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Solid Waste Bins Monitoring System using RFID Technologies

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ABSTRACT

This paper presents research work on a real time monitoring system for solid waste management. The developed system stores detailed information of the driver, vehicle and waste collection data in the database and tracks current location of the trucks in real-time. The RFID technology is implemented to handle data transmission and reception. The development tools used among others are the Integrated Development Environment (IDE) of Microsoft Visual Basic 6.0 and Microsoft Access 2010.

Key words: Waste Management, Monitoring System, RFID, Database System.

Introduction

Generally, the solid waste is defined from household's refusal and non-hazardous wastes. The non-hazardous solid wastes are from industrial, commercial, and institutional establishments such as hospitals, market waste, yard waste, and street sweepings. However, all these types of solid waste are a problem worldwide. Specially, in the developing countries, waste management is becoming an acute problem for their urbanization and economic development. Thus, solid waste management and monitoring requires immediate attention especially in countries such as China, South Korea, and Malaysia which have been categorized as emerging industrialized countries (Maher Arebey 2010).

In Malaysia, solid waste problem is one of the most severe environmental issues. Other issues that have received extensive public attention are the haze and air emissions. These anthropogenic sources are generated from indiscriminate dumping of toxic and hazardous wastes, which being raised the sensitive issues both in terms of quantity and quality. So, to know details of the solid waste that affected Malaysian environmental and related issues, the solid waste planner, monitor, and management requires comprehensive, reliable data and information on solid waste. However, the solid waste database in Malaysia is limited to manage the data by individual local authorities or waste contractors (Maher Arebey 2010).

Real time of solid waste management monitoring has sparked much controversy. A great deal of research has focused on the tracking of trucks, either on the web or by the use of secondary data (Chellappa 2005). However, little has been done on the monitoring of solid waste management in organizations. Yet this practice is growing in importance in organizations today. Therefore we believe that this issue and its impacts warrant in-depth study.

On one hand, organizations want to know where their drivers are and what they are doing when they are at work (Culnan 1999). If under normal circumstances, there are lack of information about the collecting time and area and lack of the proper system for monitoring, tracking the trucks and trash bin that have been collected in real time.

Solid waste management has no estimation to the amount of solid waste inside the bin and the surrounding area due to the scattering of waste. Moreover, there is no quick response to urgent cases such as truck accident, breakdown, and long time idling as well as to client's complaints about uncollected waste (Maher Arebey 2010). Today, by combining high-end technologies such as Global Positioning Systems (GPS), Geographic Information Systems (GIS) and Radio Frequency Identification (RFID), the location of collection vehicles and recycling bins can be determined easily. There are lack of the information about the collecting time and area. Furthermore, there are lacks of the proper system for monitoring, tracking the trucks and trash bins that have been collected in real time (Maher Arebey 2009). As technology advances, an intelligent system can be developed in order to track and monitor movement and location of truck in real-time.

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Material and Methods

The methodology of the study is divided into two parts, namely system hardware design and the programming software which would run the process. The study also includes the wireless transmission which is used.

Firstly, the RFID tag and reader are chosen and tested, in order to get the best signal and distance between them. The subsystem consists of two basic components: a RFID tag, installed on the recycling bins and the RFID reader, an antenna is attached to the truck. The RFID reader emits radio- frequency signals using the antenna for communication with the RFID tags. The Figure 1 below shows the block diagram of the intelligent system.
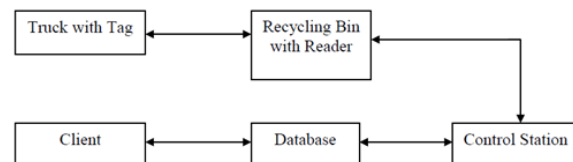
Fig. 1: Block diagram of the intelligent system.

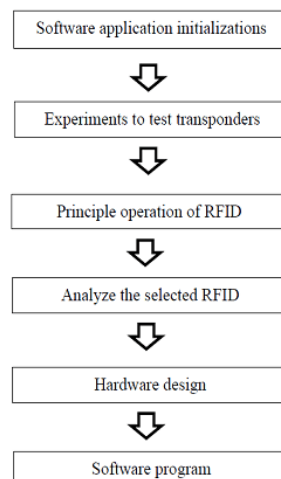The Figure 2 below is the flow chart of the theoretical frame work of the project.

