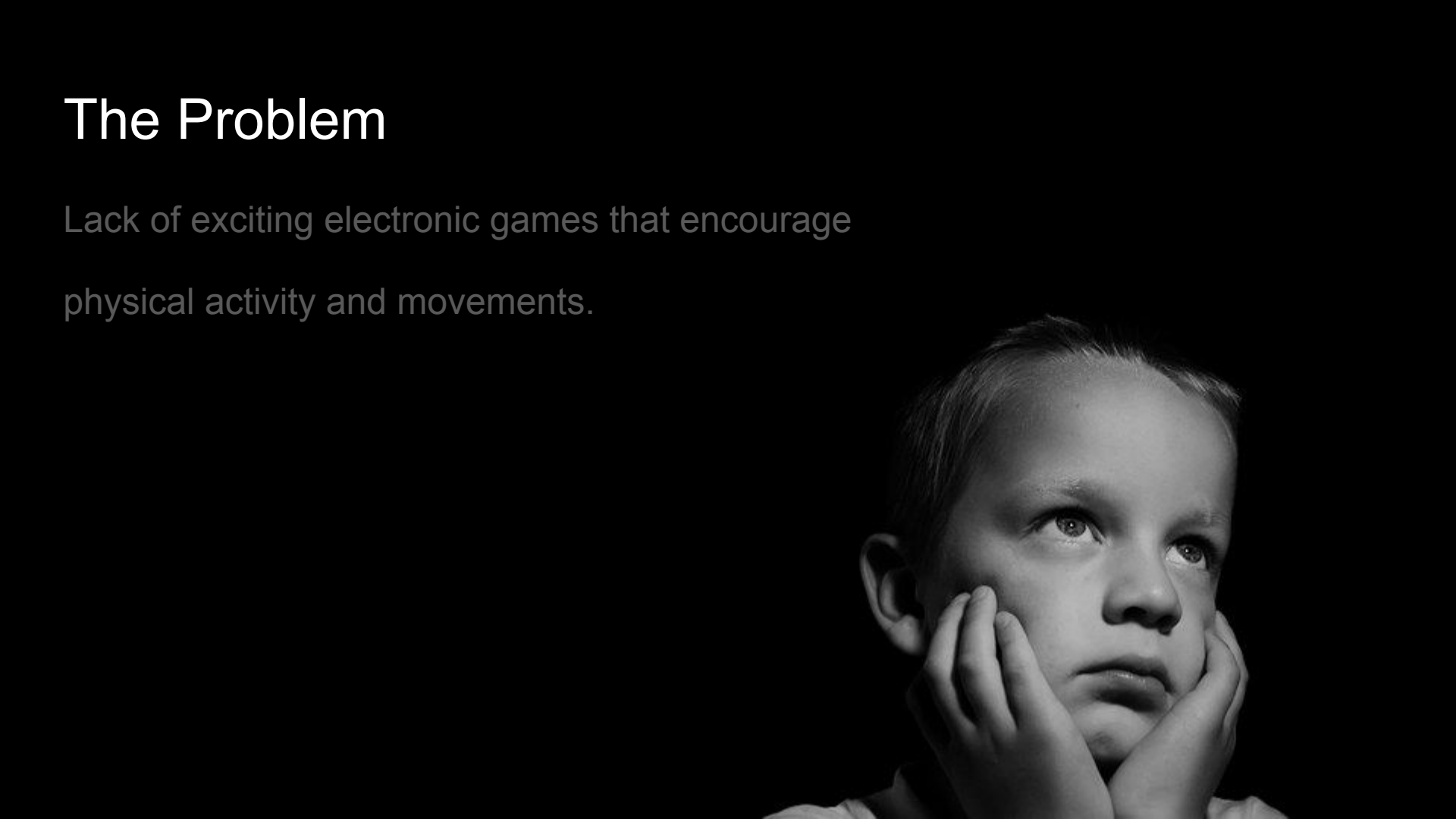
Electronic Hot and Cold Game

Team 10 - The Fighting Mongooses
Leo Garcia, Yousef Alkhelaifi, Robert Fogg, Regan Garner

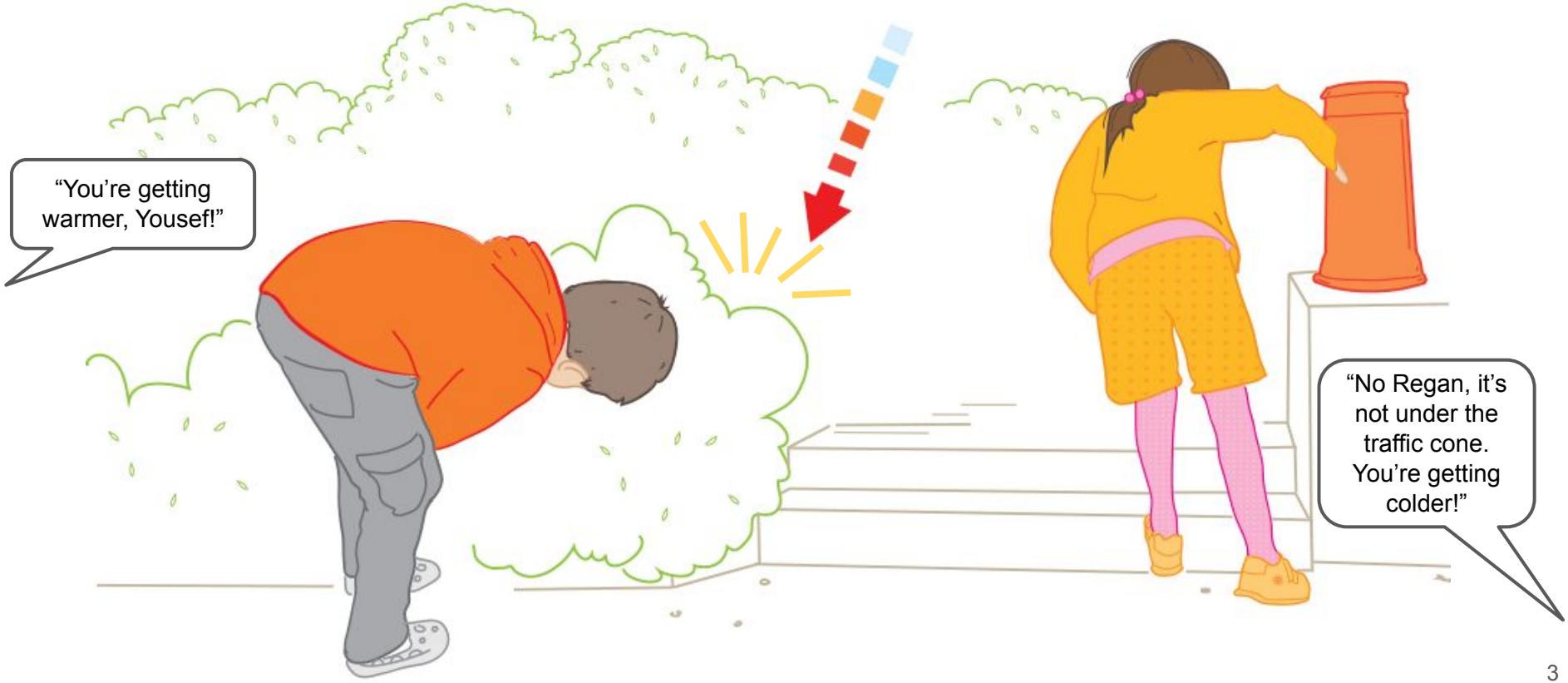
The Problem

Lack of exciting electronic games that encourage physical activity and movements.



