IoT Enabled Smart Garbage Management and Segregation System

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Abstract: In the few decades, Urbanization has increased rapidly. At the same moment there is an increase in waste production. Waste management has been an important issue to be considered to keep the country clean. This paper is a way to achieve this moral cause. At existing situation, most of the cities around the world need challenging solutions for solid waste management, as there are rapid growth in residential areas. It is observed that maximum garbage bins across the road side overflowing with garbage and it's not collected at times. It produces unhygienic condition for the people and produces bad smell around the environment this leads in increasing some harmful diseases & human illness. Municipal authorities have insufficient resources for waste management to effectively collect the waste produced. It becomes an unnecessary wastage of resources when bins are collected filled up incompletely.

The Government of India launched the "Digital India" campaign by aiming at transforming India into digital empowered society and increasing Internet connectivity. As the concept Internet of Things (IoT) would play a very vital role. At present IoT can be used efficiently to manage the solid waste. The IoT Enabled Smart Garbage Management & Segregation is an innovative system which helps to keep the environment and cities clean. By using this system, it is then possible to monitor and control in real time to segregate dry, wet and metal garbage and if garbage bin is overfilled with trash then send an SMS to the authorized person using IoT architecture.

Keywords: IOT, Cloud, RFID, Zigbee, GSM, Arduino UNO, Raspberry Pi, Thing speak, Thing view.

I. INTRODUCTION

At present, main issue for pollution is Garbage Overflow. It creates unhygienic environment in the society. There is not any proper management from Municipal Corporation towards the monitoring activity of Garbage collection and segregation. Mostly, whenever we see any unused plot, people throw the garbage and no one is there to manage which obviously increases the health problems among the people in the nearby residential areas also creating problems during rainy season by spreading the bad smell in the surrounding [1]. As the proverb "Cleanliness is next to Godliness" inspired to design the project. The government of India launched the "Digital India" campaign, by approaching IoT Technology helps to design the "IoT Enabled Smart Garbage Management & Segregation" prototype which helps the people, society and the country in proper management of the garbage and time to time collection and separation of the garbage.

Internet and its applications have become an important part of today's human lifestyle. It has become an essential tool in all aspect. Due to the huge demand and necessity, researchers went beyond connecting just computers into the web. Communication over the internet has grown from user to user interaction and device to device interactions in these days. The Internet of Things (IoT) is a concept in which physical devices and everyday objects are connected with Internet through wired and wireless networks without user intervention. Objects are communicates and exchange information. Cloud server (Thing speak) is an application platform for IoT, it includes data collection, data processing, data analytics and apps [2].

IoT Enabled Smart Garbage Management and Segregation System works in the same way, with the ultrasonic sensor is used to sense the level of garbage in the bin continuously and send an alert to authorized person when garbage bin is filled at its threshold value. The system uses the three garbage bins which are used to collect the wet, dry and metal garbage. DC motor is used to drive the conveyor belt sensors are mounted at both sides and garbage segregation gets performed. IR sensor is used to detect the object (garbage), Metal sensor is used to detect metal object, Contactless Temperature sensor used to detect wet and dry object. Servo motor is used to sort dry, wet and metal object. These details are further given to Raspberry Pi3 B+ Microcontroller and the controller gives the details to the transmitter module (Wi-Fi module). At the receiver section, Cloud server (Thing speak) in which garbage data is monitored, store and notification to authorized person if garbage is filled above its threshold value by sending SMS alert on mobile. Mobile handset is need to be connected to the Wi-Fi router so the details of the garbage bins are displayed onto the Android Mobile Application called as Thing view [3] .

II. RELATED WORK

P. Reis et al. developed the iEcoSys system (Intelligent Ecologic System). It is a technical tool that identifies the waste produced individually, using RFID tags which inserted in garbage bags called as the iBags. When collecting the waste, the recycling center recognizes the weight of every bag and the composed data and is sent to a server system using Zigbee communication standard [4]. V. Wilson et al. announce an automatic system called SWACH (Smart Waste Collecting Hopper) that helps to collect the garbage without human interference. SWACH has a web portal introduced on a server using which the user can identify the time of garbage collection. The system peripherals are executed using Arduino that senses the environment and provides essential actuation. SWACH wirelessly connects to the server to obtain the direction-finding information, using Raspberry Pi, thus porting the complete application on IOT. It is also equipped with the proficiency of detecting and avoiding obstacles that barrier its pathway [5].

