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FireWatch: Infrasonic Wildfire Detection Device

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Objective/Value proposition

Wildfire Mitigation

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- Current best means of detecting fire are seeing and smelling smoke
- It is known that wildfire gives off infrasound waves in range (0-20Hz)
- Our aim is to set up a mesh network of smart nodes and dumb nodes that can detect infrasound
- The ability to provide a signal to firefighting services when the fire is still small, could save countless homes and wilderness areas
- Will drastically improve our ability to mitigate wildfires

Previous Project Work

Team from 2018

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- Main Focus: Wireless Communication
- We unfortunately don't have much documentation/results from them.
- They did not focus on the infrasound sensing aspect.
- They purchased 4 Yagi single dipole directional antennae for Xbee

Project Requirements

Project Requirements: Microcontroller

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- Small form factor
- Lora Radio
- GPS
- Analogue to Digital Converters (ADC)
- Small but powerful processor (CPU)
- Low power modes

Project Requirements: Mesh Network

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- Send/Receive data over long distances
- Know which nodes are active and dead
- Send data quickly and reliably

Project Requirements: Enclosure

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- Fit within a 6in diameter cube
- Be able to withstand natural elements, drops from 100ft, and be shatter proof
- The total system shall weigh no more than 10 lbs
- The mechanical components shall be designed to operate indefinitely, including weather resistance except for fire damage
- Material must be able to resist sun and weather for extended time periods

Project Requirements: Infrasonic Sensor

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- Accurately detect infrasonic waves generated by wildfire
 - Will require adequate amplification
 - Vref output must be between 0 - 2 Volts
- -3 db cut-off frequency within 10 - 20 Hz
 - Cut out unwanted noise, such as wind
- As cheap as possible

