Mini-Project Report

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INDIAN INSTITUTE OF INFORMATION TECHNOLOGY

Development of Smart waste management based on a IoT platform

Project By:
Shiva Sai(18BEC012)
Kiran D(18BEC022)
Nikhil S A(18BEC033)
Nithin R(18BEC034)

Project Guide:
Dr. Prakash Pawar

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Introduction

1.1 Overview:

Waste management is all the activities and actions required to manage waste from its inception to its final disposal . This includes collection, transportation, treatment and disposal of waste together with monitoring and regulation. Waste collection methods vary widely among different countries and regions. Domestic waste collection services are often provided by local government authorities.

Curbside collection is the most common method of disposal in most countries, in which waste is collected at regular intervals by specialised trucks. Waste collected is then transported to an appropriate disposal area.

Nowadays, cities with developing economies experience exhausted waste collection services, inadequately managed and uncontrolled dumpsites and the problems are worsening. Waste collection method in such countries is an on-going challenge and many struggle due to weak institutions and rapid urbanization.

1.2 Need for improvement in smart waste management:

- By 2030, almost two-third of the world's population will be living in cities. This fact requires the development of sustainable solutions for urban life, managing waste is a key issue for health.
- Efficient and energy-saving waste management, reducing CO_2, air pollution and vehicle exhaust emissions are just a few examples for the demands of future cities. In view of that, the efficient use and responsible handling of resources become more important.
- Effectively managing waste is important in developed countries. Waste management may swallow upto 50% of a city's budget, but only serve a small part of the population.
- Sometimes, upto 60%of waste is not being collected, it is often simply burned by the roadside. It can pollute drinking water, it can spread disease to people living nearby.
- Lack of the information about the collecting time and area.
- Lack of the proper system for monitoring, tracking the trucks and trash bins that have been collected in real time.
- One of the main concerns with our environment has been solid waste

management which impacts the health and environment of our society.
- There is no quick response to urgent cases like truck accidents, breakdown, longtime idling.
- There is no quick way to respond to client's complaints about uncollected waste.
- Even with great route optimization, the worker must still physically go to the dustbin to check waste levels. Because of this, trucks often visit containers that do not need emptying, which wastes both time and fuel.
- Waste management prevents harm to human health and the environment by reducing the volume and hazardous character of residential and industrial waste.
- Improving proper waste management will reduce pollution, recycle useful materials and create more green energy.

1.3 Features of smart waste management:

- The smart, sensor based dustbin will judge the level of waste in it and send the message directly to the municipal corporation.
- It can sense all the types of waste material either it is in the form of solid or liquid.
- According to the filled level of the dustbin, the vehicles from the municipal corporation will choose the shortest path with the help of the "TRANSPORTATION SOFTWARE", which will save their time.
- It emphasizes on "DIGITAL INDIA".
- The system is simple. If there is any problem with any equipment in the future, that part is easily replaceable with new one without any difficulty and delay

1.4 Advantages of smart waste management:

- Less time and fuel consumption as the trucks go only to the filled containers.
- Decreased noise, traffic flow and air pollution as a result of less trucks on the roads.
- Our smart operating system enables two way communication between the dustbin deployed in the city and service operator. Therefore the focus is only on collection of route based fill level of the containers.
- The sensors installed in the containers provide real time information on the fill level. This information helps determine when and where to prioritise

collection.

- ❖ In this way both service providers and citizens benefit from an optimized system which results in major cost savings and less urban pollution.
- ❖ Reduces the infrastructure (trucks, containers), operating (fuel) and maintenance costs of the service by upto 30%.
- ❖ Applying this technology to the city optimises management, resources and costs, and makes it a “SMART CITY”.
- ❖ Historical information on collections helps adapt the deployment of containers to the actual needs of the city, therefore reducing the number of containers that clutter up the road and increasing public parking spaces.
- ❖ It keeps the surroundings clean and green, free from bad odour of wastes, emphasizes a healthy environment and keeps cities more beautiful.
- ❖ Reducing manpower required to handle the garbage collection.

