IS 4110 - Capstone Project Proposal

EcoBin-Smart Garbage Management System

Group 23

Department of Computing & Information Systems

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Approval of Capstone Project

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Approved/Not approved :

Signature of the Mentor :

Signature of the Internal Supervisor :

Date :

Suggestions If Any :

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Acknowledgment

With sincere gratitude, we would like to acknowledge the invaluable contributions of the following individuals and groups who have played a significant role with their expertise, knowledge, and guidance to support our group in the development and completion of our capstone project proposal.

Mentor: Mr. P L R H Shanilka

We would like to express our sincerest thanks to our dedicated mentor, Mr. P L R H Shanilka, for their invaluable advice, encouragement, and mentorship for helping us to formulate our capstone project proposal of EcoBin-Smart Garbage Management System. Their expertise, insights, and vast knowledge have been instrumental in shaping the direction of this project and overcoming challenges along the way.

Internal Supervisor: Mr. P Vigneshwaran

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We are truly grateful for their contributions and commitment to promoting recycling practices and environmental sustainability.

Group 23
Team Members

Introduction & Objectives

Introduction

EcoBin-Smart Garbage Management System (IoT) is an innovative solution aimed at revolutionizing waste management practices. EcoBin mainly provides real-time monitoring of garbage bin fill levels, optimizing waste collection routes and reducing operational costs. Reduce operational costs by up to 30% with optimized routes based on real-time fill level data.

EcoBin minimizes unnecessary pickups, saving fuel and manpower. The proposed system accessible via a mobile app and website, allowing municipalities and businesses to efficiently manage waste disposal. EcoBin uses intelligent alerts to notify authorities and users when bin capacity is reached, ensuring timely and optimal waste removal.

This system will provide a comprehensive solution for efficient and active garbage management.

Here are some major problems we identified that led in the development of this system.

- Limited data: Lack of real-time data of the bin fill levels makes it difficult to optimize routes and allocate resources effectively.
- Inefficient routes: Collection trucks frequently operate on fixed schedules, regardless of the actual bin fill levels, leading to unnecessary fuel consumption and missed bins.
- High operational costs: Waste management costs are mostly fuel, labor and vehicle maintenance.
- Unreliable service: Uncollected waste (Missed collections) or overflowing bins can cause to sanitary problems and dissatisfaction of people.
- Environmental impact: Impact on the environment: Pollution and greenhouse gas emissions are caused by inefficient routes and overflowing garbage bins.

Objectives

By addressing these identified problems and implementing the proposed solution approach, this real-time waste monitoring and management system will improve the efficiency of waste management practices. The proposed system will empower municipalities and businesses to monitor effectively fill bin levels, prevent unnecessary pickups and ensure continuous service.

Accordingly, the followings are the objectives that we hope to achieve through this project.

- Optimized routes: Collection trucks move intelligently through the city, and picking up trash and garbage only when the bins are truly full. Sensors in the bins provide real-time fill level data to the system, by allowing dynamic route planning and eliminating unnecessary pickups.
- Improved Service: Timely alerts ensure bins are emptied before overflowing, improving sanitation and citizen satisfaction. this proposed system can benefit for citizens with mobile app notifications informing them when their bins will be emptied, promoting responsible waste disposal habits.
- Reducing Operational Cost: Optimized routes lead to fuel savings and require fewer trucks, reduce manpower needed.
- Data - Driven insights: Real-time data enables analysis of waste management campaigns across different areas, identifying peak waste generating times this will leading to better resource allocation and planning.
- Environmental Benefits: Reduced fuel consumption and optimized routes contribute to reduced greenhouse gas emissions and a smaller environmental footprint.

Analysis

Feasibility Study

Technical Feasibility

EcoBin-Smart Garbage Management System demonstrates strong technical feasibility through the innovative use of IoT technology, Arduino sensors and sophisticated algorithms. The integration of above-mentioned components enables seamless automation of waste segregation, overcoming the limitations of manual sorting. It is easy to find sensors and IoT devices that are required in gathering user inputs and the Arduino sensors effectively and efficiently detect and classify various recyclable materials, such as metal, glass, paper, and plastic, ensuring accurate and reliable sorting. Our remote controlling and monitoring system is compatible with every bin located in public places. Real-time monitoring and display of bin filled levels according to empty level, half full level, and full level that demonstrates system responsiveness and effectiveness. There are many tools and frameworks that can be used in developing the user interface and programming the logic for the garbage separation process. As for those factors and our analysis of the feasibility of the project, it proves that the project is technically feasible.

