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Logbook

Type - Research

Date: 01/11/2023

Objectives: Find a project idea that is not done fairly often and make it interesting

Project ideas

I have spent like 3 hours looking at different IoT products and their implementations. Two that struck out were a bin used by waste management facilities to optimize their waste collection routes and a smart thermometer that could not only tell you the temperature but also air quality and other variables depending on the implementation. Out of these two, I have chosen to go with the waste collection as it is done less and I could adapt it slightly for my project while not having any proper full implementations of it online or at least I could find of. I want it to be more user-focused and interactive.

Type - Research

Date: 03/11/23

Objectives: Find a useful sensor to implement it with and contrast it with others that are useful

So from the lecture slides and further research, I realized the sensors covered in lectures would be very useful. The two that seemed the most useful from the lectures and online research were the IR obstacle sensor and the Ultrasonic proximity sensor. This is the thought process I had of weighing out both options and selecting which one seemed more suited for me.

Sensors

IR obstacle sensors are the first things that struck me since most projects that have similar goals to mine use them. They give out a binary output of either something being present in their range or not, the binary output makes them very easy to manage and integrate as well as cross-reference for other ways people made IoT projects with it when I made errors. They are also very cheap and available which coupled with the fact they have a very low power draw makes them very good for this project. They are very small they can help me make a smaller final product with them. Some of the things that I don't like are how environments like moisture affect their reading and they can't read very far.

Ultrasonic Sensors

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Ultrasonic sensors can give the user the power of visualization and push their awareness of the waste they are producing since they are variable and can tell you how far things are very accurately by triggering a sound and then waiting for the sound waves to bounce back which makes it very tempting for this project. Also, ultrasonic proximity sensors aren't affected by moisture and environments as much as IR which makes them ideal for the vastly varying conditions of a bin. They draw much higher power (15mA compared to 0.6mA of IR) which makes them costly to use at this point in my opinion, I need to check if there are ways to decrease it by much more. The cost is slightly higher but it is nothing too expensive with it around £5 and in bulk much cheaper. They are very thick and their output needs to be calibrated for distances of the bottom of the bin and the way the waves travel and the output needs to be handled.

For my bin, I feel like a proximity sensor is the better choice because I want it all to be about environmental consciousness, and having that visualization is very powerful.

Type - Research

Date: 06/11/23

Objectives: Research protocols for optimal selection

HTTP - Foundation blocks of the internet and is very widely implemented so can be easily picked and not regretted. Lacks security but is very easy to implement. It follows a request-response paradigm and is the basis for various web-related technologies.
The request-response paradigm is a communication model commonly used in network-based systems, where one entity, typically a client, initiates a request, and another entity, often a server, provides a response.

MQTT's keep-alive feature uses less power, beneficial for battery-operated devices which this falls into.

MQTT offers different levels of message delivery guarantees, which HTTP lacks.

HTTP is much more efficient for one-off communications which this bin does a lot of

HTTP has so many libraries for online applications it would be a good way to implement it.

WebSockets - provides a full-duplex bidirectional communication.
In a full-duplex communication system, devices can both send and receive data independently, enabling more efficient and real-time interactions. Due to that, it's very low latency and

bandwidth so it is not necessary for my project but it seems like a good candidate since we need some communication in between although we won't utilize the full duplex idea fully.

MQTT is much more suited than this although this is a good protocol in its regard bidirectional movement is not needed in our model and its low bandwidth and high connectivity would be weird to implement in a bin that I assume will have a choppy connection since it will be outside.

CoAP - Low power with very low overhead can be a useful implementation but it seems most major libraries don't support it and it is hard to implement. UDP layer implementation makes it seem interesting.

MQTT is more reliable than CoAP ensuring reliable message delivery, which is crucial for applications where message loss cannot be tolerated.

MQTT is more suited for the constant regular publishing of data to one server due to libraries and lots of IoT support.

CoAP is more useful for more restricted areas which the bin kind of falls into but it isn't very well supported and will be too much effort to implement especially when I want good visualisation for the product created so storing data and other things will be harder with CoAP making the whole code much longer to implement.

MQTT - MQTT is a solution I want to look further into and my current choice since it seems like it's very low power driven and a good way to go about it.

MQTT is designed for low-bandwidth and high-latency scenarios, making it efficient for IoT devices. However, for scenarios where continuous, real-time communication is not a primary requirement, HTTP can be more resource-efficient. HTTP's request-response model minimizes the constant overhead associated with keeping connections open.

