SHILAN ABDULLAH HASSAN

SMART CITY SERVICE MONITORI AND WASTE COLLECTION

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A THESIS SUBMITTED TO THE GRADUATE SCHOOL OF APPLIED SCIENCES OF NEAR EAST UNIVERSITY

BY
SHILAN ABDULLAH HASSAN

In Partial Fulfillment of the Requirements for The Degree of Master of Science in Software Engineering

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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To my Family….

ABSTRACT

Nowadays cities are more expanded and more population, so the amount of waste generates in the cities are increased day by day. Solid Waste Management (SWM) is important necessity for the environmental problem and sustainable development in many countries. One of the greatest worries with our environment has been solid waste management which in mixing the dustbin, the pollution of the environment has adverse also solid waste management effective public health and brings many diseases which causing poor health to the society in the city of Sulaimany.

Current technologies in any system so to solve the problems we need to focus on using smart waste monitoring and management collection, it would be more reasonable to collect them only when they are full. So, introducing a revolutionary service that combines waste monitoring and waste collection to save time, money and environment is essential. Here, using Arduino Mega and Arduino Uno, GSM/GPRS network with SIM for send message to the mobile phone driver Truck from the Centre System. Radio frequency (RF) transmitter /receiver send data to the Centre and show graphic liquid crystal display (GLCD) for display information. Smart wireless ultrasonic sensors measurement real-time fill level data from waste containers or bins and forecast the ideal time and route for emptying each container would be used as a solution suits for municipal waste collection. The system consists of five subsystems Smart Trash bin, Local Station, Smart Monitoring and Controlling, Smart Vehicle, Smart Monitoring and Controlling Interface. The recommend System would be talented to applied monitoring and collection waste management in the city.

Keywords: Smart city service; Smart Trash bin; Local Station; Smart Monitoring and Controlling; Smart Vehicle; Smart Monitoring and Controlling Interface; mobile; GSM/GPRS; Arduino

ÖZET

Günümüzde şehirler daha da genişlemiştir ve nüfus ile şehirlerde üretilen atık miktarı her geçen gün artmaktadır. Dolayısıyla, Katı Atık Yönetimi (KAY) birçok ülkede çevre sorunu ve sürdürülebilir kalkınma için önemli bir gereklilik haline gelmiştir. Çevremizdeki en büyük endişelerimizden birisi katı atık yönetimi olmuştur. Çöplerin karışması, çevre kirliliğinin insan sağlığı üzerinde olumsuz katı atık yönetim etkileri vardır ve Süleymaniye'deki toplumun sağlığının kötüleşmesine neden birçok hastalığı beraberinde getirmektedir.

gerekir çoğu atık ve geri dönüşüm konteyneri düzenli olarak toplanmaktadır. Sadece tamamen dolduklarında toplamak daha mantıklı olacaktır. Bu nedenle, zaman, para ve çevre açısından atık izleme ve atık toplamayı bir arada toplayan devrimci bir hizmet sunmak önemlidir. Burada, Arduino mega ve Arduino Uno kullanılarak SIM ile GSM/GPRS ağından Merkez Sisteminden cep telefonu sürücü Kamyonuna mesaj gönderilir. Radyo frekans (RF) vericisi / alıcısı bilgi göstermek için Merkeze ve grafik likit kristal ekrana (GLCD)veri gönderir. çöp konteynerleri veya kutularından akıllı kablosuz ultrasonik sensör ölçüm gerçek zamanlı doldurma seviyesi bilgisi ve her konteynırı boşaltmak için en ideal zaman ve rota tahmini belediye atık toplama yetkilileri ve özel atık yönetim şirketleri için bir çözüm olarak kullanılabilir. Sistem, Akıllı Çöp kutusu, Yerel İstasyonu, Akıllı İzleme ve Kontrol, Akıllı Araç, Akıllı İzleme ve Kontrol Arabirimi olan beş alt sistemden oluşur. Tavsiye edilen Sistem kentin pratik izleme ve toplama atık yönetimi için kullanışlı olacaktır.

Anahtar Kelimeler: Akıllı şehir hizmeti; Akıllı Çöp kutusu; Yerel İstasyon; Akıllı İzleme ve Kontrol; Akıllı Araç; Akıllı İzleme ve Kontrol Arabirimi; mobil; GSM/GPRS; Arduino

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LIST OF ABBREVIATIONS

SWM Solid Waste Management

MSW Municipal Solid Waste

RF Radio Frequency

SIM Subscriber Identity Module

GSM Global System for Mobile Communication

GPRS General Packet Radio Service

ICTs Information and Communication Technologies

EMF Electromagnetic Field

IoT Internet of Things

WSN Wireless Sensor Networks

DTN Data Transfer Nodes

DSS Decision Support System

TCP/IP Transmission Control Protocol/Internet Protocol

SMS Short Message Service

HTTP Hypertext Transfer Protocol

IEEE Institute of Electrical and Electronics Engineers

RFID Radio Frequency Identification

UHF Ultra High Frequency

UART Universal Asynchronous Receiver / Transmitter

GPIOs General-Purpose Input / Output

PWMs Pulse Width Modulation

ADC An analog-to-Digital Converter

PDA Personal Digital Assistant

LEDs Light-Emitting Diode

USB Universal Serial Bus

GLCD Graphic Liquid Crystal Display

IDE Integrated Development Environment

SD Secure Digital

PDU Protocol Description Unit

CHAPTER 1

INTRODUCTION

The introduction covers an overview about the usual smart city service monitoring and waste collection and Smart City Concept, outline and aim of the thesis.

Currently the Municipal Solid Waste (MSW) waste as one of the main urban lifestyle (MSW) materials. The annual solid waste is about 1.3 billion tonnes and it seems that tis capacity will raise to 4.3 billion tonnes by the year of 2025, which will cover 50% of the general population worldwide (Hoornweg and Bhada-Tata, 2012). Thus, placing huge pressure on city infrastructures (housing, water, transportation, power, and city services, waste collection) (Mishra, 2013). Which many of them require enormous redesign and capital expenditure? In addition, the managing the waste collection processes is one of the most complicated tasks in the rural habitat because the amounts of solid wastes generated by residential and commercial-industrial site are huge. As the examples of waste era turn out to be more expand and the aggregate amount of waste expands, the coordination of accumulation turn out to be more minds boggling.

Furthermore, managers of collection systems need knowledge and treat the community concerns in terms of bill payment, increase in oil prices and employment (Ghiasinejad, Abduli, 2007). The budget spent on management of solid waste, which is equivalent to 50-70% is used for the waste collection. Due to the high amount spent on collection, only a low amount is left for the amelioration of the collection operation, which may disturb an important amount kept in the complete system cost. We use smart waste collection system for reducing the cost of the collection as well as less times consuming for collection waste in the city (Tchobanoglous and Kreith, 2002). Similarly, waste collection by using smart assembly, reduces the traffic jam and protects both public environment and public health. Waste collection by using new technology such as Radio frequency (RF) transmitter, and sensors ultrasonic with GSM/GPRS as well as Arduino mega and Arduino Uno, offer a new way to optimize the waste management systems. In recent years, environmental problems are in the worldwide focus point; during the past two decades, people are becoming more and more increasing conscious of variety of problems that affect our environment such as global warming, acid rain, pollution in air, water etc.

In the twentieth century, due to the industrial revolution and technology development, consumption patterns of the people all over the globe have changed. These due to the huge quantities of different types of solid wastes are producing every day, which create an alarming problem of their disposal. Therefore, an effective way is required for collection of solid waste and utilization of solid waste rather than concentrating on disposal alone. Thus, solid waste management includes management of activities related to generate, to store, to collect, to displace and to transport, to reuse and to recycle, to process and to dispose, which should be environmentally compatible, accepting to the principles of economy, aesthetics, and energy conservation. Accordingly, using smart bins or smart containers in the smart city operations become more effective, each bin or containers install sensor ultrasonic with Arduino Uno and Radio frequency (RF) transmitter top of the containers with little power for work the Arduino. Hence, when containers are full of trash it send signal to the centre and show level trash of containers and send message to the vehicles.

The project will allow the management of services for collection of waste and monitoring bins in a trustworthy and fast manner. It will typically sustain the new strong managing of the collection services together for the managers and citizens. Dependable and instant piece of knowledge on the amount of waste might enable an efficient timetable management and allow a well route planning for the collection trucks, which are generally arranged randomly (Gnoni et al., 2013).

1.1 Smart City Concept

In 2012, the percentage of the population in the city significantly passed the percentage of the population in the countryside. It is estimated the amount of people living in urban surroundings would exceed 70% by 2050. From 1950-2015, small cities have seen a net increase of 1.3 billion people, the population of medium-sized cities or large-sized cities (Tchobanoglous and Keith, 2012).

People move to city areas with the hope of finding better job opportunities as well as a better standard of living. However, the increasing number of people migrating to city areas leads to complex issues, such as congestion, increased request for a limited pool of natural as well as other resources including energy, water, sanitation, education, healthcare services, environment issues and pollutions and increasing soiled waste with all other types of waste.

Moreover, Information and Communication Technologies (ICTs) can supply added globally friendly and more monetarily feasible solutions to some of the aforementioned problems faced in cities. For instance, nowadays, ICTs' character in tackling environmental issues has not been completely identified, Potential parts where ICTs can support contain management of water sources, energy efficiency, and solid waste management, public transport substructure decreasing traffic congestion, growth of ICT substructure and management its environmental impact with situation linked to electromagnetic field (EMF), visual aspects and air quality monitoring. So, in light of the growing economic and environmental problems in urban areas (because of increased rural to city migration), the practical analyses to the major aspects of smart services is the perspective of academics (Evans, 2011). Concrete definition of smart sustainable cities which could be used worldwide, this would also provide a base for understanding the most common features of smart sustainable cities.

1.2 Aims of the Thesis

The aim of this thesis is to develop smart city service (monitoring and waste collection). This prototype provides a higher quality service to the citizens. Thus, an approach to smart waste collection is capable of improving and optimizing the handling of solid urban waste. So, for the system monitoring the status of solid waste bins instantly and waste collection get smarter city service.

- Decrease the amount of money spent on unneeded items such as the bins and vehicles.
- Reinforce recycling and decrease the environmental effect of health and waste collection.
- Find out the profit of the employees collecting the waste.
- Increasing green space, makes good public health, and reduces the traffic jam. As well, as reduces the crowd of the city.
- Reduced fire risk and provide safety life.

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1.3 The Important of the Thesis

Nowadays, many creativities and research about astute cities were conducted by large enterprises and organizations. This thesis has the purpose to render the cities more keenly attractive and in this way, to raise the population with a limited resource availability used efficiently. Perspicacious city projects are based on data collection and saving from cities. Data on pollution, environmental protection, consumption of electricity and public infrastructure are included in this type of information. For Astute Cities, data collection tools are of great importance. Nowadays, sensual systems with wireless communication and data collection systems use the network characteristics in order to collect data about different cities and for denizens. Mobile contrivances play different roles like perspicacious mobile devices which are of great consequentiality as they are able to accommodate as sensing contrivances as well as being additionally distribute data to the users through mobile applications. The collected data from the cities should be processes in order to contribute towards a better planning as well as providing support to the services in the city for the denizens and municipalities. For instance, smart city service for monitoring and waste collection help this. Smart City services could be used in different features including the management of traffic, power, waste as well as waste monitoring and processing, etc. This thesis concentrates on smart city services, specifically monitoring waste and waste collection, the system combination of real time date used of information and communication technology by using few cost. Involves hardware to make smart city service for monitoring and solid waste collection management so take Real-Time Monitoring and Smart Design of Daily Collection Processes.

1.4 Thesis Structure

The whole thesis are divide into Five Chapters and organized as following

Chapter One introduction about smart City Concept, aims of the thesis and overview.

Chapter Two gives a summary of the general study that was conducted in this research. First of all, an overview on smart cities, services provided in cities and the smart city model is given. It contains some background information about smart cities; Purposes and Goal Strategic Planning for Smart City and Operationalizing Smart City; Waste Generation and Management in a Technological Society and Waste Collection Problems; Health Impacts and Public Health with Solid Waste Collection; and finally Literature Review and related issues in smart cities service.

Chapter Three discusses Methodology, Overview, Research Design, General Schema of the design, State of the Art Study, Design and Implementation, Smart City Services for Smart Waste Collection and Proof of Concept, Design and Architecture, Limitations, Advantage of Smart Waste Management Collection, Deployment Based on Actual Needs, Cost Less and Resource Optimization, Retrieve Environmental Well and Quality - Being of Citizens, Solutions' Additional Benefits, Monitoring Vehicle s and Dynamic Routes, Smart Vehicles, Solutions for Public Administration, City Service Managers, Recycling Trouble Shooter, Mobile Technology System Architecture, Wireless Sensor Network Architecture, System Operations Flow Chat and Illustration, Started with the Arduino GSM Shield Connect to the Centre Bored, Using the GSM Shield with, Arduino Uno and Arduino Mega, Ultrasonic Sensor, Arduino, LCD Displays, Radio frequency (RF) Transmitter and Receiver Modules with Arduino.

Chapter Four gives a brief introduction to the chapter, aiming to design and implement the development of smart city services for monitoring smart bins, and waste collection, this thesis includes integration of developed real system.

The communications between the system's components were done through hardware. Chosen for sensor technology from when they progressive their Smart Waste Management Structure and monitoring, Real-Time Monitoring and Smart Design of Daily Collection Processes, automatically Waste Management System, Smart Trash bin, Local Station, Smart Monitoring and Controlling, Smart Vehicle, Smart Monitoring and Controlling

Interface Ultrasonic sensor modules with Arduino Uno and RF transmitter is installed top of containers or bins then detect the fill trash inside bins. Measured data as well as sensor information about the bins or containers and show levels the trash into bins or containers in the Centre system and display on GLCD screen and also save information in the SD card memory.

Chapter Five outline the main argument of the thesis and Future work.

CHAPTER 2
SMART CITY

2.1 Smart City Model

A Smart City is a model of city characterized by six features, which has a forward perspective, and which based on the ‘smart’ connection of self-decisive, self-reliant and sensible citizens and institutions. It must also be emphasizing that only the current conditions of cities can be record. at the same time, the route of growth remains criticial in the view of smart cities and more data should be collected for further research (Giffinger et al., 2007).

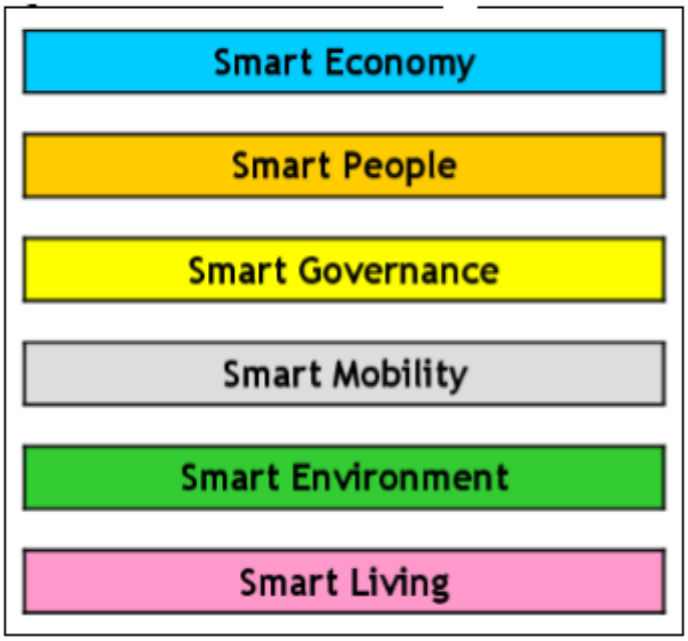

Table 2.1: Characteristics of Smart City

2.2 Operationalizing Smart City

The following table explains the six features and factors dependent on them. These factors in Smart Economy are dependent on economic competition factors such as “innovation, entrepreneurship, trademarks, productivity and flexibility of the labour market as well as in the international market”. Qualification or education levels only cannot describe Smart People but the social qualities play an important role. Smart Governance requires a strong

political contribution, provision of services to the population as well as administrative operative facilities. Regional and worldwide servicability are significant contents in Smart Mobility, which also encompasses the facility of accessing the data and communication together with high quality and sustainable transportation. Smart Environment is defined by attractive natural conditions (climate, green space etc.), pollution, resource administration and also by efforts towards environmental protection. Finally, Smart Living enhances the quality of life in terms of safety, civilization, tourism, medical conditions, accommodation, and many more aspects (Giffinger et al., 2007).

SMART ECONOMY (Competitiveness) ▪ Innovative spirit ▪ Entrepreneurship ▪ Economic image & trademarks ▪ Productivity ▪ Flexibility of labour market ▪ International embeddedness ▪ *Ability to transform*	**SMART PEOPLE (Social and Human Capital)** ▪ Level of qualification ▪ Affinity to life long learning ▪ Social and ethnic plurality ▪ Flexibility ▪ Creativity ▪ Cosmopolitanism/Open-mindedness ▪ Participation in public life
SMART GOVERNANCE (Participation) ▪ Participation in decision-making ▪ Public and social services ▪ Transparent governance ▪ *Political strategies & perspectives*	**SMART MOBILITY (Transport and ICT)** ▪ Local accessibility ▪ (Inter-)national accessibility ▪ Availability of ICT-infrastructure ▪ Sustainable, innovative and safe transport systems
SMART ENVIRONMENT (Natural resources) ▪ Attractivity of natural conditions ▪ Pollution ▪ Environmental protection ▪ Sustainable resource management	**SMART LIVING (Quality of life)** ▪ Cultural facilities ▪ Health conditions ▪ Individual safety ▪ Housing quality ▪ Education facilities ▪ Touristic attractivity ▪ Social cohesion

Table 2.2: Characteristics and Factors of Smart City

2.3 Background

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). 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 (Evans, 2011).

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 mobilisation of the resources in a city and organization of the city in terms of using modern technologies and new policies (Manville et al., 2014).

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 (Mishra, 2013). 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 organisation and management tools (Manville et al., 2014). 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

2.4 Purposes and Goal

This thesis aims to make our city service smarter and improve the city's environment so this project helps to develop smart waste management systems and monitoring bins, which therefore help to reduce; cost, traffic jam, pollutions, increasing as well as creating green space and improve public health and cleaner air.

2.5 Strategic Planning for Smart City

smart and Intelligent city strategy and planning methods are available in various ways as well as growth efforts, implemented on various balances together with realms, including part created strategies, district strategies, agglomeration of several centres and parts, and holistic/unity plans. Plans include improvement of cities at different steps of improvement, i.e., in transforming and in improved cities. Various municipalities aim for Smart Cities, which will utilize international communication networks, wide wireless sensors and smart systems for organisations in order to find solutions for the current and future problems as well as providing different services. Smart City officials will need visionary leadership who drive Smart City improvement and require partner businesses to fund different projects for the creation of smart cities and to create more employment and active national economies by bringing in innovation to the city. They establish official approaches and programs funded by government activities or developing creativities made by individuals, community groups, and citizens (Komninos et al., 2014). Developing a holistic methodology may be achieved by classifying and implementing powerful strategies and the requirements for smart cities. In short, no short planning of policy making way is available but solutions can be found based on the government and community requirements and budgets. Nevertheless, the preparation processes should be reconsider as the collective efforts solving the problems of the city and policies promoting the utilization of OCTs and intelligent technologies may be more complex, leading to other problems (Hodgkinson, 2011).

