CardiACT

ECE 1778 Creative Applications for Mobile Devices - Project Report

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Word Cout: 2496

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Note: We would not like our source code to be posted online, but are OK with the video and report being posted.

Part 1 - Introduction

What: The goal of our app is to help local emergency medical service (EMS) increase awareness of cardiac arrests, and create a bystander response system for out-of-hospital cardiac arrest (OHCA) events.

The bystander response system focuses on two aspects: 1) bystander treatment: directing bystanders to OHCA victims, in parallel with EMS, to perform cardiopulmonary resuscitation (CPR) and/or to automated external defibrillators (AEDs) to bring to the victim, 2) an AED reporting system: crowdsourcing AED data collection using bystanders to develop a reliable database. Bystanders can report locations of non-registered AEDs as well as errors or issues on already registered AEDs.

Our long term goals (and features which improve on existing apps) are as follows: 1) improve the logistic process of directing bystanders to AEDs and the OHCA victim using an optimization model based on historical cardiac arrest data, 2) develop an in-depth registration process to ensure the legitimacy of our users, and 3) allow bystanders to create highly customizable user response profile to ensure bystanders respond to victims with confidence.

The application will be presented to local EMS to implement in their service regions. Once EMS has agreed to participate, bystanders will be able to receive notifications from the app to respond to OHCAs.

***Why*:** Cardiac arrest is a significant health issue around the world and is a very time sensitive emergency event – survival decreases to less than 5% after 10 minutes without defibrillation[1-4]. In large urban environments, where traffic is heavy, EMS responders commonly take an average of 7-12 minutes to reach cardiac arrest victims.[5]

AEDs are a medical device developed to help reduce the time to treatment[6-9]. They allow for lay persons or bystanders, without medical training, to respond and treat cardiac arrest and significantly improve survival. Another treatment that can be used by both trained professionals and lay persons is CPR[10, 11]. CPR is a procedure to help restore blood circulation with manual compressions applied to the chest of the victim.

While bystander treatment (CPR and/or AED use) have been shown to improve survival outcomes, bystander involvement remains low. We aim to increase bystander's role and participation by targeting 3 endpoints to improve: 1) bystander witnessed, 2) bystander CPR applied, and 3) bystander AED used cardiac arrests.

One part of the low bystander participation is the gap in confidence and knowledge on how to respond to cardiac arrests[12, 13]. We hope the app can empower bystanders to act, and save lives.

Part 2 - Overall Design

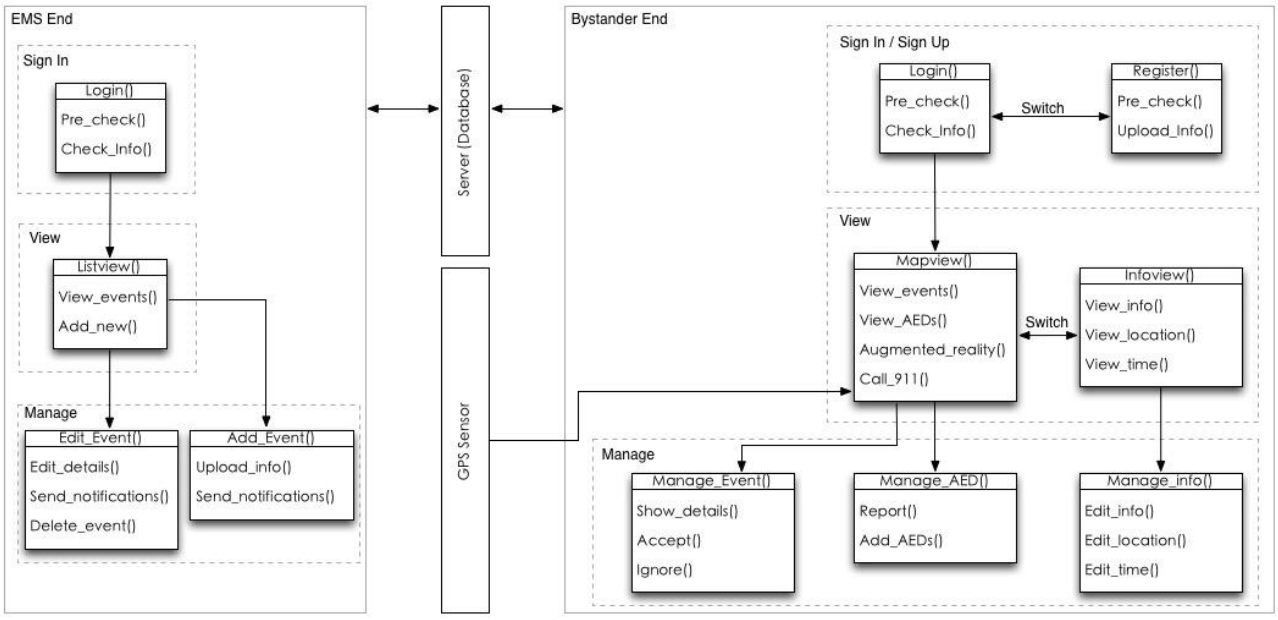

Figure 1 Block diagram of the design

Bystander End:

- **Sign in/Sign up module:** this module allows new users to register or registered users to sign in to the application. This module also asks for basic information from new users during registration.
- **View module:** this module is divided into two modules:

1) Bystanders are able to see the emergencies and the AEDs around their location. A refresh button allows for the emergency event and AED data to be updated as the user moves/zooms in or out of the map.
2) Bystander can review their own information, including their basic information, and response history.

- **Management module:** this module is divided into three modules:

1) The Manage_Event shows the emergency details and the user could respond to the emergency event (accept or ignore);
2) The Manage_AED allows bystanders to update the status of the AEDs or add a new AED;
3) The Manage_Info enables bystanders to update their own profile.

EMS End:

- **Sign in module:** the EMS has a higher level account setup that does not registration.
- **Views module:** there is a listview that shows all the emergencies on EMS End.
- **Management module:** this module has two smaller modules:

1) The Edit_Event allows EMS to edit the current emergencies and send out notifications to bystanders;
2) The Add_Event is for EMS to add emergencies to the database.

Part 3 - Statement of Functionality

• Server/Database to App Connection

objectId String	GCMSenderId String	Roles String	appIdentifier String	appName String
Qj0OgVVNxp	(undefined)	Admin	com.example.osorekoxuan.cardiactems	CardiACT EMS
Ge5Gopw2zh	(undefined)	Bystander	com.example.osorekoxuan.cardiact	CardiACT
0BeLOq63tG	(undefined)	Admin	com.example.osorekoxuan.cardiactems	CardiACT EMS
ZVPDsSZhGc	(undefined)	Bystander	com.example.osorekoxuan.cardiact	CardiACT
1mLwbqHMHH	(undefined)	Admin	com.example.osorekoxuan.cardiactems	CardiACT EMS
WYE29U030M	(undefined)	Admin	com.example.osorekoxuan.cardiactems	CardiACT EMS

Figure 2

1) We used Parse server as the backend database. Once the app is installed on a device, the server will have an object created for that device. In Figure 2, CardiACT EMS end has been installed on 4 devices, and CardiACT bystander end has been installed on 2 devices.

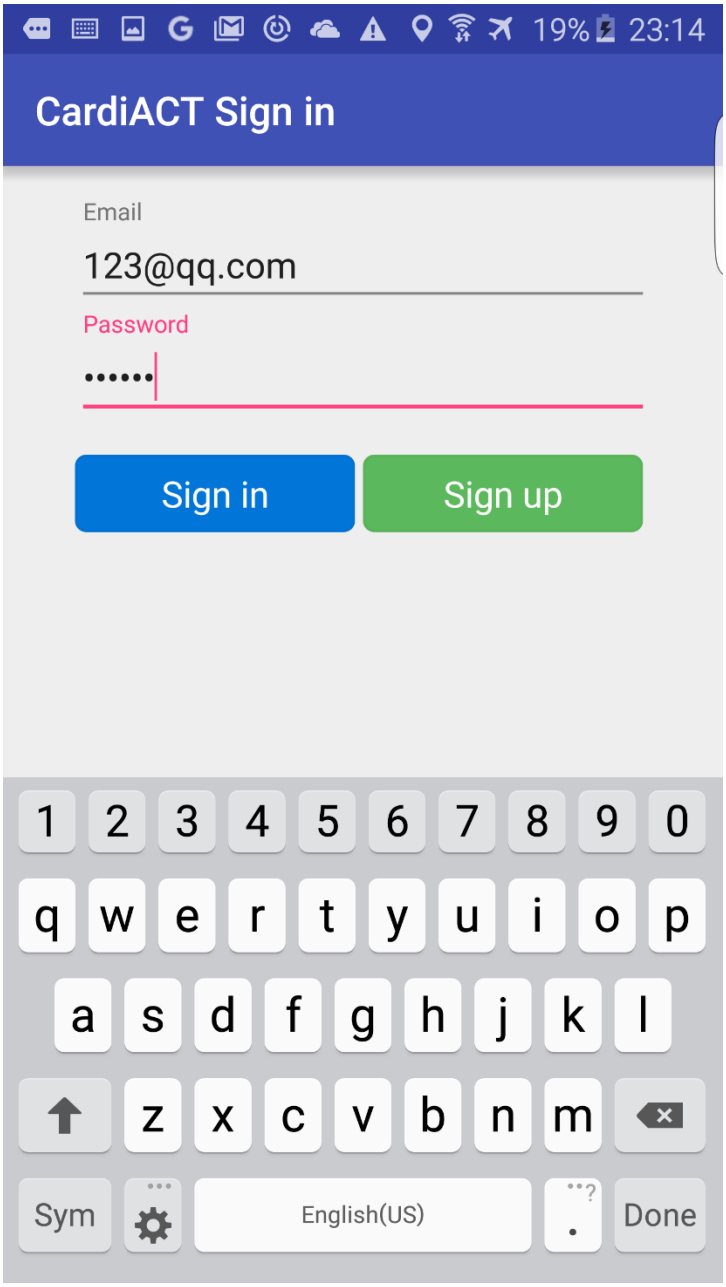

Figure 3 [Bystander end]

• Bystander user profile

1) Bystanders can sign in to CardiACT after registering (Figure 3).
2) Bystanders can check their own basic information (Figure 4).
3) Bystanders can edit their own basic information (Figure 5).

