

GNG 1103

Deliverable H: Prototype III & Customer Feedback

OPIOID OVERDOSE DETECTOR

By

GNG1103, SECTION C00, GROUP 5

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Table of Contents

Introduction	3
Arduino and Hardware Subsystem	3
Bluetooth Subsystem	5
GPS Subsystem	5
App Subsystem	6
Step-By-Step Action Plan	14
Conclusion	15
Appendix	15

Introduction

The purpose of this document is to summarize the steps taken and the tests done in the past few prototypes for this project. You will be informed on how we reached a working prototype that had all the separate components working together and giving us the final product. This included the electrical subsystem, where wiring, circuit and the sensor fall under. The software subsystem, which consists of code to run the arduino and also to run the phone app that was used for this device. And hardware subsystems, in which the bluetooth module, display, arduino nano and the battery are categorized.

This final prototype is a combination of all the previous prototypes and ideas put into action along with final touches. A comfortable watch that is connected to a sensor that is inside a ring and connected via a thin wire is what our final design consists of. However, the final idea that we presented wasn't what we had initially planned for our final product to be. Changes were made for us to be where we are today, a prime example of this would be the thin wire that we incorporated into our device to transfer data from the sensor to the watch, our original idea consisted of a bluetooth based system to transfer data. The changes made to our final device was us taking into account the feedback that we received from the client, professor and classmates during our prototype II presentation. After the final changes were made and we were well on our way to making the final working product, we also made sure that it included and met all the client requirements.

Arduino and Hardware Subsystem

The final arduino system was intended to be soldered to a metal circuit board (*Figure 1*) in order to make the device more permanent and stable. The soldered device would then use the arduino in order to control each component. In order to receive oxygen saturation readings as well as pulse, an MAX30100 oximeter chip was used. Along with the chip, there was preconceived code that we had sourced online in order to make the sensor work. Since the sensor receives data from the user's finger, it would have been placed within the 3D printed ring Mohamad had previously designed in SolidWorks as seen in *Figure 9*. This ring would then be connected to the circuit board through a thin wire and attached to the arduino nano. From there, the arduino would be connected to the speaker and bluetooth module. The arduino would then use the code created in order to allow each part to work uniformly.

As for the final prototype we currently have, the circuits are still connected to a breadboard and remain unsoldered. The arduino code and aspects that were intended to work are fully functioning as seen in the video demonstration in the appendix on page 15. Unfortunately, due to unforeseen circumstances the bluetooth module and speaker were unable to be incorporated into the final prototype. The final prototype, although not ideal, is still fully functioning and capable of completing the task we were given. (*Figure 2*).

