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IoT (Internet of Things) - Based Smart Garbage Management System: A Proposal for major Cities of Bangladesh

Abhijit Bhowmik, Md. Saef Ullah Miah, Mohaimen-Bin-Noor

***Abstract*—** IoT –internet of things has become a buzzword nowadays. There are many IoT based researches but researches on garbage management system based on IoT are not sufficient. Insufficient and inefficient garbage management system causes severe environmental problem. It also makes the air toxic. This problem has become a common problem in the world especially in Bangladesh. Dhaka city, the capital of Bangladesh lacks well organized and efficient garbage management system. Maximum roads of Dhaka city are surrounded by garbage. The bad smell of garbage affects people's mental health, inhaling toxic causes many diseases. Lack of dustbins, throwing of garbage here and there, misuse of dustbins are making city life very unhealthy and also causes a threat to environment. The dustbins are being stolen or damaged which is also a great problem. In this paper, we proposed about an efficient garbage management system based on IoT. This research works aims to provide a minimal solution to this problem using the IoT technology. We propose for a smart garbage system, which consists of sensors, RFID, IR sensors, admin and user website, Wi-Fi module etc. These smart bins will monitor the level of garbage when it will reach 75% of its capacity, it will give notification to the admin website, so the authority concerned can collect the garbage from the bins timely and there will be no overflow of garbage as the authority will get notified earlier. There will be a feature in user website that will let the user know about the nearest smart garbage bins current condition, so if there is any condition that the garbage bin of their place is full they can use the nearest bin. This research work also aims to have secured smart garbage bins, as there is chance the bins to be stolen and damaged so in this research we talk about security of the sensors and the bins will have cement body. So this research is for implementing an efficient garbage management system which will reduce expense on this sector, misuse of bins. Making a clean country, pollution free environment with an efficient and well organized garbage management system can bring a new era. It is highly anticipated that the proposed garbage management system will be able to reduce financial cost in this sector as well as reduce problems related to waste management.

Keywords*— *Internet of Things, IoT, Smart Garbage Management, microcontroller, IR sensor.

Abhijit Bhowmik
American International University-Bangladesh
E-mail: abhijit@aiub.edu

Md. Saef Ullah Miah
University Malaysia Pahang
E-mail: md.saefullah@gmail.com

Mohaimen-Bin-Noor
American International University- Bangladesh
E-mail: mohaimen.niloy@aiub.edu

I. INTRODUCTION

Garbage management is the activity and action which is followed to manage garbage, and which offers variety of solutions. This is a big issue in today's world. In Bangladesh, we face problems related to waste management acutely. So, the practice of waste management is not enough in developed and developing countries, regions. Insufficient dustbins, throwing waste here and there, illegal disposal of garbage and not using dustbins properly are common problems in Bangladesh. There is another problem which is happening mostly those dustbins being stolen damaged. This is the reason of financial loss for a country. So, protecting dustbins also becomes an issue. For present time IoT based waste management has become a major issue. As lack of waste management or absence of it causes a severe environmental problem, health problem and loss to economy [1]. There are many researches into this topic IoT based waste management, but the number of research is not sufficient enough as well as lack of implementation. Kevin Ashton, the director of the Auto ID center of MIT introduced the term Internet of Thing (IoT) in 1999 [2] [1]. It created global standard for wireless sensors and RFID. He did the initial steps. Though the concept was simple, it was very powerful. It has begun a new revolution. It is firmly established in this era.

The performances of IoT are connecting things, sensing, processing, gathering data, storing [3] [1]. We are surrounded by the applications of IoT nowadays. The applications of IoT are many such as object tracking [1], environmental monitoring [1], health care [1], smart city [4], smart home [5] many more. Though there are many researches into daily life problems and things or application related to making life easier based on IoT. The trucks or vans which are used for waste disposal, there amount also not less as the production of waste is also in huge amount. If this amount of expenditure cannot make an efficient waste management, it will turn a great financial loss as well as environmental and health issue. In an over populated third world country like Bangladesh there are issues concerned with municipal waste management [6].

