Republic of the Philippines

BULACAN STATE UNIVERSITY

Hagonoy Campus

Iba-Carillo, Hagonoy

Smart Bin - Waste Management System

In Partial Fulfillment of the Requirements
for IT 303 – System Analysis and Design

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CHAPTER 1
INTRODUCTION

Introduction

Plastic pollution is currently one of the most serious threats to our planet. Every minute, millions of plastic bottles are consumed worldwide. According to the UN Environment Programme, plastic pollution has a significant impact on the livelihoods of millions of people by altering the habitats and natural processes of the environment, reducing its ability to adapt to climate change and also has an impact on food production and people's well-being. Plastic pollution is also one of the most serious environmental issues in the Philippines (Raji, 2022). The World Bank also uses the word "staggering" to describe this country's situation. Furthermore, Environment Secretary Maria Antonia Yulo-Loyzaga stated that the Philippines produces at least 2.7 million metric tons of plastic waste, which is concerning given the country's insufficient waste management system.

Recycling plastic is the most effective way of dealing with these situations because it allows for the reutilization of plastics (Al-Salem, Lettire, Baeyens, 2009). Recycling helps to reduce waste while also assisting in the production of reusable items for the country. In the Philippines, recycling is heavily based on the monetary value of recyclable materials , making it an appealing source of income for waste collectors (Pepino, 2019). Furthermore, it has been demonstrated that rewarding people is the most effective method of getting them to recycle (Wahab, Kadir, Tomari, 2015). Reverse Vending Machines (RVM), an innovative way of rewarding people for recycling, are used all over the world. However, the cost of RVM is a critical factor in determining whether it can be implemented on a large scale to aid in effective waste management. These existing solutions are either very expensive in terms of computation and cost, or they lack the robustness and durability required for deployment (Kokoulin and Kiryanov, 2019). As a result, a low-cost, endogenously developed RVM device is required.

This paper proposes a Smart Bin as a waste management replacement solution. It is likely to be less expensive to maintain than traditional RVMs, which are costly to maintain. This system is a low-cost solution for implementing a plastic bottle waste management system that also includes a reward system to reward people who recycle using this system. Our study is unique since no other research in the region has focused on the complete design, implementation, deployment, and evaluation of a self-designed, low-cost solution for plastic waste management. This machine is also intended for large-scale implementation and to be manufactured at a low cost. The proposed machinery is also extremely simple, making it possible for anyone working on this type of system to effectively replicate it. The implementation of this system will also be extremely beneficial in encouraging people to recycle plastic bottles. This system will be implemented at the Bulacan State University Hagonoy Campus.

Project Context

Technology made revolutionary changes to our lives. Technology has touched every aspect of our life, making it easier, better, and different. The things that seemed impossible in the past now exist and are easily done. It helps us to keep in touch with the people who are away from us by using a cell phone or computers. We can send pictures, text messages and important information through email service. Computers are one such technology. It is a machine which has the capability to store large amounts of data in its memory. It works using input and output devices. Computers are a very safe tool for data storage which is being used in various fields. This technology is used in offices, banks, educational institutions, the medical sector and more.

The efficacy and accessibility of technology have significantly enhanced our lives, and it is hard to separate humans from technology. There is no need to stand in line to purchase a ticket because reservations and bookings may be made online. This is an illustration of how travel is utilizing technology. With the help of an app, we can determine our location and the distance we walked. Additionally, it takes advantage of the fact that students may utilize the internet to research the topics that their professors have given and get ready for class beforehand. Teachers can create a virtual classroom

where students can ask questions and teachers can assign assignments with the help of online collaboration technology.

The Hagonoy campus of Bulacan State University is in Iba-Carillo Hagonoy. The Municipality of Hagonoy granted 8.5 hectares of land to Bulacan State University in 1994 to meet its demands. Concrete barriers were given by the late Sen. Blas P. Ople to safeguard the land while the school buildings were being built in 1996. On the seventh day of June 2011, former president Mariani C. De Jesus and former mayor Angel L. Cruz officially opened the Bulacan State University building.

The researcher gathered information about the waste management system at the Bulacan State University Hagonoy Campus by observing the school grounds and conducting interviews and survey questionnaires with students on the campus about the methods of disposing of their used bottles and cans. The information gathered was carefully documented and analyzed, which led the researcher to develop the Smart Bin waste management system, which can be used to monitor and organize the used plastic bottles and cans of the Bulacan State University Hagonoy campus.

The current method of disposing of used plastic bottles and cans is to simply open the trash can and place them inside without knowing whether the trash can is for paper or plastic bottles and cans. It leads to incorrect waste segregation at the Bulacan State University Hagonoy Campus. The developed system will assist the school in segregating used bottles and cans, as well as the students and teachers, because if they use the Smart Bin - Waste Management System, they will receive some coins in exchange for depositing their used plastic bottles or cans in the Smart Bin - Waste Management System, By the end of the day, the system will generate a report on the daily number of bottles and cans collected.

Purpose and Description

The purpose of this study is to develop a Waste Management System or Bulacan State University Hagonoy Campus. The system has the following function: The IR Sensor should be able to send a signal to the Arduino after inserting a water bottle, the user should be able to receive a token per bottle, and report on the daily number of bottles collected.

The system uses a realistic method where sensors continuously monitor the amount of fill in each compartment and offer real-time data. These data are transmitted to a storage and processing unit so that the competent authorities may compile statistical data, identify priority collecting locations and collection paths with optimal routes, and ensure that resources are employed correctly in regions with the highest demand for service.

The project's researchers make use of the Software Development Life Cycle (SDLC). The six procedures of project definition, data collecting, data analysis, system design, and coding were used by the researchers to finish this study. The researchers first determine the requirements the system needs. The researcher will pick the system's hardware and software. Once the researchers have determined the demands of the project, it is time to meet with the management office to acquire information and important details needed for the system. As soon as they have the data, the researchers will examine it to determine what details the system needs. Once the researchers have the precise and detailed product needs, it is time to construct the full system. The system design will include extensive documentation and a thorough understanding of the hardware and communication architecture for the product being produced. After the system has been designed, coding will then start. The coding is completed in accordance with the coding standards and regulations. The code is put through a variety of code reviews and performance optimizations before the system is actually constructed.

Objectives of the Study

General Objectives:

The main objective of this study is to develop a Smart Bin - Waste Management System, for Bulacan State University.

Specific Objectives:

The following statement are the specific objectives of the study:

- To help the environment by recycling materials and reducing the need for raw materials in the production of new beverage containers.
- To create a recycling culture both inside the school and outside of the community, and to encourage good behavior of students by offering incentives/tokens.
- To design a trash bin that can detect when it is full by using sensors.
- To devise an automated and wall-following navigation scheme using ultrasonic sensors.
- To design a robot that follows real-time operation and switches on and off at real-time basis

Scope and Limitations

The project focuses on how to collect the used plastic bottles and cans to maintain the cleanliness of the school and help the users get some coins for their used cans and bottles.The users of the Smart Bin - Waste Management System, are the Hagonoy campus students as well as the head of campus, professors, guards, and other staff of the university.

