Smart Garbage Monitoring System using Internet of Things

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ABSTRACT

Internet of Things (IoT) can play a major role in keeping the city of Accra clean, greener, more efficient, and safer. This paper proposed a smart garbage collection on the grounds of level of garbage present in the dustbin. This study tries to present a garbage collection management solution based on providing intelligence to dustbin using IoT prototype with sensors. This system would help to maintain cleanness of the streets of Accra Ghana by sending signals through a sensor to a garbage collection unit alerting this unit of the collection of the garbage as and when the dustbins are full. The extreme programming (XP) method was used in building the system which uses ultrasonic sensors placed in the lids of the bins to detect the garbage level and compare it with the garbage bins depth. The system makes use of AVR family microcontroller, LEDs, a SIM800L GSM/GPRS Module and was powdered by a 12V transformer. It was found out that the use of this system assisted in identifying places or areas where garbage bins are full for collection and disposal. It was also found out that waste management companies that adapted the use of this system were achieving their goals of collecting bins at the right time as compare to companies that were not making use of such technology. It was concluded that waste management companies using the system perform better in terms of picking up bins that were full due to the signals received at any point in time which has made in Accra Ghana a community without garbage bins over flowing with rubbish.

Keywords: Internet of Things, Smart Waste management, Sensors, Technology.

1. Introduction

'Cleanliness is next to Godliness' is mostly said and acknowledged by most human society and the scenario beyond this proverb is that, keeping the environment clean is a very important way of staying healthy and it is said to place more emphasis on giving attention to cleanliness (Amoah, 2014). However, it is not as easy as to just speak out the proverb to effectively or properly manage the garbage in the streets of Accra. Currently solid management is a major concern in the metropolitan cities of developing countries which Accra is no exception. The president of Ghana stated it clear in his manifesto to make Accra the cleanest city in Africa during his tenure in office as the president of Ghana. It is therefore the responsibility of every individual of the country to help achieve this goal.

It has become a major challenge how the city of Accra is becoming dirty due to rubbish thrown all over. Most often garbage bins are being filled over and even additional waste materials being disposed and accumulated around the bin in different cities and towns of Ghana (Amoah, 2014). This huge uncontrolled accumulation of garbage is polluting the environment, destroying the beauty of the city and at the same time leading to health hazard. Due to the late collection of the garbage in the bins, bad smell is generated and also toxic and unhygienic gases are being produced which creates undesirable smells within the cities and towns which is a sure way of causing air pollution. Furthermore, the overflowed solid wastes cause gutters to get chocked which in a long run can cause floods (Asomani-Boateng, 2015).

The management of solid waste continues to be a major challenge in urban areas throughout the nation. According to Oteng-Ababio, (2011) population growth and increasing per capita income have resulted in the generation of an enormous volume of solid waste, which poses serious threats to environmental quality and human health. These improperly disposed garbage will later become the dwelling place for dangerous micro-organisms, insects and mosquitoes that breed on humans. The various metropolitan, municipal and district assemblies (MMDAs) in Ghana have tried their best to alleviate these situations in their various assemblies by providing several garbage bins throughout the towns and city and ensure trucks go round the cities to collect this garbage. Garbage are mostly collected straight from home or mass collection using trucks which visit the areas based on scheduled that is either weekly or monthly. So, what if there were some activities in the area which led to a lot of rubbish generated within the week or month and the bins become full what happens then? Dustbins become full and begin to overflow which leads to a lot of health hazard. In this era of internet, internet of things (IOT) is the technology that can easily be adopted to handle this garbage maintenance effectively (Pallavi, et al, 2017). IOT concept is being used to collect and dispose of waste via sensing, actuating, gathering data, storing, and processing the data by linking physical and virtual devices to the internet. IoT applications in waste management are engaging citizens and cities alike in the project of making waste practices more sustainable. Optimizing garbage collection routes based on actual disposal unit fill levels as measured by fill level sensors is one such applications that is proving to be quite impactful.

