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SmartBin: An Approach to Smart Living Community Using IoT Techniques and Tools

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***Abstract*- Nowadays, individuals are getting steadily dynamic in achieving the possible ways to clean their environment. The concerned teams have initiated other developments to build tidiness. Previously, prior data on filling the trash container was required, which cautions and sends cautioning messages to the city workers for cleaning the trash receptacle on schedule and protecting the city. In this framework, numerous dustbins through urban areas from various regions are associated with utilizing IoT innovation. This program can be used conveniently to verify the status of the dust bin, the garbage in the dust containers, clean the dust bin on time, and maintain the atmosphere's safety and prevent contamination from overflows from the dust containers. So, people don't have to test everyone's work manually, so they'll get a warning if the container is full. A sensor over the garbage container would be placed to detect the full amount of waste, and when it exceeds the excessive volume, a warning will be transmitted to the company office. The proposed framework based on Arduino IDE, cloud computing concept and Load Sensor will help clean any city. Load Sensors are utilized to distinguish the dimension of trash gathered in the containers. The application also gets Latitude and Longitude estimations of the territory where the Garbage Bins are put.**

***Index Terms*-- Android, Blynk app, Arduino, Cloud Computing, GPS Module, IDE, Microcontroller, Sensors.**

I. INTRODUCTION

This task aims to develop a smart bin that checks the Garbage level in the dustbins and the area of the dustbins through the Internet. However, pictures of over-full waste baskets and the refusal from containers can be seen all around for implementation purposes. Strong waste management is a major test in urban areas. The smart dustbin is thus a device that eliminates this issue or raises it to the base level. If nothing else, Greater sections of the viruses and bacterial waste cause degradation of the infected environment. This is increasingly important to secure the atmosphere through technological outlets. Agreeing to the UN, the percentage of inhabitants will rise by 20 percent to 8 billion from 2020 to 2025. While doing what it takes, our waste control programs and financial conditions are not prepared to tackle waste.

One of the difficulties in improving and making an IOT-empowered arrangement is in checking the executives of the earth. It is commonly perceived that there is a solid connection between the compelling administration of trash, decent personal satisfaction, and a sound domain. A spotless and sound condition especially impacts the engaging quality of the nation to remote guests and ventures. By 2030, nearly 66% of all people will live in city societies. This needs the improvement of realistic quires for urban living. These patterns bolster the advancement of New Urban ideas, which are expected to advance life in metropolitan regions by utilizing imaginative innovations. The "Web of Things" gives another chance to develop urban communities shrewdly and effectively.

Nowadays, bins are overburdened, and all waste flows out, causing pollution. The discovery, checking, and waste board are today's required difficulties. A traditional method for watching the diminution of unwanted holders is a perplexing, cumbersome approach that necessitates a rising amount of human work, time, and charge, which is incompatible with today's revolutions in all dimensions. To overcome such issues, there is a need to develop a bin in which the garbage procedure is digitized. The proposed work on Smart Garbage Monitoring Framework using IoT is an innovative plan that will maintain modern societies clean and healthy. Our project aims to create a system that can manage and handle all of the actions that go into making a Smart Bin a success. This will assist in testing trash rates in dustbins and display the dustbin's location on Google Maps. Previous projects have examined the risk bases and swift comebacks.

II. PROJECT SCOPE

In the present situation, we see the refuse containers being over-burden and all the waste spilling out, bringing about contamination. The discovery, checking, and waste board are the necessary problems of today. A customary way to observe the decrement in un-wanted holders is a confusing, bulky procedure

that requires increasing human effort, time and charge, which is not good with today's revolutions in any dimensions. This strategy is progressed in which junk the board is computerized. This task of a Smart Garbage Monitoring framework utilizing IoT is a creative agenda that will keep modern societies clean and healthy.

III. PROPOSED SOLUTION

Our project aims to make a system that can manage and handle all the activities involved to make a Smart Bin successful. This would help test the dustbins' waste rates and display where the dustbin is on Google's map. The bases of risks and quick comebacks are tested from previous programs.

IV. LITERATURE REVIEW

The smart dustbin proposed by Sukholthaman and Shirahada [1] is based on IoT, in which an Aurdino Uno board platform with a GSM modem interface and an ultrasonic sensor is used to build the smart bin. The sensor position is at the top of the bin and 10 cm threshold level. The sensor activates and initiates a trigger as soon as the garbage is on the same level as the threshold value. The sensor triggers the modem, which alarms the administrator of the app till the garbage in the bin is emptied. It was concluded that some factors, e.g. durability, affordability and maintenance, should have been considered during the design of the smart bin. This added to a sanitized and uncontaminated environment while going through efforts to build a smart city.

