Deliverable D:

Detailed Design, Prototype I and BOM

University of Ottawa
GNG 2101 B
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Introduction

The purpose of this document is to summarize the feedback we received from client interview 2 and provide a low fidelity prototype that will be analyzed and improved upon. In this document, you will find a functional decomposition of the physical beacons prototype along with a visual CAD render showcasing the chosen design. The physical beacon prototype was then put through a stress test via Solidworks in order to gauge how the final product will hold up and determine if another material is needed. The team has also created various flowcharts to help display app functionality while also giving the team an easier path to develop the backend coding of the app. These prototypes were then tested and then furthermore compared to the target specifications outlined in the previous deliverables to give the team a grasp of what must be improved upon. A bill of materials was also added to the end of the document which displays the budget that has been created for the 4 beacons prototypes. By creating and archiving this document, the team has started to follow the plan set out in Deliverable C while also overcoming any setbacks that have been encountered.

1. Summary of Client Feedback

- Happy with the design we presented to them
- Is ok with the use of only Android for the app
- Approved the use of three beacons, and more if the budget allows for it
- Advised us that our design may have to be adapted to work around the physical constraints of the floorplan
- Advised us to use batteries rather than ethernet for power
- We will have to adapt our design to work around and through physical barriers, that may obstruct the Bluetooth signals

2. Functional Decompositions

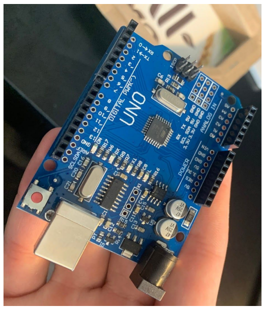
a. Components

Below is a decomposition of each component of the prototype

- **Battery**

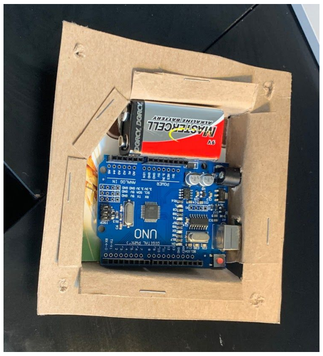
- **Case**

- **Microcontroller**



b. In Combination

This is the prototype of all the components together



3. Software Prototypes

The two sets of software prototypes displayed below show two important parts of the design of the app. Firstly, the flowcharts depict the functional breakdown of the app's screens and sub-functions to help get a better idea of how the app's different components will work together. This enables the team to have a pseudo-code to use as a reference when creating the application to remind themselves of how each function will work, and which functions are dependent on others. Secondly, the app mockups provide an example of the general layout and look of the app in order to get more effective feedback from the client in regards to optimizing the layout of the first actual app prototype to come later. This feedback will be crucial in determining the aesthetic of the user interface and how user-friendly it will be. Since the target customers for this project include visually impaired users, it is absolutely crucial to use high contrasting, large symbols to indicate the most critical information.

The prototypes are shown beginning on the next page.

App Flowcharts

Group B32 - Library Wayfinding

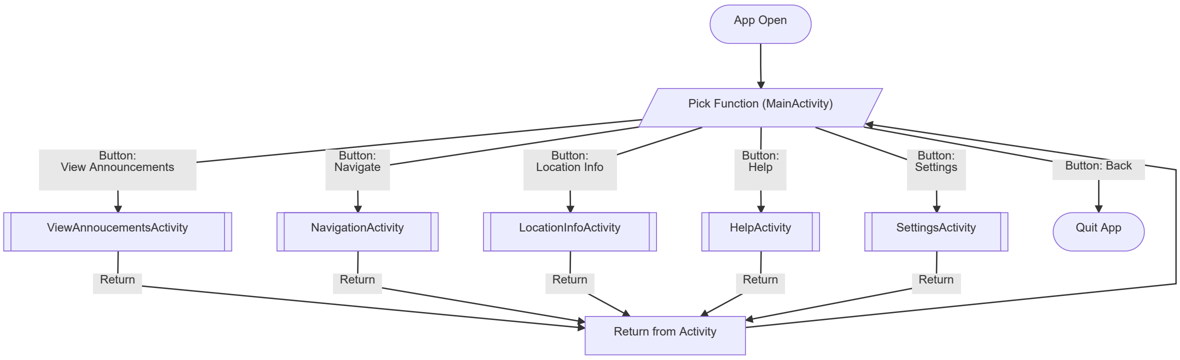
Notes

- In an Android app, an "Activity" generally refers to a single app screen. Thus, switching between screens or views of an app is equivalent to switching activities.
- The Back button is either the pressing of the phone's hardware/onscreen back button, or the pressing of a separately displayed back button in-app.
- The other buttons are displayed in-app.

