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A Reward-based IoT Solution for Waste Management with Automated Waste Segregation

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Abstract : The existing waste management system in Bengaluru, India, takes a toll on the municipality workers in terms of segregation. Due to a lack of awareness and poor segregation by citizens, waste is not disposed of properly, making many reusables unusable. It also leads to pollution and serves as a breeding ground for a variety of diseases. This paper proposes a system to counter the raising issue in the city. 'Wasteful' is a reward based IoT solution for the current waste management problem with the introduction and implementation of automated waste segregation system. The automated waste segregation system segregates the waste into wet, dry and metallic waste. The architecture of the system is divided into three parts—(a) Waste Facility, The IoT based system using RaspberryPi, (b) Wasteful Mobile application and Website, (c)AWS IoT core, which acts as the main mediator between the Waste Facilities and users along with AWS micro-services and Database.

IndexTerms **- waste management,automated waste segregation,AWS IoT core,RaspberryPi.**

I. INTRODUCTION

Waste discarded on street sidewalks is now a common occurrence in the city. Several issues arise when waste is not properly disposed of, such as, (a) breeding of various insects and contaminations leading to a lot of diseases, (b) generating a large amount of additional waste that cannot be reused, recycled, or degraded, (c) leading to several stray animals consuming toxins and non-edible wastes and (d) contributing to pollution, exacerbating the existing climate crisis. The waste collected by the municipality often is not segregated well with several localities segregating just the dry and the wet waste. Furthermore, this leads to citizens segregating a variety of other types of waste, such as medical, electronic, and glass waste, into wet or dry waste only. This in turn proposes safety concerns for the waste management workers.

Wasteful is a system that aims to install waste facilities throughout the city. The waste facilities are small spaces around the locality or a floor in an apartment that the users can utilize. The facility will have an automated waste segregator for daily household waste, which is segregated by the system into wet waste, dry waste and metallic waste. The facility will also have separate donation bins for wastes such as books, clothes and e-waste in case a user wishes to donate.

The users will have to log into the facility before being able to utilize the system. This authentication allows for rewards allocation based on the waste disposed by the user. The user is authenticated on the cloud using his/her phone number. If the user does not exist, a new user is created with the phone number. Once the user utilizes the facility, the data regarding the amount of waste disposed with the type of waste is pushed to the cloud through AWS MQTT client after which, rewards are generated for the same with the help of Lambda functions.

Users of the Facility can then use the mobile application and website to review their profile and redeem their rewards. The users can update their profile, check for the nearest facility and even call for new facility instalments in the given area. The application also provides the means for customer support and information regarding the system.

With several types of waste collected by the proposed system, Wasteful can be connected to several companies and NGOs that utilise these wastes. For instance, clothes donated for NGOs, books and papers for recycled paper manufacturers, wet waste for biogas plants and compost makers to name a few.

II. RELATED WORKS

Several researchers have proposed similar approaches when it comes to automated waste segregation system. An automated waste segregation system that segregates waste into wet, dry and metallic is implemented using Arduino Uno in [1]. The working of the similar waste segregation system is well explained by [2].

Reward based waste segregation is introduced in the proposed automated segregation system, that encourages people to use the system in return for some perks [3].

A GSM alert based automated segregation system is proposed which notifies the user when the SmartBin is full [4]. A similar approach is proposed with the automated waste segregation and monitoring system, which introduces a LCD for feedback and monitoring [5].

An alternative approach for automated waste segregation is proposed where waste is classified through image-processing using Computer Vision and Deep Learning. The approach uses YOLOv3 (You look only once) which is developed based on Convolution Neural Networks (CNNs). Furthermore, the approach introduces composting for bio-degradable wastes using the Berkley Method of Composting [6].

