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Background

Solid Waste Management becomes one of the key areas of focus for India as the population increases. The stresses on a city's waste management systems are skewed especially as urban migration remains the key trend.

Approximately one-third of all food produced for human consumption is lost or wasted. The economic costs of this food wastage are substantial and amount to about USD 1 trillion each year. However, the hidden costs of food wastage extend much further. Food that is produced, but never consumed, still causes environmental impacts to the atmosphere, water, land, and biodiversity. These environmental costs must be paid by society and future generations.

A Food Waste Index 2021 report shows that we wasted 931 million tonnes of food in 2019, with 61 percent coming from households, 26 percent from food services, and 13 percent from retail; Indians wasted 50 kg of food per capita on an annual basis.

Results show that India's urban population has increased from 2.58 crores in 1901 to 37.71 crores in 2011 due to rapid industrialization and rural to urban migration.

India generates 62 million tonnes of municipal solid waste per year, of which 75% is collected. Now, we see the major bottleneck in waste management. Only 20% of collected waste is treated. About 80% of this waste is finally dumped in landfills, thus contributing significantly to environmental degradation, and posing risks for human health.

This dysfunctional management is only going to worsen as Government of India Waste generation in the country is likely to more than double by 2030, increasing up to 165 metric tonnes (MT) per year.

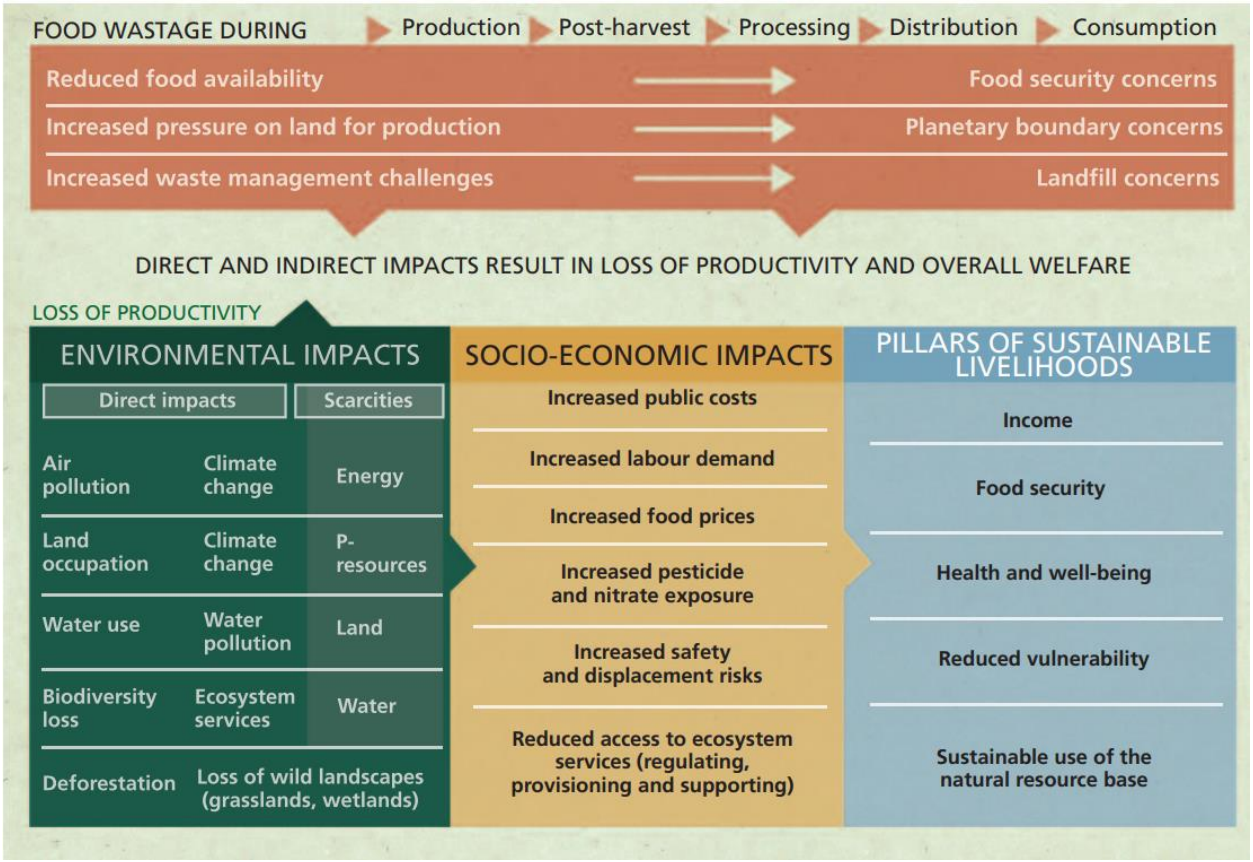
Out of the municipal solid waste generated, 50% is organic waste. India has the potential to reuse this share to produce 5.4 MT of city compost annually. Therefore, incorporating a circularity to the food production cycle and preventing the usage of inorganic fertilizers.

