Low-Cost Bus Tracking System overhauled en route Area-Trace to Atomic Hypothesis Algorithm LCBTS using AHA

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Abstract

Buses are indispensable means of transport in every metropolitan city. In fact, they are the inexorable resources of every condensed populated city. Knowing its importance, it is the need of the hour to have a mechanism that can keep a track of the buses running in the city for the convenience of the people. This paper proposes an advanced algorithm which has a better efficiency than the previously published algorithm [2]. The notion of this algorithm was devised from the fundamental theory of chemistry and its roots are derived from Neil Bohr Atomic Model. This algorithm not only gives better results but also yields results expeditiously. It uses the foundation of the Area Trace algorithm and revamps it to further enhance the potential of the algorithm. The model addresses two parts viz a GPS-GSM Module and a Traffic Management System Module. The former model deals with the analysis and estimation of the exact timely locating of the bus and the latter one is accountable for calculating the average estimated time to required destination. This paper shows the results of Atomic Hypothesis Algorithm (AHA) and discerns it from the Area Trace Algorithm.

Keywords: GPS-GSM, Atomic Hypothesis Algorithm, Area Trace Algorithm, Silver Cloud Real-Time GPS tracker, Compound Splitting technique, Traffic Management System, Vicenty distance

I. INTRODUCTION

Buses are among one of the most customary ways used by the commuters to travel in a metropolitan city, off course train being one of the others. However, not every city has a strong connectivity of trains like Mumbai. If we consider a city like Pune or Bangalore, these cities do not have a local train for daily travel. Therefore, the commuters are left with two choices, either traveling by their own car or opt for a bus. Not every person can afford a car and so it cannot add on to the convenience of every person. Secondly, if we have a close insight into the city's traffic conditions, it's very frantic to drive in such cities. As per the 2015 statistics of Pune city with a current population of 5,926,606, almost 60 percent of the population uses Pune Municipal Transport (PMT) buses. This clearly indicates that buses form one of the vital assets for the people of Pune. The situation happens to be more or less the same with other cities like Bangalore or Mumbai. However, the frequency of the buses is not at par to suffice the thirst of the commuters. Buses are overcrowded. Many times, they are delayed due to substandard traffic conditions. So there is a strong need of having a full proof system to take care of such issues.

One such system has been systematically drafted in my previous work [1] which deals with tracking of the bus and estimating its likely time of arrival. The work published in [1] is a successful extension of my previous work [2], which uses Area Trace Algorithm to predict the exact location of the bus. Area Trace Algorithm is a powerful yet distinguished method of obtaining the location of the bus. In this paper, we will be presenting Atomic Hypothesis Algorithm (AHA) which is a more advanced algorithm compared to Area Trace Algorithm. This algorithm is not only powerful than the Area Trace Algorithm but also achieves better time efficiency over it.

In this paper, we will be discussing this algorithm comprehensively. The flow of the paper is as follows. An immense review of the literature survey done for this paper is published in Section II. Section III discusses the Objective, Overview and architecture of the system and its block diagram. Section IV talks of the need and the flow of the algorithm. Section V discusses the results obtained when tested in the city of Pune. Findings and Conclusion follow in Section VI.

II. RELATED WORK

Traffic in an urban city causes a bottleneck and the whole traffic movement becomes very sluggish. Mumbai is one of such city which faces these issues. Buses being one of the best ways in commuting such cities, the system developed was able to not only track the location of the bus but also measure the Expected time of arrival for the bus. The system aims at developing a low-cost solution for every user to obtain the information of the bus transport with the following set of essential parameters like the current bus location, the seating capacity of the bus, maximum available standees allowed in the bus, current count of passengers and the expected arrival time of the bus. The system also provides the user with the fare between any source and destination [1]. It uses a Silver Cloud Real-time GPS tracker which can track the

current location of the bus. The data is sent via GPRS to the server using the POST method of the HTTP protocol. A web application was developed using JavaScript, Ajax, and MySQL and Google Maps was incorporated in it [1].

