SeatDetect

Team #18

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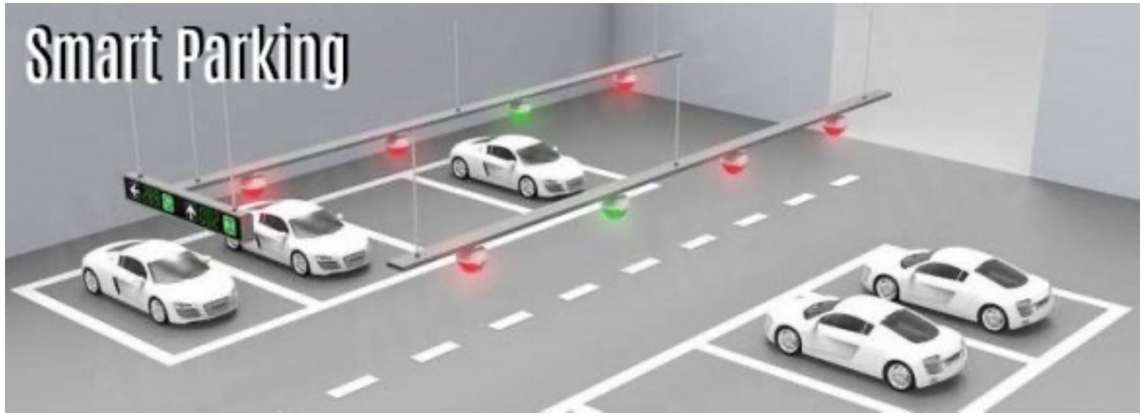
ECE 445: Senior Design Project

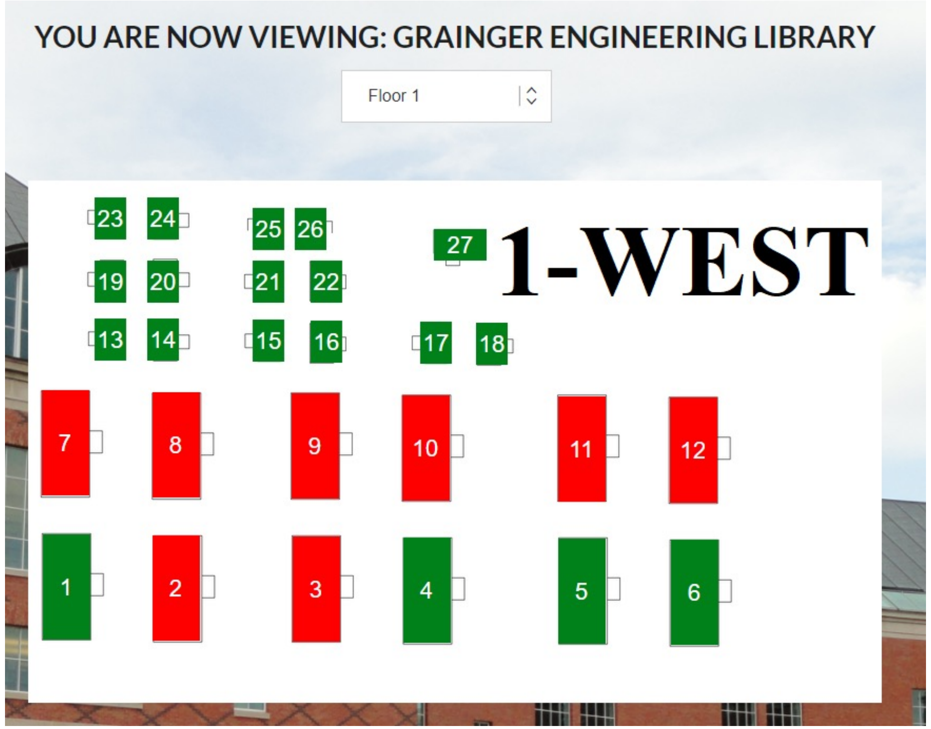
May 4, 2021

SeatDetect

INTRODUCTION

- A system that detects whether a library seat is available or not.
- Inspired by smart parking lot system.
- Reflect status changes online.





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Floor 1

1-WEST

🟩 23 🟩 24 🟩 25 🟩 26 🟩 27

🟩 19 🟩 20 🟩 21 🟩 22

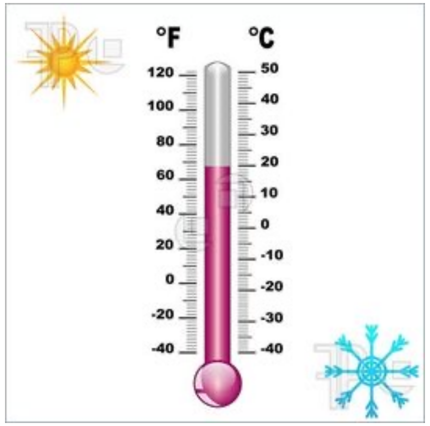
🟩 13 🟩 14 🟩 15 🟩 16 🟩 17 🟩 18

🟥 7 🟥 8 🟥 9 🟥 10 🟥 11 🟥 12

🟩 1 🟥 2 🟥 3 🟩 4 🟩 5 🟩 6

OBJECTIVE

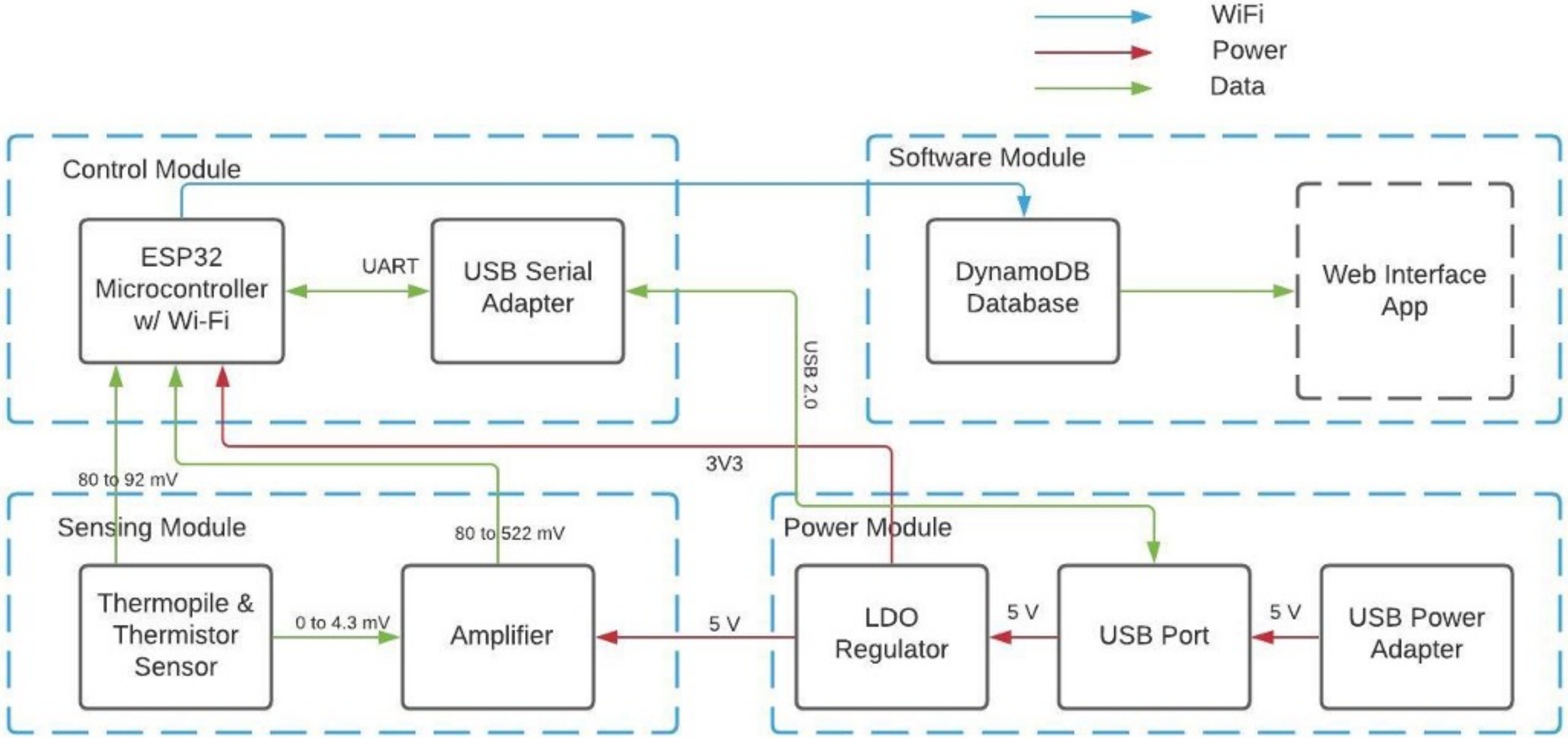
- Design a system that measures the temperature of surrounding area.
  - Used to determine whether a seat is occupied.
  - Transmit status through Wi-Fi.
  - Status updated in web application.
- Saves students' time
  - Ability to check occupancy status of the library before going.
  - Eliminate issues of students holding spots for others.



