

EMBERWATCH

Meet the team



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Project Lead
PCB D&T



Manny Lemus

Database Pipeline
Multi-Node/Mesh
Deployment



Aliston Ma

User Interface
Web Application



Jake Gilbert

Power supply
Full sensor integration



Frank Xiao

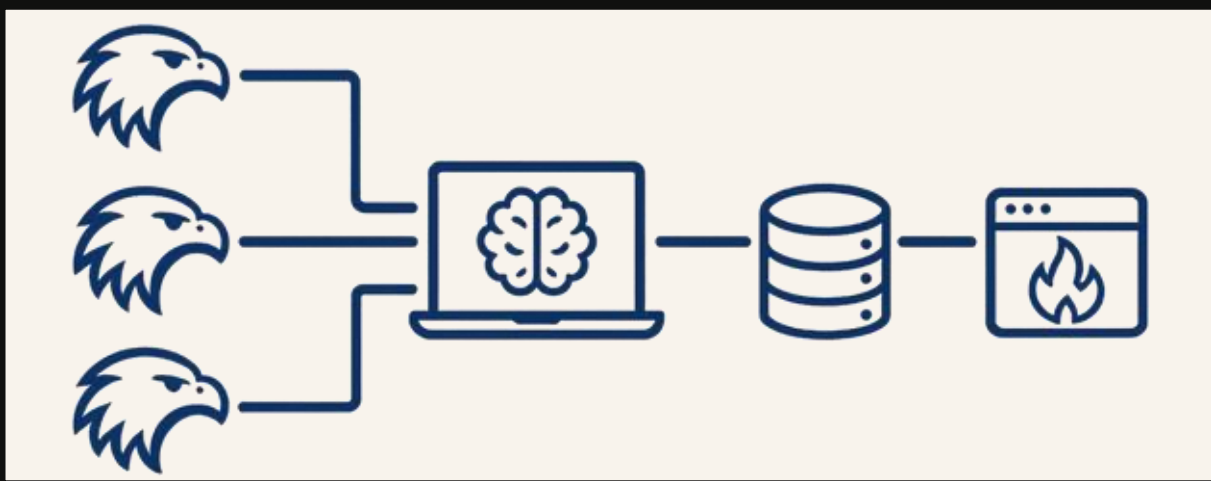
Predictive model
Data collection

Project Vision and Applications



EmberWatch aims to decrease fire response time and provide data for wildfire management.

System Design



Remote nodes

- STM32 MCU
- 5 devices
- Data transmission via LoRa Radio
- Solar powered

Central Station

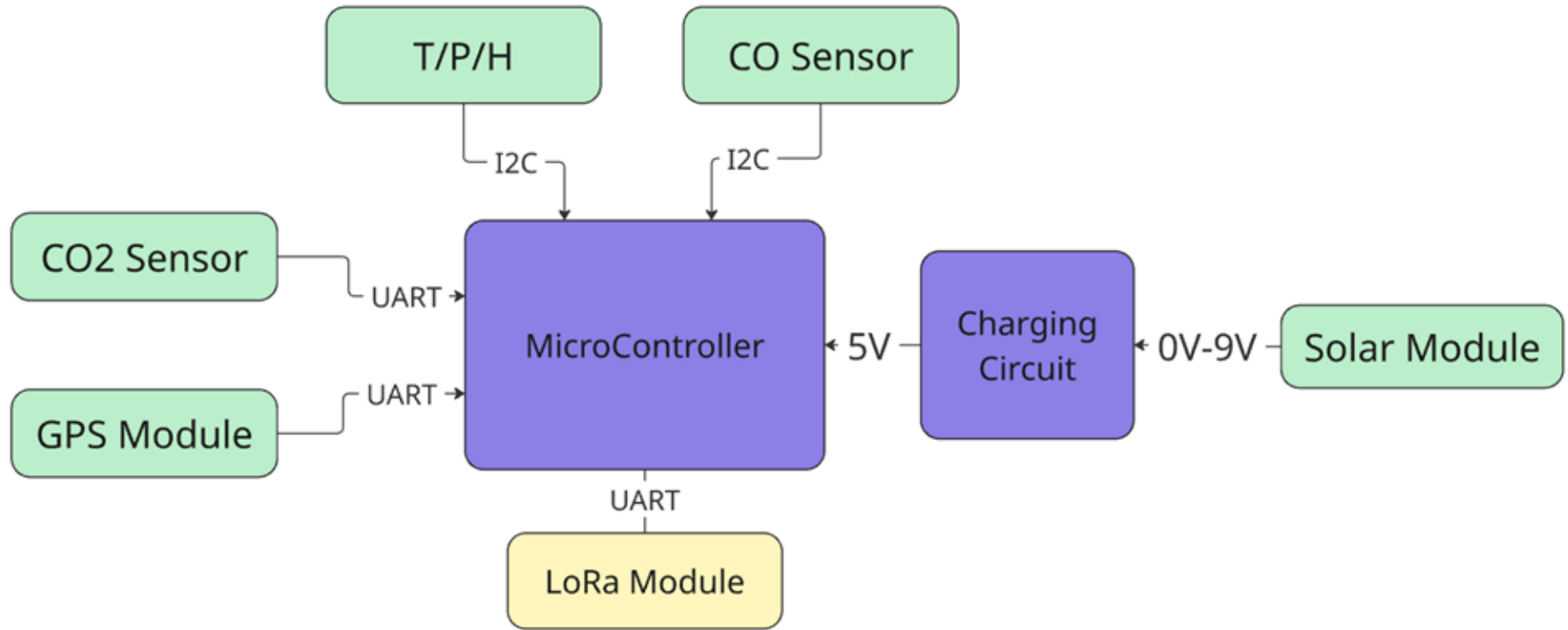
- Python script & LoRa Transceiver
- Predicts fire risk
- Organizes data in database

