1.INTRODUCTION

Smart waste management is about **using technology and data to create a more efficient waste industry**. Based on IoT (Internet of Things) technology, smart waste management aims to optimize resource allocation, reduce running costs, and increase the sustainability of waste services.

1 Project overview

The Internet of Things (IoT) is a concept in which surrounding objects are connected through wired and wireless networks without user intervention. In the field of IoT, the objects communicate and exchange information to provide advanced intelligent services for users.
This project deals with the problem of waste management in smart cities, where the garbage collection system is not optimized. This project enables the organizations to meet their needs of smart garbage management systems. This system allows the user to know the fill level of each garbage bin in a locality or city at all times, to give a cost-effective and time-saving route to the truck drivers.

1.2 Purpose

Smart waste management is about using technology and data to create a more efficient waste industry. Based on IoT (Internet of Things) technology, smart waste management aims to optimize resource allocation, reduce running costs, and increase the sustainability of waste services.

2. LITERATURE SURVEY

provides the idea of sensors-based waste bins, capable of notifying waste level status. An automatic waste bin and make use of cloud computing paradigm to evolve a more robust and effective smart waste management mechanism. Waste management is linked to different stakeholders, including recyclers, importers and exporters, food industry, healthcare, research, environment protection and related organizations, and tourism industry Mohammad Aazam et al proposed Cloud SWAM, in which each bin is equipped with sensors to notify its waste level. Different bins for each category of waste, namely: organic, plastic/paper/bottle, and metal. In this way, each type of waste is already separated and through the status, it is known that how much of waste is collected and of what type. The availability of data stored in the cloud can be useful for different entities and stakeholders in different

ways. Analysis and planning can start from as soon as waste starts gathering and up to when recycling and import/export related matters are conducted.

2.1 EXSISTING PROBLEM

Sensoneo is a smart waste management solution provider that produces two types of ultrasonic sensors that are able to monitor the fill level for waste bins of various types and sizes.

Smart waste management is about using technology and data to create a more efficient waste industry. Based on IoT (Internet of Things) technology, smart waste management aims to optimize resource allocation, reduce running costs, and increase the sustainability of waste services.

2.2 REFERENCE

1) InsungHong,SunghoiPark,BeomseokLee,JaekeunLee,DaebeomJeong, andSehyunPark, "IoT-Based Smart Garbage System for Efficient Food Waste Management" -Scientific World Journal-Aug 2014.

2) Ala Al-Fuqaha, Mohsen Guizani, Mehdi Mohammadi, Mohammed Aledhari, Moussa Ayyash, "Internet of Things: A Survey on Enabling Technologies, Protocols and Applications" -IEEE-2015.

3) TheodorosAnagnostopoulos ,ArkadyZaslavsky ,Alexey Medvedev , "IRobust Waste Collection exploiting Cost Efficiency ofIoT potentiality in Smart Cities" -EEE- April-2015.

2.3 PROBLEM STATEMENT DEFINITION

It was noted that inadequate communal containers for storing waste, lack of routine collection of waste and inadequate resources for the sanitation unit to effectively collect the waste generated are some of the problems uncounted in terms of waste management.

3. IDEATION & PROPOSED SOLUTION

Composting is a process that allows biological waste, such as rotten food, to break down naturally. This process is extremely environmentally friendly, and is starting to be done on an industrial scale in response to the swelling size of landfills. Composting allows for organic waste to be recycled rapidly, and be turned into fertilizer, which can be used in farming. Panda specializes in organic waste recycling, and is able to assist in getting a composting solution working along side standard waste removal services.

3.1 Empathy Map Canvas

An empathy map canvas helps brands provide a better experience for users by helping teams understand the perspectives and mindset of their customers. Using a template to create an empathy map canvas reduces the preparation time and standardizes the process so you create empathy map canvases of similar quality.

3.2 Ideation & Brainstorming

A reduction in the number of waste collections needed by up to 80%, resulting in less manpower, emissions, fuel use and traffic congestion. A reduction in the number of waste bins needed. Analytics data to manage collection routes and the placement of bins more effectively.

Smart waste management is characterized by the usage of technology in order to be more efficient when it comes to managing waste. This makes it possible to plan more efficient routes for the trash collectors who empty the bins, but also lowers the chance of any bin being full for over a week!

3.3 Proposed Solution

Eight Ways to Reduce Waste

- Use a reusable bottle/cup for beverages on-the-go. ...

