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Microcontroller Based Smart City Infrastructure For Garbage Collection Management System

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Abstract: Smart City is an emerging phenomenon involving the implementation of public or private information technology systems to provide smart data collection and analysis. The proposed architecture consists of four layers: signal detection and processing, a network, an intelligent user interface, and a web application layer called the Internet of Things (IoT). A proof of concept model was designed and implemented based totally at the proposed architecture. The signal detection and processing layer changed into used to generate a sensible waste management system, a field with the Arduino microcontroller module, a WiFi transceiver, a proximity sensor, a gas sensor, a temperature sensor and different electronic components. The network layer offers internet-to-microcontroller inter-connectivity among layers. The smart person configuration layer became designed with a browser-specific user specification, an abstraction of numerical attributes, and a design classification. This became performed using various sensors which include ultrasonic sensors and the GPS (Global Positioning System) to track the containers ' position and status, the GSM / GPRS and Arduino data transmission protect to comprise all of the above-stated materials into the modules. Dynamic garbage collection can greatly improve the efficiency of dynamic garbage collection and administration by delivering a cost-effective computer-aided process.

Keywords: Geographic Information System; ZigBee Wireless Sensor Network; Wireless Sensor Network; Global Positioning System; Internet of Things; ; Solid Waste Administration; Solid Waste Management TX Transmit; Waste Electrical and Electronic Equipment

I. INTRODUCTION

The management of garbage collection is one of the challenges of urbanization and a crucial problem of rapid population growth. An appropriate solid waste management system is important to improve the environment and the welfare of the population [1].

The collection of waste is a very important municipal service that requires significant expenses and the realization of this operation is expensive. The high price is due to various factors, such as human strength, car navigation, fuel, maintenance and environmental costs. Garbage can include undesirable elements such as cities, public places, societies, universities, and homes. This research is linked to Smart City and is focused on the Internet of Things (IOT) [2]. To predict the future, the Internet of Things

(IoT) is a modern model of communication. There are regular microcontrollers, digital transceivers, and a suitable protocol bank that communicates with each other [3]. Most communities across the globe, including many courtiers like Pakistan municipalities are experiencing budgetary challenges on garbage collection. Given the availability of garbage bins / waste in most cities, the main responsibility for establishing a system of sustainable hygiene rests with the residents [4]. In terms of processing systems, there are also difficulties. As a result, garbage bins, garbage often spills into accumulation. Since cleanliness is next to godliness, an environmental cleaning solution is mandatory for a community that seeks to promote the well-being of its population [5].

Since waste accumulation usually occurs after recurring service delays or unnecessary waste collection, smart city solutions can help detect about 80% of waste accumulation problems. Collection systems can therefore be more efficient by means of a warning suggestion system, so that garbage bins can be readily identified in full status. A prompt response can therefore help to promote long-term sanitation effects. This thesis addresses the design of a web-based

smart city management structure based on the DSR (Design Science Research) methodology. The specifications of a smart garbage disposal device include process efficiency, cost-effectiveness, ease of operation, versatility and portability [6]. smart garbage disposal systems with little or no input from humans ought to additionally be capable of take automated decisions about the status of waste bins, waste and garbage. The developed smart city infrastructure fulfils all these requirements through an appropriate combination of relevant state-of-the art technologies such as embedded electronics, Thing Speak IoT technology, sensors, and pattern recognition techniques (feature extraction and pattern classification) [5].

