SMARTCITY WASTE MANA[1]GEMENT SYSTEMS WITH CONNECTED TRASHCANS

A PROJECT REPORT

SUBMITTED BY

S.KALEESWARI	953320106002
S.MURUGAN	953320106004
M.KAMALI	953320106301
V.SHANMUGARAJ	953320104302

BACHELOR OF ENGINEERING

IN

Electronics and Communication engineering

Unnamalai Institute of Technology,

Kovilpatti

Anna University: Chennai-600025

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INTRODUCTION

In an increasingly urbanized world, the management of waste has become a critical challenge for cities. Traditional waste management systems often struggle to keep pace with the rapid growth of urban populations, leading to inefficiencies, environmental hazards, and unsightly scenes of overflowing trash bins. However, with the advent of smart city technologies, a new era of waste management has emerged, offering innovative solutions to address these pressing issues.

One of the key elements of this revolution is the introduction of connected trash cans, which leverage the power of the Internet of Things (IoT) and data analytics to transform the way we handle waste in our cities. These smart bins are equipped with a range of sensors and communication technologies, enabling them to communicate vital information in real-time and facilitate more efficient waste collection processes.

Connected trash cans serve as the foundation of a comprehensive smart city waste management system. By integrating these intelligent bins into the urban landscape, cities can gain unprecedented insights into waste generation patterns, optimize collection routes, and reduce operational costs while promoting environmental sustainability.

This paper explores the various aspects of smart city waste management systems with connected trash cans, highlighting their potential benefits and examining the technologies driving this transformative shift. We will delve into the key features and functionalities of these connected trash cans, their role in creating cleaner and greener cities, and the impact they can have on the overall quality of urban life.

Furthermore, we will discuss the ways in which data collected from these smart bins can be analyzed and utilized to make data-driven decisions, enhance waste management operations, and foster a circular economy. By leveraging real-time data on fill levels, collection frequencies, and operational status, cities can optimize waste collection routes, reduce unnecessary pickups, and ensure that resources are allocated more effectively.

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Project Overview

Introduction:

The project aims to implement a comprehensive smart city waste management system by integrating connected trash cans into the urban infrastructure. This system leverages the power of IoT and data analytics to revolutionize waste collection processes, optimize operational efficiency, and promote environmental sustainability.

Objectives:

The key objectives of the project are as follows:

Implement connected trash cans: Install IoT-enabled trash cans throughout the city to monitor fill levels, track collection frequencies, and enable real-time communication between the trash cans and the central waste management system.

Real-time data collection: Collect and analyze data from connected trash cans to gain insights into waste generation patterns, identify high-demand areas, and optimize waste collection routes.

Route optimization: Utilize the collected data to optimize waste collection routes, reducing travel distances, and minimizing fuel consumption and carbon emissions.

Efficient resource allocation: Improve operational efficiency by allocating resources based on data-driven insights, ensuring timely waste collection and optimizing workforc

Environmental sustainability: Promote sustainability by reducing overflowing trash bins, minimizing litter, and fostering a circular economy through effective waste management practices.

Public engagement: Encourage public participation and awareness by providing real-time data on waste generation, recycling tips, and information on sustainable waste management practices through mobile apps or public displays.

Expected Outcomes:

Improved operational efficiency: Optimize waste collection routes, reduce fuel consumption, and enhance resource allocation, leading to cost savings for waste management operations.

Environmental sustainability: Minimize overflowing trash bins, reduce litter, and promote recycling and sustainable waste management practices, contributing to a cleaner and greener city.

Data-driven decision making: Utilize real-time data and analytics to make informed decisions, allocate resources effectively, and respond promptly to changing waste generation patterns.

Public participation and awareness: Engage citizens through real-time information, encourage responsible waste disposal, and foster a sense of environmental consciousness among the community.

Purpose

IoT-enabled trash cans provide real-time data on their fill levels. This information helps waste management authorities optimize collection routes, ensuring that bins are emptied only when needed. This efficiency leads to cost savings, reduced fuel consumption, and less traffic congestion.

By monitoring fill levels, connected trash cans can send alerts when they are nearing capacity. This proactive approach prevents bins from overflowing, reducing the chances of littering and maintaining a cleaner city environment.

IoT-enabled waste management systems allow authorities to allocate resources more effectively. By analyzing data on waste generation patterns, they can adjust the number and size of trash cans in specific areas, ensuring optimal utilization and avoiding unnecessary waste collection expenses.

Smart waste management systems contribute to environmental sustainability. By optimizing collection routes, reducing vehicle emissions, and minimizing overflowing bins, the project helps reduce carbon footprint and air pollution.

Connected trash cans can be integrated with mobile applications or websites to provide citizens with real-time information on nearby waste collection points, recycling guidelines, and overall waste management initiatives. This engagement encourages responsible waste disposal practices and fosters a sense of environmental consciousness among the public.

Overall, smart city waste management systems with connected trash cans using IoT offer numerous advantages, including improved efficiency, reduced costs, environmental sustainability, citizen engagement, and better overall cleanliness and hygiene.

Traditional waste management systems are inefficient and often result in overflowing trash cans, littered streets, and unhealthy living conditions. This leads to several issues, including environmental pollution, health hazards, and overall deterioration of the city's aesthetic appeal. The current waste management system lacks the ability to monitor and manage the waste generated effectively. The lack of proper waste disposal infrastructure, insufficient waste collection frequency, and inadequate public participation exacerbate the situation.

To address these issues, a Smartcity waste Management System with connected trashcans is proposed. The system will use IoT technology to monitor the fill-level of trashcans in real-time, optimize the waste collection process, and improve public participation in waste disposal. This will enhance the efficiency of the waste management system, reduce overflowing trash cans, prevent littering, and improve the overall living conditions in the city.

Problem Statement Definition

Traditional waste management systems are inefficient and often result in overflowing trash cans, littered streets, and unhealthy living conditions. This leads to several issues, including environmental pollution, health hazards, and overall deterioration of the city's aesthetic appeal. The current waste management system lacks the ability to monitor and manage the waste generated effectively. The lack of proper waste disposal infrastructure, insufficient waste collection frequency, and inadequate public participation exacerbate the situation.