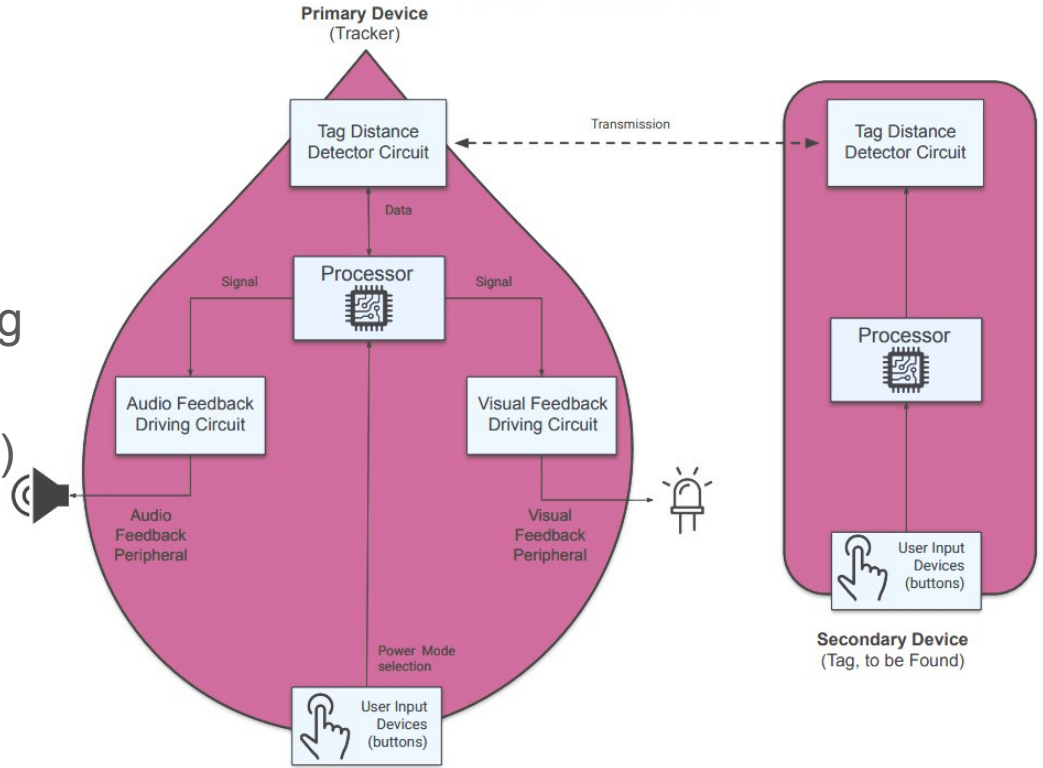
Objective:

Make an electronic version of the “hot and cold” game



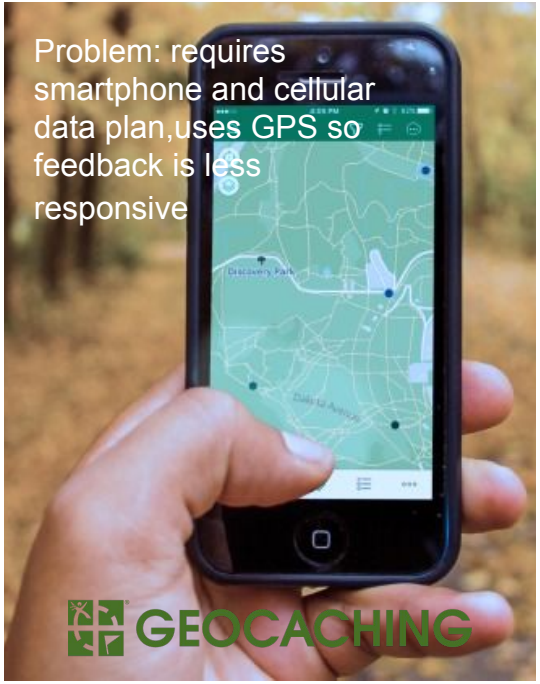
Solution

A portable tracker that can measure the distance from a hidden tag, which provides exciting feedback to the user to signal whether they are “warmer” (closer) or “colder” (further) to the hidden tag.



Alternatives:

Pokemon Go, Geocaching, MicroFox Transmitter Hunting Kits



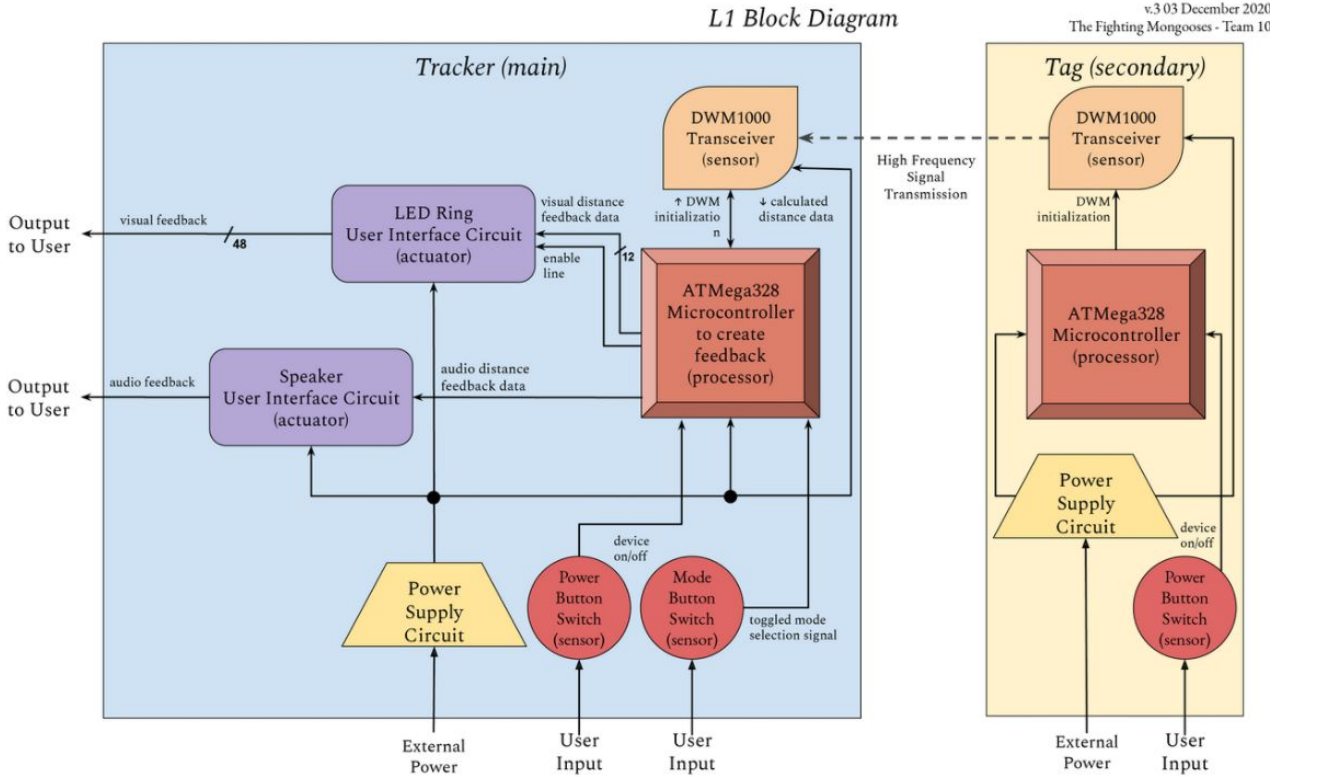
Requirements

Prioritized Project Requirements		
Must	Should	May
Be handheld		
Transmit within a 100ft range		
Follow FCC guidelines		
Update the user with proximity feedback minimally every 3-4 steps	• Provide visual feedback • Provide audio feedback	Provide directional feedback.
Have a battery life of at least five minutes	Have a battery life longer than five minutes	Use rechargeable batteries
Utilize a power switch		
		Have different modes such as a timed mode, or a race mode
		Be cased in a 3D printed housing

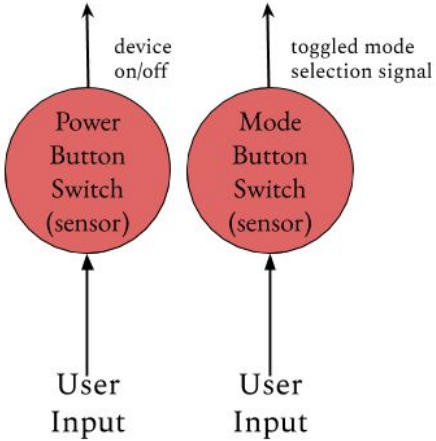
Our Approach

Primary Device, “Tracker”

