Intelligent Solid Waste Bin Monitoring and Management System

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Abstract: This paper deals with the solid waste monitoring and management system using radio frequency identification (RFID) associate with intelligent systems. The system consists of RFID system, mobile communication like (Global system for mobile) GSM and geographical information system (GIS) for tracking vehicle position. The proposed system would be able to monitor the solid waste collection process and management the overall collection process. It would provide in time solid waste collection, tracking the vehicle position through the GIS database and also overcome the disadvantages such as usage of minimum route, low fuel cost, clean environment and available vehicle. The technologies that would be used in the proposed system are good enough to ensure the practical and perfect for solid waste collection process monitoring and management for green environment.

Key words: Solid waste monitoring management, RFID, GIS, GSM.

INTRODUCTION

Generally, the solid waste is defined from households refusal and non-hazardous solid waste is from industrial, commercial and institutional establishments such as hospitals, market waste, yard waste and street sweepings (GAIA, 2002). Today, Solid waste management has changed a long way from the old days when garbage was collected by horse and disposed outside of town. Today, it is almost hard to manage waste collection process and management without high technology to pinpoint the locations of vehicles and recycling bins (Lau, 2004). In the developing countries, waste management is becoming an acute problem as urbanization and economic development increase leading to larger quantities of waste materials (Fadel, 2006). In Malaysia, the waste generation is increasing tremendously due to its developing activities and it has an accompanying problem with the disposal of this waste (Marts, 2009). The amount of solid waste generated in Malaysia is steadily increasing and the government is currently focusing on methods to approach the challenge. Table 1 show the solid waste generated (WG) in major urban area in Malaysia from 1970 until 1990 (MHLGM, 1999).

<table>
<thead>
<tr>
<th>Urban area</th>
<th>1970: WG tones/day</th>
<th>1980: WGTones/day</th>
<th>1990: WGTones/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kuala Lumpur</td>
<td>98.8</td>
<td>310.5</td>
<td>586.8</td>
</tr>
<tr>
<td>Johor Bahru</td>
<td>41.2</td>
<td>99.6</td>
<td>174.8</td>
</tr>
<tr>
<td>Ipoh</td>
<td>22.5</td>
<td>82.7</td>
<td>162.2</td>
</tr>
<tr>
<td>George town</td>
<td>53.4</td>
<td>83.0</td>
<td>137.2</td>
</tr>
<tr>
<td>Klang</td>
<td>18.0</td>
<td>65.0</td>
<td>122.8</td>
</tr>
<tr>
<td>Terengganu</td>
<td>8.7</td>
<td>61.8</td>
<td>121.0</td>
</tr>
<tr>
<td>Kota Bharu</td>
<td>9.1</td>
<td>56.5</td>
<td>102.9</td>
</tr>
<tr>
<td>Kuantan</td>
<td>7.1</td>
<td>45.2</td>
<td>85.3</td>
</tr>
<tr>
<td>Seremban</td>
<td>13.4</td>
<td>45.1</td>
<td>85.2</td>
</tr>
<tr>
<td>Melaka</td>
<td>14.4</td>
<td>29.9</td>
<td>46.8</td>
</tr>
</tbody>
</table>

Due to growing population and increasing consumption, the amount of solid waste generated in Peninsular Malaysia went up from 16,200 tons per day in 2001 to 19,100 tons in 2005, an average of 0.8 kilogram per capita per day. In Kuala Lumpur waste generation is about 3,000 tons a day and forecasts show that this will increase further in coming years (Hassan et al., 2001). To overcome the growing waste, it needs an efficient...
and robust system that can improve and reduce the time as well as the cost of the solid waste management (Kumar and Kevin, 2002; Ping and Yang, 2006). The proposed system for the solid waste monitoring and management would be in time, low operational cost and environmental friendly.

**Problem Overview:**

The main problems of the existing solid waste collection process and management system are as follows (Chandravathan, 2006; Alam Flora, 2009; MHLGM, 2008).

1. Lack of the information about the collecting time and area.
2. Lack of the proper system for monitoring, tracking the trucks and trash bins that have been collected in real time.
3. Loss of productivity due to inefficient utilization and unauthorized use of vehicles.
4. There is no quick response to urgent cases like truck accident, breakdown, longtime idling.
5. There is no quick way to response to client\'s complaints about uncollected waste.

However, with the conventional system, it is impossible to get all the facilities in time. Because, it may some trucks need to be available for important special events, some are to be on a daily schedule and some trucks may be under maintenance. To stimulate all these facilities, an effective and robust system is needed. The proposed system would be able to solve the mentioned problems with robust solution.

**Conceptual Framework:**

Solid waste collection minimization and improving its efficiency includes the costs per km and per hour to transfer the waste after collection from the various facility locations. There are some factors that affect collection productivity and efficiency (MLGPC, 2008) such as follows.

1. Service level: collection point, frequency and waste material
2. Route related: containers, distance, constraints, topography, delays and road conditions.
3. Collection methodology and climate related: crew size, collection procedure, wind and rain.

Based on the review, the developed conceptual framework for solid waste collection process, cost minimization and management can be seen in Figure 1.