- Use reusable grocery bags, and not just for groceries. ...
- Purchase wisely and recycle. ...
- Compost it! ...
- Avoid single-use food and drink containers and utensils. ...
- Buy secondhand items and donate used goods

3.4 Problem Solution fit

PROBLEMS:

This week someone asked us what we mean by waste management solutions. After all, isn't waste management simply about packing and removing waste?

There's actually a lot more to it than that, though we were flattered we made it look so easy! When we talk about waste solutions, we don't just mean taking away your waste. We mean solutions that work for your whole business, and help achieve your company's aims.

SOLUTION:

Cost effective waste management

For customers who want to save money, we have many solutions. We can look at your current waste management processes and advise where you can save money. For many companies this might mean making sure machinery is working efficiently. Waste disposal machinery in good working order will handle more waste, meaning fewer collections are required. And fewer collections mean less money spent.

Reducing your carbon footprint

We mentioned above that efficient machinery reduces collections. It also reduces your carbon footprint. Partly because the machines themselves are more energy efficient, but mostly because when fewer collections are required, there are less trucks on the road producing emissions. If you look at the example of Deli Solutions above, instead of having trucks going to and from their site twice a week, they're now only required once a fortnight.

Saving staff time

A client once told us that recycling was becoming an issue amongst staff, who had many duties to do and simply didn't have the extra time to worry about recycling processes. It's a common concern that waste management takes up a lot of staff time, but in reality the opposite is true. When you have a defined process and the right equipment, it takes less time. Products like bin lift systems make tasks easier, and the process of using them is so straightforward there is little room for error.

Space saving waste management

In the past, waste machinery was huge. And if you needed a baler, compactor and recycling bins, you'd better be prepared to rent more space to house them. Fortunately, modern technology has caught up and machinery is now made much smaller without losing any of its capacity.

As well as our modern efficient machinery, we offer space saving machines. So whatever space you have available, we can provide suitable options to make it work for you.

4. REQUIREMENT ANALYSIS

Smart waste management is about using technology and data to create a more efficient waste industry. Based on IoT (Internet of Things) technology, smart waste management aims to optimize resource allocation, reduce running costs, and increase the sustainability of waste services.