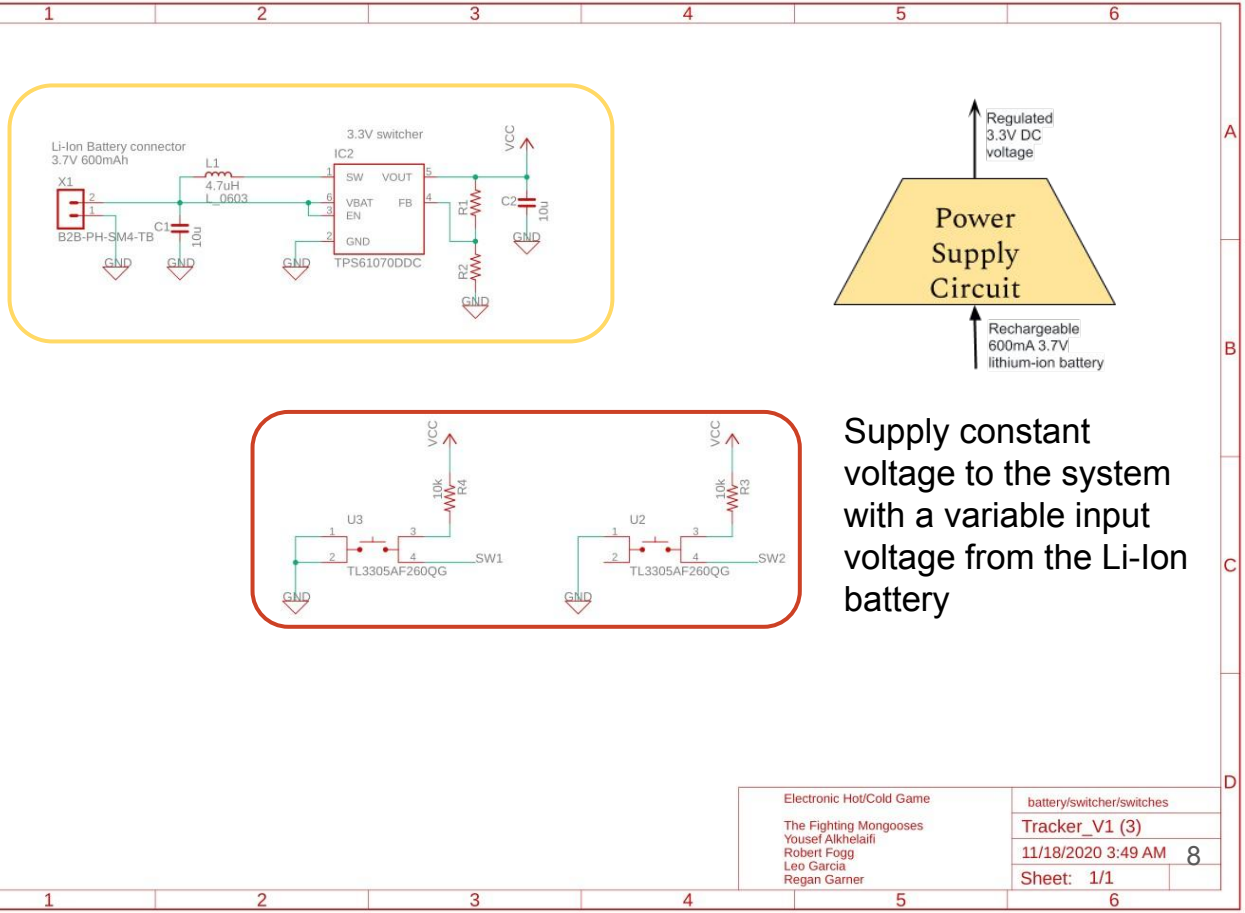
Secondary Device, “Tag”



Design: Power Supply Module

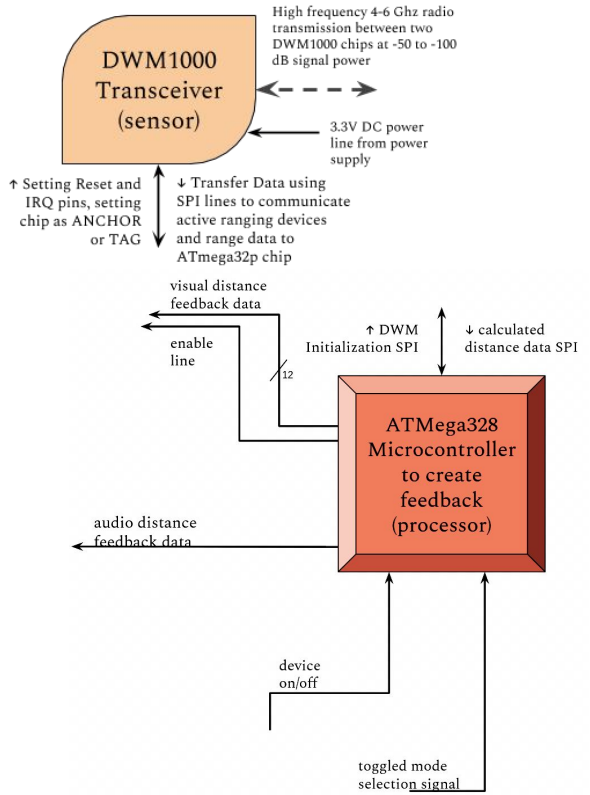


Allows the user to turn on the device and select operating mode

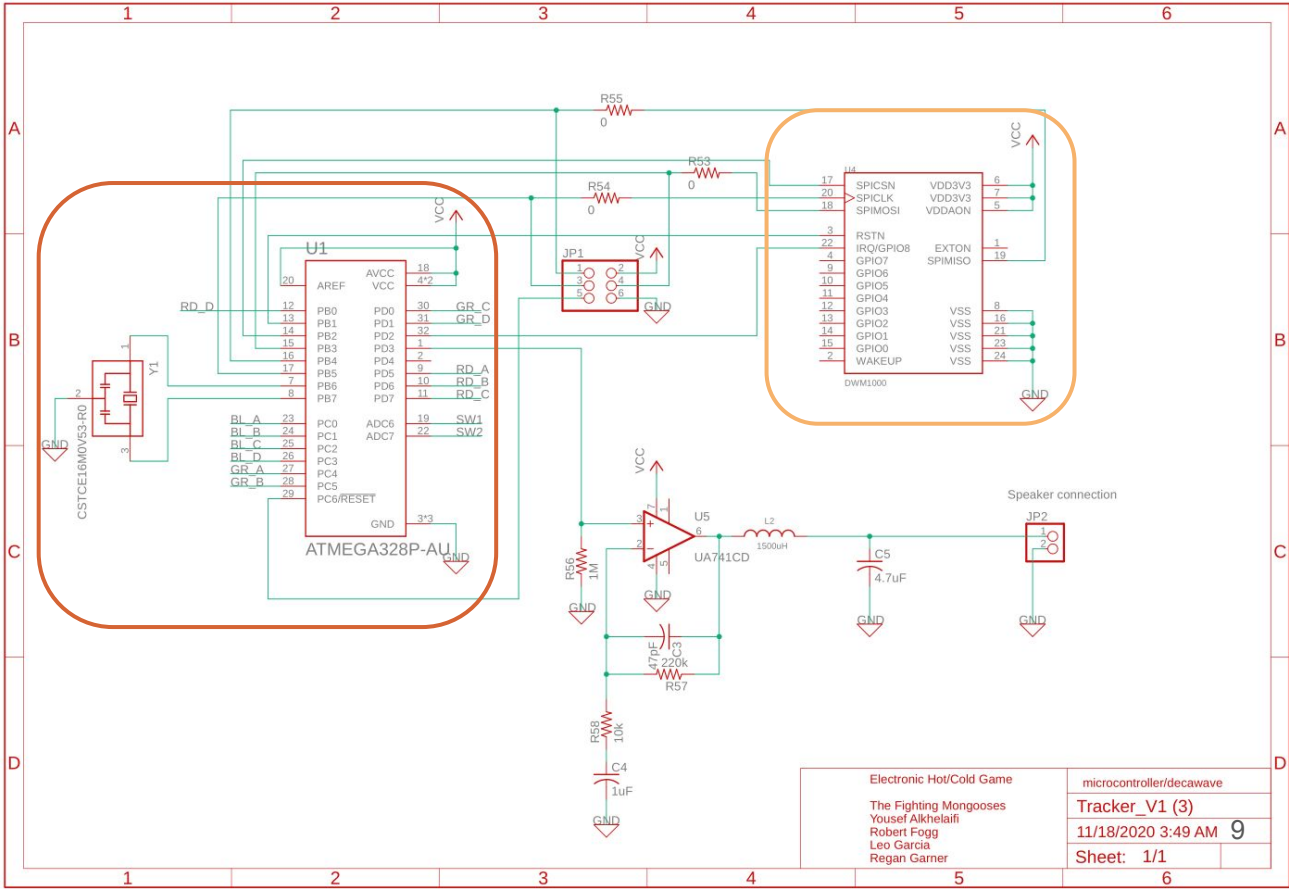


Supply constant voltage to the system with a variable input voltage from the Li-Ion battery