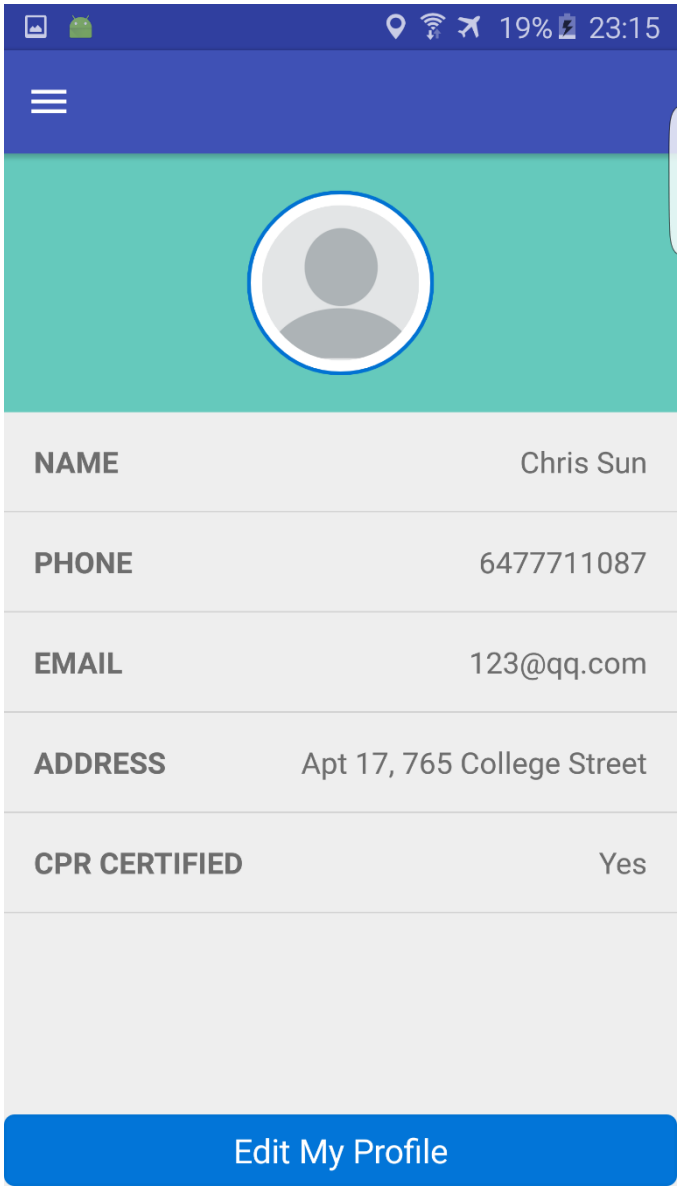

Figure 4 [Bystander end]

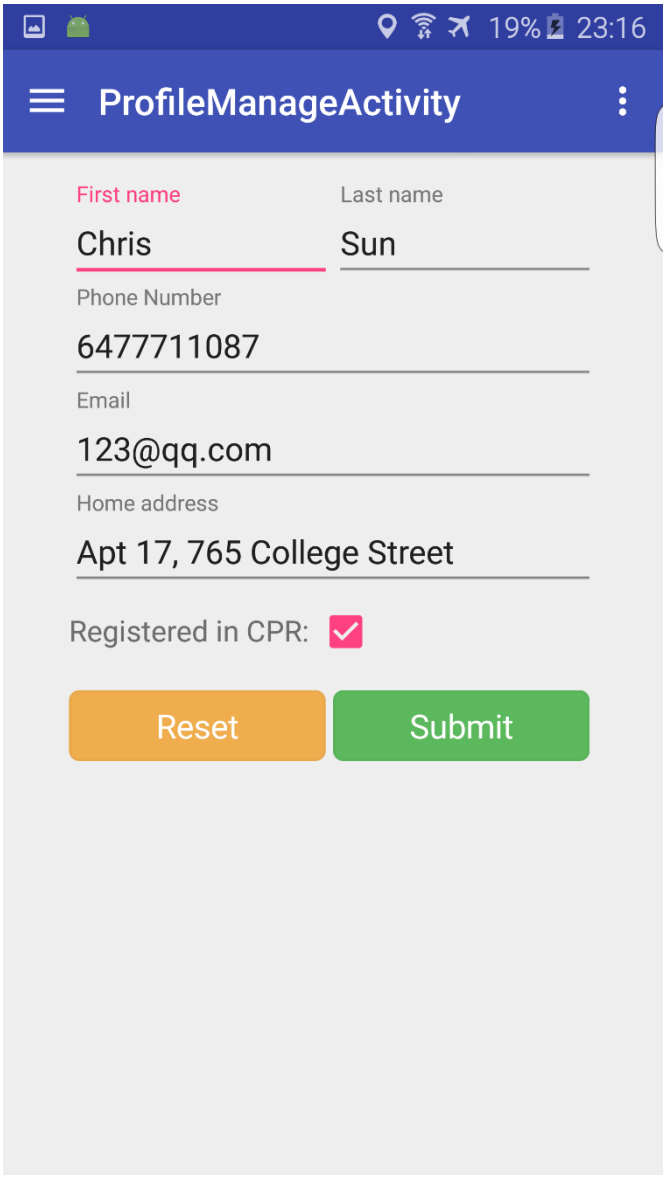

Figure 5 [Bystander end]

- **GPS Location**

1) Emergency events are displayed on a Map as RED pins(Figure 6);

2) Bystander's Location is displayed on a Map as a BLUE dot (Figure 6);

3) AEDs are displayed on a Map as GREEN pins (Figure 6);

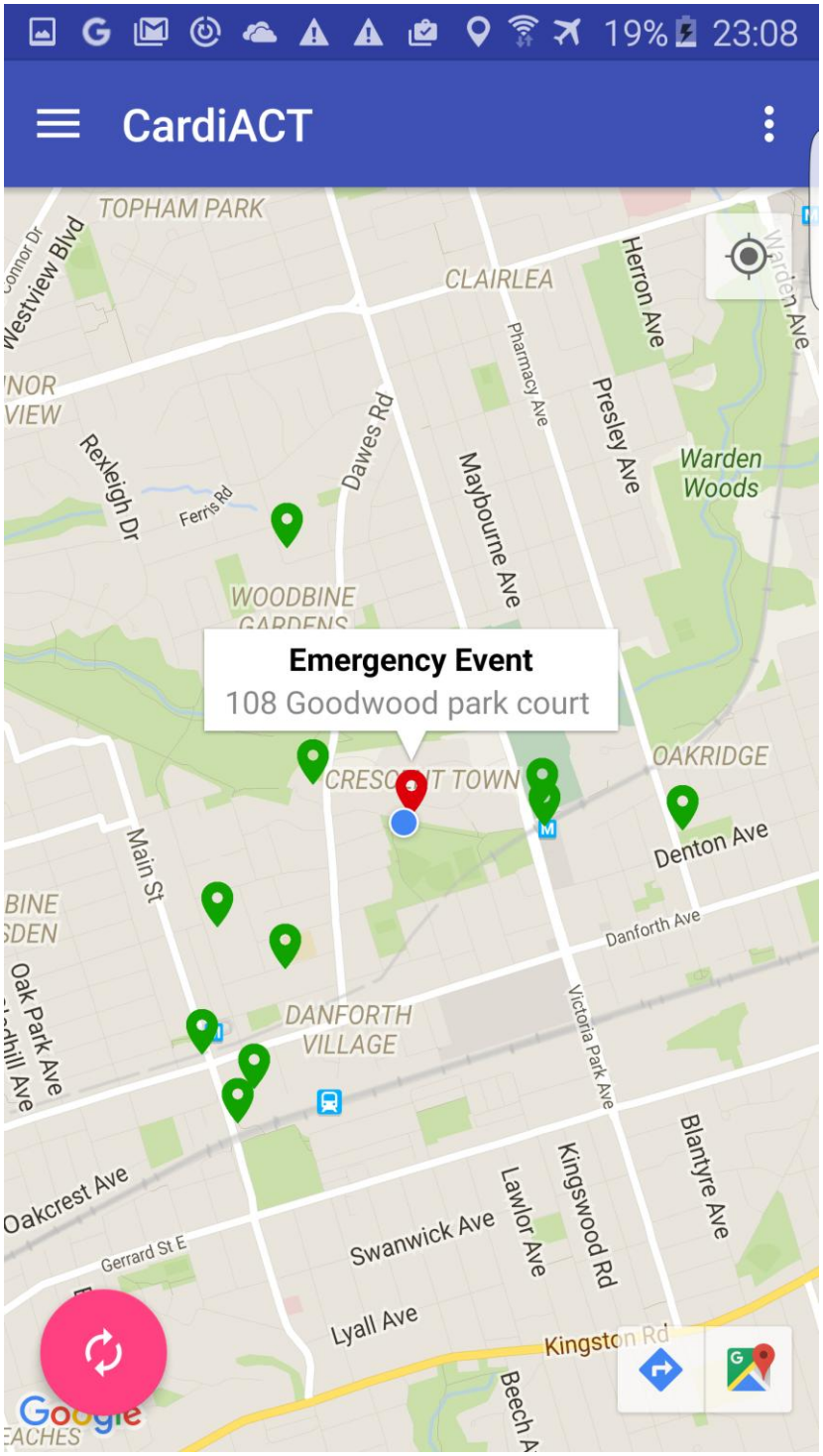

Figure 6 [Bystander end]

- **Emergency event management system**

1) EMS end can Add/Delete/Edit emergency events (Figure 7 and 8)
2) Once EMS end adds an emergency event, push notifications will be sent to bystanders (Figure 9)

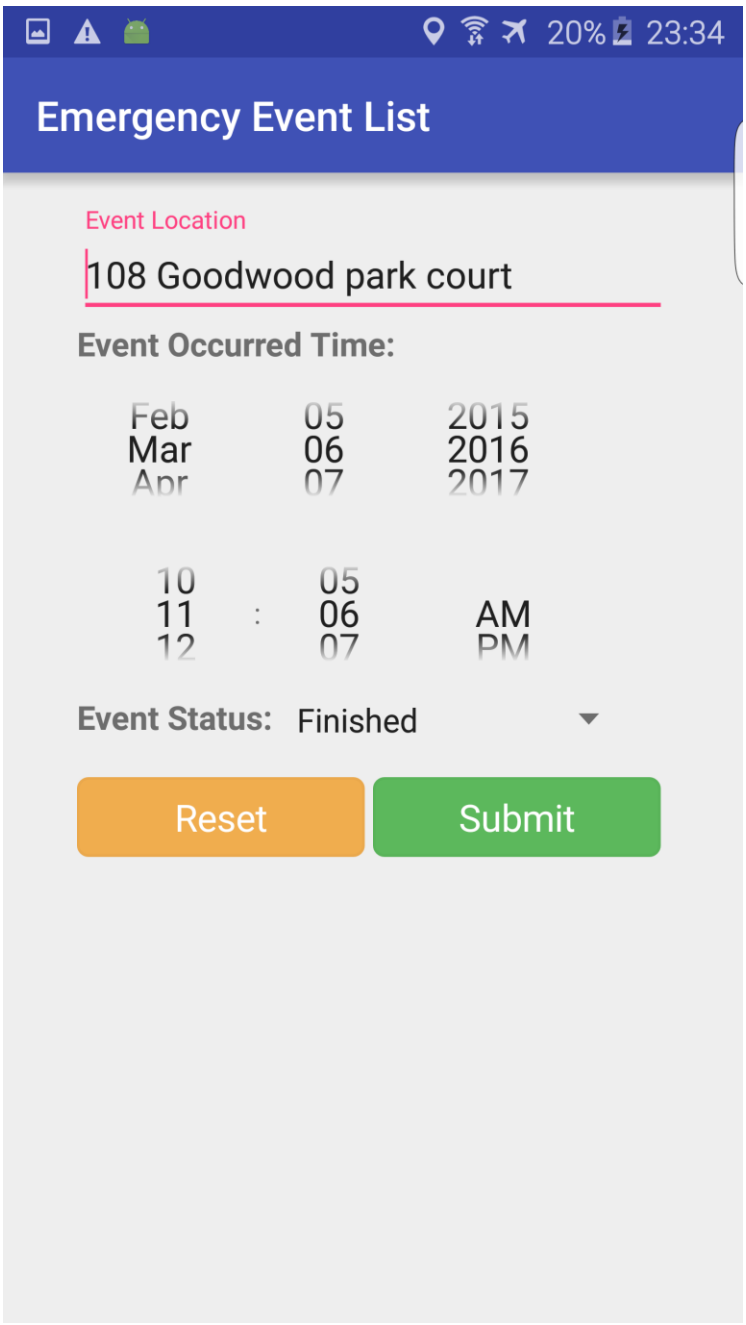

Figure 7 [EMS End]