We learned that the study's primary limitation—the fact that it was carried out at the Bulacan State University Hagonoy Campus—precludes generalizing its results. It is possible to carry out a comparable study with a bigger sample size and generalize the

findings to a wider geographic area by utilizing a different sampling strategy. The study has geographical limitations.

The government of the Philippines has regulations regarding the disposal of plastic, and since disposal is more efficient, the applicability of the model to different geographies needs to be investigated. We observe that awareness as a construct has no significant relationship with willingness, which is unexpected and counterintuitive to what the literature claims. In order to understand how this parameter enhances recycling behavior, it has to be given more attention.

Definitions of Terms

Infrared Sensor - is an electronic device that detects and measures infrared radiation in its surroundings. In 1800, an astronomer named William Herchel made an unintentional discovery of infrared radiation.

Weight Sensor - is a particular kind of transducer, a weight transducer. It transforms a mechanical force that is applied as an input, such as load, weight, tension, compression, or pressure, into another physical variable, in this case, an electrical output signal that can be measured, converted, and standardized.

Ultrasonic Sensors - are instruments that produce or detect ultrasonic energy.

Monitor - an electronic gadget with a display screen (as of television pictures or computer information)

Arduino - is a firm that creates and produces single-board microcontrollers and microcontroller kits for creating digital devices, as well as an open-source hardware and software project.

Breadboard - is a construction site used to create electronic circuit prototypes that are semi-permanent.

Smart bins - Intelligent waste management solutions include smart bins. They have wireless ultrasonic fill-level sensors that can determine how full a bin is, and through the Internet of Things, this information is relayed to a platform for cloud-based monitoring and analytics.

Reverse Vending Machines - is an equipment where individuals may deposit their used bottles and cans of soda for recycling. The machine normally provides the end user with a deposit or return amount. This is what distinguishes it as a "reverse" vending machine: rather than inserting money and withdrawing a commodity (as at a candy dispenser), the user inserts a product and withdraws a monetary value.

CHAPTER 2

REVIEW OF RELATED SYSTEMS

This section will examine several current gadgets that may be compared to the suggestion. It will include a number of significant components that, in one way or another, assist in defining the ideal hardware and software architecture of the SMART Bin. As a comparison to the intended design and execution pertinent to the research, another portion will analyze existing self- or controlled navigation schemes, and a third section will explore mobile robots.

One organization, the Defense Advanced Research Projects Agency (DARPA), patented an analogous waste collecting method back in 2003. In a systematic manner, Barrett (2003) proposes a better memory management system that recycles unused memory. The idea is comparable to a lone robot that recognizes and collects rubbish it comes across. Robots that are capable of learning can be very useful, but to use Barrett's study in this way would require a big memory for the robot. As a result, this study won't focus on creating a learning tool.

Systems for multimode garbage collection are one illustration of this. It concerns garbage collection in networked computing systems and was patented in (2005) by O'Connor et al. It is broken down into numerous categories of waste collection, which may be carried out at various times and depending on necessity. A distinct code depending on the technique used for each form of collection is used to distinguish each mode. If it is employed in this study, it will require more complex codes, which might eat up a lot of memory and other resources needed to construct the device. It's possible that the location of the SMART Bin application does not lend itself to distributed computing platforms. Again, since the SMART Bin is not a learning tool, it may as well just accept trash that has already been disposed of rather than figuring out a collecting strategy.

However, pertinent sectors are covered by what is already accessible and patented. Jones and Mass patented a mobile robot control system in 2007. According to

this invention, directing a robot can be done in a variety of ways, such as by randomly bouncing or by following a nearby object that has been spotted. By demonstrating that the collecting path may be programmed or modeled after the controls provided by Jones and Mass, it is relevant to this study. Similar to that, this study places a high value on obstacle detection as a foundation for device mobility. The collection plan will be based on the locations of the workplaces where the SMART Bin will be collecting trash rather than using random movement.

The goal of this study is to enable the gadget to navigate independently, and several other devices have already done so in a number of different methods. A garbage conveyor is utilized in a patent submitted by Ramshur (2012) to move the bins from the garage to the curb, where the garbage truck picks them up. Being the only input for the sensor, the conveyor device follows a predetermined wire, making it a fixed and effective navigation method. Even though it can be done in this study by building a robot that follows lines, the school administration might not permit students to paint lines down hallways.

The design may adopt a similar strategy. For instance, a robot cleaner that follows walls has been created employing the idea of sensors and algorithms. An autonomous cleaning robot was created by Hong and his colleagues in (2008) using the methodical and straightforward notion of building a reference wall and calculating its own path to clean a region. Using a wall as a navigational aid will be employed, even if the software design is unlikely to make advantage of the latter capability.

The current study involves research upon the adoption of the RVM‟s in North Bengaluru. However, with further research on the government policies of other states, the adoption of RVMs for the whole country can be studied. This can also be used as a basis for significant changes in the government policies for waste management. Incentive models can be used as a reference for further implementation in various other niche products that contribute towards a social cause. The same study can be integrated with modified variables to study the willingness of the organizations to make

the adoption of the RVM‟s part of their Corporate Social Responsibility. Instead of using willingness of the users as the dependent variable, convenience or involvement can be used for different projections or even more suitable solutions for the society. The model can be integrated with the Theory of Planned Behavior model (Valle et.al. 2005) and it can also be explored with consumer behavior models on how to engineer a recycling behavior in citizens (Andreasen, 1995; Geller, 1989)

Foreign Studies

In this paper, we present the Smartbin system that identifies the fullness of litter bins. The system is designed to collect data and to deliver the data through a wireless mesh network. The system also employs duty cycle techniques to reduce power consumption and to maximize operational time. The Smartbin system was tested in an outdoor environment. Through the testbed, we collected data and applied sense-making methods to obtain litter bin utilization and litter bin daily seasonality information. With such information, litter bin providers and cleaning contractors are able to make better decisions to increase productivity. **ISSNIP (07-09 April 2015)**

This paper entitled "Smart Bin for Waste Management System" plays a vital role in the waste management system. A healthy domain is essential to a solid and cheerful environment. Clean and hygienic environments are a key need in human habitable environments. Smart bin is to develop a gainful and dynamic waste administration framework. In public places, dustbins are being flooded just as the waste spills out bringing about contamination. This likewise expands the number of infections as a huge number of bugs breed on it. In this a smart bin is developed to monitor the level of waste, automatic disposing of waste and rain detection system. The outcome demonstrated that the detecting framework is effective and savvy and can be utilized to robotize any solid waste bin management process. **ICACCS (15-16 March 2019)**