Economic Feasibility

The EcoBin- Smart Garbage Management System offers an intriguing solution for waste management, offering both environmental and economic benefits. However, its economic feasibility depends on several key factors such as cost comparison, market demand, scalability and maintenance, partnerships, and data monetization. Cost comparison which is necessary to compare the possible cost savings with the initial investment made in sensors, Arduino boards and classified bins. Determine if the initial cost is justified by the savings on manual sorting costs, higher recycling rates, and possible waste-resource revenue. The market demand shows how much the target market is prepared to spend on an intelligent garbage bin. Think about focusing on particular industries with strong recycling targets or implementing pricing structures based on features. Scalability and maintenance assess the feasibility of widespread deployment as well as ongoing maintenance costs. It considers power requirements, future software updates and sensor replacements. Partnerships are helped to minimize costs and maximize resource recovery, consider partnering with recycling centers or waste management agencies. Data monetization analyzes revenue generation potential through anonymized data insights into waste generation patterns, supporting waste management optimization for municipalities or businesses. By carefully evaluating these variables and performing a comprehensive cost-benefit analysis, you can determine the true economic viability of the EcoBin system for our target market.

Operational Feasibility

The operational feasibility of the EcoBin-Smart Garbage Management System can be explained through its user-friendly and automated waste separation process. The main bin helps to minimize the need of manual intervention by automatic garbage sorting and initial garbage collection. Real-time monitor of bin fill levels and nearby bins helps users' valuable information for responsible garbage disposal. The adaptability of our system in public places enhances the operational feasibility through making it a better practical solution for municipalities and organizations to improve garbage management. The user-friendly designs and automated garbage separation processes of our EcoBin system contribute to the development of its operational feasibility by ensuring smooth integration with existing garbage management systems. In sum, the user-friendly design and alignment with the skill set of the intended user prove to be operationally viable and capable of increasing the efficiency of garbage management with an automated garbage separation system.

