Carlos Santos, Cory Holt, Drew Malinowski, Meridian Haas

FireWatch: Infrasonic Wildfire Detection Device

Objective/Value proposition

Wildfire Mitigation

- 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

- 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

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

Project Requirements: Mesh Network

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

Project Requirements: Enclosure

- 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

- 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





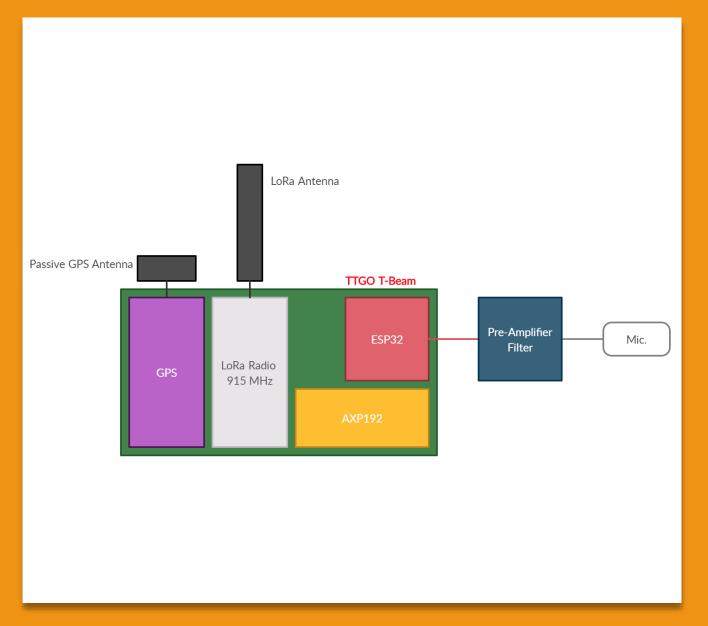


Current Design Work & Project Learning

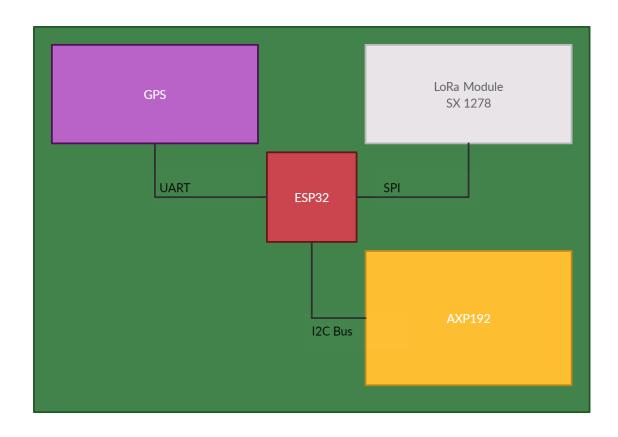
System Diagram

• Why TTGO T-Beam?

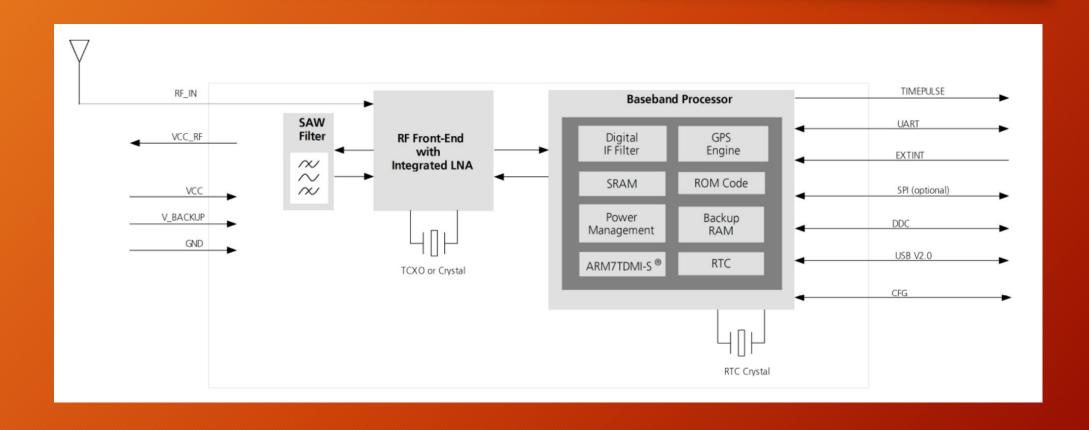
- Cheap
- Common components
- Well-documented
- Necessary peripherals on board