The approach taken by this paper, proposes a complete IoT based solution for the automated waste segregation. The proposed system contains 3 main bin sections, to begin with Regular waste - The daily waste from household can be dumped in this section. Electronic waste - E-waste for example old CDs, Electronic tapes, etc. can be dumped in this particular section. Cloth and Book waste, this section mainly acts as the donation bin. Our system also avails rewards to the users through the mobile application. Once they gain enough points, they get a chance to unlock the coupons as their reward and they can redeem them. The coupons could be like buying a product through online shopping sites. The complete proposed solution also serves for a smarter and cleaner city.

III. PROPOSED SYSTEM

Fig. 1. illustrates the facility level of the proposed system. The users utilize the facility which are equipped with bins designed for various types of wastes. The data regarding the user, facility and the bins is updated in the cloud service. The rewards are generated and updated in the user account. The data regarding the bins is updated to the companies of interest which then can collect the waste from the site.

As depicted in Fig. 2, the proposed system overall acts as middleman between the users and companies that utilize these wastes. The facilities, throughout the city, are connected with each other to ease the flow of waste collection for users as well as the companies of interest. The profits from the companies are in turn used for maintenance, improvements and rewards for the users.

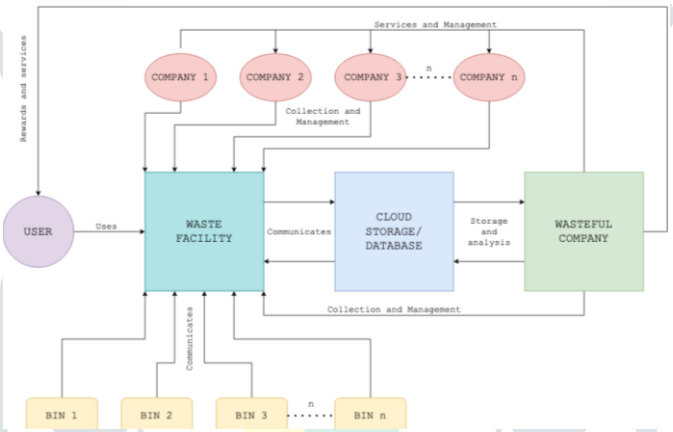

Fig. 1: Wasteful Facility Block Diagram

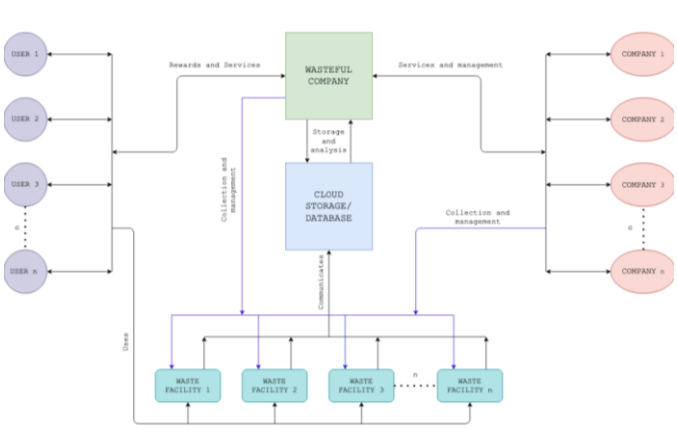

Fig. 2: Wasteful Company Level Architecture

IV. EXECUTION OF THE PROPOSED SYSTEM

4.1 Waste Facility

The current system architecture for the Waste Facility sits on a RaspberryPi. The code for the entire system is written in Python. A keypad (4x4) with a display (LCD) is presented at the start for the user to enter their phone numbers. The phone number is used as a primary key for identifying user and if the phone number does not exist, a new user is generated. Once a valid number is entered and user identified, the waste collector system is activated. As shown in Fig. 3, the system is categorized into three sections—Regular waste bin, electronic waste donation bin and clothes & books donation bin.

The category of waste is detected by the IR sensor placed at the entrance of each category. In terms of the regular waste category, an inductive proximity sensor is used to detect metallic wastes and a soil moisture sensor is used to detect any moisture in the waste indicating wet waste. In case both the sensors signal false, the waste is assumed to be dry waste. A stepper motor is placed at the entrance of the category, which sweeps according to the type of waste detected to direct it to the respective bin.

