# COMP5047 Assignment (Phase 1)

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## 1 PROJECT THEME AND SCOPE

The selected Sustainable Development Goal is Goal 12: *Ensure sustainable consumption and production patterns.*

### 1.1 Problem Space

On average, each person wastes approximately 120 kilograms of food, per year [2]. Wider society is significantly lagging in its efforts to halve per-capita food waste and loss by 2030. High-income countries, such as Australia, further exacerbate the issue. In fact, the material footprint per capita of high-income countries is 10 times that of low-income countries [2].

Waste has become second-nature in contemporary societies. Consider the simple daily ritual of brewing coffee—you grind the coffee beans, make your coffee, and then discard the grounds. Now, you might be asking yourself *what can I do with used coffee grounds?* They can serve as organic fertilizers, natural pest repellents, and even as an ingredient in homemade beauty products.

In a broader context, pervasive computing would be particularly relevant to this problem space. The unique embedded nature of pervasive computing solutions would allow for seamless integration into the household. Imagine a voice-enabled kitchen counter that provides information preparation, shelf-life, and storage information about produce. Or, a fridge that takes snapshots of food items and provides recipe ideas. Or, a rubbish bin that weighs its contents and suggests ways to minimise loss.

### 1.2 Existing Solution Review

#### 1.2.1 *Existing Solution 1:* Smart Meter

Ahammed et al. [1] demonstrate the potential of IoT-based smart meters in balancing energy supply and demand in select Bangladeshi households. While the real-world application is laudable, the research would benefit from broader testing across a variety of different households to attest to universal applicability. The reliance on internet access—which may be inconsistent—poses potential implementation challenges. The study also doesn't discuss the data security and consumer privacy implications associated with a web-based solution.

#### 1.2.2 *Existing Solution 2:* Home Garden System

In this work, Sharma et al. [4] introduce a novel IoT-based home gardening solution—leveraging a vehicular ad hoc network (VANET) and cloud technology. However, the heavy reliance on a VANET scheme might hinder wider appeal. In addition, there's a lack of focus on potential challenges—data security in cloud-based systems or system robustness against diverse environmental factors. Furthermore, whether the system can generalise to various garden types remains undiscussed, raising questions about broader application.

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#### 1.2.3 *Existing Solution 3:* Water Heater

Amasyali et al. [1] provide valuable insights into the applicability of reinforcement learning (RL) to electric water heaters—complete with a real world deployment. However, the focus on only time-of-use pricing policies limits a broader understanding of potential benefits across varied pricing schemes. The absence of comparison with non-RL-based real-world strategies also leaves a gap in evaluating the comprehensive effectiveness of the RL-based approach.

#### 1.2.4 *Existing Solution 4:* Composter

The Breville FoodCycler [1] promotes sustainable waste management at the household level. By transforming food scraps into compostable EcoChips, it significantly reduces food waste volume, potentially diverting it from landfills. However, its effectiveness is contingent on consumer usage frequency and proper maintenance. Additionally, the 300 AUD initial cost might be prohibitive for some, raising questions about widespread accessibility and adoption. Long-term durability and energy consumption should also be considered.

#### 1.2.5 *Existing Solution 5:* Thermostat

Ecobee's Smart Thermostat Enhanced [2] optimises energy consumption in households. By adjusting temperatures based on routines and occupancy, it offers potential annual savings, promoting both sustainable consumption and financial benefits. The investment of 400 AUD may, however, deter some consumers. Additionally, actual savings may vary based on individual household behaviors and external factors. Broader adoption would also depend on compatibility with varied heating and cooling systems.

#### 1.2.6 *Existing Solution 6:* Power Adapter

WiZ's Smart Plug [3] enables users to optimize their electricity consumption through remote and voice-controlled management of appliances. By facilitating energy use based on necessity, it could promote sustainable consumption patterns. However, while voice compatibility broadens user accessibility, the product's efficacy relies on user diligence in energy management. Additionally, its sustainability impact is contingent upon the production processes and materials used to manufacture these plugs. A comprehensive life-cycle analysis would provide a clearer sustainability picture.

