Road Safe Phone Case

Final Report

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Introduction

Acknowledgement
This project has been made possible by the Iowa State University ECpE Department's professors and resources. The team is grateful to have the opportunity to receive technical advice and guidance from Dr. Diane Rover. She has served as a knowledgeable point of contact as the project, providing valuable information to help the project progress. The individual that proposed this life-saving device, Christine Shea-Hunt, is also the sole provider of financial aid for the project materials. The team is committed to using the funds wisely, so that the road safe case will be created efficiently and inexpensively. The Electronics Technology Group (ETG) has also provided the team with equipment and advice that have improved the product's design.

Problem Statement and Solution
Phones have become an integral part of everyone's lives. Communication, entertainment, and organization are only a few of the advantages a phone offers. However, this small device can also serve as a fatal distraction. According to the Centers for Disease Control and Prevention, in the U.S. alone, approximately 9 people are killed and more than 1,000 injured in crashes involving distracted drivers daily (2017). Talking on the phone, sending a text message, using navigation systems, and more are just a few ways that drivers easily endanger themselves and others on the road.

To help make the road a safer place, the amount of distracted drivers must be reduced, which can be accomplished by removing the temptation of a phone. The approach to this problem will be to create a device that locks away the car key, unless the phone is swapped for the keys. Progress towards safe driving can be achieved by creating a two-sided case, in which one of the two sides always remains locked. One side will securely store the keys until the other side detects, verifies, and secures the driver's phone. Then, to reacquire the phone, the keys would need to be returned, verified, and secured in the case. In case of emergency, access to either the phone or keys will be made available, and the case can be reset to function normally and protect the drivers and the roads once again.

Operating Environment
The road safe case will mostly operate in a car, which should endure various temperatures. The case will need to be able to withstand normal and hazardous weather conditions inside a car, whether it be extreme cold or heat. The case should also fit in a spot within the car so that it remains stationary while in a mobile vehicle. The interior of a car also often gathers dust and at times trash, though this does not pose a threat to the case unless there was direct interaction with the case. Other potential environments are inside a home, because the case will portable and may be moved to other locations if the user needs to take the case to a parent to reset it or for other reasons. However, the case does not have functions that primarily relate to being outside of the car environment.

Intended Users and Intended Uses

The intended use of the road safe phone case is as its name implies. To keep the roads and drivers safe, especially drivers that are easily distracted by their phones. The case restricts the driver's ability to access their cell-phone while driving, which will increase the safety of driving for themselves and others significantly. More specifically, the road safe case not only locks away the driver's phone, but their car keys as well. In order to access one item, the other must be locked in the case. Audio capabilities such as GPS or music can still be utilized while the phone is in the case; however, the screen will not be visible.

Studies have shown that compared to adults, teenage drivers are four times more likely to get into car crashes or near-crashes when talking or texting on a cell-phone, with approximately 21% of fatal teenage driving accidents resulting from cell-phone distractions (Edgar Snyder and Associates, 2016). As a result of these trends in distracted driving, the road safe case will primarily be used by teenagers. However, an AAA poll that showed while 94% of teen drivers acknowledge the dangers of texting and driving, 35% admitted to still doing it anyway (Edgar Snyder and Associates, 2016). This demonstrates that many teenagers would not impose phone restrictions on themselves. Thus, the case will be marketed to parents who have the ability to oversee their children, and choose to enforce safer driving for them.

Distracted driving due to cell-phones is not only abundant in teens, but especially in drivers in age groups above 20 years-old as well (National Highway Traffic Safety Administration, 2012). Thus, the road safe case may also attract responsible drivers that choose to limit their distractions on their own, unlike a young teenager whose parents may buy the product for them. However, to use the product to its full potential, an additional individual should assist the driver by serving as the "parent" figure and holding the driver accountable for maintaining use of the case and not engaging in distracted driving.

Assumptions and Limitations

Assumptions:

- The case will operate off a battery as opposed to a car source.
- The case will only detect if an object placed inside is a phone and a key.
- The driver will only have one phone.
- The driver will be capable of accessing their phone in an emergency.
- The driver has a designated individual in which notifications can be sent.
- The cost to fabricate the case will be under $500.
- The case will be sold to other individuals.
- The case will make the phone screen invisible.
- The case will fit in a car comfortably.

Limitations:

- The system will operate from a battery supply because the case will be portable.

- The phone case will only detect one phone at a time; thus, it cannot restrict other passengers in the car.
- The phone's features, such as GPS or music, will only be accessible through audio because visuals will be covered by the case.
- The case must be small and lightweight to avoid restricting passenger seating, to be easily portable, etc.
- The road safe case will function as a two-person system, so that if the driver uses the emergency access to open it, an emergency contact will be alerted.
- The project must be completed with a budget of $500.
- The end cost of the product should be relatively inexpensive because this product will be made available to other potential consumers.
- The project must be completed by the end of the year.

Expected End Product and Other Deliverables

The entire design of the road safe case will be completed by the end of April, possibly with a prototype as well so that some of the parts can be tested before constructing the end product in the fall. The capabilities of the case will continue to be tested and discussed between the team and the client throughout the year, so that the final, fully-functioning product can be produced by December. The vision for this final product is the physical, portable case that easily fits in a car, and will store the car key and store or release the phone based on the circuitry built and programmed by the team to protect the user from distracted driving. This will require a locking unit powered by a motor and controlled by the Arduino, a GSM module to send emergency notifications, and possibly a printed circuit board for further capabilities.

Related Works and Literature

There is a product that was proposed in 2017 by Michael Maguire to create a "The Shellback Smartphone Safe". The idea was to create a case for the phone that does not lock, instead it can be zipped closed to keep drivers from accessing their phone while driving. However, if a driver wishes to access their phone, they can easily unzip the case and use it. Because the phone has been accessed while driving, the product will send a message to a designated person to inform them that the driver accessed their phone while driving. Due to lack of funding, this project never left the idea phase and was never marketed.

There are also phone applications that can be installed for minimal fees that will restrict a driver's access to the phone while driving at a certain speed. For example, an app called Drive Smart will allow users to direct incoming calls to voicemail, mute incoming texts and send an automatic response that he/she is currently unavailable (P, 2017). However, the biggest problem with an app such as this is that instead of avoiding people from using the phone, it tries to change certain functionalities of the phone such as muting the text and directing incoming calls without doing so in the most efficient way, which is ultimately to prevent the driver from reaching their phone during driving. Therefore, the case became a more desirable potential solution for removing the distraction of dangerously using a phone while driving.

The other main function aside from restricting phone access through simply trust or incentive or through an app stored on a phone is the physical locking feature that provides a restrictive barrier. The road safe case project proposal resembles a safe; however, with two sides for storage and with conditions that must be met for locking and unlocking. Safes open when given a number combination on a lock or a PIN pad or with a key. This approach for locking the phone and key is insufficient because the user can choose to open the case while driving, which is the issue at hand. Traditional safes also typically have one large storage area rather than separated compartments because it is simply a storage area; thus, there is no help for object detection features that can be re-implemented into the product. A new design for an object recognition subsystem will need to be created for the project.