The main objective of this paper is to discuss some of the major issues and propose solutions to them with the help of an IoT – based smart garbage management. Where there will be garbage bins around the city that will be made of cement and will be attached with wall so that the percent of stealing will be reduced. The other things that will be needed to make smart garbage bins are sensors, software, network communication,

routers. The target of this paper is to get a smart waste management which will be based on IoT for achieving real-time monitoring for waste management. For identification, device tracking and to store the information RFID technology will be used for smart garbage management system. As the bins are attached to wall, electricity that will be needed to use the technology will be provided directly from power supply. There will be a generator or portable power banks to supply electricity when load shedding will be occurred. The benefits of using RFID system is that stealing will be reduced, accurate weight measurement of garbage and the volumes. [1] When there was no garbage collection unit, people used to dispose their waste openly in empty spaces of the neighborhood that makes environment highly polluted. This traditional system needs some touch of IOT which will remove these sufferings. The benefits of using smart garbage bins are it will not pollute the air as dustbins will be closed that will only open when the user will punch their user card or get near to the bins, signal will be gone to authority to clean the garbage at 75% that will be detected by IR sensor so it will not over flown but in case of a problematic situation people can throw their dust in nearby smart garbage bins as the garbage bins will be connected with each other within in an area. There will be a mobile application by which they can see which bins are nearest and can see the garbage bins status. In this mobile some recycling tips will be added to concern the users how they can recycle the garbage so that the waste will be reduced. At authority site there will be a website where they can be able to track the whole system. Inside of the garbage there will be a poly so that it will not damage the inside area. There will be a password-based security system to secure the things that will used for smart garbage bins, only admin can loosen up those things using a password so that the garbage bins became more secure and stealing will be reduced a lot. The organization for the rest of the paper is section2 literature review, section3 will be the Methodology, section4 will be result and discussion and finally the conclusion and future work is be given on section5.

II. Literature Review

Nowadays IoT-based smart garbage management is getting attention. Though researches are not sufficient on this topic but there are many projects based on it is going to be implemented, many ideas are coming out. As it is based on IoT the topic gets more interesting as well as finding a solution of very acute problem of daily life. The researches came out same ideas about this matter though there are slight differences. This paper is also not an alternative though there is a try to approach something new. The main intentions of all ideas are same is to reduce the problems and giving the citizens of nations a healthy environment and the country, a well-organized waste management based on IoT. In [1], during this paper they projected for IoT primarily based smart garbage management that consists of smart garbage bins, routers and servers. Their perspective is collection waste matter primarily through the wireless communication. They gave a summary on smart garbage observance and showed the topology for the smart garbage bins.

The paper [7] proposed some ideas about IoT-based waste management, it will focus in IoT based garbage management for smart city and the working components are smart bin, sensors, GUI, GSM system. It showed a block diagram for their proposal.

In [3], they also give almost same proposal they talked about transmission of information wirelessly, applying IoT to urban waste management for smart city and the components are R3 board, Four SR04 Ultrasonic sensors, Wi-Fi modules etc. They proposed for detection of waste level, real time-data transmission and access etc. They talked about efficient waste collection. They have given a layout of their process. In it they talked about software which can use citizen user and official user.

From the discussion above it is mostly seen all the researches are almost same ideas though slightly giving different ideas. IoT -based waste management has becoming popular as it is a serious issue all over the world. Many researches into IoT based applications are done about different issues but comparing that there are less researches into this field though it is an alarming issue of our daily life for people of every country. So, this topic is chosen for this paper. On the other it has many future implementations too.

The proposed work is the garbage bins will be attached with sensors which will measure the limit of garbage and will compare it with the depth of the bins, not only measure it but also if the garbage bins are overflow by garbage it will give siren. As there will be software it will give all the updates. Or any destruction of the bins or someone tries to steal there will be siren and updates instantly in the software. This paper is almost working on same ideas but a little exception in garbage bin protection from being stolen.

