**Garbage Management System with SMS Notification**

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**1. Introduction**

**1.1. Project Context**

Solid waste management is a critical aspect of maintaining a clean, healthy, and sustainable environment. In Universities, where a large number of individuals reside and interact, effective waste management practices are essential to prevent pollution, promote resource conservation, and foster a sustainable environment.

Marinduque State College (MSC) is committed to upholding environmental sustainability and has recognized the need to enhance its waste management practices. The current system, while functional, faces challenges such as inefficient waste collection schedules, limited communication channels, and inadequate waste segregation practices. These shortcomings can lead to overflowing bins, unpleasant odors, and mixed waste streams, hindering the overall waste management process and compromising the campus's environmental sustainability. To address these challenges and change waste management practices within the college campus, we are embarking on an innovative effort to implement a Garbage Management System with SMS Notification. This modern system, designed to transform MSC into an ideal example of responsible management, will integrate user-friendly interfaces, a centralized database, and SMS functionality to enhance efficiency, communication, and sustainability. The Garbage Management System with SMS Notification will address the inefficiencies of the current waste collection system by applying modern technology and real-time monitoring mechanisms. Sensors or monitoring devices installed on waste bins will provide accurate data on bin fill levels, triggering SMS alerts to janitorial staff when bins are almost full. This proactive approach will ensure timely collection and prevent overflows, minimizing potential health and environmental hazards. To bridge the communication gap between waste generators and waste collectors, the system will facilitate real-time communication through SMS notifications. Students and staff will be able to report overflowing bins, request additional collection services, and receive updates on collection schedules directly through their mobile phones. This enhanced communication will streamline waste management processes and ensure that waste is collected promptly and efficiently.

The researchers chose this project because they believe that a modern Garbage Management System with SMS Notification can significantly enhance waste management practices at MSC, transforming the college into a model of responsible waste disposal and promoting a sustainable campus environment. By addressing the current system's inefficiencies and implementing real-time monitoring and communication mechanisms, we aim to create a cleaner, healthier, and more aesthetically pleasing learning environment for all.

**1.2. OBJECTIVES OF THE STUDY**

**General objectives:**

The main objective of this research is to design, develop, and implement a Garbage Management System at Marinduque State College, integrating SMS support for efficient waste collection and management. The focus will be on creating a technological solution that enhances the overall waste management process within the college campus. The system aims to streamline waste collection, improve communication among stakeholders, and promote a sustainable and eco-friendly environment.

**Specific objectives:**

1. Designing a user-friendly interface for the Garbage Management System.
2. Implementing automated garbage segregation.
3. Implementing SMS functionality to facilitate real-time communication between the system and responsible authorities.
4. Enabling SMS notifications for waste collection schedules, updates, and alerts.
5. Implementing features to encourage and monitor proper waste segregation practices.
6. Incorporating sensors or monitoring mechanisms to assess the fill level of waste bins.

**1.3. SIGNIFICANCE OF THE STUDY**

The system would be able to help one of the most important environmental challenges on college campuses: the effective management of waste. Waste management includes all the tasks required to keep an eye on the garbage produced by students at the college, from the time they produce it until it is collected, transported, and finally placed in an appropriate location, could be a landfill, an incinerator, or a recycling facility. It has presented a serious obstacle for establishments throughout the province. Therefore, garbage produced by various activities may pose health risks and damage the environment in the absence of an adequate and efficient solid waste management. There are times when students inside the campus have no proper way to dispose their waster because of full trash bins not being taken out immediately by the personnel. With the proposed system, the waste disposal can be managed more properly and efficiently by constantly monitoring the bin status and the garbage level. This system will automatically monitor the garbage level at each bin and will alert the personnel in the case where the bins are almost full.

The implementation of Garbage Management System with SMS Notification within College of Information and Computing Science inside Marinduque State College Boac Campus holds immense significance, it is expected to contribute to improving the efficiency of the solid waste disposal management. The proposed system will greatly help the college janitors, it supposes to generate and send the warning messages to the janitors via SMS when the waste bin is full or almost full, so the garbage can be collected immediately. For students and faculty by solving the problem of urgent need to throw their waste for when the bin is full, promotes better hygiene and cleanliness, the proposed system provides a healthier environment. The system helps enhance resource efficiency by optimizing garbage collection schedules based on real-time fill levels, saving the college money on operations and time. Additionally, it provides an educational purpose by showing and teaching students to use technology in a real world setting and encouraging sustainability and responsible methods of waste disposal. As part of the College of Information and Computing Sciences, this system also has a chance to showcase the institution's commitment to technological integration for operational enhancements, highlighting its forward-thinking approach. Furthermore, this project's potential success within the college setting would demonstrate its scalability and adaptability, potentially serving as a model for broader community applications, extending its positive impact far beyond the campus borders.

**1.4. Scope and Limitations of the Project**

The main objective this project is to improve the college's waste management procedures, which will increase productivity and help create a cleaner, more sustainable environment. In the end, the system will benefit the entire college community, including students and teachers, with the main users being administrative staff, janitorial staff, and college authorities in charge of waste management.