Project Design

Proposed Objective

For this senior design project, the team's goal is to eliminate the fatal distraction from the cell phone usage while the user is driving and minimize the chance of a car accident. In order to achieve this goal, the team followed the client's hardware approach to minimizing distracted driving. This involves creating a physical case that will identify the driver's key and phone, and keep one locked away at all times. If the user is in a situation in which they must have access to both items at the same time, an emergency button can be pressed to send a notification to the user's parent. The system diagram below shows this functionality as well as the components used to implement these tasks.

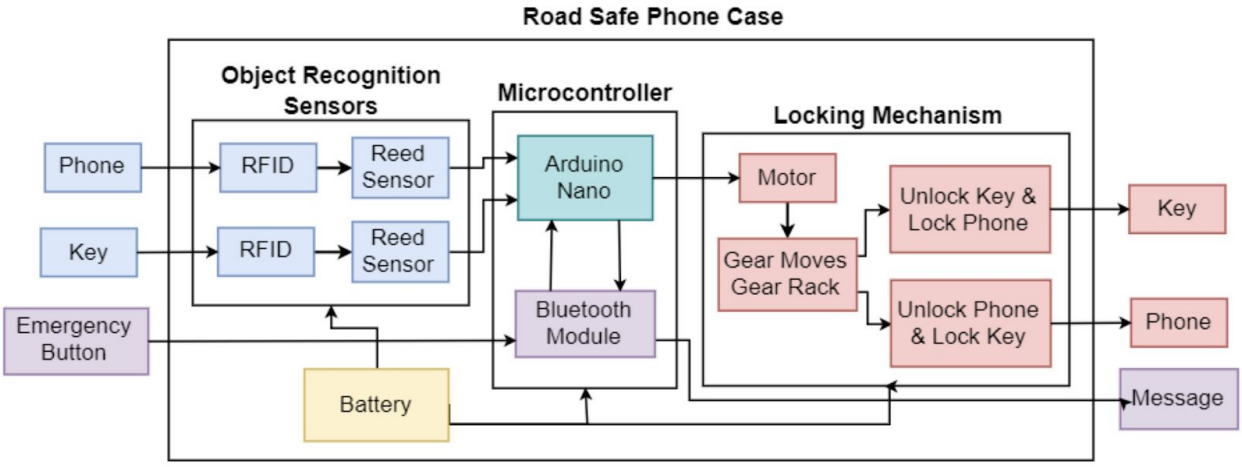

Figure 1. System Diagram

Functional and Non-Functional Requirements

Functional:

- Sensors should identify the driver's phone and car key only
- Locking mechanism should only lock one side of the case at all times
- Bluetooth connection between phone and case should enable sending messages
- Parent of driver will receive notifications from a designated app only

Non-Functional:

- Components will rely on a 9V battery supply
- Notification system will use wireless communication between components
- Case should lock within seconds of correctly triggering sensors
- Case should be able to withstand a drop from five feet
- The phone's features, such as GPS or music, will only be accessible through audio

Constraints Considerations

The timeline for this project is within two school semesters, with a small possibility of the work being done over the summer because team members have other responsibilities that must be tended to during break. This is a relatively small amount of time to create a fully functioning project especially if unexpected events, such as a broken part or faulty design are discovered when the product is being constructed during the fall. As for the parts themselves, it can be difficult to find components that fulfill to perform the desired functionalities. Thus, compromises must be reached. Another constraint to searching for parts is cost as well, with a limit of $500 to spend on resources.

As for engineering constraints regarding the case, it has been difficult to create a universal design for all phones and keys. Some of the constraints the team has followed is that the case must be large enough to fit smaller Android phones. At the same time, the case must be small enough to comply with campus 3D printing restrictions and to be carried in one hand. Lastly, the team desires that the system operate for five hours from the battery supply.

Testing Requirements Considerations

Testing requires that the mechanical linkage operates in a precise manner to have correct input and output signals to electrical components. The road safe case will need to operate in different cars and with different phones and keys. A variety of objects and environments must be accommodated for.

The criteria for each subsystem test of the project is provided below:

- For the locking mechanism testing, the team needs to ensure that the mechanical linkage operates in a precise manner to have correct input and output signals to electrical components.
- For the cell phone and key fob sensing testing, the team needs to ensure that the RFIDs are coded correctly and give precise input and out when the objects are placed into the box.
- For the cover open and close sensing testing, the team needs to ensure that the mechanical components are precisely aligned with the electronic sensing devices and perform the accurate mechanical and electrical operation.
- For emergency override system testing, the team needs to ensure that the electrical circuit has the correct design and bypass correct safety features.
- For the intrusion detection alert system, the team needs to ensure that the GMS module is compatible with the existing circuit and send out an alert message when the emergency takes place.

Testing Phase 1: Component Testing
In this stage, the team tested functionality of the basic elements in our systems which includes the battery life,sensors to detect the lid, locking systems, sending notification via phone app, emergency situation release, consistency of the 3D printed case, RFID Card edit and RFID Card read. The following criteria for each component and their respective tests are described below:

Battery life: The battery should be able to last for 5 hours. -> Connect the battery to a circuit with a motor that has similar power compared to our system to determine how long will the battery runs out.

Locking System: The internal locks should be able to lock and unlock as expected. -> Connect the motor to the gear and gear rack to see if it can lock the case correctly. When one side of the box is locked, make sure the other side is unlocked.

RFID Card Edit and Read: Be able to edit and read information to the two RFID Card.
Sending notification: be able to send notification when users lock/unlock their phones, their parents should be receiving notifications. -> Using RFID card editing software to modify the card and read the output to see if it is already changed. Also, using the RFID card to approach the reader and analysis the output of the reader.

Consistency of the 3D printed case: The case should be bent easily and should be waterproof. -> Use a model phone to play the role of the actual phone and lock it inside the case. Then drop the case from a 1 meter height to see if the case itself or components within are damaged.

Emergency Situation Release: The system should be able to unlock when the user click the emergency button, but in the meantime, their parents should receive a notification. -> Integrate button into Once the button has been pressed, the arduino will use GSM module to send message to parents phone.

Application Testing: When the case is locked, the system should send a text message to the parents. Also, when the case is unlocked, the system should also send a text message to the parents. -> Before that, each parent should sign up their account. Here, we are testing the user sign up and sign in.

As the user put in their account and password, the dialog pops out with the text successfully register. This means the database has already updated the information about this new user, and its related information should be stored inside the database.