A. Bharadwaj et al. providing a complete IOT based system that the process of tracing, gathering, and managing the waste can be monitored efficiently. Using sensors easy to collect data from the garbage bins and send them to a gateway using LORA technology. The information from several garbage bins are collected by the gateway and sent it to the cloud over the Internet via the MQTT (Message Queue Telemetry Transport) protocol [6]. A. Mohan et al. offers the waste collection mechanism using an IoT technology that uses ultrasonic sensor to measure the level of the garbage bin, weight sensor used to differentiate light waste like paper, heavy wastes. Some garbage produces an unbearable smell; hence MQ Gas sensor is used to sense the smell. These sensors are sends the data to the Arduino UNO Microcontroller which sends the information to a Raspberry Pi. The sensor values are constantly monitored and when it touches the threshold value, Raspberry Pi sends the data to the Thing Speak IOT cloud boards. A message is sent to the municipality server then garbage cleaning is authorized for the conforming garbage bin [7].

P. Nehete et al. introduced the smart garbage bin in which IR sensor being used to detect levels of the garbage filled in the dustbin; water sensor is used to find the wet garbage in the bin. The LCD is used to display status of the dustbin that is low, middle, high, empty or overflow by this technique we can monitor dustbin from the wet garbage. When garbage filled over the 70% of the dustbin level, GSM modem sends registered message to the specified mobile number which is mentioned in the system which is known as code for the system. Buzzer will create sound not only when water sensor detects wet garbage but also when garbage overflow at the same time [8]. S. Memon et al. design of the projected system, where garbage bin is fixed with ultrasonic sensor and that sensor is connected to We MOS D1 mini which is like on Arduino board having built in Wi-Fi capabilities to transfer sensor information to the garbage monitoring system. By conferring using monitor data, garbage collection truck can be informed to collect garbage from that specified garbage bin [9].

III. SYSTEM ARCHITECTURE AND IMPLEMENTATION

A. System Architecture:

Figure 1. Shows the general architecture of the proposed IoT Enabled Smart Garbage Management and Segregation system framework whose implementation includes following elements:

- Wireless Sensing Node – This unit located in each garbage bin. It contains sensors that collect ambient data from the bins, a Microcontroller that samples the sensed data, a wireless module that transmits the data to the central station [10].
- Cloud based server- This is an application platform for IoT that receives, stores, displays and analyses the data provided by the various wireless sensing nodes in real time. It also notifies to the authorized person to take suitable action.
- Software Android App – This is application software, which have to install in the smart phones for mobile live monitoring of bins and get take suitable action on it.

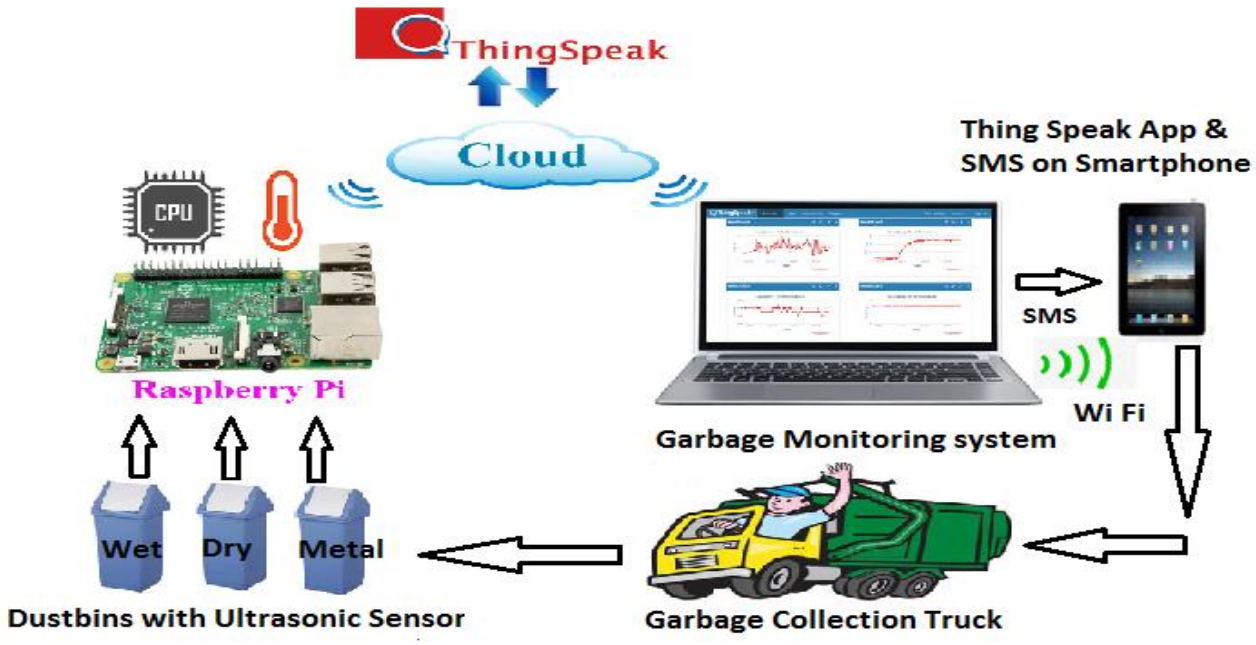

Figure 1: General Architecture of IoT Enabled Smart Garbage Management and Segregation System