HIGH-LEVEL REQUIREMENTS

1. An accuracy of occupancy status over 95% on repeated tests of the same booth is the benchmark.
2. The occupancy status should change from unavailable to available within 15 mins after the seat is no longer occupied.
3. The transfer of user data for occupancy status updates on the mobile/web app should be within 30 seconds of a status change.

BLOCK DIAGRAM



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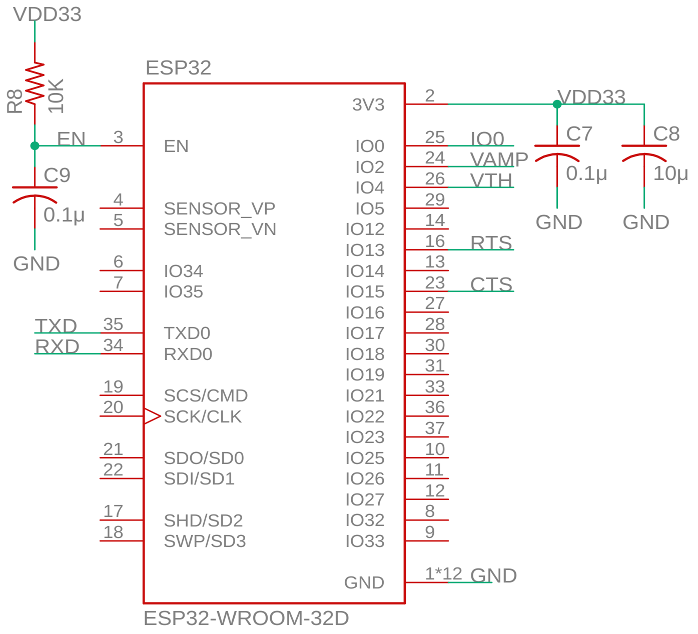
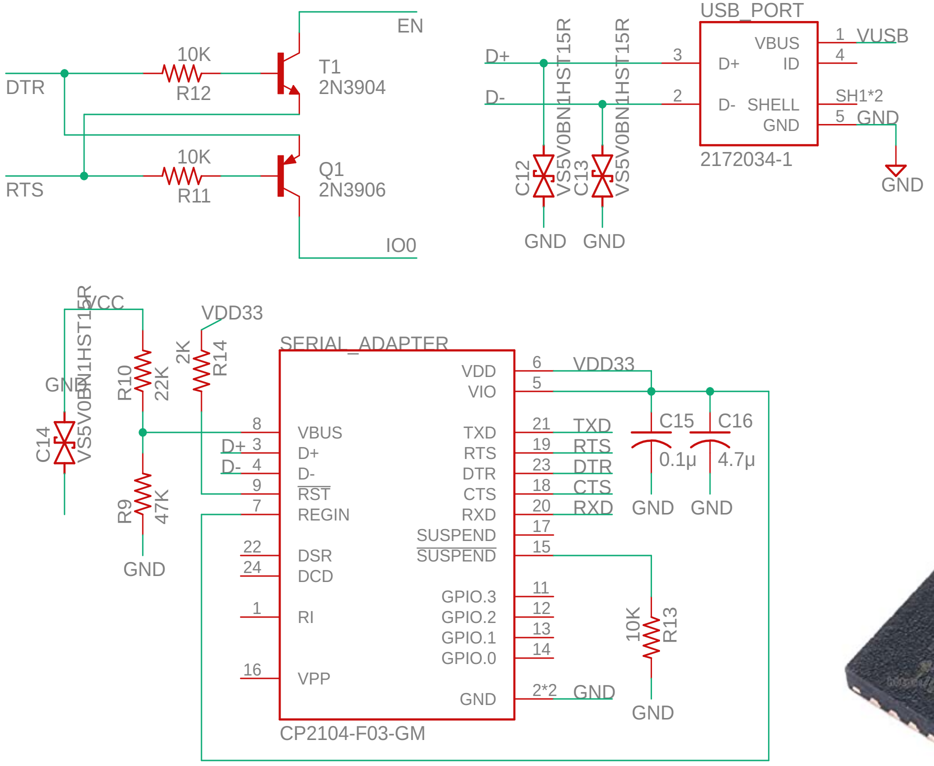
CONTROL MODULE

- ESP32 Microcontroller w/ Wi-Fi
- USB Serial Adapter

ESP32



Serial Adapter



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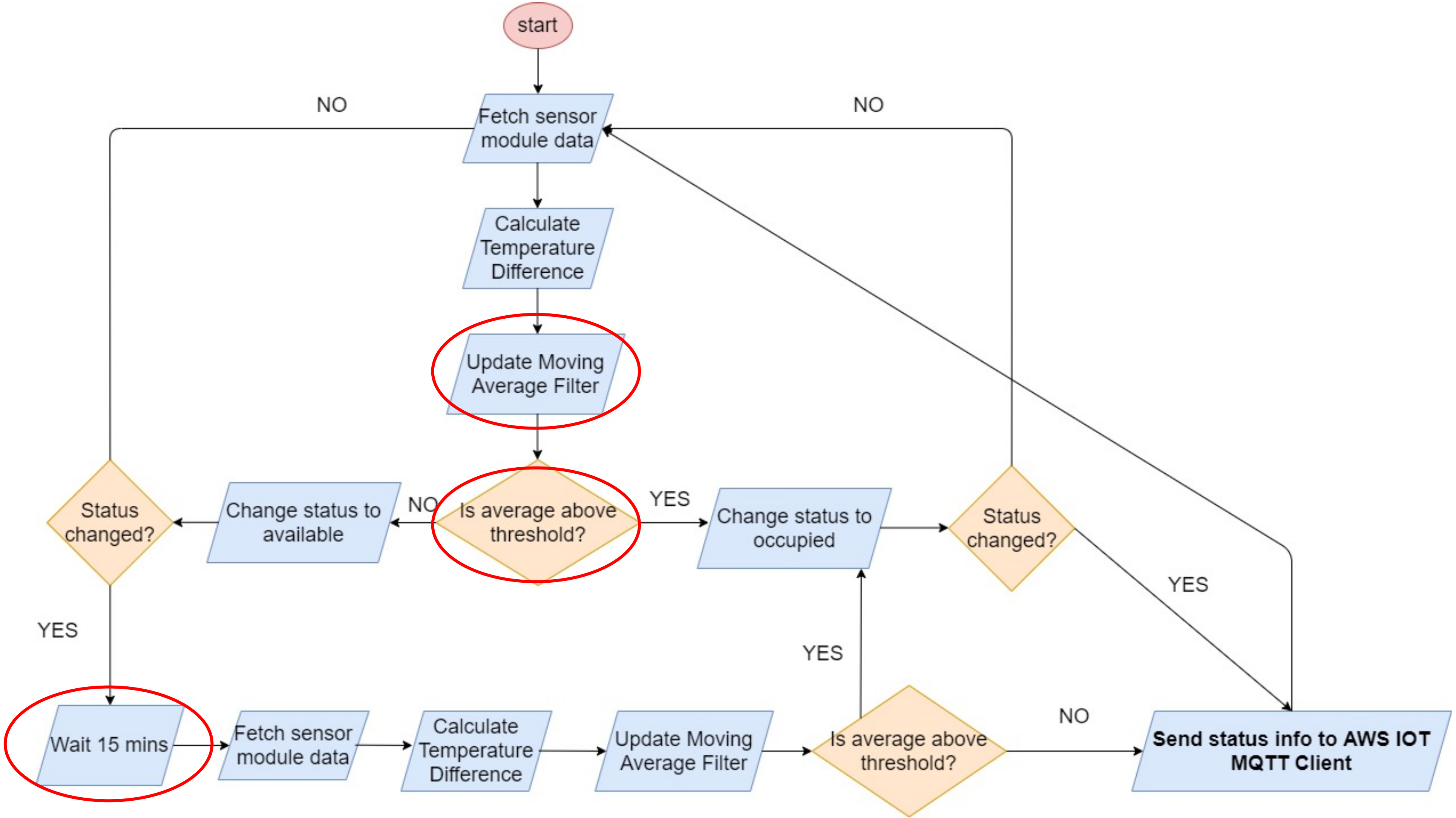
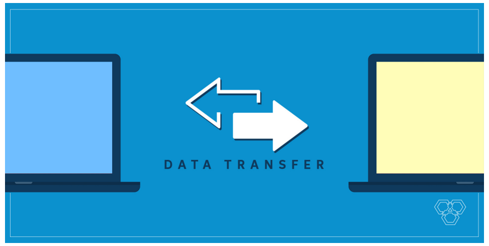
CONTROL MODULE DESIGN



start
Fetch sensor module data
NO
NO
Calculate Temperature Difference
Update Moving Average Filter
Status changed?
Change status to available
NO
Is average above threshold?
YES
Change status to occupied
Status changed?
YES
YES
YES
Wait 15 mins
Fetch sensor module data
Calculate Temperature Difference
Update Moving Average Filter
Is average above threshold?
NO
Send status info to AWS IOT MQTT Client