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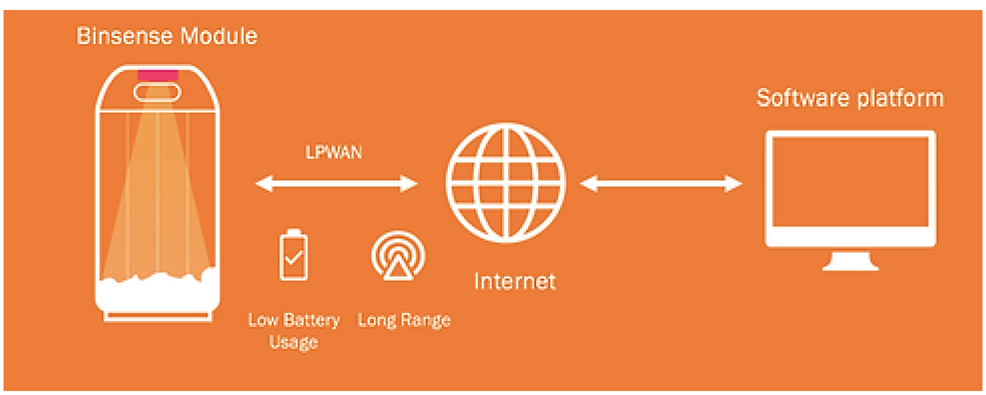
However, there are several challenges that need to be addressed to implement the proposed system effectively. These include designing and implementing a reliable and robust IoT system, integrating the system with the existing waste management infrastructure, developing an effective public participation strategy, and ensuring data privacy and security. Therefore, the aim of this project is to develop and implement a Smartcity waste Management System with connected trashcans that can overcome these challenges and improve the overall waste management system in the city.

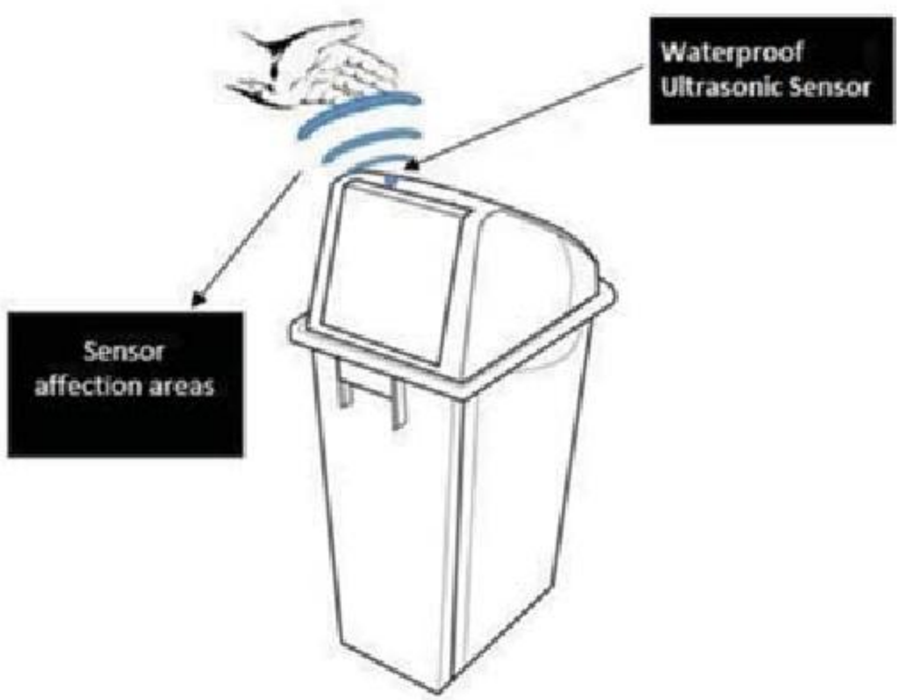
IDEATION & PROPOSED SOLUTION

Empathy Map Canvas

An empathy map is a simple, easy-to-digest visual that captures knowledge about a user's behaviours and attitudes. It is a useful tool to helps teams better understand their users. Creating an effective solution requires understanding the true problem and the person who is experiencing it. The exercise of creating the map helps participants consider things from the user's perspective along with his or her goals and challenges



