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Smart Garbage Collection Using GPS & Shortest Path Algorithm

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***Abstract*—These days urbanization is happening around the globe in a rapid mode with civilization supported by very latest technology and the trends in technology despite of being adopted in various domains both in public and private sectors. On the other hand, the environmental pollution also at alarming level due to rapid growth of the world population and human activities which are highly supported by latest technology. In this way, every governments from various countries have been facing hardships to manage the wastes from both industry and residences. These days collection of wastes have become nightmare despite of human resource or physical resources. In this study the collection mechanism of kitchen wastes from urban or town council areas were focused. Combining GPS and shortest path to the moving garbage collecting trucks is novel. The advantage of this system is, a person need not to wait at the road side to drop his garbage bag to the truck since the end user can install the application in his smart device and observe or track the garbage collecting truck's drive path. Though if a person misses the truck then this application will guide the shortest path to drop the wastes to any other trucks among the group of trucks which are going around to collect garbage in a particular geographical area. In fact, public as end user to this app can be benefited with cheaper in cost and managing time in parallel.**

Keywords—GPS, tracking, wastes, shortest path, waste management

I. INTRODUCTION

Urban areas around the globe are on the race to become more intelligent in each sector. These days intelligence is being applied despite of the domains including medical, education, legal, science technology, researches, agricultural, waste management and etc. In this track waste management including waste collection from each and every house in Sri Lanka has become as nightmare since the lack of communication between locals and waste collection team from either municipal or urban councils. With rise of population in Sri Lanka, the waste collection and dumping (management) also becomes more difficult to the government. Meanwhile, a medium size family with three to four members disposes roughly 3 to 5 Kg as kitchen waste out of all other waste materials (solid, paper, glass and polytene) and except the manufacturing companies and hotels. Solid waste management focusses the order related with controlling the public, stockpiling, accumulation, and transport, disposing of wastes with the good standards of health, economics, engineering, conservation and other environmental conservation. One of the very important challenges for the garbage collectors and the public who are going to dispose is the proper communication. People who reside urban or municipal area, must know the place of the garbage collection vehicle in order to dispose their daily waste. This paper discusses the Global Positioning System (GPS) point of the moving vehicle and the shortest path from the person who is going to dispose the waste.

II. LITERATURE REVIEW

A. GPS Tracking System with Shortest Path

In [1], the researchers have developed a solution to find placing such as ATM, Fuel Mart, Public Park and etc., around a city with shortest path using GPS and Map Service where they have not given any solution for real time updated map. And the developed application can work with Android OS mobile phones also Web Services. Further, it has mentioned that to find shortest path theories such as Optimum A* algorithm [2] has been used. A * algorithm has been enriched with a heuristic function. The heuristic function is used as an optimization algorithm that makes this algorithm is superior when compared with other algorithms. Also it is similar to BFS [2] as it will visit in depth for the selected node is considered the best. If the node was visited not lead to a solution, it will return to the previous node to destination node find other, more promising. Process back to the previous node will recur if not find the destination node that leads to the solution. Also, Merge Sort algorithm [3] is used to sorting data. Merge Sort algorithm using divide and conquer method for sorting the data [3]. All data will be broken down and divided up until only one number left, and data sorting process will be done. Google provides the services that can be used to determine the distance, where the position of a location, as well as generating a map [1]. The service can be used using web service and XML. Web service is a method of communication between two electronic devices over the Web [4]. Web service description using SOAP

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messages, typically conveyed using HTTP with an XML serialization in conjunction with other Web-related standards. Service from Google Direction provides an easy to find the distance from one location to another. Service from Google Geocoding [5] is used to obtain the location coordinates of latitude and longitude of a place. Service of the Google Static Maps can be used to generate a map [6].

According to [7], they explain a solution by developing an Android app which works based on GPS to find the optimal path between two point. In this scenario taxis are equipped with GPS devices to send locations to the centralized server and analyzing those collected data to find best path in terms of real time traffic updates according to app user's query and it results drivers can find the shortest or fastest path to reach their client. HMM (hidden Marko model) [8] is used to identify the alternative route in town or cities during high traffic situations. Also variance-entropy-based clustering approach [9] used to find out the fastest path but cannot find efficient driving direction for the passenger through Google map and Bing map, energy consumption. Further, a coherence expanding algorithm [10] is retrieves all the possible routes but cannot find most popular route. Min-max algorithm [7] is used, where it can help to find fastest and shortest path between two points and it benefits to reduce the fuel usage and noise pollution.

