A

Project Report

On

A Blockchain-Based IoT-Enabled E-Waste Tracking and Tracing System for Smart Cities

SUBMITTED TO THE SAVITRIBAI PHULE PUNE UNIVERSITY , PUNE
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
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(Information Technology)

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2023-2024

CERTIFICATE

This is to certify that Project report entitled

A Blockchain-Based IoT-Enabled E-Waste Tracking and Tracing System for Smart Cities

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Is a bonafide work carried out by us under the supervision of Prof.Mrs.P.S.Dolare and it is submitted towards the partial fulfilment of the requirement of Savitribai Phule Pune University, for the award of the degree of Bachelor of Engineering (Information Technology).

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With immense pleasure, we are presenting this project report on, **A Blockchain-Based IoT-Enabled E-Waste Tracking and Tracing System for Smart Cities**, as a part of the curriculum of B.E Information Technology.

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Date -

Place - Ahmednagar

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ABSTRACT

This project focuses on the implementation of IoT (Internet of Things) technology to enhance e-waste management in smart cities. E-waste poses a growing environmental and health concern, necessitating efficient tracking and tracing solutions. This project implies IoT based Smart Dustbin for Household is a very innovative system which will help to monitor the trash collected in the dustbin. This system monitors and informs about the level of garbage collected in the garbage bins. Ultrasonic sensors are used to detect the level of garbage collected in the bins. By deploying IoT sensors and devices in e-waste collection points and vehicles, the project aims to monitor e-waste levels, optimize collection routes, and ensure proper disposal in compliance with environmental regulations. Real-time data analysis and user engagement through mobile apps will empower both waste management authorities and citizens to contribute to responsible e-waste disposal. The project's scalability and cost-efficiency make it a pivotal step toward sustainable and environmentally responsible urban living in the digital age. The system is supported by five smart contracts that record the actions of users on the immutable distributed ledger that aid in ensuring that the business processes carried out by the participants are transparent, traceable, and secure. To store large files, such as images of e-waste materials, products, and licenses for stakeholders, we have integrated our system with a distributed storage system.

Keywords: Internet of things, smart cities, IoT sensors, Smart Dustbin , Ultrasonic sensors.

Chapter 1

INTRODUCTION

1.1 Introduction

In the contemporary digital era, the proliferation of electronic devices has become an integral part of our daily lives, contributing to unprecedented technological advancements. However, the rapid evolution of electronics has given rise to a parallel challenge – the generation of electronic waste, commonly known as e-waste. The improper disposal of electronic devices poses severe environmental and health hazards due to the presence of hazardous materials. Recognizing the urgency of addressing this issue, our project, the E-Waste Management System, aims to provide a comprehensive solution to the burgeoning problem of electronic waste.

This initiative endeavour to establish an efficient and sustainable system for the collection, recycling, and responsible disposal of e-waste, aligning with global environmental goals and local regulatory frameworks. Smart cities rely on multiple technologies to create, deploy, and promote sustainable development strategies to meet the increasing demands of urbanization. For smart cities to be sustainable, they try to be energy efficient and have a small carbon footprint.

In order to improve quality of life, the Smart City Index (SCI) examines many factors, such as health, mobility, safety, and waste management. Population growth, urbanization, and economic growth have all led to a rise in waste generation. Considering the impact of waste on public health, environment, and climate, modern waste disposal and treatment methods, such as bioremediation, incineration, and plasma gasification, are utilized. In the last two decades, the life span of electronic equipment has reduced substantially due to rapid technical advancements. Managing e-waste is currently one of the major challenges of the urban cities. E-waste is more difficult to manage than conventional waste since it contains toxic chemicals, radioactive materials, and storage devices that might lead to privacy and security issues. If the storage devices are not disposed appropriately, they may fall into the hands of adversaries who acquire storage devices in bulk and scan them for sensitive information. Through this process, they can extract important data, such as encryption keys, crypto wallets, social security numbers, blueprints of important buildings, and even classified information of the governments . Therefore, electronic devices require evidence-based tracking, tracing, destruction, and recycling. Internet of Things (IoT) is one of the building blocks of smart cities and can play a crucial role in the collection and tracking of e-waste. Moreover, blockchain can allow us undertake evidence-backed tracking, tracing, destruction, and recycling of e-waste to prevent e-waste from entering the black market.

Many of the existing solutions for supply chain and waste management are based on IoT and cloud computing. Some of these solutions also offer financial incentives in the form of tokens to motivate people to deposit waste in the designated places. Due to the absence of auditing features, there is always a risk that e-waste may enter the black market, where criminals can extract radioactive materials or confidential data from the storage devices. Moreover, these systems are typically centralized and have scalability and single point of failure issues. Moreover, these solutions often lack essential features, such as transparency, traceability, accountability, and privacy etc

1.2 Aim

To design and develop a blockchain-based Internet of Things (IOT) system designed to efficiently track and trace electronic waste (e-waste) within smart cities.

This system seeks to enhance the management, recycling, and disposal of e-waste by leveraging the immutable and transparent nature of blockchain technology combined with the real-time data acquisition capabilities of IoT devices.

1.3 Motivation

- Smart City Initiatives
- Challenges in E-Waste Management
- Technological Advancements

1.4 Objective

- Implement a Blockchain Network:
  Establish a decentralized blockchain to securely record and verify all transactions and movements of e-waste.

- Develop a User Interface:
  Create a web application for stakeholders to interact with the system, including functionalities for reporting, tracking, and managing e-waste.

- Enhance E-Waste Management:
  Improve the sorting, recycling, and disposal of e-waste by providing accurate and timely information.

- Foster
  Public Awareness and Participation: Encourage responsible e-waste disposal practices among citizens through awareness campaigns and incentives.

- Integrate IoT Sensors:
  Deploy IoT devices to monitor the condition, location, and movement of e-waste in real-time.

- Foster Public Awareness and Participation:
  Encourage responsible e-waste disposal practices among citizens through awareness campaigns and incentives.

Chapter 2

LITERATURE SURVEY

Literature survey is the most important step in any kind of research. Before start developing we need to study the previous papers of our domain which we are working and on the basis of study we can predict or generate the drawback and start working with the reference of previous papers.

Creating a comprehensive literature survey for an e-waste management project involves reviewing existing research, studies, and publications related to e-waste management. Below is an in-depth literature survey that covers various aspects of e-waste management:

Garbage Management using Internet of Things. Authors: Mrs. Pallavi Nehete Dhanshri Jangam Nandini Barne Prajakta Bhoite Shalaka Jadhav.This system uses the smart dustbin in which a GSM board sends messages by detecting the level of garbage using an IR sensor. Water sensor is used to detect the wet garbage. Uses GSM which is relatively old (can use GPRS)

Garbage Monitoring System Using IOT Authors: Ashima Bajaj Sumanth Reddy .system makes use of a microcontroller, LCD screen,This and Zigbee methodology for sending data. Ultrasonic sensors are used to detect the level of garbage collected in the bins. The LCD screen is used to display the level of garbage collected in the bins.It suffers from the same drawbacks of being time consuming and resource inefficient as technology used is not practical with output and time parameters i.e., a garbage truck should only come in a periodical manner.

IoT E-Waste Monitoring System to Support Smart City Initiatives Author:Aznida Abu Bakar Sajak This system is to design an IoT-based recycle e-waste monitoring system that will provide an efficient solution to electronics waste collection and generation data.This system only call the truck when dustbin is 100 percent full.

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Chapter 3

PROBLEM STATEMENT/DEFINITION

An IoT-enabled blockchain-based system can enhance e-waste tracking and tracing by providing real-time data, ensuring data integrity, and enabling seamless collaboration among stakeholders. This solution aims to ensure responsible e-waste management, compliance with regulations, and promote sustainable recycling practices.
In the contemporary era of rapid technological advancements, the proliferation of electronic devices has led to an alarming increase in electronic waste (e-waste). As society continues to embrace new technologies, the improper disposal and management of e-waste pose significant environmental and health hazards. Existing waste management systems are inadequately equipped to handle the specialized nature of electronic waste, resulting in widespread pollution, resource wastage, and potential health risks. The challenges encompass various dimensions,
including:
1. Environmental Impact: -
Discuss specific examples of how current disposal practices contribute to soil and water contamination, emphasising the long-term consequences on ecosystems. - Explore the cumulative effects of air pollution resulting from the release of hazardous substances, detailing the impact on air quality and human health. - Consider potential repercussions for biodiversity and the broader environmental ecosystem.

2. Resource Depletion: -
Provide a detailed analysis of the valuable resources found in electronic devices, emphasising the economic and environmental significance of these materials. - Explore the global implications of inefficient recycling methods, including the impact on international resource markets and geopolitical dynamics. - Discuss the potential for

sustainable resource management and the circular economy as alternative models for addressing resource depletion.