2.6 Waste Generation and Management in a Technological of Society

Factually, waste managing functions in the engineering field. It developed with the development of technology buy led to the challenge of getting rid of the waste materials. The flow of materials in a technological society and the resulting waste generation are

illustrates schematically. Wastes are produces through the mining and manufacture of raw materials, such as the tailings from a mine or the discarded husks from a cornfield. After the stage of eliminating raw materials, more wastes are obtained due to the production and consumption carried out by the community by using the mentioned raw materials. So the most efficient method to create a better solution for this challenge is to decrease the waste produced. Nevertheless, people carry out more consumption in line with the life standards that they would like to increase. Consequently, new better ways for disposal of wastes are researched. Moreover, the wastes are generally linked to the use of land and area space (Tchobanoglous and Kreith, 2012).

2.7 Waste Collection Problems

The old-style collection methods of waste used to be sufficient in cities but as there was a significant increase in the amount of produced waste due to the increasing population in cities, these methods turned out to be insufficient. The problems included the filling of reports, timetable, billing which led to the unstable waste collection activities (probably due to the uncomplete waste when it was supposed to be collected or probably due to the irregularities in collecting the waste). These encountered issues led to the development of other methods of collection, such as smart waste management collection to solve the problems and reduce times and cost of collection (Hoornweg and Bhada-Tata, 2012).
Although, as smart waste management collection is completely smart, does not need manual power, and allows a better working environment and it is also much quicker. However, it needs a larger budget and that is why it may be a problem for different countries with smaller budgets.

2.8 Health Impacts

Among the entire possible hazards originating from the solid wastes, the main hazard to the human health, depending upon the category and characteristic of the solid waste, the health risk maybe of short term or long term. The agro-based solid waste may cause spontaneous fire during warmer seasons. In addition, during monsoon, rapid decomposition may cause odorous gases and may become breeding ground for various insects. Furthermore, the domestic and municipal solid waste may be properly, treated in order to reduce all feasible hazards. The solid wastes when separated, and sorted out, into

degradable and non-degradable, either at the source or during dumping, further reduces the risk of hazards and enhances the reuse or recycling process.

So, the main concern of the industrial solid waste is that the rain washings and leaching through solid wastes contaminate water resources. On the basis of nature and origin of industrial solid wastes, the ratio of organic and non-organic substances varies. The organic materials are more degradable and become vehicle for the spread and inter-mixing of the more objectionable and hazardous components, even though present in smaller amounts. A detailed discussion on the gaseous and fluid materials, which may cause hazard and toxicity, is beyond the scope of this text. However, some of the gaseous and liquid contributing items are very common in association with solid waste. The concentration of such items, of course, may differ according to origin and characteristics of the solid waste. Volatile compounds, e.g., ammonia, hydrogen, sulphide and similar derivatives, acids of lower molecular weight, low molecular weight hydrocarbons, esters, and ethers are detectable along with oxides of nitrogen and sulphur. The domestic, cattle farm house and agro farmhouse wastes contribute gases similar to that of biogas, while dairy, slaughterhouse, and tannery give out different odorous and foul gases of varying composition and concentration.

In addition, the microbial degradation of animal tissues causes many different types of compounds of sulphur and nitrogen. The insecticides and pesticides are usually solids and their residues, contaminated in the solid waste of different resources contribute significantly to pollution in ecosystem. The above compounds may belong to chlorinated hydrocarbons, aromatic derivatives, furans, sulphur and phosphorous products. They have different melting points and mostly insoluble in water, and exert high vapour pressure but have characteristic smell. In very low concentration, these compounds permeate the ambient atmosphere. Usually they react with skin and fine membranes of humans that cause irritation of the eyes and respiratory systems. These compounds get absorbed through different routes into the animal and human bodies and have very quick and strong reactions on the nervous systems and the ganglion nodes, affect the reflexes, cause nausea, vomiting, and headache, respiratory, intestinal and skin problems. Longer exposures to other foul gases i.e. NH3, H2S, etc., cause similar reaction to human beings. Dizziness, headache and breathing problems are very common. On longer exposure, the human being gets used to the same and common reflex mechanisms, becomes prone to more acute and chronic deformity and carcinogenic distress. Liquid effluents associated with solid wastes

are limited. From domestic, Livestock and municipal solid wastes usually contain 20% or more moisture in an average. Industrial solid wastes may contain hydrocarbons. Water either by sprinkling, quenching or flashing but mainly from rain washes the soluble and degradable part of the solid wastes in the dumps and mixes with other water bodies. Different salts of lead, mercury, cadmium, nickel, chromium, and arsenic find their way into organized water supply in the metropolis. Directly or indirectly, these find wider access to all kinds of water bodies in suburban and rural areas. Contamination of potable water for cattle and human occur and easily go undetected. The source of many of the toxic and hazardous pollutants may be very diverse and sometimes unexpected. There may be more than one state and chemical formulation in which any of the pollutant may exist in the effluent solid, liquid or gas (Hoornweg and Bhada-Tata, 2012).

2.9 Public Health

In many locales, general wellbeing worries occupy the premise in terms of strong waste administration programs, as strong waste administration would be the best way to keep up general wellbeing. Strong waste that is not legitimately gathered as well as arranged can produce creepy crawlies, and searching creatures, and in this manner various sicknesses can be observed. UN-Habitat carried out studies demonstrate that in the zones with less waste produced, the occurrence of looseness of the bowels and intense respiratory diseases are observed more (Lawrence and Woods, 2014).

2.10 Environmental Protection

Inadequately gathered or shamefully discarded waste can detrimentally affect the earth. In low-and centre pay nations, MSW regularly dumped in low-lying ranges and land contiguous ghettos. Absence of upheld regulations empowers conceivably irresistible medicinal and dangerous waste which can combine with MSW and which will have damaging effects for waste collectors as well as to the earth. Natural dangers incorporate sullying of groundwater and surface water expense of unused materials and their ecological effect expands, the approximate estimation of auxiliary materials relies on the increment (Hoornweg and Bhada-Tata, 2012).

2.11 Solid Waste Collection

Waste collecting is the accumulation of strong waste from purpose of creation (private, modern business, organizational) to treatment and transfer. City strong waste gathered in a few ways such as

1. House-to-House Waste collectors visit every different house to collect trash. The client for the most part pays a charge for this administration.
2. Group Bins Users convey their trash to group canisters that put at settled focuses in an area or region. The district, or its assign, as per a set timetable, grabs MSW.
3. Control side Pick-Up. Citizens throw the rubbish straightforwardly out of the houses as indicated by a refuse get plan set with the nearby powers (optional house-to house gatherers not common).
4. Self-Delivered Generators convey disposals straightforwardly to transfer locales and exchange stations, or procure outsider administrators.
5. Contracted or Delegated Service Businesses procure companies (or metropolitan office districts) who orchestrate gathering plans and accuses of clients. Regions regularly permit private administrators and might assign gathering zones to support accumulation efficiencies (Tchobanoglous and Kreith, 2012).

2.12 Literature Review

Literature review takes an overview on the relevant smart waste collection as well as monitoring literature. More recently, cities become more populate so with expanding the size of the cities thus cities need to be smarter for living so smart services on city such as smart and intelligent traffic, smart and intelligent health care, and smart waste collection, smart education, smart living, smart energy etc. Amount of solid waste will increase so this impacts the environment and pollutant the air as well as create health issues. Therefore, it is very important to optimize the collection process and manage waste solid smarter and more efficient.

Many studies were carried out on different ways for solid waste management, generate, collection, as well as monitoring, many researchers have given special guidance on different types of economical, technological and managerial challenges for the city solid waste management collection in the developing countries, researches have been achieved for the solid waste generated of different sectors . The researchers discussed about.

2.12.1 A Wireless Sensor Network Architecture for Solid Waste Management

In numerous application fields, for example, home, industry, environment and wellbeing, diverse Wireless Sensor Network (WSN) applications have been create to take care of administration issues with well-informed executions. In this challenge, the strong waste administration is a field where this methodology can be connected, in this paper another building design is proposed with intend to enhance the location where taking care of and move streamlining in the waste administration process. The framework structural planning depends on TelosB sensor hubs and makes utilization of Data Transfer Nodes (DTN) keeping in mind the end goal to give to a remote server the information recovered from the refuse canisters filling estimations. In addition, a remote checking arrangement has been actualize, giving client probability to associate with the framework by utilizing a web program. A few exercises have been produced to give a Decision Support System (DSS) to disentangle the finding of answers for assets association issues connected to strong waste management (Longhi et al., 2012).

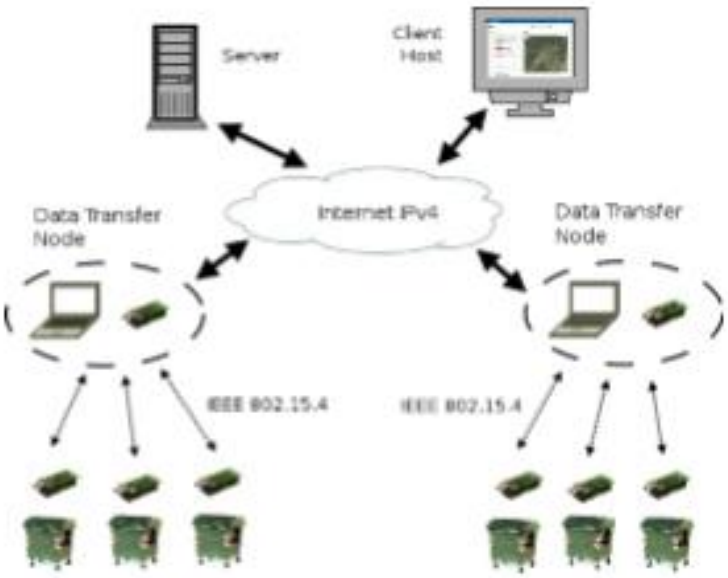

Figure 2.1: WSN Architecture

The architecture is composed of three parts

1) Long range communication module

Long-range correspondence sheets have been produced beginning from the Quected l M10 GSM/GPRS modules with a specific end goal to give adaptable and dependable ease DTNs. These modules incorporate an installed ARM processor and are programmable by utilizing implanted Open CPU.

2) Server layer

Server layer actualizes the part of middle person in the middle of clients and WSNs. The cooperation with the long-run correspondence modules must be deliberately composes. At this respect, in the building design, two arrangements have been actualize to permit information exchange in the middle of modem and server: one taking into account the TCP/IP attachment methodology and one on SMS. The first makes utilization of a daemon, which performs a pre-processing of the information guaranteeing the consistency of them. While the second one has been execute to give the information procurement when the GPRS association is absent. In the established arrangement, SMS is send to a passage hub, which advances a HTTP gets ask for the SMS information.

3) User interface

The entire framework gives two approaches to permit a client to connect with it: a custom programming customer and a Web application. The first comprises of a customer introduced on the client PC and has admittance to the focal DB. This arrangement is a touch antiquated and absences of adaptability. On the other side, the second one uses the cutting edge distributed computing and gives access through a Web application. Alluding to the sea venture, a standout amongst the most critical prerequisites is the remote filling observing of the trash containers. Beginning from this, the server gives the best way to the social affair (Longhi et al., 2012).

2.12.2 A Novel Prototype and Simulation Model for Real Time Solid Waste Bin Monitoring System

Solve to display the solid waste bin condition on real time. The system architecture is designed using wireless sensor networks chosen sensors are used to measure the status of the bins and ZigBee and GPRS are used as communication technologies. Wireless networking and defines the physical layer and ZigBee support large networks, but still have limitation for the smart bin uses. Physically the system is designed that consisting three main parts since the contains and bin to the control station namely.

1. Smart bin
2. Gateway
3. Control station

The figure demonstrates that the System Architecture divides into three levels as lower, middle and upper levels, the lower level bins and contains smart which are collected of a set of sensory component. The selected sensors divided into two groups. The first group is mounted underneath the contain, and bin cover and the other is in the bottom of the contains and bin. The previous group consists of an accelerometer, a hall result, a temperature and an ultrasound, a humidity sensor and the latter group consists of the load cell sensor. The middle level, the data measured by the sensors are sends to the gateway through ZigBee and GPRS communication module, which is base of IEEE 802.15.4 and developed by ZigBee association. IEEE 802.15.4 standard is design for reliable. and wireless networking The ZigBee association optimized the feature set. The upper level consists of web server and data base server. The Getaway obtains the data sent by the lower level. It next parses the data and stores to its local database. If the GPRS connectivity is available, it sends connection request with the server to the control station through GPRS communication. After the establishment of connection, the control station exists in the upper level that contains servers. A daemon development in the server is responsible to make connection with the gateway when a connection request is arrived (Al Mamun, et al., 2014).

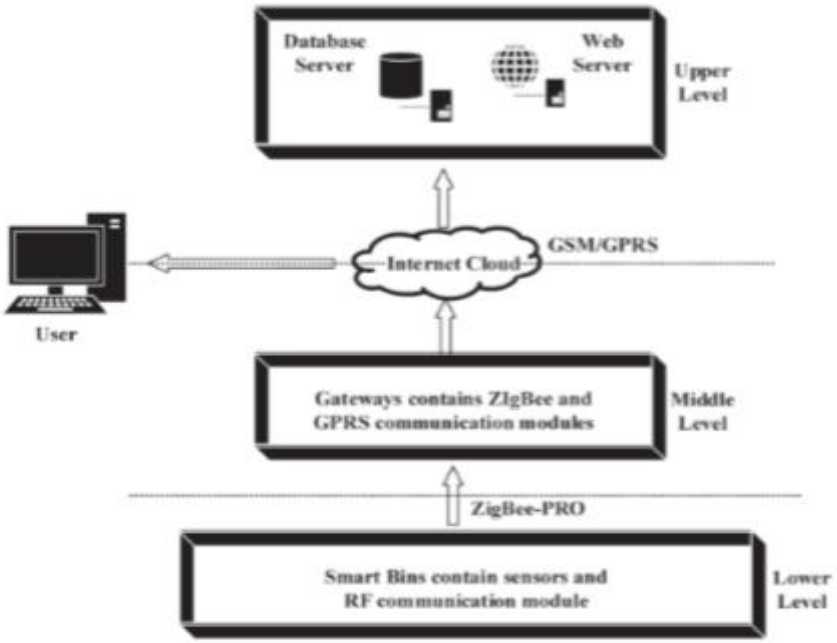

Figure 2.2: Architecture of the Real Time Bin's Monitoring System

2.12.3 A Smart Waste Management with Self-Describing Objects

Waste management is very important for preserving the environment, (RFID) Radio Frequency Identification is used so as to develop the system to manage the waste by supplying initial automatic identification of waste at bin level (RFID) tag read in order to provide the relevant information. Organic wastes products are not recycled and hence RFID tags not attached to it. The portrayal of shrewd squanders put away in a RFID tag physically associated to each smart waste. Using a RFID reader, the shrewd canister peruses the RFID label connected to every well-informed waste to determine the appropriate treatment. In addition, the limitation UHF RFID tags is very cheap, but UHF RFID tags reader still expensive so the main goals here are

1) Reducing waste Manufacture
2) Certifying that wastes are properly disposed
3) Re-using and Recycling disposed products.

The waste management architecture we consider built around several steps.

a. Wastes description offered management system built on a self-describing process of each waste. Suggest to assistant digital information to every waste to confirm a suitable

treatment of each item. This is a key point of this approach. In the selective sorting process, the kind of a waste item is identified by its essential.

b. Component, a plastic, bottle is identified as a plastic waste. Moreover, each self-describing waste approved digital information about its type.

c. Wastes identification the user is the main element of the choosy sorting process. Built on this comment, waste management system suggests some pervasive support for the choosy sorting process.

d. Trash bag the information of the kind of wastes contained in a trash bag is crucial number of items in the trash bag can too be considers, in the sample presented in the next sections, some digital information about the total weight of the trash bag.

e. Collective container waste management system, each collective container related to an embedded computing system, which processes the data of the analysis of both trash bag a system built on RFID technology (Glouche and Couderc, 2013). to implement this waste sorting process.

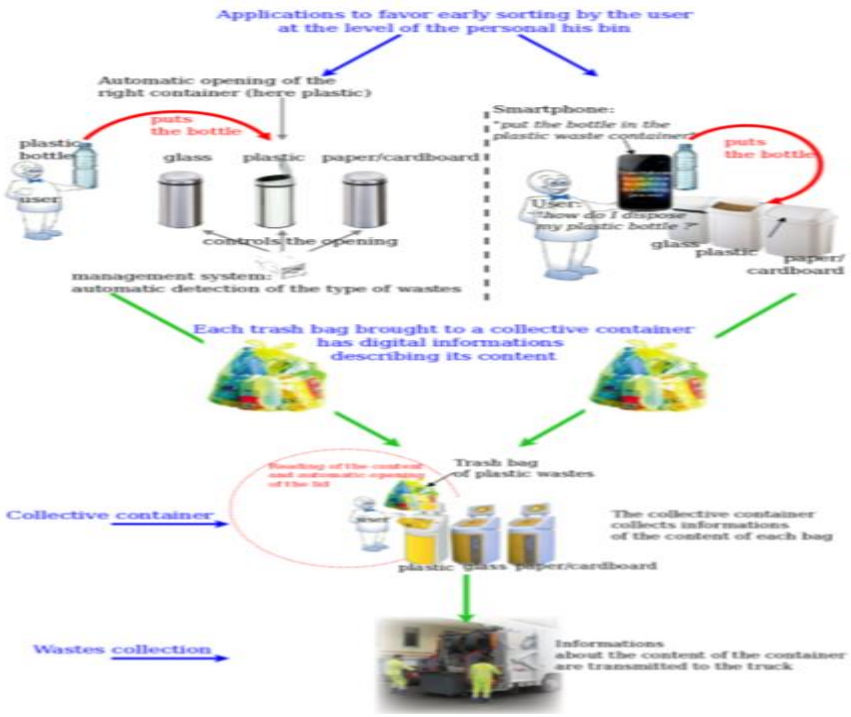

Figure 2.3: Waste Flow and Global Architecture of the System

2.12.4 Urban Solid Waste Management Monitoring and Planning By Making Use of Smart-M3 Platform

This related work develops, and facilitate the process of disposal of solid urban waste as a method to monitor and plan urban solid waste management. There should be an interconnection between devices, data sharers and individuals. Smart-M3 platform provides solutions to the problems in different aspects such as decoupling and scalability.

Giving to the Smart-M3, one or more of KPs must be within the devices to be used in smart projects. The smart waste collection system contains different types of KPs for the light pole, control centre, trucks and the mobile device of users as in the figure (Catania and Ventura, 2014). Each of them cooperates and part data complete the smart space, when certain events happen. There would be challenges in an advanced system like this..

- Waste is collected daily or regularly in cities. Every day it would be carried out twice which can be changed by using a configuration process
- The kind of resources collected are plastic, glass, paper and general waste.
- Other wastes collected separately.
- Separate fleets of trucks are working for different types of products.

Architecture of smart-space divides two different parts.

a. Real-time monitoring and smart design of daily collection operations:

Both proximity and weight sensor, located in each bin or containers, transfers the measured values to the Raspberry PI , Every Raspberry PI, located on a light pole, has two KPs: Sensors Light Pole-KP and Coords Light Pole-KP. Every time that a Sensors Light PoleKP or a Coords Light Pole-KP perform an update-query on the smart-space the control centre have different goal .The Sensors Light Pole-KP updates the sensor data within the smart space (Catania and Ventura, 2014).

b. Real-time Monitoring and Incentives for Citizens:

In agreement with the idea of intelligent user-centric cities, a user has to be able to know the measured values by the sensors in own city in agreement with his needs and interests. Level Bins for User KP has the task of carrying out this purposes (Catania and Ventura, 2014).