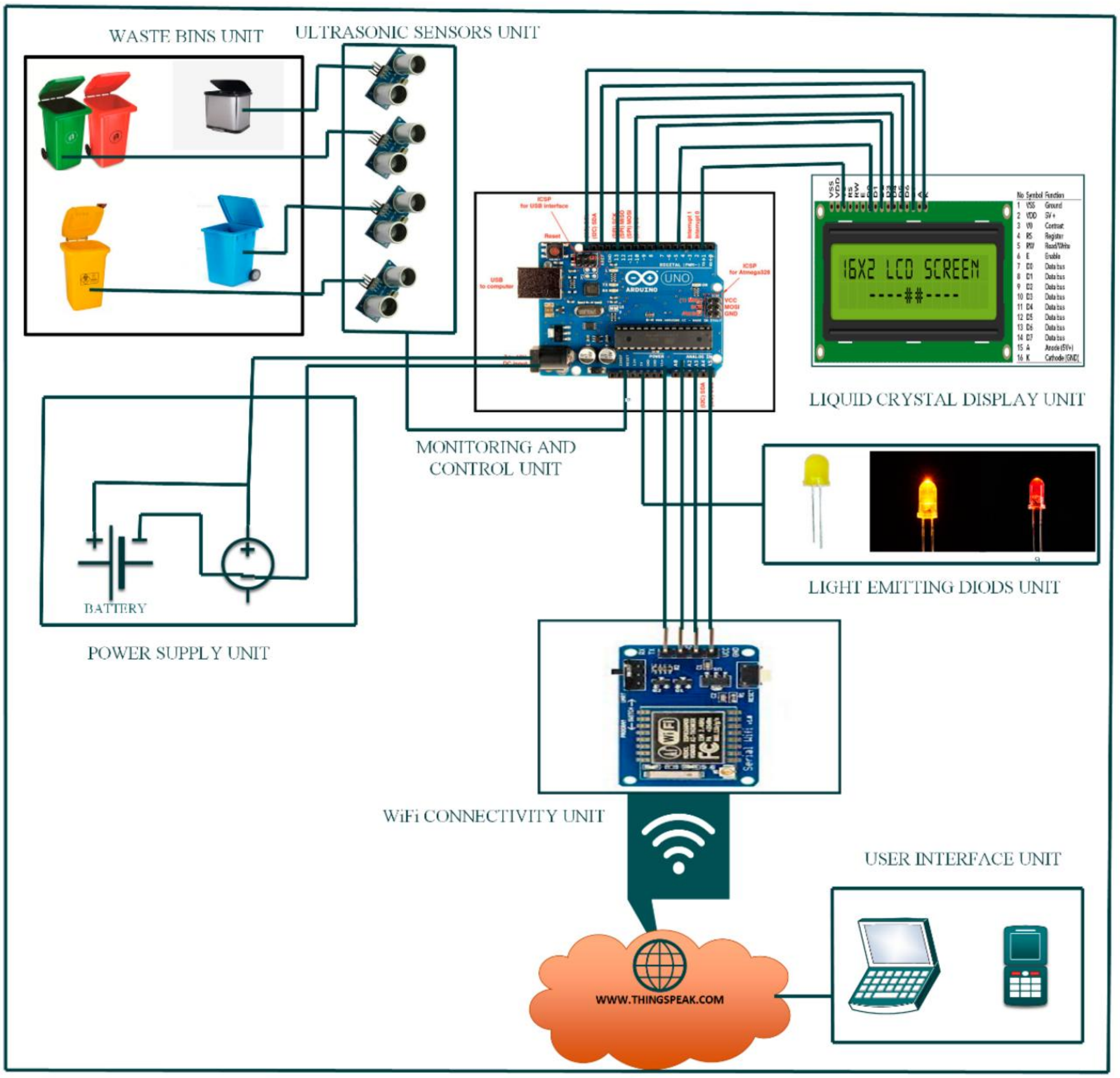
Smart Bin



Ideation & Brainstorming

Smartcity waste management systems with connected trashcans

Sensor-Enabled Trash Cans: Install sensors in the trash cans to detect the level of waste inside. When the trash can reaches a certain capacity, it can automatically send a notification to the waste management system, enabling efficient waste collection and preventing overflow.



PROPOSED SOLUTION

Project Design Phase-I

Proposed Solution Template

Project team shall fill the following information in proposed solution template.

S.No.	Parameter	Description
	Problem Statement (Problem to be solved)	Traditional waste management systems are inefficient and often result in overflowing trash cans, littered streets, and unhealthy living conditions. This leads to several issues, including environmental pollution, health hazards, and overall deterioration of the city's aesthetic appeal. The current waste management system lacks the ability to monitor and manage the waste generated effectively. The lack of proper waste disposal infrastructure, insufficient waste collection frequency, and inadequate public participation exacerbate the situation. To address these issues, a Smartcity waste Management System with connected trashcans is proposed. The system will use IoT technology to monitor the fill-level of trashcans in real-time, optimize the waste collection process, and improve public participation in waste disposal. This will enhance the efficiency of the waste management system, reduce overflowing trash cans, prevent littering, and improve the overall living conditions in the city.
	Idea / Solution description	some ideas for implementing this project: IoT-enabled trash cans: The first step is to design and develop IoT-enabled trash cans that can detect their fill-level and communicate this information to the waste management system. The trash cans can be equipped with sensors that use various technologies such as ultrasonic, infrared, or weight-based sensors to measure the fill-level of the trash can. Wireless connectivity: The trash cans should be equipped with wireless connectivity such as Wi-Fi, Bluetooth, or cellular communication to transmit the fill-level data to the cloud-based waste management system. Cloud-based waste management system: The waste management system will receive data from all connected

		trash cans and use this information to optimize the waste collection process. The system can use machine learning algorithms to predict the fill-level of trash cans and optimize the collection routes based on this information. Mobile application: A mobile application can be developed to encourage public participation in waste disposal. The app can provide real-time information on the fill-level of trash cans, the nearest available trash can, and the expected collection time. The app can also gamify waste disposal by awarding points for proper waste disposal and incentivizing users to recycle. Data privacy and security: The system should be designed to ensure the privacy and security of user data. This can be achieved by implementing data encryption, access controls, and regular security audits.
	Novelty / Uniqueness	Smartcity waste management system with connected trashcans IoT project is unique in its ability to leverage IoT technology to optimize waste management processes in urban areas. The project's real-time monitoring, optimization of waste collection, improved public participation, data-driven decision-making, and integration with existing waste management infrastructure make it an innovative and effective solution to the challenges of modern waste management.
	Social Impact / Customer Satisfactio	Smartcity waste management system with connected trashcans IoT project can significantly improve customer satisfaction regarding waste management in urban areas. By keeping streets cleaner, improving the efficiency of waste collection, incentivizing public participation, using data-driven decision-making, and providing transparency, the project can help create a more pleasant and sustainable urban environment.
	Business Model (Revenue Model	Smartcity waste management system with connected trashcans IoT project can have a variety of potential business models, depending on the project stakeholders' goals and

		needs. The project's unique features, such as real-time monitoring, optimization of waste collection, improved public participation, data-driven decision-making, and integration with existing waste management infrastructure, make it an attractive proposition for a range of business models.
	Scalability of the Solution	Smartcity waste management system with connected trashcans IoT project has the potential to be highly scalable. Its modular design, cloud-based architecture, machine learning algorithms, mobile application, and low maintenance requirements make it an ideal solution for growing cities and increasing amounts of waste. As more cities adopt smart waste management solutions, the Smartcity waste management system can be easily adapted to meet their needs. solutions, the Smartcity waste management system can be easily adapted to meet their needs.

Problem solution fit

Problem: Inefficient waste collection and management processes in cities lead to overflowing trash cans, unsightly streets, and increased health and environmental risks.

Solution: Implement a smart city waste management system with connected trash cans to improve efficiency and effectiveness.

Smart Trash Cans: Install sensor-enabled trash cans equipped with fill-level sensors and lid-opening sensors. These sensors can detect the fill level of the trash can and notify waste management personnel when the can is almost full or needs emptying.

Real-time Monitoring: Connect the trash cans to a centralized waste management system that provides real-time monitoring and data analytics. This enables waste management personnel to track the fill levels of all connected trash cans and optimize collection routes accordingly.