3. Health Concerns: -
Examine specific cases or studies highlighting the health risks associated with informal and unsafe e-waste recycling practices. - Discuss the socio-economic factors contributing to the reliance on informal recycling and its impact on vulnerable communities. - Explore potential interventions, such as health and safety regulations or community empowerment programs, to address these health concerns.
4. Lack of Awareness: -
Analyse the root causes of the general lack of awareness among the public regarding ewaste disposal, considering factors such as educational gaps, cultural attitudes, and accessibility to information. - Propose targeted strategies for raising public awareness, including the use of educational campaigns, community outreach, and partnerships with educational institutions. - Explore successful case studies where awareness campaigns have effectively changed disposal behaviours.
5. Regulatory Gaps: -
Identify specific instances where existing regulations fall short in addressing the unique challenges posed by e-waste. - Discuss potential reasons for regulatory gaps, such as rapid technological advancements outpacing legislative processes. - Propose recommendations for strengthening and updating regulations, including the integration of international best practices and collaboration. By providing a more in-depth exploration of each dimension, your problem statement will offer a nuanced understanding of the multifaceted challenges posed by e-waste. This will not only enhance the clarity of the problem but also set the stage for a comprehensive E-Waste Management System that addresses these challenges in a holistic and effective manner.

Chapter 4

SOFTWARE REQUIREMENT SPECIFICATION

A software requirement specification (SRS) is a comprehensive description of the intended purpose and environment for software under development. The SRS fully describes what the software will do and how it will be expected to perform. The SRS provides an overview of the entire SRS with purpose, scope, definitions, acronyms, abbreviations and references. The aim of the document is to gather and analyze and give an in depth insight of the complete description.

4.1 Purpose

The purpose of SRS is to provide detailed overview of the system. SRS provides a detailed description of behavior of the system with the list of assumptions and constraints of the system. The purpose of the project is to predict the class labels by using estimated gaze direction and to improve the classification accuracy using F-measure and Accuracy.

4.2 Design Implementation Details

The smart system has been implemented for shaming detection uses Random Forest machine learning algorithm. This system is applicable for predict shamming tweets on twitter.

4.2.1 Hardware Requirements

- Processor - Intel i3/i5/i7
- Speed - 3.1 GHz

- RAM - 4 GB(min)
- Hard Disk - 40 GB
- Key Board - Standard Windows Keyboard
- Mouse - Two or Three Button Mouse

4.2.2 Software Requirements

- ArduinoIDE
- CodeVisionAVR
- Scripteditor
- Hosting/domain
- FrontEnd-HTML
- Scripts-JavaScript
- Language – Java
- Database - My SQL 5.0
- IDE - Visual Studio code

4.3 Design and Implementation Constraints Constraints

Constraints can be defined as limiting factor or state of restriction or lack of spontaneity of a software. Constraints are the limitations, hurdles which stop the software team from fulfilling their responsibility. Constraints are anything that restricts or dictates the actions of the project team. Any constraints that will impact the manner in which the software is to be specified, designed, implemented or tested are noted here. 3 core major constraints:

- Time: This refers to the actual time required to produce a deliverable which in this case would be the end result of the project. Naturally, the amount of time required to produce the deliverable will be directly related to the amount of requirements that are part of the end result along with the amount of resources allocated to the project.

- Cost: This is the estimation of the amount of money that will be required to complete the project. Cost itself encompasses various things, such as resources, labor rates for contractors, risk estimates, bills of materials, etc. All aspects of the project that have a monetary component are made part of the overall cost structure.

- Scope: These are the functional elements that, when completed, make up the end deliverable for the project. The scope itself is generally identified up front so as to give the project the best chance of success. Common success measure for the scope aspect of a project is its inherent quality upon delivery.

4.4 Assumption and Dependencies

4.4.1 Assumption

- User must have basic knowledge of computer.

- For evaluating the parameters ground-truth should be given to the system for the calculation of precision, recall, accuracy and F-measure.

4.4.2 Dependencies

- The Class label for the features being tested should be in the training set.

Chapter 5

PROJECT REQUIREMENT SPECIFICATION

1. COMMUNICATION

In communication phase the major task performed is requirement gathering which helps in finding out exact need of customer. Once all the needs of the customer are gathered the next step is planning.

2. PLANNING

In planning major activities like planning for schedule, keeping tracks on the processes and the estimation related to the project are done. Planning is even used to find the types of risks involved throughout the projects. Planning describes how technical tasks are going to take place and what resources are needed and how to use them.

3. MODELING

This is one the important phases as the architecture of the system is designed in this phase. Analysis is carried out and depending on the analysis a software model is designed. Different models for developing software are created depending on the requirements gathered in the first phase and the planning done in the second phase.

4. CONSTRUCTION

The actual coding of the software is done in this phase. This coding is done on the basis of the model designed in the modeling phase. So in this phase software is actually developed and tested.

5. DEPLOYMENT

In this last phase the product is actually rolled out or delivered installed at customer's end and support is given if required. A feedback is taken from the customer to ensure the quality of the product. From the last two decades Waterfall model has come under lot of criticism due to its efficiency issues. So let's discuss the advantages and disadvantages of waterfall model.

Chapter 6

PROPOSED SYSTEM ARCHITECTURE

6.0.1 System Architecture

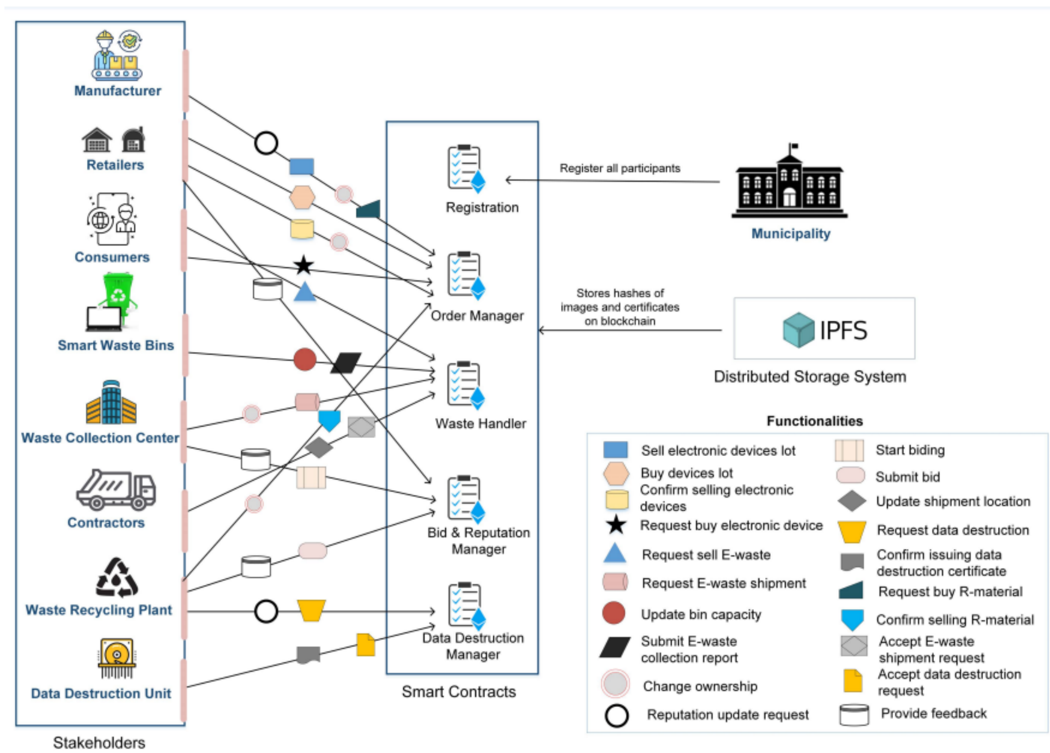

Figure 6.1: Proposed System Architecture

6.1 PROPOSED SYSTEM ARCHITECTURE

The proposed system we implemented seven modules which are as follows

1. Manufacturers

Manufacturers are responsible to manufacture the electronic devices for sale. They sells the electronic products to distributors and retailers. Before manufacturing any electrical equipment, the manufacturer undertakes market research to ensure that supply and demand are balanced. In our proposed system, the manufacturer creates a lot that is identified by a unique identity and publishes facts about the manufactured devices to the blockchain. The manufacturers record all important information on the blockchain, such as device name, type, production date, design, and type of raw material used in manufacturing process. The system also keeps track of the certificates granted by the authorities to ensure that the manufacturers have a valid manufacturing license.

2. Retailers

The retailers role is to buy electrical devices from the manufacturer or distributor and resale them in small quantities to the general public. They ensure that all of the customer's purchase requirements are addressed as quickly as possible. When the retailers buy electrical devices from distributors/manufacturers, they create lots of the bought items on the blockchain (referenced by unique identities) and allows consumers to buy electronic devices from them. They are also responsible of coordinating shipments for the delivery of the consumer orders. They also make their trading license public on the blockchain, ensuring the validity of the license.

3. Consumers

Consumers purchase the electronic equipment from retailers. In order to place a buy or sell request, consumers must beUpon detecting potential security threats, the system seamlessly transitions to the Alerts and Notifications layer. Here, Alert Generation mechanisms create immediate notifications about identified threats. These alerts are then seamlessly channeled through a robust Notification System, ensuring that relevant stakeholders are promptly informed about the security incidents. registered on the blockchain. Consumers deposit coins electronically into the retailers wallet after successful delivery of the placed order. After the usage, when the consumers want to dispose off their electronic devices, they deposit their devices in the nearby smart waste bins. The consumers may search for nearby waste bins that are registered on the blockchain by utilizing smart contracts stored on the blockchain. Ethers are automatically credited to the consumers wallets based on the type and weight of the e-waste following the disposal of e-waste into the smart waste bins.