Nowadays, the trend is clear that the use of pervasive computing technology has taken place to improve waste management by providing electronic systems which utilize

radio frequency identification at bin level. In this paper, we proposed a smart recycle bin application based on information in the smart card to automatically calculate the weight of waste and convert the weight into points then store it into the card. The wastes are tracked by smart bins using a RFID-based system integrating the web-based information system at the host server. Two crucial features of the selective sorting process can be improved using this approach. First, the user is assisted in the application of material waste classification. Second, the smart bin knows its content and can report back to the rest of the recycling chain. **ICITCS (28-30 October 2014)**

Waste collection services, today, are exhausted and unable to bear the burden of rising cities. It is one of the biggest ongoing challenges, being faced by developing economies, where a large variety of goods ranging from cars to metal and hardware end up in inadequately managed and uncontrolled dumpsites, spreading diseases and increasing pollution. However, most of these plans have been able to manage waste once it has already been created. We, therefore, propose a system through a mobile application associated with a Smart Trash Bin. The main aim of this application is to reduce human resources and efforts along with the enhancements of a smart city vision. At regular intervals the dustbin will be squashed. Once these smart bins are implemented on a large scale, by replacing our traditional bins present today, waste can be managed efficiently as it avoids unnecessary lumping of wastes on the roadside. Breeding of insects and mosquitoes can create nuisance around promoting an unclean environment. This may even cause dreadful diseases. **ICISS (07-08 December 2017)**

Waste collection and management is an integrated part of both city and village life. Lack of an optimized and efficient waste collection system vastly affects public health and costs more. The prevailing traditional waste collection system is neither optimized nor efficient. The Internet of Things (IoT) has been playing a great role in making human life easier by making systems smart, adequate and self-sufficient. Thus, this paper proposes an IoT based efficient waste collection system with smart bins. It does real-time monitoring of the waste bins and determines which bins are to be emptied in every cycle of waste collection. The system also presents an enhanced

navigation system that shows the best route to collect wastes from the selected bins. Four waste bins are assumed in the city of Mount Pleasant, Michigan at random locations. The proposed system decreases the travel distance by 30.76% on an average in the assumed scenario, compared to the traditional waste collection system. Thus it reduces the fuel cost and human labor making the system optimized and efficient by enabling real-time monitoring and enhanced navigation**. (WF-IoT, 02-16 June 2020)**

Local Studies

The more urbanized and industrialized a country becomes, the more trash it produces. Waste management has been a crucial issue to be considered. In this paper, a smart bin using GSM (Global System for Mobile communications) modem and ultrasonic sensor interface with Arduino Uno board as platform is proposed and prototyped. Technology in arduino, ultrasonic sensor and GSM module are reviewed. The GSM module is an open, digital cellular technology used for transmitting mobile voice, data services and transmission of SMS (Short Message Service). Ultrasonic Ranging Module, HC - SR04, is placed on the cover of the dustbin which will determine the status of the garbage inside. The minimum level of garbage inside the dustbin is 10 cm. Once the garbage reaches the minimum level, HC - SR04 ultrasonic sensor triggers the GSM modem which will continuously alert the required authority until the garbage is removed from the dustbin. Design shows that GSM modem and ultrasonic sensor interfacing using Arduino Uno board as platform can make garbage collection operations smarter, more efficient and less wasteful. To be more energy-efficient, solar power will be incorporated into future designs. (***Narcisa T. Morallo*2017)**

Moreover, the choice of wheels and motors will be important. More importantly, it is very crucial that the choice fits the navigation constraints of the contraption. There are two options structure-wise, whether a single motor controls the both wheels on either side of the device or each wheel is controlled by a separate motor. Servo motors can be used and rotation of the device will depend on its computed direction. On the other hand,

some devices use a motor for each wheel. To rotate, one motor will rotate relatively faster than the other one (Ramshur, 2012). Motor controllers are also used in some robotic devices. These are commercially available components with serial controllers which receive its commands from a computer, thereby controlling motor speed for each individual motor ***(Lakshmanan, et al, 2008).***

Technical Background

Microsoft Windows 7 or above Operating System

Windows 7 is built on the Windows Vista kernel and was intended to be an update to the Vista OS. It uses the same Aero user interface (UI) that debuted in Windows Vista. As a result, to many end users, the biggest changes between Vista and Windows 7 were faster boot times, new UIs and the addition of Internet Explorer (IE) 8. The OS is widely available in three retail editions: Windows 7 Home Premium, Professional and Ultimate. Starter, Home Basic, and Enterprise editions are available in some markets.

Xampp server at least (Control Panel v3.2.2)

XAMPP is a free and open-source cross-platform web server solution stack package developed by Apache Friends, consisting mainly of the Apache HTTP Server, MariaDB database, and interpreters for scripts written in the PHP and Perl programming languages.

MySQL

MySQL is an open-source relational database management system. As with other relational databases, MySQL stores data in tables made up of rows and columns. Users can define, manipulate, control, and query data using Structured Query Language, more commonly known as SQL. MySQL's name is a combination of "My," the name of MySQL creator Michael Widenius's daughter, and "SQL".

A flexible and powerful program, MySQL is the most popular open source database system in the world. As part of the widely used LAMP technology stack (which consists of a Linux-based operating system, the Apache web server, a MySQL database, and PHP for processing), it's used to store and retrieve data in a wide variety of popular applications, websites, and services.

Arduino

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino hardware to upload programs and communicate with them.

Arduino IDE

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RAD Tools - B4X - B4J Arduino

B4X is a suite of rapid application development IDEs and proprietary programming language that allows the creation of applications on the following platforms: Google Android, Apple iOS, Java, Raspberry Pi and Arduino. Although the B4X syntax is very similar to BASIC, it is an entirely new language.

B4J is a 100% free development tool for desktop, server and IoT solutions.
With B4J you can easily create desktop applications (UI), console programs (non-UI) and server solutions. B4J apps can run on Windows, Mac, Linux, and ARM boards (such as Raspberry Pi). The compiled apps are standalone, without any external dependencies.

Synthesis

The technical background provided the researchers thorough knowledge of the technologies which will be used to develop the system.The information gathered in the technical background is very essential especially the BJ4 Arduino which is the RAD tool we are going to use in the development of the hardware and which is also connected to the software. These technologies that are stated in the technical background assured the feasibility of the study. The related literature and studies also shows that the system is not only possible and that it already exists to some degree. This was supported by the different examples cited in the related literature and studies. These past researches also shows us the limitations and problems encountered by the researchers which is very important to the researchers as they will avoid it in the future.

