Faculty Of Electronics and Computer Technology and Engineering

THE DEVELOPMENT OF SMART GARBAGE SYSTEMS WITH IOT

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Bachelor of Computer Engineering Technology (Computer Systems) with Honours

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A project report submitted
in partial fulfillment of the requirements for the degree of
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Faculty Of Electronics And Computer Technology And Engineering

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DEDICATION

To my family, thank you so much because always being there for me with unfailing support, love, and understanding has been the foundation of my goals. During the good times and the bad, your sacrifices, kindness, and support have pushed me forward and kept me steady. Every goal I've reached shows how much you believe in me. I'm grateful that you have been my light and taught me the principles that have kept me going.

To the Faculty and my supervisor, your commitment to teaching, encouraging growth, and encouraging critical thought has been a huge help on this academic journey. Your advice, mentoring, and helpful criticism have not only shaped my academic interests but also given me a deep love for learning. The way I've approached my studies has been shaped by your dedication to success.

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Each of you has helped me grow in your own way, and I am so grateful for that. You all helped me succeed, and this is proof of how much your support, motivation, and friendship have helped me along my educational path.

ABSTRACT

The Development of Smart Garbage System with IoT is a stepping stone in managing waste inside the tall building for example in FKM building. It provides a proactive way for the cleaning staff to organise and improve their work. In the past, picking up trash after every class was seen as an inefficient job. Since the staff had to go up and down the tall building, the bins were often only partially full, which wasted time and energy. A microprocessor called Arduino Uno is at the heart of the system and makes sure that everything works together smoothly. Using high-tech sensor, this system correctly checks how much trash is in the bins. The NodeMCU ESP8266 modules improve this process by making bin tracking more efficient, which makes garbage gathering better. Importantly, an app that is easy to use goes along with this hardware system and gives the cleaning staff a simple way to interact with it. This app not only shows the state of trash cans in real-time, but it also makes garbage collection easier and faster. Integrating with a Firebase database is a key part of managing and organising the many bins that are spread out throughout the building. This combination of technologies greatly lowers the need for workers, stops overflow situations, and makes the cleaning staff's work much more effective. The launch of the system marks the beginning of a new era in how educational institutions handle trash. This is in line with sustainability goals and a big change from the old, time-consuming methods.

ABSTRAK

Pembangunan Sistem Sampah Pintar dengan IoT merupakan batu loncatan dalam menguruskan sisa di dalam bangunan tinggi contohnya di bangunan FKM. Ia menyediakan cara proaktif untuk kakitangan pembersihan universiti untuk mengatur dan menambah baik kerja mereka. Pada masa lalu, mengutip sampah selepas setiap kelas dilihat sebagai kerja yang tidak cekap. Memandangkan kakitangan terpaksa turun naik bangunan tinggi, tong sampah selalunya hanya separa penuh, yang membuang masa dan tenaga. Mikropemproses yang dipanggil Arduino Uno berada di tengah-tengah sistem dan memastikan semuanya berfungsi dengan lancar. Menggunakan sensor berteknologi tinggi, sistem ini menyemak dengan betul jumlah sampah di dalam tong. Modul NodeMCU ESP8266 menambah baik proses ini dengan menjadikan penjejakan tong sampah lebih cekap, yang menjadikan pengumpulan sampah lebih baik. Yang penting, aplikasi yang mudah digunakan seiring dengan sistem perkakasan ini dan memberikan kakitangan pembersihan cara mudah untuk berinteraksi dengannya. Aplikasi ini bukan sahaja menunjukkan keadaan tong sampah dalam masa nyata, tetapi ia juga menjadikan kutipan sampah lebih mudah dan pantas. Penyepaduan dengan pangkalan data Firebase ialah bahagian penting dalam mengurus dan mengatur banyak tong sampah yang terdapat di seluruh bangunan. Gabungan teknologi ini sangat mengurangkan keperluan pekerja, menghentikan situasi limpahan, dan menjadikan kerja kakitangan pembersihan lebih berkesan. Pelancaran sistem menandakan permulaan era baharu dalam cara institusi pendidikan mengendalikan sampah. Ini selaras dengan matlamat kemampanan dan perubahan besar daripada kaedah lama yang memakan masa.

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CHAPTER 1

INTRODUCTION

1.1 Background

Effective waste management is becoming increasingly challenging in today's rapidly growing urban areas, particularly in tall buildings such as universities or offices. The traditional garbage collection methods often prove inefficient, time-consuming and can lead to unsightly accumulations of trash in common areas. To deliver a real-time, effective, and sustainable waste management solution, the system uses the Internet of Things (IoT). Smart garbage bins with sensors and connectivity modules that can send data to Firebase to make up the system. After the sensors measure the trash in the bins, the communication modules provide the information to the server. The server then analyses the data to produce actionable insights that can boost waste management's effectiveness. Usually, the cleaning staff tend to collect the garbage at fixed times, but this system will help to reduce the workload for the cleaning staff, which will only collect the trash at a particular time when the garbage reaches the limit. For example, students do not usually throw trash in the lecture room building. So, the cleaning staff does not have to check to clear the garbage bin frequently. The project's overall goal is to offer a solution to promote sustainable waste management practices and increase the efficacy and efficiency of waste management procedures in institutions.

1.2 Global issue on garbage management

Across the globe, waste management that could be done better poses major risks to public health locally and worldwide. When the trash is thrown away incorrectly, it can pollute the air and water, creating places where disease-carrying organisms and bugs can grow. Whenthe trash is not picked up and thrown away properly, it can bring pests like rats, flies, and mosquitoes that like living in dirty places. People can get sick from these pests, spreading vector-borne diseases like dengue fever and malaria.

1.3 Problem Statement

Garbage collection and management in tall building are made more difficult by the current waste management practices, which could be more efficient and limited. Overflowing trash, unpleasant odors, and potential health dangers are the outcome of manual inspection and regular pickup techniques. As a result, the cleaning team is overworked and needs to focus their efforts on where they are needed most. Because of this absence of real-time information, resources are frequently distributed inefficiently, and places with little garbage are visited when necessary. Additionally, the inability to identify patterns and optimize workflows is caused by a lack of comprehensive tracking and analysis capabilities. To revolutionize waste management practices, increase efficiency, decrease operational costs, improve cleanliness, and promote sustainability in high buildings, there is an urgent need for an innovative garbage system that combines sensor-based technology, automated data collection, and intelligent analytics.

1.4 Project Objective

The objective of this project is to create a smart garbage system for big buildings. The system will use IoT, sensors, and data analytics to solve waste collection and maintenance issues:

a) Create a cost-effective system that monitors garbage levels in different regions of the building in real time to allow cleaning staff to collect rubbish only when needed and avoid overflow.

b) Use intelligent analytics to analyze waste levels and optimize collection when in need to minimize the garbage collection works at the high building.

c) Create a reliable and proactive approach to reduce overflowing trash, bad odors, and health dangers, making the community healthy.

d) The initiative intends to improve waste management in big buildings by enhancing operating efficiency and creating a more sustainable and hygienic environment for students and cleaning staff.

e) Avoid wasting the cleaners' time and energy to check every bin at every level of the building.

1.5 Scope of Project

The smart garbage system project for high building waste management covers the following:

1. Sensors and IoT devices to monitor building waste levels. Real-time monitoring andanalysis of sensor data by the central system.
2. Design and development of a centralized smart waste system management softwareprogram. Making the system easy for cleaners to use.
3. Intelligent analytics algorithms to process garbage-level data. Actionable insights and reports for resource allocation, route optimization, and waste management.
4. Create an alert system to tell cleaning staff when garbage containers are full or need immediate attention. Mobile app notifications for prompt response and collection.
5. Integrating the smart garbage system with the high building waste management and infrastructure. Working with necessary departments to integrate and minimize interruption.
6. Thorough testing and validation of the smart waste system to assure accuracy, dependability, and performance in real-world circumstances. User acceptance testing for feedback and improvements.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The smart garbage system project integrates Arduino Uno, ultrasonic sensors, NodeMCU ESP8266, and Firebase to provide a garbage management solution. This literature study carefully looks at previous research that has looked at related topics and how they work in waste management systems. The Arduino Uno is the brains of this innovative system; it handles data processing and software management. Ultrasonic sensors allow real-time monitoring of how full trash cans are, which also helps garbage pickup schedules work better and more efficiently. In addition to the new features, the ESP8266 Wi-Fi module now makes it easier to connect to Firebase and other platforms. A previous study using these parts has shown big improvements in how well and how long wisely waste is managed. Utilizing the knowledge gained from these efforts, this study aims to assist in the ongoing development, implementation, and optimization of the smart garbage system, providing practical answers to current problems in garbage management.

2.2 Smart Garbage Monitoring and notifications Using IoT

The "Smart Garbage Monitoring System Using IoT" addresses waste disposal issues and promotes urban cleanliness. This system uses IoT to automate garbage management. Smart bins may communicate and share data via IoT technology.[1] Sensors, software, and networking modules in the smart bin monitor waste in real-time. The technology warns responsible parties or waste management authorities when garbage approaches capacity. Figure 2.1 shows the block diagram of the system.

