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AN IOT BASED WASTE MANAGEMENT SYSTEM

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Abstract: *To make cities smarter the cities must be clean, green, Internet of Things (IoT) can play an important role. We present a waste collection management solution based on making waste bin smart using an IoT prototype with sensors. It can read, collect, and transmit very large volume of data over the Internet. Such system is based on the android mobile application and the sensor. We are using the different sensor for obtaining the real time status of the dustbins and then update the information by sending it to the server or mobile application via wifi module. This paper represents the smart system for the smart cities which makes the peoples responsible to keep the city clean and healthy. This project will definitely make the waste management more reliable and smart for the big cities as well as for small towns to make their city a smart city. We use Raspberry pi microcontroller and sensor for making the hardware system working and an android application for displaying and tracking the data which is send by the dustbin module..*

Keywords: *Smart dustbin, Raspberry pi, Ultrasonic Sensor.*

1. INTRODUCTION

Proper waste management is an integral aspect of city management. Continuous development efforts lead to employing novel technology to reduce operational cost while maintaining consistent levels of service.

Current waste collection efforts utilize static route planning with fixed scheduling, which indicates there still exists areas for continued development and improvement in this field.. Such an approach is costly and generates a high-carbon footprint. The slow adoption of recycling in some cities also continues to result in monetary losses. Meanwhile, the absence of waste monitoring and limited waste-bin allocation per household may lead the public to overfill their bins or discard waste in non-designated areas. The city may thereby incur additional costs for the added demand for waste removal and management. The latter is most pronounced in areas with strained infrastructure, such as restaurant clusters or narrow pathways between houses. Bursts in waste generation, such as those following national holidays, can also generate a widespread high demand for waste collection.

Our interest in this is work is to motivate the use of the Internet of Things (IoT) in order to address the problems in waste management. Specifically, a proposal is made that allows for a) monitoring the current state of waste bins and their surroundings; and b) dynamically schedule and route waste collection in different areas. To the best of our.

The remainder of this work is organized as follows. In the following section, we survey related work and motivate our proposal. In Section III we provide an overview of our proposed system, detailing both the framework for route-planning and scheduling of waste-collection, in addition to the framework for monitoring the waste-bin and its surroundings. Use-case scenarios are detailed in Section IV. Finally, conclusions and hints at future work are provided in Section V.

2. RELATED WORK AND MOTIVATION

Given the twofold objective of this work, this section reviews the related work in the two noted aspects of waste management, namely route planning and collection scheduling, and bin design enhancement efforts.

A. Route Planning for Waste Collection Waste collection relies on dedicated vehicles departing and returning to preset locations (waste sites) thatare fuel-intensive and limited in the roads they can traverse due to their sheer size. Meanwhile, general route planning emphasizes point-to-point shortest path of travel, with considerations recently expanded to avoid congestion. However, these schemes overlook incorporating other information sources such as the surrounding area environment, time of day, and/or special events.

In [2], Wy et al. propose a route-planning scheme for waste-collection vehicles with considerations for bin surroundings. The solution is specifically aimed at large-containers dedicated to large waste removal, e.g. utilizing containers at construction sites and shopping districts. A rollon-rolloff routing scheme is used that is based on a. Vehicle Routing Problem (VRP) variant with the objective of minimizing the number of waste collection vehicles. The solution employs a large-neighborhood search using an iterative heuristic.

Nuortio et al. propose a guided-variable neighborhood thresholding metaheuristic approach in [3] to address both the route planning and collection scheduling. The scheme incorporates variables that capture neighborhood status and is designed to be lightweight in terms of storage and computational requirements. The results of the scheme implementation show that the scheme outperforms other classical routing techniques.

Bing et al. modeled waste collection routing as a graph-based problem, with curbside-pickup and facility drop-off modeled as a node-routing problem [4]. The authors propose aggregating nearby nodes through cluster route planning schemes based on an Ant-Colony System (ACS) algorithm. In the scheme, a k-means clustering is initially applied to the bins to generate clusters based on bin content. Collection trucks are then grouped based on the material to be collected, with the ACS utilized to include data about current bin status to improve the waste collection efficiency. While the scheme is reported to perform favorably, considerations for scaling the ACS for large cities were not clearly pronounced. Another nature-inspired proposal is made by Minh et al. in [6], where a memetic-algorithm for the VRP is proposed for waste-collection, under constraints of time-window and conflicts.

B. Smart Bin Technologies and Services A substantial component of enhanced waste-bin design rely on proprietary hardware and software implementation. In those surveyed, a common emphasis on measuring waste level or load can be identified. This type of design tends to be straightforward, where basic sensing for weight or for level (clearance) can be installed in order to recognize The level of waste bin fullness. Prajakta et al. implement a common smart bin design where they employ two types of built-in sensors, namely level-camera sensors and load cell sensors [7]. The camera sensor is set at a threshold level to check bin fullness while the load sensor monitors bin weight. Once an event is detected by either sensor, the bin is identified and consequently added to the waste collection route.