CHAPTER 3
DESIGN AND METHODOLOGIES

Development Model

When developing a smart bin management system, understanding the appropriate development procedure is crucial. One of the greatest methods for producing software is the agile methodology. This strategy is well known for its flexibility, which enables changes to be made in the project development requirements even after the initial planning has been completed and a challenging task has been divided into several development cycles. Each of the elements performs a specific task for the development team. A direct line of communication is also ensured by the agile process, helping clients and app developers to finish the required mobile application. Additionally, even before the project is launched, it enables modifications to be made to the project and the addition of new requirements without disrupting the remainder of the development process.

There are many types of agile techniques, with Scrum having a more complex set of development principles. They emphasize project management aspects. The functions of a system are collectively segregated and prioritized in a "product backlog" using the assistance of information technology teams, businesses, and the owner of a specific product under this strategy. The next step is called a sprint, and it typically lasts for one month. It involves several team members gradually deploying a piece of software. Priorities are reviewed after delivery, and where necessary, they are altered during each cycle iteration.

Requirement Analysis

A reverse vending machine is a device for collecting and recycling used containers such as bottles and cans. This machine is designed to make it easy and convenient for people to recycle used bins and promote resource reuse. Reverse Vending Machines are intended for use by individuals and businesses in a variety of settings, including Supermarkets, airports, and other public places. The machine is designed to be easy and intuitive to use with clear instructions and prompts for the user. Reverse machines accept a wide range of containers including bottles, cans, and other recyclable materials. The machine can scan and identify the type and value of each bin used and issue vouchers or cash refunds to users as rewards for recycling. The machine's user interface consists of a touchscreen display and a series of user-operable buttons. The display provides instructions and prompts to the user and indicates the coupon or cash refund value issued for each container. Reverse vending machines offer users either vouchers or cash refunds as a reward for recycling bins. The value of the voucher or cash refund depends on the type and value of the container being recycled. Users can choose to redeem a voucher or cash refund at a machine, or deposit money into a bank account or other payment app. Sorting and processing: Reverse vending machines are equipped with sensors and other technology to sort and prepare collected materials for recycling. This machine can separate different types of materials and prepare them for transport to the recycling plant.

Functional Requirements

The functional requirements describe the system and its components that will specify its behavior or functions. It characterizes the services that the system will provide to the users.

Functional requirements no.	Functional requirements Description
1	The IR Sensor should be able to send a signal to the Arduino after inserting a water bottle.
2	The User should be able to receive a token per bottle.
3	The hardware should be able to connect to the software which counts the number of bottles.
4	Report on Daily number of Bottles Collected.

Input

- The users must insert the plastic bottles within a specific aperture inside the machine.

Output

- The system must produce a daily report on collected bottles
- The system must eject a token from the container.

Process

- The system must detect signals when inserting the bottles on the machine.
- The system must process and send reports directly on the software.
- The system must provide incentive in exchange for the inserted bottles.
- The accumulated bottles must be delivered to recycling companies.

Performance

- The system must be operational on campus hours only, 5 times a week.
- The system must support many users simultaneously.

- Response time must not exceed five seconds.
- The system will function efficiently and accurately.

Control

- The report system can be accessed by the admin only.
- The opening ensures that the device can take only one container at a time.
- The system should be able to make sure that only bottles and cans are inserted on the machine by sensing the type of bottle that is inserted.
- The system should be able to identify the size of the bottle as well as if the bottle has something inside or filled with water.

Non-functional requirements

Non-functional requirements explain how the system operates and define how a system should behave and recognize its design limitations. It depends on the users' needs.

	Non-Functional Requirements
Performance	Maximum of 5 seconds of waiting time per token
Security	Inverted metallic plates in the center of the hole, which can expand while inserting a bottle and retracts after inserting
Capacity	Can contain up to 150 bottles per bin
Reliability	Low percent chance of token system failure
Usability	It will be properly labeled with instructions especially for not people who does have any form of experience with such technology
Maintainability	All of the parts both hardware and software can be replaced

Performance

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Usability

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Maintainability

-All of the parts both hardware and software, can be replaced.

Requirement Documentation

Reverse Vending Machines are designed for easy service and maintenance, providing clear instructions for performing routine maintenance tasks and access to key maintenance components. Machines have maintenance schedules to ensure they are properly always maintained and in operation. Reverse Vending Machines meet all relevant legal and regulatory requirements to operate at each location, including any permits or licenses that may be required. This machine is designed to meet all applicable recycling regulations and standards.

Data Flow Diagrams

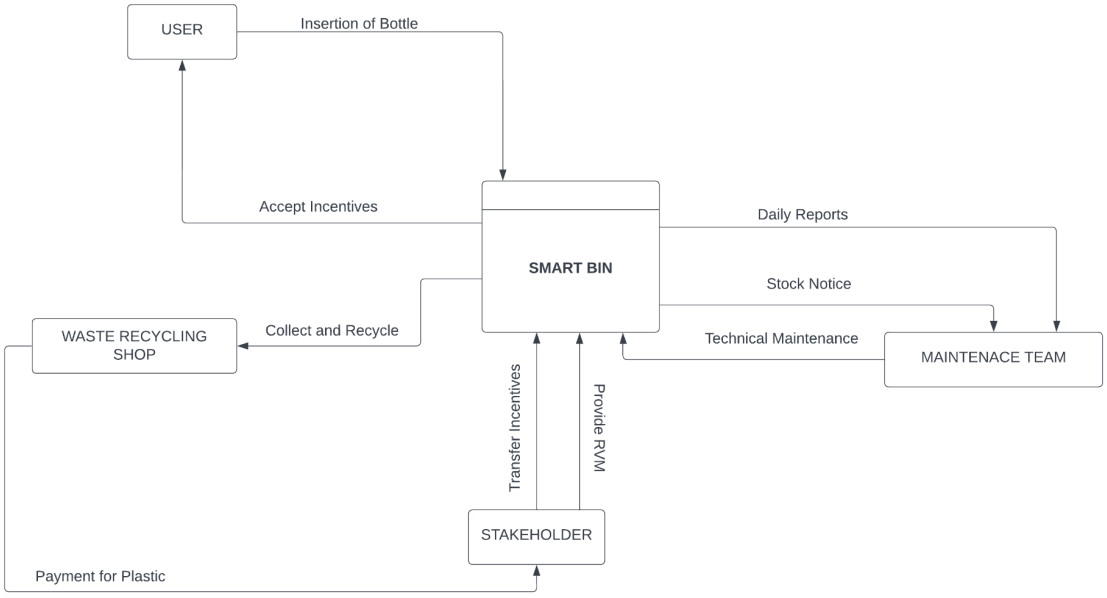


Figure 1: Context Flow Diagram of the Reverse Vending Machine

The components of the Reverse Vending Machine (RVM) system are the user, the customer, the waste recycling, the partners, the IT team, and the maintenance team. Users accept system-provided incentives after inserting bottles into the machine, which constitutes the data flow from the user to the RVM. By giving the RVM in exchange for payments for machine rentals, the customer establishes a data flow that connects them

to the system. The customer is also involved in the waste recycling process, where it receives payment for the delivered plastics by gathering and recycling the bottles provided by the RVM system. The information is also sent from the system to partners, who offer locations for the RVM placements as well as discounts.