Zuojian Zhou et al found a system for preventing taxi driver fraud activities called "A method for real-time trajectory monitoring to improve taxi service using GPS big data". This system has two methods namely, route finding and real-time monitoring of that route. This system prevents the passengers by being cheated by cunning taxi drivers. In route finding step, it will find shortest path and next step passenger can monitor the travelling path in real time. If anomalous driving behavior is detected then the system will alert to passenger and transportation bureau so they could made counter measurements. This system has two phases namely, offline phase (also called Data preparation) and online phase (also called online anomalous trajectory detection). In offline phase we could find out the data of Road network modeling and Trajectory modeling based on Open street map (OSM) and Raw GPS data. In second phase work based on offline two modeling and the algorithm they have used this phased called "OnATrade". This algorithm has two steps. In first step it recommends a route which provide based on historical trajectory and driver selects one of the short routes among all. In second step online taxi detection according to route selected in first step. Here passengers also can participate in this step from their smart devices and they can send the feedback according to driver's behavior. Abstract Trajectory modeling (ATB) algorithm [11] solves to find the shortest path.

Guddi Singh et al found a system for moving emergency vehicle called "Movement of Emergency Vehicles -Using Shortest Path Simulation Method". In this system they have designed for emergency services of fire Brigades and Ambulances. In case of accident or fire-based calamities these vehicles are able to go to the place in timely manner by using shortest path. All available information of emergency vehicle in town and other relevant information like hospital and police station are being stored into their database. In this system Traffic control signal maintaining the database and it control GSM sever with the use of a modem. The operator of the main sever can monitor the position of emergency vehicle. If the operator obtains any emergency information then he/she could use the available vehicle to destination point using Google map. GSM module used to locate the place and nearby hospital. Intelligent Transport System maintained for control the traffic light for reach emergency vehicle timely manner and short path by location sensor used in GPS, GSM and Google traffic API. To use short path they have used Dijkstra's algorithm, which finds the shortest path by using a graph. It maintain a source node and find shortest path from that source node [12][13].

Nilakshi Joshi et al developed a system called "Near real time vehicle tracking using GIS", which is a GIS based system and it aims to mitigate accidents and provide efficient path for travelers. Here, a user can download and install that particular app for following GIS activities. The user of this system can login and locates the source and the destination points. This will be stored in database in the form of longitude and latitude. This will go to the spatial database and process will have happened and sent data to GIS. System will find out the shortest path for specific location by considering accident, traffic area, location and other relevant information from received longitude and latitude. Here the longitude and latitude of the user given by GPS satellites when user locate the source and destination point. To create final map they have used Quantum GIS (QGIS) and Dijkstra algorithm is used to find shortest path [14].

Nassir Sallom Kadhim et al reported a system called "An Efficient Route Selection based on AODV Algorithm for VANET" for tracking and giving an efficient path in case of accident with the help of GPS and GSM module. There is a vehicle tracking system has been used by local emergency agencies with the help of wireless networked carried by the node (car) and GPS location from satellite. The wireless network (VANET) uses a router with vehicle and it pass the location-based data to nearest Road side unit (RSU), it passes that specific data to the internet which will access by agencies from their build electronic map system. Whenever accident happens the agencies are able to view that particular point of the vehicle and they could send the SMS to nearest Ambulance services by using GSM as well as the algorithm used in the digital map set the efficient (short path with less traffic) path for caring patients. VANET provide considerable collaboration for this system by Routing protocol (Position based, Broadcast based, Topology based, Geo cast and cluster based). Here they have suggested "VANET routing protocol algorithm (RASS-AODV)" algorithm for path finding activities[15].