[10]. The smart city service includes sensors distance measurement for perceiving environmentally and involved sensors for city conditions to support community, community resources as well as borough processes within an educational method. The thesis structures combine different technologies such as Mobile phone, Prevalent computing and ultrasonic Sensor Networks (USN) [7]. Radio frequency (RF) transmitter/receiver GSM/GPRS and Arduino everywhere computing and communication technology. With computers that can process data and information, products will adopt smart features and abilities. This may also include electronic characteristics that will allow the products to be controlling from a certain distance and contain sensors in order to detect the alterations in the surroundings. With the commencement of Internet of Things (IoT), daily used objects and devices will easily connect to different networks, the Internet of Things structure will contribute to the development of the network after the mobile and internet networks [8]. Majority of people lives in Smart cities and this amount seems to increase more. Excessive number of population cities raise, the difficulty in terms of city transportation, power, drinkable water, waste collection structures and community places. Therefore, these problems will have to be solved in a smart, effective and sustainable, but at the same time it should contribute to the state wealth and community happiness. It can be achieved through mobilization of the resources in a city and organization of the city in terms of using modern technologies and new policies [9]. Furthermore, the world's cities population is expecting to increase so by 2050 the number of city inhabitants will increase by around sixty million per year. Due to the fact that the world turns out to be municipal, a necessity of turning cities into smart cities arises to tackle the environmental problems [8]. Moreover, information and communications technology (ICT) plays an important role in empowering influence within urban areas to handle this kind of difficulties in a „smart" way. In this thesis, a Smart City can be defined as a city which is less creative. At the same, time it provides the cities with smart organization and management tools[10]. Thus, the main cause for growth of Smart Cities is the requirement in order to develop the excellence of services from city or stat activities to city populations. Currently, many projects for the creation of smart cities. Rest of the paper contain literature review, problem statement, research objective, research methodology, research scope and limitation, results and discussion and in last conclusion and references.

II. LITERATURE REVIEW

Shipping nodes of intelligent vehicles designed for intelligent container monitoring with infrared detector, radio frequency encoder and base station decoder. The system ensures that when accessing data, garbage collection retailers are billed for their popularity and location [1]. Utilized the sensor model to develop a novel and ubiquitous "smart" concept to avoid reconstructing an existing garbage disposal infrastructure. Other researchers have also reported the combination of (GSM) Global System for Mobile Communications with a multivariate sensor algorithm to measure a prerequisite parameter for bin state to minimize energy use [5]. This research combines 8051 microcontrollers, RF module, Intel Galileo Gen2 infrared sensor. They proposed an integrated low-cost system in this projected system that would allow the truck to locate the dump through the city or campus. The bin has a unique ID that makes it easier to identify when the bin is full. The aspects would be consulted by the relevant specialists of your place through the internet and can give an immediate response to clean the garbage [7]. These bins are interconnected with a system based on ARM microcontrollers (LPC2148) and feature wireless infrared systems as well as a central system that displays waste status in a mobile web browser with an HTML page via Wi-Fi. This study also used the combination of a weight sensor and an infrared sensor to detect the amount of waste in the waste container and to provide information on the container's condition. As a result, on the HTML page, the position could be updated. The main part of this project relies on the Wi-Fi system operation, important to your success [8]. The project involves the integration of the Arduino Uno panel for waste detection as a microcontroller and an infrared sensor. For the receiver part, this project has used the TSOP1738. This TSOP1738 output is connected to the board of the Arduino UNO. Compared to the ZigBee, GSM is used for the transmitter section [9]. In addition, some researchers have developed smart waste management systems using wireless sensor networks. For example, a program for tracking the real-time operation of trash cans has been developed. The system is based on a mobile multi-level sensor and RFID software platform. To filter sample data and an expandable graphical user interface, the researchers used a knowledge-based database for ease of use [10]. To determine the position of the smart bin via a unique received signal strength (RSSI) wireless sensor. The aim of the work, according to the authors, was to improve the accuracy of bin activity monitoring through an innovation in public open sensors [11]. Use RFID in a smart tray to propose a new solution. As a quick option for simple recycling, waste is designed as self-describing parts. In contrast, form recognition algorithms have also recently been used to manage intelligent waste disposal [12]. He developed a method for estimating the production of household urban waste. To collect the functions, the researchers merged each week the SVM (Support Vector Machine) and Small Partial Squares (PLS) classifiers to determine the amount of broken waste in Tehran, Iran. By comparing the SVM and PLS-SVM models, the authors reported that PLS-SVM provided higher SVM

performance in terms of predictive power and computing time [13]. It is possible to reduce costs and improve the performance of the waste management system by using the smart container to monitor the loading level and refine the collection routes [15]. In Reference [16], Researchers discuss a complex waste management system through a selection of IoT-based Smart Cities network utilities. This matrix is divided into three stages with the use of detectors, radio frequency (RFID) and actuators in the identification monitoring system. (i) Planning and execution of waste collection using truck routing solutions with dynamic route adaptation in line with the restrictions imposed; (ii) transportation to a specific location by type of waste; and (iii) recycling of waste that may be reused. Nevertheless, it was used mainly in the first, which dealt with waste management and collection.

