Applying GPS_enable mobile phone_based traffic monitoring system in Mobile Cloud Infrastructure

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Abstract

Nowadays, monitoring road and traffic prediction in urban area is becoming an important role in developing countries like ours. It is the most important part that getting and performing the accurate traffic data in all Traffic Prediction System. This paper introduces an approach of tracking traffic data using the cheapest way and it was computed the traffic data in terms of communication, computation and energy efficient ways. Mobile devices are becoming an important role not only for personal contact, but also for business and environmental sensing application. The GPS sensor of mobile device will be mainly utilized to guess a user's transportation mode, then it integrates cloud environment to enhance the limitation of mobile device, such as storage, energy and computing power. This system includes three main components: Client Interface, Server process and Cloud Storage. Some tasks are carried out on the Client. Therefore, it greatly reduces the bottleneck situation on Server side in efficient way. Most of tasks are executed on the Server and history data are stored on the Cloud Storage. Firstly, the user's transportation mode, motorize or non-motorized, is analyzed on the client side using raw GPS data, instead of submitting frequently raw data to data center. If it is only the motorize mode, some useful traffic data are offloaded to cloud. On the server side, all motorize mode are not taken into account as traffic data. In this case, the mobile data that comes from the same location are recognized as one proves. Later, these data are used as history data for future prediction to perform more accurate traffic information.

1. Introduction

Traffic prediction is becoming an important role not only in the developed countries, but also in the developing countries. There are also plenty of techniques to be used in the traffic prediction system. Cameras, road sensors on roadside, HD traffic (traffic information service), GPS devices and Accelerometers in vehicles, and Traffic signals have been being used in almost traffic prediction system. However, these techniques are very expensive to install and greatly need to emphasize on system maintenance. Because of the consequence of these ways, some developing countries are not able to utilize it and also not able to support these systems enough in their region. Fortunately, mobile phones with the riches of sensor, such as an accelerometer, digital compass, gyroscope, GPS, microphone and camera, develop immediately in the mobile market. Many clues, such as position, speed, direction and time, can be looked for by using an accelerometer and GPS enable mobile phone. Besides, these sensors are enabling new applications across a wide variety of domains, such as healthcare [3], social networks [4], safety environmental monitoring [5], and transportation [6], and give arise to a new area of research called mobile phone sensing[2]. Following these information, the current situation of traffic jam can be predicted on the specific road. In these cases, mobile information need to be accurate, otherwise the performance of the traffic prediction system may be at zero level.

Motivation for transportation mode detection is transportation surveys. Travel demand surveys have taken multiple formats, such as telephone interviews and questionnaires. These data collection strategies rely on manual labeling of data after the trip, and thus, inaccuracies are introduced. For example, a traveler may not recall the exact time that she/he boarded a transportation mode. Using GPS devices is more reliable for reporting accurate location, trip time, and trip duration. Hence, if the precise transportation modes of individual users are recognized, it is possible to provide a more realistic travel demand picture [10].

Many GPS trace sharing social networks have been implemented by many researchers. These social networks enable friends to upload and share their GPS traces. Knowledge of transportation mode, added to these GPS traces, will enable the users to reflect on their past motion more meaningfully. It also allows users to obtain additional information from their friends' travel experience. Additionally, awareness of transportation mode of a user may help to determine the user's carbon footprint, or track the amount of calories burnt. Another application of transportation mode detection is crowd sourced real-time traffic information in which traffic speeds are aggregated from probes such as mobile phones carried by travelers. Transportation mode detection enables the aggregation system to filter out the speed data submitted by non-motorized travelers or travelers on trains.[10]

2. General Architecture of Traffic Prediction System

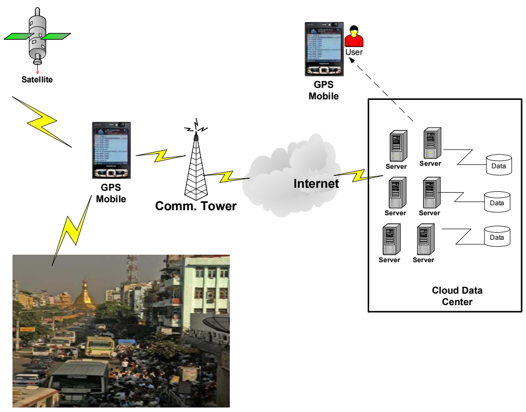

Figure 1: The general architecture of the trafficprediction system using GPS_enable mobile phone.