Dashboard

- Interactive node map
- Displays live fire risk
- Interface for area environmental data

Hardware Overview

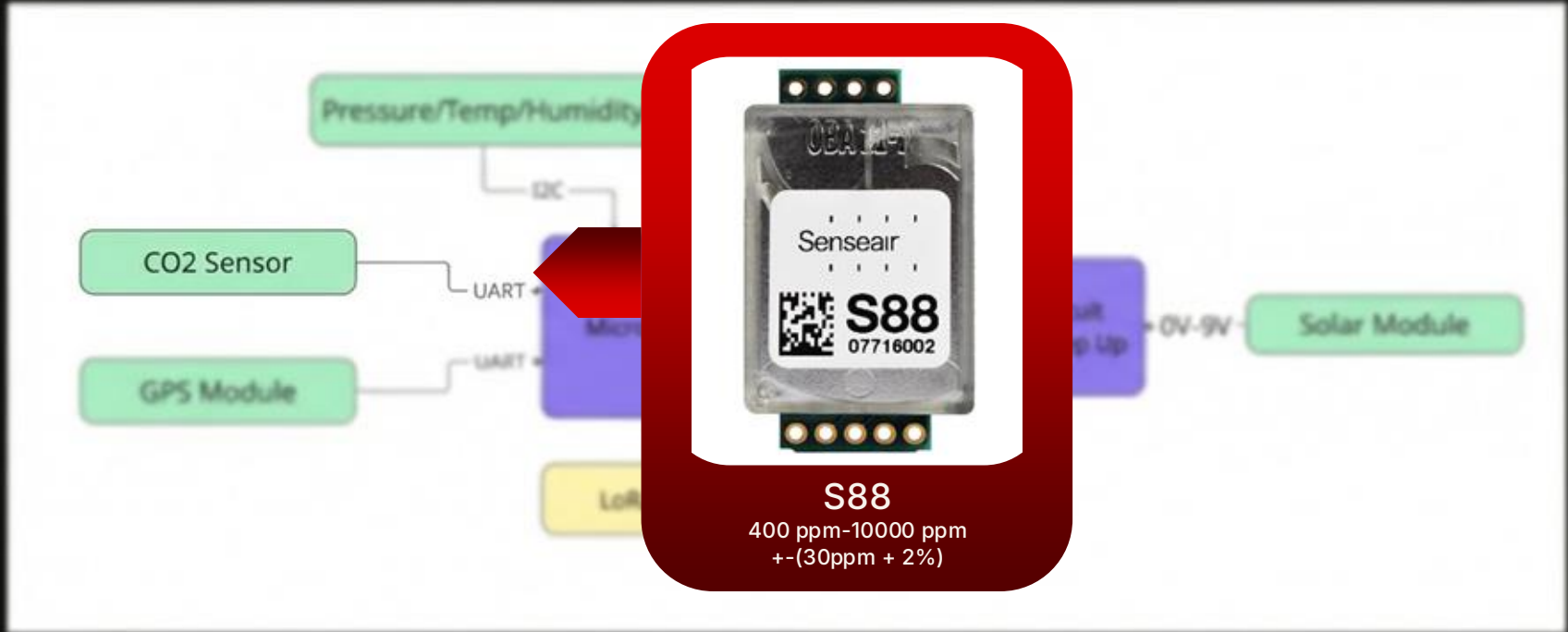
Remote Detection Sensor



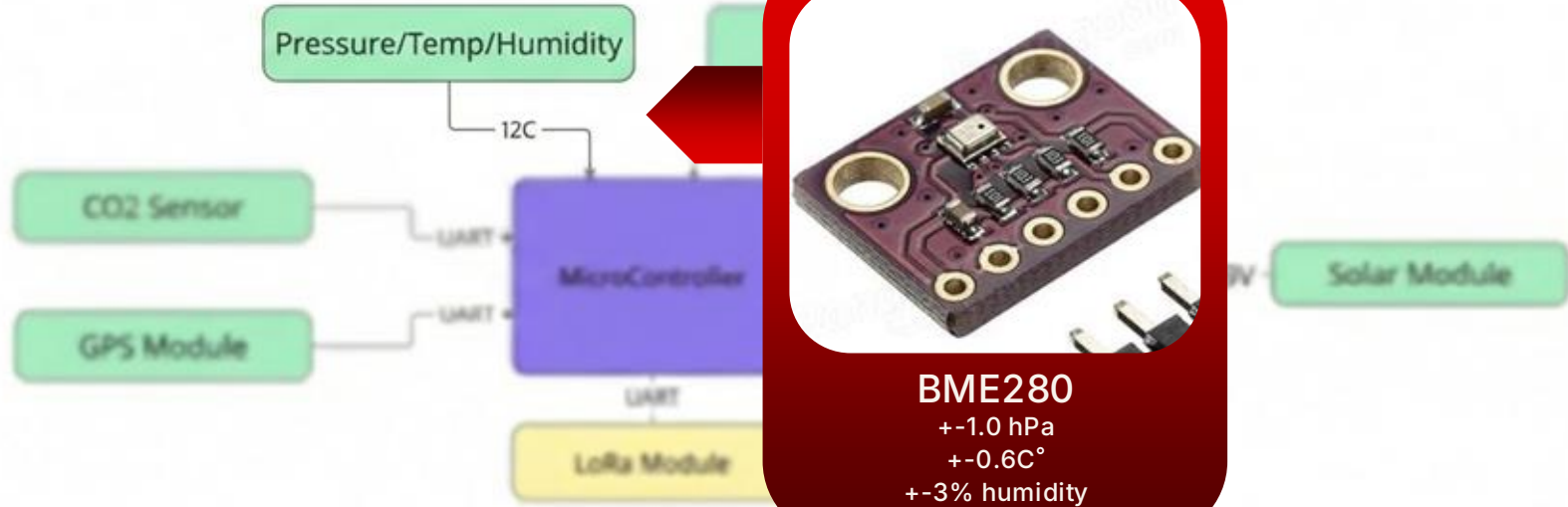