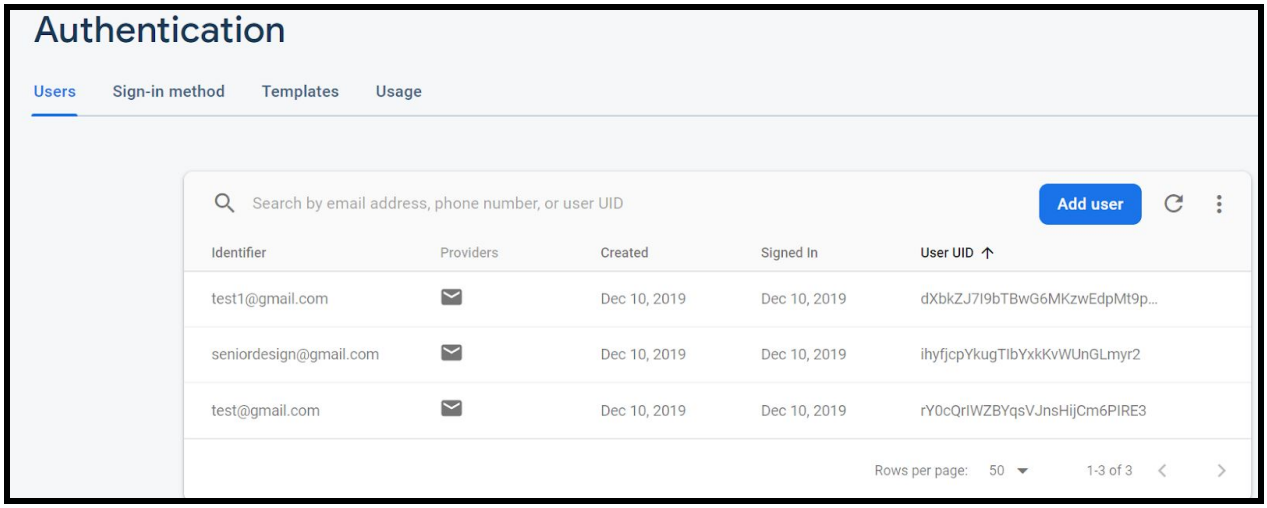

Figure 2. Authentication Page

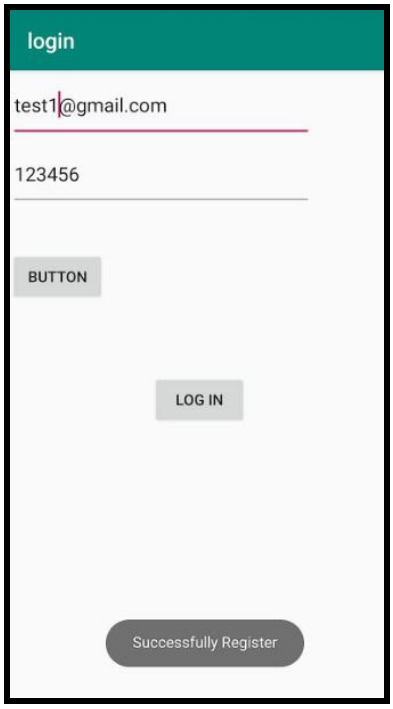

Figure 3. User Login on App

After that, the users should be able to log into the chat room where their messages should be seen in the screen. The first picture contains the message from the previous. After we enter the message Test2, this new message has been displayed on the screen. Also, if we check the database, the Test2 message should also be inside our database.

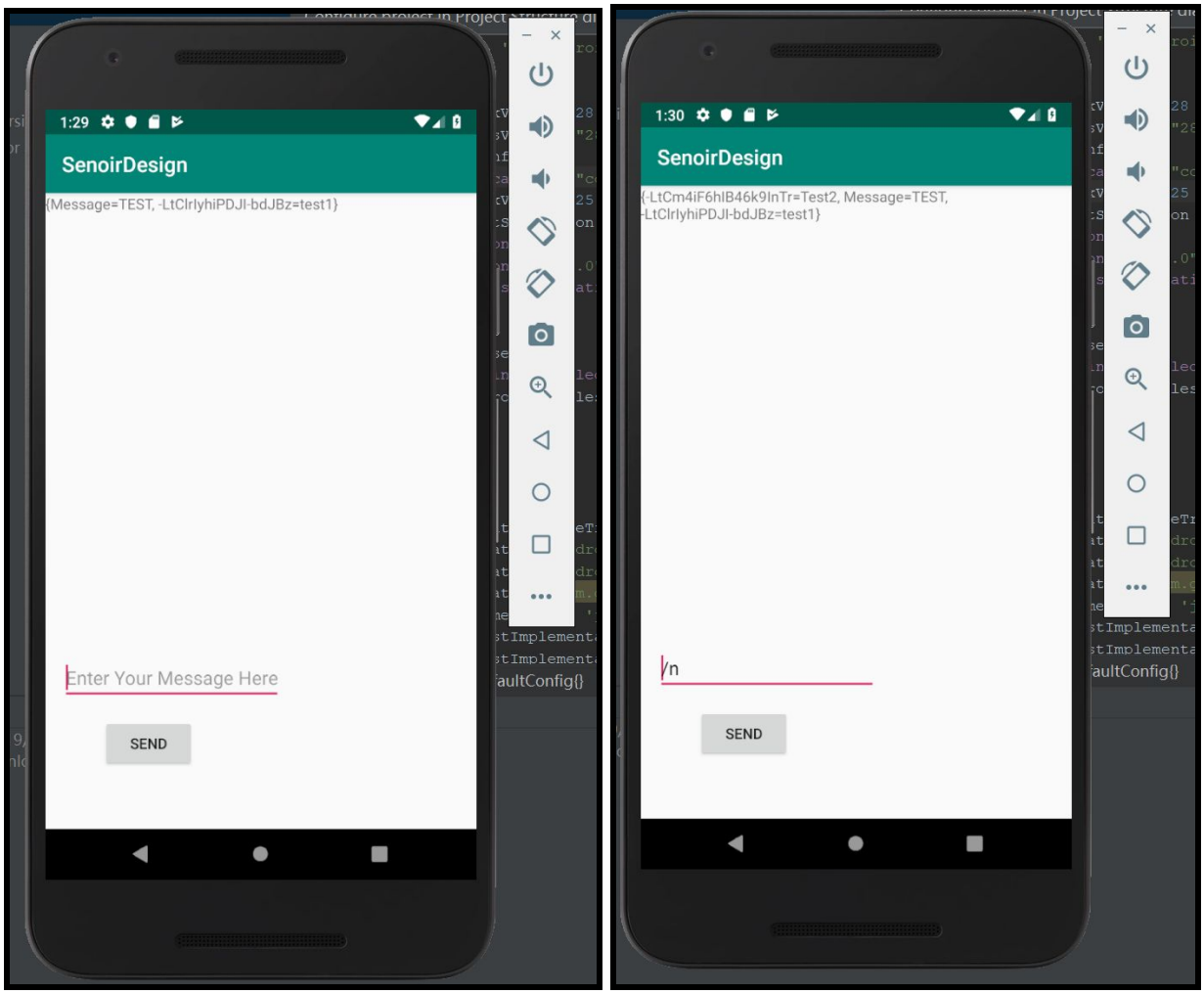

Figure 4. Messaging Test

Figure 5. Realtime Database

Testing Phase 2: Proof of Concept Prototype

After successfully testing each component in its own subsystem, the assembly of each into the entire system began. To verify the system works together, each part was connected using a breadboard, jumpers, and a small 3D printed case, as shown in the image to the right, to make the functionality easier to observe. Besides, breadboard and jumpers would be more flexible when we make some changes on the connections.