There are almost 700 functional compost plants in India with an annual production capacity of 18.9 million MT. However, given that most plants are under-utilized, currently, only 0.2 million MT are produced from city compost. The demand for solid organic waste is plenty, hence, we found it worth exploring why this impediment exists on the supply side.

The primary reason for this is poor or no segregation at source, contamination with extraneous material, odour issues, unsafe application, and higher costs compared to other products. The later the organic material is collected from the source, the more it loses its value.

Current Scenario

The adequate handling of solid waste is a critical part of any successful waste management system. Most of the municipalities are unequipped with essential tools and machinery for handling such a vast amount of unorganized waste. The schematic waste management process is commonly practiced in India. The collection of waste from door to door is the prime duty of the municipal government, where waste collection & handling is mostly done manually. Sometimes municipalities also assign the private organization for the tasks of collecting, segregation/sorting, transportation, preprocessing of waste, and final disposal. However, collected recyclable waste by the vendors sold to local scrap dealers, which was forwarded to the recycling unit outside the cities. Hence, ragpickers play an essential role in the collection and processing of waste in most privately organized cities.
The conditions of these ragpickers provide a social incentive to create humane conditions for them.



Solution

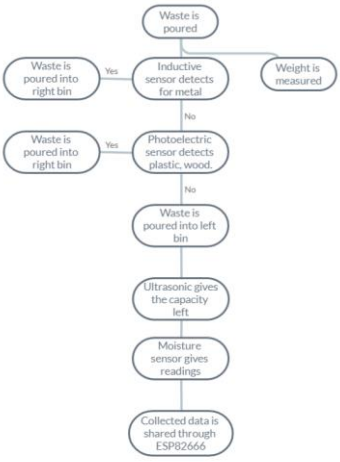
"Smart Bins" is an IoT-based solution for smart detection, procurement, transport of organic waste to be utilized by Compost making companies facilitated by real-time detection and route optimization. Our product comprises of two major USPs viz, a hardware (smart dustbin) and a software (marketplace):

Hardware (Smart Dustbins):

So, our product consists of a smart dustbin which uses different sensors and servo motor to segregate organic waste and tell the status of the dustbin to our server.

Our dustbin consists of following sensors-

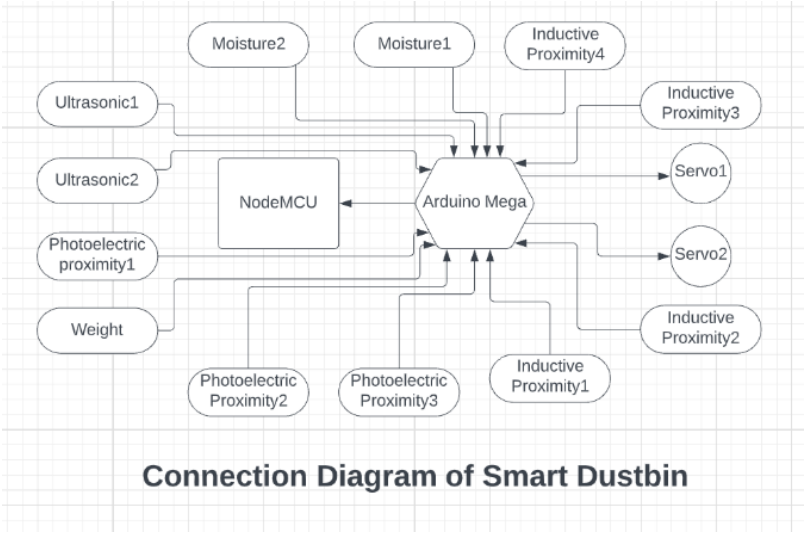
- ➔ Ultrasonic range sensor
- ➔ Capacitive soil moisture sensor
- ➔ NPN Inductive proximity sensor
- ➔ Photoelectric proximity sensor
- ➔ Weighing Load cell sensor
- ➔ Gear Servo Motor



Flowchart of Working of the Dustbin

Basic structure of a dustbin consists of two bins with a rotatable platform on top, the platform is equipped with the inductive and photoelectric proximity sensor and weight sensor on the bottom. Each bin has an ultrasonic sensor to check for bin capacity and a moisture sensor which will tell the dryness of the waste. All these sensors will be controlled through an Arduino Mega and all the data will be sent through ESP8266. All these components will be powered through an external battery of 12V.