HTTP -
- It adds a layer of security through SSL/TLS encryption, ensuring that the data exchanged between the user and the website is encrypted.
- The "S" in HTTPS stands for "Secure," and it provides a secure and private communication channel over the Internet.

TLS and SSL both use digital certificates that facilitate the handshake process and establish encrypted communications between a browser and a web server.

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Date - 11/11/23

Research -

IOT Poster feedback

He agreed that this was a good environmentally conscious idea to pursue and just tried to understand what the whole project was about. He didn't mention much to change or ideas to consider so I assumed the protocols and the sensor I am using are good for this project.

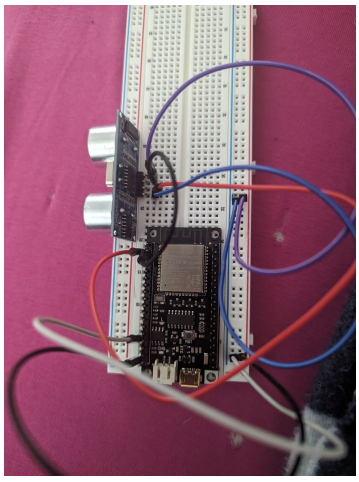
Date - 17/11/23

Practical

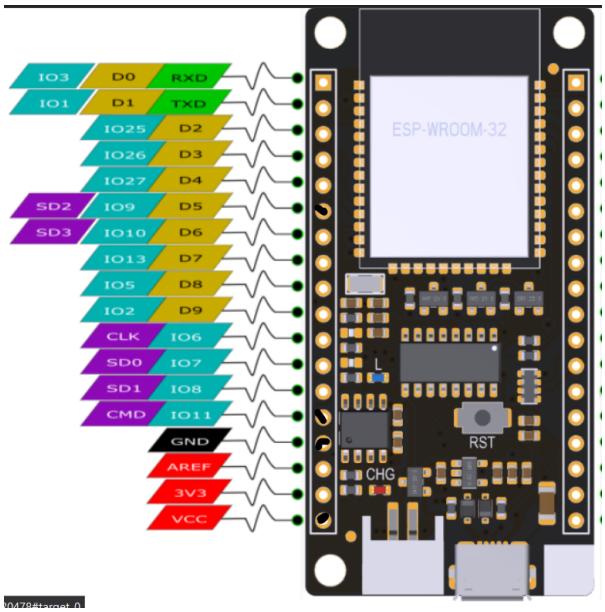
Possible Implementation

I looked at the board and found the pins and then I followed diagrams of how it should be connected which I followed and ended up with a finished prototype. The ESP32 board pins are an interesting system that I haven't experienced much before this as I never touched or built with microcontroller themes. I had to learn what each pin meant and just read through the documentation as there was no other way to learn it.
The black dots are where I will connect it and test in Figure 1(below right)

I then connected all the pins to the board it kept getting loose and not giving good results so I used some connector that placed the esp32 on the breadboard and all the pins were fully pushed through as seen in Figure 2 (below left).



In terms of taking readings with an ultra-sonic sensor I need to find values for good calibration and to do that, I placed it 5cm away from an object and calculated its value and then I moved the object further away and calculated the signal sent back and I kept doing it till I got 10



points. With those 10 points, you can make a calibrated sensor but for my project, I want it more generalized because it can vary from sensor to sensor. I am just calculating the distance based on generic sound wave speed which can be seen in the code attached to this project.
The main struggle I had was creating a URL for it as there is a httpBuilder module that I could use to make the website out and I have to add each line as seen in Figure 3. Building websites is something I am fairly confident about due to past experiences and last year's choice to do web development. This seems fine to me currently as it is a functioning website although might be hard to get further functionality working. Figure 4 is how it looks currently

Figure 3

```
html += "</style>";
html += "<script src='https://maps.googleapis.com/maps/api/js?key=AIzaSyB-X9_6gRA6fsxQn69aZ5BkQFbTg5vW3x4'></script>";
html += "<script>";
html += "function initMap() {";
html += "var map = new google.maps.Map(document.getElementById('map'), {";
html += "center: {lat: " + String(fakeLatitude) + ", lng: " + String(fakeLongitude) + "},";
html += "zoom: 15";
html += "});";
html += "var marker = new google.maps.Marker({";
html += "position: {lat: " + String(fakeLatitude) + ", lng: " + String(fakeLongitude) + "},";
html += "map: map,";
html += "title: 'Smart Bin Location'";
html += "});";
html += "}";
html += "</script></head><body>";
```