Route Optimization: Utilize the data collected from the connected trash cans to optimize waste collection routes. Advanced algorithms can determine the most efficient routes based on real-time data, reducing fuel consumption, travel time, and carbon emission

Predictive Maintenance: Incorporate predictive maintenance into the system by monitoring the health and performance of trash cans. The system can analyze historical data to identify potential issues such as damaged sensors or malfunctioning lids. This proactive approach allows for timely maintenance, reducing downtime and ensuring optimal performance.

Smart Bin Allocation: Analyze the data collected from the connected trash cans to identify areas with higher waste generation and adjust the allocation of trash cans accordingly. By strategically placing more trash cans in densely populated areas or locations prone to high waste generation, the system can prevent overflow and maintain cleanliness.

Public Awareness: Implement a public awareness campaign to educate citizens about the benefits of the smart city waste management system and encourage responsible waste disposal. Promote the use of the connected trash cans and emphasize the importance of recycling and waste reduction.

Integration with Recycling Programs: Integrate the smart city waste management system with existing recycling programs. The system can include separate compartments in the connected trash cans for recyclable materials, allowing citizens to easily dispose of recyclables while ensuring proper segregation and reducing contamination.

Data-driven Decision Making: Utilize the wealth of data collected from the connected trash cans to gain insights into waste generation patterns, peak hours, and other relevant factors. This information can help city authorities make data-driven decisions, such as adjusting collection schedules, optimizing resource allocation, and implementing targeted waste reduction initiatives

Project Design Phase-II

Solution Requirements (Functional & Non-functional)

Functional Requirements:

Following are the functional requirements of the proposed solution.

Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
Trash Can Monitoring	Trash Can Monitoring: The system should include sensors installed in the trash cans to accurately measure and monitor the fill level of each bin. The sensors should provide real-time data on the fill level, allowing efficient waste collection planning.
Connectivity and Communication:	The trash cans should be equipped with wireless or IoT connectivity to establish a seamless connection with the waste management system. The system should ensure reliable and secure communication between the trash cans and the central waste management system.
Centralized Management System:	The waste management system should have a centralized management platform or dashboard that displays real-time data from all connected trash cans. The platform should provide an intuitive user interface for monitoring and managing the trash cans efficiently.
Fill Level Thresholds and Alerts: .	Fill Level Thresholds and Alerts: The system should allow operators to set fill level thresholds for each trash can, indicating

	when it is time for collection. When a trash can reaches the predefined threshold, the system should generate automated alerts or notifications to the waste management team.

Non-functional Requirements:

Following are the non-functional requirements of the proposed solution.

Non-Functional Requirement	Description
Usability	Simple Interface: The interface of these systems is designed to be simple and easy to use. Automatic Notifications: The system can automatically notify waste management companies when a trash can is full or needs to be emptied. Efficient Data Analytics: Smart city waste management systems use data analytics to track waste generation patterns and predict future waste generation trends Customizable Settings: Users can customize the settings of the system to meet their specific needs. Real-time Feedback: Smart city waste management systems provide real-time feedback to users, allowing them to monitor the status of their waste disposal in real-time. This helps users to better manage their waste disposal and to reduce their environmental impact.
Security	Smart city waste management systems with connected trash cans can be made secure by implementing appropriate security measures and following best practices for IoT security. By doing so, these systems can provide effective waste management while

	maintaining the privacy and security of user data.
Reliability	Smart city waste management systems with connected trash cans can be made reliable by using high-quality components, implementing redundancy, performing regular maintenance, real-time monitoring, and battery backup. By doing so, these systems can provide reliable waste management solutions for cities.
Performance	Smart city waste management systems with connected trash cans can be made reliable by using high-quality components, implementing redundancy, performing regular maintenance, real-time monitoring, and battery backup. By doing so, these systems can provide reliable waste management solutions for cities.
Availability	Smart city waste management systems with connected trash cans can be optimized for availability by implementing redundancy, using cloud-based storage, performing regular maintenance, having a disaster recovery plan in place, and real-time monitoring. By doing so, these systems can provide reliable and always-available waste management solutions for cities.
Scalability	Smart city waste management systems with connected trash cans can be optimized for scalability by using a modular design, cloud-based infrastructure, distributed architecture, open standards, and future-proofing. By doing so, these systems can provide scalable waste management solutions for cities, enabling them to handle increasing amounts of waste as they grow and expand.

Project design

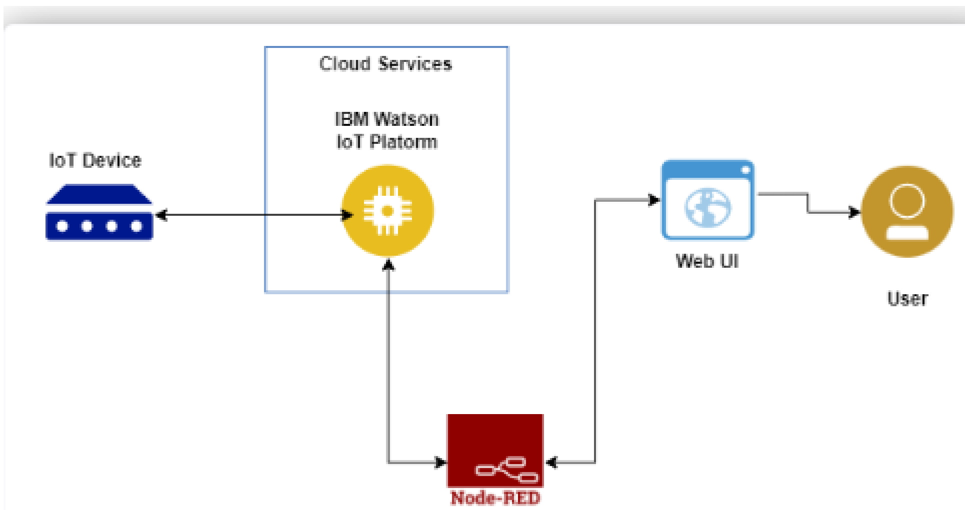
Data Flow Diagrams

A Data Flow Diagram (DFD) is a traditional visual representation of the information flows within a system. A neat and clear DFD can depict the right amount of the system requirement graphically. It shows how data enters and leaves the system, what changes the information, and where data is stored.