The connection diagram is-



Connection Diagram of Smart Dustbin

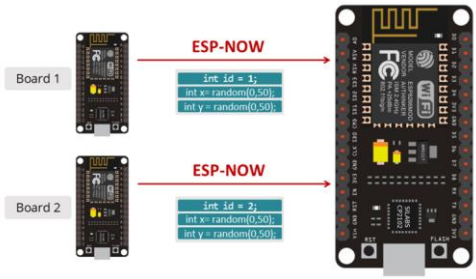
The inductive and photoelectric proximity sensors are used to detect if there is any content of plastic, wood, metal etc. If any of these is detected in the poured waste, the platform is rotated by two servo motors and the waste is poured in the right bin with its weight added to the weight already present in the right bin. If nothing non-organic is detected, then all the waste is poured into the left bin. In this way we have separated pure organic waste and waste with organic and non-organic contents.

IoT Network Implementation for the Dustbins

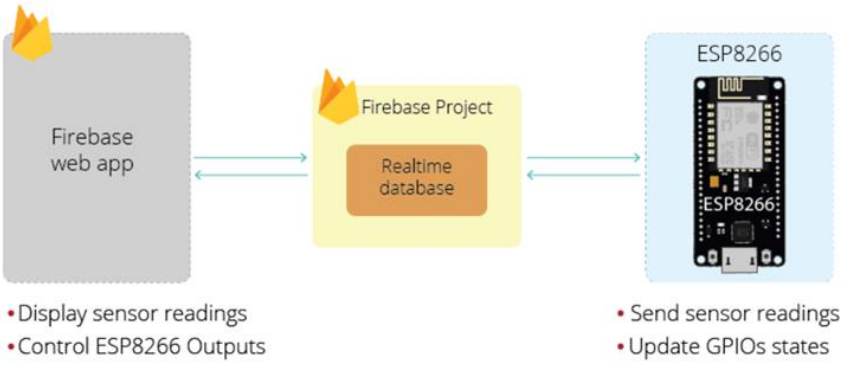
Our first task was to create a local network of the dustbins to know the relevant information about each dustbin. As shown in the figure, there is one central server which will receive data from all the other ESP8266 nodes (Dustbins).

We have used the ESP-Now Protocol instead of Wi-Fi.

Working of the system:



- Here each dustbin (ESP8266) is programmed to operate in station mode and the central server is programmed to operate in access point mode.
- Each node (Dustbin) is connected to multiple sensors like GPS, temperature, Ultrasonic sensor and collecting data in real time.
- We are sending this data from each node to the central server using the mac address of the server.
- For identifying each dustbin, we are sending unique Id from each dustbin along the sensor readings to the central server.



Benefits of using ESP-Now protocol over traditional Wi-Fi protocol:(this is novel in our implementation)

- System will be fault tolerant
- Dustbins are using the MAC-address of the server to send the data, so communication is fast as there is no 3-way handshaking each time.
- We are getting three times the range as compared to my Wi-Fi.
- Line of sight range of ESP -Now protocol is 480 meters.
- Because of this large range, we do not need to create a mesh network of the dustbins, and we can use star topology to connect the dustbins to the central server.

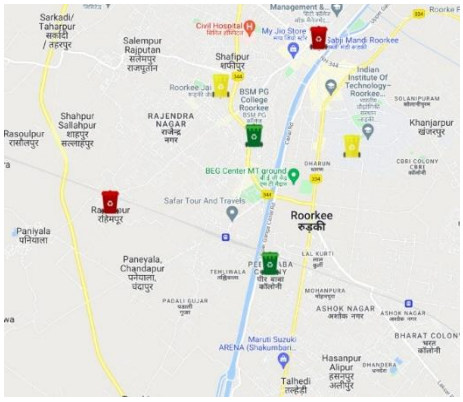
Now, once the local network is created, we need to send the data to the internet for processing and other analytics. For this we need to connect our server to the internet. To achieve internet communication of the central server, we have programmed it to operate in Access point mode as well as station mode. Once our server is connected to the internet, it will start sending data to the firebase database, and data will be updated after a specified interval in our cloud in real time.

Video Demonstration, Hardware Prototype

Unique Point about this implementation:

- We can create a large local network of dustbins, since we can achieve a range of almost 0.5 KM using ESP -Now communication protocol.
- If we have some geographic location, where internet connectivity is an issue, we can route this data to the nearest neighbor server using very few intermediary nodes, since each server is acting in station mode as well as access point mode.

