Smart Hive

Nicholas Paschke | Ahmed Alsamahi | Neil Sankineni | Sidney Amber-Messick | Ismael Torres | Ergi Masati

Executive Summary

- Support for Bee Population
- Mesh Network Data Accumulation
- Website for Beekeepers

Problem Statement

Motivation [19]

- Produce a low-cost sensor network
- Use sensor networks data
- The network will be automated

Needs [22]

- Device must measure key parameters such as temperature, humidity, C02, weight, and illumination levels of the hive
- Wirelessly connected to Wi-Fi or be able to access data remotely
- Low-cost and automated or require minimal tampering

Identification of Needs

1. Multi-sensor device to measure significant data for analysing the health of beehives or other apiculture related environments
    a. examples of such sensors would include CO2/air quality detectors, weight scales for supers/comb frames, temperature (where appropriate), illumination of interior of hive
    b. secondary objective would be to have the ability to have a modular approach to the sensor apparatus
2. he device must be wirelessly connected to Mason's Wi-Fi or be able to access data remotely
    a. his data must automatically be archived and have the ability to be extrapolated over time for further analysis of long-term health of the apiculture subject
3. The measurements of the product must be automated or require minimal tampering for the end user
4. The final product must not exceed power consumption than the surroundings of the environment is able to provide
5. The solution/product must not exceed or greatly adjust the dimensions of a colony
6. The User must be able to still complete daily care of the bees after installation of the Product
    a. such actions include but are not limited to: feeding, removing components, removing super frames, the smoking of bees, and the splitting of colonies
7. The product must in no way shape, or form harm, disable, or interfere with colony structure or development.
8. The product must be "accessible to a 13 year old" and have "less than half a page of instruction for use"
9. Developed solution must be reasonable for the end user to afford given the utility of the product (competitive market price is approximately $150-200 maximum for extraneous tools for apiculture)
    a. This price is for the final development of the product
10. Final product must be capable of withstanding weather conditions inside of the hive if embedded within the hive
11. Final product must not interfere with the location or convenience of the colony
12. The end user has also included further bonus objectives which will be listed below
    a. Sensing the population of varroa mites within a hive would greatly innovate the apiculture industry
    b. determining/predicting the event of a "swarm" or overpopulation of a hive before it occurs would be "a big hit"
    c. Being able to track a queen would be beneficial for beekeepers within our target Demographic

Measured requirements

The following list was gathered from the customer of note in a direct interview and cited within a previous project conducted on the exact grounds.

1. The power source provided on premises is an array of 4 nickel batteries (3.3 V Power supply required for Raspberry Pi)
2. The general maintenance of the apiary is short intermittent visits 4 times each week
3. Hives during acclimate temperatures, are opened to inspect the hive's health
4. A range of 1 to four sensors per frame was found to be accurate enough for the information required of the customer.
5. Light is found to be a key disturbance for the hives and must be kept to a minimum if not completely nullified [23]
6. 0.375 of an inch was found to be the minimum gap which
7. The expected temperature within the hive is 90-93 degrees Fahrenheit provided by the client, while expected humidity within the hive to support healthy colonies is 40%-60% [22]
8. The distance from the main power supply to the hives is less than 15 feet
9. System should be functional for 1 month, specified by client

Market and Application Review

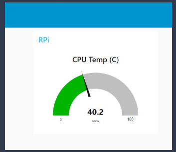
- Smart Hive 2.0 which was deployed in 2020 at George Mason University [19]

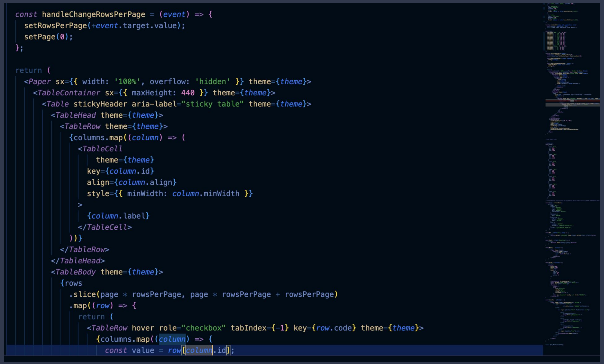
- The smart hive uses six MCP9808 sensors to measure temperature in bee hives, and includes Raspberry-Pi boards that transmit data over wifi [20]