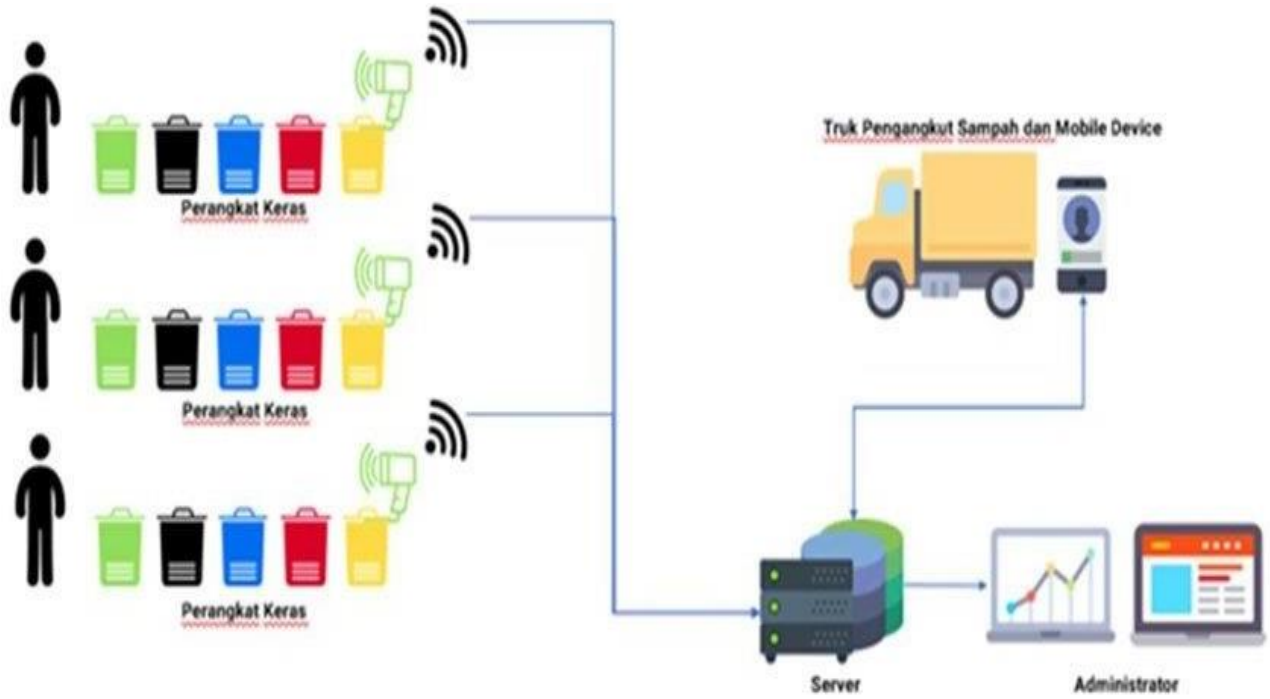
4.1 Functional requirement

Taking sensor reading from the Sensor Circuit • Pushing the data to a MySQL database. Retrieving information from database for Calculation garbage bin which fulfils the condition for garbage collection, example: Collect garbage from bins whose level is over 80% of bin.

4.2 Non-Functional requirements

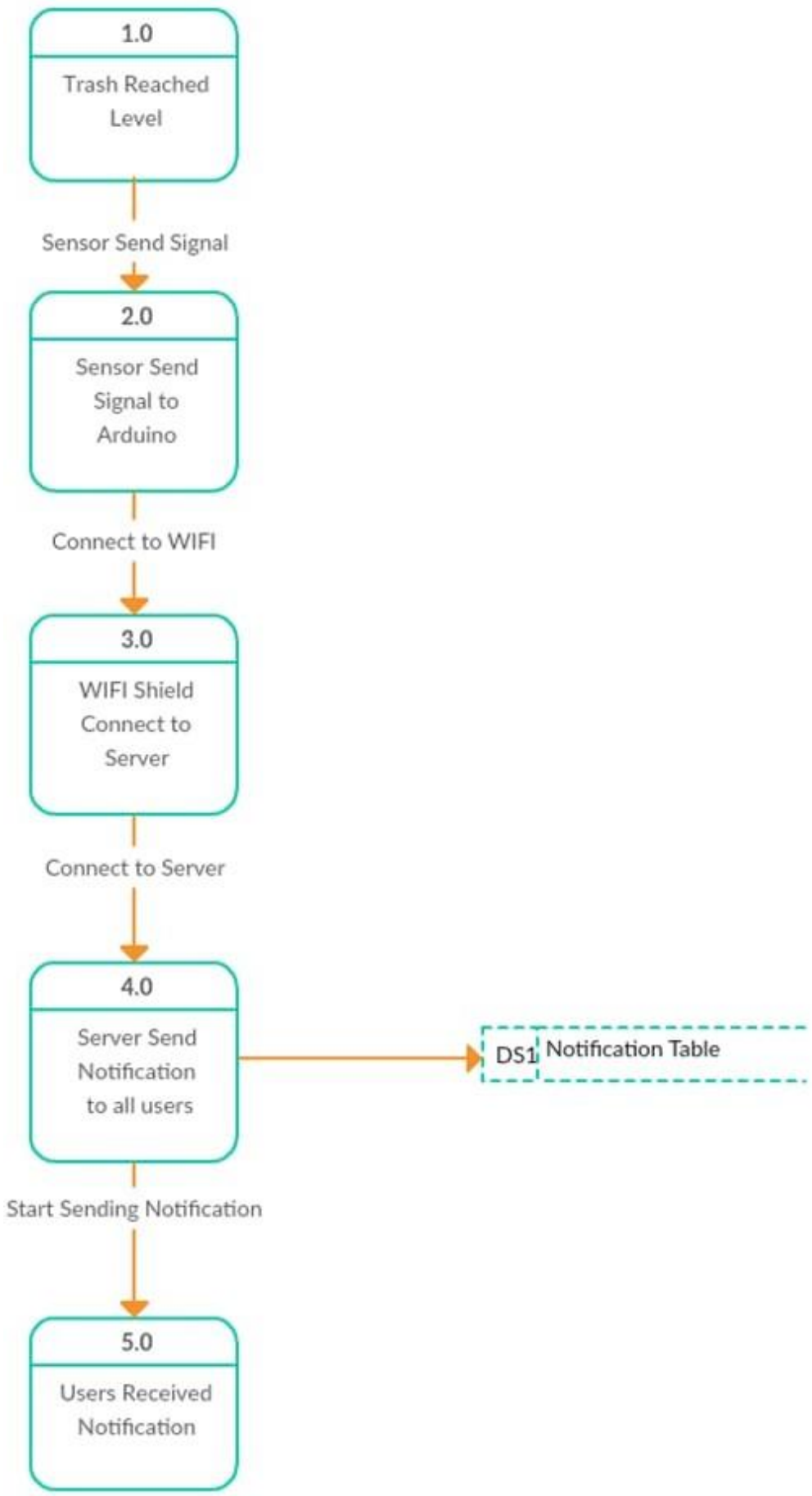
The project requires a user interface for monitoring and manually intervening (if required) in the efficient and timely collection of garbage from the selected Garbage bins.