B. Block Diagram :

Figure 2. Shows the block diagram of the IOT enabled smart garbage management and segregation system. It basically consists of four sensors, namely Ultrasonic sensor, Contactless Temperature sensor, IR sensor, Metal sensor and a servo motor which used to segregate dry, wet, and metal garbage, The cloud server which analyses data and display it on remote computer connected with internet or mobile handheld devices such as smart phone or tablet.

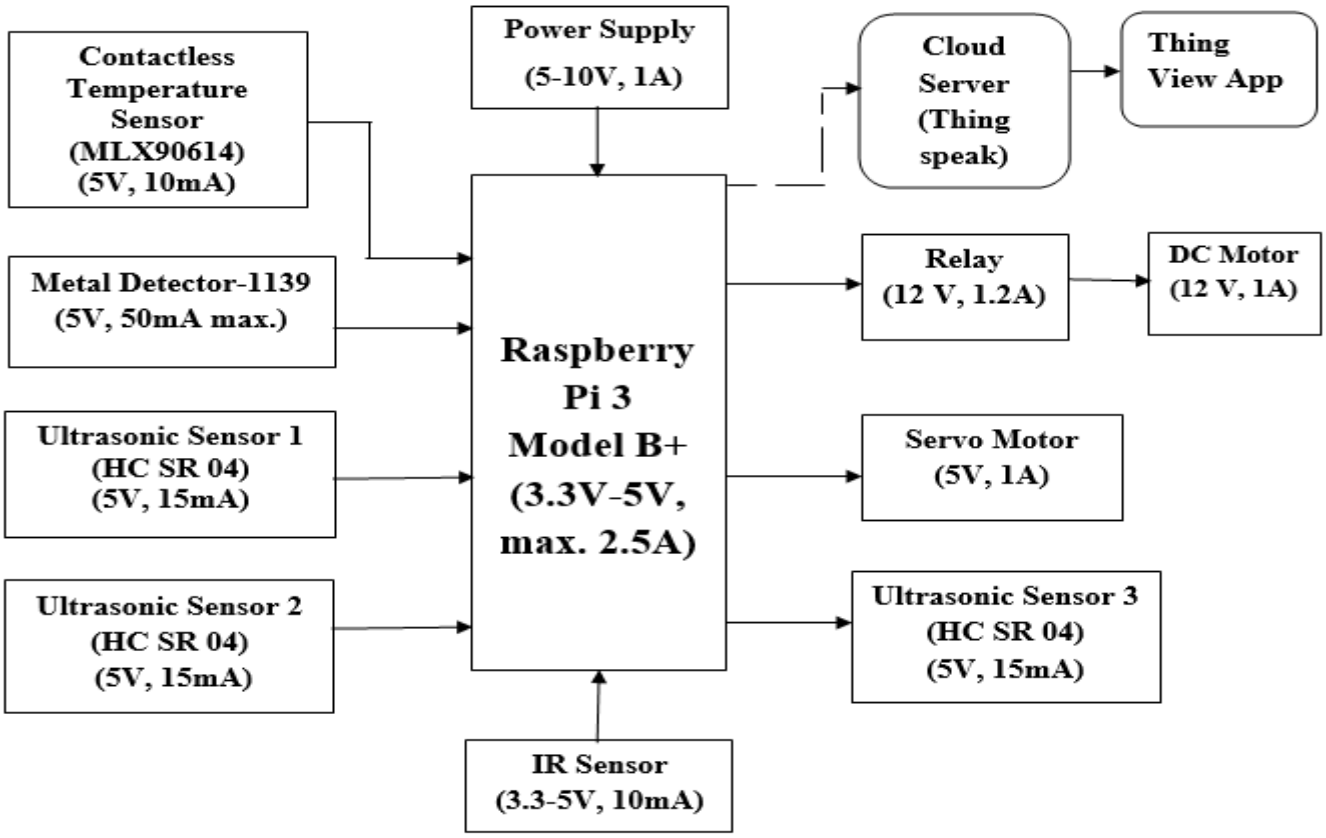

Figure 2: Block diagram of IOT enabled smart garbage management and segregation system

The concept of the project is simple whenever Wi-Fi connection is established, the transmitter and receiver device ready to perform according to the commands of the user. Microcontroller receives the command through the RX pin and matches with the given programming code of the compiler and passes the appropriate command to the Sensors, according Sensors will segregate Dry, Wet & Metal Garbage.