Risk Mitigation

Risk Mitigation: Possible Risks

- Cyber Security
- Environmental Impacts
- Wildlife Impacts



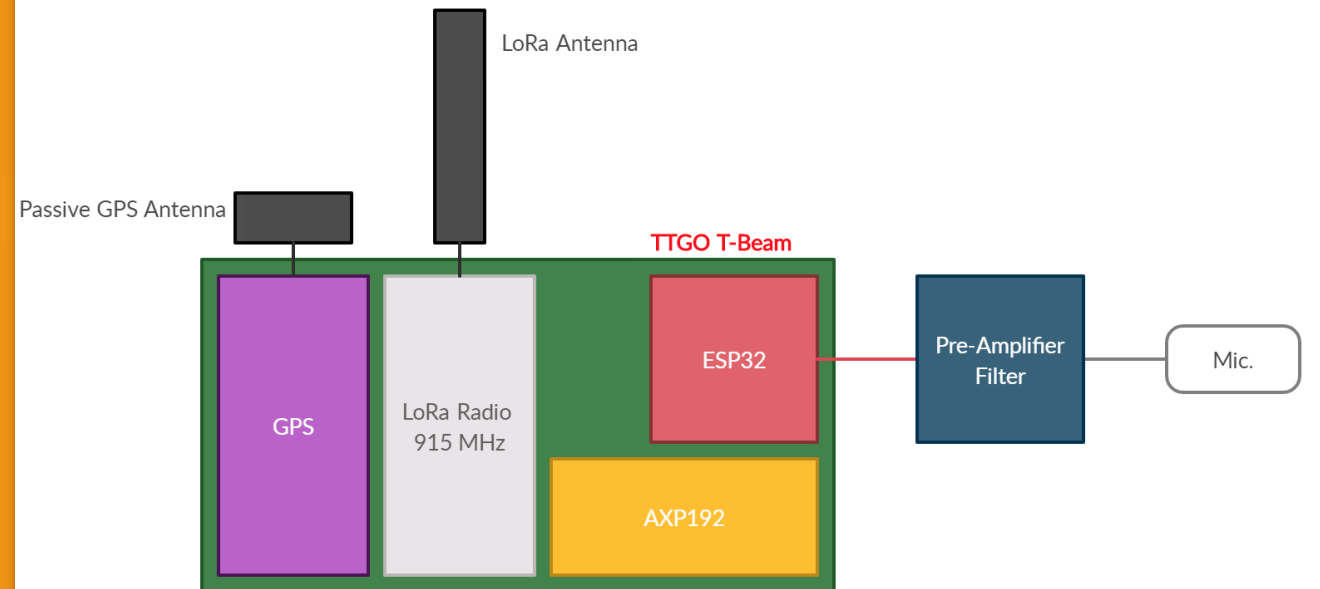
Danger
wild animals

Current Design Work & Project Learning

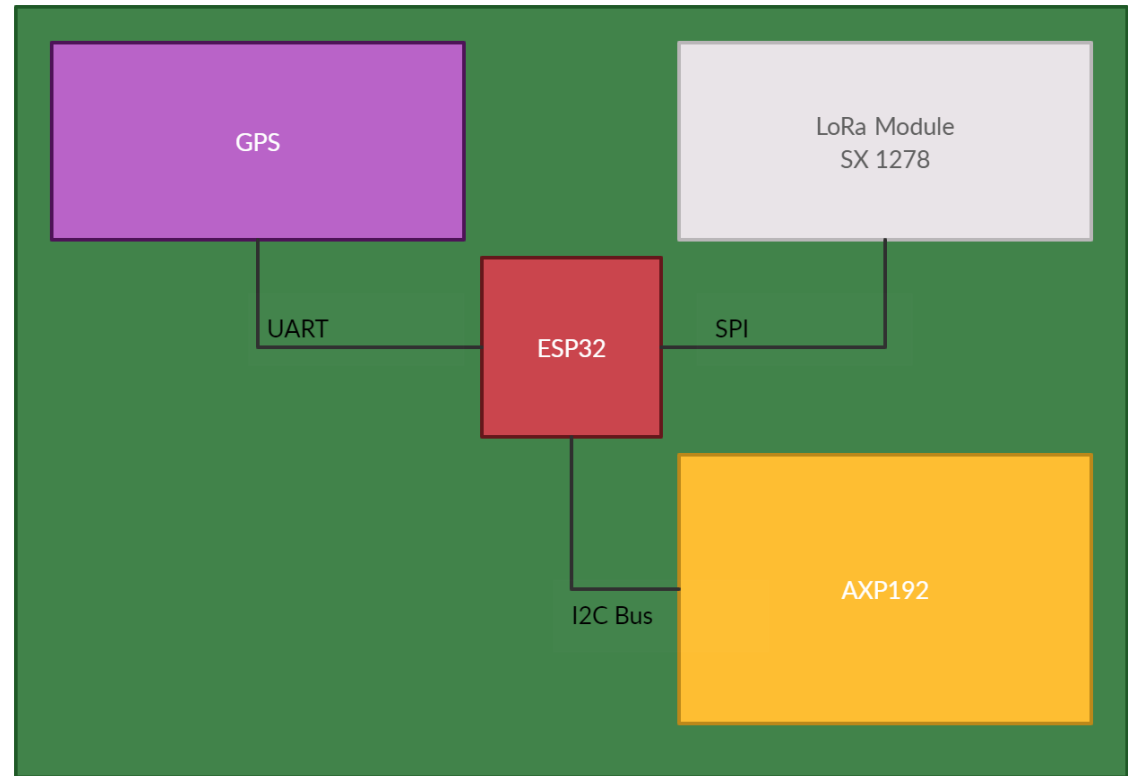
System Diagram

- Why TTGO T-Beam?

- Cheap
- Common components
- Well-documented
- Necessary peripherals on board

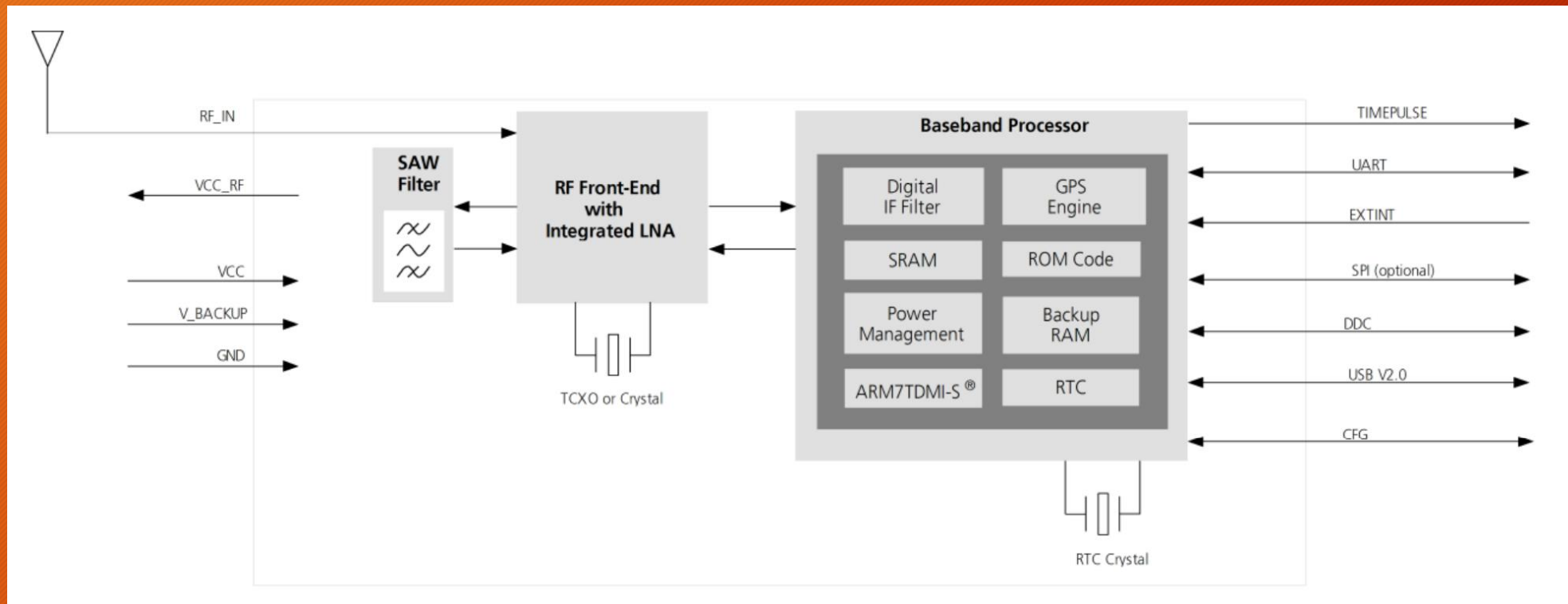


MCU / Peripheral diagram



GPS - uBlox NEO 6M

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GPS - Important features

- Real time clock
- 2.5 M location accuracy
- Power save mode - 75% lower power usage!