4. Smart waste bins

Using sensors and image recognition technologies, smart waste bins are able to differentiate between different types of waste. They are also capable of determining the weight of the e-waste that is being dumped in the containers. In our proposed system, it is assumed that IoT-enabled smart waste bins are deployed across a smart city. These bins are managed, owned, and controlled by the waste collection centers/facilities. When a waste bin reaches its maximum capacity, the server associated with the container trigger a transaction on the blockchain and requests waste shipment. In addition, it generates and sends a report about the e-waste depositor. Payments to waste depositors are based on this report.

5. Waste collection center

The e-waste collection bins are situated throughout the smart city and are managed by the waste collection center. Waste collection center also arranges transportation service provides (contractors) for the collection of e-waste and are responsible for controlling overflow of the waste bins. Waste collection center chooses contractors based on the bids that prospective contractors submit. While announcing the bid on the blockchain, the center specifies the terms and conditions (e.g., delivery time, route, and safety limits), and the applicant with best match to the defined terms and conditions is selected. The consumers who dump electronic waste are identified by the smart waste bins, and waste collection center is notified by triggering a blockchain-based event. In response, the waste collection center pays money in the form of cryptocurrency to the e-waste depositors. The center eventually sells the e-waste it collects from customers to the recycling centers.

6. contractors

Contractors are responsible for collecting and transporting electronic waste from the waste collection center to the recycling facility. During e-waste shipment and handling, the contractor adheres to all government-issued guidelines and rules for handling and managing e-waste. Contractors are obligated to deliver e-waste to the agreed-upon location in a timely and secure manner. In addition, the contractor periodically updates the involved parties on the current location, route, and estimated time of arrival. In our proposed system, the waste collection facility hires and pays the contractors after using their services. In addition, only registered contractors can be hired to transport the e-waste to their destination.

7. waste recycling plants

This facility's main purpose is to ensure that all waste is recycled. The e-waste is transported to the recycling facilities by contractors engaged by a waste collection facility. To improve public health, the environment, and the climate, processes such as incineration, bioremediation, and plasma gasification are performed on e-waste when it is delivered. Furthermore, the recycling plant identifies IT data storage devices during the e-waste segregation phase and delivers them to a data destruction facility for data destruction. The electronic devices are scrambled and r-material (recycled material) is collected and sold to the producer. After this, r-material is used to construct new electronic equipment. In essence, this proposed system seamlessly integrates advanced technologies, human expertise, and stringent security protocols. By combining real-time detection, proactive threat identification, and swift response mechanisms, the system stands as a formidable defense against the ever-evolving landscape of cybersecurity threats.

9. Data destruction facility

The data destruction facility's principal goal is to erase data from the storage devices it receives. This facility uses cutting edge data destruction procedures to ensure that data privacy is maintained during data erasing process. A certificate is issued to the waste recycling unit when the data is successfully destroyed. This certificate serves as verification that data was safely and securely erased before the electronic data storage device was recycled.

10. Smart contracts

Smart contracts are computer programs that execute themselves and reduce the need for mediators while ensuring the administration of rules as agreed upon by the parties. As part of our research, we developed five primary smart contracts, namely registration, order manager, waste handler, bid handler, and data destruction manager. The smart contracts implement functions that are called when a certain event incurs relating to the management of electronic waste.

11. Distributed storage

Blockchain technology faces scalability issues, especially when massive files and data are to be stored on the blockchain. Distributed storage solutions (e.g., IPFS) allow stakeholders, such as manufacturers, merchants, waste recycling plants, and contractors to store huge size photos and files in a reliable and secure way without worrying about the scalability issues. In our proposed system, IPFS is used to store huge files and photos related to manufactured or recycled materials, as well as, user licenses. It is not worthy that only hashes of the files are stored on the blockchain.

Chapter 7

HIGH LEVEL SYSTEM DESIGN(DFD,UML)

A data ow diagram (DFD) is a graphical representation of the ow of data through an information system, modelling its process aspects. A DFD is often used as a preliminary step to create an overview of the system, which can later be elaborated.DFDs can also be used for the visualization of data processing (structured design).

7.0.1 Data Flow Diagram: Level 0

DFDs can also be used for the visualization of data processing (structured design).A DFD shows what kind of information will be input to and output from the system,where the data will come from and go to, and where the data will be stored. Figure 7.1 shows the representation of the Data Flow Diagram

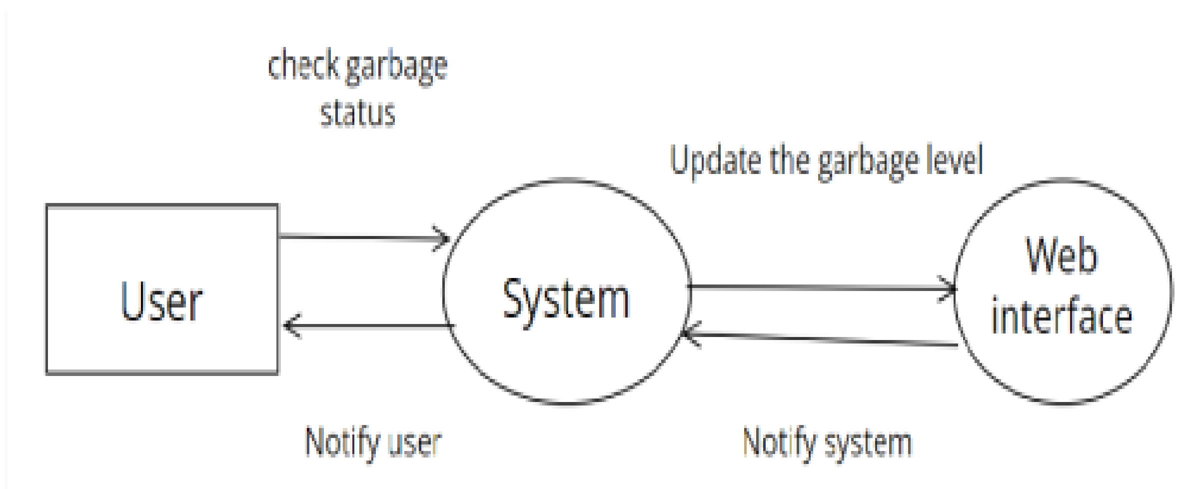

Figure 7.1: Data Flow Diagram: Level 0

7.0.2 Data Flow Diagram: Level 1

Level 1 DFDs provide a more detailed view of the system by breaking down the main process into subprocesses. It elaborates on the processes, data flows, and data stores identified in the Level 0 DFD. Processes: In a Level 1 DFD, the main process is decomposed into smaller, more detailed processes. Each sub-process represents a specific function or activity within the system. Data Stores: Data stores are repositories where data is stored within the system. They can be databases, file systems, or any other data storage mechanism. Data Flows: Data flows between processes, indicating the flow of data as it moves through the system. Each data flow represents a specific piece of information being transmitted between processes or stored in data stores. Connections: Level 1 DFDs show how data flows between processes and data stores, providing a detailed understanding of the system's internal workings 7.2 shows the representation of the Data Flow Diagram

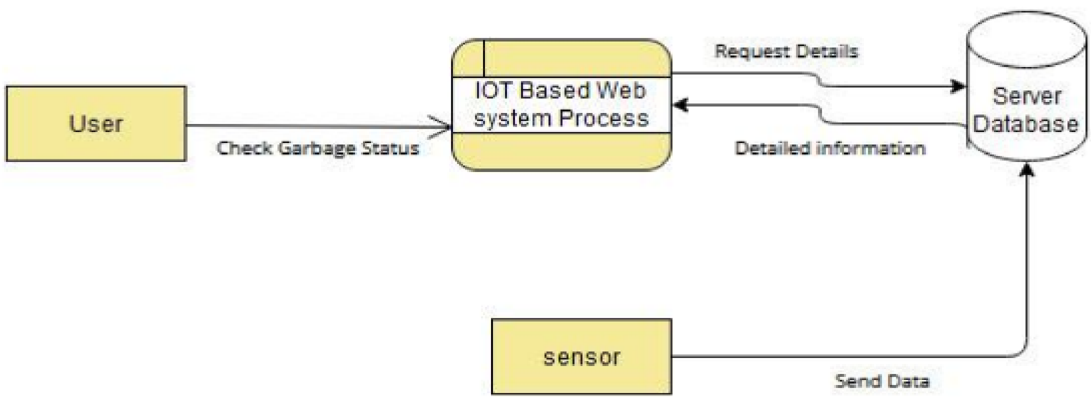

Figure 7.2: Data Flow Diagram: Level 1

7.1 UML Diagram

UML is a common language for business analysts, software architects and developers. It is used to describe, specify, design, and document existing or new business processes, structure and behavior of artifacts of software systems. The unified Modeling Language (UML) is a general purpose, developmental, modeling language in the area of software engineering that is intended to provide a standard way to visualize the design of a system.