The working of the circuit is like this, the Raspberry Pi3 will generate the required signals for controlling operation of the conveyor belt using DC motors and relay is used as a switch to drive it. As any person place an object (Garbage) on conveyor then it will recognize using IR (obstacle) sensor and it will stop the conveyor by providing the delay then, at the same time Contactless temperature sensor sense the temperature of object and decide whether the temperature of the job is high or low. If temperature is low (less than ambient temp.-1) then object should be considered as a wet and if temperature is high (similar to ambient temp.) then object should be considered as a dry furthermore, metal detector sensor sense whether the object is metallic or non-metallic. These sensors give signal input to the Servo Motor to sort the object towards left, right side or in front of conveyor belt. By using IoT and cloud computing architecture, easy to monitor the status of garbage bins through a web page and also using an Android App (Thing View).

C. Hardware and Software Description:

- **Microcontroller**: The Garbage monitoring system uses Raspberry Pi3 B+ as a Microcontroller. It is single-board computer with wireless LAN and Bluetooth connectivity. The board is powered by 5V/2.5A DC supply via micro USB connector and 40 pin GPIO headers. It has 64-bit SoC, Broadcom BCM2837B0, Cortex-A53 quad core processor running at 1.4GHz, dual-band 2.4GHz and 5GHz wireless LAN, Bluetooth 4.2/BLE, faster Ethernet,4 USB ports.
- **Ultrasonic Sensor:** The ultrasonic ranging module, HC-SR04 is used in this system for garbage volume sensing in bins due to its low cost and accuracy. The module includes ultrasonic transmitters, receiver and control circuit, powered by a 5V/15mA supply. A high-level voltage applied for 10 microseconds at the input pin of sensor which generates eight 40 kHz burst pulses which hit the target object and return. The module get detects the returned pulses. The range of the sensor is 2cm to 400 cm with an accuracy of 3 mm and 15° angle of coverage [10].
- **Contactless Temperature Sensor:** The MLX90614 is an Infrared thermometer for non- contact temperature measurements. Easy to measure Factory calibrated in wide temperature range: -40 to 125 ˚C for sensor temperature and -70 to 380 ˚C for object temperature. It available in 3V & 5V Versions with Operating Current -10mA. It has SMBus compatible digital Interface [11].
- **Metal Detector sensor:** It used to detect the metal object ranges upto 7 cm by giving active low output with LED indication & buzzer get ON when detecting the metal. Operation range can change according to size of the metallic object. It operated with 5V DC Power supply with 50mA max. Current consumption. The output is active low and can give directly to Microcontroller for interfacing applications [12].
- **IR Sensor:** The Sensor is used to detect objects and obstacles in front of sensor. Sensor has transmitting infrared light and when any object comes near or in front it then detected by the sensor by monitoring the reflected light from the object. Digital low output when detect an object in front of sensor by glowing the LED & Power LED. It operates at 3.3 to 5V power supply and ranges from distance 2cm to 30cm.

- **Servo Motor:** A servo motor is an electric device used for accurate control of angular rotation. It is used in applications that demand accurate control over motion, like in case of control of robotic arm. The rotation angle of the servo motor is precise by applying a PWM signal to it. By varying the width of the PWM signal, user can change the rotation angle and direction of the motor.
- **Thing speak Server:** Thing Speak is an open source cloud platform for the Internet of Things. Thing speak allows to build an application around data collected by sensors. Features of Thing Speak include: real-time data collection, data processing, visualizations and apps. It includes Thing Speak Channel in which the data to be stored. Each channel includes eight fields for any type of data, three location fields, and one status field. Once Thing Speak Channel is created then anyone can send data to the channel and Thing Speak process the data then the application retrieve the data [13].

D. Proposed System Implementation:

The flow chart of implemented model is like this, as the power supply ON system start and all sensors and servo get initialized then after run the program conveyor start working. If any person insert the garbage/waste (object) on conveyor then IR sensor detect object and at the same time temperature sensor will identify temperature of object, if it is low then servo set at an angle 90˚and object thrown to front side of conveyor belt and considered as a wet. If object temperature is high then metal sensor sense the object its metal or non-metal, if metal then servo set at 30˚and object thrown at metal bin. But if object is non-metal i.e. dry then servo set at 75˚, object thrown at right side of conveyor belt into dry bin. As programme run continued display the temperature and ultrasonic level of garbage bins on computer. If any dustbin is filled with garbage above it's threshold value then send SMS to authority using cloud server platform, dustbin level shown on webpage also on the Mobile App (Thing view).