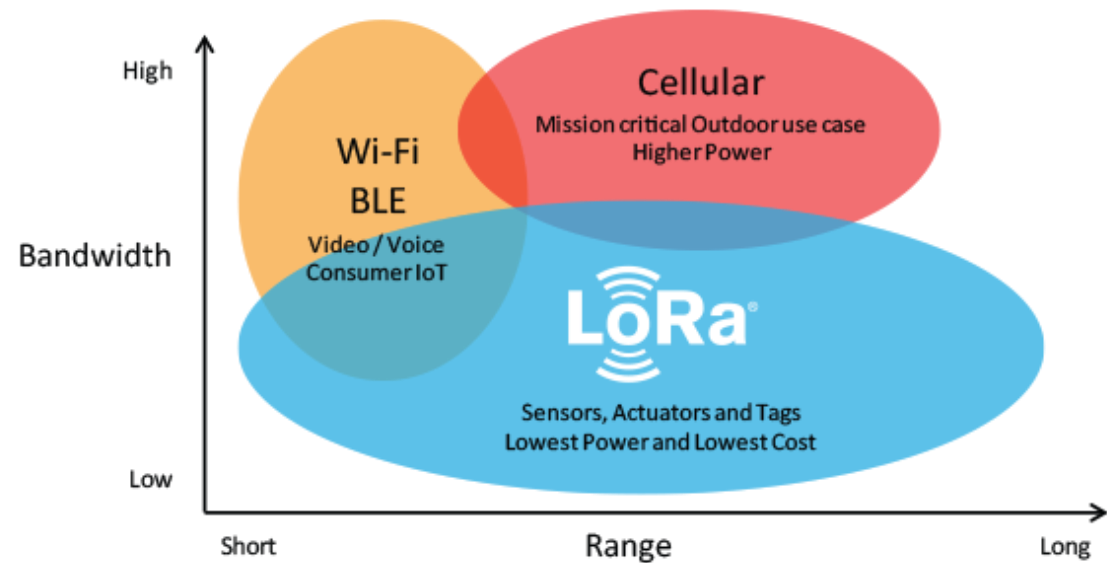
Parameter	Symbol	Module	Min	Typ	Max	Units	Condition
Max. supply current ¹⁵	I _{ccp}	All			67	mA	V _{CC} = 3.6 V ¹⁶ / 1.95 V ¹⁷
Average supply current ¹⁸	I _{cc} Acquisition	All		47 ¹⁹		mA	V _{CC} = 3.0 V ¹⁶ / 1.8 V ¹⁷
	I _{cc} Tracking (Max Performance mode)	NEO-6G/Q/T		40 ²⁰		mA	
		NEO-6M/P/V		39 ²⁰		mA	
	I _{cc} Tracking (Eco mode)	NEO-6G/Q/T		38 ²⁰		mA	
		NEO-6M/P/V		37 ²⁰		mA	
I _{cc} Tracking (Power Save mode / 1 Hz)	NEO-6G/Q		12 ²⁰		mA		
	NEO-6M		11 ²⁰		mA		

Table 11: Indicative power requirements

LoRa Protocol

Why?