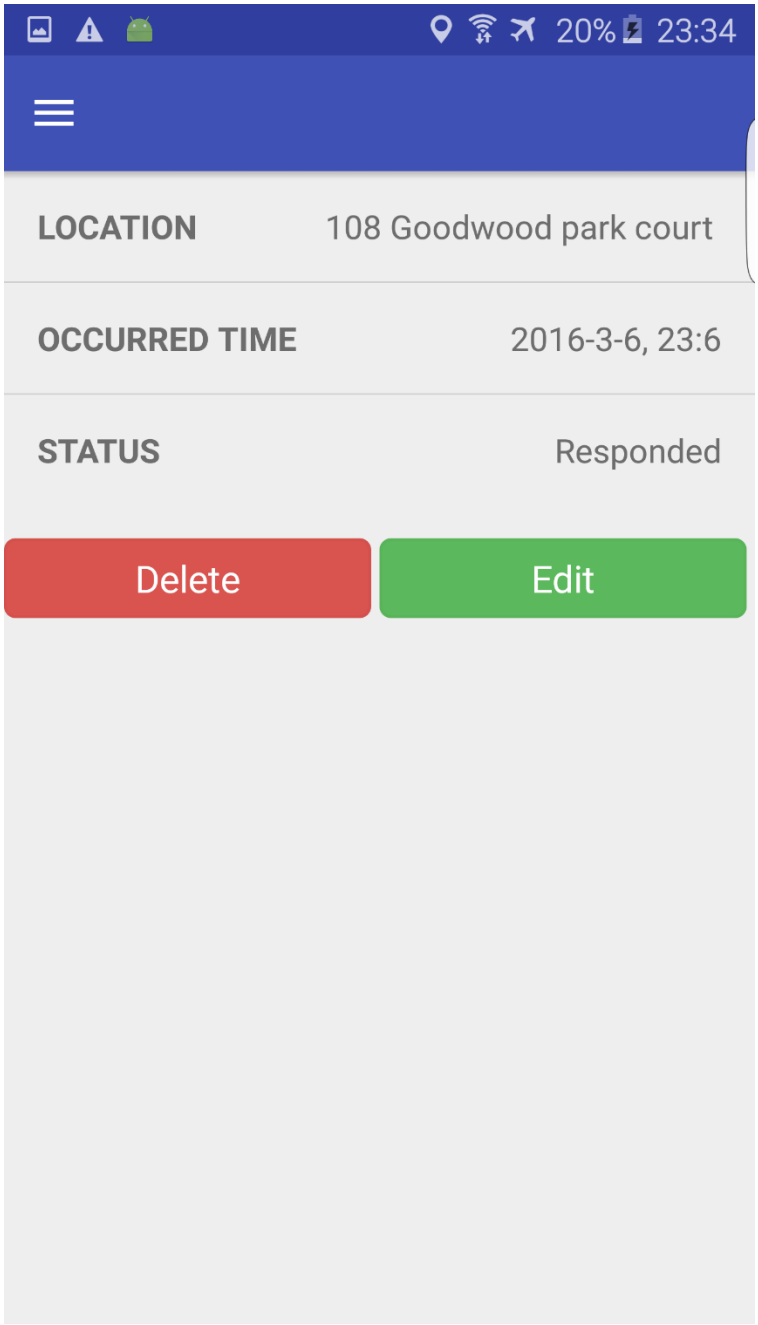

Figure 8 [EMS End]

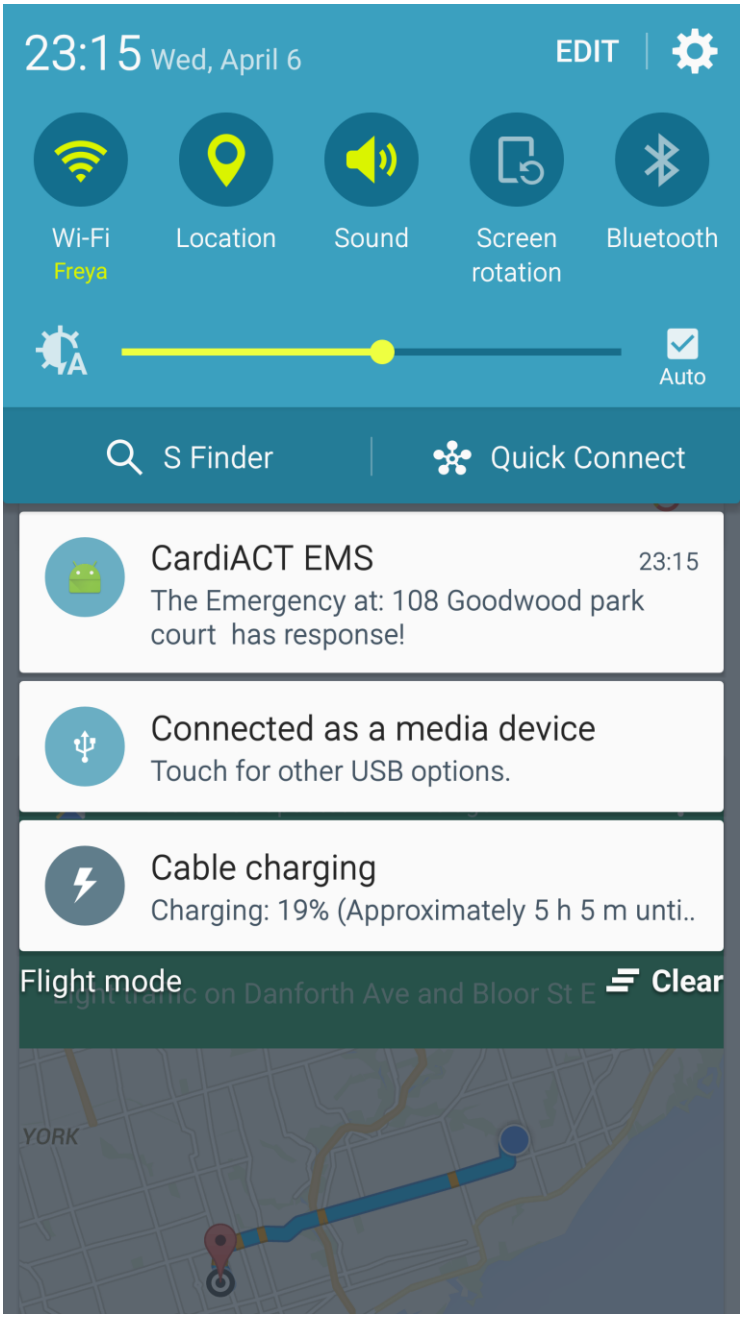

Figure 9 [Bystander end]

• Pathfinding Functionality

1) Once the bystander presses “Accept” (Figure 22) and responds to an emergency event, CardiACT will direct the bystander to the closest AED (see Figure 10).

2) After retrieving the AED and pressing “Got AED” (Figure 10), the bystander will be directed to the emergency event (Figure 11).

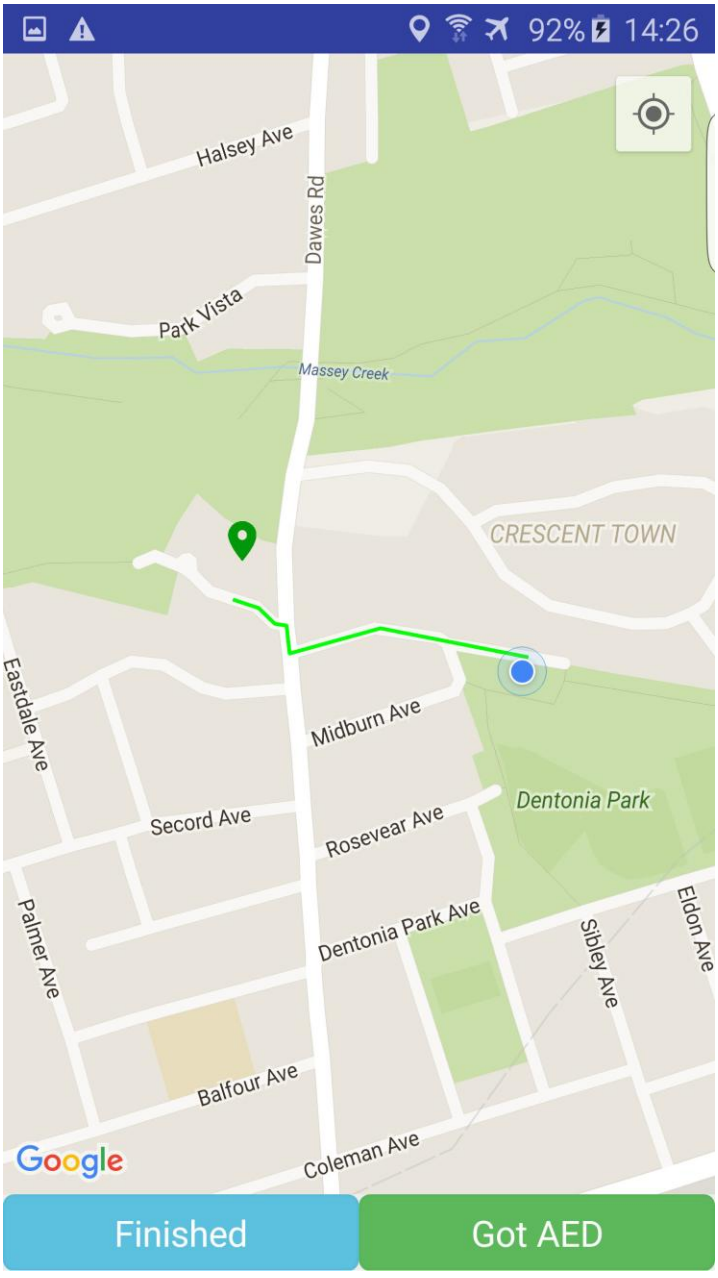

Figure 10 [Bystander end]

