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I confirm that I understand my coursework needs to be submitted online via Google Classroom under the relevant module page before the deadline in order for my assignment to be accepted and marked. I am fully aware that late submissions will be treated as non-submission and a mark of zero will be awarded.

Acknowledgment

First and foremost, we would like to express our sincere gratitude to our module leaders Mr. Sugat Man Shakya and Mr. Shishir Subedi for providing us with their assistance in helping us construct this IOT project of a smart dustbin by sharing their knowledge and offering advice. The support they provided has been invaluable for our group and we are grateful to them for providing us with the time and effort which motivated us to complete our work.

Secondly, we also want to express our gratitude towards Islington College and London Metropolitan University for providing us with this golden opportunity for completing the coursework on the subject “Cloud Computing and the Internet Of Things” and also would like to thank our colleagues and seniors for their help and suggestions, which allowed us to collaborate effectively as a team and gain new concepts and ideas that allowed us to finalize this project within the limited time frame.

Abstract

The goal of the Smart Dustbin project is to make managing waste disposal more efficient and less manual. Two ultrasonic sensors are used in the project, one to measure the amount of trash within the bin and the other to detect the presence of an object in front of the trash can. When someone approaches the trash can, the external sensor sends a signal to the Arduino board, activating the servo motor and opening the lid. An ESP8266 WiFi module is used to transmit data from the internal sensor, which measures the trash level, to the cloud computing platform ThingSpeak. To identify consumption trends and improve waste management tactics, the data generated can be evaluated. Additionally, a buzzer is used to notify the user when the trash level exceeds a predetermined level. Waste management could be revolutionized by the Smart Dustbin concept, making it more effective, practical, and environmentally beneficial.

Table of Contents

List of Figures

List of Tables

1. Introduction

Waste management refers to the process of collecting, transporting, handling, and disposing of human waste as a whole. In general, waste management encompasses all aspects of human waste, including waste minimization or reduction (Safeopedia, 2018).

The volume of waste produced is continuously increasing, and waste management is a crucial component of contemporary civilization. As the population grows, so does the amount of waste in urban areas. Using IOT and sensor-based circuitry, a smart IoT dustbin that runs automatically assists in resolving this issue. Ordinary trash cans must be opened by pressing the foot against the lever and then thrown away. A person must also keep track of when it is full so that it may be emptied and not overflow. The Smart Dustbin IoT project is one of the new technologies being created to simplify waste management procedures to address this issue. The major goal of this project is the development of a waste management system that would be more effective and efficient with the usage of cloud computing technology which will be reliable for storing the data and information (NevonProjects, 2020).

Smart IoT dustbins are an ultimate solution that uses the Internet of Things (IoT) and cloud computing to deliver and store real-time waste management data and information in the cloud and also can be monitored remotely. Such dustbins are installed with two sensors, one that can measure the amount of trash in the bin and inform the users via notifications, and another one collects the data and sends it to a cloud-based platform for analysis and storing also where the users are notified through a web application 'ThingSpeak' which is a platform solution for IoT analytics that allows you to gather, visualize, and analyze live data streams (ThingSpeak, 2023). Smart Dustbin includes hardware components such as Arduino, ESP8266 wifi module, Servo Motor, and Ultrasonic sensors. These components assist in opening the lid, detecting human hands and waste, and providing visual feedback with the use of LED lights. The code needed to conduct the aforementioned action is loaded into Arduino UNO, a microcontroller. Also, the proposed solution for this smart dustbin is to employ a Wi-Fi module, which is more advantageous than a GSM module. Hence, Waste collection schedules and routes can thus be improved, waste overflow reduced, and overall waste management effectiveness increased.

Figure 1: Our prototype at the initial phase

This project focuses on employing cloud computing to store and examine the information gathered by smart dustbins. For managing enormous amounts of data, cloud computing provides a scalable and economical alternative. The waste management system can analyze data gathered by smart dustbins fast and effectively utilize cloud-based analytics to produce insights and improve waste management procedures (Maddileti & Kurakula, 2020).

Therefore, the Smart Dustbin IoT project has the potential to completely transform trash management by delivering real-time data and insights that can help optimize waste collection and lessen environmental impact.

2. Background

System Overview:

Smart Dustbin with a notification system IoT project is a smart waste management solution designed to address the challenges faced by municipalities and other waste management organizations. The project aims to provide a more efficient and effective way of managing waste by using IoT technology to monitor and optimize waste collection and disposal processes.

The goal of the project is to develop a smart trash that can recognize when it is full and alert the waste management team to come to pick it up. A signal is sent to the waste management team by the dustbin's sensors, which track the amount of rubbish inside it and alert them when it hits a set threshold. This ensures that the trash can is routinely emptied, preventing overflow and the resulting hygienic and environmental problems.

Design diagram:

Flowcharts:

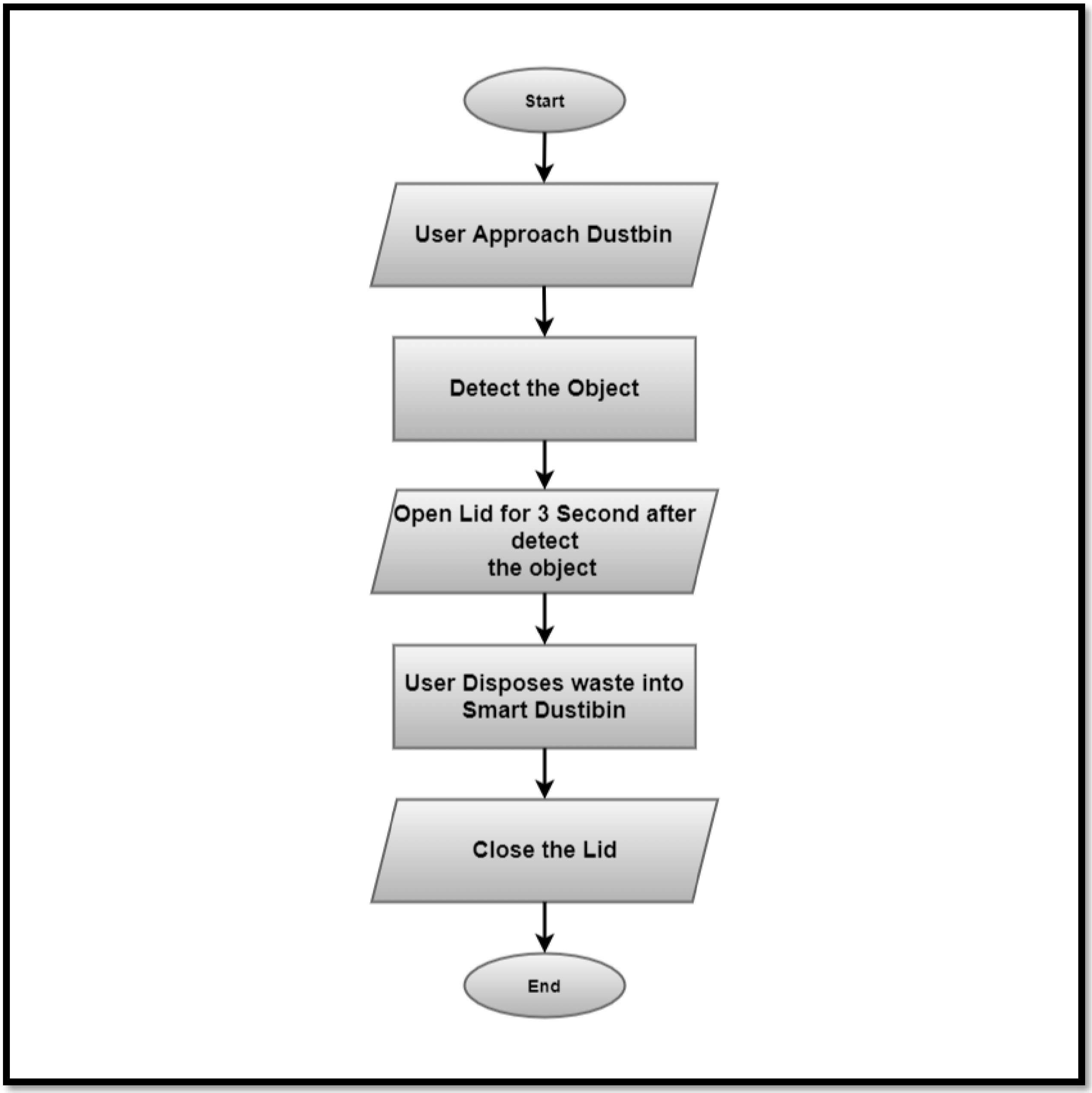

Figure 2: Flowchart to open and close the dustbin lid

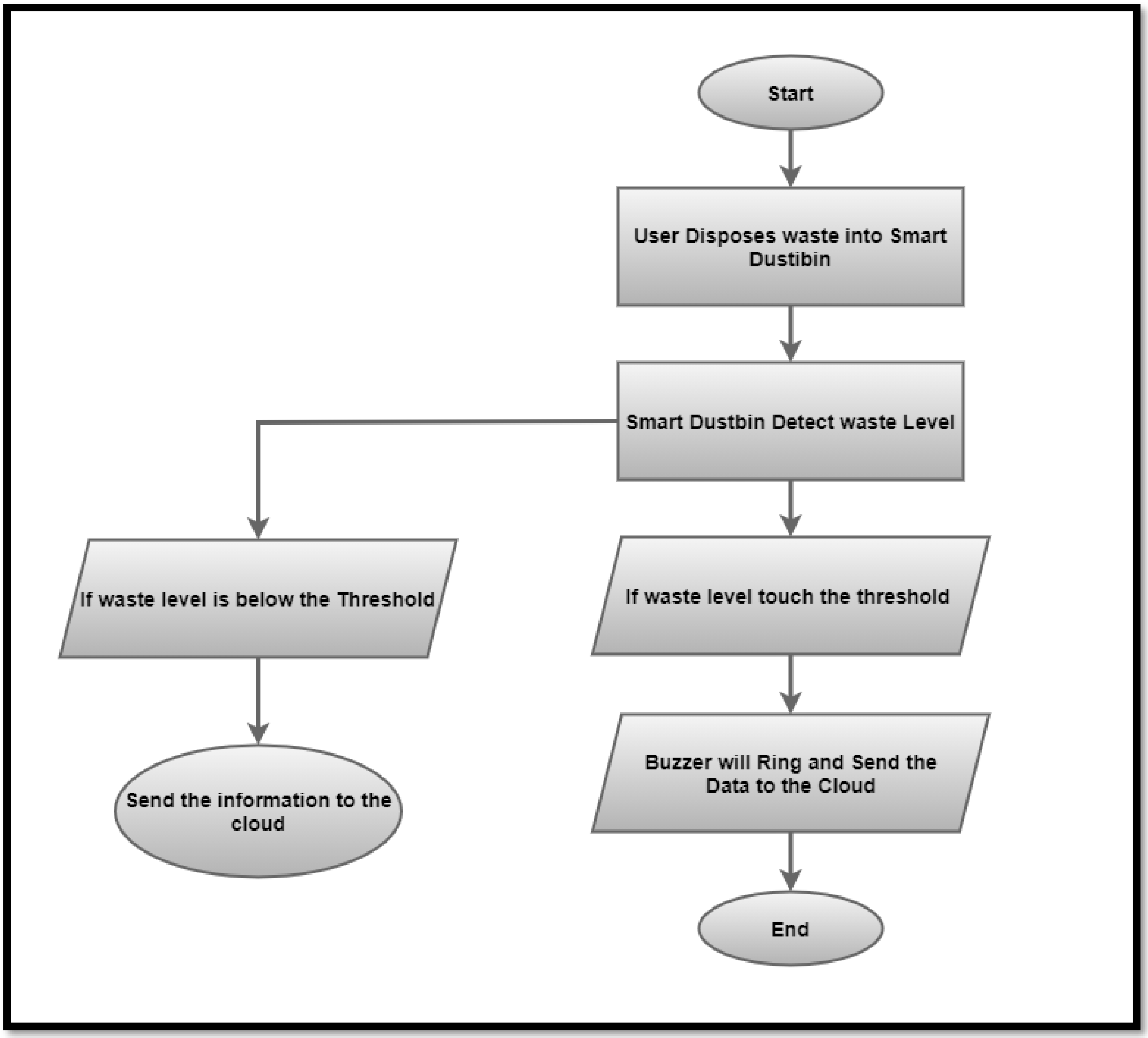

Figure 3: Flowchart to send data to the cloud

Circuit Diagrams:

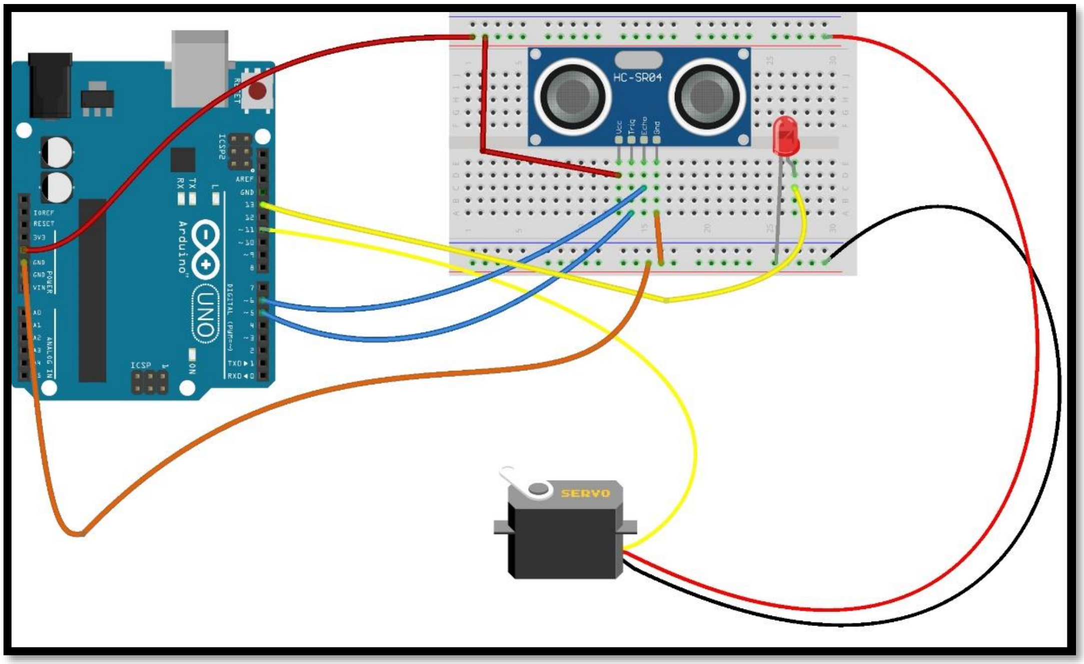

Figure 4: Circuit diagram for opening and closing the lid

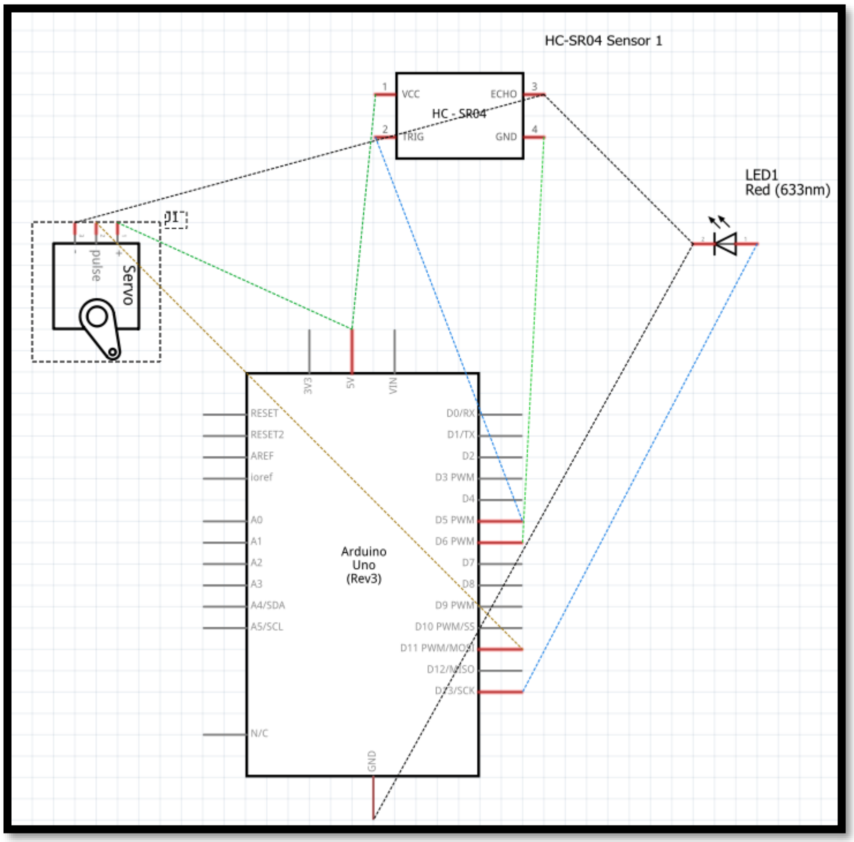

Figure 5: Actual representation of circuit diagram to open/close the lid

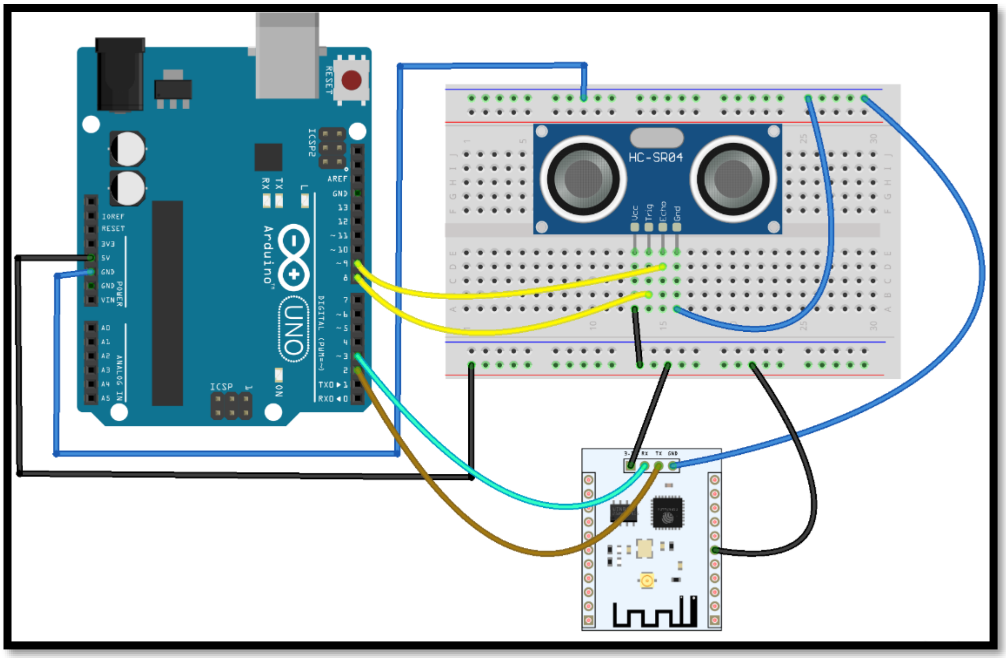

Figure 6: Circuit diagram to send data to the cloud

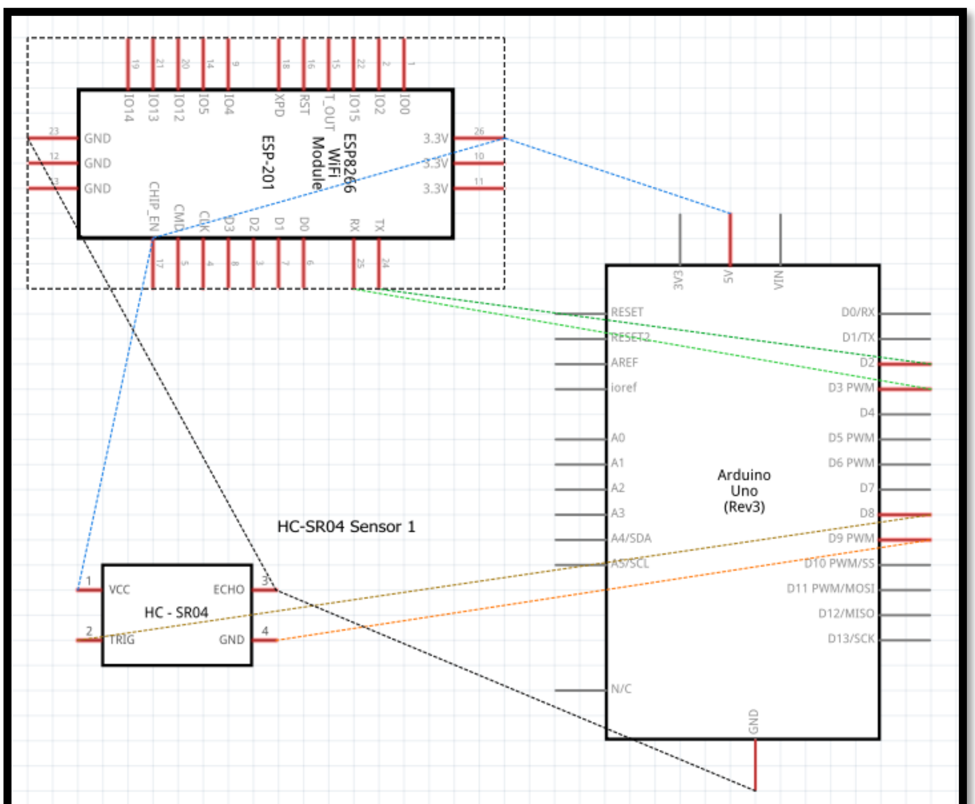

Figure 7:Actual representation of circuit diagram to send data to the cloud

Requirement Analysis:

Hardware:

- Arduino Uno: The Arduino Uno is a board that is available for public use and has been designed to include a microcontroller which is essentially a circuit board that can be programmed. It also includes an Integrated Development Environment (IDE) which is software that allows users to write and upload computer code to the board. The board itself has several input/output pins which can be programmed through the IDE using a type-B USB cable (Gupta, 2021) (Arduino Official Store, 2023).

- Breadboard: The ultrasonic sensor is a device that uses sound waves to measure the distance of an object from its position. It utilizes SONAR technology and is capable of providing highly accurate distance measurements within a range of 1 to 13 feet. The sensor is composed of both an ultrasonic transmitter and receiver module, and its user-friendly design makes it easy to operate (Shawn, 2022) (Science Direct, 2023).

- Ultrasonic Sensor: Ultrasonic sensors are devices that use ultrasonic waves to measure the distance between the sensor and an object or target. These sensors emit ultrasonic waves and receive the reflected waves from the object or target. The period between the emission and reception of these waves is used to calculate the distance between the sensor and the object. In our project, we integrated ultrasonic sensors with the breadboard and Arduino. The LED on the breadboard indicates the distance measured by the sensors (Jost, 2019).

- Jumper Wires: Jumper wires are essentially cables that are used to establish a connection between two points. In our project, we utilized jumper wires extensively, connecting the Arduino board to the breadboard and ultrasonic sensors. These wires enabled us to transmit signals and data accurately and efficiently between the various components of the project (Hemmings, 2018).

- Servo Motor: A servo motor is a type of rotary actuator that is commonly used in applications that require precise and accurate rotation angles. When sensors detect input, they send it to the controlling unit which processes the data and sends instructions to the actuator (in this case, the servo motor) to perform a physical operation. This allows the servo motor to move with precision and accuracy to carry out specific tasks as required (Robocraze, 2022).

Software:

Arduino IDE: Programming and uploading code to an Arduino board is an uncomplicated process with the help of Arduino Software (IDE), which is an open-source platform. The IDE is compatible with any type of Arduino board, making it easy to write and upload code for various projects (Team, 2023).

3. Development

Planning and Design:

At first, our team gathered and let each member pitch the idea he/she has for the project. Each member opined different ideas; However, we ended up choosing ‘Smart IOT Dustbin’ as it was budget-friendly and aids to resolve the real-life issue. During the planning and design stage, we discussed defining our project’s overall purpose, features and requirements. We identified the key requirements of our project that involved hardware and software components required by creating a detailed document that outlined how required components could be integrated.

At this stage, we identified the required hardware components, such as Arduino Uno, breadboard, jumper wires, ultrasonic sensors, and servo motor. To proceed further, we utilized an online tool called TinkerCAD, which is commonly used for designing circuit diagrams and simulating electronic circuits. This tool allowed us to create a visual representation of how the different hardware components would be interconnected and enabled us to test the circuit design before physically building the system.

Since we were required to implement cloud computing technology, it was already a challenging task to execute, considering we were limited to theoretical knowledge of this domain. Furthermore, we needed to consider factors like frequency and amount of data transfer, protocols to use and overall impact on the system due to cloud requirements.

Resource Collection:

This phase involved acquiring the necessary hardware components and resources to build the actual system. We were able to obtain several critical components, including an Arduino Uno microcontroller, a breadboard, jumper wires, ultrasonic sensors, a servo motor, a 9V battery, and LED lights from the college's resource department. However, since a dustbin model was not available in the department, we had to purchase one on our own, which required us to identify a suitable model that fits well with our project's requirement, thus, we purchased one from a nearby hardware store. Our team’s ability to identify suitable alternatives was essential to the successful completion of our project.

<u>System development:</u>

Phase→ 1

To reiterate, the project is to develop a system integrated with a dustbin that detects an object within a specified range (i.e., 27 cm) using an ultrasonic sensor and opens the dustbin's lid using a servo motor. In this phase, it was required to use tools such as an Arduino UNO, a breadboard, a servo motor, an ultrasonic sensor, an led light and some jumper wires which can be seen in Figure: 2. The connection between these components was achieved by adhering to instructions mentioned in the table: 1.