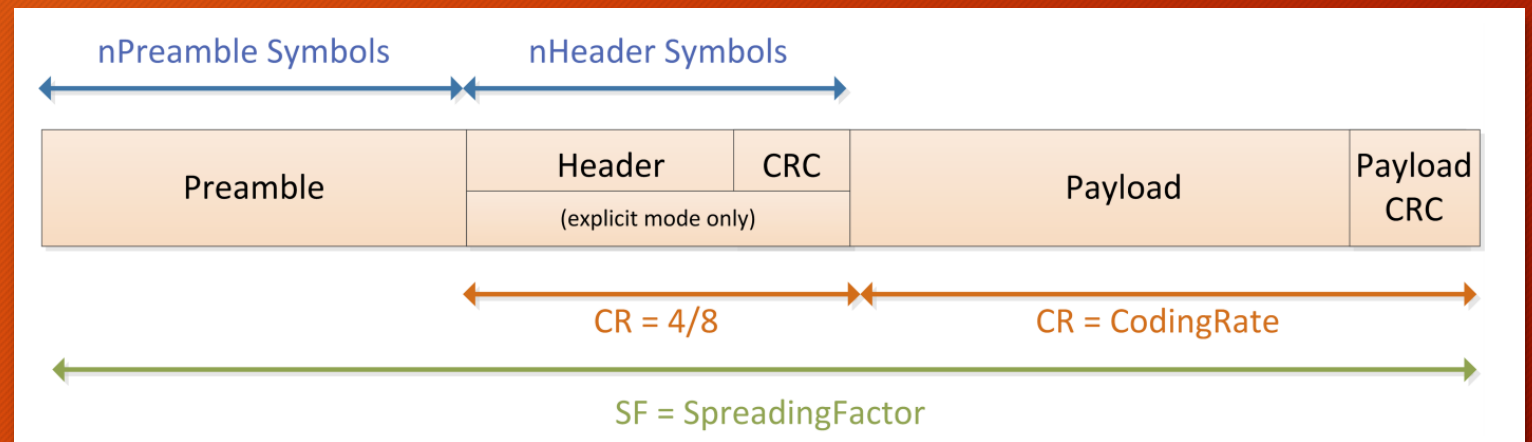
Low Bandwidth, Low power,
long range



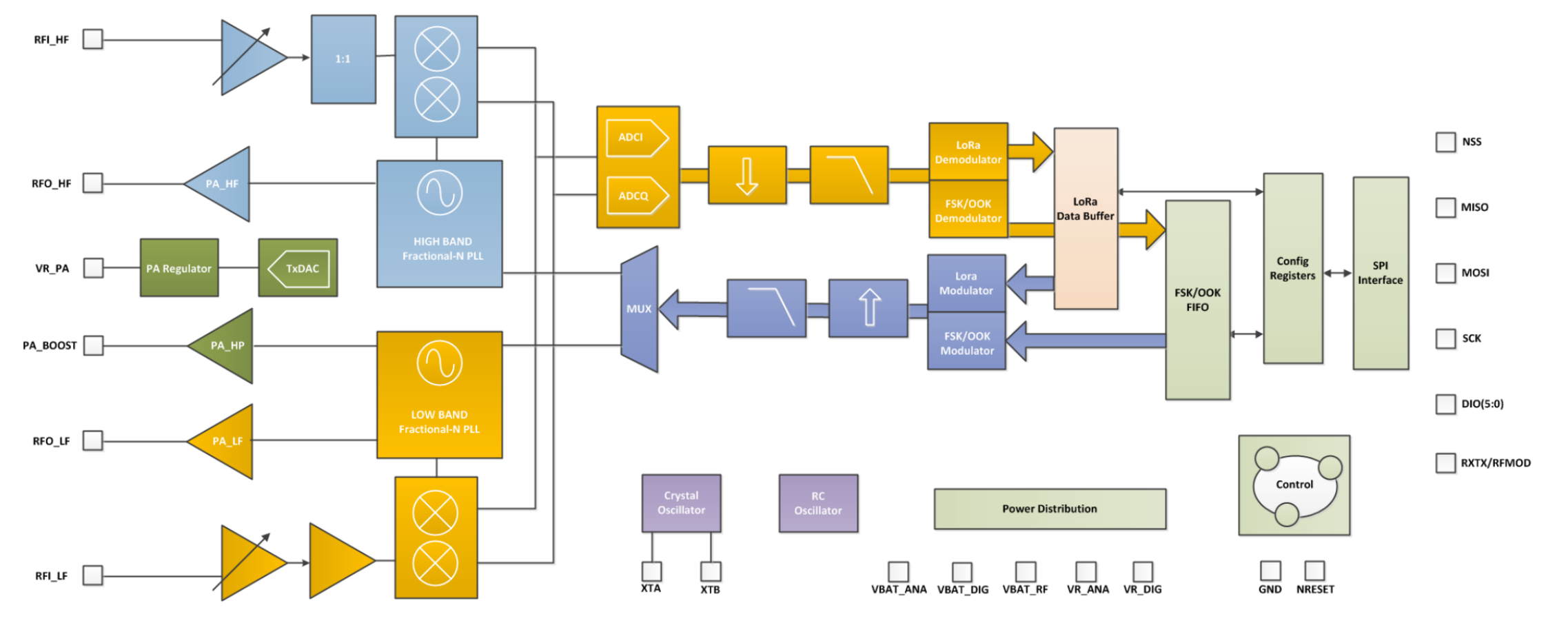
LoRa packet structure

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- Preamble - up to 65000 symbols to synchronize packet reading
- Optional header
 - Payload length
 - CRC
- Payload
 - Up to 255 bytes of data
- Optional CRC
 - Cyclic redundancy check
 - Detect transmission errors



Radio Module - SX1276



Radio module configuration parameters

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- Transmit power
 - 2 to 20 dB - default 17 dB
- Spreading Factor
 - High spreading factor increases range and power usage
- Preamble length
 - Up to 65000 bits
- Sync word
 - Kind of like a password for our network
- CRC on/off