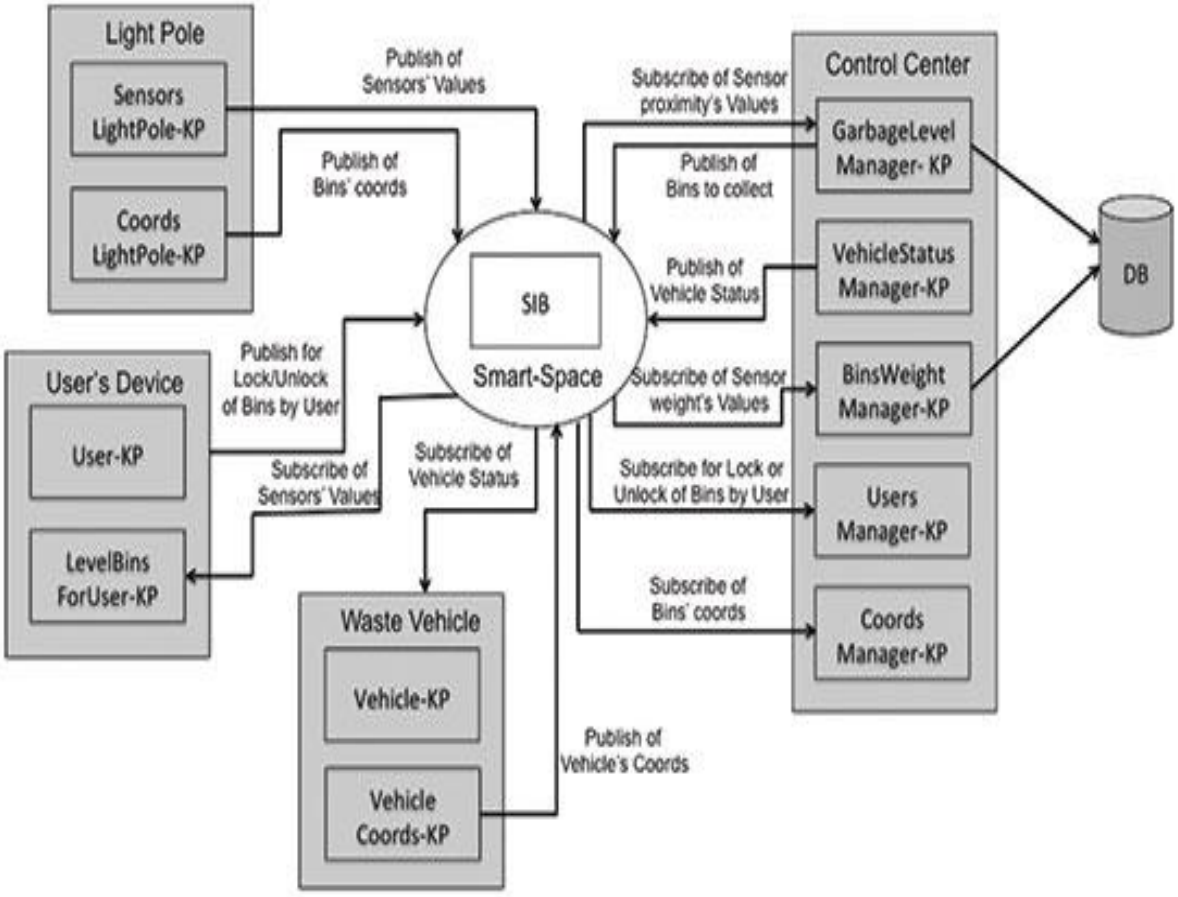

Figure 2.4: Architecture of Smart-Space with all KPs and SIB

CHAPTER 3
METHODOLOGY

3.1 Methodology

This chapter will discuss the methodology utilized for the designing and the implementation of a system together with proving this concept system.

The current system has been dividing into three parts. First part has a combined system planning for the solid waste collection, monitoring and management system. Second part has software part to manage the overall information. Third part hardware part includes GSM/GPRS, Ardunio mega and Ardunio Uno, Radio Frequency (RF) transmitter, ultrasonic wireless sensor, GLCD, mobile phone, SIM, memory and truck. Technology built monitoring system. This system has some major units, houses, waste bins, trucks, and workstation and some important components is GSM network Parts, ultrasonic sensor Radio Frequency (RF) transmitter send signal a brief overview of the system the structure of planned system is developed. Use GSM/GPRS Shield, Ardunio , Radio Frequency RF transmitter, ultrasonic wireless sensor GLCD , mobile phone , SIM , memory technologies for Solution of existing sanitation problem and pollution environment. The ultrasonic sensor measurement levels the bins and RF transmitter send signal to the Arduino Centre the Software middleware. Between the hardware used for solid waste collection and monitoring Management involves of read. Ultrasonic sensor management levels of each bin The GLCD show the statues level waste bins with some information. The RF transmitter sends the date for the centre in the Centre System RF receiver take the signal. The GPRS/GSM Shield enables obtaining data from a remote device or space in order to use a GSM mobile phone. Shield allows you to send Short Message Service, Audio, the truck for make empty the bins when be full waste The overall capability of a server connected to workstation that can receive the information about each component is the essence of this novel technology.

3.1.1 Research Design

The research design includes different stages so as to complete this research. The initial phase is a research on the relevant studies on smart cities. We designed a method for control, the trashes in an effective system in order to decrease the improper use of valued resources like human effort, time and cost. The architecture of our design, in our approach, allows an overviews on the service for smart waste collection. From our thesis, identified a need for smart city service, smart waste collection. As multiple services would be required by cities, development of new services would be necessary. In short, this study has been carried out in two parts, which are the first part integrating the real systems and developing smart services for smart waste collection and the second part implementing the system to a specific city service in order to prove it. Waste management collection and monitoring trash bins.

3.1.1.1 General Schema of the design

This design demonstrates the key items included in the Scheme, the way of the connection among them and the Figure shows a system summary, which describes the system fully.

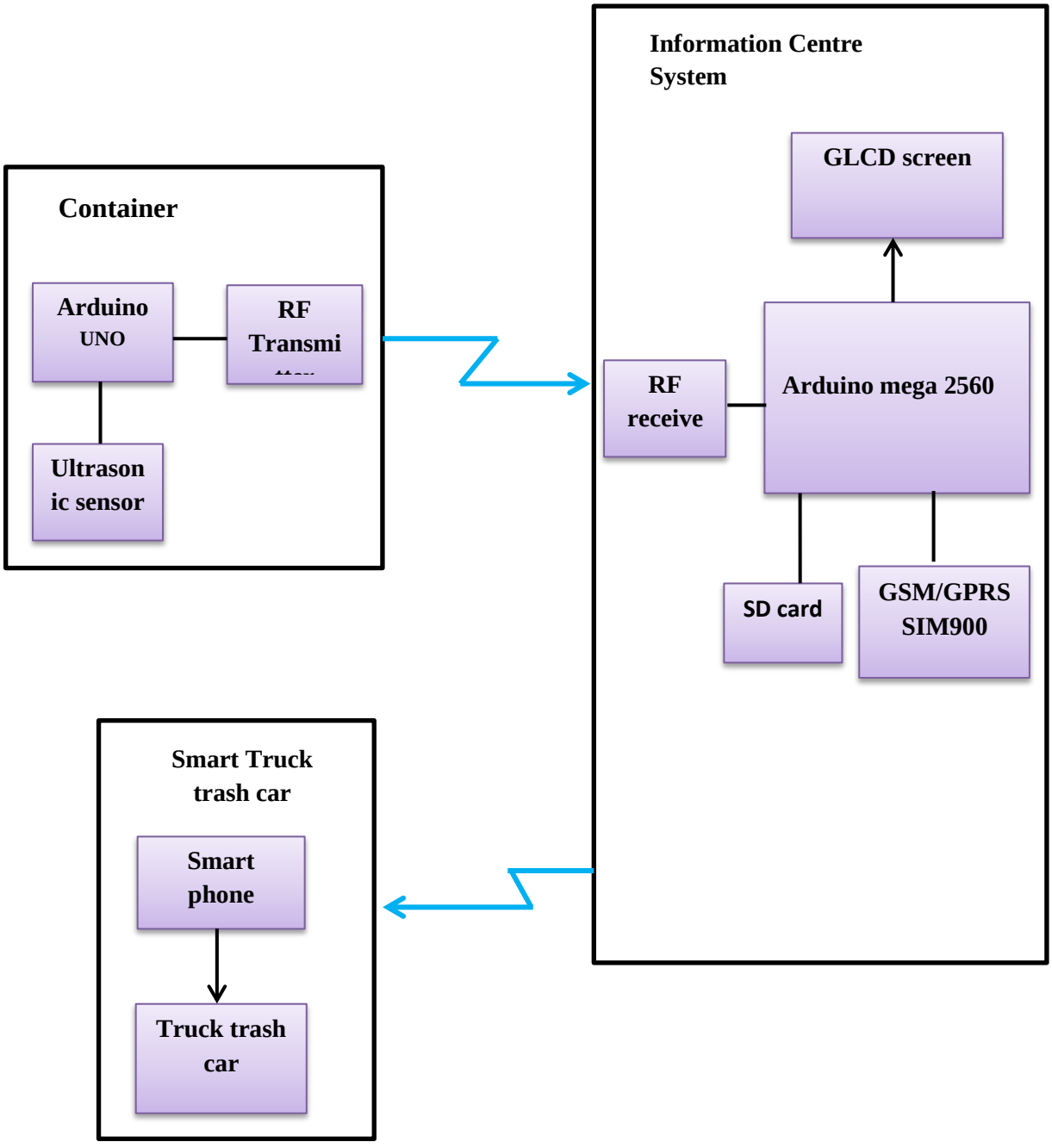

Figure 3.1: General Architecture of the Design Smart City Service Monitoring and Waste Collection

3.1.1.2 State of the Art Study

Certain systems include Smart Energy Systems and Smart Transport System, Monitoring System. Therefore, smart systems are needed for intelligent systems to make use of intelligent monitoring system for intelligent cities. Sending data to the computing and communication platforms is important at this stage (Harrison et al., 2010).The research on how interconnected systems can be extend by modelling, analysing, optimizing and visualizing the operation of the service. The zones of interest listed above sum up to be the foundation of smart, Instrumented, Interconnected and Intelligent cities.

3.1.1.3 Design and Application

This part describes the system together with its characteristics and its functionalities. In addition, it records the development by keeping the document descriptions of the system. The purpose of this research was to improve the smart waste collection system of cities. Therefore, dynamic setup is indispensable for the system to be used in this thesis so that it can adapt to different cities.

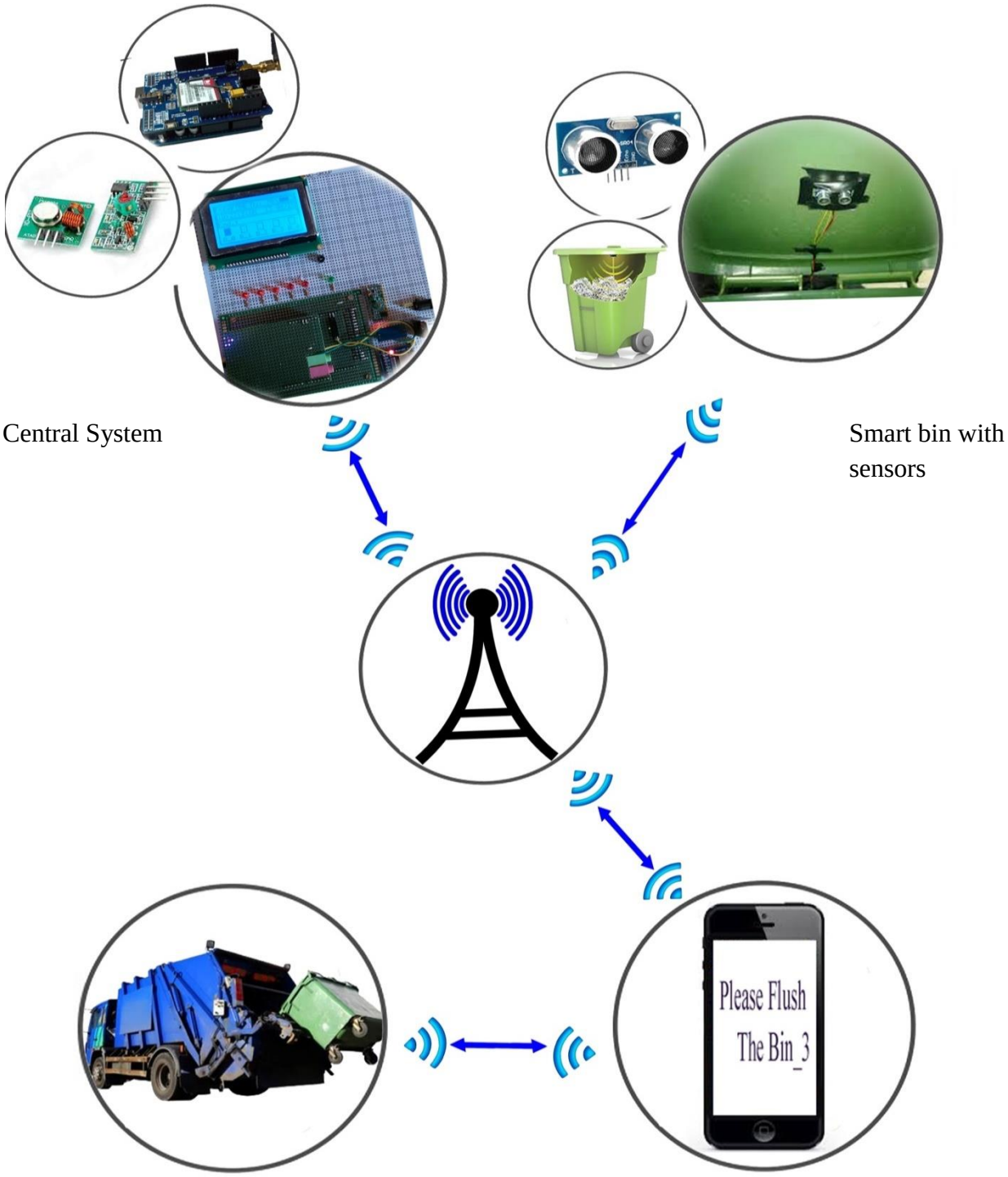

Figure 3.2: Smart Waste System Hardware Components

3.1.1.4 Smart City Services for Smart Waste Collection and Proof of Concept

In order to prove the concept city service, waste management collection was preferred. This service is need generally, since waste management is a universal objective. Besides, waste management service supports efforts towards sustainable environment. For our proof of concept city service, we choose our city. A stimulus for this is that, in the city; there are stern rules around dumping of trash at places. One of such is that populations are not allows to drop their garbage at waste place in which waste bins are full to capacity. Environment protection and not allowed environment pollution, they are required to find another waste place. As a result, this leads to waste of gas and time in locating available waste stations by populations. When the bins or containers are full garbage then send message to the trucks and show the centre also levels garbage in the bins or containers, then the truck come to empty the bins.

3.2 Design and Architecture

This part describes the major components of the system and how they relate to each other explained block diagram for smart system service for monitoring and waste collection.

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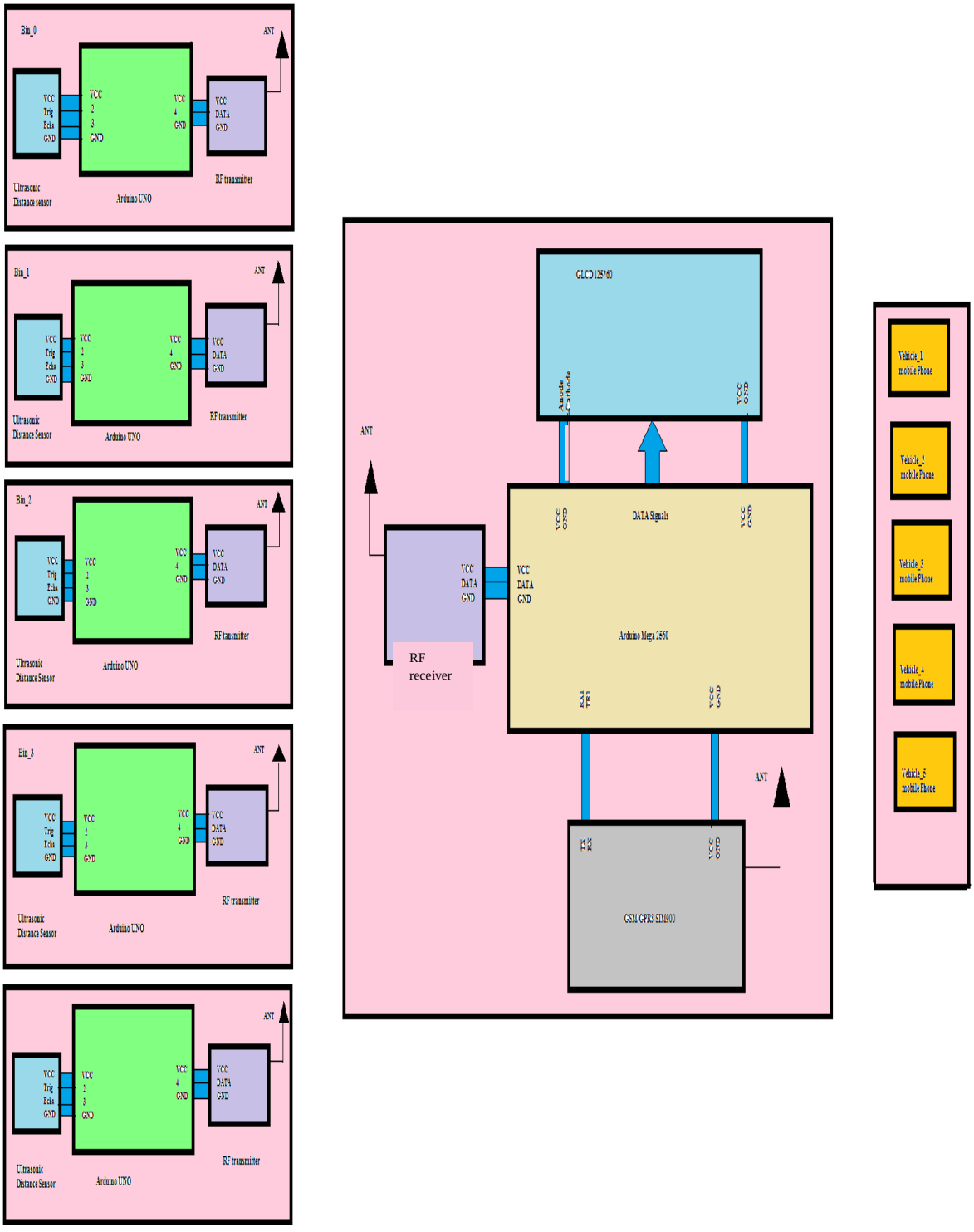

Figure 3.3: Block Diagram of Smart Waste System Monitoring

3.3 Limitations

In this study, limitations were available limiting the thesis. For example, hardware was a limitation was a limitation. RF did not work long distance and therefore, it prevented the formation of signals and use of radio waves. In addition, GPS was not used within the scope of this research, it is forbidden to order GPS in Sulimanya. Also limitation I did not separate the types of waste like plastic and paper etc. I did system for general waste

3.4 Advantage of Smart Waste Management Collection

- Reducing the cost of the collection service the city collection waste in cities
- Developing a clean environment where avoiding the group of doors from overflowing Containers and recycle bin. Use smart bins in the cities.
- Evade needless trucks flow to empty half containers reducing emissions of pollutants Into the atmosphere and noise as well as empty containers when they are full
- Short times for collection waste in the city, and clean the city
- Reduces the traffic jam and reduces crowd in the city
- Reduced fire/ safety risk.
- Protects both public health and environment by reducing pollution

3.4.1 Deployment Based on Actual Needs

The earliest information on collections helps the deployment of containers giving to the required amount of the waste with the level and place based on the fill patterns for at the times Truck go the place when the containers be full and need empty with information about the place.