Remote Detection Sensor



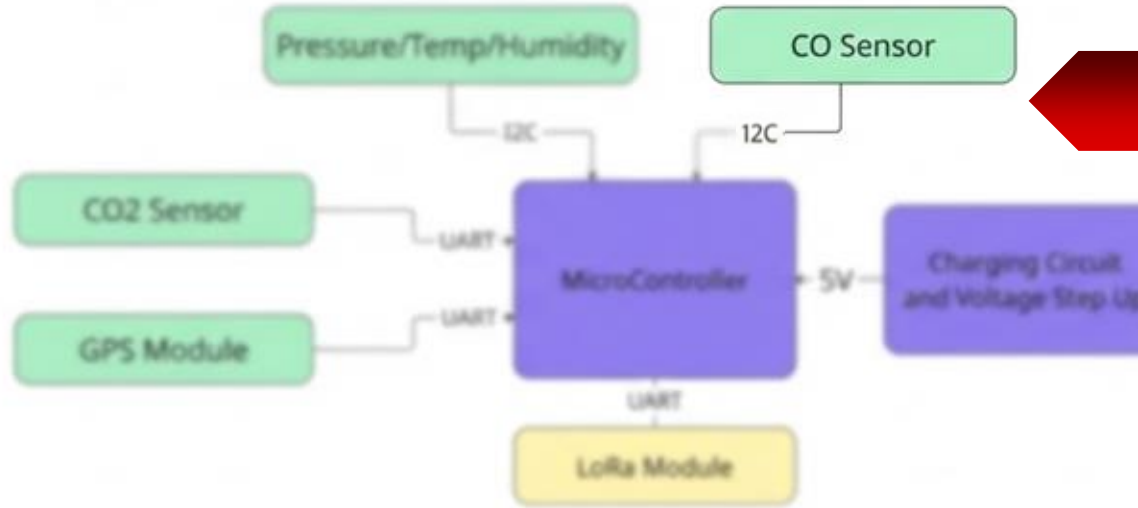
Remote Detection Sensor



Remote Detection Sensor



Remote Detection Sensor



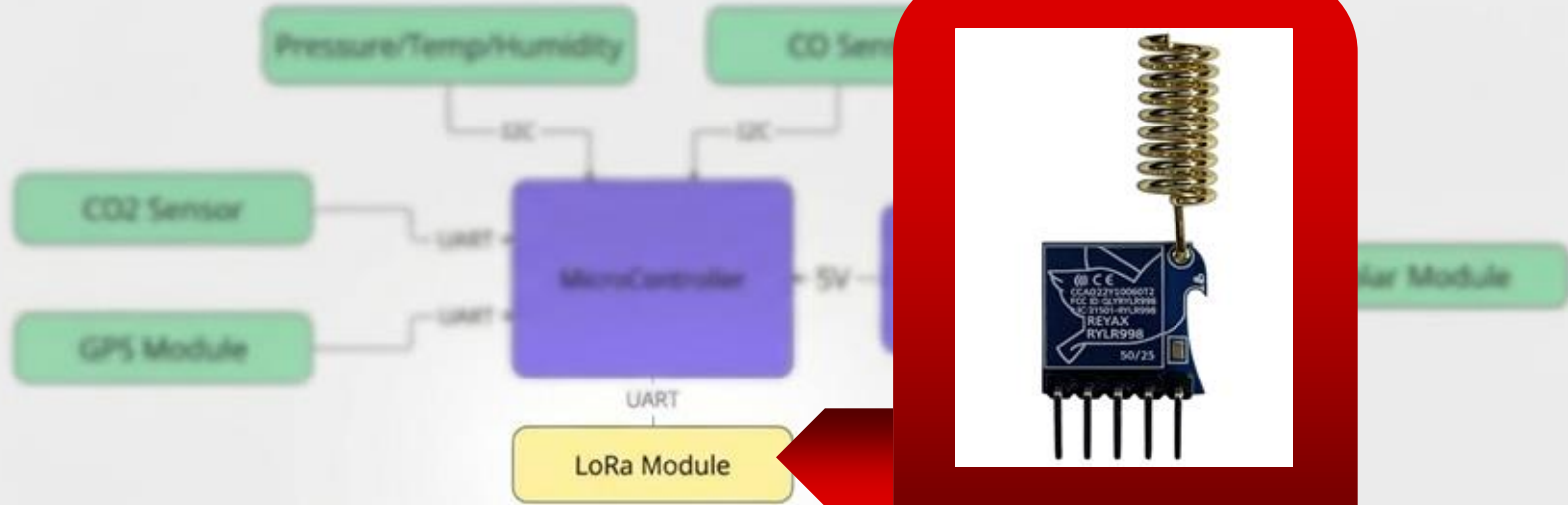
SEN0466
0-1000 ppm
High accuracy
Low Power