Legal & Regulatory Feasibility

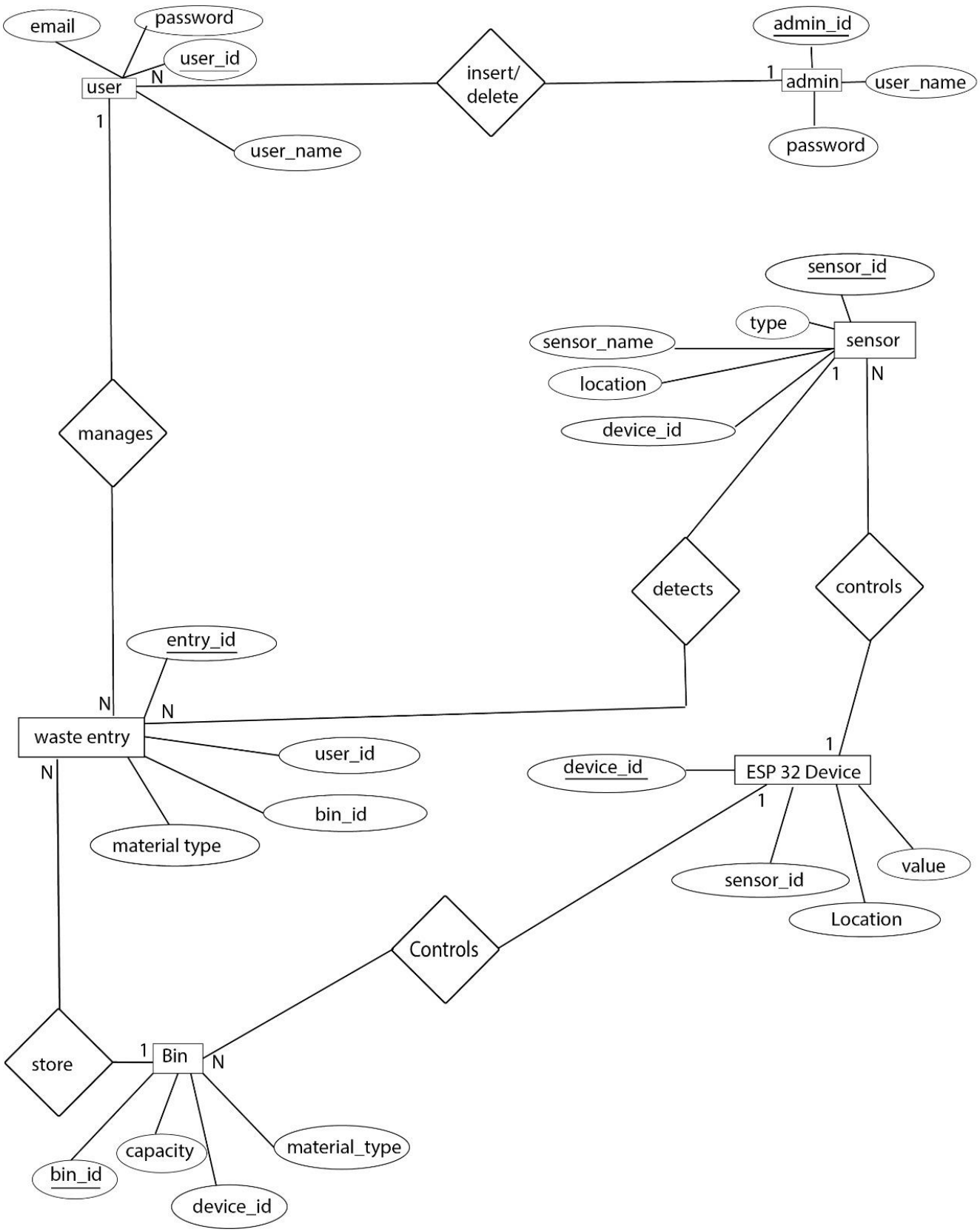
Our EcoBin system complies with recycling regulations by automating the garbage sorting process for different materials by meeting the criteria set for responsible garbage disposal in public spaces. We ensure compliance with data privacy and security regulations, industry standards and any specific regulations related to government or semi-government or private organizations and IoT devices.

Social & Environmental Feasibility

Our EcoBin-Smart Garbage Management System presents a significant advance in social and environmental feasibility with its operations and functionalities. The EcoBin system simplifies user engagement and also actively encourages recycling habits for people by automating waste sorting through IoT and sophisticated algorithms. The user's awareness of the clear indications about available and nearby locations of bins and bin fill levels enhances a sense of community responsibility towards waste disposal. According to the above-mentioned social function, this system significantly reduces landfill waste by efficiently separating recyclable waste materials, including metal, glass, paper, and plastic to align with wider environmental goals. Our EcoBin system contributes towards resource conservation and minimizes the environmental footprint associated with traditional garbage management system by promoting recycling habits. The user-friendly design of our system acts as an effective tool to promote the social and environmental potential of public spaces and is used to positively influence community behavior.