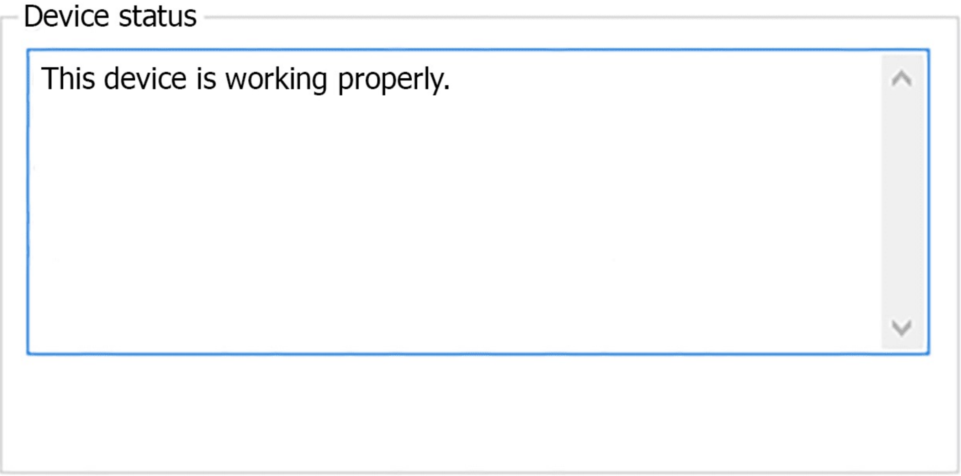
CONTROL MODULE R&V

- Requirement #1: The control unit must be able to reliably transfer up to 10kB of data within 1 second to ensure 6.8kB can be sent out to convey occupancy status and cubicle ID.
- Steps to verify R #1:
  1. Connect the control unit wirelessly to a computer as a wireless serial device
  2. Add the name and password of the personal hotspot in Arduino code to connect to a Wi-Fi network
  3. Transmit the data over the serial link and record the time it took to transfer the data



CONTROL MODULE R&V

- Requirement #2: When the USB port is plugged into a computer, the device must show up as working.
- Steps to verify R #2:
  1. Plug the device into a computer with the CP210x software drivers installed
  2. Verify it is listed as a serial device



Device status

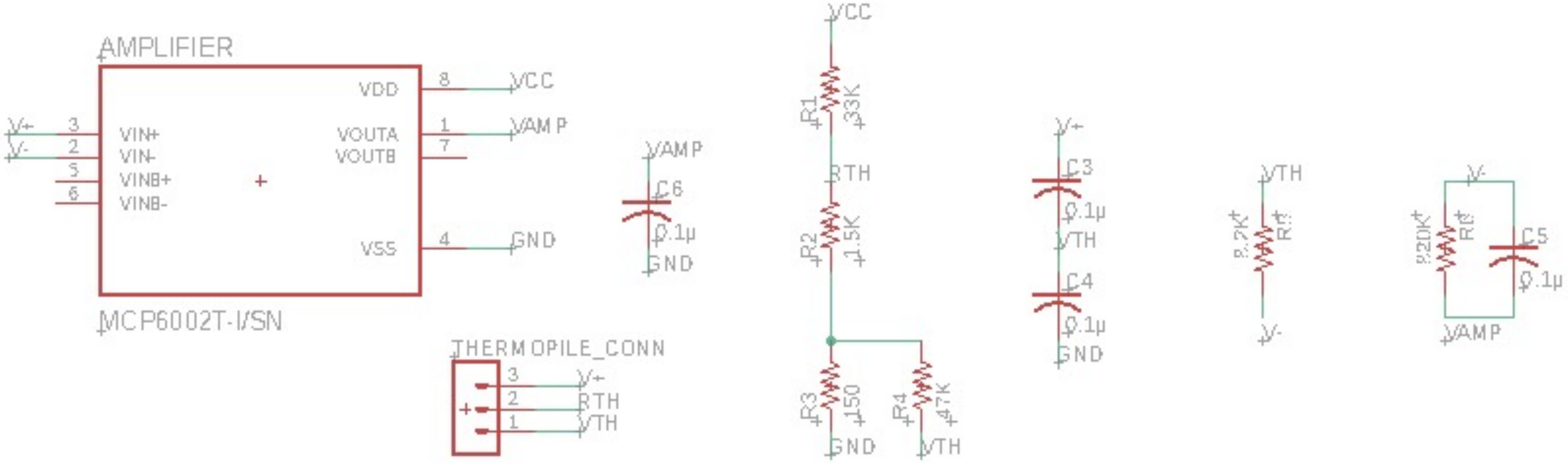
This device is working properly.

CONTROL MODULE R&V

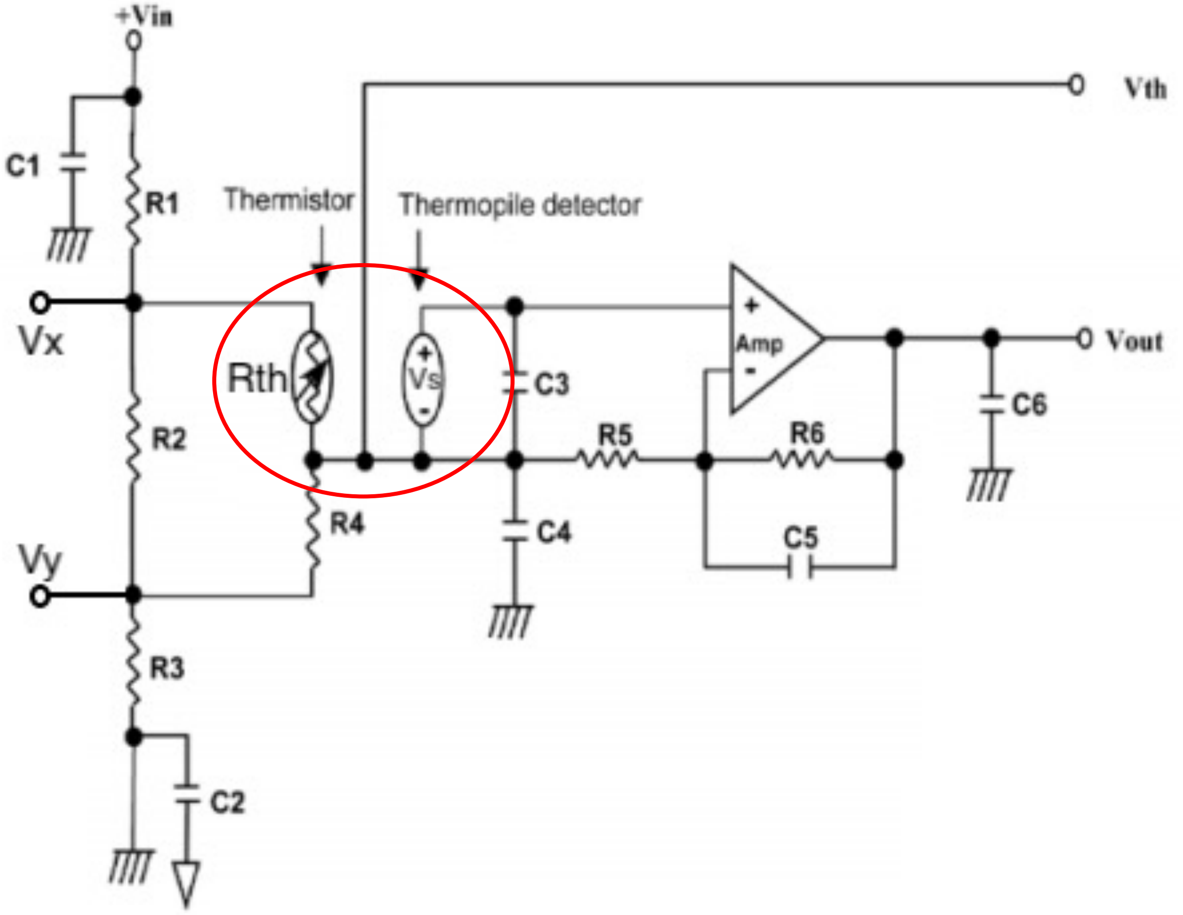
- Requirement #3: The control unit must be able to persist the data with the correct SeatID into the backend DynamoDB table of the software module within 10 seconds of receiving the signal.
- Steps to verify R #3:
  1. Repeatedly occupy and leave one seat containing the sensor
  2. Confirm the record in the database has been updated

SENSING MODULE

- Thermopile Sensor
- Amplifier



SENSING MODULE DESIGN



$$T_O = \sqrt[B]{\frac{V_{out} - V_{th}}{S\left(1 + \frac{R_6}{R_5}\right)} + T_A^B}$$

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SENSING MODULE R&V

- Requirement #1: The amplifier must amplify the voltage from the sensor by a factor of 100 ± 5% (gain of 100).
- Steps to verify R #1:
  1. Measure the voltage before (V_{in}) and after (V_{out}) the op-amp while the complete circuit is under operation.
  2. Check if V_{out}/V_{in} is within 5% of 100.