The project started with the requirement analysis phase, which involved analyzing the current processes and procedures, determining the first requirements, and designing a prototype. The work breakdown structure (Appendix A), was developed to facilitate the division and distribution of tasks.

The project also covered the system design and development. After the project development, the system was tested in two ways, which are alpha and beta testing to identify and fix the errors and bugs.

The target user of the developed project are the janitorial staff of the College of Information and Computing Sciences.

**1.5. Definition of Terms**

BLYNK App – is an application used for live monitoring of the device to monitor the garbage level of the garbage bin.

ESP 8266 – a microcontroller that the developers will use as a development board.

GSM Module – is a device that provides a wireless data link and communication between a network and the device with the help of sim card.

Internet of things – is utilized between the connection of IOT based devices to the connected device that exchange data over the internet.

Microcontroller – is a device that can control an electronic system like Arduino that will be used when developing the project

Sensor – is a device that detect or measure a physical attribute of the user and then records indicates or react accordingly.

**2. REVIEW OF RELATED LITERATURE**

**2.1 Garbage Management**

**Internet of Things**

The Internet of Things (IOT) was first proposed in 1999 by a member of the Radio Frequency Identification (RFID) development community. In recent years, the proliferation of mobile devices, embedded and ubiquitous communication, cloud computing, and data analytics have all contributed to the IOT's increased relevance in real-world scenarios. The term "Internet of things" describes a kind of network that uses information-sensing devices to connect anything to the Internet according to predetermined protocols. This allows for information exchange and communication to be conducted in order to accomplish smart recognition, positioning, tracing, monitoring, and administration [3].

Internet of things technologies are consisting of smart objects integrated with different sensors. The sensors make it possible for the physical and virtual environments that make it possible to gather and process information in real time. Different types of sensors are available for a variety of uses. The sensors can measure things like temperature, humidity, air quality, pressure, flow, movement, and electricity, among other things.

The majority of sensors need to be connected to the sensor gateways. This can take the form of a Personal Area Network (PAN) like Bluetooth, ZigBee, and Ultra-Wideband (UWB) or a Local Area Network (LAN) like Ethernet and Wi-Fi connections. Wide Area Network (WAN) technologies like GSM, GPRS, and LTE can be used to connect sensors to backend servers and applications in cases where they are not connected to sensor aggregators. Wireless sensor networks (WSNs) are networks made up of sensors that typically use low power and low data rate connectivity. WSNs are becoming more and more common because they can support a much higher number of sensor nodes while still having a sufficient battery life and a wide coverage area. [3]

**2.2 Sensor and Smart Object Based Waste Management**

A Wireless Sensor Network (WSN) is a network with enormous number of wireless sensors that are installed to track the system's environmental or physical characteristics. WSN uses sensor nodes with onboard CPUs to keep an eye on the surroundings in a particular region. The coordinator node is a central node that receives connections from all of the sensor nodes. The coordinator nodes in turn are connected to the base station, which functions as the WSN processing unit. For the purpose of sharing data, the base station is online. Applications for WSN have already been demonstrated in a number of areas, including waste management, industry, home automation, environmental monitoring, agriculture, and fitness and health monitoring. [4]

Bar codes, magnetic cards, and smart cards are just a few examples of earlier identification systems that are naturally extended by RFID technology, an automated system that is based mainly on radiofrequency microwave transmission [4]. The use of RFID systems is growing steadily even though their theory of operation dates back to the early days of radio frequency communications [4]. Through RFID technology, the data can be read from tags and sent over a radio frequency range without requiring a physical connection to an information processing system. The three components of an RFID system are an antenna, a tag, and a reader.

Using RFID technology, several trash can level monitoring systems have been created.

A project developed by [4], the truck's camera captures images of the trash bins, which are then sent to the central monitoring station for verification of the waste collection process. To optimize waste collection, no routing methods are used by the system. The developed system made use of an additional infrared sensor to determine the level of filling in the trash can. Because sensors are equipped to assess the emptiness of trash bins, this system does not use any cameras. The unoccupied level and pressure of trash bins were measured using a series of sensors. A camera is also included in the system for the creation of GIS to assist the truck driver in performing optimized waste collection from trash bins. A load-cell sensor was used to measure the weight of trash bins in an RFID-based outdoor trash bin monitoring system. Threshold levels are determined by the weight of the filled and empty trash bins [4].

