Smart City Implementation of Smart Bin Using Raspberry Pi

R.Chawngsangpuii[1,*],
[1]Department of Information Technology, Mizoram University, Mizoram, India.

Abstract **-** In this paper, a model of smart IOT-based dustbin using Raspberry Pi for handling sanitation issues related to garbage management system is presented. The increase in population also entails unhygienic conditions for the life of citizens in terms of spreading of contagious diseases and sickness. As a result, for avoiding the many problems caused, IOT-based Smart Bin is proposed. Since the government has taken many initiatives in developing Smart Cities in India, any Smart City Project will not be complete without having a Smart Garbage Management System. A smart system able to give real-time information about the status of the garbage bin is needed. This system should be able to alert the municipality for cleaning or picking the bin on time, thereby safeguarding the environment and also the health issues of the citizens. For implementing the system, message can be sent to the person authorized for the purpose to gather the garbage from the actual and precise location.

Keywords : *Internet of Things (IOT), Raspberry Pi, HC-SR04 Ultrasonic Sensor, GSM 800A module, Smart bin, objects, LED.*

1. INTRODUCTION

A big challenge in urban cities in the present scenario is systematic and smart waste management system with the rapid growth in population which comes with the rate of urbanization. Hence, the need for sustainable urban development planning is crucial. We proposed a Smart bin using IOT-based hardware Raspberry Pi to notify when the bin is full with the help of an ultrasonic sensor. The sensor detects the information about the volume of garbage in the garbage bin. The python program sends an alert message when the garbage bin is full. It can also provide the location of the full garbage bin to collect the garbage by using the GPS800A module. This process enables the waste collector to collect the waste and empty the bin efficiently. Detecting waste or refuse is a tedious process and can exhaust human efforts, costs and time. The difficulties and complications involved can be avoided with the automated and smart model proposed.

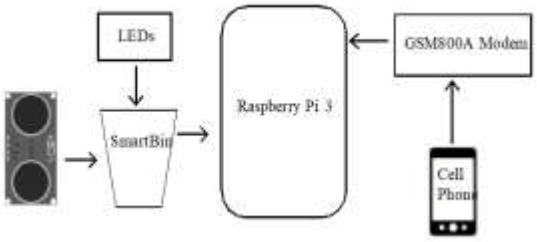

Fig. 1: Block Diagram of Smart Bin

2. PURPOSE OF IOT

Internet of Things (IOT) can be defined as a network of 'Smart' objects or devices that are able to connect and communicate through the Internet [1]. It is used to connect physical devices that are connected to the Internet. Objects or things have IP addresses and the capability to gather and transmit data over the network without the help of human. The things or objects can sense, communicate and exchange information which renders smart services for users. Management of waste has become a considerable issue in industrial, academic and government sectors, which thereby led to major IOT application field. Thus, a smart waste management system is crucial for a clean and healthy city. In the proposed system, the smart garbage bins can connect to the internet in order to acquire the real-time data of the garbage bins. Managing the garbage bins

involves observing the status of bins and consequently taking necessary actions. However, manually keeping a close watch on the status of the garbage bin is a strenuous task since numerous garbage bins can be positioned at different locations. The garbage bins are equipped with Raspberry Pi Model 3 board with HC-SR04 ultrasonic sensor. The sensor detects the height of waste in the garbage bins and accordingly sends signals to the Raspberry Pi.

3. HARDWARE COMPONENTS

3.1 Raspberry Pi

It is a board which is low-cost and just the size of credit card. It is a small computer having capability of any desktop computer and able to work on low 5v power supply. The standard OS in Raspberry Pi is debian-based Raspbian operating system. It also supports most Linux OS such as, Windows 10 IOT Core, Ubuntu MATE, RISC OS, Snappy Ubuntu Core, OSMC, PiNET, LibreElec, Pidora. Raspberry Pi is a system-on-chip(SoC) based on Broadcom BCM2837 containing Broadcom Arm processor and a videocore. It is a single-board computer developed by the Raspberry Pi Foundation, founded in 2009, in the UK with the aim of promoting basic computer education in schools and developing countries [2].

