

Project Title (TBA)

Real-time location device that makes use of ultrawideband, BLE, & Apple Find My network



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Initial Project and Group Identification Document
Group 23: Divide and Conquer Version 2.0

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1. Project Details

1.1 Motivation

People have a lot of stuff, many of most could be misplaced, left behind, or stolen. There are some items you can't afford to lose. What if you could make any personal object trackable? It would cut out the need for time-consuming searches and not quite being able to retrace your steps. The (INSERT NAME HERE) helps people track and find their possessions.

1.2 Goals & Objectives

The goal of this senior design project is to create a device that will be able to track any object the user attaches to. We want this finder to be simple in design and have a small footprint for the most user applicability. This small form factor is possible by eliminating a speaker in the device to audibly help users find their item and solely relying on the real-time location system. Another way to cut down on device dimensions is utilizing ultrawideband devices with the integration of an RF antenna on the module and SoCs supporting Bluetooth Low Energy.

This device would be capable of being located on a smartphone application map. It would also be capable of providing real-time location and distance. Acting as an anchor for the finder, these tracking features would only work with a smartphone application as a receiver. We will incorporate this device into the Apple Find My network to achieve mobile map location. Real-time direction and distance will be possible through the use of the Nearby Interaction Framework on Apple iPhones 11 and later.

1.3 Features & Function

- Lightweight and small
- Ultrawideband technology
- Precision tracking up to 20cm
- Bluetooth Low Energy technology
- Tracker localization by Apple crowdsourced Find My network
- NFC capabilities
- Long-lasting battery
- Built-in loophole design to eliminate 3rd part accessory purchases

1.4 Products Used to Identify Project Features

There are similar tracking products on the market, Apple has its AirTag, and Samsung has its SmartTag. Both of these devices are similar in functionality, using Bluetooth and UWB technology to locate the device. We decided it was best to mimic these with our device as UWB has very precise location pinning. We decided to use Samsung, Apple, and a third-party device to help identify product features. Below are some of the features of each:



Figure 1-1: Apple AirTag

- Nordic nRF52832
- Single frame with 3 antennas
- AirTag measures 1.26 inches in diameter, and it has a height of 0.31 inches
- 11 grams in weight
- Managed in Find My app
- AirTag uses a replaceable CR2032 battery
- IP67 water and dust resistance rating
- Only compatible with iPhones
- Speaker for locating

Apple air tag is conveniently small and uniquely shaped. This design choice forces the consumer to invest in their 3rd party accessories to use it more generally. We will consider removing this in our design. The AirTag has a metal surface that would tend to scratch up considering it is on a keychain or something similar.



Figure 1-2: Samsung SmartTag

- 1.8 inches in length and width with 0.4 inches thick
- 13 grams in weight
- Speaker for locating
- Square in shape
- IP53 rating for water resistance
- Replaceable CR2032 battery
- Only compatible with Samsung devices

Samsung smart tag has a more user-friendly design made out of hard plastic with an included keyhole. We will be closely following this device as far as squareness goes.



Figure 1-3: Chipolo ONE Spot

- Speaker for locating
- Only uses Bluetooth technology
- Round in shape
- Works with apples "Find My" app
- 1.49 inches in diameter and 0.25 inches thick
- 8 grams in weight
- IPx5 rating splashproof
- Replaceable CR2032 battery

The Chipolo one spot was chosen to help identify product features because it is a third-party device that can be used in the Apple "Find My" app. What we will do differently is integrate ultra-wideband technology into our device.

2. Requirements & Specifications

2.1 Engineering Requirements

Requirements from table 2-1 are determined from our investigation of other products on the market currently. Requirements such as this increased user desirability to use the product, ease of use, and functionality.

	Engineering Requirement	Justification
#1	Device should be internally powered with 3V battery	Increase user operability and reduce device size
#2	Device should be less than 20 Grams	The device will need to be unnoticeable while carried by the user
#3	Precision Finding To 20 Centimeters	Users will be led to their missing item
#4	Device Will Communicate With Apple iPhone Within 30 Seconds	Implementation of Apple's robust find my network features
#5	Ultrawideband Range of 15 Meter	Helpful for users using the precision finding feature
#6	Bluetooth Low Energy Range of 10 Meters	Used for smartphone background tasks
#7	Device should be battery powered for at least 3 months	Increase user operability

Table 2-1: Engineering Requirements

2.2 Constraints

The constraints listed in table 2-2 are based on the environment and conditions the device will be working in.