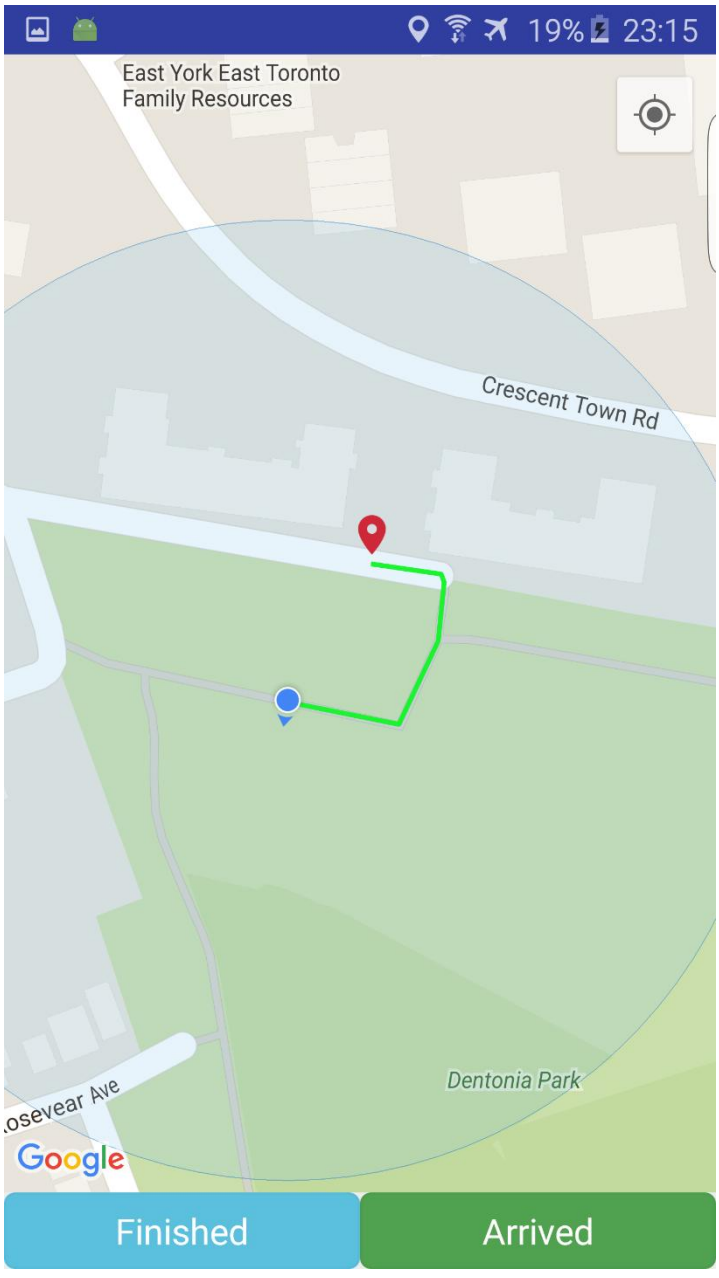

Figure 11 [Bystander end]

- **AED reporting system**

1) If bystanders notice any AED information that is inaccurate, they can report the error using the “Report Error” button (Figure 12). After modifying the information, by pressing “Submit” in Figure 13, EMS End will receive notification with reported AEDs (Figure 14).

2) The color of the reported AED pin will turn YELLOW (Figure 15).

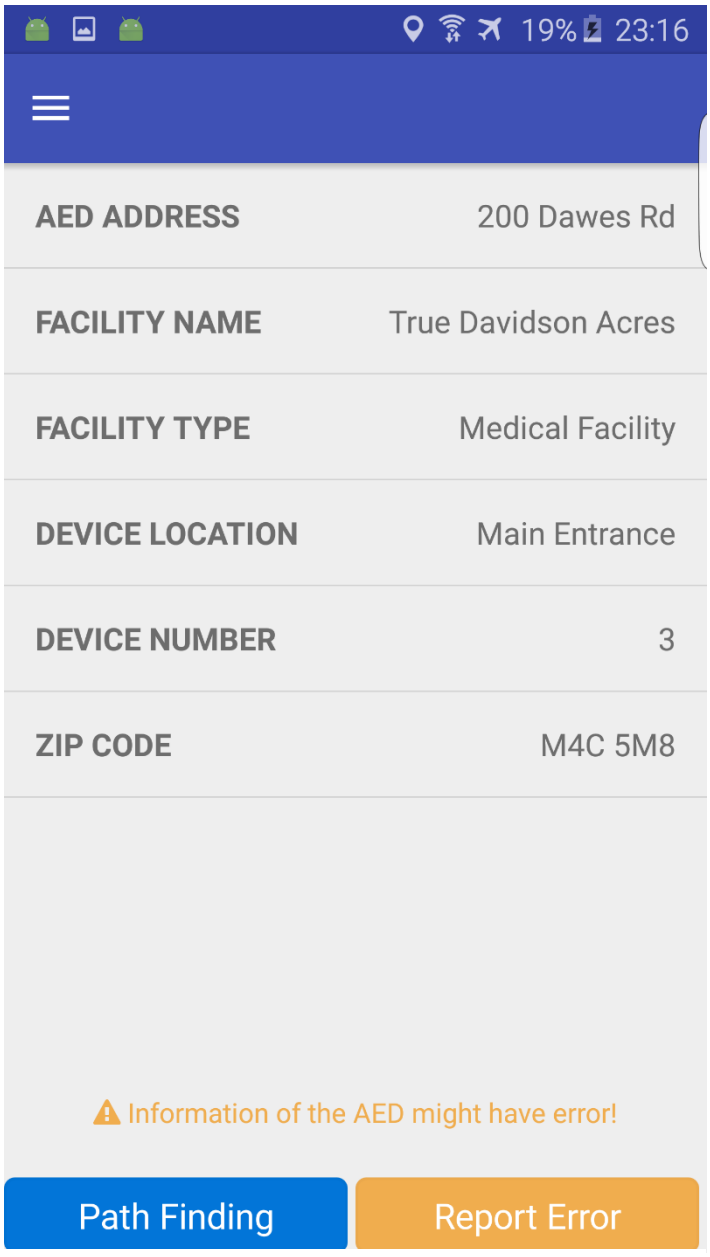

Figure 12 [Bystander end]

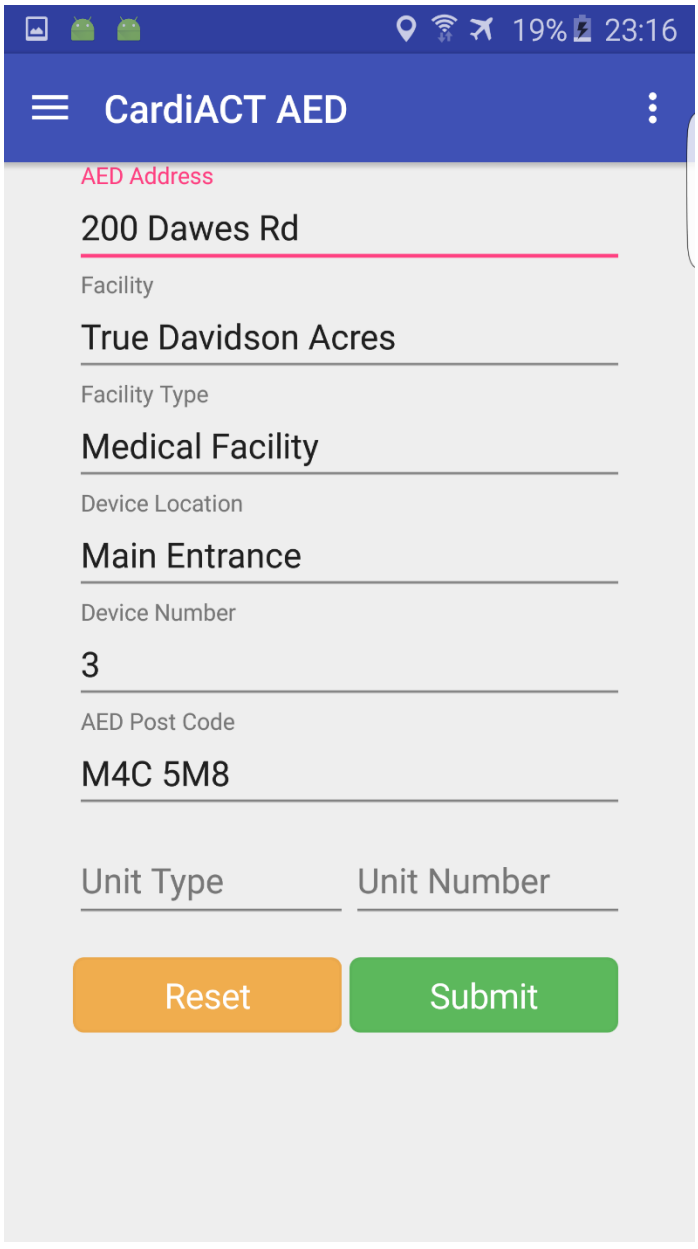

Figure 13 [Bystander end]

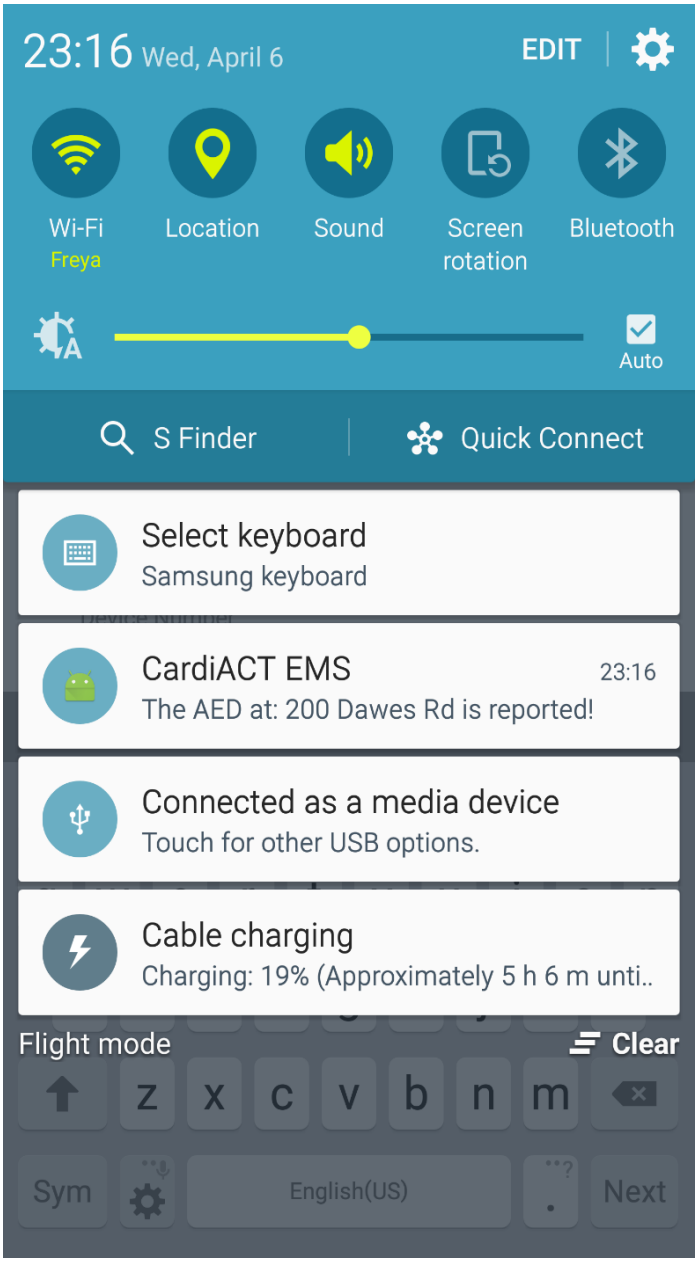

Figure 14 [EMS End]