Remote Detection Sensor



Remote Detection Sensor



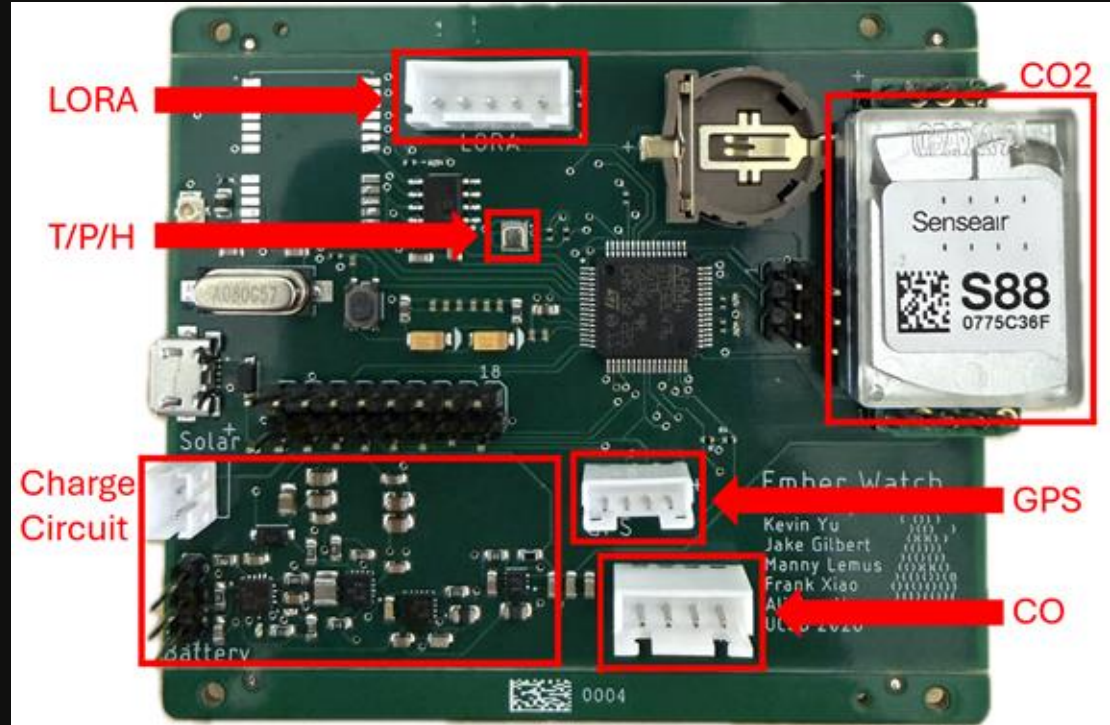
RYLR998

NUVOTON MCU
Power Save Mode
200-300m range



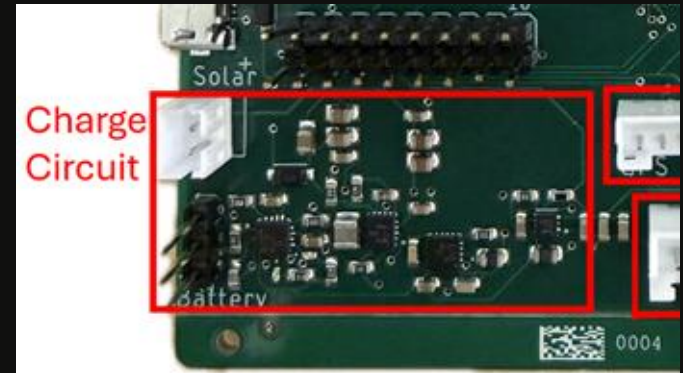
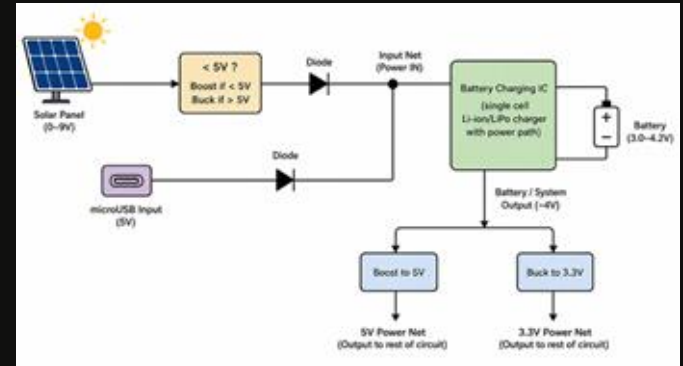
Printed Circuit Board

- 4 layer PCB
- 6cm X 8cm
- STM32L476RGT6 MCU
- Powered via:
 - Micro USB
 - Battery
 - Solar Panel
 - 3V3
 - 5V



Charging Circuit

- Supports 5V–36V input
- Allows simultaneous charging and use of LiPo battery
- 5V and 3.3V output nets
- All power sources routed through battery charging IC
- Protected with Schottky diodes