### 1.3 Novel Solution Proposal

#### 1.3.1 *Novel Solution 1:* Smart Kitchen Counter

Fig 1 depicts 10 sketches of various smart kitchen counters and Fig 2 depicts 10 sketches of a refined solution. The refined solution is a voice-enabled smart assistant which empowers you in the kitchen. The sketches in Fig 2 illustrate the features of the solution, it can:

(1) Answer questions about the shelf life of produce
(2) Remind you to turn off the stove if its been left on
(3) Recall when you purchased produce, and the use-by date
(4) Suggest recipes based on the contents of the pantry
(5) Remind you to take dishes off the stove when they are cooked
(6) Answer questions about how much of a particular grocery item you consumed
(7) Convert units of measurement

[1] https://www.breville.com/au/en/products/food-disposal/bwr550.html
[2] https://www.amazon.com.au/ecobee-Smart-Thermostat-Enhanced-Compatible/dp/B09XXTQPXC/ref=sr_1_3?crid=2NU9OMTOMIJN0&keywords=ecobee&qid=1694176777&s=home-improvement&sprefix=ecobee%2Chome-improvement%2C226&sr=1-3
[3] https://www.officeworks.com.au/shop/officeworks/p/wiz-smart-plug-australia-new-zealand-white-wizplug

(8) Suggest pairings for food items
(9) Suggest alternative ingredients when the pantry doesn't have the preferred ones
(10) Add items to the grocery list


Fig. 1. Crude Smart Kitchen Counter Ideas

*1.3.2 Novel Solution 2:* Enhanced Smart Fridge Fig 3 depicts 10 sketches of various enhanced smart fridges and Fig 4 depicts 10 sketches of a refined solution. The refined solution is a voice-enabled smart assistant which allows you to take control over the food in your fridge. The sketches in Fig 4 illustrate the features of the solution, it can:

(1) Inform you about the shelf-life of produce
(2) Remind you to close the door if it's ajar
(3) Tell you when produce is about to go bad, and suggest a dish to prepare
(4) Suggest recipes based on its contents
(5) Suggest that you move items to the pantry to lengthen shelf-life
(6) Suggest that you purchase less of a particular item that you didn't use

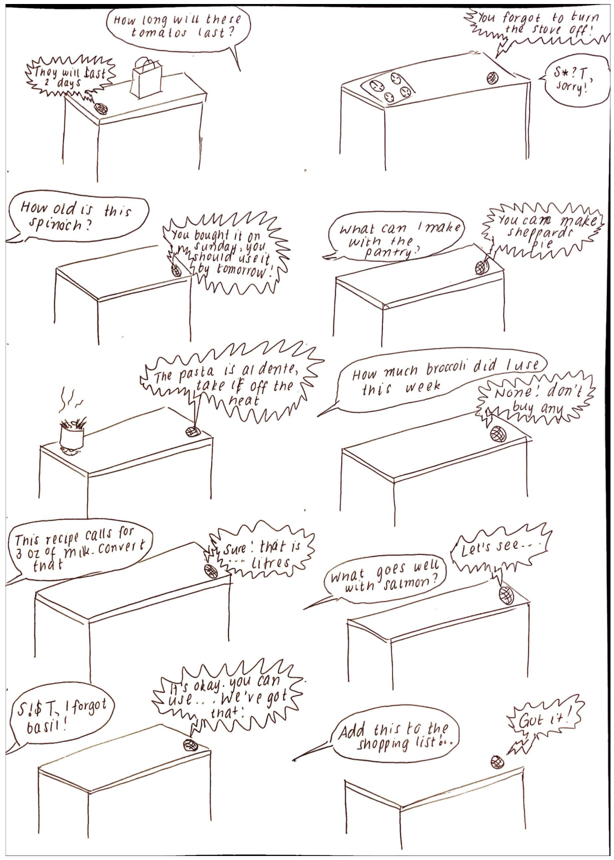


Fig. 2. Refined Smart Kitchen Counter Idea

(7) Convert units of measurement
(8) Answer questions about what food and drink is inside
(9) Suggest alternative ingredients when you forget to purchase the preferred one
(10) Answer questions about what you put on the shopping list

*1.3.3 Novel Solution 3:* Smart Rubbish Bin Fig 3 depicts 10 sketches of various smart rubbish bins and Fig 4 depicts 10 sketches of a refined solution. The refined solution is a Wi-Fi-enabled rubbish bin equipped with a scale that allows you to take charge over the waste and loss in your house. The sketches in Fig 4 illustrate the features of the solution, it can:

(1) Weigh its contents
(2) Use WiFi to share insights
(3) Display the current weight of its contents
(4) Use Bluetooth to share insights
(5) Provide insights about food waste for the past week
(6) Operate using a rechargeable battery
(7) Suggest ways to minimise waste

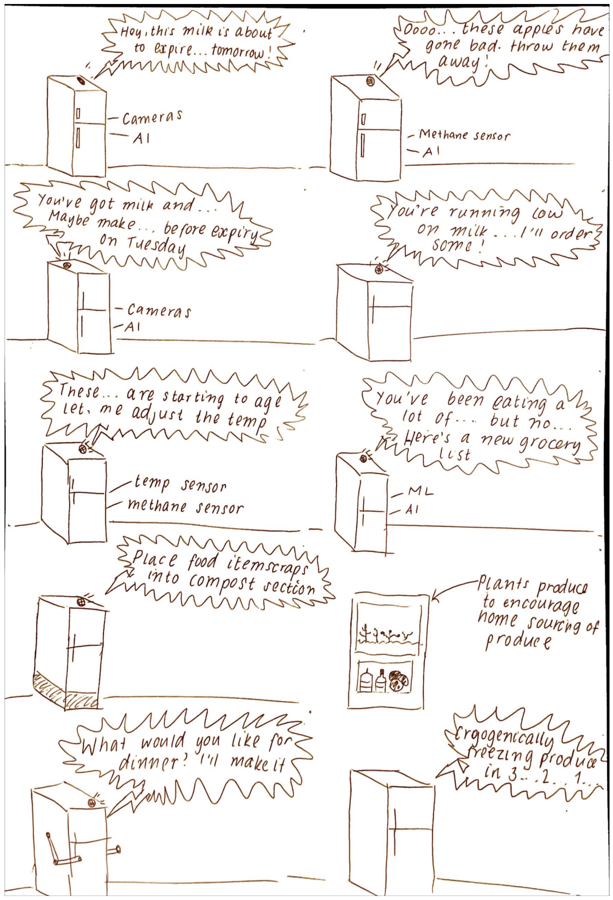


Fig. 3. Crude Enhanced Smart Fridge Idea

(8) Notify you when the battery is running low
(9) Notify you when the bin is full
(10) Provide trend insights

### 1.4 Novel Solution Selection

*1.4.1 Justification:* Smart Rubbish Bin

By comparing the feasibility and practicality of the three ideas, we decided on the smart rubbish bin. As discussed, waste is a huge problem in countries around the world currently, and recyclable is a mainstream trend. Among the above three ideas, smart rubbish bin can help people recycle waste. In addition, since smart fridge and smart kitchen counter are embedded in refrigerators and stoves, it is unrealistic for people who have already installed these devices to replace them. But smart rubbish bin can be accepted by most people.

*1.4.2 Relation to Characteristics of Pervasive Computing:* Embedded

The device is placed inside of a rubbish bin, blending into the natural environment

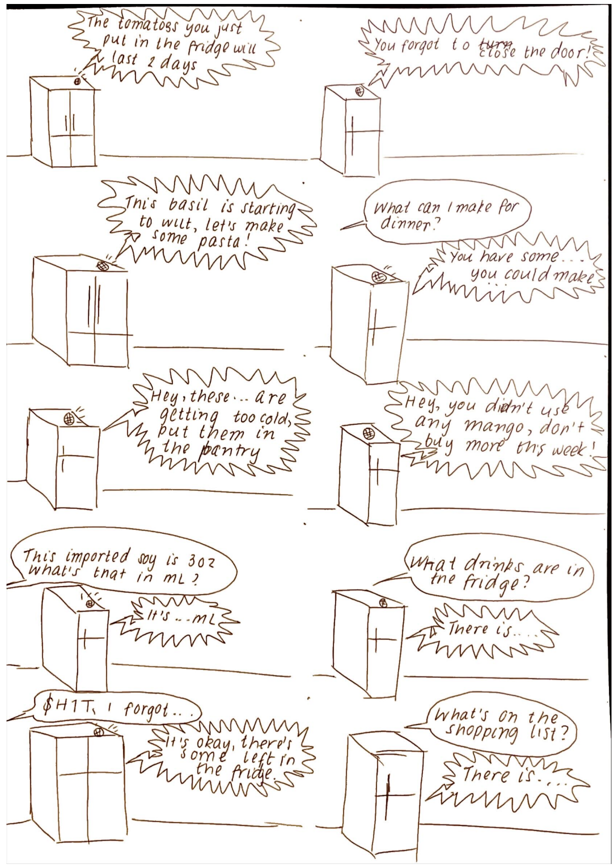


Fig. 4. Refined Enhanced Smart Fridge Idea

#### 1.4.3 *Relation to Characteristics of Pervasive Computing:* Context-aware

Since it connects to the user's device via Bluetooth, it will be able to detect when the user is nearby and automatically connect to their device