Figure 4

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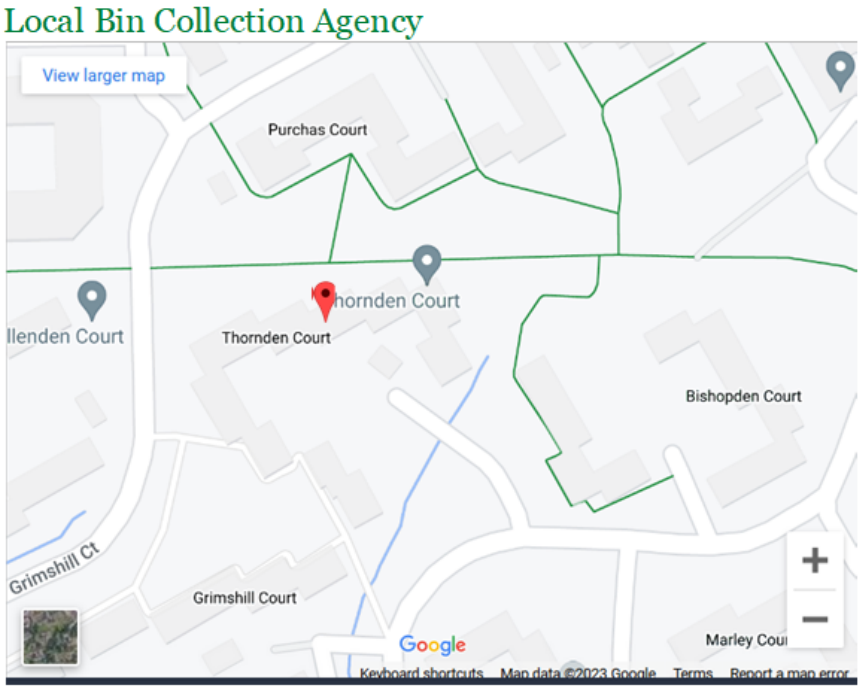

Errors while implementing -
For some reason, my connections kept getting lose and I needed to hammer in the pins onto the breadboard

In terms of code, I only had one error where I mapped the pins the wrong way around in the code as implementing the code was just putting code into a http packet for mqtt.

Limitations - Dynamically generating messages and sending them over to the server is not a good way to deal with it.

As I kept looking more into dynamically generated websites it seemed like I was creating websites too often and it could lead to mqtt constantly sending out the message which is easily subject to attacks and miscommunication. The performance of this is fairly quick although battery life can suffer from having it always active as it will constantly drain a specific amount of battery since I will have to keep it awake with variables in the RTC.

Date Another implementation

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My friend recommended I look into Firebase for my interactions with the website and when I looked into it I realized it is just perfect for storing information as well as creating an IoT demo product or an actual product to sell to consumers.

I created a Firebase account with Firebase tokens and other things linked to my account so I can start using them in my code when I download the package.

Turns out Firebase is not the only implementation and I found out about Kuzzle as well as just using a bunch of tools together self-hosted like MongoDB for databases, CoAP for data flow control (and others described later in the presentations).

Firebase is the one that's most suited for me as it has all the implementations in place for an easier way to build it.

After downloading Firebase I adjusted the position of the map as well as the title and tried dynamically generating a marker.
Dynamically generating the marker was a very painful and challenging endeavor which in the end broke after adjusting the code for reasons to do with positioning the map marker to the map. Figure 5 shows it working

