A SURVEY ON INTERNET OF THINGS BASED SMART BIN

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Abstract: The conventional method of waste management has proven to be quite expensive and time-consuming, and the sorting of waste still is a challenge in traditional systems due to the lack of a habit of waste segregation by category. With the advent of IoT and IA technology, however, the traditional waste management approach can be replaced by the implementation of smart sensors for real-time monitoring and waste assessment, presenting an intelligent waste management system that saves both time and money. The main goal of this study is to develop a smart waste bin, equipped with sensors and actuators, to enable the proper allocation of waste for citizens' benefit and environmental cleanliness. The ultrasonic sensors for filling level, sensors for user identification, servo motor for lid opening, LCD display for fill level notification, motion detection sensor for identifying user departure and lid closure, camera for capturing garbage type images, and GPS sensor for basket location notification will all be connected to an Arduino UNO and a LoRaWAN network for communication between nodes (baskets) and database servers for system processing and monitoring.
Keywords: Internet of Things, Smart Waste, Smart Bin.

1. INTRODUCTION

The trends of contemporary living in society have become increasingly reliant on sustained connectivity, resulting in the emergence of the 'Internet of Things (IoT)' concept, forty years after the invention of the internet. The cohesiveness behind the advent of IoT is believed to have materialized during 2008-2009, when individuals began to experience an overload of interconnected network devices. The quantity of connected "things", including both individuals and devices, has experienced exponential growth over time, necessitating the existence of IoT. Due to the innovative impact, it has had on society, resulting in the development of online communication between devices, the creation of intelligent cities, and the facilitation of people's lives, IoT has appeared as one of the most popular technologies. A smart city is a complex infrastructure that employs various sensors to collect and analyse data to manage assets and optimize resource utilization with minimal waste. The aim of a smart city is two-fold: to enhance the utilization of resources and to provide its inhabitants with a high standard of living. A smart city is not an autonomous infrastructure, but rather a compilation of several sub-infrastructures. Our focus in this paper is Smart Waste Management System. The challenge of implementing a waste disposal system without compromising the cleanliness of the city is currently being faced by numerous developed and developing cities. Proper waste management needs a substantial infrastructure, workforce, and funding, which many cities, both developed and developing, lack. Inadequate waste management leads to the accumulation of waste within the city, contributing to an unclean and unsanitary environment, while developed cities that successfully implement the right infrastructure for waste disposal incur significant expenses. Recent reports have revealed that advanced cities such as New York spend billions of dollars to manage their waste. Consequently, there exists a pressing need for a dependable, facile, and cost-effective waste management system. Waste management represents an important challenge confronting contemporary society, serving as a clear indicator of collective concern for the environment(Galinina et al., 2016; Goumagias et al., 2021).

In both personal and professional contexts, every individual has a role to play in the management of waste. The decisions we make regarding our contribution to either a sustainable society and economy or a deteriorating environment and ecosystem are of immense importance. Even though authorized collectors cater to a substantial proportion of the population in the region, the rampant disposal of waste in illegal landfills remains a major issue. Moreover, there is a dearth of selection and recycling options, and the inadequate information and data regarding waste types further worsen the problem. The primary institutions responsible for waste management also face capacity constraints. To make greater progress and achieve better results, the proposed plan aims to address these challenges and implement corrective measures at a higher level. This will be based on a comprehensive understanding of how resources can be utilized and in compliance with legislative requirements(PLANI-KOMBËTAR-PËR-MENAXHIMIN-TË-MBETURINAVE-NË-REPUBLIKËN-E-MAQEDONISË-SË-VERIUT-2021-2031.Pdf, n.d.).

Smart bins play a crucial role in smart waste management systems by offering real-time fill level monitoring, optimizing waste collection, promoting waste segregation and recycling, reducing environmental impact, ensuring cost-effectiveness and resource efficiency, and providing blockchain transparency. Equipped with sensors, smart bins continuously monitor their fill levels and trigger collection requests when approaching capacity, optimizing collection schedules and routes (Diware, 2023),(College of Computer Studies, Northern Bukidnon State College, Philippines et al., 2023). This leads to reduced fuel consumption, cost savings, and a lower environmental impact (Kumar et al., 2023). By providing accurate data on fill levels, waste management teams can allocate resources effectively and focus on bins that need immediate attention (Antora et al., 2022). Some smart bins have compartments for different types of waste, encouraging users to segregate their waste and promote recycling and proper disposal practices (Antora et al., 2022) . Optimized waste collection reduces emissions from collection vehicles, contributing to a decrease in the carbon footprint and environmental impact of waste management operations . Smart bins also contribute to cost-effectiveness by reducing unnecessary trips, saving time, and using resources efficiently . In systems that incorporate blockchain technology, smart bins provide transparent and immutable records of waste disposal and collection data, ensuring accountability and transparency . Overall, smart bins are integral in transforming waste management into a smarter, more efficient, and environmentally conscious process .