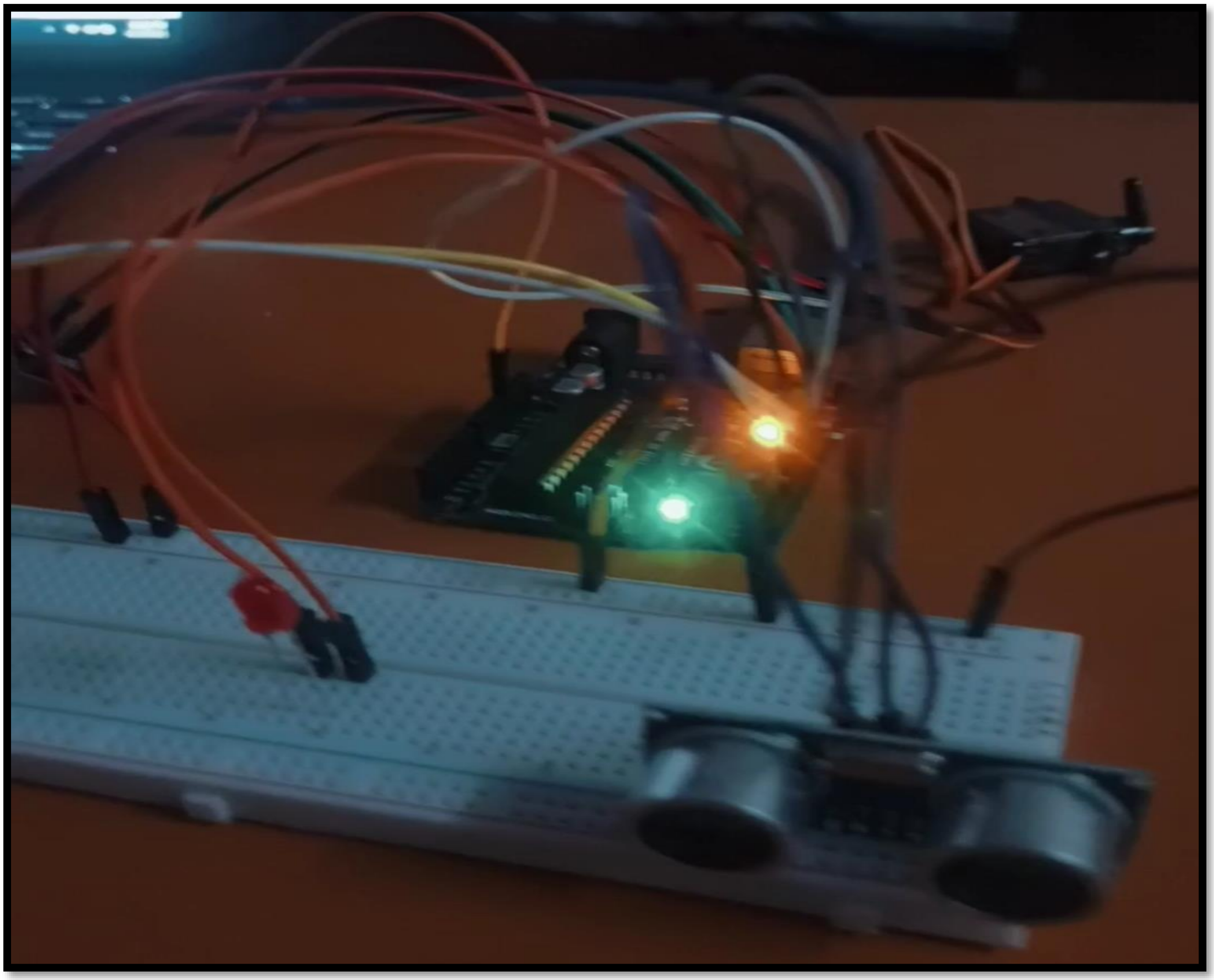

Figure 8: Phase 1 configuration to facilitate movement of a dustbin lid

Components	Pins	Arduino UNO's ports
Ultrasonic sensor	VCC GND Trig Echo	5V GND Digital Pin 5 Digital Pin 6
Servo motor	Ground (Brown) Power (Red) Control (Orange)	GND 5V Digital Pin 11
LED light	Positive Negative	Digital Pin 13 GND

Table 1: Wiring configuration of Phase-1

Phase→ 2

Considering two Arduino UNO's have been used in this project, phases 1 and 2 are independent of each other. This phase requires components such as Arduino UNO, ESP8266 Wi-Fi module, another ultrasonic sensor and some jumper wires as shown in Figure: 3. The connection between these components was achieved by adhering to instructions mentioned in Table: 2. Here, the sensor is integrated with arduino UNO along with esp8266 Wi-Fi module so that sensor takes input and sends the data using the Wi-Fi module to the ThingSpeak server. Thus, we can monitor those data remotely.

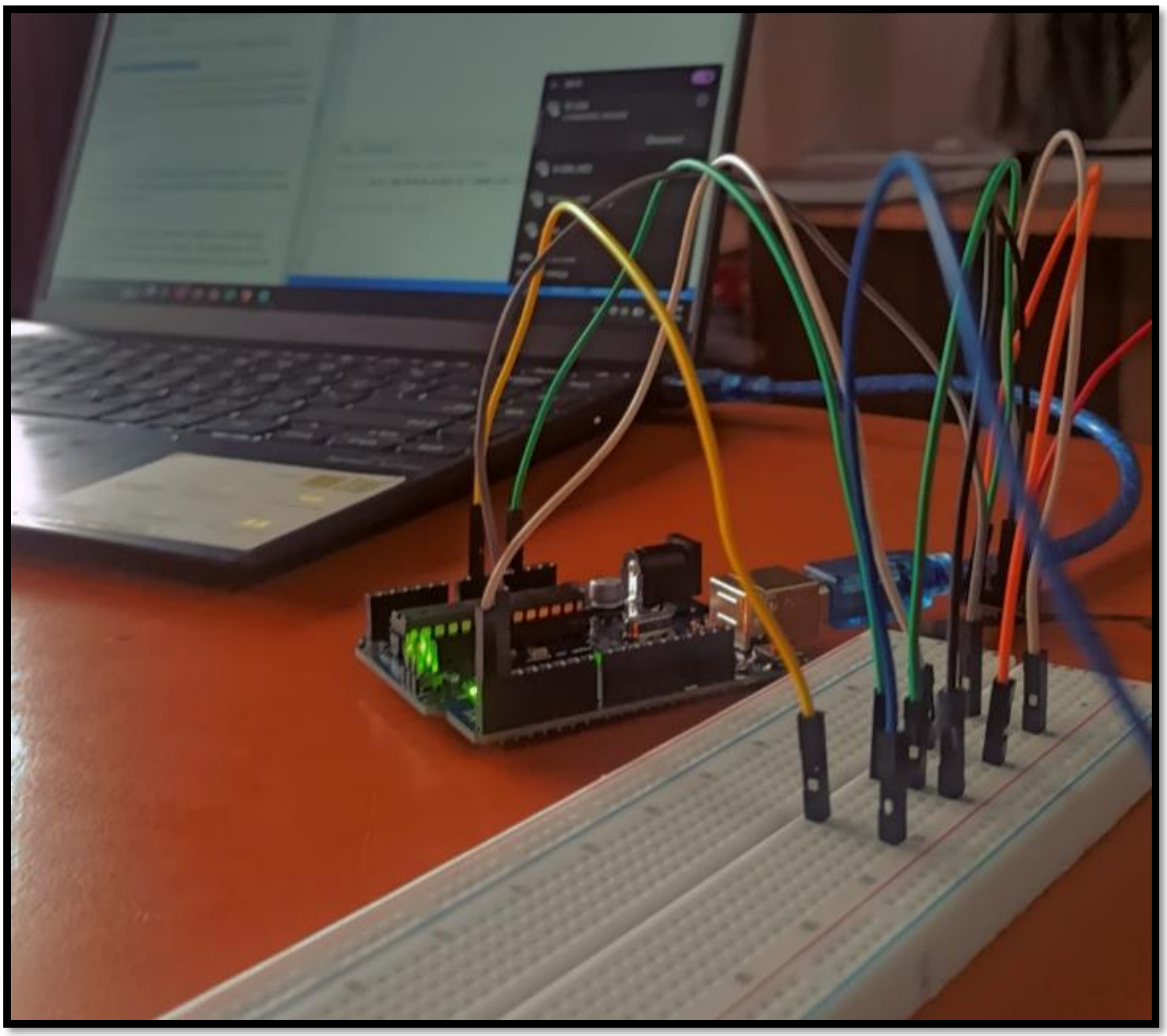

Figure 9: Phase 2 configuration for sending data to the thingSpeak platform

Components	Pins	Arduino UNO’s ports
Ultrasonic sensor	VCC GND Trig Echo	5V GND Digital Pin 8 Digital Pin 9
ESP8266	RX TX GND 3V3 EN	3 2 GND 5V 5V

Table 2: Wiring configuration of Phase-2

4. Results and Findings

The initiative's findings show that the smart IoT trash container uses a servo motor to lift the lid when it detects an item within a certain distance. The dustbin's trash level may be precisely monitored thanks to the garbage level detector. Virtual tracking was made possible when the required radius was achieved since the sensor used the Wi-Fi module to transmit information to the cloud server. Reduced unneeded tangible interaction with the dustbin, which may assist in stopping the transmission of ailments, constitutes a single of the main advantages of this effective IoT dustbin. Clients may also keep an eye on the waste quantity and make plans for regular waste pickup thanks to the online surveillance capability.

