Smart Waste Management System for Crowded area

Makkah and Holy Sites as a Model

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***Abstract*—**

In implementing the smart cities the great challenge is how to manage waste with low cost and high performance. Waste has a negative impact in the society quality which smart city aims to improve it. Makkah and holy sites [Mona, Arafat, and Muzdalifah] are very congested areas where waste management is a big challenge. Three factors make it a big challenge, behind its natural, small area, short period of time and the increasing of the Pilgrimages' member. The process of collected wastes, separated it, and transports the containers daily and quickly to avoid any prospect of a spread of diseases is a complex process. This paper aims to study the concept of the waste management and proposed smart systems for waste management system with recycling .The proposed system will use the sensors technique insite the container, as a lower level, to separate the waste into 4 categories [food, plastics, papers, and metal] and use actuator at a top level to inform the management system to collect the container. The proposed system will save time, money and efforts compared to the recent process of the waste management system and improve the society quality as all.

Keywords—Internet of Thing, Smart Cities, Waste Management System, Sensor, Big Data.

1. INTRODUCTION

The services and application of the Internet have strongly influenced communication, information and marketing[1]. Internet of Thing [IoT] is one of the biggest services that implementing by the Internet. [2] defined it as "*Internet of Thing is the network of physical objects that contains embedded technology to communicate and sense or interact with their internal states or the external environment*". Internet of thing has a great positive effect on the quality of society as a whole. It aims to provide access to a wide variety of object of everyday life as monitoring sensors, house appliances, cameras, monitoring vehicles. Those objects need to connect with the user of it and at the same time connect with each other by using the platform of the Internet [3, 4].

Smart cities are one of the most prominent applications of IoT, where it provides the ability to manage, monitor and control the devices remotely, and analyzing the massive streams of real-time data to generate an action or make a right decision [5, 6]. Smart cities aim to provide smart infrastructure and services to the people and organizations by dynamic expert systems that able to explore real-time information [7].

the traditional way of managing waste is using landfill which determined by the local government. The collection, transportation, consolidation, and disposal of waste procedures are also determined by the local government [8]. High transportation costs and inefficient usage of the resources are one of the important issues that face the waste collection companies every day in their operation [7].

Increasing focus on environmental health in the world continues to get attention to reducing accumulation of waste and garbage. Waste Management System represented an important part of smart cities and consider as one of the most dynamic expert systems that needed [9]. One of the most critical issues that appear when implementing the concept of the waste management system is to minimize the effects of the waste in the environment [9].

During the 2018 pilgrimage season, there were about 2.371.656 Muslims [Pilgrims] attended the Hajj event from outside and inside the Kingdom of Saudi Arabia [10]. More than 51.000 tons of waste was collected from the beginning of the season until to the first day of the Eid al-Adha [11]. This volume increased to 130 thousand tons by the end of the season, while reached to the one million tons per year [12]. There were about 7,386 supervisors, drivers and cleaners, supported by 359 different waste types of equipment to clean the holy sites during the pilgrimage season [11]. In this situation, waste management is a great challenge for the waste services at the holy sites.

The rest of this paper is organized as follows: section 2 gives a brief review of researches in the area of smart cities, waste management system and the problem of the managing waste in the holy sites. Section 3 explains the components of the waste management system. Section 4 shows the proposed system. Section 5 explains the conclusion and future work.

2. REVIEW

Using the concept of Internet of Things [IoT] integration with data access networks, Geographic Information Systems [GIS], combinatorial optimization, and electronic engineering which can contribute to improve cities' management systems was explained by [13]. This data put into a spatio-temporal context and processed by graph theory optimization algorithms can be used to dynamically and efficiently manage waste collection strategies. A realistic scenario is set up by using Open Data from the city of Copenhagen, highlighting the opportunities created by

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this type of initiatives for third parties to contribute and develop Smart city solutions.

Three different sensors (infrared, metal, and light sensors) were used to developing a trash splitter [14]. The results showed that the devices have similar accuracy garbage sorting is a metal (98%), organic (26.67%), paper (32%), and plastics (58%).The accuracy of the mixed waste sorting is a metal (94.67%), organic (28%), paper (12%), and plastics (41.3%).