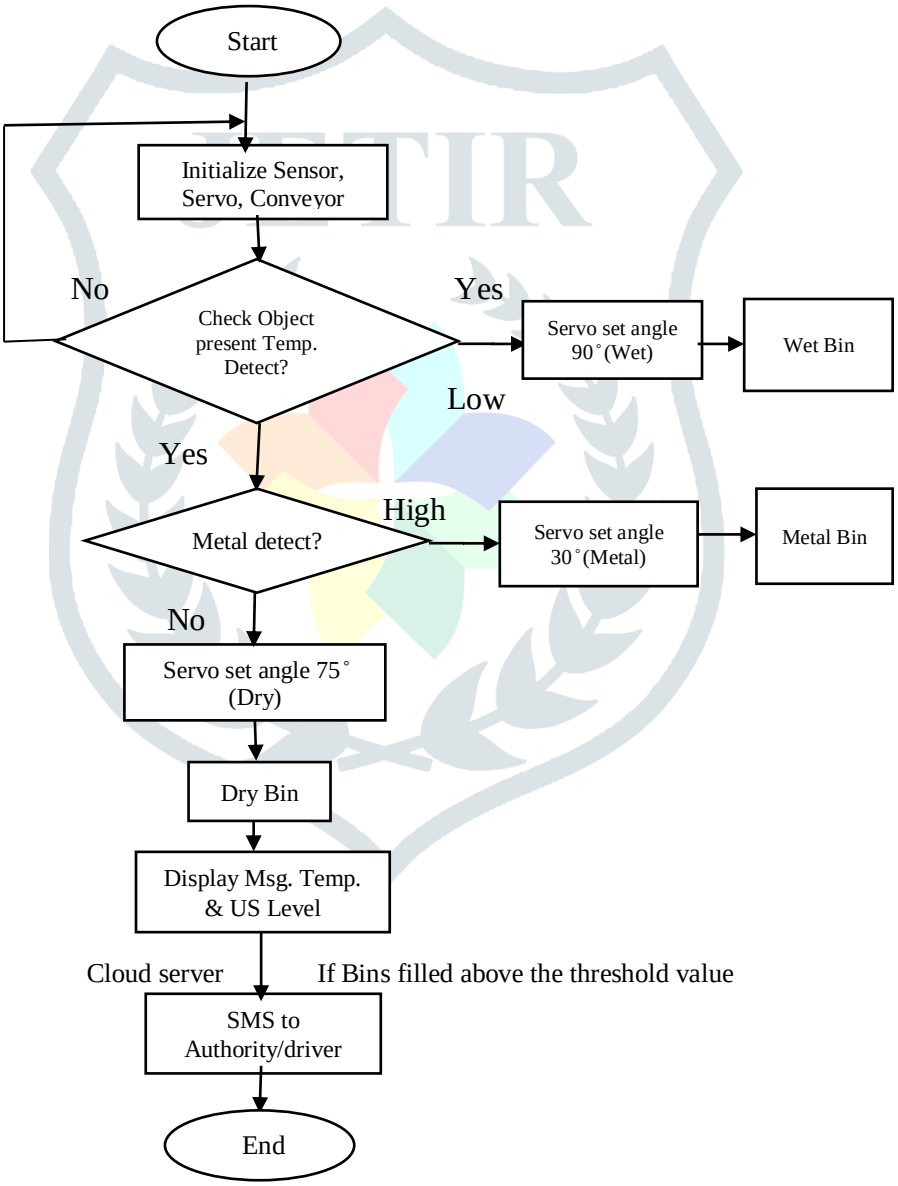

Figure 3: Flow chart of implemented model

IV. RESULTS AND DISCUSSION

A snapshot of the implemented IoT enabled smart garbage management and segregation system prototype is shown in Figure 4. The setup includes 28 cm length of three dustbins for storage of dry, wet and metal garbage. Each dustbin is fixed with Ultrasonic sensor HC-SR 04. Ultrasonic sensor has four pins namely VCC, Trig, Echo and GND. The sensor is interfaced with Raspberry Pi 3 Model B+ Microcontroller. The Ultrasonic sensor continued sense level of Dustbins.