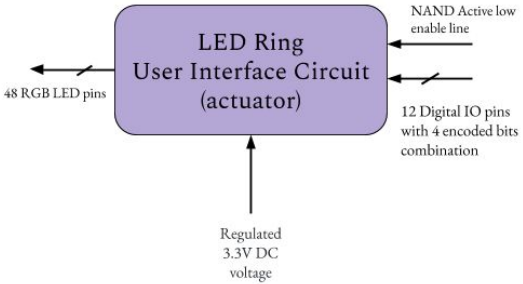
Design: Processor and Ranging Modules



Interface between the DWM1000 ranging chip and the processor

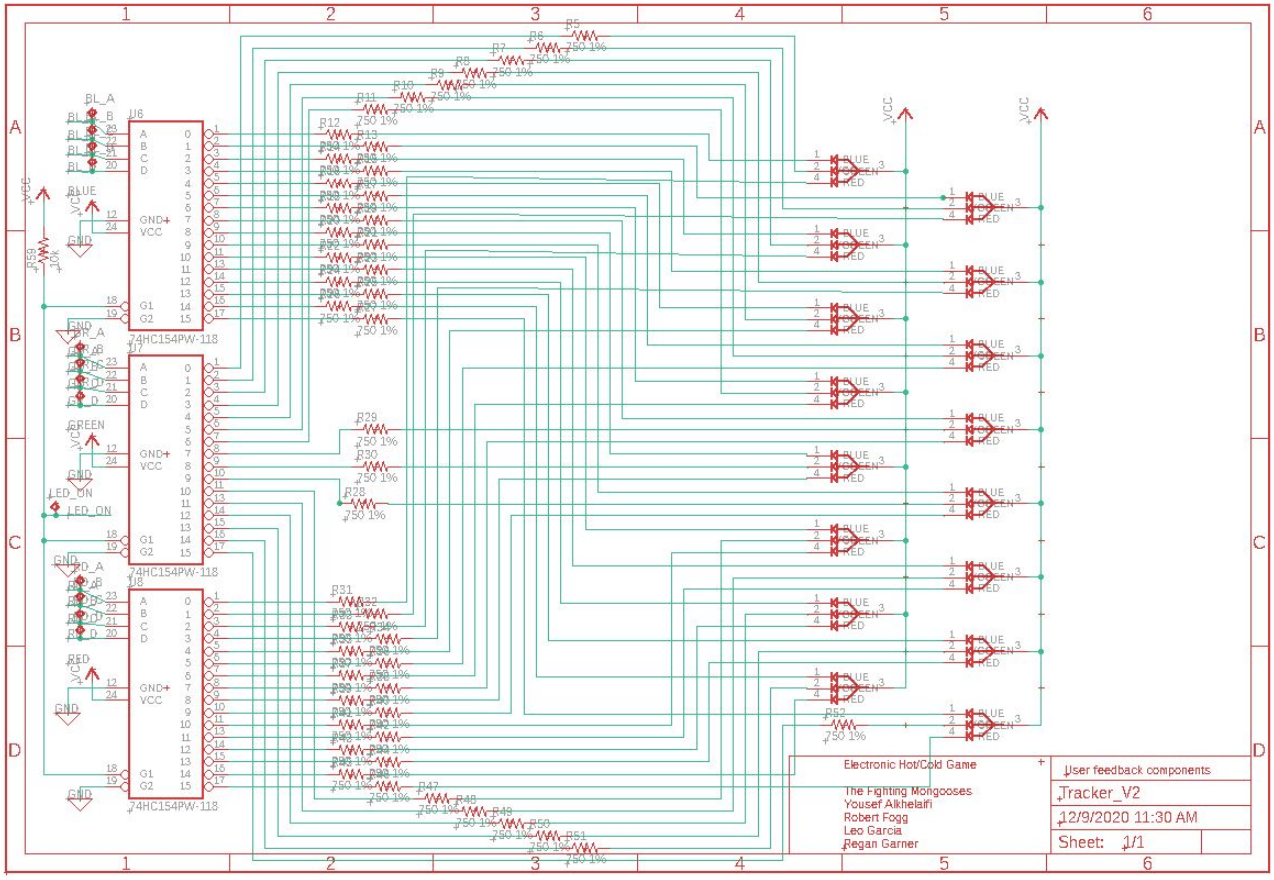


Design: Visual Feedback

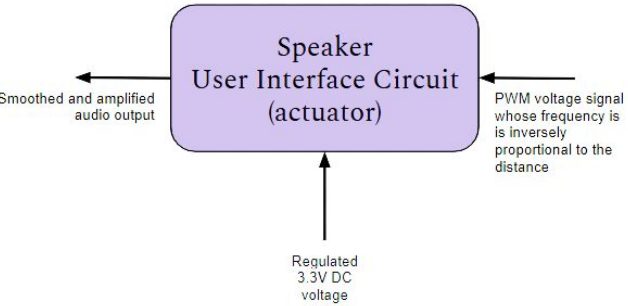


Design a circuit that controls 16 4-pin RGB LEDs that correspond to the calculated ranging data using 13 output pins from the processor

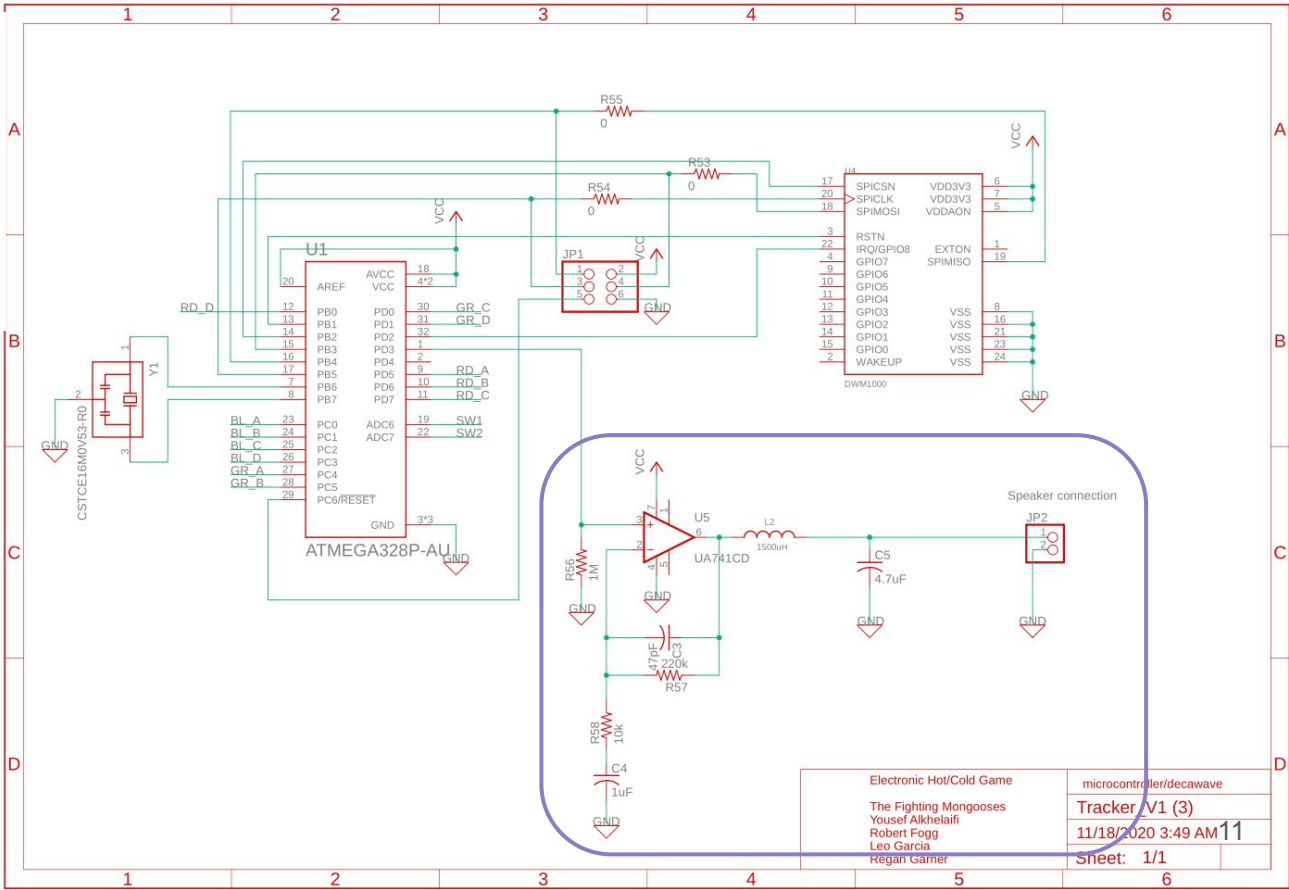
- 12 digital output lines from processor input into 3 4-to-16 decoder chips; R-G-B
- Enable line