The following tables represent the test cases that were carried out to evaluate the smart IOT dustbin.

Test 1

Test	1
Objective	To test whether the sensor detects the item or hand and opens the lid or not.
Activity	The hand was placed within the given range.
Expected Outcome	The lid should open.
Actual Outcome	The lid was opened.
Conclusion	The test is successful.

Table 3: Test case 1

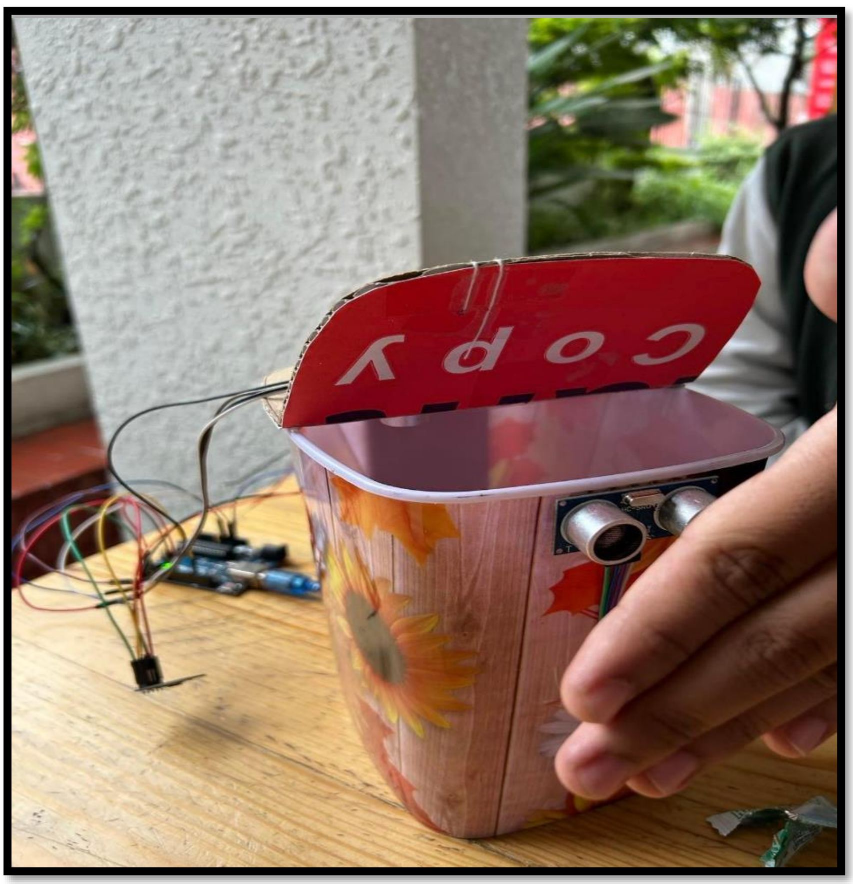

Figure 10: Testing whether the sensor detects the object or not

Test 2

Test	2
Objective	To test if the lid closes or not within the time frame after the hand is remove.
Activity	The hand was moved away.
Expected Outcome	The lid should close.
Actual Outcome	The lid was closed.
Conclusion	The test is successful.

Table 4: Test case 2

Figure 11: Testing whether servo motor closes the lid or not

Test 3

Test	3
Objective	To test the data of the capacity of the dustbin when the dustbin is empty.
Activity	The dustbin was empty.
Expected Outcome	The data on the high capacity of the dustbin should be shown on the think speak web application.
Actual Outcome	The data on the high capacity of the dustbin was shown on the think speak web application.
Conclusion	The test is successful.

Table 5: Test case 3

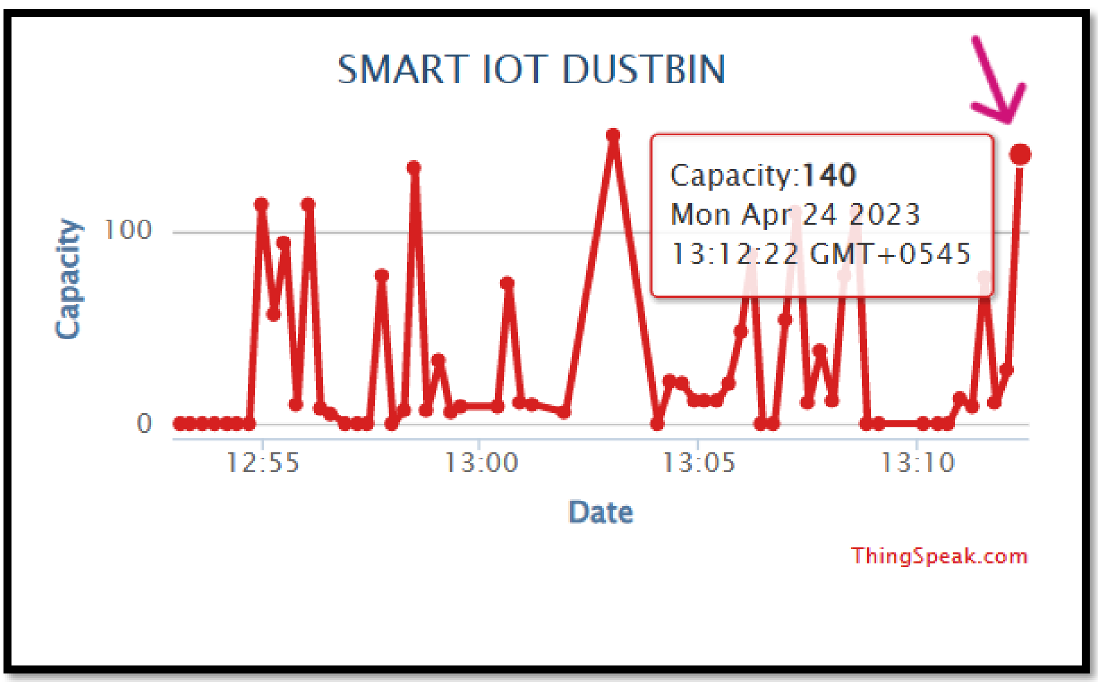

Figure 12: The high value of Capacity indicating dustbin was empty

Test 4

Test	4
Objective	To test the data on the capacity of the dustbin when the dustbin is full.
Activity	The dustbin was filled.
Expected Outcome	The data on the low capacity of the dustbin should be shown on the think speak web application.
Actual Outcome	The data on the low capacity of the dustbin was shown on the think speak web application.
Conclusion	The test is successful.

