3.1 Context Model (UML)

3.1.1 Overview

The Context Model for the Smart Waste Management System (SWMS) outlines the system's boundaries and the data flow between SWMS and external entities. It includes both a high-level Context Diagram and a more detailed Data Flow Diagram (DFD) to illustrate these interactions.

3.1.2 Components

The main components involved in this model are:

- **SWMS (Smart Waste Management System)**: The core system that monitors bin statuses, processes data, and triggers alerts and route optimization.
- **External Actors**:
    - **Waste Management Personnel**: Interacts with the system by receiving notifications and optimized collection routes.
    - **System Administrator**: Manages system configurations and updates bin information.
    - **Notification Service**: Sends alerts when bins reach full capacity.
    - **Database**: Stores data on bin statuses, user information, and routes.
    - **Camera Device**: Captures images of waste bins for status assessment.

3.1.3 Data Flow

The Data Flow Diagram (DFD) provides a detailed look at how data moves within the SWMS:

- **Camera Device** captures bin images and sends them to **SWMS**.
- **SWMS** processes the image data, determines bin status, and triggers alerts if necessary.
- **Notification Service** delivers notifications to **Waste Management Personnel**.
- **Database** stores records of bin statuses, routes, and user data.
- **System Administrator** updates configurations and bin details as needed.

