A SMART WASTE MANAGEMENT SYSTEM IN DHAKA CITY CORPORATION UTILIZING IOT DEVICES

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This Report Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Computer Science and Engineering

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APPROVAL

This Project titled "**A Smart Waste Management System in Dhaka City Corporation Utilizing IoT Devices**", submitted by "**Sharif Uddin**" to the Department of Computer Science and Engineering, Daffodil International University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on July 16, 2024.

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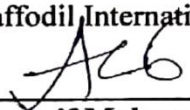

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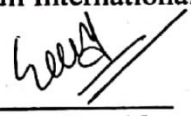

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DECLARATION

I hereby declare that this project has been done by us under the supervision of **Professor Dr. Md. Fokhray Hossain, Professor,** and Department of Computer Science and Engineering (CSE) at Daffodil International University (DIU). We also declare that neither this project nor any part of this project has been submitted elsewhere for the award of degree.

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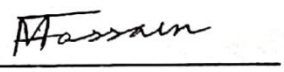

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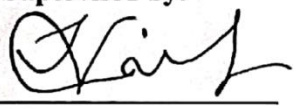

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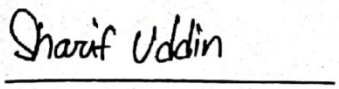

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ABSTRACT

The growing metropolitan area of Bangladesh's Dhaka City highlights the pressing need for creative waste management solutions to deal with the country's growing population densities and related environmental problems. This study looks at how a sophisticated waste management system using cutting-edge IoT technology is developed and put into use. The aim is to provide innovative methods for efficient waste collection and handling, acknowledging noteworthy obstacles and incorporating pertinent parties. The suggested system allows for real-time trash level monitoring and efficient scheduling and routing of collection routes by incorporating IoT sensors into waste bins. An intuitive online tool gives stakeholders useful information that they may use to make well-informed decisions and run operations more effectively. This all-encompassing approach tackles the intricate waste management issues facing Dhaka City by fusing sustainability principles, stakeholder participation, and technological innovation. Through resource and environmental optimization, the suggested method seeks to improve garbage collection routes and schedules, fostering a more hygienic, livable, and sustainable urban environment. Furthermore, the community is engaged through an easy-to-use online interface that provides individuals with garbage information and promotes proper disposal methods. Through the seamless integration of IoT technology and community interaction, this project intends to establish sustainable trash management solutions that are adapted to Dhaka's urban context, reduce environmental impact, and boost efficiency.

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CHAPTER 1

Introduction

1.1 Overview

Bangladesh's capital city of Dhaka is facing enormous waste management issues due to the city's fast urbanization and population expansion. Traditional waste management systems are being overwhelmed by the volume and complexity of garbage created. These systems mostly rely on manual processes. The general livability of metropolitan environments, environmental sustainability, and public health are all seriously threatened by this insufficiency. Effective waste management is essential to minimizing adverse environmental effects, attaining sustainable development objectives, and preserving the cleanliness and visual appeal of the city.

This study investigates how Internet of Things technology can revolutionize garbage management in Dhaka in light of these obstacles. Smart trash management systems with IoT capabilities provide effective waste collection routes, optimal resource allocation, and real-time monitoring. Dhaka City Corporation can greatly improve the efficacy and efficiency of its waste management procedures by putting such systems in place, which will help to create a cleaner, more livable, and sustainable urban environment.

This project uses the Internet of Things (IoT) and other contemporary technical breakthroughs to remedy the limitations of Dhaka's current garbage management system. The ultimate objective is to create an intelligent waste management system that enhances operational effectiveness and promotes urban development and environmental sustainability. The results of this study will serve as a basis for further investigation and the use of intelligent waste management strategies in Dhaka and other comparable urban environments across the globe.

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1.2 Background of the Project

Bangladesh's fast urbanization, especially in Dhaka, the country's capital, has created serious problems for the country's public services and urban infrastructure. The complexity and amount of trash produced in Dhaka are increasing along with the city's population. The growing waste management requirements of such a densely populated metropolitan centre are beyond the capabilities of traditional waste management systems, which mostly rely on manual operations. The general livability of metropolitan areas, environmental sustainability, and public health are all seriously threatened by this deficiency.

In addition to preserving the city's aesthetic attractiveness and cleanliness, efficient waste management is essential for reducing the garbage's negative environmental effects. Ineffective waste management techniques can cause pollution, the spread of illness, and other risks to the general public's health. Furthermore, creative waste management solutions become essential as cities work to achieve the Sustainable Development Goals (SDGs), especially SDG 11 (sustainable cities and communities) and SDG 7 (affordable and clean energy). These objectives stress how crucial it is to lessen the negative effects of cities on the environment, enhance waste management techniques, and improve air quality.

In this regard IoT technology is a viable answer to Dhaka's trash management problems. Real-time monitoring, effective resource allocation, and optimized waste collection routes are all possible with IoT-based smart waste management systems. By considerably increasing the efficacy and efficiency of waste management procedures, such systems can support the development of a more hygienic, livable, and sustainable urban environment.

The pressing need to solve the shortcomings in Dhaka's current waste management system and investigate cutting-edge, technologically advanced solutions is what inspired

this study. The purpose of this project is to create a smart waste management system that supports environmental sustainability and urban development while simultaneously increasing operational efficiency through the use of IoT technology. Future research and the application of intelligent waste management techniques in Dhaka and other comparable metropolitan environments will build upon the findings of this study.

1.3 Problem Statement

The Dhaka Metropolitan Area is struggling with sustainability and formal waste disposal, marked by inefficient waste collection and recycling mechanisms, further intensified by the city's exponential population growth (Sayeda Shahpara Shah, 2022). The city's environmental deterioration and public health hazards are clear consequences of poor garbage management. The ecology and the health of Dhaka's citizens are seriously threatened by the ineffective waste management system, which also has an impact on the city's cleanliness and hygiene. Considering these conditions, implementing practice-efficient waste management plans is essential and calls for teamwork to tackle the growing challenge.

Thus, the goal of this study is to address the shortcomings of Dhaka City's current waste management system, both in terms of effectiveness and sufficiency. Its specific goal is to investigate how modern technology developments, in particular the IoT, can be used to create intelligent waste management systems. By streamlining rubbish collection, cutting expenses, and enhancing overall effectiveness, this method hopes to make Dhaka's urban environment greener and more sustainable.

1.4 Objectives

Adoption of a smart trash management system that uses IoT technology is a suggested remedy for Dhaka City Corporation's (DCC) waste management problems. By streamlining the entire waste management process—from collection to disposal—this strategy increases sustainability and efficiency. Implementing IoT-enabled sensors and

devices at different waste management stages forms the basis of this system. By installing these sensors in garbage cans, you can track fill levels in real time and relay data to a central system. Through constant waste-level monitoring, the system can dynamically optimize waste collection routes, minimizing operational costs and ensuring that bins are emptied before they overflow. The creation of a centralized administration platform that unifies data from all IoT sensors is another component of the proposed approach. For instance, the platform can identify regions that regularly generate a lot of waste, which could lead to focused interventions like bigger bin capacities or public awareness campaigns on waste reduction.

1.5 Proposed Solution

This project's main goal is to conduct a thorough investigation into the complex garbage collection and recycling procedures under the control of the Dhaka City Corporation. The use of modern technology innovations, especially the IoT revolutionary potential, to solve the intricate problems associated with urban trash management is at the heart of this project. By thoroughly examining current approaches and taking a proactive stance against common challenges, this study aims to develop novel solutions that have the potential to revolutionize the way waste is gathered, handled, and disposed of in Dhaka's busy metropolitan setting. Through the painstaking design and implementation of state-of-the-art systems and infrastructure, the ultimate goal is to coordinate a smooth and effective waste management framework that not only improves the sustainability and cleanliness of the city but also acts as a model for other urban centers around the world facing comparable waste management a large amount of issues in this world.

1.6 Scope and Limitations

The development and deployment of an Internet of Things (IoT)-based smart waste management system for Dhaka City Corporation are included in the study's purview. Included in the spotlight are:

- **IoT Sensor Deployment**: Identification and deployment of IoT-enabled sensors to monitor waste levels in real-time.
- **Data Integration**: Development of a centralized management platform to aggregate and analyze data from various sensors.
- **Route Optimization**: Utilization of real-time data for optimizing waste collection routes to enhance efficiency and reduce operational costs.
- **Predictive Analytics**: Implementation of predictive analytics to anticipate waste collection needs and support strategic planning.
- **Stakeholder Engagement**: Evaluation of the impact on stakeholders, including city planners, waste management authorities, and residents.
- **Environmental and Health Benefits**: Assessment of potential improvements in public health and environmental outcomes due to enhanced waste management practices.
- **Technical Constraints**: Challenges related to the deployment and maintenance of IoT sensors, including connectivity issues and hardware reliability.
- **Data Accuracy**: Potential inaccuracies in sensor data, which could affect the system's effectiveness in real-time monitoring and decision-making.
- **Implementation Costs**: High initial costs associated with the installation of IoT infrastructure and training personnel to manage the system.
- **Scalability**: Difficulties in scaling the proposed system to cover the entire city, particularly in densely populated or under-resourced areas.
- **User Adoption**: Resistance from stakeholders, including waste management workers and residents, in adopting new technologies and practices.
- **Regulatory and Policy Challenges**: Regulatory hurdles and the need for supportive policies to facilitate the implementation and operation of IoT-based waste management systems.
- **Environmental Factors**: External factors such as extreme weather conditions that could impact the functionality of the IoT sensors and overall system performance.

