SOFTWARE REQUIREMENTS SPECIFICATION

for

SMART WASTE MANAGEMENT SYSTEM (SWMS)

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Contents

Revision History

Name	Date	Reason For Changes	Version
21	22	23	24
31	32	33	34

1 Introduction

1.1 Purpose

The ultimate purpose of this project is to achieve a smarter and cleaner city by regulating the waste materials in the community dustbins by simply using state of the art technologies like rfid tags and raspberrypi.

1.2 Document Conventions

Following conventions shall be followed in this and all subsequent documents:

- Fonts: We will use Times New Roman font throughout the document with a font size of 12.
- Highlighting: Any updates or changes in the requirements will be highlighted in yellow. Important points will be bolded for emphasis.
- Priorities: Priorities assigned to higher-level requirements will be inherited by their detailed requirements. If a detailed requirement needs a different priority, it will be explicitly stated.
- Requirement Identifier: Each requirement will have a unique identifier for easy reference.
- Versioning: The version of the document will be mentioned in the footer of each page. Any changes made to the document will result in an update in the version number.
- Comments: Any assumptions, constraints, or comments will be italicized.

Please note that these conventions are subject to change and any changes will be documented in the revisions section of the SRS. This is to ensure that the document remains consistent and easy to understand.

1.3 Intended Audience and Reading Suggestions

This document is intended for the following readers:

- **Developers**: Who will use this document to understand the system requirements and to design and implement the system.

- **Project Managers**: Who will use this document to plan and track the progress of the project.
- **Marketing Staff**: Who will use this document to understand the system's capabilities and to market the product effectively.
- **Users**: Who will use this document to understand the functionality of the system.
- **Testers**: Who will use this document to understand the system's requirements and to create test cases.
- **Documentation Writers**: Who will use this document as a reference to write user manuals and help guides.

The SRS is organized into various sections that describe the purpose, scope, definitions, system overview, system requirements, and appendices. The document begins with an overview and proceeds with detailed requirements.

1. All readers should start with the **Introduction** section for an overview of the SWMS.
2. **Developers**, **Testers**, and **Project Managers** should focus on the **System Requirements** section.
3. **Marketing Staff** and **Users** might find the **System Overview** and **Functional Requirements** sections most useful.
4. **Documentation Writers** should read the entire document to understand the system thoroughly.

Please note that this is a suggestion for reading the document. Depending on the role and requirements, one might need to refer to different sections of the document. It is recommended to read the entire document for a complete understanding of the SWMS.

1.4 Project Scope

The Smart Waste Management System (SWMS) is a comprehensive solution aimed at revolutionizing waste management in smart cities. By harnessing the power of Artificial Intelligence (AI) and Radio Frequency Identification (RFID), the system shall streamline the management and monitoring of waste disposal, thus promoting a cleaner and healthier urban environment.

The SWMS will bring about several key benefits, making it a promising tool for transforming waste management in smart cities. These include:

- **Sustainability**: The SWMS promotes sustainable practices by optimizing waste collection and disposal, reducing the overall environmental impact.

- **Cost-Effective**: By improving operational efficiency, the system can potentially reduce the costs associated with waste management.
- **Scalability**: The system is designed to be scalable, allowing it to adapt to cities of varying sizes and waste management needs.
- **Citizen Engagement**: The SWMS could include features to engage citizens, such as notifications about collection schedules or initiatives for waste reduction.
- **Data-Driven Decision Making**: The data collected and analyzed by the SWMS can aid city officials in making informed decisions about waste management policies and strategies.

1.5 References

<List any other documents or Web addresses to which this SRS refers. These may include user interface style guides, contracts, standards, system requirements specifications, use case documents, or a vision and scope document. Provide enough information so that the reader could access a copy of each reference, including title, author, version number, date, and source or location.>

2 Overall Description

2.1 Product Perspective

The SWMS is an integral part of a broader smart city model being developed. While it introduces a novel approach to waste management using AI and RFID technology, it's designed to work in harmony with other components of the smart city model.