1.5 Applications of smart waste management:

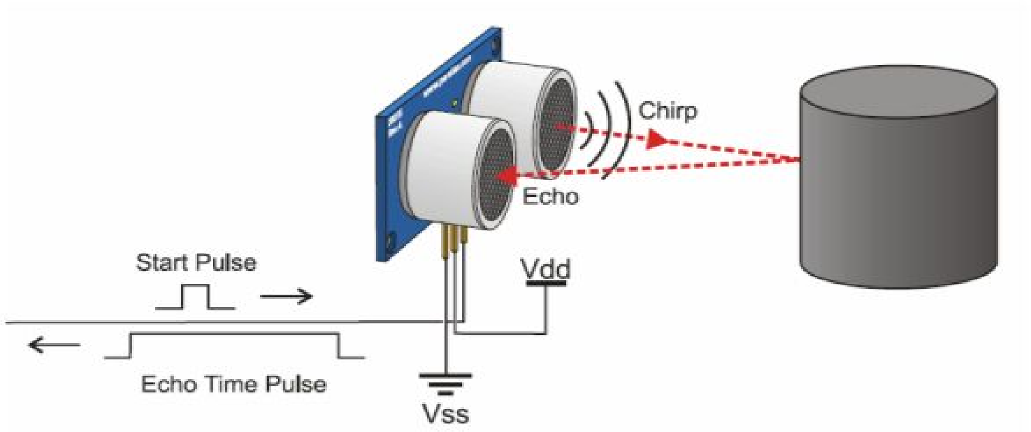
- ❖ This can be best used by municipal corporations for their betterment of management regarding collection of wastes.
- ❖ With the help of proper technology (GPS & SOFTWARE APPLICATIONS) we can guide the trucks to choose the shortest path.
- ❖ It also favours the “SMART CITY” project and “DIGITAL INDIA”.

Components Required for designing:

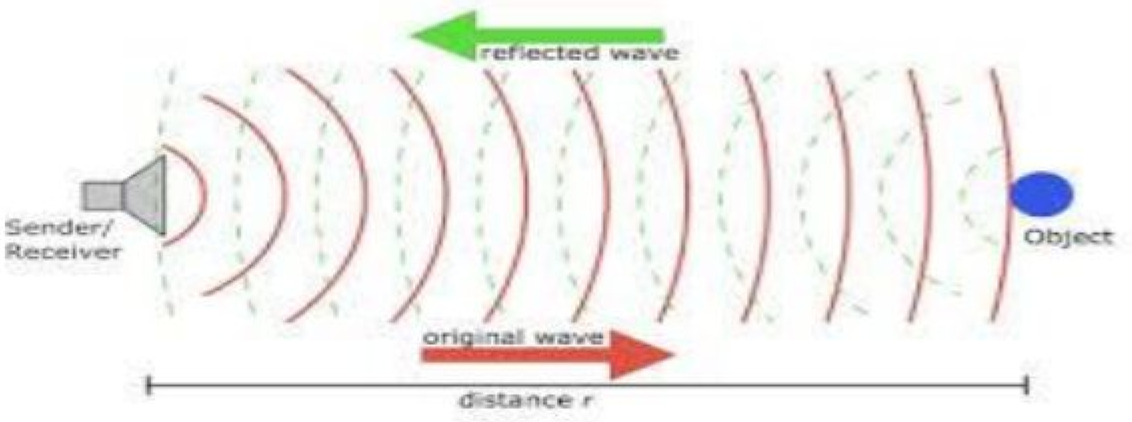
1. Garbage Container:
   A waste container is a container for temporarily storing waste, and is usually made out of metal or plastic.
   The curbside dustbins usually consist of three types: trash cans (receptacles made of metal or plastic), dumpsters (large receptacles similar to skips) and wheelie bins (light, usually plastic bins that are mobile). All of these are emptied by collectors, who will load the contents into a garbage truck and drive it to a landfill, incinerator or consuming crush facility to be disposed of.

2. Ultrasonic Sensor:
   A special sonic transducer is used for the ultrasonic proximity sensors, which allows for alternate transmission and reception of sound waves.
   The sonic waves emitted by the transducer are reflected by an object and received back in the transducer. After having emitted the sound waves, the ultrasonic sensor will switch to receive mode. The time elapsed between emitting and receiving is proportional to the distance of the object from the sensor.