Main App Flowchart

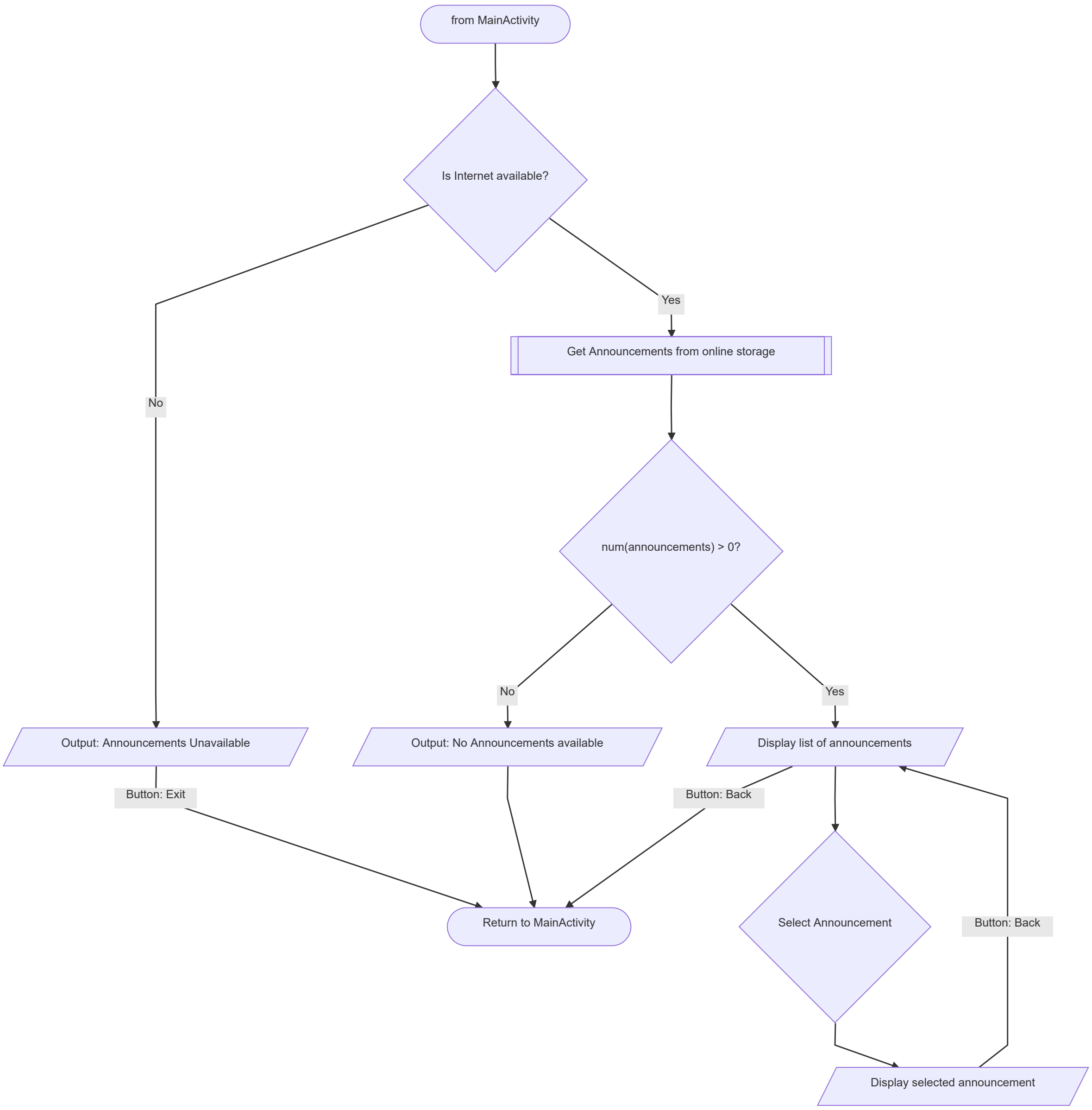
`MainActivity`

- App home screen.