#### 1.4.4 *Relation to Characteristics of Pervasive Computing:* Anticipatory

After the device connects to the user's device, it can anticipate that the user might want to gain some insight into their waste usage. As a result, it sends the data to the device

#### 1.4.5 *Relation to Characteristics of Pervasive Computing:* Adaptive

When nearly full, it can notify the user so that they can empty it.

#### 1.4.6 *User Scenario:* Tracking Waste Over the Course of One Week

Charlie is a programmer and he is very busy at work every day. Recently he notices that his living expenses were getting higher. Through analysis, he found that the waste was increasing due to tight working hours. Therefore, he decided to buy a smart rubbish bin to help him alleviate the waste problem. Charlie made a cup of coffee in the morning and threw the coffee grounds into the rubbish. After getting home from get off work in the evening, he ordered a pizza

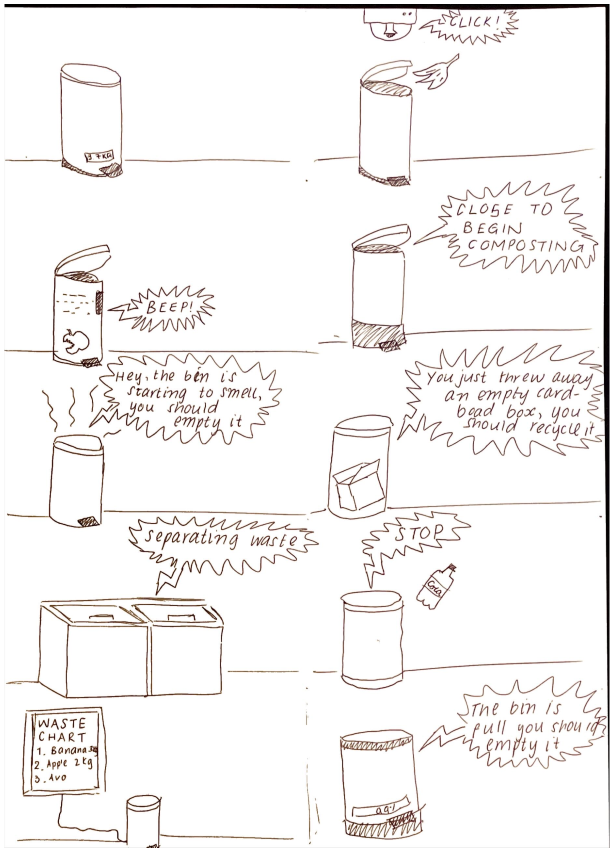


Fig. 5. Crude Smart Rubbish Bin Ideas

delivery and had some drinks. Then he threw the takeaway box and drink can into the rubbish bin. Charlie was able to check the status of the rubbish bin on his phone and get an alarm if it was full or the waste has been left out for a long time to prevent any smell. After a week, the smart rubbish bin gives a summary of the week's waste and some suggestion for savings: *"You can use coffee grounds as fertilizer, you can make takeout boxes into containers to store items, and you can sell drink cans to garbage recycling stations."*

## 2 DESIGN AND TECHNICAL CONCEPT

### 2.1 Conceptual Diagram

Fig 7 depicts the conceptual diagram of the smart rubbish bin.

### 2.2 Description

*2.2.1 Sensors:* HX711 Weight Sensor

The HX711 is primarily used to interface with load cell, which are transducers that convert a physical force (weight) into signal. It will communicate with the FireBeetle using $I^2C$ [3] in the project. The project will use the weight sensor to measure the weight of the prospective food waste.