Working Of Ultrasonic sensor:



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



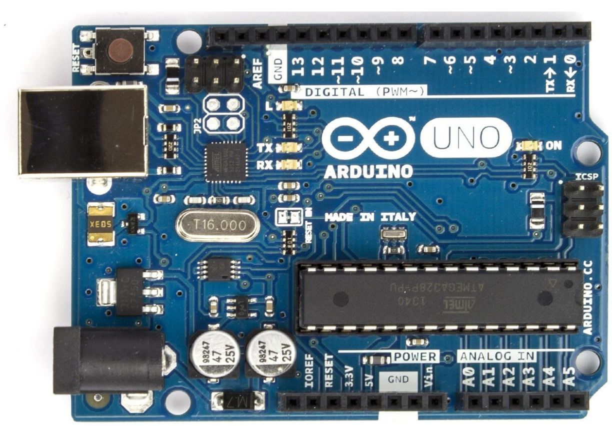
- Not affected by object colour and transparency as it detects distance through sound waves.
- Works well in places that are dim.
- Tend to consume lower current/power.
- Multiple interface options for pairing with a microcontroller, etc.

3. Arduino Uno Board:

   Arduino is a software company, project, and user community that designs and manufactures computer open-source hardware,open-source software, and microcontroller-based kits for building digital devices and interactive objects that can sense and control physical devices.

   The project is based on microcontroller board designs, produced by several vendors, using various microcontrollers. These systems provide sets of digital and analog I/O pins that can interface to various expansion boards (termed shields) and other circuits. The boards feature serial communication interfaces, including Universal Serial Bus (USB) on some models, for loading programs from personal computers. For programming the microcontrollers, the Arduino project provides an integrated development environment(IDE) based on a programming language named Processing, which also supports the languages C and C++.

   The first Arduino was introduced in 2005, aiming to provide a low cost, easy way for novices and professionals to create devices that interact with their environment using sensors and actuators. Common examples of such devices intended for beginner hobbyists include simple robots, thermostats, and motion detectors.

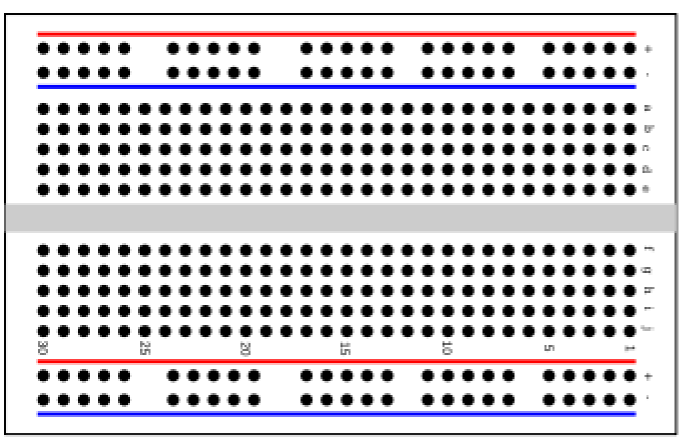


Arduino Software:

The Arduino project provides the Arduino integrated development environment (IDE), which is a cross-platform application written in the programming language Java. It originated from the IDE for the languages Processing and Wiring. It is designed to introduce programming to artists and other newcomers unfamiliar with software development. It includes a code editor with features such as syntax highlighting, brace matching, and automatic indentation, and provides a simple one-click mechanism to compile and load programs to an Arduino board. A program written with the IDE for Arduino is called a "sketch". The Arduino IDE supports the languages C and C++ using special rules to organize code.

4. Bread Board:

A breadboard is a construction base for prototyping of electronics. Originally it was literally a breadboard, a polished piece of wood used for slicing bread. In the 1970s the solderless breadboard (AKA plugboard, a terminal array board) became available and nowadays the term "breadboard" is commonly used to refer to these. "Breadboard" is also a synonym for "prototype". Because the solderless breadboard does not require soldering, it is reusable. This makes it easy to use for creating temporary prototypes and experimenting with circuit design. For this reason, solderless breadboards are also extremely popular with students and in technological education. Older breadboard types did not have this property. A variety of electronic systems may be prototyped by using breadboards, from small analog and digital circuits to complete central processing units (CPUs).