The researchers[2] have discussed the management of the garbage collection problem. They created a model of the bin having a microcontroller interface with an IR wireless system and a central system which gives the status of rubbish in the bin. This status of the bin could be checked on an html page from the mobile phone's browser. One incorporated benefit was cost reduction. Only WI-FI was needed for sending or receiving data on the sender device, and on the admin side, a weight-based sensor was needed. The only problem was the sensor could not detect the level of waste but only the weight.

A method for garbage collection in residential areas has been discussed in [3]. Compared to previous ones, this methodology used an ultrasonic sensor to detect the garbage status. This sensor transmits the data with the help of a GSM module to the controller. The GUI developed by them was built using MATLAB. In addition to this, two sets of 3 slave units were attached in the bin and the control room, and there was also a master unit.

The researchers [4] have formed a measurable examination between current bins and their serving population. "The work done at first checks the delivery of bins in some areas of Bangladesh territory using average adjacent neighbour functions. Most specifically, the current bins' spatial circulation has shown to be dominatingly grouped. As a result of this, a large number of extra bins were designed. It is shown that the number of existing dustbins is not enough in the study area. Analyst functions are used for calculating the increase in pollution produced by the existing dustbins. It is found that fire is used to get rid of the trash, and this causes air pollution. "The conclusion thus obtained would appreciate the recent waste management situation of Research Article Volume 6 Issue No. 6 International Journal of Engineering Science and Computing, June 2016 7114 http://ijesc.org/ Dhaka city and to maximize place the required number of dustbins to prevent further pollution to the environment.

The researchers proposed an IoT-enabled SWM for smart city applications, which helped collect on-time garbage and reduced the total cost of the garbage collection process. The proposed work demonstrated that the waste management system in IoT emphasizes the concerned members to detect cleaning problems in real-time. Therefore, productivity along with cleanliness is surely provided by this system. The end-to-end delay has been considered for the proposed framework [5]. The term "delay" is signed as the total period taken by a pack to get reached the destination, which results from many factors that include the level of interference along the path. The delay of Propagation is also considered during the evaluation of delay. It has been seen from the results that the proposed scheme outperforms the current works.

This research work clearly emphasizes terminating the trash from garbage bins automatically when a specific level is reached. The approach has paved an amazing way to construct a smart city with appropriate hygiene techniques involved. Automation easily tracks reducing the manual effort along with the tough process that's involved in terminating the wastes of dumpsites [6]. This method also minimizes the number of vehicles used for the process every day, saving fuel and workforce costs. By implementing or including such the smartest technologies in our daily life, tidiness can be maximized in the city, and the life span of living organisms can be extended.

Another recent work [7] suggested an IoT-focused, intelligent waste clean system for cleaning sensor systems to check waste levels in the waste containers continuously. With this method, the device warns the approved individual automatically via GSM/GPRS once the waste level is sensed over the dustbins. The system uses a microcontroller which offers the GSM/GPRS system interface between the sensors. In addition, an Android program is used to track the related information on various waste levels in different locations and to incorporate the information. A new user will log on to the list and not just the manager of this system. However, anyone will set up an account, and the system allows users non-designated access to the account. This method can be enhanced by positioning two bins to collect dry and wet waste separately. In this situation, the wet waste can be further refined and used for the processing, lightweight and cost-effective, of biogas that is durable.

Navghane et al. [8] have also suggested using the combined weight and infra-ray sensors for an adaptive waste collection bin. These sensors are fitted respectively with the capacity to detect weight and various waste amounts. In this situation, the IR sensors will view the different waste levels in the dust bins and activate the weight sensor to forward the results when their threshold level is reached. A cell phone with a Wi-Fi router is also supported to view details of the waste bin via a web browser using Javascript. However, the device disadvantage is the inability of users to gain notice of the bins status and assign

collection trucks when a person does not have access to the handset or when the battery or the Internet fails. In future, the device may be expanded by submitting the bin status to the cleaning vehicle directly rather than the authorized office of the individual.