Example: (Simplified)

Solution and Technical architecture

Solution Architecture:



A solution architecture for a smart city waste management system with connected trash cans typically involves a combination of hardware, software, and communication technologies. Here's a high-level overview of the solution architecture:

Connected Trash Cans : Sensor-enabled trash cans with fill-level sensors and lid-opening sensors.Communication modules to transmit data from the sensors.Communication Infrastructure:Wireless connectivity (e.g., cellular, Wi-Fi, or LoRaWAN) to enable communication between the trash cans and the central system.Gateways or base stations to aggregate and transmit data from multiple trash cans to the central system.

Centralized Waste Management System : Cloud-based infrastructure to process, store, and analyze data from connected trashcans.Data management and storage components to handle the large volume of sensor data.Real-time data processing and analytics capabilities for efficient decision-making.Application programming interfaces (APIs) to integrate with other systems and services.User interface/dashboard for waste management personnel to monitor and manage the system.

Data Processing and Analytics: Data ingestion and preprocessing to clean and validate incoming sensor data.Analytics engines and algorithms to analyze fill-level data, lid-opening events, and other relevant parameters.Predictive analytics to identify maintenance needs, optimize collection routes, and detect abnormal waste generation patterns.

Route Optimization : Routing algorithms that leverage real-time and historical data to optimize waste collection routes.Integration with geographic information systems (GIS) to visualize and manage collection routes.Integration with navigation systems or mobile applications used by waste collection teams for route guidance.

Predictive Maintenance : Machine learning algorithms to analyze sensor data and detect anomalies or maintenance requirements.Alerting and notification mechanisms to notify maintenance teams about issues or potential failures.Integration with maintenance management systems to schedule and track maintenance activities.

Integration and Interfaces : Integration with existing waste management systems, such as billing and customer service systems.Integration with recycling programs and facilities to ensure proper waste segregation and recycling.APIs and interfaces to exchange data with other smart city applications or platforms (e.g., traffic management, environmental monitoring).

Security and Privacy : Robust security measures to protect data privacy and prevent unauthorized access.Encryption protocols for secure data transmission between trash cans, gateways, and the central system.Access control mechanisms to ensure only authorized personnel can access the system and its data.

User Stories

Use the below template to list all the user stories for the product.

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Team Member
Operator	Trash Can Monitoring	USN-1	As a user , want the trash cans to be equipped with sensors to detect the fill level of each bin accurately.	I want the trash cans to be equipped with sensors to detect the fill level of each bin accurately.	High	Murugan

Operator	Real time monitoring	USN-2	As a user, want the trash cans to be connected to a central waste management system for real-time monitoring and data analysis	I want the trash cans to be connected to a central waste management system for real-time monitoring and data analysis.	High	Kaleeswari
Operator	Waste manageme nt	USN-3	As a user, want the waste management System to automatically generate	I want the waste management system to	Low	Kamali

Project Design Phase-III

Data Flow Diagram & User Stories

Date	16.05.2023
Team ID	NM2023TMID19394
Project Name	Smartcity waste management systems with connected trashcans

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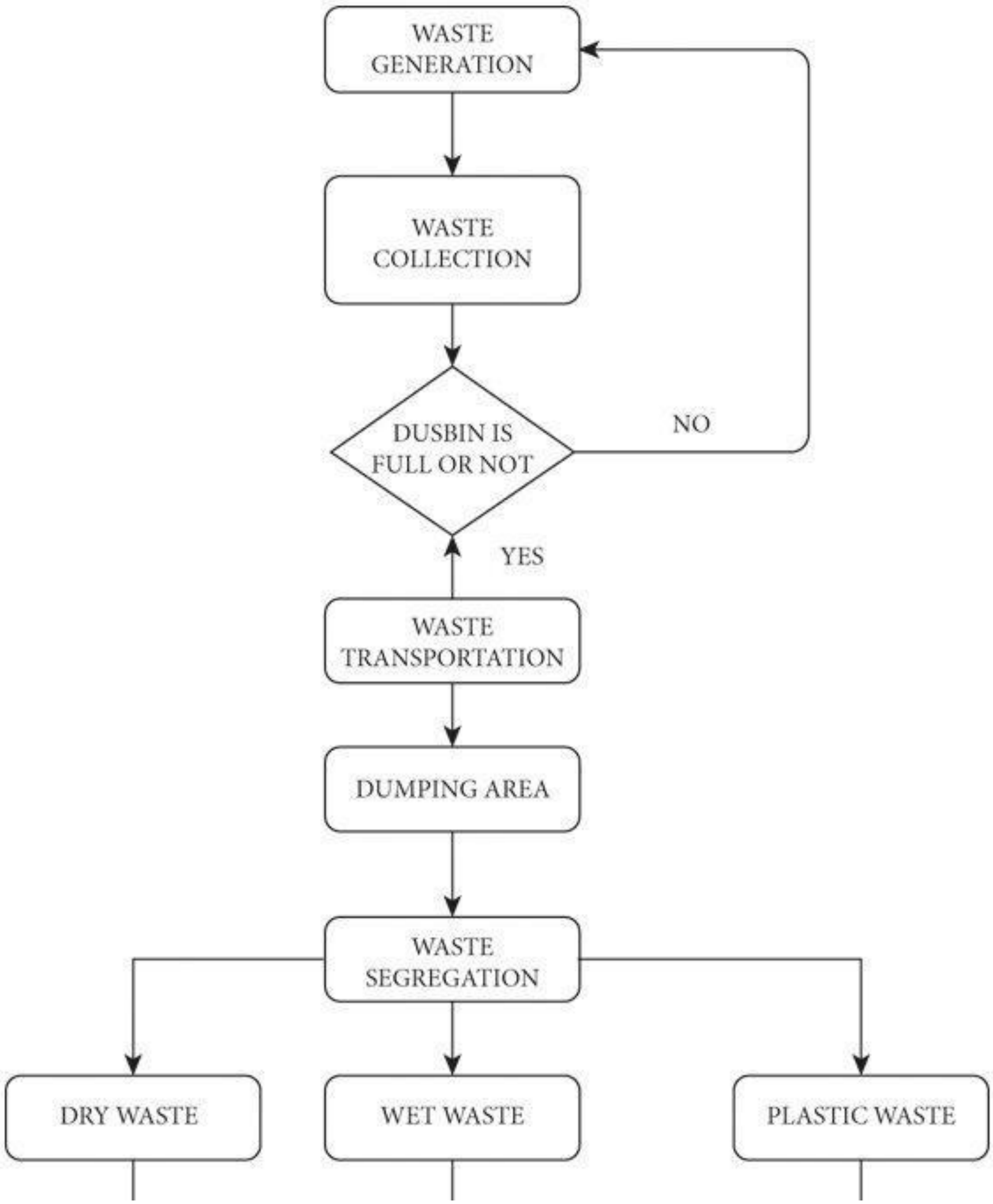
WASTE GENERATION
WASTE COLLECTION
DUSBIN IS FULL OR NOT
NO
YES
WASTE TRANSPORTATION
DUMPING AREA
WASTE SEGREGATION
DRY WASTE
WET WASTE
PLASTIC WASTE

