



SOLID WASTE COLLECTION BIN MONITORING SYSTEM FOR VIRAC, CATANDUANES

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Abstract. The city of Virac is the capital city of the Province of Catanduanes, one of the coastal provinces in the Bicol Region. The city through the efforts of its Local Government Unit (LGU), has been very aggressive in the Solid Waste Management Campaign. The developer is one of the proud daughters of Catanduanes, and had the vision to help improve the Solid Waste Management campaign of the province – thus conceived the concept of the Solid Waste Collection Bin Monitoring System.

It is enough that people segregate their wastes, it is also the prime responsibility of the people and the LGU to monitor the collection bins around the city. The system is designed to monitor the status of the Solid Waste Collection bins through the use of Arduino and SMS technologies. The system is a combination of hardware and software (mechatronics) that monitors the garbage level in the trash bins regularly. Arduino technology is used to monitor the level of the trash bins, while SMS technology is used to send messages to the server to give an alarm about the level of garbage inside each trash bin. The system also is evaluated using an industry-accepted quality standard – in this case ISO 9126.

The findings of the study depict that the system is applicable to the garbage collection and disposal activities of LGU-Virac, having an overall mean of 3.854167. The components of the system are fully functional and are deemed to be essential to the entire operation of the system. The system was evaluated against its functionality, reliability, usability, efficiency, maintainability, and portability.

Along with the positive findings of the study, the developer deems it necessary to implement the developed system to help the LGU of Virac to monitor the solid waste collections, to better serve the people of Virac. The system also having been seen as usable and portable can be upgraded as the need arises.

Key Words: Garbage Disposal, Monitoring System, Solid Waste Collection Bin, System with Arduino, System with SMS

INTRODUCTION

Waste collection and rubbish disposal play an extremely important role in the global cleanliness and sustainability drive, with people's health and the conservation of resources being the responsibility of every government. To ease the pressure on government agencies, numerous privately-managed organizations also play a part in these waste management and recycling programs. In many cities, it means that local government agencies have been left with the responsibility of overseeing the work done by these privately held organizations.

Thousands of years ago humans simply dug a hole and buried their refuse and waste. This was an effective technique for these early people because their population was relatively small and they did not produce waste on the same scale or with the levels of complexity that modern humans do. Burying the rubbish helped to prevent bugs and rodents from becoming a nuisance and spreading diseases. In the modern world burying all of our rubbish is not a sustainable solution. While primitive humans produced very little waste, and that which was produced would biodegrade quickly, modern humans produce much larger amounts of waste, much of which is not biodegradable. Additionally, many types of waste may be damaging to the soil, groundwater, and surrounding habitat (Mohammed, 2016).

Improper waste disposal is one of the biggest environmental issues here in the Philippines. It caused bigger problems that affect not only the environment but also the health and life of the people. This problem may be resolved or it will remain a problem for the country in the next few years. Mismanagement of waste disposal has a serious effect on ground and surface water contamination, flooding, air pollution, water pollution, etc. People will suffer in the next years of existence if they continue this kind of activity. Health security maybe not be secured or guarded when it comes to drinking contaminated water because of the improper disposal of the waste (Tumala, 2017).

In the province of Catanduanes, an awareness campaign on the implementation of the Solid Waste Management Act of 2000 and its parallel version, Municipal Ordinance No. 2012-17, was launched by Mayor Florida Alberto to secure public consciousness of the provision of the law. The LGU also strictly implemented last January 2015 – the “No Segregation, No Collection” policy as stipulated in Section 24, Article 7 of the Municipal Ordinance 2012-17. Additionally, the LGU only collects non-recyclable materials and special waste as mandated by section 10, Chapter 2 of RA 9003. The law clearly states that

segregation and collection of solid waste shall be conducted at the barangay level, specifically for biodegradable, compostable, and reusable wastes. Solid Waste Collection Bin Monitoring System for Virac, Catanduanes is such a great contribution to the advocacy of the Local Government Unit in the province.