2. LITERATURE REVIEW

The following research paper (Soh et al., n.d.) presents the outcomes of a Smart Waste Collection Monitoring and Alert System based on the Internet of Things (IoT). The purpose of this system is to keep track of waste material at designated garbage collection areas. The system runs by utilizing an ultrasonic sensor connected to Arduino UNO to monitor the garbage level in waste bins. The waste bin depth level is then transmitted through the Arduino Ethernet Shield, which connects to the Internet, and sent to the Ubidots IoT Cloud. This cloud stores the obtained waste bin level data into an IoT database, which is then highlighted on an online dashboard for real-time visualization. When the waste bin is nearly filled, the Ubidots Event manager triggers an alert notification that is sent to the garbage collector's mobile phone via SMS for immediate waste collection.

The proposed system aims to enhance waste collection efficiency and make it more systematic. The results of the study suggest that the proposed system can indeed increase waste collection effectiveness and avoid garbage overflow. However, it is crucial to provide better facilities for collecting and transporting garbage to further improve the waste management system.

The system is designed to be user-friendly and cost-effective, making it suitable for implementation in various waste management scenarios. The smart waste collection system is a significant step towards smart cities and a sustainable environment. The system can also be used to monitor waste material in industrial settings, where the volume of waste generated is large.

The proposed system has several advantages over traditional waste collection methods, such as reducing the time and cost associated with garbage collection. The system also helps to reduce the environmental impact of waste by promoting efficient waste collection and management. The smart waste collection system is a step towards achieving a more sustainable future.

Future work could include expanding the system to incorporate more waste collection areas, as well as integrating additional sensors to monitor other waste-related factors. The system could also be expanded to include machine learning algorithms to predict waste levels and optimize waste collection schedules. Overall, the proposed system has the potential to revolutionize waste management and improve the overall quality of life.

The issue of high garbage generation (Chowdhury et al., 2018) in India has become a significant problem that requires immediate attention. The existing methods of garbage monitoring and disposal are not efficient and further contribute to the degradation of the environment. A smart approach is necessary to tackle this issue and ensure proper waste management. In this regard, the proposed solution is an IoT-based approach that employs ultrasonic and MQ4 sensors for garbage monitoring and disposal. The system utilizes smart bins that can check the level of garbage filled in the biodegradable and non-biodegradable bins.

When the threshold level is crossed in the non-biodegradable bin, the information is sent to the municipal corporation for the disposal of the garbage. If the biodegradable bin exceeds the threshold level, a lid will slide open and the waste will be deposited in the underlying chamber.The microcontroller facilitates the interface between the sensor system and the GSM system. Furthermore, the Android device detects the location of the dustbin by comparing coordinates and updates the location of the respective vehicle to collect the waste. This will immensely aid in the efficient management of garbage collection.

The proposed system is a more convenient and practical approach to garbage monitoring and disposal, as compared to the manual system. It is a significant step towards a 'smart city' that emphasizes proper disposal of garbage and aims to restore the environment to a green and healthy state. The proposed system will also help in reducing the

risks associated with the accumulation of garbage and enhance the quality of life of the local population. Thus, the adoption of the proposed solution will contribute to the creation of a sustainable and environmentally friendly society.

The utilization of blockchain technology is suggested in this paper (França et al., 2020) to enhance the management of solid waste in small municipalities. The innovative system operates by giving permission to the citizens to sell their solid waste to the collecting agent of the City Hall voluntarily. The citizen is then rewarded with Green Coins that are equivalent in value to the market prices of the materials in currency. The citizen can use these Green Coins to purchase goods from authorized trades and the traders can exchange the Green Coins for currency every two weeks at the City Hall's finance office. The proposed system is built upon the Blockchain public network architecture of Ethereum and a cloud computing environment to ensure greater security and to protect against local risks, such as power outages, data loss, attempts to gain unauthorized access, and other typical issues. The methodology used in this research paper is the Design Science Research (DSR) that includes the development of an information system to solve the challenge of integrity and quality assurance of information in a business model. The proposed system is expected to offer a sustainable solution to the problem of solid waste management, and it is anticipated to be a significant contribution to the field of waste management. The use of blockchain technology in this system would encourage citizens to participate in the management of solid waste and promote a culture of recycling and environmental sustainability.