The authors of [17] collect information on the use of waste and provide a model to help identify and determine if additional landfills are needed in a particular area. From the daily information on the garbage, the cleaner has planned well when to send the cleaning tools so that he can empty the box and turn the cleaning truck. The proposed model uses the information needed for the compartments in comparison [18] to identify the successful routes to switch the lens. In the concept, the total delivery capacity and transmission of poison the model of access to information, is known to be certain constraints. When a dump hits a load point, the garbage detectors are turned on and sent to the base station to connect with the server to analyze the information and find the best path for retrieval. The trucks eventually go to the emptying zone where the quantity of landfills visited is tested and the optimum collection route is defined with the optimization goal focused on a decreased waste collection rate. The method provides a three-heuristic approach to waste management, first considering the closest unit a higher limit-based collection and upper and lower threshold-based collection. MATLAB was used to solve value and time-based optimization models as well as a heuristic process simulator based on Java. The authors' guidelines explicitly address search algorithms for an optimal waste collection route with a focus on reducing the time and cost of collection. Reference [19] defines a household waste management system based on biological and physico-chemical methodologies that can eliminate or significantly reduce the level of collection and transport of waste.

III. PROBLEM STATEMENT

The current situation in Pakistan has also shown that urban and rural communities experience untimely or delayed garbage, the garbage collection. A problem in service administration that leads to accumulation or overspill of garbage, garbage contravenes the objective of the national waste management, which is to promote a clean environment. Therefore, in order to contribute towards solving the foregoing problems, this study proposes the development of Microcontroller based smart city infrastructure for garbage management system.

IV. RESEARCH OBJECTIVES

(i) To design a framework of smart garbage collection management system.
(ii) Developing timely and accurate information for the appropriate agents on the location of the garbage bins.
(iii) To design and simulation flexibility and ubiquity in the monitoring of garbage disposal activities by supervisors and administrators.

V. RESEARCH METHODOLOGY

The prototype consists of the microcontroller Arduino ATmega328P. It is used for the sensor system and the Azure Cloud interface. The local recycling bins are integrated with low cost, smart gas and ultrasound sensors connected to the cloud. The cloud sensor acts as a central center for all recycling bins. Trash sends the status of the gas content and its level of filling to the central cloud platform.

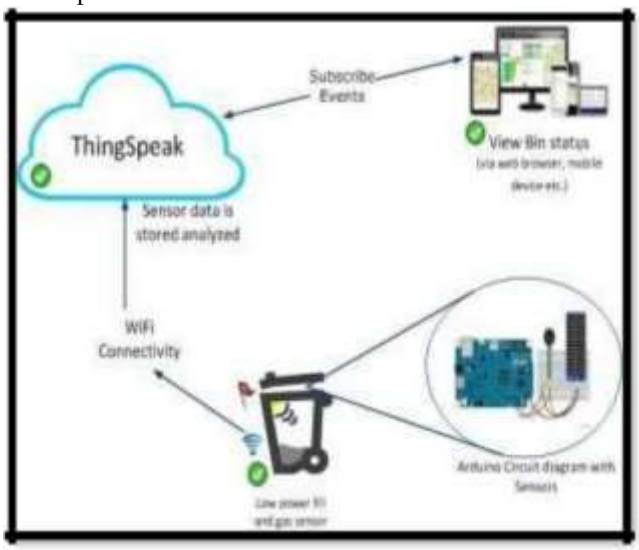

Figure 2: Conceptual model Diagram

The cloud platform also sends data to the client application in the GUI (web or mobile) showing the current gas content and its status (whether full or not). Use a database that is maintained on a central server to generate monthly or annual reports on the amount of waste collected during a week, a month or a year. This data can be used for management purposes. This prototype is aimed at ensuring collections occur only when needed, Over-filling is eliminated, and reduced collection costs, reduced harmful gas levels and residents enjoy a friendly waste management service. Figure 2 illustrates the conceptual design.