Fig. 2: The Raspberry Pi 3 Board

Table 1. Specification of the Raspberry Pi 3 Model B+ Board

System on Chip	Broadcom BCM2837B0
GPIO	40 pins
CPU Type/Speed	ARM Cortex-A53 1.4GHz
RAM size	1GB SRAM
Integrated Wi–Fi	2.4GHz and 5GHz
Ethernet	1000Base-T
Wireless LAN	802.11ac/n
Ethernet speed	300Mbps
USB Ports	4
PoE	Yes
Bluetooth	4.2

3.2 HC-SR04 Sensor

Ultrasonic sensors are used to measure distances with the help of ultrasonic waves. The reason of being accurate for small distances makes ultrasonic waves a good choice. The other reason being no disturbance to the human ear as ultrasound is more than 20,000 hertz which are not detectable by humans [3].

Fig. 3: HC-SR04 Ultrasonic Sensor

Table 2. Pin Description of HC-SR04

Pin No	Pin Symbol	Description
1	Vcc	5V DC Power Supply
2	Trig	Trigger Pin
3	Echo	Receiving Pin
4	GND	Ground Pin

Working of Ultrasonic Sensor

HC-SR04 is also known as an ultrasonic transducer that has both transmitter and receiver. It is used mainly to determine the distance of an object. The distance of object from the sensor is determined by the amount of time the transmitter takes to send and receive the reflected waves at the receiver. The sensor works on the principle of "non-contact" technology which employs SONAR (Sound Navigation Ranging) for accurate and precise readings [4]. Sonar is a technique that exploits sound propagation to detect, navigate or communicate with objects under the surface of the water by means of echoes [5].

The HC-SR04 sensor works with the formula

$$\boldsymbol{Distance = Speed \times Time}$$

The HC-SR04 sensor has 4 pin interface named Ground, Echo, Trigger and Vcc respectively. When the sensor module is connected to 5V power supply, the transmitter starts transmitting the ultrasonic waves which travel through the air until it hit the target object. The incident signal gets reflected back from the target object and this is collected by the receiver part of the sensor. The distance is directly proportional to the time it takes these waves to return at the receiver. If the Trig pin is kept high for a period of 10 µs, then the waves will be generating and will get collected by the Echo pin. For the period the waves take to travel and come back to the receiver, the echo pin will remain turned on.

Therefore, formula to calculate the distance of the object is given as

$$\boldsymbol{Distance = (Speed \times Time)/2}$$

It is required to divide the value by 2 since time taken is the "two-way" travel of the waves to travel and come back from the object.

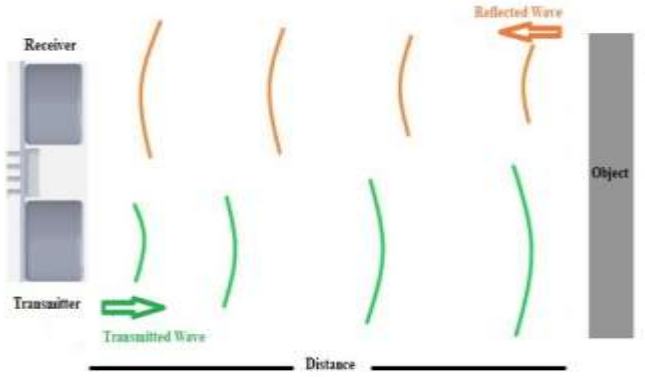

Fig. 4: Working of Ultrasonic Sensor

3.3 GSM 800A Simcom Module

The GSM800A Module uses the brain of SIMCOM 800 SoC and is a small design of both GSM & GPRS module. The module has capability of all GSM related tasks and supports "AT command" along with TTL output. As the module can work directly on 5V & 12V, it is capable for directly interfacing with microcontrollers such as Arduino, ARM, Raspberry Pi, etc. The features of the module include speaker, mic connectivity using berg strips, good network connectivity and the support for DTMF (Dual-tone multi-frequency) feature on call.