**2.3 IOT AND WASTE MANAGEMENT**

In recent years, the Internet of Things has become one of the most important technologies of the twenty-first century. The development of low-power sensors, long-range connectivity, cloud computing, and machine learning are just a few examples of the technological advancements that have accelerated the deployment of IoT systems. An Internet of Things (IoT) environment is made up of a network of web-centric smart devices that gather, transmit, and process data from their environment using embedded electronic components like sensors, CPUs, and communication hardware. Sensor data can be shared and sent to the cloud for analysis by connecting IoT devices to any edge device, like an IoT gateway. These devices can communicate with one another and act upon received data at times. [4]

Numerous IoT-enabled waste management systems have been developed and put forth in the literature to aid in solid waste management. The quality of services is enhanced by waste management authority. Researchers in created a reliable management system that makes use of WSN combines two distinct wireless technology. Waspmote as a sensor node, from Libeum has been used. All of the data that the sensor node reads is sent to the receiver segment via GPRS and Zigbee communications, with Meshlium acting as an intermediate gateway [1] [10]. The receiver segment used a created web application to display all of the data that was gathered and stored it in a database. Thus, the proposed automated system can be used to monitor the solid waste bin's current status in real time.

In the study of [1], a Smart Waste Management System [SWMS] developed by [5] manipulates geospatial technology and intelligence sensor such as ultrasonic sensor via IoT technology for reliable Smart City and M2M solution.

Using a SWMS application, the local government can keep an eye on the waste collection operator and make sure the service provider is providing the services as agreed upon. Geographic information system [GIS] application is also carried out as a tool for waste management planning that supports decisions. [1].

**2.4 SMS NOTIFICATION SYSTEM**

Short Message Service (SMS) technology is one of the most stable and widely used means of mobile communication after the telephone. Most college students have cell phones that can receive text messages notifying them of events.

In principle, text messages can be used as one-way communication, providing information such as reminders or alerts to users, or as two-way communication, allowing users to send and receive information.

Additionally, mobile text messages are a great way to communicate when information needs to be sent over long distances, when there isn't a reliable infrastructure or communication system, or when people are unable to meet the concerned staff in person. This is especially true when the cost of the text message is relatively low and almost everyone can use it.

**2.5 USE OF SMS NOTIFICATION IN GARBAGE COLLECTION**

Most of the time, we observe that the trash can is overfilled, which instantly results in an unclean environment in the immediate vicinity. Contamination could result in health issues and the spread of disease.

In a project developed, the device consists of smart bins or containers, each mounted with a global system for mobile communication (GSM) module, a 16-bit microcontroller (PIC 18F472), and a laser sensor. When the waste container is filled, the device notifies the control center that the waste level is full and sends a text message (SMS) to the driver's cell phone informing them of which waste bin needs to be emptied. Thus, the garbage is taken out fast. Additionally, the system can be used in any city to manage waste and create an intelligent, pollution-free environment [2]. The SMS function introduces the conception and implementation of an intelligent waste management device that will quantify the waste level in the waste bin in real-time and send an SMS warning to the appropriate authority.

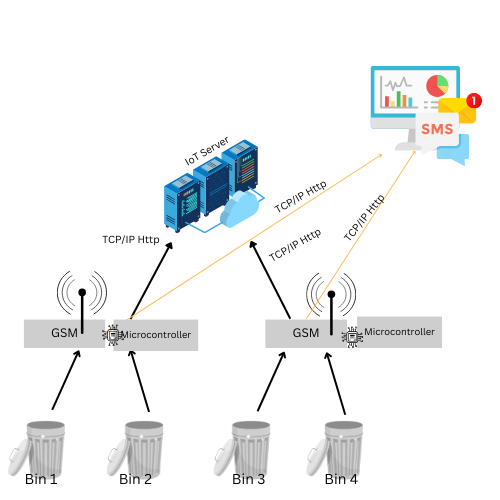
**2.6 Synthesis**

The constantly evolving and expanding nature of the Internet of Things (IoT) offers an opportunity for creative advancements in waste management systems. The Internet of Things (IoT) is characterized by a system of intelligent devices that are equipped with different sensors. This allows for the automatic gathering of data and communication between devices through networks. The incorporation of sensors and microcontrollers is a crucial approach in the field of waste management. The system consists of multiple sensors that are connected to a central coordinator and a base station. This setup enables the real-time monitoring of environmental and physical attributes.

These sensors play a crucial role in the proposed IoT-based garbage management system, as they can automatically segregate and measure essential parameters such as garbage level. The data collected by these sensors contribute to a comprehensive approach to waste monitoring, providing valuable insights for efficient waste management.

In addition to these technological improvements, the literature suggests the integration of Short Message Service (SMS) technology for reliable communication. SMS notifications, serving as a one-way communication channel, have a crucial function in waste management. The basic components of the system architecture in the proposed IoT-based garbage management system with SMS notification are ultrasonic sensors, Arduino Uno microcontrollers, and GSM modules. The mentioned components establish an effective foundation for detecting trash levels in real-time and promptly sending SMS notifications to janitorial staff. The synthesis of these literature findings is essential in the proposed waste management system based on IoT, which includes SMS notification. The project seeks to develop a comprehensive solution by incorporating IoT sensors and IoT-based garbage management technologies that include SMS notifications. The system architecture consists of ultrasonic sensors, ESP8266 microcontrollers, and GSM modules. These components work together to create a strong framework for detecting trash levels in real-time and sending timely SMS messages to janitorial staff. The integration of these technologies suggests a garbage management system that is intelligent, effective, and adaptable, in line with the most recent developments in IoT and sensor technologies.