Low-cost bus tracking using Area Trace Algorithm allows the user to know the current location of the bus using an elementary mobile phone without using any data connection [2]. This algorithm simply makes use of Short Message Service (SMS) which is sent to the server for interpretation. The Server interprets the SMS and calculates the bus location and its expected time of arrival. It further sends the assigned name of the location to the user in SMS format using its helper module. Area trace algorithm is one of the innovative approach to calculate the bus location and has successfully shown satisfactory results in [1].

Another algorithm namely Cell Based Algorithm [3] was implemented in the city of Bangkok. This algorithm divided the entire Bangkok area into 6400 square cells. For prognosticating the travel path, it used the A* algorithm and incremental weighted update algorithm was used to calculate the time of travel.

Circle Split Method was used in a GPS mounted vehicle and a map matching technique was used. The map was deeply researched and it was divided different areas with certain circles. The shapes and dimensions of the areas were estimated by the centers and the radiuses [4].

As per the work published by the Cyprus Research Promotion Foundation's Framework Programme for Research, Technological Development and Innovation (DESMI 2008), Event Based Bus Monitoring System (EBM) focuses more specifically on minimizing the communication signals to achieve an adequately accurate monitoring of bus arrival times [5]. The results of EBM show that it uses only 3.5% of the total volume of signaling messages, thereby reducing it to a significant extent.

The work in [6] shows Real Time Bus Monitoring and Passenger Information bus tracking device which obtains the GPS data of bus locations and display it on the GLCD as per the passengers request. Further, GHOST (Galileo EnHancement as BoOster Of the Smart CiTes) [7] which is an Intelligent Transport System (ITS) was able to exploit the geo-referenced information of the urban elements and monitor them in a smart, continuous and an autonomous way.

Mobile Enterprise Sensor Bus (M-ESB) [8] uses a multi-sensor data acquisition and sharing interface for a mobile sensor grid and router which feed into the remote data cloud. It also proposes a new mobile service model for the public bus company to act as a Virtual Mobile Service operator. Vehicle Traffic Monitoring using Wireless Sensor Network in South Africa [9] presents the use of WSN technology as a tool for controlling the traffic signals between Johannesburg and Pretoria. Additionally, RFID scanners are also used in the system to identify the congested areas and accordingly inform the traffic officer at the Traffic Monitoring System. The traffic officer can in return decide and suggest the best route for the motorists.

United States of America has a bus tracking system called Next Bus [11] wherein a user can register and login to know the estimated arrival time of any bus at any bus stop. The lacuna of the system is that it does not tell the user the exact location of the bus but just tries to satisfy him with the time left for arrival.

III. SYSTEM ARCHITECTURAL MODEL

A. Objective

The main objective of the system aims at developing a low-cost panacea for people of all categories to avail a shrewd solution for knowing the Expected Arrival Time for a bus. As discussed before, Pune and Mumbai are desperately in need of a system that can help them in knowing the bus arrival time. Time is a crucial parameter for people living in these cities. If they can get the expected arrival time for the next bus, they can decide upon whether to wait for that bus or choose some other means of transport like a rickshaw or taxi.

As per the Government norms for running a smooth transportation, buses are assigned proper timings on each route, but rarely are the buses seen following that timetable. This serious issue is seen not due to the fault of the Government but due to the Traffic seen in every nook and corner of the city. Lastly, bus stops are overcrowded many times and people need to wait for the bus in scorching sunlight, which paves way for serious maladies like sun stroke.

The last but not the least advantage of the system is its low-cost solution. For any user to avail the developed system, he/she need not have a costly smart phone. A basic mobile handset will do the job as smartly and relentlessly as a smart phone.

B. Overview

The system uses Silver Cloud Real-time GPS tracker to fetch the bus's location at any point of time. POST method of HTTP protocol is used for sending data to the server by GPRS. JavaScript, Ajax, and MySQL are used for the development of the software. Google contributed extensively for propping the system.

As discussed above, the user just needs to send a sms in a specified format as "BUS bus_number nearest_busstop" to a specified toll-free number and the system would in turn calculate all the required details and send him back the required information in a standard format as "BUS bus_number nearest_bus_stop_for_bus_location AV-SEATS max_count STANDEE max_standee_allowed PASS current_count_of_passengers TIME expected_arrival_time", where BUS stands for bus number requested, LOC gives the nearest location where the bus is located, AV-SEATS shows the maximum number of seats available in that bus, STANDEE gives the count of maximum number of passengers who are allowed to travel standing in the bus, PASS gives the current number of passengers travelling in that bus and TIME gives the expected arrival time for the bus [1]. This paper presents the advanced work done on [1].