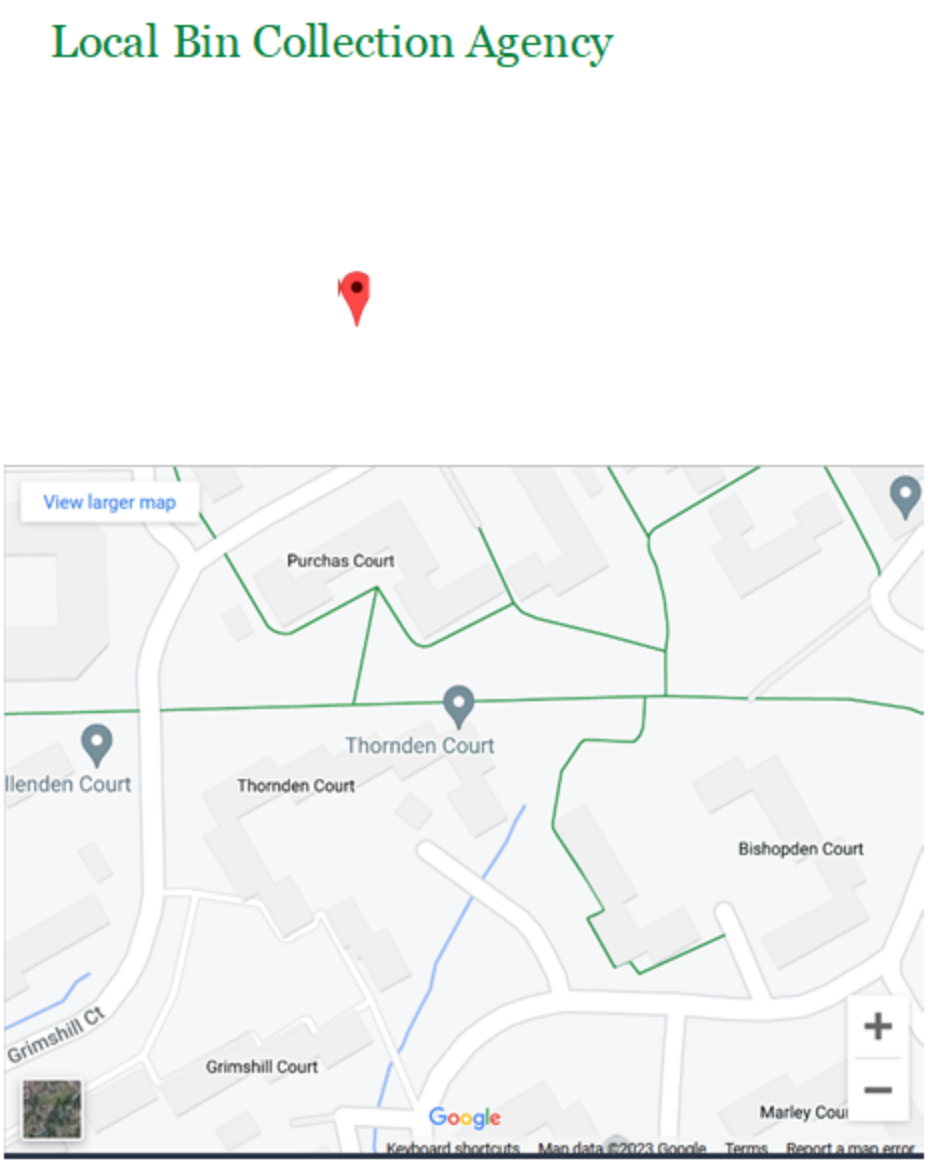

Figure 5

This was the case due to me trying to implement my pin through CSS and pictures of pins which is not an ideal way to do it as it doesn't stick to the page which was my oversight. It was fixed by consulting the Google Maps API which has documentation on this and how to implement one on an object. As you can see from Figures 6 and 7 it works.

Figures 6 and 7.

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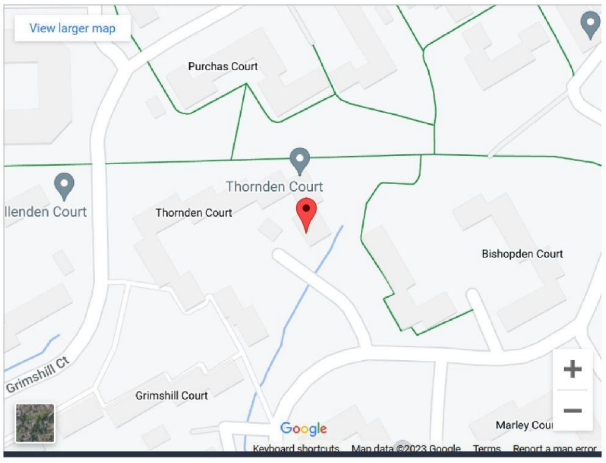
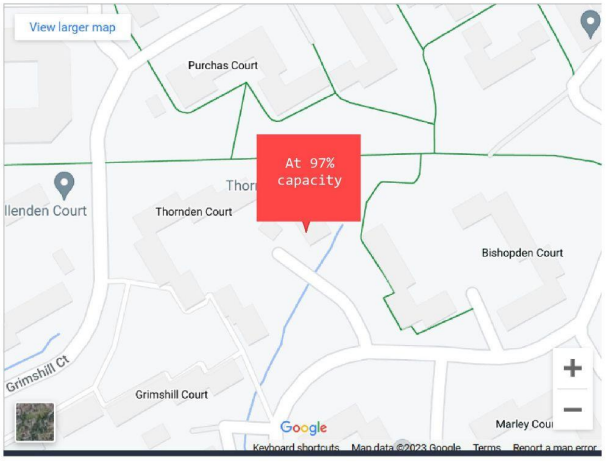
Local Bin Collection Agency



