COMP5047 Assignment (Phase 3) [Group 5]

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1 TASK 1: PROGRESS REPORT

1.1 Task 1A: Conducted Activities

1.1.1 Implementing an interface

Successfully created a user-friendly interface by Node-Red, enhancing user experience and interactions.

1.1.2 Implementing a server

Successfully set up a stable server for real-time updates, ensuring continuous uptime.

1.1.3 Writing embedded processing code

Successfully developed code for the DFRobot ESP32 FireBeetle Microcontroller, ensuring efficient multitasking.

1.1.4 Performing a technical evaluation

Conducted a comprehensive assessment of the system, revealing efficiency and highlighting areas for optimization.

1.1.5 Troubleshooting issues

Encountered intermittent connectivity issues but successfully resolved them, ensuring a robust, uninterrupted system operation.

1.2 Task 1B: Uncompleted Activities

1.2.1 Integrating supplementary components

Could not incorporate additional actuator due to supply chain disruptions and budget constraints.

1.2.2 Conducting a user study

Restricted in-person interactions and time constraints hindered a comprehensive user feedback collection.

1.3 Task 1C: Challenges

1.3.1 Ensuring equal contribution

Naturally, some group members were quieter than others, so those who were more vocal tended to contribute more. To encourage contribution from all team members, we worked around the group to spotlight individual contributions. This occasionally helped remove focus on specific individuals.

1.3.2 Exchanging knowledge

Due to unequal contributions, knowledge of the assignment and solution was consolidated—only a couple group members had substantial technical knowledge. As a result, collaborating on more technical matters became difficult. We used Discord to communicate remotely and GitHub to manage source code. This did help in exchanging knowledge.

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2 TASK 2: REVISIONS FOR PREVIOUS PHASES

2.1 Task 2A: Revised Answers

2.1.1 Task 1A: Problem Space Identification (Phase 1)

Despite *Sustainability Goal 12: Ensure sustainable consumption and production patterns*, food wastage is still a substantial issue in wider society. Each person discards an average of 120 kilograms of food annually [2]. The urgency to reduce per-capita food waste and loss by 2030, as pleaded by the UN, remains a significant global challenge.

High-income countries, such as Australia, contribute disproportionately to this problem, with a material footprint per capita ten times that of low-income countries [2]. In such countries, wasteful practices have become second-nature, evident in everyday rituals like brewing coffee, resulting in the disposal of coffee grounds.

Pervasive computing solutions offer a broader perspective on addressing wastage. These solutions, with their embedded nature, can seamlessly integrate into households. They can promote sustainable consumption and production patterns by reducing household wastage, all without disturbing the user's environment.

2.1.2 Task 1D: Idea Selection (Phase 1)

Terra, a WiFi-enabled weight-sensing bin, represents the solution to the excessive levels of food waste exhibited by Australian households, emphasising the need for sustainable consumption and production patterns. By facilitating data-driven insights, Terra allows the user to take control over wastage in their household.

2.1.3 Task 1E: Relation to Characteristics of Pervasive Computing (Phase 1)

Embedded. Beneath the unassuming exterior of a waste bin, a microcontroller and network-enabled scale, are both discretely embedded within the bin itself. This embedded design ensures that Terra blends into the user's daily routine without disrupting the aesthetics of their living space.

Anticipatory. Once the user connects to Terra, it immediately sends waste insights for the past day. This feature empowers users with real-time information, enabling them to make informed decisions about their consumption patterns and waste management.

Adaptive. When the bin reaches its predefined maximum capacity, the user receives a notification, reminding them to empty it. This adaptive behavior ensures that users are promptly alerted when it's time to take action, reducing the risk of overflows and waste spillage. Terra's adaptive notifications contribute to efficient and effective waste management within the household.

2.1.4 Task 1F: User Scenario (Phase 1)

Charlie, a busy programmer, is facing the daily challenge of managing his household waste efficiently. Over time, he noticed an increase in his living expenses, primarily due to the growing amount of waste generated during his hectic workdays. Intrigued by the prospect of reducing wastage and saving money, he decided to adopt Terra as a solution to his problem.

His typical day begins with making a cup of coffee in the morning, followed by a day filled with work-related tasks. After work, he often orders takeout meals and enjoys some drinks. Each of these activities generates waste, from coffee grounds to takeaway containers and drink cans. Charlie places all of these items into Terra.