- Companies (Arnia, Solution Bee, Broodminder) make smart hives using expensive parts, no website available. Documented by Frank Linton [21]

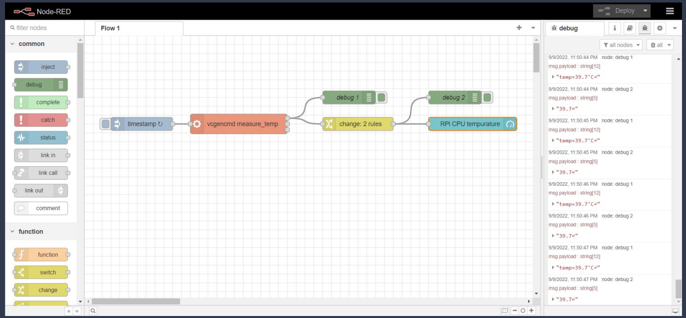
- Our improvements: More data collected (CO_2, humidity), lower cost sensors, more expandable software/website

Approach





Server



BeeBox

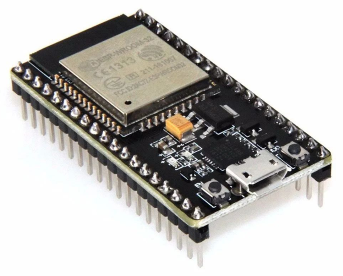
Smart Frame

Server

- Cloud-based solution or microcontrollers for Kubernetes
- MERN stack or HTTP server via python script

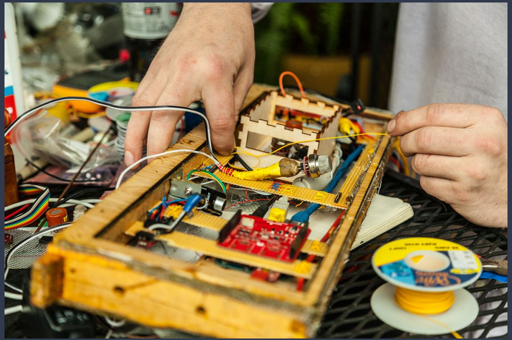
BeeBox

- Microcontrollers such as an ESP32, Beaglebone Black, or Raspberry pi zero
- Will need to transmit data schema and read information from sensors



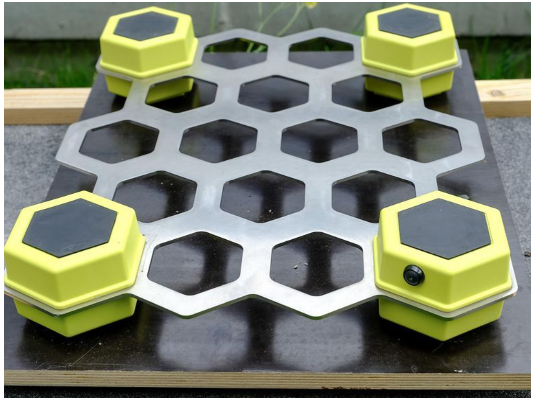
SmartFrame

- GPIO or microcontrollers on frames
- Beebox would make frames more expensive



Alternative Sensors

- Weight/Illumination were bonuses identified by the customer
- Low cost, accuracy important



Decision matrix for parts

*All parts and datasheets are cited at the end of the presentation

Temperature

	Weight ->	9	10	5	2	10	
Part Number:		Cost	Durability	Size	Digital/Analog	Accuracy	Final Rank
DHT22		9	6	9	10	9	43
DS18B20		10	3	7	10	8	38
DHT11		9	6	9	10	7	41
LM35		6	4	9	5	10	34

Humidity

	Weight ->	9	10	5	2	10	
Part Number:		Cost	Durability	Size	Digital/Analog	Accuracy	Final Rank
BME280		5	6	9	10	7	37
SHT40		6	7	10	10	8	41
DHT22		9	6	9	10	9	43
DHT11		9	6	9	10	8	42

Illumination

	Weight ->	9	10	5	2	10	
Part Number:		Cost	Durability	Size	Digital/Analog	Accuracy	Final Rank
LM393		10	6	8	10	8	42
UUGEAR LSM		9	6	8	10	8	41
KY-018		9	3	9	10	8	39