Prajakta et al.[9], suggested an automated waste management method based on image processing and the GSM module. The machine uses a camera to gather garbage at any location alongside a load cell sensor situated at the base of the trash bin to accomplish that. In this case, snapshots of the basin are taken continuously while the load cell sensor takes the weight to verify whether they are complete. In addition, the threshold level for comparing the camera's result with the load sensor is set. After meeting the threshold, the controller will send a report to the responsible authority via the GSM module, notifying them of the complete disposal of the waste bin. The vehicle for collecting the waste bin is then dispatched to collect waste using a robot mechanism. The pitfall is, however, that the camera takes images during the entire process, although its threshold is met. The use of a camera is either inappropriate or meaningless.

Kalpana et al.[10], proposed that stores all the data about the dustbins and their server location. The users are liable in this framework for tracking the waste level in the bin and submitting such data to the server. The related authority accesses the information through the web at the receiving end, and an urgent response to the disposal of the bin garbage may be launched. The bin can only be disconnected from the system if a user sends a bin status via a mobile application to the server. The downside is that the concerned authorities cannot monitor the level of waste in real-time but must wait for messages. Furthermore, if the user cannot send the message, it means that if the bin is full, the environment is littered with waste.

Ghate et al.[11], suggested in their work a device that could tell about waste bins when they are complete or at the waste level. Alerts are then sent to the relevant authority to promptly remind them of the waste disposal in the bin so that the air stays safe. The ZigBee and GSM technologies allowed remote monitoring of solid waste bins in real-time, particularly if nearly complete, to notify the corresponding authorities about the waste bin's status. The disadvantages are, however, the limitations of the systems used. In the event of changes in environmental conditions, for example, GSM has a bandwidth delay, Ultrasonic sensing precision, and ZigBee has a poor transmission rate. These factors influence optimal system efficiency. A web server will be built to provide efficient GUI and control and an embedded framework for all containers fitted with GPRS. Thakker et al. [13] proposed an intelligent waste bin with alarms working following other systems. The machine will alert the appropriate authority when the waste bin is ready or fully full. In addition, the project recommends a technique to eliminate biodegradable and non-biodegradable waste using NIR spectroscopy rather than dumping all sources of waste on landfill sites. The downside of NIR is that it contains fewer spectrum details and can be impaired by accuracy. The approach to the waste collection has been developed by Mahajan et al. [14]. This device integrates sensors into a typical garbage bin in public places and sends the ARM 7 controller a warning to the garbage collection truck driver when the waste bin hits the sensor level. It is said that the garbage bin has been finished and must be emptied as soon as possible. The restriction of technologies used nevertheless influences the system's optimal efficiency, as defined in [14].

Papalambrou et al.[15], proposed a multiuse and flexible waste bin device architecture that can identify and provide reliable waste amounts of the containers while using less energy and providing economic sections. The machine uses ultrasonic sensors that detect and transmits estimates of waste fill levels: the modelling, simulation and execution of the framework with MATLAB. In applying the RFID technology, the data collectors and the RFID reader read and interpret the details and have active RFID tags. In addition, the statistical study of the simulation in conjunction with tests and field research has verified the system's accuracy and reliability using a limited fingerprint data load. However, the downside of this work can be less accurate and ultrasonic sensors impaired by sensing precision under shifting environmental conditions, including the disadvantage of the technology used like RFID. The maximum machine efficiency was greatly hampered. Al-Jabi et al. [16] suggested implementing an appealing waste management scheme. To assess how people deal with waste control, the machine incorporates IoT cameras, RFID tags, weight and ultrasonic sensors. However, this proposed alternative restricts using an RFID card for identification via the RFID reader attached to the bin whenever a person chooses to put trash. In this respect, the state of bins cannot be submitted to an application server if a card is missing or harmed. Thus, implementing algorithms to account for the bin filling rate, the position of the collecting truck and the shortest route to the location can boost this method, so that each bin can efficiently measure its threshold and simplify the bin dumping operation. Baby et al. [17] created an intelligent waste bin to gather waste easily. The machine works by alerting the relevant storage and disposal authority about the condition of a bin. The machine guides the waste trucks to places where the bin is filled. When it senses the waste bin level has been hit, the device immediately sends notice in email and text messages to the competent authorities. The advantages of this scheme are the substantial time and resources saved by authorities, the elimination of contamination and the prevention of disease transmission. The restriction is, however, that the text message sent at the bin collection request does not specify the exact coordinates and identity of the bin.

