

Project Proposal

Food Deterioration Reminder: An IoT-based system that aids in keep tracking food products.

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Abstract

Food waste is a global problem with significant environmental, economic, and social costs. It is estimated that one-third of all food produced for human consumption is lost or wasted yearly. This waste has a number of negative consequences, including increased greenhouse gas emissions, reduced water availability, increased food insecurity, and economic losses. The growing issue poses significant challenges to global food security and environmental sustainability.

This project outlines the development of an Internet of Things (IoT)-based solution to reduce food waste. The proposed solution called Do It Yourself, Food Deterioration Reminder (DIY FDR), use sensors to track the food cooking cycle and send alerts to users when food it's getting overcooked. The DIY FDR detect and alert users about potentially deteriorating food, encouraging and implementing no wastage through overcook.

The project draws inspiration from successful real-world innovations like Wasteless, Mimica Touch, and Ovie Smarterware, and addresses their limitations by offering a versatile solution applicable at both retail and consumer levels.

DIY FDR employs Arduino Nano and ESP8266 Wi-Fi modules for communication and notifications, a DHT11 sensor for monitoring temperature and humidity, Soil Moisture Level for determining level of water in the pot, Buzzer sound to notify, distance sensor to determine when someone is close, water pump used to remediate the action when no one is close and the food is still being cooked and a servo showing the status of water pump.

The system's strength lies in its offline functionality, sound, email and sms notification with it's cost-effectiveness. This report outlines the system's objectives, methodology, and functionalities, contributing to reducing food waste and promoting sustainable food management practices.

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Introduction

Background of the Study and Problem Statement

Food waste impacts the environment, economy, and society. It is a major issue that needs to be addressed. Food production is a major cause of climate change and environmental devastation, so it's a top sustainability issue[1].

FAO estimates 1.3 billion tons of food is lost or wasted annually, one-third of all food produced[5]. FAO replaced the broad estimate with Food Loss Index and Food Waste Index in October 2019 report[4]. The report defines food loss and waste as the decrease in food quantity or quality. Food losses occur along the supply chain from harvest to retail, but not at retail while Food waste occurs at retail and consumption levels. This definition aligns with SDG Target 12.3.

Target 12.3: Halve global per capita food waste [\[edit\]](#)

The full title of Target 12.3 is: "By 2030, halve per capita global food waste at the **retail and consumer levels** and reduce food losses along production and supply chains, including post-harvest losses."^[1]

This target has two components (losses and waste) measured by two indicators.^[1]

Figure 1. SDG Target 12.3

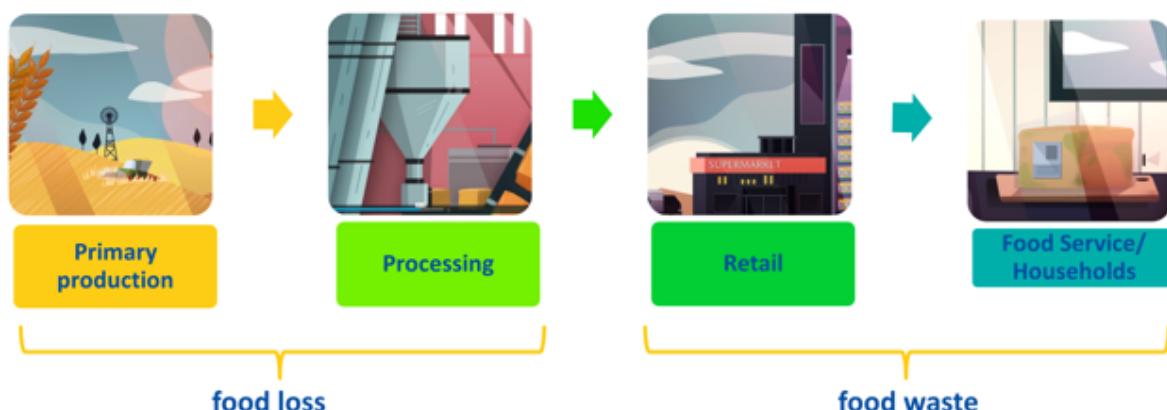


Figure 2: Food loss and waste

Figure 2. Loss Analysis

Scope and Justification

The Food use hierarchy with seven tiers is grouped into three treatment categories:

- The green tiers represent food not being wasted as waste is either prevented or reused.
- Yellow/orange tiers: Recycle or recover energy from food waste.
- Tip of the pyramid: Disposal.