7.1.1 Class Diagram

In software engineering, a class diagram in the Unified Modeling Language (UML) is a type of static structure diagram that describes the structure of a system by showing the system's classes, their attributes, operations (or methods), and the relationships among classes. It explain which class contains information. Class diagram describes the structure of a system by showing the system's classes, their attributes, and the relationships among the classes. Proposed system contains six different types of classes and each posses their own attributes and operations. Main classes of the proposed system are Pre-processing, discovery of aesthetic communities, image enhancements. Class diagram for a system is in Figure 7.3 Figure

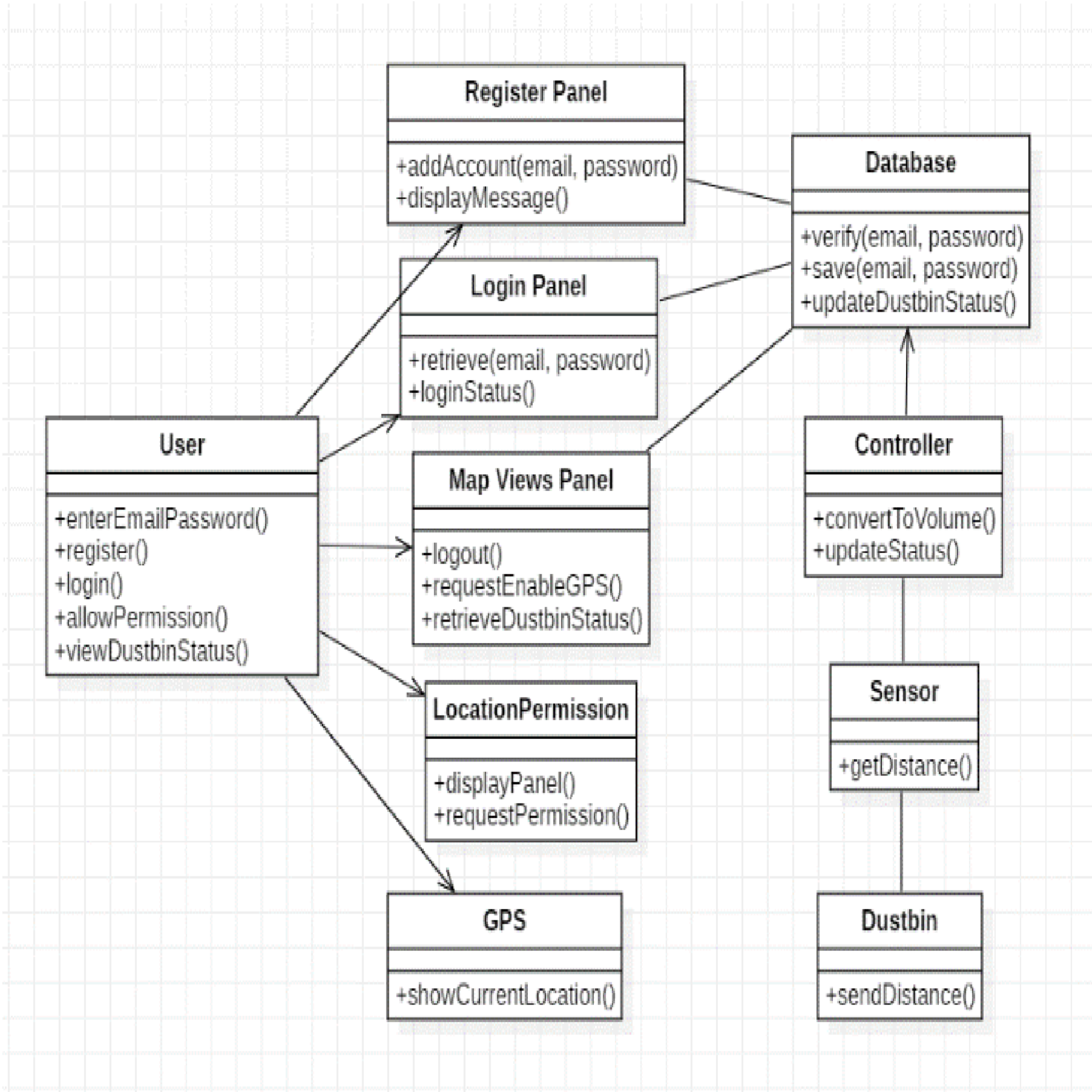

Figure 7.3: Class Diagram

This diagram appears to be a class diagram for a system that manages users interacting with a smart dustbin. It outlines the classes involved, their methods, and the relationships between them. Here's a detailed explanation:

Classes and Their Responsibilities:

1. User
- Methods:
- +enterEmailPassword(): Allows the user to input their email and password.
- +register(): Registers a new user in the system. - +login(): Logs the user into the system.
- +allowPermission(): Grants necessary permissions (e.g., location).
- +viewDustbinStatus(): Views the status of the dustbin.

2. Register Panel
- Methods:
- +addAccount(email, password): Adds a new user account to the database.
- +displayMessage(): Displays messages, possibly for success or error notifications.

3. Login Panel
- Methods:
- +retrieve(email, password): Retrieves user information based on email and password.
- +loginStatus(): Manages the status of the login attempt (e.g., success or failure).

4. Map Views Panel
- Methods:
- +logout(): Logs the user out of the system.
- +requestEnableGPS(): Requests the enabling of GPS for location tracking.
- +retrieveDustbinStatus(): Retrieves the status of the dustbin (e.g., fullness).

5. Location Permission
- Methods:
- +displayPanel(): Displays the panel to request location permissions.

- +requestPermission(): Requests the necessary location permissions from the user.

6. GPS
- Methods:
- +showCurrentLocation(): Displays the current location of the user.

7. Database
- Methods:
- +verify(email, password): Verifies the email and password for login.
- +save(email, password): Saves new user credentials in the database.
- +updateDustbinStatus(): Updates the status of the dustbin in the database.

8. Controller
- Methods:
- +convertToVolume(): Converts sensor data to volume information (e.g., how full the dustbin is).
- +updateStatus(): Updates the dustbin status based on new data.

9. Sensor
- Methods:
- +getDistance(): Measures the distance from the sensor to the trash level, which helps determine how full the dustbin is.

10. Dustbin
- Methods:
- +sendDistance(): Sends the measured distance data from the sensor to the system.

Relationships:
- User interacts with multiple panels (Register Panel, Login Panel, Map Views Panel) and has methods to manage their experience (login, register, etc.).
- Register Panel and Login Panel interact with the Database to manage user credentials.
- Map Views Panel interacts with Location Permission and GPS to manage location-

based functionalities and retrieve dustbin status.
- Database is a central component that verifies user credentials and updates dustbin statuses.
- Controller converts sensor data into meaningful information (volume) and updates the status of the dustbin. - Sensor in the Dustbin measures distance and sends this data to the Controller.

This diagram helps illustrate how different parts of the system work together to manage user interactions with a smart dustbin, tracking its status and managing user access.

7.1.2 Use Case Diagram

A use case diagram is type of behavioral diagram created from a Use-case analysis. Its purpose is to present a graphical overview of the functionality provided by a system in terms of actors, their goals (represented as use cases), and any dependencies between those use cases. Figure 7.4 shows the representation of the Use Case Diagram of the system.