Node-RED plays a vital role in Charlie's waste management routine. When he connects to the user interface, he can immediately request insights about his waste production. These insights help Charlie become aware of, and reduce, his environmental footprint.

Additionally, Terra's adaptability ensures that Charlie is never caught off guard by an overflowing bin. When Terra reaches its maximum capacity, it sends Charlie a notification, prompting him to empty it. This adaptive behavior prevents wastage accumulations and maintains a healthy living space.

As time passes, Terra tracks Charlie's waste. It can send insights for the past 24 hours, week, or even month. These insights help Charlie be conscientious and stay committed to sustainability.

Here, Terra demonstrates its practicality and effectiveness in promoting sustainable consumption and waste reduction. Charlie's experience with Terra showcases how pervasive computing solutions can empower individuals to make informed decisions, reduce waste, and contribute to a more sustainable future.

2.2 Task 2B: Revised Conceptual Diagram

Figure 1 depicts the revised conceptual diagram.

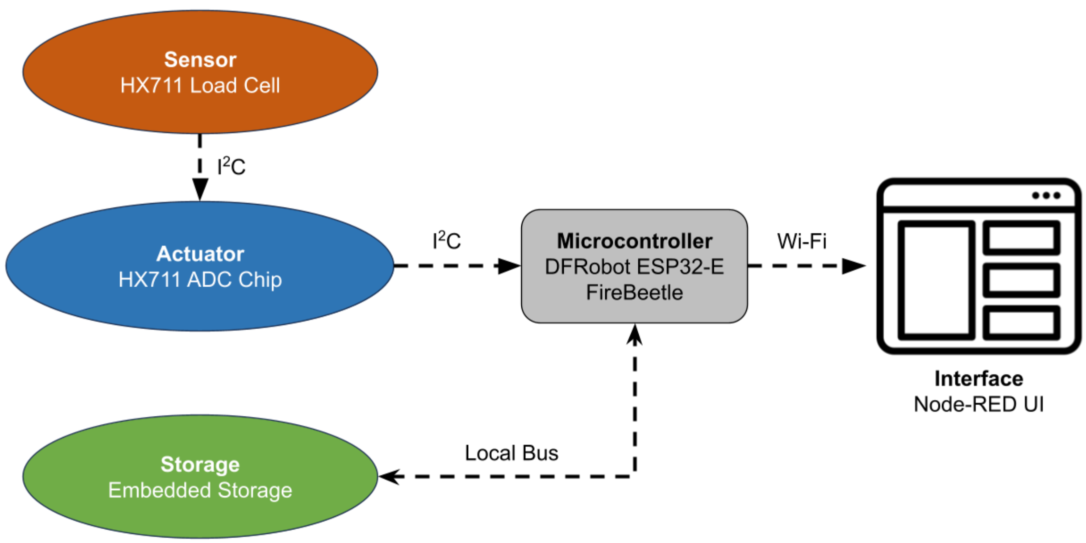


Fig. 1. Revised conceptual diagram.

HX711 Load Cell. The HX711-compatible load cell plays a pivotal role in Terra's functionality. It is responsible for accurately sensing the weight of waste within the rubbish bin. This load cell communicates with the HX711 Analog-to-Digital Converter (ADC) chip using the I^2C protocol. The load cell provides raw weight data to the HX711 Converter Chip, ensuring precise weight measurements.

HX711 ADC Chip. The HX711 ADC chip acts as an intermediary between the load cell and the FireBeetle. It receives raw weight data from the HX711-compatible load cell via I^2C communication. Once the raw weight data is received, the HX711 ADC chip processes and manipulates it, converting it into a format that is understandable to the ESP32 FireBeetle. This chip ensures accurate and reliable weight data conversion.

Embedded Storage. Embedded storage refers to the internal storage capacity integrated into the FireBeetle. This built-in storage serves as a repository for various types of data, including sensor readings and user-defined settings. Data is stored securely within the ESP32 FireBeetle, allowing for efficient data access and retrieval as required. This feature ensures that essential data is readily available for analysis and user interactions.

DFRobot ESP32-E FireBeetle. The FireBeetle serves as Terra's central processing unit, playing a pivotal role in data processing and communication. The FireBeetle receives the converted weight data from the HX711 ADC chip and handles its further processing. Equipped with Bluetooth capabilities, it facilitates seamless communication with phones and tablets using Node-RED. The FireBeetle utilises WiFi connectivity to establish a connection with the user's smart device, enabling user interactions and data exchange.