MCU / Peripheral diagram



GPS - uBlox NEO 6M



GPS - Important features

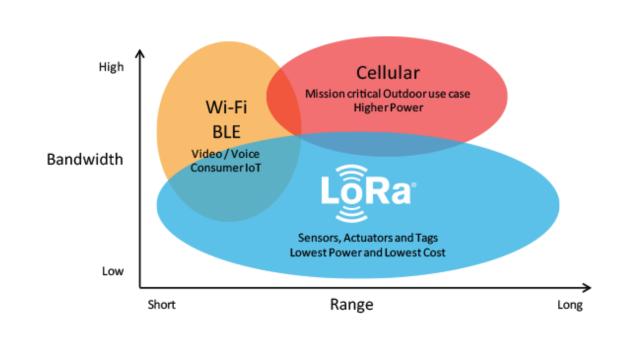
- Real time clock
- 2.5 M location accuracy
- Power save mode 75% lower power usage!

Parameter	Symbol	Module	Min	Тур	Max	Units	Condition
Max. supply current ¹⁵	lccp	All			67	mA	$VCC = 3.6 V^{16} / 1.95 V^{17}$
	Icc Acquisition	All		47 ¹⁹		mA	
	Icc Tracking	NEO-6G/Q/T		40 ²⁰		mA	
	(Max Performance mode)	rmance mode) NEO-6M/P/V 39 ²⁰ mA	mA	\(\(\alpha\) = \(\alpha\) \(\alpha\) \(\alpha\)			
Average supply current ¹⁸	Icc Tracking	NEO-6G/Q/T		38 ²⁰		mA	$^{-}$ VCC = 3.0 V ¹⁶ / $^{-}$ 1.8 V ¹⁷
	(Eco mode)	NEO-6M/P/V		37 ²⁰		mA	- 1.0 V
	Icc Tracking	NEO-6G/Q		12 ²⁰		mA	_
	(Power Save mode / 1 Hz)	NEO-6M		11 ²⁰		mA	_
Table 11: Indicative pow	er requirements						

LoRa Protocol

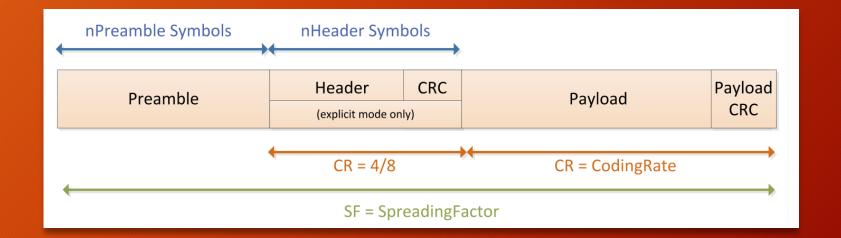
Why?