Design: Audio Feedback



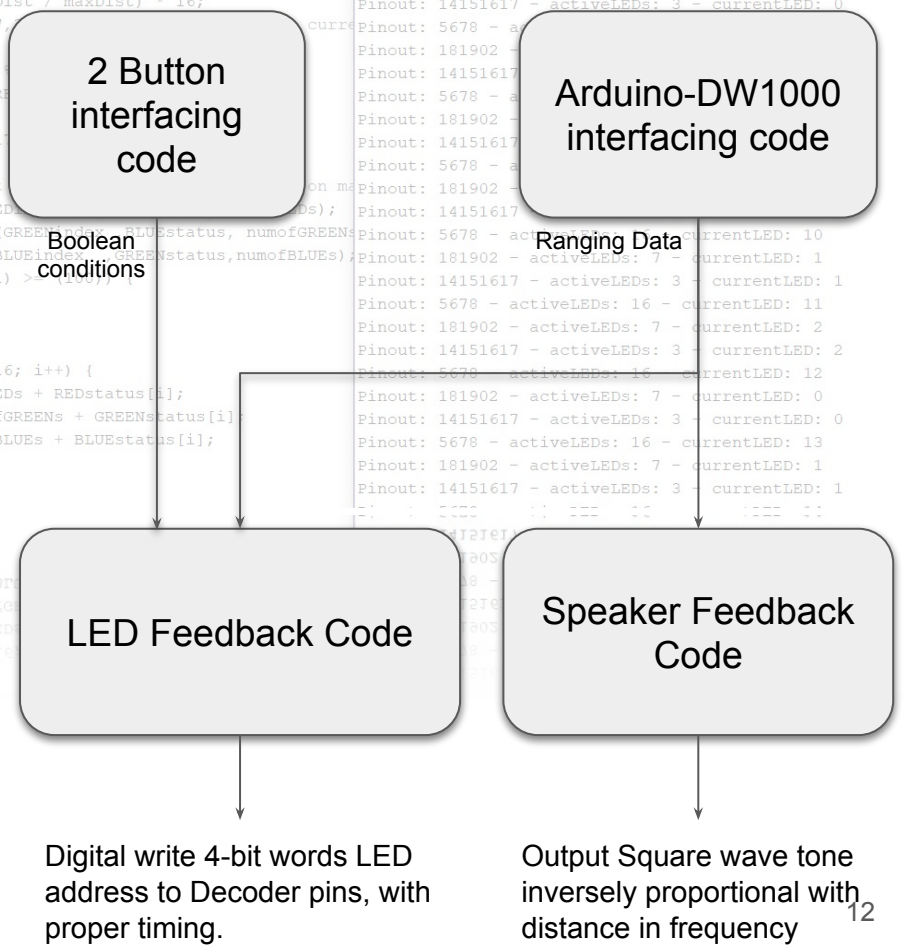
Design a circuit that outputs a smoothed and amplified audio signal whose frequency is inversely proportional to the calculated distance to indicate to the user how close they are to the secondary device.



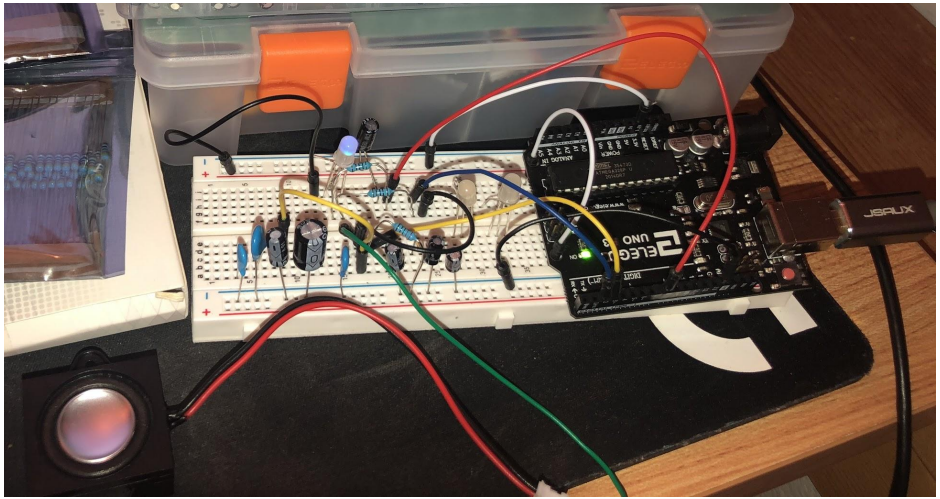
Design: Firmware

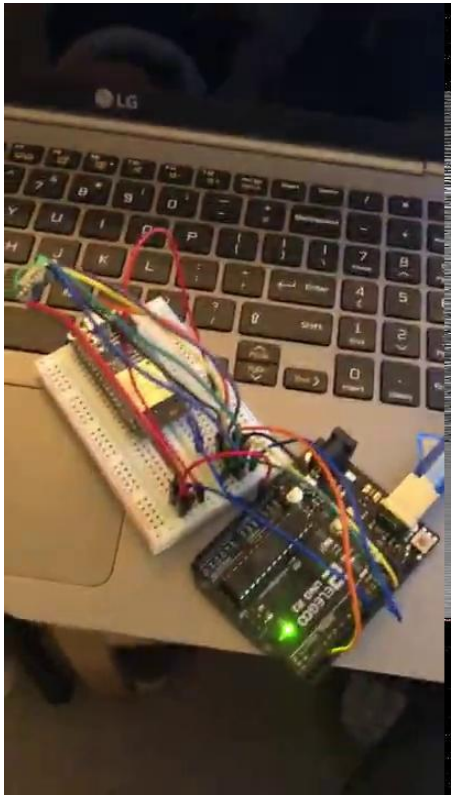
Challenges:

- Use the DW1000 two-way ranging capabilities to provide stable and usable range data for user feedback, using Dw1000 library.
- Design code that will drive 16 LEDs using 4 pins. By sending 4-bit word to 4x16 decoder, Make the code modular so it can be repeated for all 3 decoders to drive each color of the RGB LED array.
- LED code must be able to select individual LEDs to activate, as well as activate multiple LEDs simultaneously by rotating the selected LEDs in a counter-clock fashion With high enough frequency to appear continuous to the user
- Code must allow the user to interface via 2 buttons
- Driving Speaker with ranging data to be lower at greater distances and higher at closer distance.