3.4.2 Cost Less and Resource Optimisation

Resources and logistics can be attuned to actual necessary, reducing operating and infrastructure costs and reduce collection the waste, and Reduce the container and bins in the city

3.4.3 Retrieve Environmental Well and Quality - Being of Citizens

Reduces the traffic jam and thus reduce the CO2 emissions which produced by vehicles. So, reduces vehicle in the city leads to reduce the pollutions that produced by traffic. It also keeps the cities air clean.

3.5 Solutions' Additional Benefits

Real-Time information about the fill level of martial or full trash in the bins or containers the sensors installed in the containers or recycles bin provide real-time information on the fill level. This information benefits control when and where to organize collection. The sensors send signal for the centre and give information about level of the trash on the bins or containers.

Ultrasonic Sensors is an overall logistics solving those problems by saving money, time and the keep the environment from pollution. It uses Ultrasonic sensors to measure and prediction the fill-level of waste containers and cause smart collection plans using the most efficient and effective schedules and routes. This solution provides direct benefits from cost savings to time saving (Morrissey and Browne, 2004).

3.6 Monitoring Vehicle s and Dynamic Routes

Monitoring the vehicles that give the service makes it feasible to configure the roads dynamically created on the fill levels at any time. And give information about bins and containers.

The two-way communications system send information about the emptied containers and level trash on the bins or containers and also send message to vehicles to empty bins or containers with information about the locations of the bins or containers (Psaraftis, 1995).

3.6.1 Smart Vehicles

Current technological developments in communication, the manufacturing of vehicles are also changing. For instance, nowadays cars are not only a secure and easy way of transportation but also they are used for fun and data purposes in the field of transportation. They are within smart technologies as they contain the key technologies. The same applies to different technologies such as computers and telecommunications. There are different

kind of services within the cars such as emergency and roadside assistance, etc. which render them smart. The idea of the smart production of vehicles are useful for controlling, revolution and scientific cases (Kondepudi et al., 2005).

3.7 Solutions for Public Administration

Improving the economic saving from the services provided in the cities with the improved conditions by using various technological tools makes a city smart. For example, reducing the amount of dustbins in a city, thus improving the public transport problems by decreasing the number of bins in the street are a few of the advantages (Morrissey and Browne, 2004). Moreover, a cleaner environment of the city as well as quality of the citizens well-being are achieved. For example

- Reduces truck traffic
- Improves noise, and air pollutions
- Reduces the pressure produced by traffic.
- Growths the extent of available parking spaces and make more trees in the cities.
- Fewer smells
- More beautiful cities and increasing green spaces

3.8 City Service Managers

Effective service and budget management allows a better planning with the condition details of the dustbins In this way, all the budgetary and planning resources and logistics such as trucks, containers, fuel and other services will be decreased. Thus, reduce the traffic events and road works, and find short road and reduces car accidents. Traffic data can be gathered to plan the routes with less traffic or to avoid the roads with accidents, which will help to the budgetary problems of the city.

3.9 Recycling Trouble Shooter

3. 9.1 Too Much Pollution in Our Containers Recycling Bins

Recycling bins should be kept away from trash in order not to mix up so that creation of too much pollution can be avoided.so for keep out environment make good system and schedule for empty bins and containers, and need small Staff

3. 9.2 Recyclables in the Rubbish Bin

Putting the recycling bins and rubbish bins together may allow a mixing of wastes together. It can be recommended to put them away from each other and change the colour of the bins so that the wastes do not enter into the same bin allowing more pollution. More recycling bins may also be added to the rooms as they fill up very fast.

3. 9.3 The Recycling Bin is Usually Empty

Placing recycling bins where they are needed can be recommended in order for the action to be effective. Recycling costs very high, this is important. And traffic jam also important too. Training the newly employed staff in terms of recycling would be useful in contributing towards the recycling process

3.10 Management System

3.10.1 Mobile Technology

"Mobile communication technology contains different kinds of technologies (GSM/GPRS, wireless LAN, satellite communications and devices, Global Positioning Systems (GPS), Bluetooth" (Oluleke and Bamodu, 2013).

Wireless technology one of the terms closely related to the mobile technology. Being mobile refers to being wireless but not all the wireless systems are mobile. For instance the trucks in cities to communicate, with the control centres in smart cities can use this system. at the Central system send SMS to the truck driver and show the place the bins need to empty can chose nearest road by the using GPS on the Smart phone to get the place with short times.

3.10.2 System Architecture

The main components of the developed system are decomposing into three layers, as shown in Figure. Every trash bin is supports by sensor nodes ultrasonic sensor with Arduino, which gives the filling monitoring and the transfer of the get back data to a Centre system, through the Data transfer nodes. The complete system allows the interaction among various kind of wireless networks through various standard sets, such

the RF Transmitter (RFM12B-S2 Wireless Transmitter - 915MHz), Wi-Fi, GSM and GPRS. Taking into account a city status, the main task is the combination of the various Low Power Area Networks. Ultrasonic sensor nodes and were built on Tiny Operative System. The RF Transmitter connect between them through Gateway stations that consist of Transfers High data rate date up to 115.2 kbps in digital mode or 256 kbps in analogue mode exchange mechanism between the centre system and the bins as showed.

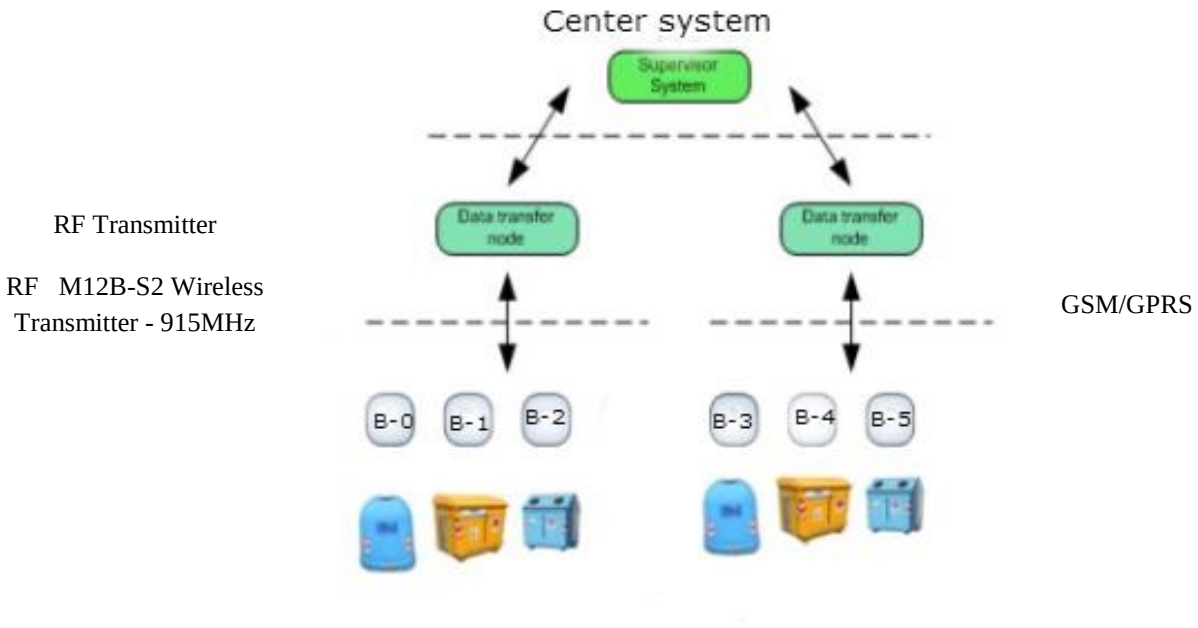

Figure 3.4: Project System Architecture

3.10.3 Wireless Sensor Network Architecture

In the system, three main suitability statuses are available which represent the level of trash in 90 precent at the dustbins. In addition, the main system observes the status and carries out the required actions regarding the situation.

- Non-qualified this is a state when the place does not have enough waste or trash, which requires waste collection
- Almost qualified this is a state between qualified and non- qualified state. All places in this state when a waste collection activity is on-going must be considered as well for waste collection.

- State Qualified this is a state when a waste station needs to be visits for waste collection. This state requires urgent action to be taken

Bin 1 20 % full Bin2 55 % full Almost qualified Bin3 95% full Qualified

Figure 3.5: Display of Possible States of Waste Stations

Test circumstance: Accept we have a waste administration organization with ten reuse receptacles of same structure at different places. The enthusiasm of the organization is to know when to go for waste gathering utilizing elective way to deal with timetable timing. They control two primary variables. The first is the Qualified settings and furthermore, the base number of containers that can be measured for any waste gather.

3.10.4 System Operations Flow Chat and Illustration

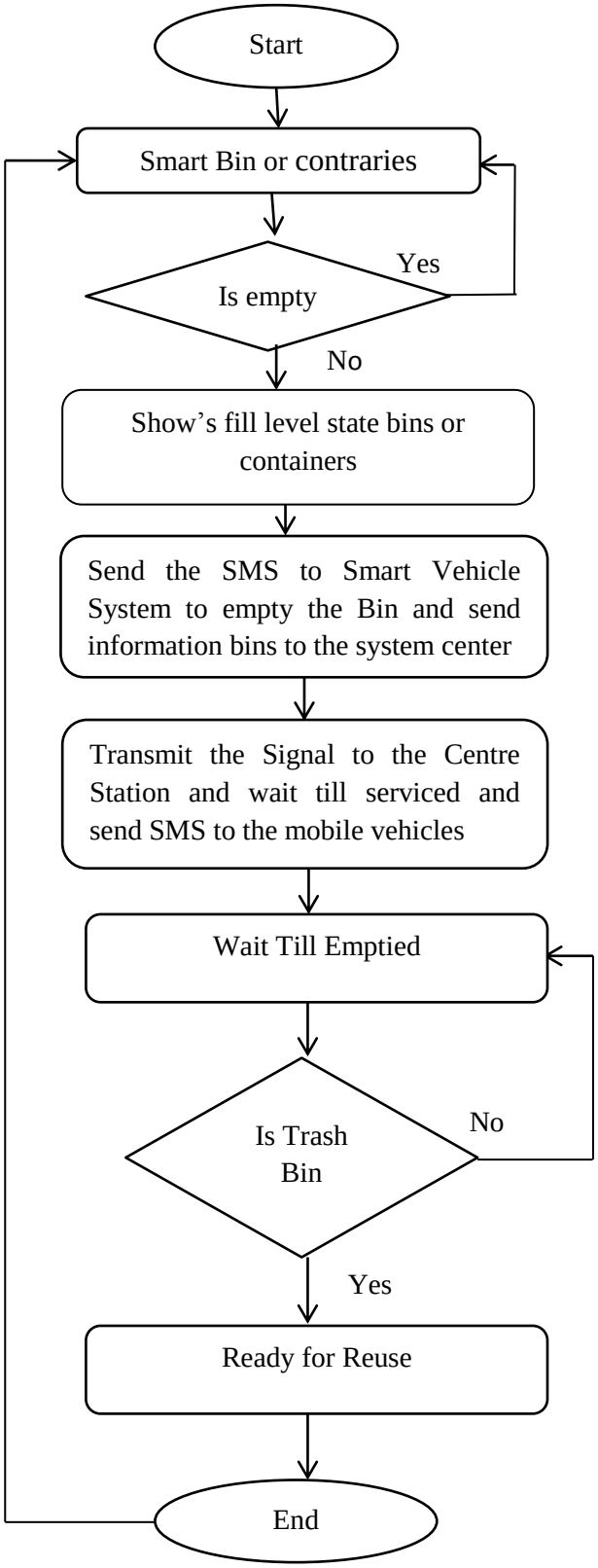

Figure 3.6: Flow Chart of Application Simple Module

3.11 Started with the Arduino GSM Shield Connect to the Centre Bored

The GPRS Shield relies on upon SIM900 module from SIMCOM and great with Arduino and its clones. The GPRS Shield gives you a way to deal with pass on using the GSM telephone framework. The shield grants you to achieve SMS, MMS, and GPRS and Audio by method for UART by sending AT commands (GSM 07.07, 07.05 and SIMCOM redesigned AT Commands). The shield also has the 12 GPIOs, 2 PWMs and an ADC of the SIM900 part (They are each of the 2V8 method of reasoning) present on-board (Zaghloul, 2014).

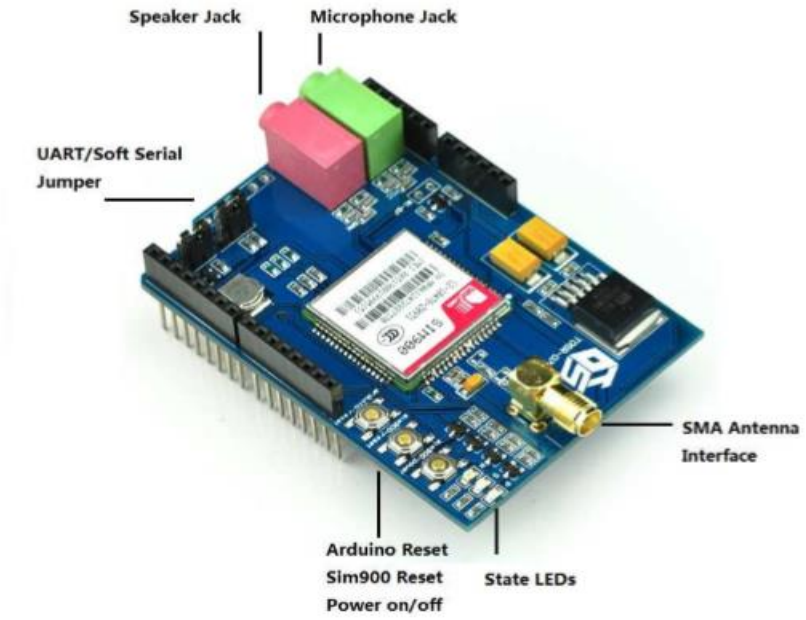

Figure 3.7: GSM/GPRS-SIM900

3.11.1 Using the GSM Shield with, Arduino Uno and Arduino Mega

The GSM shield corresponds with a connected Arduino through the Software Serial library. As a matter of course, this correspondence utilizes advanced pins 2 and 3. On the Uno this works without alteration, however to utilize the Leonardo, Yun, or Mega sheets, some slight changes are required.

The GPRS/GSM Shield gives you an approach to utilize the GSM PDA system to get information from a remote area. The shield permits you to accomplish this through any of the three strategies:

• Audio

• GPRS Service

The GPRS Shield is good with all sheets, which have the same structure component (and pinout) as a standard Arduino Board. The GPRS Shield is organize, then controlled through its UART utilizing basic AT charges. Taking into account the SIM900 module from SIMCOM, the GPRS Shield is similar to a mobile phone. Other than the interchanges includes, the GPRS Shield has 12 GPIOs, 2 PWMs and an ADC (Zaghloul, 2014).

Specifications

- Quad-Band 850/900/1800/1900 MHz - would take a shot at GSM networks in all countries across the world.
- GPRS multi-space class 10/8
- GPRS portable station class B
- Compliant to GSM stage 2/2+
- Class 4 (2W@850/900MHz)
- Class 1 (1W@1800/1900MHz)
- Control via commands (GSM 07.07, 07.05 and SIM COM improved AT Commands)
- Short message administration
- Free serial port choice
- RTC supported with Super Cap
- Power on/off and reset capacity upheld

3.11.1.1 The Indicator LEDs

The GSM Shield has three pointer LEDs for the GSM Shield power, SIM900 power and net status.

Flickering, a LED will be included in Arduino board and configured effectively. Put accompanying content into Arduino supervisor. Since IDE contains the code, confirm it and transfer to the Arduino board. Touch "Check" key and then the message done accumulating will show up at the base of the project content. Transfer it on the Arduino board, which will originate from the USB port. Later, press the "Transfer to I/O Board" catch. 2 LEDs are available as RX and TX which flash a byte at once. "Instruments/Serial Port

```
/* Blinking LED
* ---------- *
 *
Turns on and off an LED connected to pin 13
  * */
int ledPin = 13;                          // LED connected to
                                          // digital pin 13
void setup()
{
pin Mode (ledPin, OUTPUT);                // sets the digital
                                          // pin as output
}
void loop()
 {
 Digital Write (ledPin, HIGH);            // turns the LED on
  delay (1000);                           // waits for a second
 Digital Write (ledPin, LOW);             // turns the LED off
Delay (1000);                             // waits for a second
 }
```

Expecting that program has been transferred. Accurately join a LED to the pins 13 and GND on the board as you find in the delineation.

GSM Shield power (P)

This LED is use to show the force status of the GSM Shield. In the event that the outer power supply is joins with the Arduino board, then the GSM Shield will get power, and thus the LED light will turn on.

SIM900 power(S)

This LED is use to show the force status of the SIM900.After the SIM900 is force on, the status LED light will turn on.

Net Status (N)

This LED is use to demonstrate the net status. The LED will squint gradually or rapidly as indicated by distinctive states.

Status	Description
Off	SIM900 is not running
64ms On/800ms Off	SIM900 not registered the network
64ms On/3000ms Off	SIM900 registered to the network
64ms On/300ms Off	GPRS communication is established

Table 3.1: Light Status

The buttons

There are three buttons on the GSM shield board.

SIM900 Power Button

Stack the GSM shield on your Arduino principle board. The GSM shield will running naturally when you power up your Arduino fundamental board. In the event that you need, turn on/off the SIM900 module physically. Simply press the sim900 force catch one second.

SIM900 Reset Button

Reset theSIM900 module.

Arduino Reset Button

Reset the Arduino fundamental board. Same capacity as the Reset Button which on the Arduino primary board.

Our test representation will control D8 pin to turn on the SIM900 when the Arduino barricade fuelled. We want to use UART send AT commands. Set the jumper to how position. We use soft serial, set to SW position. We test sketch use soft serial. Therefore, we keep it on SW position normally.
If we are using MEGA 2560, only need to connect the central pins of RX and TX jumpers to RX1 TX1 on Arduino Mega 2560. And change the code setting (Zaghloul, 2014).

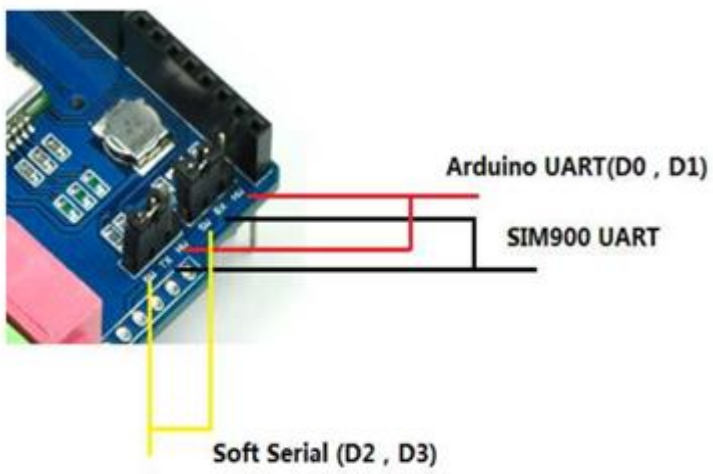

Figure 3.8: Setting Jumper

3.11.2 Use Two Methods

1. Using AT commands
2. Using Arduino code (Uno –Mega) perfect

We will make the Arduino board for corresponding with the PC by UART convention. Copy a second serial port (UART) utilizing programming on the computerized pins D2 and D3 and patch finishes all the correspondence between this second programming serial port and the genuine equipment serial port. By doing this, all the information originating from the PC (joined with the genuine equipment UART), would be transferred as is to the GPRS Shield (associated with programming UART).

• Run Arduino IDE 1.0 or later

• Open new draw window and compose a be neat

```
Software Serial my Serial (2, 3);
void setup()
{
 mySerial.begin(19200);              // the GPRS baud rate
 Serial.begin(19200);                // the GPRS baud rate
}

void loop()
{
 if (mySerial.available())
 Serial.write(mySerial.read());
 if (Serial.available())
 mySerial.write(Serial.read());
}
```

- Upload the sketch program to the Arduino board.

