Utilizing Mobile Phone Users information for Urban Traffic Planning – a study of Guwahati City

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Abstract

Congestion on urban roads is an universal problem throughout the cities of the world. Congestion not only spoils the time of the travellers on urban roads but sometimetime takes life of serious patients travels towards the hospitals. Moreover, the increasing amount of carbon emission due to stopage of cars on the urban roads not only a threat to environmental system but also creates health hazards to the urban dwellers. Intelligent Transport System (ITS) brings many technologies starting from inductive coils to sensor networks to detect reals time traffic on urban roads.

Mobile phones are the equipments which are very common to every people not only living on urban areas but also in village areas also. Maximum people while moving on urban roads carries mobile phones with them for communicating with others. So, the use of mobile phone by most of the traffic commuters of urban roads can be exploited for real time planning by the traffic controllers. In this context, detection of mobile phone subscriber's position and direction of movement can be used as important parameters in many applications of traffic planning and control. Transition record of mobile phones across the Base Transceiver Stations (BTS) and Signal strength between Mobile Phone and the BTS can act as agents to compute the subscribers position and direction of movement. Moreover, the past records of the movement of the subscribers are also taken as input as probe to detect a group of users and can be used for traffic planning. When we consider the information about all the mobile phone users moving on the urban roads it gives real time traffic scenario of an urban traffic network. The traffic scenario are in terms of (a) number of traffic users on a road segment and (2) number of traffic users moving towards (upstream) and opposite (downstream) of a traffic point are two important information. The real time statistics about number of traffic users and their direction can be used to minimise probable traffic congestion on an urban road segment, specially at the traffic junctions.

City of Guwahati is considered as the gateway of North Eastern India and people from the adjacent north eastern states when travels to other parts of the country have to enter to the Guwahati city for taking facility on different modes of communication. Moreover, numerous people from the state of Assam daily travel to the Guwahati city due to business, medical, political etc reasons. Thus, congestion problem is a day to day activity faced by of urban traffic commuters and there is an urgent need if Intelligent Transport System. Thus, if the real time traffic situation is collected from the mobile phone networks it will be easier to control the traffic on urban roads, by intimating about the road condition to the vehicle drivers or operators for their diversion to non-congested path.

Keywords **:** Mobile Phone Network, Urban Traffic Network, Urban Traffic Congestion, City Traffic Network, Signal strength

Introduction

Urban traffic volume at a particular point of time is important information needed by the urban traffic managers to plan and control the flow of traffic on urban roads. Traffic congestion has been considered as a hazard to the urban traffic commuters. The congestion not only spoils time and fuel, it sometimes becomes the killer of serious patient carrying to the hospitals. The congestion is also responsible for environment pollution making the life measurable to the urban dwellers. Increase in vehicle density on urban roads, sometimes becomes uncontrollable due to limited infrastructure of urban traffic networks. The demand and increase in urban traffic directly relates to the population growth of a city. When considering the present urban population and the projected urban population of Guwahati city it has been found that there will a sharp increase in urban population of the Guwahati city and till then it will be very tedious job to control the urban traffic with the limited infrastructure of Urban Traffic Managers. The study of urban population of Guwahati city by a study by Guwahati Metropolitan Development Authority [1] shows a sharp increase in population as shown in table -1.

Table 1: Population estimates of Guwahati Municipal Area

Year	Population in GMA	% in increase
2005	1,033,584	----------
2010	1,244,713	20.4268835
2015	1,498,970	20.4269579
2020	1,805,163	20.4268931
2025	2,173,902	20.4269088

These sharp increase of 20% in population each five yearly intervals indicates increase in demand of vehicles and thus increase in vehicles on urban roads. Compared to these, increase in population and urban vehicles increase of road infrastructure has not been expected because of increase in urban area has a limitation.