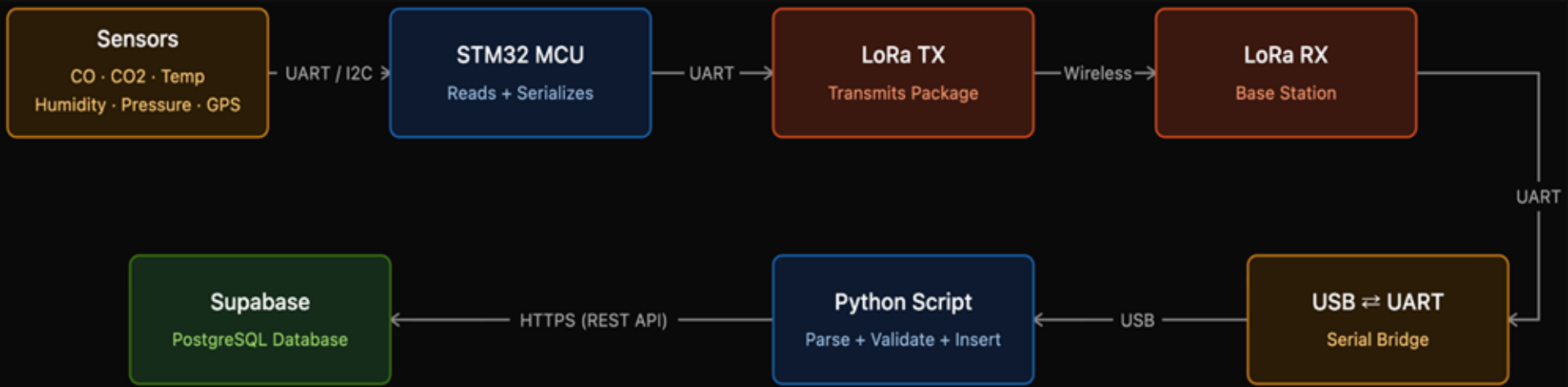


Software Overview

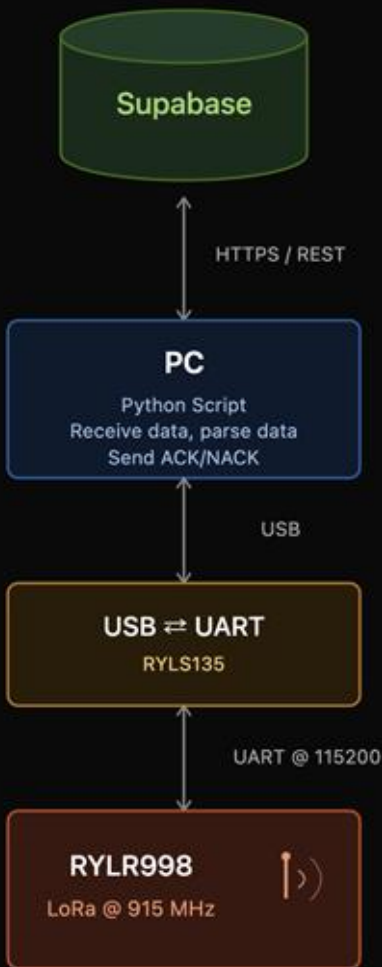
Database Pipeline

This diagram illustrates how sensor data flows through the processing pipeline into the database.

Provides storage for analytics and ML-based fire risk prediction.



Central Monitoring System



Packet Header

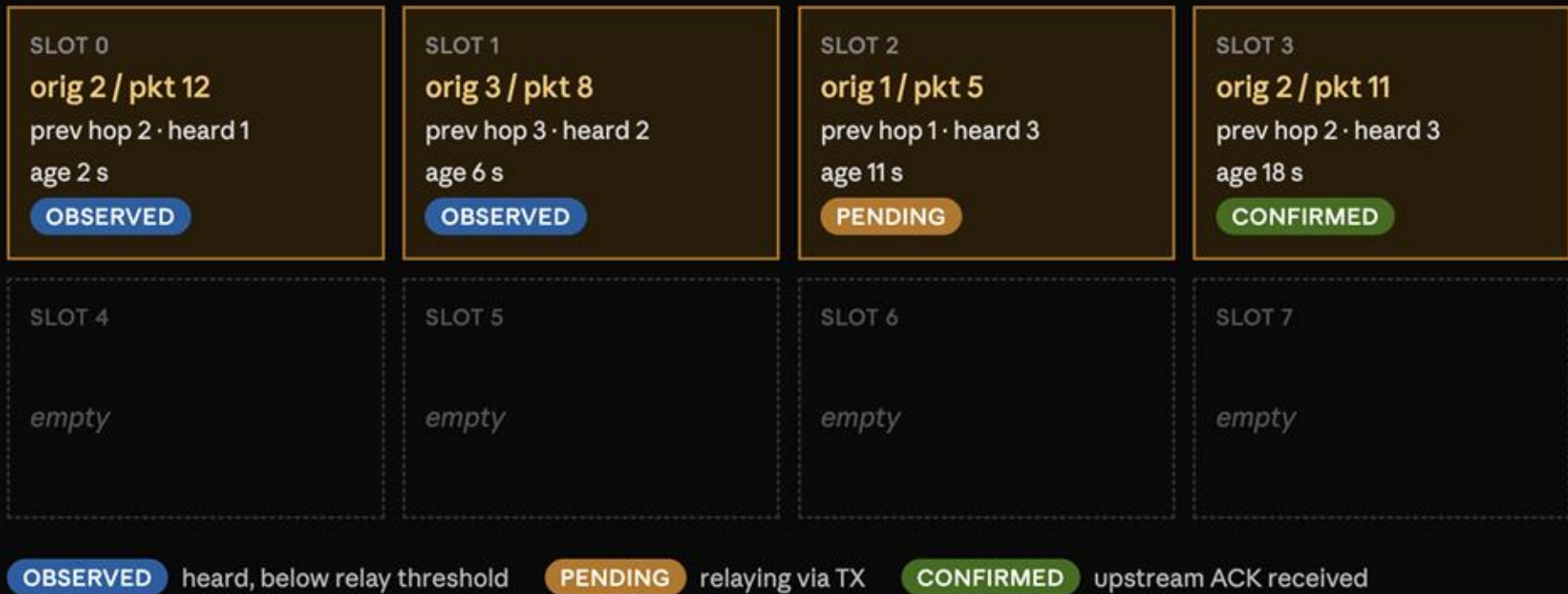
Ex: Node 2 is not being heard by Central Monitoring System: Hub "0".