This system focuses on whether the user is travelling with motorized transportation mode or non-motorized transportation mode by only using GPS and an accelerometer data. For estimating the situation of traffic, it does not need to analyze detail whether bike or car or motorbike. While bus, taxi, biking and motorbike are defined as the group of motorized transportation mode, only walking man is recognized as non-motorized mode in this system. There are three main components that are Client process, Server process and Storage.

This system does not take into account every GPS as traffic probe. If the average speeds to the given time window is less than the predefined threshold, it automatically rejects this probe. Only the assurance data, e.g. motorize transportation mode, is sent to server. This work is only done on Client, mobile device, to be accurate and be far away from the incorrect data submission due to the Internet connection. This way greatly reduces enormous amount of ineffective jobs, such as communication cost, sending data repeatedly and server bottleneck problems, for the system.

On the server side process, it previously detects whether the submitted data comes from the same vehicle or not. If so, all data from the same bus is taken as only one traffic probe. Later, these probes are going to be used as a historical data to improve the quality of the system. Furthermore, this system is divided into two parts, client side and cloud side. Some tasks are done on the client and the rests which are computation intensive .The data storage parts are carried out on the Cloud storage. In these cases, all history data are stored on the Cloud. On the other word, this idea can be named as Mobile Cloud Computing.

Mobile Cloud Computing is widely accepted as a concept that can significantly improve the user experience when accessing mobile service. By removing the limitation of mobile devices with respect to storage and computing capabilities and providing a new level of security by a centralized maintenance of security-critical software for e.g. mobile payment applications, it is expected that it will fine brad acceptance on the business as well as consumer side. Research indicates that Mobile Cloud Computing will additionally help to make visions of context-aware services become reality [7]. Mobile devices are not suitable for computation intensive application. It still has the limitation of storage, power and CPU. Because of that, this system takes again the advantages of the Cloud computing to improve the quality of it. This task greatly improves in the reduction of the power usage on the mobile phone as well as the leverage of Cloud storage.

3. RELEVANT WORK

D. Patterson, et- al [1] and L.Liao, et.al [11] use an unsupervised learning technique to detect the transportation mode of a traveler. The transportation modes that are detected in this system include buses, cars and walk. The work in the system is able to predict the traveler's goals, such as trip destination and trip purpose. In addition to GPS data, the system uses historical information about the user. Historical information includes, past user trips and information about where the users parked their cars. In our approach, we only consider the user's transportation mode, motorize or non-motorize, as a historical data. We don't analyze traffic proves in detail, such as bike or motorize or car.

N.D. Lane, et-al [2] also determines the user's current mode of transportation by applying a Boosted Naïve Bayes classifier to data collected from the sensors of the mobile device for the analysis of traffic patterns and CO2 emissions. For generating this Boosted Naïve Bayes classifier, it needs to develop an application to collect training data firstly. Importantly, the propose approach is different than that in [2]. The system does not give bother to get the training data previously. It keeps the true data from the result of mobile device as a historical data and afterward these history data are integrated with the live result to improve the accuracy.

The prior research in [8] has a different focus; it considers extracting the semantic location from outdoor positioning systems. Likewise, [9] learns and recognizes the places a mobile user visited by observing the Wi-Fi and GSM radio fingerprints. This work does not consider Wi-Fi or GSM information. Instead, we consider GPS and history data.

4. Research Issue

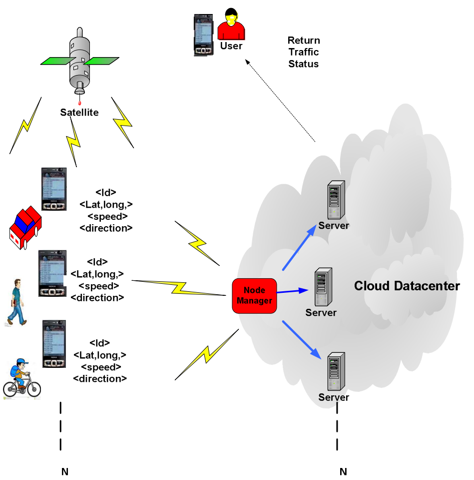

Figure 2: The general architecture of previous research area

The figure 2 describes that the density of traffic jams is predicted using the location based service with the assistance of satellite in the space. The location of individual can be predicted by using GPS which continuously receives the signal from the satellite. These days almost Mobile device reaches the market with the plenty of sensor devices, such as Camera, GPS and so on. Moreover, all of people are able to won Mobile device for their personal communication. Form the researcher point of view, the increment in the number of cell phone owners is the good news for solving the problem of everyday traffic conjunction.