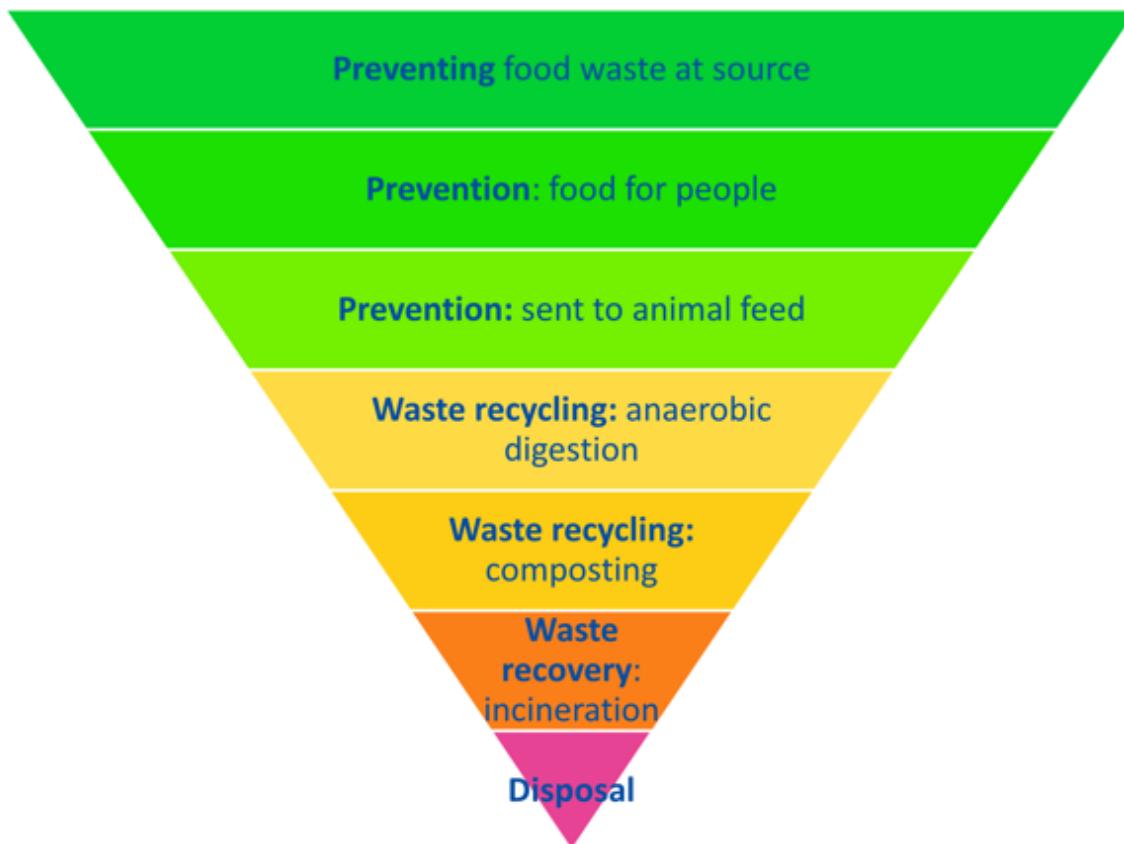


Figure 3. Food Use Hierarchy (adapted from WRAP UK)

The first priority which is the prevention of waste serves as the justification for this project proposal and it is scoped to prevention at the household/consumer and retail level since 70% [8] of food waste occurs at this level.

Aim and Objectives

The aim of this study is to develop an IOT-based project that detect and alert its users about potentially deteriorating (overcook) food in order to prevent food wastage.

The specific objectives are to:

1. Detecting when the food is being overcook

2. Notifying it's user about the potentially deteriorating food through overcook
3. Remedy action to prevent the overcook when no one is close by pumping water back into the pot when the water level is low
4. Sending notification to household member not at home through email and SMS as a call to action

Methodology

The literature review start by exploring real-world innovations that are already solving the problem and then adopt a qualitative research design, focusing on a systematic review of existing literature on how the solution works by conducting an extensive search of key resources such as scholarly articles and reports, academic journals, conference papers, reports, reputable online sources by using different academic databases, including IEEE Xplore, ScienceDirect, Google Scholar etc. Relevant keywords and search terms such as "food industry IOT," "Food waste solution" etc. will be used. Boolean operators (AND, OR) will be applied to refine search results.