Software (Marketplace and database):

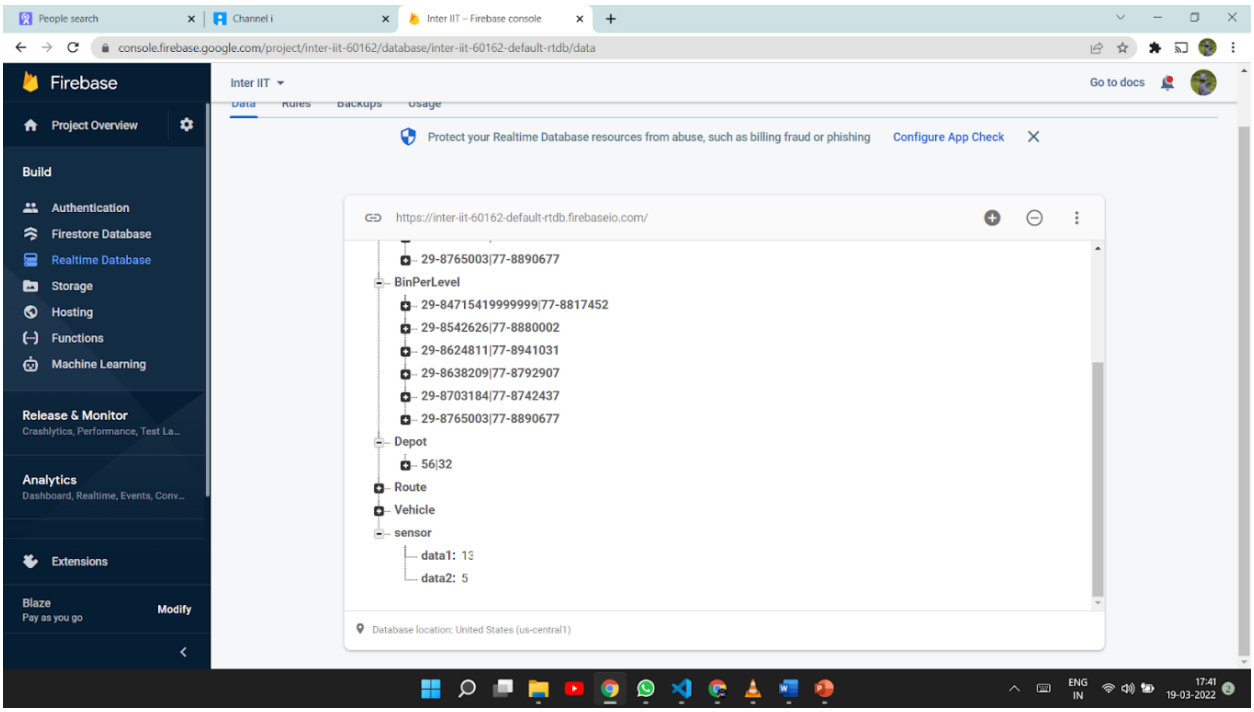


Bin Management:
The Data collected through Ultrasonic Sensor is stored on Firebase which continuously tells how much each bin is filled and accordingly the UI is displayed with Red, Yellow and Green Bins. As well as depending on the air quality detected by the sensors, the color of bins may change to red, even if not fully filled, to avoid rotting and stinking.

Firebase:

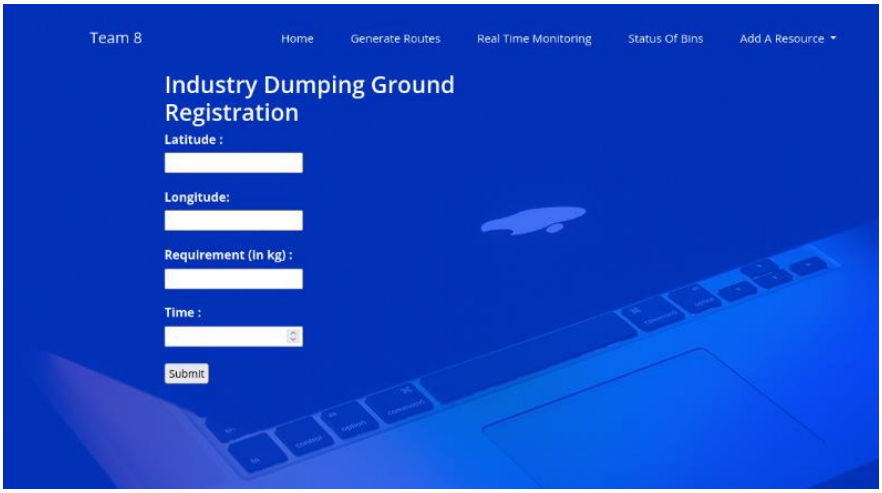
- Bin Level

The Data of how much the bin is filled, is repeatedly stored in Firebase Database. According to it the status of Bins is updated. A database is created on Firebase to keep a track of percentage filled in each bin. The database also keeps a track of the industry requirements to whom we will be supplying the collected organic waste.