The paper(Sheng et al., 2020) discusses the development of a smart waste management system using LoRa communication protocol and TensorFlow based deep learning model. The system consists of smart sensors embedded into the system to perform real-time monitoring and allow for better waste management. The bin consists of several compartments to segregate the waste including metal, plastic, paper, and general waste compartment which are controlled by the servo motors. In the TensorFlow framework, waste classification and object detection are performed using a pre-trained model, while ultrasonic sensors are incorporated into each waste compartment to monitor waste levels, GPS modules are integrated for real-time bin location monitoring, and RFID modules are embedded to identify waste management personnel. Web-based Android applications are developed to interface with a web server to provide information from sensors monitoring bin status, amount of waste in the bin, and time of waste collection. The data are processed by a graph theory optimization algorithm to obtain the shortest path for reaching the bin to efficiently manage the waste collection strategies.

The paper discusses the creation of a smart waste management system that utilizes the LoRa communication protocol and a deep learning model based on TensorFlow.The waste detection model is trained using Anaconda Distribution, a general-purpose Python notebook used to perform tasks such as machine learning, training the neural network, data visualization, predictive analytics, and bias mitigation. Transfer learning is performed on a pre-trained model, SSDMobileNetV2 by retraining the model with our own sets of waste images. The training is performed until the error is around 1.0000, which took around 20000 epochs. The error is around 1.0000 because this is a lightweight object detection model suitable for portable devices like mobile phones and Raspberry Pi with limited computing power, but, on the contrary, it is able to perform detection at a relatively high speed of 31ms.11 represents the performance and precision of the waste detection model.

The paper concludes that the proposed system can effectively classify waste and monitor the filling level of the waste in real-time, which can lead to efficient waste management and reduction in costs.

The proposed study(Wahab et al., 2014) introduces a novel smart recycle bin application that utilizes information stored in smart cards to automatically determine the weight of waste and convert it into points, which are then stored in the card. The smart bins are equipped with an RFID-based system that integrates with a web-based information system at the host server, allowing for the monitoring and tracking of waste. This approach can significantly improve the selective sorting process by providing two crucial features. Firstly, the user is assisted in the proper classification of materials for disposal. Secondly, the smart bin can report its content to the recycling chain, which can facilitate the process of waste collection, planning, and special intervention by operators in case of abnormal conditions.

The study also highlights that the reported information about the content of each bin can be used to compute statistics on each type of waste in the recycling process. This can help to better understand and manage the recycling process, leading to more effective waste management strategies. The proposed approach is particularly useful for recycling glass (brown), paper (blue), and aluminium cans and plastic products (orange). The smart recycle bin can automatically evaluate the value of each waste item thrown in it and provide a 3R card, which can be redeemed for rewards.

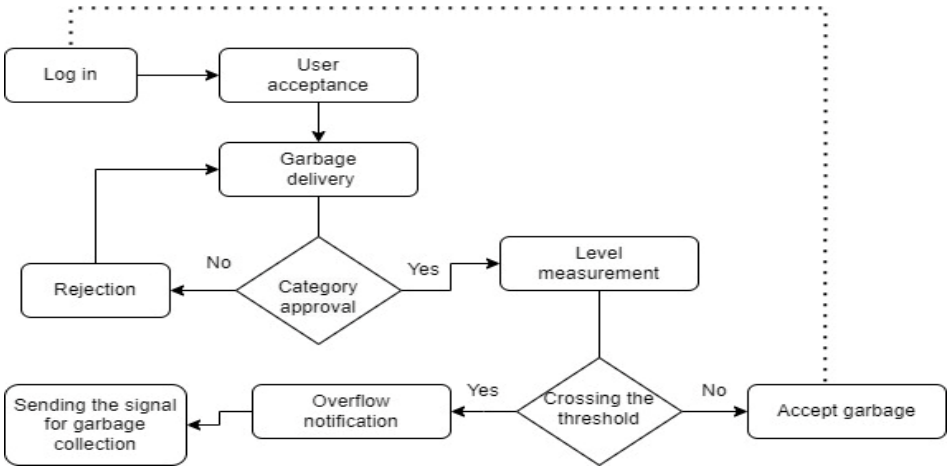
Overall, this study presents a promising solution to the problem of waste management by leveraging advanced technologies such as RFID and smart cards. The proposed approach can significantly improve the efficiency and accuracy of the selective sorting process, leading to more effective waste management strategies. The study also

highlights the potential benefits of using reported information about waste content to compute statistics and better plan waste collection and recycling efforts. This approach represents a significant step forward in the field of waste management and has the potential to make a significant impact on environmental sustainability.