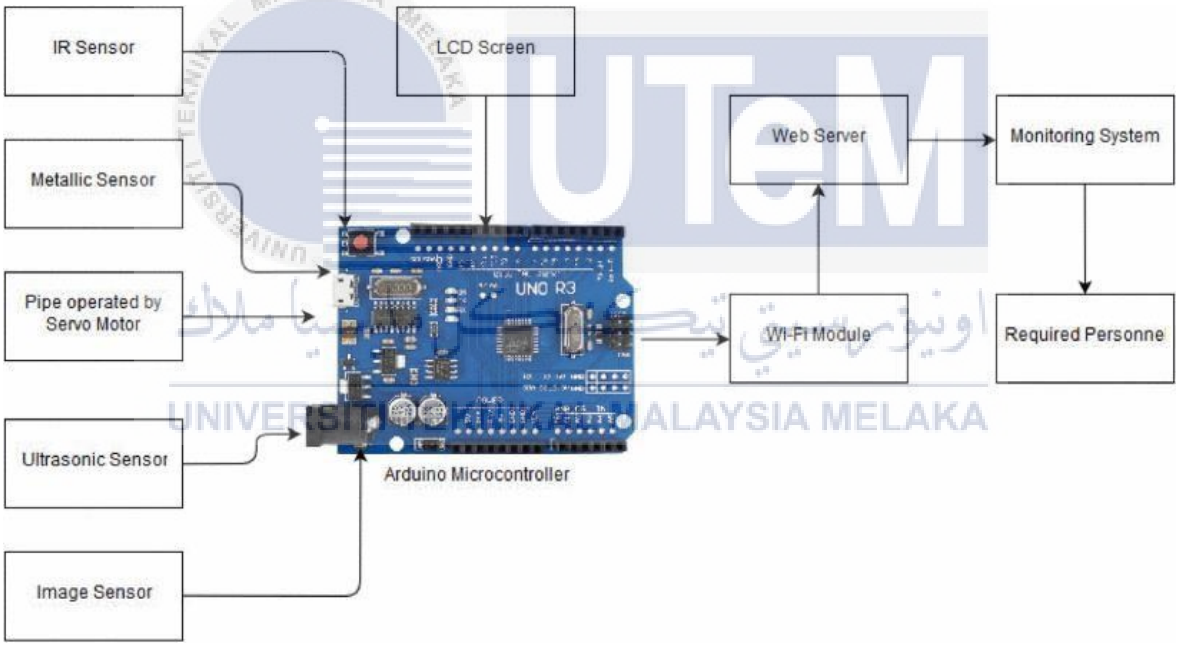

Figure 2.1 Block Diagram of smart garbage monitoring system[2]

The proposed solution outperforms existing trash management methods. Real-time data and notifications remove waste bin checkups. Individuals and waste management organizations save time, effort, and resources. The system also allows prompt garbage collection and disposal, reducing overflow and health risks. The article describes the system's components and addresses smart waste management- related works. It describes the

smart bin's operation and shows its efficacy through experiments. The authors also suggest linking the system with garbage collection infrastructure and improving waste segregation and recycling.

The "Smart Garbage Monitoring System Using IoT" study shows how IoT solutions may transform garbage management. The suggested system automates garbage monitoring and segregation using IoT, computer vision, and sensor integration. The system uses real-time data and notifications to enhance trash management, cleanliness, and the environment.[2]

2.3 Waste Management System related with IoT

Overflowing trash cans in public spaces are the main source of frustration for those in charge of keeping things tidy. This results in several problems, including the spread of disease and unpleasant aesthetics. Researchers have proposed using Internet of Things (IoT)-based smart trash management systems to overcome these difficulties and ensure public cleanliness and health. This paper aims to examine the existing literature on IoT-based trash management systems.[3]

Smart trash management in cities can benefit greatly from the Internet of Things. Waste collection can be improved, and expenses can be decreased using sensor and communication system integration. Real-time monitoring of trash cans is essential to modern waste management systems, as it not only warns authorities when cans are overflowing but also allows them to plan collection routes more efficiently. The effectiveness of waste management is enhanced by this method, which reduces the number of round trips needed to refill containers.

Ultrasonic sensors are commonly employed in modern garbage cans as part of intelligent waste management systems. These sensors send out ultrasonic pulses and use echoes to calculate the volume. When a certain limit is reached, the system sends a notification to the city's central server, which then initiates the cleaning procedure. Automation of previously manual monitoring tasks is made possible by this integration. Furthermore, authorities may monitor rubbish collection activities in real-time with the help of IoT and adjust as needed.[4]

Researchers have created mobile applications that connect to web servers to facilitate effective communication and remote monitoring. These programs take microcontroller- generated alarms and relay them to the main office in the city, eliminating the need for human oversight. Notifications from the sensors are transmitted to the application using Wi-Fi modules, allowing for an uninterrupted data flow. The flowchart is shown in Figure 2.2.

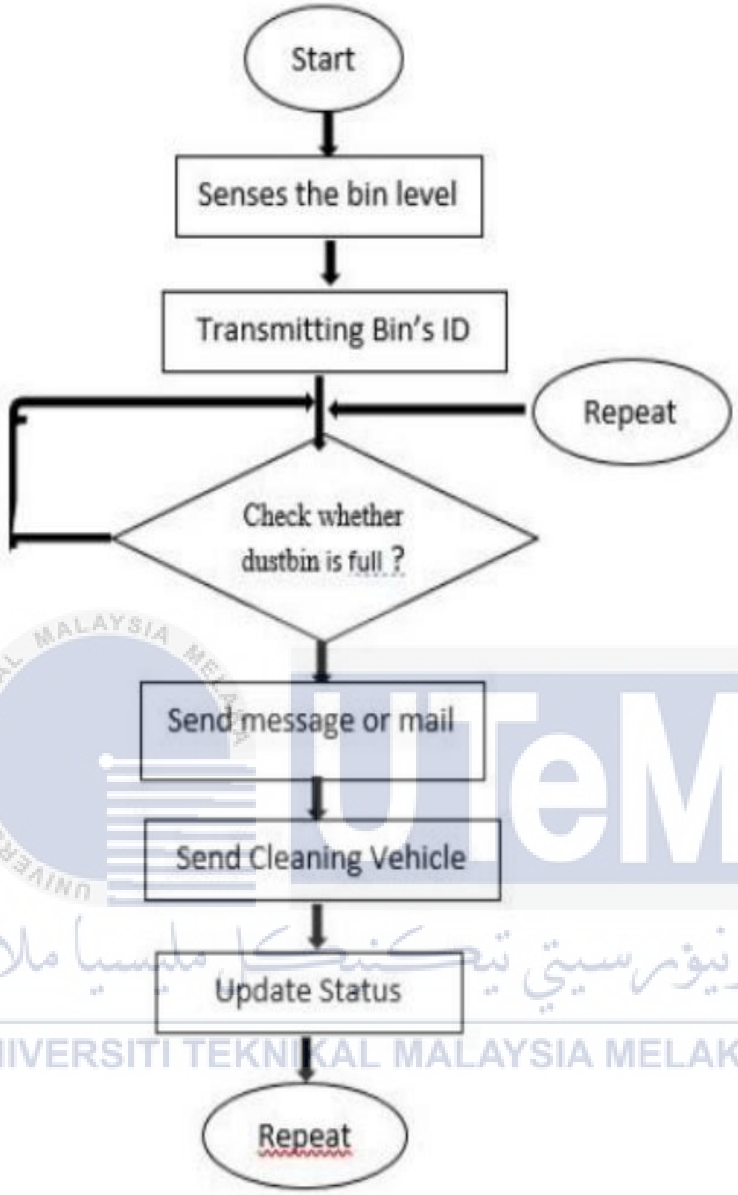

Figure 2.2 Waste Management System based on IoT[4]

IoT-based smart waste management systems have considerable promise for resolving trash disposal issues. Real-time monitoring, more effective waste collection, and cleaner cities are all possible thanks to the combination of sensors, mobile applications, and web servers. Enhancing the capabilities of these systems and developing comprehensive solutions for sustainable waste management in urban contexts requires ongoing research and development activities.[5]

2.4 Smart Waste Monitoring using IoT

Today's world worries about uncollected rubbish and its environmental and health effects. Researchers and practitioners are investigating IoT technology in waste management systems to address this issue.[6] This literature review summarizes IoT-based smart waste collection monitoring research.

IoT in trash management improves efficiency, costs, and sustainability. Ultrasonic sensors monitor waste bin fill levels in IoT-based systems, as shown in Figure 2.3. These sensors measure the bin's lid-to-waste material distance to provide real-time bin status data. IoT platforms send this data to central monitoring systems or cloud databases.

Figure 2.3 Waste bin model[6]

Some research has integrated IoT systems like Ubidots, Blynk, IBM Bluemix, and Device Pilots to link devices to see and analyze data. These user-friendly interfaces let stakeholders monitor waste bin fill levels, generate alarms, and schedule waste collection more efficiently.

The literature evaluation emphasizes hardware and software development for IoT-based waste management systems. Microcontrollers like Arduino Uno boards, Ethernet Shields, and Raspberry Pi devices connect sensors and establish internet access. Data transmission to IoT platforms requires MAC, IP, and MQTT settings.