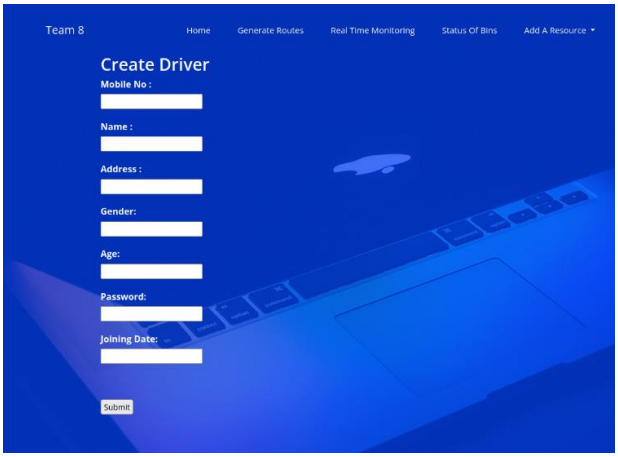
- Industries:

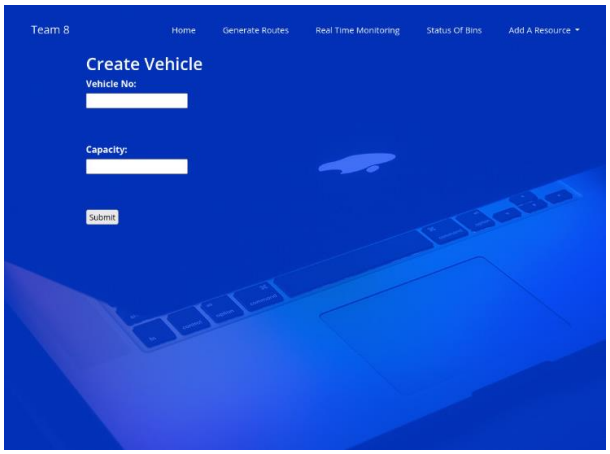
The database also keeps a track of the industry requirements and their location (dumping points) to whom we will be supplying the collected organic waste. Also, the industries mention the desired time of delivery.



- Driver details

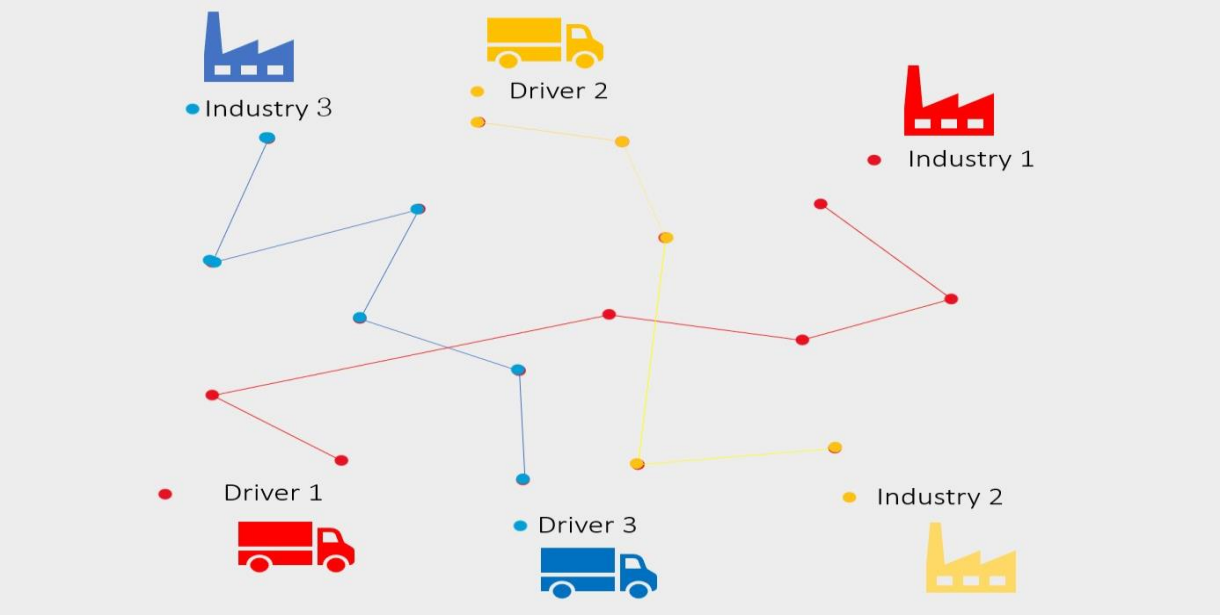
Driver can register its vehicle and its location on firebase to get the optimized path depending on his location