DFD Diagrams

ER Diagrams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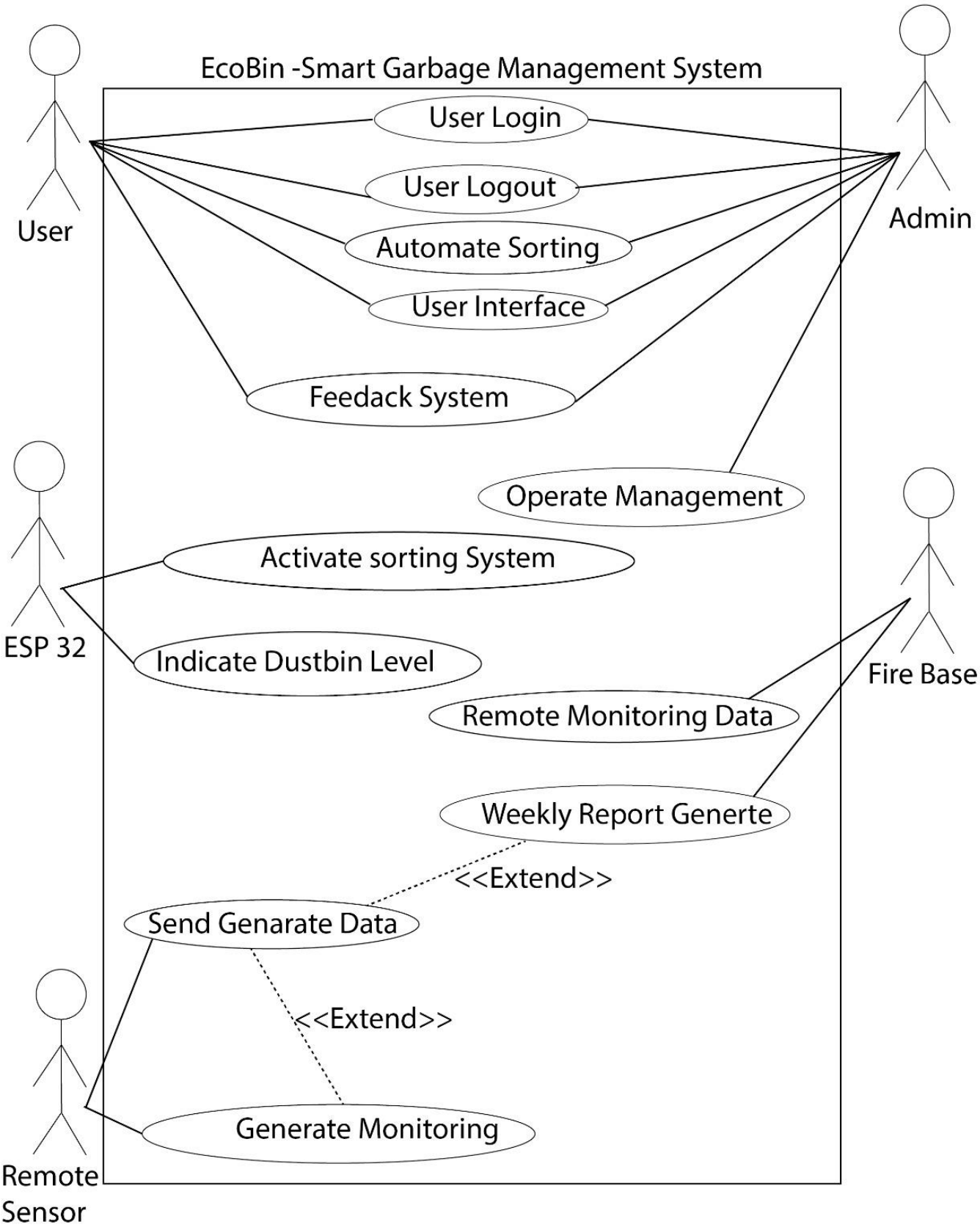
Use Case Diagrams



Hardware & Software Requirements

Hardware Requirements

- Intel(R) Core™ i5 – 6200U CPU @ 2.3GHz Processor
- 8.00 GB RAM
- Internet Connection
- Wires
- Mobile Device (Android or iOS)
- Uno Board
- Remote Sensor
- ESP 32 Device (Control Device)

Software Requirements

- Visual Studio Code
- Firebase
- React.js
- Web Browsing Software (Google Chrome / Microsoft Edge / Mozilla Firefox)
- Flutter
- Arduino

Tables & Structure

Number of Modules

There are two modules in the proposed web application and mobile application.

- System Admin
- System User

Details of Modules

Our effort aims to develop a remote monitoring and automated garbage separation and sorting system for organizations. This system consists of two modules; admin and user.

- System Admin

  The admin module of our remote monitoring and automated garbage separation and sorting system provides significant administrative functionalities such as;

  - User Management
  - Access Control
  - Weekly or Monthly Report Generator
  - Bin Configuration and Maintenance
  - Remote Monitoring for Bin Fill Levels
  - Location Mapping and Bin Placement
  - System Configuration and Updates
  - Security Management

- System User

  The user module allows authorized users to access the remote monitoring for bin fill levels and location mapping through the EcoBin system. The system provides significant user functionalities such as;

  - User Account Management
  - View Bin Availability
  - Locate Nearest Bin
  - Feedback and Suggestions
  - Weekly or Monthly Report Generator
  - Historical Data Access
  - Waste Disposal

Data Structure

The data structure of the EcoBin-Smart Garbage Management System consists of multiple data structural components that work together to manage garbage separation, bin status display, and detection information effectively and efficiency.