Local Bin Collection Agency



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IOT video:01/12/23

This is my first implementation of the product with a Firebase back-end shown in the video.

I was ill for a while and I couldn't attend the IOT video session so I didn't get feedback although the video I generated was something I was happy about I could have talked about my IOT technologies more and how the code works.

Date 02/12/23
Actual tests - Bin wifi range, Bin erroneous results, bin empty

Objectives**:** Conduct tests to assess the bin's Wi-Fi range, accuracy in detecting erroneous results, and responsiveness when empty.

Bin Wi-Fi Range Test:

> Set up the bin at various distances from the Wi-Fi router to evaluate the effective range of connectivity.
>
> Noted signal strength and consistency at different distances.

Bin Erroneous Results Test:

> Simulated different scenarios to test the sensor's accuracy, such as partially obstructed bin opening and varying object sizes.
>
> Adjusted sensor settings to minimize false readings.

Bin Empty Test:

> Conducted tests to ensure the sensor accurately detects when the bin is empty.
>
> Calibrated the sensor to differentiate between an empty bin and a low-fill condition.

Outcomes:

> Determined the optimal placement range for reliable Wi-Fi connectivity.
>
> Enhanced sensor accuracy in distinguishing between genuine waste levels and erroneous readings.
>
> Confirmed reliable detection of empty bin conditions, ensuring accurate data for waste management analysis.

These tests are crucial for refining the bin's functionality and reliability in real-world scenarios.

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The results were as expected and when i did get errors like erroneous results test i just realized i need to change the way i handle the variables like making sure multiple readings are being taken

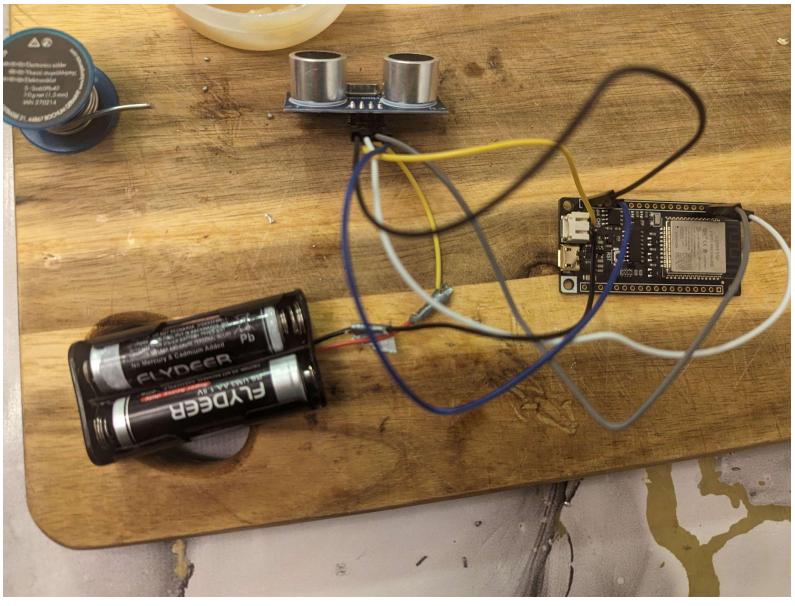
Date - 07/12/23

Date Soldering it in.

I wanted to have a slightly final product-looking feel for it so I soldered it all in so I could start creating the outer box for it.

Soldering it in was challenging as the ESP board and components were much smaller than expected but after there was an error with chopping too much wiring of the battery off leading me to soldier in other wires to extend it so I could work with it.
I have done soldering before so it wasn't too challenging outside of the very small form factor which was uncomfortable to someone with really big hands like me. As you can see in Figure 8 it went really well at the end

I also put it all in a box which shall be shown and discussed later as the box had perfect dimensions of around 8cm by 5cm by 3cm which made it fit snugly with all the components which can be seen on Figure 10.
Figure 8



Date UI implementation- I wanted to add buttons that do nothing to just talk about future features if I had time for them in the design jury.