Now all done to start use Arduino with also method

3.11.2.1 Using AT Commands

Led Net would blink every three seconds by choosing the COM port for Arduino at 19200 8-N-1 by continuously pressing it after the GPRS Shield is connected to the network. No data will be seen on the monitor but will be obtained from the shield through "AT+IPR=19200". (AT+IPR=0 auto-banding)

```
 RDY
+CFUN: 1
+CPIN: READY
 Call Ready
```

The GPRS Shield will respond positively when "AT" is monitored by carriage return to the Arduino board. AT Commands will be ready when GPRS Shield is set up.

A. Sending a text message (SMS) –AT COMMAND

After installing GSM shield in Arduino board and seeing power line, AT+CMGF=1 should be sent by using serial terminal programming. The SMS can be sending in the text mode and PDU (or parallel) mode via the shield. the content mode will be chosen followed by an OK reaction by the GPRS Shield (Tang, et al. 2015).

AT+CMGS="+XXXXXXX" will be sent which will make the GPRS Shield to begin tolerating content for another message implied for the telephone number indicated (supplant the number with the telephone number of the objective telephone). The GPRS Shield will send a > flagging you to begin writing the message.

B. Make a Call –AT COMMAND

- Input ATD158********;
- Respond OK, you will receive a call.
- Input ATH to end a call.

3.11.2.2 Using Arduino code (Uno – Mega) compatible sending a text message (SMS)

- With the GPRS Shield evacuated, download this portrayal into our Arduino. The GPRS Shield should be evacuates so it does not meddle with the programming of Arduino, which happens over the Hardware UART (utilizing FT232RL).
- Disconnect the Arduino from USB port to evacuate energy to it.
- Set the Serial Port jumpers on the GPRS Shield in Arduino position (i.e. Arduino's RX joined with GPRS_TX and TX of Arduino associated with GPRS_RX)
- Connect the reception apparatus to the GPRS Shield and embed the SIM Card.
- Mount the GPRS Shield on Arduino.
- Apply energy to the Arduino
- Using USB port or by means of outer power supply.
- Switch on the GPRS Shield by utilizing the force switch. Hold up till the Network LED (D1) begins squinting.
- Using a pen or a plastic tweezer get to the reset switch on the Arduino Board and reset the microcontroller to run the representation from the begin. Try not to take a stab at removing so as to resetting the Arduino and applying energy to it as this will kill the GPRS Shield.

- If nothing turns out badly, the SMS will be gotten on receiver's handset.

3.11.3 Network Led

The Network LED shows the different states of the GSM module i.e. power on, Network registering and GPRS connectivity. At the point when the modem fuelled up, this Network LED will flicker every second. After the Modem registers in the network (it takes 10-60seconds), this LED will blink in step of 3 seconds at slow rate. At this stage we can start using the modem or our application. This demonstrates the modem is enlists with the network.

3.12 Ultrasonic Sensor

Ultrasonic separation estimation modules like this: SRF-06 are a powerful approach to sense the vicinity of close-by articles and the separation to them. Regularly Robots utilize these to sense articles or crashes and make fitting move.

Ultrasound is a high recurrence sound (commonly 40 KHz is utilized). A short burst of sound waves (regularly just 8 cycles) is conveyed the "Transmit" transducer (left, above). At that point the "Get" transducer listens for a reverberation. In this manner, the rule of ultrasonic separation estimation is the same as with Radio-based radar (Fuqing et al., (2008).

Features

- Detecting reach: 3cm-4m
- Best in 30 degree point
- Electronic block perfect interface
- 5VDC power supply
- Breadboard friendly
- Dual transducer
- Arduino library ready

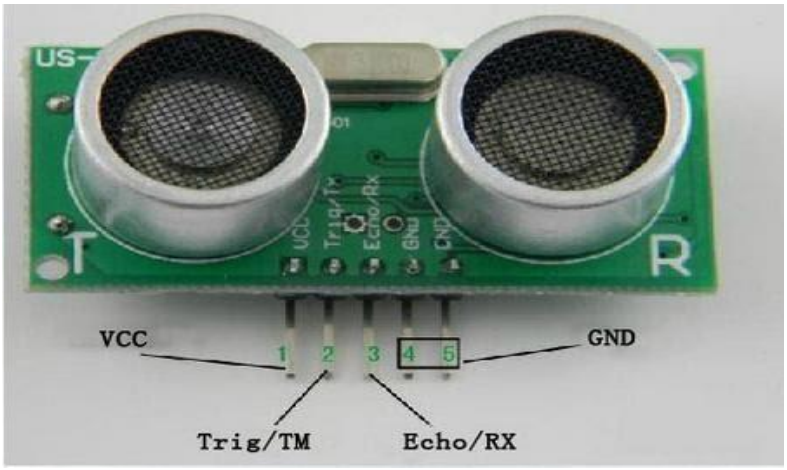

Figure 3.9: SRF06 Ultrasonic Sensor

Specification

- Working Voltage : 5V(DC)
- Working Current : max 15 mama
- Working recurrence: 40HZ
- Output Signal: 0-5V (Output high when snag in extent)
- Sentry Angle: max 15 degree
- Sentry Distance: 2cm - 500cm
- High-exactness: 0.3cm
- Input trigger sign: 10us TTL motivation
- Echo sign: yield TTL PWL sign

3.13 Arduino

The Arduino environment has been intended to be anything but difficult to utilize Arduino is utilized as a part of numerous instructive projects far and wide, especially

3.13.1 Arduino Hardware

The Arduino board executes codes, controls and reacts to power. Specific parts are linked in order to create power. The parts may be sensors changing physically to power so that the board can sense it. Cases of sensors incorporate switches, accelerometers, and ultrasound

separation sensors. (Margolis, 2011). and presentations. Different authority sheets can be used with Arduino programming and Arduino-perfect sheets which include a USB connector in order to empower and transfer the items to the Arduino Uno.

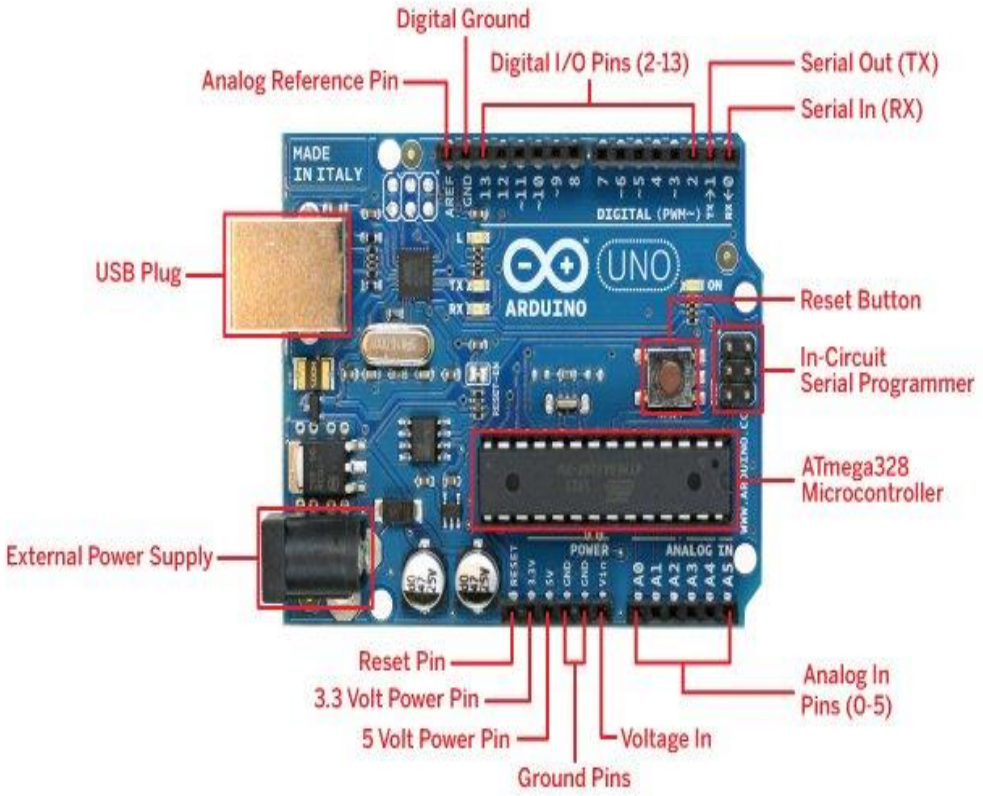

Figure 3.10: Arduino Uno

3.13.2 Arduino Software

Programming projects, called representations, are made on a PC utilizing the Arduino integrated development environment (IDE). The IDE empowers you to compose and alter code and change over this code into directions that Arduino equipment gets it (Margolis, 2011)**.** The IDE additionally exchanges those directions to the Arduino board (a procedure called transferring).

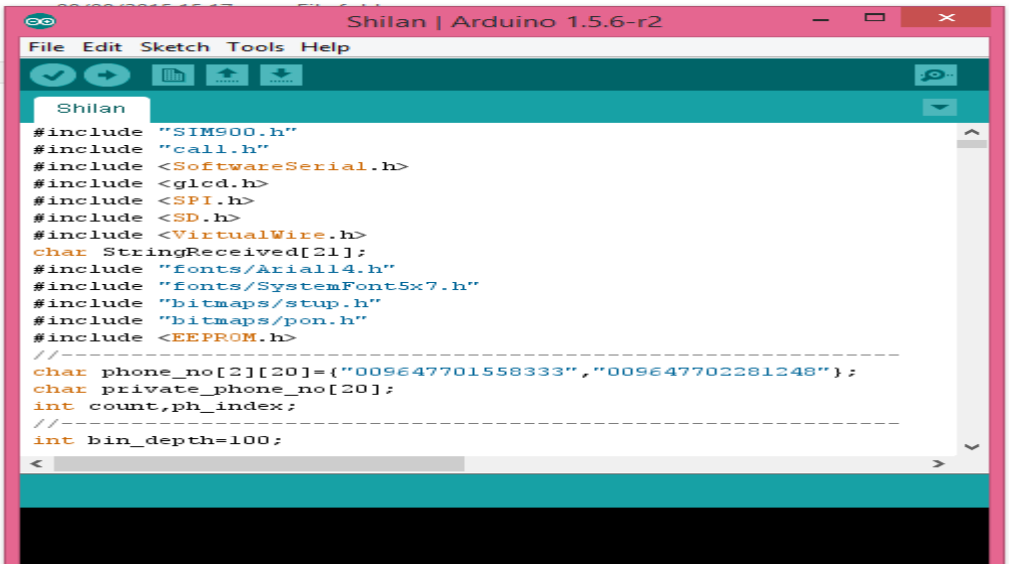

Figure 3.11: Software Application

3.13.3 The C Language

Several languages are using to program microcontrollers, from hard-core Assemblage language to graphical programming languages like Flow code. Arduino sits somewhere in between these two extremes and uses the C programming language with C++. It does, however, wrap up the C language, hiding away some of the complexity. This makes it easy to get started.

The C language is, in registering terms, an old and admired language. It is well suited to programming the microcontroller since it was invented during an era when compared with today's monsters; the typical computer was quite poorly endowed.

C is a simple language to learn, yet incorporates into proficient machine code that only takes a small amount of room in our limited Arduino memory (Simon Monk, 2014).

```
int led Pin =  13;
 // LED connected to digital pin 13
 void setup()
{
Pin Mode (led Pin, OUTPUT);
}
void loop()
{
```

```
Digital Write(led Pin, HIGH);
  // set the LED on
delay (1000);
 // wait for a second
Digital Write (led Pin, LOW);
  // set the LED off
 delay(1000);
    // wait for a second
}
```

3.14 LCD Displays

Our venture needs to show the outcome more than a couple of numeric digits, we likely need to utilize a LCD show module. These have the favourable position that they accompany inherent driver hardware, so a considerable measure of the work is as of now accomplished for us and we don't need to survey round every digit, setting every fragment. Likewise, there is something of a standard for these gadgets, so there are loads of gadgets from distinctive producers that we can use similarly. The gadgets to search for are the ones that utilization the GLCD 125* 64 driver chip. GLCD boards can be entirely costly from retail electronic segment suppliers; they can regularly be purchased for a couple of dollars, especially in the event that we are willing to purchase a couple at once.

This venture will permit us to show a message on a LCD module.

Figure 3.12: LCD Display

3.15 Blink Led

The sheets intended to make it simple to flicker a LED utilizing computerized pin 13. Certain (Diecimila and LilyPad) include the LED assembled into board. Some (Mini and BT), has 1 KB resistor on its pin, permitting to join a LED specifically. (To interface a LED to another computerized pin, you ought to utilize an outside resistor.) LEDs have extremity, which means they will just light up on the off chance that you situate the legs legitimately. The long leg is regularly positive, and ought to join with pin 13. The short leg interfaces with GND; the knob of the LED will likewise commonly have a level edge on this side. On the off chance that the LED doesn't

illuminate, having a go at turning around the legs (you won't hurt the LED in the event that you connect it to in reverse for a brief timeframe).

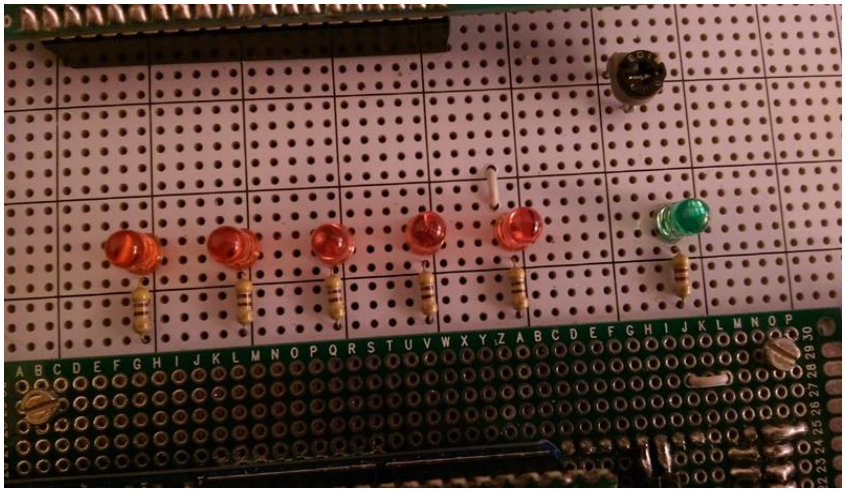

Figure 3.13: Blink LED

3.16 Radio frequency (RF) Transmitter and Receiver Modules with Arduino

The remote transmitter and collector modules work at 315 Mhz. They can undoubtedly fit into a breadboard and function admirably with microcontrollers to make an exceptionally basic remote information join. With one sets of transmitter and beneficiary, the modules will just work conveying information one-way, we would require two sets (of diverse frequencies) to action equally a transmitter/receiver pair, These modules are unpredictable and will receive considerable measure of commotion. Both the transmitter and collector work at basic frequencies and don't have IDs. Subsequently, a strategy for sifting this clamour and blending transmitter and collector will be fundamental. The sample codes underneath shows such an illustration for essential operation. It would be ideal if you allude to the illustration code and connections beneath for approaches to fulfil powerful remote information join (Heinonen, 1999).

Receiver Module Parameters

1. Item Model: MX-05V
2. Working voltage: DC5V
3. Quiet Current: 4mA
4. Accepting recurrence: 315 MHz
5. Recipient affectability:- 105DB
6. Size: 30 * 14 * 7mm

3.16.1 Technical Parameters of The Transmitter Module

1. Item Model: MX-FS-03V

2. Dispatch separation: 2000-5000 meters (diverse voltage, distinctive results). On the off chance that the two areas altered, then one can utilize an outer receiving wire that has pick up, and point the reception apparatuses at one another. This will altogether build the reach. On the off chance that the two gadgets are not in altered areas then an outer receiving wire will help, however we need to utilize an Omni-directional reception apparatus.

3. Working voltage: 3.5-12V

4. Measurements: 19 * 19mm

5. Working mode: AM

6. Exchange rate: 4KB/S

7. Transmitting force: 10mW

8. Transmitting recurrence: 315 MHz

9. An outside reception apparatus: 25cm common multi-centre or single-centre line

10. Pin out from left → right: (DATA; VCC; GN

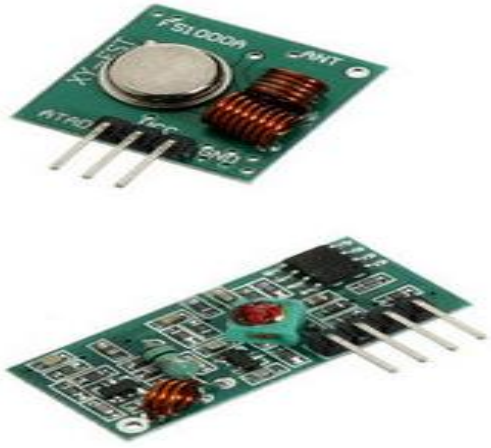

Figure 3.14: RF Transmitter and Receiver

CHAPTER 4

RESULTS

4.1 Proof of Concept and Thesis Application

For verification of the idea, we consider waste reuse administration framework in the city. Our framework giving information from receptacle or holders furnished with sensors situated at different areas of the city to control the status of the canister or compartment in deference to amount of waste it contains and level waste in containers or holders. Introduce the sensor on the highest point of the canisters or compartments. The continuous information is put away and made realistic through open defined interface for the city and uncommon organizations. The data is utilized to give esteem additional administration, which wants to benefit the nationals and the city and additionally squander administration frameworks. The evidence of thought is to show how the proposed can be suitable and supportive in development and organization of various sorts of Smart city administrations. We prescribe a superior alternative to supplant routine based waste gathering. Rather than utilizing a routine made timetable, our framework screens the status of receptacles or holders at reuse puts and established on the framework's settings; caution the administration when waste gathering procedure is expected this guarantees just reuse places that are genuinely due for accumulation are gone to furthermore takes out the need to visit stations with almost no measure of

In the second side of this thesis provides center system for citizens to monitor the status of bins and monitor fill the bins and level the bins. Data about the station of bins and how much waste in the bins is important in some places for when the bins are full then the truck can go to the place to empty the bins thus reduce the cost as well as reduce traffic jam.

The third side of the thesis is that vehicles with mobiles, when the bins are filled of the trash then the central system sent message to the vehicles to go to the place where the bins are located to empty them.

4.2 Real-Time Monitoring and Smart Design of Daily Collection Processes

Each ultrasonic sensor is installed in every container, transmits to the deliberate qualities information Arduino with TR transmitter we have considered just the estimations of ultrasonic sensor, in order to group which holders are adjacent to their fill level. Along these lines, the sensor sends date to the middle where the receptacles and compartments are checked and here the control focus is notified the containers to change the level of canisters the date esteem. The control focus uses to gather information from the different ultrasonic sensors and assess the level of filling of a receptacle. We have measured four distinct levels empty, half empty, half full and full. All data associated with the level of receptacles are sparing in the memory of the inside, so the historical backdrop of genuine information and communicator timestamp can be valuable to a conclusion procurement structure that could find answers for the issues of association of assets connected to the association of strong waste. For instance, dissecting the while take to fill the receptacles in one of the zones of a city can help understanding the best number of canisters that should be disseminated in that zone. Here, if a large portion of the canisters are filled in a brief timeframe, the examination of information prescribes that new receptacles or holders must be included that zone so as to give a more efficient administration to subjects. Generally if the containers are filled in a very long time, it implies that it may lessen the quantities of receptacles without influencing the administration.

In the wake of having known the level of garbage of a receptacle, one of the following two cases can happen.