Daniel Delling et al developed a navigation system called "Navigation Made Personal: Inferring Driving Preferences from GPS Traces" for mobile devices, car, and web. This system also there is a GPS electronic map app used by users of the system and they could set the source and destination area. To identification purpose in the map there is a green flag has been used for identify the source and red flag used for destination area and number of white flags are continuously used to join the source and destination area. Here they had used "Dijkstra" algorithm for finding the shortest path[16].

Wook-Sung Yoo and Lina Kloub found an application called “Traveler’s Sidekick” for GPS navigation system with shortest path. This app has three parts namely, User Interface (UI), Control unit and Database part. UI used for display the map according to the user input. Control unit act as an intermediate device in between UI, Google map API, Database and Algorithm. The major responsibility of Control unit is that communicate with map API and routing algorithm to produce an optimal route according to the user input. Database stored all location given by the user. User of the systems are able to login and select a route for their preferable area and also, they can additionally add the favorite place list for future usage. Once the user login and if they select the source and destination it will give the shortest path and they are able to travel through that route. Here Google Maps JavaScript API V3 was used to display the map and calculate the distance of any two locations [5]. The login Information and favorite information will store in the database for further action. To identify the shortest path they have used “divide and conquer algorithm”[17].

III. METHODOLOGY

The major objectives of the proposed garbage vehicle monitoring systems are; 1) real time monitoring of the route of the garbage vehicle for drop the garbage 2) providing the shortest path for who missed to drop garbage in to the vehicle.

A. System Architecture

Fig 1 shows the architecture of the system how a vehicle being tracked. Figure 1 shows the system architecture of vehicle tracking system. Here GPS Satellite transfers Location (GPS Points) information to GPS Tracking system/ GPS enabled Smart phone attached with Vehicles and these locations are transferred to GGNS Server through BTS/ GSM Tower via GSM/ 4G network. GGNS server stores all the Locations of GPS devices in the meantime same information are stored in database. App Device makes requests to GGNS Server and App Server to get GPS points and relevant Google Map respectively. Further, App Server directs this request to Google Map Server and the responses are combined with GPS Points received from GGNS server and send to the End-Users (System Users). In the case of missing the garbage vehicle, then the user of the system could find the shortest path from app (digital map with GPS points) to get the vehicle, to do so Dijkstra’s shortest path algorithm has been adopted with the application.