1.7 Report Layout

The first chapter, Introduction, provides it includes the project's background in section 1.1, overview in section 1.2, problem statement in section 1.3, objectives in section 1.4, proposed solution in section 1.5, scope and limitations in section 1.6, report layout in section 1.7, and a brief summary in section 1.8. The second chapter, Literature Review, discusses previous similar studies. It covers an introduction in section 2.1, related work in section 2.2, comparative analysis in section 2.3, efficiency and cost savings in section 2.4, challenges in section 2.5, and a summary in section 2.6. Chapter three, Research Methodology, justifies the research methodology. It discusses the project approaches in section 3.1, requirement analysis in section 3.2, sensor integration in section 3.3, software development in section 3.4, testing and validation in section 3.5, deployment and training in section 3.6, and concludes in section 3.7. Chapter four, Implementation, is dedicated to the practical application of the project, including materials, experiment results, and discussion. It describes hardware integration in section 4.1, sensor deployments in section 4.2, installation of IoT in section 4.3, integration of GPS in section 4.4, microcontroller setup in section 4.5, Firebase database integration with sensors in section 4.6, interaction between the system and web application in section 4.7, software integration and development in section 4.8, agile software development model and key components in section 4.9, implementation of agile smart waste management system in section 4.10, centralized data management in section 4.11, the back-end framework in section 4.12, the front-end library and runtime environment in section 4.13, employee management in section 4.14, real-time monitoring of waste fill levels in section 4.15, collection status in section 4.16, administrator reporting and analytics in section 4.17, user interface and user experience in section 4.18, security and authentication in section 4.19, and concludes in section 4.20. Chapter five, Impact on Society, discusses the impact of the proposed IoT-based waste management system on various domains. It includes an overview in section 5.1, strengths in section 5.2, weaknesses in section 5.3, opportunities in section 5.4, threats in section 5.5, and concludes in section 5.6.

The final chapter, Conclusion, provides a summary of the project, conclusions drawn from the research, and suggestions for future work in sections 6.1, 6.2, and 6.3, respectively, followed by the necessary references.

1.8 Summary

In conclusion, Dhaka's rapidly increasing population and urbanization have placed tremendous strain on the city's current waste-management infrastructure, underscoring the urgent need for a comprehensive and long-term solution. The potential of IoT technology to upgrade waste management systems to data-driven, intelligent, and efficient systems was investigated in this study. To optimize collection routes, reduce operating costs, and monitor waste levels in real-time, the proposed system places a strong emphasis on the deployment of IoT-enabled sensors and devices. Data from these sensors will be integrated into a centralized management platform that will offer real-time analytics and predictive insights to support strategic planning and decision-making. Dhaka City Corporation can greatly improve the effectiveness and sustainability of waste management procedures by putting into place IoT-based smart waste management systems. This method contributes to a cleaner urban environment by lowering operating costs and guaranteeing prompt waste collection. Better public health and environmental outcomes will benefit stakeholders, including city planners, waste management authorities, and citizens, supporting the city's sustainable development goals.

CHAPTER 2

Literature Review

2.1 Overview

This section presents a detailed investigation and analysis of many relevant studies on waste management for Internet-of-Things-based smart cities. The fill level of waste features, such as waste bin size and size, was collected by me using IoT sensors. The administrator will notify the website panel, staff, and relevant authorities when a bin is filled. Garbage bins with sensors are also used to collect waste such as bin size. Device bins and embedded sensors are scattered throughout Dhaka City. After five seconds, the bins are processed according to the type of garbage, its location, level, and state of filling or infilling, and then forwarded to a central station for further processing and storage.

They created smart waste bins that monitored waste using the IoT and managed municipal waste. These bins can efficiently collect waste, identify fires in waste, and estimate future waste generation. Creative solutions become increasingly crucial when infrastructure stresses increase and resources are depleted. Powered by IoT technology, smart trash management has great promise. Prepare to transform waste collection, recycling, and disposal procedures effectively. The literature review thoroughly discusses current research and advances in intelligent waste management techniques, paying particular attention to their applicability and potential impact in urban environments similar to those of Dhaka City Corporation.

2.2 Related Work

Extensive studies on smart waste management strategies conducted in urban settings worldwide have been revealed through a thorough assessment of the current literature. In-depth case studies and scholarly articles highlight how IoT technologies can completely change how waste management is performed. Through the use of Internet-of-Things technology, these researchers seek to improve the sustainability and effectiveness of

waste management procedures while satisfying the requirements of commercial sectors and private citizens operating recycling enterprises. Scholars have identified several approaches intended to address distinct waste management risks and viewpoints. These solutions help reduce costs and promote environmental conservation by streamlining waste collection procedures and providing more effective and efficient waste management methods. In particular, in highly populated urban regions like Dhaka City, the significance of resource optimization and supporting recycling programs is emphasized to lessen the environmental impact of trash disposal. Research shows that by guaranteeing that only full bins are picked up, IoT-based solutions can drastically reduce the number of waste collection visits, resulting in fuel and labor cost savings. These systems may also categorize the different types of waste, which helps shape legislation and recycling initiatives aimed at overall reducing waste output.

Predictive analytics give city planners the ability to predict the patterns of trash generation, allowing for preemptive planning and averting overflow. This guarantees the effective use of waste-management resources. Overall, the literature highlights the critical role of IoT technology in modernizing waste management systems and addressing the challenges faced by rapidly growing urban centers.

2.3 Comparative Analysis

A comparative examination of the examined provides a thorough overview of the benefits and challenges of using IoT technology in the management of trash, covering a variety of urban environments and technical implementations. We list the main points of comparison here:

2.4 Efficiency and Cost Savings

- **Traditional Waste Management Systems:**
  - Depends on set times for the collection of waste, which frequently results in inefficiencies. Excessive operational expenses as a result of late collections that

cause overflows and needless visits to empty bins.

- Limited data collection, mostly done by hand, which increased labor expenses, and delayed response times.

- **IoT-Enabled Smart Waste Management Systems:**

  - Utilizes real-time data from sensors to optimize collection routes, ensuring bins are collected only when full.

  - Significant reduction in operational costs, including fuel and labor.

  - Improved resource allocation and reduced environmental impact through fewer collection trips and lower emissions.

- **Key Studies:**

  - Several studies demonstrate up to a 30% reduction in collection costs and a 25% reduction in fuel consumption due to optimized routing.

  - Papers highlight improved collection efficiency and faster response times.

  - Environmental Impact.

- **Traditional Waste Management Systems:**

  - High carbon footprint due to frequent collection trips.

  - Inefficient handling often leads to waste overflow and illegal dumping, exacerbating environmental degradation.

- **IoT-Enabled Smart Waste Management Systems:**

  - Lower carbon footprint through optimized routing and reduced trips.

  - Enhanced monitoring reduces incidents of overflow and illegal dumping, contributing to - cleaner urban environments.

After comparing the research articles, it is evident how much more effective IoT-enabled smart waste management solutions are than traditional methods. Some of the key benefits are enhanced safety, improved public participation, better data analytics, less environmental impact, increased efficiency, and cost savings. These findings show how IoT technology, particularly in rapidly urbanizing areas like Dhaka City urgent problems associated with trash management in the twenty-first century and provide a cleaner, more sustainable environment.

2.5 Challenges

Due to rising urbanization and population expansion, Dhaka city produces 5,000 tons of garbage per day, posing a significant waste management burden. The amount of waste generated in the city is too much for the outdated waste management system, which frequently overflows, illegally dumps rubbish, and seriously damages the environment. When trash is found in public spaces, social conditions deteriorate and the city becomes less livable. By 2025, Dhaka is expected to produce over 47,000 tones of solid waste per day, increasing the system's capacity. Moreover, the problem is exacerbated by the public's lack of awareness of and participation in sustainable waste management practices. To surmount these challenges, an all-encompassing approach utilizing modern technology like the Internet of Things is required. By doing this, waste management will be optimized, productivity will increase, and adverse effects on the environment, public health, and economy will be decreased. (Ahmed, 2019).