Current solutions, general and IoT-based will be analyzed to show their differences, strengths, weaknesses, and constraints. The methodology will focus on studies published in the last 10 years for novelty, prioritizing European countries.

The review is carried out with the belief that IoT will half food wastage for locations where it hasn't been utilised and as a hypothesis/assumption there is sufficient literature available to provide insights into the applications and benefits of IoT in food process optimization and wastage reduction.

Literature review

Wasteless

Wasteless, a start-up founded in 2016 in Israel, developed dynamic pricing software to help retailers adjust prices according to the remaining shelf life[2]. AI-powered solution automatically sets optimal prices for fresh food, based on shelf life and volume.[7]. Food prices drop as the expiry dates approach. Electronic shelf labels show the original price, expiry date, and new price.[10]. Wasteless helps supermarkets reduce food waste at source, maximizing economic, social, and environmental benefits.[6]

In 2018, a UC study found that Wasteless reduced food waste by 32.7% and increased profit by 6.3% in five years.[13] 2/3 of consumers chose discounted food, but it's unclear if this reduced waste. Intermarché will introduce Wasteless in 2020 to reduce food waste.[11]



Figure 4. Dynamic shelf labels for products with varying 'use by' dates

Customers shopping by April 12th will buy the \$1.80 Chobani yoghurt because of the low price which avoids disposal by retailers.

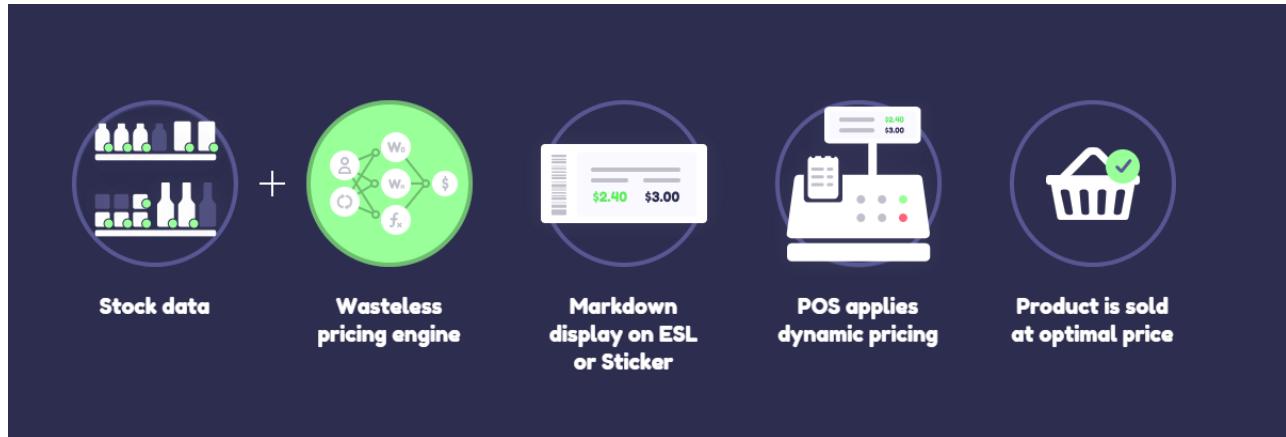


Figure 5. How Wasteless works

Wasteless collects data (stock) that includes the expiry date and uses RFID to uniquely identify the product[2], the engine uses AI to compute price and Electronic Shelf Labels (ESL) for the display of real-time product prices, which can be updated dynamically through wireless communication. POS integration was used to adjust prices in real time. The system thrives at an increasing profit for retailers since wastage is reduced and an incentive for customers to purchase below the standard price. Nevertheless, the implementation cost for small-size retailers is expensive.

Mimica Touch

Wasteless only aims to get the food product to consumers before the expiry date but it's reported that up to 83% of food waste in Europe is still fresh and edible, while the printed expiry dates say otherwise [14]. Expiration dates are not standardised, so good food is wasted most of the time.

Mimica, a UK-based start-up helps decide when food is fresh and when to throw it out.



Figure 6 Mimica Bottles.