C. Functional Block Diagram

The functional block diagram of LCBTS using AHA is depicted in Fig. 1.
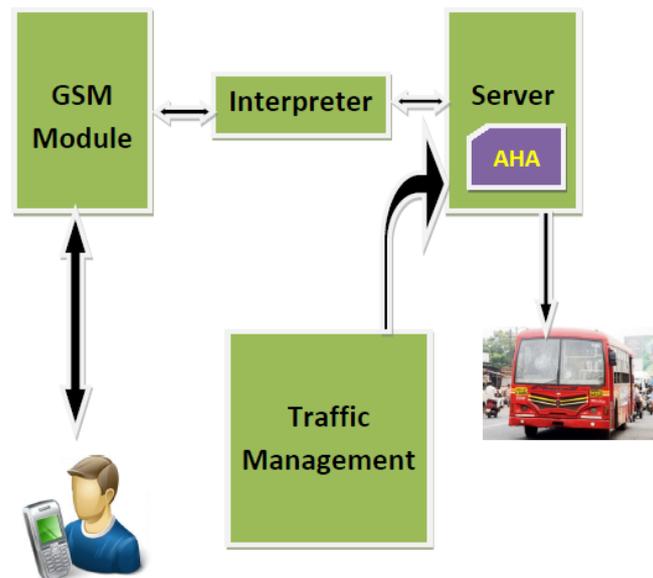
Fig 1. Block diagram of LCBTS using AHA

It comprises of the following five modules:

a. User

User is a common man who wants to know information of the bus like its expected time of arrival, seating capacity, available seats, etc. The user simply sends a message from his mobile phone to a toll free number to get the above details.

b. GSM Module

The sms sent by the user over the mobile network using Global System for Mobile Communications (GSM) technology is sent to the Interpreter for further decoding. Digitization of the data sent over sms is done by the GSM. It follows with the compression of the data and sending it over the channel. In India, GSM user 900 MHz and 1800 MHz frequency bands. GSM technology was built using Time Division Multiple Access (TDMA) technology. TDMA benefits as it provides three times more capacity as compared to analog systems keeping the number of channels constant.

c. Interpreter

Interpreter is simple yet an important module. It is this module which is responsible for decoding the message. It uses the Compound Splitting technique of Natural Language Programming (NLP) for understanding the received message. It further cleaves the message using Information Retrieval. The Compound Splitting Algorithm

considers words found in the lexicon as possible parts and automatically determines which split is beneficial for retrieval [10].

Interpreter also encodes the message to be sent back to the User Module over GSM. This encoded message is a format which is easy for any user to understand. The same has been discussed above in this section.

d. Server

The server receives the decoded message from the server which has details about the bus number whose location needs to be fetched. The server pings the tracker using POST method of the HTTP protocol asking for its current location The tracker on the bus immediately sends its location to the server.

Server now calls the AHA for knowing the buses that are nearby the requested current location. AHA cleverly computes by processing only the required nodes in the space rather than all the nodes unlike the former Area Trace algorithm [1].

Finally, based on the periodic information received from the Traffic Management module and the AHA calculations, it acquires all the required information about that bus. This entire information is returned by the server to the Interpreter Module.

e. Traffic Management

The AHA calculates its distance based on the Vincenty distance [12] and Traffic Management module helps to cluster this data. We do not get into the details of this module here. The working of this module remains same as in [1].
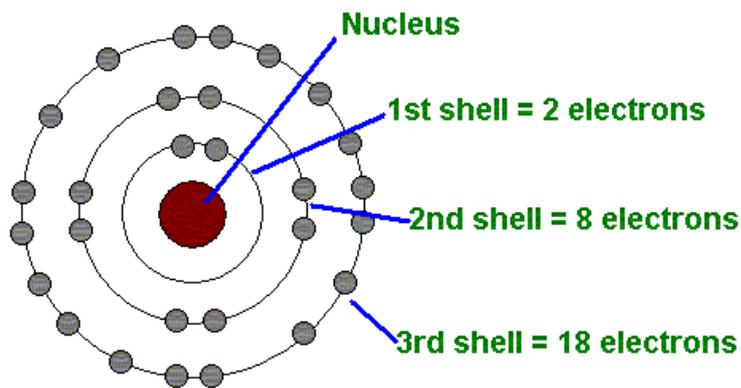
IV. ALGORITHM