Online dashboards can analyze garbage buildup patterns using ultrasonic sensor data from waste containers. This data helps waste management authorities optimize collection routes and cut costs. IoT-based smart garbage collection monitoring and alert systems can transform waste management. These systems solve garbage collection and disposal problems using sensors, IoT platforms, and real-time data processing. More research is needed on scalability, interoperability, and sustainability to use these systems in varied urban areas.[6]

2.5 Smart garbage management system for a sustainable urban life: An IoT-based application

The development of a smart waste management solution for metropolitan areas integrates an Arduino Uno microcontroller, an identification system, a display system, and a communication system. The researchers created a single Arduino program to control the system's components.

An ultrasonic sensor inside the waste bin also checks the garbage level. The percentage of waste in the bin is measured by monitoring the time between transmitting ultrasonic sound and receiving reflected sound waves. A waste bin LCD displays this information. After waste collection, the lid system is reactivated. The Arduino IDE develops OS-compatible software. The full flow of the system is shown in Figure 2.4.[7]

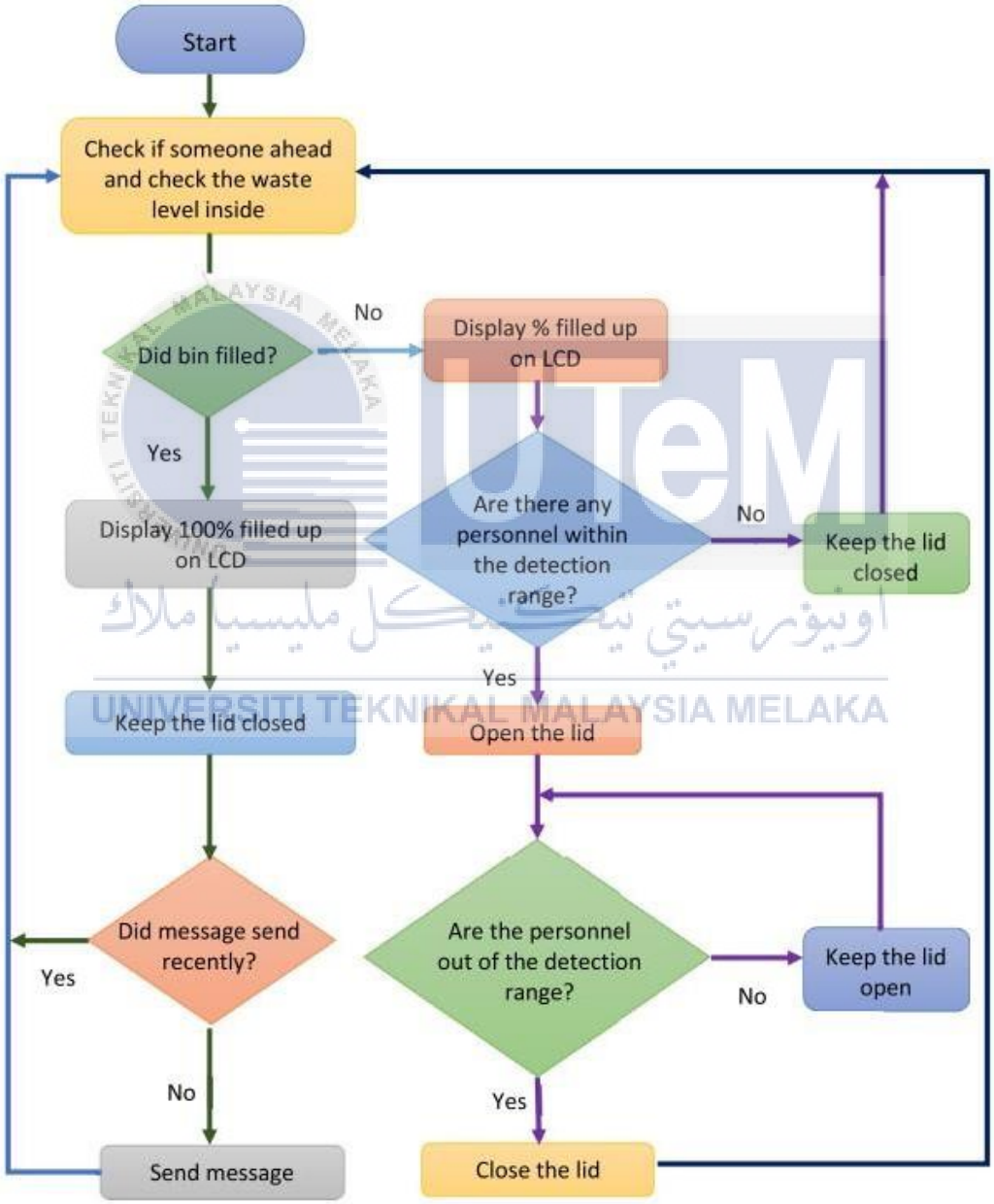

Figure 2.4 Flowchart of the system[7]

A smart waste bin prototype was created and tested under various scenarios. After filling the bin, the waste collection authority received a message. This study uses hardware, software, and testing to prove the smart trash management system's viability and efficacy.[7]

2.6 Smart Garbage Monitoring System using the Internet of Things (IoT)

An Arduino or Raspberry Pi-based trash monitoring system leveraging an open IoT platform offers a cost-effective and efficient waste management solution for modern civilization. The review discusses similar waste management system publications and their methods and findings. Employment of weight sensors to detect trash in dustbins. This research lacked deep- depth information. An infrared (IR) sensor emits invisible light was employed to identify garbage. According to the review, IoT technology in waste management systems allows real- time monitoring and control.

The suggested system uses hardware and software, and the system's architecture is shown in Figure 2.5. Arduino/Raspberry Pi board, ultrasonic sensor, DC motor, and IR sensor. The ultrasonic sensor checks trash depth, while the IR sensor identifies closed people and opens the bin door. IoT modules send data to web servers.

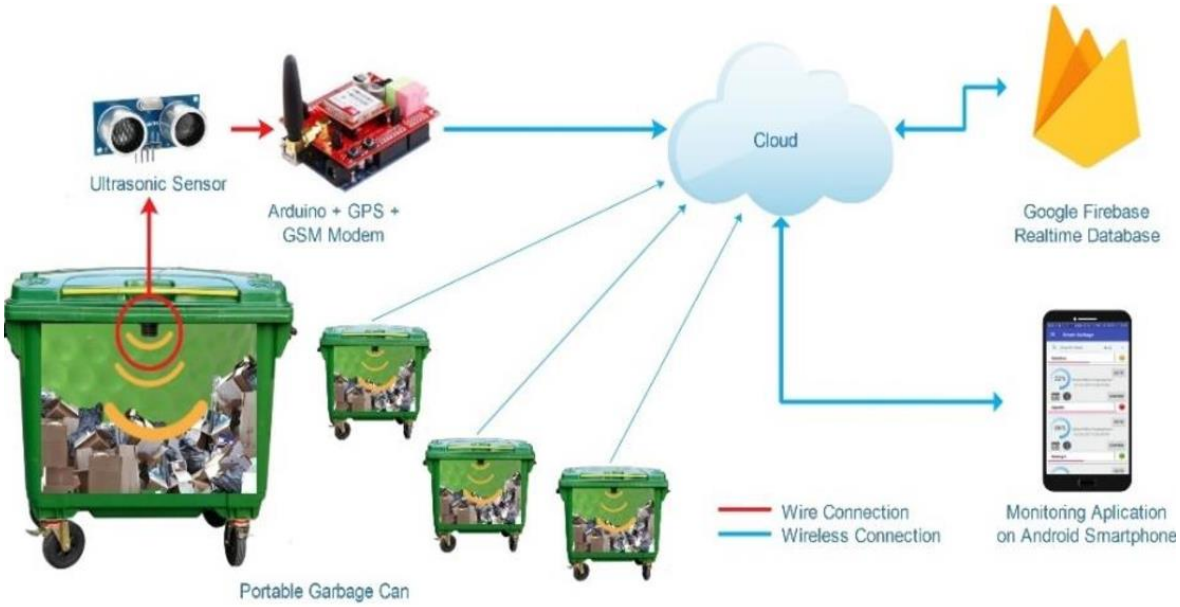

Figure 2.5 IoT-based Smart Garbage Architecture[8]

Using sensor data, one study used Raspberry Pi to track and regulate the industrial environment. A web-based IoT-based waste management control system tracked waste levels, dangerous gas conditions, and bin weight. IoT-based studies visualized garbage levels and directed rubbish pickup. An Android app retrieves and displays bin data, alerting waste management personnel when the bin reaches a threshold. This summarizes an IoT-based waste monitoring system's methodology. It covers hardware integration and IoT data transmission and monitoring. The review discusses related research and its findings. The proposed approach may improve waste management and collection efficiency.[8]

2.7 Application of Firebase in Android App Development

Web applications increasingly use unstructured data like videos, photos, music, text, and files. RDBMS have trouble efficiently managing unstructured data. Firebase, a new

platform, manages vast amounts of unstructured data effectively. Firebase can store JSON data and perform faster than RDBMS, as shown in Table 1.[9]

Firebase lets developers create high-quality apps. It stores data in JSON format as a backend system and database. Firebase Analytics delivers app usage and engagement data. Firebase Cloud Messaging (FCM) supports Android, Web Apps, and iOS messaging and notifications.[10] Firebase Auth allows social login and email/password login.