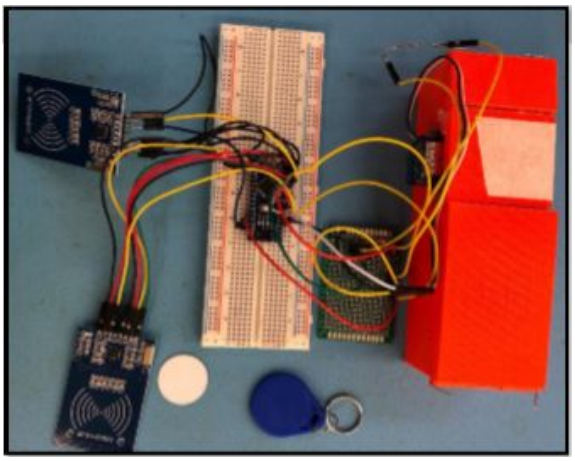

Figure 6. Concept Prototype

Results: The initial vision of this device involves a two sided case. Side 1 of the phone case would Hold the key or key fob necessary to operate the vehicle.
The driver would open Side 2 and place their cell phone in the case. When the cell phone is in place and the Side 2 door is shut and locked, Side 1 door would automatically snap open to deliver the key or key fob, thereby eliminating the use of a cell phone while driving. The phone could not be retrieved until the key/key fob is placed back into Side 1. Once the key/key fob is back in place, the door to Side 2 would open allowing access to the phone.

Testing Phase 3: Engineering Prototype

Once the system had the breadboard assembled version working, we want to solder all the parts together because it will save us a lot of space and it is easier to put the system into the case.

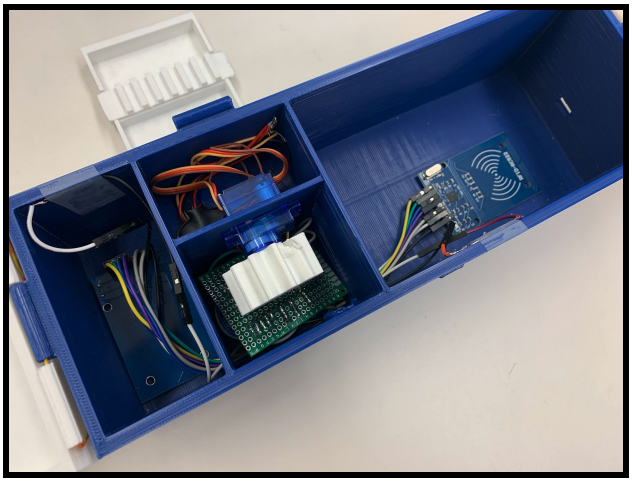

Figure 7. Engineering Prototype

Results: During this process, smaller wires were used to fit inside the case. The connections between each component were soldered and larger components were taped or glued in place. During the testing, the team has observed that the lid sensors were fragile and easy to break. Also, the RFID reader and locking mechanism did not perform proper locking sequence. The team troubleshooted the connection of each component and reassessed the code. However, during the retesting, the input port of the microcontroller burned out. Though, the battery was still able to supply voltage to the case, the team could not perform further testing because the code could no longer be adjusted.

Statement of Work

Task 1: Object Recognition

- Objective: To successfully detect whether the object in the case is strictly a phone or a car key.
- Approach: Using a charging port to detect the input and recognize the owner's phone. Another sensor can be used to verify the phone and key as well, such as a proximity sensor or a form of machine learning with a camera if that is affordable and compatible with other parts.
- Expected Results: If the driver is to put in the wrong object to attempt to access the phone while they are driving, the case will not unlock because the object is incorrect.

Task 2: Locking Mechanism

- Objective: To keep one side of the case sturdily locked at all times. Throughout this semester, the team has made a significant improvement on the locking mechanism. The new locking mechanism design saves a lot of power and pin usage for the Arduino board. The old design requires two circuits and two electrical bolt locks for each side of the case. The bolt lock does not have an active safety feature and can easily gain access by disconnecting the power source or breaking the lock coil. Also, electrical bolt lock needs to be energized continuously to maintain the locking condition, which consumes a lot of power.
- Approach:The new locking mechanism design is to use a motor operating lock which is made of a servo motor and a gear rack. The operation of the motor lock based on the output of the object detection sensor. The control for the circuit will be coded using a microcontroller.
- Expected Results: The motor operating lock only energizes when the status of the case changes, which saves a lot of power. Also, the motor operating lock has stronger safety feature than the bolt lock; even the motor is de-energized, the case can still maintain its locking condition.

Task 3: Emergency Access and Alert

- Objective: To successfully resolve the situation when the driver encounters a car accident and needs to use the phone for seeking help. In this instance, the case should automatically open. The parent or designated individual should also be alerted that the user is in an emergency. Afterwords, the case should function normally again.
- Approach: An emergency button will be placed on the case that will cause the circuit to override the circuit and open the locked side. The team is considering using a Global System for Mobile (GSM) communication module, which will work but is expensive. The search for an alternative alert approach is still under progress.
- Expected Results: The case will always function normally unless in the case of an emergency, in which a designated person will be notified.

Task 4: Physical Case

- Objective: To successfully make the physical case with pre-designed space to integrate the circuit components as well as the phone and car key. This includes making the case function for smart keys, which allows the driver to keep the key fob pocketed when unlocking, locking and starting the vehicle, meaning that the car can start as long as the

key is anywhere inside the car. Working around this would require blocking the signal between the smart key and the vehicle.

- Approach: Record measurements of circuit parts, locking tools, various phones and car keys, and other materials to design a case layout. Then use 3D software to create the layout of the case and a 3D-Printer to supply the materials and make the physical case. Aluminum or another metal is effective for canceling magnetic fields and blocking signals, so a material of this sort will line the inside of the key-holding portion of the case.
- Expected Results: A solid and good-looking case with the space for circuits components that works for old and new vehicles.

Task 5: Testing Product

- Objective: To make sure that all components work together after implementation.
- Approach: The team will test individual components first to make to confirm they work separately. After combining all the components all together, then the final product will be tested as a whole and make sure all the functionalities are still functional and meet the requirements from the client.
- Expected Results: To produce a fully functional and reliable road safe case which meets all the demands from the client.

Project Timeline, Estimated Resources, and Challenges

Project Timeline

The project team was assembled at the end of January, and February has marked the start of the design portion of the project. The initial schedule for the major research and design tasks are represented in the Spring 2019 Gantt Chart below.