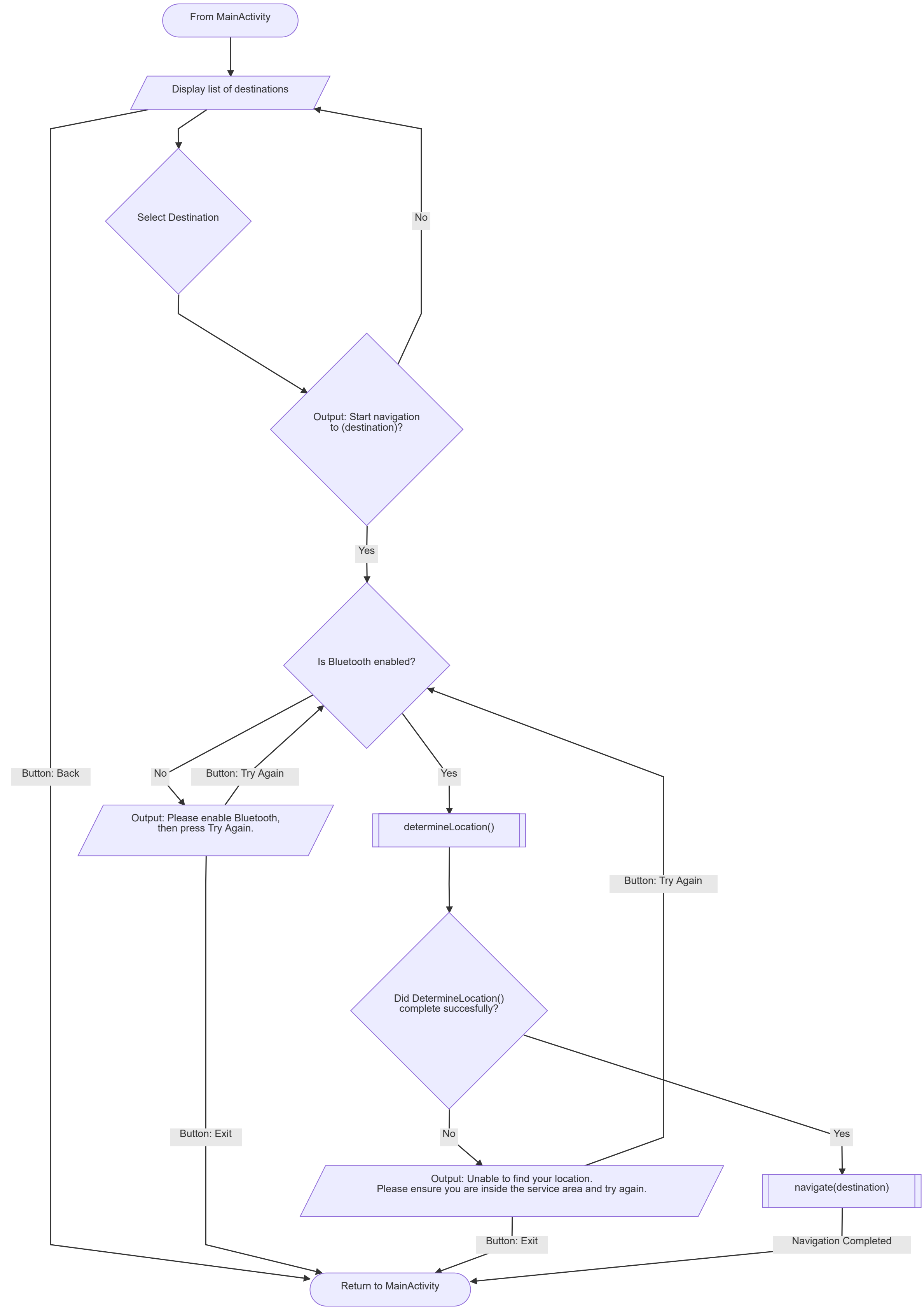
`ViewAnnouncementsActivity`

- App screen for viewing announcements broadcast by an employee.


from MainActivity
Is Internet available?
No
Yes
Get Announcements from online storage
num(announcements) > 0?
No
Yes
Output: Announcements Unavailable
Output: No Announcements available
Display list of announcements
Button: Exit
Button: Back
Return to MainActivity
Select Announcement
Button: Back
Display selected announcement

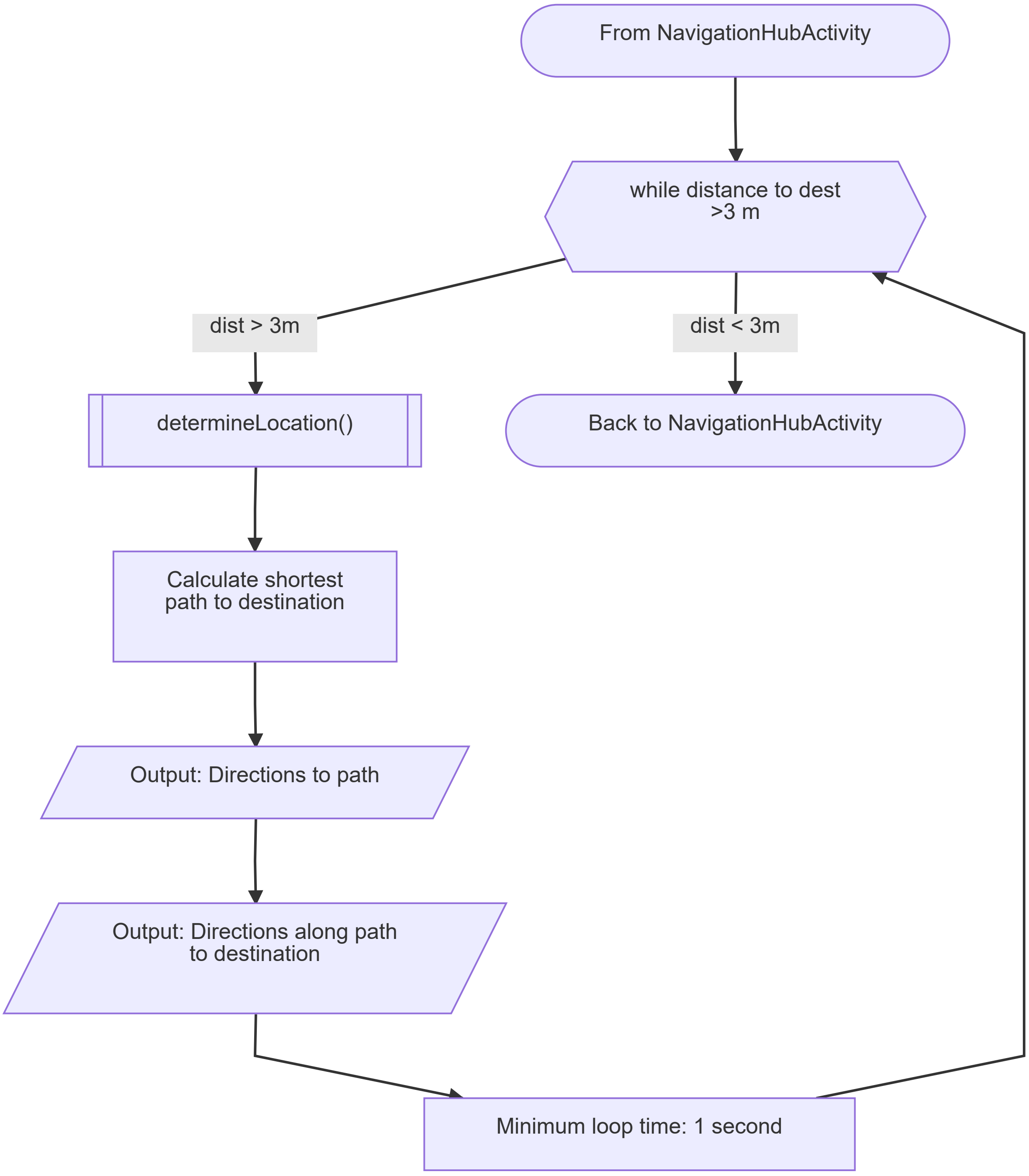
`NavigationActivity`

- App screen for navigating to a location.
- Called by `MainActivity`.