**System Architecture**

**Figure 1** shows the schematic diagram of the garbage management system with SMS notification. It consists of several ultrasonic sensors, the Arduino Uno microcontroller, and the GSM module. The ultrasonic sensors are used to detect the level of each garbage bin, and they will send this information to the Arduino Uno, which acts as a system controller. In the case where the bins are already full or almost full, then it will generate a warning message or notification, which will be sent to the janitorial staff via SMS using the GSM module. And the IoT server allows janitorial staff to connect hardware components to the cloud, allowing the user to analyze real-time monitoring from the device and remotely monitor from anywhere.

**Figure 1**. Garbage Management System with SMS Notification Schematic Diagram.

**3. METHODOLOGY**

**3.1 Requirement Analysis Procedure**

The organization's essential information and processes were gathered through a series of survey questionnaires and observations. The intended institution of interest is Marinduque State College's College of Information and Computing Sciences. The organization was provided with a Letter of Survey Interview (see Appendix A).

The respondents from the chosen organization were picked according to our specific objectives by the proponents. We employed a range of predetermined interview questions (Appendix B) to interview the appropriate user for our projects, specifically the janitorial staff employed in the College of Information and Computing Sciences. An inventory of inquiries that we employ to elicit a response from our interviewee. Furthermore, a daily workflow observation was undertaken at the colleges of information and computing sciences. The acquired data from the survey interview was evaluated to provide a deeper understanding of the organization's requirements. To enhance our understanding of the conducted research, we also analyzed unpublished theses and research related to the project.

To determine the project's scope according to the sequence of required tasks, a Work Breakdown Structure (Appendix C) was developed. The written statement of work is executed in accordance with this document guide. The schedule of the project activities that the development team is required to complete was determined using the Gantt Chart (Appendix C). The process of the organization's current system was illustrated using a Flowchart Diagram (Appendix E). To illustrate how the system and the external entities interacted, this was depicted. It is an exceptional tool for delving thoroughly into the existing process. To illustrate the developed system's operations and the user's interaction with it, the Use Case (Appendix F) was drafted.

**3.2 Feasibility Analysis Procedure**

A feasibility analysis was performed to determine whether the project is worthy of proceeding further. A preliminary investigation was conducted at the College of Information and Computing Sciences to analyze the existing system. A formal letter (Appendix A) was sent to the Dean of the College of Information and Computing Sciences for approval in conducting the investigation that involves the students of the organization.

Operational feasibility was used to determine and ensure that the organization meets the development requirements. A series of interviews with the organization’s janitorial staff was conducted to gain knowledge about the organization’s garbage management process. The open-ended questions (Appendix B) were asked of the janitorial staff. The survey cycles within the College of Information and Computing Sciences are the system's intended users. The collected data was analyzed to see if the operation of the organization is feasible.

Through SWOT analysis (Appendix F), the developers identified the organization’s strengths and weaknesses in adapting to the changes that the system may bring, and the opportunities and threats that the organization may encounter when the system is implemented in the organization were also indicated. The organization’s available technical resources were inspected and compared with the minimum technical specification through gap analysis (Appendix I).

Technical feasibility was used to determine if the developers had the technical resources needed to develop the system. The developers assessed themselves to see if they had the capability of developing the system. The SWOT analysis (Appendix H) was used to know the strengths and weaknesses of the developers. The opportunities and threats that the developers may face in developing the system were also indicated. The developers' available technical resources were checked, which are the hardware and software needed in the development. The specifications were inspected and compared to the minimum technical specifications through gap analysis (Appendix I).

Furthermore, economic feasibility was used to determine if the benefits of the project outweigh the estimated cost. The list of supplies and materials for the organization within a year was bought. With this information, the total amount of materials and supplies consumed by the organization was calculated. The estimated expenses of the organization for their supplies, which increased by 10% every year, were also calculated. The supplies and materials that the organization still needs if the system is implemented were also computed.

Since the organization’s total garbage bins consist of five, the developer also calculated the overall cost of the components, including the garbage bin, ESP8266, Arduino, and other components that they designed. The results are compared to the cost of the organization’s current garbage management system , which determines if the project is economically feasible.

**3.3 Development and Testing Procedure**

The development model the developers will use in this project is the prototyping model. In this model, the prototype of an IoT-based Garbage Management System device was built, tested, and modified based on the feedback received from the users. The system development model represents the process of doing this project to allow the users to evaluate and try it out before implementation.

The process started with data gathering and interviewing the janitorial staff. Then, the gathered data was analyzed, resulting in a requirements document. It became the basis of the initial prototype that the developers developed. This prototype model was designed to detect possible theft attempts or establishment breakers.

In developing the prototype design, Arduino UNO and ESP8266 serve as the device microcontrollers. The Arduino standard API (Application Programming Interface) is use to construct the Arduino, ESP8266, GSM module, and sensors. In enabling control over the system, the Blynk app was used. The Blynk app will allow a user to interact with the device; this app has drag-and-drop features, enabling easy access. With the Blynk library, it is possible to control the device directly from smartphones without any code.