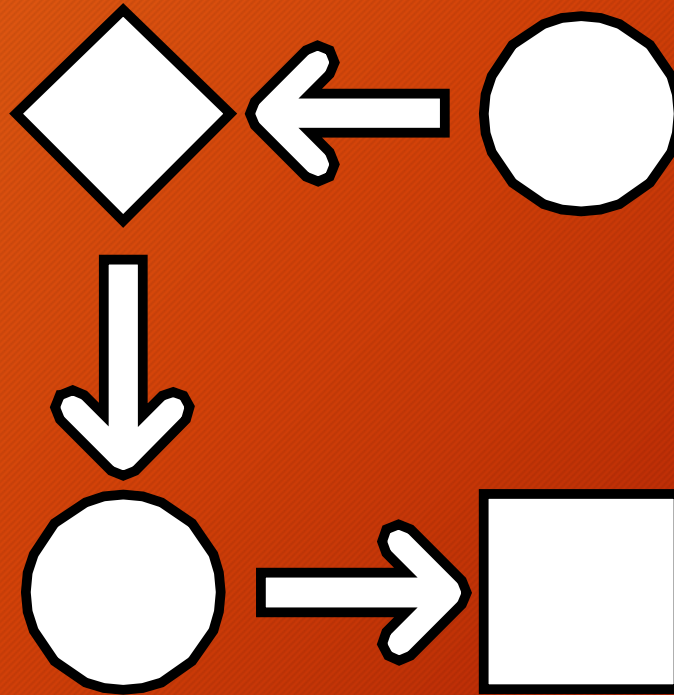
LoRa Demo

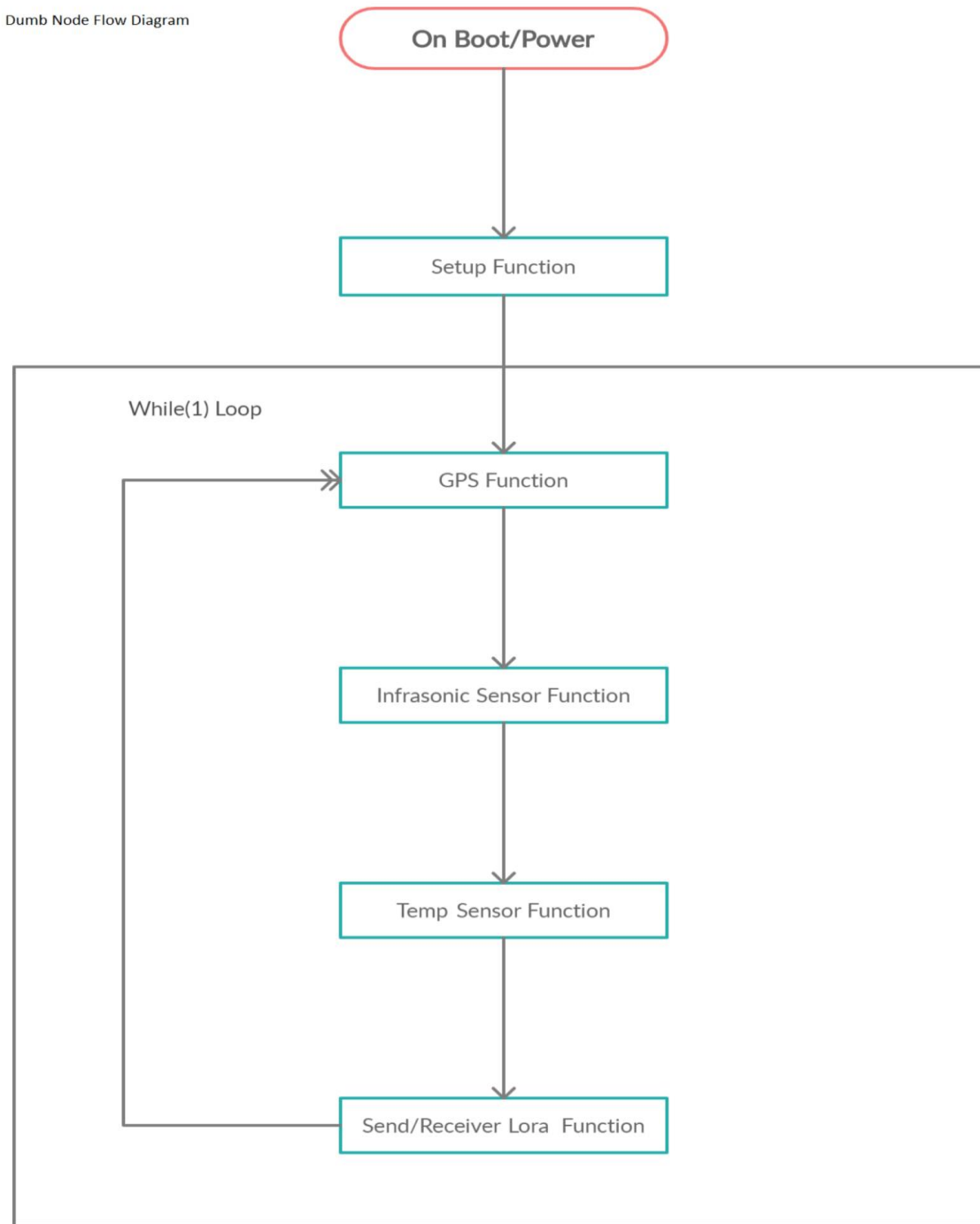
22

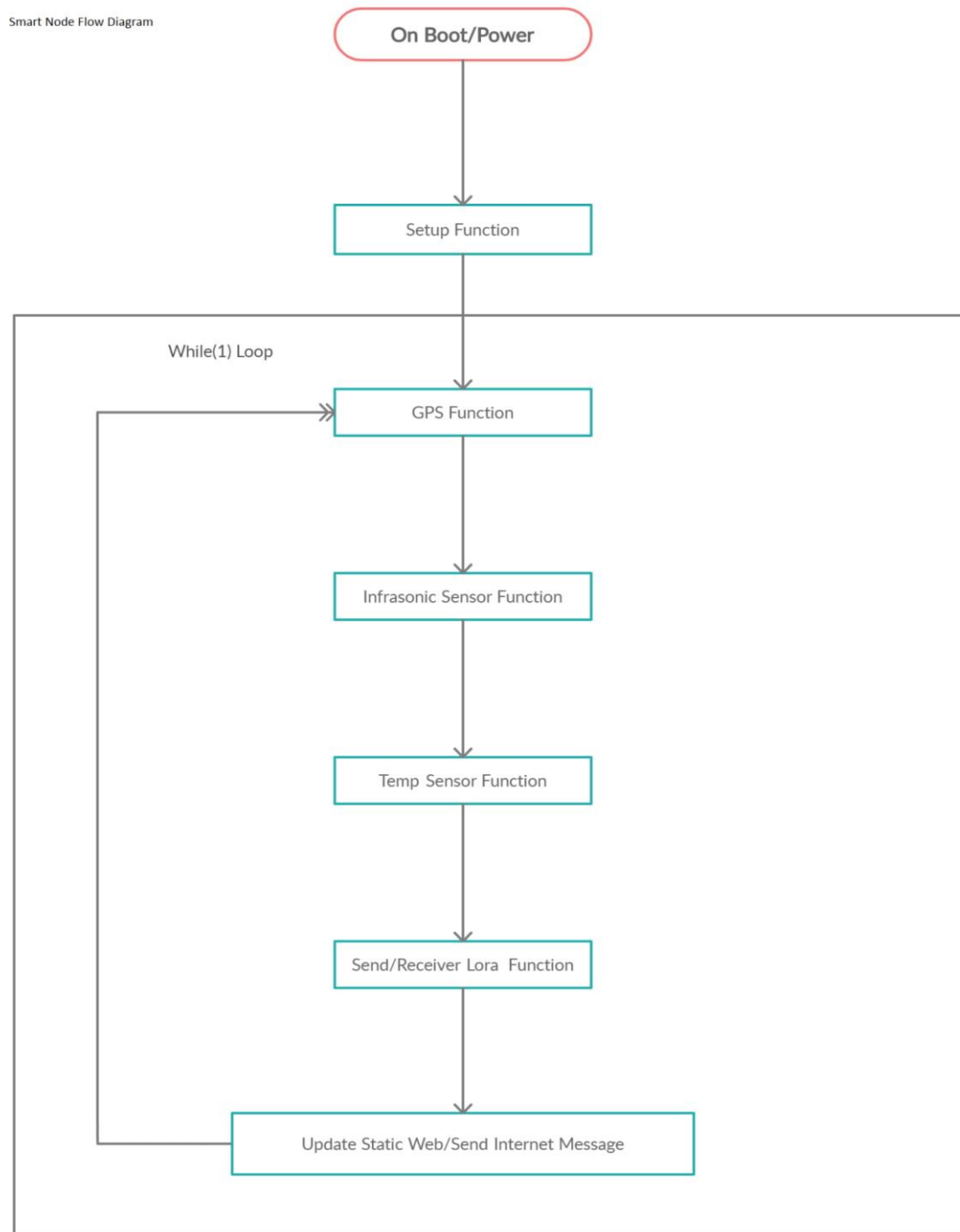
- Carlos has a simple demonstration of our Dev. Boards communicating