2. Literature Review

2.1 Smart Waste Management Systems

IoT applications in waste management are engaging cities and the citizens alike in the project of enhancing our waste practices more sustainable (Vikrant Bhor, 2015). Optimizing garbage collection routes based on actual disposal unit fill levels as measured by unit fill level sensors is one application that's proving to be impactful today (Asomani-Boateng, 2015). Waste management companies track consumption patterns in their service areas based on historical patterns, identify their availability to collect materials and schedule their operations accordingly (Shyam, 2014). This general practice follows across the industry, from municipal waste management teams to specialized companies that focus on commercial and industrial markets. Smart waste management could turn this model on its head, giving organizations real-time visibility into the status of collection receptacles so they can avoid unnecessary pickups and optimize operations. IoT solutions are making this

possible. According to a Waste360 report, IoT projects are already taking shape in the form of waste and recycling containers that use radio-frequency identification technology to allow haulers to track assets in the field (Gopal Kirshna, 2017). This ensures that garbage and recycling dustbins does not get missing. The news source also highlighted sensors that alert teams to how full containers are, and even vehicles that connect to the internet to access and transmit telematics data are becoming popular (Prabu, 2015). According to Vasileios et al, (2014) using IoT can track garbage or bin location , load, missing or stolen bins, the level of the waste in a garbage bins and to suggest the shortest route for rapid collection of solid waste with minimum or no human interference. When IoT technologies are combined, they add a critical layer of intelligence to operations, giving organizations real-time data updates that allow them to become more responsive to the needs of their customers and less reliant on projections and similar estimates. Operational gains are not the only advantage of IoT-enabled recycling and waste management solutions (Amoah, 2014). The ability to embed connected technologies into receptacles is also allowing for the use of artificial intelligence, machine learning, and cameras to eliminate some long-standing problems in the recycling industry. Smithsonian reported that emerging recycling bins using computer vision can process the type of material placed in the container and automatically sort it. This simultaneously eliminates human error and makes it much easier for downstream recycling centers to process goods.

Over the last decade the term Internet of Things (IoT) has attracted a lot of attention by projecting the vision of a global infrastructure of networked physical objects, enabling anytime, anyplace connectivity for anything and not for anyone only (Gigli, M. and Koo, S. , 2011), The IoT can also be considered as a global network which allows the communication between human-to-human, human-to-things and things-to-things which are things in the world by providing unique identity to each and every object (Pallavi K.N., 2017) According to (Gigli, M. and Koo, S. , 2011), IoT describes a world where just about anything can be connected and communicates in an intelligent fashion that has never happen ever before. Most of us think about "being connected" in terms of electronic devices such as servers, computers, tablets, telephones, and smart devices.

In what is called the Internet of Things, Sensors and actuators embedded in physical objects—from roadways to pacemakers—are linked through wired and wireless networks, often using the same Internet IP That connects the Internet (Ala Al-Fuqaha, 2015). These Networks churn out huge volumes of data that flow to computers for analysis. When objects can both sense the environment and communicate, they become tools for understanding complexity and responding to it swiftly.

2.2 Waste Collection and Transportation

We are living in an age where tasks and systems are fusing together with the power of IoT to have more efficient systems, while providing data for millions of people to use and capitalize (Sequeira, 2019). The MSW (Master of Social Work) collection is done using various methods. House-to-house method involves waste collectors visiting each house to collect garbage. The user usually pays. Community bins method has users bringing their garbage to bins placed in fixed locations. Curb side pick-up involves users leaving garbage outside their homes based on the collector's schedule. Under the self-delivered method, generators of waste deliver their garbage to disposal sites. Delegated service involves businesses hiring firms to arrange schedules for waste collection (Hoornweg, 2012). Worldwide waste collection rates as of 2012 stood thus: 41% collection in low income countries, about 69% in lower middle-income countries and 98% in high income countries. Waste collection by region also showed sub-Saharan Africa with the lowest rates of 45% and OECD countries at 98%. All other regions ranged between 60% and 85% (Hoornweg, 2012). Waste collection in Accra has been outsourced completely to the private sector. These private companies use house to house collection in higher earning communities with well-planned settlements, low population density and accessible homes. This involves waste collectors visiting homes of customers to their rubbish (Oteng-Ababio, 2011). In low income areas with poor settlements, the communal container collection (CCC) method is used, which involves households transporting their rubbish to large skips in central areas (Asomani-Boateng, 2015). A skip is a large open-topped waste container made for loading onto a special type of truck.