GSM stands for "Global System for Mobile communication" and is a system for digital mobile network in many parts of the world [6]. GPRS stands for "Global Packet Radio Service", employing packet switching system which allows higher data rate [7]. A GSM /GPRS modem comprises of GSM/GPRS module along with components such as communication interfaces (e.g. RS-232) and power supply for embedded systems [8]. It has a SIM card slot like mobile phones, signal status LED, RS-232 Interface to start communication with the network.

Table 3. Specification of GSM800A Simcom Module

1	Complete Quad-band GSM/GPRS (SMT type)	8	Configurable baud rate
2	GPRS class 2/10	9	Control via AT commands
3	Quad-band 850/900/1800/1900MHz	10	5V interface with MCU kit for direct communication
4	Low Power	11	Built-in SIM Card holder
5	Transmit SMS, voice and data information	12	Built-in Powerful TCP/IP protocol stack for data transfer over GPRS
6	Small size of 24*24*3 mm	13	Built-in Network Status LED
7	Input Voltage : 5V-12V DC		

Fig. 5: GSM 800A Module

4. THE WORKING PRINCIPLE

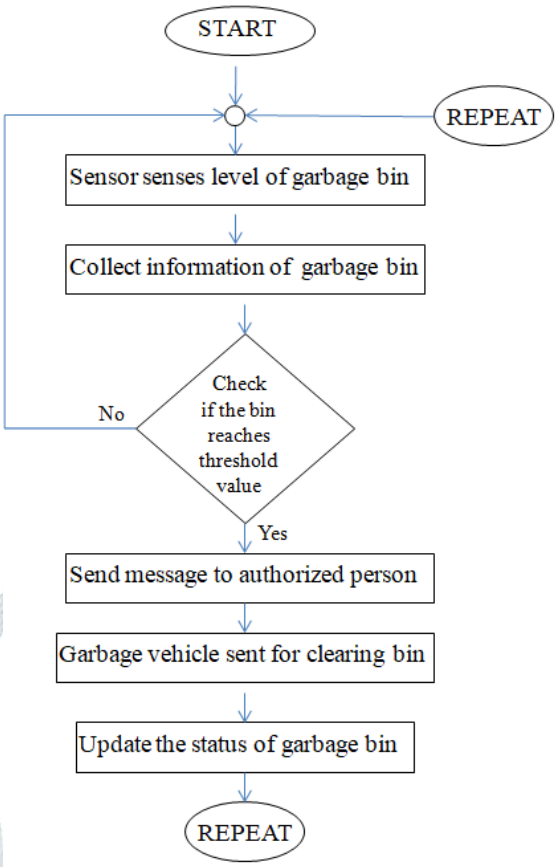

Fig. 6: Working Principle of Smart Bin

The above flow chart describes the process of the proposed system. In this system, each and every garbage bin has Ultrasonic Sensor associated with it. The sensor calculates the time elapsed for sound wave to travel front and back and this is sent to Raspberry Pi. The Raspberry Pi then calculates the level or height of trash in the bin by using this time pulse. If the level of trash in the bin reaches to its threshold value, then an alert message can be sent to the concerned department. The department can then send garbage collector to collect the garbage and empty the bin. Updating the status of the bin is a continuous process to check the level of the garbage and has to be repeated.

In the proposed system, the garbage bins are able to communicate with concerned person via the internet made possible by smart devices. The garbage bins are equipped with a raspberry pi system connected with ultrasonic sensor and the GSM module. The HC-SR04 sensor senses the level or height of the garbage in the bins and transmits signals to the RPi. Data or information can be received about the status of the bin on the authorized person's mobile phone. In this way, a smart and efficient way of collecting garbage from any area can be achieved.