Therefore, in such situations intelligent control of vehicles on urban roads is necessary with new technologies. Control and management of vehicles on urban roads has become an emergent area of research and many research papers have been published to control and manage the vehicles on urban roads. Urban Traffic Control has been transformed into Intelligent Transport System (ITS) with many techniques and equipments blended with Information and Communication Technology. Real time traffic counts are done with Magnetic loops, Pneumatic cables, CCTV's, wireless sensor networks, Vehicular adhoc networks, Car to Car Communication Systems, Mobile Phone Networks. Most of the techniques need infrastructure cost and effort and a plan to implement the ITS except the Mobile Phone Networks needs less infrastructure costs. Only a suitable mapped of mobile phone network on urban traffic network is necessary at this point. Considering 100% traffic users are carrying the mobile phone while travelling we can think of a system which can give us a lot of data. The data can further be processed to retrieve useful information to control the urban traffics to minimize the traffic congestion.

Guwahati City Traffic Control Points

There are basically many types of traffic commuters in Guwahati city as per the travel scheme. Most of these commuters are:-

(a) Traffic Commuters came from outside the city who wants to travel to the other parts of the country via bus route, railroad, and air routes directly.

(b) Traffic commuters came from outside the city who will travel to other parts of the country via bus route, railroad, air routes but after halt at Guwahati city.

(c) Traffic Commuters who do not came from outside the city will not travel to the other parts of the country, who came for business, education, medical reasons.

(d) Traffic commuter who lives in Guwahati City and working in the offices or have business in the city.

So each kind of people have different types of travel plan where few can be bifurcated to the destination through the by pass roads,

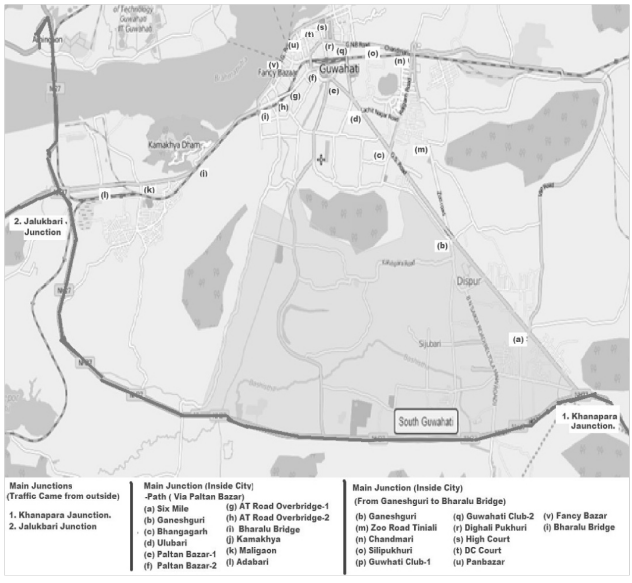

Fig :1 : Map of Guwahati City with few Traffic Control Points (Courtesy : wikimapia.org)

There are many traffic junctions which affects the traffic position of the city of Guwahati. Although all the junctions are important, few of important junctions have been shown in fig:1. As shown in fig-1 two main junctions where thousands of vehicles enter to the Guwahati city are Khanapara and Jalukbari. Both the junctions are acts as gateways of Guwahati City towards East and West. Both the junctions are improved with construction of over bridges and the congestion problems have been reduced to a larger extent. The people, who want to travel through Guwahati to the other places from east to other places without entering the city inside, may travel towards the bypass roads to avoid congestion inside Guwahati city.

People, who are to enter the Guwahati city may face the congestions occurred at different places from time to time depending on the traffic situations. If the real time traffic situation can be estimated on different roads or road junctions, then the traffic commuters can be informed through the roadside bulletin boards, internets or any other means, who may take alternative path to reach their destination.

GSM Networks

Global System for Mobile (GSM) is a second generation (2G) system has been started worldwide for the telecommunication system for voice and data communication. The entire GSM network has been divided into GSM Service area, Public Land Mobile Network (PLMN) area, Mobile Switching Centre (MSC) Service area, Location Area and Cells. The GSM service area is the total area served by the combination of all member countries where a mobile phone service is available. There are many PLMN area under a country belongs to the GSM network. The next level of the network is MSC Service area. There are many such areas out of which one is called gateway MSC, which is regarded as incoming transit exchange. The next division called Location Area (LA). There are many BTS cells under a Location Area.