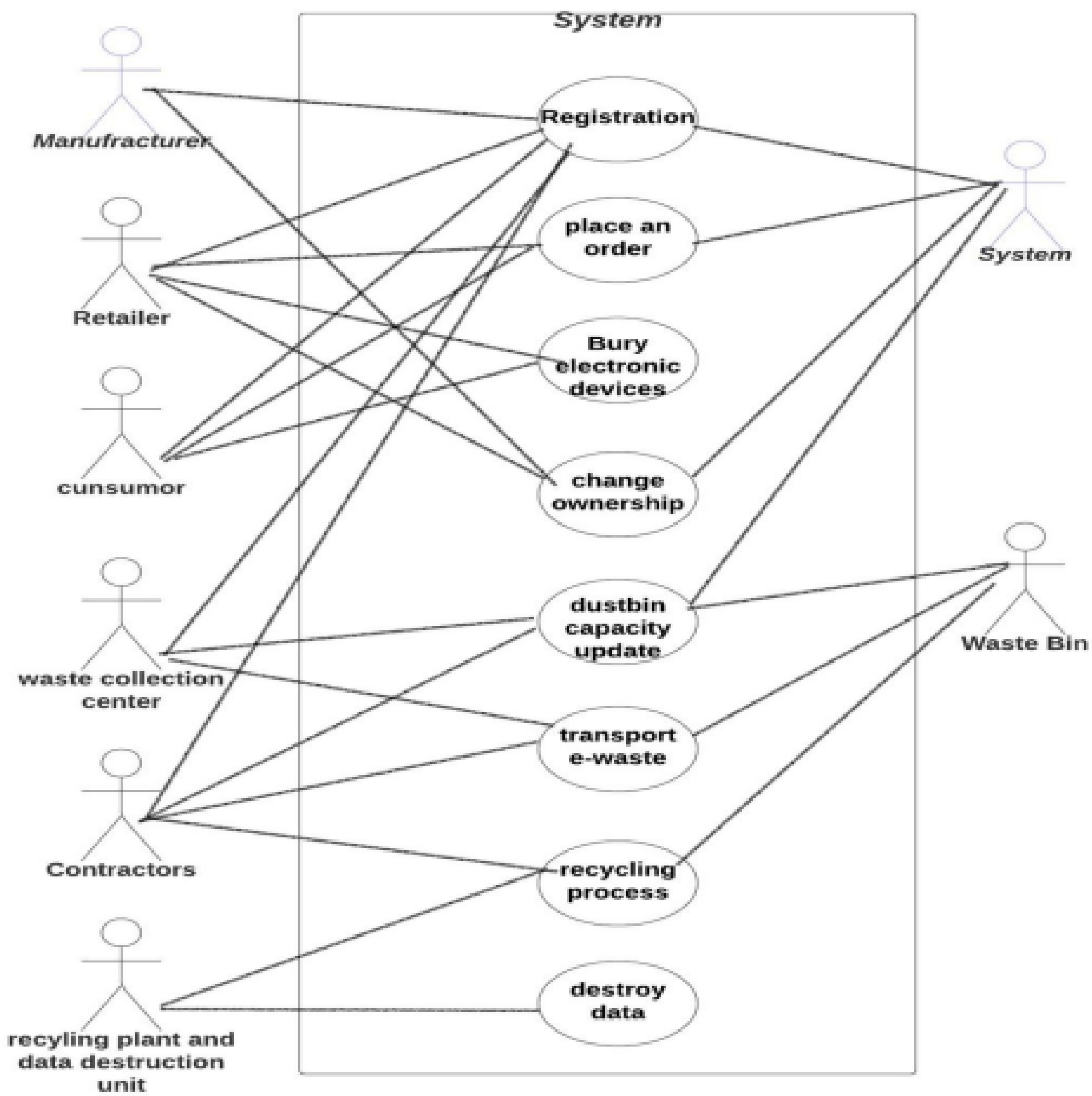

Figure 7.4: Use Case Diagram

This use case diagram represents the interactions between different actors and the system concerning the lifecycle of electronic devices, from registration to recycling and data destruction. The diagram helps to understand the roles and responsibilities of each actor in managing electronic waste (e-waste).

Actors:

1. Manufacturer: This actor represents the companies that produce electronic devices.
2. Retailer: This actor represents the sellers of electronic devices.
3. Consumer: This actor represents the end-users who purchase and use electronic devices.
4. Waste Collection Center: This actor is responsible for collecting e-waste from various sources.
5. contractors: This actor represents third-party service providers involved in the transportation and handling of e-waste.
6. Recycling Plant and Data Destruction Unit*: This actor is responsible for recycling electronic devices and securely destroying data.
7. System: This actor represents the automated system managing the various processes.
8. Waste Bin: This actor symbolizes the disposal points where consumers can discard their electronic waste.

Explanation of Use Cases

1. Registration: The process where users or entities register with the system.
2. Place an Order: The process of placing an order for new electronic devices.
3. Bury Electronic Devices: The process of discarding electronic devices that are no longer in use.
4. Change Ownership: The process of transferring the ownership of electronic devices from one user to another.
5. Dustbin Capacity Update: The system's function to update the capacity of waste bins as e-waste is added.
6. Transport E-Waste: The process of transporting collected e-waste to recycling centers.
7. Recycling Process: The process of recycling electronic devices to recover usable

materials.

8. Destroy Data: The process of securely destroying data stored on electronic devices.

Relationships Between Actors and Use Cases

- Manufacturer:
- Interacts with Registration, Place an Order, and **Change Ownership.
- Retailer:
- Interacts with Place an Order, Change Ownership, Transport E-Waste, and Recycling Process.
- Consumer:
- Interacts with Place an Order, Bury Electronic Devices, Change Ownership, and Dustbin Capacity Update.
- Waste Collection Center:
- Interacts with Transport E-Waste, Dustbin Capacity Update, and Recycling Process.
- Contractors:
- Interacts with Transport E-Waste, Recycling Process, and Destroy Data.
- Recycling Plant and Data Destruction Unit:
- Interacts with Recycling Process, Destroy Data, and Transport E-Waste.
- System:
- Interacts with all use cases to manage and streamline the processes.
- Waste Bin:
- Interacts with Dustbin Capacity Update, Bury Electronic Devices, and indirectly with Transport E-Waste through the waste collection process.

7.1.3 Sequence Diagram:

Sequence diagram is another important diagram in UML to describe the dynamic aspects of the system. Sequence diagram is basically a flowchart to represent the ow from one activity to another activity. The activity can be described as an operation of the system. The control ow is drawn from one operation to another.This own can be sequential, branched, or concurrent. Sequence diagrams deal with all type of ow control by using different elements such as fork, join, etc. Figure 7.5 shows the representation of activity diagram.

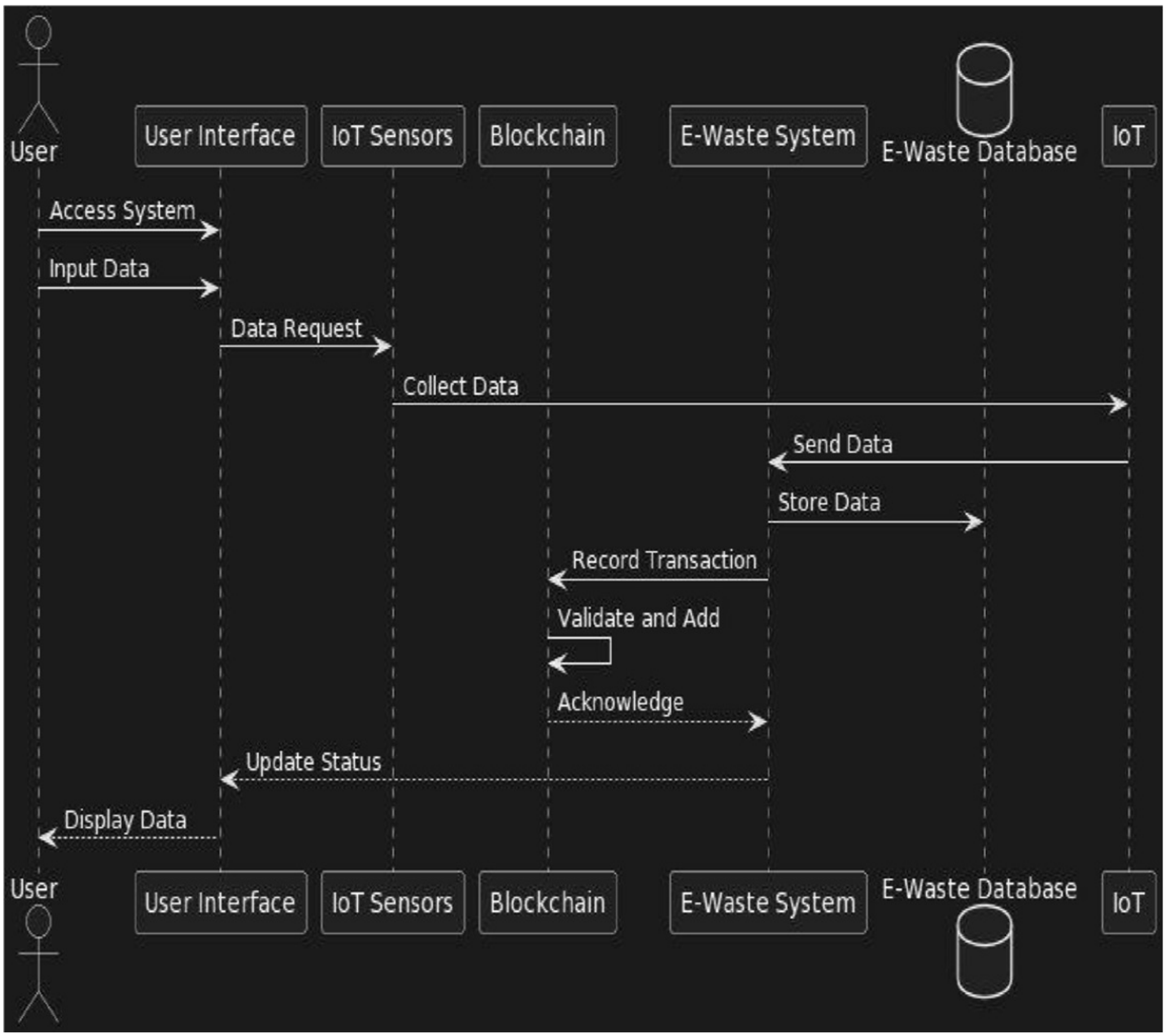

Figure 7.5: Sequence Diagram

This diagram is a sequence diagram, which illustrates the interactions and the order of events in a specific scenario within an e-waste management system. The system involves a user interface, IoT sensors, blockchain, an e-waste system, and an e-waste database. Here's a step-by-step explanation of the diagram:

1. User: The individual interacting with the system.
2. User Interface: The platform where the user inputs and views data.
3. IoT Sensors: Devices that collect data related to e-waste.
4. *Blockchain*: A decentralized ledger that records transactions securely.
5. *E-Waste System*: The central system managing e-waste data and operations.
6. *E-Waste Database*: The database storing e-waste-related data.