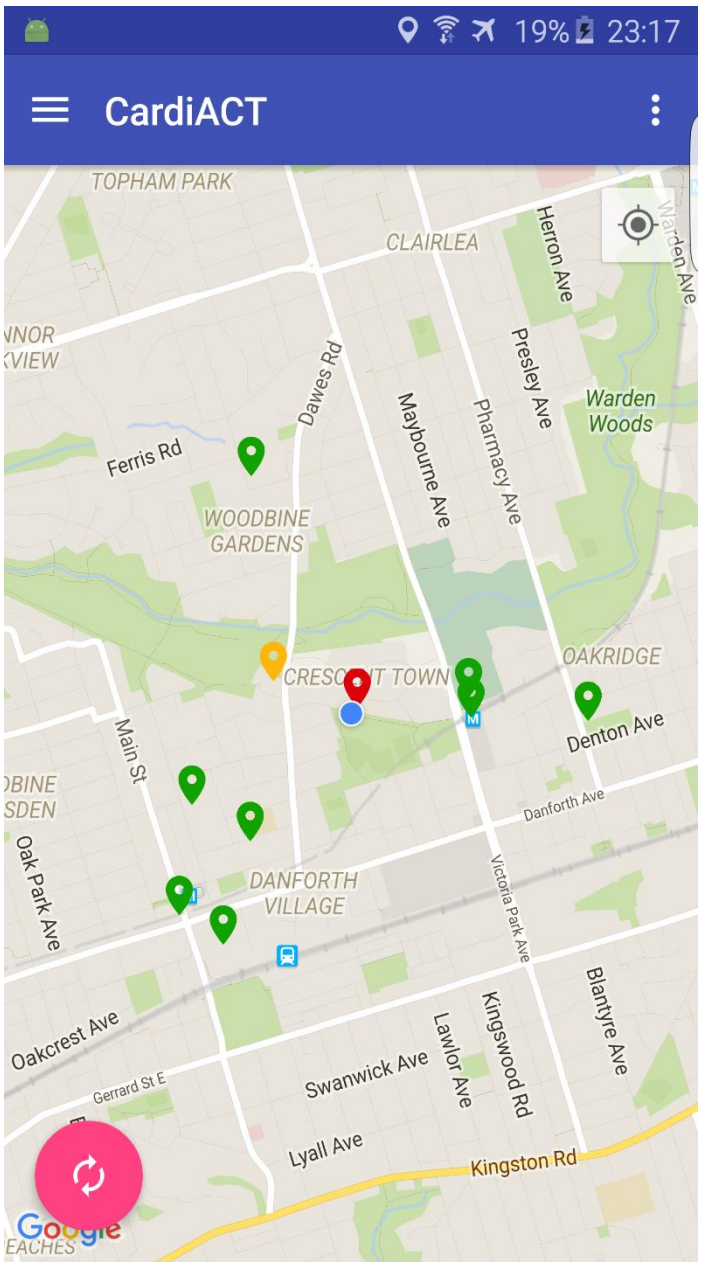

Figure 15 [Bystander end]

- **AED management system**

1) EMS end can add, delete, and edit AEDs from the AED database (Figure 16 and 17).

2) From the EMS end, the reported AEDs will be listed first (Figure 18).

3) EMS end can accept or ignore reported AEDs information (Figure 19), after the reported AED has been verified by EMS end, the YELLOW pin of that AED on map will turn GREEN again.

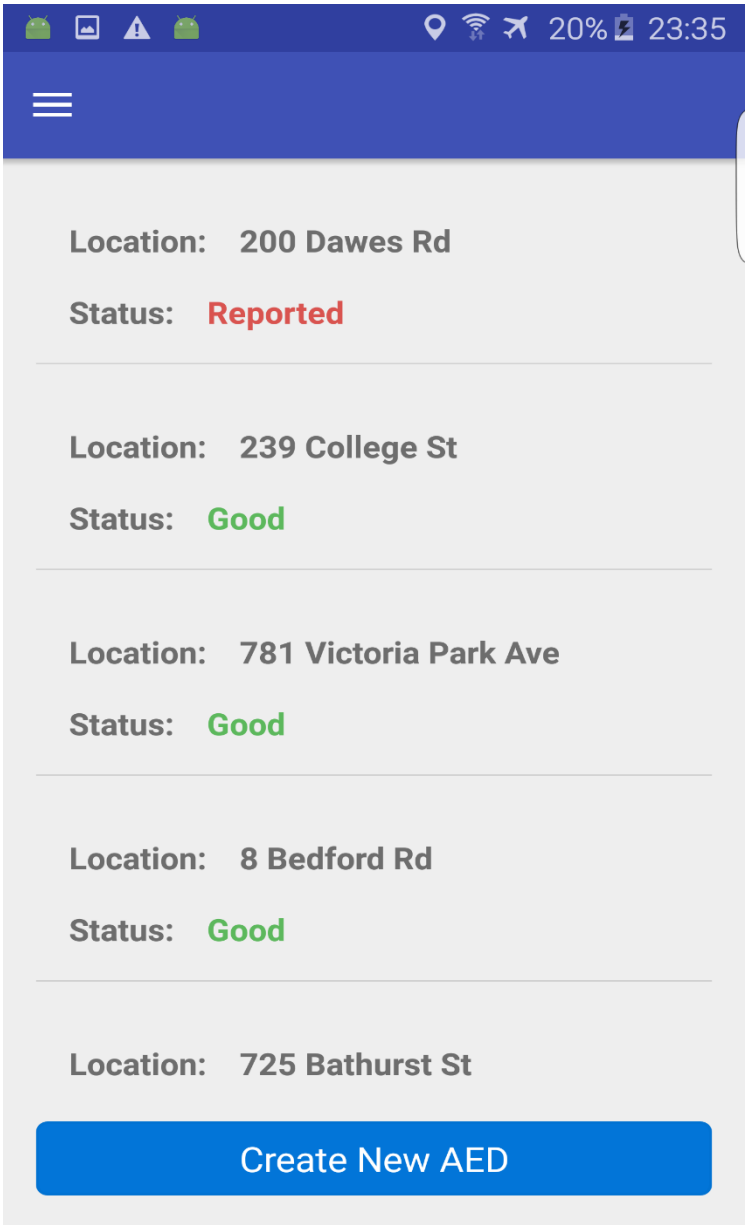

Figure 16 [EMS End]

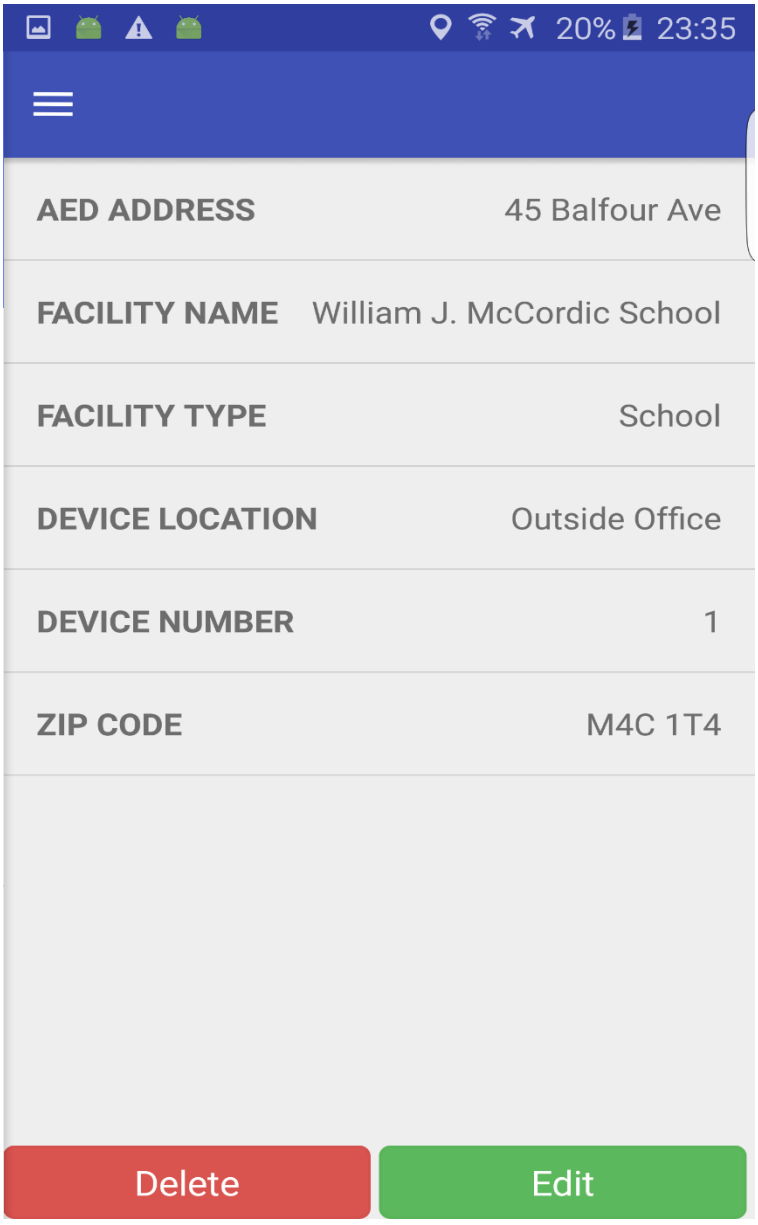

Figure 17 [EMS End]