2.6 Summary

The evaluation of the literature highlighted how urgently contemporary waste management systems are needed in areas that are quickly urbanizing, such as Dhaka City. The existing conventional waste management procedures are insufficient to handle the massive amount of trash created daily, leading to severe issues for the environment, human health, economy, and society. The usage of IoT-based smart waste management systems is one possible solution to these issues. IoT technology can optimize waste collection routes, provide real-time data, and boost overall efficiency, all of which can reduce operating costs and enhance environmental effect. Additionally, by increasing public awareness and involvement, these systems can support recycling and waste disposal practices that are less harmful to the environment. Adopting smart trash management will not only improve Dhaka's quality of life, but it will also act as a model for other cities dealing with related issues.

CHAPTER 3

Research Methodology

3.1 Overview

This chapter describes the research approach used to look into how IoT technology might improve Dhaka City Corporation's (DCC) trash management system. Traditional trash management techniques have grown more and more ineffective due to Dhaka's fast urbanization and population increase, posing serious operational, health, and environmental risks. The main goals of this research are to address the difficulties involved in educating and training stakeholders on new technologies and to suggest practical Internet of Things-based solutions to these problems. This study makes a number of recommendations aimed at enhancing Dhaka City Corporation's waste management system, all based on the thorough data analysis. These suggestions are based on the DCC's unique goals and difficulties, as well as best practices from other cities and IoT technology breakthroughs. The ultimate objective is to create a system for trash management that is scalable, effective, and sustainable so that it can be used as a model by other cities dealing with comparable issues.

3.2 Requirement Analysis

In order to create an efficient IoT-based solution, the requirement analysis for this project entailed determining and comprehending the particular requirements and limitations of the Dhaka City Corporation's (DCC) current trash management system. To obtain insights, important parties were consulted, including citizens of the city, waste management authorities, government representatives, environmental specialists, and tech companies. Significant issues with the current system were found after a thorough evaluation, including ineffective garbage collection, expensive operating expenses, threats to the environment and public health, a lack of real-time data, and low public awareness. These results led to the definition of functional requirements, which included

data integration for thorough analysis, route optimization, automated notifications, and real-time monitoring using IoT sensors. Reliability, security, cost-effectiveness, scalability, and user-friendliness were the main non-functional requirements.

3.3 Sensor Integration

Because sensors enable the collection of environmental data, their integration is essential to the IoT and smart systems. An Arduino is required in order to measure fill levels in the four colorful bins Blue, Green, Yellow, and red using an ultrasonic sensor. Select the appropriate ultrasonic sensor and place it at the top of the container, ensuring that it is in the proper location and unobstructed. In order to manage and obtain real-time data, it should be necessary to attach the sensor to Arduino so that it can receive power and data from the environment via a WI-FI connection. To determine the distance to the material's surface in the container programmed the Arduino to transmit a pulse from the sensor and measure the time it takes for the pulse to bounce back. Adjust the sensor to precisely measure empty and filled distances precisely to calibrate it. In order for the Arduino to transmit the fill level data to a central server or cloud service, must next link it to a communication module, such as Wi-Fi or Bluetooth. Create software to handle this distance data and transform it into helpful fill-level information. To increase battery life, ensure to control power effectively, particularly if you're using a wireless arrangement. Maintain the accuracy and functionality of the system by regularly checking and updating it frequently.

3.4 Software Development

A web application is built using the MERN-stack, which includes Mongo DB, Express.js, React.js, and Node.js, throughout the software development process. A smooth surfing experience is ensured by the dynamic and user-friendly interface created with React.js. In the meantime, server-side logic and API endpoints are developed using Express.js and

Node.js, which provide seamless communication between the application's frontend and backend components. The solid Mongo DB backend database is in charge of keeping track of important information including user profiles, bin information, and operating logs. Administrators and employees have several login portals designed specifically for their positions and duties. Employees that log in are granted access to a monitoring interface, which allows them to monitor bin fill levels in real time and take immediate action in the event of an issue. Conversely, administrators have more capabilities than regular users, which enable them to create comprehensive reports about bin usage and cleanliness in addition to keeping an eye on bin levels. Additionally, managers are able to procedures since they receive prompt information when bins are cleaned. The smart waste management system's overall usability and efficiency are improved, enabling administrators and staff to maximize waste management operations and promote a cleaner, healthier environment.

3.5 Testing and Validation

To ensure the functioning and dependability of smart systems and the IoT, testing and validation are essential. Each component, including the software and sensors, is individually tested at the start of the process to find and fix any possible problems. The coherence and compatibility of these components when functioning as a unit are then evaluated through integration testing. After that, extensive system testing assesses key performance indicators like speed and data handling capacity. After that, security testing is implemented to protect the system from possible dangers like hacking and data leaks. To confirm that the system satisfies user needs and is intuitive to use, actual user testing is carried out. These thorough testing methods are necessary to guarantee the system's usability and reliability and to make sure it is ready for a safe and successful deployment in real-world circumstances.

3.6 Deployment and Training

The deployment and training phase, which comes after the exhaustive testing and validation phase, is a crucial stage in the smart waste management systems implementation. The process of deployment entails a variety of tasks, such as the careful mounting of sensors in trash cans, web application on hosting servers to guarantee dependability and accessibility. Simultaneously, administrators and staff participate in extensive training programs designed to transmit the fundamental information and abilities required for competent system utilization. These training courses include a wide range of subjects, such as becoming acquainted with the features of the system, interpreting data, and troubleshooting methods. Through the provision of necessary skills to stakeholders, the deployment and training phase strengthens the basis for successful system operation and maintenance.

3.7 Summary

In conclusion, the development of a smart waste management system represents a significant stride toward addressing the complex challenges of urban waste management. Through meticulous requirement analysis, innovative design, and rigorous testing, the system has been tailored to meet the diverse needs of users while ensuring efficiency, reliability, and security. By harnessing technologies such as the IoT and implementing robust features such as real-time monitoring and comprehensive reporting, the system offers a holistic solution to optimize waste collection and disposal processes. To maintain the system's efficacy and relevance in the ever-changing urban setting, ongoing monitoring, adaption, and stakeholder interaction will be necessary. At the end of the day, the smart waste management system has the potential to significantly improve public health, the environment, and urban communities' quality of life.

CHAPTER 4

Implementation

4.1 Overview

Effective waste management is becoming an increasingly important concern as urbanization quickly changes cities throughout the world, particularly in densely populated urban centers like Dhaka City. The increasing volume of garbage generated exceeds the capacity of traditional waste management systems, resulting in inefficiencies, environmental damage, and threats to public health. These problems may be solved in part by integrating IoT technology, which makes trash management systems smarter and more effective. The proposed smart waste management system for Dhaka City Corporation is presented in this chapter.

It uses Internet of Things technology to optimize garbage collection; lower operating costs, and improves overall system efficiency. This system seeks to minimize environmental effect, improve the quality of life for Dhaka's citizens, and streamline trash management procedures by leveraging real-time data from IoT-enabled sensors and devices. The components, functionality, and anticipated advantages of the suggested system will all be covered in detail in the parts that follow, along with a discussion of the implementation techniques and possible difficulties.

The integration of Internet of Things sensors, centralized data administration, and an intuitive web application, this innovative project seeks to completely overhaul waste collection and management procedures. The system aims to facilitate timely garbage collection, optimize resource utilization, and create a cleaner, healthier, and more sustainable urban environment by utilizing real-time monitoring and management capabilities.

4.2 IoT-Hardware Integration

For effective garbage management and real-time monitoring, IoT hardware integration is essential in the construction of a smart waste management system for Dhaka City Corporation. The hardware components of the system are covered in detail in this section, along with the deployment and integration of IoT devices that are necessary for communication and data collecting.

4.3 Sensor Deployments

One of the most important parts of Dhaka City Corporation's proposed smart trash management system is the installation of IoT sensors. These sensors will collect data in real-time on garbage levels, bin placements, and environmental conditions. They will be strategically placed in waste bins, collection vehicles, and crucial spots throughout the city. Environmental sensors detect temperature, humidity, and toxic gases to identify and manage health hazards, while fill-level sensors in garbage bins monitor waste accumulation, preventing overflow and decreasing unsightly waste in public areas. Rubbish collection vans and bins equipped with location sensors will maximize collection routes and guarantee timely rubbish pickup. Wireless technologies such as GSM, LTE, or LoRaWAN will be used to transfer the gathered data to a central server, guaranteeing real-time updates for precise decision-making. The GPS tracker system will respond to which area’s bins are filled and what is the quantity right now. All the real-time data, power, and centralized database connect with the sensor and everything will be managed by the Arduino microcontroller.