Changing: Node-RED UI. The Node-RED UI signifies a more interactive and user-friendly platform for system interfacing. Node-RED is a flow-based development tool that allows users to wire together Terra and online services. By integrating Node-RED UI into the system, users can now benefit from a graphical interface that's more intuitive and customisable.

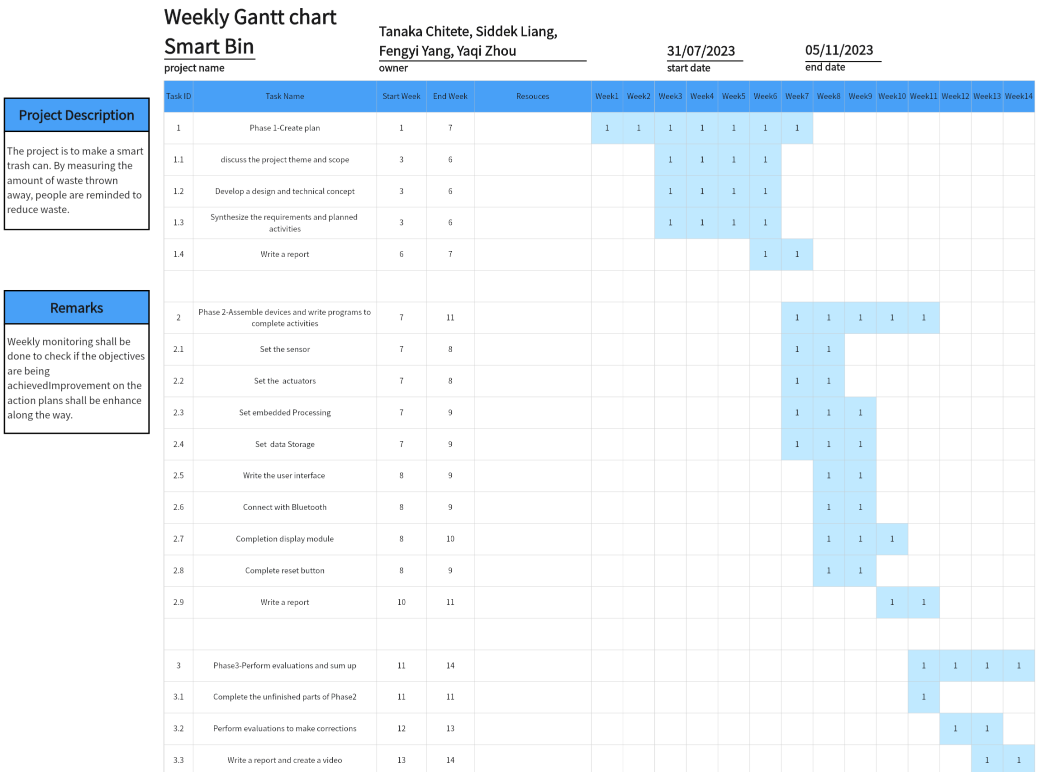
2.3 Task 2C: Revised Project Plan

Figure 2 depicts the updated project plan.

3 TASK 3: EVALUATION PLAN AND RESULTS

3.1 Task 3A: Plan

(1) *Accuracy* — Terra's accuracy will be evaluated by comparing its weight measurements to known weights using controlled experiments.
(2) *Physicality* — Terra's dimensions, weight, and materials will be verified.
(3) *Ethical Considerations* — Ethical considerations will be paramount throughout the evaluation process. The University of Sydney Participant Information Sheet (PIS) and Participant Consent Form (PCF) will be obtained and tailored for our project as required. Thus, ethical approval will be obtained as per university policies and national ethical guidelines.
(4) *Wireless Connectivity* — Terra uses WiFi for networking. Our team will measure the strength and stability of the WiFi signal at varying distances and with different obstacles. We will also test data transfer speed when connected to different networks.
(5) *Server Connectivity* — Terra utilises MQTT protocol for server communication. We will measure the time taken for Terra to update the new weight of Terra's contents.



Weekly Gantt chart

Smart Bin
project name

Tanaka Chitete, Siddek Liang, Fengyi Yang, Yaqi Zhou
owner

31/07/2023
start date

05/11/2023
end date

Project Description

The project is to make a smart trash can. By measuring the amount of waste thrown away, people are reminded to reduce waste.