Low Bandwidth, Low power, long range

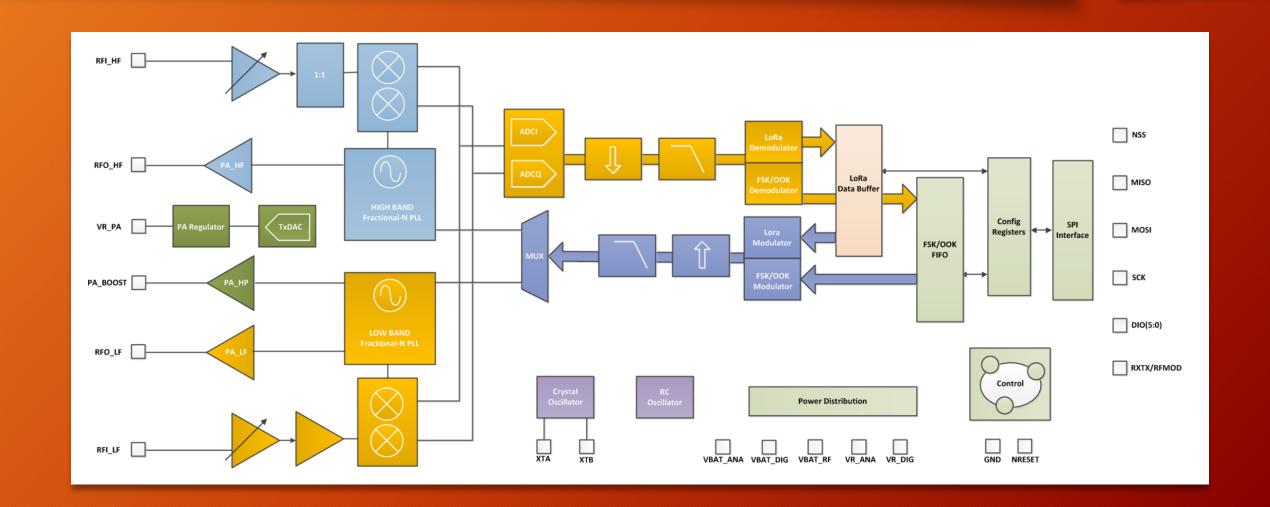


LoRa packet structure

- 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



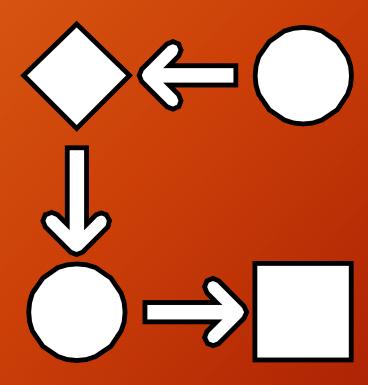
Radio module configuration parameters

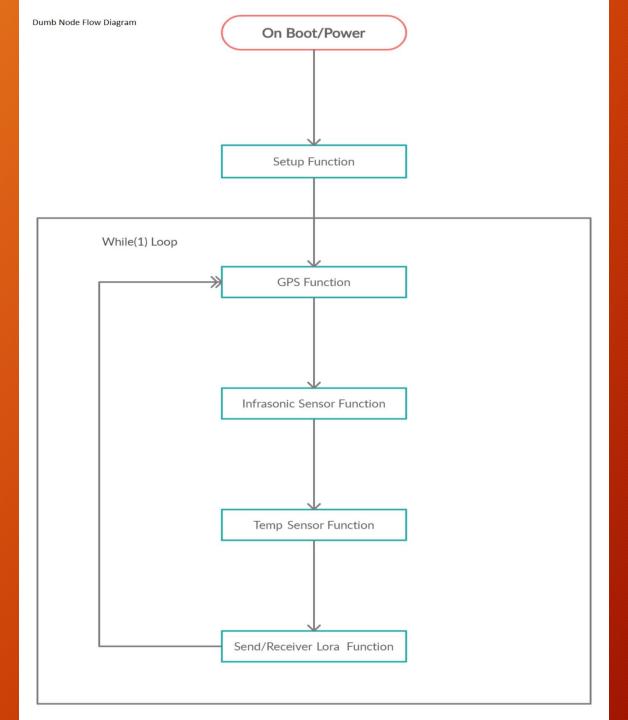
- Transmit power
 - 2 to 20 dB default 17 dB
- Spreading Factor
 - High spreading factor increases range and power usage
- Preamble length
 - Up to 65000 bits
- Sync word
 - Kind of like a password for our network
- CRC on/off