Our view is that such one-dimensional monitoring is limited, and that monitoring should extend to identifying the nature of the waste load in addition to its volume/weight, as well as identifying bin surroundings to identify over-filling or bad parking. For example, it is possible to design a system such as that proposed by Thakkerc and Narayanamoorthi in [8], which addressed recyclable plastic material. The proposal comprises a bin equipped with a Near-Infrared (NIR) reflectance spectroscopy sensor that is used to detect and isolate recyclable plastics. Three ultrasonic sensors are utilized near the top of the bin each with a different orientation in order to ensure an adequate coverage of the entire bin. The system further incorporates a load cell as a backup to the ultrasound sensor, but without considerations for fusing (combining) sensed data. A similar system is proposed by Bharadwaj et al. in [9], but with no emphasis on recycling. The bin is equipped with two IR level sensors, a load cell sensor to monitor the weight, and one or more non-waste related sensors such as a temperature and humidity sensor, in addition to a sound sensor to monitor noise pollution.

Several solutions for smart-bin design can be found in the waste management industry, including solutions from vendors such as Enevo, Ecube, and Labes. For example, Enevo offers a "smartening" solution where a bin is retrofitted with GSM communication capabilities, with a self-contained kit that includes a cyber-based DSS. The kit is comprised ofa level sensor, load sensors, a rapid temperature rise and motion sensors. The temperature sensor allows for the detection of fires, and acts of vandalism while achieving 20-40% reduction in collection cost [10]. Ecube offers a similar service that further includes a solar-power trash-compactor [11]. The retrofitting kit and smart bins are outfitted with multiple fill sensors along with a GPS for location monitoring and theft protection. was investigated by Catania and Daniela propose the use of the Smart-M3 platform to investigate cloud-based aggregation and processing of sensed data [13]. Employing such platforms facilitates easier data sharing, higher scalability and design flexibility. It also allows access to other platforms, both governmental and private, to achieve better resource management to be deployed in city areas and optimal planning of waste collection. It also allows normal users to monitor the status of bins in their vicinity which can work to curb the number of overfilling events. The Smart-M3 system is specifically open-source, which further allows for solution duplication and maintenance.

C. Motivation The aforementioned works in route planning do not comprise a comprehensive survey of the literature. They are representative of the general approaches applied in the context of route-planning for waste collection. It could be observed that such solutions mainly rely on road-network and road-traffic data in order to process collection routing and scheduling problems. Considerations are not made, however, for critical aspects such as neighborhood status (narrow paths with inaccessible bins to trucks), time of day, current events, and special circumstances of the region under consideration. Extending considerations for the status of the waste bin and its content is also yet to be made.

Meanwhile, the offered smart-bin solutions largely rely on level and load sensing to trigger the need for waste collection and including the bin on the collection route/schedule. Identifying load type or surroundings as well as more dynamic aggregation and processing of sensed data are necessary for future improvement and safety considerations. For example, in high temperate climates, even a low level of waste remaining for prolonged periods of time can become a fire hazard or a source of air pollution.

Our aim in this work is to design an integrated waste collection and routing system that takes the status of the surrounding area into consideration. The system integrates the smart bin design to improve waste collection efforts. Additionally, the system captures the dynamics of the smart bin as well as its surrounding area and the environment.

3. AN IOT-BASED ARCHITECTURE FOR WASTE MANAGEMENT

The proposed architecture comprises four main components, namely a smart waste-bin, a mobile app, a driver module and a cloud component. This details the elements and operation of each of these four components, as well as their interaction. A schematic overview of the system is shown in Figure 1.

A. Smart Waste Bin Technology and Services The smart-waste bin component of the architecture is responsible for updating the architecture components on its contents volume and type, as well as its surroundings. The smart waste-bin is equipped with a mix of sensors that facilitates both sensing and communication to the cloud.

The target implementation comprises a microcontroller, such as an Raspberry pi board. The microcontroller provides management to several connected sensors. Sensor choice depends on the implementation objective and configuration. A certain design instance detailed here assumes a basic implementation which includes the minimum necessary combination for our considerations. These include the following components and sensors:

a. Android mobile.
b. Raspberry pi board;
c. Ultrasonic sensors;
d. GPS;

Figures 1 illustrate the placement of the above components and sensors, with the label identifying the component/sensor number. component and sensor choice is discussed afterwards. The ultrasonic sensors provide data about the status of the the bin. For example, it provides information if the bin is temporarily inaccessible due to full of garbage. The output of level detector is given to raspberry pi board When the dustbin is filled up to the highest level, the output of ultrasonic sensor receiver becomes active low, this output is given to raspberry pi board to send the message to the admin module via IoT module.GPS identifies the position of the waste bin, while the microcontroller is used for data collection, aggregation, and transmission to the cloud.