The authors [9] proposed novel algorithms that aim to management of the trade-off between the immediate collection and its cost. The proposed system minimizes the time required for serving high priority areas while keeping the average expected performance at high level. Comprehensive simulations validate the proposed algorithms on both quantitative and qualitative criteria which are adopted to analyze their strengths and weaknesses.

How to optimizing waste management in the context of Smart Cities using the realization of the Internet of Things [IoT] architecture was discussed in [15]. By a novel typology of sensor node that provided with a single-chip microcontroller, a sensor able to measure the filling level of trash bins using ultra sounds and a data transmission module based on the Low Power Wide Area Network technology. The node architecture analyzed focusing on the energy saving technologies and policies, with the purpose of extending the batteries lifetime by reducing power consumption, through hardware and software optimization.

The author [16] implemented a project called "IoT Based Smart Garbage and Waste Collection bins" to avoid overloaded garbage bins or dustbins placed at public places. The dustbins were interfaced with microcontroller based system having IR wireless systems along with central system showing the current status of garbage, on mobile web browser with html page.

The concept of using a camera was applied in [17]. They proposed an advanced Decision Support System [DSS] for efficient waste collection in Smart Cities. The system incorporated a model for data sharing between truck drivers on real-time in order to perform waste collection and dynamic route optimization. For capturing the problematic areas and provide evidence to the authorities, the surveillance cameras were incorporated.

The author [18] showed that the weight of the waste in the months of Ramadan and Hajj compared to normal days was increase from 122% to149%. And that percentage increase in the month of Hajj from the normal rate ranges in other months from 242 to 304%.

[19] explained that there was an immediate need to develop public-private partnership [PPP] to improve MSW management system in Makkah city including waste reuse and recycling. It is theoretically estimated that climate will be saved from 5.6 thousand tons emission of methane [CH4]; a major source of GHG emissions and 140.1 thousand Mt.CO2 eq. of global warming potential [GWP]with carbon credit revenue of worth 67.6 million SAR by recycling glass, metals, aluminum and cardboard. In the other side, the recycling the net revenue of 113 million SAR will be added to the national economy every year only from Makkah city.

3. THE RECENT WASTE MANAGEMENT SYSTEM.

The municipality of Makkah is controlling and managing the waste in Makkah. The waste was collecting and transporting directly to the landfill or via transfer stations and then disposing of it in landfill [20].

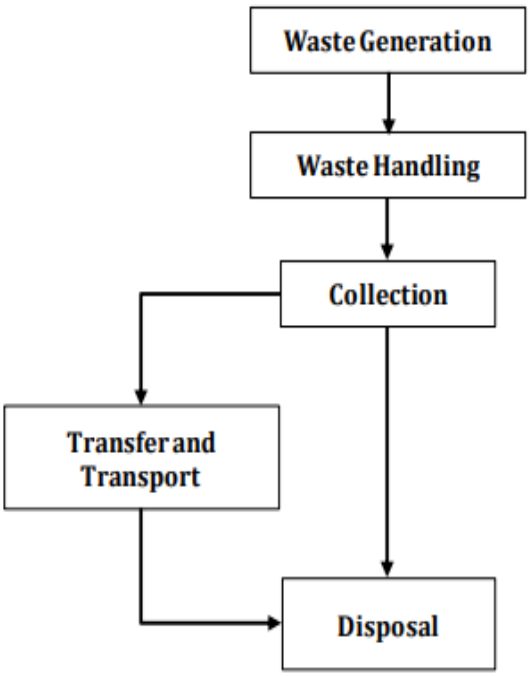

Figure 1: The System for Solid Waste Management in Makkah until 2011 [20].

The recent system in Makkah was starting to build in 2011 by Mari Matic. Using the Metro Taifun System, waste is collected from 318 waste inlet points and then transferred via a 30-kilometer pipe network to a Central Utility Complex [21]. According to [22] the project:

1. Transporting waste in underground pipes with a length of 30 KM under the central area of Makkah.
2. It was extending to 7 km outside the Haram area.
3. The project allows the transfer of 600 tons per day in more than 318 sites.