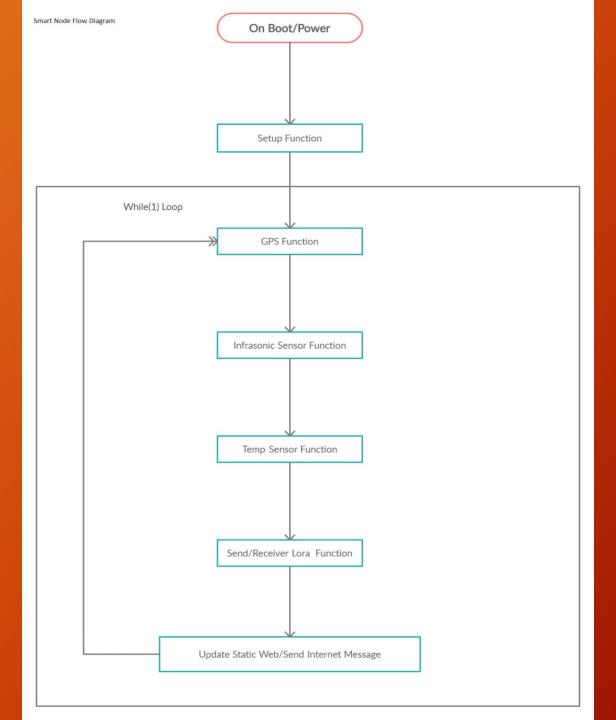
LoRa Demo

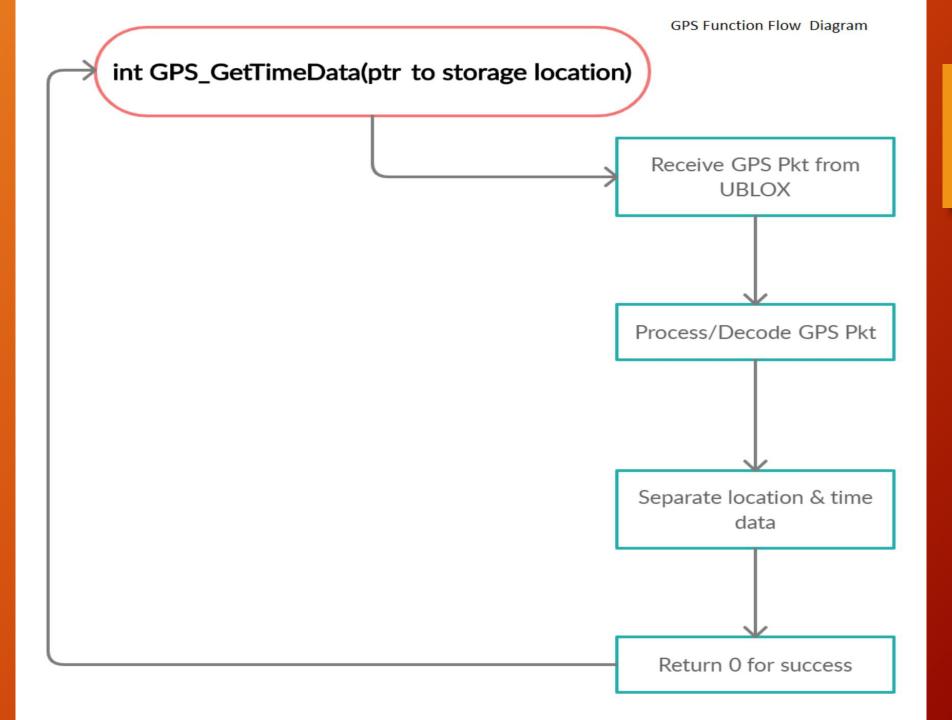
• Carlos has a simple demonstration of our Dev. Boards communicating