As a component of a larger system, the SWMS interfaces with other systems in the smart city model. For instance, it can share data with traffic management systems to optimize waste collection routes, or with citizen services portals for real-time updates and notifications.

The SWMS's major components - RFID-tagged waste bins, AI-powered scheduling system, data analytics dashboard, and alert system - are designed to interact with each other and with external interfaces in the smart city model to provide a comprehensive waste management solution.

2.2 Product Functions

The Smart Waste Management System (SWMS) is designed to perform a variety of functions to optimize waste management in smart cities. Here is a high-level summary of the major functions it shall perform:

- **RFID Tagging**: Each waste bin in the city is equipped with an RFID tag. This allows the system to monitor the status and location of each bin in real-time.
- **AI-Powered Scheduling**: The system uses AI algorithms to optimize waste collection schedules. This ensures efficient use of resources and minimizes the time that waste remains uncollected.
- **Data Analytics Dashboard**: The SWMS provides a user-friendly dashboard for city officials. This dashboard displays real-time data on waste management, allowing officials to monitor the system's performance and make informed decisions.
- **Alert System**: The system sends real-time alerts in case of overflow or other irregularities in waste bins. This allows for quick resolution of issues and maintains the cleanliness of the city.
- **Visual Monitoring** (Potential): The Raspberry Pi camera could potentially monitor the physical state of the waste bins visually. This could provide another layer of data to improve waste management.

2.3 User Classes and Characteristics

The primary user classes include:

Waste Management Personnel

- *Role*: Waste management personnel are responsible for the on-ground operations of waste collection and disposal. They interact with the system on a daily basis.
- *Requirements*: They need a user-friendly interface to receive and update waste collection schedules. They also need to be able to report issues or irregularities in the system.
- *Importance*: Waste Management Personnel are the key users as they ensure the smooth operation of the system.

City officials

- *Role*: City officials are responsible for overseeing the implementation and operation of the system. They make decisions based on the data and insight provided by the system.
- *Requirements*: They require access to a comprehensive dashboard for monitoring and analyzing waste management data. They also need to receive important alerts and updates about the system's operation.
- *Importance*: City officials are crucial users as their decisions directly impact the effectiveness of the system.

Citizens

- *Role*: Citizens are the end-users who will use the waste bins equipped with RFID tags. Their usage patterns will contribute to the data analyzed by the system. They shall be able to raise complaints related to waste disposal through the system.
- *Requirements*: While citizens may not interact with the system directly, they require regular waste collection and timely resolution of any waste-related issues. They may also benefit from features like notifications about collection schedules or initiatives for waste reduction.
- *Importance*: Although citizens are less directly involved with the system's operation, their cooperation and compliance are essential for the success of the system.

2.4 Operating Environment

The Smart Waste Management System is designed to operate in a diverse and flexible environment to accommodate the varying infrastructures of different smart cities. Here are the key aspects of its operating environment:

1. **Hardware Platform**: The SWMS can operate on various hardware platforms used by smart cities. This includes servers for data processing and storage, RFID readers for collecting data from waste bins, user devices for accessing the system's dashboard, and Raspberry Pi and its camera for potential visual monitoring capabilities.

2. **Operating System**: The SWMS should be compatible with multiple operating systems. This includes various server operating systems for backend operations, popular desktop and mobile operating systems for frontend access, and Raspberry Pi OS for the operation of the Raspberry Pi and its camera.

3. **Software Components**: The SWMS needs to coexist with several software components in a smart city infrastructure. This includes database management systems for storing waste management data, data analytics tools for processing and visualizing data, and network management software for ensuring secure and reliable data transmission.

4. **Applications**: The SWMS should integrate seamlessly with various applications used in smart cities. This includes traffic management systems for route optimization, citizen services portals for real-time updates and notifications, and other smart city applications.