Table 6: Test case 4

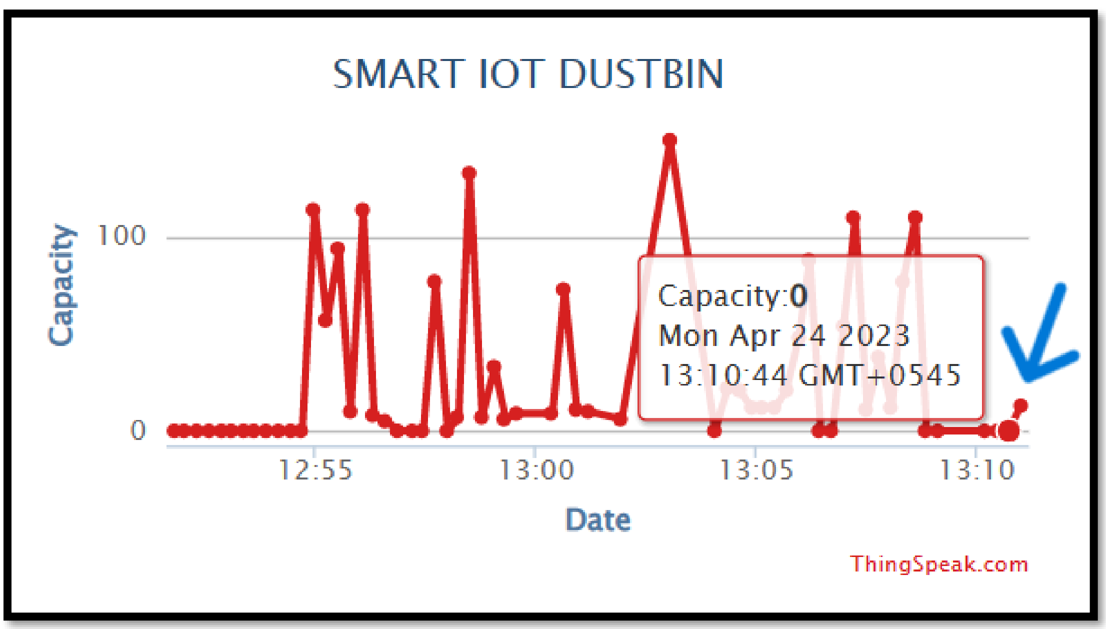

Figure 13: The lowest value of Capacity indicating dustbin was full

5. Future Works

As seen from the above report, by facilitating more effective and environmentally friendly waste collection and disposal, smart dustbins have the potential to transform waste management. This project considers the creation of a smart dustbin that can monitor trash levels and uses ultrasonic sensors to detect the presence of an object in front of the dustbin. After all the work done on the project, there are still many things that could still be implemented in a smart dustbin. These things are left for future work to improve the project even more and introduce smart dustbins to society. The future works that could be implemented or improved are as follows:

User-Friendly Interface:

The dustbin could be made more creative and user-friendly with the addition of voice commands or touch screens. As those kinds of things could help make user interaction with the dustbin easier.

Notification System:

To help users correctly dispose of waste, the smart dustbin could be integrated with an app that alerts them when it is getting close to or full. An AI algorithm could also be utilized to help optimize the timing of waste collection.

Powered with renewable energy:

Smart dustbins could be powered by renewable sources of energy like solar power to make them more sustainable and increase their impact on society while reducing the impact on environmental changes

Analysis:

The dustbin can be used for more than just waste disposal and management; it can also be used to gather information on waste generation patterns, which can be utilized to inform decisions and create the best possible waste management strategy.

Management features:

Unlike the traditional dustbin, the smart dustbin could consist of two different waste disposals one for renewable and the other for non-renewable wastes and it should allow users to choose from one of two as it helps manage the disposal of waste easier since users or other people don’t have to spend their time separating renewable waste with non-renewable ones.

Health and Safety:

As dustbins no matter how smart will still be used for waste disposal they should have features that improve health and safety while reducing risks of spreading diseases. It would also be excellent to include odors prevention so that smell from the dustbin won't cause problems outside.

6. Conclusion

To conclude, a smart dustbin is a reliable and effective solution for the proper management of waste in a more efficient and sustainable manner. By the implementation of various IoT sensors and cloud computing technologies, the project also focuses on real-time monitoring of waste levels in the dustbins, also optimizes the schedules of waste collection, minimizes the overflow of wastes, and eventually contributes to making a better, cleaner and healthier surrounding.

Also, the development of a Smart IoT Dustbin using various electronic components such as sensors, actuators, Arduino, breadboards, and jumper wires has shown significant promise in improving waste management systems. Sensors monitor garbage levels automatically, while actuators open and close the bin's lid. These components are linked together using a breadboard and jumper wires, resulting in a stable and efficient power and data transmission system. Furthermore, the Smart IoT Dustbin's use of cloud computing has enabled the storage of data generated by the system. The cloud-based data storage solution is secure, scalable, and accessible from anywhere on the planet, enabling centralized data analysis and management. The capacity to evaluate and derive insights from the Smart IoT Dustbin's data can lead to better decision-making processes and methods for eliminating waste.

The capacity of the Smart IoT Dustbin to interface with other devices and systems via the cloud opens the door to better waste management systems. For example, the data acquired by the dustbin might be shared with waste collection companies in order to optimize their routes and timetables, resulting in more efficient and cost-effective waste management methods. Furthermore, the system's data can be shared with city planners to help them better understand waste management patterns and inform future urban planning decisions.

The benefits of this smart IoT dustbin project include the reduction of human intervention required for trash management, better utilization or utilization of available resources, and improvements in public health. Furthermore, the use of cloud computing improves the project's scalability, dependability, and cost-effectiveness.

As a result, employing cloud computing to construct a smart dustbin IoT project is a step toward creating a smarter and more sustainable planet.

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8. Appendix

Some of the Key Terminologies

Internet of Things (IOT):

The IoT is an ensemble of connected determining gadgets, mechanical and electronic technology, items, creatures, or individuals who can exchange information over a system without needing interaction between humans or computers. The Internet of Things (IoT) ecology comprises smart devices with web access that employ embedded hardware, such as processors, sensors, and communications gear, to collect, transmit, and respond to the information they get from their surroundings. By linking to an IoT router or another edge gadget, which either sends data to the cloud for analysis or analyzes it locally, IoT devices exchange the sensor-related data they collect. These occasionally act on the data they exchange (Gillis, 2022).

Microcontroller:

A microcontroller is a compact, reasonably priced microcomputer that is made to carry out the particular functions of embedded systems, such as showing microwave data and accepting distant indications, among others. The CPU, memory (RAM, ROM, EPROM), Serial ports, peripherals (timers, counters, etc.), and other components make up a generic microcontroller (Tutorials Point, 2023).