From MainActivity
Display list of destinations
Select Destination
No
Output: Start navigation to (destination)?
Yes
Is Bluetooth enabled?
Button: Back
No
Button: Try Again
Yes
Output: Please enable Bluetooth, then press Try Again.
determineLocation()
Button: Try Again
Did DetermineLocation() complete succesfully?
Button: Exit
No
Yes
Output: Unable to find your location. Please ensure you are inside the service area and try again.
navigate(destination)
Button: Exit
Navigation Completed
Return to MainActivity

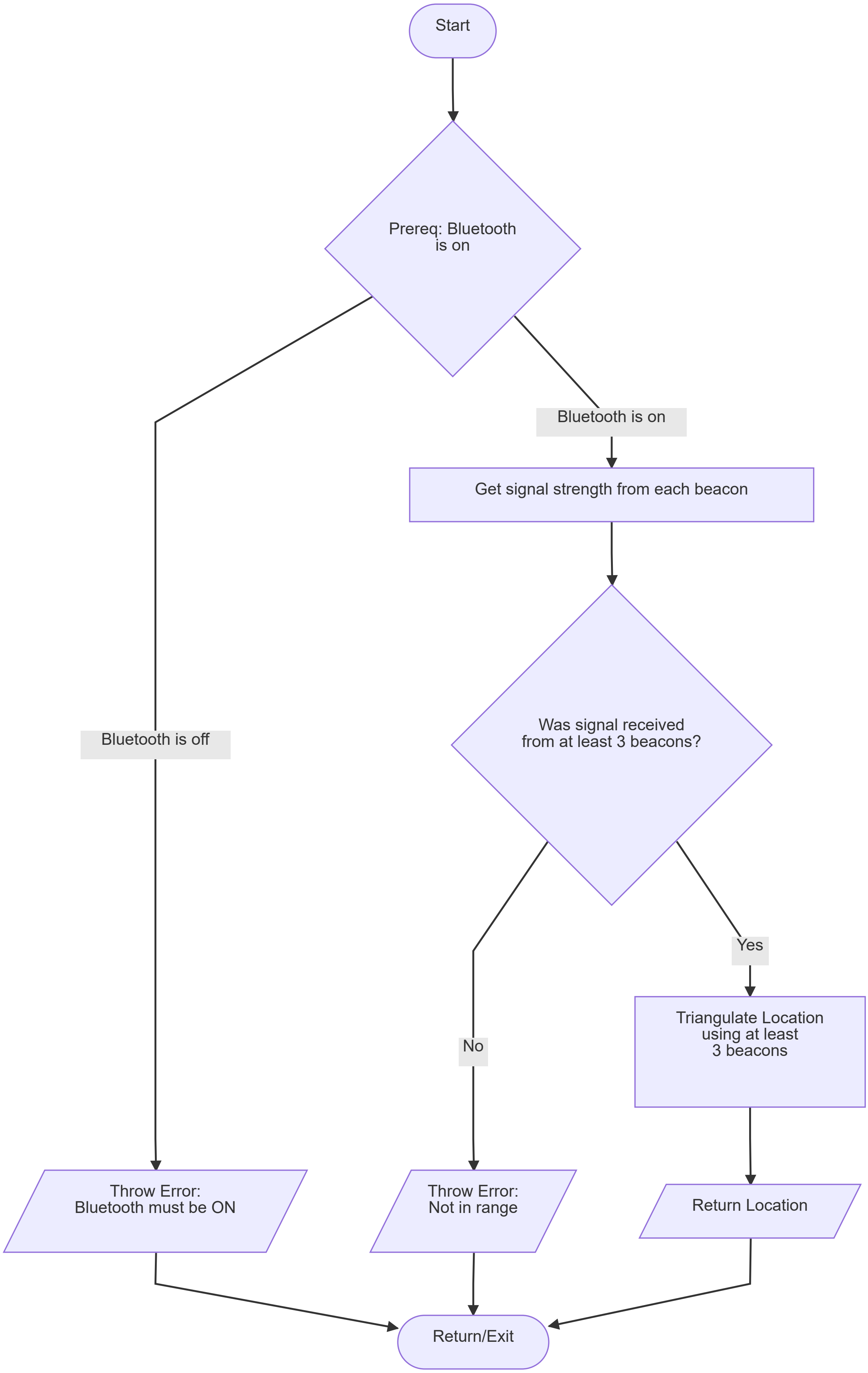
`navigate()`

- Sub-function for navigating to a location.
- Called by `NavigationActivity`.


From NavigationHubActivity
while distance to dest >3 m
dist > 3m
dist < 3m
determineLocation()
Back to NavigationHubActivity
Calculate shortest path to destination
Output: Directions to path
Output: Directions along path to destination
Minimum loop time: 1 second