Table 2.1 Comparison between Firebase and SQL[9]

Basis of comparison	**Firebase**	**SQL(RDBMS)**
Data Storage	Stored as JSONTree	Stored in a Relational Model as Rows and Columns (Tables)
Schema flexibility	Dynamic Schema, data can be added, updated, or deletedanytime	Fixed Schema. Altering willresult in goingoffline temporarily.
Speciality	Data which has no definite type or Structure	Data whose type is known in advance
Technique	Synchronize data	Fire Query

Firebase lets developers create high-quality apps. It stores data in JSON format as a backend system and database. Firebase Analytics delivers app usage and engagement data. Firebase Cloud Messaging (FCM) supports Android, Web Apps, and iOS messaging and notifications.[10] Firebase Auth allows social login and email/password login.

Firebase's Real-time Database synchronizes and stores data on its cloud. Real-time synchronization ensures data updates across devices and platforms. Firebase Storage uses Google Cloud Storage to send app files securely. Developers may store and retrieve photos, audio, video, and user-generated information. Document-model NoSQL database Firebase

is cloud-hosted. It stores and synchronizes user data in real time and is horizontally scalable. Mobile apps benefit from this. Firebase's offline optimization and user-based security enable serverless apps.[11]

Firebase Crash Reporting provides precise error reports and crash analysis, and Firebase Test Lab for Android provides cloud-based infrastructure for testing Android apps. Firebase Notifications let mobile app developers focus on user notifications. An Android app leveraging Firebase's features can demonstrate its capabilities. The program can support user authentication, real-time database updates, and file storage. Firebase's powerful features can enhance Android app development and improve user experience. Google's Firebase mobile app development platform offers several data management capabilities for iOS, Android, and web apps. Create a Firebase project with a real- time database (RTDB) and use your ESP8266 board to store and retrieve values. Firebase lets you construct apps to control the ESP8266 remotely.[12]

Firebase helps web apps manage vast amounts of unstructured data. Firebase outperforms RDBMS with its rapid performance, real-time synchronization, and secure file storage. Developers may easily construct high-quality apps using Firebase's concepts and functionalities. Developers can create unique and efficient apps across platforms as Firebase improves.[13]

2.8 Comparison on the previous related project

Title and Author	Main component	Methodology	Advantage	Disadvantage
Smart Waste Collection Monitoring and Alert System via IoT by Zainal Hisham Che Soh, Mohamad Azeer Al-Hami Husa, Syahrul Afzal Che	Arduino UNO, Ultrasonic sensor, Ubidots cloud	Utilize an ultrasonic sensor connected to Arduino UNO to monitor the waste bin's garbage level. Connect Arduino UNO to an Ethernet Shield to establish an Internet connection. Send waste bin depth-level data to the Ubidots IoT Cloud for storage in an IoT database. Display the waste bin depth level on an online dashboard for real-time visualization.	- Efficient waste management through real-time monitoring of waste bin levels. - Immediate notification alerts to garbage collectors for timely waste collection.	The cost implications for implementing the IoT-based waste monitoring system include hardware and Internet connectivity.

Abdullah, Mohd Affandi Shafie		Set up Ubidots Event Manager to send a notification alert via SMS to the garbage collector's mobile phone when the waste bin is nearly filled.		
Waste Management System Based on IoT by Sapna Suryawanshi, Rohini Bhuse, Megha Gite, Dhanashri Hande	- Arduino UNO - Ultrasonic sensor - GSM module	- Utilize an ultrasonic sensor interfaced with Arduino UNO to measure the level of garbage in the dustbin. - Send an alert signal to the municipal web server when the garbage reaches a certain level. - Verify the task of emptying the garbage using an RFID tag, confirming the completion of the cleaning process.	- Efficient and timely garbage clearance through real-time alerts. - Automatic identification of garbage levels in the dustbin using RFID technology. - Remote monitoring and tracking of the cleaning process,	- Initial setup and integration of the system may require technical expertise. - Dependence on reliable internet connectivity for web server and Android application communication.

		- Integrate an embedded module with RFID and IoT facilitation to support the system. - Develop an Android application linked to a web server for remote monitoring and notification of alerts.	reducing manual effort.	- The cost implications for implementing the smart garbage system include hardware and software components.
Smart Garbage Monitoring System using Internet of Things (IoT) by Prakash Kanade, Dr Jai Prakash Prasad	- Arduino UNO - DC motor - IR sensor	An ultrasonic sensor, IR sensor, DC motor, and IoT technologies monitor and manage dustbin garbage. Ultrasonic sensors measure waste distance, while IR sensors detect adjacent people. The DC motor opens the dustbin based on this information. IoT sends dustbin data, including garbage level and position, to a server for waste disposal.	-Automation and efficiency in trash monitoring -Cost-effective compared to manual methods -Real-time monitoring for effective waste management	- Initial setup and maintenance may require technical expertise. - Reliance on internet connectivity for data transmission.

2.9 Summary

Waste management via the Internet of Things (IoT) can lead to new and improved methods, according to several research. The title "Smart Garbage Monitoring System Using IoT" emphasizes that smart bins may communicate using IoT technology to automatically collect rubbish. Live tracking and warnings prevent garbage can overflows, saving customers and wasting management firms time, effort, and resources. Other studies demonstrate the benefits of IoT-based smart waste management systems that use ultrasonic sensors to assess bin capacity and improve rubbish collection. Mobile apps and simple interfaces simplify tracking and communication in these systems. IoT technology could improve trash collection by providing real-time data and identifying optimal practices. How Firebase can manage unstructured data, real-time database synchronization and secure file storage in Android app development is also discussed. These studies demonstrate how IoT, and similar technologies are overhauling garbage management to make cities cleaner and more efficient.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The first step to making large buildings cleaner and more efficient is installing IoT-based smart trash systems. This inventive solution automates cleaning duties to change garbage pickup and checks. The method relies on IoT-powered bin gadgets strategically placed in trash cans. Using weight and fill level, the sensors assess the bins' fullness. These IoT monitors notify a central control unit immediately when trash reaches a particular quantity. This central control unit receives wireless data from various IoT devices as the system's brain. A warning is given when the control unit detects too much trash. This alerts cleaning staff to empty garbage cans immediately. The system's most crucial components are IoT sensors (which detect weight or fill level), microcontrollers or development boards (like Arduino Uno), wireless connection modules (like NodeMCU ESP8266), central control units, and a warning system. The trash cans must be changed for this plan to function. After these adjustments, adding IoT sensors and ensuring system functionality will be trivial. This smart garbage system uses IoT to do more than gather trash. By making cleaning easier and keeping staff away from filthy areas, it boosts efficiency and preserves their health.

3.2 Choosing and analyzing equipment for sustainable development

Since the equipment that has been used is cheap, it is possible for the project to achieve long-term cost savings by investing in such equipment. These cost reductions can be achieved through lower energy and operational expenses, which is consistent with the ideals of sustainable development. Social aspects of development included in sustainable development are things like the health of individuals and communities. The project can uphold social responsibility standards by selecting equipment that supports fair labor practices, and ethical sourcing. This ensures that the project will have a beneficial impact on the individuals who participate in the project's creation.

3.3 Methodology

A real-time database, hardware, and software comprise the system. I connected an Arduino Uno, ultrasonic sensor, and NodeMCU esp8266 wifi module. The tools will go under the bin lid. Ultrasonic sensors gather up rubbish first. The ESP will receive the percentage next. The NodeCU will then read the data it planned to send to Firebase, a real-time database. Firebase percentages are sent to the console. I constructed an app using Flutter as the main interface. It retrieves Firebase percentage data and display it in the percentage bar. I set Firebase's alert level at 80% and wrote "Almost full!" when it reached it. A warning will show when the number reaches danger. Finally, I created a button that prints the timestamp in a box in the app and in Firebase when the trash can is empty.

3.4 Elaboration of the Process Flow

The smart garbage system works well when the hardware is set up carefully and the steps are clearly laid out. The block diagram and outline below show the system's main parts and the steps that need to be taken for it to work.

3.4.1 Block Diagram of the Smart Garbage System

Firstly, the hardware setup is all about carefully connecting and setting up the parts. With its built-in ultrasonic sensors, the Arduino Uno correctly measures how much trash is in the bins. Firebase is the central storage hub that makes it easier to store and get real-time garbage load info. This flow of data is controlled by the ESP8266 module, which uses Wi-Fi to quickly send data from the Arduino Uno to Firebase. An advanced threshold monitoring method is now used by the system. This method sends out alerts when the amount of trash goes over certain limits.

The first smart garbage system that monitored a single bin was successfully set up. To add a second system, the hardware setup must be copied, and the software architecture must be changed so that it can monitor a second bin within the same database and application framework. By using the same set of Arduino Uno, ultrasonic sensors, ESP8266 modules, and other parts, the second bin is added to the current setup. Firebase's system database infrastructure has been expanded to handle data streams from the newly added bin. This makes sure that the new bin is seamlessly integrated while keeping separate data records in the shared database. Along these lines, changes are made to the Android app to make its interface better so that monitoring and control tools for the second bin can be added without any problems. This systematic method is designed to successfully control garbage levels by

using sensor data, real-time transmission, and careful improvement of alert systems. This will improve the efficiency of garbage control in waste management practices in the long run.