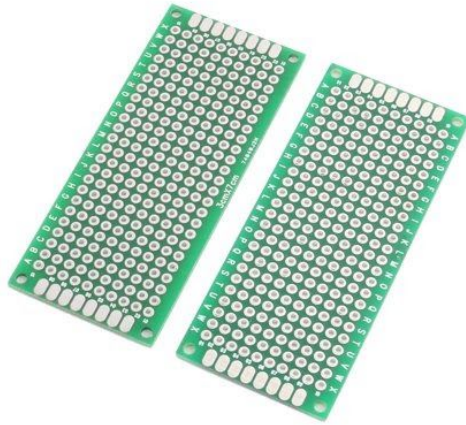


Figure 1: Metal Circuit Board

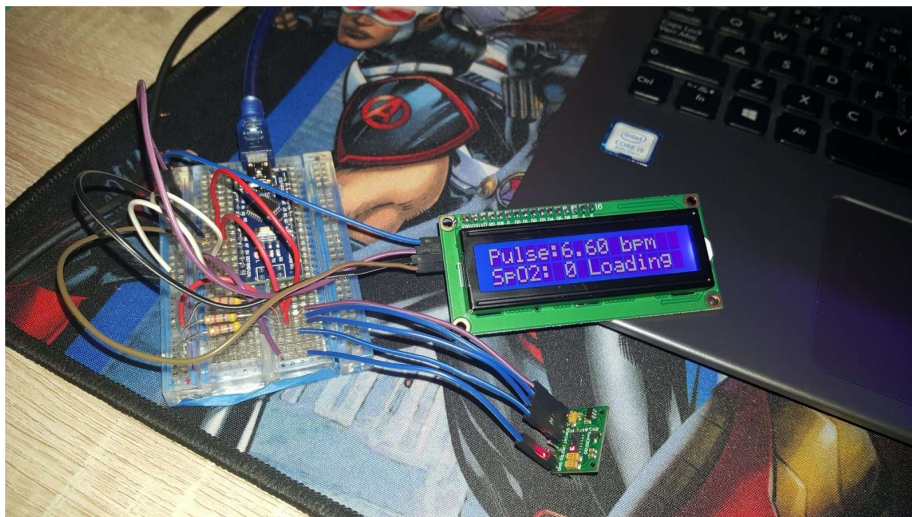


Figure 2: Final Prototype

Bluetooth Subsystem

The final bluetooth system was intended to be composed of an HC-05 bluetooth module (*Figure 3*) which would transmit sensor data to an Android application (discussed further in “Subsystem 5.” However, a complication arose which prevented this subsystem’s completion. One group member, Ru, has the HC-05 module, and is also the only one with an Android phone. Therefore, we could not get a full bluetooth connection between the app and hardware since Sheetal (the group member which has the arduino/hardware systems) and Ru are on different ends of the province.

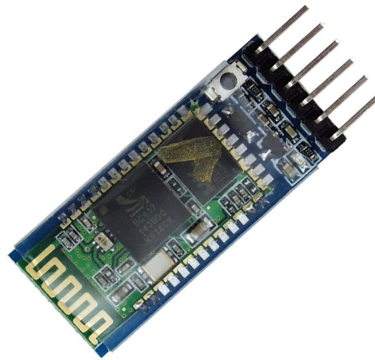


Figure 3 - HC-05 Bluetooth Module.

The failure of this subsystem is further analyzed on page 13-14 - “The Implications of Dependencies and How we Overcame Them.” This one failure gets its own section because so many other features relied on its functionality.

GPS Subsystem

The purpose of the Global-Positioning System(GPS) subsystem is to ensure that our device is able to send out the accurate location of the user to the selected trusted contact in the shortest time possible. A stimulation Android app was first created through MIT App Inventor, and GPS location tests were carried out by the team on the school compound. At the beginning of the first few tests, our team encountered some setbacks as the locations that were detected and sent were absurd and far from accurate. One of the tests even directed us to the border of Russia, which is thousands of miles away from our actual location in Ottawa, Canada. Thus, we revised our app and codes to find out the source of the problem and come up with a solution. After a few tries, we found out that we inverted the longitude and latitude coordinate in the app. We resume

testing after fixing the problem. Tests were carried out to ensure that our device is able to fulfill the following requirements:

1. The location coordinates sent out were accurate and precise.
2. The phone application and GPS location will continue to be running in the background even when the phone is locked or turned off.
3. The GPS location and message were able to be sent out even after the user exits from the application on the phone.

The tests were carried out smoothly and the results were as intended. Unfortunately, before we were able to integrate both the device and the GPS subsystem together, we encountered an unforeseen situation which is the outbreak of COVID-19 in Ottawa which lead to our team facing a challenge where we were unable to combine the Bluetooth component (HC-05 Bluetooth Module) that was supposed to be used to connect both of the device and the phone application. This is because components of the device were distributed to different members of the team and coincidentally the Bluetooth module is with Ru while the main components are with Sheetal where both of them are at different ends of the province and unable to meetup.

In conclusion, we were not able to show the readings of the user's blood oxygen saturation level, heartbeat rate and etc on the interface of the application and only the GPS location coordinates were able to be detected and sent. In replacement, we designed a desktop application to replace the MIT App Inventor which has been a constraint as it restricts the user to be an Android phone user. We carried out a video demonstration (refer to the appendix on page 15) to show how the desktop application works and how the phone application and GPS location would have function if we were able to integrate the device and the application.

App Subsystem

The phone app was created in MIT app inventor, one week before campus got shut down and group members were separated. It was essentially supposed to tie up the oximeter data and gps subsystem into one program. **It's real purpose is just to execute one if-statement** - that is, if the SpO2 levels are below 90%, send the phone's coordinates, last recorded pulse, and SpO2 levels to a pre-user-saved emergency number. A video demo is shown on page 15 of what it was supposed to be. *Figure 4* shows the user interface.