Spring 2019 Gantt Chart:

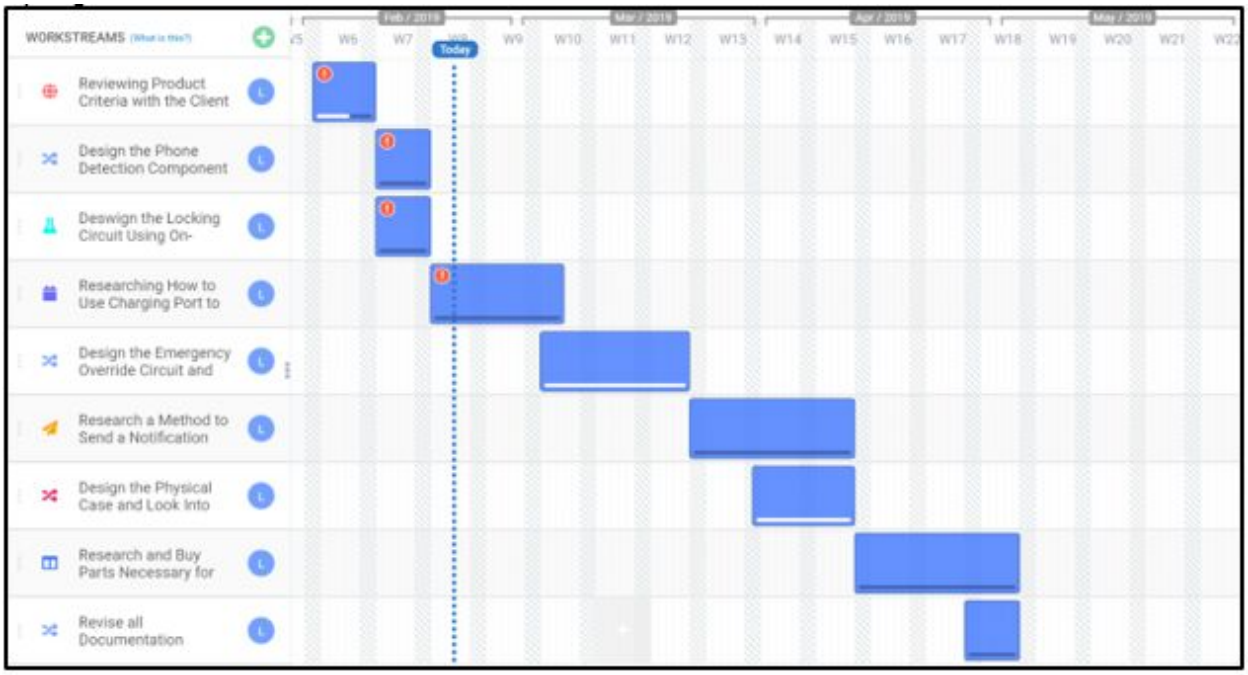

Figure 8: Gantt Chart for Project Timeline during Spring 2019

An explanation of the tasks in chronological order:

1. Review product criteria with the client to ensure the design meets their needs.
2. Design and research object proximity or recognition sensors for the case.
3. Design the locking circuit and test using on-campus resources.
4. Research how to use charging port to detect the phone belongs to the driver.
5. Design the emergency override circuit and reset for normal functioning component.
6. Research a method to send a notification from the case to alert emergency access.
7. Design the physical case and look into materials to build it.
8. Determine the most ideal parts that are essential for the circuits.
9. Revise all documentation needed for the project construction during the fall.

After summer break, the project resumed with the construction portion. The team's initial schedule for building each of the main components are represented in the Fall 2019 Gantt Chart below.

Fall 2019 Gantt Chart:

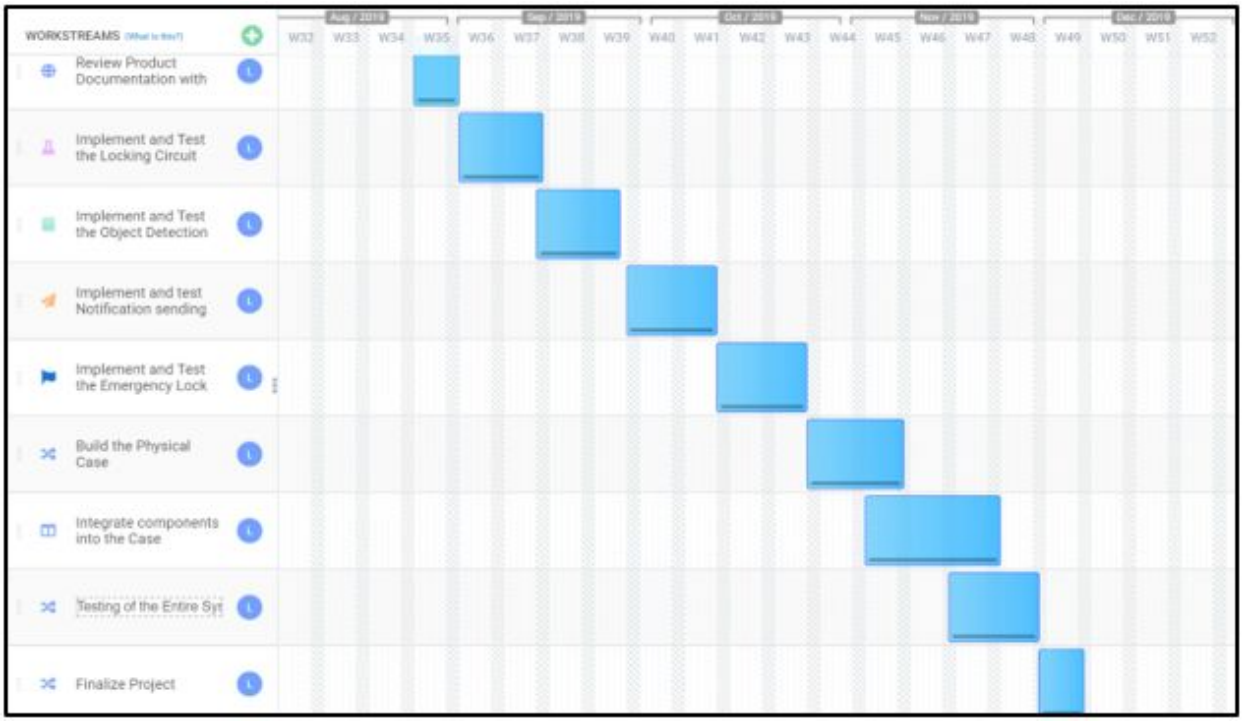

Figure 9: Gantt Chart for Project Timeline during Fall 2019

An explanation of the tasks in chronological order:

1. Review product documentation with client and team as a refresher.
2. Implement and test the locking circuit and verify it works with object detection.
3. Implement, test, and integrate the emergency override circuit into the system.
4. Implement and test the emergency notification sending and reset.
5. Verify that all components work together.
6. Build the physical case to fit all parts.
7. Integration of the circuit components into the physical case.
8. Testing of all the components as an integrated system.
9. Finalize documentation and the physical project itself.

Personnel Effort Requirements

In order to accomplish the goals set out by our project timeline, the team agreed upon spending 6-8 hours a week per member to work individually or with others to find new technical approaches for current project issues. Weekly meetings with the advisor helped to tackle technical difficulties and keep the team on task as well. Constant communication with the client to update the project status and optimize the functionalities of the project has also been important to make sure that the team is on the same page with the client throughout the development of the product. For a final summary of personal contributions, please see the weekly and biweekly reports on our team website.

Other Resource Requirements

Resources that the team has used throughout the project is the campus 3D printing centers, in order to easily construct the case at a low cost. Advice has also been asked from our project advisor or additional professors with other specialities with project components we have contemplated using. Finally, a parts supplier has been necessary to order the project components from the outside of the school, if not supplied by the Electronics Technology Group. This has been achieved mostly through Amazon or other online distributors.