- Bin Data Structure

  Each bin is represented as a separate data structure that included with properties such as BinID, Location, and BinStatus in our EcoBin system database. The BinID helps to uniquely identify each bin located in public places, allowing for easy reference. The bin stores geographic coordinates, for facilitating location mapping and user guidance. BinStatus indicates the current fill level of the bin as empty or half full or full.

- Material Classification Data Structure

  A classification data structure is used to manage recyclable materials that includes properties like MaterialID and MaterialType. MaterialID uniquely identifies each recyclable material and MaterialType specifies the type of material (metal, glass, paper, or plastic).

- Garbage Collection Event Data Structure

  The data structure records this event when waste is deposited in the main bin. This event has attributes like EventID, TimeStamp, and BinID. EventID uniquely identifies each waste collection event, TimeStamp records the time when waste was deposited.

- Sensor Data Structure

  The sensor data structure is utilized with properties like SensorID, SensorType, and SensorStatus.

- Algorithm Configuration Data Structure

  The configuration data structure used to support sophisticated algorithms by including attributes like AlgorithmID, AlgorithmParameters, and AlgorithmStatus. AlgorithmID uniquely identifies each algorithm in the system and parameters used to store configurable settings for algorithm customization. The status attribute indicates whether the algorithm is active or not.

- User Interaction Data Structure

  This data structure used to record user interactions for monitoring and engagement and it includes attributes like UserID, InteractionType, and TimeStamp. UserID uniquely identifies each user who accesses to the system and TimeStamp records the time of the interaction of users. InteractionType specifies the action of the user such as waste disposal, checking bin status, and checking bin availability.

Proposed System

The EcoBin-Smart Garbage Management System is an IoT-based system that facilitates the separation of recyclables from general waste. Our system, which consists of Arduino sensors and sophisticated algorithms, automatically identifies and classifies various recyclable materials including metal, glass, paper, and plastic. Each type of recyclable material bin has its compartment, ensuring effective and efficient waste management. Our EcoBin system has a main bin to collect waste dropped by people. After waste is put in the main bin, it will be separated into different bins to complete the garbage separation process after detection by its sensors. In sum, our proposed system indicates the amount of garbage filled in the bins that are located in public places by three levels (empty, half-full, and full), and it displays the locations of garbage bins that are available and nearby for the users to dump. By simply putting their waste in the bin, users encourage recycling habits and support environmental sustainability as the system handles sorting.

The distinctive features of our proposed system are,

- There is a classification of garbage that we throw away.
- The real-time level of garbage levels in the garbage bins within the city is updated to the user and the administrator.
- Once the trash levels in the trash bins are full, a notification will be sent to the admin.
- For the user, there is real-time update about the location of the empty garbage bins in the city.
- A weekly or monthly report is generated for the user and administrator so that the user can gain insight into their waste disposal and the administrator can take decisions on how to manage the waste properly.

Functional Requirements

- User Login
- Automated Sorting: Automatically identifying and sorting various recyclable materials.
- Sensor Integration: Use sensors to identify materials such as papers, metals, and plastics.
- Compartmentalization: Divide the bin into separate compartments for different recyclables.
- Sorting Mechanism: A system that allows sorted materials to be moved to appropriate bins.
- User Interface (UI): Make the bin interface as easy to use as possible for users to interact with, including instructions on where to put waste.
- Feedback System: Use audio-visual or visual cues to let users know when a compartment needs to be emptied or when the bin is full.
- Remote monitoring: Remote monitoring of bin status and fill levels through web or mobile app.
- Data logging: Observe the types and amounts of waste in the bin for analysis.
- User Logout