III. Methodology

The following table illustrates some survey data along with an estimation of per day garbage generation rate. The survey was mostly conducted in dry season and from 514 urban areas in Bangladesh. This urban areas are composed with 6 city corporations along with 298 municipalities and 210 other urban centers. For generating the total waste generation of these area, per capita waste generation rates for each of the 6 city corporations, each of the municipalities and each of the urban centers were individually taken into account. The rate of total waste generation is estimated by summing up the waste generation rate for each of the city corporations with an average of all the municipalities and an average of all other urban centers.

In a study conducted by JICA it was found that there is a significant number of people who are not permanent residents of these urban areas but every day they spend a significant amount of time there. These people are referred as floating urban population and they usually travel to these areas from some other localities because of their business, job, education or treatment. As a result, for estimating the total population in these urban areas, the study considered a 10% increase of the total population. The same study suggested that during wet season the garbage generation rate is usually increased by 46%. A related study conducted in 1991 found this variation ranges from 15% to 50%. As the data was collected in dry season, in the study, a 46% increase was considered to estimate the garbage generation rate for wet season [4].

Table 1: Estimation of average garbage generation in 514 urban areas of Bangladesh for the year 2005 [4]

City/Town	WGR* (kg/cap/day)	No. of City/Town	Total Population (2005)	Estimated Population** (2005)	TWG*** (Ton/day)		Average TWG (Ton/day)
					Dry season	Wet season	
Dhaka	0.56	1	61,16,731	67,28,404	3,767.91	5,501.14	4,634.52
Chittagong	0.48	1	23,83,725	26,22,098	1,258.61	1,837.57	1,548.09
Rajshahi	0.3	1	4,25,798	4,68,378	140.51	205.15	172.83
Khulna	0.27	1	8,79,422	9,67,365	261.19	381.34	321.26
Barisal	0.25	1	3,97,281	4,37,009	109.25	159.49	134.38
Sylhet	0.3	1	3,51,724	3,86,896	116.07	169.44	142.76
Municipalities	0.25	298	13,831,187	1,52,14,306	3,803.58	5,553.22	4,678.42
Other Urban Centers	0.15	210	83,79,647	92,17,612	1,382.64	2,018.66	1,700.65
Total	0.41(Avg.)	514	3,27,65,516	3,60,42,067	10,839.75	15,826.04	13,332.89

*Waste Generation Rate,
** Considering additional 10% as floating people,
***Comparing Total Waste Generation for wet season against dry season [4].

Based on the estimated total population for the year 2005 the average of waste generation rate for dry season and wet season was calculated to conclude estimating the average per day waste generation rate for all the seasons. The table illustrated above implies that per day 13,332.89 tons of garbage is generated in the urban areas of Bangladesh, which results per day waste generation results in 0.41 kg/capita [4].

A. Material

The 8051 microcontroller is an 8-bit single chip microcontroller which was made by Intel in 1981. It has a dual in-line package layout with 40 pins. The 8051 microcontroller can be optimized for any control application. It is used to retrieve the data from the sensor. It also process the retrieved data from the sensor. The processed data is wirelessly transmitted to the central system IGM (Intel Galileo Microcontroller) using a Radio Frequency Transmitter (RF Transmitter). This microcontroller comes with a built in RAM (Random Access Memory) of 128B and 4KB ROM (Read Only Memory). It also have 2 timers, 1serial port and 4 Input-Output ports.