SENSING MODULE R&V

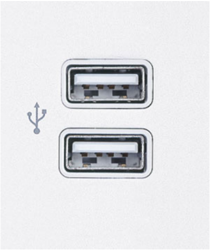
- Requirement #2: V_{out} must be between 80 and 520 mV.
- Steps to verify R #2:
  1. Put the system under the highest and lowest room temperatures possible.
  2. Check if V_{out} is between 80 and 520 mV.
  3. Stand in front of sensor and way from sensor.
  4. Check if V_{out} is between 80 and 520 mV.

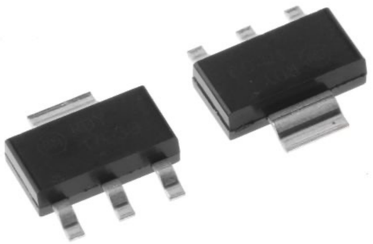
SENSING MODULE R&V

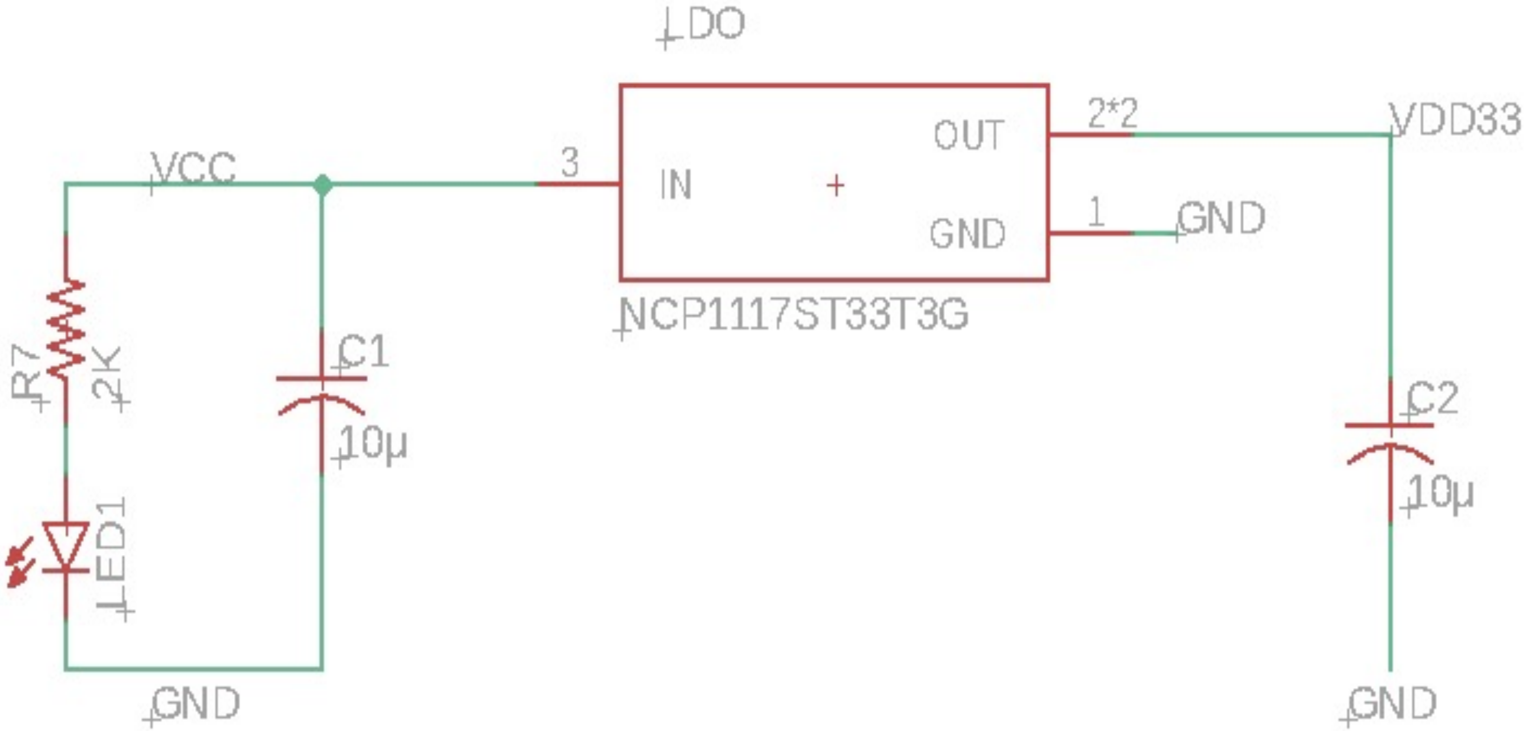
- Requirement #3: V_{out} must achieve at least a 50% decrease when the human leaves the seat.
- Steps to verify R #3:
  1. Stand in front of the sensor and away from the sensor while measuring V_{out} .
  2. Divide the first measurement by the second measurement to see if it decreased by at least 50%.

POWER MODULE

- USB Power Adapter
- USB Port
- LDO Regulator







POWER MODULE R&V

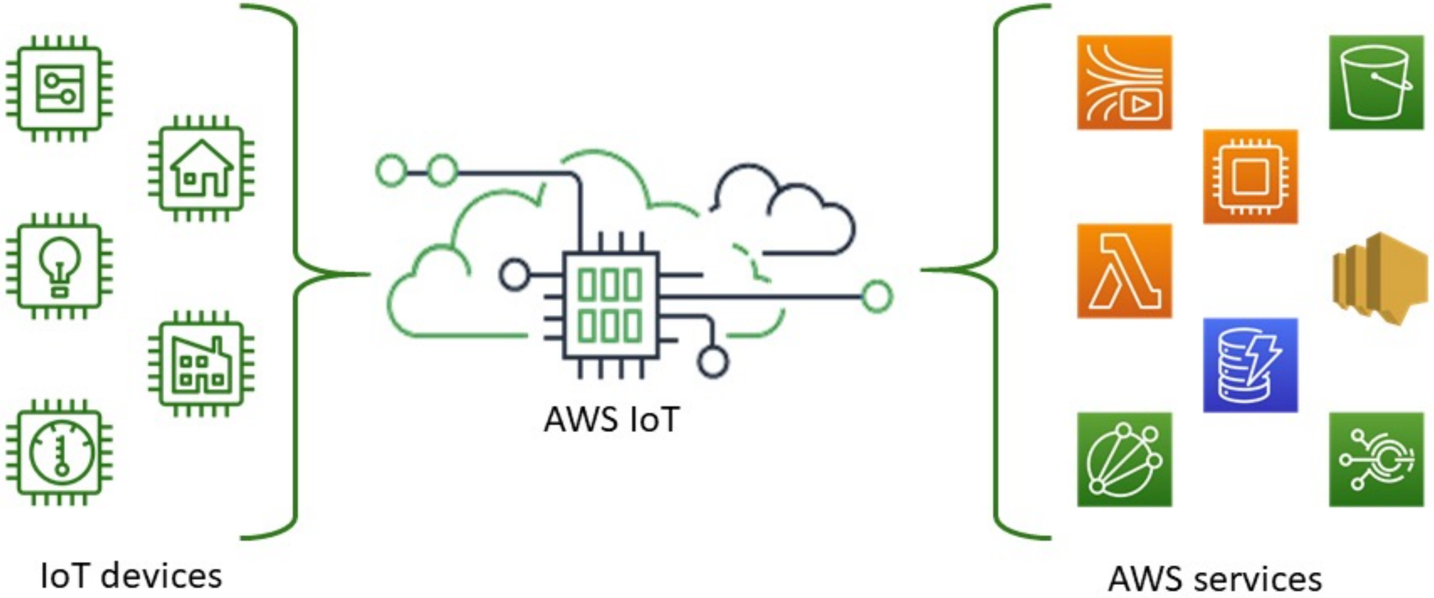
- Requirement #1: The subsystem must be capable of outputting a regulated 3.3V ±0.1 V at 750mA.
- Steps to verify R #1:
  1. Provide the subsystem with 4V from a power supply
  2. Connect the regulated output to a resistive load pulling 750mA
  3. Measure the steady state output voltage using an oscilloscope

POWER MODULE R&V

- Requirement #2: Maintain thermal stability below 125°C
- Steps to verify R #2:
  1. Use an IR thermometer to measure the IC