Additionally, the transfer of incentives to the machine and stock notices for the maintenance team's restocking are included in the data flow from the system to the IT team and maintenance team, in addition to the resolving of the machine's technical issues.

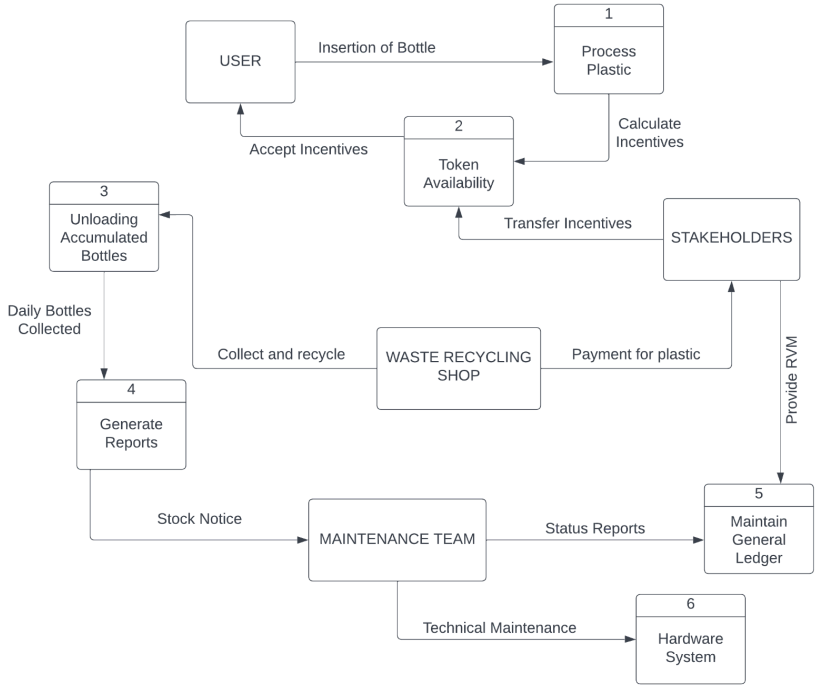


Figure 2: Level 1 Diagram of the Reverse Vending Machine

The level 1 diagram of the Reverse Vending Machine defines the subsystems by the numbered upright rectangles. The first subsystem is about token availability which is directly connected to the customer which refills the token storage and the user which receives the token per insertion, second is maintain general ledger which consists of direct reports from the customer and the partners, third is unloading accumulated bottles

which is handled by the waste recycling that also transmit status reports and income to the customer, fourth is software system which contains system statuses that are reported to the customer and partners, and fifth is hardware system containing hardware status report directly to the customer and partners.

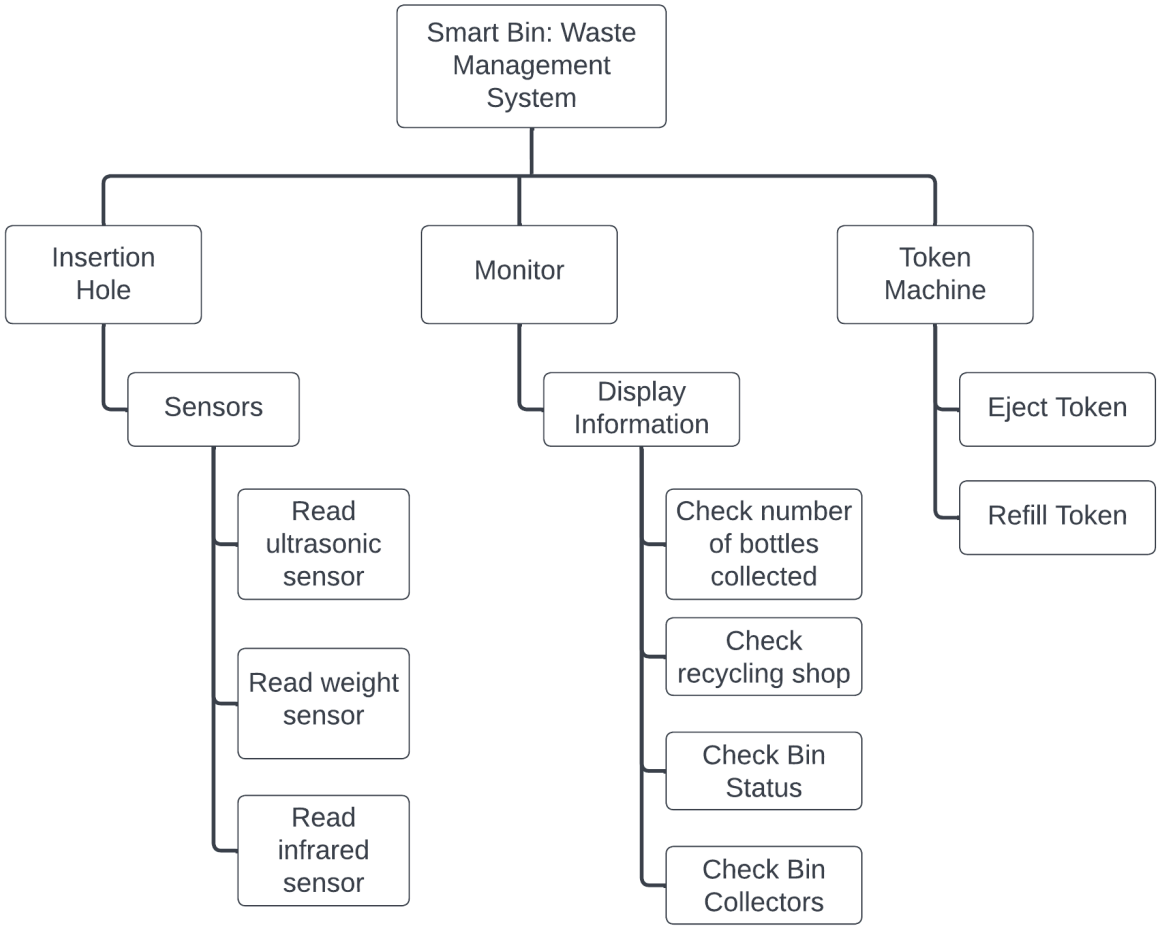


Figure 3: Hierarchical Diagram

The Hierarchical Diagram shows the relationship between several layers of entity in a leveled manner. The Smart Bin contains three main entities, the Insertion Hole, Monitor and the Token Machine. Under the Insertion Hole are the sensors that will be read when inserting a bottle which consist of the ultrasonic, weight, and infrared sensors. The Monitor will display information about the bottles collected, recycling shop,

bin status, and bin collectors. Lastly, the Token Machine can eject and refill the tokens inside the machine.