A. Exigency

The existing algorithm for available for calculating the estimated arrival time of bus namely Area Trace Algorithm has a drawback that it reckons the distance from all possible bus stops located in its vicinity based on the input parameters received for the algorithm. This increases the computations for calculations. Also, the processing time of the algorithm increases. The algorithm, no doubt, being robust and fault tolerant, takes more time for fetching the results.

B. Working

Area Trace algorithm [1] divides the entire bus route of Mumbai into a hardcoded fixed number of areas using its classification parameters. These parameters do work in the practical scenario, but they eventually end up consuming more time, thereby increasing the number of computations.

In this paper, we present an the Atomic Hypothesis Algorithm (AHA) which is an advancement of the prior algorithm which gives better performance and a cheaper solution for the same. The analogy of AHA comes from Neil Bohr's Atomic Model which inspires its simulation for its application in the system. Bohr's Model was proposed in 1913 to explain the quantized shell of an atom. It explains how electrons revolves around the nucleus in stable orbits. As shown in the Fig. 2, electrons revolves in a fixed orbit around the nucleus. Each orbit is labeled using an orbit number 'n' which starts for 1. The maximum number of electrons which can be accommodated in each orbit is given by '$2n^2$' i.e. the first, second and third orbits can accommodate 2, 8, 18 electrons respectively.

Fig 2. Neil Bohr's Atomic Model

This rational concept, when implemented in AHA has proved to give more satisfactory results than Area Trace Algorithm. The best part of the algorithm is its dynamic mapping strategy. Fig 3 shows the implementation of AHA.
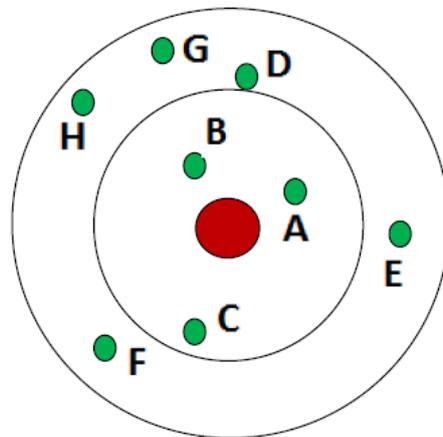
Fig 3. Atomic Hypothesis Algorithm Modelling

Server pings the tracker and obtains the current location of the bus. The call is now given to AHA for calculating the nearest bus stops to the current location. AHA takes as input the current location and fetches the map of the all marked bus stops in its database. The AHA quantizes the maps into shells like the Bohr's model. AHA decides the value of n dynamically depending upon the bus location received. If the received location resides in a densely populated unit where the number of residents is more, naturally the number of bus stops will be high. In such cases, the radius of the first and second shell is chosen as 0.3 miles and 0.6 miles respectively. Whereas for a sparely populated unit, the radius of the first and second shell is chosen as 0.5 miles and 0.8 miles respectively. These units are selected very carefully after several iterations. Trial and error have proved out this to be a best mentioned values of the orbit suiting for Pune Municipal Transport (PMT).

In the former case of densely populated unit from Fig 3, AHA only chooses the nodes A and B ignoring node C, it being farer. It further calculates the Vincenty distance between the current location and the nodes A and B to find the nearest node based on the latitudinal and longitudinal distance calculated. In case, if the algorithm fails to locate two nodes in the first orbit, it increases its tour to the next level of orbit. The same procedure is repeated for the area covered in this shell. The algorithm is proven to give results in a maximum value of 'n' ranging up to 2.

C. Algorithm

1. Read current input location of the bus.

2. Decide the area as being densely or sparsely populated.

3. For 1st orbit, locate a maximum of two nodes.

4. Calculate Vincenty distance between those points and store the least one.

5. If the first orbit doesn't locate two nodes, move to second orbit and locate a maximum of eight nodes. Repeat Step 4.

6. Return result to the server.

D. Vicenty distance

Various distance measures like Vicenty, Great circle, Haversine; are available for calculating the distance between any two nodes on the maps. Vicenty distance proves to be of more practical use among these as it gives more practical results. the error in Vincenty is just 6 μm as compared to great circle which gives a value of 0.75 m [12].