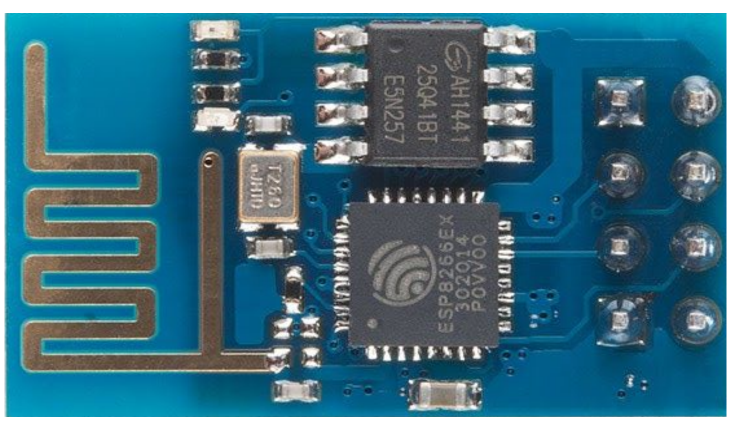


A modern solderless breadboard consists of a perforated block of plastic with numerous tin plated phosphor bronze or nickel silver alloy spring clips under the perforations. The clips are often called tie points or contact points. The number of tie points is often given in the specification of the breadboard.

The spacing between the clips (lead pitch) is typically 0.1 in (2.54 mm). Integrated circuits (ICs) in dual in-line packages (DIPs) can be inserted to straddle the centerline of the block. Interconnecting wires and the leads of discrete components (such as capacitors, resistors, and inductors) can be inserted into the remaining free holes to complete the circuit. Where ICs are not used, discrete components and connecting wires may use any of the holes.

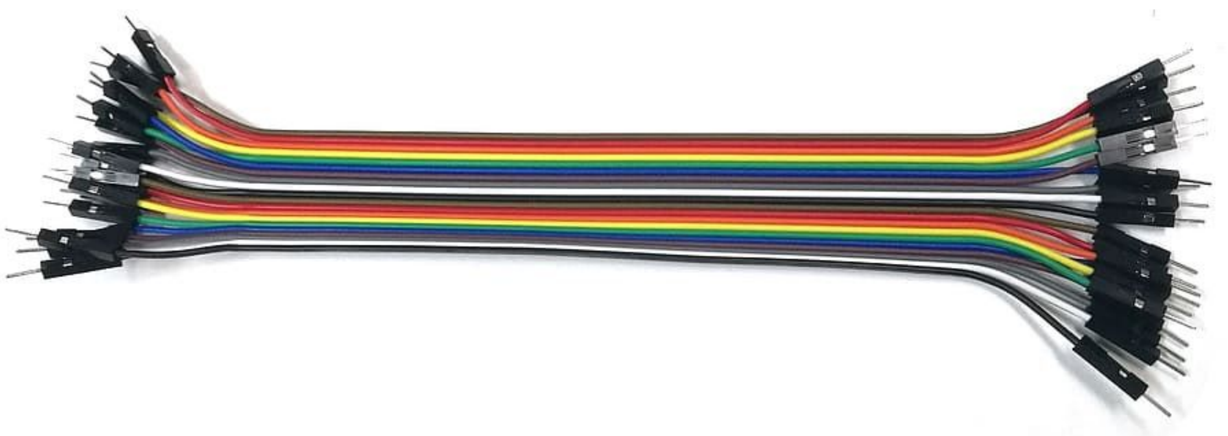
5. ESP8266 Wifi Module:

   The ESP8266 WiFi Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your WiFi network. The ESP8266 is capable of either hosting an application or offloading all WiFi networking functions from another application processor. Each ESP8266 module comes pre-programmed with an AT command set firmware, meaning, you can simply hook this up to your Arduino device and get about as much WiFi-ability as a WiFi Shield offers. The ESP8266 module is an extremely cost effective board with a huge, and ever growing, community.