Every part was inspected deliberately. After the development, a series of testing procedures, like alpha testing and beta testing, were done. The develop device was examined to identify its possible issues or bugs. The system's functionality will be test to ensure it is error-free. Another purpose of this test is to evaluate the system's compliance with the specified requirements. The actual results will be compared to the expected results.

**3.4 Implementation Plan**

Prior to installation, the developers will present the intended usage of the device to the selected organization, explaining the purposes of each component and detailing the operational procedures, including the implementation of text instructions to facilitate user-device interaction.

The developers will assess and appraise the needs and all essential technologies, encompassing software and hardware components. Owners must possess a minimum of one smartphone in order to receive the message notifications. Additionally, it is imperative for owners to install the Blynk application in order to gain access to real-time monitoring. Subsequently, the developer will exhibit to the owner the process of activating and monitoring the waste management system, which will promptly detect and respond to the fullness of the garbage bins.

Furthermore, the developers will furnish a tutorial on the user's registration process within the Blynk application and a printed manual elucidating the operational protocol of the system. The manual encompasses both functional and technical documentation of the system, as well as a comprehensive procedure for accessing real-time monitoring through the Blynk App. Additionally, it offers text-based commands to cease the notification of messages. The device can be powered on and off by manually activating the system. By doing so, users will acquire the requisite comprehension of the system and the equipment.

Moreover, the developer has the responsibility of providing guidance to the user. The developer will set up a schedule for the installation at the College of Information and Computing Sciences. The developer will ensure that the system operates with efficiency and precision.

**4. Results and Discussion**

**4.1 Description of the Existing System**

An IoT-based Garbage Management System with SMS Notification was developed to improve the garbage management system in the College of Information and Computing Sciences, which uses manual monitoring and management. It is designed to provide automated and real-time monitoring to reduce problems regarding the overflowing of garbage, segregation, and stray animals that scatter the garbage from the bins. It can alert the janitorial staff through text messages when someone attempts to enter. It can also segregate garbage automatically. Moreover, janitorial staff can see a real-time view of the garbage level status.

The effectiveness of this garbage management system could be more reliable if they were using automated monitoring and management. Another thing that is challenging is to notice if the garbage bin is full and the garbage is not properly segregated. There is no technology implemented to monitor and display what is happening in the garbage bin of the College Information and Computing Sciences. Most of us know that we cannot control the behavior of individuals who throw garbage in the wrong manner. In this case, the manual garbage management system is not efficient, as they should switch from a manual to an automated process that can automatically segregate, monitor the garbage level, and send notifications when the garbage bin is full. In this case, the developers develop this project so that the organization feels at ease monitoring and managing the garbage bins in the College of Information and Computing Sciences.

**4.2 Requirement Specification**

An IoT-based Garbage Management System with SMS Notification was developed to improve and automate the manual monitoring and management of garbage bins in the College of Information and Computing Sciences. It is designed to provide real-time monitoring and management of the garbage bins and to automate the segregation process. It can alert the janitorial staff when the garbage level is full. Moreover, the janitorial staff can have real-time monitoring through the Blynk app.

**Technical features**:

Bin Level Sensors

Wireless connectivity

Support SMS notifications.

App-based Dashboard

Garbage scanner for segregation

**Functional Requirements**

Functional requirements contain the specific functions that the developed project can provide to the organization.

1. **Monitoring real-time events:** This allowed them to have a real-time view of the level of garbage in the bin.
2. **Automated Garbage segregation.** The system will automate the segregation process of the garbage into the garbage bin.

Connect to the system: allow the user to connect to the system to keep updated on the events happening in the garbage bin.

**Send an alert via SMS:** The system will send an alert message when the proximity sensor detects that the garbage bins are full.

**Non-Functional Requirements**

Non-functional requirements specify criteria that can be used to judge a system’s operation rather than specific behavior.

Security: The data communication between the IoT devices, servers, and SMS servers should be encrypted to ensure the confidentiality and integrity of the information. The system shall only allow the janitorial staff or an authorized person on the Blynk app to access the device.

Usability: The device must be easy to operate and understand.

Availability: The device must always be accessible and have internet connectivity.

Reliability: The system will ensure that the monitored events will be reliable.

**4.3 Results of Feasibility Analysis**

**4.3.1 Operational Feasibility**

For the operational feasibility, the SWOT Analysis (Appendix F) conducted shows that the organization has the strengths needed to implement this project. The organization has the resources to help with the project, and they know how to use smartphones and other new technologies that are out there right now. However, the dependency on internet connectivity, technical issues and initial investment, which is the organization's weakness. They can the garbage monitoring and management by replacing their existing proves with this technology. Consequently, the malfunction of either the device or sensors may affect due to the occurrence of natural disaster and the clear motive to destroy of someone who may attempt to alter the device.