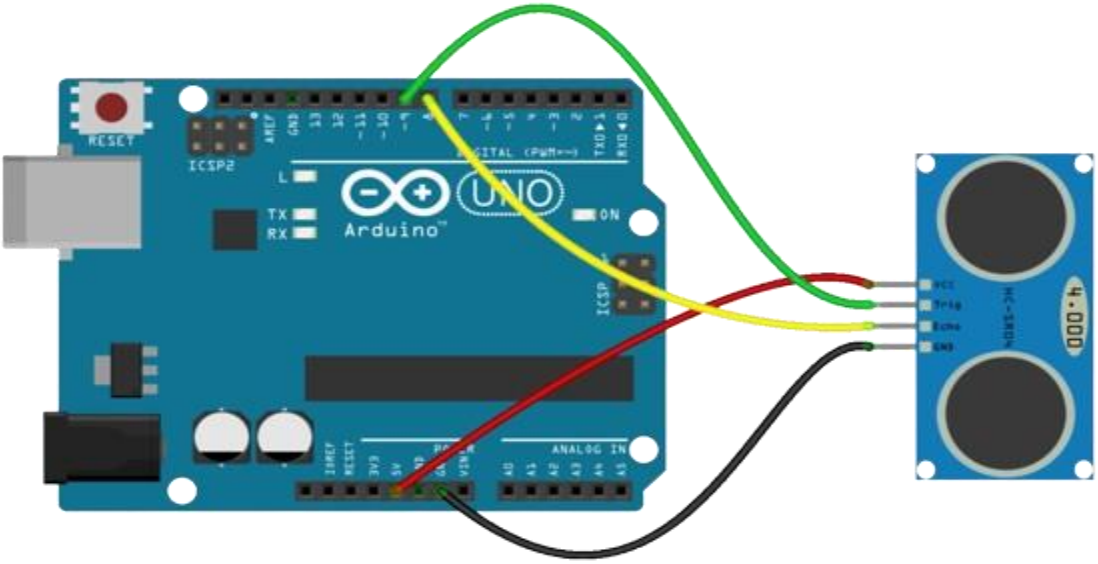

Figure 4.3: Connected the sensor with Arduino Microcontroller

This figure illustrates the setup process of integrating a sensor with an Arduino microcontroller, showing the connections and configuration necessary for enabling IoT-based monitoring in smart waste management systems.

4.4 Installation of Internet of Things

The installation of IoT sensors—more especially, ultrasonic sensors—into garbage cans around the city is a crucial part of the proposed comprehensive smart waste management system. These sensors send data to a central computer while continuously monitoring the fill levels and interior environmental conditions of the bins. The fill level of the bins can be reliably determined by using ultrasonic sensors to measure the distance to the waste's surface. The optimization of garbage collection routes and schedules depends on this data.

4.5 Integration of GPS

The integration of GPS modules with the sensors will improve their performance and enable accurate tracking of each bin's location. The complete coverage of waste

management services and the optimization of collection routes depend on this geographic data. Real-time reporting of the position and fill level of each sensor-equipped bin will enable a comprehensive picture of the city's waste levels.

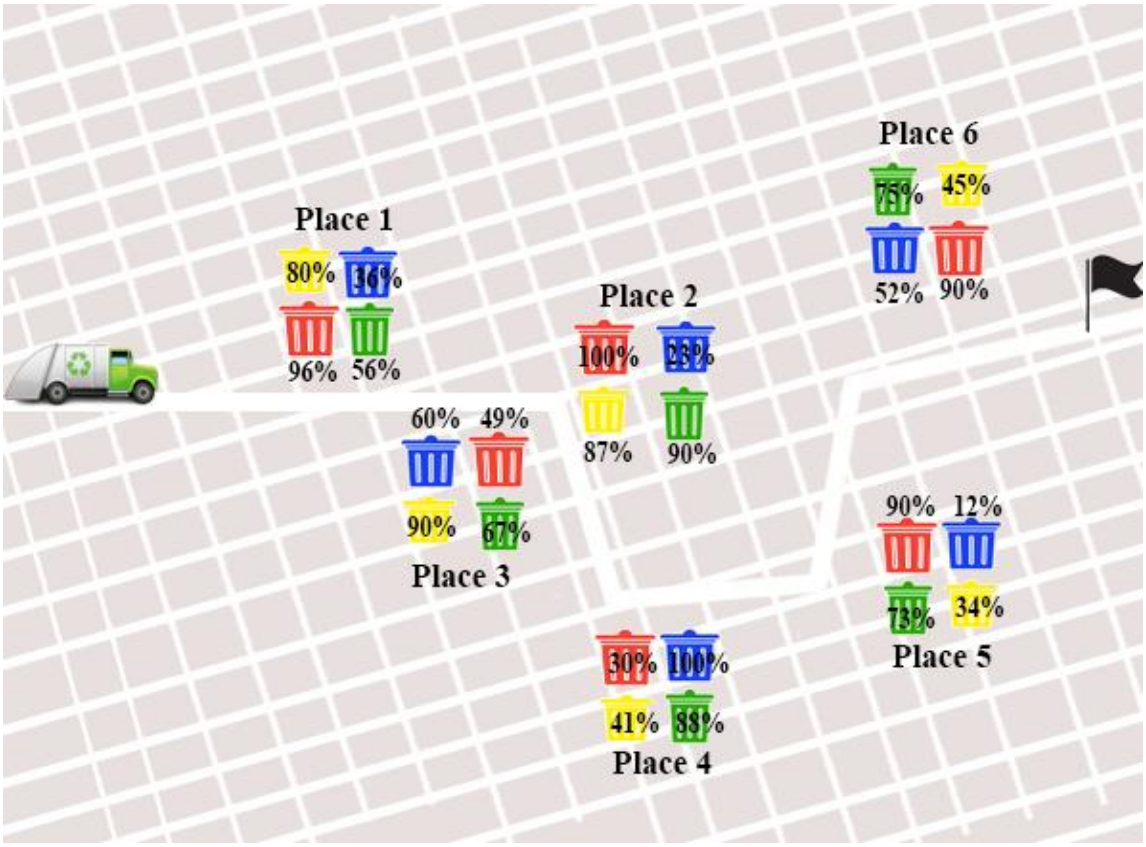

Figure 4.5: The figure is the waste level in bins various locations

This figure shows the waste levels in bins across different locations, providing a visual representation of the data collected by the smart waste management system.

4.6 Microcontroller

As part of the deployment plan, an Arduino or other microcontroller is linked to an ultrasonic sensor in each bin. Local data processing will be handled by the Arduino, which will also read location data from the GPS module and the output of the ultrasonic

sensor. Then, utilizing Firebase, a potent and adaptable real-time database platform, this data will be sent to a central server. The efficient and dependable data storage and retrieval provided by Firebase makes it easier for the sensors and the centralized system to communicate with each other. In order to enable prompt and effective waste collection, the real-time data gathered from the sensors will be processed and analyzed to produce actionable insights. The system can optimize resource utilization and minimize operational expenses by minimizing the frequency of collection visits by guaranteeing that garbage bins are emptied only when necessary.

4.7 Firebase Database Integration with Sensors

In this intelligent waste management system, centralized data management is essential. Firebase is a crucial component in handling real-time data updates and synchronization. All data from the Internet of Things sensors is collected and managed in a centralized database. This guarantees that information that is accurate and current is available to decision-makers. By facilitating the coordination of garbage collection activities, this centralized method enables the dynamic modification of collection routes and schedules in response to actual needs. Additionally, centralized data Management improves accountability and transparency while giving a thorough picture of the system's performance and facilitating ongoing development.

4.8 Interaction between the system and web application

The system's user-friendly online application facilitates communication between municipal officials, waste collection operators, and the general public. This programmed allows users to monitor real-time data, generate reports, and receive notifications regarding issues with waste collection. Real-time data updates and synchronization are made possible by the web application's interaction with Firebase, ensuring that users always have access to the most recent information.

Furthermore, the application allows for data visualization via interactive maps and dashboards, which helps with issue area detection and waste management strategy optimization. By combining IoT technology, Firebase for real-time data management, centralized data administration, and an intuitive web application, the proposed smart trash management system aims to address the complex challenges of garbage management in Dhaka City Corporation.

The system's real-time monitoring features allow for timely waste collection, fewer overflowing bin incidents, and a reduction in the associated health risks. Efficient resource usage will minimize the environmental impact of waste collection operations in addition to cutting operational costs. Ultimately, the goal of this innovative approach is to create a new standard for waste management in rapidly growing cities, leading to a more sustainable, healthy, and clean urban environment.

4.9 Software Integration and Development

Agile software development offers a systematic approach that guarantees effective integration and strong development practices in the construction of a smart waste management system for Dhaka City Corporation. This section examines the ways in which Agile concepts can be used to support software component integration and system iterative development.

4.10 Agile Software Development Model and Key Components

Agile is an incremental, iterative software development methodology that prioritizes adaptability, and ongoing development. It works especially well for intricate projects like smart city, where stakeholder feedback is essential and requirements change over time.

