**Smart Waste Management using Internet-of-Things for smart cities**

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1. ABSTRACT

***Many times, the garbage bins at the public places in the cities are overflowing due to increased amount of waste. It creates unhygienic conditions for the people in the nearby surrounding as well as ugliness to that place leaving bad smell and even worse can cause illness and disease to people*** [6]. ***A big challenge in the urban cities is that of waste management as there is a rapid growth in the rate of urbanization. So, there is a need of sustainable urban development plans***[5]. ***To overcome waste management problem, developer has created the idea to applied Smart Waste Management Using Internet of Thing (IoT). Roughly, IoT is a concept that can connect numerous and various physical objects to the Internet with the help of sensors and other wireless technologies and extracting data from them to perform an action in context with the data read, which easier mean, able to control smart object remotely***[11]. ***Through IoT, the ability to control, monitor and manage the waste management at the same time over the network with less work, time and cost is possible. Moreover, it will make the cities greener, safer, and more efficient.***

***Keyword: Smart Waste Management (SMW), Internet of Things (IOT), Smart City, Sensor, Microcontroller***

1. INTRODUCTION

As the time passes by, there are many new technologies emerging, which aim to help mankind. The Internet of Things (IoT) is no exception. IoT is bringing about a drastic change in communication. It is said that ‘The Internet of Things will be as transformative to the world, as was the industrial revolution’. IoT is the integration of the embedded, network, and information technologies, and the main factor that is driving IoT is the phenomenal decrease in the cost of sensors, processing power and bandwidth, and increase in wireless coverage[2].

One of the main concepts of IoT is to make it as efficient as possible for users to control devices as per usage and save resources. When it comes to the waste industry, waste and recycling collectors are always looking at ways to minimise cost and increase productivity as much as possible. This would mean better usage of manpower, cut the fleet cost and increasing productivity.

Waste management is an activities and action of disposal the waste. This include start from the collection, transport, treatment, until disposal of waste together with monitoring and regulation. It is an essential city service. There are many opportunities exists worldwide for smart technology to optimize the efficiency and improve the quality of waste management services. Currently, most urban waste collection operations focus on emptying containers according to provided schedules. This is clearly inefficient, with less garbage contains bins being emptied, unwise use of city assets and unnecessary fleet fuel consumption. However, smart waste collection solutions can detect waste levels, provide route optimization and analytics operation. Municipalities and waste service managers are realized that these kinds of technology can help them meet sustainability goals (such as zero waste), improve the quality of the services for residents and reduce operational costs. [5]

The IoT can change the way of waste collection to be perform such can be able know the status of bins which help the workers to collect the waste efficiently and reducing the cost. Consumers on the other hand, will be able to pay less for the services and other related costs.

1. CASE STUDY

Study show that a lot of city has problems in their waste management. First is overflow bins which can cause disease. The waste overflow will keep increasing since the number of people also increases. Next problem is the inefficient operation of waste management since the collection of the waste is fixing. Therefore, they need to follow the schedule regardless of the bin is full or not. Sometimes, the truck just wastes their time since the bin is not full. It not just wastes their time but also money and energy.

So, to overcome this problem, a few cities have implemented Smart Waste Management (SWM). In Washington D.C. the waste collection is reduced from 21 times a week to 3 times a week. This help the management focus more on other waste issues. After that in Seoul the waste collection reduced up until 66% after they implement SMW. It also reduced the collection cost 83% which it huge amount of money has been saved. Next is Hermosa Beach, California the overflow waste and operational cost reduced to 90%.

In conclusion, it’s proved that SMW is effective and reliable to be implementing in every place, city and country.

1. FEATURES

The smart garbage bin sensor can detect the level of the waste and will directly send the information to the municipal corporation. The smart bin also can sense all the type of waste either it in liquid or solid form. According to the information given by the smart garbage bin which show the level filled of waste, the waste collector’s vehicle will choose the shortest path of waste collection to optimize the work through some software. This smart system is very simple, if there are any problem with the equipment in the future, that part will be replace in no time and without any difficulty[7].