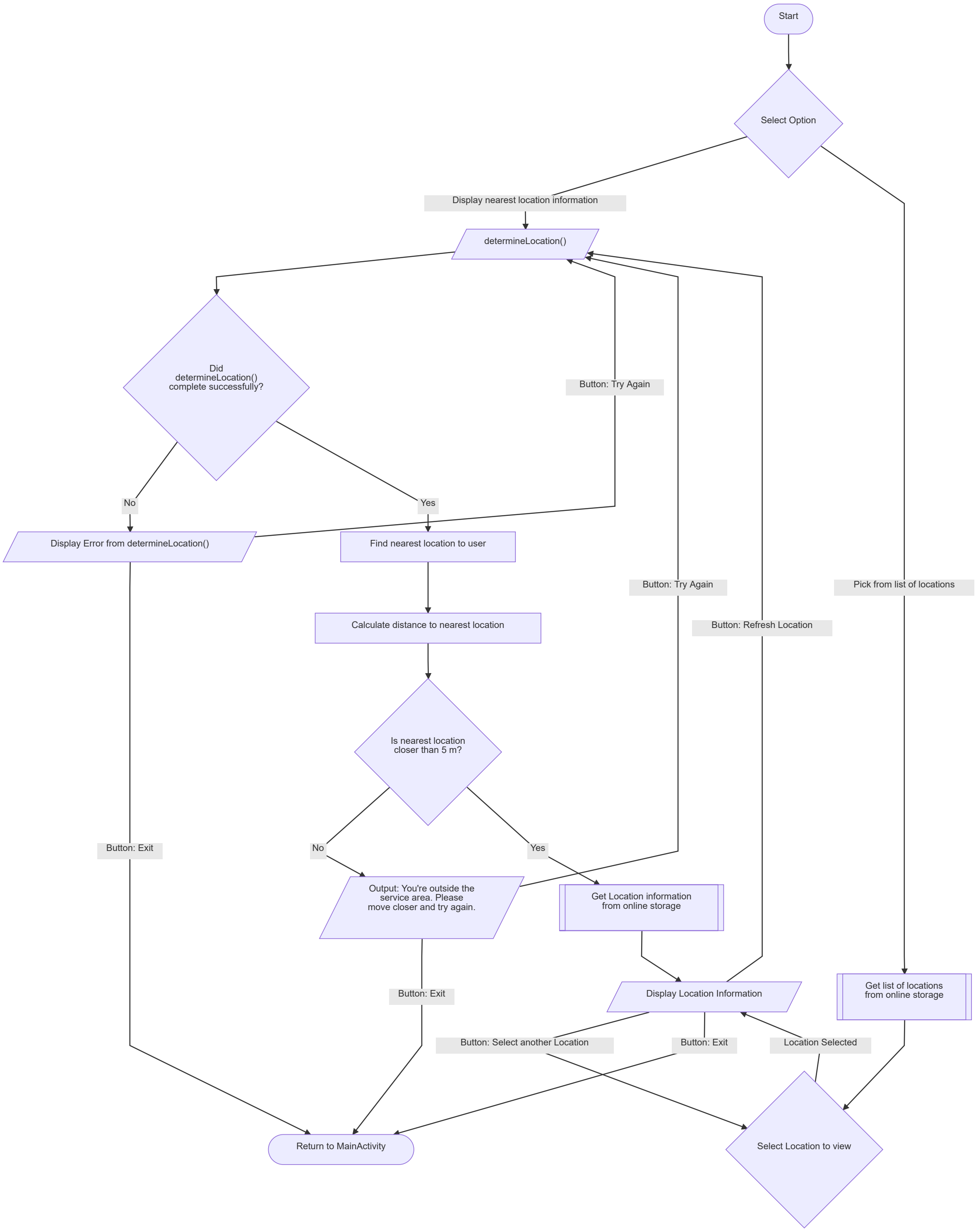
`determineLocation()`

- Sub-function for determining the user's current location.
- Called by `NavigationActivity`, `navigate()` and `LocationInfoActivity`.


Start
Prereq: Bluetooth is on
Bluetooth is off
Bluetooth is on
Get signal strength from each beacon
Was signal received from at least 3 beacons?
No
Yes
Triangulate Location using at least 3 beacons
Throw Error: Bluetooth must be ON
Throw Error: Not in range
Return Location
Return/Exit