Remarks

Weekly monitoring shall be done to check if the objectives are being achievedImprovement on the action plans shall be enhance along the way.

Task ID	Task Name	Start Week	End Week	Resouces	Week1	Week2	Week3	Week4	Week5	Week6	Week7	Week8	Week9	Week10	Week11	Week12	Week13	Week14
1	Phase 1-Create plan	1	7		1	1	1	1	1	1	1							
1.1	discuss the project theme and scope	3	6				1	1	1	1								
1.2	Develop a design and technical concept	3	6				1	1	1	1								
1.3	Synthesize the requirements and planned activities	3	6				1	1	1	1								
1.4	Write a report	6	7							1	1							
2	Phase 2-Assemble devices and write programs to complete activities	7	11								1	1	1	1	1			
2.1	Set the sensor	7	8								1	1						
2.2	Set the actuators	7	8								1	1						
2.3	Set embedded Processing	7	9								1	1	1					
2.4	Set data Storage	7	9								1	1	1					
2.5	Write the user interface	8	9									1	1					
2.6	Connect with Bluetooth	8	9									1	1					
2.7	Completion display module	8	10									1	1	1				
2.8	Complete reset button	8	9									1	1					
2.9	Write a report	10	11											1	1			
3	Phase3-Perform evaluations and sum up	11	14												1	1	1	1
3.1	Complete the unfinished parts of Phase2	11	11												1			
3.2	Perform evaluations to make corrections	12	13													1	1	
3.3	Write a report and create a video	13	14														1	1

Fig. 2. Revised project plan.

3.2 Task 3B: Results

Specifications	Result
Accuracy	As previously mentioned, the calibration object is the charging AirPods Pro (2nd generation) charging case, which has a specified weight of 50.8g[1]. The reading retrieved from Terra was 51g. The reading retrieved from Terra was 51g. The percentage error is 0.39%,which is more than acceptable for the scale's application.
Physicality	The overall dimensions after assembly are 120 x 100 x 30 mm. Considering the smart scale fully embeds itself inside the bin, this is perfectly acceptable.
Wi-Fi	Strong signal up to 10 meters, with minor drop-offs beyond that range. Wi-Fi connection was encrypted with WPA3, no vulnerabilities detected during the testing period.
MQTT	Average latency time was 600 ms. All messages were encrypted, with no data breaches detected.

3.3 Task 3C: Implications

Terra is a highly-performant solution. Integration of WiFi 6 networking and the MQTT protocol offer fast and stable connection, which is important for sending data in a timely manner. A GUI implemented in Node-RED shows that the solution is easy to use and has the ability to be widely adopted.

The HX711 Weight Sensor's accuracy shows how precise the system is, which makes sure that the waste level is carefully monitored. Processing and storing data are both efficient. The HX711 Converter Chip and local storage show that Terra can work for a long time without needing to be serviced. Notably, the system puts data security first by using secured links to lower the chance of a breach.

However, the processor latency is a sign that Terra might benefit from being optimized or upgraded in the future. To sum up, Terra works well, is easy to use, and is safe. It is ready to be used by more people, but it might benefit from being iterated on a few more times before wider adoption.

3.4 Task 3D: Future Perspective and Impact

As we look ahead, Terra promises transformative changes in waste management. Key future enhancements include integrating AI analytics to predict waste trends and using IoT for interconnected, optimised waste collection, which can lead to reduced emissions. An eco-friendly version with solar panels is also envisioned, adding a self-sustaining dimension to the system.

The smart bin's potential applications extend beyond domestic settings. It's perfectly suited for large-scale events, ensuring efficient, real-time waste handling. In the broader context of smart cities, these bins can revolutionize urban sanitation and sustainability.

Most crucially, Terra closely aligns with SDG Goal 12. By providing real-time feedback on waste, the it educates users about their consumption behaviors, encouraging sustainable choices. This data-driven approach can influence production trends, advocating for a demand-based model, thereby reducing overproduction and waste.

In essence, Terra isn't just a smart bin; it's a step towards a sustainable future. By merging advanced tech with environmental goals, it lays the groundwork for cleaner urban landscapes and fosters a more responsible consumption culture, directly addressing global sustainability challenges.