CO2

	Weight ->	9	10	5	2	10	
Part Number:		Cost	Durability	Size	Digital/Analog	Accuracy	Final Rank
K30		4	5	7	10	8	34
SCD30		6	5	7	10	8	36
EE895		5	6	8	10	9	38
CCS811		7	4	8	5	7	31

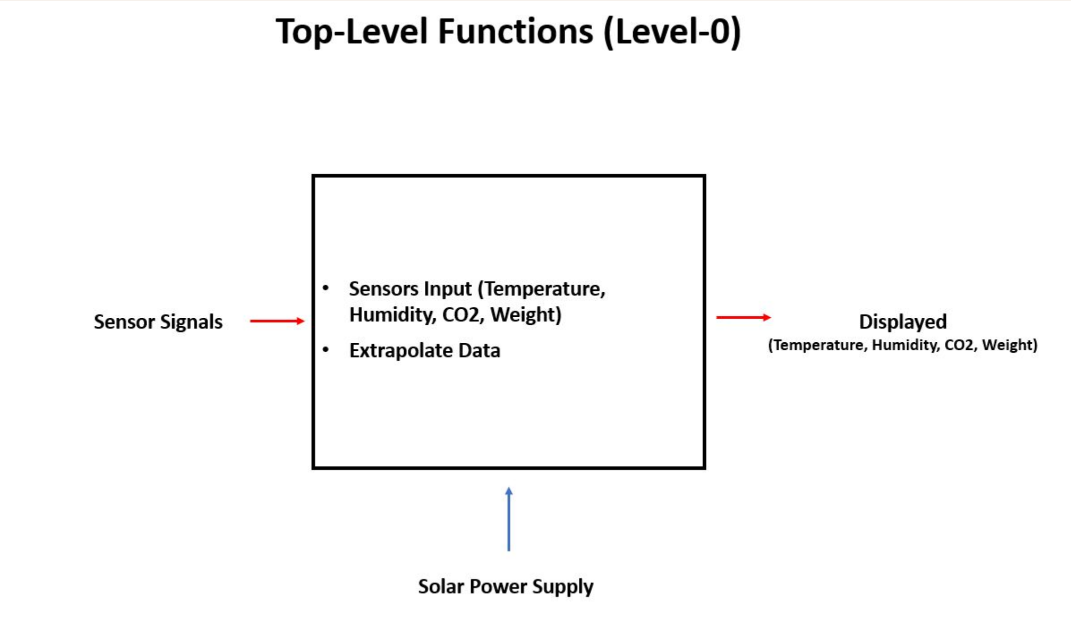
Weight

	Weight ->	9	10	5	2	10	
Part Number:		Cost	Durability	Size	Digital/Analog	Accuracy	Final Rank
HX711		7	7	9	5	10	38
H26R0		7	5	10	5	8	35
MF02A-N-221-A01		8	3	8	0	8	27