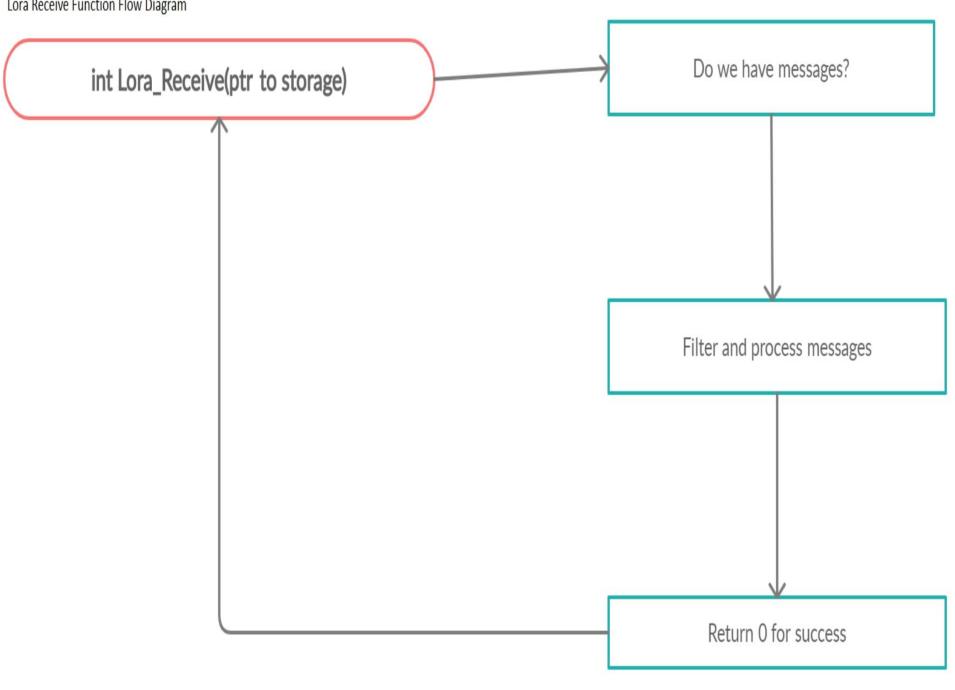
Control Flow Diagrams

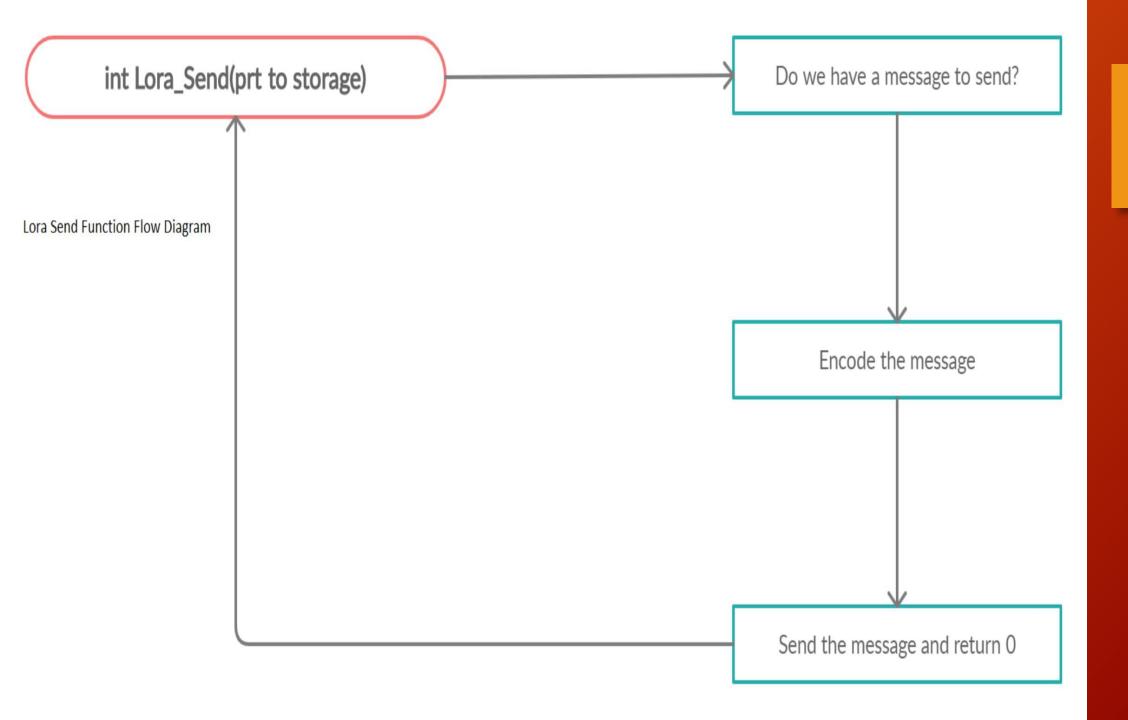


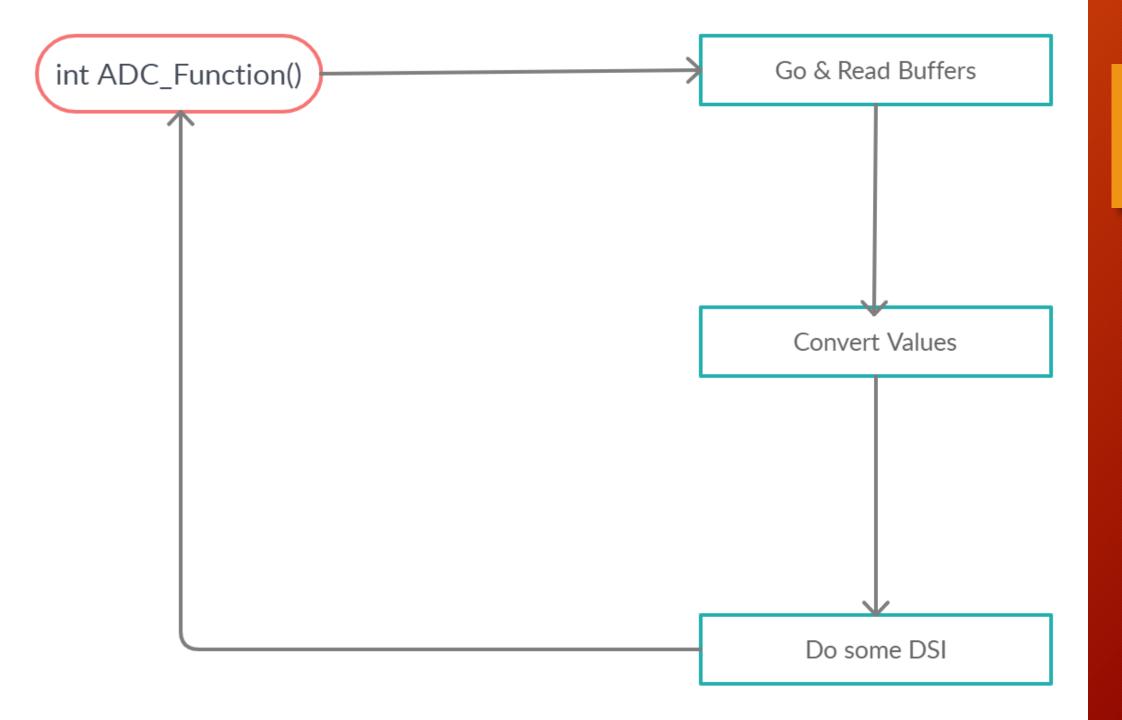


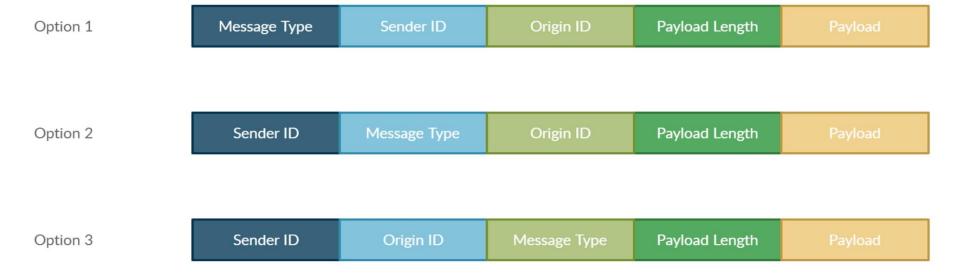












Message Type:

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 compromised 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**.