6. Jumper Wires:

   Jump wires (also called jumper wires) for solderless breadboarding can be obtained in ready-to-use jump wire sets or can be manually manufactured. The latter can become tedious work for larger circuits. Ready To-use jump wires come in different qualities, some even with tiny plugs attached to the wire ends. Jump wire material for ready-made or homemade wires should usually be 22 AWG (0.33 mm2) solid copper, tin-plated wire - assuming no tiny plugs are to be attached to the wire ends. The wire ends should be stripped 3⁄16 to 5⁄16 in (4.8 to 7.9 mm). Shorter stripped wires might result in bad contact with the board's spring clips (insulation being caught in the springs). Longer stripped wires increase the likelihood of short-circuits on the board. Needle-nose pliers and tweezers are helpful when inserting or removing wires, particularly on crowded boards.

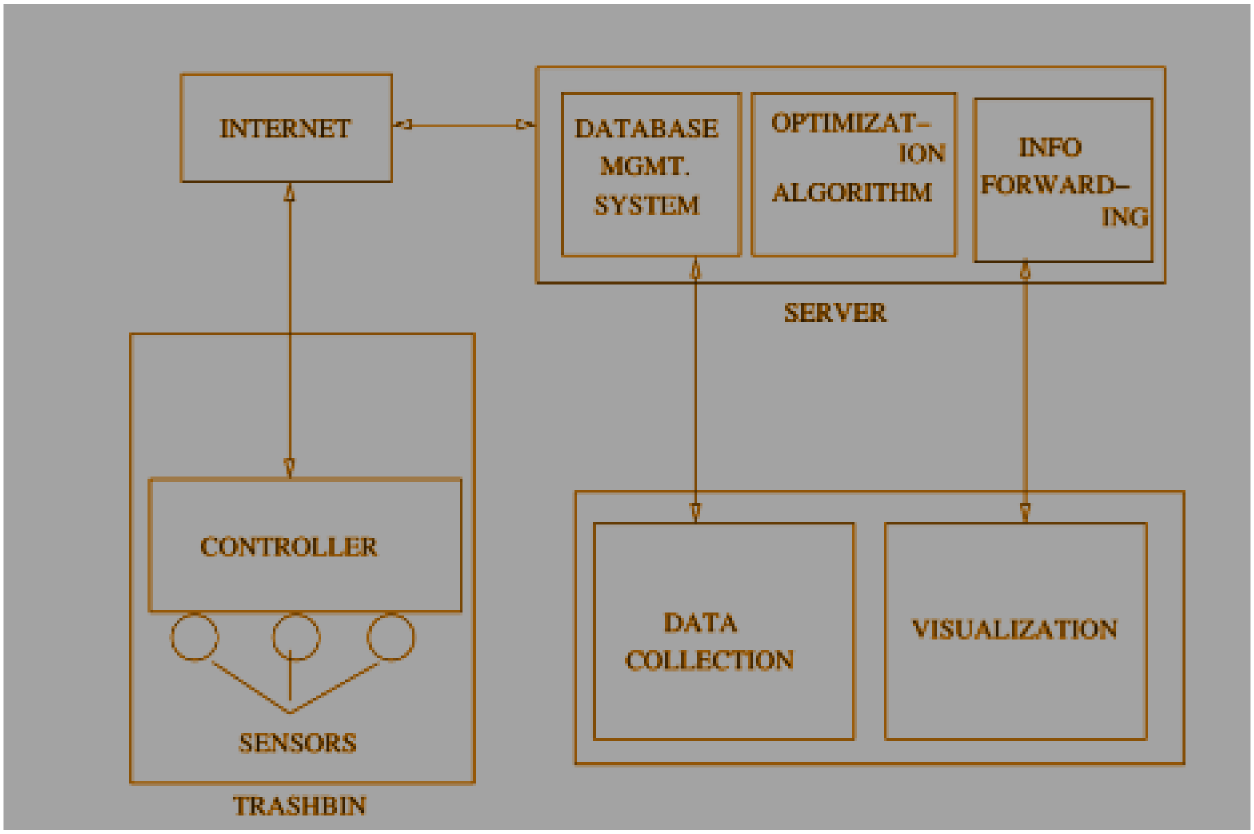


   Differently colored wires and color-coding discipline are often adhered to for consistency. However, the number of available colors is typically far fewer than the number of signal types or paths. Typically, a few wire colors are reserved for the supply voltages and ground (e.g., red, blue, black), some are reserved for main signals, and the rest are simply used where convenient.