3.1.4 Context Diagram

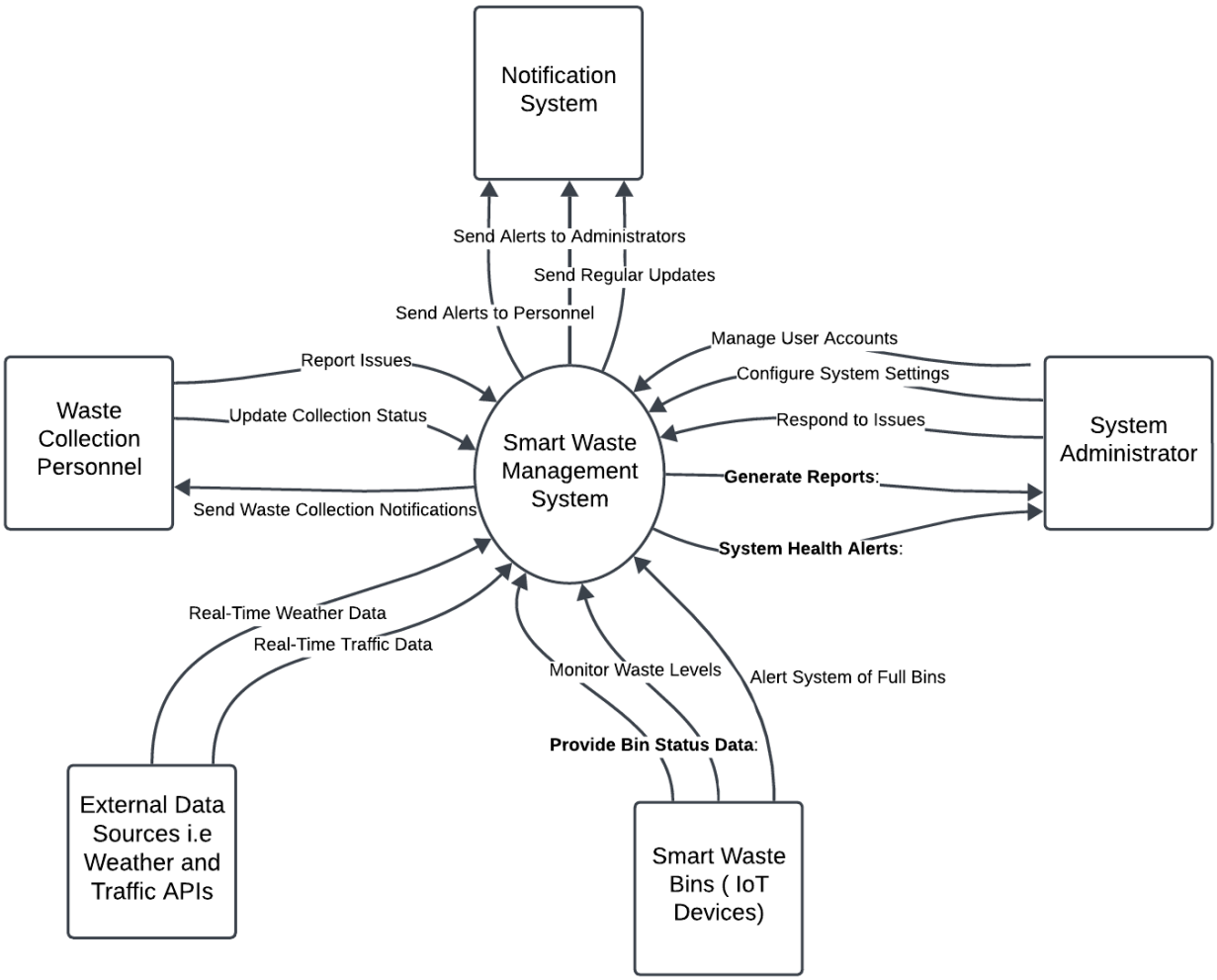

Figure 3.1: Context Diagram for Smart Waste Management System

3.1.5 Data Flow Diagram (DFD)

The Data Flow Diagram illustrates the movement of data between the SWMS, its internal processes, and external actors:

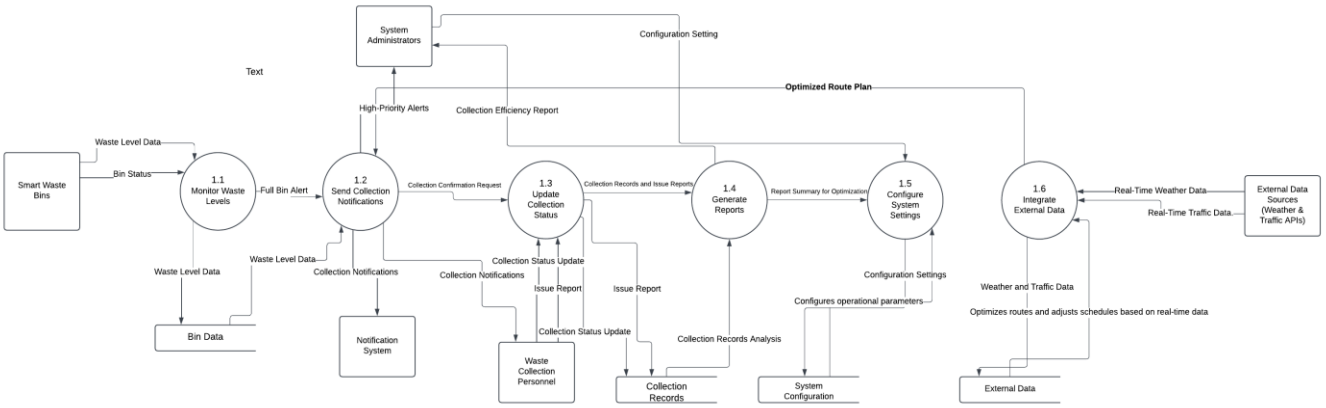

Figure 3.2: Data Flow Diagram for Smart Waste Management System

3.2 Interaction Model

3.2.1 Overview

The Interaction Model focuses on how different actors and components of the Smart Waste Management System (SWMS) interact to achieve the system's functionality. It includes a **Use Case Diagram** and a **Sequence Diagram** to illustrate the primary user interactions and the sequence of events.

3.2.2 Components

The main components involved in the interaction model are:

- **Actors**:
  - **Waste Management Personnel**: Monitors bin statuses, receives notifications, and follows optimized routes for waste collection.
  - **System Administrator**: Manages configurations, updates bin data, and monitors system performance.
  - **Camera Device**: Provides real-time images of bin fill levels for processing.
- **System Components**:
  - **SWMS**: The central system that processes bin data, sends notifications, and optimizes routes.
  - **Notification Service**: Delivers alerts to waste management personnel.
  - **Route Optimizer**: Calculates the most efficient route for waste collection.

3.2.3 Use Case Diagram

The Use Case Diagram visualizes the primary interactions between the system and its users, highlighting key functionalities such as monitoring bin statuses, receiving notifications, and optimizing routes.