E. Flowchart
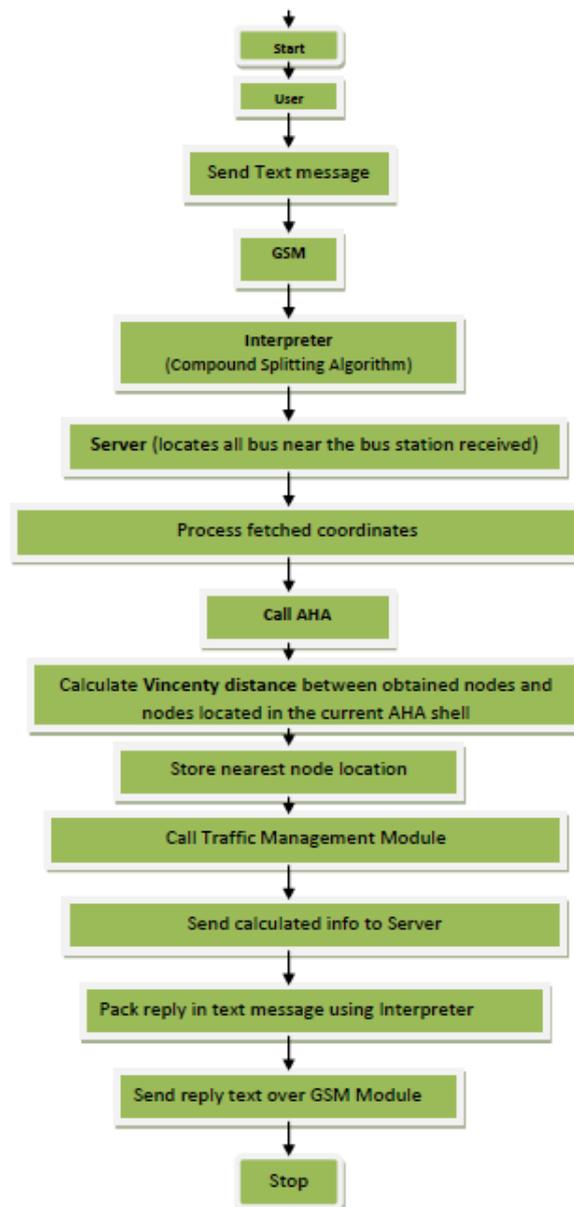
V. RESULTS

The implementation of LCBTS using AHA consists of two parts: locating the current location and estimating the distance from various nodes as per AHA. One such recorded scenario is depicted in Fig 4. The system was tested on the roads of Pune on the PMT routes for two months. PMT route number 16, 19, 22 and 24 were taken for demonstration purposes. Fig. 4 shows the details of the bus on Route 24. As we can locate in the figure, the current detected location of the bus is Sarasbaug.
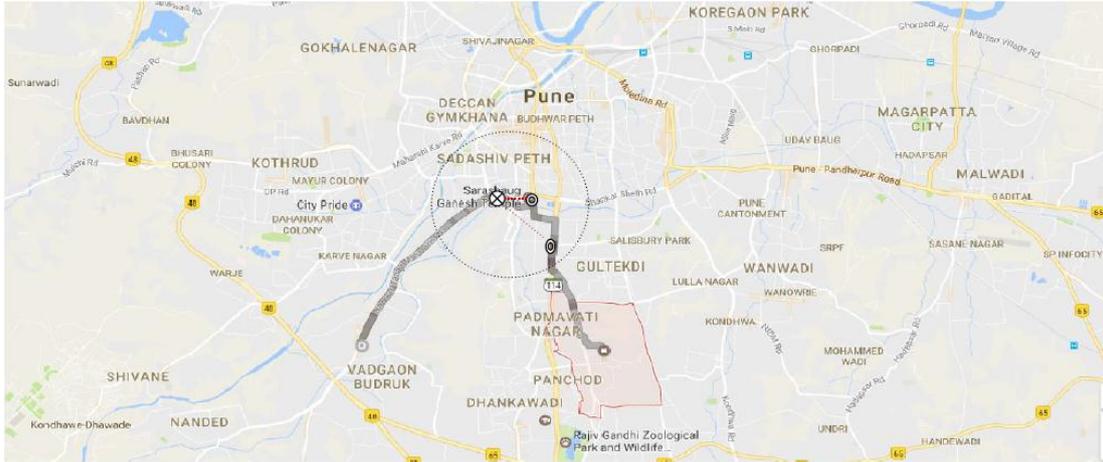
Fig 4. Result showing case study on PMT Route