Aazam et al. [18] suggested a cloud-based, intelligent waste management mechanism. The waste containers are fitted in with sensors to the sensor and warn the amount of waste sent and deposited in the cloud. In addition, the route can be configured and route chosen for waste collection based on obtained statuses of waste containers for efficient and productive urban and waste management. It is constrained in that since each form of waste must have a bin for recycling, door-to-door waste cannot be added. In addition, its expansion to a particular context and developments in particular waste treatment in a country may be the potential change. In such instances, the study of large data from multiple locations may be used to analyze the data gathered.

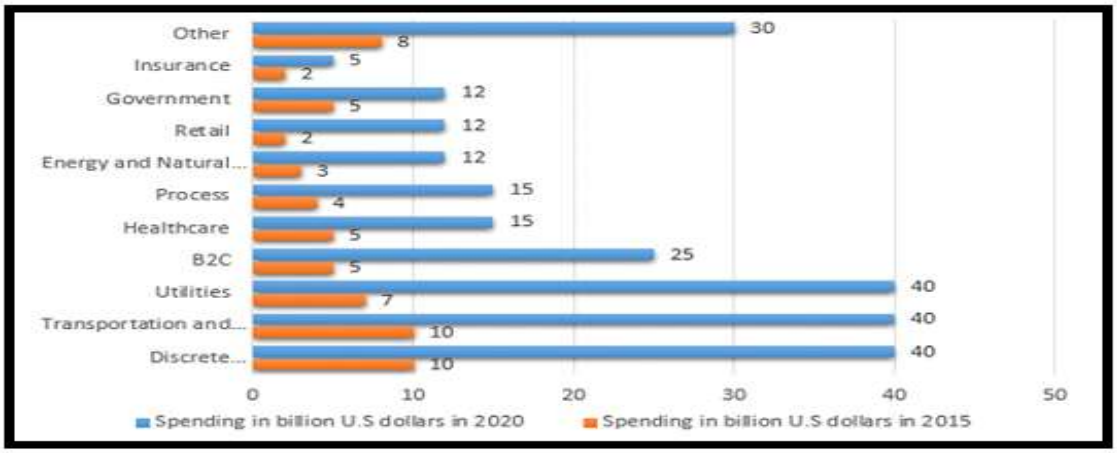

FIGURE 1. Total Spending on this technology [12]

V. OVERALL DESCRIPTION

We will develop a self-contained product to release corruption and make our environment clean and healthy. The system has three parts, i.e., dumpsite, control room and vehicle. NodeMCU will be placed as a foundation of our dumpsite. This will be attached with a few sensors named Temperature, smoke, load and other required environmental detectors. After detecting the level of waste, a notification will be generated to notify to control room for further actions. The control room has an application with the admin interface to check the notification and maintain records and database. The third part includes the vehicle sent by the control room to discharge the trash from the can, and vehicles have a building Wi-Fi for our dumpsite to transmit the data over the cloud for the control room's later use. That's why we are developing a product to make our atmosphere cleaner named "Smart bin" to help us make our environment neat and release the corruption of careless management (see Fig. 1).

The built application gives the following benefits:

- Waste Level location inside the dumpsite. Transmission of the data remotely to concerned authorities.
- Status of the System can be accessed from anywhere at any time remotely.
- Real-time information transmission and access.
- Avoids the floods of waste holders.
- The concerned authorities will send a vehicle through the optimal route to discharge the trash.
- Improves environment quality-Fewer scents and cleaner urban communities.
- This framework has no individual use. However, it can be utilized by a city, state or nation (see Fig. 2).

Using this framework, the waste gathering would wind up productively, and a decrease in transportation expenses can be seen.

In this different Operating Environment, we can execute this software and applications:

- Smart Phone (Android)
- Pc or Laptop
- Tablets
- GSM through portable devices

Likewise, the Internet is required to work on this product or application.

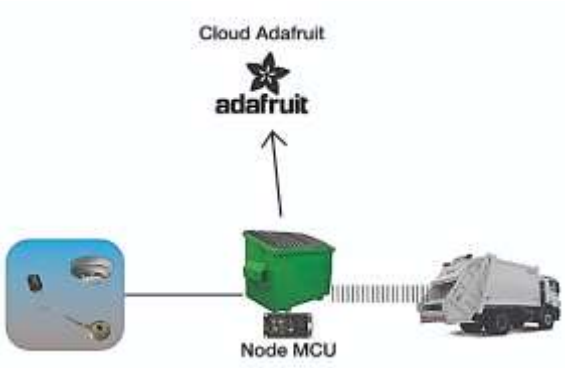

FIGURE 2. The physical structure of the "SmartBin"

VI. OVERALL DESCRIPTION

These are the following design, and implementation constraints are as:

• The knowledge of all dumpsites, vehicles and area locations must be stored in the cloud that is attainable through the application.

