place in detecting the child with beacon because the application is dependent on the GUI of the Android OS version installed on it. The higher version of Android OS, the faster progress of the application. The version of Bluetooth can also be considered as factors for the time of detection because the beacon can only be access through Bluetooth 4.1 and above versions. The developed system had a very satisfactory rating because of its user-friendly interface and notification and security features through the use of smartphone and the new innovation of Bluetooth device, which is the Beacon technology. Possible inclusion such as utilization of a higher version of Android OS, which is the 8.0 (Oreo) version; utilizing also a higher version of Bluetooth, which is 4.1 and above; and lastly, using a higher signal proximity of beacon will lead to better results. Additional features of the Android application such as adding a radar page, and a function that the user can modify the name of the beacon could make the detection faster and easier to prevent them from getting lost. These additional features and modifications lead for a better level of satisfaction of the users.

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