This location is given as input to the system. AHA tracked two nodes namely 'Shri Mahalaxmi Chowk' and 'Mitra Mandal Chowk'. The results of AHA suggested that that the 'Shri Mahalaxmi Chowk' is the nearest node. Further, with the help of the Traffic Management Module, the information was received to the end user.

The same scenario was also tested with the Area Trace Algorithm. However, it used a total of four possible nodes namely namely 'Shri Mahalaxmi Chowk', 'Mitra Mandal Chowk', 'Peshwe Park' and 'Hotel Ganraj'. Thus it can be seen that AHA gave results with a 50% reduction in time complexity. Several simultaneous runs of AHA and ATA over vivid tracks showed that AHA gives better performance by saving an average of 40% computations. Thus, any user demands will now be fulfilled 40% faster adding to its convenience.

The work presented in this system only focuses on the revamped method of time retrieval. AHA guarantees a superior result in lesser time. Fig 5 shows the graphical representation of various tested Scenarios.
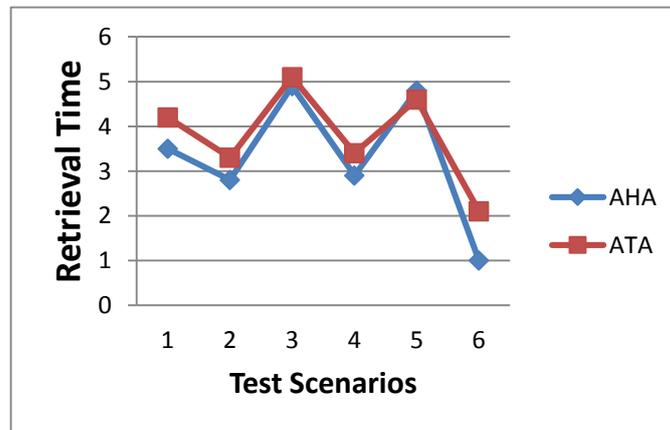
Fig. 5 Statistical results for copious scenarios noted

VI. CONCLUSIONS

LCBTS using AHA offers a low-cost solution for the common man. We are mainly focusing in this paper in developing a low-cost solution for the common man as well as a system which is more robust and fault tolerant. Atomic Hypothesis Algorithm purifies the Area Trace algorithm giving more better results.

The future work of this system is to build a GLCD screen to be displayed at each bus stop displaying the arrival time for each expected bus by using a minimum number of computations. Also, developing an android app for reducing the retrieval time is another milestone to be achieved.

VII. DECLARATIONS

A. Ethics approval and consent to approval

We voluntarily agree to participate in the research and give informed consent for enrolling in the journal contribution.

B. Consent for Publication

We, the authors of *'LCBTS Using AHA'* , give the guarantee for novel work and grant *'Human centric computing and Information Sciences'* consent for publication.

C. Availability of data and material

Not applicable.

D. Competing interests

Not applicable

E. Funding

The research is completely self funded.

F. Authors contribution

This paper is a part of my PhD Research work at Kalinga University, Naya Raipur, Chattisgarh. I am a Professor working with Mumbai University. I have been working extensively on this project since last 2 years and have done considerable contribution to the same in IEEE digital Xplore.

In this process, I have derived certain new and fresh algorithms which I am sharing with you in this paper. Currently, I am in the process of patenting my work. My ultimate aim of the research is to implement this full-fledged project with BEST (Mumbai) or Pune Municipal Transport (PMT) and aid the convenience of numerous people who will be enormously benefitted from this research.

I am confident that this will end the suffering of the individuals who use Buses as their transportation medium.

G. Acknowledgements

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