5. PROJECT DESIGN



5.1 Data Flow Diagrams

The protection of society and environment from garbage accumulation and its polluting effects is carried by waste management companies, the services provided by these companies are improving life overall quality. By preserving raw materials, proper collecting and elimination of trash have reduced pollution and environmental impact.


1.0
Trash Reached Level
Sensor Send Signal
2.0
Sensor Send Signal to Arduino
Connect to WIFI
3.0
WIFI Shield Connect to Server
Connect to Server
4.0
Server Send Notification to all users
DS1
Notification Table
Start Sending Notification
5.0
Users Received Notification

5.2 Solution & Technical Architecture

Waste bins are part of our lives for decades and mostly its condition are overflowing due to improper waste dumping, collection and management, which leads in foul smell and unhygienic condition, thus inherently results in environment pollution.

5.3 User Stories

In this article, we will tell you how an IoT-enabled Smart Waste Management system can help you combat this eternal problem

The Smart City concept is about collecting real-time data.

6. PROJECT PLANNING & SCHEDULING

Week Work	1st	2nd	3rd	4th	5th	6th	7th	8th
Title Selection& LiteratureReview								
Component Collection								
ProblemDiscussion/ TemplateDesigning								
CircuitDesign, Connecting &Backend								
Testing anddebugging								

Finalizing &Documentation								

6.1 Sprint Planning & Estimation

Sprint (now part of T-Mobile) strives to efficiently manage the resources used in its business operations. By working to procure just what is needed and optimizing how the company disposes of generated waste, Sprint is reducing its environmental footprint while improving the company's bottom line. In late 2019, Sprint announced expanded sustainability goals, including the goal to divert 50% of its operational waste stream (as measured in volume) from the landfill by 2025. This includes waste generated by employees in stores, commercial office buildings, and network facilities where Sprint has operational control of vendor and service selection

6.2 Sprint Delivery Schedule

Sprint's systematic approach to waste management across the company includes:

- **Source reduction and reuse** – Sprint follows the five R's of Zero Waste to consistently improve its program: refuse, reduce, reuse, rot, recycle. For example, when polystyrene cups were removed from break rooms and replaced with reusable mugs, Sprint experienced a decrease in the amount of coffee consumed as well as associated items like stir sticks and sugar packets. Coffee grounds and filters are collected for composting.
- **Education and behavior change** – Sprint's support messaging for waste stream decals is changed often to keep communications fresh and interesting. One such effort included posting quick response (QR) codes on program posters that directed the device to short animated videos describing the recycle/reuse process.
- **Ongoing measurement and benchmarking** – Regular monitoring of each facility's diversion rate alerts program managers to possible changes in behavior or equipment needs.
- **Continuous service level and rate optimization** – Waste service needs at Sprint can change when headcount or project activity changes. Keeping a watchful eye on low tonnage compactor notifications can optimize collection and reduce costs.

6.3 Reports from JIRA

Navigate to the project you want to report on. From the project sidebar, select Reports. The reports overview page displays. Select a report from the overview or from the project sidebar to begin generating the report.

Jira does not have a built-in feature for providing audit log for deleted issues, therefore deleted issues are lost forever.

unfortunately JIRA doesn't allow to recover deleted issues. You could do that restoring an old backup in a clear instance and, after doing that, export this specific issue and restore via csv import.