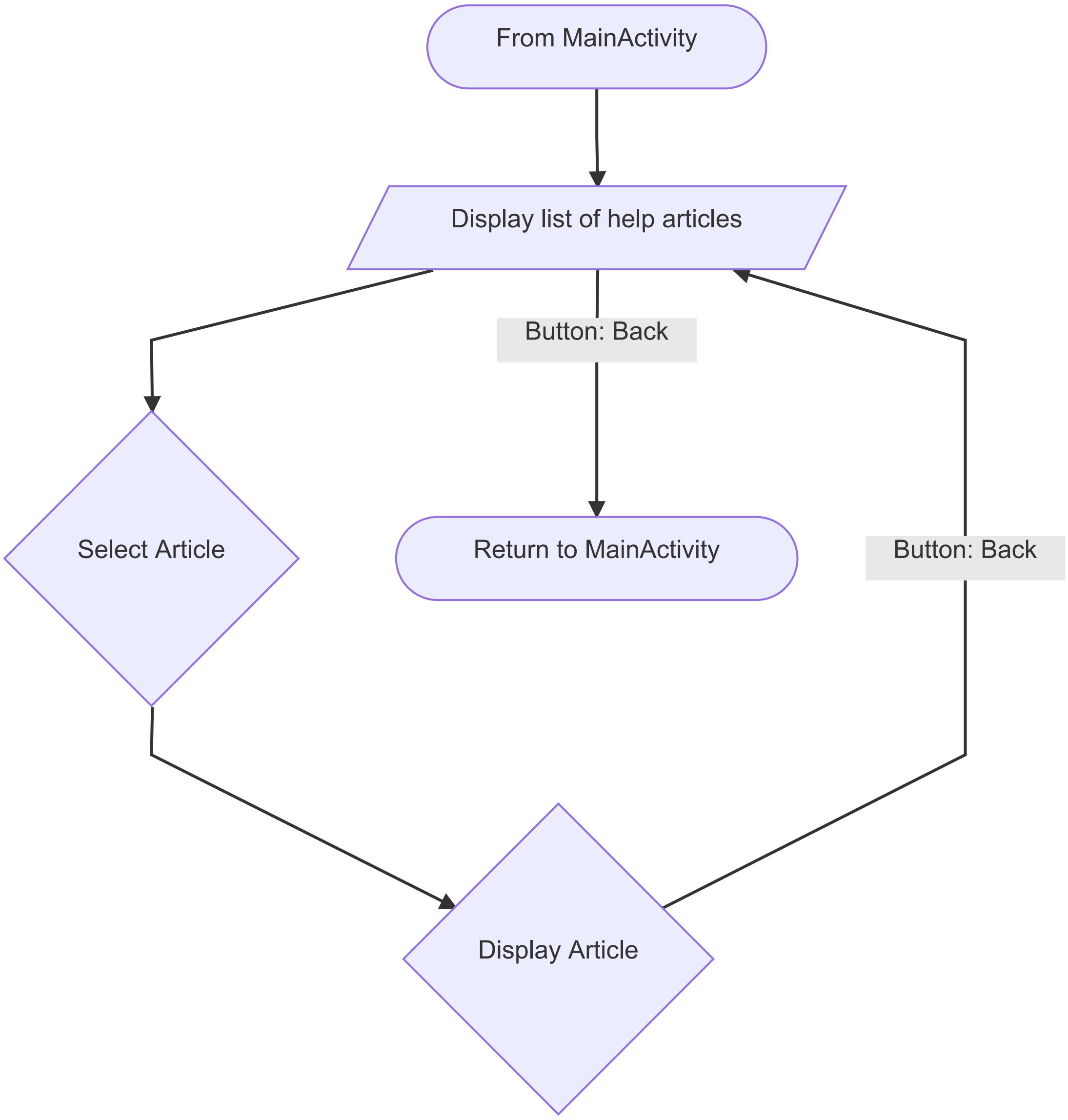
`LocationInfoActivity`

- App screen responsible for displaying information about any tracked location stored in the database.
- Called by `NavigationActivity` and `MainActivity`.


Start
Select Option
Display nearest location information
determineLocation()
Did determineLocation() complete successfully?
Button: Try Again
No
Yes
Display Error from determineLocation()
Find nearest location to user
Button: Try Again
Pick from list of locations
Calculate distance to nearest location
Button: Refresh Location
Is nearest location closer than 5 m?
Button: Exit
No
Yes
Output: You're outside the service area. Please move closer and try again.
Get Location information from online storage
Button: Exit
Display Location Information
Get list of locations from online storage
Button: Select another Location
Button: Exit
Location Selected
Return to MainActivity
Select Location to view

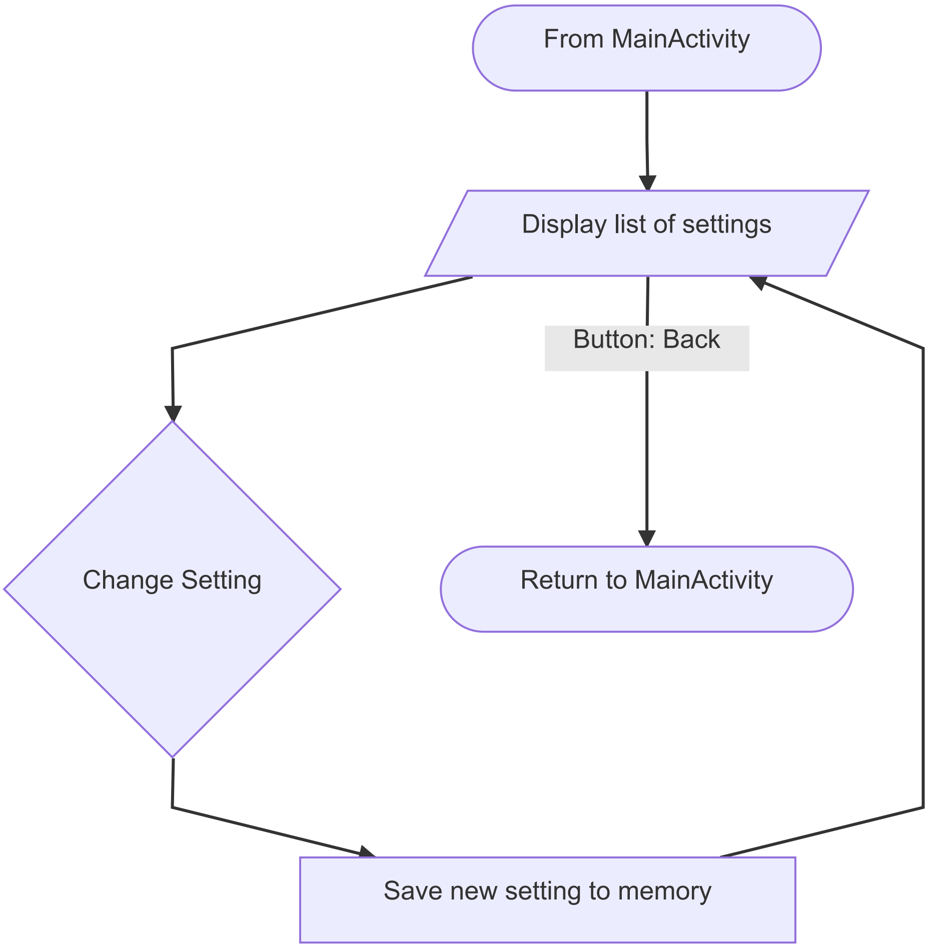
`HelpActivity`

- App screen for reading more about how to use the app.

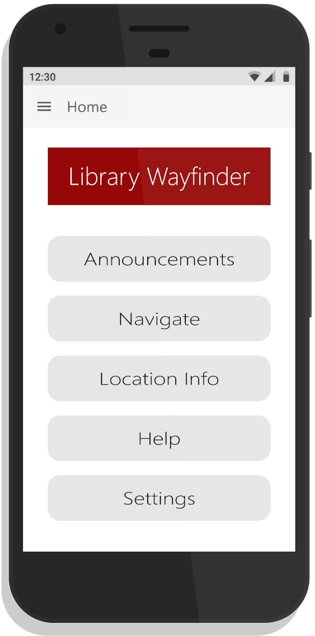


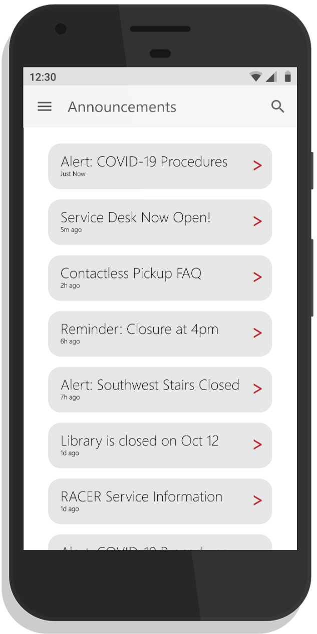
`SettingsActivity`

- App screen for editing app preferences.