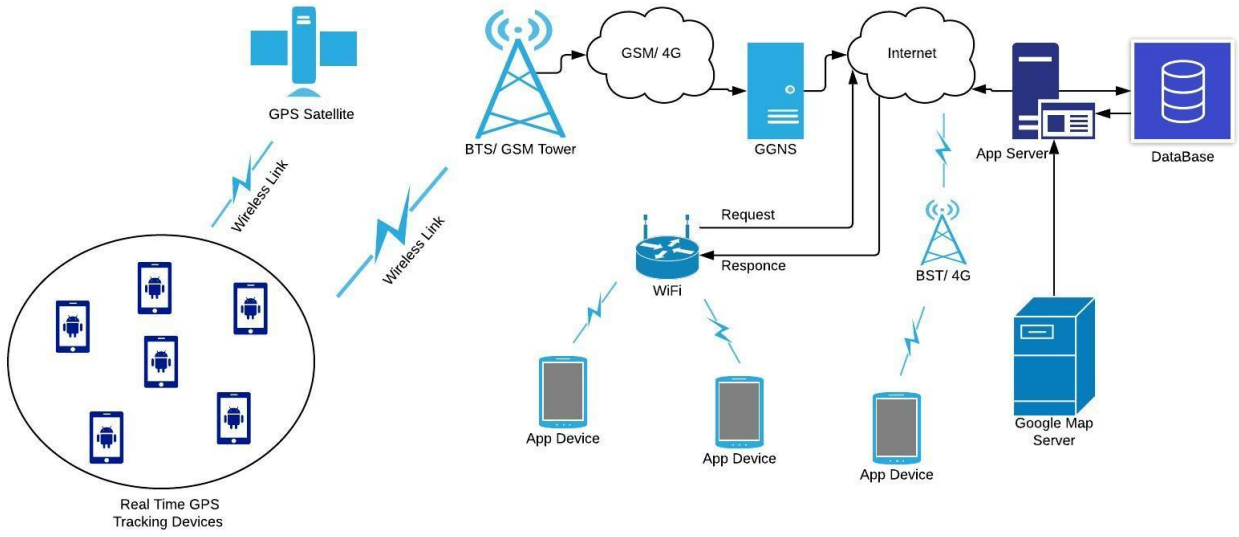

Fig. 1. System Architecure of Vehicle Tracking System

B. System Components

App Server: Applications server is a server used to install, operate and host application to the end-user of the system for effective usage of the applications[18]. This sever acts as intermediate device in between user of the system and database [19]. It works according the client-server architecture (request-response). In this system, it responses the request gain from end-user and sends a request to Google map server as an intermediate device to obtain the user needs meanwhile store the information to the database.

GGNS: GGNS is standard for **Gateway GPRS Support Node.** It is used with Serving GPRS Support Nodes (SGSNs) with same network for establishing and maintaining subscriber Internet Protocol (IP) and route the data traffic between subscriber’s mobile station or base transceiver station and internet; thus, a data could pass from BTS to internet in a quick manner. It is one of the main components of GPRS network [20]. Major responsibility of GGNS is providing internetworking in between GPRS or 4G networking and external devices [21].

Google Map: Google map is a service that provide thorough information of all geographical area through web services. The Google map provides street, locations, street view, real time traffic system, car, bicycle and satellite view of majority place all over the world[22][23]. This map is used for real time monitoring of vehicle location in smart device application or any relevant applications we are dealing with. The Google map automatically handles access to the Google Maps servers, displays location and place on map[24].

GPA, GPS Satellite and GPS devices: The Global Positioning System (GPS) is a network of about 30 satellites orbiting the earth at an altitude of 20,000 km. The system was originally developed by the US government for military navigation but now anyone with a GPS device, be it a SatNav, mobile phone or handheld GPS unit, can receive the radio signals that the satellites broadcast[25]. This is used for the purpose of getting the location on the earth. GPS receivers are used to get the locations from satellites. GPS receiver calculate the earth's longitude and latitude up to 10 m from obtained signal from several satellites.

GPS units use a method called trilateration to determine the position, speed, and elevation of an object. GPS satellites broadcast their location and time constantly, and every satellite has a sophisticated atomic clock inside to be used for timing calculations. Tracking devices calculate the distance and time that it takes the GPS signals to travel to the surface from the satellites. The device requires signals from at least four satellites to provide an accurate location. With this in mind, the GPS satellite system was designed to have a minimum of four satellites in range for users with a clear view of the sky[26].

Base Transceiver Station: A BTS can dynamically decide and switch between active and sleep modes based on network traffic. Each BTS estimates its own traffic load, collects those of the neighboring BTSs, and then dynamically decides on its state of operation. Thus, the decision on the operation state of a BTS fully depends on its own traffic load and one-hop neighborhood traffic load information[27].

Database: Database used for storing data (user's login information, GPS points) coming from application server. Normally relational databases have been used for small amounts of data but in case of huge and frequently changed (GPS point) data, we can't use relational database thus we should move to NoSQL databases [28]. This system also must be maintained under NoSQL database.

Dijkstra's algorithm: Normally this algorithm used in graph to find the shortest path from one node to another. This is developed for the purpose of overcoming single source shortest path problems. It finds shortest path with very less amount of cost by guiding the routes [29]. In this algorithm, it chooses a single node called "source" node and it find the shortest path by routing other all node form source node and it find the shortest path. Once it found the short path it will finish the routing and algorithm will end.