The main material used in Mimica's technology is a vegan gel which is produced and set as a solid layer that conceals a sheet layer of plastic bumps beneath it.

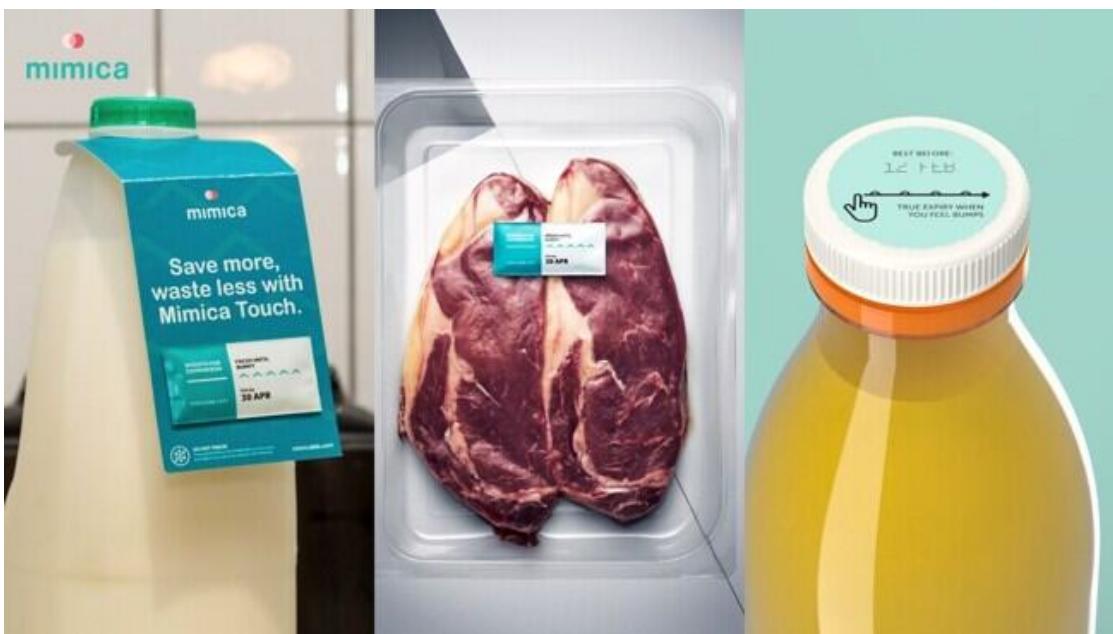


Figure 7. Mimica Labels

Consumers run their fingers over the surface. When it feels smooth, it means that the food is still fresh regardless of the expiry date, and when it feels bumpy the food is no longer good for consumption.[9]

The product provides an accurate, real-time indication of the product's freshness and is the logical next step from the current printed date system. However, Mimica Touch will turn bumpy much quicker if the food is kept incorrectly because it responds to the same temperature conditions as the food and consumer acceptance is a challenge as it's difficult to convince buyers that a product is safe for consumption after the expiration date.

Ovie Smarterware

Wasteless and Mimica Touch have proven to be a great solution only at the retail level and do not consider the wastage that may result when the food is at the consumer level which accounts for a large proportion of food waste [4]. The food stored in fridges can be easily forgotten, contributing to unnecessary waste.

Ovie Smarterware introduced a smart food storage system that helps track consumer fridges and reduce food waste by using smart tags attached to food containers[3]. It also makes use of cloud computing paradigms by offering some extensive features via the mobile application and integration with smart homes (Alexa).



Figure 8. Smartwares

Part of the tools used is the LED light.

- Green, food is fresh
- Yellow means to eat food before it goes bad
- Red light implies food is past its date. [3]

With this product, consumers will be able to prioritise taking food products that could get wasted easily. Drawbacks include data privacy concerns, smart tags incurred costs and potential customer perception, with cloud computing, machine learning, and human-computer interaction paradigms used.

Summary

Wasteless, Mimica Touch and Ovie Smarter ware are great solutions that aim at minimising food wastage by ensuring consumption/sale before deterioration. Wasteless and Mimica touch targeting retail and supermarket suffers from reduced cost for retailers and consumer acceptability respectively. Ovie smarter home is challenged by the data privacy of users and the cost of getting smart tags for each product.