The developers conducted a comparison between the technological specifications of the organization's resources and the technical requirements necessary for the developed device. According to the operational feasibility gap analysis (Appendix G), the organization has the necessary hardware technology to meet the technical standards of the planned device. This includes smartphones like Android devices and an internet connection provided by PLDT. However, they lack the software program on their devices. Hence, it is vital to acquire and install the Blynk application from Google Play for Android, Huawei App Gallery, and the App Store.

**4.3.2 Technical Feasibility**

Since it is an IoT-based garbage management system with an SMS notification prototype, the developers must buy the necessary hardware materials to build a prototype. Still, the developers can support the software based on the results of the technical feasibility-gap analysis (Appendix I).

The SWOT analysis (Appendix H) shows that the developers have the right skills to work on the project because they are software development researchers with a background in computer programming. In terms of marketing, they have experience promoting and selling products on different social media and e-commerce platforms.

Thus, developers will have enough time to construct. While developers may have more time to construct the device, its accuracy may be hindered when deploying it to other organizations due to the need for additional resources to configure it. Trust and reliability are the key security considerations. Consequently, developers must establish their credibility as reliable and trustworthy providers of the systems. If they achieve success in this project, developers have the opportunity to seek support from government entities such as DOST, DICT, or other organizations to facilitate the expansion of the technology's capabilities, given its Internet of Things (IoT) nature. Furthermore, the expertise acquired by developers in the process of creating the device will enable them to improve the precision and dependability of this technology during maintenance or while expanding the device's capacity. Due to the volatile pricing of electronic equipment on the market, developers face challenges in obtaining affordable, sometimes inferior materials, even from reputable stores. Furthermore, the progress and usefulness of the device are impeded by power interruptions and inadequate network signals. Regarding competitiveness in garbage management systems, large companies have a significant advantage due to their substantial resources.

**4.4 Description of the Proposed Project**

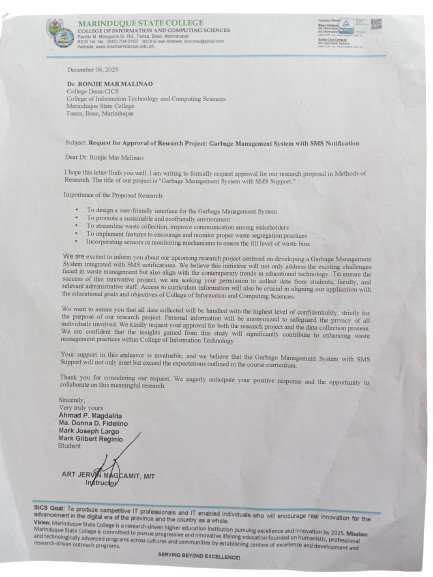
The system prototype will be constructed progressively with each component designed to fulfill a specific function. The components of the system are the ESP8266, also known as NODEMCU, sensors, a GSM module, and a battery. Subsequently, it will be integrated with its corresponding materials to operate the system in a collaborative manner.

The prototype consists of a waste bin equipped with a number of interconnected components including ESP8266, sensors, a GSM module, and a battery. In the event of sensor activation, the GSM Sim900a module would promptly send an SMS notification to the janitorial personnel. In addition, there is a sensor that categorizes the waste deposited into the trash bin. Moreover, the ESP8266, when connected to the Internet, has the capability to monitor the garbage level in real time. Furthermore, the system is equipped with a built-in battery that may sustain its operation during brief power interruptions. This will facilitate the janitorial crew in

efficiently monitoring and managing garbage.

**APPENDICES**

**APPENDIX A**

**Letter of Request: Preliminary Interview**

**APPENDIX B**

**Interview questionnaire**

**Questionnaire**

Good day! We are 3rd year college students in section C, taking a bachelor of science in

information technology at Marinduque State College, Tanza Boac. We are conducting a interview as part of our research, “Garbage Management System with SMS Notification." We are grateful for your participation in this survey and appreciate you taking the time to do so. Rest assured that none of the responses you provide will be shared with anyone else, and your identity will be protected throughout the research process. We are thankful for the time and effort you put into completing the survey, and we warmly acknowledge the vital contribution you will make in advance. Your response to this survey would be greatly appreciated. Thank you very much.

1. What is the existing garbage management system in your institution?

2. What are the process of garbage monitoring and management in your existing system?

3. How do you monitor the level of garbage bins in College of Information and Computing

Sciences?

4. What is the common problem that you encounter in your current garbage management

system?

5. How do you manage the problem that you encounter in your existing the garbage

management system

6. Have you experienced using IOT- Based or automated garbage management system? If yes, can you describe your experienced in using it.

7. If no, do you think you can adopt using a IoT based management system if implemented in CICS?

8. Do you think using IoT based management system will help to solve the problem that you encounter?

9. If we are given an opportunity to develop a IoT Garbage management System, what are your suggestions for functionality and features?