B. The Driver Module The mobile app is used by municipal waste disposal vehicle drivers to identify the route and scheduled bin location. The mobile app functions as a point of connection between the driver and the cloud. Additionally, the mobile app can be installed by the residential crowd to control dumping allowances per user or household.. Users can login using the app to see the status of the bin. The bin measures the waste weight at each usage for recording purposes. Fig 3 illustrate the driver module

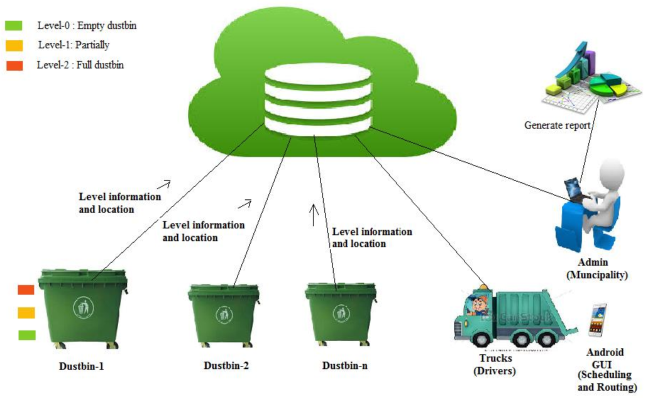

Fig1. Proposed IoT based waste management architecture

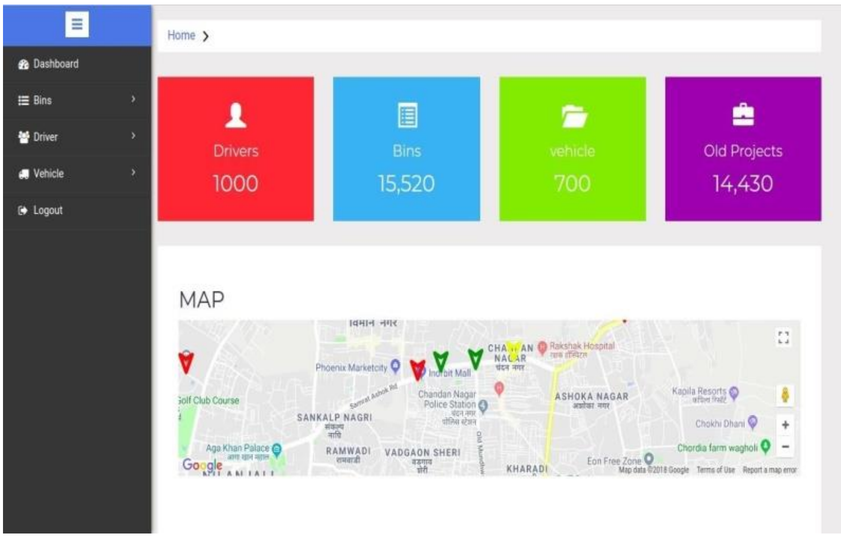

Fig. 2. An illustration of the Home page of the Admin Module

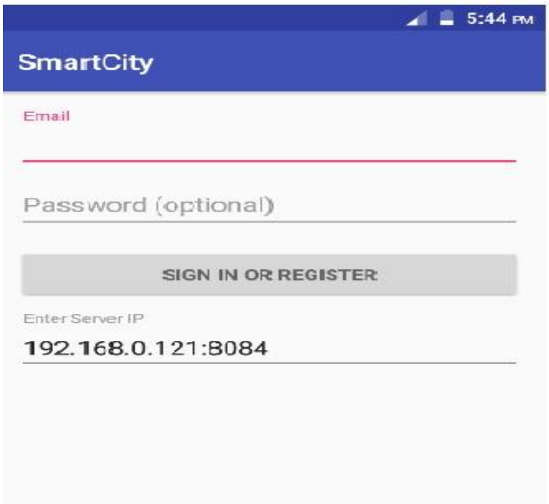

Fig. 3. An illustration of the Home page of the Driver Module

C. The Admin Module The web page is used by the municipal officer who work in the waste management department. the admin module functions as middle layer between the driver and the ultrasonic sensor.it receives the dustbin status via raspberry pi board and according to that it manages the driver module to collect the garbage from the bins. Fig 2 illustrate the home page of the admin module.

D. The Database Server The database is the main processing unit of the system. Data is aggregated from end-users' apps and drivers, weather condition, current sport and celebration events with a potential effect on waste truck routing or waste amount (month of Ramadan at night), traffic rush hour, and each bin's surrounding environment. Our proposed system reacts actively to the triggering events of waste collection by analyzing data from waste bins and drivers' apps to optimize the waste collection routes. For example, the system can react to traffic rush hour by avoiding waste collection from these areas during this period.

4. RESULT

1. Admin Module :	1. Receives the status of the bin from IoT module. 2. Allocate new driver. 3. Allocate new bin.
2. IoT Module:	1. Information in this architecture is transferred Via IoT module.
3. Driver Module :	1. Receives the notification when bin reaches to threshold value 2. Update the status of the bin

5. CONCLUSION

This paper presents an architecture based on IoT with the objective of improving waste management systems. Our approach is a holistic review of the waste management system, starting from smartening-up the waste-bin to optimize waste collection times and anticipating the nature of collected waste to considerations of the collection vehicles, their route planning and scheduling. The presented architecture depended on a cloud-based implementation for the processing and computation core.

The system offers great flexibility in terms of implementation, especially given its complete dependence on off-the-shelf technology. It also allows for varied waste-collection objectives. The architecture is currently undergoing prototyping of its different components, and future work will offer further elaboration on their implementation and testing.

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