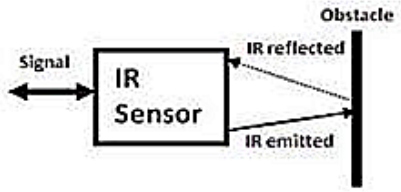

Fig. 1. Working process of IR Sensor [7]

An IR sensor (Infrared sensor) is used to monitor the level of garbage in the trash-bin. This sensor detects whether the trash-bin is filled up to a certain level with garbage. The IR sensor has an emitter, a detector and some associated circuitry. The emitter is just an Infrared Light Emitting Diode (IR LED) and the detector is just an Infrared Photodiode. This IR photodiode is sensitive to infrared rays which is emitted by the IR LED light. Whenever the light of IR LED falls on the IR photodiode, the resistance and output voltage of the photodiode changes in proportion to the magnitude of the received IR LED light.

Amplitude Shift Keying (ASK) is implied by the Radio Frequency transmission system with a transmitter/receiver pair. This pair operates at 434MHz. First, the transmitter module encodes the serial input and transmit the signal in radio frequency. The receiver module, which is placed away from the transmission source, receives the signal that was transmitted in radio frequency by the transmitter module and decode it. The transmitter and reception modules are considered as two nodes and one way communication between these two nodes is allowed in the system. The parallel inputs received from the remote switches, is converted to a set of serial signals by the encoder in transmitter node. After encoding the signals, they are transferred to the reception node through radio frequency serially. The decoder in the reception node, decodes the signal received in serial format through radio frequency and retrieve the original signal. The retrieved signal is the output and it can be observed in corresponding LEDs.

Intel is one of the pioneer in providing the ultimate processors, boards and tools to its community. Intel introduced Intel Galileo and Intel Galileo 2 boards as their first initiative of service. Both of them are compatible with Arduino headers and reference APIs. Intel Galileo boards are not only open source but also open hardware. As a result, all the source code and hardware schematics are available over the internet. For using and modifying, these source codes and hardware schematics can be downloaded without any cost.

The Intel Quark X1000 SoC was stored on Intel Galileo Gen 2 as capacity of the memory. Both of them has the same power headers, the same clock frequency and the same I2C and SPI speeds. Intel Galileo Gen 2 offers the same set with major improvements like PWM for Arduino headers.

The following block diagram illustrates all the components used in garbage level in trash-bin monitoring system. The system consists of IR sensor, 8051 microcontroller, power supply, RF transmitter, RF receiver, Intel Galileo microcontroller and a web browser. The whole system is divided into two parts.

One is the transmitter part and the other is the receiver part.

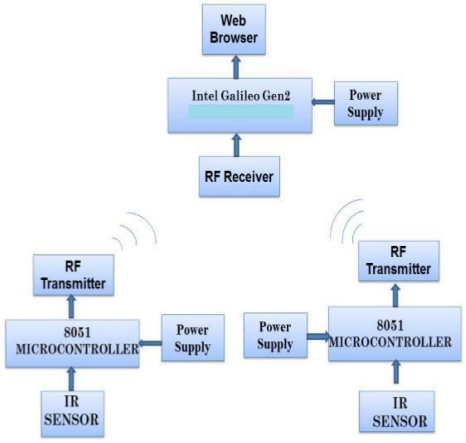

Fig. 2. A Block Diagram illustrating the working flow of the proposed system [7]

The 8051 microcontroller, RF transmitter and sensors are used in the transmitter part and all of them are attached with the trash-bin. The attached sensors monitor the level of garbage in the trash-bin. Whenever the trash-bin reaches up to a certain level, the sensor detects the content of the bin and drives the data to the 8051 microcontroller. To maintain the stability of the system, a +9V battery is connected to the 8051 microcontroller as the power supply. The 8051 microcontroller then retrieves the signal data from the sensor. After retrieving data from the sensor, it is processed. The processed data is transmitted to the central system (Intel Galileo microcontroller) wirelessly through the radio frequency transmitter. As soon as the RF transmitter transmits the signal data, the receiver part comes into play. In the receiver part there are RF receiver, Intel Galileo and a web browser. The RF receiver is receives the data signal transmitted by the RF transmitter. The Intel Galileo Gen 2 microcontroller process the received data and after processing, the processed data is sent to the client which in this case is a web browser.