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Team Member
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Operator	Waste management	USN-3	As a user, want the waste management system to automatically generate	I want the waste management system to	Low	Kamali

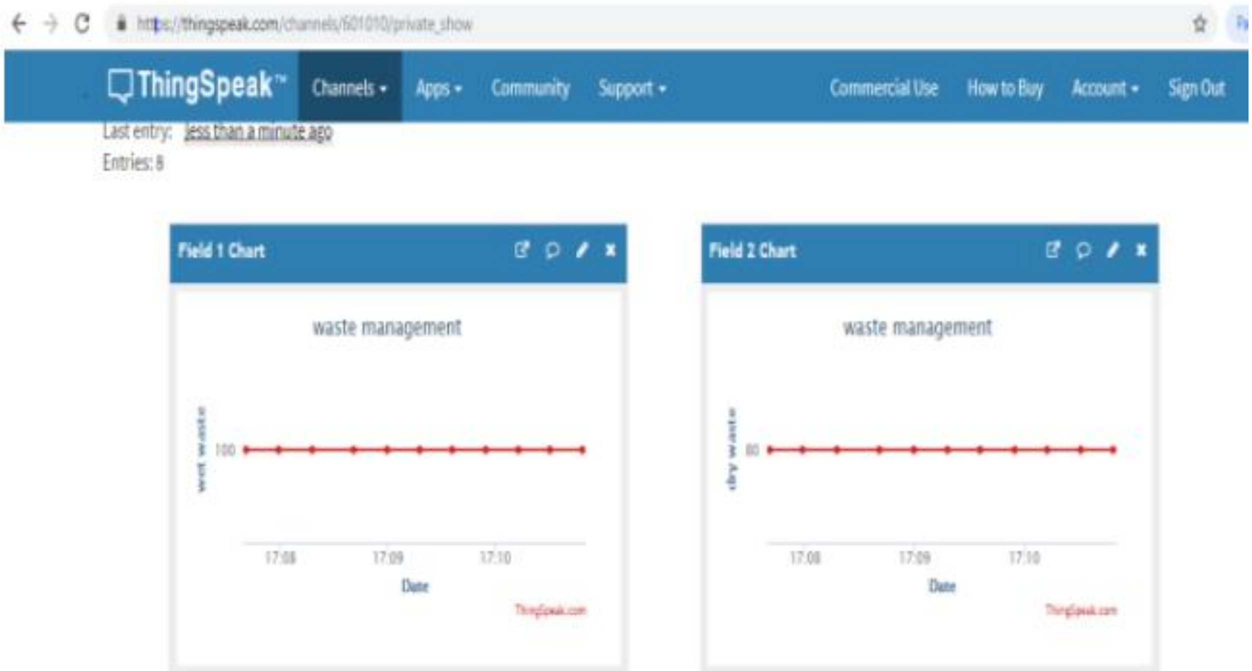
User Type	Functional Requirement(Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Team Member
	system		notifications when a trash can is nearing full capacity, so that timely collection can be scheduled.	automatically generate notifications when a trash can is nearing full capacity, so		

				that timely collection can be scheduled.		
Operator	Real-time data	USN-4	As a user, want the waste management system to optimize collection routes based on real-time data, reducing unnecessary trips	I want the waste management system to optimize collection routes based on real-time data, reducing unnecessary trips	Medium	Shanmugaraj

PROJECT PLANNING & SCHEDULING

Sprint Planning & Estimation

ThingSpeak ThingSpeak is an IoT analytics platform service that allows you to aggregate, visualize and analyze live data streams in the cloud. ThingSpeak provides instant visualizations of data posted by your devices to ThingSpeak. With the ability to execute MATLAB code in ThingSpeak you can perform online analysis and processing of the data as it comes in. ThingSpeak is often used for prototyping and proof of concept IoT systems that require analyticsScreenshot