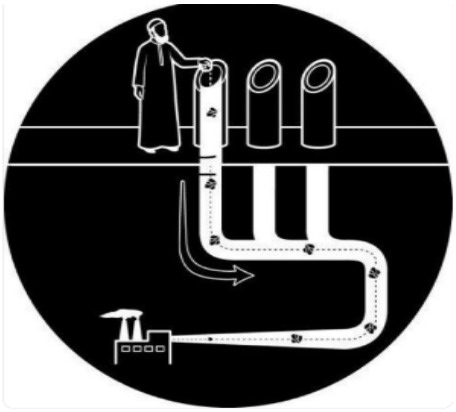

Figure 2: The Metro Taifun System 2017 [22].

Besides the Metro Taifun System, there were 9 containers with a capacity of 54 tons, 6 tons per container, in different places in Makkah and holy sites [23]. The containers were solar powered and used the sensor to send a message when it was full.

4. SMART WASTE MANAGEMENT SYSTEM ARCHITECTURE

The general architecture of the smart waste management system contains the following components:

1. Trash Bins Fill Level Monitoring System: Any type of weight measuring used to detect the level of garbage filled in the trash bin. Sensors can measure the weighting of the bin by three ways: measuring the humidity to distinguish between dry and wet waste, measuring the distance between the sensor and the garbage and finally creates an electrical signal which magnitude is directly proportional to the force being measured [24].
2. **Global system for mobile communication (GSM) Module:** is a class of wireless modem devices which are designed for communication of a computer with the GSM network and to activate communication with the network it requires a SIM card (25)**.**
3. **Control and Monitoring system:** The whole part of smart waste management system controlled by it.
4. **Trash Bins Location Tracking System:** The full trash bins will be changed by the clean one so that the Central Web Server has to register the new location.
5. **Vehicle Tracking & Scheduling System:** A GPS navigation device calculates geographical location by receiving information from GPS satellites and sends it to the Central Web Server. It provides real-time data and location updates for each vehicle.

THE PROPOSER SYSTEM ARCHITECTURE.

The proposed smart waste management system [which called Makkah-SWMS] aims to raise the current system efficiency by providing smart trashcans with the concept of recycling and sensor networks.

The architecture of the proposed Makkah-SWMS follows the general architecture of a smart waste management system beside recycling.

The system architecture composed of three layers:

1- Physical Layer.

2- Middleware Layer.

3- Management Layer.

The physical layer presents the infrastructure that contains the trashcans with sensors and access to the internet. The system integrated and transferred the data from the smart trashcans using the Wireless Sensor Network to the central system for further processing. The collected data is used to monitoring and optimizing the daily selection of trashcans when it reaches the capacity. The trucks are getting the right direction by using the GPS information. The following figure (1) shows the layers of the Makkah-WSN.

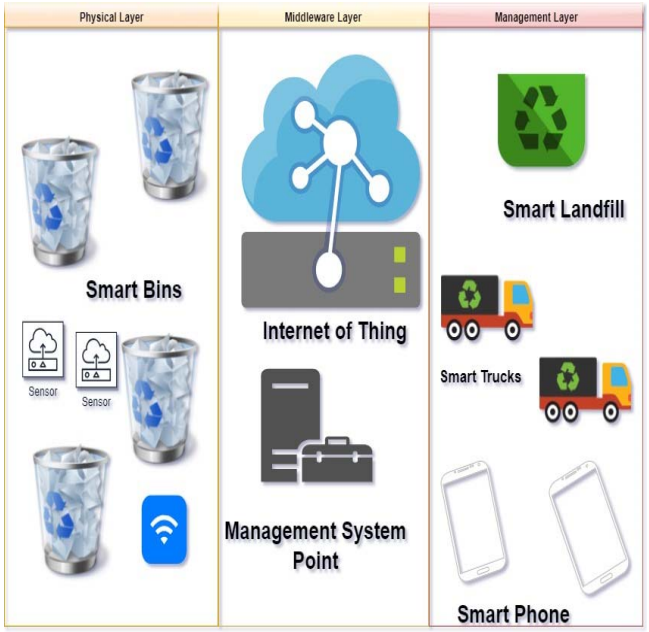

Figure3: Proposed Makkah-WSN architecture

According to [19] the following table [1] shows the percentage of waste quantities in Makkah:

Table1: Makkah's waste quantities.