Pseudo code for proposed algorithm:

```
dist[s]← 0                          //distance to source vertex is zero
for all v ∈ V−{s}
do dist[v]← ∞                       //set all other distances to infinity
S← ∅                                //S, the set of visited vertices is initially empty
Q←V                                 //Q, the queue initially contains all vertices
While Q ≠∅                          //while the queue is not empty
do u ← mindistance(Q, dist)         //select the element of Q with the min distance
      S ← S U {u}                   //add u to list of visited vertices
      For all v ∈ neighbors[u]
      do if dist[v] > dist[u] + w(u,v)   //if new shortest path found
      then d[v] ←d[u] + w(u,v)      //set new value of shortest path
return dist                         //if desired, add traceback code
```

C. *Practical example of proposed algorithm*

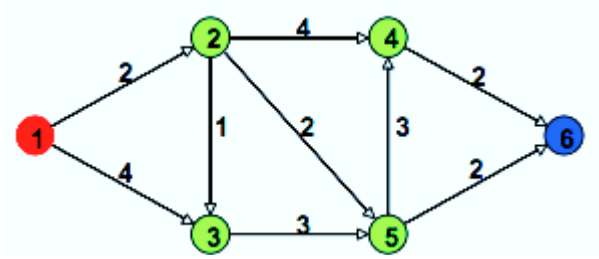

Fig. 2. Example of shortest path

Fig 2 shows the practical mechanism of Dijkstra algorithm. In this graph;

Red - source node	1,2,3,4 – weights
Blue - destination node	Circle numbers – vertex
Green – Other nodes	Arrows – Edge of the

The possibility of the routing path and distance of the path as bellow.

TABLE I. ROUTING TABLE FIG 2

Possible path	Distance
1-2-4-6	8
1-2-5-6	6
1-2-3-5-6	8
1-2-5-4-6	9
1-3-5-6	9
1-3-5-4-6	12

Here the algorithm routing the path using all possible ways and it will select the optimum short path (In this case 1-2-5-6) and provide the output to digital map with the help of GPS points.

IV. RESULT AND DISCUSSION

This section provides features of Android GPS tracking application and its operation.

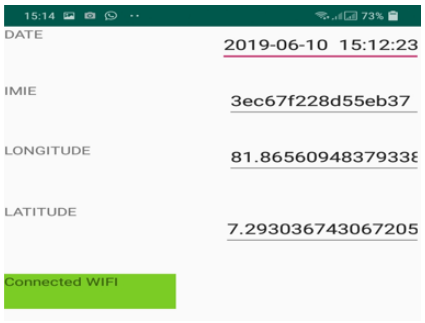

Fig. 3. GPS App without google map.

Fig 3 shows the front-end of GPS Application without connected to the Google map. Using this front-end developer could set the real time GPS tracking device with the help of IMEI number of the smart device. Once it is set, the movements of GPS points could be calculated using GPS satellite which passes the data to Google map through the proposed architecture

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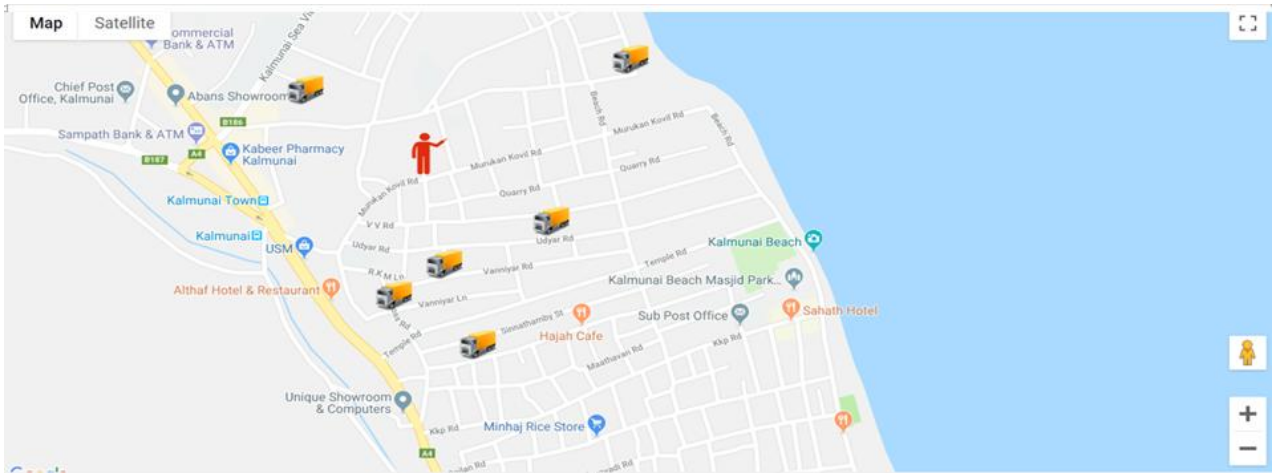