(a) Problem 1

Figure 2 shows the general architecture of previous research area. In this system, raw GPS data from the individual's mobile device are sent to the data center, Cloud, via the Internet. Although this system makes the client light, the server is going to face the bottleneck situation to handle a thousand of mobile phones. Overtime, the situation goes into system performance degradation. Moreover, this system may introduce some communication cost. In the traffic prediction system, the transportation mode, e.g. car, motorbike or bus, are defined as the traffic probe. Because of this assumption, if the raw GPS data, including a mature of non-transportation mode and transformation mode, from mobile device are sent to the data center, it increases the communication cost and time spent for non-valuable data. We assume that there are thousands of mobile devices coming to alert as a probe. This system does need thousands of servers to classify whether these devices are transportation mode or not. In this case, the server may suffer from the bottleneck situation and later the system will be going to face the performance degradation. Another problem is communication cost. GPS receipts the data every second and sends these raw data to the Cloud not knowing whether it is usable or not.

(b) Problem 2

The analyzed data sent from mobile device should not be taken into account as a traffic data. These submitted data may come from the same vehicle, such as buses or taxi. If these data are recognized roughly as a traffic probe, it greatly effects on the long term performance of the system.

5. Design of System Architecture

In order to some issues mentioned in previous system, this research introduces the idea of dividing task in to two parts, server side processing and client side processing. In this case, some processes that are not computation intensive processes are going to be executed on the client and the rest tasks and the storage of individual historical data, such as transportation mode, are all done on the server side. Besides, it previously detects whether the submitted data comes from the same vehicle or not.

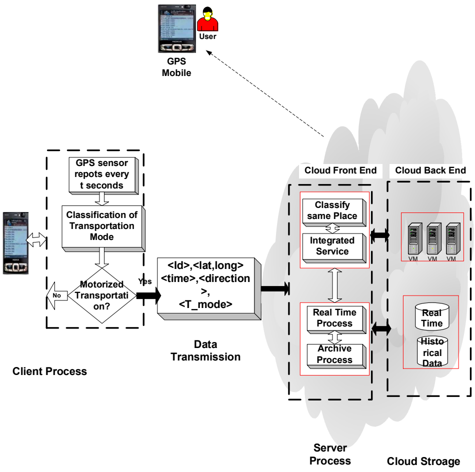

Figure 3: Propose System Architecture

If so, all data from the same bus is taken as only one traffic probe. Later, these probes are going to be used as a historical data to improve the quality of the system. This system solves a lot of problems encountered on the mobile device and decreases a large amount of tasks on the client side. But, the nature of traffic prediction system does not recognize GPS data from a walking man as a traffic probe. Therefore, the classification of transportation mode for each device is needed to carry out previously. This process is performed on the client side. After that, the usable data, only transportation mode, is submitted to the Cloud.

6. System Model

The system is composed of two parts, client and server side.

6.1. Client Side

Definition 1.GPS sensor log. A sensor GPS log pi represents data submitted from the GPS sensor embedded on a traveler's mobile device. The format of the report is <lat, lon, t, v, h, acc> where: lat represents the latitude; lon represents longitude; t represents the timestamp of the sensor report; v represents the current ground speed of the device; h represents the direction of travel; and acc represents the accuracy level of the latitude and longitude coordinates. The measurement units of the GPS sensor report attributes are: latitude (lat) and longitude (lon) are in decimal degree; current ground speed (v) is measured in meters per second; direction of travel (h) is specified in degrees counting clockwise from true north; accuracy level (acc) is defined in meters; and time t is in seconds.

Definition 2. A GPS trace T is a sequence of GPS sensor reports, T = p0 → p1 → · · · → pk, where the timestamps in the sequence strictly increase.

	Latitude	Longitude	Speed	Time
P1:	Lat1	Long1	Sp1	T1
P2:	Lat2	Long2	Sp2	T2
………				
Pn:	Latn	Longn	Spn	Tn

Figure: 4 GPS Log

Average Speed

In terms of speed, we use the speed value returned by the GPS sensor when it is available; this is more accurate than calculating the speed from consecutive GPS locations points [10]. For a sequence of GPS reports we compute the average speed. This feature has been used in many existing works [10,12,13,14].

GPS log: a sequence of GPS points, pi € P

P={p1,p2,….,pn}

Pi={lat, long, speed, timestamp}

Let {p1, p2, p3, p4…pn} be a finite set of GPS sensor reports submitted within a time window.

Average speed (P.V)= $(\sum i=1 \text{ to } np_{iv}) / n$ (1)

where pi^v is the current ground speed obtained from the GPS sensor report.