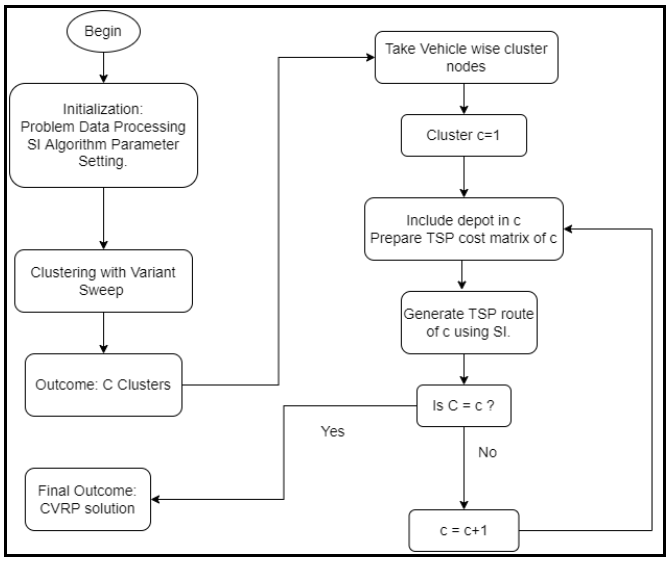
Optimized route:
It is generated according to industrial requirement through VRP Algorithm.

CVRP Algorithm:
According to the CVRP Algorithm the given data points are treated as different nodes (in our case- Bins). Now each node corresponds to some weight which is gained after reaching the node. A requirement is provided and according to it, a connection between nodes is provided which is approximately equal to requirement.

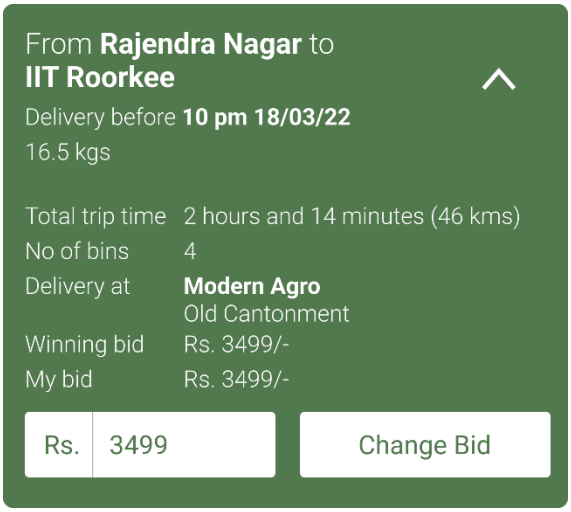


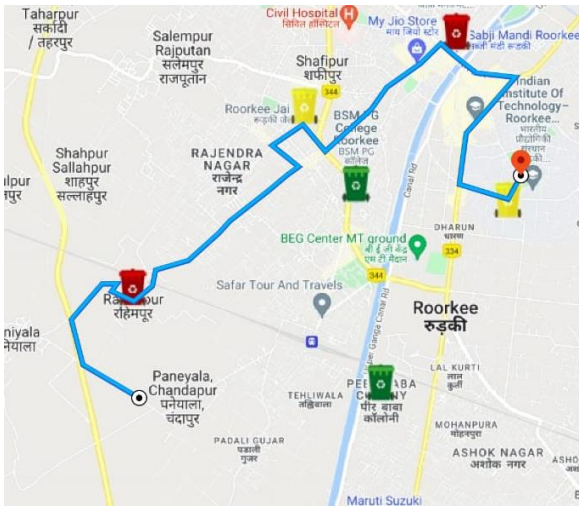
A diagram representing connection of routes based on requirements is shown above.

CVRP Algorithm in our case:
According to the requirements provided by the industries, a route is generated connecting the different bins based on how much the bin is filled through data provided by the Ultrasonic sensor. As all the bins are connected on a single route for an Industry, the bins cannot be used for mapping of other routes. Now unique routes will be created based on the requirements of Industry.