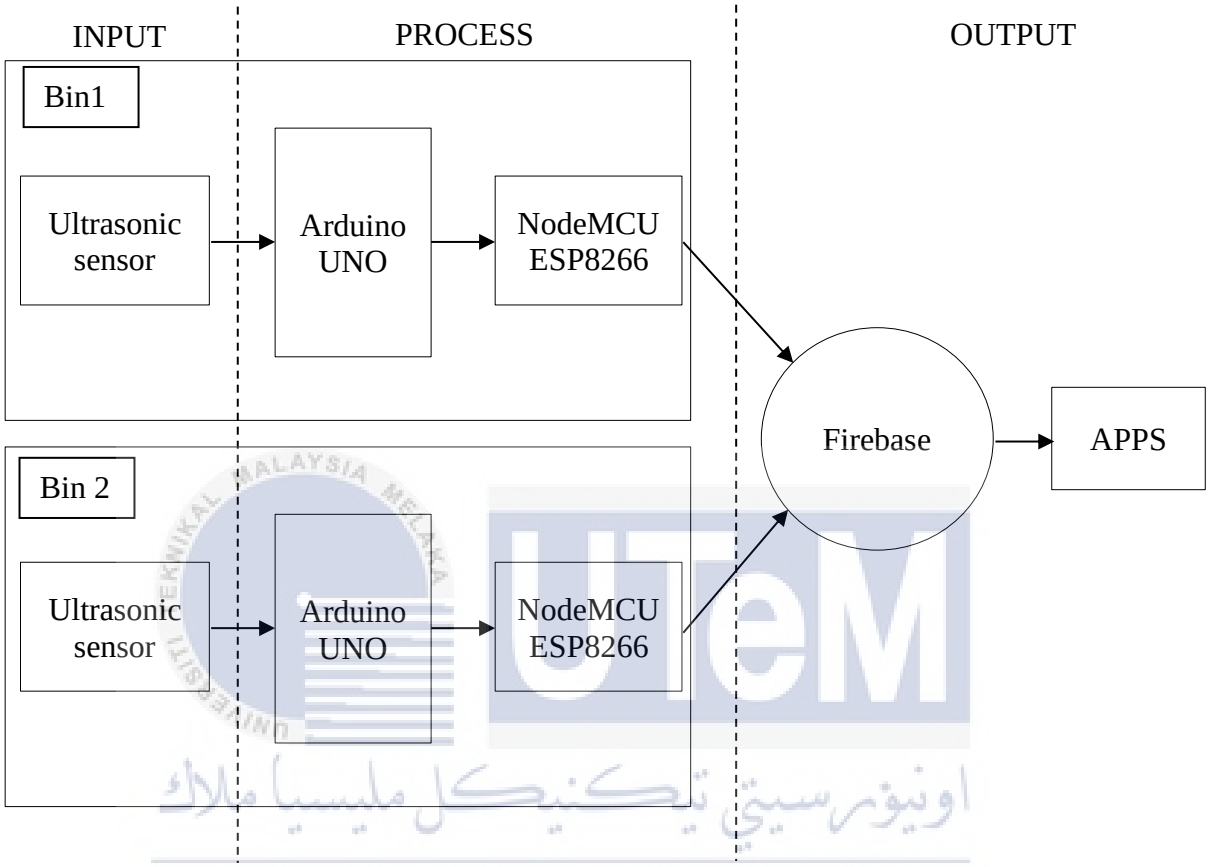

Figure 3.1 Block Diagram

3.4.2 Flowchart of the Smart Garbage System

The work flow of the flowchart in Figure 3.2:

1. Firstly, when people throw the rubbish in the bin, the sensor will detect the percentage of the garbage load in the bin.
2. Next, the percentage will be sent to Firebase and in real-time, the Smart Bin app will read the data from Firebase.

3. If the load is hitting the threshold limit which is at 80%, it will trigger the notification on the app. Then, the cleaner will collect the garbage.
4. If the load is still not hitting the threshold, the system will return until the percentage is hitting the threshold.

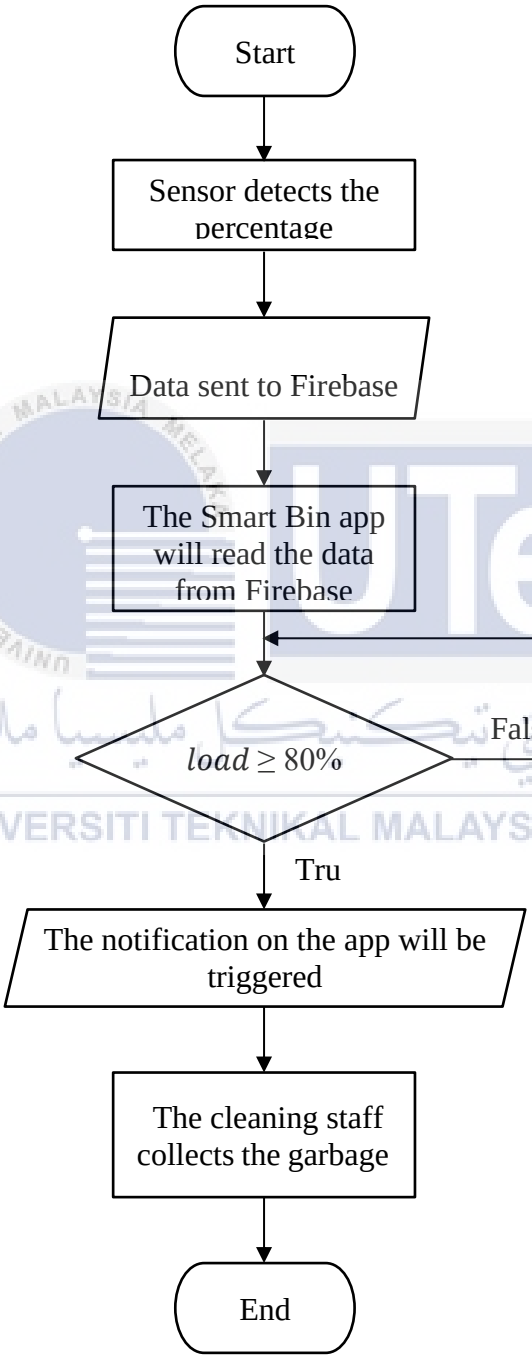

Figure 3.2 Flowchart

3.5 Equipment Requirements

In the development of the smart garbage system for tall buildings, careful consideration and selection of appropriate hardware components are pivotal to the system's efficiency and functionality. This part lists the most important pieces of tools that the system needs to work properly. The main microprocessor is an Arduino Uno, which works with an ultrasonic sensor and a NodeMCU ESP8266 Wi-Fi module to make up the hardware backbone. Each part's unique role in finding the trash level and sending data will be explained, giving you a better idea of how the system is put together. Technical specifications and deployment strategies will also be talked about so that everyone has a full idea of the equipment that is needed for the smart garbage system to work.

3.5.1 Hardware equipment

Table 3.1 Hardware Equipment

No.	Components	Quantity	Descriptions
1.	Arduino UNO 	2	The Arduino Uno is the main microcontroller used in this project, responsible for data processing and controlling sensor integration.[14]
2.	Ultrasonic Sensor 	2	The ultrasonic sensor in this project works by emitting sound waves and measuring the time it takes for the waves to bounce back, providing distance data.[15]

3.	NodeMCU ESP8266 	2	The NodeMCU ESP8266 module is the communication bridge between the Arduino Uno and the Firebase database, enabling wireless data transmission.
4.	9v battery 	1	The 9v battery is to provide a power supply to the system.

Hardware setup: Connect the Arduino Uno, the ESP8266 and the ultrasonic sensor using the pin configurations specific to each component. Make that the power supply and connections are in working order.

Ultrasonic Sensor and Arduino UNO Integration: Programming the Arduino Uno as the microcontroller to read data from the ultrasonic sensor is the first step in integrating the ultrasonic sensor. The ultrasonic sensor determines the distance from its current position to the next level of waste in the container. This data will be used to calculate the amount of waste that has accumulated.

Integration of ESP8266 and Firebase: This involves setting up the ESP8266 to make a Wi-Fi connection and communicate with the Firebase platform. The garbage load data will be stored in Firebase, and it may be retrieved via that service. Establish the required rules and authentication for your Firebase database.[16]

Transmission of Data: Write some code on the Arduino Uno to transmit the trash load data to the ESP8266 module. After that, the ESP8266 will send this information to the database maintained by Firebase.

Threshold Monitoring and Alert System: Implementing a threshold limit in the Arduino code is the first step in creating a threshold monitoring and alert system. If the garbage load exceeds the threshold, the ESP8266 should activate an alert system. This can be accomplished by sending a notification to a predetermined device or using a service that sends emails or text messages.

Testing and Improvement: Validate the system by placing rubbish in the bin and seeing the data updates on the application and Firebase. This will ensure that the system works as intended. Adjust the threshold limits and the warning mechanism so that they are optimal based on the results of the tests.