DIY FDR alleviates the major challenges through its versatility: usage at retail and consumer level, offline data storage with the esp web server and a sound notification instead of LED light for rapt attention to the product that needs to be used or purchased before it deteriorates.

Project Implementation

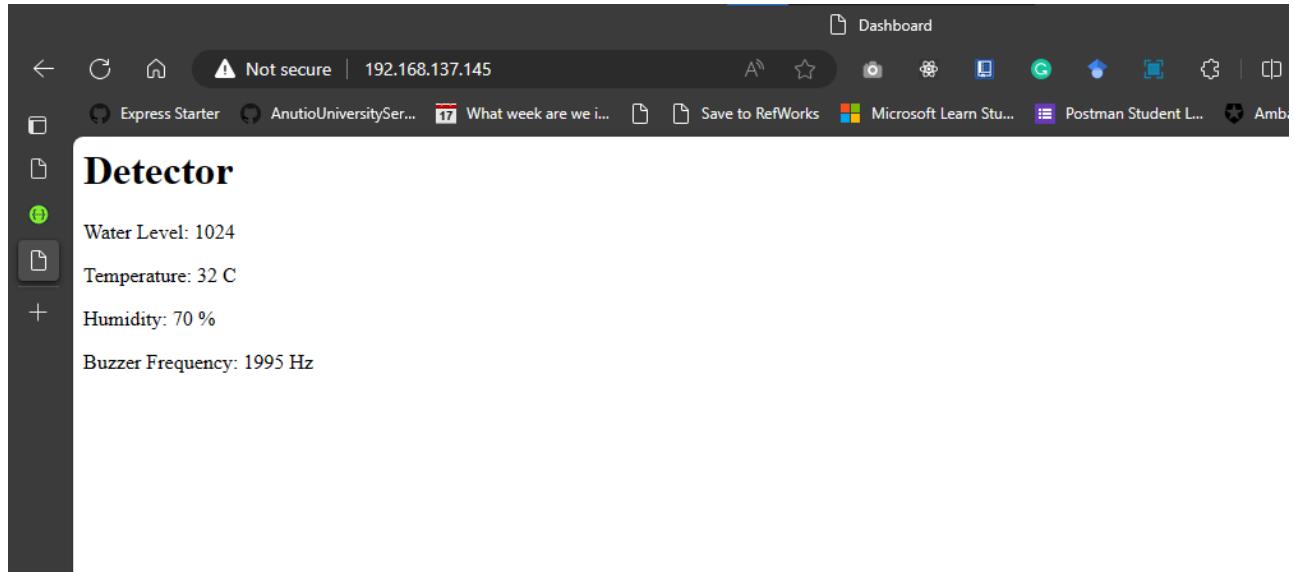
Project Overview

Do It Yourself, Food Deterioration Reminder (DIY FDR) is an IoT-based project that helps reduce food waste caused by overcooking. As a smart system, it detects when the water level in a pot is low and notifies the user at home or abroad through a variety of notification methods, including sound, email, and SMS.

The system consists of two nodes: the Detector and the Remedy. The Detector, as its name suggests, detects overcooked food and sends a signal to the Remedy node. The Remedy node attempts to remediate overcooking when it notices that no one is nearby to take action, such as checking the food's texture or turning off the power source.

The Detector node has a water level sensor, temperature and humidity sensor, buzzer, switch, and LED light. These are used as follows:

- The water level sensor detects when the water level in the pot is low and sends a signal to the Remedy node to determine its action if no one is nearby.
- The Temperature and Humidity Sensor is used to determine the status of the pot, i.e., whether it is cooking or not. This is because when a remedy action, such as pumping water back into the pot, is taken, the temperature at that time is reduced and the cooking status can be shown as mild cooking.
- The buzzer is responsible for emitting an amusing sound to notify a call for action. It works through communication from the Remedy node. When the distance sensor from the Remedy node notices that no one is nearby, it sends a signal to the Detector node, so that the buzzer can emit its amusing sound. The sound stops when someone is nearby.
- The switch and LED light are used to turn the system on and off. The functionality of the system begins with the detector node. When the system is powered on by the switch, the LED light turns on, indicating that the kit is powered. The brightness of the LED light changes depending on the water level status.