Engineering Constraint	Justification
The maximum measurements of the device should not exceed 36mm x 8mm x 36mm	The tracker should be a convenient size to place or attach to most objects
iOS 16 compatibility only	location features require this operating system
Apple iPhone 11 or later compatibility only	Certain generations of iPhones are equipped with ultrawideband technologies

Table 2-2: Engineering Constraints

2.3 Standards

After investigation, the standards listed in table 2-3 were most related to the project. These standards will be a guideline for completing the project and ensure it will work as designed.

Governing Body	Designator	Standard	Creation Date
IEEE	802.15.1	Bluetooth	2002
IEEE	802.15.4z	UWB physical Layers & Associated Ranging Techniques	2020
IEEE	802.15.4	Ultra-WideBand	2009
IEEE	1118.1	Microcontroller	1990
IPC	2221	Generic standard for printed circuit board design	1998

Table 2-3: Standards

2.4 House of Quality

Figure 2-4 shows features and qualities consumers would like to have in a device such as ours and competitors. Our engineering requirements are shown in the House of Quality to clearly illustrate our areas of maximizing and minimizing.

Column #	1	2	3	4	5	6	7	8
Direction of Improvement	◇	▲	▼	▲	▼	◇	◇	▼
Engineering Requirements	Light Weight	Ultra WideBand Connectivity	Dimensions	Bluetooth Connectivity	Efficient	Accurate	Connectivity	Ease of Use
Customer Requirements (Explicit and Implicit)								
Precision Finding	▽	●	▽	○	▽	●	○	○
Replaceable Battery	○	▽	▽	▽	●	▽	▽	●
Durable	○	▽	▽	▽	▽	▽	▽	▽
Compact Design	●	▽	●	▽	●	▽	▽	●
Useable Design	●	▽	○	▽	○	○	○	●
Long Battery Life	▽	○	▽	○	●	▽	○	●
Range	▽	▽	▽	●	▽	○	○	▽
Device Compatibility	▽	●	▽	○	▽	▽	▽	▽
Target	≤ 20 grams	Ultra Wideband range ≥ 15 meters	≤ 36mm x 8mm x 36mm	BLE Range ≥ 10 meters	3V battery powered	Precision Finding ≥ 20cm	iPhone communication 30 seconds	Battery Powered ≥ 3 months

Correlations	
Positive	+
Negative	-
No Correlation	

Relationships	
Strong	●
Moderate	○
Weak	▽

Improvement	
Maximize	▲
Target	◇
Minimize	▼

3. Project Block Diagram

3.1 Hardware Block Diagram

In the figure located below, figure 3-1, which is the block diagram for the project, is all of the layers and specifications that the group will have to follow to accomplish the project. Moreover, in the figure, it could be seen that there are several different colors representing each part that each of our group members will be focused on and their names and their names are associated based on the color that each of the members has chosen to work on. However, even though the members specified the field that they would like to focus on the most, their area of work does not only limit to the specified field chosen since some of the areas require more work and research to be made.