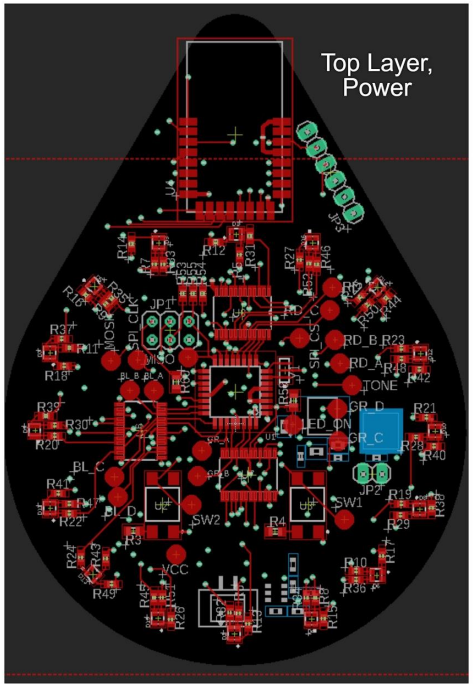


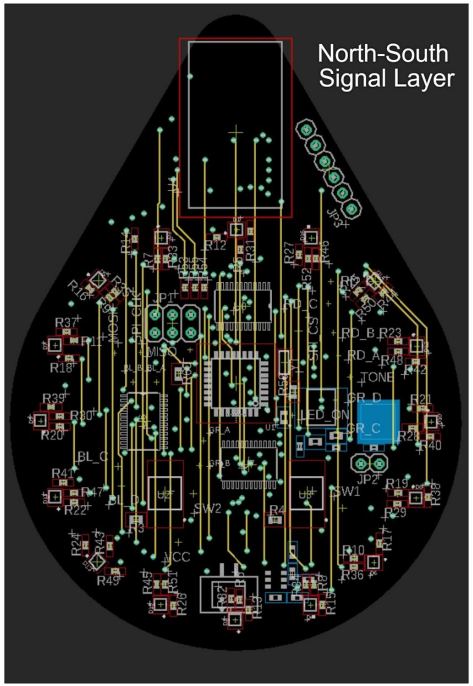
Implementation: Prototyping

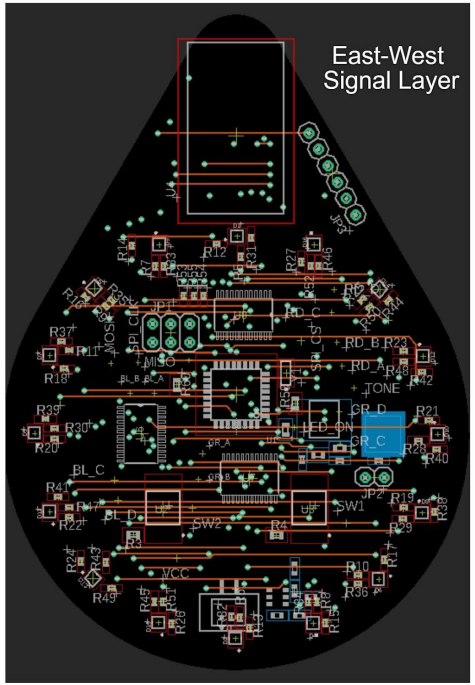


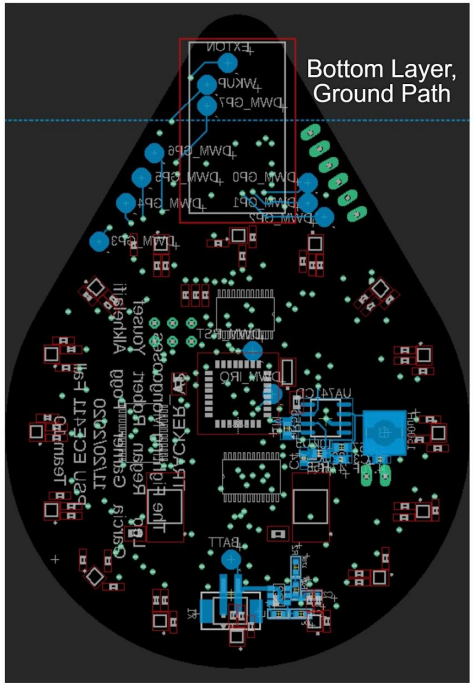


Design: PCB Layout

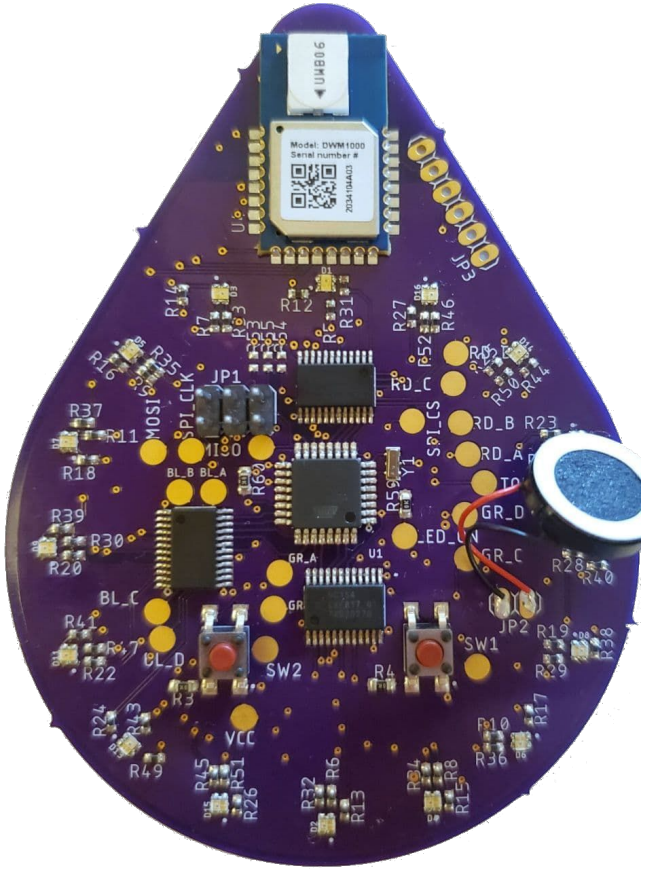




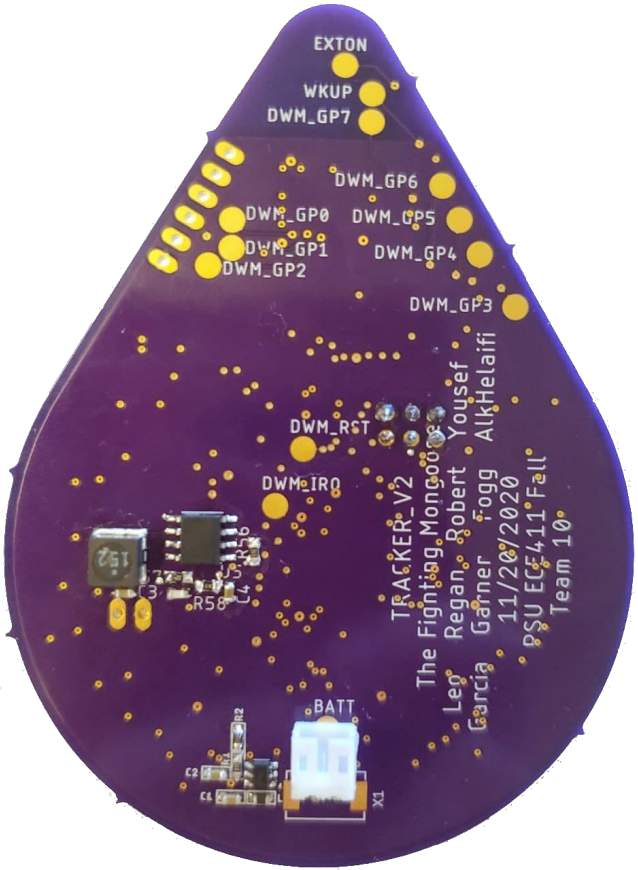




Implementation: Fabricated Boards



Front of Primary Device, “Tracker”



Back of Primary Device, “Tracker”