Hop	Originator	Final Dest	Prev Hop	Next Hop	Type/TTL	Packet ID	CRC
Node 2 → Hub 0	"2"	"0"	"2"	"0"	"DATA/4"	"12"	"0xABCD"

Packet Payload Structure

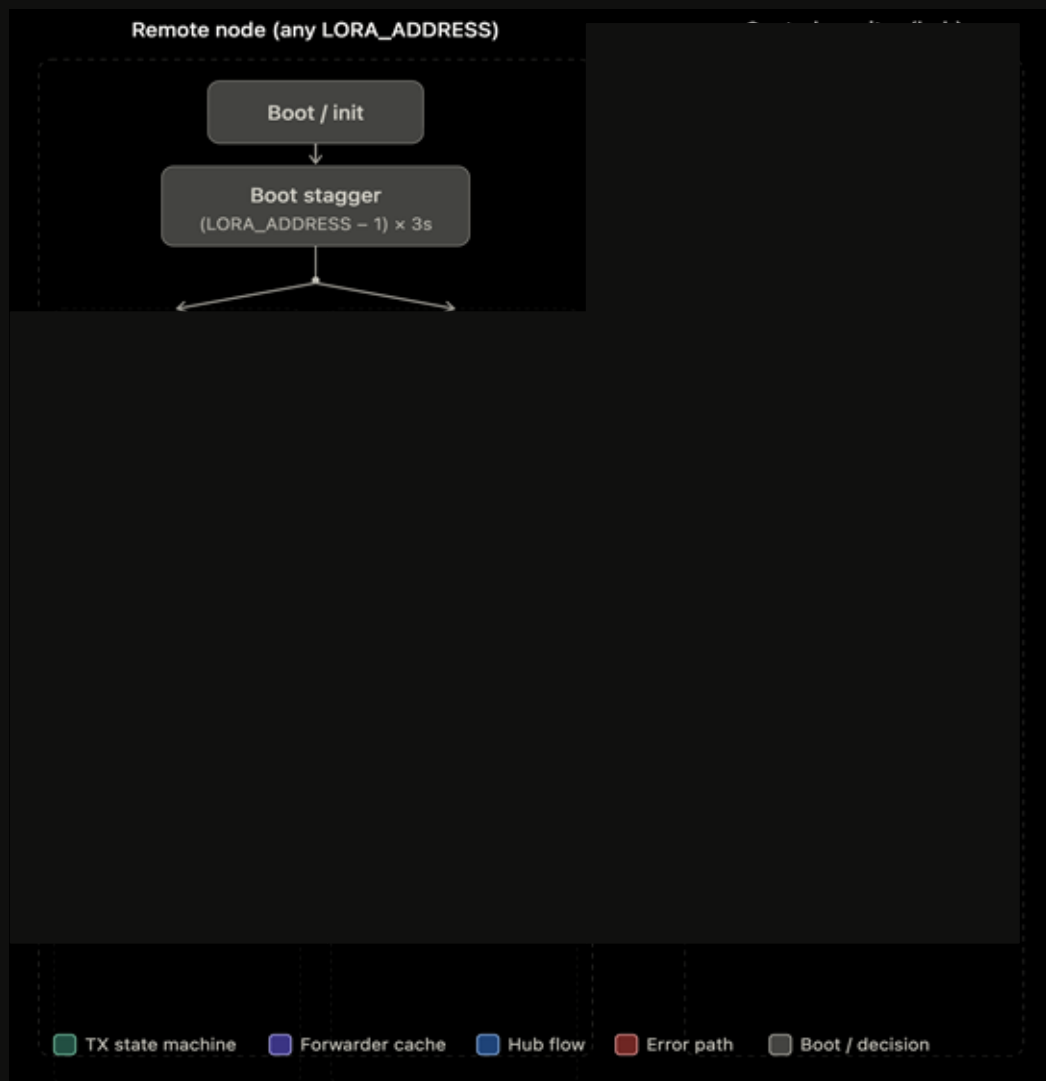


Node Cache for Mesh Implementation



Eviction policy: empty or expired slot first, otherwise evict the oldest entry

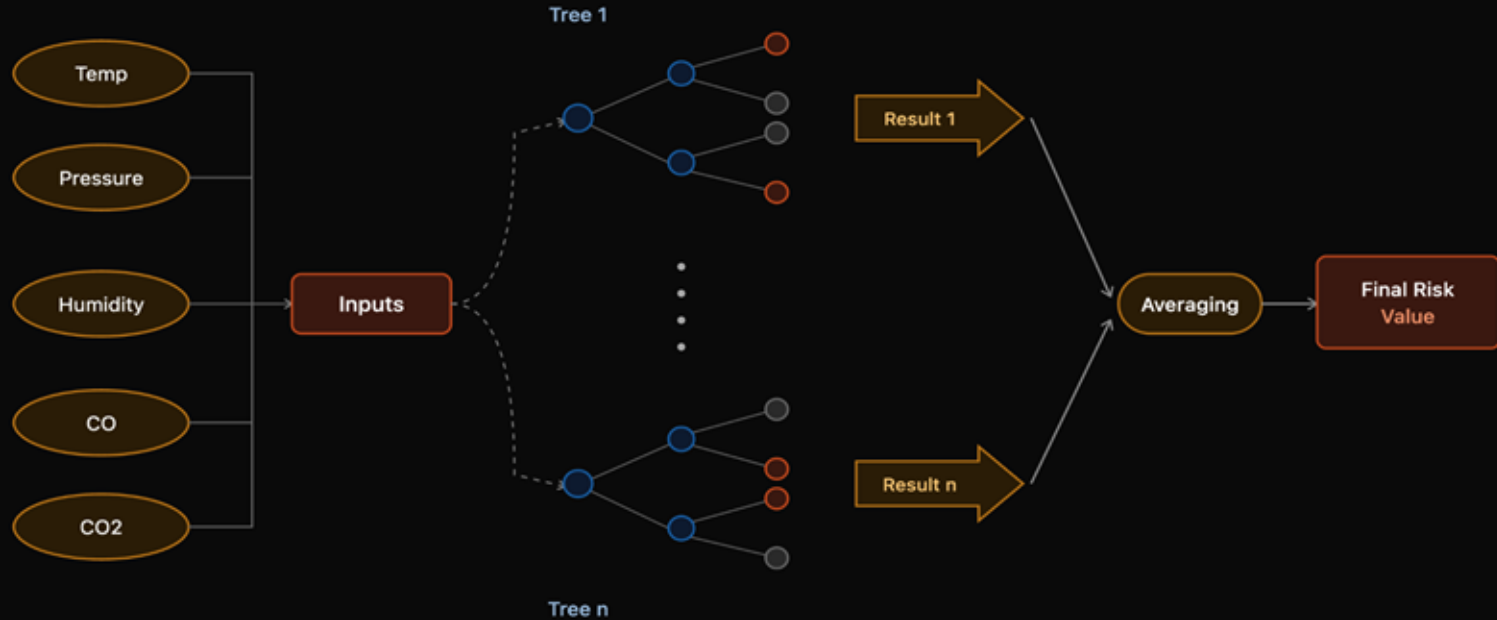
Node State Diagram



Predictive Risk Modeling

Fire Prediction — Random Forest Model

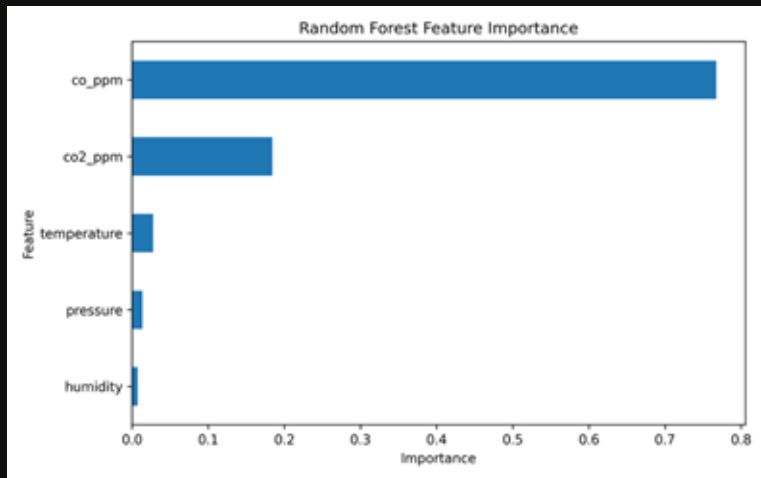
Sensor features → n decision trees → averaged risk score



● Decision split ● Leaf — fire ● Leaf — no fire

Training Results and Applications

- With the Random Forest Model, the testing accuracy is as below:
 - Mean Squared Error: 0.01185
 - R^2 Score: 0.94392
