Android-Based Child Monitoring Application Using A Smartwatch and Geofence Service

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Android-Based Child Monitoring Application Using A Smartwatch and Geofence Service

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Abstract. This article discusses implementing an application to monitor children's movements using virtual borders. This virtual boundary is known as a geofence. This geofence is used to mark which areas can be occupied by the child. This child monitoring application with geofence facilities was built using the unified software development process (USDP) method. USDP is divided into 4 stages, namely Inception, Elaboration, Construction, and Transition. This application is designed to assist parents in monitoring children's movements in realtime. This child monitoring application with geofence facilities begins with an investigation of system requirements, followed by a system architecture design and a use case diagram design. Data needs in this system include the actors involved, namely children and parents. Children use smartwatches and parents use Android smartphones. The latitude and longitude positions of the child and parent are stored in the Firebase database. Geofences are set by parents and are used to restrict children's movement in certain areas. In designing this system, the haversine formula is used to calculate the distance between the child's position and geofence to find out whether the child is still in the permitted area. When the child leaves geofencing, a response will appear to the parents.

1. Introduction

Parents are very busy looking for money, to provide for their families. Often, they do not have time to control the movements of their children because they are busy with work in the office. Parents often worry about their children's safety, while parents are not there for their children. Parents are often worried about the safety of their children, while parents are not beside their children. Accidents can happen to children, or parents lose their position of movement when their children do outdoor activities [1]. Parents want a system that can monitor the position of their children and can restrict their children's movement. Parents want to be notified if the child moves outside the area that is not permitted. This is to reduce the unwanted incidence of the parents, to their children.

Now, GPS technology is present in our midst to help determine the position of an object on earth [2][3][4][5]. This GPS technology [6] can be combined with virtual restrictions (geofences) to limit the movement of an object in a certain area. To get the GPS latitude and longitude position, a GPS signal receiver hardware is required. The GPS receiver requires a minimum of 3 GPS satellite signals to obtain accurate latitude and longitude coordinates. If the satellite signal is obstructed by tall buildings, mountains, or trees, the accuracy of the position coordinates will be reduced. Now GPS signal receivers are getting smaller in size, and are now embedded with other hardware, such as smartphones and smartwatches.

This GPS technology can be combined with virtual restrictions (geofences) to limit the movement of an object in a certain area [7][8]. The utilization of GPS coordinates can be used on a virtual boundary (geofence) by setting the virtual boundary in advance. The passable area is marked as

a benchmark for children to do their activities. The system is made to detect whether the position of children, is still in the permitted area, or is outside the boundaries of the safe area. Notification will be given to parents if their children are doing activities outside the geofence.

2. Related Work

Karthikeyan has built an app for parents who have little time to take care of work at home because they are busy with office work [9]. The application was built, using GPS and geofence services. Application users can be customers and can also be service providers. The app also provides services such as baby care, patient care, home care, orphan care, and location sharing services. Users as service providers such as household maintenance, plumbing workers, electrical workers can register themselves into this system. Another feature is the use of geofence to monitor and track baby sitters around users as customers.

Dhiraj Sunehra built a tool that parents use to monitor their child's position at school [10]. This tool is also connected to school authorities so that schools can also monitor children's movements while in school. In this study, the child data transmission module was made with an ARM7 LPC 2148 microcontroller [11] which was connected to several modules. The modules are a GPS receiver module, a GSM module, and a power supply module. The latitude and longitude position of the child is sent periodically through the device used by the child, to the parent's smartphone via SMS message. Parents' smartphones can see the position of their child on the google map according to the position data that has been sent. The hardware for transmitting the children's positions still has a relatively large size so it is necessary to think about using a tool that has smaller dimensions. Likewise, how to send a position using an SMS message needs to increase the speed of data transmission, for example via the internet.