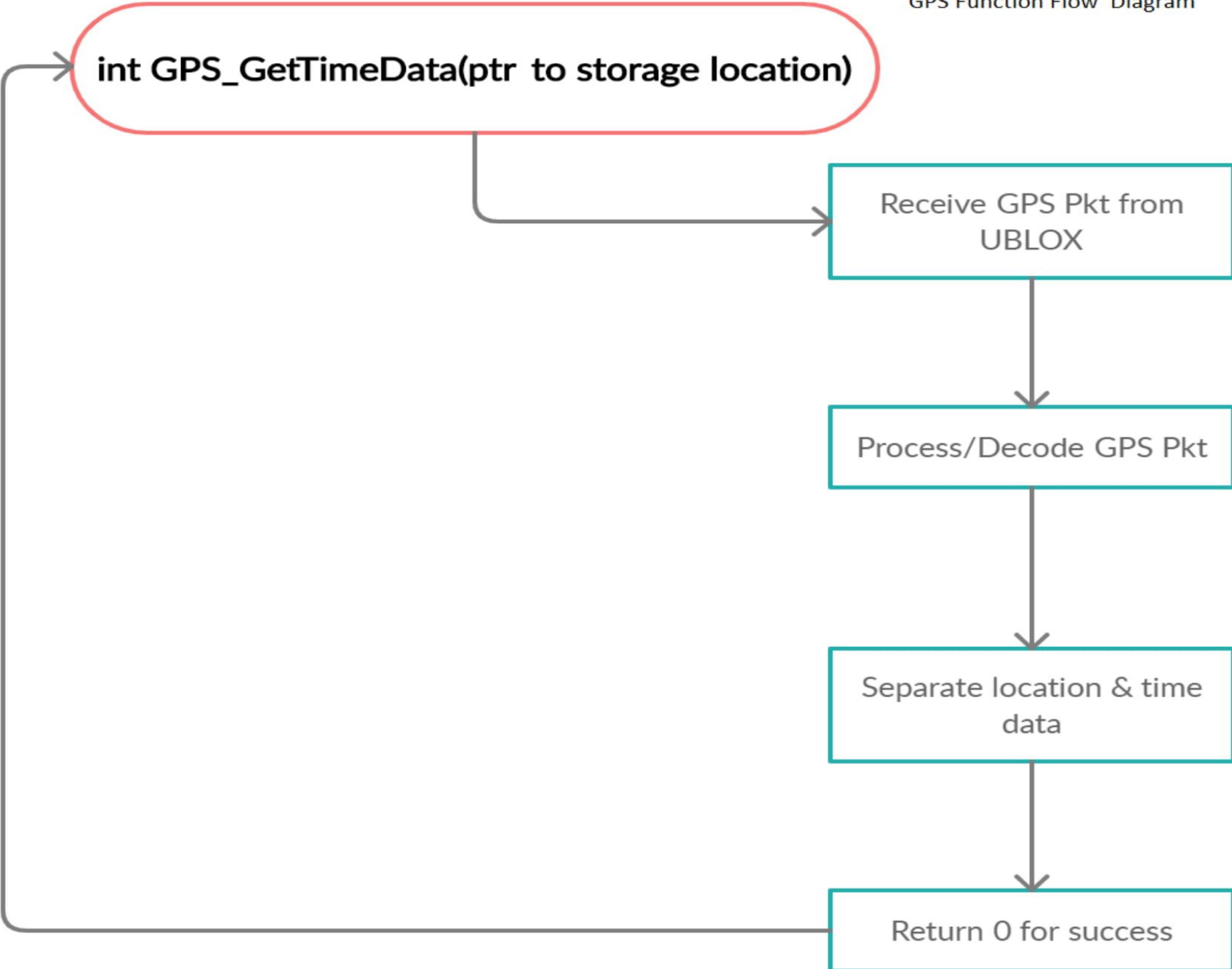
Control Flow Diagrams

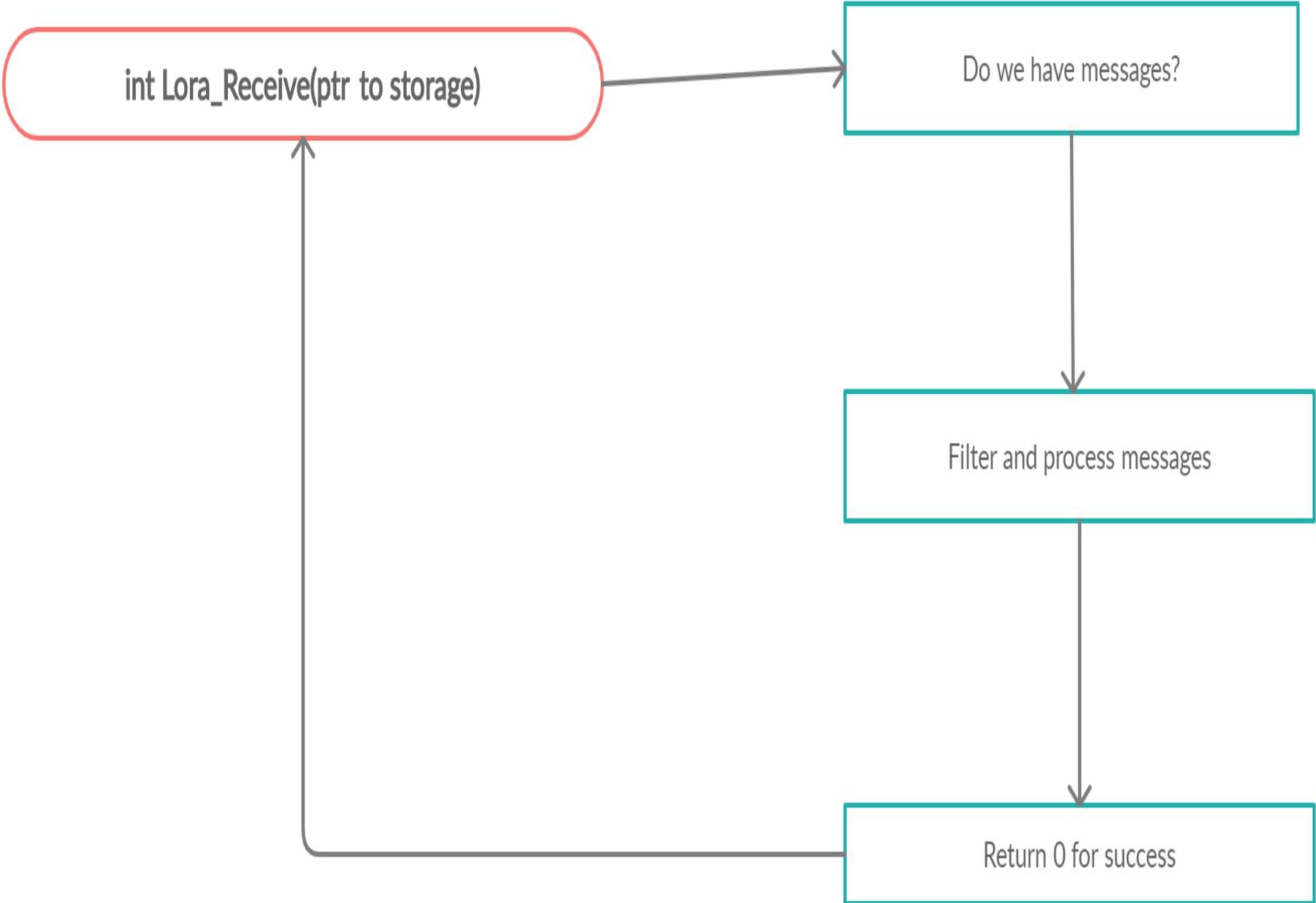