• SQL server will be used to get and retrieve data on the database.

• The Smartbin is running 24/7 a day.

• Administrator may access this product by using the application through mobile on which the Internet is available.

• All administrators have their unique Id and Password for entering the product and doing actions such as sending the vehicles to the concerned area.

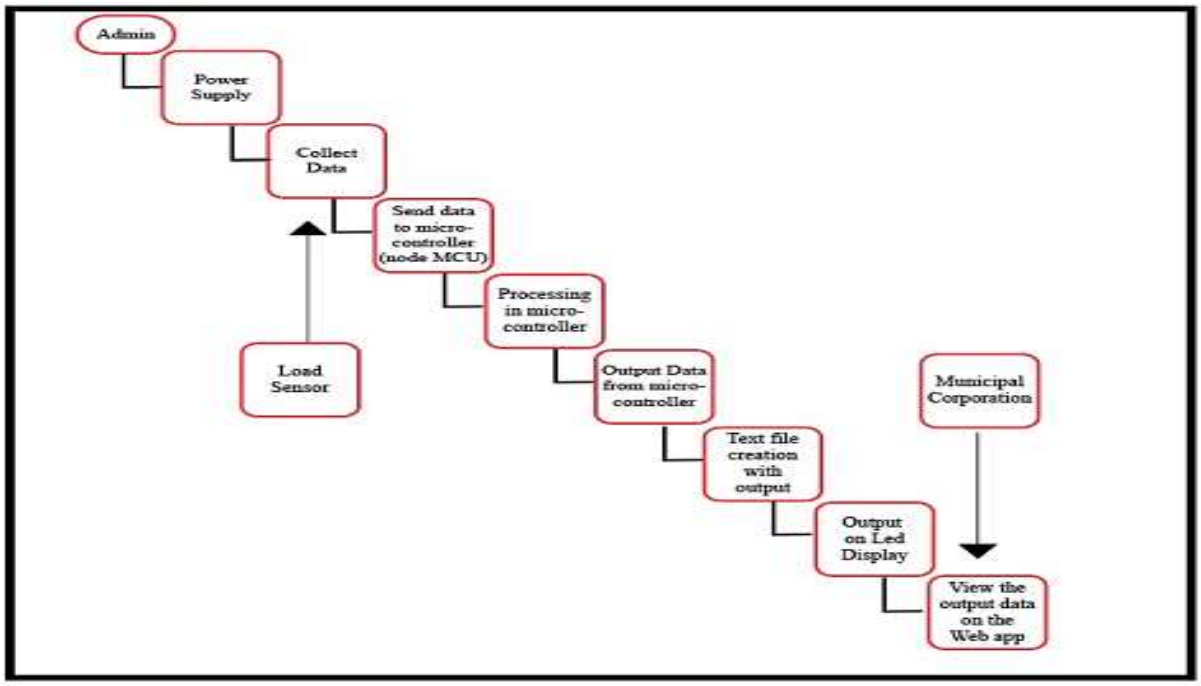

FIGURE 3. Workflow of the system

VII. OVERALL DESCRIPTION

The customary method for physically checking the losses in waste receptacles is an awkward procedure. It uses increasing human exertion, time and cost, which can be dodged without much of a stretch with our present advances. This is our answer, a technique wherein squandering the executives is computerized (see Fig. 3).

Our design approach is based on engineering design methodology and applies user-centred design principles. The design process starts with identifying the needs, deriving requirements, conceptualizing the solutions, evaluating the concepts and finalizing the design (see Fig. 4).