Aditi Gupta purpose architecture model for child safety through smartphones that provides features to track the child's location and send instant messages [12], if the child is in an emergency. The proposed system architecture model is equipped with geofence facilities. The system will send an SMS as a notification if the children cross the virtual limit that has been previously set. Parents can set multiple geofences at any time according to their interests

3. Methodology

This study uses the Unified Software Development Process (USDP) software engineering development method. USDP is a methodology for software development, especially object-oriented software. This method begins with the creation of a use case, which in principle is to obtain user requirements specifications. The USDP method has 4 working phases, namely Inception, Elaboration, Construction, and Transition. In each phase, there are stages carried out iterations, namely the requirements, analysis, design, implementation, and testing stages.

3.1. Use Case Diagram

Use cases can be used to describe the functional requirements approach [14]. The basic concept of this diagram is the relationship between actors and use cases. Use Case diagrams consist of several basic elements, namely Actors, Boundary Systems, Use Cases, and the relation between use cases. Actors can be a person, a profession, an institution, a hardware device, or another system plays in interacting with the system. Use cases are initiated by the actor and may involve the roles of other actors. The use case must have at least one actor. Boundary system in the form of a square as a barrier system, which is built. Use cases are in the form of a set of functionality system that describes the facilities owned by the system. Between use cases, can have a relationship with each other. Relationships can be "include" and "extend". Include indicates the calling of a use case by another use case. Extend indicates the expansion of another use case if the conditions or conditions are met.

3.2. Haversine Formula

Haversine law [13] is a formula used to calculate the distance between two points on earth. This distance is used to compare the distance that has been set as a geofence. If the distance of a point

exceeds the distance specified in the geofence, it can be said that the position of the point is outside the permitted area.

$$Haversine\left(\frac{d}{r}\right) = haversine(\emptyset_2 - \emptyset_1) + \cos(\emptyset_1)\cos(\emptyset_2)\, haversine(\lambda_2 - \lambda_1) \quad (1)$$

Where
haversine(x)=1-cos(x)/2
d is the distance between the two points
r is radius of the sphere
Ø_1,Ø_2 is the latitude of point1 and latitude of point 2
λ_1,λ_2 is the longitude of point 1 and longitude of point 2

4. Proposed Design System

This research requires 2 actors as system users, namely parents and children. Parent and child actors have different roles in the system. In this case, children are objects that are monitored by parents.

The system is functionally designed to have the following facilities:

- Parents can see all children's positions in real-time on google map.
- Parents can see all names of their family members
- Parents can look back on the trajectory of the children who have been through.
- Parents can set out geofence for each child.
- Parents can receive a notification if children cross the predetermined geofence limit.
- Children can send their position in real-time to the server.

The hardware needed to support communication between parents and children is:

- Smartphone used by parents
- Smartwatch equipped with GPS, used by children

This application has been built using Android Studio and Google API to display the google map. The firebase database is used to store real-time system data.

4.1. Architecture System

Monitoring the movement of children with geofence service applications requires primary data such as data on children's positions, family data, the boundary of geofence data, and parent data. In figure 1, the GPS satellites will provide position data for each smartwatch used by the children. The smartwatch, via the embedded app, will send the children's position to the Firebase database via the internet network. Parents, through their smartphones, will retrieve data from the Firebase database, which then displays the children's position on a google map. Parents can also make geofence settings via their smartphone devices. Notification is given to parents via a smartphone device if children are outside the permitted area.