SOFTWARE MODULE

- AWS
  - IOT
  - DynamoDB
- Web Application



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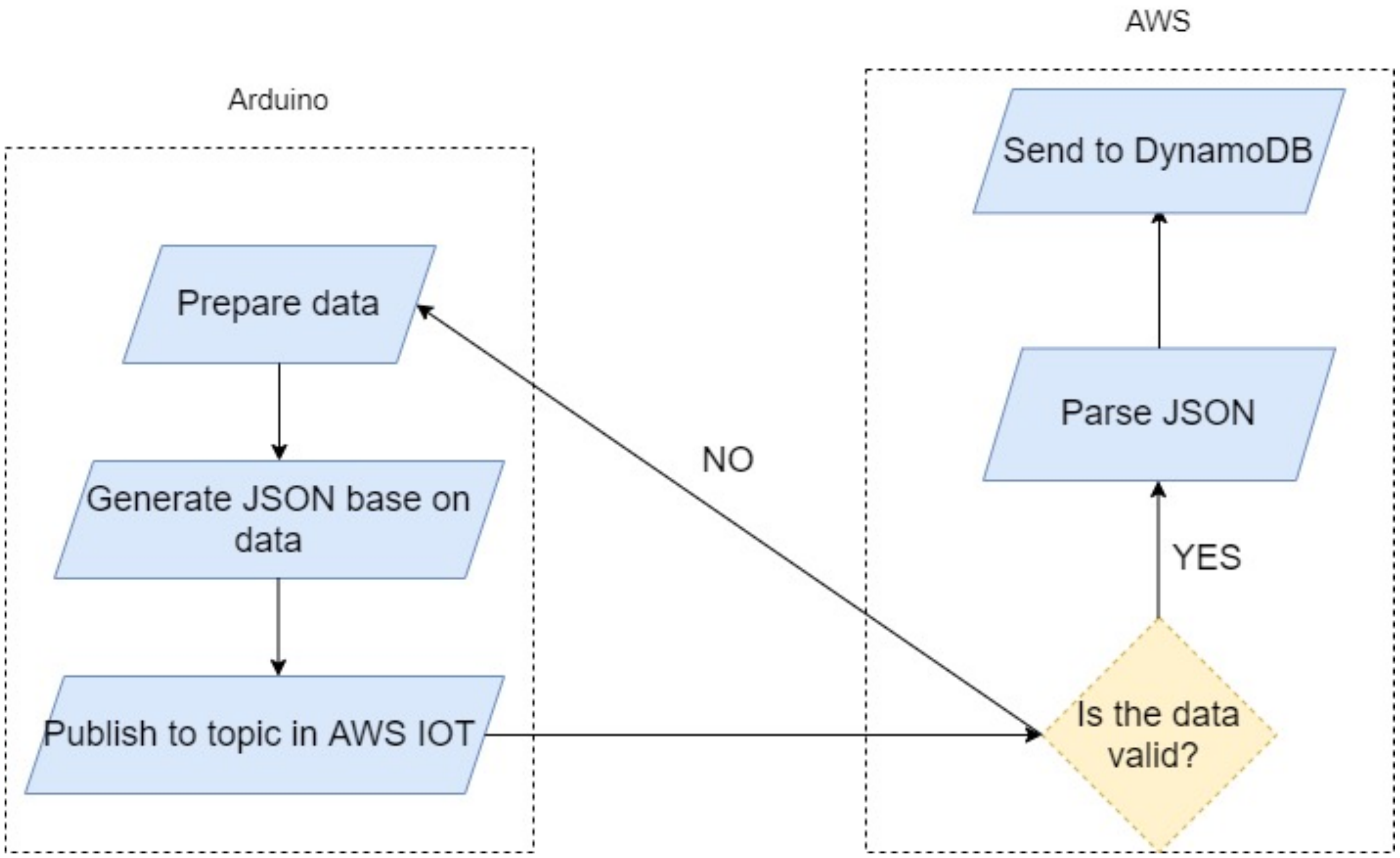
FIRMWARE TO AWS FLOWCHART



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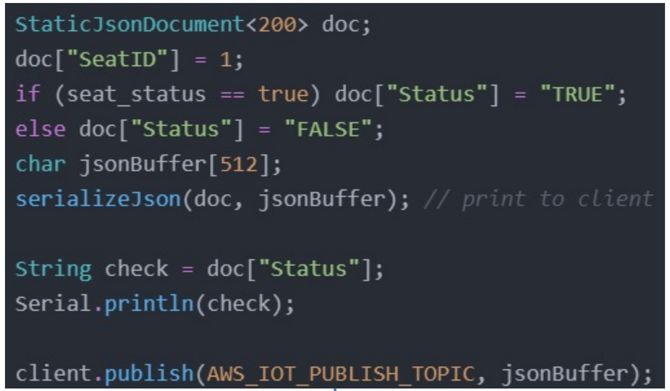
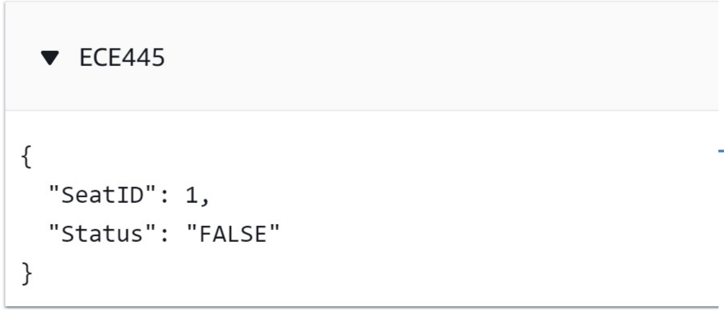
FIRMWARE TO AWS PROCESS



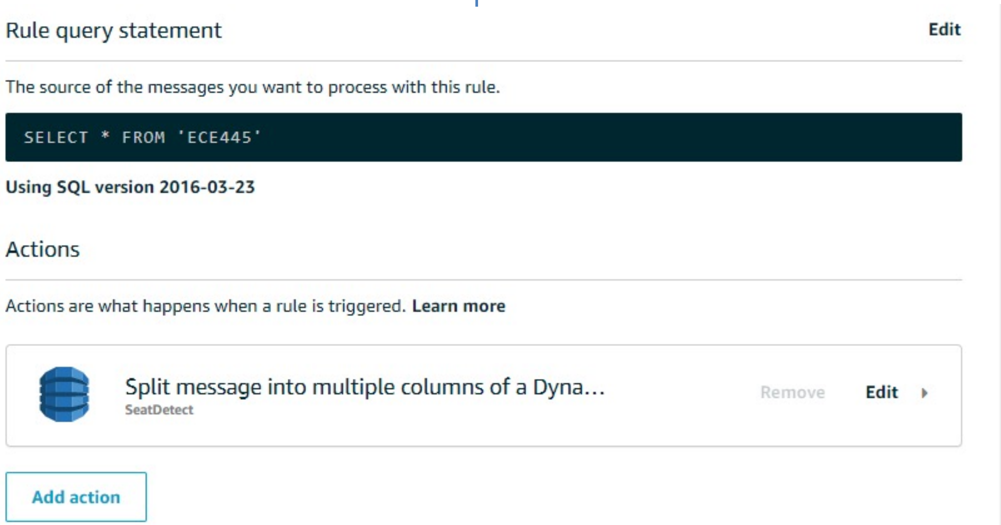
```
StaticJsonDocument<200> doc;
doc["SeatID"] = 1;
if (seat_status == true) doc["Status"] = "TRUE";
else doc["Status"] = "FALSE";
char jsonBuffer[512];
serializeJson(doc, jsonBuffer); // print to client

String check = doc["Status"];
Serial.println(check);

client.publish(AWS_IOT_PUBLISH_TOPIC, jsonBuffer);
```



```
{
  "SeatID": 1,
  "Status": "FALSE"
}
```



Rule query statement

The source of the messages you want to process with this rule.

```
SELECT * FROM 'ECE445'
```

Using SQL version 2016-03-23

Actions

Actions are what happens when a rule is triggered. **Learn more**

Split message into multiple columns of a Dyna...
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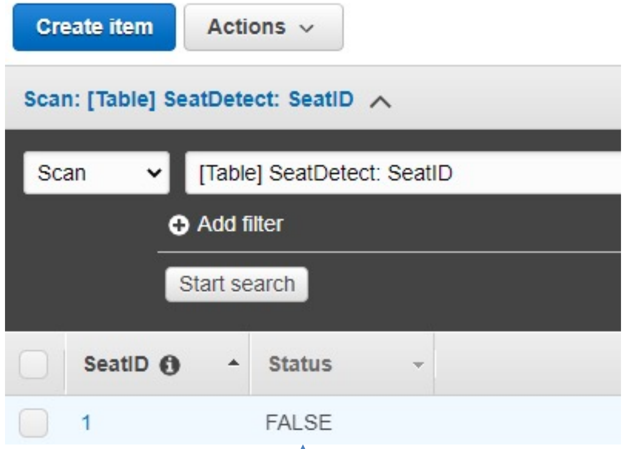