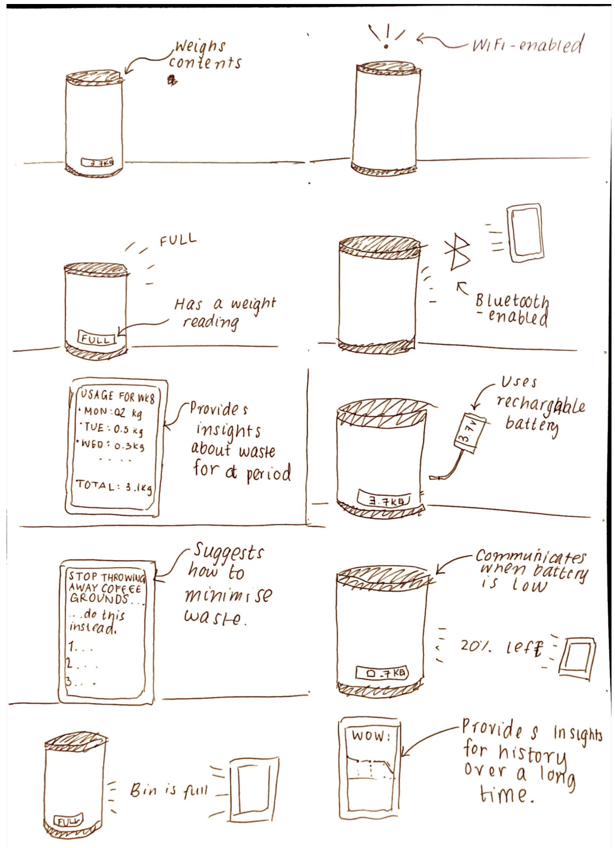


Fig. 6. Refined Smart Rubbish Bin Ideas

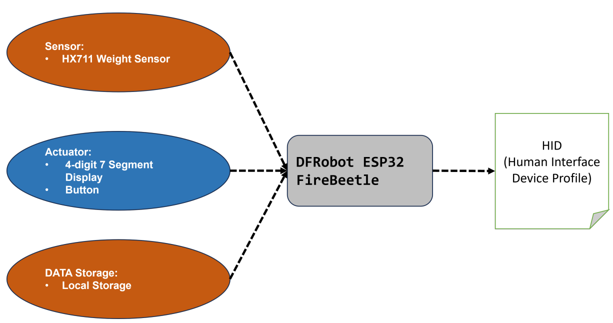


Fig. 7. Conceptual Diagram

#### 2.2.2 *Actuators:* Load Cell

A load cell is used in weighing scales for measuring the weight of prospective food waste. The signal from load cell is manipulated by the embedded processing.

#### 2.2.3 *Embedded Processing:* C++ Program

The embedded system consists of both hardware and software components. Specifically, the FireBeetle and C++ programming. Embedded processing performs specific tasks within microcontrollers.

#### 2.2.4 *Data Storage:* Local Storage

The embedded system needs to store data collected from sensors, user settings, and operational logs.

#### 2.2.5 *Networking Methods:* Bluetooth

The project designs custom hardware interfaces that connect to embedded system via Bluetooth. These interfaces can include input/output components, collecting information from users and providing food waste measurement and instruction.

#### 2.2.6 *Interfaces:* LightBlue Mobile App

One of the user interfaces is the LightBlue mobile app. It will allow the user to the FireBeetle and communicate with it. It also enables the user to send waste information to the device and collect information (scale, instructions) from the device.

#### 2.2.7 *Interfaces:* 4-digit 7 Segment Display Module

This module is used to show the measured weight in 4-digit read from the load cell and then processed by the FireBeetle. Users can read the weight from the 4-digit 7-segment Display while weighting the waste or reseting the scale.

#### 2.2.8 *Interfaces:* Reset Button

The reset button is used to set the scale to zero or to tare it. This is useful while users weigh the food waste in the bin. They need to install the bin, press the reset button to set the display to zero, and then add the food waste.

### 2.3 Challenges

#### 2.3.1 *Challenge 1:* Maintaining Bluetooth connectivity

Since the scale will be placed inside the bin, and underneath a rubbish bag; connectivity will be affected by the walls of the bin and the plastic of the bag.

#### 2.3.2 *Challenge 2:* Ensuring compatibility between all components

Due to differences in micro-controllers and various components—sensors, actuators, libraries etc—ensuring compatibility is an issue. So, we made sure to source items which are made specifically for the FireBeetle.

#### 2.3.3 *Challenge 3:* Minimising battery usage

The battery cell is very small, only 400 mAh. So, determining out how to maximise battery life (to minimise annoyance to the user) will be paramount.