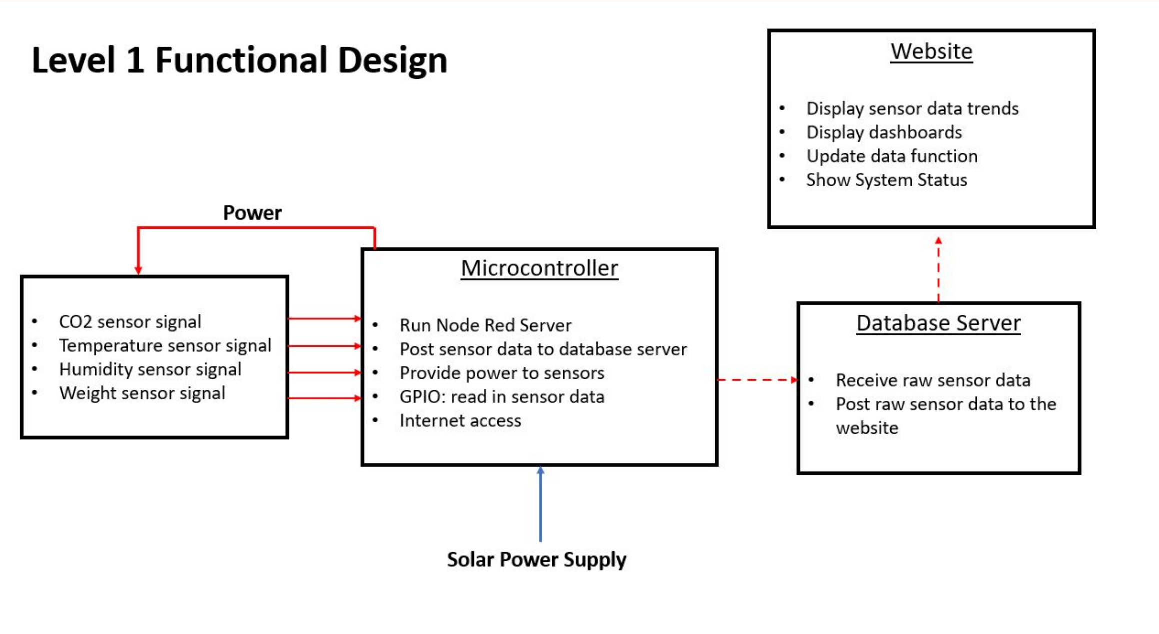
System Design

Functional Decomposition

Top-Level Functions: Level-0

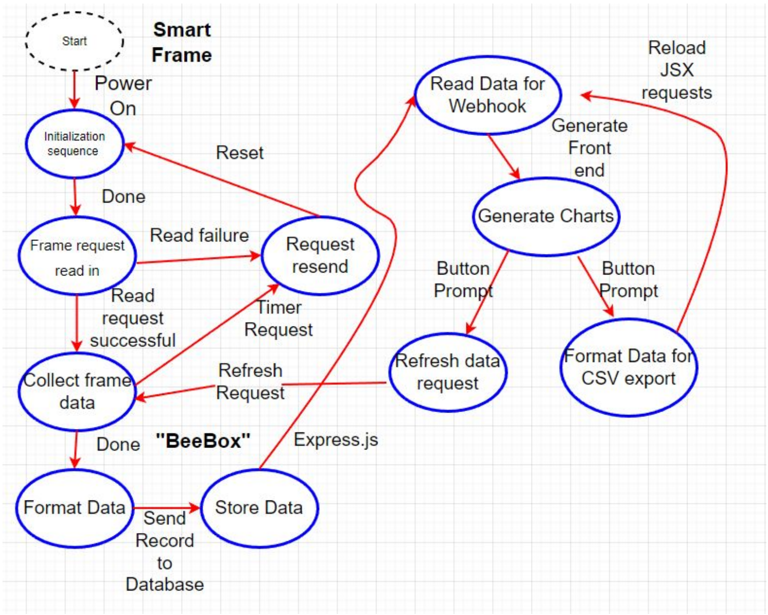


Functional Design: Level-1



System

- Raspberry Pi
- 5v Power supply
- 26 ¾” solar panel
- Node Red
- MongoDB



Weight [1][4][12]

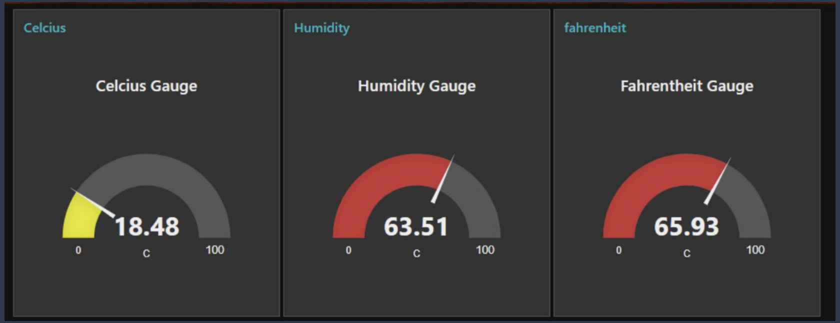
- Monitoring the weight of a beehive gives beekeepers an indication of the start and stop of nectar flow
- Sudden drop in weight can suggest that the bee colony has swarmed
  - Hive itself has been unusually affected by external factors and needs to be seen
- Comparing weight between the hives gives the beekeeper a sense of productivity [23]

Temperature [7]

- Alerts beekeepers to dangerous conditions within the hive including excessive heat
- Indicated that the hive needs to be moved or properly ventilated
- Low heat indicates that the hive needs to be insulated from cold water [23]

C02 [20]

- Levels allow beekeepers to better ventilate their hives
- Bees can tolerate higher levels of c02 than humans
- High levels can still kill them [23]



Humidity [22]