□	SeatID	Status
□	1	FALSE

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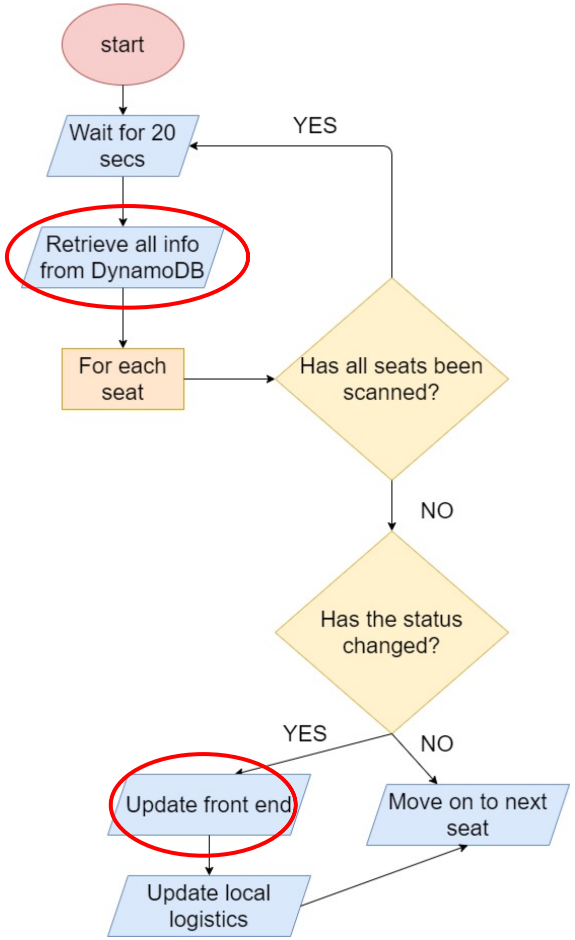
WEB APPLICATION FLOWCHART



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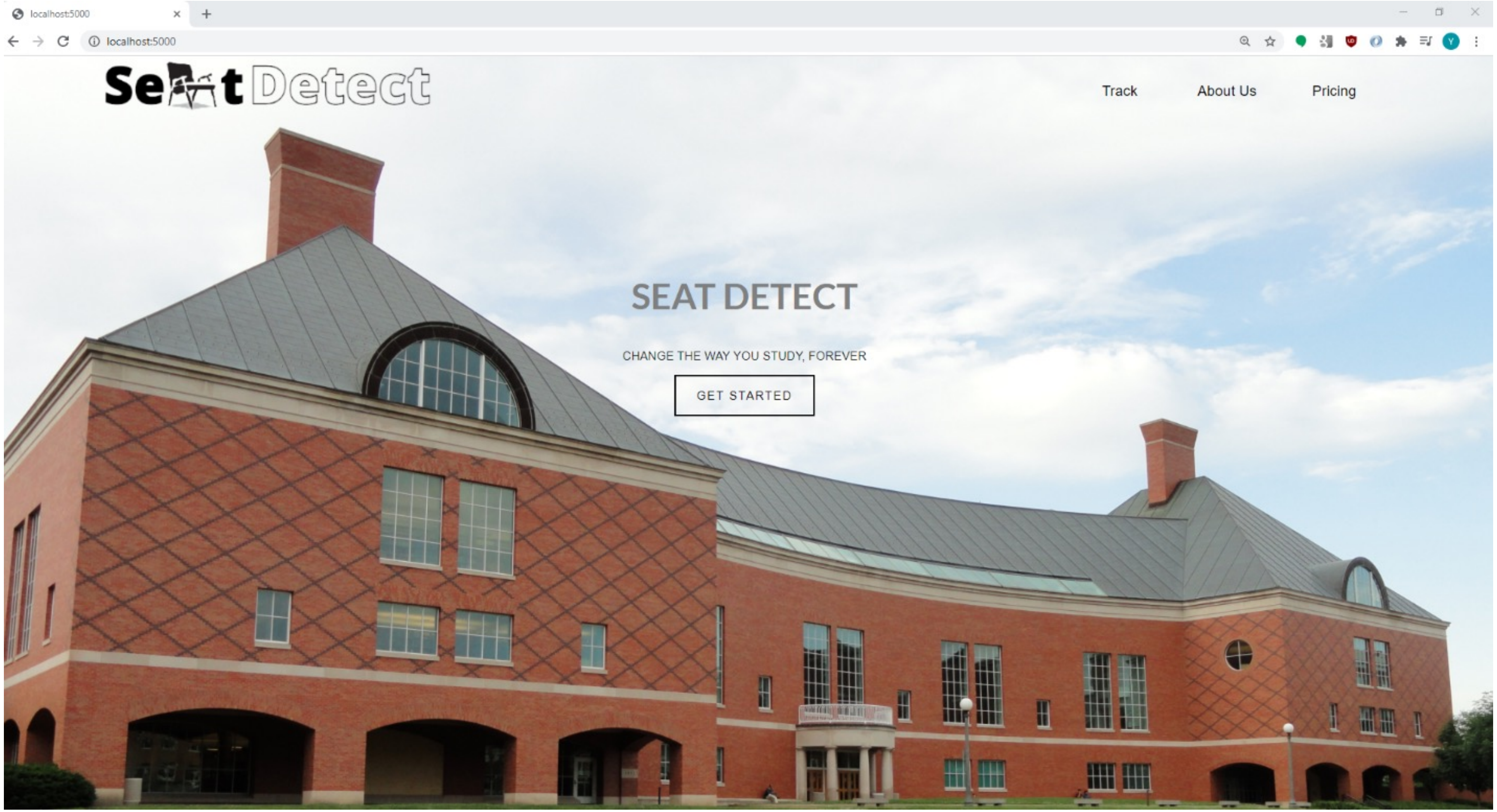
USER INTERFACE