Fig. 2: Flow chart of the theoretical frame work.

In this project, the constructions are divided into several parts. First is the software application initialization where software such as Integrated Development Environment (IDE), Microsoft Visual Basic 6.0 and Microsoft Access 2010 are used. Next, experiments are conducted to test the available transponders. Once it is completed, the principle operation of the RFID system is studied and the selected RFID system is analyzed. Finally, the hardware design and software program are constructed.

Principle Operation of RFID System:

In the process of choosing the proper RFID system for data collection from a truck, it is understood that the system should be capable to transmit and receive data from a reasonable distance. Following is the requirements for the system that is built:

• Capable of transmitting and receive data when the condition of the tag is not moving.
• Capable of storing data or system which can record data for identification purpose.
• Small in size which can be fitted into the truck and bin.

The functions of the system which is built are as follows:

- Able to monitor whether the waste in the bin is collected or not and where is the bin located.
- Able to monitor who is the driver in charge at a particular work shift and which truck was used and the next destination of the driver as well as the waste collection time.
- Capable to identify latest 10 history of waste collection at a particular bin location.
- Small size tag which is easy to be attached at the bin (stored in a compartment which cannot be modified.)
- The data in the tag can be updated anytime.

Analysis of the Selected Passive RFID:

After analyzing the system requirements of this upcoming project, the passive RFID system are chosen based on the features available. The device which has been chosen is the product from EM Microelectronic-Marin SA PIC16F876A receiver chip and transponder EM4150. Both of these devices function as radio frequency transmitter and radio frequency receiver. In this project, both these devices are used to build the data storage system of the waste bins monitoring system. The transponder EM4150 is used to allow multiple drivers and trucks to be assigned within the application. This would have not been possible with EM4102 tags, which can only be assigned to maximum of two drivers. The EM4150 on the other hand, enables the system to locate multiple choices of drivers and trucks because it could write data in the tag addresses. Moreover, no external supply buffer capacitance needed due to low power consumption and it is cost efficient.

Figure 3 below shows the flow chart of the transceiver and transponder. The EM4150 will transmit data to the transceiver by modulating the amplitude of the electromagnetic field, and receive data and commands in a similar way. Simple commands will enable write to EEPROM, to update the password, to read a specific memory area, and to reset the logic. The coil of the tuned circuit is the only external component required, all remaining functions are integrated in the chip (Custom Computer Services, Inc. 2007).

Figure 4 shows the flow chart of the mode of operation. The EM4150 is supplied by means of an electromagnetic field induced on the attached coil. The AC voltage is rectified in order to provide a DC internal supply voltage. When the DC voltage crosses the Power-On level, the chip enters the Standard Read Mode and sends data continuously. The data to be sent in this mode is user defined by storing the first and last addresses to be output. When the last address is sent, the chip will continue with the first address until the transceiver sends a request. In the read mode, a Listen Window (LIW) is generated before each word. During this time, the EM4150 will turn to the Receive Mode (RM) if it receives a valid RM pattern. The chip then expects a valid command (Custom Computer Services, Inc. 2007).
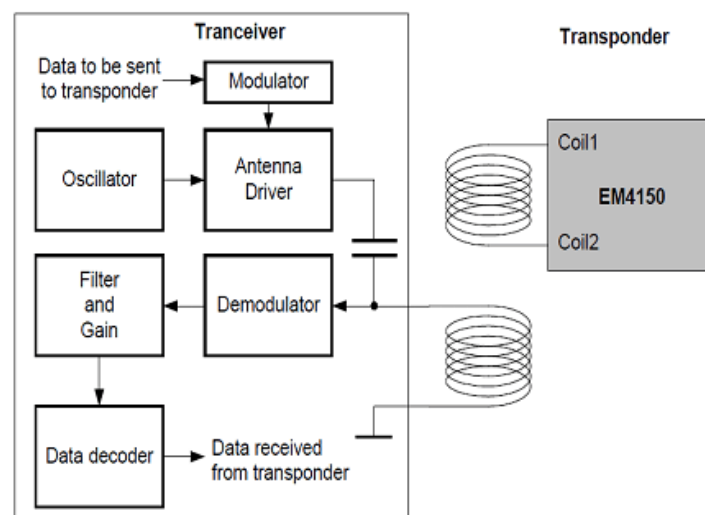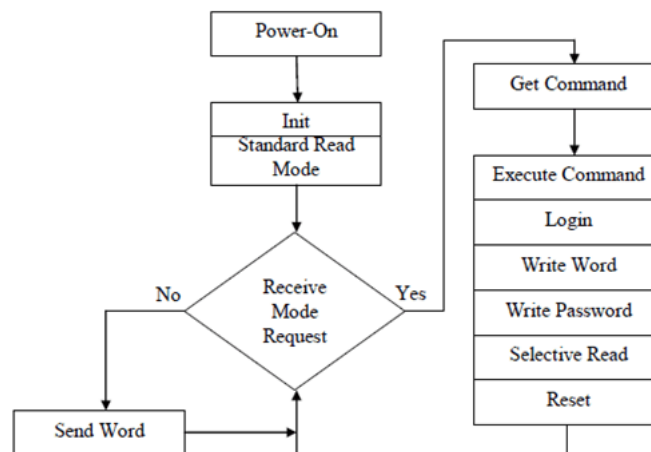