- Iterative Development: Agile breaks the project up into short sprints, which are usually two to four weeks long. Every sprint produces a potentially shippable

product increment, enabling early and regular input from stakeholders. Software components are tested extensively and integrated gradually thanks to this iterative methodology.

- Agile teams are comprised of developers, testers, designers, and domain specialists and are considered cross-functional teams. This cooperation guarantees that software elements are seamlessly integrated and in line with the objectives of the project and the needs of the users.
- Prioritization and User Stories: User stories, which outline particular functionalities from the viewpoint of the end user, are used to record requirements. Prioritizing these user stories according to their technical viability and business value enables the team to concentrate on delivering features that are of the utmost importance within each sprint.
- Continuous Integration and Delivery: Code updates are automatically tested and integrated into a common repository as part of continuous integration and delivery methods, which are encouraged by agile. This guarantees regular software component integration, lowering integration risks and facilitating problem discovery in advance.

4.11 Implementation of Agile in Smart Waste Management System

- **Sprint Planning:** To priorities user stories and establishes sprint goals, the development team holds sprint planning sessions. To ensure effective integration and development, this entails delegating duties, calculating efforts, and breaking down tasks.
- **Daily Stand-Ups:** These sessions give team members a chance to coordinate their efforts, talk about their progress, and pinpoint any integration or development issues. This encourages open communication and teamwork among the members.
- **Sprint Review and Retrospective:** A sprint review is held at the conclusion of every sprint to show stakeholders the integrated software increment and get their

input. After the sprint, there is a sprint retrospective to evaluate the process and pinpoint areas that should be improved for subsequent iterations.

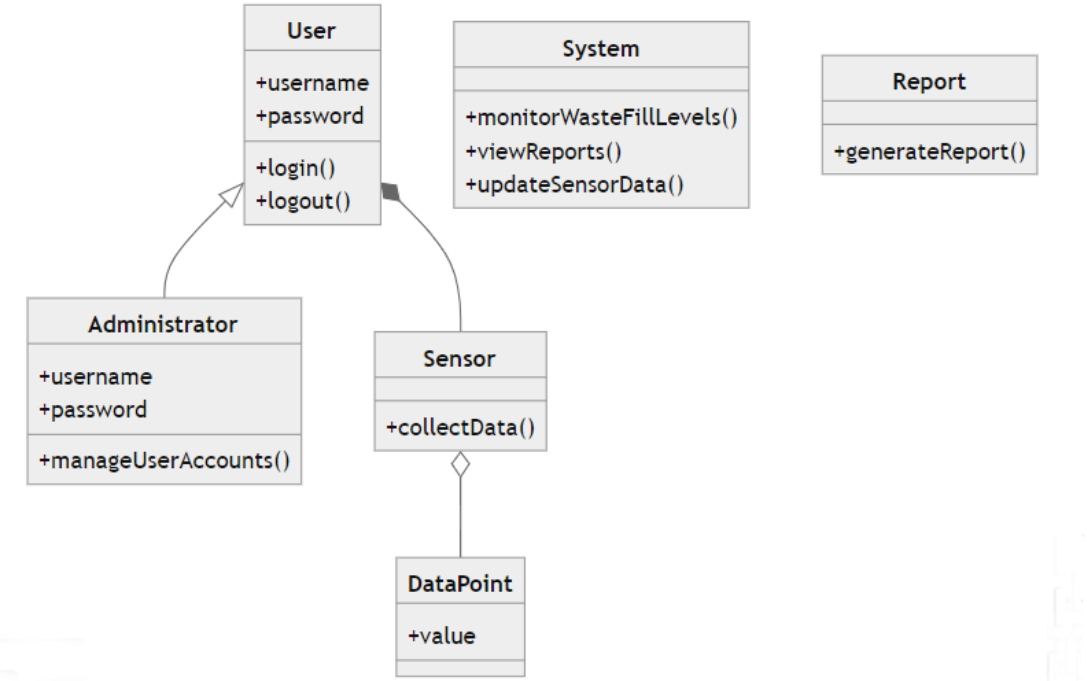

Figure 4.11: Class Diagram for Smart Waste Management System

This figure presents the class diagram for the smart waste management system, detailing the system's structure, including classes, attributes, methods, and the relationships between them.

4.12 Centralized Data Management

Because of its robust and scalable architecture, which is linked to the front and back ends for real-time update, add, and delete operations based on the interface interact module and massive data consistency with the interface, the MERN stack is a popular option for building centralized data management systems. The database without SQL The foundation of data storage, Mongo DB offers flexibility in managing enormous volumes of unstructured data. Integrating different data types is easy and essential for satisfying

the dynamic and ever-changing requirements of modern applications because of its schema-less nature.

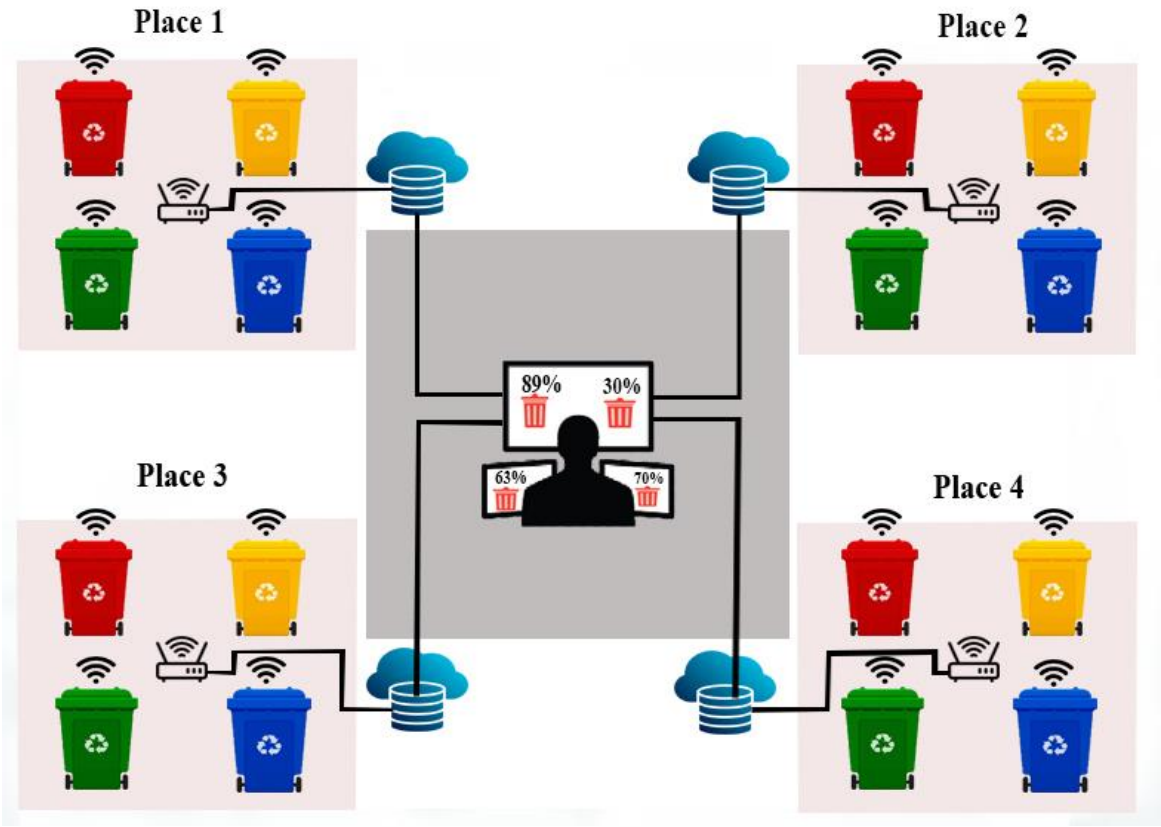

Figure 4.12: Monitoring the waste level in bins central administrator

This figure illustrates the central administrator interface for monitoring the waste levels in bins across various locations, providing real-time data and alerts for efficient waste management.

4.13 The Back-end Framework

Express.js, the backend framework, serves as middleware by allowing communication with the Mongo DB database and taking in and processing client-side data requests.

Express.js is used to centralize data management at the server level, enabling the application to enforce standard standards for authorization, authentication, and data validation. Centralization is necessary to maintain data security and integrity because it enables the implementation of uniform rules and procedures across all data transactions.

4.14 The Front-end Library and Runtime Environment

React.js is a front-end library that pulls data from the centralized backend using well-defined APIs. This separation of duties ensures that the client-side code remains clean and focused on the user interface and user experience because all data activities are managed by the backend. The centralized data management technique simplifies state management on the client side because all data manipulations occur through interactions with the centralized backend services. The Node.js runtime environment, which provides a high-performance, non-blocking architecture ideal for real-time applications, is the foundation upon which the entire MERN stack is constructed. Node.js ensures that data operations in centralized data management systems are handled efficiently and with little latency, increasing the overall speed of the application. Because it is event-driven, many data requests can be handled concurrently, maintaining the application's responsiveness even under high load.