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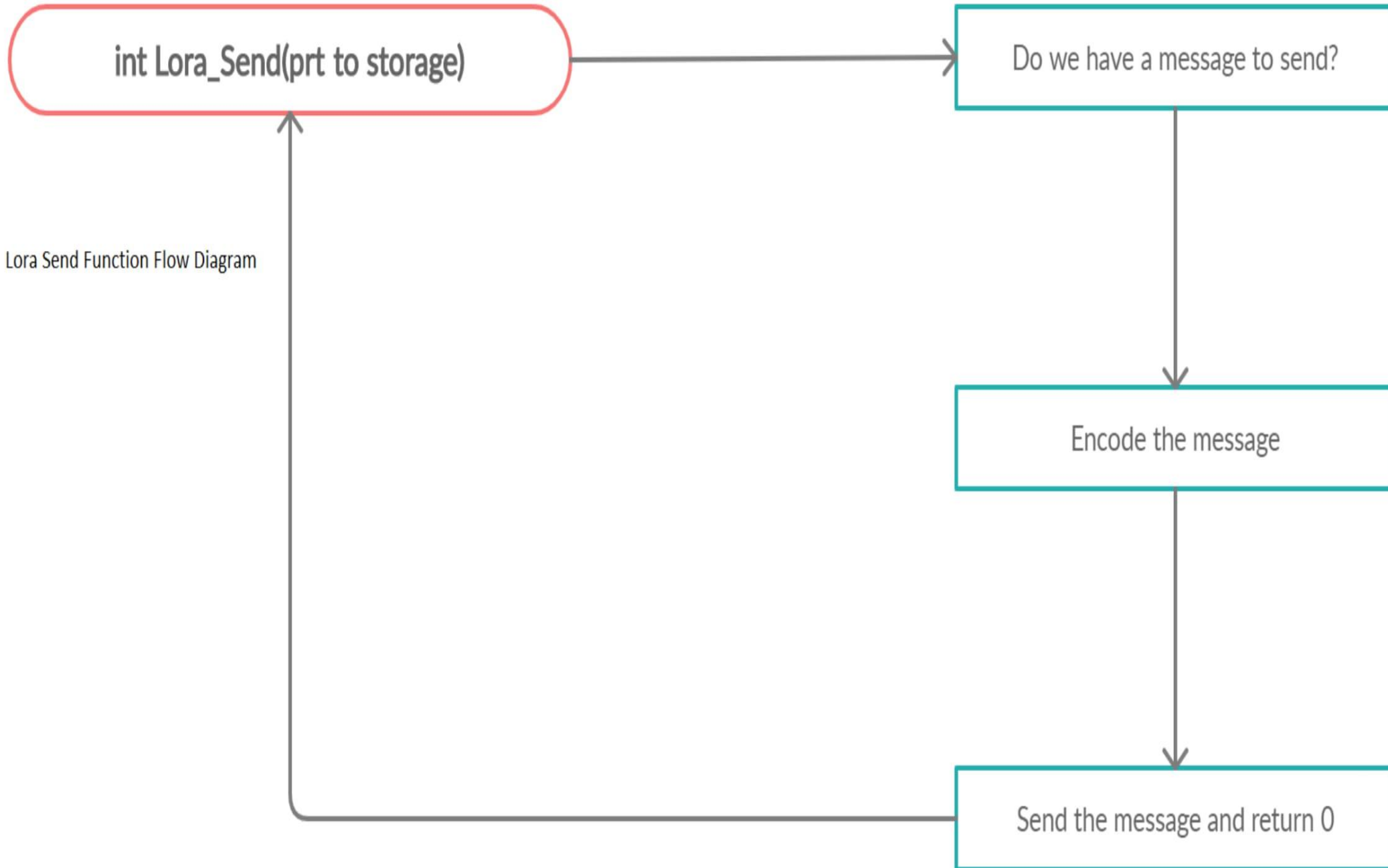