Purpose and Description

The Solid Waste Collection Bin Monitoring System for Virac, Catanduanes is a good support to the Manpower of the solid waste collection in the province. The purpose is to ensure solid waste being collected in particular areas in the province properly monitored daily to have fast disposal. The communication between the bin and the system's server will be thru Short Message Service (SMS). The system will evaluate the message sent by every bin then a color coded lights will be displayed so that it will be easy to check the current status of each bin: orange meaning "standby", green meaning "empty", yellow meaning "near full" and red is "full". To avoid delay of the garbage disposal, a regular monitoring and sending of information will be expected between the server and the bin.

Specific Objectives

Specifically, the study aimed to:

1. design and develop a system using a combination of hardware and software (mechatronics) that:
 - 1.1. monitors the garbage level in the garbage bin regularly by using an open-source electronics platform called Arduino;
 - 1.2. sends alerts via short message service (SMS) to the server that indicates the current status of the bin;
 - 1.3. evaluates and displays the status of each bin thru coded lights.
2. validate the proposed system in terms of :
 - 2.1 functionality
 - 2.2 reliability
 - 2.3 usability
 - 2.4 efficiency
 - 2.4 maintainability
 - 2.5 portability

Analysis and Quick Design

Analysis and quick design is the first phase in the methodology of this study. It is a process of collecting and interpreting facts, identifying the problems, and decomposition of a system into its components. It is also the part wherein the existing system is being analyzed. The analysis is conducted for the purpose of studying a system or its parts in order to identify its objectives. It is a problem-solving technique that improves the system and ensures that all the components of the system work efficiently to accomplish their purpose.

The first activity made by the developer was to visit the Local Government Unit (LGU) office to conduct a casual interview regarding the garbage collection and disposal system in the area of Virac, Catanduanes. The developer confirmed that there is a chance that waits for enhancing the current system of garbage disposal. The usual way of collecting and disposing of garbage which is common to most towns in Catanduanes is the manual of checking of garbage pile and disposing of it when the bin is full. The municipal truck will collect and then carry the garbage to the disposal area.

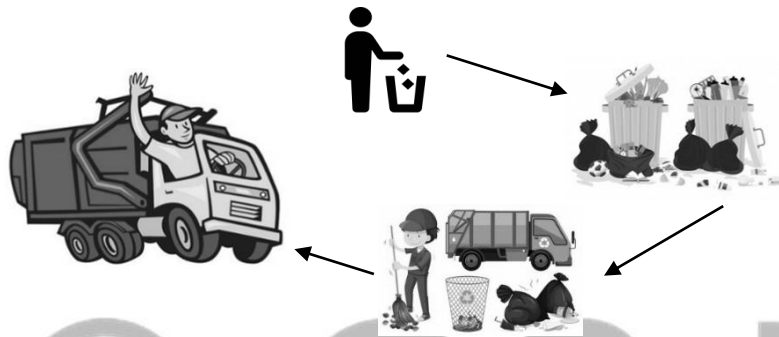


Figure 1 - Existing System of Garbage Collection and Disposal

Figure 1 showed how garbage collection and disposal are being made in Virac, Catanduanes. It is normally collected in garbage bins and when full, the LGU-assigned workers carry the garbage to the disposal or designated area.

Prototype Cycles

Prototype Cycles are important to the developer. This is the phase where the developer can think about their solutions in a different way (tangible product rather than abstract ideas), as well as to fail quickly and cheaply so that less time and money is invested in an idea that turns out to be a bad one. There are three main activities in prototype cycles: build, refine, and demonstrate. After the casual interview, the developer prepared the necessary things needed in the development of the project – that includes the preparation of the software and hardware requirements, likewise the diagrams of the planned system for easy development. There were several research made and documentation while prototyping. The developer went to IT experts thrice to secure their feedback on the developed system. Until the project study is ready for testing and evaluation of the stakeholders and IT experts.