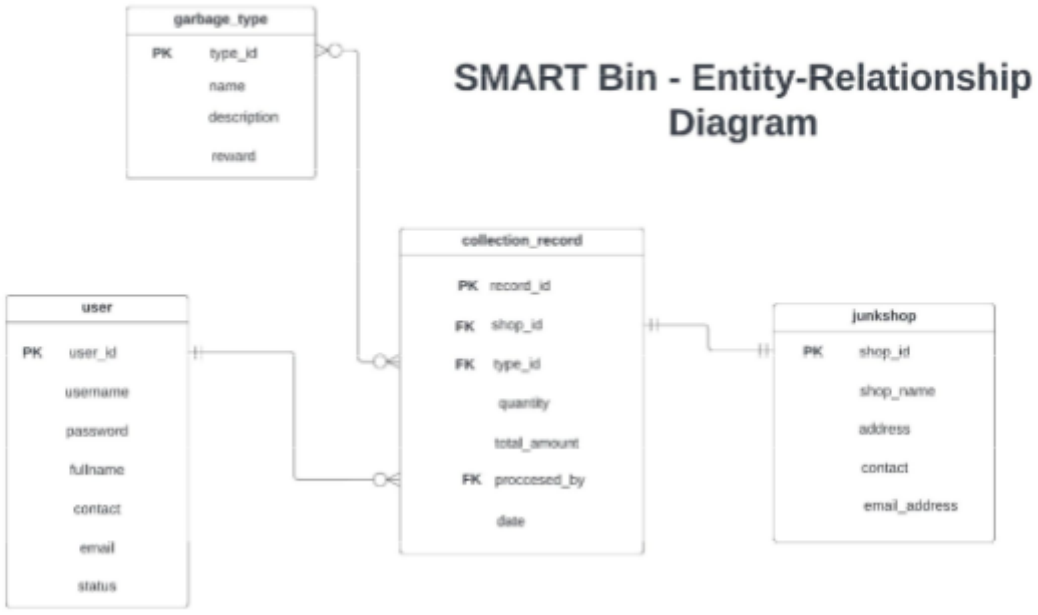


Figure 4: Entity Relationship Diagram of Smart Bin – Waste Management System

The ERD depicts the relationships between the various entities in our system. The primary key in the user table is the user_id, which is linked to the foreign key processed by the collection record via a one-to-many relationship. The primary key in the garbage_type table is the type_id, which is linked to the foreign key type_id in collection_record via a many-to-many relationship. The primary key in the junk shop table is the shop_id, which is linked to the foreign key shop_id in collection_record via a one-to-one relationship.

Software Development

The researchers mainly focus on the hardware of the study but it still has software involved in the system. The software will be mainly used for the contents in the monitor which includes the number of bottles collected which is also separated categorically, the statues of the bins, if it is full or not, and lastly it will show who emptied the bins. For the software, the researchers use these technologies listed and defined below.

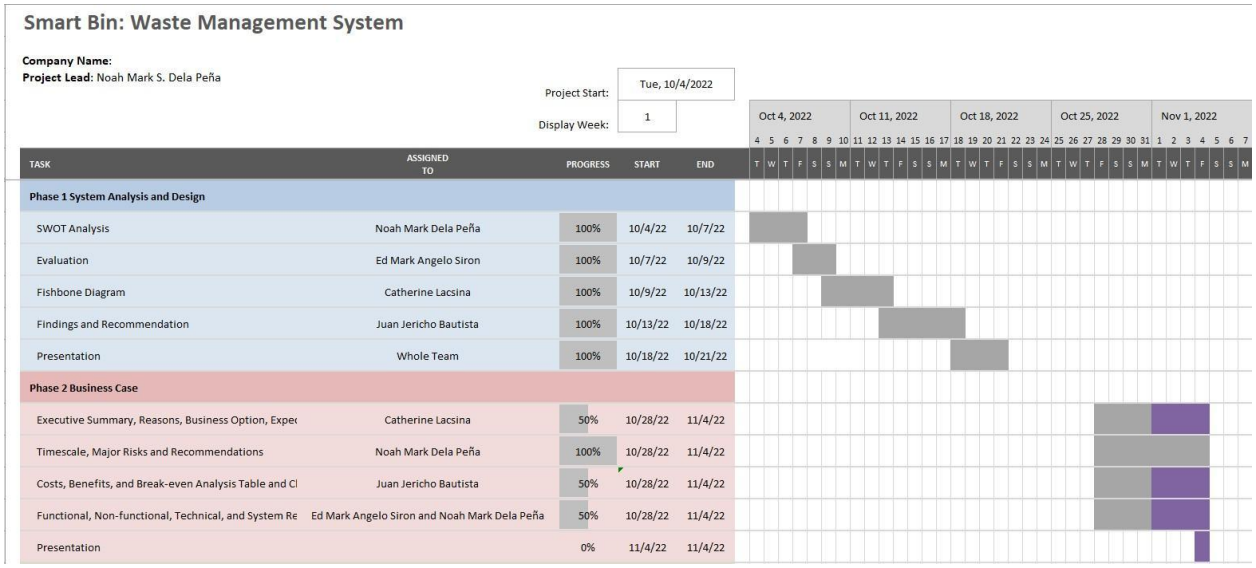
Arduino IDE - as the text editor for the arduino board which will be connected to the User interface and the database.

RAD Tools - B4X - B4J Arduino - as the language used to program the arduino functions.

Xampp server at least (Control Panel v3.2.2) - as the server for our functions and database.

MySQL - for the main functions which are going to be used to insert and manipulate data in the database.

Timescale:

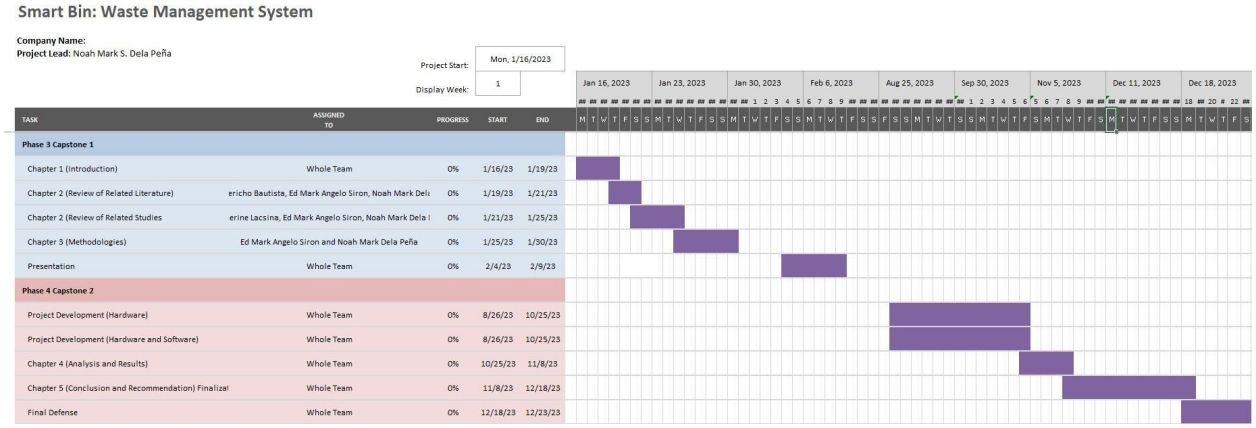


Smart Bin: Waste Management System

Company Name:
Project Lead: Noah Mark S. Dela Peña

Project Start: Tue, 10/4/2022
Display Week: 1

TASK	ASSIGNED TO	PROGRESS	START	END
Phase 1 System Analysis and Design				
SWOT Analysis	Noah Mark Dela Peña	100%	10/4/22	10/7/22
Evaluation	Ed Mark Angelo Siron	100%	10/7/22	10/9/22
Fishbone Diagram	Catherine Lacsina	100%	10/9/22	10/13/22
Findings and Recommendation	Juan Jericho Bautista	100%	10/13/22	10/18/22
Presentation	Whole Team	100%	10/18/22	10/21/22
Phase 2 Business Case				
Executive Summary, Reasons, Business Option, Expec	Catherine Lacsina	50%	10/28/22	11/4/22
Timescale, Major Risks and Recommendations	Noah Mark Dela Peña	100%	10/28/22	11/4/22
Costs, Benefits, and Break-even Analysis Table and Cl	Juan Jericho Bautista	50%	10/28/22	11/4/22
Functional, Non-functional, Technical, and System Re	Ed Mark Angelo Siron and Noah Mark Dela Peña	50%	10/28/22	11/4/22
Presentation		0%	11/4/22	11/4/22



Smart Bin: Waste Management System

Company Name:
Project Lead: Noah Mark S. Dela Peña

Project Start: Mon, 1/16/2023
Display Week: 1

TASK	ASSIGNED TO	PROGRESS	START	END
Phase 3 Capstone 1				
Chapter 1 (Introduction)	Whole Team	0%	1/16/23	1/19/23
Chapter 2 (Review of Related Literature)	ericho Bautista, Ed Mark Angelo Siron, Noah Mark Del	0%	1/19/23	1/21/23
Chapter 2 (Review of Related Studies	erine Lacsina, Ed Mark Angelo Siron, Noah Mark Dela I	0%	1/21/23	1/25/23
Chapter 3 (Methodologies)	Ed Mark Angelo Siron and Noah Mark Dela Peña	0%	1/25/23	1/30/23
Presentation	Whole Team	0%	2/4/23	2/9/23
Phase 4 Capstone 2				
Project Development (Hardware)	Whole Team	0%	8/26/23	10/25/23
Project Development (Hardware and Software)	Whole Team	0%	8/26/23	10/25/23
Chapter 4 (Analysis and Results)	Whole Team	0%	10/25/23	11/8/23
Chapter 5 (Conclusion and Recommendation) Finalizat	Whole Team	0%	11/8/23	12/18/23
Final Defense	Whole Team	0%	12/18/23	12/23/23

Cost and Benefit Analysis

Costs:

BREAKDOWN OF ONE TIME COST WORKSHEET

Assuming that the project development duration is 3 MONTHS

A. Development Cost

Description	Salary/Month	Mo.	Sub Total
1 System Analyst	₱ 15,000.00	3	₱ 45,000.00
1 Programmer	₱ 18,000.00	3	₱ 54,000.00
1 Hardware Engineer	₱ 26,000.00	3	₱ 78,000.00
1 Researcher	₱ 10,000.00	3	₱ 30,000.00
TOTAL			**₱ 207,000.00**

B. User Training

Description	Honoraria	Day/s	Sub_Total
2 days User Training	₱ 1,000.00	2	₱ 2,000.00
Training Kit	₱ 2,500.00		₱ 2,500.00
TOTAL			**₱ 4,500.00**

C. Additional Hardware/Software

Description	Price/s	QTY	Sub Total
Monitor	₱ 2,000.00	1	₱ 2,000.00
Arduino Board	₱ 5,000.00	1	₱ 5,000.00
Sensors	₱ 10,000.00	1	₱ 10,000.00
TOTAL			**₱ 17,000.00**

Total One Time Cost = Total Development Cost + Total User Training + Total Additional Hardware/Software

BREAKDOWN OF ONE TIME COST WORKSHEET

A. Development Cost	₱	207,000.00
B. User Training	₱	4,500.00
C. Additional Hardware/Softeare	₱	17,000.00
TOTAL ONE TIME COST	**₱**	**228,500.00**

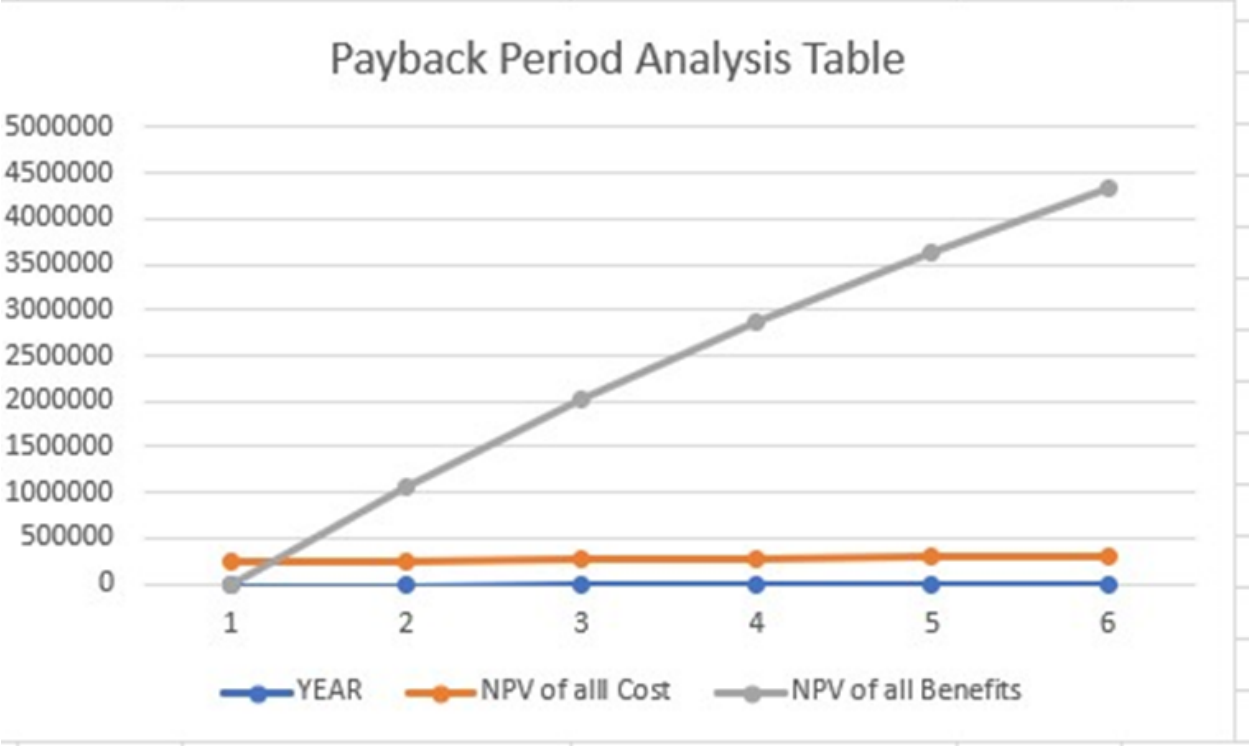
Total One Time Cost = Total Development Cost + Total User Training + Total Additional Hardware/Software