1. PROBLEM DEFINITION

There are number of the dustbin are getting overflowing and concern person do not get the information in time causes bad smell which look bad of the city and also can probably spread harmful disease

**5.1 Disadvantages of the existing system**

Usually, today existing garbage system is collected by the worker once a week. Sometimes, it seems ineffective, increase cost and consume time because the truck will go and empty the container whether they are full or not. At some cases, maybe some bins are being use very frequently cause rapidly overflowing and spread over the road and pollute the environment. It creates unhygienic environment and effect the look of the city. Moreover, the bad smell will spread and may cause illness to human being[7][5][6].

**5.2 Advantages of the proposed system**

This Proposed waste management are provided with low cost embedded devices which help to get the real-time information on the fill level of the garbage bin and an unique ID will provided for each garbage bin so that the worker can easily identify which the garbage bin is fill. When the level of the waste reaches the threshold limit, the device will be transmitting the level along with the garbage bin unique ID. This information can be access by the in-charge corporation from their headquarter through internet. At this point, the calculation of routes for the shortest path is been made to cut the cost, reduce the waste time collection, and optimize the resource. Lastly, an immediate action can be made to collect and clean the garbage bin. This is very intelligent waste management of the services in the city. This way of management can secure and improves the quality of environment which made the cities cleaner and stop unhygienic smell[7][5][6].

1. SYSTEM ARCHITECTURE

The architecture overview is like shown in Figure 1. It has two domain/server and three main parts. Why we use domain/server instead of cloud computing this is because server is more reliable than domain in term of secure and data speed transfer. We use administration domain and service domain. The three main parts is smart control, transceiver and smart display.

For smart control we use sensor like IR and Ultrasonic. We also need microcontroller such as Arduino, Raspberry Pi and any microcontroller for smart control. Transceiver we need Wi-Fi and internet to transfer the data or information and for smart display we can use Monitor or LCD[2].

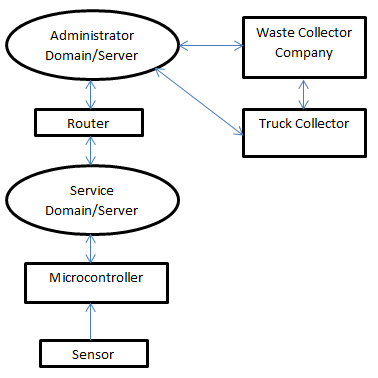


Figure 1: Basic Architecture

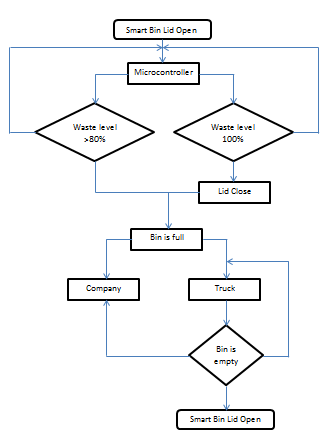


Figure 2: Flow of the Process[10].

**6.1 Working principal and design**

The dustbin or bin will attach with sensor that can determine the level or percentage of the waste in the bin. Sensor need microcontroller in order to for it send the data to the server such as raspberry pi. Since raspberry pi already has the WI-FI function so we don’t need extra electronic component like espresso to connect with the internet. The bin lids or top of it is connected with sensor so that the sensor cans determine the level of the waste inside the bin. If the bin full the lid will be close or lock. Next, the microcontroller will send the data to the service server if the waste is above 80% inside the bin. Then the service server will send the data to the administrator server. After that the administrator server will send the data to the waste collector company and the truck that collect the waste. This will give notice to the company and person in charge to collect the waste at real time. To collect the waste need to punch RFID card to notify the company that they have collect the waste. The company will also know that if the bin is empty or not[4].