Plan:

An ultrasonic sensor will be placed on the interior side of the lid, the one facing the solid waste. As trash increases, the distance between the ultrasonic and the trash decreases. This live data will be sent to our microcontroller.

System Architecture:



We propose a smart waste collection system on the basis of the level of wastes present in the waste bins. The data obtained through sensors is transmitted over the Internet to a server for storage and processing mechanisms. It is used for monitoring the daily selection of waste bins, based on which the routes to pick several of the waste bins from different locations are decided. Every day, the workers receive the updated optimized routes in their navigational devices. The significant feature of this system is that it is designed to update from the previous experience and decide not only on the daily waste level status but also the predict future state with respect to factors like traffic congestion in an area where the waste bins are placed, cost-efficiency balance, and other factors that is difficult for humans to observe and analyze. Based on this historical data, the rate at which waste bins get filled is easily analyzed. As a result, it can be predicted before the overflow of wastes occurs in the waste bins that are placed in a specific location.Depending on economic requirements specified at early stages, the optimized selection of waste bins to be collected is expected to improve collection efficiency.

- ❖ Sensors: We can determine the waste level by measuring the distance from the top of the trash bin to the waste by sonar. The sonar that can be used in this prototype should provide measurement from 2cm to 400cm with 3mm accuracy, which is adequate for typical waste bins, e.g.,Ultrasonic Ranging Module (HC-SR04). It is essential to optimize the battery usage for achieving a bigger lifespan of the devices. Sensing and data forwarding rates, and wireless technology used have a strong influence on energy consumption. Collection and forwarding of data can be done once or twice in a day.

- ❖ Access Network Interface: The data collected is sent to a remote server via a wireless link. For our work, WiFi is considered as a network access technology.

- ❖ Artificial Intelligence (AI): The forecast of waste levels for the future and learning how to select the daily waste bins is based on historical data through artificial intelligence algorithms.

- ❖ Optimization algorithms: Once the identification of waste bins have been done, the shortest path for collection of the same is done.

- ❖ Information adaptation and forwarding: The destination path must be sent to the collectors in understandable format.

Algorithm for Large-Scale Implementation:

1: Install several waste-bins at multiple locations in the city;

2: Embed each of waste-bins with IoT devices;

3: Define threshold value for wastes for each of the waste-bins;

4: Collect the wastes in the waste-bins;

5: Send the collected data(using smart waste-bins algorithm) over the Internet to the servers;

6: Store and process the information in the server;

7: Calculate and send the optimized routes to send the vehicles for waste collection(using SP algorithm);

8: Empty the wastes from the identified waste-bins;

9: Use the collected data for monitoring daily selection of waste-bins;

10: Predict future traffic in specific location as per Server(future prediction)algorithm

Smart waste bin Algorithm:

1: Sense the level of wastes in waste-bins every 2 hour during the weekday ;

2: Sense the level of wastes in waste-bins every 1 hour during the weekend ;

3: Compute the rate at which waste-bins is getting field ;

4: If the waste-bins level is more than 70% then send the message to the *server to send the vehicle for waste collection;*

5: If the waste-bins level is below 70% then send the message to the server, not to send the vehicle for waste collection.

Shortest path Algorithm:

1: Consider street network as a graph;

2: Consider street segments as edges and joining points as vertices;

3: Calculate an accurate shortest travelling distance between two locations;

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

Future prediction Algorithm:

1: Get waste level for every day of the week from all waste-bins ;

2: Observe the changes in the waste levels during the week-days and weekends;

3: Note down the drastic changes during the specific days;

4: Calculate the distance to waste-bins which have significant rise in waste levels;

5: Speed up the route optimization process for those days;

6: If the rate fill of waste-bins in a given area is very high, send alert to municipality to increase vehicles & waste-bins.

Thank You!