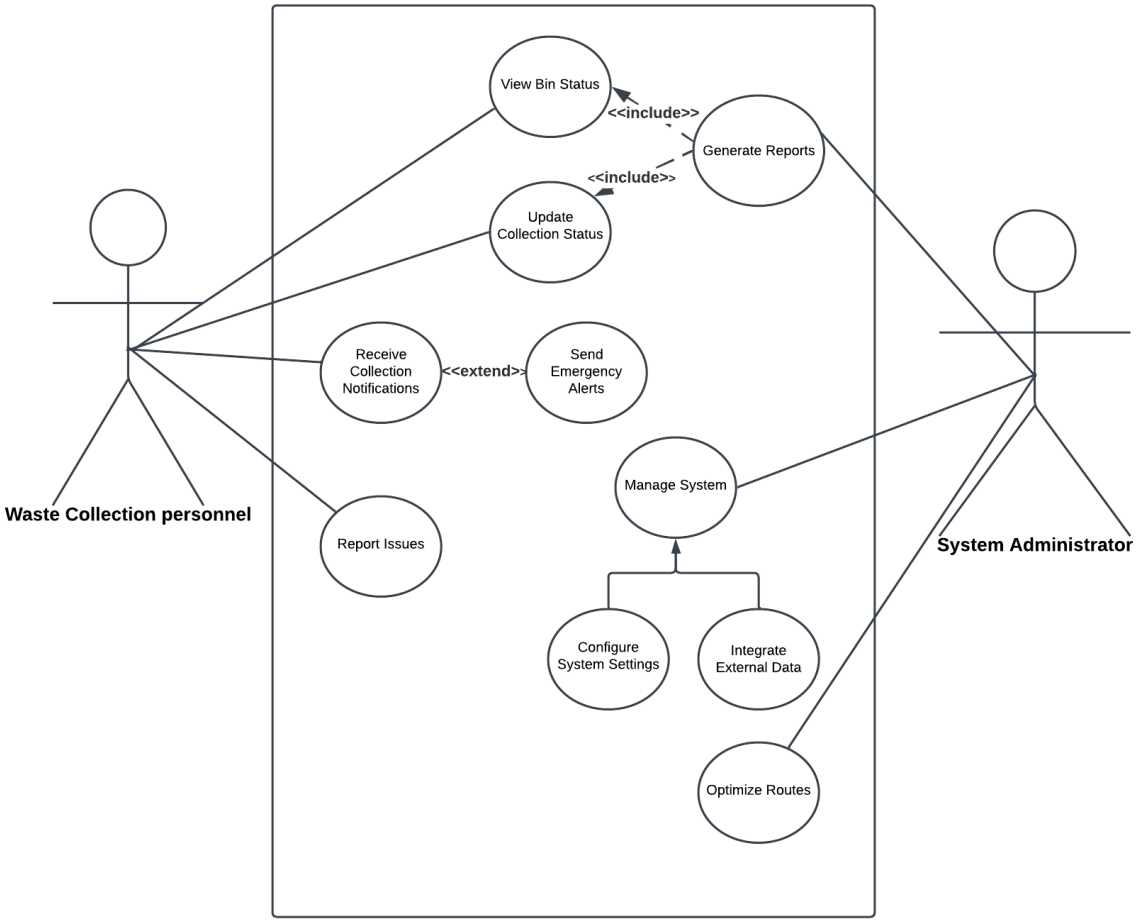

Figure 3.3: Use Case Diagram for Smart Waste Management System

3.2.4 Sequence Diagram

The Sequence Diagram depicts the flow of interactions over time, showing the order of operations when the system processes bin statuses, sends notifications, and provides optimized routes.

Key Processes in the Sequence Diagram:

1. **Image Capture**: The Camera Device captures bin images and sends them to the SWMS.
2. **Image Processing**: SWMS processes the image, assesses bin status, and determines if a notification is needed.
3. **Notification**: If the bin is full, the SWMS triggers the Notification Service to alert the Waste Management Personnel.
4. **Route Optimization**: SWMS requests the Route Optimizer to calculate the most efficient collection route.
5. **Route Delivery**: The optimized route is sent to the Waste Management Personnel.