The remedy node houses the water pump, distance sensor and servo and it functions as follows:

- The water pump is responsible for remediating the overcook by pumping water back into the pot when a signal is received from the detector node.
- The distance sensor senses if someone is close to the node in order to determine whether or not to make an amusing sound from the buzzer. This implies that the remedy node also sends a communication to the detector node.
- The servo is basically meant for displaying whether the water pump is on or not (This is communication within the node)

Technologies Used

The project makes use of painless mesh for node-to-node communication i.e. Detector and Remedy and it serves web requests via the ESP web server. It was set up to connect using the PC mobile hotspot credentials

Mobile hotspot

Share my Internet connection with other devices



Share my Internet connection from

Wi-Fi



Network name: Oluseed

Network password: mic12345

Network band: Any available

Edit

Devices connected: 2 of 8

Device name	IP address	Physical address (MAC)
ESP-486247	192.168.137.220	c4:5b:be:48:62:47
ESP-151264	192.168.137.43	44:17:93:15:12:64

The response in JSON as shown below

The screenshot shows a web browser window with the address bar displaying 'Not secure | 192.168.137.145/json'. The page content is a JSON object with the following structure:

```
1 {  
2   "Content-Type": "application/json",  
3   "Status": 200,  
4   "WaterLevelSensor": {  
5     "sensorName": "Water Level",  
6     "sensorValue": 402  
7   },  
8   "TempHum": {  
9     "sensorName": "Temperature and Humidity Sensor",  
10    "temperature": 31,  
11    "humidity": 72  
12  },  
13  "BuzzerSensor": {  
14    "sensorName": "Buzzer",  
15    "frequency": 219  
16  }  
17 }
```

It was discovered that the painless mesh overrides the WIFI client because it creates its own hub of connection namely home IoT. As a result, the WIFI code was commented out.