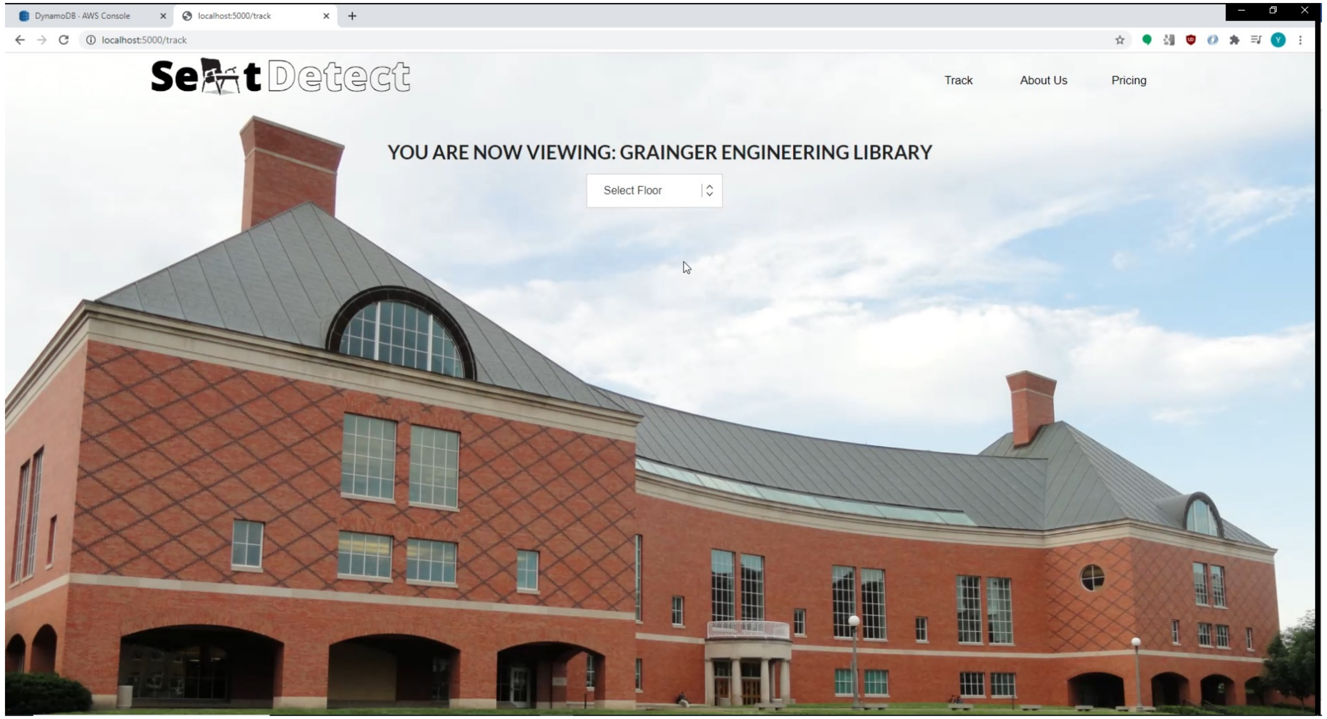


SEAT DETECT

CHANGE THE WAY YOU STUDY, FOREVER

GET STARTED

USER INTERFACE



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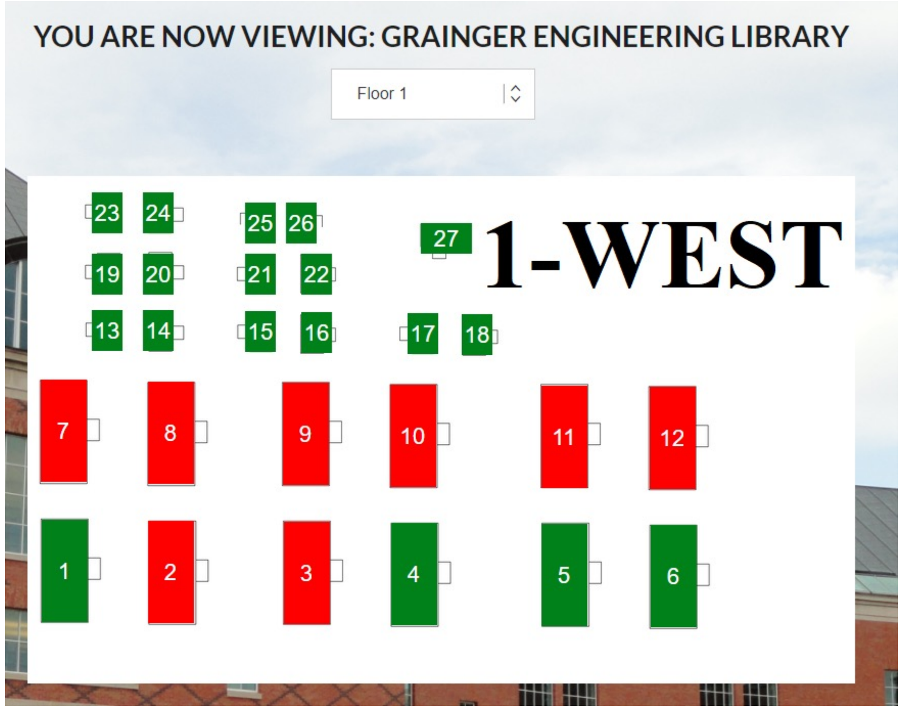

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SOFTWARE MODULE R&V

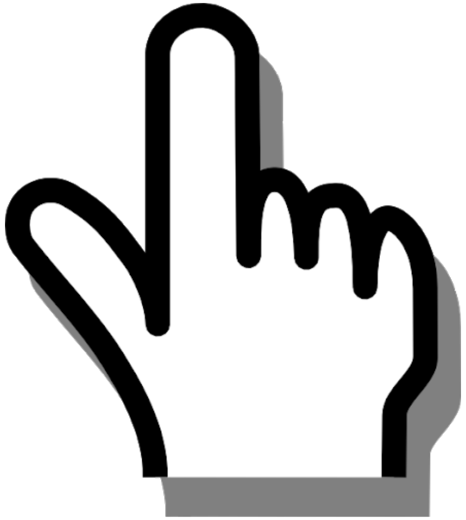
- Requirement #1: The module must reflect the status changes detected by the control module and display the change within 30 secs.
- Steps to verify #1
  1. Repeated occupy a singular seat
  2. Confirm the status has been reflected to the user

SOFTWARE MODULE R&V

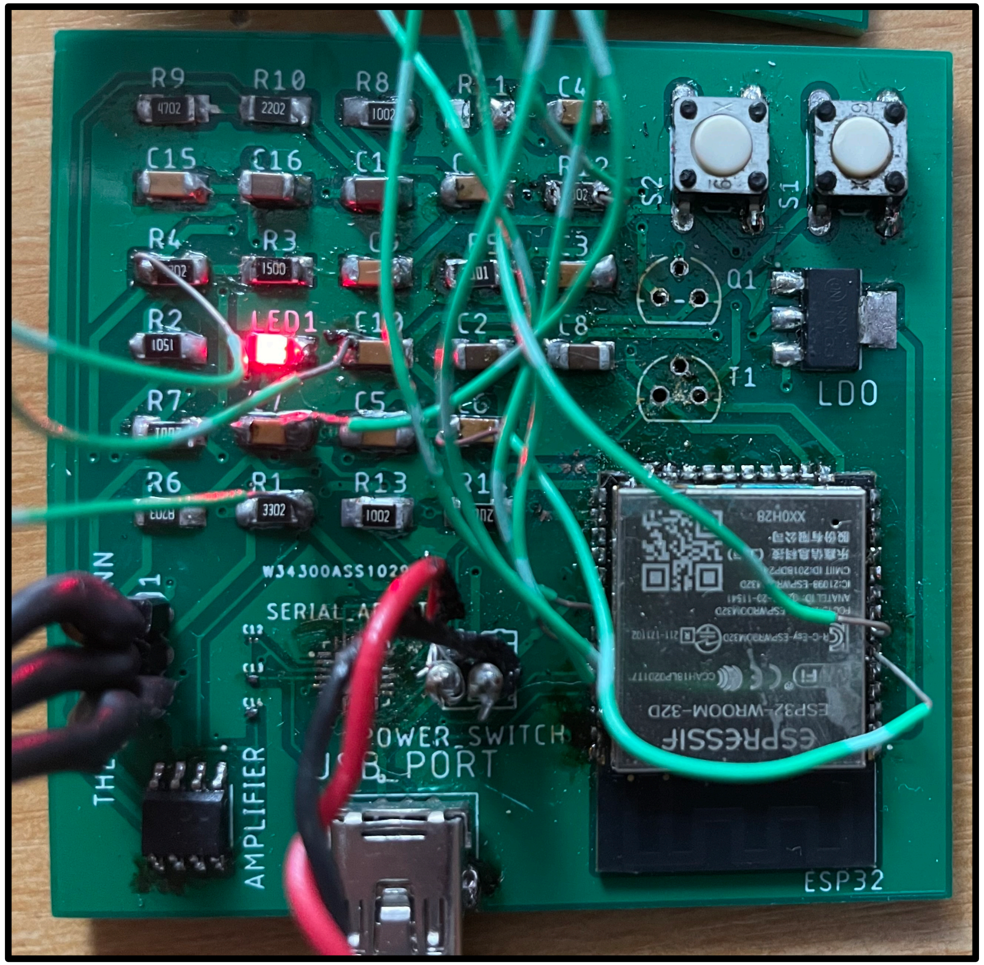
- Requirement #2: The web interface app must be able to establish a connection with the DynamoDB database.
- Steps to verify #2
  1. Manually change status values in DynamoDB
  2. Confirm the status has been reflected to the user

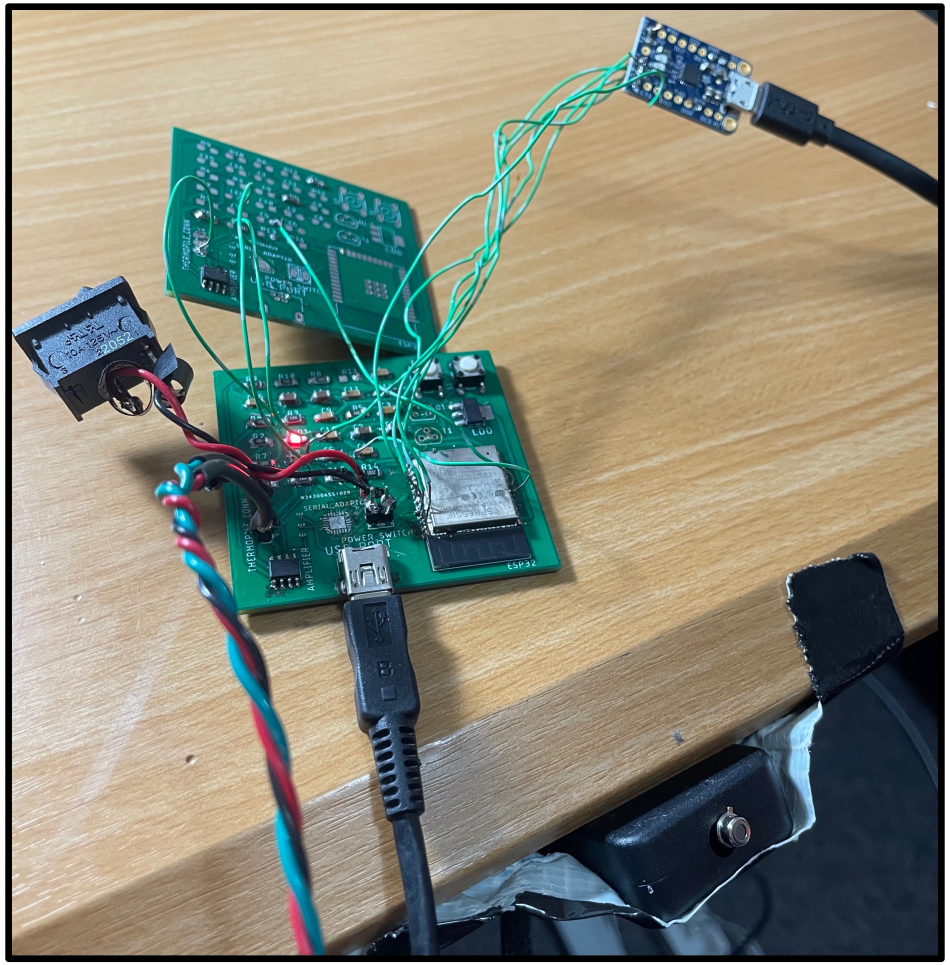
SOFTWARE MODULE R&V

- Requirement #3: The front end must contain comprehensive internal linking.
- Steps to verify #3
    1. Click through all combinations of hyperlinks