Mobile Phone Network (MPN) and its database: The mobile phone network is different from that of a Landline communication that it should give service to the customers when they are in motion. A mobile phone at switch on state is continuous connected to the Mobile phone network via the BTS with a radio signal. The local operator of the MPN gives the network service to the mobile phone. When the mobile subscriber with his mobile phone moves from one BTS cell to another the network keeps the track of the subscribers location is called location update. When a subscriber moves with their mobile phones from a BTS Cell to another, the Cell is connected by a signal and the presence of the mobile phone is recorded in a database called Visitor Location Register (VLR). The VLR also keeps connection with Mobile Switching centre. The home

location of a mobile phone, also keeps the track of the movement of the mobile phone subscriber in a register, called Home Location Register (HLR).

Literature Review

Identification of Mobile Station (MS) position has been an important area of research and many research papers has been discussed for the identification purpose. However, the accuracy of finding the exact position has not yet been efficient. Discussing the about finding position P. Brida et al [2] has discussed the issue with reference to geometric algorithm called Adaptive Geometric Algorithm. They evaluated the performance of the algorithm in real GSM network. Handover procedure of mobile stations from one BTS to another is also a case related to many issues together with the signal strength. P Jahangir [3] has discussed the handover procedure as efficient handover prioritization schemes when user is switching between the cells. Sufficiency about signal strength between an area and the BTS has been discussed Shalangwa D. A. et al [4], they proposed a method to find the adequacy and sufficiency. The proposed that the signal strength received by Adamawa State University is fairly adequate but not sufficient enough to meet up with customer's demand. Syed Asad Hussain et al [5] proposed a method called triangulation method to find out individual subscribers position in Mobile phone network. The proposed an independent system can run to fine subscribers position with the help of the signal strength. Privacy in using mobile phone has been discussed by Klaus et al [6], and propose an adversary model and a privacy metric that allows for the evaluation of possible privacy loss by using mobile phone network. They also proposed the requirement of a privacy aware mobile phone network.

1. Position Identifications

Our research interest on finding the position of a mobile phone or a mobile station is with reference to a road segment or a road junction. Because we are interested on the crowd or the number of mobile phones on a road segment together with its classification of vehicles on which the mobile phone user is moving. The direction of movement is also important to us because we want know the direction of the mobile user towards which road junction it is moving. We shall, propose a system which can automatically compute the position of a subscriber on a road segment. The direction of the movement will also be used to compute the traffic flow towards a road junction. If we can estimate the probable flow towards a road junction then measures can be taken to mitigate the probable congestion in advance.

We shall use two methods to compute the position of a mobile subscriber.

1.1 Geometric method : A method as discussed in [2] by P. Brida et al called Adaptive Geometric Algorithm taking three BTS cells in consideration to compute the position of a mobile phone.

Description:

To describe the method, let us take the following figure as an example, where, we have three adjacent BTS cells with two road segments.

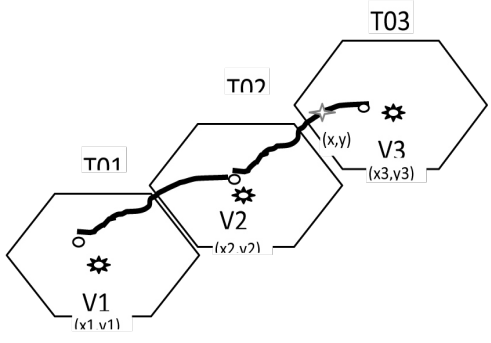

Fig-2 : A portion of a Urban Traffic network inside BTS cells

The three BTS cells are named as T01, T02 and T03 and we have three road junctions V1, V2 and V3 mapped to T01, T02, T03 respectively. The co-ordinate of the points V1, V2 and V3 is known, which are (x1,y1), (x2,y2), (x3,y3) respectively. Suppose, a mobile subscriber is moving with a mobile phone who is presently at the position (x, y), which is an unknown co-ordinate. Suppose the signal strength of this unknown point (x, y) from V1, v2 and V3 is d1, d2, d3 respectively. The signal strength d1, d2, d3 are the normalised signal strength, means that it is assumed that the signal strength of a BTS Towers are equal. if the strengths are different than also it will be normalised in such way that it becomes equal. We can find out the value of x and y with the distance calculation formula. We have following three equations:

$$d1^2=(x-x1)^2 + (y-y1)^2 \quad \text{-------- (i)}$$
$$d2^2=(x-x2)^2 + (y-y2)^2 \quad \text{-------- (ii)}$$
$$d3^2=(x-x3)^2 + (y-y3)^2 \quad \text{-------- (iii)}$$

Using (i), (ii) and (iii) we can find the co-ordinate (x,y) i.e. the mobile phone location of a particular subscriber.

1.2 Comparison method: We shall use the movement pattern to find the position of a mobile phone within a BTS cell. The movement pattern of a mobile phone is a value which is already stored in a database. To find the present position of a mobile subscriber inputs such as signal strength of the BTS cell and the adjacent BTS cells is given, with these values and the movements pattern can find the present position of a mobile subscriber.

Description: We may use a data store where each of the roads information together with the movement pattern with directions will be stored. As for an example the signal change pattern for the road segment is represented as ABC, ACB, BAC, CAB etc means that at position (x_i, y_i) the mobile phone has a signal strength A from tower T01, B from tower T02 and C from Tower T03. Again at position (x_{i+1}, y_{i+1}) the signal strength has changed to the pattern ACB and so on. If we compare the change in signal strength at several positions by a mobile station with the values those has been stored in a database, then perhaps we can find out a match to find the current position of a mobile equipment on a road segment.

We shall compare Signal strength and position in both the cases and find the actual position of the mobile equipment..

2. Direction Identification

Identification of the direction of a mobile phone is also done by the signal strength at two consecutive signal strength readings of two BTS's in a mobile phone network. The procedure for detection of the direction can be explained by the following procedure.

2.1 Detection of subscriber's direction: Suppose there are two BTS cells (say T01 and T02) and a subscriber is moving through a road segment falls under two BTS. Suppose the signal strength for the mobile phone with BTS Cell T01 is C1 and BTS Cell T02 is C2. Then we can describe the situation of the movement of direction with the following conclusions in table-2.

Table-2: Conditions for direction finder

Options	Signal strength of T1 (C1)	Signal Strength of T2 (C2)	Direction of movement
1	Increasing	Increasing	MS is moving towards the centre of T01 and T02
2	Increasing	Decreasing	MS is moving towards the centre of T01 and going in opposition to centre of T02
3	Decreasing	Increasing	MS is moving towards the centre of T02 and going in opposition to centre of T01
4	Decreasing	Decreasing	MS is moving in opposition to the centre of T01 and T02

Again, the data store where each of the roads information together with the movement pattern with directions may be stored may give information about the movement of a particular mobile equipment holders transition records. The records of the movements i.e. the transition pattern can also be used to find the direction of a mobile user. As for an example the transition record of a mobile equipment is represented as T01T02T03T04 means that the mobile user is moving on the road segment towards T04 from T01.

Applications

There are numerous applications in finding the position of subscriber of a mobile phone at any point of time. Since, most of the cases the carrier of the mobile is the owner of the mobile phone or a person identified by him or her. Few areas of application are:-

(a) Criminal investigation :
(b) Urban traffic management
(c) Disaster management
(d) Transportation management
(e) Sales team management
(f) Security management

Conclusion

Using mobile phone networks is in experimental stage at different cities of the world. Inductive loops are in much use to detect the real time traffic conditions. However, finding the exact position of the mobile subscribers still is a problem and accuracy in this case may not be achieved to a desired level. However, the rough estimate of the mobile users on urban roads may help the traffic authority to control and bifurcate the traffics through other non-congested paths.

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