4 WEEKLY DIARIES

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; Refined concept iteratively; 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; Co-wrote sections 1.4, 2.2, 2.3, and 3.2 of Phase 1 report; Performed final edit of Phase 1 report
7	Experimented with MQTT and Node-RED to broadcast and receive messages between FireBeetle and Node-RED; Experimented with MQTT and Node-RED to control LED brightness; Acquired weight sensor kit from Core Electronics, and a bin from Kmart
8	Brainstormed technical evaluation; Brainstormed usability evaluation; Acquired battery and display module from Core Electronics
Mid-semester Break	Assembled scale; Wrote embedded processing code; Configured version control; Troubleshot hardware and software; Documented and shared circuit structure and code with group
9	Noted feedback and marks on Phase 1 report; Translated assignment specification for Phase 2 to report sections; Sourced report template; Wrote sections 1.1, 1.2, 2, 3.1, and 3.2 of Phase 2 report; Co-wrote sections 4.1, 4.2, 6.1, and 6.2 of Phase 2 report; Performed final edit of Phase 2 report; Demonstrated working prototype in tutorial
10	–
11	–
12	Purchased drill; Cut hole into bin to provision power supply from connected computer; Noted feedback and marks on Phase 2 report; Translated assignment specification tasks for Phase 3 to Phase 3 report sections; Sourced report template; Wrote tasks 1C and 2A of Phase 3 report; Co-wrote tasks 1A, 1B, 2B, 3A, and 3B of Phase 3 report; Recorded user instruction video; Performed final edit of Phase 3 report; Will demonstrate final solution in subsequent tutorial

4.2 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
7	Atending the lab and used NodeRED/MQTT and a microcontroller to control the luminance of an LED using pulse width modulation (PWM). And discussed ideas and contributed to ideation to improve the user interface of the project.
8	Join the meeting(Lab) for discussing Evaluating Systems, specifically evaluation plan, abstract tasks and concrete Tasks and contributed to the ideation.
Mid-semester Break	Implemented partial interface on node-red, try some features from dashboard
9	Completed the Revised Conceptual Diagram added descriptions and confirmed with Tutor. Stated the changes from the initial plan and wrote the changes. Wrote the technical aspect of evaluation plan.
10	Conducted the study in Mosquitto Username and Password Authentication.
11	Implemented the user interface on Node-Red. Wrote the code for WIFI and MQTT set-up.
12	Participated in the video recording. Wrote the Task 3 of the report. Co-wrote the task 1A, 1B on report.

4.3 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
7	Use Node Red and MQTT to control PWM to adjust brightness, and use the scroll interface. Participate in project discussions and make some suggestions for project functions.
8	Discuss evolution in the tutorial, including technical assessment and usability assessment.
Mid-semester Break	Self-study about fire beetle kit and Node Red.
9	Receive feedback from the tutor on phase1 and summarize and improve it. Assign the task of phase2. Responsible for phase2 6.2 and 8.3
10	–
11	Using MQTT username and password to ensure the security of communication.
12	Assist in recording video, editing video and voiceover. Assign the task of phase2. Responsible for phase3 task 3C and 3D

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	Discussed the topic and decided it.Learned IoT
4	Followed the user handbook of FRobot ESP32 FireBeetle, controled the led brightness through PWM.
5	Learned to use Bluetooth and WiFi on FRobot ESP32 FireBeetle.Used Bluetooth and WiFi to control light brightness.
6	Learned to use PWM control the motor speed. Wrote sections 3.2 and 3.3
7	Used NodeRED and MQTT and microcontroller to control the brightness of an LED.Discussed the project.
8	Discussed the evaluation plan, including abstract tasks and concrete tasks.
Mid-semester Break	Learned some NodeRED knowledge.
9	Received feedback from the tutor on phase1 and improve the gantt chart. Assigned the task of phase2. Responsible for phase2 5 and 8.4
10	Learned how to set up username and password to connect to an MQTT with the Node Red and tried it.
11	Checked the project for errors and review Node Red. Learned about the security and Privacy for Pervasive Systems.
12	Assigned the task of phase3. Completed the gantt chart. Wrote the report 2.3 and 4.4.

REFERENCES

[1] Apple (Australia). 2022. *Airpods Pro (2nd generation) - technical specifications.* Retrieved October 13, 2023 from https://www.apple.com/au/airpods-pro/specs/

[2] United Nations. 2023. *Ensure sustainable consumption and production patterns.* Retrieved September 8, 2023 from https://sdgs.un.org/goals/goal12