The following flow charts illustrate process of detecting garbage level in trash-bin by IR sensor for both of the transmitter and the receiver parts. In the transmitter part, the sensors attached to the bin detects the level of garbage in the bin and sends the signal to the microcontroller. The microcontroller checks the status of the bin and transmits the signal to the central system through radio frequency. On the other hand, the receiver part receives the data sent by the transmitter part and displays the bin status on the browser.

B. Architectural Overview

The smart garbage bins that are installed throughout the city will be connected with each other based on the area. These smart garbage bins will exchange the information among them and send all the information to the main server using wireless communication. The architecture will have two section, administration domain and service domain. All information of the smart garbage bins will be transferred by administration domain. In the service domain, inhabitants will take out their garbage that will be noticed to take the information from it [3].

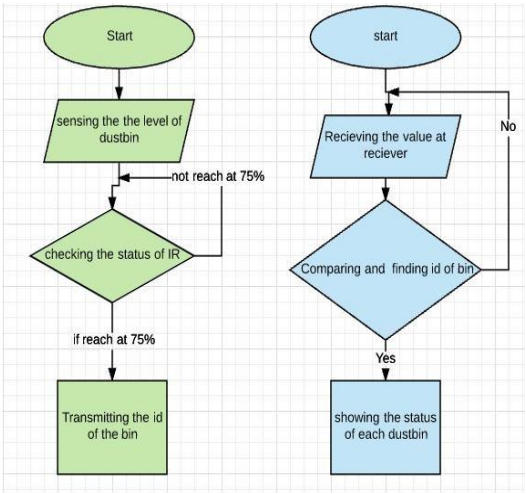

Fig. 3. Sensing level of garbage bin by IR Sensor

C. Administration Domain

All the status information likes- any malfunction or displacement of materials are collected. The server that is needed for smart garbage bin is the maintenance server. By using RFID card users can throw out their waste in the bin. The smart garbage maintenance server acts as an essential part in handling all the data related with the smart garbage bins like the quantity of waste matter every smart garbage bin has, the amount of waste matter a group of companies has collected, also the information regarding the state of the smart garbage bins. Thus, if a malfunction is detected in an exceedingly smart garbage bin once analyzing the standing info, associate administrator is distributed to visualize the matter, and the smart garbage maintenance server induces residents to use a close-by smart garbage bin. All data managed within the administration domain is available through a web-based service; through that the administrators will verify the state of the system and users will see the status with the application which will be installed on mobile. This domain is wherever the occupants put away their garbage. Once an occupant's RFID card touches the RFID reader of a smart garbage bin, the lid opens for the user. The resident then throws away his refuse within the bin supported the collected data, a refuse collector collects the refuse from the smart garbage banana administrator inspects or repairs the bin and a cleaner cleans the bin as necessary. The smart garbage bins exchange data like-their capability through a WMN [3].

Smart garbage bins are distributed according to area. Each area will have a router to maintain the smart garbage bins. Smart garbage bins pass the information to its area router. Then Area routers send the information to the header router. It creates a system in which one area smart garbage bins can get the information of another area's smart garbage bins.

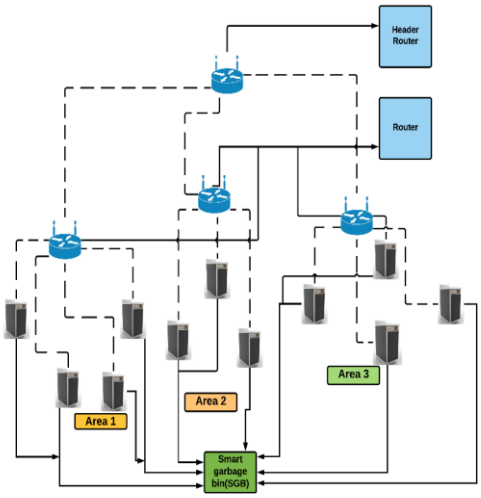

Fig. 4. Network Topology of Smart Garbage Bin

D. Middleware of smart garbage management system:

The proposed service works by cooperating between the central server which is in the administration domain and a smart garbage bin which is in the service domain. In the administrator domain, the router plays the role of a distributed server. As a result, whenever the number of smart garbage bins increase, it will be able to improve the weakness of a centralized server. Network traffic increases according to the number of smart garbage bins. Multiple routers are used for managing network traffic and minimizing the load. The centralized server in the administration domain comprises of the two modules: service management module and maintenance management module [3].