- Honey production within an excessive amount of humidity can be dangerous to bee colonies
- High humidity levels alert beekeepers that moisture build-up is occurring
- Better ventilation and water removal is needed. [23]

Illumination

- Light is an important indicator of potential threats to a beehive, including a swarm [23]
- Sensors will indicate what light levels are healthy and not
- Levels can pick up on threats to a hive that other sensors may not indicate

Preliminary Experimental Plan

Experiments

Experiment #1

Testing if sensors work with our microcontroller (Raspberry Pi), and are accurate compared to readings we receive with measuring tools within a certain percentage

Experiment #2

Testing if our database receives and transmits data to our online tool reliably over many trials and circumstances – introducing hazards

Preliminary Project Plan

1. Interfacing sensors with microcontroller
2. Sending sensor data to the database using Node-RED
3. Implementing the database server with MongoDB
4. Developing our online tool for displaying data, sending data from server to website

Potential Problems

Propolis

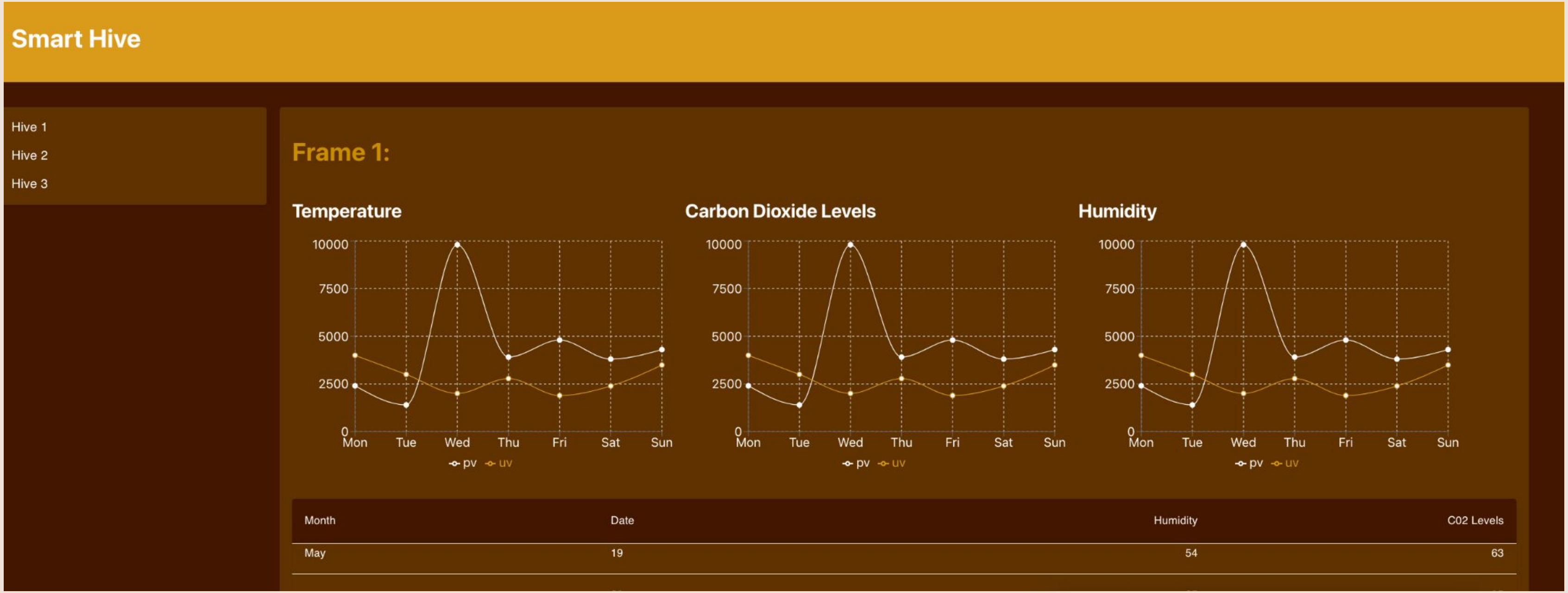
Connectivity

Weather Conditions

Power consumption

Website lag hosting front end and back end concurrently

Website Demo



- The website will be open source once a build is complete, allowing future students to update our design
- The website will additionally allow for downloads and renaming of all the temperature data in CSV file format

The End.

Thank you!

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