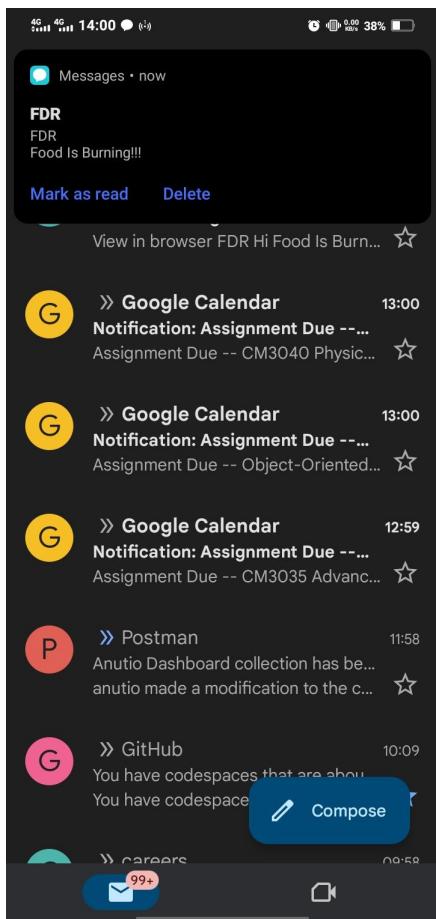
```
--> startHere: New Connection, nodeId = 3192414791  
Adjusted time 4673510. Offset = -97931004  
Adjusted time 4884096. Offset = -107  
startHere: Received from 3192414791 msg=Hello from node (Detector) 3192414791  
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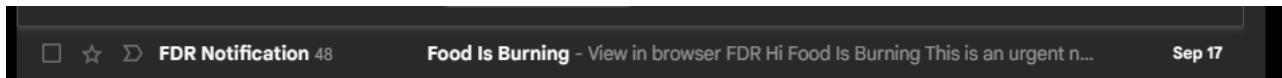
---- Opened the serial port COM3 ----
--> startHere: New Connection, nodeId = 2467631716
Changed connections
startHere: Received from 2467631716 msg=Hello from node (Remedy) 2467631716
startHere: Received from 2467631716 msg=Hello from node (Remedy) 2467631716
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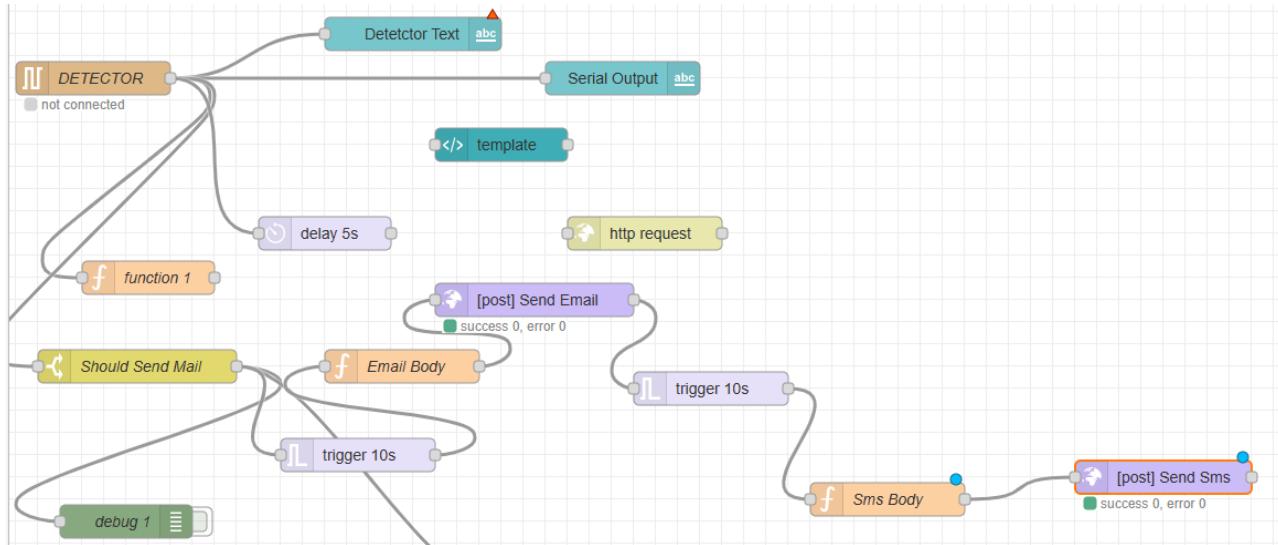
The system automatically sends out an email and SMS making use of an external API written in nodejs and deployed to heroku.



When the video was recorded and tested, it sent 48 emails notifying that the food was burning



Node-red was used for making this request. The figure below shows the flow used



The JSON file is provided in the zip file

Arduino Library Used

- Painless Mesh
- PageBuilder
- PageStream
- DHT
- ArduinoJson
- Servo

Running the Project

Upload the code provided through the Arduino IDE, only one node needs to be connected to a port as required for the painless mesh connection.

Critical Evaluation

The original idea for the project was to develop a system that could track food through its expiry date. However, as the development progressed, it became clear that this would be better suited for a project with a different scope, such as mobile application development, rather than IoT. This is because the system would require maintaining a database of user functionality, such as registration and sign-up.

While keeping the original aim in mind, it was discovered that a lot of food is wasted domestically due to overcooking. This served as the rationale behind the project's development. As the project demonstrated the function of IoT, it was extended to real-world use through the automatic notification of email and SMS.