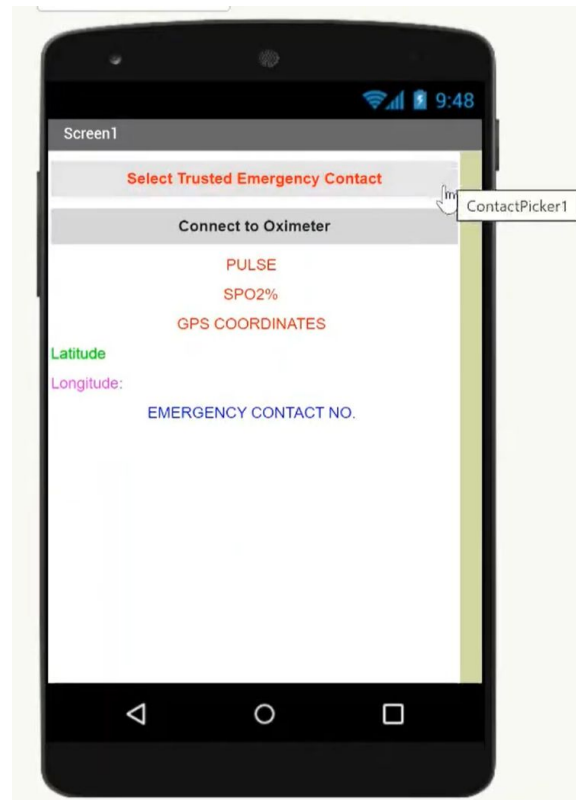


Figure 4 - User interface of the final application.

Due to our separation, we weren't able to use this app because it depended on the bluetooth module, hardware, and phone all being in functional condition and in close proximity to one another.

Had we all still been in Ottawa, the result of this app would have been a synchronized harmony of all data. However, what we have now are fully functional subsystems scattered hundreds of kilometres away from each other.

Ideal Design at this Point

The final design was supposed to have all the components seen in the following 2 figures:

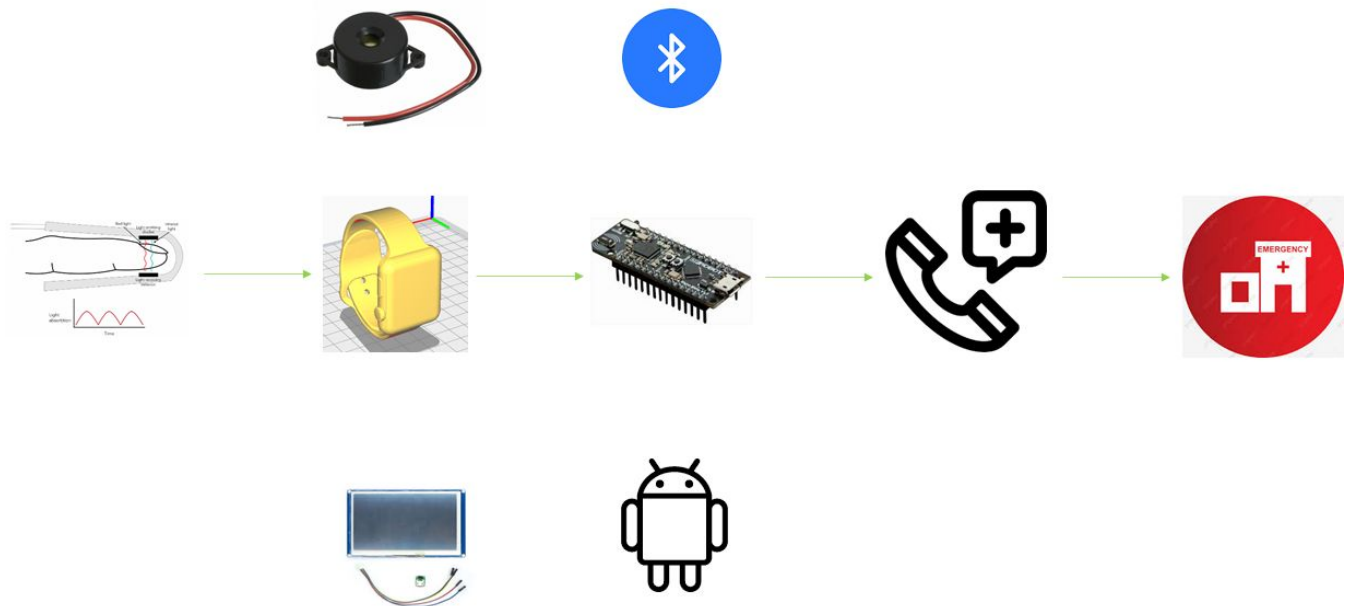


Figure 5 - An ideal flow chart of the final device with the following sequence:

Oximeter data is recorded at the finger

Data sent to a display on the watch

Data interpreted/regulated by an arduino nano

If the user's vitals are indicative of an overdose (i.e $\text{SpO}_2 < 90\%$):

- A speaker tries to keep them awake through alerts
- Information that is sent to the Android app via bluetooth will be sent as an SMS to an emergency contact.
- The emergency contact will call provide the SMS information they got to EMS.

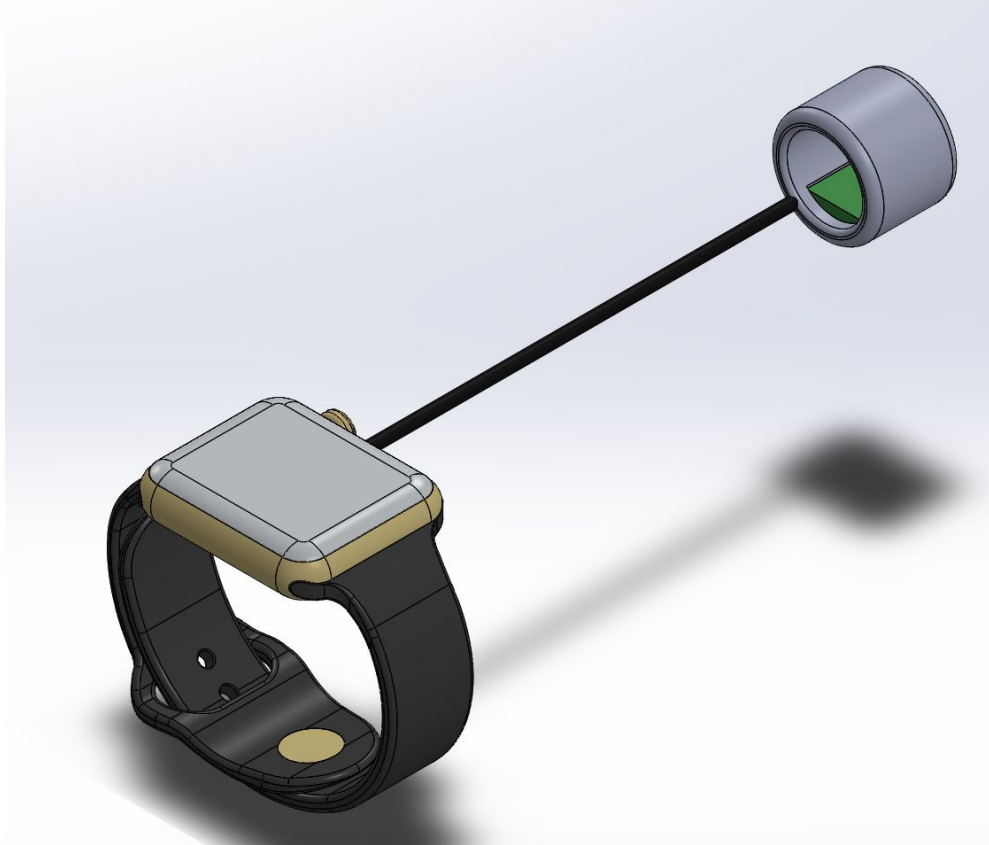


Figure 6 - An ideal visualization of the final assembly we intended to have (Oximeter in a ring connected to hardware in a wrist watch via a wire). Crafted in Solidworks.