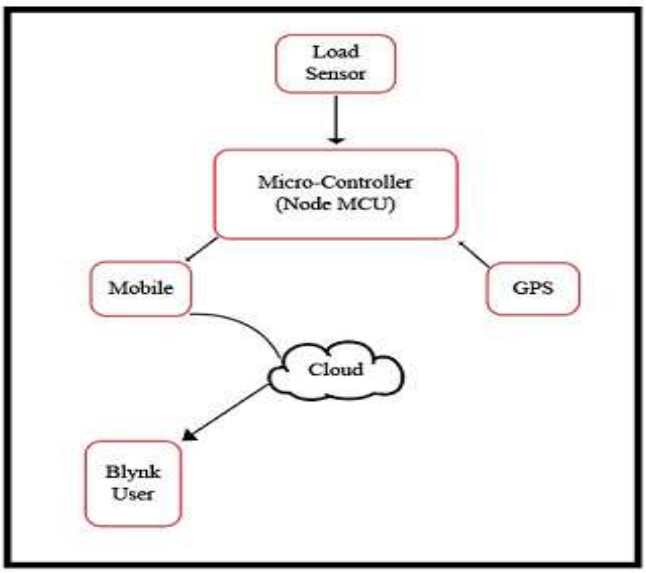

FIGURE 4. Methodology

VIII. FUNCTIONAL REQUIREMENTS

First, an administrator must create his admin id and password for doing activities on the product. There are two types of administrators in this product. They have different authorities and orders to do different jobs. These are as follows: administrators have complete access to perform functional work on the product and have all rights about the product use. He also gave the authority to act according to the requirement and maintained and updated the product according to the different time intervals and needs. Regular workers have only some rights given by the main administrator. They only use this product according to their rights.

The user of the system will check the updates about the dumpsites and the location of the dumpsites. Suppose we want to locate a new dumpsite in another or different area with a different level of trash. In that case, the administrator will update the system of that dumpsite according to the location and level of the dumpsite. And if we want to remove a dumpsite, the administrator will also update the system according to that.

IX. NON-FUNCTIONAL REQUIREMENTS

A. PERFORMANCE REQUIREMENT

For the development of any software, it is very important to design and create a copy of the required software capable of working on the requirements. The most important thing during the development of the software is the maintenance and gradation of software according to future requirements. And also, a very important part of the software is that if we want to upgrade our software and find some bugs in it, then we have a complete and easy way to remove and find the bugs that are present in the software. These are the following requirements to maintain the software in future for better performance:

- Different User Name and Passwords for Admin and Users.
- Security of the Passwords.
- Make a Successful Database.

B. SAFETY REQUIREMENTS

Safety Requirements:

Probably, if there is damage in a wide portion of our software database due to some issues, then hacking data from the database is possible. Due to this issue, the admin can also face some problems regarding the dumpsites and the location of the dumpsites and vans. So it is very important to do some secure and strong work. For any loss of data admin always has the backup of complete information on the product. Through this backup of data, he can recover his loss. The administrator should try to change the record secret key time by time, which could help lessen the opportunity to hack the information. Through this method, the administrator can make his product more secure from hacking information.

C. SECURITY REQUIREMENTS

Only the administrator can access all other user accounts to check the details and maintain the software. The worker working in this department has no access to check the data of other users and cannot check the administrator's data. Also, the administrator can check the location of the vehicles and dumpsites. Administrators have only the right to assign usernames and passwords to the user, and only they can register an authorized user. He can also protect his product from unauthorized users or persons.

C. EXTERNAL INTERFACES REQUIREMENTS

In external interface requirements, the software provides a good graphical user interface through which they can use and understand the system easily and operate the operation according to their requirements. In this interface, everyone can check the garbage level and the location of the dustbin, which can maintain and update according to the requirements. The following are the external interfaces requirements:

Arduino IDE, Arduino Language, Blynk Application, Internet, C/C++, and OS have been the software interfaces

D. FUNCTIONALITIES

The main purpose of the mobile application is to get the Garbage level in the dust bin and get a notification or status of the garbage in the dust bin. It's the most convenient method to Empty dust bins at the right time and makes our environment neat and clean from garbage overflowing from the bins. Through this mobile application, we can check the location of the dust bins. Through the application, we check our dust bin's location and also the status of garbage in the bins and collect garbage from the dust bins on time before it overflows the dust bins and also makes a neat and clean environment from the garbage and save peoples from different diseases that spread due to garbage. This meant use save Humanity also.

When the check first opens the Blynk application, he sees the home screen interface and the Google map to check the location of the garbage on the map. After signup the account with your G-mail id and get a password to check the details about the garbage level and location of the garbage throw map. He can also check the result online at any time, anywhere, through the Internet.