Fig. 4. Garbage collector attached in this map

Figure 4 shows the daily routine of garbage collector in specific area. All six vehicles drivers' real time GPS tracking device IEMI numbers are registered by the admin of the system. Here GPS points of registered vehicles came from front-end of the system. Whenever (during the duty time of garbage collectors) end-user uses this application they are able to monitor the movement of all vehicles and they could be ready for drop their garbage on time and they don't need to wait for vehicle for a longer period of time.

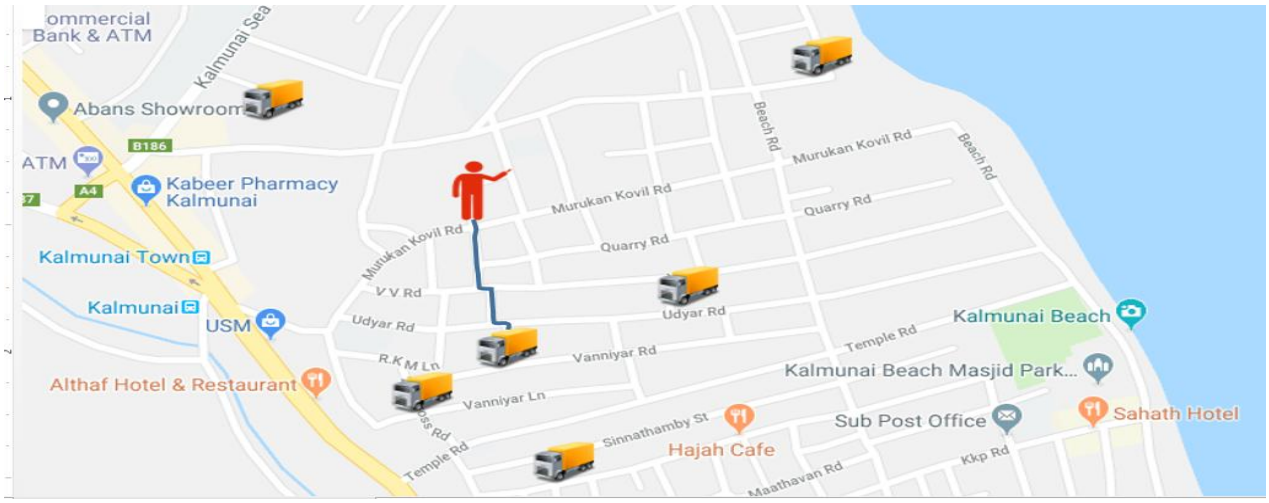

Fig. 5. Google map with shortest path

Fig 5 shows the shortest path with garbage collector vehicles. If any end-user missed the vehicle then they don't need to wait until next routine period of garbage collector. Instead of that they could locate the spot of garbage collector and they are able to find the nearby garbage collector using this application. The algorithm provides the facility that giving short path by routing all possible routes and eventually it will find the nearby collector. Figure 5 is the output of nearby collector of GPS tracking application. Normally in contemporary if people are missed to drop then they want to wait until next time but this application overcome that stuffs and provide customer satisfaction via this solution.

V. CONCLUSION

Through this paper, a handy, economically low cost, efficient way has been proposed and developed. In fact, it is a better solution to those who misses to handover the disposals to the collecting truck scheduled in a particular path. Since this application is showing the exact location of the garbage collecting truck, the public can appear to the road on time and can drop the wastes. Further, it saves the waiting time to the public. Moreover, if a person misses, then this app can guide the shortest path to the nearest garbage collecting truck.

Shortest path is proposed using Dijkstra 's algorithm. This algorithm made blue path for shortest distance of garbage collecting vehicle. This application only works in online and GPS points of the vehicle, identify by GPS satellites using IEMI number of real time GPS tracking device. In contemporary rapid world GPS tracking is common and old technology but in the case of garbage collection it is new and inevitable. It can be concluded, that the end-user of this applications will get higher advantages with cheaper cost.

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