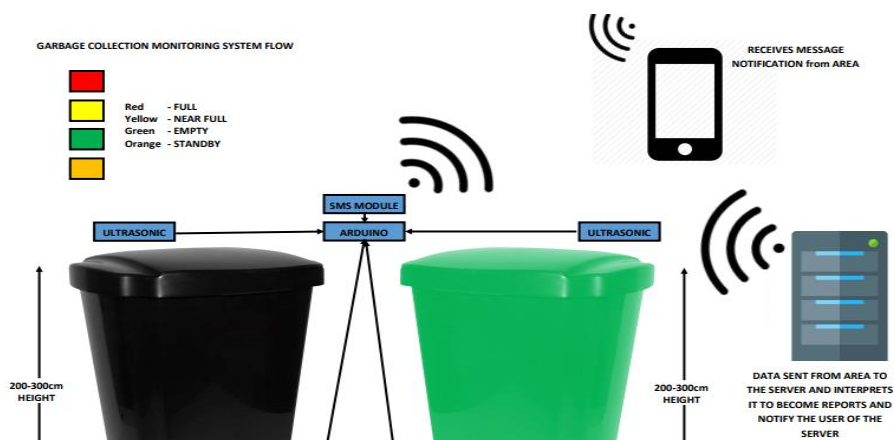


Figure 2 - System Architecture of the Developed System

Figure 2 showed the system architecture of the developed Solid Waste Collection Bin Monitoring System for Virac, Catanduanes. The communication between the bin and the system's server was thru Short Message Service (SMS). The system will evaluate the message sent by every bin then a color-coded light was displayed so that it will be easy to check the current status of each bin: orange meaning "standby", green meaning "empty", yellow meaning "near full" and red is "full".

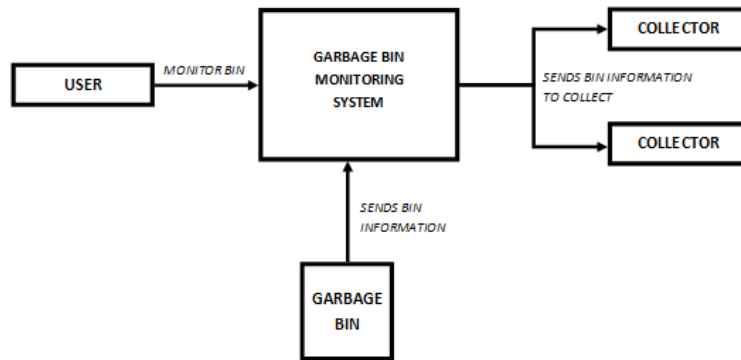


Figure 3 - Context Flow Diagram of the Developed System

Figure 3 depicted the context flow diagram of the Garbage Bin Monitoring System. The user monitors the garbage at the collection area by using the developed system. The garbage bin will also send information to the system. When the bin reached its fullness, the system will send information to the collector for garbage disposal.

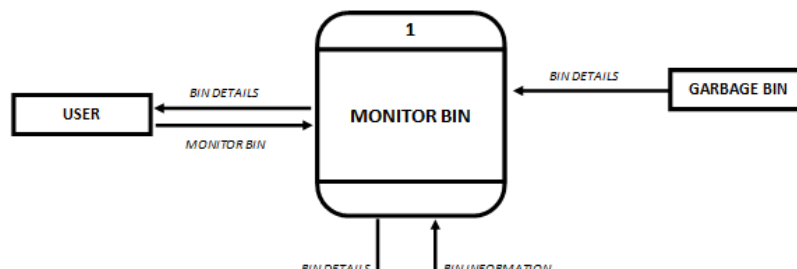


Figure 4 - Data Flow Diagram - Monitoring Bin

Figure 4 displayed the data flow diagram of the developed system. The User monitors the bin with the aid of the system; the system provides the user with bin details. The garbage bin gives details on the status of whether it's nearly full or full and ready for disposal.