Financial Requirements

This system has several associated costs.The cost of associated components will be high relative to volume production if this product is to be marketed. If the case is produced in high volume, the cost per component will be closer to what is shown in the lowest cost column below.

The team estimated the current cost (excluding shipping and extra parts (packs of 20, etc.) to be equal to $37. The cheapest cost (considering only 3D printing material cost) was estimated to be somewhere between $10 - $15.

Part Name	Description	Quantity	Cost per Each	Lowest Cost
Arduino Nano	LAFVIN Nano V3.0, Nano Board ATmega328P (Amazon)	1	4.66	2.00
RFID reader	RC522 RFID RF IC Card Sensor Module (eBay)	2	1.46	1.00
RFID anti-metal sticker	YARONGTECH 8 x NFC sticker RFID anti-metal (Amazon)	2	0.87	0.75
3D Printed case	Lids, compartments, locking mechanism. Case weight = 300g of material = $6 Charge for using campus printer = $remainder	1	25.00+	$6-10
Circuit components	2 resistors, many wires, emergency push button (free from ETG)	1	0.00	0.25

Servo Motor	Organizer 5 Pcs SG90 9G Micro Servo Motor Kit (Amazon)	1	1.80	1.70
Reed sensor	Reed sensor pack of 20 (Amazon)	2	0.45	0.28
Magnet	To activate reed sensor (Amazon)	2	0.05	0.05
Battery	Non-rechargeable 9V Alkaline battery	1	0.66	0.60

Table 1. Bill of Materials

Conclusion

At this point, the team has achieved most of the functionalities proposed by the client, such as the locking system, device detection, and layout and construction of the case. However, some tasks, such as the emergency notification system, provided difficult for the team to fully implement within the time allotted. Other complications during the integration of the software and hardware for the final prototype resulted in time lost on troubleshooting components that had already been proven to work in earlier prototypes.

Regarding work that is yet to be done, the team is still in the initial phases of the app development and incorporating the app with the bluetooth module. Despite not being able to achieve each functionality, there is a good foundation for another group of engineers to continue developing the product for the client. As distracting driving continues to be a fatal problem, our team plans has kept detailed documentation of our design process, and plans to advise the client to resume development of this project.

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Appendix I: Operation Manual

DISCLAIMER

The following instructions for using the Road Safe Phone Case are compatible for its latest prototype. The design of the product is subject to go under revision before it is introduced on the market, at which time these instructions will need to be updated.

Caution should be taken when using the product to ensure that it is safe from damage and continues to work properly. A firm grip is advised when carrying the case around to avoid dropping and damaging the case. Environmental factors should be considered as well to ensure the case and items within it do not sustain damage from possible hazardous weather conditions, such as rain. As for when the case is in use within a car, careful placement of the case so that it remains stationary during the car ride can prevent damage of the product and the phone inside.

INTRODUCTION

Phones have become an integral part of everyone's lives. However, cell phones also serve as a fatal distraction. Talking on the phone, sending a text message, and using navigation systems when driving can easily endanger a driver and others on the road. The Road Safe Phone Case greatly minimizes distractions by ensuring that an individual does not have access to both their car keys and cell phone at the same time. These instructions will describe the process for setting up the case and each type of situation it may be used in, such as initial use, driving, not driving, and emergency situations.

SETUP

The Road Safe Phone Case will come with two stickers, one to place on the cell phone and one to place on the car key. Each sticker will be designated for one of the two objects, and should be attached to whichever it is assigned to.

This final version of the case will use an app to send notifications from the case to the parent in the case of an emergency situation. Additional functionality may be included in the app when it is produced. However, the app is still in its initial phases, so the setup for this is still pending.

DISCUSSION

Use Case 1: Initial Use

Upon receiving the case, the phone side will be locked. To start using the case, the keys should be placed into the smaller, unlocked side of the case. After the keys have been placed into the case, close the lid. If the correct car key was placed inside the case and the key side lid of the case is closed, the key side will lock and the phone side will be unlocked. If the incorrect key was placed in the case, the case will not do anything, leaving the phone side locked. After the keys have been locked away, the case is now in the "Not Driving" use case situation.

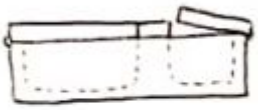

Figure 1a. Initial Case

Figure 1b. Correct Key

Figure 1c. Incorrect Key

Use Case 2: Not Driving

In this situation, the user only has access to the phone because the car key is locked away in the case. This means that the user is not driving and does not need access to their car key, which can cover many circumstances such as studying at school (shown in *Figure 2a.*), being at work, or lounging at home. At this time, the case should remain in an easy to find place so that the user can easily insert their phone into the case to retrieve the car key when they need to drive again.

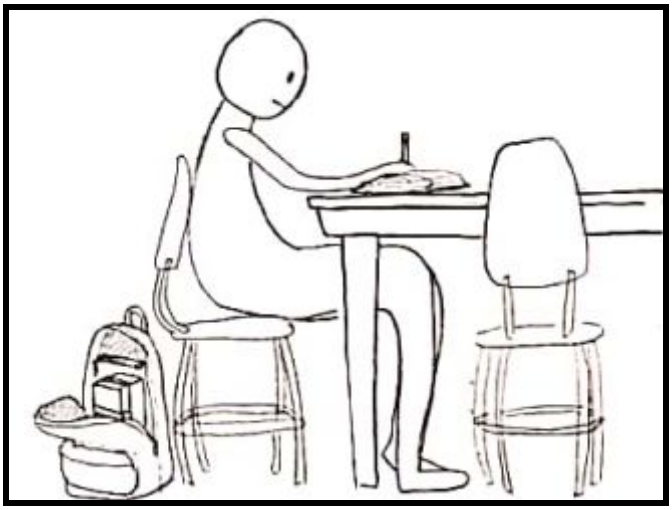

Figure 2a. Studying

In order to retrieve the car key in order to begin driving, the user must place the correct cell phone inside the case and close the phone side lid. This will cause the phone side to lock and the key side to unlock. If the incorrect phone is placed in the case, the case will not do anything, leaving the key side locked.

Figure 2b. Correct Phone

Figure 2c. Incorrect Phone

If the user is not driving but needs access to both their car key and phone, they are able to press the “emergency” button, which will open the opposite side of the case and allow the user to enter the “Access to Both / Emergency“ use case situation.

Use Case 3: Driving
In this situation, the user only has access to the car key because the phone is locked away in the case.

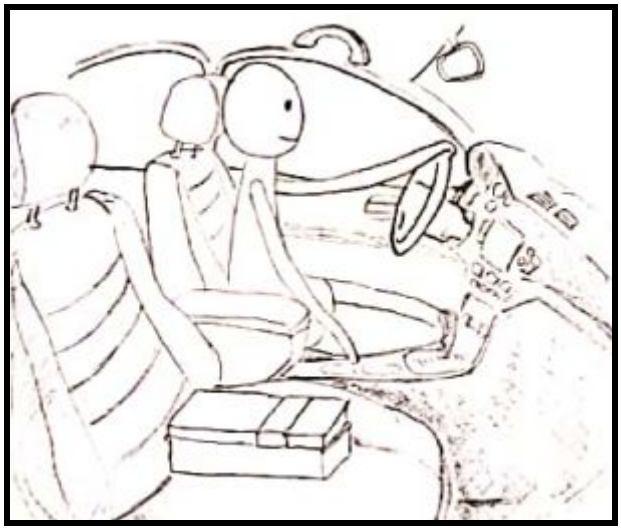

Figure 3a. Driving Car

In order to retrieve the phone after the user is done driving, the user must place the correct car key inside the case and close the key side lid. This will cause the key side to lock and the phone side to unlock. If the incorrect car key is placed in the case, the case will not do anything, leaving the phone side locked.