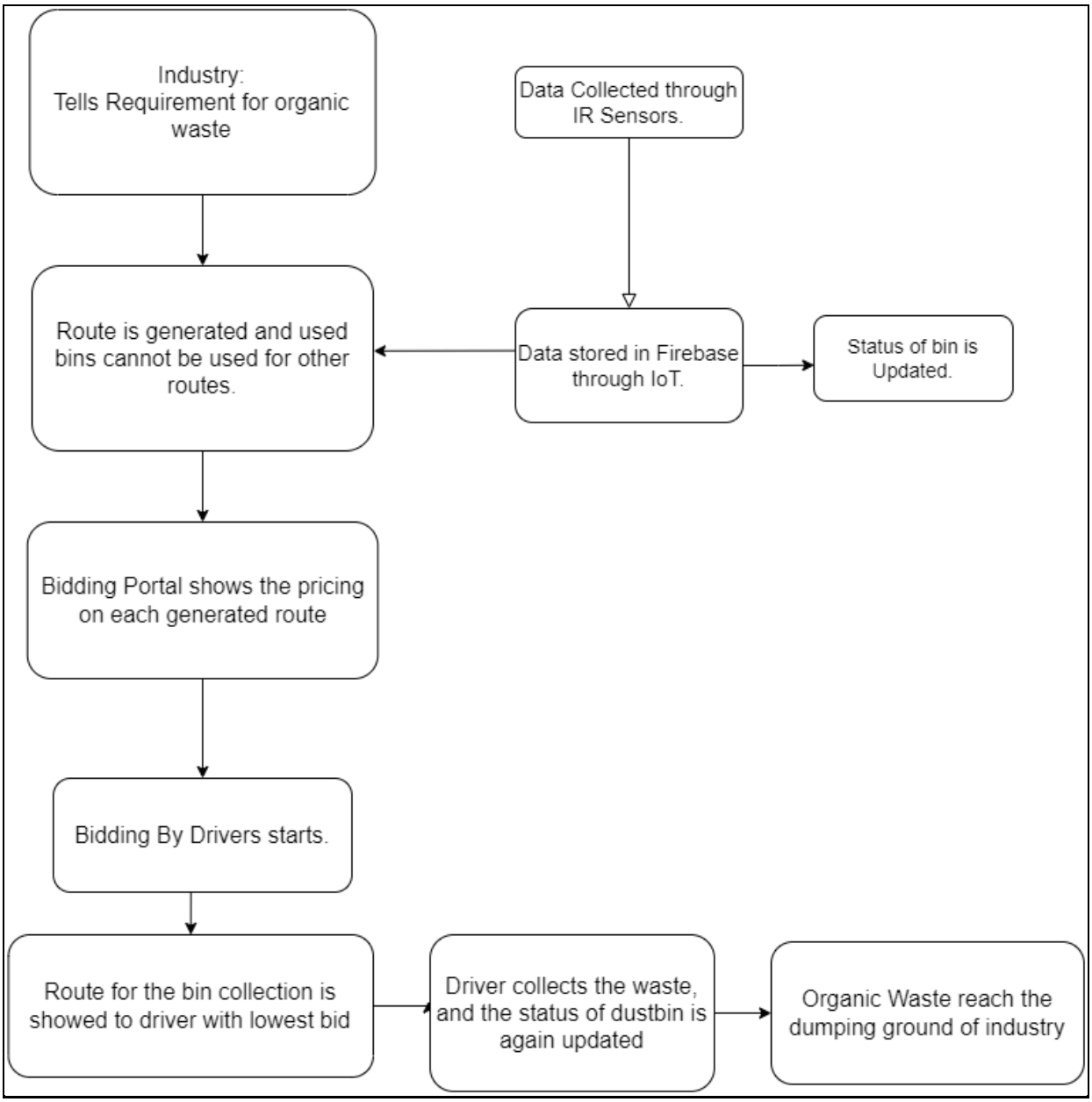
Bidding:
The Drivers will bid for the available option of routes and Dump location displayed. The Driver with lowest bid will be given the contract. Once the Bidding is completed, the driver will be displayed with the location of the bins which are to be collected along with the route. Finally, the Organic Matter Will be dumped in the industries.