1. IMPLEMENTATION

**ALGORITHM 1: Smart waste management system**

**Inputs**: Amount of Wastes generated, Number of Waste bins embedded with IoT devices, Capacity of Waste bins, Nearest-neighbour shortest path algorithm for finding the optimized routes.

**Output**: Optimized routes to visit and empty identified Waste bins.

**Description**:

1: install several garbage bins at multiple locations in the city.

2: provided unique ID and embed IoT devices to each of garbage bins.

3: define threshold value for wastes for each of the garbage bins.

4: collect the wastes in the waste bins.

5: send the collected data (using algorithm 3) over the Internet to the servers.

6: store and process the information in the server.

7: calculate and send the optimized routes to send the vehicles for waste collection using algorithm 2.

8: empty the wastes from the identified waste bins.

9: use the collected data for monitoring daily selection of waste bins.

10: predict future traffic in specific location as algorithm 4 to optimize future routes.

11: update the optimized routes in navigational devices.

**ALGORITHM 2: Shortest path calculation**

**Inputs:** Distance from waste bins to worker stations;

**Output**: Optimized routes between two points where the waste in needs to be collected;

**Description:**

1: consider street network as a graph.

2: consider street segments as edges and joining points as vertices.

3: calculate an accurate shortest travelling distance between two locations.

4: calculate the distance from one-to-all waste bins to speed up the route optimization process.

**ALGORITHM 3: algorithm in waste bins sensors**

**Inputs:** Waste for each day of the week/weekends.

**Output**: level of wastes in waste bins.

**Description:**

1: sense the level of wastes in waste bins every 2 hour during the weekday.

2: sense the level of wastes in waste bins every 1 hour during the weekend.

3: compute the rate at which waste bins is getting field.

4: if the rate is high every 1 or 2 hr, then send message to sever for sending the vehicle for waste collection.

5: if the garbage bins level is more than 80% then send the message to the server to send the vehicle for waste collection.

6: if the garbage bins level is below 50% then send the message to the server, not to send the vehicle for waste collection.

**ALGORITHM 4: Analysis algorithm used by the servers**

**Inputs:** Waste level data for each day of the week/weekends.

**Output:** Predicted waste level data for the coming days.

**Description**:

1: get waste level for every day of the week from all waste bins.

2: observe the changes in the waste levels during the week/weekends.

3: note down the drastic changes during the specific days.

4: when waste bins are getting filled faster, send alert to charge/change the batteries (area of research).

5: calculate the distance to waste bins which have significant rise in waste levels.

6: speed up the route optimization process for those days.

7: if the rate fill of waste bins in given area is very high, send alert to municipality to increase vehicles & waste bins[1].

1. COMPONENT

1. **Garbage container**

2. **Sensor**: Ultrasonic sensors generate high-frequency sound waves and evaluate the echo which is received back by the sensor, measuring the time interval between sending the signal and receiving the echo to determine the distance to an object[7].

3. **Microcontroller**: designed for embedded applications.

1. CONCLUSION

It is very important to have a robust way of managing the waste. With the proposed intelligent waste management, a smarter way of handling and disposal of waste is created. The system is based on IoT sensing prototype. It is responsible for measuring the waste level in the waste bins and later send this data (through Internet) to a server for storage and processing. This data helps to compute the optimized collection routes for the workers.

1. FUTURE WORK

Smart waste management still has a lot improvement that can be done. First, is in term of security so that it can prevent the system from eavesdropping, message forgery, tampering and hacking. We can also improve on the power supply. Instead using battery, we can use direct power supply from electricity poles or we can use solar panel. Improvement on the design of the bin so that it can store more waste and reduce the number of bin at the same time. Do research, survey and case study time the waste collected, placement of the bin and type of season or day the bin is full so that it can reduce the number of the bin, cost and give best route to collect the waste.

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