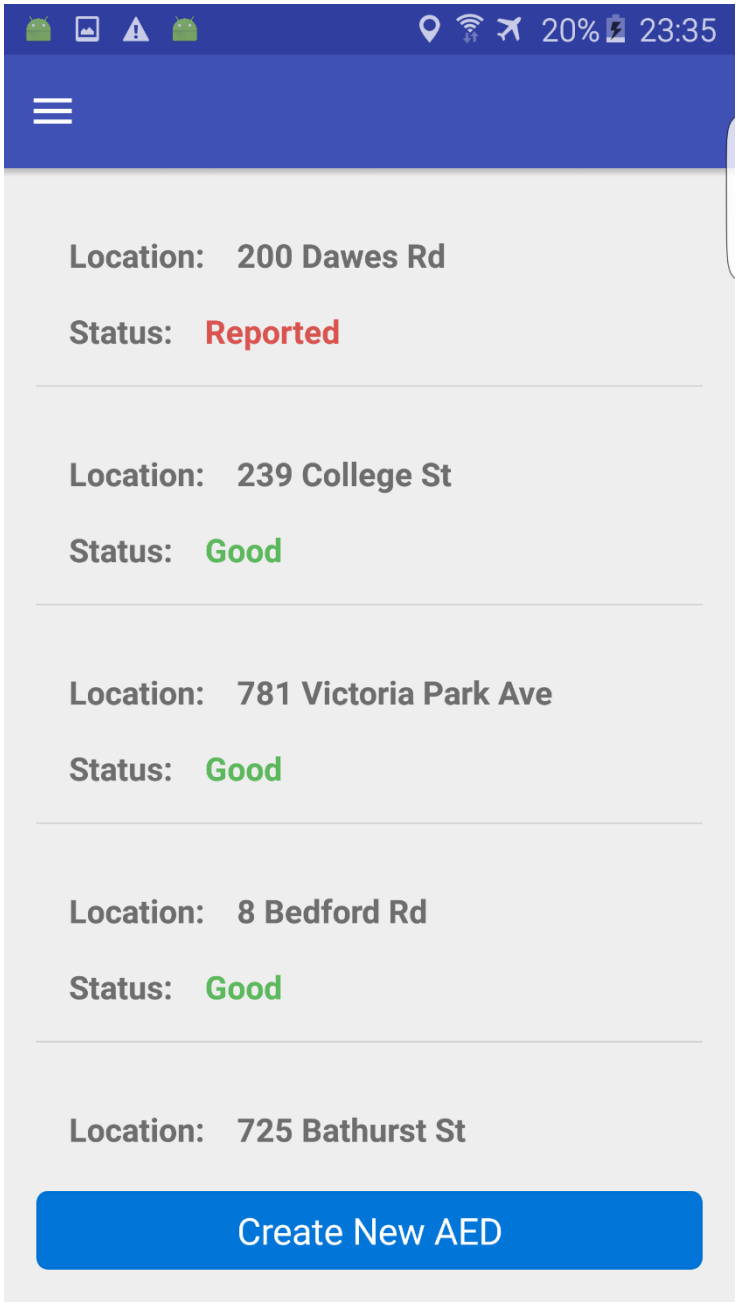

Figure 18 [EMS End]

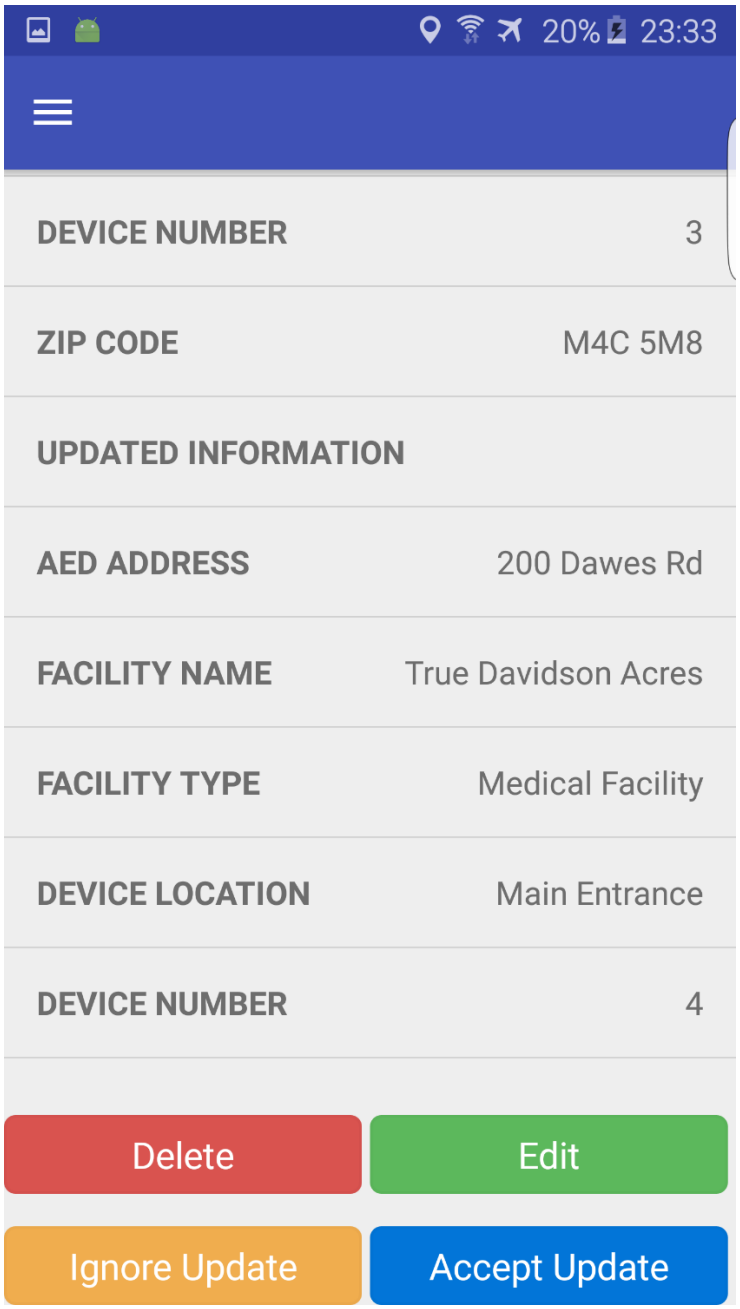

Figure 19 [EMS End]

- **List views for managing emergency event and AEDs**

1) We created AED list view (Figure 18) and emergency event list view (Figure 20) on EMS end, so that EMS could manage things easily.

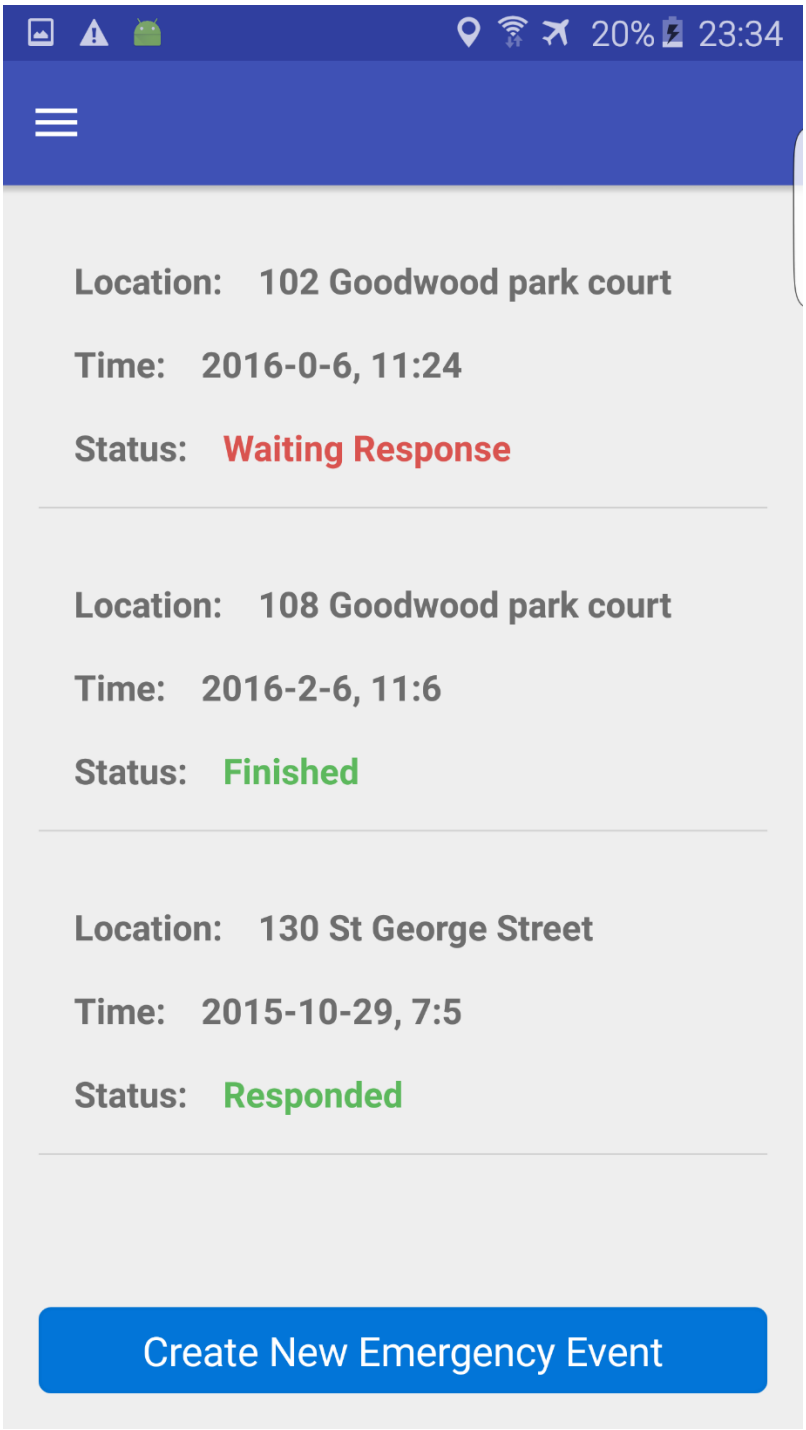

Figure 20 [EMS End]

- **Custom push notification receiver**

1) We have added an action button for event push notifications (Figure 21)
2) If we tap the push notification, we will see full screen details of the emergency event and can choose to either accept or decline the event (Figure 22 and 23)

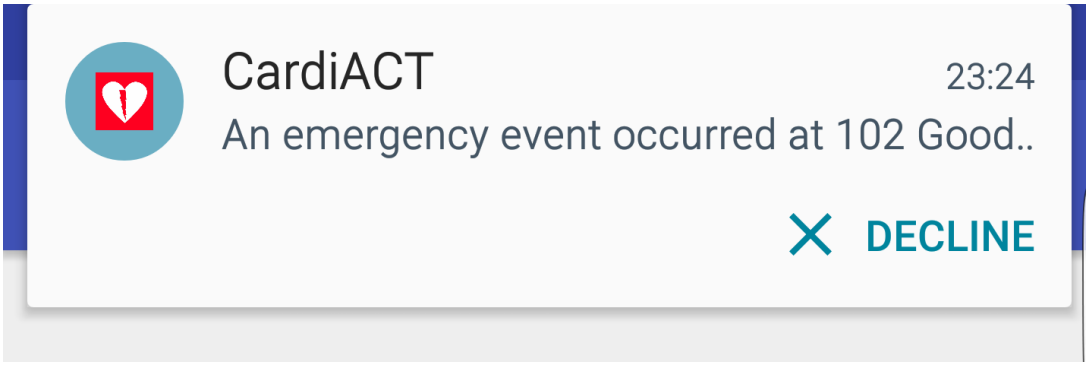

Figure 21 [Bystander End]