E. Service Management Module and Maintenance Management Module:

The service management module is built on the data obtained from a smart garbage bin. It includes a user information manager for storing and modifying the user data. A service provider has to provide an android based web services. It also requires to provide a data analyzer for analyzing the data for compiling statistics. The unit price of the wasted food is determined using a weight manager. There is also an RFID card manager that manages the RFID card data. The maintenance management module is built with a device information manager. It deals with the information of each smart garbage bin. A battery manager is used to check the battery status of the bins. A communication manager manages the communication status, and an area information manager manages the area information [3].

F. System Resource Management:

The system resource management module monitors the status of resource for each smart garbage bins and the other routers. This module consists a distributed manager. This distributed manager plays a specific role to each smart garbage bins for analyzing the data to determine the status of the smart garbage bins. The data is analyzed based on the management strategy for the smart garbage bin resource distribution. For example, if one smart garbage bin is already full or out of serviceable or even malfunctioned, the system resource management module provides necessary data to guide the residents to the neighboring smart garbage bins. Apart from the system resource management and maintenance management, there is a database manager in the router that cooperates with the database manager on the server. It receives the necessary data on the allocated smart garbage bins. The middleware of a smart garbage bin is situated in the bottom layer of the system architecture. It possess a device status manager module that checks the status of the smart garbage bin, a weight manager that deals with measuring the weight of the waste inside the bins, and a data gathering manager that processes the data which is received from any of the other smart garbage bins, the router or the server [3].

The planned smart garbage bin proposes Associate in nursing economical waste product assortment system by observance the capability of the smart garbage bins. Once the collectors request the status data of the smart garbage bins on their assortment route from the server through a smart phone, the server provides the data| on the placement and variety of smart garbage bins that require to be collected by utilizing the world information within the server middle-ware to the collector's smart phone. The mobile application shows the placement of the smart garbage bins that require to be collected, still because the optimized assortment path generated supported the standing data of the smart garbage bins. Waste product assortment is often conducted once per day. However, in a very business space wherever there's a lot of waste product than in different locations, the waste product assortment ought to be performed over once per day [1].

Fig. 5. Interface for garbage Collector application

User accessibility needs to be considered as the top most priority in the operational process of smart garbage bins. The goal is that the smart garbage bins should tempt the residents of an area to use them by cooperating with each just because for the stability of the service and user handiness. In order to maintain the stability, cases

such as lack of capacity or battery power failure needs to be considered. Additionally, when a communication problem arises in a smart garbage bin, the header authority is passed on to another smart garbage bin for the service dependability [3].

(i) Case 1: Lack of Capacity or Battery Power Failure. A current RFID based garbage collection system, residents may be unable to place their waste due to a lack of capacity or when the garbage bins are turned off because of a battery power failure. The proposed system should be able foresee and prevent such cases before they arise [3].

(ii) Case 2: A Communication Failure Occurs. Whenever a communication failure arises in a certain smart garbage bin, the problem can be identified during the communication among the smart garbage bins. If a smart garbage bin does not receive an acknowledgement message from the adjacent or neighboring smart garbage bin within 5 seconds after sending data, the system detects that a communication failure has occurred in the network. After detecting a communication failure, the problem is reported to the router and the router passes the information to the header router [3].