**APPENDIX C**

**Work Breakdown Structure**

**Table 1. Work Breakdown Structure for Garbage Management System with SMS Notification**

|  |
| --- |
| 1. INITIATION   1.1. Conceptualization  1.2. Choose an organization  1.3. Conduct preliminary investigation  1.3.1.Prepare a letter for the interview  1.3.2. Prepare interview questionnaire  1.3.3. Letter of approval  1.3.4.Observe and Interview  1.3.5. Record an interview  1.3.6.Close-out interview  1.4. Define problem or opportunity  1.4.1.Identify problem domain |
| 1. PLANNING   2.1 Gather project requirements  2.1.1. Develop WBS  2.1.2. Create Gantt Chart  2.1.3.Create Data Flow Diagram  2.1.4. Plan Resource  2.1.5.Plan Budget  2.1.6.Compile Project Plan  2.1.7. Approve Project Plan |
| 1. EXECUTING   3.1. Manage and complete the materials  3.2. Design a prototype for the proposed project  3.3. Obtain formal approval of the design project  3.4. Test materials and equipment  3.5. Development of the System  3.5.1.Coding to Arduino IDE  3.5.2. Creating Schematic Diagram  3.6. Developed Device Testing  3.6.1. Setup materials and install the device  3.6.2. Alpha Testing  3.6.3. Beta Testing |
| 1. MONITORING & CONTROLLING   4.1. Review Prototype Design  4.2. Update and revise changes in the project  4.3. Submit the final document  4.4. Implementation of the project deliverable  4.5. Secure and Maintain |
| 1. CLOSING   5.1. Project Acceptance  5.2. Close-out of the project. |

**APPENDIX D**

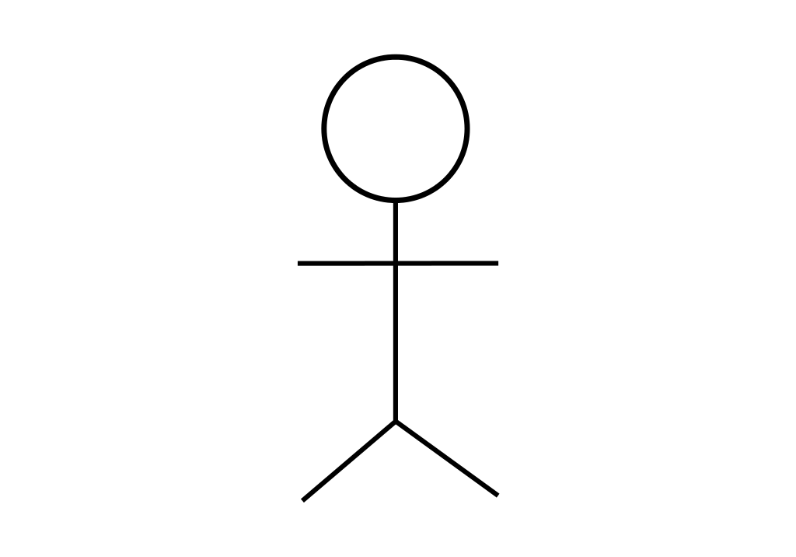
**Gant chart**

**Table 2. Gant chart for Garbage management System with SMS Notification.**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Project Activities** | **November 2023** | | | | **December 2023** | | | | | **January 2024** | | | | | **February 2024** | | | | | **March 2024** | | | |
|  | W1 | W2 | W3 | W4 | W1 | W2 | W3 | W4 | W1 | | W2 | W3 | W4 | W1 | | W2 | W3 | W4 | W1 | | W2 | W3 | W4 |
| I. Initiation | | | | | | | | | | | | | | | | | | | | | | | |
| • Conceptualization |  |  |  |  |  |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |
| • Choose an organization |  |  |  |  |  |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |
| • Conduct preliminary investigation |  |  |  |  |  |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |
| • Define Problem or Opportunity |  |  |  |  |  |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |
| • Identify problem domain |  |  |  |  |  |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |
| II. Planning | | | | | | | | | | | | | | | | | | | | | | | |
| • Gather project requirements |  |  |  |  |  |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |
| III. Executing | | | | | | | | | | | | | | | | | | | | | | | |
| • Manage and complete the materials |  |  |  |  |  |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |
| •Design a prototype for the proposed project |  |  |  |  |  |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |
| • Obtain formal approval of the design project |  |  |  |  |  |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |
| • Test materials and equipment |  |  |  |  |  |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |
| • Development of the system |  |  |  |  |  |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |
| • Developed device testing |  |  |  |  |  |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |
| IV. Monitoring and Controlling | | | | | | | | | | | | | | | | | | | | | | | |
| • Review prototype design |  |  |  |  |  |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |
| • Update and revise changes in the project |  |  |  |  |  |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |
| • Submit the final document |  |  |  |  |  |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |
| • Implementation of the project deliverable |  |  |  |  |  |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |
| • Secure and maintain |  |  |  |  |  |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |
| V. Closing | | | | | | | | | | | | | | | | | | | | | | | |
| • Project acceptance |  |  |  |  |  |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |
| • Close-out of the project |  |  |  |  |  |  |  |  |  | |  |  |  |  | |  |  |  |  | |  |  |  |

**APPENDIX F**

**Use Case Diagram of Garbage Management System with SMS Notification**

****

Janitorial staff

Micro Controller

**APPENDIX E**

**No**

**Flowchart of Developed Garbage Management System with SMS Notification**

**No**

**Yes**

Repeat

Waste Collection

Send Alert

**Yes**

Level >=Threshold

Receive, Update, store waste level status

Connection established?