Actual Design at this Point

In reality, a lot of components were discarded from our final “product.” This was due to dependencies of subsystems (*Figure 7*) and failure of hardware. The following figures and tables display what components ended up being included in our final design and why:

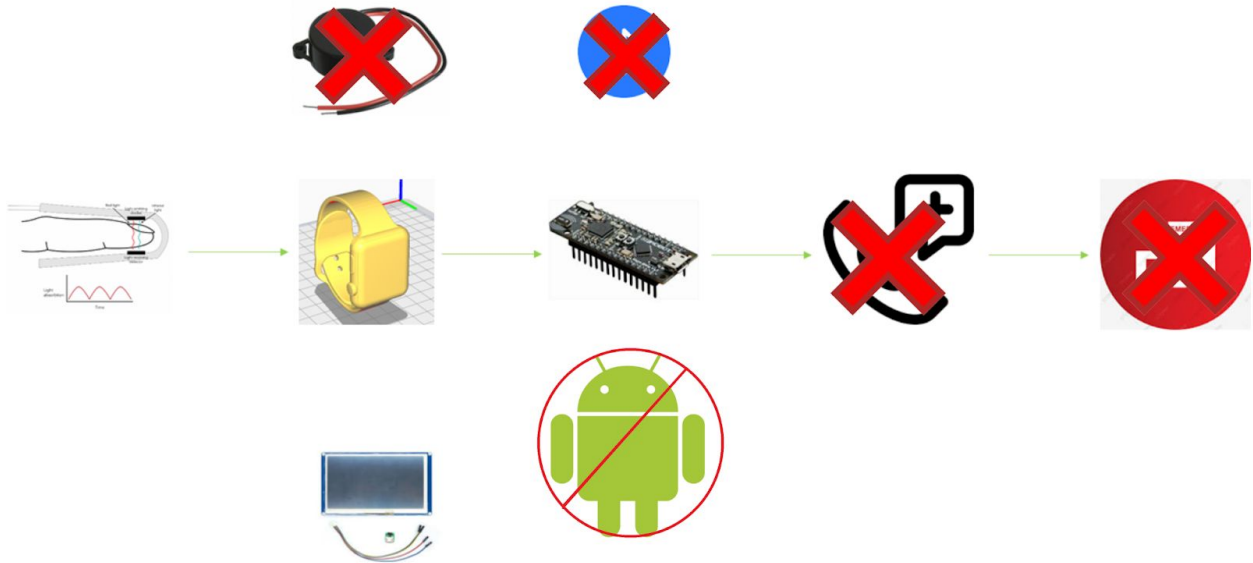


Figure 7 - Actual final design’s components. The components/subsystems crossed out have their failures further analyzed in *Table 1*.

Component/ Subsystem	Purpose	Reason for Failure	Testing done/intended
Speaker	Alert overdosing users via audible cues in efforts of keeping them conscious.	The system failed spontaneously - assumed to have busted.	We intended to test if the speaker went off at the right time (when oxygen levels are below 90%). We also intended to see where we could place the speaker in the watch without it protruding in an obtrusive manner.
Bluetooth	Send oximeter data to the Android app.	Oximeter/hardware was hundreds of kilometres away from the bluetooth module.	We would have tested if the bluetooth module sent reliable data without failure (all the time). This would have been done by keeping the system running for hours and seeing if at any point no data was being sent to the phone.
Android app	Detect phone GPS coordinates and have them ready to be sent via SMS, along with oximeter data, if an overdose is detected.	Dependency on Bluetooth.	GPS subsystem has been successfully tested (refer to “App Subsystem”).
SMS Sending	Send GPS coordinates, pulse, SpO2, to a pre-set emergency contact.	Dependency on Android app.	Although we just tested the sending of GPS coordinates, we assume that we could have sent the other information via SMS. We tested this system by repeatedly sending data via text and seeing if it was done in a timely manner.

Notifying EMS	If an SMS is successfully sent, then EMS can successfully be sent the information through the emergency contact.	Dependency on SMS sending.	The testing for this system is just ensuring that SMS messages are successfully received. This was tested by seeing how long it took for someone to receive an SMS. It was found to be successful.
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Table 1 - All subsystems/components that failed or weren't included in our final design, what their purpose was, why they failed, and the testing we did or intended to do on them (with colours indicative of our success doing so).