X. RESULTS AND DISCUSSIONS

After the successful implementation and testing of the application and the project is ready to deploy and show its features and functionalities into the client environment. We have used the Arduino IDE framework for the dynamic and responsive project. Moreover, the use of different Hardware makes the project more efficient. Through this Hardware, we can easily understand the working and the purpose of our project, and through this project, we can implement this part of Smart Cities in our cities to have a neat and clean environment. The keen canister was used without a battery charger and the power source by the power bank. The power bank oversaw effectively gave power to the module and kept the framework running. With the help of proper technology, the management can be guided in garbage collection. This project can add an edge to the urban area aiming to get smart and eco-friendly. The main aim of this project is to reduce human interactions and efforts along with the betterment of a smart city vision. We have often seen garbage spilling over from the dumpsite onto streets and the carefree behaviour of the community towards it, and this was an issue that required immediate attention. The process includes minimum human resources to handle the smart network of the system because s when humans have involved, the chances of errors are at a maximum level. So, with the proper guidance of the cantonment board or any other municipal corporation, we can build the less expensive and cost-effective module to implement the project on the smart city level here because the cost can be minimized on the higher level of implementation. Any other authority can also have our idea to give their best on the services like AL- Burak, LCB and LBW. These companies can implement this structure to provide the best services (see Fig. 5).

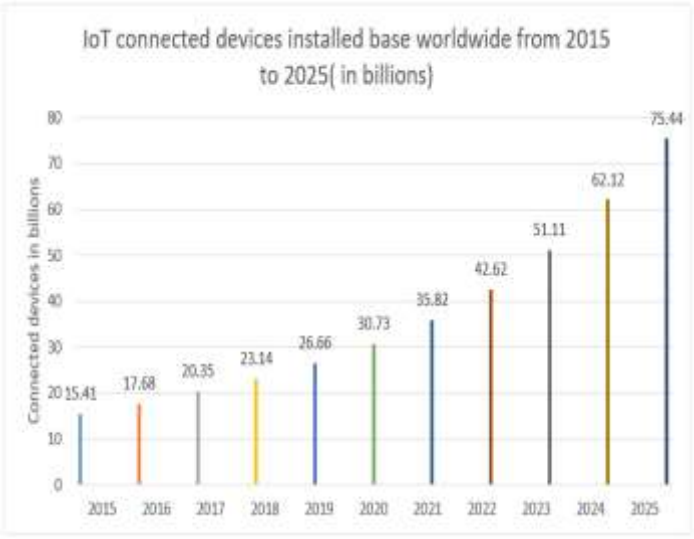

FIGURE 5. Installed base worldwide from 2015 to 2025 [7]

XI. WORKING

B. LID OPENING WITH RAIN SENSOR

The lid of the bin is closed when it is raining and open when it's dry outside. When the respective sensor is activated, the lid opens and closes accordingly to detect the rain condition (see Fig. 6).

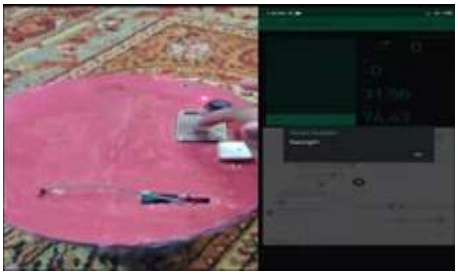

FIGURE 6. Rain sensor working

C. WEIGHT SENSOR NOTIFICATION

We are detecting weight and getting notified through the app (see Fig. 7).

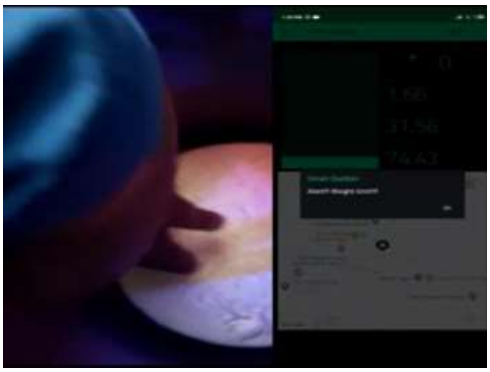

FIGURE 7. Weight Sensor working

D. SONAR WORKING

We are getting an update regarding the waste in the bin using an Ultrasonic sensor. When we move our hand near the respective sensor, as shown in Fig. 8, the status of the dustbin is shown in response on the right side, whether it's full or whatever status it is.