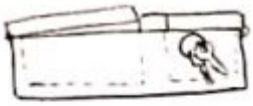

Figure 3b. Correct Key

Figure 3c. Incorrect Key

If the user is driving their car but needs access to both their phone and car key, they are able to press the “emergency” button, which will open the opposite side of the case and allow the user to enter the “Access to Both / Emergency“ use case situation.

Use Case 4: Access to Both / Emergency
State D can be quite ambiguous or misleading by being named emergency state because this could correspond to a situation in which the user has lost their phone but needs to drive somewhere, in which they are using their phone while a mechanic is using their keys to assess their vehicle, and several other situations in addition to an actual emergency. The team plans to cover all these cases with a general statement along the lines of “The driver has access to both the phone and car keys

To resume use of the case, one of the two objects will need to be placed into the case and locked away.

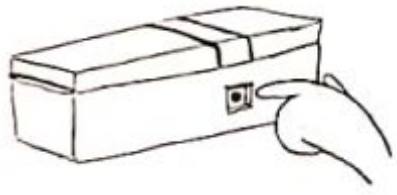

Figure 4a. Emergency While Driving

Figure 4b. At the Mechanic

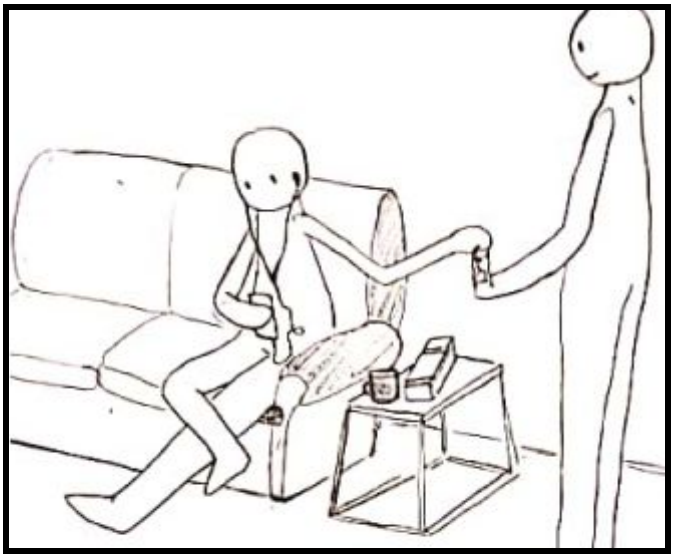

Figure 4c. Parent Borrows Car

CONCLUSION

The Road Safe Phone case should be relatively simple to use after a short time, as it does not have many use cases. With regular use, the driver will become accustomed to storing their phone away while driving. This method for safe driving is one of many.

Appendix II: Alternative Versions of the Design

Initial Approach Considerations

For this project, the team's goal is to eliminate the fatal distraction from the cell phone usage while the user is driving and minimize the chance of a car accident. In order to achieve this goal, the team researched approaches other than what was originally proposed by the client, which was to build a physical case to lock away the phone. Some other options explored were making a software that can sense the moving speed of the vehicle and use that to determine whether the phone should be accessible or creating an app or some form of an interface with the vehicle to force the driver's phone to enter "Air Mode" during the drive. The disadvantage of this approach is that the software does not have firm control over cell phone usage, the user can delete or turn off the app easily, and could not discriminate if the user is a driver or passenger.

A further analysis of the software-based and hardware-based solutions are shown in the tables below. For hardware the team focused on the advantages and disadvantages of the case, which would be a new product, a physical case that is portable and more restrictive on the user. For software, an improvement on an existing app or creating interface with car to restrict users when they choose to was explored.

PROS	CONS
● Can't touch or look at the phone ● Safer because a parent or designated person has more control over driver's phone usage ● Easy emergency access ● Has not been made before, first of its kind ● Possibly more preferable by older generation or protective parents because this option is more restrictive and physical	● Physical case - needs to be carried at times and must have space in the car to accommodate it ● More expensive to purchase ● If another phone is in the car, driver could use friend's phone ● Difficult to fully enforce this tactic on a driver ● Infotainment and GPS capabilities are more limited because they can only be accessed through audio and speech

Table 1: Hardware Approach

PROS	CONS
● The product is already on the phone, so it is easier/more convenient to access ● Ability to look at the navigation (also a drawback) ● Easy emergency access ● Cheaper ● Blocks or replies to calls for the driver to let others know they are driving ● Possibility for driving analysis or parental control/communication options	● Driver can look at the phone ● Less control over usage because apps or plug-ins can easily be disabled ○ To undo 'safe-driving mode', user can tap to unset easily or if the app relies on vehicle speed, it may allow for traffic usage while driving ● If another phone is in the car, driver could use friend's phone ● Difficult to fully enforce this tactic on a driver

Table 2: Software Approach

The expertise of each team member as well as the compatibility of all components must be considered carefully to ensure the project can be completed within the timeline. Given that our expertise was in hardware and that the client had suggested that approach, it was the path that was taken. Software-based features that may complement the road safe case may be explored with further development of the case.

Locking Mechanism Considerations

The initial lock that was used in the design was an electric solenoid lock, which is designed to lock only one side of the case at a time. Initially, the team planned to use two of these locks or one larger version of this lock that could be manipulated to lock either side of the case. However, the lock consumes a lot of power when holding its locking position, and if the case momentarily loses power, the locking status of the case changes. This led the team to research other locking mechanism

Emergency Notification System Considerations

The hardware case design has been consistent, but the notification module has been changed as we learn more about the project and talk to the client.

Version 1: GSM Module

At the beginning, the team was trying to use a GSM module. A GSM modem is a class of wireless modem, designed for communication over the GSM network. It requires a SIM card just like mobile phones to activate communication with the network. However, after looking into some online resources and talking to AT&T, it was found that it requires the user to pay for a monthly plan, about $6/month. The team does not think it is a good approach for the convenience of the client. Thus, other options will be explored to find some other suitable and

inexpensive methods to send messages. The GSM module will now serve as a last resort because it is proven to work, but costly.

Version 2: SMS Module

We kept looking for other alternative ways and found SMS might be a good candidate. But there are also some limitations. Our current implementation for using the SMS module for the notification system can only work on the emulator. However, in order to use the SMS module on an actual Android device, we need to purchase the relevant SMS gateway service in order to use their API. Therefore during our implementation, we can only send SMS message on the emulators instead of the actual device. So this plan had also been denied due to the extra money.