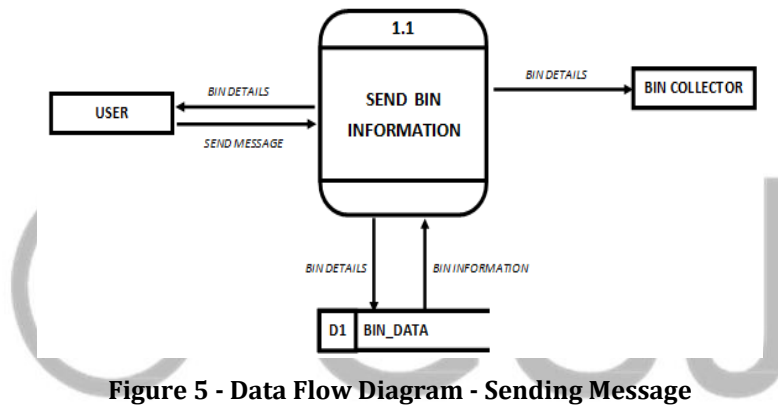


Figure 5 - Data Flow Diagram - Sending Message

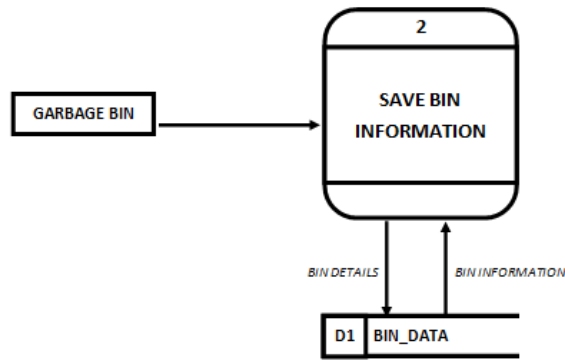


Figure 6 - Data Flow Diagram - Save Bin Information

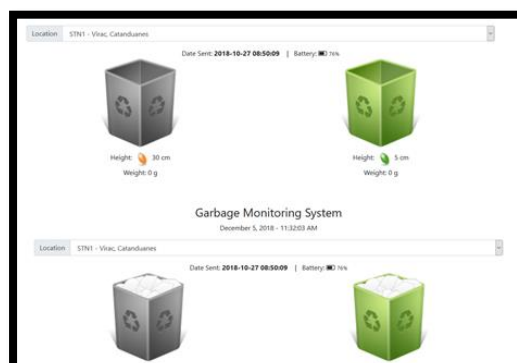


Figure 7 - Bin Information

Figure 7 reflected the information and gives an indication to the garbage collector when to pick up and dispose of the garbage collected by the bin.

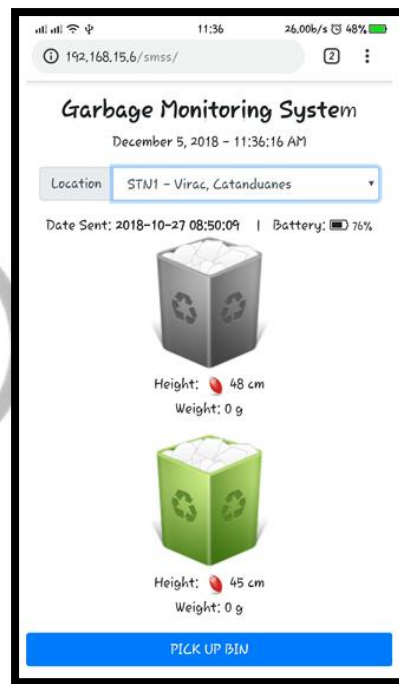


Figure 8 - Bin Information and Mobile View

Figure 8 displayed the bin information and mobile view which can be seen on the service mobile phone of a garbage collector.



Figure 9 - Sample Text Message

Figure 9 displayed the sample messages received by service mobile phones to garbage collectors.

**Table 10 - Overall Evaluation
 Of the Solid Waste Collection Bin Monitoring System**

Quality Characteristics		Section Mean	Interpretation
1.0	Functionality	3.790	more than what is expected
2.0	Reliability	3.915	more than what is expected
3.0	Usability	4.000	more than what is expected
4.0	Efficiency	3.915	more than what is expected
5.0	Maintainability	3.540	more than what is expected
6.0	Portability	3.965	more than what is expected
Overall Mean		3.854167	Very Applicable

Table 10 provided an overall evaluation of the system as reflected by the different respondents consulted by the researcher. The system from the perspective of the respondents turned out to be “more than what is expected” with an overall mean of 3.85. The system is considered to be “Very Applicable” as perceived by the different respondents. Of all the characteristics being evaluated, the usability of the developed system got the highest evaluation results with a mean of 4.0.