Sequence of Events:

1. Access System: The user starts by accessing the system through the user interface.
- Interaction: User → User Interface

2. Input Data: The user inputs necessary data through the user interface.
- Interaction: User → User Interface

3. Data Request: The user interface requests data from the IoT sensors.
- Interaction: User Interface → IoT Sensors

4. Collect Data: The IoT sensors collect the relevant data (e.g., amount and type of e-waste).
- Interaction: IoT Sensors

5. Send Data: The IoT sensors send the collected data to the e-waste system.
- Interaction: IoT Sensors → E-Waste System

6. Store Data: The e-waste system stores the data in the e-waste database.
- Interaction: E-Waste System → E-Waste Database

7. Record Transaction: The e-waste system records the transaction on the blockchain.
- Interaction: E-Waste System → Blockchain

8. Validate and Add: The blockchain validates the transaction and adds it to the ledger.
- Interaction: Blockchain

9. Acknowledge: The blockchain sends an acknowledgment back to the e-waste system that the transaction has been validated and recorded.
- Interaction: Blockchain → E-Waste System

10. Update Status: The e-waste system updates the status based on the new data and transaction confirmation.
- Interaction: E-Waste System → User Interface

11. Display Data: The updated status and data are displayed to the user.
- Interaction: User Interface → User

- The user initiates the process by accessing the system and inputting data. The system requests data from IoT sensors, collects it, and sends it to the e-waste system.The data is stored in the database, and a transaction is recorded on the blockchain.The blockchain validates the transaction, and the e-waste system updates the status.Finally, the updated information is displayed to the user.

This sequence diagram effectively shows how data flows and interactions occur between different components in the e-waste management system, ensuring data integrity and user awareness.

7.1.4 Activity Diagram:

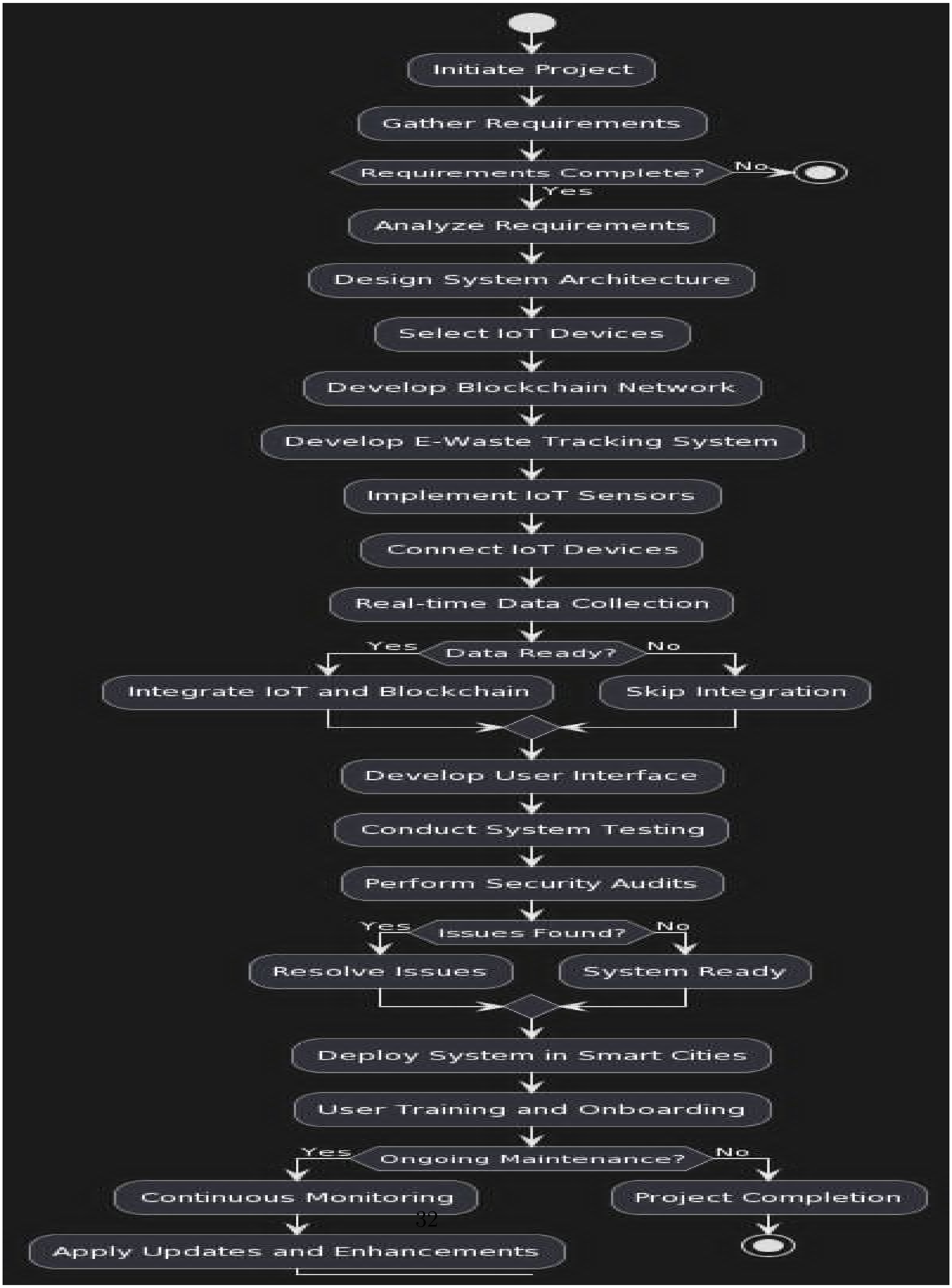

Figure 7.6: Activity Diagram

An activity diagram is a type of behavioral diagram in Unified Modeling Language (UML) that represents the workflow of a system or process. It visually depicts the sequence of activities and the flow of control or data between them. Here's an explanation of the key components and elements commonly found in an activity diagram. This is an activity diagram, which illustrates the workflow or steps involved in developing and deploying a smart e-waste management system. Here's a step-by-step explanation of the process depicted:

Activities and Decision Points:

1. Initiate Project
- Start the project by setting initial goals and plans.

2. Gather Requirements
- Collect all necessary requirements from stakeholders.

3. Requirements Completed?
- Decision Point: Check if all requirements are gathered.
- If No, loop back to "Gather Requirements."
- If Yes, proceed to "Analyze Requirements."

4. *Analyze Requirements
- Analyze the gathered requirements to ensure they are clear and actionable.

5. Design System Architecture
- Design the overall system architecture based on the analyzed requirements.

6. *Select IoT Devices
- Choose appropriate IoT devices for the e-waste management system.

7. Develop Blockchain Network
- Develop the blockchain network for secure and transparent transaction recording.

8. Develop E-Waste Tracking System

- Create the system for tracking e-waste using the selected IoT devices.

9. Implement IoT Sensors

- Install and set up IoT sensors for data collection.

10. Connect IoT Devices

- Connect the IoT devices to the system for communication and data transfer.

11. Real-time Data Collection

- Start collecting real-time data from the IoT sensors.

12. Data Ready?

- Decision Point: Check if the data collection process is ready.
- If No, loop back to "Real-time Data Collection."
- If Yes, proceed to "Integrate IoT and Blockchain."

13. *Integrate IoT and Blockchain

- Integrate IoT devices with the blockchain network for secure data handling.

14. Skip Integration

- If integration is not necessary, this step is skipped.

15. Develop User Interface

- Develop the user interface for user interaction with the system.

16. Conduct System Testing

- Perform testing on the entire system to ensure it works as intended.

17. Perform Security Audits

- Conduct security audits to ensure the system is secure.

18. Issues Found?

- Decision Point: Check if any issues are found during testing or audits.
- If Yes, proceed to "Resolve Issues."
- If No, proceed to "System Ready."

19. Resolve Issues
- Address and fix any issues found during testing and security audits.

20. System Ready
- Confirm that the system is ready for deployment.

21. Deploy System in Smart Cities
- Deploy the e-waste management system in selected smart cities.

22. User Training and Onboarding
- Train users and onboard them to the new system.

23. Ongoing Maintenance?
- Decision Point: Determine if ongoing maintenance is needed.
- If Yes, proceed to "Continuous Monitoring."
- If No, proceed to "Project Completion."

24. Continuous Monitoring
- Continuously monitor the system and apply updates and enhancements as needed.

25. Project Completion
- Mark the project as complete if no further maintenance is required.

Summary:

The diagram shows a comprehensive process starting from project initiation, through development and testing phases, to deployment and ongoing maintenance. Decision points guide the workflow, ensuring that each step is properly completed before moving to the next. The loopbacks and conditional steps ensure thorough preparation and testing before the system is deployed and maintained.

7.1.5 Object Diagram:

An object diagram in UML (Unified Modeling Language) is a static snapshot of instances in a system at a particular point in time. It represents the objects, their attributes, and their relationships. While a class diagram provides a blueprint for the classes, an object diagram provides an instance-level view of the system, capturing the state of a system at a specific moment.