- Feature Importance is shown below
- Applying this model to the central monitoring system to predict the fire risk and transmit data into our database.



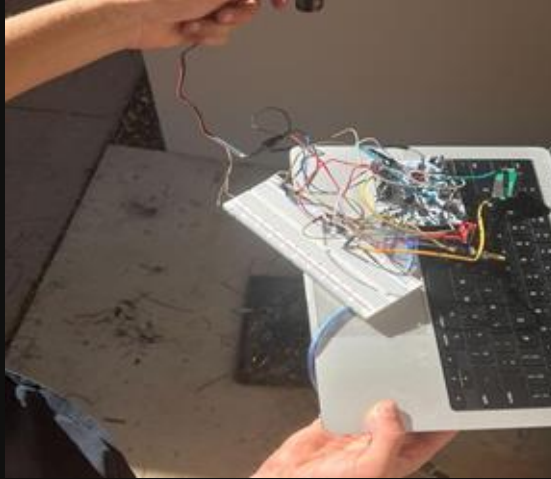
	CO2 float8	Timestamp time	Fire float8	SensorID int8	RSSI int8	SNR int8	
	723	13:33:49	0.01425266093659	1	-52	11	
	517	13:33:53	0.01425266093659	2	-45	11	
	516	13:33:59	0.01425266093659	2	-43	10	
	723	13:34:00	0.01425266093659	1	-56	9	
	2	13:34:03	0.01425266093659	3	-40	9	
	508	13:34:31	0.01425266093659	2	-39	11	
	508	13:34:33	0.01425266093659	2	-44	10	
	841	13:34:36	0.01425266093659	1	-49	9	
	963	13:34:37	0.01425266093659	1	-49	11	
	924	13:34:43	0.01425266093659	1	-50	11	
	2	13:34:47	0.01425266093659	3	-41	9	
	508	13:34:48	0.01425266093659	2	-41	10	