3. Methodology

This study adopted the Extreme programming language perhaps it is the best known and most widely method used of the agile methods. This uses the object-oriented approach as its preferred development paradigm and encompasses a set of rules and practices that occur within the context of 4 framework activities: planning, design, coding, and testing.

The accomplishment of any IoT-enabled application depends on the collection huge amount of data, mostly in real-time, and purification of these data into insights on which users can act. Since sensor technology has increased, a whole collection of everyday objects is being connected to the net to exchange information interactively. Today, garbage collection is ineffectually being p done using static routes and schedules by waste management companies. Garbage bins overflow with waste and some tied in polythene bags and drop around the dustbins on the streets of Accra which eventually causes unnecessary clean-up

cost. The smart dustbin is a solar powered waste compacting bin which its sensor monitors the amount of waste that has been accrued and routinely compacts the waste so that it can hold up to 10 times the normal dustbins. It also wirelessly transmits filled level information to cloud server.
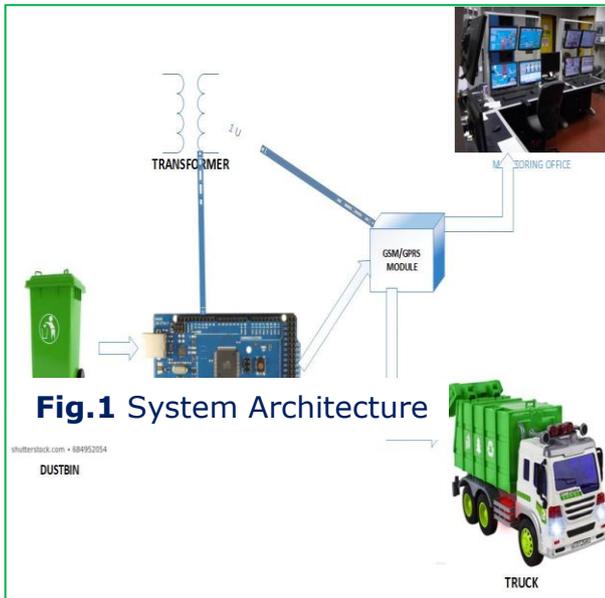
Fig.1 System Architecture

3.1 Arduino Mega

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. The Mega 2560 board is compatible with most shields designed for the Uno and the former boards Duemilanove or Diecimila.

3.2 Ultrasonic Sensor

The HC-SR04 ultrasonic sensor uses SONAR to determine the distance of an object just like the bats do. It offers excellent non-contact range detection with high accuracy and stable readings in an easy-to-use package from 2 cm to 400 cm or 1" to 13 feet. The operation is not affected by sunlight or black material, although acoustically, soft materials like cloth can be difficult to detect. It comes complete with ultrasonic transmitter and receiver module. In this project, the ultrasonic sensor is connected to the Arduino Mega and the sensor is programmed to a specified limit. This limit serves as an indicator in the device that communicates about the level of the bin.

SIM800L is a miniature cellular module which allows for GPRS transmission, sending and receiving SMS and making and receiving voice calls. Low cost and small footprint and quad band frequency support make this module perfect solution for our project because it requires long range connectivity. After connecting power module boots up, searches for cellular network and login automatically. On board LED displays connection state (no network coverage - fast blinking, logged in - slow blinking).

A Step-down Transformer is a type of transformer, which converts a high voltage at the primary side to a low voltage at the secondary side. Step down Transformer reduce the

output voltage and reduce the risk of high voltages such as shocks. By the way, it can provide more power with the same input power level or the same need. Step-down transformers reduce the output voltage and reduce the risk of high voltages such as shocks. The number of turns in the secondary winding of a step-down transformer is less than the number of turns in the primary winding of the transformer.

3.3 PHP

PHP stands for Hypertext Preprocessor. The first work was done by Rasmus Lerdorf and dates to about 1994. Lerdorf originally used it for his personal page (previously called PERSONAL Home Page) – specifically to track visitors. Soon, a lot of additional functions were added. It took a few years, though, for it to become a language and not just a set of tools. PHP is a scripting language, especially designed to put up web sites. A common use is data retrieval from SQL databases. The language is also used to create charts and other graphics. A designer can, for example, create image links or power a thumbnail image gallery. PHP carries out common website duties like accepting passwords, authenticating users, and managing forum posts and guest books. Facebook integration is another common use. With PHP, you can even make a website that allows users to generate content – that includes users who do not even know the basics of HTML! (Software Framework, 2016).