7. CODING & SOLUTIONING (Explain the features added in the project along with code)

7.1 Feature 1;

```
Serial.println();
WiFi.begin(ssid, password);
   while (WiFi.status() != WL_CONNECTED) {
delay(500);
Serial.print(".");
   }
Serial.println("");
Serial.println(WiFi.localIP());


   if (!client.connected()) {
Serial.print("Reconnecting client to ");
Serial.println(server);
       while (!client.connect(clientId, authMethod, token)) {
Serial.print(".");
```

```
delay(500);
        }
Serial.println("Connected TO IBM IoT cloud!");
    }
inputString.reserve(200);
}

long previous_message = 0;
void loop() {




while(Serial.available())
{




HTTPClient http;
  String postData;
  String key = Serial.readString();
Serial.print(key);
  if(key.toInt()== 100)
  {
postData =
"username=fantasy&password=596692&to=8072114401&from=FSSMSS&me
ssage=Dear user yourmsg is your Controlled Bin is Full plz Clean Sent By
FSMSG
```

```
FSSMSS&PEID=1501563800000030506&templateid=1507162882948811640
";
Serial.print(key);
http.begin("http://smsserver9.creativepoint.in/api.php");
http.addHeader("Content-Type", "application/x-www-form-urlencoded");
int httpCode = http.POST(postData);
  String payload = http.getString();
Serial.println(payload);
http.end();
delay(1000);
  }



Serial.print("GARBAGE LEVEL: ");
Serial.print(key);
Serial.print("%");
 int a=key.toInt();
      String payload = "{\"d\":{\"Name\":\"" DEVICE_ID "\"";
            payload += ",\"GARBAGE LEVEL\":";
            payload += a;
            payload += "}}";

Serial.print("Sending payload: ");
Serial.println(payload);

       if (client.publish(publish_Topic1, (char*) payload.c_str())) {
Serial.println("Published successfully");
       } else {
```

```
Serial.println("Failed");
      }

}

}
```

8. TESTING

Testing is finding out how well something works. In terms of human beings, testing tells what level of knowledge or skill has been acquired. In computer hardware and software development, testing is used at key checkpoints in the overall process to determine whether objectives are being met.

8.1 Test Cases

Garbage bins play a vital role in the waste collection process at the primary level itself. But the collected waste in the garbage bins must regularly be monitored, and from there it must be delivered to processing plants. This practice of continuous monitoring, transporting and processing contributes to the waste management.

Test case description	Required input	Information and related requirements	Test case status indicating pass or fail
The user or concerned service provider should register with the required details	User input details for registration	User Name, Email ID, Phone Number, and Security Password	Pass
The user or concerned service provider tried to log in to the monitoring portal with registered details	User login details	User Name, Security Password	Pass or Fail
Monitoring website portal indicating home, user, SGB status	User monitoring home screen should be display	The developed prototype for Smart Garbage Bin must be kept 'ON.'	Pass

8.2 User Acceptance Testing

User Acceptance Testing (UAT) is a type of testing performed by the end user or the client to verify/accept the software system before moving the software application to the production environment. UAT is done in the final phase of testing after functional, integration and system testing is done.

9. RESULTS

Smart waste management focuses on solving the previously mentioned solid waste management problems using sensors, intelligent monitoring systems, and mobile applications. The first smart waste management solution to make the waste collection process more efficient is sensors.

9.1 Performance Metrics

Long-range radio (LoRa) communication is a widespread communication protocol that offers long range transmission and low data rates with minimum power consumption. In the context of solid waste management, only a low amount of data needs to be sent to the remote server. With this advantage, we proposed architecture for designing and developing a customized sensor node and gateway based on LoRa technology for realizing the filling level of the bins with minimal energy consumption.

We evaluated the energy consumption of the proposed architecture by simulating it on the Framework for LoRa (FLoRa) simulation by varying distinct fundamental parameters of LoRa communication. This paper also provides the distinct evaluation metrics of the the long-range data rate, time on-air (ToA), LoRa sensitivity, link budget, and battery life of sensor node. Finally, the paper concludes with a real-time experimental setup, where we can receive the sensor data on the cloud server with a customized sensor node and gateway.

10. ADVANTAGES & DISADVANTAGES

ADVANTAGES;

Following are the benefits or advantages of Smart Waste Management:

➡It saves time and money by using smart waste collection bins and systems equipped with fill level sensors. As smart transport vehicles go only to the filled containers or bins. It reduces infrastructure, operating and maintenance costs by upto 30%.

➡It decreases traffic flow and consecutively noise due to less air pollution as result of less waste collection vehicles on the roads. This has become possible due to two way communication between smart dustbins and service operators.

➡It keeps our surroundings clean and green and free from bad odour of wastes, emphasizes on healthy environment and keep cities more beautiful.

➡It further reduces manpower requirements to handle the garbage collection process.

➡Applying smart waste management process to the city optimizes management, resources and costs which makes it a "smart city".

DISADVANTAGES;

Following are the drawbacks or disadvantages of Smart Waste Management:

➡System requires more number of waste bins for separate waste collection as per population in the city. This results into high initial cost due to expensive smart dustbins compare to other methods.

➡Sensor nodes used in the dustbins have limited memory size.