G. Security of Sensors:

Security is an important issue. Security is protection from hostile forces, being free from danger or threat. There is a major problem of Smart Garbage Monitoring System that the sensors might be stolen. To solve this problem some process is required that will give security to the sensors. The sensors which are attached to bin will be entrusted with cover which will be embedded with a system. It will be a password protected system and only the people who are related to servicing of the bins will have the password. This is an advanced security technique that uses android technology. Hence, users will use their android mobiles for operations rather than employing a keypad.

An ATmega series controller is used in this proposed system along with a Bluetooth modem, an android mobile, a buzzer, a relay driver, a motors and lamps for achieving remote controlled operations of the trash-bin lid.

The project is designed to open and close a garbage bin lid with a portable android device such as an android mobile phone or an android tablet. The system is operated by entering a password in an android application. The android device is connected to the system through Bluetooth. A Bluetooth modem is attached to the ATmega microcontroller. The microcontroller is programmed with a particular password for opening and closing the waste bin lid. Only the people associated with this garbage management process is authorized to know this particular password. A GUI based android application interacts with users to enter this particular password. Once the password is entered in the android application, the password is sent to the microcontroller. As it is sent via Bluetooth, the Bluetooth of the phone has to be connected and paired with the Bluetooth modem which is attached with the control device before sending the data. The password stored in the microcontroller's memory is compared with the password received via Bluetooth to ensure that the user has entered valid password. After the password verification process, the microcontroller sends control signal to the relay driver if and only if the password is valid. The relay then performs mechanical operations to open the garbage bin's lid through a motor. Once the lid is open, the motor automatically closes the lid after a certain time has elapsed. This time is set on the microcontroller to reverse the rotation of the motor. There is also a buzzer in this system which generates a buzz if any invalid password is entered in the application. A lamp is also used for better visualization. This security process may give a secure Smart Garbage Monitoring System.

IV. Result And Discussion

From this paper and all discussion, the results come out like the position of the garbage bins will be notified via web software. Any displacement of garbage can be known as positioning will be attached. Internet of things IoT is a concept in which the objects around us are connected and the transmission medium among this object is wired and wireless, it works without intervention [3], [4]. Here waste management and the combination of IOT internet of things giving a smart and technology-based thought which will develop our waste management Bangladesh is one of the most populated countries and production of waste is also in high rate. So, if waste management can be implemented with technology like IOT it may open a new era. Here in this paper mainly shows the bins will be attached sensors, have data connections. So, it must be kept in concern that the goal of minimizing expenses and having an efficient waste management.

V. Conclusion

The main objectives of this paper are to maintain and reduce garbage from our locality. All the major cities of Bangladesh are highly populated, and this research showed how badly these cities need an efficient waste management system. So, it is high time; we should focus on waste management. Here waste management and the combination of IoT – internet of things giving a smart and technology-based thought which can be developed for our waste management purpose. Here in this paper mainly focuses on smart waste management capable garbage bins and the communication between them and to the central system. Using this system, status of the trash-bins can be monitored ubiquitously. This system will be able to assist to monitor the status of each trash-bin in real time.

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Abhijit Bhowmik completed his B.Sc. in Computer Science & Engineering and M.Sc. in Computer Science from the American International University- Bangladesh (AIUB). Currently, he is working as a Senior Assistant Professor and Special Assistant, Office of Student Affairs (OSA) in the Department of Computer Science, AIUB. His research interests include wireless sensor networks, video on demand, software engineering, mobile & multimedia communication and data mining.

Mohammad Saef Ullah Miah is pursuing his PhD and serving as assistant professor (on leave) in the CS department of AIUB . Possessing real life experience of software development, project management indulged in to teaching. He has completed MSC and BSC from AIUB. Besides the professional life he serves the open source projects and have a keen interest in the field of technology.

Mohaimen-Bin-Noor has completed B.Sc. in Computer Science & Engineering and M.Sc. in Computer Science from American International University- Bangladesh, Dhaka, Bangladesh. Currently, he is working a Lecturer in the Department of Computer Science, AIUB. His current research interest includes Data Science, Graph Algorithms and M-Learning.