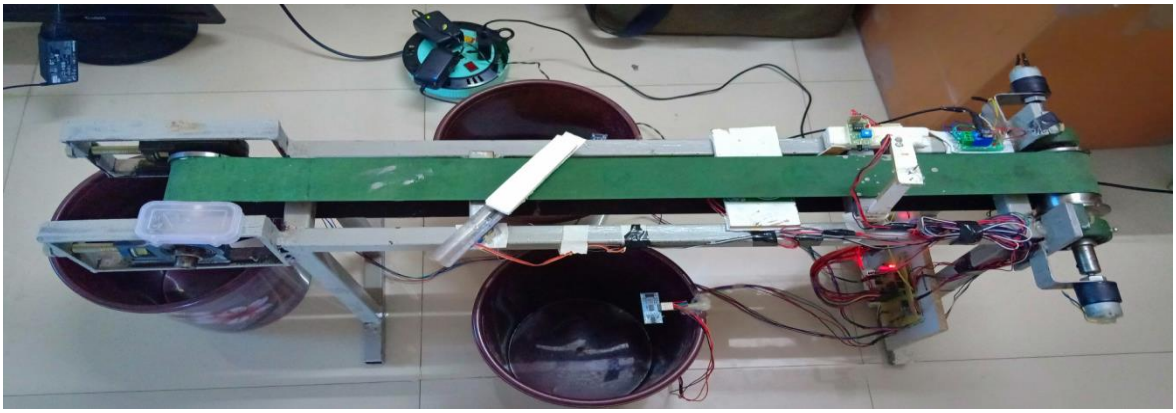

Figure 4: Testing of the IoT enabled smart garbage management and segregation system prototype

A. Ultrasonic Sensor Data on Thing Speak Cloud Server:

The measured trash levels of three bins metal, dry and wet object count readings thus displayed on the Thing speak server is shown in Figure 5. The thing speak web server stored and display the data on the web page along with its date, sending and received time also shows the wet, dry and metal object count [14]. User can monitored the real time status of garbage bin on the webpage.

Figure (a) Figure (b)

Figure (c) Figure (d)

Figure (e) Figure (f)

Figure 5: (a), (b), (c), (d), (e) & (f) Received Sensor Data displayed on Thing Speak Cloud server

Figure 5 (a) Ultrasonic sensor 1 data
Figure 5 (b) Ultrasonic sensor 2 data
Figure 5 (c) Ultrasonic sensor 3 data
Figure 5 (d) No. of Wet object data in dustbin
Figure 5 (e) No. of Metal object data in dustbin
Figure 5 (f) No. of Dry object data in dustbin

The transmitted sensor data can also be viewed on Thing Speak app called as Thing View. Thing View is the app which shows the status of garbage bins to take immediate action by cleaning the garbage filled bins. The data displayed on Android Mobile App named as Thing view App is shown in Figure 6

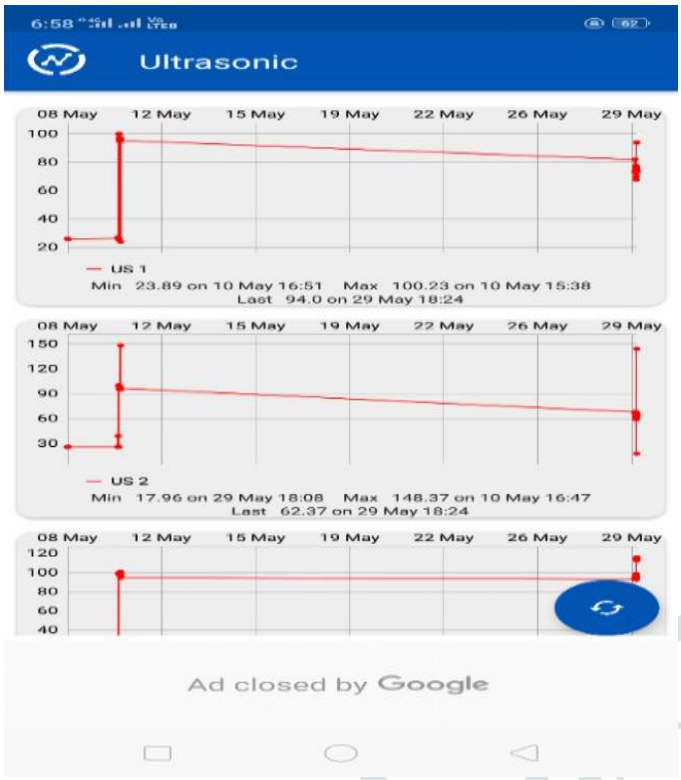

Figure (a)