➡Wireless technologies used in the system such as zigbee and wifi have shorter range and lower data speed. In RFID based systems, RFID tags are affected by surrounding metal objects (if any).

11. CONCLUSION

Due to the absence of sustainable waste management technology, the current waste disposal situation is likely to worsen. This work presents an enhanced solution to the problem of waste management by the littering of the garbage bins once they are full.

12. FUTURE SCOPE

In this report, smart bin is built on a microcontroller based platform Arduino - Uno board, which is interfaced with Ultrasonic sensor. It will stop overflowing of dustbins along roadsides and localities as smart Dustbins are managed in real time.

13. APPENDIX

Type of MSW	Composition of waste	Sources
Biodegradable waste or organic waste	Paper, wood, kitchen waste, animal waste, rubber, yard waste, food	Household, Food processing industries, Organic farms
Recyclable waste	Plastic, Metals, Aluminium foils, Tins, Paper and cupboard, Bottles	Shops, Automobile industries, scraps yards
Hazardous waste	Paints, electronic waste, aerosol spray cans, light tubes, fluorescent lamps, chemicals, tyres	Paint industries, Household, Chemical industries
Toxic waste	Pesticides, herbicides, fungicides	Chemical industries, various pesticides and herbicides manufacturing industries
Inert waste	Construction waste, debris, rocks and sand	Construction sites, building demolishing sites

Source Code;

```
#include <ESP8266WiFi.h>
#include <WiFiClient.h>
#include <PubSubClient.h>
#include <ESP8266WebServer.h>
#include <ESP8266HTTPClient.h>

const char* ssid = "SMART-G";
const char* password = "10112019";

#define WT A0
#define CY D0

String key;
#define ID "1yww18"
#define DEVICE_TYPE "ESP8266"
#define DEVICE_ID "SMARTWMS"
#define TOKEN "IOT-1234567"

char server[] = ID ".messaging.internetofthings.ibmcloud.com";
char publish_Topic1[] = "iot-2/evt/Data1/fmt/json";
char publish_Topic2[] = "iot-2/evt/Data2/fmt/json";
char authMethod[] = "use-token-auth";
char token[] = TOKEN;
char clientId[] = "d:" ID ":" DEVICE_TYPE ":" DEVICE_ID;
String inputString = "";
bool stringComplete = false;
WiFiClientwifiClient;
PubSubClientclient(server, 1883, NULL, wifiClient);
```

```
void setup() {
Serial.begin(115200);
//    dht.begin();
Serial.println();
WiFi.begin(ssid, password);
   while (WiFi.status() != WL_CONNECTED) {
delay(500);
Serial.print(".");
   }
Serial.println("");
Serial.println(WiFi.localIP());

   if (!client.connected()) {
Serial.print("Reconnecting client to ");
Serial.println(server);
       while (!client.connect(clientId, authMethod, token)) {
Serial.print(".");
delay(500);
       }
Serial.println("Connected TO IBM IoT cloud!");
   }
inputString.reserve(200);
}

long previous_message = 0;
void loop() {
```

```
while(Serial.available())
{




HTTPClient http;
  String postData;
  String key = Serial.readString();
Serial.print(key);
  if(key.toInt()== 100)
  {
postData =
"username=fantasy&password=596692&to=8072114401&from=FSSMSS&me
ssage=Dear user yourmsg is your Controlled Bin is Full plz Clean Sent By
FSMSG
FSSMSS&PEID=1501563800000030506&templateid=1507162882948811640
";
Serial.print(key);
http.begin("http://smsserver9.creativepoint.in/api.php");
http.addHeader("Content-Type", "application/x-www-form-urlencoded");
int httpCode = http.POST(postData);
  String payload = http.getString();
Serial.println(payload);
http.end();
delay(1000);
  }
```

```
Serial.print("GARBAGE LEVEL: ");
Serial.print(key);
Serial.print("%");
 int a=key.toInt();
      String payload = "{\"d\":{\"Name\":\"" DEVICE_ID "\"";
            payload += ",\"GARBAGE LEVEL\":";
            payload += a;
            payload += "}}";

Serial.print("Sending payload: ");
Serial.println(payload);

       if (client.publish(publish_Topic1, (char*) payload.c_str())) {
Serial.println("Published successfully");
       } else {
Serial.println("Failed");
       }

}

}
```

GitHub & Project Demo Link;

GITHUB:

https://github.com/IBM-EPBL/IBM-Project-14169-1659543610

PROJECT DEMO LINK:

https://youtu.be/HWwyVGPV5ok