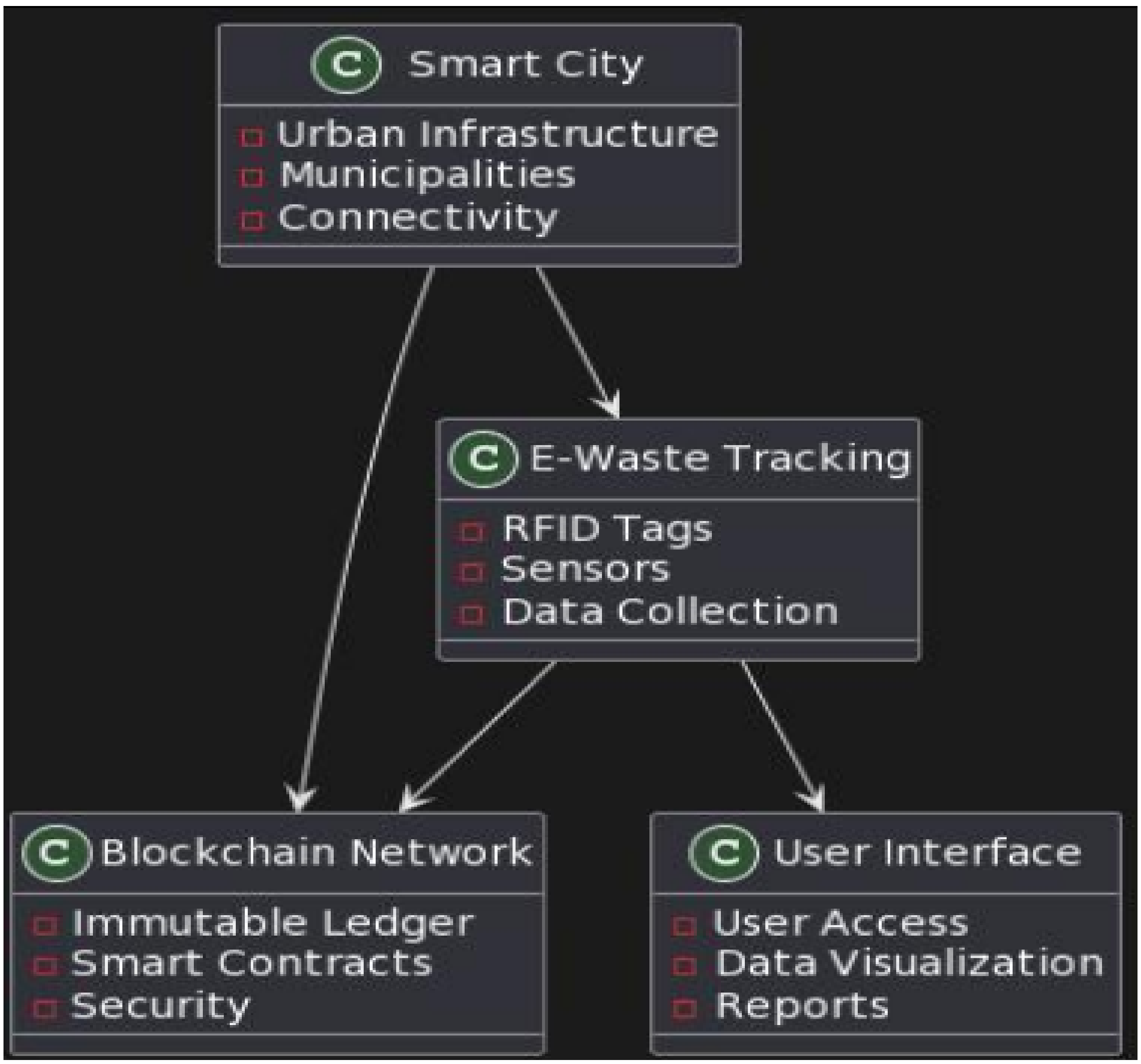

Figure 7.7: Object Diagram

This diagram illustrates the integration of e-waste tracking within a smart city ecosystem. It highlights the interaction between various technological components such as blockchain networks and user interfaces to ensure effective e-waste management.

Explanation of Main Components

1. Smart City: Represents the overarching infrastructure and connectivity provided by the urban environment. This is the central hub where all other components integrate.
2. E-Waste Tracking: This system is dedicated to monitoring and managing electronic waste within the smart city.
3. Blockchain Network: A secure and immutable ledger that records all transactions and interactions related to e-waste.
4. User Interface: The platform through which users interact with the e-waste tracking system, accessing data and generating reports.

Explanation of Sub-Components

- Smart City:
- Urban Infrastructure: Refers to the physical and organizational structures needed for the operation of the smart city.
- Municipalities: Local government entities that manage and regulate city functions, including waste management.
- Connectivity: The network infrastructure that allows seamless communication between different parts of the smart city.

- E-Waste Tracking:
- RFID Tags: Used to tag electronic devices, enabling their tracking throughout their lifecycle.
- Sensors: Devices that collect data on the status and location of e-waste.
- Data Collection: The process of gathering information from RFID tags and sensors for analysis.

- Blockchain Network:
- Immutable Ledger: Ensures that all data recorded in the blockchain is tamper-proof

and permanent.
- Smart Contracts: Self-executing contracts with the terms directly written into code, used for automating e-waste management processes.
- Security: Measures taken to protect the integrity and confidentiality of data within the blockchain.

- User Interface:
- User Access: Controls and manages how users interact with the system.
- Data Visualization: Tools and techniques used to graphically represent e-waste data for easy interpretation.
- Reports: Generation of detailed reports based on the collected and processed data.

Relationships Between Components
- The Smart City infrastructure provides the foundation for the E-Waste Tracking system, ensuring connectivity and support from municipalities.
- E-Waste Tracking relies on RFID tags, sensors, and data collection to monitor e-waste, which then feeds into the Blockchain Network for secure and immutable record-keeping.
- The Blockchain Network utilizes an immutable ledger, smart contracts, and robust security protocols to manage e-waste data effectively.
- The User Interface allows stakeholders to access and interact with the e-waste tracking data, offering visualization tools and report generation capabilities to make informed decisions.

Summary
This diagram outlines a comprehensive framework for integrating e-waste management into a smart city ecosystem. It highlights the synergy between urban infrastructure, advanced tracking technologies, secure blockchain networks, and user-friendly interfaces. By leveraging these components, the system aims to enhance the efficiency and transparency of e-waste management processes.

7.1.6 Deployment Diagram:

A deployment diagram is a type of UML (Unified Modeling Language) diagram that shows the physical arrangement of hardware and software in a system. It illustrates the architecture of a system as the deployment (distribution) of software components on various pieces of hardware (nodes).

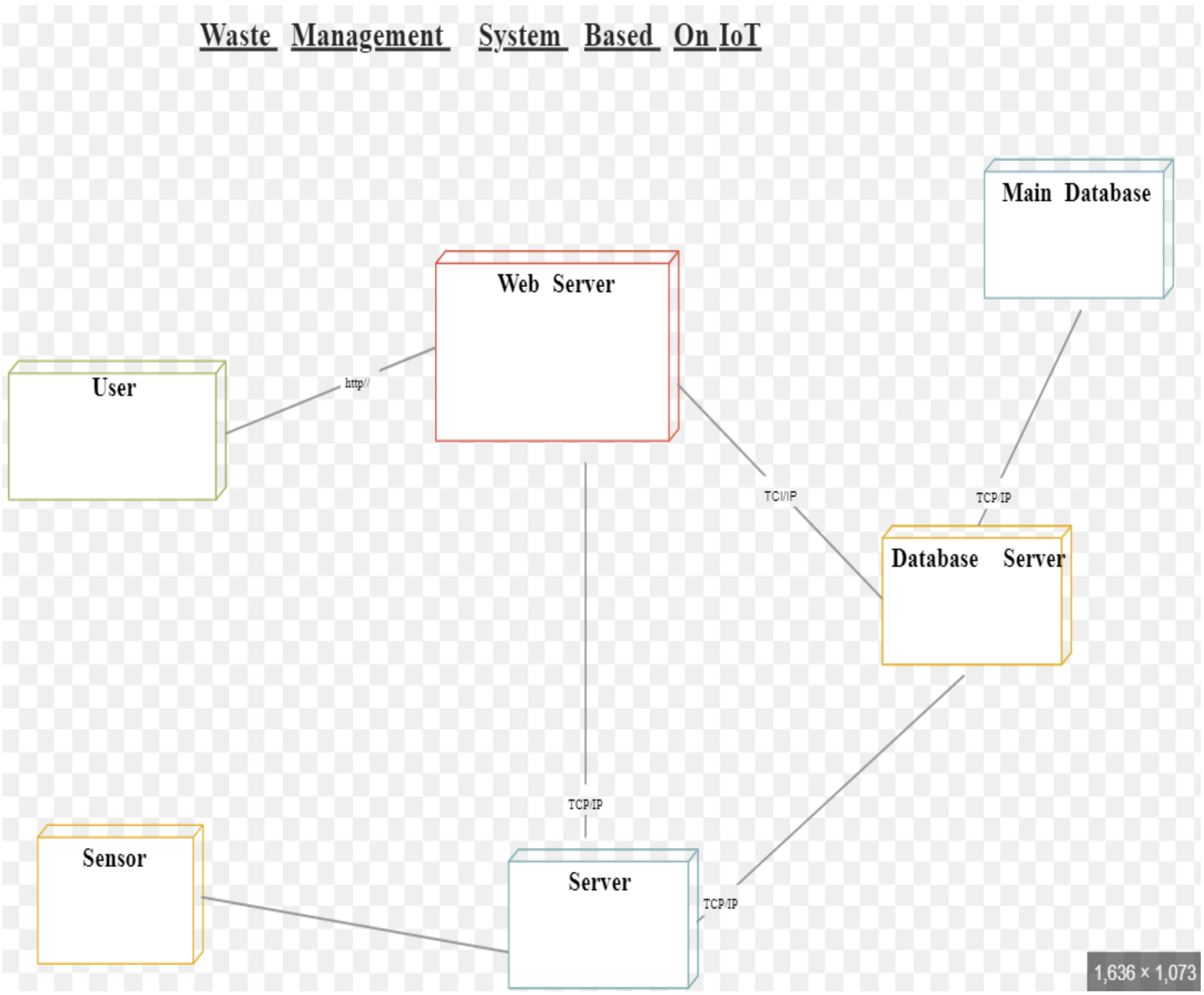

Figure 7.8: deployment Diagram

Chapter 8

SYSTEM IMPLEMENTATION

8.1 Algorithms

Algorithm 1 : Placing a Request to Buy Electronic Devices From Manufacturer

article algorithm algpseudocode

Input: Quantity, type, service time, device EA **Output:** Emit DataDestructionRequestPlaced Event Caller is not a registered user **This service cannot be granted due to unverifiable Ethereum address.** Caller is WasteRecylingPlant AND Permit.GetPermitofDataDestructionUnit() is not Expired AND Reputation_Score ¿ Minimum_Value AND Device.Type = Storage Generate an identifier to uniquely identify the order. Update status of the order to 'Submitted'. Emit an event for the entities participating to let them know that the data destruction request was successfully placed using the waste recycling unit EA, the device EA, and the data destruction unit EA. Display an error and restore the smart contract to its initial state.