PROJECT BUILD





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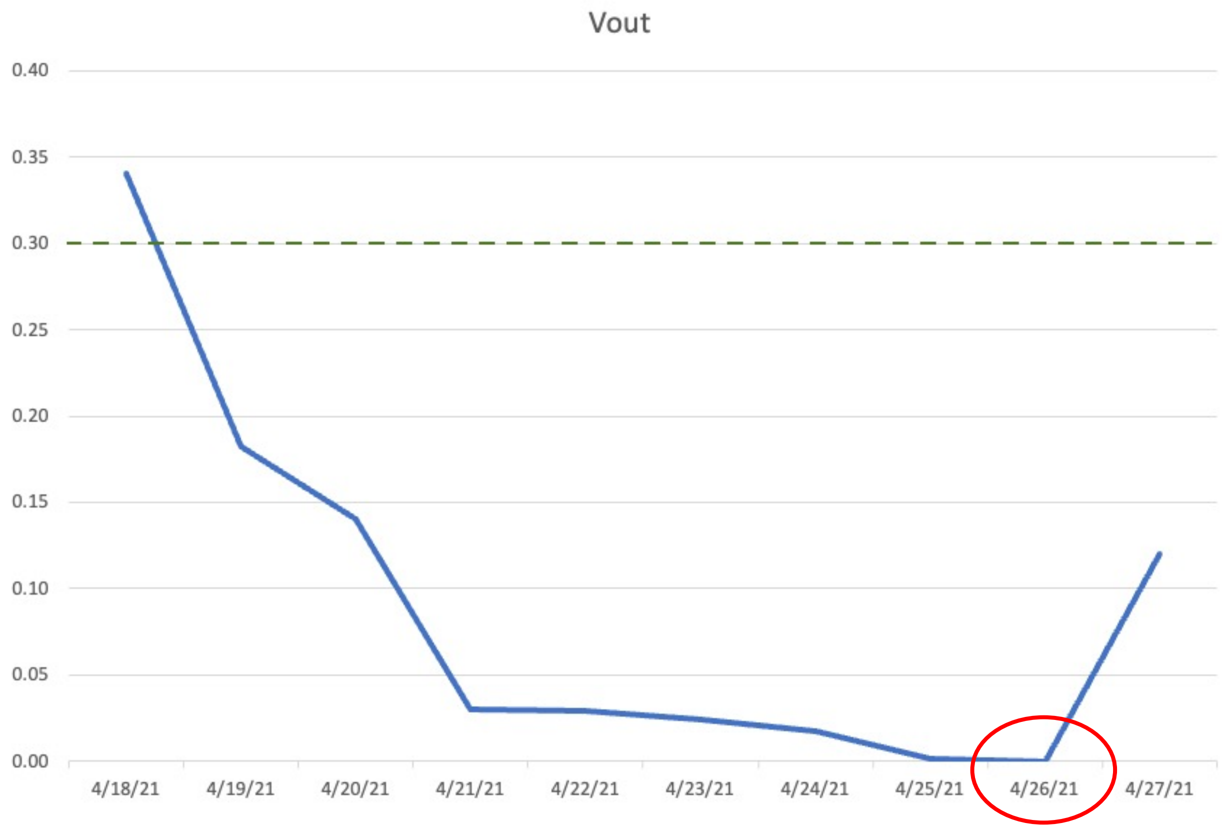
SUCCESS AND CHALLENGES

- Successes
  - Firmware
  - Software
- Challenges
  - Hardware

FAILED VERIFICATIONS

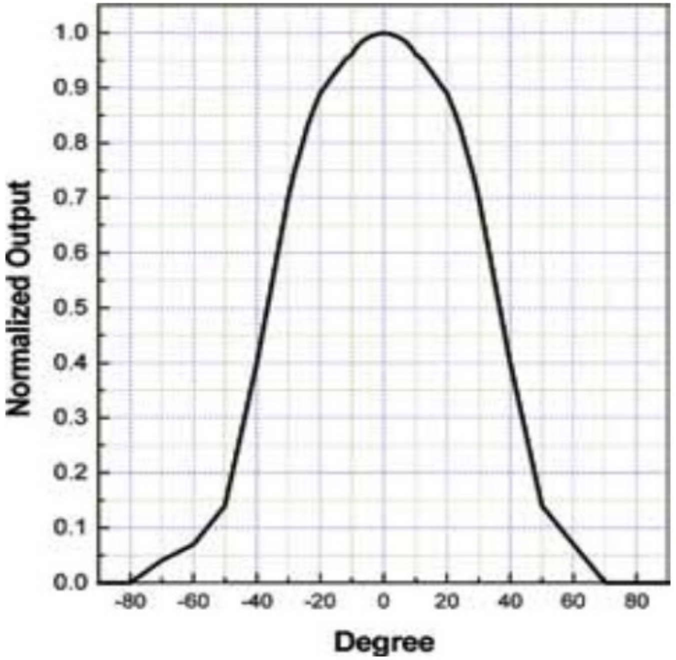
- An accuracy of occupancy status over 95%.
    - "V_{out} must be between 80 and 520 mV."
    - "V_{out} must achieve at least a 50% decrease when the human leaves the seat."

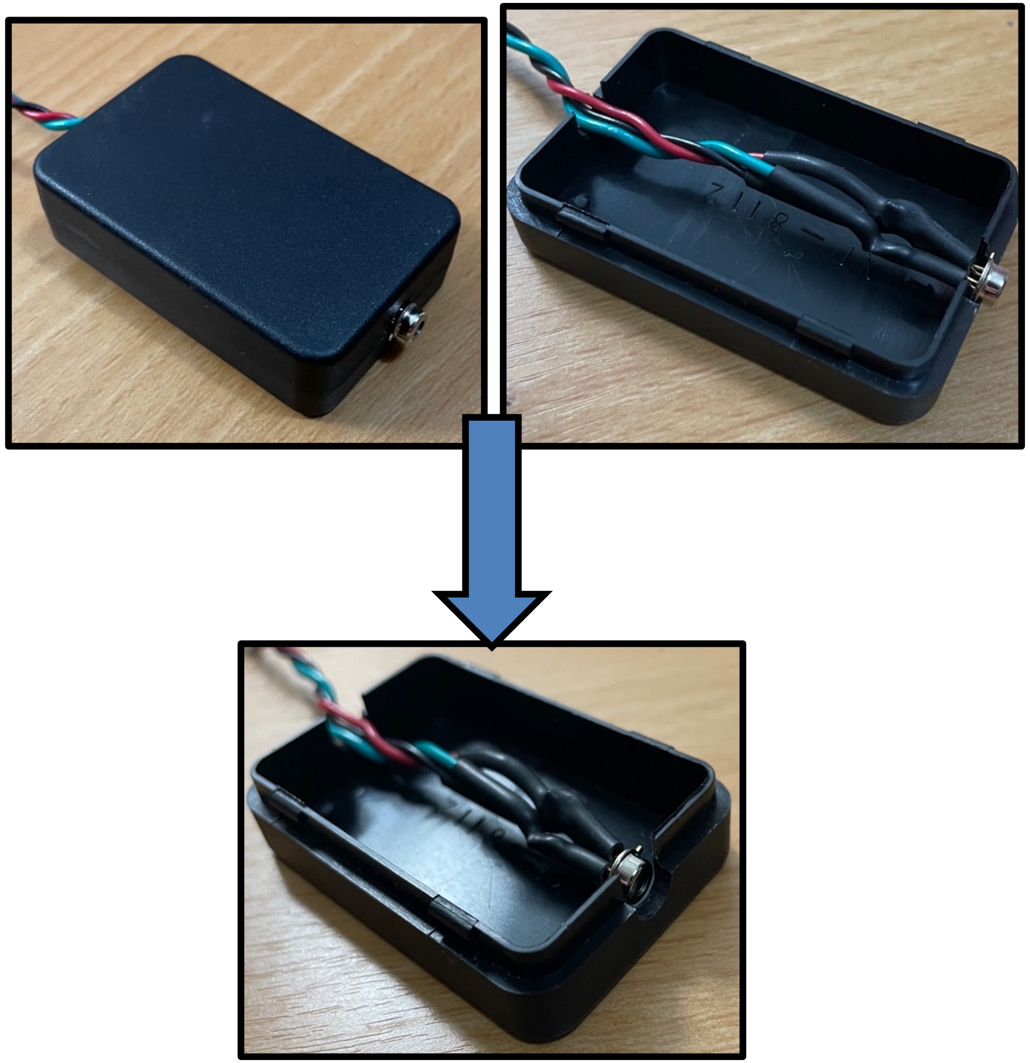


Demo Day

FAILED VERIFICATIONS

- FOV obstruction
- Contamination and damage





FUTURE WORK

- Striking a balance between cost and effectiveness of the sensor
- Website automation instead of manual refresh
- Code Modularity

QUESTIONS?