Lora Message Structure Diagram

Amplifier Demo

Design Validation

Senior Capstone Design					
Project:	Infrasonic Wildfire Detector		Primary Author:	FireWatch Team	
Team:	FireWatch		Date:	10/22/2020	
Design Validation Plan & F	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	Smart, Dumb nodes	12/8/20	TBD	TBD

1/18/20

2/1/20

2/1/2020

4/10/21

TBD

TBD

TBD

TBD

TBD

TBD

TBD

TBD

received.

Generate random test messages Smart nodes

Infrasound Sensor

Infrasound Sensor

Infrasound Sensor and Nodes

to send between Smart and Internet. Keep a running count of messages sent vs received.

Generate and detect an

infrasonic sound wave

Generate and detect an

infrasonic sound wave

Bonus: Sensor detects an actual Light a fire and see readings

Send Messages between 1

Smart Node and "The Internet"

Infrasonic sensor can detect 1 -

5 Hz sound waves (crown fires)

Infrasonic sensor can detect 1

kHz - 5 kHz sound waves

(surface fires)

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

В	С	D	Е	F	G	Н	1	J	K	L	М	N	0	Р	Q	R	S	Т
Capstone Project Schedule Te	nplate -	Fall-Spri	ng															
		Project:																
	Last	Updated:		1/20														
		Year									2020							
		Month		Se	pt			0	ct				Nov				D	ec
Task Descriptio	Duration	Assigned	9/7	9/14	9/21	9/28	10/5	10/12	10/19	10/26	11/2	15/9	11/16	11/23	11/30	12/7	12/14	12/2
Project Research and Planning	4 weeks	7-Sep																
Ordering Parts	5 weeks	5-Oct																
Preliminary Design Work	6 weeks	28-Sep																
3D modeling/3D printing 1	4 weeks	21-Sep																
Initial microphone testing	5 weeks	19-Oct																
Software development	23 weeks	2-Nov										_						
Circuit design	4 weeks	16-Nov																
Signal Processing Software	12 weeks	8-Feb																
Full enclosure design/testing	15 weeks	18-Jan																
Testing/troubleshooting	5 weeks	1-Mar																
Prepare for Design Expo	4 weeks	5-Apr																
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	Р	Q	R	s	Т	U	V	w	х	Υ	Z	AA	AB	AC	AD	AE	AF	AG	АН	Al	AJ	AK	AL	Al				
Т																												
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j :	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					
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Project:	FireWatch													
Last Updated	9/17/2020													
				Υ	ear				Item					
Expense Items	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Total					
Equipment/Tools:														
Sound equipment		\$ 300	-						\$ 300					
Travel:			!											
Safety net						\$ 100			\$ 100					
			i i		<u> </u>				\$ -					
Supplies / Parts / Services:														
Microcontrollers		\$ 73.2							\$ 73					
Fabrication Materials		\$42.38	\$ 200						\$ 242				<u> </u>	
Misc Electronics		\$ 4	\$ 250						\$ 254					
PCB			- 1			\$ 200			\$ 200					
Radio equipment			I		\$ 300				\$ 300					
Long-range Antenna?							\$ 400		\$ 400					
			1						\$ -					
									\$ -					
									\$ -		Expenses			
			i							\$ 1,870	Subtotal			
Shop Usage (est. Hrs):									Hours					
Machine Shop			i				20		20				is is the amou dget remainin	
									0			nu	mber is negat	tive, the
									0			pro	oject is OVER	budget.
									0					
									0					
									0					
						Grade	uate Stude	nt Support	\$ -	including	fringe			
								Overhead						
							University	Overhead		5% of all e				
								Totals	\$ 1,963					
										Budget	Excess			

Future Plans

- 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