Coding and Solutioning

```
#define SW_VERSION " ThinkSpeak.com" // SW

version will appears at innitial LCD Display

#include < ESP8266WiFi.h>

const int M1_FORE = D1; //D5

const int M1_BACK = D2; //D6

const int Weight = D3; //D6

const int trigPin1 = D5; //D5

const int echoPin1 = D6; //D6

const int trigPin2 = D7; //D7

const int echoPin2 = D8; //D8

// defines variables

long duration1,duration2;

int distance1,distance2;
```

```
}

WiFiClient client;

WiFiServer server(80);

const char* MY_SSID = "vivo 1820";

const char* MY_PWD = "hello123";

const char* TS_SERVER = "api.thingspeak.com";

String TS_API_KEY ="49TH83LL0I1SJDJN";

void connectWifi()

{

Serial.print("Connecting to "+ *MY_SSID);

WiFi.begin(MY_SSID, MY_PWD);

while (WiFi.status() != WL_CONNECTED)

{

delay(1000);

Serial.print(".");

}

Serial.println("");

Serial.println("WiFi Connected");

Serial.println("");

server.begin();

Serial.println("Server started")

Serial.print("Use this URL to connect: ");

Serial.print("http://");

Serial.print(WiFi.localIP());

Serial.println("/");

}
```

```
void sendDataTS(void)
{
 int water_value = analogRead(A0);
 digitalWrite(trigPin1, LOW);
 delayMicroseconds(2);
 digitalWrite(trigPin1, HIGH);
 delayMicroseconds(10);
 digitalWrite(trigPin1, LOW);
 duration1 = pulseIn(echoPin1, HIGH);
 distance1 = duration1*0.034/2;
 Serial.print("Distance_1: ");
 Serial.println(distance1);
 digitalWrite(trigPin2, LOW);
 delayMicroseconds(2);
 digitalWrite(trigPin2, HIGH);
 delayMicroseconds(10);
 digitalWrite(trigPin2, LOW);
 duration2 = pulseIn(echoPin2, HIGH);
 distance2 = duration2*0.034/2;
 Serial.print("Distance_2: ");
 Serial.println(distance2);

 Serial.print("Water_Value: ");
 Serial.println(water_value);
 if(digitalRead(Weight) == LOW)
```

```
{
if(water_value < 700)
{
digitalWrite(M1_FORE,HIGH);
delay(2000);
digitalWrite(M1_FORE,LOW);
delay(1000);
digitalWrite(M1_BACK,HIGH);
delay(2100);
digitalWrite(M1_BACK,LOW);
}
else
{
digitalWrite(M1_BACK,HIGH);
delay(2000);
digitalWrite(M1_BACK,LOW);
delay(1000);
digitalWrite(M1_FORE,HIGH);
delay(2000);
digitalWrite(M1_FORE,LOW);
}
}
if (client.connect(TS_SERVER, 80))
{
String postStr = TS_API_KEY;
```

```
 postStr += "&field1=";
 postStr += String(distance1);
 postStr += "&field2=";
 postStr += String(distance2);
 postStr += "\r\n\r\n";
client.print("POST /update HTTP/1.1\n");
 client.print("Host: api.thingspeak.com\n");
 client.print("Connection: close\n");
 client.print("X-THINGSPEAKAPIKEY: " +
TS_API_KEY + "\n");
 client.print("Content-Type: application/x-wwwform-urlencoded\n");
 client.print("Content-Length: ");
 client.print(postStr.length());
 client.print("\n\n");
 client.print(postStr);
 delay(100);
 }
 client.stop();
}
void setup()
{
 Serial.begin(9600);
 delay(10);
 connectWifi();
 pinMode(trigPin1, OUTPUT); // Sets the trigPin as
```

```
an Output
 pinMode(echoPin1, INPUT); // Sets the echoPin as
an Input
 pinMode(trigPin2, OUTPUT); // Sets the trigPin as
an Output
 pinMode(echoPin2, INPUT); // Sets the echoPin as
an Input
 pinMode(M1_FORE, OUTPUT); // Sets the
MOTOR_FORWARD as an Output
 pinMode(M1_BACK, OUTPUT); // Sets the
MOTOR_BACKWARD as an Output
 pinMode(Weight,INPUT);
 digitalWrite(Weight,HIGH);
}
void loop()
{
 sendDataTS();
 delay(16000);
}
```

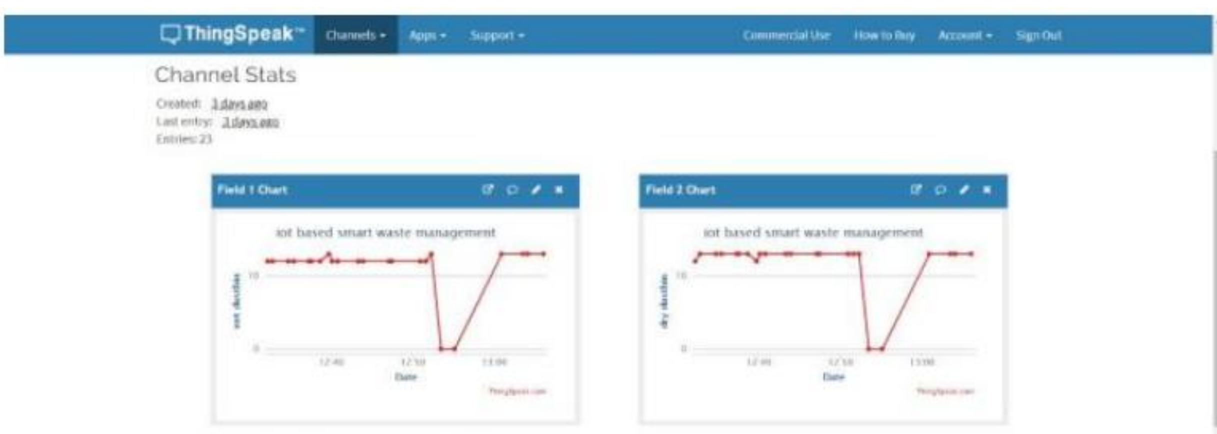
RESULT AND DISCUSSION

The below figure shows the graphical representation of levels of waste in both containers as uploaded to the ThingSpeak cloud. This page can be accessed by any person who has the username and password of the account. The use of IoT-enabled trash cans allows waste management personnel to monitor the fill levels of trash cans in real-time. This data helps optimize waste collection routes, ensuring that trash cans are emptied when they reach capacity, minimizing overflow and unsightly streets.

By optimizing waste collection routes based on real-time data, cities can reduce fuel consumption, travel time, and labor costs associated with waste collection. Predictive maintenance capabilities also help prevent costly breakdowns by identifying maintenance needs in advance.The data collected from connected trash cans provides insights into waste generation patterns and peak hours. This information helps allocate resources effectively by adjusting collection schedules and deploying personnel to areas with higher waste generation during specific times.

Efficient waste collection reduces the emission of greenhouse gases and promotes environmental sustainability. By minimizing unnecessary waste collection trips and optimizing routes, cities can reduce carbon footprint and contribute to a cleaner environment.IoT-enabled waste management systems generate a wealth of data that can be analyzed to gain insights into waste generation trends, identify problem areas, and inform future planning and decision-making processes. Data-driven insights help optimize waste management strategies and allocate resources where they are most needed.

IoT-based waste management systems can facilitate citizen participation and engagement in waste reduction initiatives. Connected trash cans can provide feedback to citizens, such as notifications when a trash can is full or reminders to recycle, encouraging responsible waste disposal practices.IoT technology enables remote monitoring and control of connected trash cans, reducing the need for physical inspections and allowing for timely intervention in case of issues. Remote monitoring also helps detect and address illegal dumping or suspicious activities around the trash cans.



Advantages

The use of IoT-enabled trash cans allows waste management personnel to monitor the fill levels of trash cans in real-time. This data helps optimize waste collection routes, ensuring that trash cans are emptied when they reach capacity, minimizing overflow and unsightly streets.