- Denotes a Transportation Mode: P.V >Vt
- Denotes a non-Transportation Mode: P.V<Vt

Where Vt is the predefined threshold.

Driving->Walking->Driving->Walking

The system concludes the above nature to be Driving (Transportation Mode).

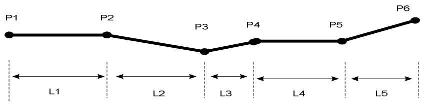

Figure: 5 Transportation Mode

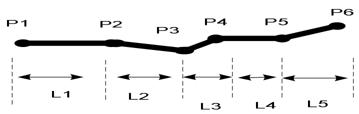

Figure: 6 Non-Transportation Mode

6.2. Server side process

Every data submitted form mobile device at every t time will be classified to define accurate traffic data. Firstly, these data are analyzed whether the corresponding device are in the same place or not according the location (latitude and longitude). In this case, this system needs to group the numerous GPS_location into similar counterpart. For this aim, one of the data mining functionalities, cluster analysis is going to be used in this research. In detail one of the major clustering methods, distance based clustering is specially utilized. The distance between two points is calculated by using Haversine formula.

Haversine formula: $a = \sin^2(\Delta\varphi/2) + \cos(\varphi_1).\cos(\varphi_2).\sin^2(\Delta\lambda/2)$

$c = 2.\text{atan2}(\sqrt{a}, \sqrt{(1-a)})$

$d = R.c$

where φ is latitude, λ is longitude, R is earth's radius (mean radius = 6,371km)

Note that angles need to be in radians to pass to trig functions!

After they have been clustered into the similar group, their average speeds are executed again to predict that they are on the same vehicle. After that, these outcomes are integrated with the history data. The history data means the mobile device frequently takes the bus or drives a car. The latest outcome results are stored altogether with the previous history data on the Cloud storage with the corresponding mobile id.

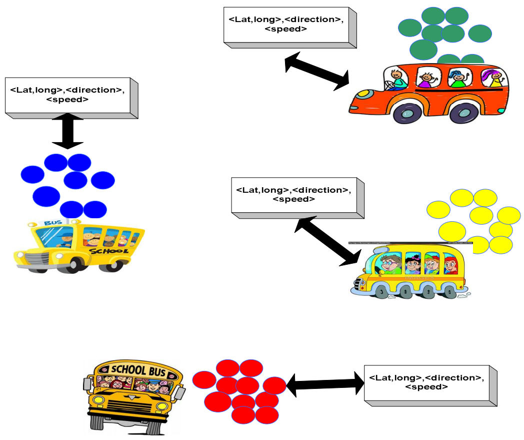

Figure: 7 the simple example of clustering latitude and longitude into similar group

7. Experimental Result

The following figure shows the nature of bus by only using the GPS speed. In this analysis, the highest speed is over 12 m/s. The lowest is 0 m/s. The velocity of the bus is almost fluctuated, but it is not constant under 2m/s. According this figure, we can predict this vehicle is the transportation mode. We use data from the GPS sensor reports. Specifically, these data were taken along the road from the University of Computer Studies, Bahan to Hlaing Campus.

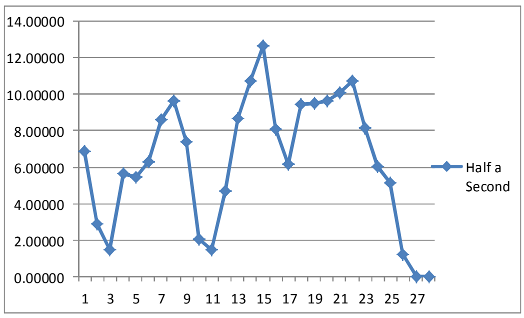

Figure: 8 the analysis of nature of bus by using GPS speed.

The figure 8 represents how much difference in speed over two mobile phones on the same bus. This experiment was done along the Phyi and Inn Ya road from University of Computer studies, Bahan to HlaingCompus. In my experience, the satellite does not give the exactly same speed and location to the mobile devices on the same vehicle. However, there is not a big gap between them.

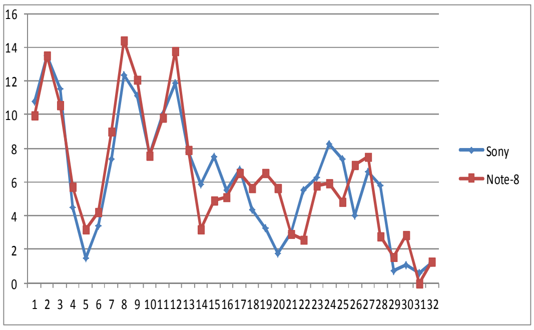

Figure: 10 the detection of difference in speed of two mobile phones carrying on the same bus by using GPS .