VI. RESEARCH SCOPE AND LIMITATION

This research drew inspiration from an awareness that prompt smart garbage management is a basic requirement for sustainable environmental cleanliness within

communities. The challenges being faced by citizens with respect to garbage accumulation, there is a need to critically study garbage management as a way to foster cleaner environments. The scope of the present research covers the use of smart city technological paradigms for effective garbage and waste management. There are countless intelligent solutions based on IoT for waste management systems around the world, in developed countries and in the first world, to be specific. However, waste and garbage management are also a great problem in poor developing countries as garbage is scattered all over roads due to improper methods of collection and dumping thus polluting the environment. Due to lot of factors including socio-economic and cultural drawbacks existing smart solutions are not compatible in developing countries like Pakistan, as there exist basic problems regarding the primary task of waste and garbage management like proper disposal, collection, sorting, recycling etc. DSR is a IOT mechanism in which we find the gradually QoS related good results by putting several iteration on design or model to get optimum throughput .

VII. RESULTS AND DISCUSSION

This research therefore takes advantage of the Microcontroller concept and use of algorithms to come up with a sensor-based system for detection and monitoring of bin fill-level and gas content, and transmit this information to the user via dashboards and reports. The users can also configure notifications and be notified upon certain triggers as bin fill-up. The ultrasonic sensor with Arduino and the RT transmitter placed above the containers send a signal to the center and inform the center of the level of the containers or bins. View garbage cans with container level information, half full or empty with Arduino and GPS / GRPS.

ThingSpeak Web Application Configuration Results

Figure 3 illustrates the home page of this report for a customized and personalized ThingSpeak web application. The page contains a standard menu bar at the bottom that indicates the configuration commands used. There are tags that include Page Title, Channel ID, Author and Access after the menu bar.

Figure 3: The customized home page on ThingSpeak web applicatio

It also includes connection tabs for intermediate tags, private view, public view, channel configuration, API keys, import / export information. Clickable buttons are also available, such as Add View, Export Data, MATLAB Analysis, and MATLAB Screen. At the bottom of the page you will find channel statistics. There are 200 entries in Channel Statistics for each of the six areas. It clearly shows the quality of the Smart Trash to ThingSpeak web application data transmission. Initially, the access option was made available to the public to test the application's features. To secure in the ThingSpeak application the data and parameters of this search. As shown in figure 4, the streamed data from smart garbage to the each data field is captured graphically.

Figure 4: ThinkSpeak field data visualization

The graph shows the transmission of real-time data from the sensor, as well as the timestamps of the Y and X axes. The data was fully available in 90 seconds for each sensor of the ThingSpeak web application. This shows that the Smart Garbage and ThingSpeak web application that was designed works best. The ThingSpeak web application for this study provides ubiquitous computing. This means that anywhere, anywhere, data generated from the Smart Recycle Bin is available. Figure 4 shows the status page of the trash loaded

in the menu bar of the main window when you click on this button. The page includes the Enter container ID tab, verify status key, 2 text boxes to show the recovered status. The page also contains a graph plotting frame for visual appeal and a Cancel button for closing of the page. The researcher clicked the Check Status button to test the page's functionality. This generates the information about the bin status and the date / time as shown in the figure. Notably, the returned status actually matched the actual garbage bin status. This indicates that the website and model identification are working properly. Figure 5 shows the location of the container. Use the drop-down list to identify the container ID and press the location search button on the page to display the container location coordinates and the Google Earth TM image.

Figure 5: Matlab ThingSpek Channel View

The location information is also quite important, similar to the bin status information. This is because it provides the Cleaning staff with accurate direction to locate ready-to-collect bins.

A client sends specific queries to retrieve smart garbage information in the ThingSpeak web application. Applicable functions (methods) process the recovered data on the client request and display the bin status as well as the user's location information to access and take the necessary actions. A prototype of the web based smart city infrastructure for refuse disposal management has been fully implemented and evaluated by the researcher as reported in this chapter. The hardware circuit was constructed in the laboratory and loaded with the embedded program to produce the smart garbage bin. Evaluation results showed that all the electronic sensors, the microcontroller board, other electronic components as well as the embedded program were working optimally. The ThingSpeak web application was properly configured and the evaluation result showed that it was able to seamlessly and consistently establish connection with smart garbage bin.

B. Simulation Results

At simulation time T2 = 53 minutes, 8 out of 25 distribution bins will be full, and bins 1, 5, 6, 10, 18, 19, 20 and 24 will have different waste levels in each figure 4.9.