5. **Network**: The SWMS operates in a networked environment, requiring reliable internet connectivity for real-time data transmission and updates.

2.5 Design and Implementation Constraints

The design and implementation of the Smart Waste Management System are subject to several constraints:

1. **Raspberry Pi Specifications**: The hardware and software specifications of Raspberry Pi and its camera will impose additional constraints. For instance, the processing power and memory of Raspberry Pi, the resolution and field of view of the camera, etc., will need to be considered during design and implementation. These constraints might affect the complexity and performance of the AI algorithms and the overall system design.

2. **RFID Read Range**: The read range of RFID tags can be a constraint. The system needs to be designed to ensure that the RFID readers can accurately detect and read the tags on the waste bins, even in challenging urban environments.

3. **Data Volume**: The system will be collecting and processing large volumes of data from numerous waste bins across the city. This could pose challenges in terms of data storage, processing, and real-time analysis.

4. **AI Model Training**: The AI models used for optimizing waste collection schedules will need to be trained on historical waste management data. If such data is not readily available or is of poor quality, it could constrain the effectiveness of the models used.

5. **Network Connectivity**: The system relies on network connectivity for real-time data transmission. Network issues or connectivity gaps in certain areas of the city could impact the system's performance.

6. **User Interface Design**: The system's user interface needs to be intuitive and user-friendly for city officials and waste management personnel who may not have advanced technical skills. This could constrain the design and functionality of the user interface.

7. **Power Supply for Raspberry Pi**: Ensuring a reliable power supply for the Raspberry Pi and its camera could be a significant constraint, especially considering the outdoor deployment of the system.

8. **Environmental Conditions**: The system components, especially the RFID tags and Raspberry Pi, need to withstand various environmental conditions like rain, heat, dust, etc. This could impact the choice of materials and designs used for these components.

2.6 User Documentation

The following user documentation components will be delivered along with the Smart Waste Management System:

1. User Manual: A comprehensive guide providing detailed information about the system, its features, and how to use them. This will be provided in PDF format for easy access and printing.

2. Online Help: An interactive online help system integrated into the SWMS. This will provide users with immediate assistance and guidance while using the system.

3. Tutorials: Step-by-step tutorials guiding users through various tasks, functions, and installation of the SWMS. These could be provided as video tutorials or interactive online guides.

4. FAQs: A list of Frequently Asked Questions (FAQs) addressing common queries and issues related to the SWMS.

5. Troubleshooting Guide: A guide to help users diagnose and resolve common problems they might encounter while using the SWMS.

All user documentation will be provided in English, and will adhere to standard documentation practices for clarity and ease of understanding.

2.7 Assumptions and Dependencies

The design and implementation of the Smart Waste Management System are based on several assumptions and dependencies. These assumptions and dependencies need to be validated and managed throughout the project lifecycle to ensure the successful implementation and operation of the SWMS. Changes in these factors could require adjustments in the system's design or operation.

Assumptions

- **Raspberry Pi Performance**: It is assumed that the Raspberry Pi and its camera can perform reliably under various environmental conditions and can handle the computational load of the SWMS.
- **Camera Data Quality**: The system assumes that the camera can provide clear and accurate visual data under various lighting and weather conditions.
- **Power Supply**: It is assumed that a reliable power supply will be available for the Raspberry Pi and its camera, especially considering the outdoor deployment of the system.
- **RFID Technology**: It is assumed that the RFID technology used for tagging waste bins is reliable and efficient. Any malfunction or inefficiency in the RFID tags or readers could affect the system's performance.
- **Data Availability**: The effectiveness of the AI algorithms used for optimizing waste collection schedules is based on the assumption that sufficient and accurate waste management data is available for training the models.
- **Network Connectivity**: The system assumes reliable network connectivity for real-time data transmission and updates, including the data from the Raspberry Pi camera.
- **User Compliance**: The system assumes that city officials, waste management personnel, and citizens will use the system as intended. Non-compliance or misuse could affect the system's effectiveness.