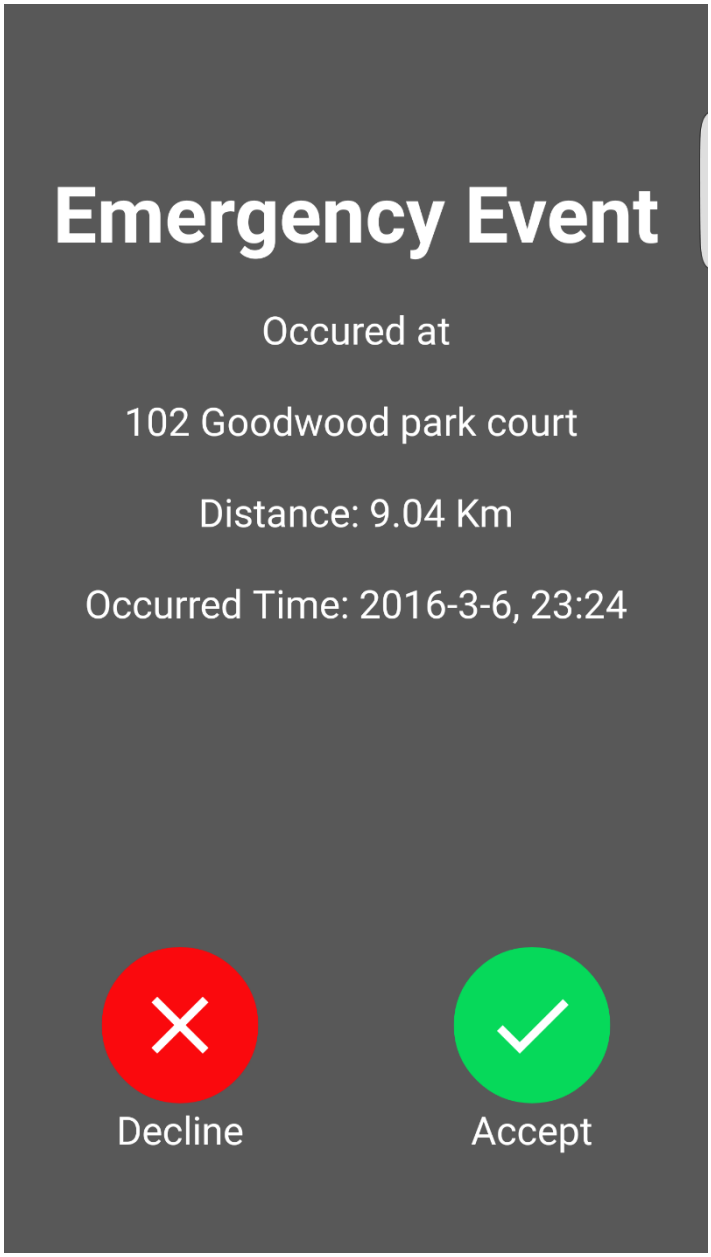

Figure 22 [Bystander End]

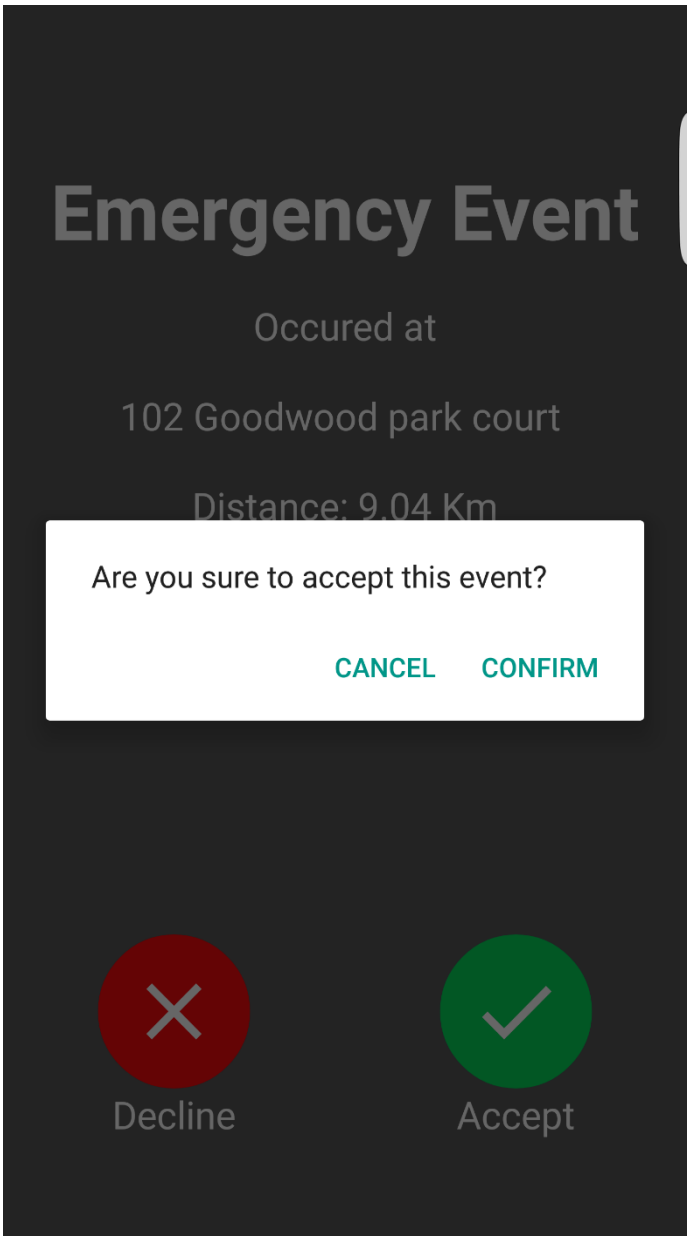

Figure 23 [Bystander End]

- **Treatment/CPR Instructions**

1) A bystander presses the “Arrived” button (Figure 11) once the bystander is with the victim. CardiACT will then show the CPR Instructions with audio (see Figure 24).

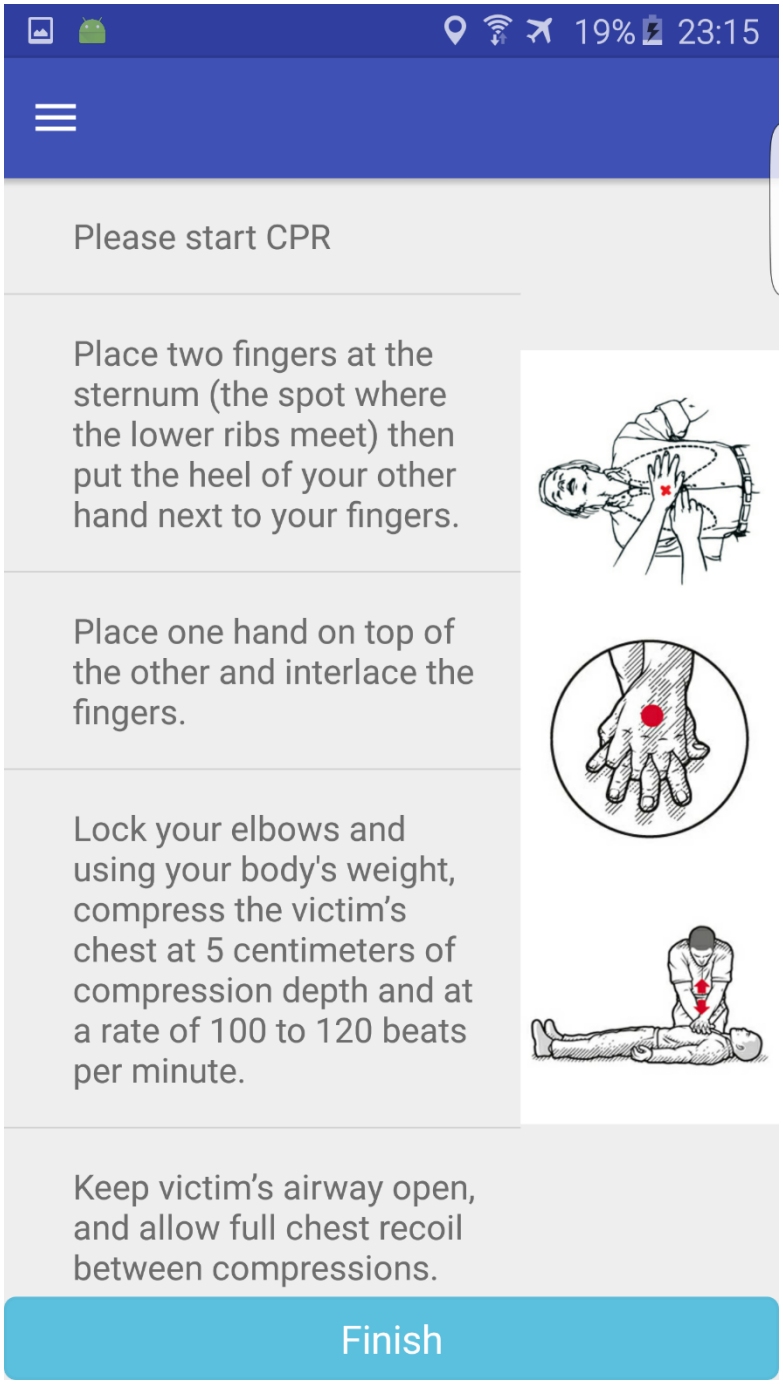

Figure 24 [Bystander End]

- **Authority Verification**

1) Bystander are requested to login when they want to accept an emergency event or report an AED error (Figure 25).