Establish connection with server

Waste detection in a garbage bin

**APPENDIX F**

**Operational Feasibility-SWOT Analysis**

**Table 3. Results of Operational Feasibility-SWOT Analysis**

|  |  |
| --- | --- |
| **Strength** | **Weakness** |
| **Efficiency:** Waste collection is made easier by automation and smart technologies.  **Environmental Impact:** Enhances waste management practices, reducing environmental footprint.  **Data Insights:** Provides valuable data for better decision-making and planning.  **Expertise:** The chosen organization is capable of using smartphones and aware of emerging technologies we have right now | **Initial Investment:** Developing the device can have high costs for purchasing hardware and for implementation.  **Technical Issues:** Dependency on technology might lead to disruptions or malfunctions.  **Dependency on Connectivity:** Reliance on consistent internet or network connections for efficient usage of device. |
| **Opportunity** | **Threats** |
| **Expansion Possibilities:** Potential for scalability and integration with other smart city initiatives.  **Public Engagement:** Opportunities for community involvement in waste management practices.  **Technological Advancements:** Continuous improvements in technology can enhance system efficiency. | **Cybersecurity Risks:** Vulnerabilities to hacking or data breaches.  **Resistance to Change:** Resistance from traditional waste management systems or organization to adopt new technology. |

**APPENDIX G**

**Operational Feasibility-Gap Analysis**

**Table 4. Results of Operational Feasibility – Gap Analysis**

|  |  |  |
| --- | --- | --- |
| **Technical Specification Needed for the proposed device** | **Technical Specification of Available Resources** | **Action Needed** |
| **Hardware** | | |
| Smart Phone   * Android 6.0 or Higher | Android | Use the available smartphone of the user |
| Router   * With internet connection | CICS Internet Connection | Use available internet connection |
| **Software** | | |
| Blynk App / Site | None | Install the Blynk app on the available device |

**APPENDIX H**

**Technical Feasibility -SWOT Analysis**

**Table 4. Results of Technical Feasibility -SWOT Analysis**

|  |  |
| --- | --- |
| **Strength** | **Weakness** |
| **Management Team:** team members are Software Development researcher with background in programming, as a result, we have the necessary skills to develop the project.  **Time**: Developers have enough time to develop the project. | **Complex Integration:** Challenges in integrating various technologies and systems seamlessly.  **Reliability:** Potential issues with sensor accuracy or malfunctions affecting data accuracy.  **New:** Developers are relatively new to Arduino technology and are not established as experts.  **Resources:** Most of the necessary component hardware for developing the device are not available at the developer’s location, therefore they may have to purchase it online. |
| **Opportunity** | **Threats** |
| **Technological Advancements**: The technology used is IoT, therefore continuous improvements in IoT and sensor technology can enhance system capabilities.  **Data Utilization:** Opportunity to leverage collected data for analytics and optimization.  **Collaborative Innovation**: Potential partnerships with tech firms or government organization like DOST or DICT will be possible for innovative solutions. | **Data Security Risk**s: Vulnerability to cyber threats and data breaches.  **Dependency on Suppliers:** Risks associated with reliance on specific technology suppliers or platforms.  **Obsolete Technology:** Rapid technological evolution might lead to the system becoming outdated.  **Service Provider:** Frequent power outage and weak signal will hinder the development of the project and the device’s functionality. |

**APPENDIX I**

|  |  |  |
| --- | --- | --- |
| **Technical Specification Needed for the proposed device** | **Technical Specification of Available Resources** | **Action Needed** |
| **Hardware** | | |
| **Microcontroller**   * **ESP8266** | None | Purchase the needed micro controller |
| **GSM Module**   * **SIM900A** | None | Purchase the needed GSM Module |
| **Ultrasonic Sensor**   * **HC-SR04 Ultrasonic Sensor** | None | Purchase the needed Ultra Sonic Sensor |
| **16x2.I2c- LCD display** | None | Purchase the needed LCD Display |
| **Jumper wires** | None | Purchase the needed Jumper Wires |
| **Bread Board (for protype)** | None | Purchase a bread board |
| **Power Supply**   * **Power Cable** | None | Purchase the power supply cable compatible to the micro controller |
| **Software** | | |
| **Operating System**   * **Windows 7,8,10,11** | Windows 10 | Use the available operating system |
| **Arduino IDE** | None | Install Arduino IDE on the developer’s computer |
| **Blynk App** | None | Install Blynk App on developers Smartphone |

**Technical Feasibility-Gap Analysis**

**Table 6. Results of Technical Feasibility-Gap Analysis**

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