Software Demonstration

Overall Flow Chart:



Business Model

Key Partnerships

Our chief partner would be Silicon Labs for sourcing our hardware and software.
The motivation for the choice of silicon labs for sourcing the constituents' elements of our product lies in:
- Optimization and Economy of Scale: As Silicon Labs is present all-around India and the world
- Reduction of Business Risk and Uncertainty
- Acquisition of high-quality hardware and software
- Match in Company Ideals: Focus on ESG goals and CSR

Delivery Partners

We plan to onboard local delivery partners for carrying the organic wastes to our nodes for collection and segregation.
We chose the delivery partners to be local:
- As they are aware of the conditions on-ground and can deal with the nuances
- Their services are price-effective as compared to outsourcing it to a logistics company
- We can train the partners to effectively use our route optimization application

Suppliers

Restaurants and Messes:
A huge proportion of food gets left or/and is wasted in food outlets. This food can be directly sourced from restaurants. We aim to onboard these outlets and get them to sign-up for using our bins for disposing of their food items. These items are less likely to contain wastes like metal/glass.
Households:
Household solid waste has a huge percentage of organic waste that can be utilized for composting.

Key Activities

- Design, Manufacturing, and Assembly of our smart bins customized to the general methods of food waste disposal
- The bins are monitored using IoT to detect their status of being full to prioritize the bins that need to be cleared sooner.
- The route optimization algorithm and the transport application provide the driving partners

Key Performance Indicators

Total Revenue made:

This is the most important metric to track which indicates how much liquid cash inflows in the system and tells us our status and scale.

M-o-M growth rate:

This metric helps in tracking the rate of expansion and whether it is enough for sustenance and scalability of the business.

Profit Margin:

Profit Margin helps us to assess how the as we onboard more truck drivers, the unit economics of the solution changes and the product gets cheaper as the solid electronics are sourced in bulk.

Percentage Accuracy of detection:

The higher this statistic, the more convenient it is for the compost making facilities.

Average delivery time per tons of waste sold:

This assesses the execution success of our Average Weekly Waste collected by the bins

Weekly downloads and retention rate of delivery partners

These indicators will assess each individual activity we perform.

Unit Economics

Cost structure

Firstly, we analyze, where are the avenues where we can incur costs.

Fixed Costs:

The Fixed costs associated with the product are stated below. They will be a one-time investment and will require large initial capital flow. We created a minimalistic product, easy to assemble and which does not require a Wi-Fi for its IoT operation.

Software Development and IoT software: The software needs to be set up initially, which will take up the heavy lifting of logistics

Manufacturing Facility for Hardware

Bin components

Manufacturing Cost

Legal Costs

Operational Costs:

These costs are incurred regularly as we operate, the amount will increase in general as we scale up but the operational cost per item will decrease.

Transportation Costs

Electricity and Rent

Bins upkeep

Software Maintenance

Source of Revenue

- Revenue from the organic material sold to the under-utilized compost making facilities.
- Commission from marketplace bids

Impact

Stakeholders

The truck drivers operate on low margins. Our bidding system would enable the drivers to choose the most economically optimal trips allowing them to maximize profits with each trip.
The ragpickers go through inhumane conditions scrapping through waste, by segregating we help them in two ways, by removing the organic wastes for ragpickers looking for metal, plastics, etc. we remove the issue of bad odor. By removing the harmful often sharply edged objects from the supposedly “safe” organic waste we make the processing of the waste by compost creating facility hassle-free.
Municipal Corporation would welcome this idea with open arms as it greatly solves the capture, storage, and utilization of solid waste reducing the amount of waste that goes in landfills.

Investors

The immense demand for organic waste will be fulfilled by our solution procuring and transporting segregated organic waste while being financially feasible. The transportation costs factored in the unit economics indicate that the instrumental cut in the COGS was due to route optimization and bidding system.

ESG and CSR reporting ensure the company is progressing towards sustainable goals that we set for ourselves. We aim to analyze the company through the ESG Framework which factors in the environmental, social, and governance (ESG) proposition of the company.

We follow this framework as this is an exhaustive framework for mapping out the impact brought forth by a business
ESG-oriented investing has experienced a meteoric rise—global sustainable investment now tops $30 trillion.

SDG Mapping

Sustainable goals targeted: 8, 9,11, 12, 15

SDG 8: Decent work and economic growth
We are revolutionizing the waste management space upholding the self-respect and honor of the rag pickers. Truck drivers are also provided with the right options so that they can choose the best paths for themselves.

SDG 9: Industry, innovation, and infrastructure
The Waste Management sector will get centralized leading to the breakdown of the informal sector.

SDG 11: Sustainable cities and communities

Sustainable cities would require mechanisms to cope with the anthropogenic stressors resulting from rural to urban migrants.

SDG 12: Responsible consumption and production

Responsible management leads to data and insights which can drive government to create incentives and disincentives promoting responsible consumption.

SDG 15: Life on land

One of the major USPs is the reduction in wastes disposed in landfills. When organic waste is landfilled, it rots and produces methane. This methane is 22 times more damaging to the environment as a greenhouse gas than carbon dioxide. This makes it difficult to meet our climate change obligations.