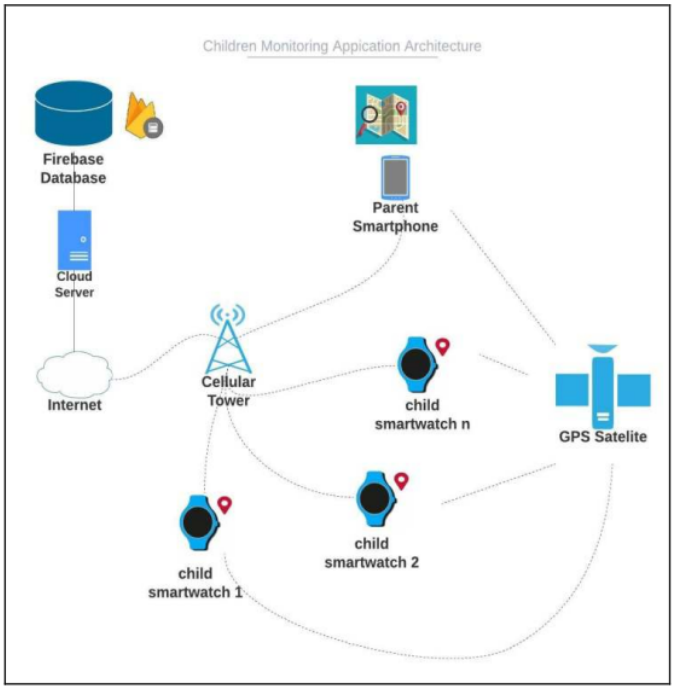

Figure 1. System Architecture of Monitoring Movement Children With Geofence Service

4.2. Use Case Diagram System

In the use case diagram figure 2, the use case send position is carried out by the child actor, where children first do the use case children login. Validation of children's users is carried out on case children login. Only registered children's cellphone numbers can enter the system. Once valid, children can send their latitude and longitude positions through the smartwatch. The positions of these children are stored in the firebase database.

Use case register family is carried out by the parent actor, to register the family name to the mobile application. In addition to the family name, the head family number, head family name, family address, and password are also registered. The id number of the family will be given by the system after registration. The use case register family member is carried out by the parent actor, to register the name of the member name of the family. This use case is used to register children's data. Children data such as children's cellular card number, child name, nickname, and date of birth. Before the parent actor registers the family member, they do the use case parent login. The parent actor performs the use case parent login to validate that the parent actor has the right to enter the application.

Use case see list family member is done by the parent actor, to see all family members registered in the system. This facility is to make it easier for parents to know which of their children are not or who have been registered. This list can be used as a medium to help choose the position of their child on the google map.

Use case see family member on google map is done by the parent actor to see the position of the child on google map. The parent can see the position on the android smartphone screen. The position of the child will move in real-time, according to the movement of the children.

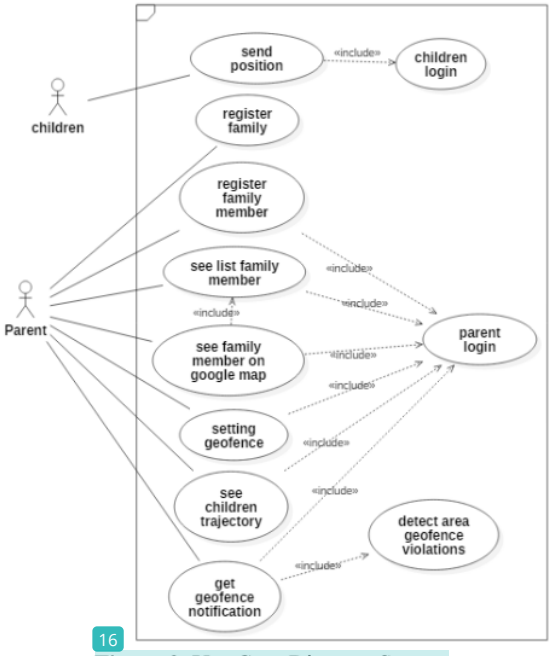

Figure 2. Use Case Diagram System

Use case setting geofence is carried out by the parent actor, to set a virtual barrier against the movement of children. This virtual divider is arranged by creating an area in the map area with circle shapes. The center points of the circle shape are stored in the firebase database. This center point is in the form of latitude and longitude coordinates, which will be used when detecting the area. There are 2 detection areas, namely areas that can be moved by children and areas that cannot be crossed by children.

Use case gets geofence notification is carried out by the parent actor to find out whether the children are crossing virtual boundaries or not. The movements of the children were recorded at each timestamp. Children who use the smartwatch as a GPS position generator, make movements at any time and are sent in real-time to the firebase database server.