- If the level of a container almost to the full or half full accumulation, by the inside framework making an association between the receptacle and the vehicle by send message for the vehicle, which ought to gather the zone of the city where the canister is found. Making this association does not imply that the truck will absolutely enhance the container. This phase of the choice will be applies by another segment of the control focus.

- If the level of a container is in the unfilled or half-exhaust accumulation, evacuate the associations between the receptacle and the related vehicle to the zone where the Canister is found then don't sending the message for the vehicle for go to that zone to

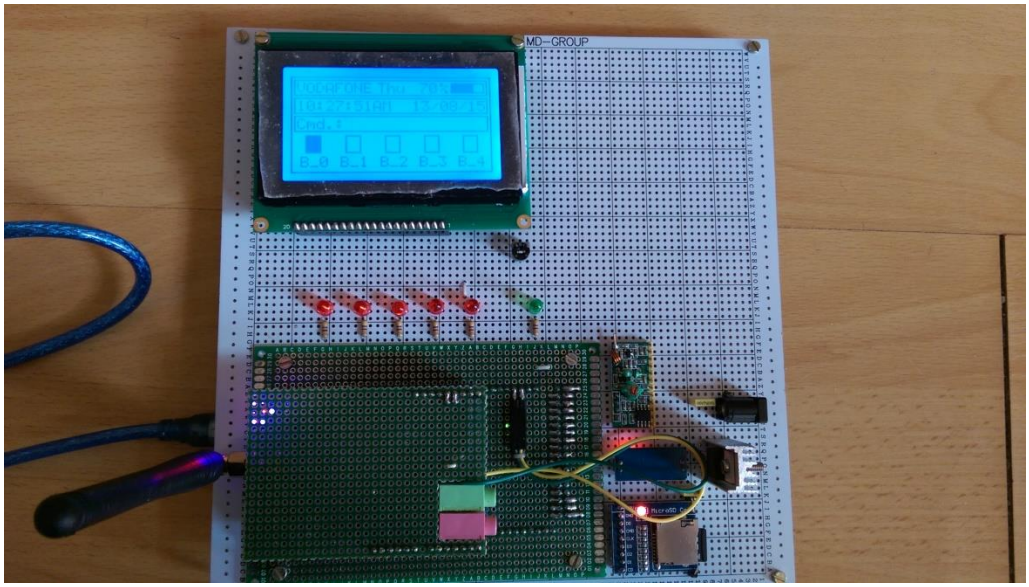

Figure 4.1: GLCD Central System Monitoring

4.3 Automatically Waste Management System

Design a system for managing the wastes in an effective way in order to reduce the improper use of valuable resources like human energy, time and cost. The architecture of the design in the method, we distributed the general system of waste discovery into four subsystems, Smart Trash bin System, Smart Vehicle System, Local Station and Smart Monitoring and control. Complete these sub-systems work smart and in organization to automate the waste organization in the Smart Waste Bin(s) so as to dispose-off the waste as and when necessary without keeping a unceasing eye on the waste bins manually.

4.3.1 Smart Trash bin

Smart Garbage System personifies an electronic device known as Smart Garbage Bin, which consists of a Radio Frequency (RF) transmitter and Sensors. The sensors sense the waste situation was being collected by the Smart Garbage Bin. One type of sensor is used in the Smart Trash Bin. The ultrasonic sensor use for measurement which is used to sense the distance of the level waste in the Smart trash bin the ultrasonic sensor whose function is to detect the of the waste in the smart trash bin. There is one sensor, which placed near the top of the Smart Trash Bin. The use of one ultrasonic sensor makes the decisions more

dependable and accurate. The Radio Frequency RF signal is transferred only when the whole sensor are in a high state. Whenever the Smart Garbage Bin is filled up to the specified load and level, the sensor get activate and it creates a signal that is transferred by the RF transmitter fitted in the Smart Garbage Bin. The signal transferred via the Radio Frequency RF transmitter is received via the RF receiver which is present at the local base place. After receiving the signal, the local place translates the trash bin place and then sends a signal data to the in the Center and smart monitoring and control there which sends SMS to Smart Vehicle about the place of the trash bin and filled the bins The monitoring and control in addition bins.

4.3.2 Local Station

The local Station is the Radio Frequency RF receiver place that is not far distant from the smart garbage bins and gets the state of the bins by RF communication. This base location receives the status of the close garbage bins on steady basis and the base locations keeps this situation information complete with the monitoring and controlling. The local places keep track with the monitoring cum control finished the internet. The use of SMS this automation makes this system actual and dependable with long distance attention. Or use internet. App to observer the information on Smart Phone, for those do not have smart phone, they can send an SMS & receive the information as a text message.

4.3.3 Smart Monitoring and Control

The Smart control and Monitoring is a centrally located control for all the smart working of this management structure. This is the heart of the whole structure and every time takes signals as input from the local Station spread finished a zone. It is the signal data from the local Station that appeals the control to make a choice about the management of waste of some specific trash bin. The local Station and the monitoring with control communicate with the GSM/GPRS and mobile at l local Station. The Center Screen GLCD the information of the filled Smart Trash Bin are displayed accordingly on the border, developed the total number of Smart Trash Bin(s) and their information like times and date, with level of trash in the bins whether filled or unfilled is also displayed on the border Screen.

Figure 4.2: G LCD Output for Result

4.3.4 Smart Vehicle

The Smart Truck System is mobile interlaced truck that continuously keeps road with the monitoring and controlling about the status of the previous jobs that have been given to it and always waits for the new duty. The Smart Truck system contains of a task outline display. The new task of disposing a garbage bin and all the relevant details about it are showed on the GLCD screen current in the smart truck. The Smart Truck System after receiving all the details of the bin by SMS and the place of the bins and uses a robotic arm for disposing specific garbage bin. The robotic arm in the truck has a jaw shaped flanges that pick the bin and pops out the waste in the truck's waste holding container which has a great size. After the conclusion of the task, the smart truck acknowledges the monitoring and controlling. The truck then moves on to perform next duty in the line given to it by the monitoring and controlling. the truck by the screen have chosen the road and short road which one by short times get the place have the container.so this way for Reduce traffic jam and Reduce number of truck and reduce the cost.

4.3.5 Smart Monitoring and Controlling Interface

The interface at the smart Monitoring and controlling has developed using GLCD screen which is C and C++ programming language with Arduion software that can be seen as expansion of the model and implemented. The software installs Arduion on the center System in Smart Monitoring and controlling, which receives the information from the base location through internet. The Smart Waste Bin through RF transmitter sends signal to Centre system. At the Centre system, the details about the filled waste bin(s) are displaying on the interface like the location of the waste bin, unique waste bin code, etc. Accordingly, the software gets further information of the waste bin which has sent the signal like the city, locality, area to which this waste bin belongs and then makes a decision about the truck to be selected to dispose of the waste. The smart monitoring controlling smartly selects the truck keeping in view the distance, cost and others reasons and reduce the implementation cost of the overall system. Then the given job has accomplished successfully by the Centre system, and send message to the truck. This makes the overall system efficient and reliable, Displays the status of the Smart Waste Bin(s). Whenever the Smart Waste Bin gets filled an alarm signal created and the information of the filled Smart Waste Bin are displayed on the screen GLCD. The total number of Smart Waste Bins, whether filled or unfilled is also displayed on the screen.

4.4 Processes

Since the comprises, of four substructure and the fundamental substructure on which the others work is the Smart waste System which has the practical unit called as Smart waste Bin. It including of sensors, ultrasonic sensors, Adriano UNO no and the RF transmitter ultrasonic sensors use to measure the levels trash into the bins At whatever point the Smart waste Bin gets filled, the sensors get initiated and produce a high standard which is bins is full This Ardiano sign transmitted by the RF transmitte

r mounted on top of the Smart waste Bin. This transmitted signal received by the RF receiver tag. The RF receiver set the central System station. The RF receiver in the Central system gets the sign and afterward the sign is sent to the Arduino mega and GSM/GPRS then monitoring the date on the Centre System. At this checking controlling and monitoring the data and status levels of the Smart waste Bin is shown GLCD. Next step of the filled Smart waste Bin are shown on the Smart Monitoring and controlling. The Smart

Monitoring and controlling then sends the data sign to the Smart Vehicle System. by using GSM/GPRS send the message to the Vehicle and zone when the then when the vehicle is gotten the message, it moves to the spot and arranges off the waste from that leftover container that has sent signal data to show Trash Bin filled state to the controlling and Monitoring in the Center System On the task finish an undertaking done message send by the vehicle to the checking and controlling hovel. If the vehicle, doesn't go to the empty the bib after one hour the system send message other vehicle.

4.5 Summary of Thesis

A Smart (save money, decrease trash, progresses public health and impact, decrease environmental pollution, reduce traffic jam, increasing space and grown green space). Residential waste decrease program means incentivizing populaces to decrease and recycle by charging per unit for trash disposal. In the city of Sulimany, the service's city is not able to save money. The Smart strategy empowers government to take control of the quantity they spend on garbage. Usually talking, Smart communities treat waste like a utility. Approximately cities and towns along with many more worldwide, have implemented to collection solid waste. When people pay by the unit, they become more aware of the waste they produced, which activates a lasting sustainable behavioral modification. SMART communities create proportional unit based valuing structures that contain all costs related with waste and recycling. Residents pay as they go for waste, while unlimited recycling is available to all households with no extra cost.

It is the impartial of a Smart waste organization collection to make a successful, possibly cost actual inhabited reprocessing program while working within the current collection infrastructure. Possibly as a throw away level that continues on its own without a great deal of re-education effort easy-to-use as easy to understand and involved, and cost actual in that complete costs are less than different programs.by using smart stuffing. The ultrasonic sensor put on the top of the bins with Arduino and RT transmitter send signal to the center and informs the center about the level of rubbish in the bins or containers. So, the center use GLCD to show bins with level of the bins full half full and empty information about bins or container with Arduino and GPS/GRPS, here the message will be send to the trucks and advise them the bins or containers are full of trash and need to be emptied, the center also give information about road it also backup all information in the memory card. the

center also give information about road it also backup all information in the memory card, then can read all information the backup in the SD card.

CHAPTER 5
CONCLUSION and FUTURE WORK

In this chapter, we give our concluding thoughts on this thesis work. In the first and second sections, this work we conclude and future work. And last section this chapter has References.

5.1 Conclusion

A Smart City is an efficient and sustainable place with intelligent public services. There is not just a single style of Smart City; each one can become more effective and sustainable with different solutions that can be tailored to its specific needs. The cities of the future must be more sustainable ,safer, effective, relaxed, and communicating. They will be an urban environment that is always connecting with the residents and capable of managing public services in real time to progress their quality of life, waste collection, through traffic management, irrigation systems, alerting the local authority when an event occurs and allowing the government to stay in touch with the people. Technologies allow us to make more reasonable decisions.

Technology driven initiatives to encourage people and children to throw rubbish in the bin, this will keep them up on good conduct, keep on health, save the environment, make more space for Malls, Restaurants, Parks, Schools, Universities and Homes.
So, the smart waste management system is a step forward to make the manual collection and detection of wastes smart in nature and monitoring waste collection. The developed system by using five subsystems Smart Waste System, Local Station, Smart Monitoring and controlling, Smart Truck System and Smart Monitoring and controlling Interface the Smart waste to monitor the bins filling, include the Centre system get data from Wireless ultrasonic Sensor Networks have been working to specific sensors with RF transmitter use with arduion and, use GSM/GPRS.

Solid waste collection management processes and monitoring. This offer the organization of wastes is effective and time saving process than the presently start technique in which worried urban worker has to see for the filled waste bins manually through different spots in a region/street for testing regularly whether The waste bin is filled or not and show

waste levels bins, which is difficult and time consuming development. This smart of waste too decreases the human effort and as a result the cost of the whole process. This system might be implemented at any residence with simplicity and within reasonable quantity of time. The implementation costs for the smart is also affordable. The general method for the discovery and management of waste becomes efficient and intelligent. This planned system would not only purpose for collecting and updating data automatically and timely, but similarly it might analyses and use data intelligently. The planned system would solve a lot of problems connected to solid waste collection, minimizing cost, monitoring and accelerate the management. The system has many advantages than the other system was done before because

- The hardware used more developer and using Arduino is open foundation can use free to Get the schematics and programming software and advance them with free code libraries. And used to GSM/GPRS One advantage of using SMS is that it will preserve the shield having to begin a GPRS connection which will usually take longer and may use more power.
- offer a higher quality service to the citizen
- can be easily implemented in the city and Easy-to-use Service
- can be used everywhere when the place have network and signal of mobile phone with SIM card
- Economical design.

5.2 Future Work

As a feature of continuation for this task, loads of future work is ahead for the full usage and full organization of this undertaking in urban communities. Future proposals and work could be concentrating on the accompanying:

- Separate type of waste collection put in difference bins by using other sensor..
- Use mobile application with GPS shield for show the route and send message the nearest truck in the bins..
- Application of improvement in other city administration this would likewise decide the part of the structure that should be disconnected from city administrations. Deliberation of structure capacities would make it less demanding to apply structure to different city administrations without requiring numerous program

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APPENDICES

APPENDIX 1

HARDWARE COMPONET

There are have hardware component used to the project and design, development and implementation