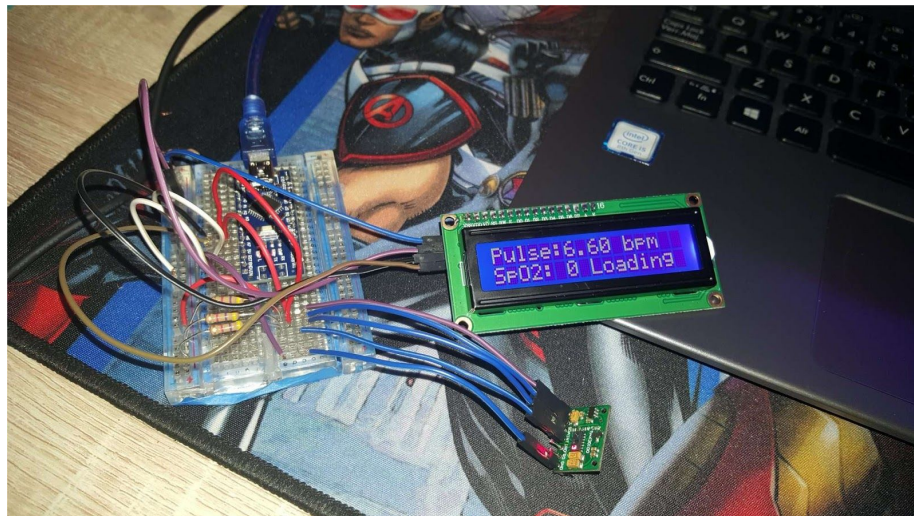


Figure 8 - Actual final physical assembly.

The physical assembly was nowhere near as pretty as we expected it to be- but... it was functional. Had we more time to worry about the visual appeal of the system and less to worry about the actual functionality of it (which was our priority), we would have tried to encase everything in a watch and ring (*Figure 9*) and started benchmarking comfortable watch straps. Even if our hardware was functional in time though, we still wouldn't have been able to get the physical assembly of the device optimized due to CEED facilities (our only source of manufacturing these parts) being closed.

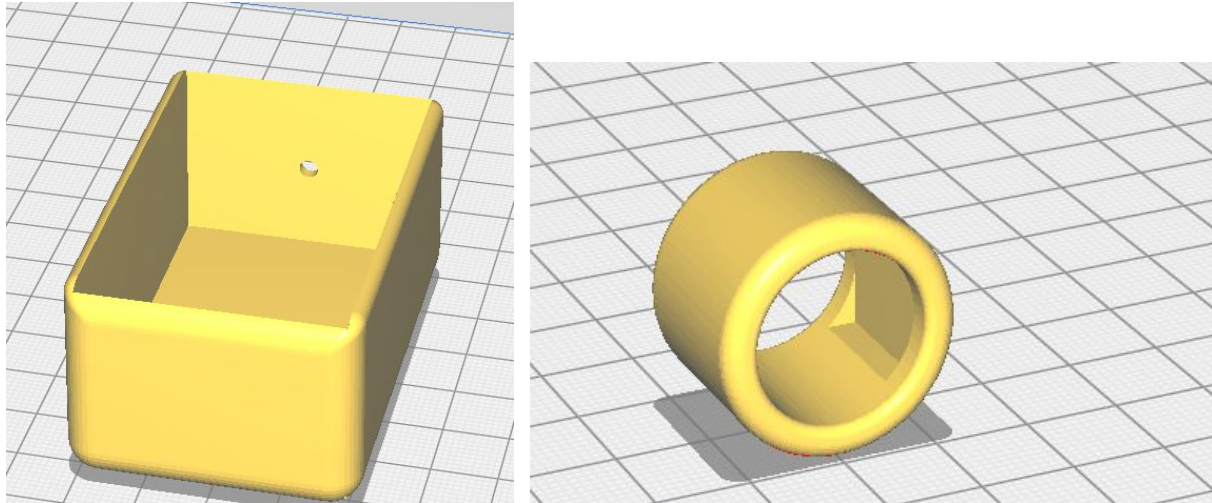


Figure 9 - Models of a watch case (left) and ring (right) ready to be 3D printed and encase our components. All modelling and dimensioning were done in solidworks to ensure that the hardware would sit flush (**watch case**: 69mm x 44mm x 32mm, **ring**: 20mm x 25mm x 25 mm).

The Implications of Dependencies and How we Overcame Them

A big lesson from the last week has been how one small thing going wrong could impact the entire project. *Figure 10* displays the failed subsystems due to the bluetooth subsystem's failure.