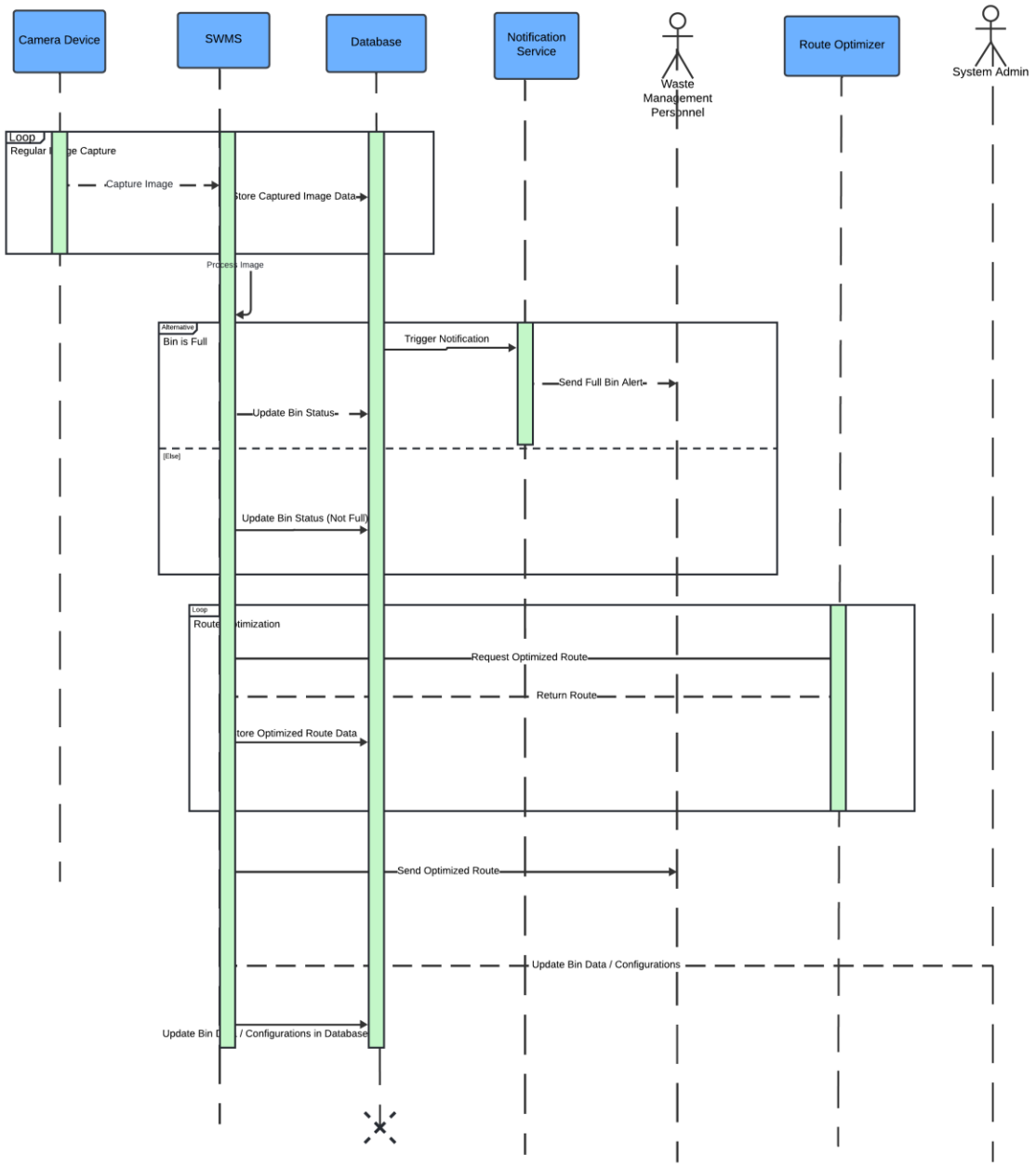

Figure 3.4: Sequence Diagram for Smart Waste Management System

3.3 Structural Model

3.3.1 Overview

The Structural Model defines the internal structure of the Smart Waste Management System (SWMS), illustrating how different system components are organized and related. It includes a **Class Diagram**, showing the main classes, their attributes, methods, and relationships such as inheritance, aggregation, and association.

3.3.2 Components

The primary components of the Structural Model are:

- **Classes**:
  - **User**: Represents waste management personnel and administrators, storing user details and providing login functionalities.
  - **AdminUser**: A specialized type of user with additional privileges for managing system configurations.
  - **WasteBin**: Represents each waste bin in the system, containing attributes like location, status, and capacity.
  - **NotificationService**: Manages the sending of alerts to personnel when bins are full.
  - **RouteOptimizer**: Calculates the most efficient route for waste collection based on bin statuses.
  - **Route**: Stores information about collection routes, including start and end points.

3.3.3 Relationships

The Class Diagram includes the following relationships:

- **Generalization**:
  - **AdminUser** inherits from **User**, indicating that an AdminUser is a specialized form of User with additional functionalities.
- **Aggregation**:
  - **WasteManagementSystem** aggregates multiple **User** and **WasteBin** instances, showing a whole-part relationship.
- **Association**:

- **WasteManagementSystem** interacts with **NotificationService** and **RouteOptimizer** for sending alerts and optimizing routes.