Dependencies

- **Raspberry Pi OS**: The operation of the Raspberry Pi and its camera is dependent on the Raspberry Pi OS. Any changes or updates to this OS could impact the system's operation.
- **Camera Compatibility**: The system's operation is dependent on the compatibility of the Raspberry Pi camera with the rest of the system. Any changes or issues with the camera could impact the system's performance.
- **Third-Party Libraries**: If the system uses third-party libraries for operating the Raspberry Pi or processing the camera data, it would be dependent on the reliability and compatibility of these libraries.

3 External Interface Requirements

3.1 User Interfaces

The Smart Waste Management System will have two primary user interfaces:

Dashboard for City Officials

This interface will provide city officials with access to real-time data on waste management. It will include features such as:

1. **Data Visualization**: Graphs and charts to visualize waste management data.
2. **Alerts Panel**: A section to display real-time alerts about overflow or irregularities in waste bins.
3. **Scheduling Interface**: An interface to view and manage waste collection schedules.
4. **Help Button**: A standard help button on every screen to provide assistance to users.

Interface for Waste Management Personnel

This interface will be designed for on-ground personnel responsible for waste collection. It will include features such as:

1. **Collection Schedule**: A clear display of the waste collection schedule optimized by the AI algorithms.
2. **Navigation Assistance**: Integration with a mapping service to assist personnel in navigating the collection routes.
3. **Issue Reporting**: A feature to report issues or irregularities in the system.
4. **Help Button**: A standard help button on every screen to provide assistance to users.

Both interfaces will follow a consistent style guide to ensure a uniform look and feel. They will be designed to be user-friendly and intuitive, with clear labels for all buttons and functions. Error messages will be displayed in a clear and understandable manner.

Keyboard shortcuts will be provided for frequently used functions to enhance usability. The interfaces will also be designed to be responsive, ensuring compatibility with various device sizes and screen resolutions.

3.2 Hardware Interfaces

The SWMS interfaces with several hardware components to collect, process, and display waste management data. Here are the key hardware interfaces:

1. **RFID Tags and Readers**: RFID tags attached to the waste bins interface with RFID readers to transmit data about the status and location of the bins. The nature of the data interaction is wireless, using radio frequency communication protocols.

2. **Raspberry Pi and Camera**: The Raspberry Pi and its camera, used for potential visual monitoring of waste bins, interface with the SWMS software. The Raspberry Pi collects visual data from the camera and processes it using the SWMS software. The data interaction is through the Raspberry Pi's GPIO (General Purpose Input/Output) pins and the CSI (Camera Serial Interface) port.

3. **Servers**: The servers used for data storage and processing interface with the SWMS software. They receive data from the RFID readers and Raspberry Pi, process it using the SWMS's AI algorithms, and store it in the system's database.

4. **User Devices**: The devices used by city officials and waste management personnel to access the SWMS's dashboard interface with the SWMS software. They receive data from the servers to display on the dashboard and send user inputs back to the servers. The data interaction is through standard internet communication protocols.

5. **Network Hardware**: Network routers, switches, and other hardware used for data transmission interface with all other hardware components. They facilitate the transmission of data between the RFID readers, Raspberry Pi, servers, and user devices.

3.3 Software Interfaces

The SWMS interfaces with several software components for its operation:

1. Operating Systems: The SWMS is compatible with multiple operating systems, including server operating systems for backend operations, Raspberry Pi OS for operating the Raspberry Pi and its camera, and popular desktop and mobile operating systems for frontend access.

2. Database Management System: The SWMS interfaces with the central database management system for storing and retrieving waste management data. The system sends data items such as RFID tag readings and camera images to the database for storage, and retrieves this data for processing and display on the user dashboard.

3. AI Libraries: The SWMS uses AI libraries such as TensorFlow or PyTorch for implementing the AI-powered scheduling function.