#### 2.3.4 *Challenge 4:* Calibrating the load sensor

Variances and tolerances in manufacturing necessitate the calibration of all load sensors, regardless of whether they have come from the same production line. Doing so accurately will require both patience and diligence.

#### 2.3.5 *Challenge 5:* Reading data sheets

The complexity of certain sensors necessitates a thorough read through of the sensors data sheet to prevent improper use and potential damage.

# 3 REQUIREMENTS AND PLANNED ACTIVITIES

## 3.1 Item List

| Item | Link | Quantity | Unit Cost (AUD) | Total Cost (AUD) |
|---|---|---|---|---|
| Weight Sensor Kit | Core Electronics | 1 | 50.50 | 50.50 |
| LiPo Battery | Core Electronics | 1 | 12.05 | 12.05 |
| LiPo Battery Charger | Core Electronics | 1 | 5.05 | 5.05 |
| LiPo Battery Bag | Core Electronics | 1 | 5.95 | 5.95 |
| 4-Digit LED 8-Segment Display Module | Core Electronics | 1 | 8.80 | 8.80 |
| Rubbish Bin | Kmart | 1 | 5.00 | 5.00 |

Without 4-Digital LED Segment Display, the total cost for the items sourced from Core Electronics is 73.55 AUD with 7.16 AUD in shipping, totaling 80.71 AUD. The total cost for the item sourced from Kmart is 5.00 AUD with free pickup. Each group member will contribute 21.43 AUD. The extra cost of 4-Digital LED Segment Display will be paid by Siddek Liang.

## 3.2 Evaluation Plan

### *3.2.1 Evaluation Approach*

We plan to use a combination of technical and usability evaluation methods to assess the overall success of the project.

### *3.2.2 Technical Evaluation*

(1) Measure the accuracy of the HX711 weight sensor in measuring food waste.
(2) Assess the reliability of Bluetooth connectivity within the bin.
(3) Evaluate the functionality of the 4-digit 7 Segment Display Module.
(4) Ensure proper functioning of the reset button.
(5) Test the load cell for precision and accuracy.
(6) Measure and analyze battery usage and efficiency.

### *3.2.3 Usability Evaluation*

Collect user feedback through surveys and interviews, such as how easy it is to connect to the bin, get data from it,and set up app, to understand user satisfaction and the user-friendliness. Consider possible user scenarios and evaluate them.

### *3.2.4 Data Analysis and Report*

Analyze technical data for accuracy and reliability. Evaluate user feedback for overall satisfaction. Write evaluation report based on data. And provide recommendations for improvements.

| Task ID | Task Name | Start Week | End Week | Resouces | Week1 | Week2 | Week3 | Week4 | Week5 | Week6 | Week7 | Week8 | Week9 | Week10 | Week11 | Week12 | Week13 | Week14 | Week15 | Week16 | Week17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Phase 1-Create plan | 1 | 7 | | | | | | | | | | | | | | | | | | |
| 1.1 | discuss the project theme and scope | 3 | 6 | | | | | | | | | | | | | | | | | | |
| 1.2 | Develop a design and technical concept | 3 | 6 | | | | | | | | | | | | | | | | | | |
| 1.3 | Synthesize the requirements and planned activities | 3 | 6 | | | | | | | | | | | | | | | | | | |
| 1.4 | Write a report | 6 | 7 | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |
| 2 | Phase 2-Assemble devices and write programs to complete activities | | | | | | | | | | | | | | | | | | | | |
| 2.1 | Set the sensor | 7 | 11 | | | | | | | | | | | | | | | | | | |
| 2.2 | Set the actuators | 7 | 11 | | | | | | | | | | | | | | | | | | |
| 2.3 | Set embedded Processing | 7 | 11 | | | | | | | | | | | | | | | | | | |
| 2.4 | Set data Storage | 7 | 11 | | | | | | | | | | | | | | | | | | |
| 2.5 | Write the user interface | 7 | 11 | | | | | | | | | | | | | | | | | | |
| 2.6 | Connect with Bluetooth | 7 | 11 | | | | | | | | | | | | | | | | | | |
| 2.7 | Completion display module | 7 | 11 | | | | | | | | | | | | | | | | | | |
| 2.8 | Complete reset button | 7 | 11 | | | | | | | | | | | | | | | | | | |
| 2.9 | Write a report | 10 | 11 | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |
| 3 | Phase3-Perform evaluations and sum up | | | | | | | | | | | | | | | | | | | | |
| 3.1 | Complete the unfinished parts of Phase2 | 11 | 13 | | | | | | | | | | | | | | | | | | |
| 3.2 | Perform evaluations to make corrections | 11 | 13 | | | | | | | | | | | | | | | | | | |
| 3.3 | Write a report and create a video | 13 | 14 | | | | | | | | | | | | | | | | | | |