Implementation

After all of the evaluation and testing conducted by the developer, identified IT experts in the region, and the three stakeholders in the Local Government Office (LGU) office in Virac, Catanduanes, the system is now ready for implementation. Any time that the LGU

is prepared for the funding and manpower to be assigned to the Solid Waste Collection Bin Monitoring System's installation, the developer is ready to assist the team. Likewise, the project is ready for the additional development of the Solid Waste Collection Bin Monitoring System which will be ordered by the LGU Virac, Catanduanes.

Findings

During the development and after testing and evaluation of the developed system the following findings have been established:

1. The LGU Virac, Catanduanes is using the usual monitoring of garbage along the market site, street corners, and private and government offices at the heart of the city. The development of the Solid Waste Collection Bin Monitoring System is applicable to the garbage collection and disposal activities in the city after having a 3.854167 overall mean in the evaluation result among the respondents. With such results in evaluation, the developed project is appropriate to the needs of the LGU in Virac, Catanduanes.

The component parts are fully functioning and essential to the entire operation of the system. The Short Message Service (SMS) and coded lights aid in the monitoring activity of the system.

2. LGU Virac, Catanduanes considered their garbage collection monitoring and disposal activities as normal but need improvement because they really needed to maintain the cleanliness and orderliness of their area. An awareness campaign on the implementation of the Solid Waste Management Act of 2000 and its parallel version, Municipal Ordinance No. 2012-17, was launched by the Municipal Mayor to secure public consciousness of the provision of the law.

The developed system is considered an aid to the realization of the Municipal Ordinance. Considering the evaluation results on the functionality of the system, it resulted in a 3.790 overall mean which means the developed system in the area of functionality was rated as "more than what is expected".

In validating the reliability of the system, it resulted in a 3.915 overall mean from the identified respondents and evaluators, which means that the system is "more than what is expected".

The usability of the system was validated also and it was found that the system orientation can be easily understood in such a way that anybody can use the system with ease by simply observing the environment of the system. It has also a 4.0 overall mean from the evaluators. It was also the highest-rated quality characteristic of the system during the testing, evaluation, and validation of the respondents.

The efficiency of the system which responds and processes data in a little amount of time was validated by the respondents and was rated with an overall mean of 3.915 which means that the system's efficiency functions more than what is expected".

The developed system's features and functions can be modified to make it more adaptable to its client's environment and needs, thus the validators rated the developed system with a 3.540 overall mean, which means its maintainability is "more than what is expected".

The developed system complies with portability standards, and thus received a rate of 3.965 overall mean from the validators – which means the system’s portability is “more than what is expected”.

Conclusions

Based on the findings of this study the following conclusions are formulated:

1. The developed system is considered to be “Very Applicable” as perceived by the different respondents. The developed system is serviceable to the Local Government Unit (LGU) of Virac, Catanduanes. The LGU employees assigned to dispose of the garbage were the immediate beneficiaries. The system has functions and features that can be easily learned by the user.
2. The developed Solid Waste Collection Bin Monitoring System passed the International Organization for Standardization (ISO) 9126 – (which is concerned primarily with the definition of quality characteristics to be used in the evaluation of software products). Having been with an overall mean of 3.854167 the system is therefore deemed to be very applicable to be installed. Likewise, the system caters to the need of LGU of Virac, Catanduanes.

Recommendations

Based on the conclusions the following recommendations are hereby offered:

1. The current system in solid waste collection monitoring system in Virac, Catanduanes may be improved through the implementation of the project study entitled: Solid Waste Collection Bin Monitoring System for Virac, Catanduanes.
2. With the overall evaluation conducted by the developer to different stakeholders and IT experts, the system perspective of the respondents turned out to be “More than what is expected”, thus, the system is considered to be “Very Applicable” as perceived by the three (3) IT Experts and three (3) LGU employees who validated the developed system.
3. Additional functionalities may be studied and integrated into the new Solid Waste Collection Bin Monitoring System to greatly improve the services offered.
4. Additional bins for residue may be studied.
5. The server should be the one to send SMS to the garbage collector. No more intervention of the system in charge. LGU will just monitor the system operations.