As shown in Fig. 4, a conveyor belt is placed on the system which directs the waste from the entrance to respective bins of each category. In case of electronic waste donation bin and clothes & books donation bin, the conveyor starts moving as and when the waste is detected by the IR sensor.

Once, the waste reaches the bin, level of waste is calculated using ultrasonic sensors. In the proposed system, the level of the bin is calculated by finding the distance between the sensor and the topmost waste in the bin. Equation1 is used to calculate the same of each bin where '*level*' refers to the level of the bin, '*totalCapacity*' refers to the total distance from the sensor to the base of the bin when the bin is empty, and '*time*' refers to the raw ultrasonic value received.

$$\square\square\square\square\square = \square\square\square\square\square\square\square\square\square\square\square\square\square\square - \left[\frac{(0.034+time)}{2}\right] \quad (1)$$

The type of waste along with the facility ID, user phone number and the amount of waste is published to the AWS IoT core. The entire facility of the system can be modified as per needs. Some of the modifications include RFID system for user authentication instead of phone number, different types of bins suited for the location and use of load cell or any other type of weight sensor to calculate the amount of waste disposed.

Fig. 3: Waste Facility prototype - Front View

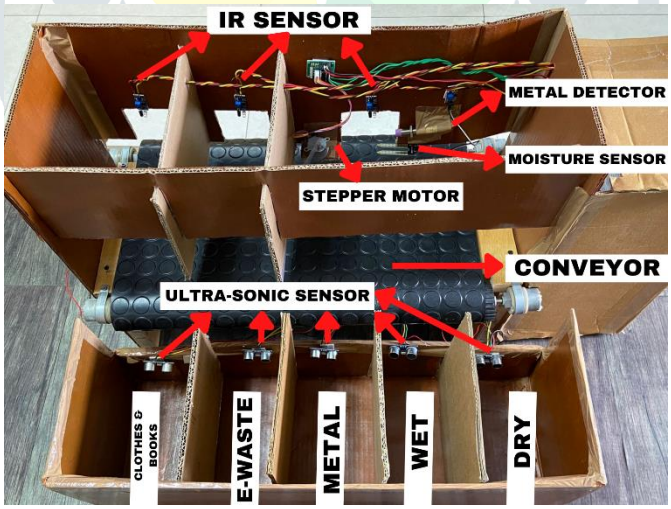

Fig. 4: Waste Facility prototype - Top View

4.2 Cloud Architecture

The proposed system takes up the approach of AWS 'serverless' architecture, which abstracts out the complexities and technicalities in setting up instances on the cloud. The system uses AWS MQTT client for communication between the IoT core and the Waste Facility. Each waste facility is assigned an ID for the IoT core to identify. The details of the facility such as bin levels are published to the cloud along with the facility ID. The details of the users and amount of waste disposed is published to the cloud as well, along with the user phone number and facility ID.

The Aws IoT core subscribes to the topics the facility will publish to. The proposed system utilises AWS Lambda functions to mediate the communication between the IoT core, database and APIs. The data received from the facility is updated in the database through these Lambda functions. The data from the database is then pulled through Lambda function and passed on to the API to be later pulled by the mobile application.

4.3 Mobile Application and Website

With the help of AWS API Gateway, the data from the cloud is pulled and displayed on the mobile application and website. Each user can log in to the mobile application with their mobile number and password, check their profile, check nearest facility and even redeem their rewards. The android application provides customer support through in-app chats, FAQs and contact support for the user assistance.

V. CONCLUSION

Wasteful proposes a solution for waste management along with encouraging the citizen to follow through. The waste facilities are connected throughout the city for users to utilize. The proposed system is flexible, and it can be modified according to requirements, such as, medical waste bins specifically suited for hospitals. The proposed system is cost efficient and smarter than some of the existing work. With limited means for segregation, the paper is open to research and improvements.

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