Version 3: Google Firebase and Android Studio

Currently,the team is using google firebase as our project's server and back-end development. One of the key features we need from Firebase is the real-time database. Real-time Database in Firebase is a cloud-hosted database. By utilising this feature of Firebase, there is no necessity to make your own database or own API, Firebase handles all the components that usually come along with creating a backend for applications. It gives an adaptable, expression-based rules language to define how your data should be organized and when information can be perused from or composed to. With this tool, the app has been created. However, due to the time-frame, we are unable to deliver a complete version of the app. In this final version, we have accomplished the following functionality: the online chat room, which can currently display the text information and the user sign up and log in page.

Appendix III: Other Considerations

A consideration that the team did not think of until the very end of the project was the case design, in terms of being easy to manufacture and troubleshoot the circuit within. When the final prototype was being constructed, it was difficult to position the motor in place with screws because there was not enough room to fit a screwdriver in the case. Gorilla glue, hot glue, and UV glue were considered as alternatives for securing some of the components within the case. Also, attempting to fit multiple connections in small designated holes within the walls and compartments of the case proved difficult. Rather than thinking of the case design from a manufacturing approach, only the convenience of size and layout for the user was considered.

Other considerations that team researched but did not actually implement because other methods were considered concerned the emergency notification system, as this presented the most difficulty for the team. The software options that were researched are considered below:

Script:
After talking to the client, and realize that the client was unwilling to pay the monthly plan for GSM gateway service, we then tried using script language to start the build-in message application inside the phone when a particular button is triggered. However, after doing the research and consult both our advisor and some professors in Computer Science Department, using scripting language in our case seems very hard. The Scripting Layer for Android (SL4A) does not support the latest version of the Android. Furthermore, none of our team members have the experience in developing scripting language. In the past, we only have the experience of writing scripts on computer, and throughout our research, we also found out that the tutorial for scripting on the Android system is quite rare. Therefore, the using scripts seems like impossible.

Hosting-Server:
Before knowing about Google Firebase, we were looking for external host servers. However, in order to fully implement the host servers, we need to do a lot of extra work, including implementing all the backend handler for different requests as well as creating another database using SQL, etc. Furthermore, host server also requires monthly payment. Therefore, after learning about the firebase, we decided to use it. Also, firebase also provides lots of other libraries such as the authentication, cloud storage, etc.

Appendix IV: Code

```
#include <SPI.h>
#include <MFRC522.h>
#include <Servo.h>
 Servo myservo;
#define RST_PIN 9       // Configurable, see typical pin layout above
#define SS_1_PIN 10     // Configurable, take an unused pin, only
HIGH/LOW required, must be different to SS 2
#define SS_2_PIN 8      // Configurable, take an unused pin, only
HIGH/LOW required, must be different to SS 1
int state = 0;
int pos = 0;
#define NR_OF_READERS   2

byte ssPins[] = {SS_1_PIN, SS_2_PIN};

MFRC522 mfrc522[NR_OF_READERS];   // Create MFRC522 instance.

/**
 * Initialize.
 */
void setup() {

  Serial.begin(9600); // Initialize serial communications with the PC
  while (!Serial);    // Do nothing if no serial port is opened
(added for Arduinos based on ATMEGA32U4)

  SPI.begin();        // Init SPI bus

  for (uint8_t reader = 0; reader < NR_OF_READERS; reader++) {
    mfrc522[reader].PCD_Init(ssPins[reader], RST_PIN); // Init each
MFRC522 card
    Serial.print(F("Reader "));
    Serial.print(reader);
    Serial.print(F(": "));
    mfrc522[reader].PCD_DumpVersionToSerial();
  }

  myservo.attach(2);  // attaches the servo on pin 9 to the servo
object
```

```
  pinMode(6, INPUT);
  pinMode(4, INPUT);
  pinMode(3, INPUT); // Emergency button

  Serial.begin(9600);   // Initiate a serial communication
  SPI.begin();          // Initiate  SPI bus
  mfrc522[0].PCD_Init();   // Initiate MFRC522
  mfrc522[1].PCD_Init();   // Initiate MFRC522
  Serial.println("Put your card to the reader...");
  //Serial.println();
}

/**
 * Main loop.
 */
void loop() {


    for (uint8_t reader = 0; reader < NR_OF_READERS; reader++) {
    // Look for new cards

    if (mfrc522[reader].PICC_IsNewCardPresent() &&
mfrc522[reader].PICC_ReadCardSerial()) {
  Serial.print("UID tag :");
  String content= "";
  byte letter;
  for (byte i = 0; i < mfrc522[reader].uid.size; i++)
  {
     Serial.print(mfrc522[reader].uid.uidByte[i] < 0x10 ? " 0" : "
");
     Serial.print(mfrc522[reader].uid.uidByte[i], HEX);
     content.concat(String(mfrc522[reader].uid.uidByte[i] < 0x10 ? "
0" : " "));
     content.concat(String(mfrc522[reader].uid.uidByte[i], HEX));
  }
  Serial.println();
  content.toUpperCase();


if (digitalRead(3) == HIGH && state == 2) { // If phone is inside and
emergency button is pressed
      pos = 100;
      myservo.write(pos);
```

```
      delay(150);
  } else if (digitalRead(3) == HIGH && state == 1) { // If key is
inside and emergency button is pressed
      pos = 15;
      myservo.write(pos);
      delay(150);
  } else if (digitalRead(6) == HIGH && digitalRead(4) == HIGH &&
content.substring(1) == "7B 4E 4A 0A" && state == 2) { //          2
      pos = 100;
      myservo.write(pos);
      delay(150);
  } else if (digitalRead(6) == HIGH && digitalRead(4) == HIGH &&
content.substring(1) == "40 AE 58 DB" && state == 1) {//    4
      pos = 15;
      myservo.write(pos);
      delay(150);
  } else if (digitalRead(4) == HIGH && content.substring(1) == "7B 4E
4A 0A" && digitalRead(6) == LOW) { //key is inside      3
    Serial.println("Key is in the case");
      state = 1;
      pos = 100;
      myservo.write(pos);   // lock key side
      delay(150);
  } else if (digitalRead(6) == HIGH && content.substring(1) == "40 AE
58 DB" && digitalRead(4) == LOW) {  //phone is inside     1
    Serial.println("Phone is in the case");
      state = 2;
      pos = 15;
      myservo.write(pos);               // tell servo to go to
position in variable 'pos'
      delay(150);                       // waits 15ms for the servo
to reach the position
  }

      // Halt PICC
      mfrc522[reader].PICC_HaltA();
      // Stop encryption on PCD
      mfrc522[reader].PCD_StopCrypto1();
    } //if (mfrc522[reader].PICC_IsNewC

mfrc522[reader].PCD_Init(ssPins[reader], RST_PIN);

  } //for(uint8_t reader
```

```
}

/**
 * Helper routine to dump a byte array as hex values to Serial.
 */
void dump_byte_array(byte *buffer, byte bufferSize) {
  for (byte i = 0; i < bufferSize; i++) {
    Serial.print(buffer[i] < 0x10 ? " 0" : " ");
    Serial.print(buffer[i], HEX);
  }
}
```