3.3.4 Class Diagram

The Class Diagram showcases the main classes, their attributes, methods, and relationships:

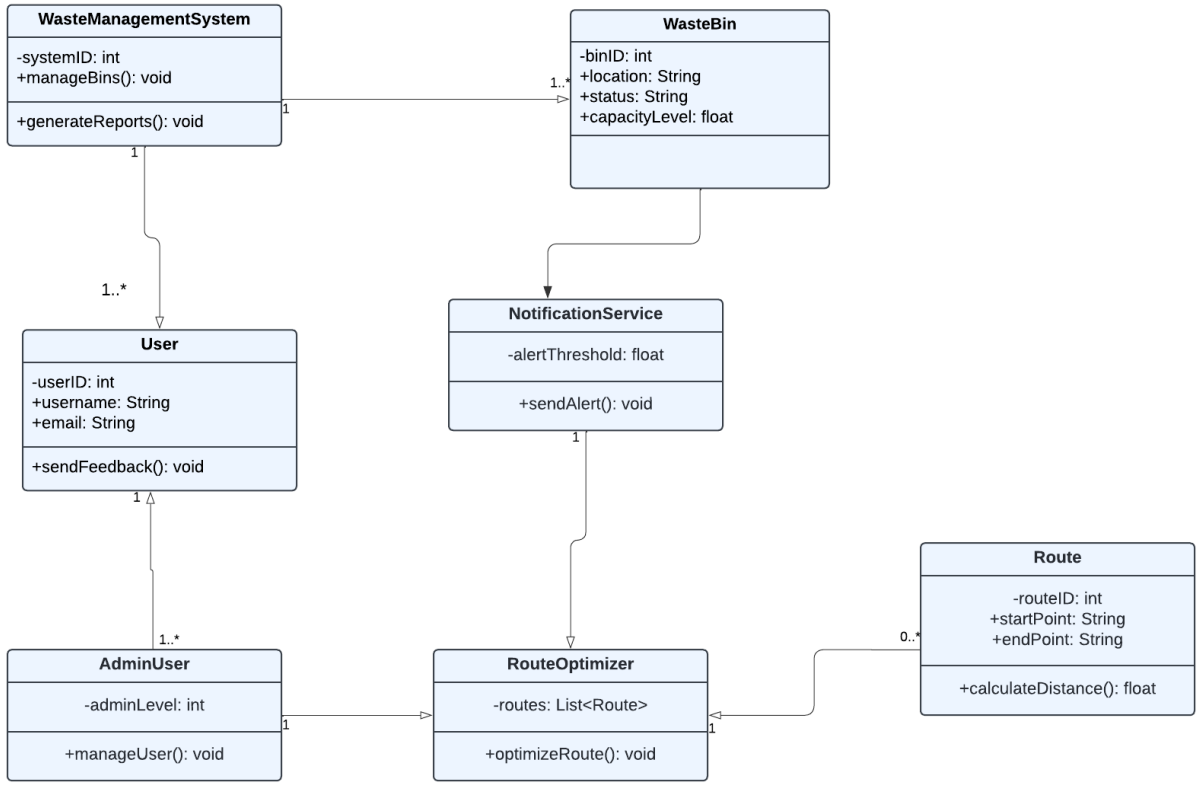

Figure 3.5: Class Diagram for Smart Waste Management System

3.4 Behavioral Model

3.4.1 Overview

The Behavioral Model focuses on the dynamic aspects of the Smart Waste Management System (SWMS), illustrating how the system responds to various events over time. This

section includes an **Event-Driven Model** represented by a **State Diagram**, which shows the possible states of a waste bin and the transitions triggered by specific events.

3.4.2 Components

The Behavioral Model for SWMS includes:

- **States**:
  - **Empty**: The initial state when the bin has little to no waste.
  - **Partially Full**: The bin is accumulating waste but not yet near capacity.
  - **Near Full**: The bin is almost full and requires monitoring.
  - **Full**: The bin has reached maximum capacity and needs to be emptied.
  - **In Service**: The bin is actively being emptied or maintained.
  - **Out of Service**: The bin is unavailable due to maintenance or malfunction.
- **Transitions**:
  - **Waste Added**: Moves the bin from a lower fill level (e.g., Empty to Partially Full).
  - **Threshold Reached**: Triggers the transition from Partially Full to Near Full.
  - **Full Capacity Reached**: Marks the bin as Full, prompting a notification.
  - **Emptied**: Resets the bin to the Empty state after waste collection.
  - **Maintenance**: Moves the bin to Out of Service for repairs or servicing.
  - **Service Restored**: Returns the bin to an operational state (Empty or Partially Full).