Figure 6: bins location

Figure 6 shows the unit test efficiency. All modules passed the test successfully as shown in the server application and the average execution time for any of the tested modules is 225.52ms. It clearly illustrates the lack of coding errors in the implemented system software and optimum runtime. The analysis of the user software that has been introduced.

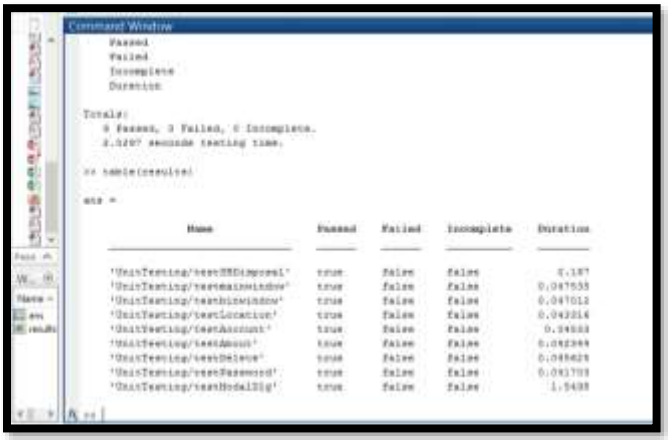

Figure 7: The client application's unit testing result

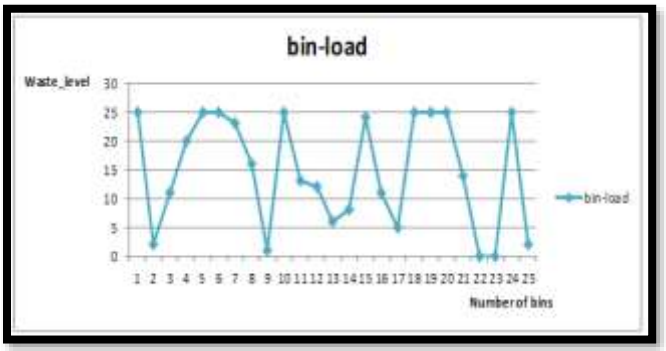

Figure 8: Bins with different waste levels

In Figure 8 The number of containers per brand was obtained for the entire container (the optimal path for waste collection per path). Figure 9 also shows the color change in the box for various debris levels and the optimal waste collection cart route. In the case of the example, if 500 UCU is the estimated cost per unit of waste charged by the resident for the waste collection process, the total income of 100,000 UC collected by the truck for the collection operation will be 25 containers. Different levels of waste are permanently recorded for each container number per product with a simulation time of T= 93 minutes.

Figure 9: Garbage Bin Status

The case study area map of the Geographic Information System (GIS) is used to identify smart devices. For calculating the cost per runway displacement, the distance from one node to another is used. The company's benefit and loss made by deducting the profits earned. Therefore, an efficient route for waste collection is accomplished by using mathematical models developed for optimized route optimization to aid urban waste management
decisions. When bin 1 is full, an ultrasonic sensor attached to the lid detects the level and instructs the receiver that the particular bin is completely filled via short message service. The same thing happens when Trash 2 is full. The ultrasonic sensor detects the level and sends commands via the microcontroller. The bin statuses (level and status).

(i) Tray connection (ii) Tray battery level (iii) Google Map ultrasonic sensor (iv) with Arduino UNO. The ultrasonic sensor is positioned close to the top of the bin and can sense waste filled levels in the garbage. (v) The radiofrequency signal is transmitted only when the sensor is full when the intelligent container is loaded at a certain load or level. The sensor has created a signal and is transmitted to the smart container via the RF transmitter.

(vi) The signal sent by the RF transmitter is received by the RF receiver at the central station.

VIII. CONCLUSION

(i) To provide a framework for enhanced refuse disposal management. This objective was realized through the development of a smart city architecture as an amendment of a smart city architecture. The proposed architecture in this study is compact and incorporates pattern recognition (feature extraction and pattern classification) for intelligent decision making on the status of smart garbage bin. The IoT web application in the proposed architecture also provides some remarkable benefits for smart garbage bin management.

(ii) Provide the waste disposal managers with accurate and timely information about the container condition.

(iii) To inject cost effectiveness into refuse disposal management.

(iv) To provide flexibility and ubiquity in the monitoring of refuse disposal activities by supervisors and administrators.

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