Implementation: Bill of Materials

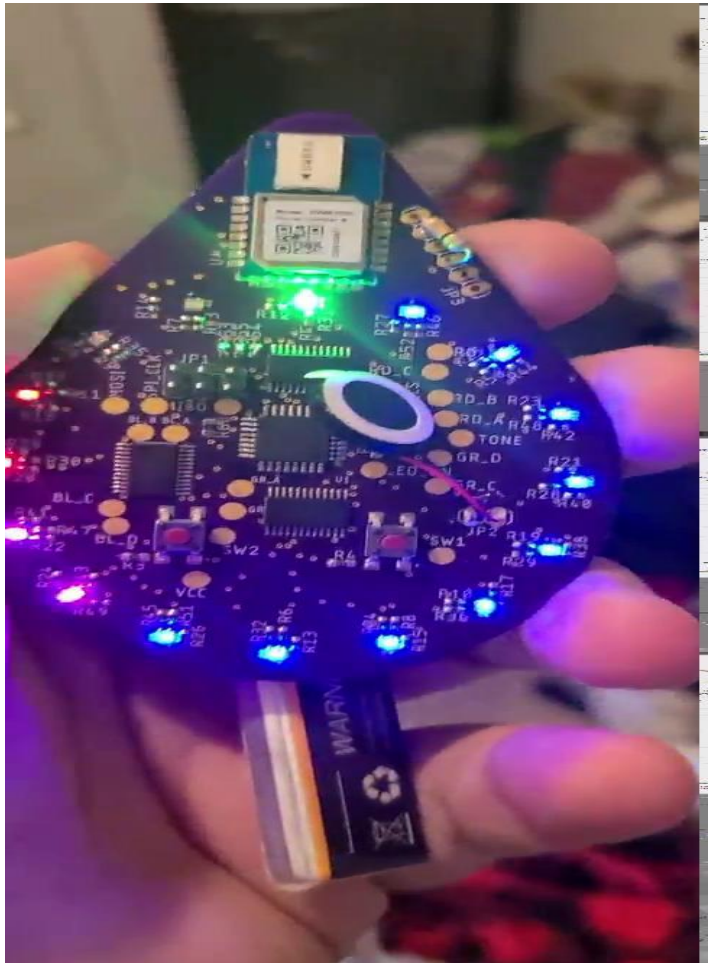
Qty Per Tracker	Total Qty	Part Reference	P/NP	Manufacturer	Manufacturer Part Numer	Value	Description	Distributor	Distributor Part Numer	Price Per Unit	Price Total
2	12	C1,C2	NP	AVX Corporation	0603ZD106KAT2A	10uF	10uF XR5 0603 Ceramic Capacitor	Digi-Key	478-10766-1-ND	$0.10	$1.15
1	6	C3	NP	AVX Corporation	06035A470JAT2A	47pF	47pF XR5 0603 Ceramic Capacitor	Digi-Key	478-1171-1-ND	$0.05	$0.32
1	6	C4	NP	Samsung Electromech	CL10A105KA8NNNC	1uF	1uF XR5 0603 Ceramic Capacitor	Digi-Key	1276-1102-1-ND	$0.04	$0.21
1	6	C5	NP	Samsung Electromech	CL10A475KQ8NNNC	4.7uF	4.7uF XR5 0603 Ceramic Capacitor	Digi-Key	1276-1045-1-ND	$0.04	$0.25
16	96	D1-D16	NP	Everlight Electronics C	LED_EAST1616RGBA3	-	LED Tri-Color Blue/Green/Red 468nm/518nm/632nm 4-Pin	Digi-Key	1080-1550-1-ND	$0.16	$15.01
3	18	IC1,IC4,IC5	NP	Nexperia USA Inc	74HC154PW	-	4-line to 16-line data SELECTOR/MULTIPLEXER	Digi-Key	1727-5944-1-ND	$0.99	$17.82
1	6	IC2	NP	Texas Instruments	TPS61070DDCR	-	90% Efficient Synchronous Boost Converter with 600-mA Switch	Digi-Key	296-17151-1-ND	$1.31	$7.86
1	6	JP1	NP	TE Connectivity	5-146258-3	-	Pin header	Mouser	571-5-146258-3	$0.49	$2.94
1	6	L1	NP	TDK Corporation	MLZ1608N4R7LT000	4.7uH	Fixed Inductor 4.7uH 400mA 320mOhm 0603	Digi-Key	445-9286-1-ND	$0.15	$0.90
1	6	L2	NP	Wurth Elektronik	744043152	1500uH	Fixed Inductor 1.5mH 90mA 9Ohm	Digi-Key	732-3660-1-ND	$1.43	$8.58
2	12	R1,R56	NP	Stackpole Electronics I	RMCF0603FG1M00	1MΩ 1%	1M ohm 1% 1/10W 0603 resistor	Digi-Key	RMCF0603FG1M00CT-ND	$0.02	$0.18
1	6	R2	NP	Stackpole Electronics I	RMCF0603FT178K	178kΩ 1%	178k ohm 1% 1/10W 0603 resistor	Digi-Key	RMCF0603FT178KCT-ND	$0.02	$0.09
3	18	R3,R4,R58	NP	Stackpole Electronics I	RNCP0603FTD10K0	10kΩ 1%	10k ohm 1% 1/8W 0603 resistor	Digi-Key	RNCP0603FTD10K0CT-ND	$0.06	$1.04
48	288	R5-R52	NP	Stackpole Electronics I	RMCF0402FT750R	750 1%	750 ohm 1% 1/16W 0603 resistor	Digi-Key	RMCF0402FT750RCT-ND	$0.01	$1.53
3	18	R53-R55	NP	Stackpole Electronics I	RMCF0603ZT0R00	0Ω	0 ohm Jumper 1/10W 0603	Digi-Key	RMCF0603ZT0R00CT-ND	$0.01	$0.23
1	6	R57	NP	Stackpole Electronics I	RMCF0603FT220K	220kΩ 1%	220k ohm 1% 1/10W 0603 resistor	Digi-Key	RMCF0603FT220KCT-ND	$0.02	$0.09
1	6	U1	NP	Microchip Technology	ATMEGA328P-AU	-	AVR AVRÂ® ATmega Microcontroller IC 8-Bit 20MHz 32KB (16K x 16) FLASH 32-TQFP (7x7)	Digi-Key	ATMEGA328P-AU-ND	$2.01	$12.06
2	12	U2	NP	E-Switch	TL3305AF260QG	-	Tactile Switch SPST-NO Top Actuated Surface Mount 50mA 12V	Digi-Key	EG5353TR-ND	$0.18	$2.12
1	6	U4	NP	Decawave Limited	DWM1000	-	802.15.4 IR-UWB Transceiver Module 3.5GHz ~ 6.5GHz Integrated, Chip Surface Mount	Mouser	772-DWM1000	$17.90	$107.40
1	6	U5	NP	Texas Instruments	UA741CD	-	General Purpose Amplifier 1 Circuit 8-SO	Digi-Key	296-11106-5-ND	$0.44	$2.64
1	6	X1	NP	*	B2B-PH-SM4-TB	-	JST PH series header 2.00mm pitch disconnectable crimp style connectors, vertical (side entry type	Digi-Key	455-1734-2-ND	$0.50	$3.00
1	6	Y1	NP	Murata	CSTNE16M0V530000R0	-	16MHz Ceramic Resonator Built in Capacitor 15pF Â±0.3% -20Â°C ~ 80Â°C Surface Mount	Digi-Key	490-17948-2-ND	$0.22	$1.33
1	6	SP1	NP	Soberton Inc	SP-1304	32Ω	32 Ohms General Purpose Speaker 200mW 300Hz	Digi-Key	433-1095-ND	$1.66	$9.96
1	6		NP	Makerfire	PowerWhoop mCPX	-	600mA 3.7V Li-Ion Battery	Amazon		$5.50	$32.99
									Cost Per Tracker	Qty Trackers	Overall Cost
									$63.05	6	$229.70