4. Data Analytics Tools: The SWMS interfaces with data analytics tools for processing and visualizing waste management data. These tools take raw data from the system and transform it into graphs and charts for the data analytics dashboard.

3.4 Communications Interfaces

The SWMS uses various communications interfaces for data transmission and user interaction:

1. Network Protocols: The system uses standard internet communication protocols for data transmission between the RFID readers, Raspberry Pi, servers, and user devices. This includes protocols such as HTTP or HTTPS for web-based communication.

2. RFID Communication: The system uses radio frequency communication protocols for data transmission between the RFID tags and readers.

3. Security and Encryption: All data transmission is secured using standard encryption techniques to protect sensitive data and ensure privacy.

4. Data Transfer Rates: The system is designed to handle the data transfer rates required for real-time data transmission and updates.

5. Synchronization Mechanisms: The system shall use synchronization mechanisms to ensure that all components of the system have access to the most recent data.

4 System Features

Waste management is a bigger problem than waste disposal within a city. The main aim is to channel the waste generated and not let it accumulate in a single area. To achieve this, we intend to install RFID chips and make community dustbins smart enough to send empty (how much) signals to the control room, through which a trash van can come and make it empty.

4.1 Detection of level

4.1.1 Description and Priority

The main aim is to detect the level of emptiness in a community dustbin and assign the nearest trash van to make it empty.

4.1.2 Stimulus/Response Sequences

Dual detection is needed to control the waste, which includes a sensor inside the trash can and a community CCTV camera to monitor the nearby areas of the bin. If someone throws something out of the dumping area, the camera must be able to capture it. The functioning of the sensor includes simply the detection of the level of trash.

4.1.3 Functional Requirements

1. Waste Collection Optimization
a) The system shall employ AI algorithms to optimize waste collection routes based on real-time data.
b) RFID technology will be used to track and monitor waste bins, providing accurate information on fill levels.
2. Environmental Impact Reduction
a) The SWMS shall promote sustainable waste management practices to minimize the environmental impact of waste disposal.
3. Operational Efficiency
a) Operational efficiency improvements shall be achieved by automating waste collection processes and reducing resource wastage.
4. Scalability
a) The system shall be designed to adapt to cities of varying sizes and accommodate diverse waste management needs.
5. Citizen Engagement Features

a) The SWMS shall provide features for citizen engagement, such as notifications about waste collection schedules and initiatives for waste reduction.

5 Other Nonfunctional Requirements

1. Cost-Effectiveness
a) The SWMS shall demonstrate cost-effectiveness by reducing overall operational costs associated with waste management.
2. Reliability
a) The system shall operate reliably under various conditions to ensure continuous waste management functionality.
3. Security
a) Robust security measures shall be implemented to protect sensitive data, ensuring the integrity and confidentiality of information.
4. Data Analysis and Reporting
a) The SWMS shall facilitate data-driven decision-making by collecting, analyzing, and presenting relevant data to city officials.

6 User Roles

1. City Officials
a) City officials shall have access to comprehensive data analytics and reporting tools to make informed decisions.
2. Waste Management Personnel
a) Waste management personnel shall use the system for route optimization, waste bin monitoring, and operational efficiency.
3. Citizens
a) Citizens shall interact with the SWMS through features such as notifications and initiatives to actively participate in waste reduction efforts.

7 Constraints

a) The SWMS development shall adhere to relevant environmental regulations and standards.
b) Integration with existing city infrastructure and waste management systems may be required.

8 Assumptions and Dependencies

a) The successful implementation of the SWMS assumes the availability of reliable AI and RFID technologies.
b) Dependencies include collaboration with city authorities for access to infrastructure and data.

9 Conclusion

The Smart Waste Management System aims to address the challenges of waste management in smart cities by providing a comprehensive, scalable, and sustainable solution. This SRS serves as a foundation for the development and successful deployment of the SWMS, ensuring alignment with project goals and stakeholder expectations.