Use case see children trajectory is done by the parent actor, to look back at the trajectory of the children. Which areas are frequently traversed by children will appear in this case. If an accident occur or losing track of their child, parents can trace back their child's last position as an initial search for their child's position.

4.3. Circular Shape Geofence Detection

This application uses the haversine formula to calculate the distance between the child's latitude and longitude position and the geofence center point. Geofence in this study uses a circular shape so that the allowable outer distance can be calculated by calculating the distance from the center point to the outer position of the geofence. In figure 3, detection is done by first calculating the distance between the center point and the outermost position of the geofence. We call this distance the maximum distance. Then we calculate the children's position distance with the geofence center point which we call the child distance. If the child's distance is greater than the maximum distance then the child's position is outside the allowed area.

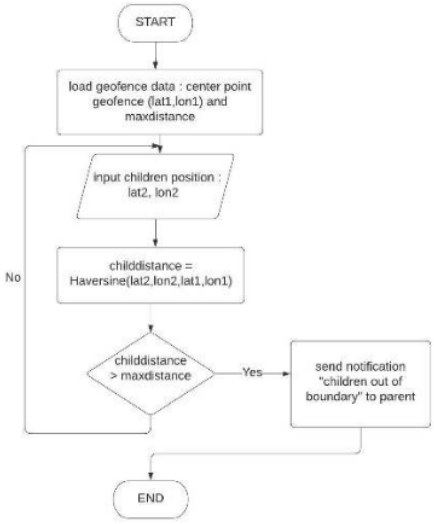

Figure 3. Flowchart for Circular Shape Geofence Detection

5. Implementation

This application uses the map facility from Google. To use the Maps JavaScript API, we must have an API key. The API key is a unique key used to authenticate requests related to the application that we make in terms of resource ma usage from google. For our application's firebase implementation, we must ensure that we are using target API level 16 (Jelly Bean) or higher and us g Gradle 4.1 or later. Implementation of the smartwatch using the Q1 Pro smartwatch with the Android 6.0 operating system, CPU: MTK6737 Quad Core, 1.3GHz.

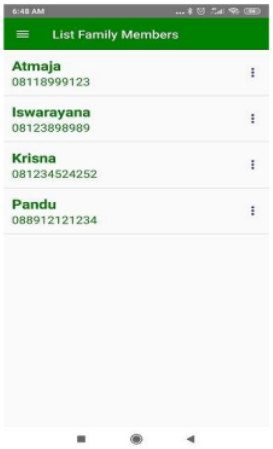

Figure 4. Display list family member on the parent screen

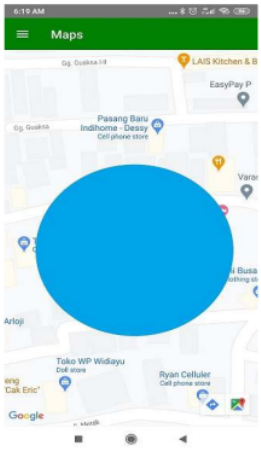

Figure 5. Setting Circle Shape Geofence

Figure 6. Smartwatch display

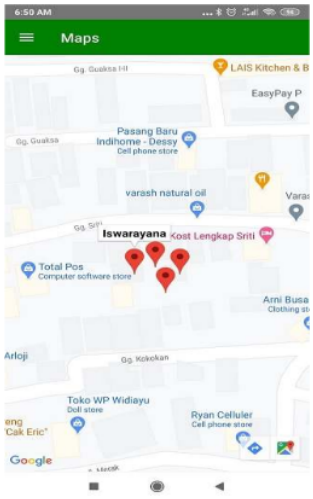

Figure 7. Child position display on the parent screen

6. Conclusion

This application is designed to use 2 main actors, namely the actor parents and children. In designing this application, there are several main use cases, namely use case see family members on google map, use case setting geofence, use case get geofence notification, use case geofence detection, and use case see children trajectory. The system architecture is designed by connecting the smartwatch used by children and the smartphone used by parents. Both of these devices are connected via the internet so that all the position data of the children is stored in real-time in the firebase database.

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Acknowledgments

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