Cloud Computing:

To provide quicker creativity, adaptable assets, and scale savings, cloud computing is the distribution of computer services via the internet ("the cloud"), including servers, storage devices, databases, networking, software, analytics, and analytics. Usually, you only pay for the cloud amenities you use, which lowers operating costs, improves infrastructure management, and enables you to grow as your business demands transform. A significant change from how organizations have traditionally viewed IT assets is the use of cloud computing (Microsoft, 2023).

The following are the tools used for the overall completion of the project:

- Arduino
- ESP8266 Wi-Fi module
- Servo Motor
- Ultrasonic Sensors
- Breadboard
- Jumper wires
- 9V Battery
- LED lights
- Dustbin

There were two separate codes used for this project. Among which, one facilitates the opening and closing of the dustbin lid, while another one sends the data to the cloud platform.

For opening and closing of lid, the following code was utilized.

```
// Include the Servo library for controlling the servo motor

#include <Servo.h>

// Create a Servo object named myservo

Servo myservo;

// Initialize the initial position of the servo motor

int pos = 20;

// Define the trig and echo pins of the 1st ultrasonic sensor

const int trigPin1 = 5;

const int echoPin1 = 6;
```

```
// Define the LED pin for visual feedback
const int led = 13;

// Declare variables for calculating distance1
long duration1;
float distance1;

// Setup function runs once when the microcontroller starts
void setup()
{
// Attach the servo motor to pin 8 (DIGITAL)
myservo.attach(11);

// Set the trig pin as an output and the echo pin as an input
pinMode(trigPin1, OUTPUT);
pinMode(echoPin1, INPUT);

// Set the LED pin as an output
pinMode(led, OUTPUT);

// Initialize the servo motor to its initial position
myservo.write(pos);
}
```

```
// Loop function runs continuously after setup function

void loop()

{

// Send ultrasonic pulses to the dustbin

digitalWrite(trigPin1, LOW);

delayMicroseconds(2);

digitalWrite(trigPin1, HIGH);

delayMicroseconds(10);

digitalWrite(trigPin1, LOW);


// Measure the duration1 of the reflected pulse

duration1 = pulseIn(echoPin1, HIGH);


// Calculate the distance1 based on the duration1 of the pulse

distance1 = 0.034*(duration1/2);


// If an object is detected within 27cm, open the dustbin lid and turn on the LED

if (distance1 < 27)

{

digitalWrite(led,HIGH);

myservo.write(pos+160);

delay(2000); //kati ber samma lid open rakhne ho ta!!
```

```
}
// Otherwise, close the dustbin lid and turn off the LED
else
{
digitalWrite(led,LOW);
myservo.write(pos);
}

// Wait for a short amount of time before repeating the loop
delay(300);
}
```

<u>For sending data to the cloud platform, the following code was utilized.</u>

```
#include <SoftwareSerial.h>

#define RX 2

#define TX 3


String AP = "Islington-College ";

String PASS = "I$LiNGT0N2023";

String API = "1GMH2WCJHQKSUNME";

String HOST = "api.thingspeak.com";

String PORT = "80";

String field = "field1";


int countTrueCommand;

int countTimeCommand;

boolean found = false;

int valSensor = 1;

SoftwareSerial esp8266(RX,TX);


void setup()

{

  Serial.begin(9600);

  esp8266.begin(9600);
```

```
  sendCommand("AT",5,"OK"); //sending AT cmd to module; wait for 5 sec; expected
response string

  sendCommand("AT+CWMODE=1",5,"OK");

  sendCommand("AT+CWJAP=\""+ AP +"\",\""+ PASS +"\"",20,"OK");

}


void loop()

{

 //reads data from sensor and stores it in the 'valSensor' variable

 valSensor = getSensorData();


//Building a string of data that will be sent to the ThingSpeak platform.

 String getData = "GET /update?api_key="+ API +"&"+ field +"="+String(valSensor);


//Sends a command to the ESP8266 Wi-Fi module to configure it to work with multiple
connections.

 sendCommand("AT+CIPMUX=1",5,"OK");


 sendCommand("AT+CIPSTART=0,\"TCP\",\""+ HOST +"\","+ PORT,15,"OK");


//Sending a command to the Wi-Fi module to prepare to send data to the ThingSpeak
platform

 sendCommand("AT+CIPSEND=0," +String(getData.length()+4),4,">");
```

```
//Sending the data string to the ThingSpeak platform using the ESP8266 Wi-Fi module
 esp8266.println(getData);delay(1500);countTrueCommand++; //counter incremented to track the number of successful data transmissions.

//Sends a command to the Wi-Fi module to close connection to ThingSpeak platform
 sendCommand("AT+CIPCLOSE=0",5,"OK");
}

int getSensorData() {
  int trigPin = 8;
  int echoPin = 9;
  long duration;
  int distance;

  pinMode(trigPin, OUTPUT);  // set the trigger pin as output
  pinMode(echoPin, INPUT);   // set the echo pin as input

  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);

  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
```

```
  digitalWrite(trigPin, LOW);


  duration = pulseIn(echoPin, HIGH);
  distance = (duration/2) / 29.1;   // calculate the distance in centimeters


  return distance;
}


//Sending commands to the WI-FI module (with 3 parameters)
void sendCommand(String command, int maxTime, char readReplay[])
{
  //Prints the current value of a counter to the serial monitor
  Serial.print(countTrueCommand);


  //Prints the command being sent to the serial monitor.
  Serial.print(". at command => ");
  Serial.print(command);
  Serial.print(" ");


  while(countTimeCommand < (maxTime*1))
  {
    //sends the command to the ESP8266 module
    esp8266.println(command);
```

```
    //checks if the response from the ESP8266 module contains the expected
readReplay string
    if(esp8266.find(readReplay))
    {
      found = true;
      break;
    }
    countTimeCommand++;
  }
  if(found == true)
  {
    Serial.println(">>SUCCESS<<");
    countTrueCommand++;
    countTimeCommand = 0;
  }
  if(found == false)
  {
    Serial.println("<<Fail>>");
    countTrueCommand = 0;
    countTimeCommand = 0;
  }
  found = false;
 }
```

Individual contribution

Student Name	Roles	Contribution
Aryan Shrestha	❖ Setting up hardware connections among every component ❖ Writing code for both the servo motor setup and cloud setup ❖ Development section of the report	20%
Kamana Thapa	❖ Introduction and conclusion section of the report ❖ Modifying the code to meet the report's requirement ❖ Refining the prototype with attractive hardware modification	20%
Roshan Kumar Mandal	❖ Designing flowcharts and circuit diagram for the report ❖ Identifying the components required for the project ❖ Background section of the report	20%
Somia Dahal	❖ Carrying out the test cases for the report ❖ Appendix section of the report ❖ Reviewing and refining the code for the project	20%
Swikriti Timilsina	❖ Future works and abstract section of the report ❖ Acknowledgment section of the report ❖ Researching relevant libraries for the code	20%

Table 7: Individual contribution