Qty Per Tracker	Total Qty	Part Reference	P/NP	Manufacturer	Manufacturer Part Numer	Value	Description	Distributor	Distributor Part Numer	Price Per Unit	Price Total
1	3	U1	NP	Microchip Technology	ATMEGA328P-AU	-	AVR AVRÂ® ATmega Microcontroller IC 8-Bit 20MHz 32KB (16K x 16) FLASH 32-TQFP (7x7)	Digi-Key	ATMEGA328P-AU-ND	$2.01	$6.03
1	3	Y1	NP	Murata	CSTNE16M0V530000R0	-	16MHz Ceramic Resonator Built in Capacitor 15pF Â±0.3% -20Â°C ~ 80Â°C Surface Mount	Digi-Key	490-17948-2-ND - Tape & Re	$0.26	$0.78
1	3	U4	NP	Decawave Limited	DWM1000	-	802.15.4 IR-UWB Transceiver Module 3.5GHz ~ 6.5GHz Integrated, Chip Surface Mount	Mouser	772-DWM1000	$17.90	$53.70
1	3	U2	NP	E-Switch	TL3305AF260QG	-	Tactile Switch SPST-NO Top Actuated Surface Mount 50mA 12V	Digi-Key	EG5353TR-ND - Tape & Reel	$0.18	$0.53
1	3	L1	NP	TDK Corporation	MLZ1608N4R7LT000	4.7uH	Fixed Inductor 4.7uH 400mA 320mOhm 0603	Digi-Key	445-9286-1-ND	$0.15	$0.45
2	6	C1,C2	NP	AVX Corporation	0603ZD106KAT2A	10uF	10uF XR5 0603 Ceramic Capacitor	Digi-Key	478-10766-1-ND	$0.10	$0.58
1	3	R1	NP	Stackpole Electronics I	RMCF0603FG1M00	1MΩ 1%	1M ohm 1% 1/10W 0603 resistor	Digi-Key	RMCF0603FG1M00CT-ND	$0.02	$0.05
1	3	R2	NP	Stackpole Electronics I	RMCF0603FT178K	178kΩ 1%	178k ohm 1% 1/10W 0603 resistor	Digi-Key	RMCF0603FT178KCT-ND	$0.02	$0.05
6	18	R3 - R8	NP	Stackpole Electronics I	RMCF0402FT750R	750 1%	750 ohm 1% 1/16W 0603 resistor	Digi-Key	RMCF0402FT750RCT-ND	$0.01	$0.10
2	6	R9,R10	NP	Stackpole Electronics I	RNCP0603FTD10K0	10kΩ 1%	10k ohm 1% 1/8W 0603 resistor	Digi-Key	RNCP0603FTD10K0CT-ND	$0.06	$0.35
2	6	D1,D2	NP	Everlight Electronics C	LED_EAST1616RGBA3	-	LED Tri-Color Blue/Green/Red 468nm/518nm/632nm 4-Pin	Digi-Key	1080-1550-1-ND	$0.16	$0.94
									Cost Per Tracker	Qty Tags	Overall Cost
								cost w/o board	$21.18	3	$63.54
Boards	Qty ordered	Total cost	/board								Total Cost
Tracker	7	173.4	24.771						Cost per set	$109.01	$293.24

Testing & Results: LED & Speaker functionality

Test Writer: Leo Garcia						
Test Case Name:	LED and Speaker Feedback Test - Primary Device				Test ID #:	
Description	Verify that each of the red, green, and blue pins function correctly on each LED on the primary device (tracker). Verify that the speaker outputs a range of at least five distinguishable frequencies.				Type:	X White Box Black Box
Tester Information						
Name of Tester	*The Fighting Mongooses*				Date:	
Hardware Version					Time:	
Setup:	Fully charge the primary device and enter debugging mode by holding down both primary device buttons for 5 seconds					
Step	Action	Expected Result	Pass	Fail	N/A	Comments
1	Press the power button once	Flash all red LEDs in sequence	☺			
2	Press the power button once	Flash all blue LEDs in sequence	☺			
3	Press the power button once	Flash all green LEDs in sequence	☺			
4	Press the other button	Speaker will produce five tones of audibly distinguishable frequencies		☹		
Overall Test Result:						

Testing & Results: Visual Range Accuracy



Test Writer: Regan Garner						
Test Case Name:	Visual Range Accuracy Indication Test				Test ID #:	
Description	Verify that the visual feedback generated due to the calculated distance between the two devices is following the actual distance between the tracker (primary device) and tag (secondary device) can communicate between.				Type:	White Box X Black Box
Tester Information						
Name of Tester	*Robert Fogg*				Date:	
Hardware Version					Time:	
Setup:	Fully charge the devices and enter ranging mode by pressing the left button.					
Step	Action	Expected Result	Pass	Fail	N/A	Comments
1	Place the tracker directly on top of the tag.				⊗	
2	Move the tracker 0.5m away from the tag.	Number of illuminated LEDs decreases OR no change	☺			
3	Move the tracker to be 1m away from the tag.	Number of illuminated LEDs decreases OR no change	☺			
4	Move the tracker to be 1.5m away from the tag.	Number of illuminated LEDs decreases OR no change	☺			
Overall Test Result						

Failed Solutions:

- RF time of flight calculation using simple antenna and Arduino
  - (does not work because processor is not fast enough)

- RSSI relating signal strength to distance using Arduino
  - (doesn’t work because there’s too much noise at the legally allowed bandwidth)

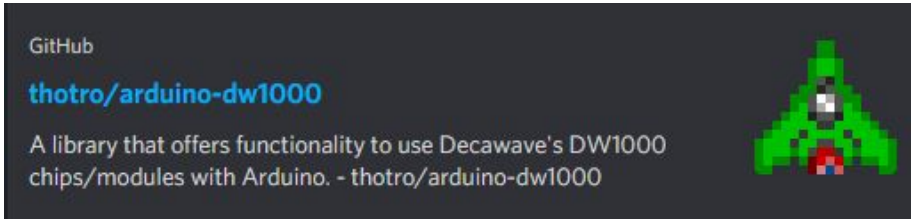
Intellectual Property (Licensing)

DrAtomic/industry-design is licensed under the
MIT License

A short and simple permissive license with conditions only requiring preservation of copyright and license notices. Licensed works, modifications, and larger works may be distributed under different terms and without source code.

Permissions	Limitations	Conditions
✓ Commercial use	✕ Liability	ⓘ License and copyright notice
✓ Modification	✕ Warranty	
✓ Distribution		
✓ Private use		

Previous Work



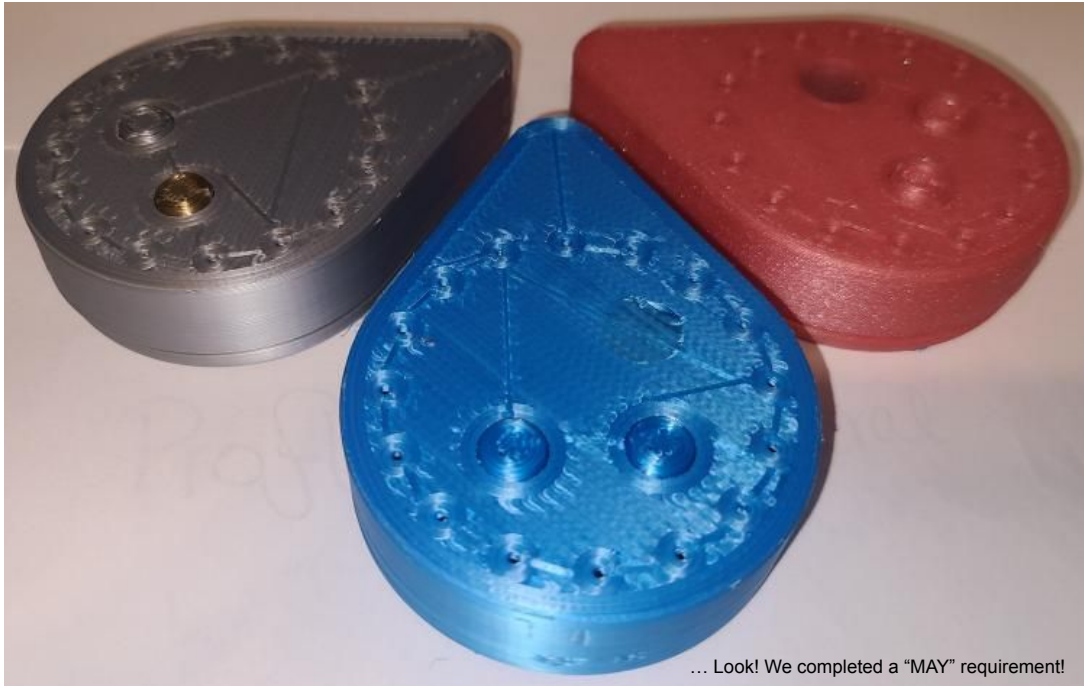
DWM1000 ranging code is taken from the “anchor” and “tag” example sketches from the thotro/arduino-dw-1000 repository, which we have modified to facilitate extracting the ranging data to the ATMega328p

https://github.com/thotro/arduino-dw1000

Contributions

Yousef	Robert	Leo	Regan
• Designed audio feedback circuit • Designed visual feedback circuit • Wrote feedback firmware • Prototyping • Implementing final device • Debugging firmware	• Finalized CAD schematic • Finalized CAD PCB design • Attached surface mount components • Designed and manufactured 3D printed cases • Implementing final device • Debugging firmware	• Taught teammates how to use GitHub • Initial antenna design • Managed GitHub • Contributed to writing feedback firmware • Implementing final device • Debugging firmware	• Documentation • Managed Team Wiki • Initial filter design • CAD schematic for initial antenna & filter design • CAD schematic rough draft • Implementing final device • Debugging firmware

Thank You!


… Look! We completed a “MAY” requirement!