The code was released in the mid-1990s. Israel's Andi Gutmans and Zeev Suraski did a major overhaul in 1997 with the goal of using PHP to run an e-Commerce site. Their version, termed PHP 3.0, had more of the features we expect and see today. Scripts as series of Perl scripts that he used to track visitors to his website and see who was viewing his credentials. He eventually rewrote PHP as a scripting engine and added support for forms. PHP has been evolving since 1994 as open source code. PHP code could be initiated directly into HTML that makes up a webpage. The execution of this PHP code in HTML page depends on how the code was written. Because PHP is a server-side technology, the user does not need any special browser or plug-ins to set the PHP in action. PHP, which is widely used has the properties:

- *Rapid Application Development (RAD) Support*
- *Object-Oriented Constructs*
- *Platform Independent*
- *Simplified Development*
- *Powerful, Flexible, Simplified Data Access*
- *Data Access to the Operating System Platform*

- *Improved Coding*
- *Open Source*

3.4 MYSQL Server

A database is a structured collection of data. It may be anything from a simple shopping list to a picture gallery or the vast amounts of information in a corporate network. To add, access, and process data stored in a computer database, you need a database management system such as MySQL Server. Since computers are very good at handling large amounts of data, database management systems play a central role in computing, as standalone utilities, or as parts of other applications. (Dev.mysql.com, 2019)

There are many options for one who chooses a back-end for an enterprise level application like Oracle, MySQL Sever, MSSq1 Server and many more. However, MySQL Sever was chosen as the back-end due to its various features like:

- *Support for multiple platforms*
- *Integration for application servers*
- *Integration with Windows Operating System*
- *Centralized Management*
- *Reliability*
- *Scalability*
- *Replication*

3.5 Apache Web Server

This project is purely web-based application, and Apache 2.4 web server be used as its web server. However, all other web servers with PHP integration could equally be used, which means that, the application is not limited to Apache web server only. Apache was chosen due to its flexibility in deploying PHP and MySQL server. To simplify workload, a Xampp (Xampp Server 1.8. l) will be used to deploy the application

3.6 HTML/CSS

HTML is a computer language devised to allow website creation. These websites can then be viewed by anyone else connected to the Internet. It is relatively easy to learn, with the basics being accessible to most people in one sitting; and quite powerful in what it allows you to create. (Shannon, 2019) HTML consists of a series of short codes typed into a text-file by the site author, these are the tags. The text is then saved as a html file and viewed through a browser. HTML describes the structure of Web pages using markup. HTML is a formal recommendation by the World Wide Web Consortium (W3C) and is generally adhered

to by all major web browsers, including both desktop and mobile web browsers. HTML5 is the latest version of the specification. Cascading Style Sheets (CSS) are now the standard way to define the presentation of your HTML pages, from fonts and colors to the complete layout of a page.

They are much more efficient than using HTML on every page to define the look of your site. CSS helps Web developers create a uniform look across several pages of a Website. (Techterms.com, 2019) Instead of defining the style of each table and each block of text within a page's HTML, commonly used styles need to be defined only once in a CSS document. Once the style is defined in cascading style sheet, it can be used by any page that references the CSS file.

Plus, CSS makes it easy to change styles across several pages at once. The CSS specification is managed and maintained by W3C, with CSS 3 being the currently supported release

Arduino is an open-source platform used for building electronics projects. Arduino consists of both a physical programmable circuit board, often referred to as a microcontroller and a piece of software, or IDE (Integrated Development Environment) that runs on your computer, used to write and upload computer code to the physical board.

Unlike most previous programmable circuit boards, the Arduino does not need a separate piece of hardware (called a programmer) to load new code onto the board which can simply use a USB cable. Additionally, the Arduino IDE uses a simplified version of C++, making it easier to learn to program. Finally, Arduino provides a standard form factor that breaks out the functions of the micro-controller into a more accessible package.

4. Conclusion

This study presented a smart waste management monitoring system which is based on the use of IoT technology. This system involves measuring the waste level in the dustbins and then sends signal to a unit to alert truck drivers of the pick points of dustbins that a full. The system then sends data via internet to a server for processing and storage that is computed to optimize collection routes for the employees. This system only focused on solid waste.

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