4.15 Employee Management

Employees will have a dedicated section of the online application where they may manage their waste monitoring responsibilities. We shall discuss the following in this section:

- **Sign Up/Log In**: Employees can create accounts and log in securely to access the system. Authentication protocols will ensure that only authorized personnel can access sensitive data.

- **Dashboard**: A personalized dashboard will provide an overview of the bins they are responsible for. This includes real-time updates on bin fill levels, location, and status.
- **Task Management**: Employees can view and manage their assigned tasks, such as scheduled bin checks or urgent bin emptying requests real-time from location.

Figure 4.15: Employee Login Page

This figure displays the login interface for employees, allowing them to access the smart waste management system to monitor and manage waste levels in designated areas.

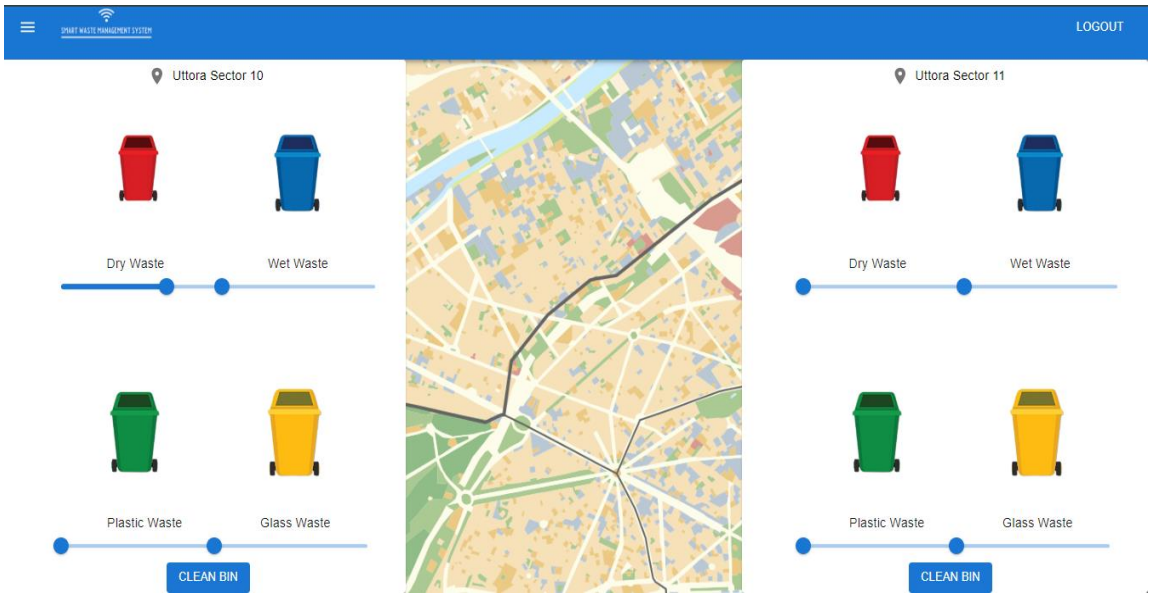

Figure 4.15: Employee Dashboard for Monitoring the Bins Waste Level

This figure shows the employee dashboard, where staff can monitor the waste levels in bins across various locations in real-time. The dashboard provides an interface for efficient waste management and timely interventions.

4.16 Real-time Monitoring of Waste Fill Levels

Real-time Data Display: Interactive maps and dashboards will show the current fill levels of all bins in the city. Color-coded indicators (e.g., green for empty, yellow for half-full, red for full) will provide an at-a-glance status update.

- **Sensor Integration**: Data from IoT sensors installed in the bins will be continuously transmitted to the web application, ensuring that the displayed information is always up to date.
- **Alerts and Notifications**: The system will generate automatic alerts when bins reach critical fill levels, ensuring timely waste collection. Alerts can be customized based on predefined thresholds.

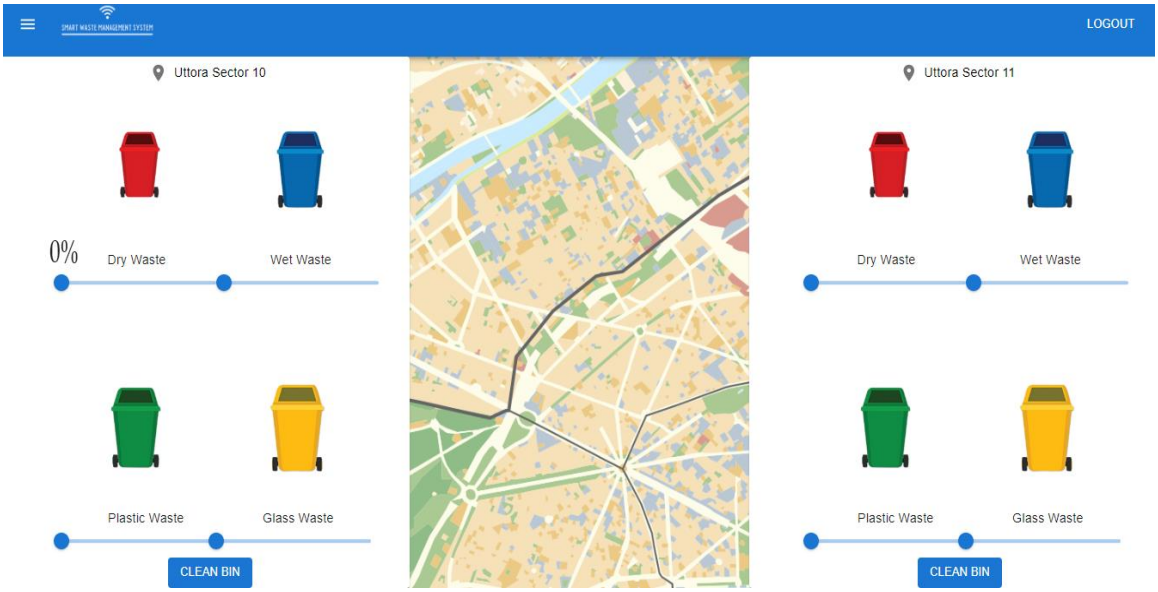

Figure 4.16: Bin Fill Level - 0%

This figure shows an empty trash bin, indicating a fill level of 0%. This status represents optimal conditions for waste collection, ensuring cleanliness and preventing overflow.

Figure 4.16: Bin Fill Level - 52%

This figure illustrates a trash bin with a fill level of 52%. This indicates moderate waste accumulation, suggesting that timely collection is needed to prevent overflow and maintain cleanliness. Monitoring this level is crucial for effective waste management.

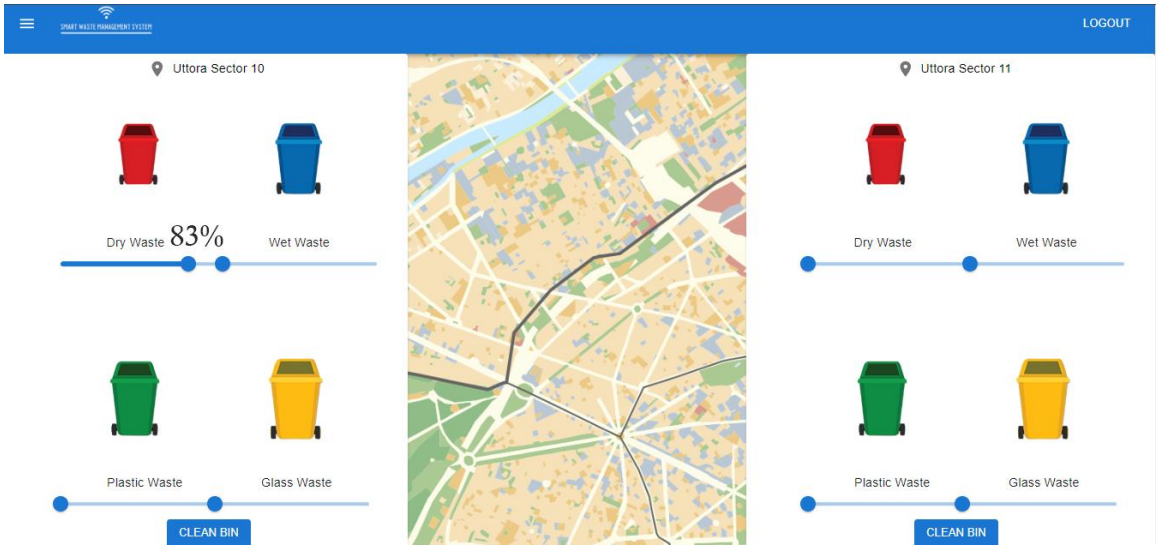

Figure 4.16: Bin Fill Level - 83%

This figure depicts a trash bin at 83% fill level, indicating a high accumulation of waste. This level suggests an urgent need for collection to avoid overflow and ensure proper sanitation. Effective monitoring is essential for timely waste management.