App Mockups





Alert: COVID-19 Procedures
Just Now

Service Desk Now Open!
5m ago

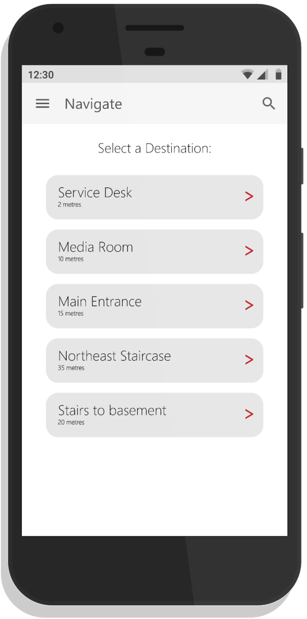
Contactless Pickup FAQ
2h ago

Reminder: Closure at 4pm
6h ago

Alert: Southwest Stairs Closed
7h ago

Library is closed on Oct 12
1d ago

RACER Service Information
1d ago



Select a Destination:

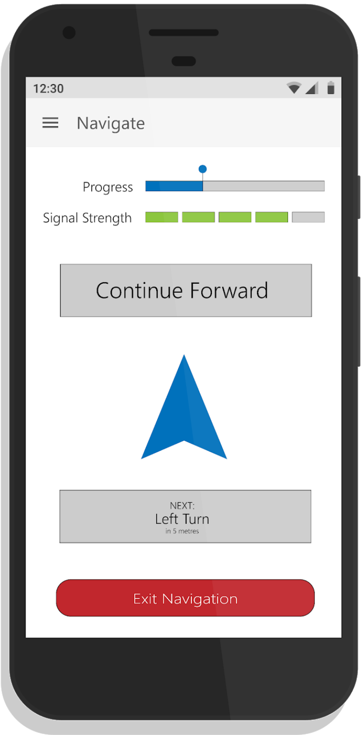
Service Desk
2 metres

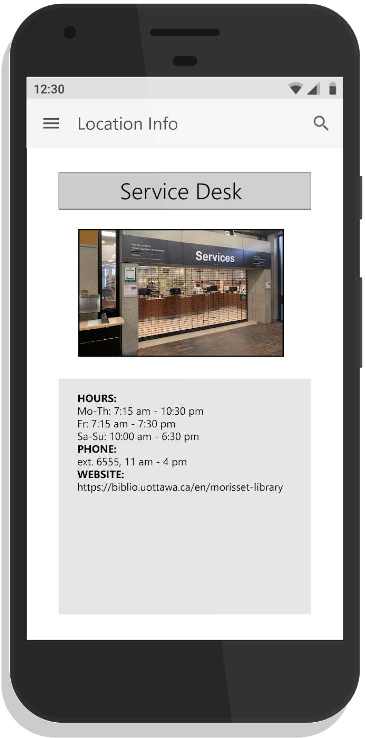
Media Room
10 metres

Main Entrance
15 metres

Northeast Staircase
35 metres

Stairs to basement
20 metres





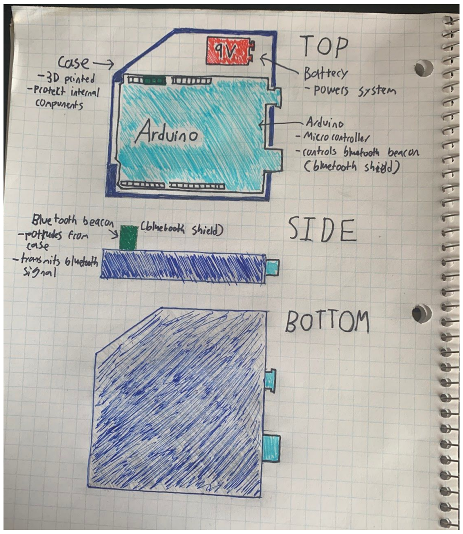
HOURS:
Mo-Th: 7:15 am - 10:30 pm
Fr: 7:15 am - 7:30 pm
Sa-Su: 10:00 am - 6:30 pm
PHONE:
ext. 6555, 11 am - 4 pm
WEBSITE:
https://biblio.uottawa.ca/en/morisset-library

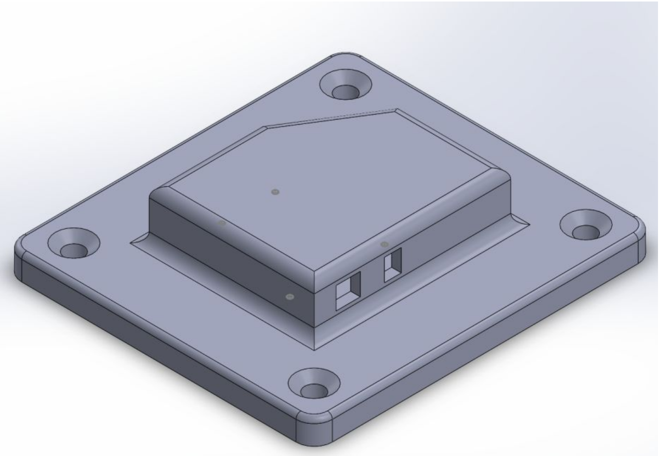
4. Critical product assumptions

- The unit can be mounted to the wall as one unit (is one unit)
- The unit's casing can be penetrated by Bluetooth signals
- The unit casing fits within the size and weight target specifications