3.5.2 Software equipments

Programming and transferring code to Arduino boards may be easily done using the Arduino IDE (Figure 3.3), an integrated development environment. This feature makes developing code using the Arduino programming language, which is based on C/C++, easier.[17] After completing the coding task, the programme can be checked for bugs before being uploaded to the Arduino board. The IDE is equipped with the Serial Monitor tool, which allows for real-time communication and output monitoring. It provides a basic and user-friendly environment for creating and uploading programmes, making it an important tool for working on Arduino projects.

Figure 3.3 Arduino IDE

Next, Flutter app as shown in Figure 3.4 is a key part of the smart garbage system that makes it easy to work with and control. The way it works lets users, especially cleaning staff, see real-time information about how full and what state garbage bins are in. The app shows correct data from the IoT-enabled bins thanks to Firebase integration, which makes tracking easier.[18]

In addition, the app's alerting system is an important part of the waste management system. It quickly warns staff when garbage levels rise above certain levels, which improves collection schedules and cuts down on trips to bins that are only partially full. This improved communication makes the project's trash management more efficient, which is in line with its goal of using technology to bring garbage control up to date and make it work better.[19]

Figure 3.4 Flutter dev software

3.6 Summary

IoT-based smart waste systems improve cleanliness and efficiency in tall buildings. IoT-enabled bin sensors automate waste monitoring, saving cleaners time. Bin emptying is triggered by central control unit notifications when limits are exceeded. Accurate IoT sensors, Arduino Uno microcontrollers, NodeMCU ESP8266 wireless modules, central control units, and alarm systems are essential.

To monitor a second bin, hardware replication and software adjustments are needed. Thorough testing ensures dual-bin synchronization. Setup requires careful Arduino Uno wiring and ultrasonic sensor integration. The ESP8266 communicates with Firebase to improve trash collection via threshold alarms. Arduino Uno, ultrasonic devices, 9V battery, and NodeMCU ESP8266 are needed. Arduino IDE programming with Flutter app real-time monitoring and alarms improve trash management efficiency and personnel safety.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

The goal of the smart garbage system project was to make the tall building cleaner and more efficient. The information will display how well the system checks and records bin waste. It will show how well the Arduino Uno can read data from an ultrasonic sensor and show it on the Firebase. When the NodeMCU ESP8266 is used as a Wi-Fi module to connect hardware to the cloud, it works well with the Arduino Uno. You can send and receive data with this connection, which makes it easier to connect to Firebase. I also made a custom game with the flexible Flutter software to go with this hardware framework. This app was made to help cleaning staff figure out the best times to pick up the trash by giving them real-time information. This app makes sure that messages are sent correctly and on time by working well with hardware that you already have. For colleges, the way they deal with waste is about to change because of how hardware and software work together. The project's outcomes will display how well the smart waste system works, its flaws, and its potential in college situations.

4.2 Results and Analysis

A smart garbage system was created using hardware system of Arduino Uno and ultrasonic sensors. In data collecting and visualization, the hardware components work well. Ultrasonic sensors measured waste levels accurately. The Arduino Uno processed and displayed data well. Then NodeMCU ESP8266 will read the data from Arduino UNO. Later project stages will discuss these enhancement options. The threshold monitoring system

informs when the garbage load exceeds restrictions due to software programming. Then, NodeMCU ESP8266 will sent the received data to realtime database Firebase.

The created app is an important part of improving waste management because it lets cleaning staff know in real time when trash needs to be picked up. This app should be functioning finely thanks to its easy-to-understand interface, which was carefully designed using Flutter software. It sends important notifications straight to cleaners. Its main job is to check how full the bin is, and when it reaches a certain amount, usually set at 80%, the app sends one of several automated notifications. These alerts go off right away, telling cleaning staff to start collecting trash right away. This makes sure that the bins are filled before they get full. This proactive approach, made possible by the app's quick and accurate notifications, makes the trash collection process much easier, which improves the general efficiency and cleanliness of the tall building grounds.

Table 4.1 Description of the smart garbage system

Length of garbage bin (prototype)	25cm / 10L
0% Load	25cm
50% Load	14cm
80% Load	5cm

In Figure 4.1 shows full image of the bin used. There are three testing made, for 0%, 50% and 80%. In Figure 4.2, it show connection between the hardwares which is, the

Arduino Uno, as the microcontroller connected to NodeMCU ESP8266 as the wifi module and the ultrasonic sensor as the sensor to detect the garbage load. Lastly, for Figure 4.3, it show the placement of the setup of the hardware which is under the bin lid.

Figure 4.1 Full bin image

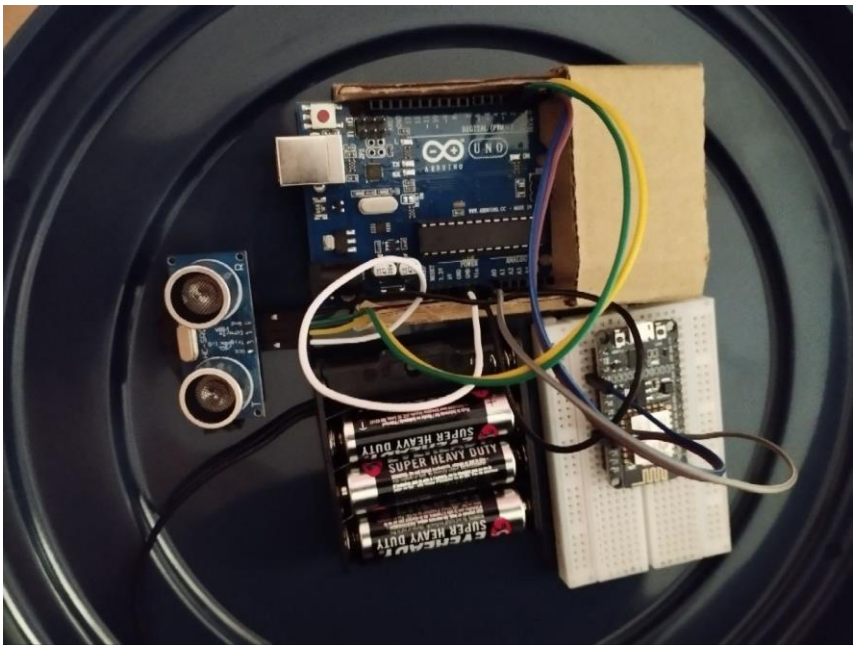

Figure 4.3 Hardware connections

Figure 4.2 Hardware placement

4.2.1 Accuracy reading when the bin is empty. (set as 25cm / 0% ± 2%)

The table 4.2 presents the results of accuracy readings obtained during assessments conducted on an empty bin, set with a target range of 25cm/ 0% ±2%. The readings were taken ten times to evaluate the precision of the system. The data showcases a notable division between accurate and inaccurate measurements as shown in graph in Figure 4.4. Fifty percent (50%) of the readings yielded an accuracy of 0%, aligning perfectly within the specified range, indicating precise distance measurements when the bin was empty. However, the remaining 50% of the readings displayed deviations from the expected accuracy range. These readings ranged from 3% to 5%, signifying slight discrepancies in distance measurements, therefore classified as inaccurate. The consistent occurrence of accurate readings (0%) showcases the system's reliability in producing precise measurements, yet the presence of deviations in the other half of the data shows the need for further assessment and potential calibration to improve overall accuracy.

Table 4.2 Empty bin reading

Reading	Accuracy Range	Description
1	0%	Accurate
2	0%	Accurate
3	0%	Accurate
4	0%	Accurate
5	0%	Accurate
6	3%	Inaccurate
7	4%	Inaccurate
8	4%	Inaccurate
9	5%	Inaccurate
10	5%	Inaccurate

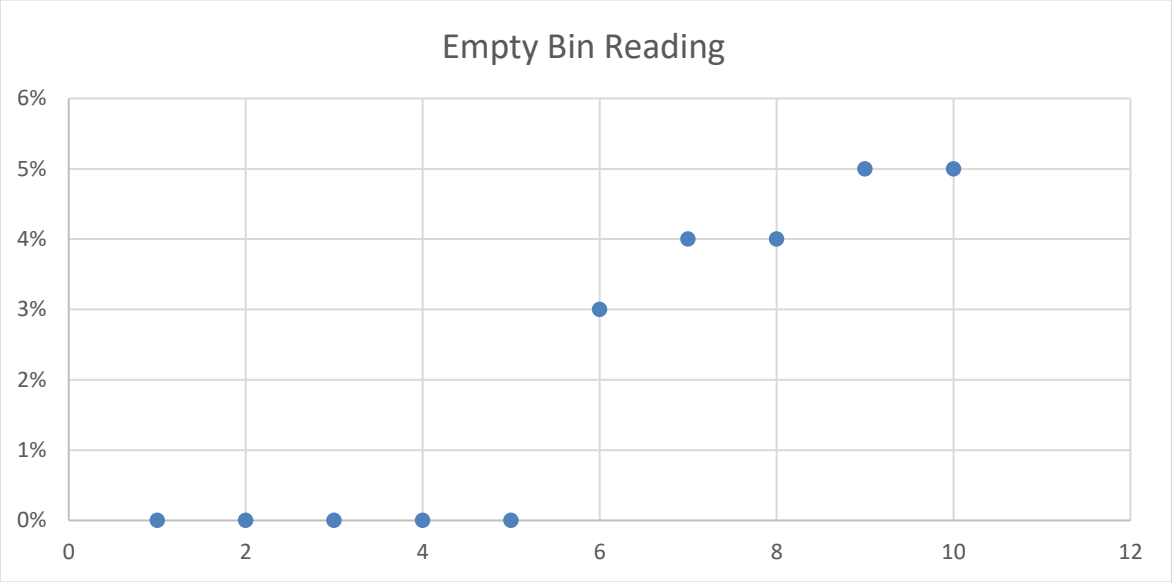

Figure 4.4 Graph for empty bin reading

4.2.2 Accuracy reading when the bin is half full. (set as 12cm/48%±2%)

Table 4.3 shows ten recorded readings of percentage levels that show how much the bin may contain when it's half full (set at 12 cm/48% ±2%). These numbers came from measuring the system and then analyzing the data. The readings for the percentages go from 43% to 57% as shown in Figure 4.5. The requirements for evaluating accuracy were set between 46% and 50%, the range for accurate measurements. Out of the ten readings, six were within this range, showing accurate results within the expected range. In the table, these numbers range from 46% to 50% and are marked as "Accurate.". On the other hand, four readings, ranging from 43% to 57%, were not within the acceptable precision range. The measures in this group are marked as "Not Accurate," meaning the system's readings did not meet the expected accuracy standards.