4.17 Collection Status

When employees have collected trash from the bin, they can change its status by clicking the "Clean Bin" button on the web application. This action updates the database by marking the bin as emptied and resetting its fill level. The system records the date and time of the collection and provides an accurate log of the garbage collecting activities. This feature ensures that the waste collection process is closely watched over and managed at every stage.

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4.18 Administrator Reporting and Analytics

Administrators have access to extensive data and analytics through the internet application. These reports provide data on employee performance, trends in waste collection, and the overall efficacy of the system. With this application, administrators can generate reports on demand and filter data based on employee, location, and date. In order to improve system performance, this function supports trend analysis, collection route optimization, and informed decision-making.

- **Report Generation**: Detailed reports on bin usage, collection efficiency, and cleanliness will be available. These reports can be generated on a daily, weekly, or monthly basis and exported in various formats (PDF, Excel).
- **Analytics Dashboard**: An interactive dashboard will provide visual analytics, such as charts and graphs, to help administrators identify trends and patterns in waste generation and collection.
- **Real-Time Bins Fill Level Check**: Administrators can define and track custom metrics, such as average fill levels, collection frequency, and response times to alerts.
- **Historical Data**: Access to historical data will allow for trend analysis and long-term planning. This data can be used to optimize waste collection routes and schedules, improving overall efficiency.

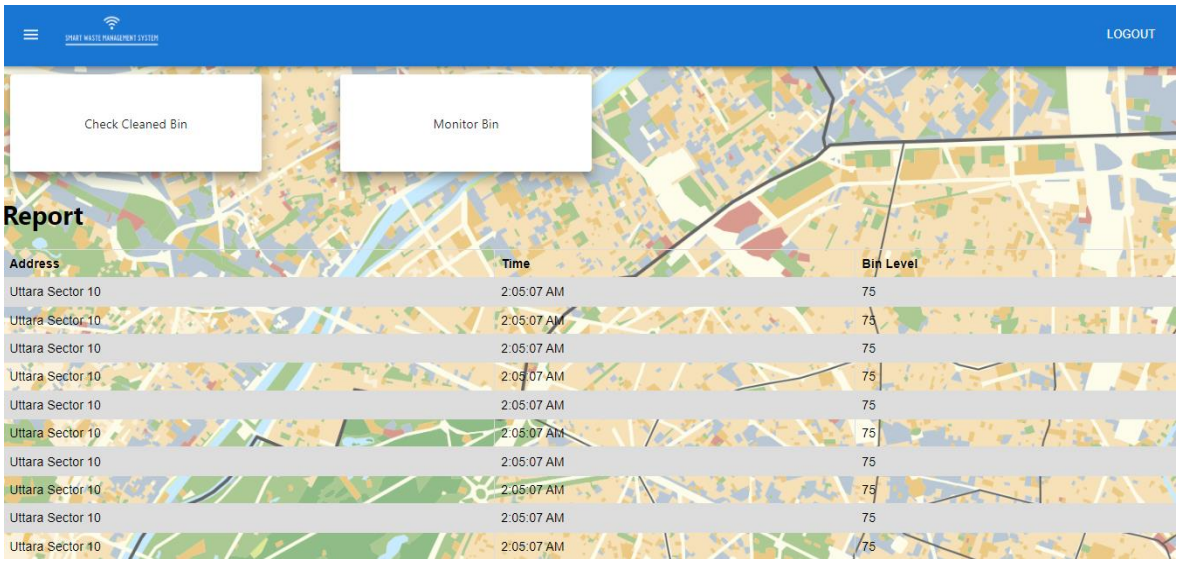

Figure 4.18: Administrator Dashboard - Real-Time Location, Date, Time, and Bin Waste Levels

This figure presents the Administrator Dashboard, displaying real-time data including location, date, time, and bin waste levels. This dashboard enables efficient monitoring and waste collection, facilitating timely responses to varying fill levels and enhancing.

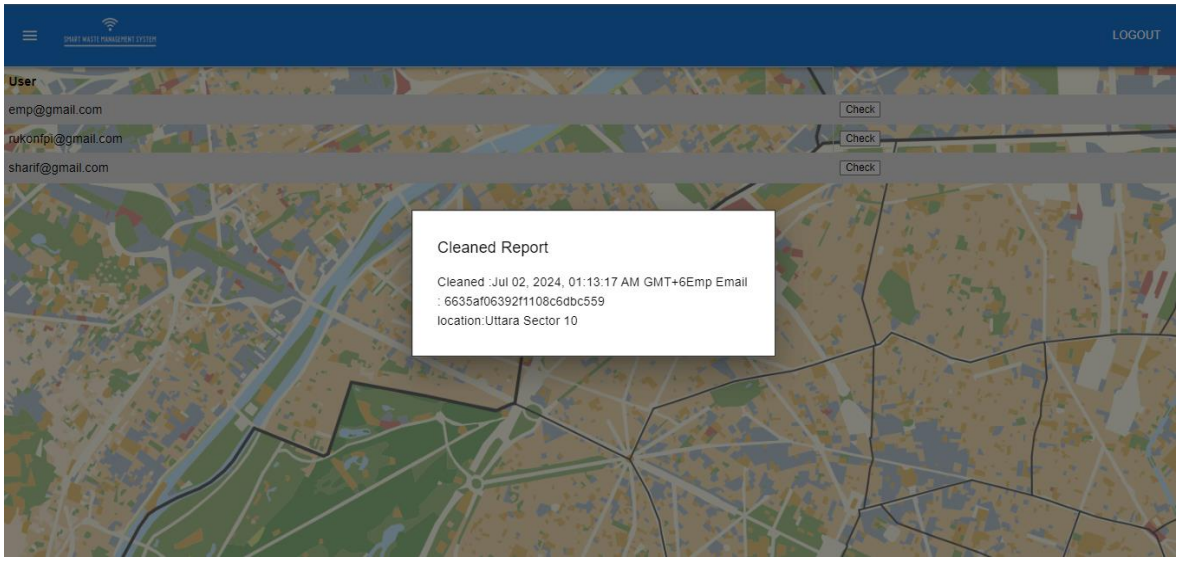

Figure 4.18: Administrator Reporting and Analytics - Real-Time Location, Date, Time, and Cleaned Bin Status

This figure showcases the Administrator Reporting and Analytics dashboard, featuring real-time data on location, date, time, and cleaned bin status. This is allows for effective monitoring of waste management activities, enabling informed decision-making.

4.19 User Interface and User Experience

The web application's straightforward and user-friendly design makes it simple for administrators and personnel to explore and utilize its capabilities. React.js makes it possible to create a responsive UI that works perfectly on a range of devices and screen sizes. The application has several interactive features, such as dynamic charts, graphs, and maps, which enhance user experience and make data understanding easier.

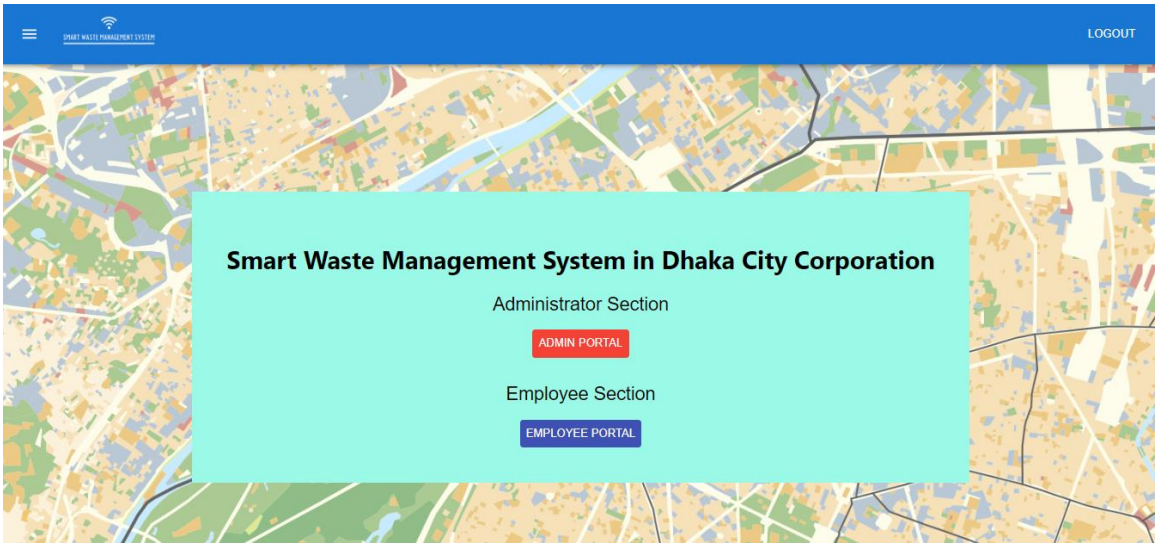

Figure 4.19: User Interface of the Smart Waste Management Application

This figure displays the user interface of the Smart Waste Management Application, showcasing its design and features for user interaction, waste tracking, and management functionalities.