1 Input: Electronic device EA, shipment delivery due date, quantity, and type
2 Output: Emit PurchaseOrderPlaced Event
3 if Retailer is not a registered user then
4 The request is rejected due to an unverifiable Ethereum address.
5 end
6 else
7 if Order placing entity is a Retailer AND
QuantityRequested ¡ Lot.GetLOTQuantity() AND
QuantityRequested ¿
Lot.MinimumOrder$_{t}hresholdANDTrade_{l}icence$

$! = Expired AND Manufacturer.GetReputationScore$
$() > Minimum_Threshold then$

8 Set request status to 'Waiting'.
9 Create an order ID.
10 Inform the stakeholders by emitting an event
reporting the successful placing of a request for
electronic devices using the retailer EA,
amount requested, and electronic device EA.
11 end
12 else
13 Display an error message and return the smart
contract to its initial state.
14 end
15 end

Algorithm 2 Submitting Bids to Confirm Delivering e-Waste in a Particular Region

This algorithm ensures that only verified and legitimate users can request and receive a data destruction certificate. It checks the order and payment status along with the reputation score to prevent fraudulent activities. The use of IPFS and blockchain ensures the integrity and transparency of the certificate issuance process, providing a secure and verifiable record of data destruction.
1 Input: Waste contractor EA, bid
2 Output: Emit ContractorsSelected Event
3 if Waste contractor is not a registered user then
4 The request is rejected due to an unverifiable Ethereum address.
5 end
6 else
7 if WasteContractor has a valid permit to ship
e-waste AND Bidscount ! = Threshold$_limit AND$

$biding.status == OpenANDBiding_Value <$
$MaximumThresholdANDReputation_Score$
$> Minimum_value then$

8 Register the bid.
9 Create Bid submission ID.
10 Set bidding status to “Submitted”.
11 Bidscount+=1.
12 Inform the stakeholders by emitting an event reporting the successful placing of a bid for shipping electronic waste in a particular region using the Waste contractor EA, biding values, biding ID, and status.
13 end
14 else
15 Display an error message and return the smart contract to its initial state.
16 end
17 end

Chapter 9

SYSTEM TESTING

Test cases are built around specifications and requirements, i.e., what the application is supposed to do. Test cases are generally derived from external descriptions of the software, including specifications, requirements and design parameters. Although the tests used are primarily functional in nature, nonfunctional tests may also be used. The test designer selects both valid and invalid inputs and determines the correct output without any knowledge of the test object's internal structure. Test Design Techniques Typical black-box test design techniques include:

- Decision table testing
- All-pairs testing
- State transition Analysis
- Equivalence partitioning
- Boundary value analysis
- Cause-effect graph
- Error guessing

Advantages

- Ecient when used on large systems
- Since the tester and developer are independent of each other, testing is balanced and unprejudiced
- Tester can be non-technical.

- There is no need for the tester to have detailed functional knowledge of system.
- Tests will be done from an end user's point of view, because the end user should accept the system. (This testing technique is sometimes also called Acceptance testing.)
- Testing helps to identify vagueness and contradictions in functional specifications.
- Test cases can be designed as soon as the functional specifications are complete.

Disadvantages

- Test cases are challenging to design without having clear functional specifications.
- It is difficult to identify tricky inputs if the test cases are not developed based on specifications.
- It is difficult to identify all possible inputs in limited testing time. As a result, writing test cases may be slow and difficult.
- There are chances of having unidentified paths during the testing process.
- There is a high probability of repeating tests already performed by the programmer.

1] Test case For Registration Page:

Test Case ID	**Test Case Procedure**	**Input Data**	**Expected Output**	**Actual Output**	**Test Status**

1	Checking the functionality of Submit Button	1.Enter valid User name 2.Enter valid email-id 3.Enter valid Password 4.Enter valid date 5.Enter valid contact no. 6.Click on Register Button	Accept and Login page should be displayed	Accept and Login page displayed	Pass
2	Checking the functionality of Submit Button	1.Enter invalid User name 2. Enter valid email-id 3. Enter valid Password 4. Enter valid date 5. Enter valid contact no. 6. Click on Register Button	Error should come and Register page should be displayed	Error comes and Register page displayed	Pass
3	Checking the functionality of Submit Button	1.Enter valid User name 2. Enter invalid email-id 3. Enter valid Password 4. Enter valid date 5. Enter valid contact no. 6. Click on Register Button	Error should come and Register page should be displayed	Error comes and Register page displayed	Pass
4	Checking the functionality of Submit Button	1.Enter valid User name 2. Enter valid email-id 3. Enter invalid Password 4. Enter valid date 5. Enter valid contact no. 6. Click on Register Button	Error should come and Register page should be displayed	Error comes and Register page displayed	Pass

5	Checking the functionality of Submit Button	1.Enter valid User name 2. Enter valid email-id 3. Enter valid Password 4. Enter invalid date 5. Enter valid contact no. 6. Click on Register Button	Error should come and Register page should be displayed	Error comes and Register page displayed	Pass
6	Checking the functionality of Submit Button	1.Enter valid User name 2. Enter valid email-id 3. Enter valid Password 4. Enter valid date 5. Enter invalid contact no. 6. Click on Register Button	Error should come and Register page should be displayed	Error comes and Register page displayed	Pass

2] Test case For Login Page:

Test Case ID	**Test Case Procedure**	**Input Data**	**Expected Output**	**Actual Output**	**Test Status**
1	Checking the functionality of Login Button	1.Enter valid User name 2 .Enter valid Password 3. Click on Login Button	Accept and User's home page should be display	Accept and User's home page displayed	Pass
2	Checking the functionality of Login Button	1.Enter valid User name 2 .Enter Invalid Password 3. Click on Login Button	Error should come and Login page should be displayed	Error should come and Login page displayed	Pass

3	Checking the functionality of Login Button	1.Enter Invalid User name 2 .Enter valid Password 3. Click on Login Button	Error should come and Login page should be displayed	Error should come and Login page displayed	Pass
4	Checking the functionality of Login Button	1.Enter Invalid User name 2 .Enter Invalid Password 3. Click on Login Button	Error should come and Login page should be displayed	Error should come and Login page displayed	Pass

Chapter 10

PROPOSED GUI

add project screens here

Chapter 11

PROJECT PLAN

Schedule		Date	Project Activity
July	1st Week	01/07/2023	Project Topic Searching
	2nd Week	08/07/2023	Project Topic Selection
	3rd Week	15/07/2023	Synopsis Submission
August	1st Week	05/08/2023	Presentation On Project Ideas
	2nd Week	12/08/2023	Submission Of Literature Survey
	3rd Week	19/08/2023	Feasibility Assessment
September	1st Week	02/09/2023	Documentation for paper publishing.
	3rd Week	16/09/2023	Design Of Mathematical Model
	4th Week	24/09/2023	Paper is publish.
October	1st Week	09/10/2023	Report Preparation And Submission
December	3rd Week	19/12/2023	1st module presentation
	4th Week	26/12/2023	Discussion and implementation of 2nd module
January	1st Week	02/01/2024	Preparation for conference
	2nd Week	09/01/2024	Study of algorithm.
	3rd Week	16/01/2024	Discussion about modification.
	4th Week	24/01/2024	1st and 2nd module presentation
	5th Week	30/01/2024	Discussion on flow of project and designing new module
February	1st Week	06/02/2024	Modification of modules.
	2nd Week	13/02/2024	Designed test cases for our module.
	3rd Week	20/02/2024	Worked on user interface.
March	1st Week	06/03/2024	Integration of all modules.
April	1st Week	8/04/2024	Final Report.
May	1st Week	10/05/2024	Final Presentation.

Figure 11.1: Project Plan

CONCLUSION

A blockchain-based e-waste management system holds great promise for smart cities. By leveraging the transparency and security of blockchain technology, it enables efficient tracking, disposal, and recycling of electronic waste.This not only ensures environmental sustainability but also promotes responsible waste management practices, contributing to the overall advancement of smart city initiatives

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