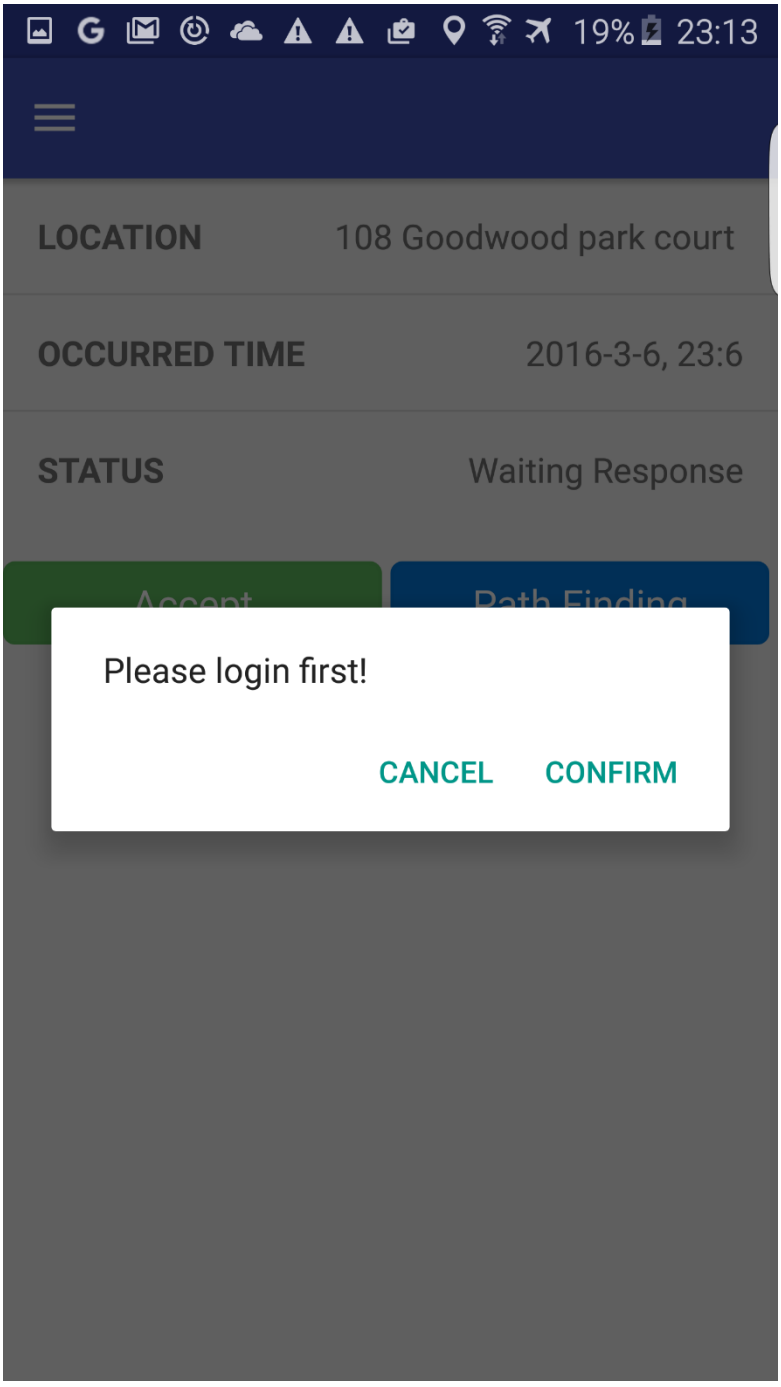

Figure 25 [Bystander End]

Part 4 - What did you learn?

Overall, the course was very vigorous and a great learning experience both in technical abilities and soft skills. Below are 3 aspects highlighting what we learned.

- **Clearly defining your goals**

We initially proposed supplementary novel and unorthodox features, including augmented reality and bystander level diagnostic tools, to help improve treatment of OHCAs. This resulted in an overly complex design that distracted from the main purpose of the app. Augmented reality seemed like a useful way to enhance the response system to help bystanders locate AEDs. However, a simpler means of achieving the same goal is through organized documentation and collection of AED information. By including pictures as well as location descriptions of the registered AED, bystander responders would be able to just as easily find the AED. We learned by focusing on a design which is simple and feasible, we can improve utility of the app.

- **Importance of communication**

Collaboration and communication is very important in the class. Our group kept in constant contact throughout the year and our healthy discussions promoted the critical analysis of the design and allowed us to converge to our final design.

The course also taught us the importance of communication outside of the group. Presenting your design to the stakeholder and audience is extremely important. Taking time to plan out the structure and flow of the presentation is essential to show all the strengths of the design and engage the audience. This course really allowed us to help improve our presentation skills and we found this to be very helpful for our personal growth.

- **User testing and debugging**

User testing and debugging was critical for the development of the app. We found out one of our major features, GPS location, was not reliable indoors halfway through the project by actually testing the app. We then placed emphasis on testing the app in numerous locations real world locations, including confined rooms and basements, to ensure functionality properly.

We should have begun testing much earlier in the design process. Problems could have been discovered earlier and we could have alleviated stress on the group in preparation for the final prototype. We learned while implementation of a feature is one achievement on its own, consistent testing and debugging is required to complete the design process.

Part 5 - Contributions

•Jingnan Chen (Programmer)

- Connected the app with Parse Server
- Developed the path finding capabilities
- Debugged/Reviewed the profile management system
- Debugged/Reviewed the AED reporting and management system
- Developed the emergency event response and management system
- Debugged/Reviewed the AED/emergency event assignment system
- User testing and Quality assurance
- Writing and proofreading reports

•Zixuan (Freya) Yu (Programmer)

- Connected the app with Parse Server
- Developed the map view with displayed information of both ends
- Developed the profile management system
- Developed the AED reporting and management system
- Developed the emergency event response and management system
- Developed the AED/emergency event assignment system
- User testing and Quality assurance
- Writing reports

Christopher Sun (Specialist)

- Problem/Idea formation
- Established user decision pathways for app use
- Data collection for AED locations
- Develop optimization model for bystander deployment/logistics
- Development of slides + script for presentation
- Writing and proofreading reports
- User testing and Quality assurance
- Provided background research for bystander treatment

Part 6 - Specialist Projects: Specialist Context

- **Practical application and implications:**

This application has tremendous implications in the world of resuscitation science and treatment of OHCAs. Treatment initiatives have begun to expand towards using innovative technology to help improve survival. Mobile apps have received a lot of attention and are being developed across the globe. In the US, “PulsePoint Respond” provides a bystander cardiac arrest response system to over 600 communities. The mobile app “Staying Alive” has also developed a bystander response system that is functional in France, Belgium and Switzerland. However, there has not been implementation or development of any apps that focus on OHCA treatment in Canada. This is major opening in the market and gap in treatment that needs to be addressed. Each country has differences in structure of emergency medical response systems, regulations for medical related apps and devices, healthcare systems, and political biases. A one size fits all solution is not possible. Overall the app has enormous potential in terms of practical applications and improving survival.

- **Research implications:**

Bystander response has been shown to improve survival of cardiac arrest, however many academic studies which have examined this were conducted in a controlled environment or a single location setting. Accurate measurements of when bystander CPR and/or AEDs are applied to victims have never been available in real life scenarios because there is no system which collects this data. For example a bystander, in the heat of the moment, will not know what time they reach the victim and when they apply CPR. The only way to get this data without the app would be to examine security footage capturing the event, if there was any, and examine their timestamps. This would be very costly in terms of time and financial resources. Using data collected from this app, researchers can determine exact response times of bystanders and determine the relationship between survival and time of bystander treatment. The relationship of the "distance between an AED and the victim" and "AED use/shock delivery" can also be determined through data from the AED reporting system. This can improve AED placement guidelines by allowing policy makers to estimate how many AEDs are needed within a given target area. Additionally, surveying the registered users can provide valuable insight towards increasing AED use, and regarding factors that deter them from responding.

- **Limitations:**

The limitations of the application should not be overlooked and are two-fold: 1) for the app to be put in practice, willingness, financial support, and technological savvy from a local EMS group is required; 2) data from this app will still not be able to capture the unknown time between the actual arrest of the victim, and when the victim is found and EMS is notified. This is a known problem in the field.

Part 7 - Future Work

Our group is focusing on the following 4 features for future work:

- **Enhanced User Assignment model**

The current assignment algorithm notifies all users within a 400m radius of the victim and directs them to an AED if they are untrained in CPR and straight to the victim if they are trained. To optimize the response and notification system, a model can be implemented to minimize the distance traveled by all notified bystanders, while prioritizing CPR trained responders to go directly to the victim (Appendix 1). This model requires an integer programming solver to be implemented into the app.

- **User Profile: Specified Response Area**

Bystander response is still not guaranteed with registered bystanders. To improve the likelihood of response, we would like to implement a function that allows bystanders to define an area which they are comfortable responding in. This would allow them to be familiar with the environment and know of the exact location of AEDs in the area in case of an emergency. Bystanders would be able to create a response polygon on a map which indicates where they would like to be a responder. The bystander would only be notified if both their GPS location, and location of the victim are within the boundaries of the polygon.

- **AED reporting system: Picture/Directions**

Allowing bystanders to report geotagged pictures or videos will help EMS verify and locate AEDs to be included in the app - reducing the number of missed or falsely reported AEDs. This information can also be included in the AED information pins to help responding bystanders obtain the AED for treatment.

- **Enhanced accuracy of GPS Location**

GPS location is critical for the functionality of the application in both the bystander response system and AED reporting system. Creating a foolproof system for the app to determine both indoor and outdoor locations is an aspect of the app that will need to be monitored at all times if the app is put into the practice.

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Appendix 1 - Optimization Model

Pseudo-algorithm for assignments:

1) Obtain coordinates/lat and long of all AEDs and bystanders within 400m of the victim
2) Calculate all distances between bystander and AEDs and AEDs and victim
3) Create an binary array indicating if bystander is trained in CPR
4) If no AEDs within 400m send all bystander to victim
5) If AEDs, then run assignment model (see below)
    a. Use x_{ij} and y_{ij} outputs as assignment of bystanders to designated location
6) Refresh if AED has been picked up bystander
    a. Repeat from step 4)

The formal description of the optimization model we used is given below.

Variables:

- x_{ij} is a binary variable indicating whether bystander *i* is assigned to victim *j.*
- y_{ik} is a binary variable indicating whether bystander *i* is assigned to AED *k.*

Data:

- C_{ij} is the distance in meters between bystander *i* and victim *j.*
- A_{ik} is the distance in meters between bystander *i* and AED *k* plus the distance from AED *k* to victim *j.*
- T_i is a binary indicator for when bystander *i* is trained in CPR.

Sets:

- J is the number of victims in the area (usually 1)
- I is the number of responders being notified
- K is the number AEDs in the area

Minimize $\sum_{i=1}^{I}\sum_{j=1}^{J} C_{ij}x_{ij} + \sum_{i=1}^{I}\sum_{k=1}^{k} A_{ik}y_{ik}$

Subject to

(1) $\sum_{i=1}^{I} x_{ij} \geq 1, \text{for all } j = 1, \dots, J$

$$\sum_{j=1}^{J} x_{ij} + \sum_{k=1}^{K} y_{ik} = 1, \text{for all } i = 1, \dots, I \quad (2)$$

$$\sum_{j=1}^{J} x_{ij} \leq T_i, \text{for all } i = 1, \dots, I \quad (3)$$

$$x_{ij} \in \{0,1\}, \text{for all } I \text{ and } J \quad (4)$$

$$y_{ik} \in \{0,1\}, \text{for all } I \text{ and } K \quad (5)$$

Constraint descriptions:

(1) At least 1 bystander is assigned to victim j for response
(2) Maximum of 1 assignment per bystander
(3) The bystander i must be trained in CPR to respond directly to victim
(4) Assignment variable is binary
(5) Assignment variable is binary