Data Collection



Laboratory Fire Dataset containing Multi Sensor Data.csv

#1 - open source data



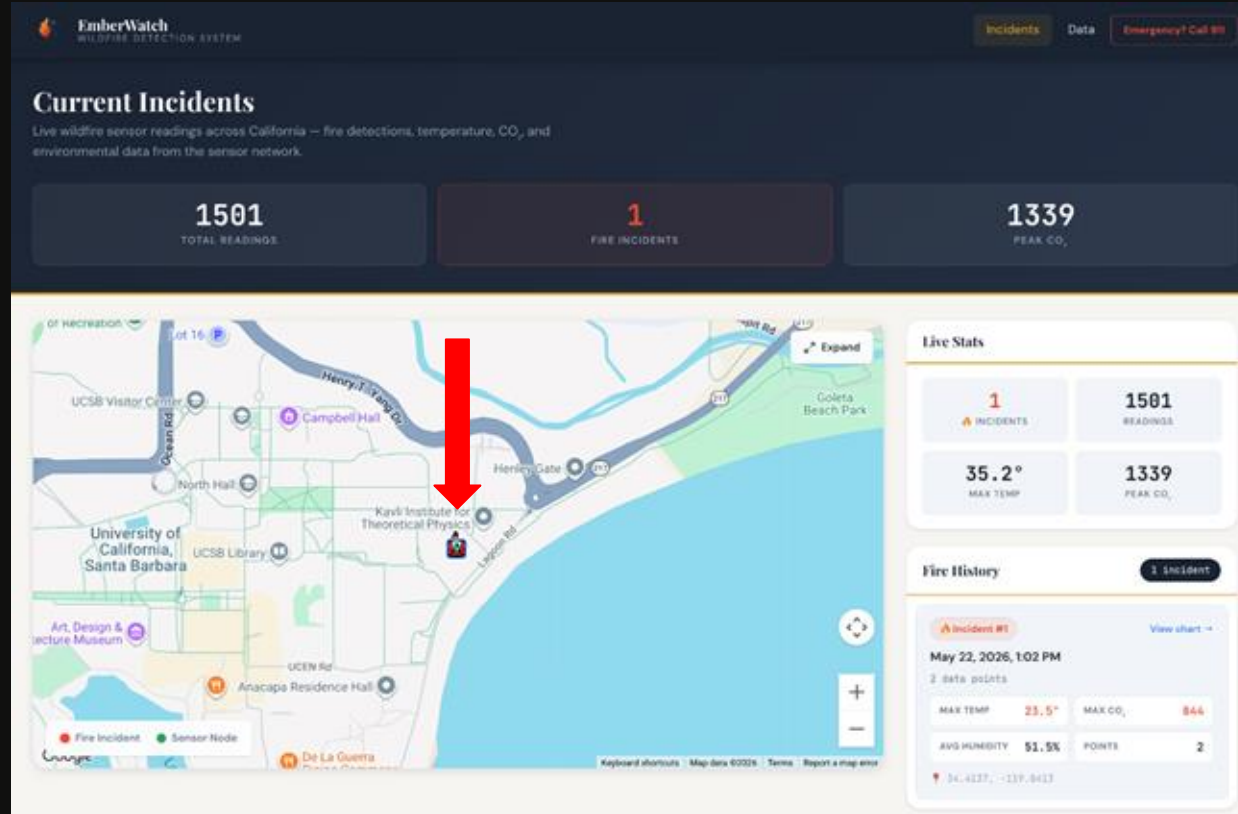
#2 - small fire



#3 - medium sized
fire

User Interface

Website to visualize fires in real time:



- Shows fire readings
- Live stats displaying incident data
- Shows fire history with the data of corresponding fire



Figure 1

- Clicking on the fire point will display a time graph of our data (temperature, CO2, Humidity, and Pressure)
- Fire point displays the fire's data
- Filter can go through date and time

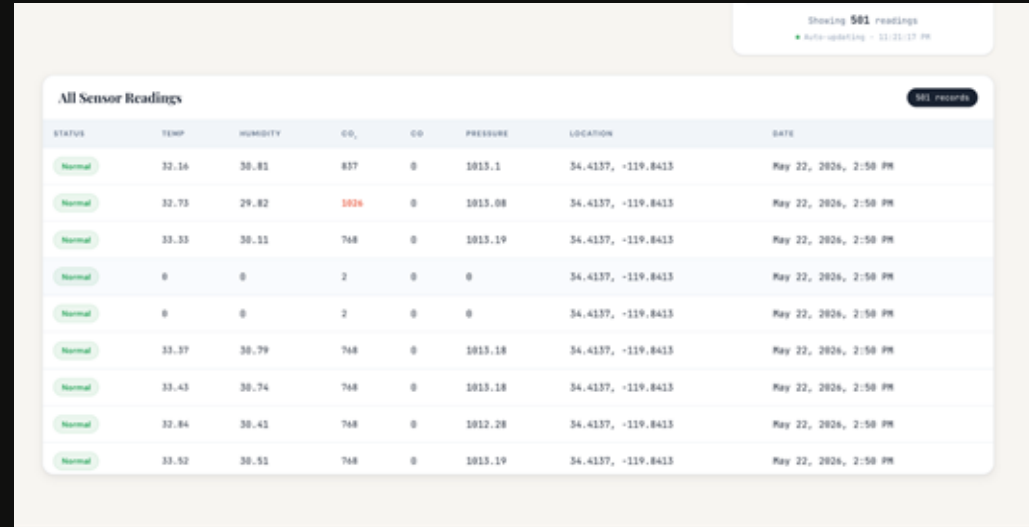
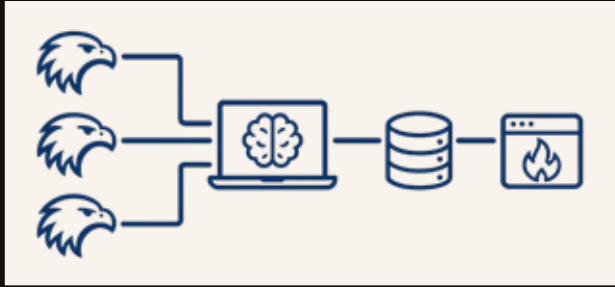


Figure 2

Webapp also displays live database data displaying all sensor readings.

Conclusions and Findings

Overall Achievements



- Achieved a full end-to-end test
- Verified fire detection capability

Range and Scalability Limitations



- LoRa range
- Gas sensor range
- Realistic coverage

Future Work



- Expand range and count with mesh network
- Redesign PCB
- Field testing



Thank you!