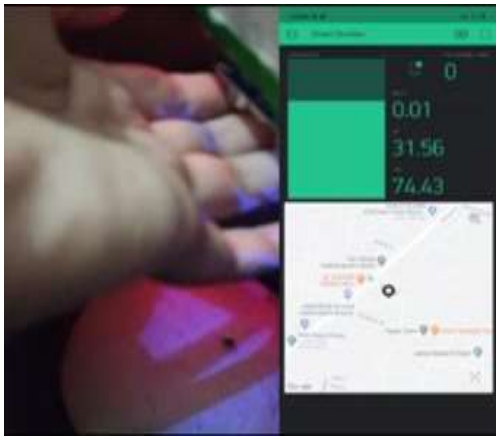

FIGURE 8. Weight Sensor working

E. GPS LOCATION

We were getting live updates on the app using the GPS module. The bottom right of the image shows respective locations. This sensor defines the location of the dustbin (see Fig. 9).

FIGURE 9. Dustbin Location Sensor

XII. CONCLUSION

The project we established is an Online Monitoring System formally known as SmartBin. This consists of a mobile-based application and hardware-based project, which is made with the Objectives of providing certain facilities to the environment and humans for their ease. This project is about how to make the environment more neat and clean or healthy. This project aims to progress a healthy environment where people live healthy, pollution-free, and comfortably in their homes. In short, through this project, we make our cities smart, neat and clean by overflowing garbage from the dust bins. This program can be used conveniently to verify the status of the dust bin and the garbage in the dust containers, clean the dust bin on time, maintain the atmosphere's safety and prevent contamination from overflows from the dust containers. Through this application, we also save time, make a healthy environment for people, decrease the causes of the diseases in people, and make a neat and clean environment. Dust bins can be managed through the GPS module on the map, and the level of garbage in the dustbin can be with the help of the Load Sensor Module.

XIII. FUTURE WORK

In the future, we can add the concepts of artificial intelligence to strengthen our mission to serve people from different diseases and remove all disease-causing things to make the environment healthy for the people. We can add a chatbot that can communicate with visitors of mobile application and provide some basic information about what the mobile application is about and the type of services we are offering. We can train our chatbots to learn from user queries. The most recent and highly demanding field of computer science is IOT, in which we can connect all our cities to the Internet. Through Smart Cities, we can reduce the human effort to do action, and in future, all cities will become more efficient and smart, and humans will become more relaxed about doing things. They can do everything through their mobile application only by pressing a button. They can solve all their problem in Smart Cities very smartly. The mixture of all the fields mentioned above will produce a remarkable project. We have completed the project "Smart Garbage Management," but there's still room for change. For instance, we intend to expand our model and make it more dynamic. Our model works on the assumption that there's only one collecting truck. This can be implemented on a larger scale, with more collector trucks, given the required funds and time. We also intend to make our routing algorithm better and more efficient. The vast majority of the past work on this matter concentrated on using cell systems to associate with the web to send the sensor's information to a

server. This paper considered utilizing the cell system to send totality SMS alerts straightforwardly to the client. Hence, the work right now is considered a savvy gadget, not an IoT arrangement. This framework doesn't offer all the offices that gave by the web utilizations of IoT items and papers referenced previously. Wherever compared and the costs of production and labour are attributed to a separation from the nearness of an internet website. Therefore, the expense of this paper reduces. An indoor check's effect indicates that the device performed flawlessly under typical circumstances.

Furthermore, the open-air tests revealed that a cell board centred on the sun worked sufficiently to load and sustain the container. The mechanism will take post-paid provisions to address this problem as far as the flexible expiration date for scheme participation is concerned. The USB DC-DC Step-up Module, Li-Ion battery charging kit and 3.7V Li-Ion battery-driven batteries are often used as an extraordinarily integrated power bank to circumvent the problem of the scheduled shutdown. This will likewise diminish the expense of the framework by almost half. Any computer devices may be loaded off for the consumer to minimize expenses to have a top view from the power store. The solution may be discarded. You may still use the concept of the platform or control station listed and rising total costs in turn. However, different receptacles associated with a single control station and the Wi-Fi module's range constraint need to be considered.

Regarding protection, should the vandalizing and a GPS tracker occur to comply in the event of a robbery, the designer finds it to be ex-center to have an accelerometer sensor to give an alert. The sensor can't differentiate between a person, an entity or an unusual event that shakes the receiver. The main thing the criminal would do would be to disengage force in the frame, so the GPS module in the container zone would be futile. Nevertheless, if there is an explosion, a temperature or smoke sensor can be attached to the frame to give a warning.

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The authors declare they have no conflicts of interest to report regarding the present study.

CONFLICT OF INTEREST

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