5. Physical Prototype

- **Visual Designs**





Sketch of the Arduino Case and its components

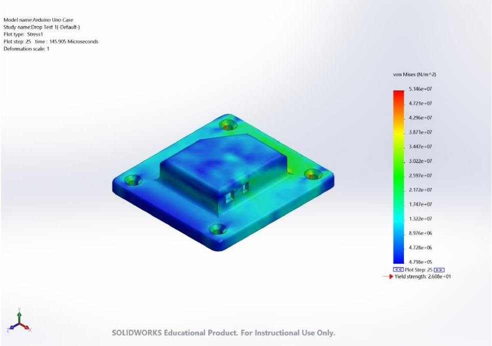
CAD Model of the case based on the sketch created previously

- **Explanation**

Our prototype is going to utilize three main components. The first part is the case. The case is going to be used to hold all of our components together, as well as help secure it to the ceiling or wall. In the sketch, it is marked in blue and has the main function of holding the other components together. The CAD design on the right shows the sketch in combination with the strategy to mount it to the wall or ceiling. The second main component is the microcontroller and Bluetooth shield. These are labeled in light blue and green on the sketch. The purpose of these is to transmit a Bluetooth signal to the app on the cellular device. The last component is the power source. This is represented by the red battery in the sketch, and its purpose is to supply power to the microcontroller.

6. Prototype Analysis and Evaluation

The team has carried out a few tests to compare the first prototype of the case and compared it to the previously determined target specifications. To start, the team has created a CAD model to determine the mass and dimensions of the prototype. The mass of this case is estimated to be 610g using the software provided by Solidworks and the material properties of PLA. Additionally, the cardboard cutout was measured to be 100g. Although the case in the CAD model is higher than the ideal specification, it should be noted that the dimensions of the case are in reference to the dimensions of an Arduino UNO. The team plans to move towards using ESP32 modules which are much smaller than the Arduino UNO's. This should significantly reduce the mass of the case, meeting the target specification of the weight. Next, the Solidworks model was measured to determine its size. Once again, because the reference dimensions were used from the Arduino UNO datasheet, the dimensions are greater than that of the target specifications. The current prototype measures approximately: 180 mm x 163 mm x 38 mm. In this case, two of the dimensions are larger than the target, but if the team moves to the ESP32 board, the dimensions will be reduced significantly. The figure below shows a stress test performed on the case during a drop from three metres using Solidworks. This test analyzes the durability of each point on the case by calculating its yield strength after the impact.



Strength test created, dropping the case from 3 metres.
This test was performed using software included in Solidworks 2019.

Finally, the team was unable to calculate the expected lifespan of the batteries for the Arduino being used since the team members could not acquire a multimeter and other materials needed to build a circuit using the batteries. It would have been preferable to build a circuit and calculate the current in a parallel series to estimate the lifespan of batteries.

7. Client Meet Preparation

During the next client meeting, the team plans to have a solid, medium-fidelity prototype. This would entail the group to have a 3D printed version of our beacon prototype along with the proper Bluetooth shields and the proper Arduino electronics from Makerspace. Software-wise we plan to have an early version of the app with low functionality but with a polished layout which will allow the client to get a grasp of how easy/hard the application will be to navigate and provide them with a better sense of the solution that we are aiming to provide. For the next client meeting our group plans to smooth out any problems they have with our current designs and further gain a better understanding of how our app/beacon combo is going to work in the library which will in turn point the team in the right direction for the final product presentation.

8. Bill of Materials (BOM)

*The BOM listed below is for 4 beacons

Material	**Location**	**Quantity**	**Unit Cost**	**Extended Cost**
3D printed case	From Makerlab	4	$ -	$ -
Battery Clips	From Makerlab	4	$ 1.00	$ 4.00
AA Batteries	From Makerlab	16	$ 0.60	$ 9.60
M3 Screws	McMaster-Carr (93640A125)	16	$ 0.19	$ 3.04
M3 Heat Inserts	McMaster-Carr (94180A331)	16	$ 0.14	$ 2.24
MCU + Bluetooth	From Makerlab	4	$ 17.00	$ 68.00
Shipping			**$ -**	**$ -**
Subtotal				**$ 86.88**
Taxes				**$ 11.29**
Grand Total				**$ 98.17**

Justification:

The BOM featured above focuses on the physical components of the prototype, as the software being used is free. Overall this BOM is centered around the building of four beacons, although the minimum number required to perform the task is three. Item one on the list is the 3D printed case, which is free, as printing PLA is free of charge in the Makerspace at uOttawa. Item two is the battery clips, which will be used to safely secure the batteries in the case. These will be purchased from Makerlab, at a unit cost of $1.00. Item 3 is the required power source to make the beacon work. We have chosen to use AA batteries, as they provide the necessary 5V, to the microcontroller. Each beacon requires 4 batteries, at a unit cost of $0.60. Items 4 and 5 are required to mount the beacon to the roof or wall. Concrete screws and heat inserts were chosen, as the majority of the walls and ceilings in Morisset Library are made out of concrete. The Unit cost for both is $0.33, and a total of 4 of each per beacon is required. The last item on the BOM is the Microcontroller Unit and Bluetooth Shield. These components are the backbone of the beacon as they output the Bluetooth signal that the cellular devices pick up. The unit cost for these ranges from $9.00-$17.00, so it has been put into the budget at $17.00, to account for the maximum cost. If Makerlab can provide cheaper MCU's and Bluetooth Shields, the extra money will go towards making more beacons.

Conclusion

This document showcases the final design concepts chosen to pursue based upon the concepts come up with in the past deliverable. This document broke down the physical and software prototypes created, all of the subsystems, and the flow diagrams. In the future, this document will act as an effective reference for each team member to review the progression and growth from prototype to prototype. This document will also serve as a reference guide to the cost associated with the project. The team is excited to continue developing this project to improve the Morisset Library's ability to cater to its visually impaired customers.