5. PYTHON CODE FOR IMPLEMENTING SMART GARBAGE BIN

```
#!/usr/bin/python
import RPi.GPIO as GPIO
import time
GPIO.setmode(GPIO.BCM)
TRIG = 23
ECHO = 24
Print ("Distance measurement in progress")
GPIO.setmode(TRIG,GPIO.OUT)
GPIO.setmode(ECHO,GPIO.IN)
while True:
GPIO.output(TRIG, False)
print "waiting for sensor to settle"
time.sleep(1)
GPIO.output(TRIG, True)
time.sleep(1)
GPIO.output(TRIG, False)
while GPIO.input(ECHO)==0:
 pulse_start = time.time()
while GPIO.input(ECHO)==1:
 pulse_end = time.time()
pulse_duration = pulse_end – pulse_start
distance  = pulse_duration * 17150
distance  = round(distance, 2)
if distance > 2 and distance < 400:
 print ("Distance:" , distance – 0.5, "cm")
else:
 print ("Out of range")
```

6. RESULT AND ANALYSIS

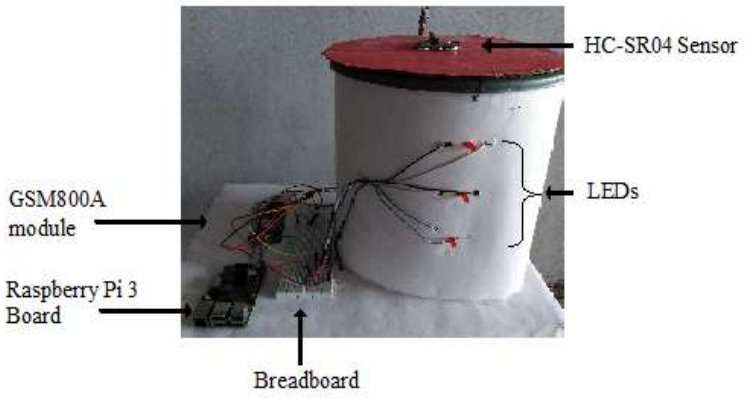

Fig. 7: Working Model

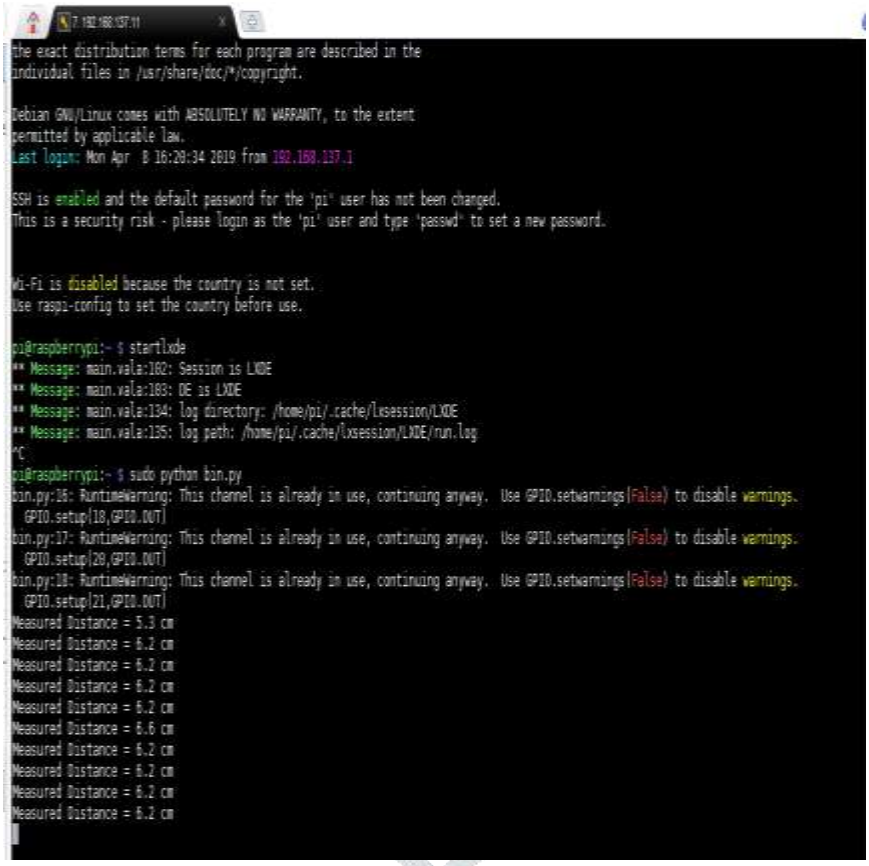

Fig. 8: Distance measured by the Ultrasonic sensor

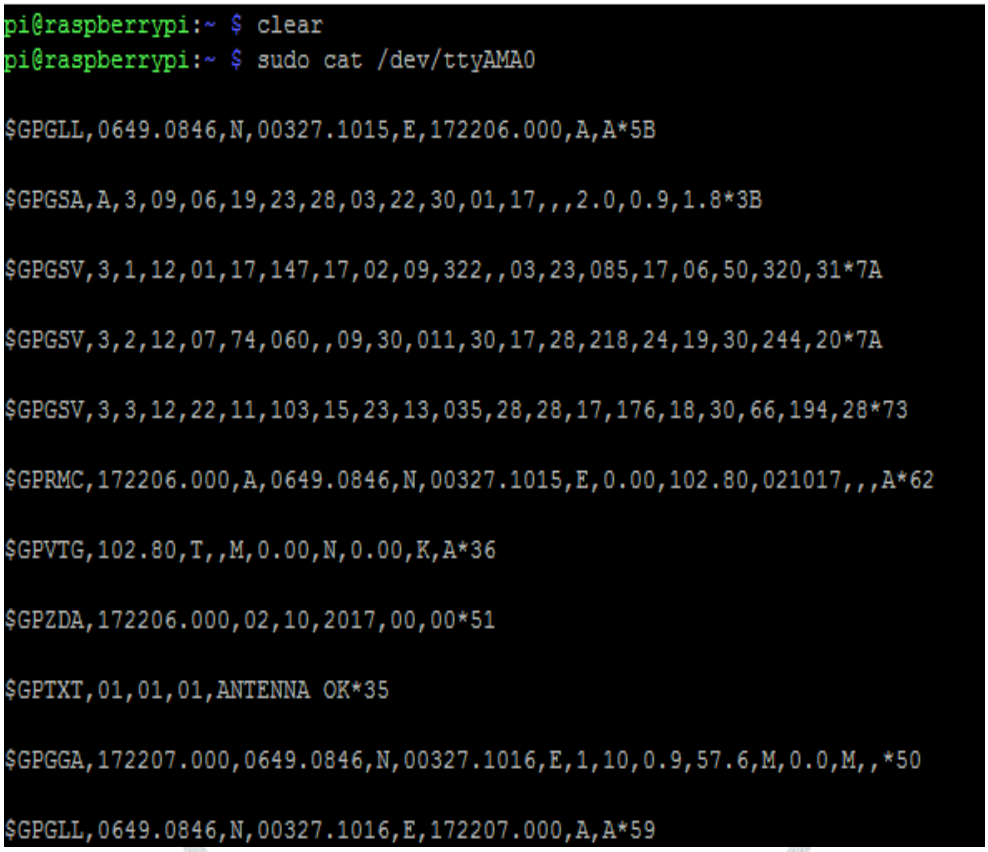

Fig. 9: Results from the GSM/GPRS Module

7. CONCLUSION

The implementation of Smart Bin provides a clean and healthy environment for society as well as cities. It utilizes various resources such as the Raspberry Pi Model 3, HC-SR04 ultrasonic sensor, the GSM800A module, the global internet and smart phone. The smart system allows us to send status of the garbage bins and SMS notification or alert when the garbage reaches its ceiling level. An efficient system which gives real-time information about the status of the garbage bin is achieved. Since it also alerts the municipality for cleaning or picking the bin on time, it safeguards the environment and this in turn solves many health issues faced by the citizens. Incorrect reports about the location of the garbage bins are not possible as the system is able to keep track of all the bins and their status. This can reduce the number of trips that garbage vans will have to take when wrong reports are made, which lead to overall expenditure reduction. This smart bin implementation model can be useful and practical in the smart cities across the globe.

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