3. PROPOSED SYSTEM

The initial stages of establishing an efficient waste management system involve the task of raising public awareness regarding the proper methods of waste collection and categorization, which serves as a fundamental aspect of this system. It should be noted that pre-sorting waste into distinct categories at the outset can significantly contribute to the overall efficacy of the process, thereby eliminating the need for further categorization at a later stage. Considering this, we have devised a Smart bin that, in addition to its other features, serves as a mechanism to encourage citizens to adopt responsible waste disposal practices by offering incentives for waste disposal according to specific categories. This objective will be achieved through the employment of one of the most widely discussed technologies of the present time, Blockchain, which will facilitate the distribution of Bitcoin coins as rewards.

Figure 1-Algorithm of garbage acceptance

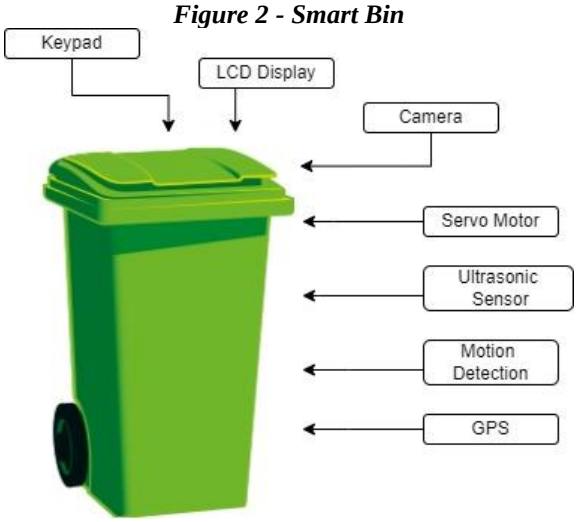


In Figure 1, a block diagram depicting the overall operating mode of the Smart Bin is presented. The figure provides a comprehensive perspective of the aforementioned block diagram. When users correctly dispose of trash, the Smart Bin triggers a reward transaction on the blockchain, issuing a certain amount of Bitcoins to the wallet address of the specified user.

On the outer structure there will be a small Bitcoin symbol or logo, indicating the integration of Bitcoin into the smart bin system. Blockchain facilitates secure and permissioned data sharing among stakeholders, such as waste management authorities, recycling companies, and environmental organizations. This allows for collaboration, coordination, and efficient decision-making in waste management processes.

The structure of the smart bin and the basic view is shown in Fig. 2 where we have shown all the necessary sensors and actuators. First, the person who will dispose of the waste has a kind of interaction with the smart bin by marking an identification code, a code which, after being verified, sends a signal to the Servo Motor, which opens the lid of the bin, the next step after emptying of waste is taking the image of the bin through a Camera placed in the lid which verifies if the type of waste has been thrown according to the specific category of the bin, and if the disposal is done properly the lid is closed but if we have thrown a product of another category then we do not have a lid closure and the reward transaction cannot be carried out in the wallet, so we have to remove the product. After the verification is done, there is also a Motion Sensor, which will show that there is no person in front of the bin, so the final closing is done to continue then, if necessary, with the throwing of waste by other people. Also, at the moment of closing, we have the Ultrasonic Sensor for measuring the distance to the nearest object, that is, the identification of waste - how close they are to the lid. This device is placed inside, or on the lid of the bin, or on the frame as close as possible to the lid (without obstructing its opening), with the two cylindrical sensors oriented towards the bottom of the bin. The purpose is that when the lid is closed, the sensors measure the distance from their position to the waste that is at the top, and compared to the depth of the bin, calculate the percentage of how full the bin is.

Figure 2 - Smart Bin



We have also presented the information about the level of filling of the bin in percentages on an LCD located in the Smart Bin exposed to all users. All these data will be stored in a database where we will have information about all registered users and for all the smart bins located at certain points. Also, the bins are equipped with GPS to determine the location. All this data will be processed and assembled from the base.

4. CONCLUSION

The implementation of smart sensors and IoT technology in waste management systems can provide real-time monitoring, waste assessment, and intelligent waste management, saving time and money. The proposed smart waste management system using IoT, and deep learning models can enhance waste collection efficiency, avoid garbage overflow, and promote efficient waste collection and management. The system can compute statistics on each type of waste, leading to more effective waste management strategies. The integration of blockchain technology facilitates secure and permissioned data sharing among stakeholders, enabling collaboration, coordination, and efficient decision-making in waste management processes. The proposed system aims to achieve a more sustainable future by reducing the time and cost associated with garbage collection and reducing the environmental impact of waste.

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