Fig. 3: Flow chart of the transceiver and transponder.

The 1024 bit EEPROM is organized by 32 words of 32 bits. The Table 1 below shows the memory map of EM4150 transponder and Figure 5 and Figure 6 shows the EM4150 transponder and RFID Reader respectively.

Fig. 4: Flow chart of mode of operation.

Table 1: Memory map of EM4150 transponder

	Control Word		Protection Word
0-7	First Word Read	0-7	First Word Read Protected
8-15	Last Word Read	8-15	Last Word Read Protected
16	Password Check On/Off	16-23	First Word Write Inhibited
17	Read After Write On/Off	24-31	Last Word Write Inhibited
18-31	User Available	-	

Fig. 5: EM4150 Transponder.

Fig. 6: RFID Reader.

Hardware design:

The hardware subsystem in the project consists of two basic components: a RFID reader, an antenna is installed on the truck and RFID tags that will be attached to the waste bins. The RFID reader emits radio-frequency signals using the antenna for communication with the RFID tags.

The ICD is connected to the prototyping board using the modular cable, and connect the ICD to the PC using the 9-pin serial cable for ICD-S or the USB cable for ICD-U. The prototyping board is powered up. The LED on the ICD will be dimly illuminated. Finally, the 9-pin serial cable is connected to RS-232; to the RS-485 adapter board, and to the PC using the USB port. The RFID tag and reader will be chosen and tested, in order to get the best signal and distance between them.

In this project, the RFID tag will be placed at the bin and the reader will be placed at the truck. Figure

7 shows the truck attached with RFID reader and waste bins attached with tag. Therefore, once the truck approaches the bin, the reader will automatically read the signal from the tag. But since the tag provided is very limited, therefore only one tag can be used. In this case, only one tag can be used at a time but with multiple selections of driver and truck.
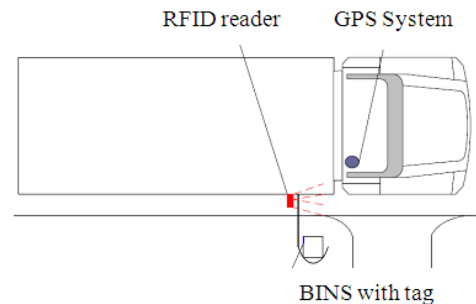
Fig. 7: The truck attached with RFID reader and the waste bins attached with tag.

Software program:

Figure 8 shows the flow chart of the program development in the PIC16F876A using C compiler. This program only will control how the reader going to read or write the EM4150 transponder. The most important part of the program is allowing the control of the EM4095 reader IC, the reading or writing of EM4150 transponder and other important functions such as RFID functions, RS-485 communications and standard library. As shown in Table 1, the address 18-31 is available to write data. Therefore in this project, only two data need to be stored which are DriverID and TruckID. So to make the process simple, address 20 has been assigned for DriverID while address 21 for TruckID. The program will require the user to choose whether to read or write the tag. If the read command is selected, then the reader will read tag data in address 20 and 21. If the write command is selected, then the reader will write the tag data in address 20 and 21. Finally, the program will check the status of the process and display it.
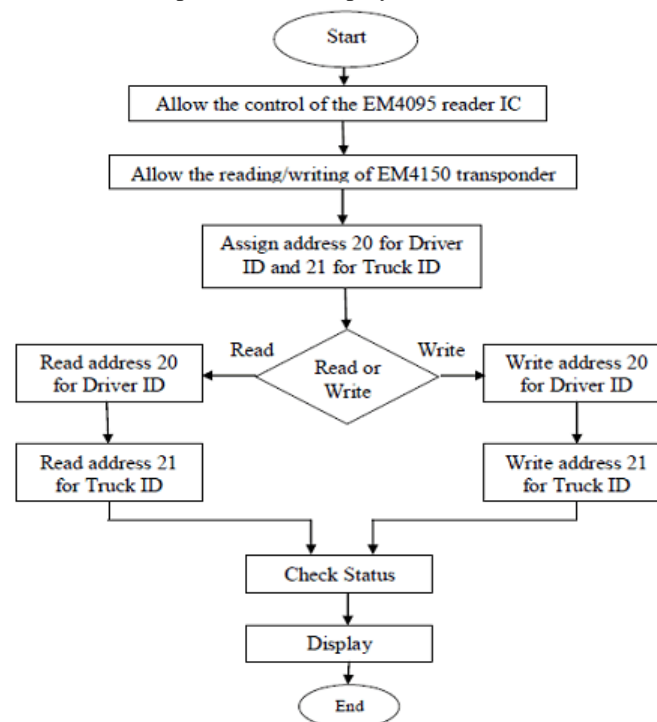
Fig. 8: Flow chart of the program development in the PIC16F876A using C compiler.

Figure 9 shows the flow chart of the driver details option in the main window. The window pops out once

the 'Open Driver' button is clicked at the home window. This menu allows user to add new Driver ID, Driver Name, IC Number, Contact Number and Add Photo. Once the details are successfully entered, the program checks for the Driver ID whether it is entered or otherwise since it is the main variable to determine each driver. The truck used by the driver, bin location and waste collection time can be reviewed if the Driver ID is entered as mentioned above. The program also allows user to view details of the previous driver which has been stored in the database. An error will occur if the Driver ID is not entered. Figure 10 shows a sample window of a driver's detail.
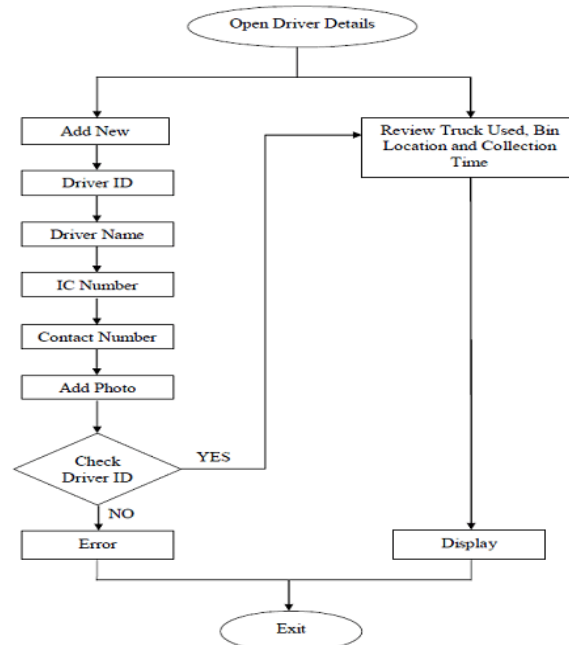
Fig. 9: Flow chart of the driver details option.

Fig. 10: Sample window of a driver's detail.

Figure 11 shows the flow chart of the truck details option in the main window.