The following figure shows the speed of normal walking person by using GPS sensor data. This data is computed along the PaYaMi Road near Hlaing campus.

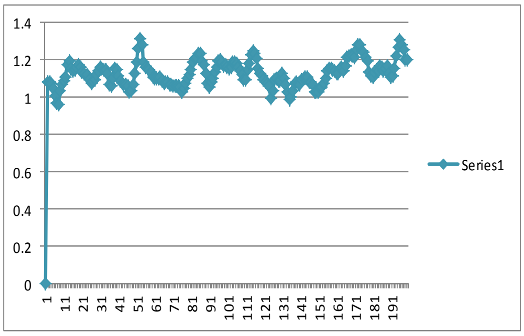

Figure: 11the walking speed executed by using GPS sensor data.

8. Conclusion

In this paper, we emphasize to provide the accurate traffic probe based on GPS data. A work aiming to infer transportation modes from GPS logs based on supervised approach. Using our approach, it greatly reduces the communication cost and prevents the system from server bottleneck by approaching the way of getting the true traffic data. In addition to the higher accuracy achieved with this technology, the proposed traffic monitoring system has other advantages over current systems based on loop detectors. From the standpoint of transportation agencies, the system comes at almost no installation and maintenance cost. Thus, a traffic monitoring system based on GPS-enabled mobile phones is particularly appropriate for developing countries, where there is a lack of resources and monitoring infrastructure, and the penetration of mobile phones in the population is substantial. Mobile phone sensing systems will ultimately provide both micro- and macroscopic views of cities, communities, and individuals, and help improve how society functions as a whole.

References

[1]D. Patterson, L. Liao, D. Fox, and H. Kautz, Inferring High-Level Behavior from Low-Level Sensors, ACM UBICOMP 2003.

[2]Nicholas D. Lane, EmilianoMiluzzo, Hong Lu, Daniel Peebles, TanzeemChoudhury, and Andrew T. Campbell.A survey of Mobile Phone Sensing, September 2010.

[3]S. Consolvo et al., “Activity Sensing in the Wild: A Field Trial of Ubifit Garden,” Proc. 26th Annual ACM SIGCHI Conf. Human Factors Comp. Sys., 2008, pp. 1797–1806.

[4]E. Miluzzo et al., “Sensing meets Mobile Social Networks: The Design, Implementation, and Evaluation of the CenceMe Application,” Proc. 6th ACM SenSys, 2008, pp. 337–50.

[5]M. Mun et al., “Peir, the Personal Environmental Impact Report, as a Platform for Participatory Sensing Systems Research,” Proc. 7th ACM MobiSys, 2009, pp. 55–68.

[6]A. Thiagarajan et al., “VTrack: Accurate, Energy-Aware Traffic Delay Estimation Using Mobile Phones,” Proc. 7th ACM SenSys, Berkeley, CA, Nov. 2009.

[7]Andreas Klein, Christian Mannweiler, Joerg Schneider and Hans D. Schotten Chair for Wireless Communications and Navigation, “Access Schemes for Mobile Cloud Computing”, 2010.

[8]J. Liu, O. Wolfson, H. Yin. Extracting Semantic Location from Outdoor Positioning Systems.Int. Workshop on Managing Context Information and Semantics in Mobile Environments (MCISME), 2006.

[9]J. Hightower, S. Consolvo, A. LaMarca, I. Smith, J. Hughes. Learning and Recognizing the Places We Go. ACM Conference on Ubiquitous Computing, 2005.

[10]Leon Stenneth, OuriWolfson, Philip S. Yu, Bo Xu, “Transportation Mode Detection using Mobile Phones and GIS Information”, November 2011.

[11]L. Liao, D. Fox, H. Kautz. Learning and Inferring Transportation Routines.AAAI 2004.

[12]Y. Zheng, Q. Li, Y. Chen, X. Xie, and W. Ma, Understanding mobility based on GPS data. In Ubiquitous Computing, ACM New York, 2008, pp. 312-321.

[13]S. Reddy, M. Mun, J. Burke, D. Estrin, M Hansen, and M. Srivastava. Using Mobile Phones to Determine Transportation Modes.ACM Transactions on Sensor Networks, Vol. 6, No. 2, Article 13, 2010.

[14]Parkka, J., Ermes, M., Korpipaa P., Mantyjarvi J., Peltola, J., Activity classification using realistic data from wearable sensors, IEEE Transactions on Information Technology in Biomedicine 10, 1 (2006), 119-128.