Table 4.3 Half Full bin Reading

Reading	Accuracy Range	Description
1	43%	Not Accurate
2	45%	Not Accurate
3	46%	Accurate
4	47%	Accurate
5	47%	Accurate
6	48%	Accurate
7	48%	Accurate
8	50%	Accurate
9	53%	Not Accurate
10	57%	Not Accurate

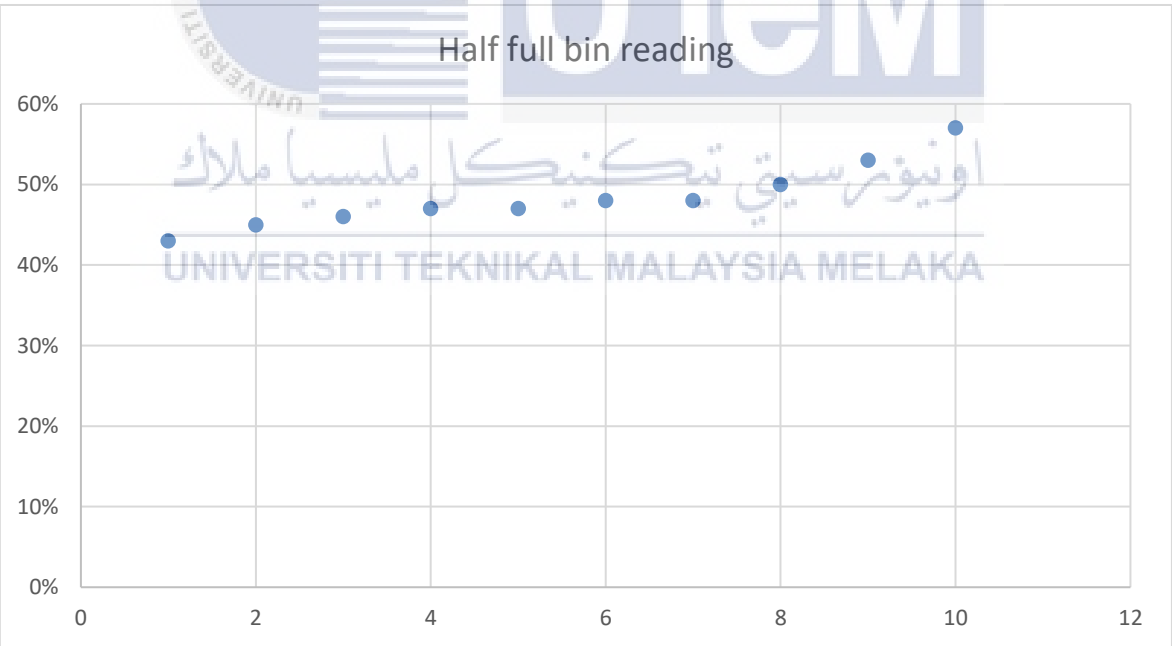

Figure 4.5 Graph for half full bin

4.2.3 Accuracy reading when the bin is almost full. (set as 5cm/80%±2%)

As part of testing how well the system can figure out how full bins are, several tests were used to get accurate readings in table 4.4. The accuracy percentage for ten separate tests is shown in each row of the table, which corresponds to a different number. The success rates that have been recorded are between 75% and 85%. Based on the set criteria, these readings have been put into groups. An exact measurement within the range of 78% to 82% means that the bins are almost full. According to this standard, measurements that are very close to meeting the expected accuracy standards are considered "Accurate" as shown in Figure 4.6. These measurements have values of 78%, 80%, or 81%. Instead, numbers that are outside of this range have been marked as "Not Accurate," which includes values of 75%, 77%, 83%, and 85%. Putting the data in ascending order makes it easier to see how the system's accuracy changed during these tests, which helps us understand how well it works at accurately figuring out the bins' fullness.

Table 4.4 Full bin reading

Reading	Accuracy Range	Description
1	75%	Not Accurate
2	77%	Not Accurate
3	78%	Accurate
4	78%	Accurate
5	78%	Accurate
6	80%	Accurate
7	80%	Accurate
8	81%	Accurate
9	83%	Not Accurate
10	85%	Not Accurate

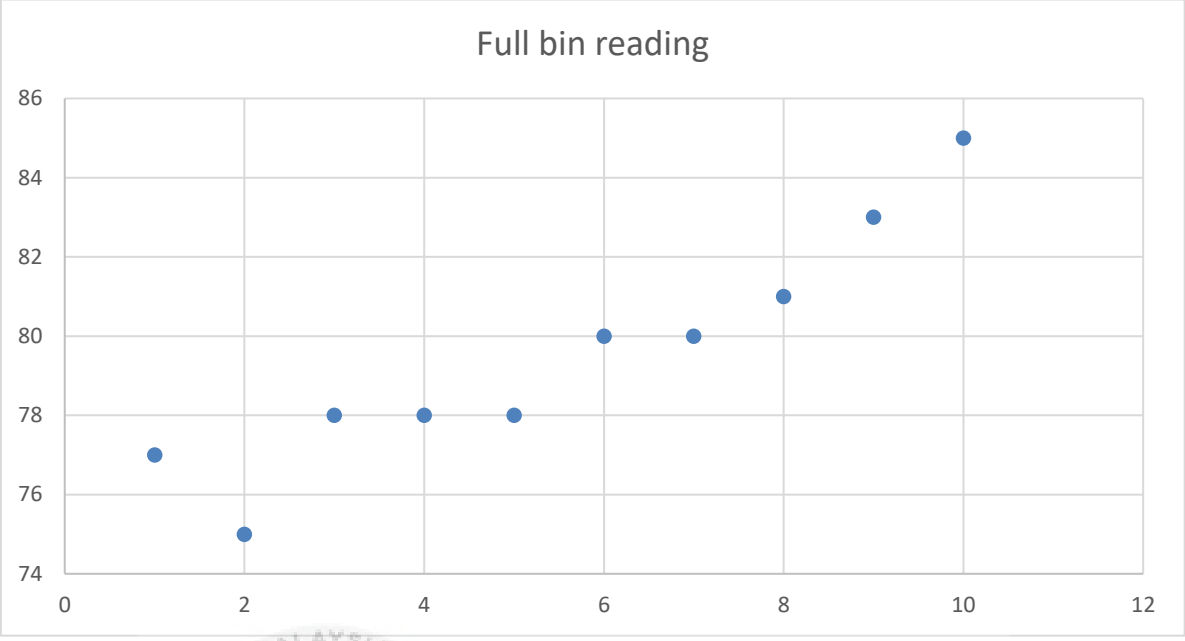

Figure 4.6 Graph for full bin

4.2.4 Firebase setup for smart bin database

Since the project needs to send and sync data in real time, Firebase connects the hardware infrastructure (which includes the Arduino Uno, ultrasonic sensors, and the NodeMCU ESP8266) to the application that users see. Firebase is a cloud-based service that lets you send and receive data in a safe and scalable way as shown in Figure 4.7. L1 is the name of the first bin and L2 is the name of the second bin. It will show the percentage under the name of each bin. To be more specific, it lets the hardware send the data about the amount of filling in the bins to the cloud in real time. The developed app then gets to this info and processes it. The app uses Firebase to send commands and notifications back to the hardware, which does things like sending cleaners alerts when trash cans hit 80% of its load that needs to be picked up.