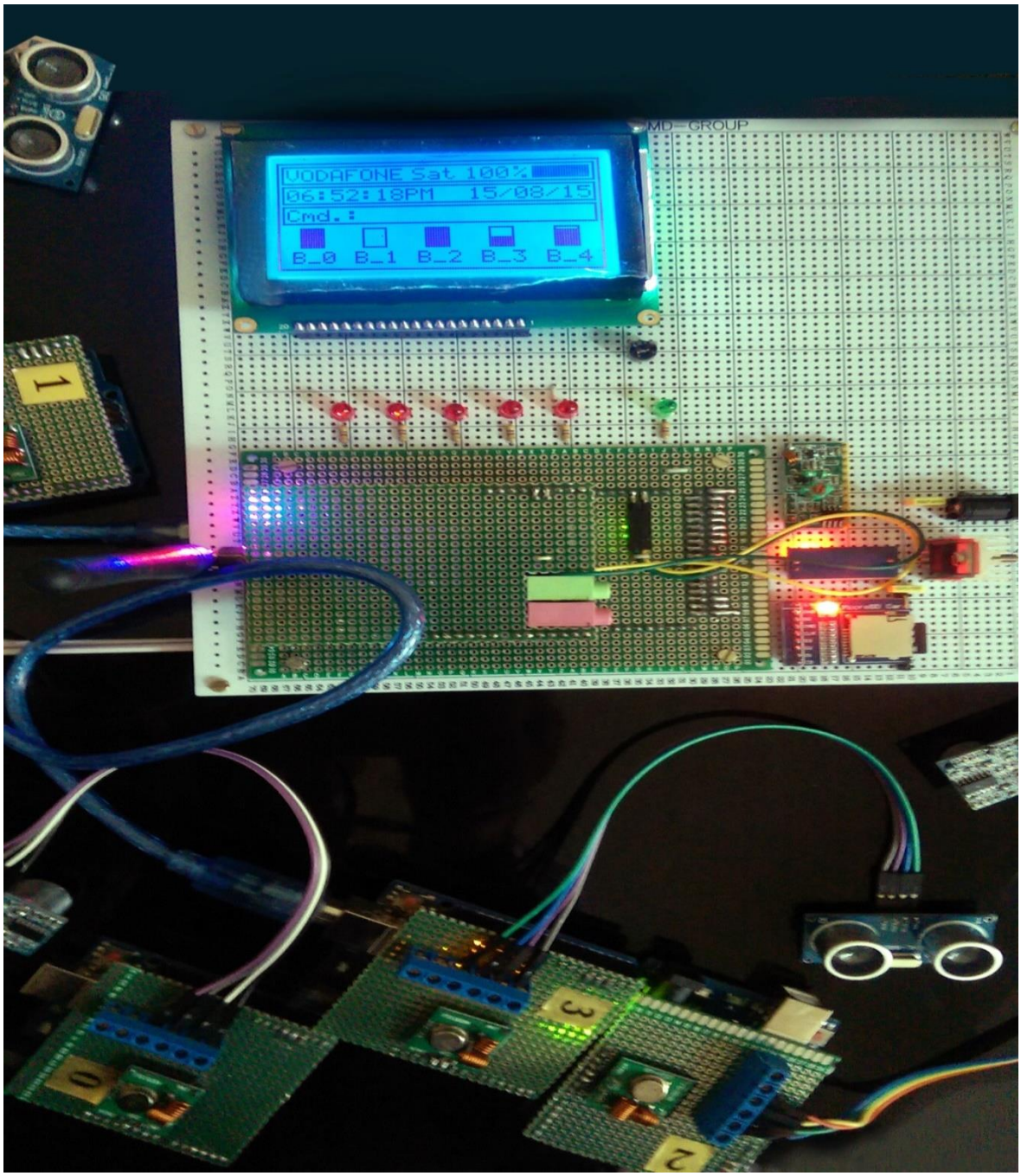

Figure A: Hardware System

APPENDIX 2

SOURCE CODES

For the design, development and implementation of this thesis, different technologies were used. The following the program in the Centre System for the Smart waste monitoring and collection management by using C and C++ language

```
#include "SIM900.h"
#include "call.h"
#include <SoftwareSerial.h>
#include <glcd.h>
#include <SPI.h>
#include <SD.h>
#include <VirtualWire.h>
char StringReceived[21];
#include "fonts/Arial14.h"
#include "fonts/SystemFont5x7.h"
#include "bitmaps/stup.h"
#include "bitmaps/pon.h"
#include <EEPROM.h>
//-------------------------------------------------------------
char phone_no[2][20]={"00905488555583"};
char private_phone_no[20];
byte count,ph_index;
//-------------------------------------------------------------
int bin_depth=100;

int bin_dist_0,bin_dist_1,bin_dist_2,bin_dist_3,bin_dist_4;
int bin_state_0=0,bin_state_1=0,bin_state_2=0,bin_state_3=0,bin_state_4=0;
```

```
long
current_time_0,next_time_0,current_time_1,next_time_1,current_time_2,next_time_2,curr
ent_time_3,next_time_3,current_time_4,next_time_4;

// RTC Model ----------------------------------------------

char time[14];

char cal[15];

char s_date[3];

char week[7][4]={"Thu","Fri","Sat","Sun","Mon","Tue","Wed"};

// SD  Model ----------------------------------------------

Sd2Card card;

SdVolume volume;

SdFile root;

const int chipSelect = 53;

File myFile;

const int sd_led = 25;

const int led_0=35;

const int led_1=33;

const int led_2=31;

const int led_3=29;

const int led_4=27;

// Carrier LED ----------------------------------------------

const int power_led = 5;

// GLCD  Model ----------------------------------------------

#if DISPLAY_HEIGHT < 64

#error ks0108 example requires a display at least 64 pixels tall

#endif

#if DISPLAY_WIDTH < 128

#error ks0108 example requires a display at least 128 pixels wide

#endif

// General ----------------------------------------------
```

```
int flag=0;
//long max_time_1=300000;
//long max_time_2=900000;
long max_time_1=180000;
long max_time_2=180000;
unsigned int now_day;

#include "sms.h"
SMSGSM sms;
CallGSM call;

int numdata;
boolean started=false;
char smsbuffer[160];
int strength;
char n[20];
char inData[200];
char signal[10];
int index;
char inChar;
char st_len[3];
int st_len1;
int percent;
int fl=0;
byte stat=0;
//------------------------------------------------------------------
void setup()
{
 int i;
```

```
 Serial.begin(9600);
 count = EEPROM.read(0);
 if ((count<0) || (count>4))
 {
  EEPROM.write(0, 0);
  EEPROM.write(1, 0);
  ph_index=0;
  count=0;
 }
  else
 {
  count = EEPROM.read(0);
  ph_index = EEPROM.read(1);
 }
//-------------------------------------------------------------------
 vw_setup(2000); // Bits per sec
 vw_set_rx_pin(23);
 // Start the receiver PLL running
 vw_rx_start();
//-------------------------------------------------------------------
 pinMode(led_0,OUTPUT);
 pinMode(led_1,OUTPUT);
 pinMode(led_2,OUTPUT);
 pinMode(led_3,OUTPUT);
 pinMode(led_4,OUTPUT);

 digitalWrite(led_0,LOW);
 digitalWrite(led_1,LOW);
 digitalWrite(led_2,LOW);
```

```
 digitalWrite(led_3,LOW);
 digitalWrite(led_4,LOW);

 pinMode(53,OUTPUT);
 pinMode(power_led,OUTPUT);
 pinMode(sd_led,OUTPUT);
 digitalWrite(power_led,LOW);
 digitalWrite(sd_led,LOW);
//-------------------------------------------------------------------
 //led_off();
 initialize_glcd();
 draw_main_boarders();
 check_sd();
 power_on_modem();
 read_carrier();
 //set_time();
 delsms();
}
//-------------------------------------------------------------------
void power_on_modem()
{
  pinMode(8,OUTPUT);
 digitalWrite(8,LOW);
 delay(1000);
 digitalWrite(8,HIGH);
 delay(3000);
 digitalWrite(8,LOW);
 delay(1000);
}
```

```
// ------------------------------------------------------
void led_off()
{
 digitalWrite(power_led,LOW);
}
//-------------------------------------------------------------------
void led_on()
{
 digitalWrite(power_led,HIGH);
}
//-------------------------------------------------------------------
 void set_time()
{
 gsm.SimpleWriteln("AT+CCLK =\"15/07/24,05:09:00+04\"");
 delay(1000);
}
//-------------------------------------------------------------------
void initialize_glcd()
{
 GLCD.Init(NON_INVERTED);
 GLCD.SelectFont(System5x7);
 GLCD.SetFontColor(BLACK);
 GLCD.ClearScreen();
}
//-------------------------------------------------------------------
void check_sd()
{
 if (!SD.begin(53))
  GLCD.DrawString("SD Faild!",4,4);
```

```
 else
  GLCD.DrawString("SD OK!",4,4);
 delay(1000);
}
//-----------------------------------------------------------------
void read_carrier()
{
 if (gsm.begin(9600))
 {
  started=true;
 }
 else GLCD.DrawString("STATUS=IDLE", 5, 5);
//-----------------------------------------------------------------
 if(started)
 {
  digitalWrite(power_led,HIGH);
  GLCD.DrawString("Power On ", 4,4);
  delay(1000);
  //draw_main_boarder();
  //draw_sensor_boarders();
  draw_carrier_name();
  GLCD.DrawString("Cmd.:            ", 4, 28);
 }
}
//-----------------------------------------------------------------
void draw_power_on()
{
 GLCD.SetFontColor(BLACK);
 GLCD.DrawString("POWER ON", 5, 5);
```

```
}
//---------------------------------------------------------------
void draw_carrier_name()
{
 int i;
 char full_response[100],carrier[10];
 gsm.SimpleWriteln("AT+COPS?");
 i=0;
 delay(2000);
 while(Serial1.available())
 {
  full_response[i]=(Serial1.read());
  i++;
 }
 full_response[i]='\0';
 for(i=0;i<8;i++)
  carrier[i]=full_response[i+20];
 carrier[8]='\0';
// Serial.print("***");Serial.print(carrier);Serial.print("***\n");
 //GLCD.SetFontColor(WHITE);
 GLCD.DrawString(carrier,4,4);
}
//---------------------------------------------------------------
void draw_main_boarders()
{
 GLCD.DrawRect(0, 0, 127, 63, BLACK);
 GLCD.DrawRect(2, 2, 123, 10, BLACK);
 GLCD.DrawRect(2, 14, 123, 10, BLACK);
 GLCD.DrawRect(2, 26, 123, 10, BLACK);
```

```
 GLCD.DrawRect(102, 4, 21, 6, BLACK);

 GLCD.DrawRect(9,39,9,11,BLACK);GLCD.DrawString("B_0", 6,53);
 GLCD.DrawRect(34,39,9,11,BLACK);GLCD.DrawString("B_1", 31,53);
 GLCD.DrawRect(59,39,9,11,BLACK);GLCD.DrawString("B_2", 56,53);
 GLCD.DrawRect(84,39,9,11,BLACK);GLCD.DrawString("B_3", 81,53);
 GLCD.DrawRect(109,39,9,11,BLACK);GLCD.DrawString("B_4", 106,53);

}
//-----------------------------------------------------------------
void delsms()
{
 for (int i=1; i<=10; i++)
 {
  int pos=sms.IsSMSPresent(SMS_ALL);
  if (pos!=0)
  {
   Serial.print("\nFind SMS at the pos ");
   Serial.println(pos);
   if (sms.DeleteSMS(pos)==1)
   {
    Serial.print("\nDeleted SMS at the pos ");
    Serial.println(pos);
   }
   else
   {
    Serial.print("\nCant del SMS at the pos ");
    Serial.println(pos);
```

```
   }
  }
 }
 Serial.println("DELETED");
}
//------------------------------------------------------------------
void Signal_Strength()
{
 Serial1.println("AT+CSQ");
 delay(500);
 read_String();
 strtok(inData, ",");
 strcpy(signal,strtok(NULL, ","));
 //delay(3000);
}
//------------------------------------------------------------------
void read_String()
{
 index=0;
 while(Serial1.available() > 0) // Don't read unless
// there you know there is data
 {
  if(index < 199) // One less than the size of the array
  {
   inChar = Serial1.read(); // Read a character
   inData[index] = inChar; // Store it
   index++; // Increment where to write next
   inData[index] = '\0'; // Null terminate the string
  }
```

```
 }
 st_len[0]=inData[8];
 st_len[1]=inData[9];
 st_len[2]='\0';
 st_len1=atoi(st_len);
 percent=st_len1*100/31;
 if(percent<10)
 {
   GLCD.GotoXY(76,4);
   GLCD.write(' ');GLCD.write(' ');
   GLCD.GotoXY(88,4);
 }
  else if(percent<100)
       {
        GLCD.GotoXY(76,4);
        GLCD.write(' ');
        GLCD.GotoXY(82,4);
       }
       else GLCD.GotoXY(76,4);

 GLCD.print(percent);
 GLCD.DrawString("%",95,4);
 GLCD.FillRect(102, 5, percent/5, 4, BLACK);
 GLCD.FillRect(103+percent/5, 5, 19-percent/5, 4, WHITE);
}
//---------------------------------------------------------------
void print_time()
{
 char full_time[100];
```

```
char hr_st[4],mnth[4];
int i=0,hr_int,int_date,int_mnth,index;
gsm.SimpleWriteln("AT+CCLK?");
delay(250);
while(Serial1.available())
{
 full_time[i]=(Serial1.read());
 i++;
}
full_time[i]='\0';
// Serial.print(full_time);Serial.print("\t");
for(i=0;i<=7;i++)
 time[i]=full_time[i+19];
time[8]='A';time[9]='M';
hr_st[0]=time[0];hr_st[1]=time[1];hr_st[2]='\0';
hr_int=atoi(hr_st);
if(hr_int>12)
{
 hr_int=hr_int-12;
 time[8]='P';
}
else if(hr_int==0) hr_int=12;
time[1]=hr_int%10 + 0x30;
time[0]=hr_int/10 + 0x30;
time[11]='\0';
cal[0]=full_time[16];cal[1]=full_time[17];cal[2]='/';
cal[3]=full_time[13];cal[4]=full_time[14];cal[5]='/';
// cal[6]='2';cal[7]='0';
cal[6]=full_time[10];cal[7]=full_time[11];cal[8]='\0';
```

```
 s_date[0]=cal[0];s_date[1]=cal[1];s_date[2]='\0';
 mnth[0]=cal[3];mnth[1]=cal[4];mnth[2]='\0';
 int_date=atoi(s_date);
 int_mnth=atoi(mnth);
 switch(int_mnth)
 {
   case 1:index=0;break;
   case 2:index=31;break;
   case 3:index=31+28;break;
   case 4:index=31+28+31;break;
   case 5:index=31+28+31+30;break;
   case 6:index=31+28+31+30+31;break;
   case 7:index=31+28+31+30+31+30;break;
   case 8:index=31+28+31+30+31+30+31;break;
   case 9:index=31+28+31+30+31+30+31+31;break;
   case 10:index=31+28+31+30+31+30+31+31+30;break;
   case 11:index=31+28+31+30+31+30+31+31+30+31;break;
   case 12:index=31+28+31+30+31+30+31+31+30+31+30;break;
 }
 now_day=(index+int_date-1)%7;
 GLCD.SetFontColor(BLACK);
 GLCD.DrawString(time,4,16);
 GLCD.DrawString(week[now_day],55,4);
 GLCD.DrawString(cal,77,16);
}
//-----------------------------------------------------------------
void save_all_to_sd(char bin_number)
{
 myFile = SD.open("HISTORY.txt", FILE_WRITE);
```

```
 if (myFile)
 {
  digitalWrite(sd_led,HIGH);
  myFile.println("------- Recieved Message -------");
  myFile.print(  " Time     : ");myFile.println(time);
  myFile.print(  " Date     : ");myFile.println(cal);
  myFile.print(  " Day      : ");myFile.println(week[now_day]);
  myFile.print(" Bin number_");
  myFile.println(bin_number);
  myFile.println("--------------------------------");myFile.println();
  myFile.close();
  delay(100);
  digitalWrite(sd_led,LOW);
 }
}
//---------------------------------------------------------------------
void send_sms(char bin_number)
{
 char temp[200];
 strcpy(temp,"Please: Flush Bin_");
 temp[18]=bin_number;
 temp[19]='\0';
 if (sms.SendSMS("+905488555583",temp)) // your private mobile no. "the car to flush the
bins
 {
  myFile = SD.open("HISTORY.txt", FILE_WRITE);
  if (myFile)
  {
   digitalWrite(sd_led,HIGH);
```

```
  myFile.println("********* Sent Message *********");
  myFile.print(  " Time     : ");myFile.println(time);
  myFile.print(  " Date     : ");myFile.println(cal);
  myFile.print(  " Day      : ");myFile.println(week[now_day]);
  myFile.print(" Please: Flush Bin_");
  myFile.println(bin_number);
  myFile.println("**********************************");
  myFile.close();
  delay(100);
  digitalWrite(sd_led,LOW);
 }
 }
}
//---------------------------------------------------------------
void execute_command(char mess[])
{
 char charge[25],at_com[50];char t[100];
 int i,j;
 myFile = SD.open("HISTORY.txt", FILE_WRITE);
 if (myFile)
 {
  digitalWrite(sd_led,HIGH);
  myFile.println("------- Received Message -------");
  myFile.print(  " Time     : ");myFile.println(time);
  myFile.print(  " Date     : ");myFile.println(cal);
  myFile.print(  " Day      : ");myFile.println(week[now_day]);
  myFile.println(mess);
  myFile.println("--------------------------------");
  myFile.close();
```

```
 delay(100);
 digitalWrite(sd_led,LOW);
}
if ((mess[0]=='C') && (mess[1]=='h') && (strlen(mess)==15))
{
 strcpy(charge,"\"*133*");
 for(i=0;i<13;i++)
  charge[6+i]=mess[i+2];
 charge[i+6]='\0';
 strcat(charge,"#\"");
 strcpy(at_com,"AT+CUSD=1,");  // AT+CUSD=1,"*133*credit#"
 strcat(at_com,charge);
 gsm.SimpleWriteln((at_com));   //sending AT+CUSD=1,"*121#"
 delay(5000);
 char resp[300];
 gsm.read(resp, 300); //this command will send the response to the serial port and, at the same time, copy to "resp" string
 i=0;
 while(resp[i]!="")
  i++;
 i++;
 j=0;
 Serial.println(resp);
 while ((resp[i]!="")  && (resp[i]!='\0'))
 {
  t[j]=resp[i];
  i++;
  j++;
 }
```

```
 t[j]='\0';
 //Serial.println(t);
 if (sms.SendSMS("+905488555583", t)) // your private mobile no. "the car to flush the bins
 {
  myFile = SD.open("HISTORY.txt", FILE_WRITE);
  if (myFile)
  {
   digitalWrite(sd_led,HIGH);
   myFile.println("********* Sent Message *********");
   myFile.print(  " Time     : ");myFile.println(time);
   myFile.print(  " Date     : ");myFile.println(cal);
   myFile.print(  " Day      : ");myFile.println(week[now_day]);
   myFile.println(t);
   myFile.println("**********************************");myFile.println();
   myFile.close();
   delay(100);
   digitalWrite(sd_led,LOW);
  }
 }
}
else
 if ((mess[0]=='F') && (mess[1]=='u') && (mess[2]=='n') && (mess[3]=='d') && (strlen(mess)==4))
 {
  strcpy(at_com,"AT+CUSD=1,\"*133#\n\"");
  gsm.SimpleWriteln((at_com));   //sending AT+CUSD=1,"*121#"
  //Serial.println(at_com);
  delay(5000);
  char resp[300];
```

```
  gsm.read(resp, 300); //this command will send the response to the serial port and, at the same time, copy to "resp" string
  i=0;
  while(resp[i]!="")
   i++;
  i++;
  j=0;
  while ((resp[i]!="") && (resp[i]!='\0'))
  {
   t[j]=resp[i];
   i++;
   j++;
  }
  t[j]='\0';
  if (sms.SendSMS("+905488555583", t))  // your private mobile no. "the car to flush the bins
  {
   myFile = SD.open("HISTORY.txt", FILE_WRITE);
   if (myFile)
   {
    digitalWrite(sd_led,HIGH);
    myFile.println("********* Sent Message *********");
    myFile.print(  " Time     : ");myFile.println(time);
    myFile.print(  " Date     : ");myFile.println(cal);
    myFile.print(  " Day      : ");myFile.println(week[now_day]);
    myFile.println(t);
    myFile.println("**********************************");myFile.println();
    myFile.close();
    delay(100);
    digitalWrite(sd_led,LOW);
```

```
  }
 }
}
//----------------------------------
else
if (sms.SendSMS("+905488555583", "Command Error!"))  // your private mobile no. "the car to flush the bins
 {
  myFile = SD.open("HISTORY.txt", FILE_WRITE);
  if (myFile)
  {
   digitalWrite(sd_led,HIGH);
   myFile.println("********** Sent Message **********");
   myFile.print(  " message  : ");myFile.println(  "Command Error!" );
   myFile.print(  " Time     : ");myFile.println(time);
   myFile.print(  " Date     : ");myFile.println(cal);
   myFile.print(  " Day      : ");myFile.println(week[now_day]);
   myFile.println("**********************************");myFile.println();
   myFile.close();
   delay(100);
   digitalWrite(sd_led,LOW);
  }
 }
}
 //-----------------------------------------------------------------
void bin_events(int bin_dist,int &bin_state,long &bin_current_time,long &bin_next_time,char bin_name)
{
 switch (bin_state)
 {
```

```
//*****************************************************
case 0:
{
 if (bin_dist<=10)
 {
  bin_current_time=millis();
  bin_state=1;
 }
 break;
}
//*****************************************************
case 1:
{
 if (bin_dist<=10)
 {
  bin_next_time=millis();
  if (bin_next_time-bin_current_time>=max_time_1)
   bin_state=2;
 }
 else bin_state=0;
 break;
}
//*****************************************************
case 2:
{
 send_sms(bin_name);
 count++;
```

```
EEPROM.write(0, count);
   bin_state=3;
   break;
  }
  //*****************************************************
  case 3:
  {
   bin_current_time=millis();
   bin_state=4;
   break;
  }
   //*****************************************************
   case 4:
  {
    if (bin_dist<=10)
   {
     bin_next_time=millis();
     if (bin_next_time-bin_current_time>=max_time_2)
     bin_state=2;
    else bin_state=4;
   }
    else
     bin_state=0;
    break;
   }
  //*****************************************************
 }
}
```

```
void Check_Bin()
{
  char head[5];
  char dist[5];
  int distance,i;
  for(i=0;i<=2;i++)
  head[i]=StringReceived[i];
  head[3]='\0';
  for(i=3;i<=5;i++)
   dist[i-3]=StringReceived[i];
  dist[3]='\0';
  distance=atoi(dist);
 //distance=100;
  if(distance>100) distance=100;
  if(strcmp(head,"B0,")==0)
 {
   digitalWrite(led_0,HIGH);
   bin_dist_0=distance;
   GLCD.FillRect(10,40,7,10,BLACK);
   GLCD.FillRect(10,40,7,(bin_dist_0*10/bin_depth)-1,WHITE);
   bin_events(bin_dist_0,bin_state_0,current_time_0,next_time_0,'0');
   digitalWrite(led_0,LOW);
  }
  //-------------------------------------------------------------------------
  else if(strcmp(head,"B1,")==0)
  {
   digitalWrite(led_1,HIGH);
   bin_dist_1=distance;
```

```
 GLCD.FillRect(35,40,7,10,BLACK);
 GLCD.FillRect(35,40,7,(bin_dist_1*10/bin_depth)-1,WHITE);
 bin_events(bin_dist_1,bin_state_1,current_time_1,next_time_1,'1');
 digitalWrite(led_1,LOW);
}
else if(strcmp(head,"B2,")==0)
{
 digitalWrite(led_2,HIGH);
 bin_dist_2=distance;
 GLCD.FillRect(60,40,7,10,BLACK);
  GLCD.FillRect(60,40,7,(bin_dist_2*10/bin_depth)-1,WHITE);
bin_events(bin_dist_2,bin_state_2,current_time_2,next_time_2,'2');
digitalWrite(led_2,LOW);
}
else if(strcmp(head,"B3,")==0)
{
 digitalWrite(led_3,HIGH);
 bin_dist_3=distance;
 GLCD.FillRect(85,40,7,10,BLACK);
 GLCD.FillRect(85,40,7,(bin_dist_3*10/bin_depth)-1,WHITE);
 bin_events(bin_dist_3,bin_state_3,current_time_3,next_time_3,'3');
 digitalWrite(led_3,LOW);
}
else if(strcmp(head,"B4,")==0)
{
 digitalWrite(led_4,HIGH);
 bin_dist_4=distance;
 GLCD.FillRect(110,40,7,10,BLACK);
```

```
 GLCD.FillRect(110,40,7,(bin_dist_4*10/bin_depth)-1,WHITE);
 bin_events(bin_dist_4,bin_state_4,current_time_4,next_time_4,'4');
 digitalWrite(led_4,LOW);
 }
 //GLCD.DrawString("    ",4,4);
 //GLCD.GotoXY(4,4);
 //GLCD.print(distance);
}
//---------------------------------------------------------------------
void loop()
{
 uint8_t buf[VW_MAX_MESSAGE_LEN];
 uint8_t buflen = VW_MAX_MESSAGE_LEN;
 int i;
 if (count==4)
 {
  count=0;
  EEPROM.write(0, count);
  ph_index=1-ph_index;
  EEPROM.write(1, ph_index);
 }
  count=EEPROM.read(0);
  ph_index=EEPROM.read(1);
  strcpy(private_phone_no,phone_no[ph_index]);
 if (vw_get_message(buf, &buflen))
    {
     // Message with a good checksum received, dump it.
     for (i = 0; i < buflen; i++)
```

```
    StringReceived[i] = char(buf[i]);
    Check_Bin();
        //GLCD.DrawString(StringReceived,4,50);
   }
if(started)
{
 int p=sms.IsSMSPresent(SMS_ALL);
 if(( p==1)&& (fl==0))
 {
  sms.GetSMS(1, n, smsbuffer, 160);
  //GLCD.DrawString("P.N.:  ", 5, 19);
  //GLCD.DrawString(n, 39, 19);
  GLCD.DrawString("               ", 35, 28);
  if (strcmp(n,"+905488555583")==0) // your private mobile no. "the car to flush the bins
  {
   GLCD.DrawString(smsbuffer, 34, 28);
   execute_command(smsbuffer);
  }
  //delay(1000);
  delsms();
  delay(1000);
  flag=1;
 }
 else
 {
  // Print Time ---------------------------------------------------------------
  print_time();
  // PIR Sensor ---------------------------------------------------------------
```

```
  //get_pir();
  //if((pir_value==1) && (flags[3]==0))
  //send_sms(3,pir_value);
  //……
  // TEMP & HUM Sensor ----------------------------------------------------
  //get_temp_and_hum();
  //if ((temperature_value>=50.0) && (flags[0]==0))
  //send_sms(0,int(temperature_value*100.0));
  //if ((humidity_value>=75.0) && (flags[1]==0))
  //send_sms(1,int(humidity_value*100.0));
  // ---------------------------------------------------------------------
  // GAS Sensor ----------------------------------------------------------
  //get_fire();
  //if ((output_value>25) && (flags[2]==0))
  //send_sms(2,int(output_value*100.0));
  // ---------------------------------------------------------------------
  Signal_Strength();
  fl=0;
 }
 }
}
```