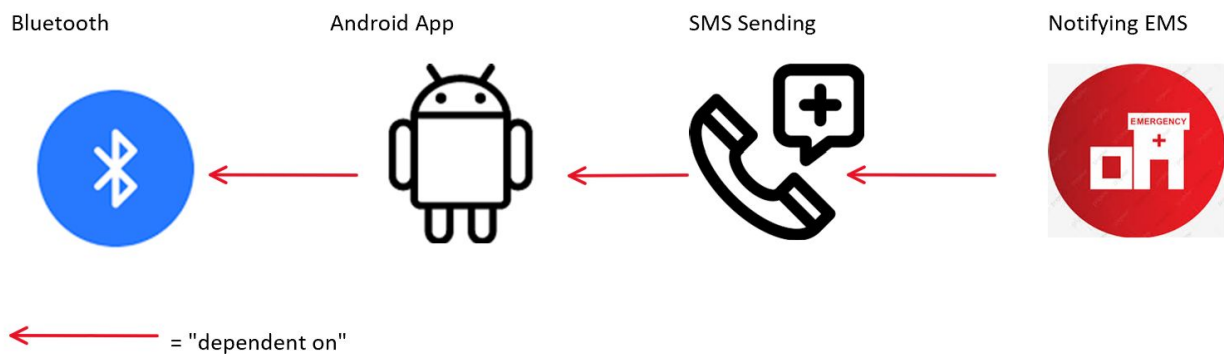


Figure 10 - An illustration (meant to be read from right to left) that shows the implications that the bluetooth failure had on other dependent subsystems.

Although this situation was unforeseen and its implications seemed very dramatic, we still found ways to test subsystems that relied on bluetooth.

We still managed to test the GPS subsystem to the extreme (with Ru performing dozens of trials). This reassured us that this device could truly save a life because it's location accuracy was spot on (always detecting a location which google maps said was 0 metres away from Ru's true location). A video demo, on page 15 shows the GPS subsystem in action.

The implications on the phone app ended up being compensated for by a desktop simulation of what the app would have done. Essentially, when we realized that we couldn't get the arduino connected to the phone app, Sheetal took action right away and familiarized herself with Java and Processing (a computer program mainly used to generate user interfaces and GUI's). The simulation served to show that it was fully possible to have an application which could detect pulse and SpO2 levels from an arduino. Video demo shown on page 15.

Step-By-Step Action Plan

1. Printing our final SolidWorks design (**1 day**)
 - a. This includes: Watch and ring components + additional add-ons
2. Testing comfortability of design (**1 day**)
 - a. This includes: Determining which materials would be better suited for our application
3. Soldering the circuitry to a metal circuit board for permanence (**1-2 days**)
 - a. This includes: Ensuring all aspects of the circuit are fully functioning
4. Making the circuit fit inside of the 3D printed pieces (**1 day**)
 - a. This includes: Ensuring everything is secure and does not fall apart during use
5. Testing with device (**2 days**)
 - a. This includes: Wearing the device for long periods of time and testing its capabilities
 - i. Such as: bluetooth connection distance, battery life, waterproofing, etc
6. Making improvements for any discovered issues (**1-2 days**)
 - a. This includes: Remodelling design if needed and any adjustments
7. Aesthetics (<**1 day**)
 - a. This includes: Ensuring the product is appealing and meets our criteria
8. Ensuring all software is still functioning after compiling (**1-2 days**)

- a. This includes: Testing the app and ensuring the user is able to connect through bluetooth seamlessly, accurate readings are being made, and is able to send out emergency information in case of overdose.
9. Preparing for presentation and Design Day (**2 days**)
 - a. This includes: Creating a helpful presentation and practicing to ensure everything goes smoothly during the event.

Conclusion

All the separate components of the device have been brought together into a final working product. However, with the unexpected situation of school closure and everything being inaccessible, the device is not aesthetically pleasing as we had planned at the beginning of the process when we started to put everything together.

However, we had all the components working and could present to the class in our presentation how the final product would function. As a team, we intend to get started on the user manual as soon as possible, where the steps we took, problems we faced and the different approaches we took would be included. This is in case there is something similar that other people might attempt in the future.

Throughout this project and especially in the final prototype, we all learned how important it is to trust one and other, the dependency on one person to finish for the team to continue onto the next task, and what it means to work as a team. The most important lesson we learned was that no matter how carefully and thoughtfully you plan something out, there will always be unexpected situations that you cannot foresee but will have to overcome.

Appendix

1. [Opioid Overdose Video Demonstration](#)