Non-Functional Requirements

- Accuracy: To minimize pollution, the system's ability to identify and sort recyclables must be highly accurate.
- Dependability: Verify that the system operates reliably across a range of handling scenarios and environmental conditions.
- Scalability: Create a system that can be easily expanded to handle different bin sizes and types.
- Power efficiency: If the system is connected to a power source, optimize power consumption to extend battery life or reduce energy costs.
- Security: Implement security measures to stop unauthorized users from modifying or accessing system data or functionality.
- Maintenance: Build the system with access to spare parts for maintenance and repair.
- Compatibility: Ensure compatibility with existing standards and waste management infrastructure.
- Availability: Except for scheduled maintenance periods, the system is available and accessible to users at all times. It has a high percentage of uptime and minimal downtime for maintenance or upgrades.
- Usability: The web application interface is intuitive and user-friendly, allowing users to easily navigate, monitor generated data, and perform required actions. The system requires minimal training for users to understand and operate it effectively.
- Cost-Effectiveness: To promote widespread adoption, aim for a cost-effective design that strikes a balance between affordability and performance.
- Accessibility: Consider features such as tactile indicators or audible cues to accommodate users with disabilities.
- Environmental Impact: Reducing the environmental impact of the system by using sustainable materials and operating it efficiently.

Methodology

Our innovative EcoBin-Smart Garbage Management System calls for an agile approach to development. This system can be developed under the following phases of the agile methodology with project flexibility and user-centeredness.

- Phase 01 - Project Initiation

  This is one of the most significant phases of this project. In this phase, we begin by reinforcing a clear vision for our project. The vision of the EcoBin system demonstrates how EcoBin will revolutionize waste management and promote sustainability among users and organizations. We involve internal and external stakeholders including users and waste management authorities to ensure that their needs are reflected in our project. We recognize users' desired functionalities as "user stories" prioritizing high-impact features for the initial iteration by considering different user perspectives. We will conduct short development cycles called "sprints" which last 1-2 weeks to keep our project focused and efficient. Each sprint has a clear roadmap with the estimated effort required for each feature.

- Phase 02 - Iteration Planning

  In this phase, we break down the prioritized user stories for each sprint into smaller and achievable tasks which makes development manageable and allows for quick feedback loops. Our team members will collaboratively plan each sprint, ensuring everyone understands their roles and responsibilities. Tasks are assigned based on expertise and workload management. We define clear "acceptance criteria" that ensure its successful completion for each task. This helps to ensure transparency and avoids misunderstandings.

- Phase 03 - Development and Testing

  We conduct short daily meetings in this stage that will keep our team members informed about the system development status, foster collaboration, and identify any drawbacks early on. As well as, we frequently integrate code and automated tests to identify bugs or system functional errors and maintain code quality that helps to prevent major issues that can be appear later in development stages. At the end of each sprint, we use demos to showcase our advancements. User and stakeholder feedback will be crucial in iterating and improving our EcoBin system.

- Phase 04 - Retrospection and Adaptation

  We conduct review sprint achievement that consider on what worked well, what functioned well, what challenges we faced during the development, and what we learned from each sprint. By learning these continuously, we can make the EcoBin project adaptable and efficient. Then, we will adjust backlog priorities of the system based on feedback and learnings. After that, we prioritize user stories for future sprints for ensuring that our project evolves with user needs and technical discoveries. We will consistently enhance our development procedure, communication tactics, and teamwork to ensure that all of our team members prosper in an agile setting.

- Phase 05 - Iteration and Deployment

  In this final stage, we focus on the repetition of sprint cycles. We repeat sprint cycles, continuously implementing, testing, improving, and enhancing features of the EcoBin system based on user feedback and data. In sum, we deploy system prototypes or pilot systems in small areas that helps to allow us to collect real-world data and user feedback before wider deployment of the system. This reduces risk and ensures wider acceptance. We use data and user feedbacks as a good guidance for continuously improving and enhancing our system. This user-centric and user-friendly approach ensures that EcoBin system truly meets the needs of the community.

Modules Split-Up & Gantt Chart References

Activity	Time Duration (In Weeks)														
	01st Month				02nd Month				03rd Month				04th Month		
	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
Learning Technologies															
Project Planning & Scope Definition															
Requirement Gathering & Analysis															
Sensor and Algorithm Selection															
Prototype Development															
Designing Phase & User Interface Development															
System Integration															
Circuit Designing															
Testing and Optimization															
Deployment and Maintenance															

Cost Analysis

Name	Price	Quantity	Total
Total Cost			

Conclusion

References

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