4.20 Security and Authentication

Security is a crucial part of the web application. The software implements strong authentication and permission protocols to ensure that only authorized individuals may view sensitive data and do assigned duties. Passwords are securely hashed and stored, and client-server communication is protected, to prevent unauthorized access and data breaches.

4.21 Summary

With the proposed smart waste management system for Dhaka City Corporation, urban rubbish management has evolved considerably. The system addresses the drawbacks and challenges of traditional trash management methods by utilizing IoT technology, centralized data administration, and an easy-to-use web application. The system's real-time monitoring and management functions reduce the adverse effects of the city on the environment, ensure timely waste collection, and enhance overall livability. This innovative approach not only provides a practical solution to the current trash management issues, but it also establishes the foundation for future advancements in smart city technology. Combining advanced data analytics with predictive capabilities ensures that the city's waste management infrastructure can adapt to changing demands, enabling proactive trash management.

CHAPTER 5

Impact on Society

5.1 Overview

The wider effects of deploying an Internet of Things (IoT)-based smart waste management system in Dhaka City Corporation are covered in this chapter. It looks at the consequences for day-to-day living, the advantages for society and the environment, moral issues, and the sustainability strategy. The goal of the debate is to give a thorough understanding of the ways in which this system might improve both the environment and the general well-being of the city's residents.

5.2 Impact on Life

The implementation of an IoT-driven intelligent waste management system has the potential to greatly enhance Dhaka's citizens' quality of life. Cleaner streets and public areas can result from the system's timely waste collection and reduction of waste bin overflow. This cleanliness can lessen the transmission of illnesses, increase the city's overall appearances, and improve the quality of the air. Living in a more hygienic environment will benefit residents' health and boost their contentment with their urban surroundings.

5.3 Impact on Society Environment

There are significant advantages for the environment and society when a smart waste management system is implemented. By minimizing the quantity of garbage that ends up in landfills, efficient waste collection and disposal help to mitigate the effects of climate change and reduce greenhouse gas emissions. By highlighting regions with significant production of recyclable materials and encouraging more environmentally friendly waste

management techniques, the system also aids recycling programmers. This supports the city's endeavors to realize the Sustainable Development Goals (SDGs), including SDG 13 (Climate Action) and SDG 11 (Sustainable Cities and Communities).

5.4 Ethical Aspects

When putting in place an intelligent waste management system, ethical issues must be taken into account. IoT technology collecting entails data collection, which brings up issues with data security and privacy. To preserve residents' privacy, it is crucial to make sure that the information gathered from trash cans and other devices is anonym zed and stored safely. Furthermore, equitable implementation of this technology is necessary to guarantee that all neighborhoods, irrespective of socioeconomic standing, get the advantages of enhanced waste management services. Gaining public trust and tackling ethical issues require openness and community involvement.

5.5 Sustainability Plan

For the smart waste management system to be successful in the long run, a sustainability plan is essential. Strategies for ongoing enhancement and adjustment to shifting waste generation patterns should be part of this approach. To maintain the system's effectiveness and efficiency, regular upgrades and maintenance are required for the IoT devices and central administration platform. In order to motivate locals to take part in waste reduction and recycling initiatives, the strategy should also include education and awareness initiatives. To maintain the system's benefits, cooperation with stakeholders—such as governmental bodies, business partners, and community organizations—is crucial.

5.6 Summary

In conclusion, Dhaka City Corporation has the opportunity to revolutionize waste management methods through the adoption of a smart waste management system that leverages Internet of Things technology. This might result in major gains in environmental sustainability, public health, and quality of life. The city can guarantee that these advantages are realized in a just and long-lasting way by tackling ethical issues and creating a strong sustainability plan. For the benefit of present and future generations, this chapter emphasizes the significance of using technology to build cleaner, more sustainable urban environments.

CHAPTER 6

Conclusion

6.1 Summary of the Project

The goal of this project was to leverage IoT technology to build and implement a smart trash management system for Dhaka City Corporation. The system was designed to tackle the issues brought forth by increasing urbanization and ineffective waste management techniques. The integration of Internet of Things sensors for real-time waste fill level monitoring, the creation of a web application with an interface and data visualization, and the setup of a centralized data management system utilizing Firebase were important project components. Agile software development techniques were also stressed in the project to guarantee adaptability and response to changing needs. The system was designed to enhance waste collection, boost operational effectiveness, and encourage environmental sustainability in metropolitan settings through extensive testing, validation, and implementation phases. The project's results demonstrated how IoT-driven solutions may revolutionize municipal trash management procedures and establish a standard for other smart city projects.

6.2 Conclusion

The aim of this project was to solve the issues brought about by rising urbanization by proposing an IoT based smart trash management system for Dhaka City Corporation. In order to optimize waste collection procedures, lower operating costs, and boost overall waste management efficiency, the system integrates IoT sensors, GPS, microcontrollers, and a centralized database to provide real-time monitoring and data-driven insights into waste levels, collection schedules, and bin conditions.

In order to gather and analyze data in real-time, the deployment method entailed installing IoT sensors in waste bins to monitor ambient conditions and fill levels. These sensors then communicated with a centralized system via Firebase. User interactions are facilitated by a MERN stack web application, which enables administrators to provide reports and better oversee waste collection while staff keeps an eye on bin statuses. The system's usefulness and dependability are improved by the Agile SDLC methodology, which guarantees ongoing development and response to input. The waste management procedures in Dhaka are currently inefficient due to costly disposal methods, poor rubbish collection, and low public knowledge. These issues are addressed by this integrated strategy. This system is significant because it has the potential to change Dhaka's waste management system, making it more efficient, sustainable, and adaptable to the expanding needs of the metropolis.

6.3 Further Suggested Work

There are multiple opportunities for additional improvement in order to take the smart waste management system to even higher levels. By extending the sensor network to encompass more regions and categories of garbage, a more comprehensive dataset will be produced, facilitating more accurate resource allocation and decision-making. Further improvements in operational efficiency can be achieved by optimizing waste collection routes through the use of machine learning algorithms and other advanced data analytics approaches. Strong public awareness initiatives and extensive training initiatives are necessary to promote community involvement and guarantee the system's long-term viability. To optimize the system's impact and foster synergies, integration with other smart city efforts, like traffic management and environmental monitoring, is necessary. Enhancing eco-friendliness and encouraging reprocessing will support resource efficiency and environmental preservation. Dhaka City Corporation can realize the full potential of the smart waste management system in creating a cleaner, greener, and more sustainable urban environment by following these routes.

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APPENDICES

APPENDIX A: TECHNICAL SPECIFICATIONS

Title: A Smart Waste Management System in Dhaka City Corporation Utilizing IoT Devices

Student ID: 213-15-4475

A1.1 Ultrasonic Sensors

- Model: HC-SR04
- Operating Voltage: 5V DC
- Frequency: 40 kHz
- Max Range: 4 meters
- Min Range: 2 centimeters
- Accuracy: ±3mm

A1.2 Arduino Microcontroller

- Model: Arduino Uno R3
- Operating Voltage: 5V
- Input Voltage (recommended): 7-12V
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Flash Memory: 32 KB (ATmega328P) of which 0.5 KB used by boot loader
- Clock Speed: 16 MHz

A1.3 MERN Stack Components

- Mongo DB: No SQL database for storing sensor data and user information.
- Express.js: Web application framework for handling API requests and server-side logic.
- React.js: Front-end library for building user interfaces, providing dynamic and responsive interaction.
- Node.js: JavaScript runtime for executing server-side code.

APPENDIX B: SYSTEM ARCHITECTURE

B1.1 Overview

The smart waste management system architecture comprises several interconnected components to ensure efficient data collection, processing, and user interaction.

B1.2 Hardware Components

- Ultrasonic Sensors**:** Deployed in waste bins to measure fill levels.
- Arduino Microcontrollers**:** Interface with sensors to collect and transmit data.
- Power Supply Units: Provide necessary power to sensors and microcontrollers.

B1.3 Software Components

1. Data Acquisition Module:
   - Collects data from ultrasonic sensors.
   - Processes sensor data to determine waste bin fill levels.

2. Centralized Data Management:
   - Utilizes Mongo DB for storing sensor data and system logs.
   - Implements Express.js for server-side logic and API management.

3. Web Application:
   - Built with React.js for a dynamic and responsive user interface.
   - Allows administrators and employees to monitor waste levels and manage collection schedules.

4. Real-time Database Integration:
   - Firebase is used to store and retrieve data in real time. Provides authentication and secure access to the system.

A Smart Waste Management System in Dhaka City Corporation Utilizing IoT Devices

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