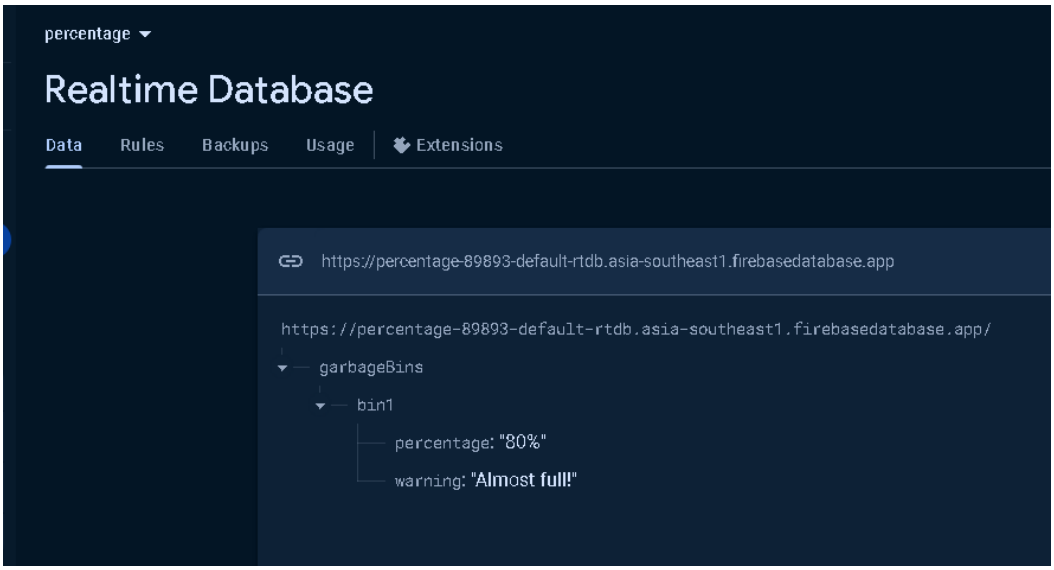

Figure 4.7 Firebase setup

4.2.5 Application interface (GUI)

The layout of the app shows a list of trash cans as shown in Figure 4.8 along with their current fill percentages as shown in Figure 4.9. This lets you see in real time how much trash is in each bin. Because the app is easy to use and works with the hardware infrastructure without any problems, these percentages are always being updated based on information sent by sensors connected to the bins. The app sends out instant alerts as the fill level gets close to a predefined threshold, which is set at 80%. These alerts are sent to the cleaning staff to let them know which bins need attention and to make sure that the trash is picked up on time. Cleaning staff can use the app's easy-to-use interface, ability to show the current state of multiple bins, and notification system to get useful information. This makes strategic trash management easier and makes sure that bins are emptied quickly as they get close to full. In the end, the Flutter app is a key part of making a high-building in-trash collection more efficient by providing real-time tracking and timely alerts that speed up the cleaning process.[20]

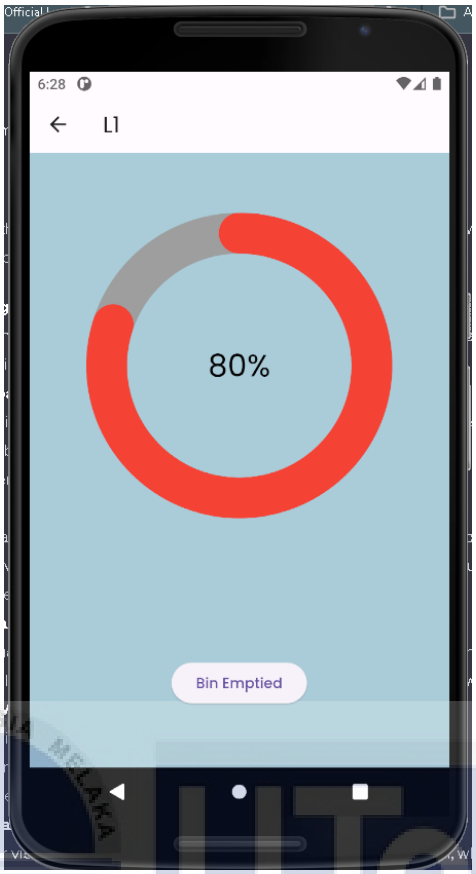

Figure 4.8 Percentage bar page

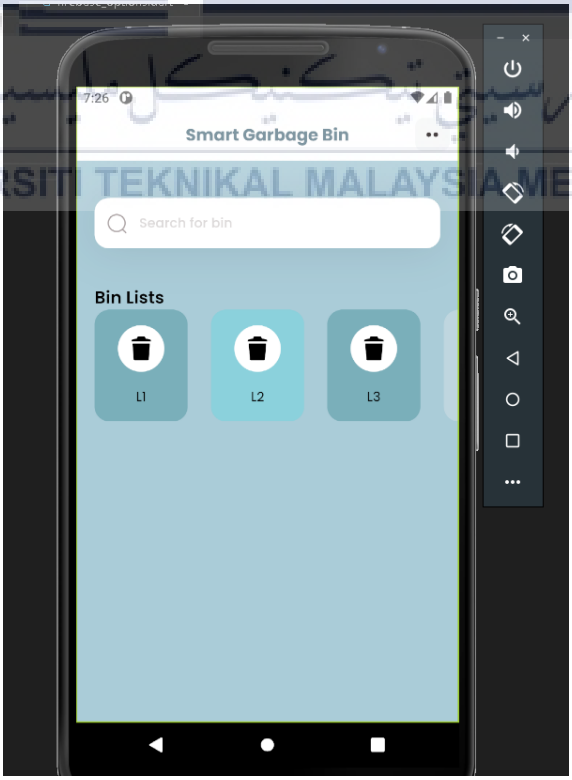

Figure 4.9 The main page of the app

4.3 Summary

The Arduino Uno,NodeMCU ESP8266 and ultrasonic sensors included in the smart waste system project were successfully implemented, allowing for accurate measurement of garbage load. This project for managing trash uses tools like Arduino Uno, ultrasonic sensors, and NodeMCU ESP8266 to check how full trash cans are. All these parts talk to a simple Flutter app through Firebase, which lets the system interact. In real-time, this app shows how many different trash cans are in the building and works as a central dashboard. The app tells the cleaning staff when bins get close to the 80% level that was set by the system. With these alerts, trash is picked up on time, making the school more efficient and cleaner. Firebase is the foundation; it makes it easy for hardware and software to share data, for accurate and fast alerts to be sent, and for proactive waste management to be possible. By giving useful information for better trash collection, this all-around method makes universities cleaner.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The implementation of IoT-based smart garbage systems marks a significant leap in enhancing cleanliness and operational efficacy within tall buildings. This creative project adds automation to the usual ways of dealing with trash, which makes jobs that were previously done by cleaning staff easier. Using Internet of Things (IoT)-enabled bin sensors and a central control unit, the system correctly tracks the amount of trash in bins and sends out timely alerts when limits are crossed, which improves how often trash is collected. The system works well thanks to important parts like exact IoT sensors, microcontrollers, wireless modules, and alert systems.

The project's dedication to sustainability is shown by its use of low-cost tools and fair procurement, which is in line with social responsibility standards. The approach describes a step-by-step process that includes setting up hardware, sending data, and keeping an eye on thresholds. Careful calibration and testing make sure that the garbage control is accurate. The addition of a second bin for monitoring within the same framework shows how flexible and scalable the system is. Real-time data transmission and effective warning systems make it possible for hardware and software to work together without any problems. This is a big step forward in the efficiency of waste management.[21] This project shows how IoT technology can change things for the better by making trash management much better and focusing on sustainability, efficiency, and the health and safety of cleaning staff.

5.2 Future Works

This is some of recommendations for future works that could be done:

i) **Integration with Smart City Initiatives:** Work with smart city projects to connect the trash collection system to a bigger smart infrastructure. This will make cities smarter and more efficient.

ii) **Machine Learning Integration:** Use machine learning methods to guess how garbage will build up, which will help you make the best decisions about when to collect it and how to use your resources. This could boost productivity by predicting times when there will be a lot of trash and making the best use of cleaning schedules.

iii) **Advanced Sensor Integration:** For more accurate and complete data collection, look into and use more advanced sensors or technologies that offer extra metrics for garbage tracking. For example, image-based recognition systems or AI-driven sensors can help.

iv) **Smart Routing and Collection Optimization:** Create algorithms that use real-time data to find the best pickup routes for cleaning staff, so that they spend the least amount of time and gas and get the most out of the bins.

v) **Sustainability Analysis:** Do an environmental impact assessment to figure out how much the system will help with reducing waste, saving energy, and being environmentally friendly overall. This will give you useful information for making changes and expanding the system in the future.

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APPENDICES

Appendix A Gantt chart for BDP2

No.	Activities	week 1	week 2	week 3	week 4	week 5	week 6	week 7		week 8	week 9	week10	week 11	week 12	week 13	week 14
1	Made an adjustment based on panel suggestions								M							
2	Brainstorming idea for the application								I							
3	Finishing the harware prototype								D							
4	Meeting with supervisor								S							
5	Discuss the project's analysis with supervisor								E							
6	Do the claim form submission for PSM								M							
7	Collect the data analysis															
8	Do a final test on the system								B							
9	Do the report writing based on BDP2 template								R							
10	submit PSM2 report draft to supervisor								E							
11	do a preparation for the PSM2 presentation								A							
12	Submit PSM2 Report and Logbook								K							

Appendix B Bill of Materials (BOM)

No.	Item	Description	Item Quantity (pcs)	Cost
1.	Arduino UNO +usb	Arduino UNO R3 Atmel Atmega328p	2	RM79.80
2.	Wi-Fi module	NodeMCU ESP8266	2	RM29.80
3.	Ultrasonic Sensor	HC-SR04	2	RM6.40
4.	Battery	Energizer battery 9v	1	RM12.50
5	Dustbin	SDB365 (10L)	1	RM20.00
Total				RM148.50