RECURRING COST

Description	Unit Cost	Anually
Software Maintenance	500/month	₱ 6,000.00
Incremental Communication	1000/month	₱ 12,000.00
Hosting	2500/year	₱ 2,500.00
TOTAL		**₱ 20,500.00**

Use this data as legend in the chart showing the Payback

YEAR	NPV of alll Cost	NPV of all Benefits
0	228,500.00	0.00
1	246,803.57	1,070,892.86
2	263,146.05	2,027,047.19
3	277,737.54	2,880,756.42
4	290,765.66	3,642,996.81
5	302,397.91	4,323,568.58



The Payback Period Analysis Chart based on the Break-Even Analysis Table result of Waste Management System. These two tables show that the actual break-even point occurs on Year 3, 5 months, and 16 days. Thus if the project will be implemented on December 1, 2022, it will give an estimated payback period on May 17, 2025.

Time Restriction

- The project or the proposed system requires hardware tools or components, which will be made manually, which might slow down the development drastically.

- Our response to this risk is to have a proper schedule for all of the tasks that we need to complete. Also, we will divide and conquer all of the tasks listed in our respective roles.

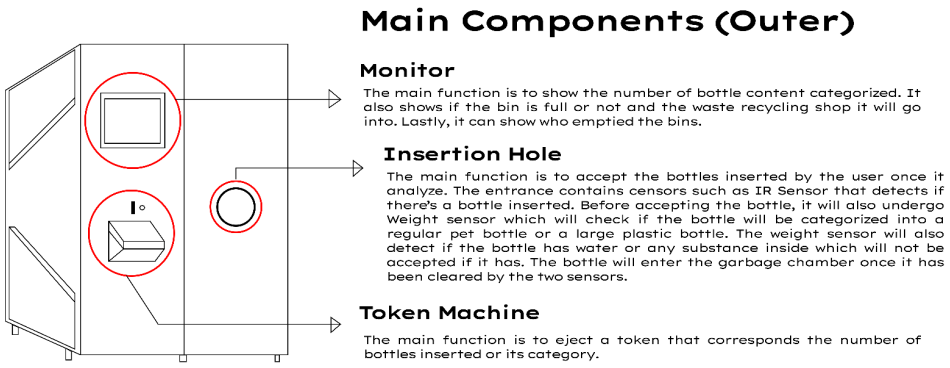
Workforce (or manpower)

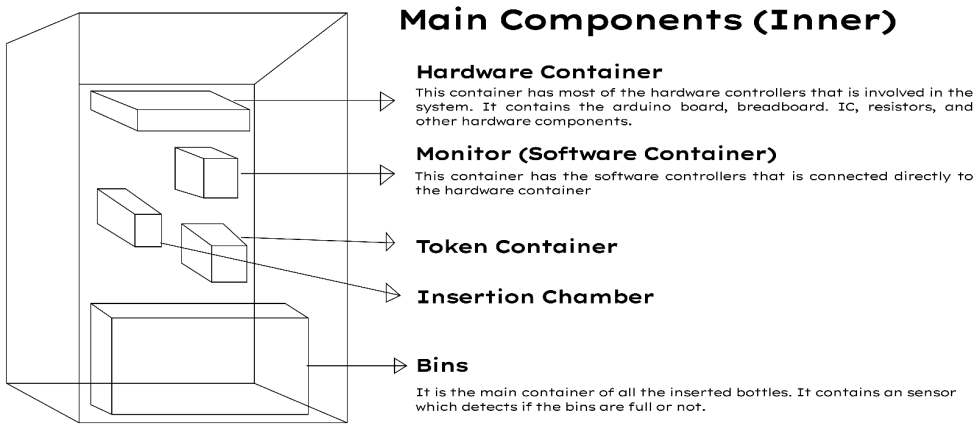
- Our group has four members, which is not enough to cover all of the desired roles. Which is why every member has two to three roles to cover every role that we need. This is a bit problematic because we need to transcend our current skills to provide what is needed.
- Our response to this problem is to again have a proper schedule of all of the tasks so that we will not be pressured to perform multiple tasks at once. Also, Our assigned roles require personal responsibility, but after that, we will assist one another to have a continuous flow of work.

Cost

- As students, we may not have enough money to pay for all of the physical tools. Required to complete the project or system we planned.
- Absence of financial requirements for the task we will perform. Our team requires some financial support, such as a solicitation that would pay for a portion of the money required for the project we have in mind.

Description of Prototype





The figure shows the prototype of the Smart Bin - Waste Management System. The outer components or the main structure of the Smart Bin consists of the Monitor, Insertion Hole, and the Token Machine. The monitor is used to display the number of bottles collected which is also separated categorically, the statues of the bins, if it is full or not, and lastly it will show who emptied the bins. The Insertion Hole accepts the bottle from the users but it will undergo the sensors which are explained in the figure. Lastly, the token machine which will eject the token that corresponds to the number of inserted bottles and its category.

As for the inner components of the Smart Bin, it consists of the Hardware and software containers, Token container, insertion chamber, and the bins. The hardware and software containers contain the software and hardware components such as

arduino and breadboard, monitors, and other materials. The token container contains all of the tokens which are going to be ejected from the system. The insertion chamber leads the plastic bottles to the bins and the bins collect all of the inserted bottles.

Implementation Plan

The purpose is to turn waste into a valuable token. A reverse vending machine for old plastic bottles with the intention of turning each plastic bottle placed into the device into a token. The reverse vending machine that we will create will also recycle plastic bottles and help to reduce pollution. Because each plastic bottle you or I place into the machine has an equivalent value, earning a reward token for each plastic bottle you collect. By doing that, we can reduce the amount of plastic waste in the neighborhood or location where it was found. The equipment will be placed in public places like schools, barangay halls, and shopping malls so that authorities can watch what is going on. They can also check what goods are entering the machine if they are not plastic bottles.