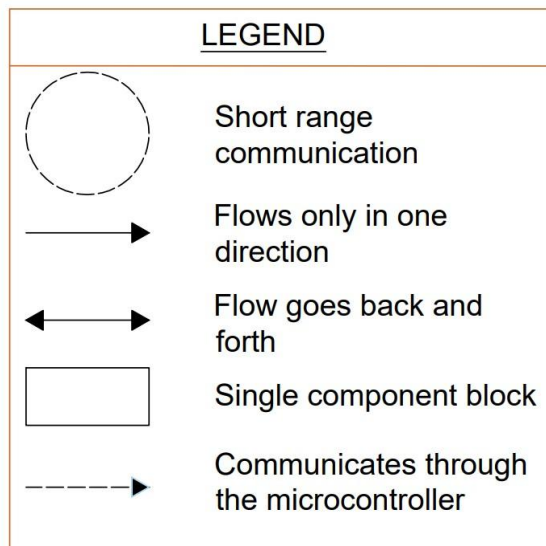
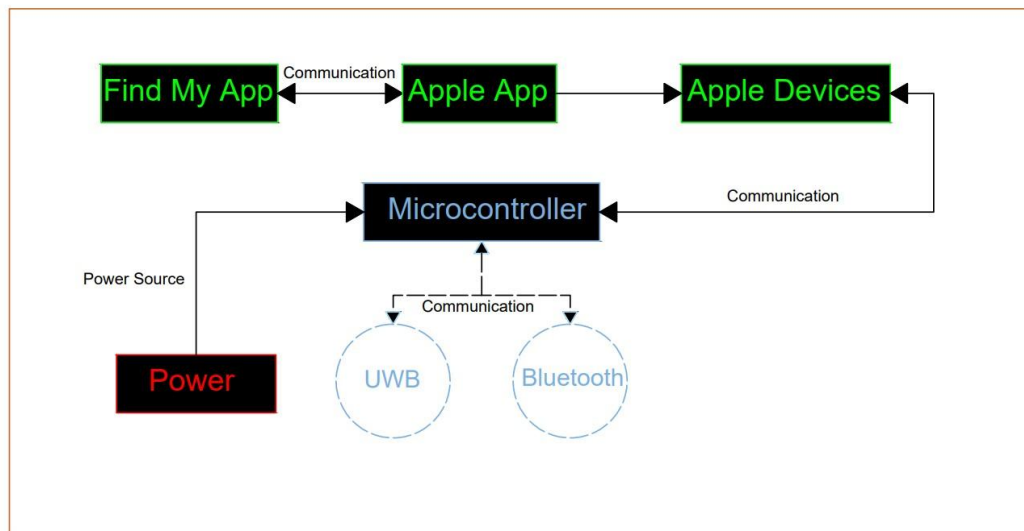


Figure 3-1: Hardware Block Diagram

4. Project Budget

4.1 Development Bill of Material

There is no project without a well-established budgeting plan because it plays a big role in any project’s realization. Hence, in the tables below, there is a list of the different parts and software that will be needed, along with the estimated prices calculated based on the actual, 2022, market price.

Description	Unit Price	Quantity	Total Cost
UWB dev. board	\$19.50	1	\$19.50
MCU dev. board	\$39	1	\$39
Apple dev. program fee	\$99	1	\$99
Total			\$157.50

Table 4-1: Development BOM

4.2 Single Unit Bill of Material

This part of the budget, table 4-2, represents the total price that making one tracking device will cost. As for now, the total price listed is not the long-term goal targeted by the group because we are aiming for the device to be cheaper than the other devices on the market, such as the Air Tag, Samsung Tag, and Tile, while being as competitive as they are.

Description	Unit Price	Quantity	Total Cost
MCU	\$6	1	\$6
UWB	\$8	1	\$8
Misc. components (capacitors, resistors, etc.)	\$10	N/A	\$10
Battery	\$4	1	\$4
PCB manufacturing	\$15	1	\$15
Case manufacturing	\$25	1	\$25
Total			\$68

Table 4-2: Single Unit Cost

5. Project Milestone

5.1 Milestones

Table 5-1 consists of milestones that our group is expected to complete to have a successful senior design I/II and project.

Senior Design I	Weeks
Group Formation	Week 1
Project Brainstorming	Week 1 - 2
Project Idea Proposals	Week 3
Uwb Investigation	Week 3
Microcontroller Investigation	Week 3
Divide & Conquer V1	Week 3 - 4
Divide & Conquer V1 Meeting	Week 5
Project Revisions	Week 5
Divide & Conquer V2	Week 6 - 8
Order Prototyping Parts	Week 7
Continue Project Documentation	Week 9 - Week 12
Finalize Paper	Week 13 - 16
Fall Break	
Senior Design II	Weeks
Group Regathering and Project Coordination	Week 1
Begin Prototyping	Week 2 - 4
Test and Debug	Week 5 - 10
Final Revisions and Document Submission	Week 10 - 13
Final Project Presentation	Week 13 - 16

Table 5-1: Milestones