Waste type	Average waste [%]
Food	50.6
Paper & Cardboard	18.6
Plastic	17.4
Textile, wood, leather	4.06
Glass	2.9
Metal	2.71
Other	3.73

The food presented more than the half percentage of the waste. Plastic, Metal, and Paper presented about 38.71% of the total waste. Food waste can be turn to other useful matter.

Makkah-SWMS sort wastes in various categories to make waste management easier and efficient. The main components of the system will explain in the following table:

Table 2: Makkah-SWMS Components

No	Name	Amount
1	capacitive proximity sensors	2
2	Metal Sensor	1
3	Infrared Sensor	1
4	Servomotor	5
5	Ultrasonic sensor	1
6	Compute	1
7	Solar Cell	1
8	Control Program	1

The scenario of the Makkah-SWMS is divided in to two phases.

- Phase one separates the waste into five categories and send alert message to the control system when the trashcan is full .The sensors inside the trashcan works as follow :
  - In the first step the Capacitive proximity sensors separate papers and plastic inside the trashcan, while the second ones detect papers and transfer them to sector A and the plastic moved automatically to sector B.
  - In the second step, the metal sensor is used to detect metal and transfer it to sector C.
  - In the third step, the infrared sensor detects glass and transfer it to sector D.
  - In the fourth step the reminding waste transfer to sector E.
  - Finally Ultrasonic sensor sense the level of the trashcan fill.
- Phase two through GSM/GPRS the Arduino IDE system sends SMS to the waste vehicle through Radio Frequency receiver when the trashcan is full.

The following flowchart illustrates the sensors operation inside the system logically.

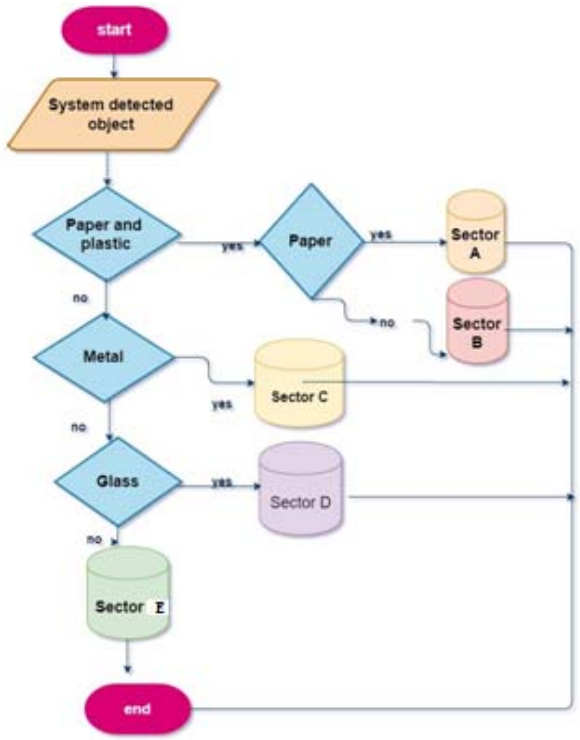

Figure 4: Proposed Makkah-WSN architecture

In the top of the trash bin ultrasonic sensor is placed, and used to sense the waste fill level inside. When the ultrasonic sensor state if the trash bin is in full level or not, the radio frequency signal will be sending to system control. The signal is received via the radio frequency receiver which is connected with the system control.

5. CONCLUION

The proposed system have many advantages than the other systems done before because the concept of recycling of waste is applied inside the trashcan not just to deciding the trashcan is filled or not yet. The benefits of recycling will improve the quality of the humane life and economy. On the other hand the system will reduce the global warming and play very important role to make the world healthier and also help to make the environment more suitable for living.

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