3.4.3 Event-Driven Model (State Diagram)

The State Diagram illustrates the different states of a waste bin within the SWMS and how it transitions between these states based on certain triggers.

Key Transitions:

1. **Empty → Partially Full**: Triggered by waste being added to the bin.
2. **Partially Full → Near Full**: When waste reaches a specified threshold level.
3. **Near Full → Full**: When the bin reaches full capacity.
4. **Full → In Service**: When the bin is being emptied by waste management personnel.
5. **In Service → Empty**: After the bin is emptied, it returns to the Empty state.
6. **Any State → Out of Service**: If the bin requires maintenance or encounters a malfunction.

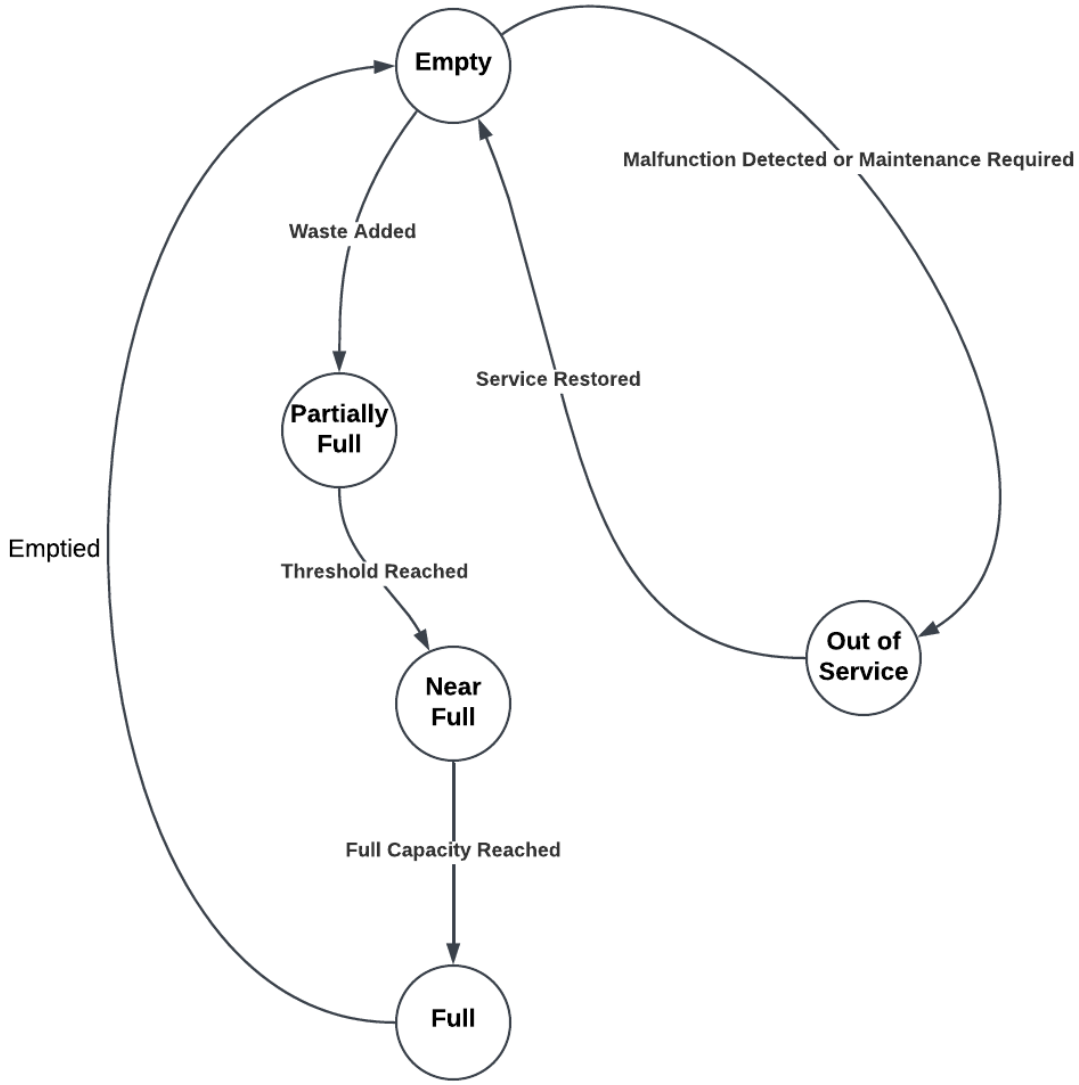

Figure 3.5: State Diagram for Smart Waste Management System