By optimizing waste collection routes based on real-time data, cities can reduce fuel consumption, travel time, and labor costs associated with waste collection. Predictive maintenance capabilities also help prevent costly breakdowns by identifying maintenance needs in advance.

The data collected from connected trash cans provides insights into waste generation patterns and peak hours. This information helps allocate resources effectively by adjusting collection schedules and deploying personnel to areas with higher waste generation during specific times.

Efficient waste collection reduces the emission of greenhouse gases and promotes environmental sustainability. By minimizing unnecessary waste collection trips and optimizing routes, cities can reduce carbon footprint and contribute to a cleaner environment.

IoT-enabled waste management systems generate a wealth of data that can be analyzed to gain insights into waste generation trends, identify problem areas, and inform future planning and decision-making processes. Data-driven insights help optimize waste management strategies and allocate resources where they are most needed.

IoT-based waste management systems can facilitate citizen participation and engagement in waste reduction initiatives. Connected trash cans can provide feedback to citizens, such as notifications when a trash can is full or reminders to recycle, encouraging responsible waste disposal practices.

IoT technology enables remote monitoring and control of connected trash cans, reducing the need for physical inspections and allowing for timely intervention in case of issues. Remote monitoring also helps detect and address illegal dumping or suspicious activities around the trash cans.

Environmental sustainability: Smart waste management systems promote better waste sorting and recycling practices by providing real-time feedback to users. This encourages citizens to be more conscious of their waste disposal habits, leading to increased recycling rates and a cleaner environment.

Data-driven decision-making: The connected infrastructure allows authorities to gather data on waste generation patterns, which can be analyzed to identify trends, optimize waste management strategies, and plan future infrastructure development.

Disadvantages:

High implementation costs: Implementing a smart waste management system with connected trash cans requires significant initial investment in hardware, software, and network infrastructure. This can be a barrier for cities with limited financial resources.

Technological limitations: The effectiveness of the system relies on the accuracy and reliability of sensors and connectivity. Malfunctions, sensor inaccuracies, or network issues can lead to improper waste management, false alarms, or missed opportunities for optimization.

Privacy and data security concerns: Connected trash cans gather data on waste disposal patterns and user behavior. This raises privacy concerns if not handled properly. Safeguarding data and ensuring compliance with privacy regulations is essential to maintain public trust.

Limited scalability: Expanding a smart waste management system to cover an entire city can be a complex and time-consuming process. Scaling up the infrastructure, connectivity, and data processing capabilities may pose…

Dependency on power supply: Connected trash cans require a stable power supply for their sensors and communication systems to function properly. Power outages or failures can disrupt the real-time monitoring and waste management processes.

Overall, while smart city waste management systems with connected trash cans offer numerous advantages in terms of efficiency, cleanliness, and sustainability, careful consideration of the implementation costs, technology reliability, privacy concerns, scalability, and power supply is crucial for successful adoption and operation.

Future Scope

Integration of advanced technologies: As technology continues to advance, there are opportunities to integrate additional features into connected trash cans. For example, incorporating artificial intelligence (AI) and machine learning algorithms can improve waste sorting and recycling processes by automatically identifying recyclable materials and providing feedback to users. Additionally, the use of robotics or automated systems for waste collection and sorting can enhance efficiency and reduce manual labor.

Internet of Things (IoT) and connectivity expansion: The IoT ecosystem can be further leveraged to enhance connectivity and communication between trash cans, waste management authorities, and citizens. Integrating more sensors and IoT devices into the waste management infrastructure can provide valuable data on factors like waste composition, temperature, and humidity, enabling more informed decision-making and proactive maintenance.

Predictive analytics and optimization: By utilizing data collected from connected trash cans, predictive analytics can be applied to forecast waste generation patterns and optimize waste collection routes and schedules. This can lead to further cost savings, reduced environmental impact, and improved overall efficiency in waste management operations.

Citizen engagement and behavior modification: The future of smart city waste management systems lies in empowering and engaging citizens. Gamification techniques, mobile applications, and interactive platforms can be developed to encourage residents to actively participate in waste reduction and recycling initiatives. Real-time feedback, rewards, and educational campaigns can motivate behavioral changes and foster a sense of environmental responsibility among the population.

Collaboration and interoperability: To create a truly comprehensive waste management system, collaboration between different stakeholders is essential. Integration with other urban systems such as transportation, energy, and water management can help identify synergies and optimize resource allocation. Additionally, ensuring interoperability between different cities and regions can enable the exchange of best practices and standardized waste management approaches.

Circular economy principles: Future smart waste management systems should strive to align with the principles of the circular economy. This involves focusing on waste prevention, resource recovery, and the promotion of sustainable production and consumption. Connected trash cans can play a pivotal role in facilitating the transition to a circular economy by enabling efficient recycling and reuse practices and fostering a culture of waste reduction.

In summary, the future of smart city waste management systems with connected trash cans holds immense potential for advancements in technology, data analytics, citizen engagement, and sustainability practices. By leveraging these opportunities, cities can enhance their waste management capabilities, reduce environmental impact, and create more livable and sustainable urban environments.

Conclusion

In conclusion, smart city waste management systems with connected trash cans offer numerous advantages and hold great potential for the future of urban waste management. These systems provide efficient waste collection, improve cleanliness, reduce costs, promote environmental sustainability, and enable data-driven decision-making. However, they also come with challenges such as high implementation costs, technological limitations, privacy concerns, scalability issues, and dependency on power supply.

Looking ahead, the future scope for these systems is promising. Integration of advanced technologies like AI, machine learning, and robotics can enhance waste sorting, recycling, and collection processes. Expanding connectivity through IoT can improve communication and data exchange. Predictive analytics and optimization can further optimize waste management operations. Citizen engagement and behavior modification can be fostered through gamification and educational initiatives. Collaboration and interoperability with other urban systems can maximize resource allocation and efficiency. Embracing circular economy principles can contribute to sustainable production and consumption practices.

By addressing these future directions, cities can create more efficient, sustainable, and livable environments. The continued development and implementation of smart city waste management systems with connected trash cans will play a crucial role in creating a cleaner, greener future for urban areas.

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Github & Demo video link

Github link

https://github.com/Kalisiva/rolex

https://github.com/naanmudhalvan-SI/PBL-NT-GP--6048-1680844924

Demo video link

https://youtu.be/MBd-mJuXqcc