Fig. 8. Project Plan

### 3.3 Project Plan

## 4 DIARY

### 4.1 Tanaka Chitete

| Week | Activities |
|---|---|
| 1 | Collected DFRobot ESP32-E microcontroller and Kitronik Inventor's Kit; Installed required software; Got started with Arduino development |
| 2 | Brainstormed project ideas—came up with smart-bin concept; Experimented with console output—configured and used `Serial.printf()` and related functions to produce console output; Documented and shared code with group |
| 3 | Conducted research on project hardware components—sensors and actuators; Experimented with LED-circuit-building and PWM—assembled a circuit with an LED to implement PWM to control the brightness; Documented and shared circuit structure and code with group |
| 4 | Conducted further research on project hardware components—sensors and actuators; Experimented with photo-transistor-circuit-building—assembled a circuit with an LED and photo-transistor to implement light-sensing to control ambient lighting; Documented and shared circuit structure and code with group |
| 5 | Conducted research on project software components—interfaces and communication; Experimented with Bluetooth and WiFi communication—modified the previous circuit to communicate photo-transistor readings via Bluetooth and WiFi; Documented and shared circuit structure and code with group; Translated tasks to report sections; Sourced report template |
| 6 | Finalised project hardware and software components; Purchased all parts; Experimented with motor and transistor—assembled a circuit with a fan, motor and transistor to implement PWM to control brightness and motor RPM; Documented and shared circuit structure and code with group; Wrote sections 1.1, 1.2, 1.3, and 3.1; Contributed to sections 1.4, 2.2, 2.3, and 3.2 |

### 4.2 Fengyi Yang

| Week | Activities |
|---|---|
| 1 | Install all software and drivers required for tutorial. |
| 2 | Get the kits and write simple code to check if the ESP32 FireBeetle can be written on the computer. |
| 3 | Brainstorm and decide on the theme of smart rubbish bin. |
| 4 | Based on the Canvas code and handbook, use a photo transistor to sense the surrounding brightness and adjust the brightness of the LED light through PWM. |
| 5 | Use the Bluetooth module and Wi-Fi module of the FireBeetle to send the current brightness of the environment to the mobile phone. |
| 6 | Drive the motor by using transistor. And control the speed of motor by PWM. Wrote section 1.4 |

### 4.3 Siddek Liang

| Week | Activities |
| --- | --- |
| 1 | FRobot ESP32 FireBeetle has not been collected, installed the essetial kits and previewed the arduino development |
| 2 | Familiar with microcontrollers, trying to use the series communication |
| 3 | Follow the user handbook of FRobot ESP32 FireBeetle, assembled the circuit and use code sample to implement PWM control of the led brightness. Collaborate with team members to modified the code. |
| 4 | Follow the code and circuit diagram on user handbook of FRobot ESP32 FireBeetle, rearranged the code control the led brightness by analog of photo transistor. |
| 5 | Worked on Bluetooth and Wifi on FRobot ESP32 FireBeetle. Tranfering the signal read from photo transistor to mobilephone via http. Guided team members to learn about the WIFI module. |
| 6 | Assemble the circuit for PWM to control the motor RPM. Conduct the lab learning(transistor, PWM control). Researched on 4-digit 7-segments and added the interface to the project. Wrote section 2.1 and 2.2; Proof-read all sections, editing content where necessary |

### 4.4 Yaqi Zhou

| Week | Activities |
| --- | --- |
| 1 | Install the necessary accessories and understand arduino development |
| 2 | Learned how to use the FRobot ESP32 FireBeetle, learned how to use VS Code for arduino development |
| 3 | Discussion topic and learn IoT |
| 4 | Follow the user handbook of FRobot ESP32 FireBeetle, control the led brightness |
| 5 | learned to use Bluetooth and Wifi on FRobot ESP32 FireBeetle. |
| 6 | Learned to use PWM control the motor speed. Wrote sections 3.2 and 3.3 |

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