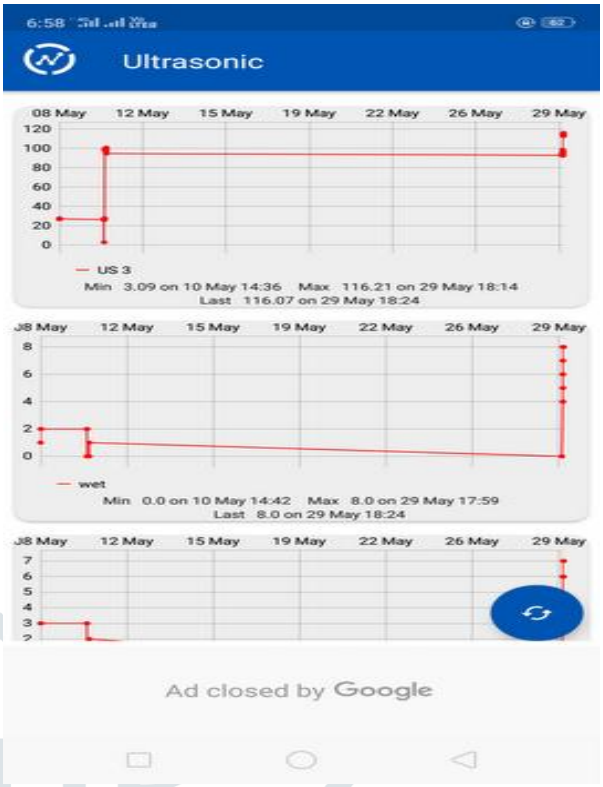

Figure (b)

Figure 6: (a), (b) Received Sensor Data on Android Mobile (Thing view App)

Figure 6 (a) Ultrasonic sensor 1 data and Ultrasonic sensor 2 data Figure 6 (b) Ultrasonic sensor 3 data and Wet object count

Table 1: Reading of different sensors collected by cloud server for garbage segregation

Entry	Object (Garbage)	IR Sensor Object Status	Temperature Sensor in (˚C)		Metal Sensor	Servo Motor Rotation in Degree	Result
			Ambient Temp.	Object Temp.			
1	Wet Object	Object Detect	37.07	35.83	Buzzer OFF	90˚	Wet
2	Metal Object	Object Detect	37.09	36.81	Buzzer ON	30˚	Metal
3	Dry Object	Object Detect	37.11	36.95	Buzzer OFF	75˚	Dry
4	Mixed Object (Wet+ Metal)	Object Detect	37.07	34.77	Buzzer ON	90˚	Wet
5	Mixed Object (Wet+ Dry)	Object Detect	37.09	35.53	Buzzer OFF	90˚	Wet
6	Mixed Object (Dry +Metal)	Object Detect	37.07	36.89	Buzzer ON	30˚	Metal
7	Mixed Object (Dry +Metal)	Object Detect	37.09	36.81	Buzzer ON	75˚	Dry

B. Snapshot of Message Received on Mobile:

The SMS alert received on mobile phone of Authority is shown in Figure 7. As program start run continue display the temperature and ultrasonic level of garbage bins on computer. If any dustbin is filled above its threshold value then send SMS to authority using cloud server platform and dustbin level shown on webpage. The user can monitor the dustbin level on Mobile App. If any dustbin is filled in this range then SMS alert is send to the user.