Lora Send Function Flow Diagram

int ADC_Function()

Go & Read Buffers

Convert Values

Do some DSI



Option 1



Option 2



Option 3

**Message Type:**

What type of message are we receiving? Is it a temperature reading? Infrasonic sensor reading? Are you still there request?

Sender ID:

The sender ID is comprised of its MAC address (6 Bytes). It could be the lower or upper Bytes? Or all the Bytes?
Sample MAC: DE:AD:BE:EF:12:34

Origin ID:

Same as the **Sender ID** except it can be all 0's. All 0's to indicate the message origin is the **Sender ID**. If it's set to anything else the message originated from another node.

Payload Length:

Bytes to indicate the length of the **Payload** in Bytes. For now we can use 1 Byte for a total of 256 possible values 0-255.

Payload:

The data being sent in Bytes. Amount is set by the **Payload Length**.

Amplifier Demo

Design Validation

Senior Capstone Design					
Project: Infrasonic Wildfire Detector			Primary Author: FireWatch Team		
Team: FireWatch			Date: 10/22/2020		
Design Validation Plan & Results (DVP&R)					
Requirement	Test	Test Subject	Target Date	Result	Recommendation
Will survive a 20 foot drop.	Drop 20 ft and inspect.	Shell prototype with weight inside.	3/20/21	TBD	TBD
Will survive a 20 foot drop.	Solid Model Simulation	CAD model	11/30/20	TBD	TBD
Send Messages between 1 Smart Node and 1 Dumb Node	Generate random test messages to send between Smart and Dumb nodes. Keep a running count of messages sent vs received.	Smart, Dumb nodes	12/1/20	TBD	TBD
Send Messages between 1 Smart Node and 2 Dumb Nodes	Generate random test messages to send between Smart and Dumb nodes. Keep a running count of messages sent vs received.	Smart, Dumb nodes	12/8/20	TBD	TBD
Send Messages between 1 Smart Node and "The Internet"	Generate random test messages to send between Smart and Internet. Keep a running count of messages sent vs received.	Smart nodes	1/18/20	TBD	TBD
Infrasonic sensor can detect 1 - 5 Hz sound waves (crown fires)	Generate and detect an infrasonic sound wave	Infrasound Sensor	2/1/20	TBD	TBD
Infrasonic sensor can detect 1 kHz - 5 kHz sound waves (surface fires)	Generate and detect an infrasonic sound wave	Infrasound Sensor	2/1/2020	TBD	TBD
Bonus: Sensor detects an actual fire	Light a fire and see readings	Infrasound Sensor and Nodes	4/10/21	TBD	TBD

Infrasound Sensor Testing

- Our plan is to generate infrasound using a function generator and a subwoofer
- We will feed the subwoofer low frequency signals and try to detect them with our infrasound sensor



Project Management

P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM
						2021																	
		Dec				Jan				Feb				Mar				Apr					
11/23	11/30	12/7	12/14	12/21	12/28	1/4	1/11	1/18	1/25	2/1	2/8	2/15	2/22	3/1	3/8	3/15	3/22	3/29	4/5	4/12	4/19	4/26	

Future Plans

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- Build sensor circuit on breadboard and test microphone capsules
- Design and Print PCB
- Drop Test 3D printed model
- Improve design and 3D print larger scale
- Testing and Code Validation
- Purchase Batteries and Test Longevity