This window pops out once the 'Open Truck' button is clicked at the home window. This menu allows user to add new Truck ID, Truck Registration Number and Model. Once all the details are successfully entered, the program check for the Truck ID is entered or otherwise since it is the main variable to determine each truck. If it is entered, then user can review the driver name that used the truck, bin location and waste collection time. The program also allow user to view details of the previous truck which has been stored in the database. An error will occur if the Truck ID is not entered. Figure 12 shows the sample for a truck details.
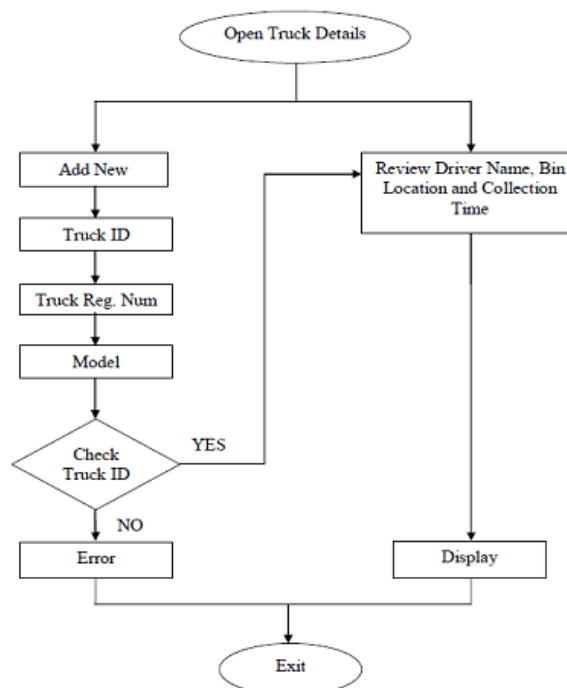
Fig. 11: Flow Chart of the truck details option.

Fig. 12: Sample window of a truck's detail.

Figure 13 shows the flow chart of the truck and driver selection option. This window opens when the 'Select Driver and Truck' button is clicked at the home window. At this moment, the auto read will be disabled. The purpose of such action is to avoid confusion in the system whether the reader is going to read or write the program. Once the button is clicked, the reader automatically switches to writing mode. The tag can be checked if it is successfully written on. Similar function is available and can be accessed by clicking on the 'Check Tag' button. The data will then be displayed on the display bar of the window. In order to clear the data in the tag, just click on the 'Clear Tag' button. Then, the memory in address 20 and 21 will be cleared. Figure 14 shows the driver and truck selection window.

Results and Discussion

The real time monitoring is observed from the home window of the application. The history information can be viewed by just clicking on the 'Next' and 'Previous' button. Figure 15 illustrates an example showing results of the real time monitoring system.
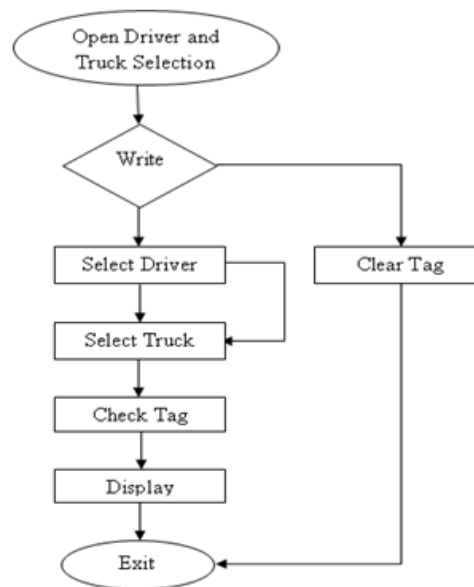
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Fig. 13: Flow chart of the truck and driver selection option.

Fig. 14: Driver and truck selection window.

Fig. 15: Real time monitoring system .

Once the data of new Driver ID, Driver Name, IC Number, Contact Number and Add Photo have been added, the details of each driver can be viewed by clicking on the 'Next' and 'Previous' button. This database can store a huge number of driver details. By default, history of the last ten trips will be displayed on the employee details's window too. Figure 16 shows an example of the display.

Once data of the new Truck ID, Truck Registration Number and Model are available in the system, the details of each truck can be inspected by clicking on the 'Next' and 'Previous' button. The database can store up to ten last trip histories. Figure 17shows an example on the truck's detail.

Conclusion:

A new solution is introduced that integrates passive RFID, to enhance solid waste collection efficiency. The developed system provides improved performance on real-time bin status, driver and truck details with time and location of the truck service. RFID can also be used for inventory control systems. The EM4150 used in this project is unsuitable to use in real-time application due to the short range of frequency detection which

is approximately 4 cm. Hence, it is only suitable to use to build this prototype. The appropriate frequency that can be used is the Ultra High Frequency which has range of 860 MHz to 960 MHz with the reading distance up to 5 m. The maximum approximation communication distance for passive RFID is around 6 m.

Fig. 16: Example of driver details.

Fig. 17: Example of truck details.

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