I made it slightly more organized and I have plans to extend this later as well. As well as made a bar graph of the last 7 days using chart.js in Ajax library in javascript that accesses the database of Firebase which is another thing that was very easy to set up.

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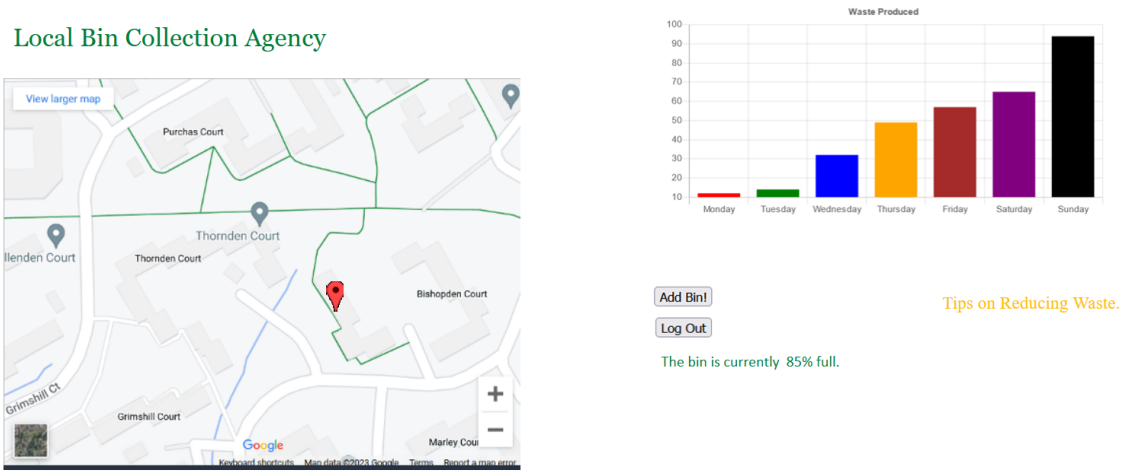

Figure 9

Date 12/12/23
Battery life

I decided to ponder on ways to implement a sleep cycle for my product as during the lecture I was thinking if I could implement this since this would be a massive battery life boost as I don't need this device constantly awake

After a few hours doing another project, I opened up the project and implemented a solution as the feedback loop that I had was relatively straightforward since my project should just sleep and keep sleeping until it reaches an hour.

The process involved is pretty self-explanatory and the state of deep sleep is the one I used as well as just normal awake for like a few seconds as deep sleep cuts down the functionality to a timer which is the only function needed before it wakes up to take the readings. I had no errors when implementing this.

Date 13/12/23
IoT presentation

In terms of the presentation, I feel like it went well reinforcing my idea of having a map implemented although they also found a flaw in my thinking and I needed to revisit the project where the user has the hand over the bin when it is open and is taking readings it will take in the values at the anomalous rate.

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Date 15/12/23
Final tests

The tests one of the supervisors who looked at the project and made comments on were implemented and anomalous results aren't included I made a method that takes all the hourly readings with the time attached and when it records the plot for the graph it tries to make it from the least anomalous data where drift in between is nothing major compared to the next two points.

This was a fairly simple fix where I added them all into an array and looked for anomalous results.

I didn’t have time to implement a picture of a bin with how full it is due to time constraints. I would have used progress bars through CSS and JS where the CSS directs how full the bar is.

Reflections

- **Approach:** I tackled this project with an open mind, focusing on learning what IOT has to offer and user experience.

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- **Ease:** The research phase was straightforward, as I quickly identified unique IoT products for inspiration.
- **Difficulty:** Calibrating the Ultrasonic sensor although not using the calibrated format and managing the software integration with Firebase were the most challenging aspects.
- **Changes if Redone:** I would allocate my time to adding a more modular approach so the code isn't tailor-made for me and the user can log on to Firebase.
- **Learnings:** I gained insights into IoT device integration, sensor calibration, and the importance of thorough testing.
- **Feedback Request:** I'd appreciate feedback on how I could have approached this project differently or made it more unique.
- **Personal Feelings:** I felt challenged yet excited throughout the project, especially when I saw the final product come together.