![Conceptual Framework](image)

**Fig. 1:** Conceptual framework for solid waste minimization.

**Rfid Application in Solid Waste Management and Monitoring System:**

RFID has the chances to improve and enhance the waste management efficiency, it is important to understand the processes involved (Watty, 2008). Not only can RFID enhance waste management operations, but new systems also offer communities the opportunity to be more environmentally responsible. For these
reasons, RFID system has been proposed. Typically, recording the collection process is a manual operation which is the responsibility of the truck driver. Although some of solid waste companies have involved GPS system to capture the time spent but they cannot get the accurate trash bin information. Using the manual operations, numbers can be misread, misreported, mistyped or left blank altogether; Furthermore, asking drivers to manually collect this data is a significant distraction to their main responsibility of his driving. The RFID components are part of a larger, highly integrated, vehicle mounted system. Components of a basic system include an RFID reader, an RFID antenna and RFID tags attached on the bins. RFID data logs can be automatically downloaded from the RFID reader to designated server via GSM wireless connectivity.

The download process will be automatically initiated when the truck comes within range of the RFID system, the complete process will be fully automated and requiring no action from the driver. Not only does the RFID system track and give information about the trash bins, but enhance the whole system. It is not possible to use GPS for indoor positioning. Even when outdoors if the GPS receiver is too close to buildings where the trash bins are located, it is difficult to get accurate position information. When the truck reaches the RFID tag, it would be detected by the RFID reader and send the information via GSM which will be mapped on the GIS map. The truck illustration and equipment installed can be seen in Figure 2.

![Fig. 2: The truck attached with RFID reader, GPS receiver and GSM module and the recycling bin attached with tag.](image)

**Fig. 2:** The truck attached with RFID reader, GPS receiver and GSM module and the recycling bin attached with tag.

**MATERIAL AND METHOD**

The structure of the proposed system is developed using RFID, GIS and GSM for solution existing problems and streamline solid waste monitoring and management efficiencies. In this system, there is a great deal of process intelligence that would ensure the system capability and also justify its validity. This is not only in time-related factors such as time spent to, from and at locations, but more importantly, the accurate tracking of a solid waste bin’s serial number and location. These elements are important to ensure the proper collection and management of waste.

![Fig. 3: Architecture of solid waste monitoring and management system.](image)
The solid waste management tracking system addresses the above constraints to provide a solution. The proposed system is a web-based solution. Solid waste management clients will be able to view and retrieve trucks and their trash bins information via a web-based. The architecture is client-server architecture where the web browser is the client. GSM and GIS are chosen for the communication between the tracking unit and the server and vehicle position tracking. It is also ideally suitable for data transfer over an always on-line connection between the control station and trucks. The location information collected through the GPS in real time and would be stored in a central database in which all client would be able to access this information via web-base management system. Figure 3 shows the architecture of the system.

**System Interface:**

This section describes the hardware and software design of the system as well as the functionalities of each component. The trucks and bins monitoring and locating system based on RFID, GSM and GIS is a computer network system developed for real-time truck surveillance. The GPS receiver receives the positioning data from the GPS satellites (24 satellites distributed on 6 different earth tracks) continuously GPS module calculates its own geographical coordinates with the data from three or more satellites, the coordinate data which include the position and the state of the truck are sent to GSM network in form of short message by GSM module. The received information is transferred via GSM network to the communication gateway of the control station. After proper handling, the information is transmitted to the GIS monitoring terminal. By doing so, the monitoring centre can grasp detailed real-time truck information and shared with clients via web-based.

This subsystem consists of three basic components: RFID reader, an antenna that is installed on the trucks and RFID tags that is attached to the trash bins. The RFID reader emits radio-frequency signals using the antenna for communication with the RFID tags. A GSM module is integrated with the RFID reader for sending and receiving SMS. When truck's driver enters or leaves the solid waste collection place, the RFID reader communicates with the tag that attached to the recycling bin all the information are sent to control station in real time by SMS using GSM module. Figure 4 shows the process of updating the electric map.

![System Interface Flowchart](image-url)

**Fig. 4:** system interface for solid waste monitoring.
RESULT AND DISCUSSION

The research is able to develop the prototype of the solid waste monitoring and management system using RFID, GPS, GIS and GSM. This provides a novel effective solid waste monitoring and management system for real time tracking purpose. The proposed system also provided the location of trucks and solid waste collection of the recycling bins in real time application, monitoring and management, which maximize the waste collection efficiency. Not only can they enhance collection, but new systems also offer communities the opportunity to be more environmentally responsible. Figure 5 shows the GUI of the developed prototype, which is able to intend to perform the following tasks as mention below.

1. Give an overview on all available information related to trucks and bins.
2. Provide the real time bin status.
3. Provide a cartographic representation of the legal and actual route associated to trucks.
4. Permit real-time map data edition through a useful administration interface.

To keep map database up-to-date, tracking and monitoring support have has a real time database available for real-time map database edition. With this feature, a map database administrator can add / modified / deleted some entries such longitude and latitude of the truck and bin including related information.

Fig. 5: GUI layout of the bin monitoring system.

Conclusion:

The developed system integrated by using RFID, GPS, GSM and GIS, in which it would pioneer work for solid waste collection process monitoring and management. This proposed system would not only function for collecting and updating data automatically and timely, but also it could analyze and use data intelligently. The proposed system would solve a lot of problem related to solid waste collection, monitoring, minimizing cost and accelerate the management.

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