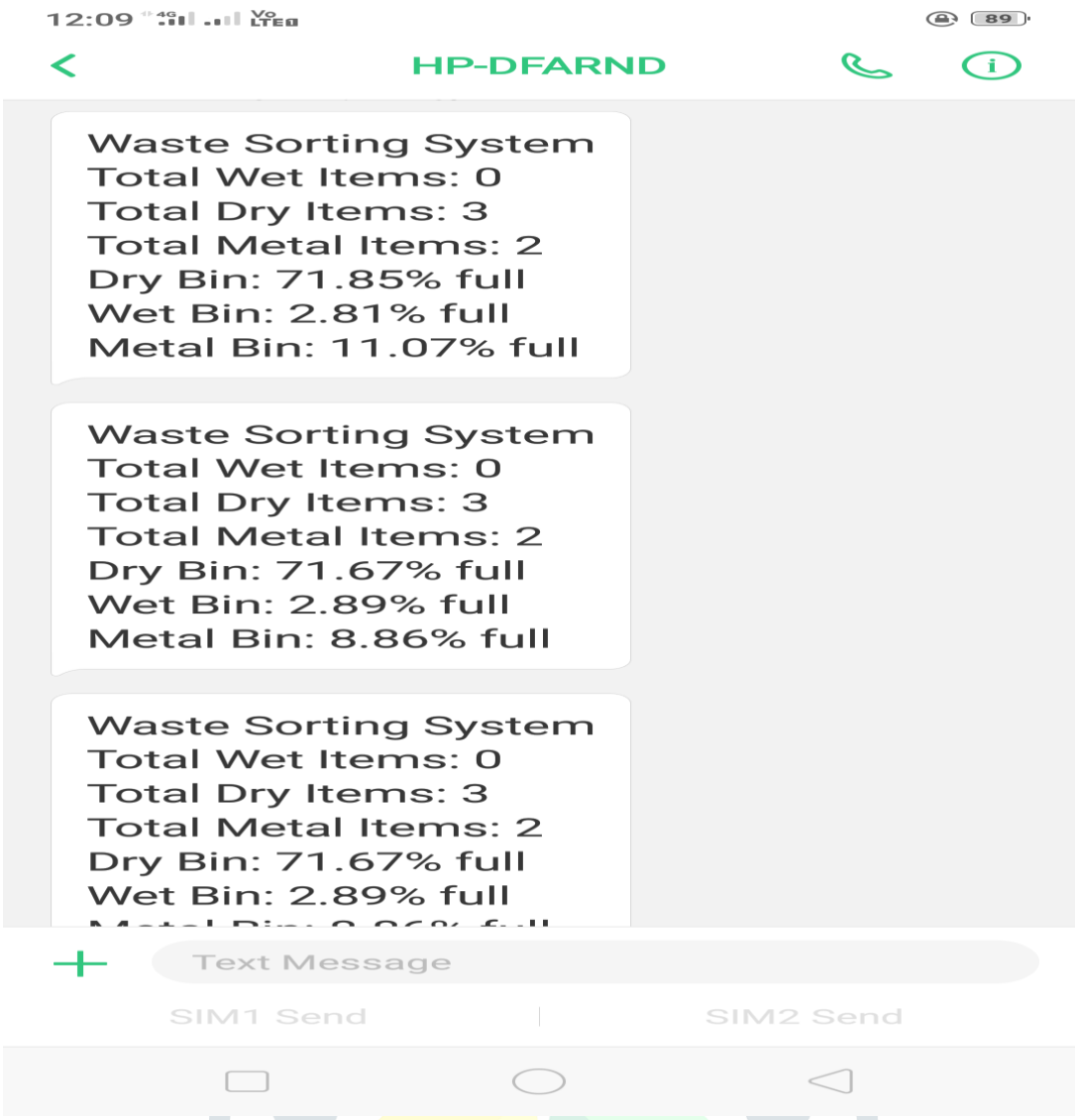

Figure 7: Messages Received on Mobile

- Dustbin Low: 50-60 %
- Dustbin Middle: 70-80 %
- Dustbin High: 90-100 %

V. CONCLUSION

The main purpose of this project is to reduce human resources and efforts along with the development of a smart city vision. It has been observed that garbage spilling over from dustbins on the street; this was an issue that required immediate attention, hence proper waste management system is necessary to avoid spreading some deadly diseases. The proverb "Cleanliness is the only medicine to all diseases" that inspired to design the project. This implementation of IoT enabled Smart Garbage management and segregation system been developed as a prototype which uses the internet, IR sensor, Ultrasonic sensor, Contactless temperature sensor, Metal sensor, servo motor and raspberry pi. This system assures to send notification using SMS alert to concern authority and monitored status of bins on dashboard when the garbage level reaches its maximum. The dustbins data can be stored on Thing speak cloud sever and anyone can monitor the data, user can check the status of garbage bins on webpage, also on Android Mobile phone using Thing view App. This system also helps to monitor the fake report hence can reduce the corruption in the overall management system. This reduces the total number of trips of garbage collection vehicle and hence reduces the overall expenses associated with the garbage collection. It ultimately helps to keep cleanness in the society. Therefore, the IoT enabled smart garbage management and segregation system makes the garbage collection and separation more efficiently.

The system has been tested in a real situation. This system significantly reduces the average cost of maintaining a clean and safe environment in bins by optimizing the waste bin pick-up schedule and also prevents dangers like fire and germs spread. This system shall be beneficial to keep dry, wet & metal garbage separately for safe and clean environment. It provides remote access to the system to deliver service at any time of the day. With this system, anyone can control as well as monitor the devices at remote location. More importantly, this system uses the existing communication infrastructure and free Thing Speak cloud server services available in the city. Being wireless the system is easy to deploy and maintain. It may be noted that this system is particularly relevant for developing countries; it's a cost-effective, quick and efficient implementation. This project ensures waste collection on time which ensures less pollution of environment, no spread of disease and a cleaner surrounding.

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