Bin_0

The following programing program for bin_0 by using sensor ultrasonic with Arduino and RF transmitter each bins have the special for it self

```
#include <NewPing.h>

#include <VirtualWire.h>

#define TRIGGER_PIN  3  // Arduino pin tied to trigger pin on the ultrasonic sensor.

#define ECHO_PIN     2  // Arduino pin tied to echo pin on the ultrasonic sensor.

#define LED_PIN      13

#define MAX_DISTANCE 500 // Maximum distance we want to ping for (in centimeters). Maximum sensor distance is rated at 400-500cm.


NewPing sonar(TRIGGER_PIN, ECHO_PIN, MAX_DISTANCE); // NewPing setup of pins and maximum distance.

char sd[20];   // for RF

int distance;

//---------------------------------------------------------------------------

void setup()

{

 Serial.begin(9600); // Open serial monitor at 115200 baud to see ping results.

 vw_setup(2000); // Bits per sec

 vw_set_tx_pin(4);// Set the Tx pin. Default is 12

 pinMode(LED_PIN,OUTPUT);

 digitalWrite(LED_PIN,LOW);

}

//---------------------------------------------------------------------------

int get_distance()

 {

 int i;

 delay(50);

unsigned int uS = sonar.ping();
```

```
 i=uS / US_ROUNDTRIP_CM;
 return(i);
}
//--------------------------------------------------------------------------
void loop()
{
 distance=get_distance();
 if(distance<10) sprintf(sd, "%c%c,%c%c%d",'B','0','0','0',distance);
   else if(distance<100) sprintf(sd, "%c%c,%c%d",'B','0','0',distance);
    else sprintf(sd, "%c%c,%d",'B','0',distance);
  //Serial.println(sd);
  digitalWrite(LED_PIN,HIGH);
  vw_send((uint8_t *)sd, strlen(sd));
  vw_wait_tx(); // Wait until the whole message is gone
  delay(250);
  digitalWrite(LED_PIN,LOW);
}
```

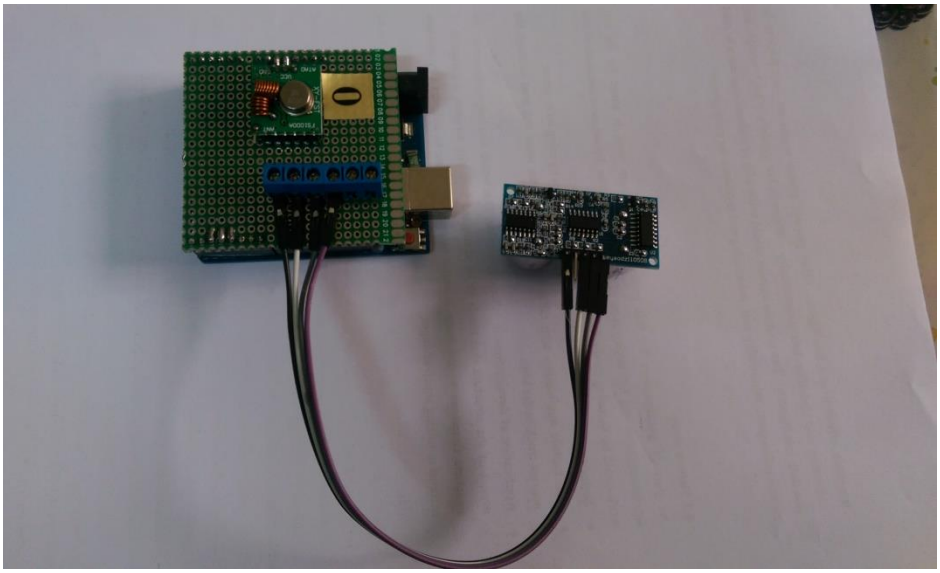

Figure A-1: Ultrasonic with Arduion and RF Transmitter for bin-0

Bin_1

```
#include <NewPing.h>

#include <VirtualWire.h>

#define TRIGGER_PIN  3  // Arduino pin tied to trigger pin on the ultrasonic sensor.

#define ECHO_PIN     2  // Arduino pin tied to echo pin on the ultrasonic sensor.

#define LED_PIN      13

#define MAX_DISTANCE 500 // Maximum distance we want to ping for (in centimeters). Maximum sensor distance is rated at 400-500cm.


NewPing sonar(TRIGGER_PIN, ECHO_PIN, MAX_DISTANCE); // NewPing setup of pins and maximum distance.

char sd[20];   // for RF

int distance;

//---------------------------------------------------------------------------

void setup()

{

 Serial.begin(9600); // Open serial monitor at 115200 baud to see ping results.

 vw_setup(2000); // Bits per sec

 vw_set_tx_pin(4);// Set the Tx pin. Default is 12

 pinMode(LED_PIN,OUTPUT);

 digitalWrite(LED_PIN,LOW);

}

//---------------------------------------------------------------------------

int get_distance()

{

 int i;

 delay(50);

 unsigned int uS = sonar.ping();

 i=uS / US_ROUNDTRIP_CM;
```

```
 return(i);
}
//--------------------------------------------------------------------------------
void loop()
{
 distance=get_distance();
 distance=50;
 if(distance<10) 96print(sd, "%c%c,%c%c%d",'B','1','0','0',distance);
  else if(distance<100) 96print(sd, "%c%c,%c%d",'B','1','0',distance);
  else 96print(sd, "%c%c,%d",'B','1',distance);
  //Serial.println(sd);
  digitalWrite(LED_PIN,HIGH);
  vw_send((uint8_t *)sd, strlen(sd));
  vw_wait_tx(); // Wait until the whole message is gone
  delay(250);
  digitalWrite(LED_PIN,LOW);
}
```

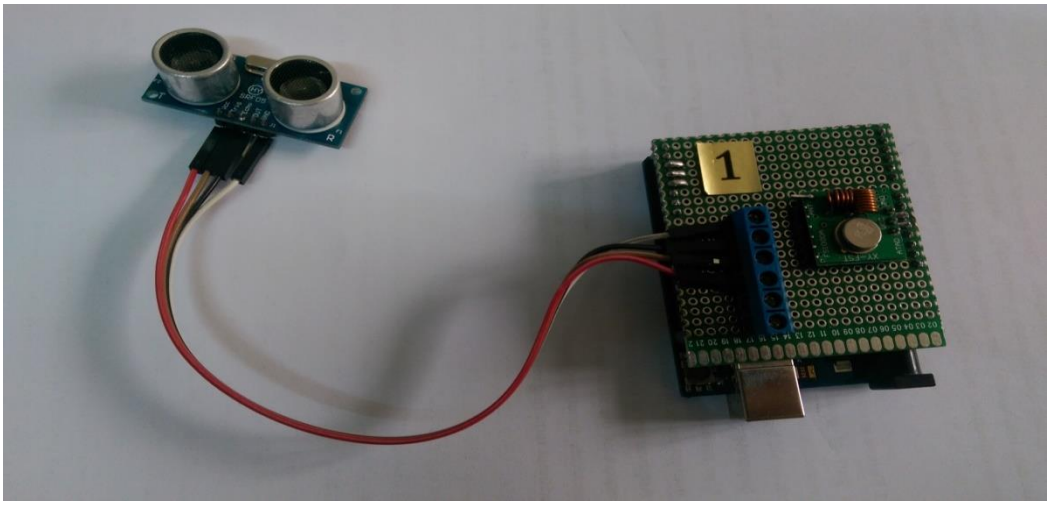

Figure A-2: Ultrasonic with Arduion and RF Transmitter for bin-1

Bin_2

```
#include <NewPing.h>

#include <VirtualWire.h>

#define TRIGGER_PIN  3  // Arduino pin tied to trigger pin on the ultrasonic sensor.

#define ECHO_PIN     2  // Arduino pin tied to echo pin on the ultrasonic sensor.

#define LED_PIN      13

#define MAX_DISTANCE 500 // Maximum distance we want to ping for (in centimeters). Maximum sensor distance is rated at 400-500cm.


NewPing sonar(TRIGGER_PIN, ECHO_PIN, MAX_DISTANCE); // NewPing setup of pins and maximum distance.

char sd[20];   // for RF

int distance;

//---------------------------------------------------------------------------

void setup()

{

 Serial.begin(9600); // Open serial monitor at 115200 baud to see ping results.

 vw_setup(2000); // Bits per sec

 vw_set_tx_pin(4);// Set the Tx pin. Default is 12

 pinMode(LED_PIN,OUTPUT);

 digitalWrite(LED_PIN,LOW);

}

//---------------------------------------------------------------------------

int get_distance()

{

 int i;

 delay(50);

 unsigned int uS = sonar.ping();

 i=uS / US_ROUNDTRIP_CM;

 return(i);
```

```
}
//--------------------------------------------------------------------------------
void loop()
{
 distance=get_distance();
 //distance=25;
 if(distance<10) sprintf(sd, "%c%c,%c%c%d",'B','2','0','0',distance);
   else if(distance<100) sprintf(sd, "%c%c,%c%d",'B','2','0',distance);
    else sprintf(sd, "%c%c,%d",'B','2',distance);
  //Serial.println(sd);
  digitalWrite(LED_PIN,HIGH);
  vw_send((uint8_t *)sd, strlen(sd));
  vw_wait_tx(); // Wait until the whole message is gone
  delay(250);
  digitalWrite(LED_PIN,LOW);
}
```

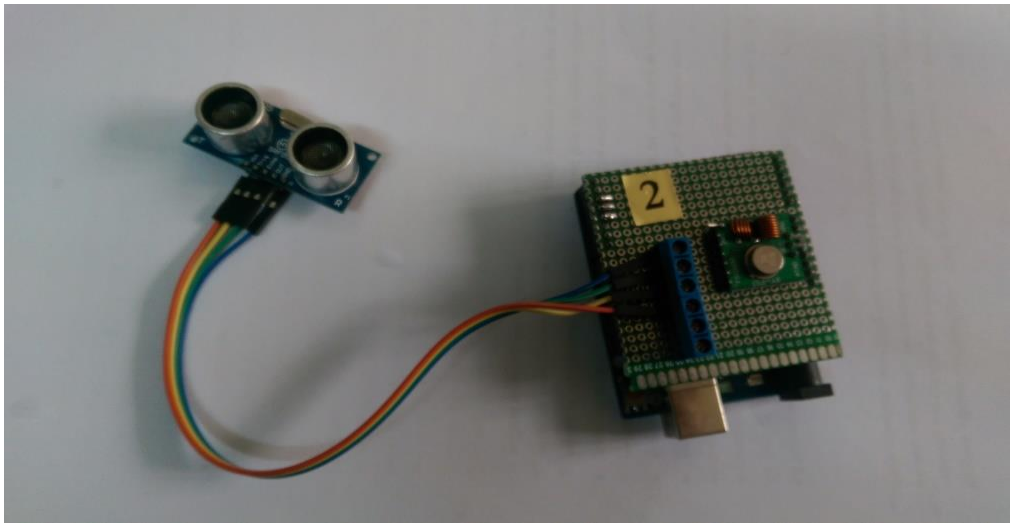

Figure A-3: Ultrasonic with Arduion and RF Transmitter for bin-2

Bin_3

```
#include <NewPing.h>

#include <VirtualWire.h>

#define TRIGGER_PIN  3  // Arduino pin tied to trigger pin on the ultrasonic sensor.

#define ECHO_PIN     2  // Arduino pin tied to echo pin on the ultrasonic sensor.

#define LED_PIN      13

#define MAX_DISTANCE 500 // Maximum distance we want to ping for (in centimeters). Maximum sensor distance is rated at 400-500cm.


NewPing sonar(TRIGGER_PIN, ECHO_PIN, MAX_DISTANCE); // NewPing setup of pins and maximum distance.

char sd[20];   // for RF

int distance;

//---------------------------------------------------------------------------

void setup()

{

 Serial.begin(9600); // Open serial monitor at 115200 baud to see ping results.

 vw_setup(2000); // Bits per sec

 vw_set_tx_pin(4);// Set the Tx pin. Default is 12

 pinMode(LED_PIN,OUTPUT);

 digitalWrite(LED_PIN,LOW);

}

//---------------------------------------------------------------------------

int get_distance()

{

 int i;

 delay(50);

 unsigned int uS = sonar.ping();

 i=uS / US_ROUNDTRIP_CM;

 return(i);
```

```
}
//--------------------------------------------------------------------------------
void loop()
{
 distance=get_distance();
// distance=25;
 if(distance<10) sprintf(sd, "%c%c,%c%c%d",'B','3','0','0',distance);
   else if(distance<100) sprintf(sd, "%c%c,%c%d",'B','3','0',distance);
    else sprintf(sd, "%c%c,%d",'B','3',distance);
  //Serial.println(sd);
  digitalWrite(LED_PIN,HIGH);
  vw_send((uint8_t *)sd, strlen(sd));
  vw_wait_tx(); // Wait until the whole message is gone
  delay(250);
  digitalWrite(LED_PIN,LOW);  }
```

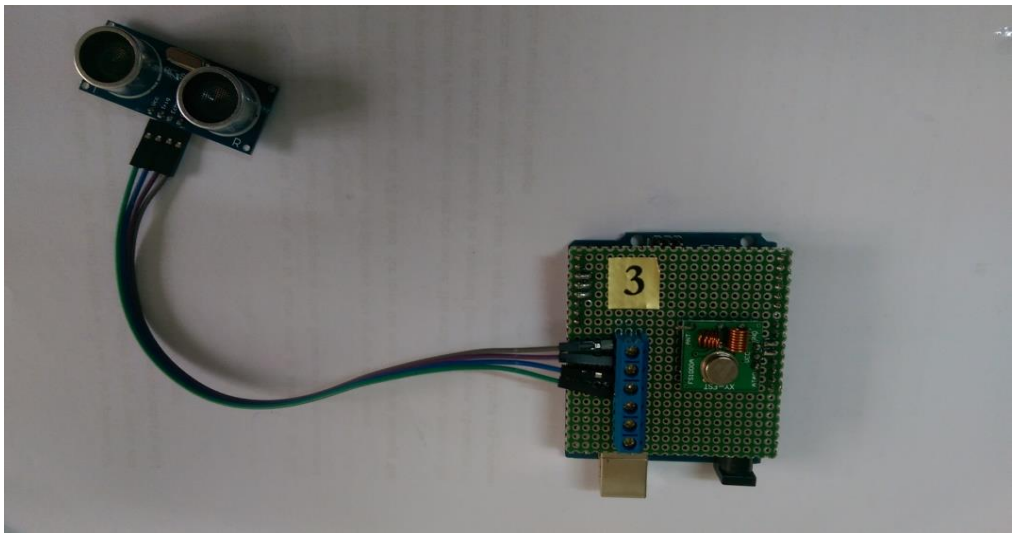

Figure A-4: Ultrasonic with Arduion and RF Transmitter for bin-3

Bin_4

```
#include <NewPing.h>

#include <VirtualWire.h>

#define TRIGGER_PIN  3  // Arduino pin tied to trigger pin on the ultrasonic sensor.

#define ECHO_PIN     2  // Arduino pin tied to echo pin on the ultrasonic sensor.

#define LED_PIN      13

#define MAX_DISTANCE 500 // Maximum distance we want to ping for (in centimeters). Maximum sensor distance is rated at 400-500cm.


NewPing sonar(TRIGGER_PIN, ECHO_PIN, MAX_DISTANCE); // NewPing setup of pins and maximum distance.

char sd[20];   // for RF

int distance;

//---------------------------------------------------------------------------

void setup()

{

 Serial.begin(9600); // Open serial monitor at 115200 baud to see ping results.

 vw_setup(2000); // Bits per sec

 vw_set_tx_pin(4);// Set the Tx pin. Default is 12

 pinMode(LED_PIN,OUTPUT);

 digitalWrite(LED_PIN,LOW);

}

//---------------------------------------------------------------------------

int get_distance()

{

 int i;

 delay(50);

 unsigned int uS = sonar.ping();

 i=uS / US_ROUNDTRIP_CM;
```

```
 return(i);
}
//-----------------------------------------------------------------------------
void loop()
{
 distance=get_distance();
// distance=25;
 if(distance<10) sprintf(sd, "%c%c,%c%c%d",'B','4','0','0',distance);
else if(distance<100) sprintf(sd, "%c%c,%c%d",'B','4','0',distance);
 else sprintf(sd, "%c%c,%d",'B','4',distance);
//Serial.println(sd);
  digitalWrite(LED_PIN,HIGH);
  vw_send((uint8_t *)sd, strlen(sd));
  vw_wait_tx(); // Wait until the whole message is gone
  delay(250);
  digitalWrite(LED_PIN,LOW);
}
```

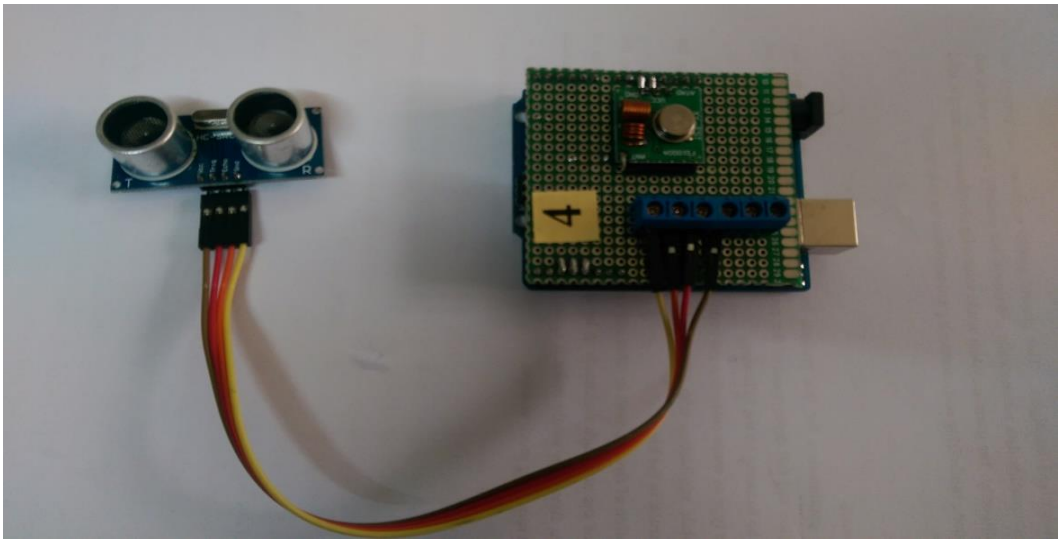

Figure A-5: Ultrasonic with Arduion and RF Transmitter for bin-4