The initial project is likely to be developed in the final project after acquiring the knowledge required in mobile development. This will then be a solution utilizing mobile apps and IoT.

Conclusion

The FDR project is a solution that notifies and remediates the problem of overcooking, with this it still depends on the cook performing some action such as turning off the power supply to the pot, a solution that will automatically perform this could be put in place by using IOT kit that triggers the switch for the power supply.



Figure 10. Development Tools



Figure 11: A Node.

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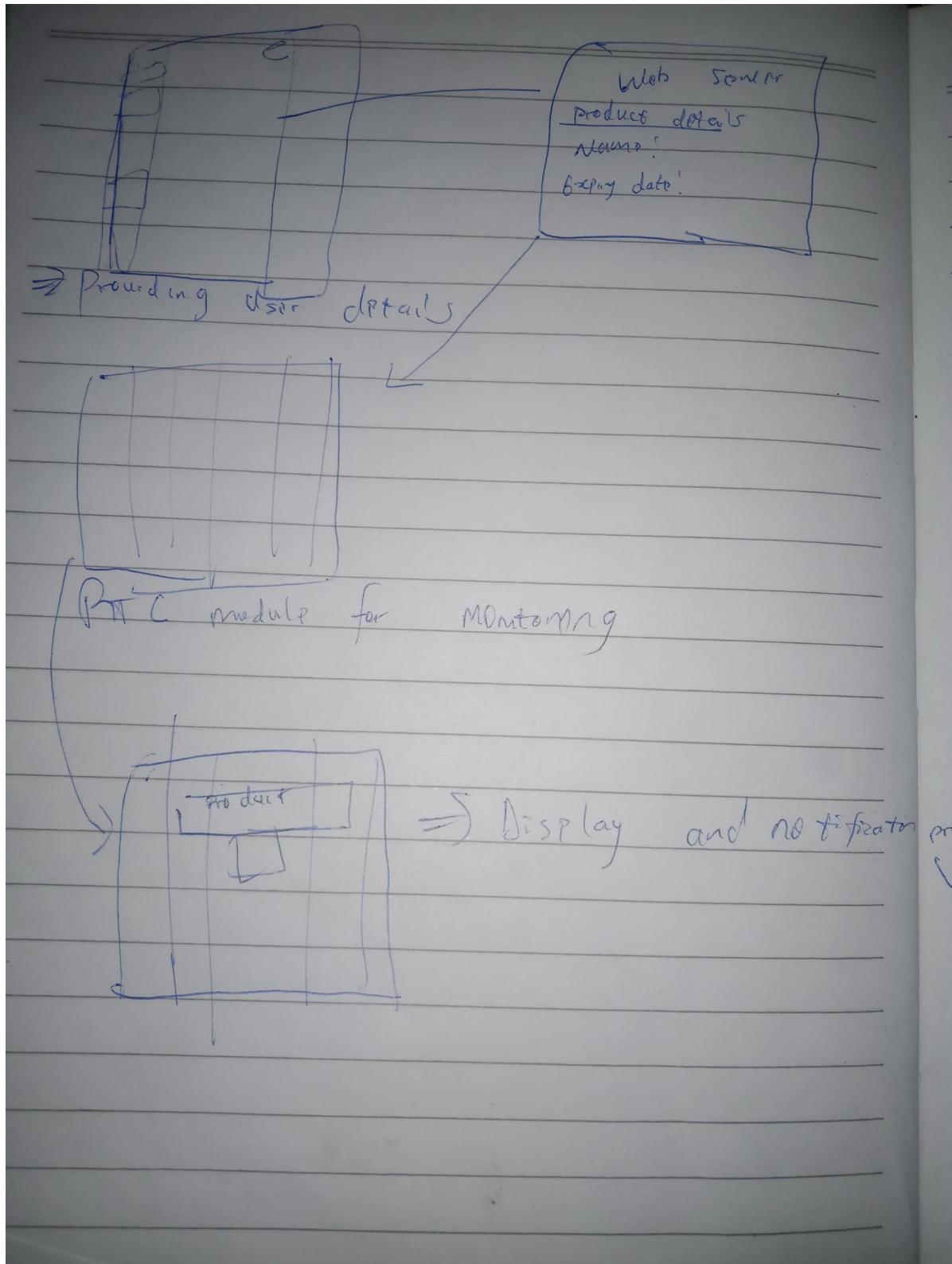
Resources

 About Wasteless - <https://www.wasteless.com/>

[Accurate food freshness indication with Mimica - YouTube - Mimica \(mimicalab.com\)](#) - This case study video describes the problem of overcautious printed expiry dates resulting in perfectly fresh food and beverage products being thrown away when they are safe to consume, and how Mimica's innovative solution can have a direct impact on unnecessary food waste.

<https://wrap.org.uk/>

Appendices



This shows the data flow between the IOT nodes and the principle highlighted on how the system functionalities proceeds.

Component List

1. Water Level Sensor
2. Switch
3. LED light
4. DHT11 Temperature and Humidity sensor
5. Servo
6. Ultrasound distance sensor
7. Water pump
8. Digital Relay
9. Buzzer
10. 2 ESP8266 Micro Controller
11. 2 linked Bread Boards
12. Jumper Wires
13. A power source (for water pump)
14. 2 USB cables

Abbreviations

- RFID: Radio Frequency Identification: is a technology that uses radio waves to automatically identify and track objects or people with RFID tags or labels
- AI: Artificial Intelligence
- POS: Point of Sale
- LED: Light Emitting Diode
- DIY FDR: Do It Yourself, Food Deterioration Reminder

Pdf screenshot of the code are included in the zip file

