Zone-Based Update Strategy for Location based Services (LBS)

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Abstract. Location-based service (LBS) is one of the most important applications related to GIS. In the past few years, there has been a rapid expansion of activities in LBS providing pedestrians with easy access to useful information whilst travelling from one place to another. LBS systems use the power of mobile networks to locate a user and provide data and services based on the location they are in. In view of the fact that the volume of this information is huge, this paper presents a new database update mechanism which will enable improvement of performance of the service provided by LBS Systems. Such mechanism will reduce the usage of network bandwidth which will contribute in minimising the power consumption of the user's device (Mobile Smartphone, PDA …etc.). This is because the mobile device receives less information and avoids uploading any superfluous data.

Keywords: Location Based Services (LBS), Mobile GIS.

1 Introduction

The rapid development in mobile telecommunications and satellite navigation has resulted in a birth of LBS, a new system that combines these two main technologies [1]. LBS system in its basic architecture is a mobile device with satellite navigation receiver (GPS) and mobile network interface connected over wireless networks to the server which hosts information about points in a geographical area (see fig. 1.) [2]. LBS systems combine the location information of the user with intelligent application in order to provide services [3]. LBS systems have been developed to be a useful resource of information for pedestrians which can enable them to obtain necessary information on the move. However, the performance of an LBS system is still subject to shortcomings mainly caused by its components [4].

Despite its being considered as the most accurate locating system, GPS still has two main drawbacks; the availability and the full accuracy. This can directly influence

the overall performance of any LBS system in particular within urban environments [5]. Mobile device is the user gateway to access information, however, several limitations are acknowledged: memory size, battery lifetime and processor capabilities. Therefore, these three factors have a direct impact on LBS systems [6]. GIS database server is the main container which hosts all information to be accessed by user's mobile device. It is essential that the database should be managed and accessed in an efficient way, otherwise unnecessary processing time and delay might occur which can contribute in reducing the efficiency of the whole LBS system [7][8][9]. Mobile wireless network enables data to be transferred between LBS server and the end user's mobile device. This communication channel suffers from lack in bandwidth, particularly when many users are using the mobile network [10]. Therefore, minimizing the amount of data to be transferred over the mobile network can significantly assist in minimizing delay and packet loss, which can directly enhance the performance of LBS system.

Addressing the mentioned problems will enhance the efficiency of LBS systems. Therefore, this paper is tackling the problems through proposing a new mechanism for managing the GIS database by dividing it into a number of geographical zones. In such a way, the amount of data to be loaded to the end-user mobile device will be reduced, which will have a positive impact on the network, mobile device and the database. Traditionally, LBS system updates the end users through sending large information associated with a large geographical area. Nowadays, to enhance the efficiency and better manage the huge database, LBS system is being developed to use zone-based strategy, i.e. smaller geographical areas [11][12].

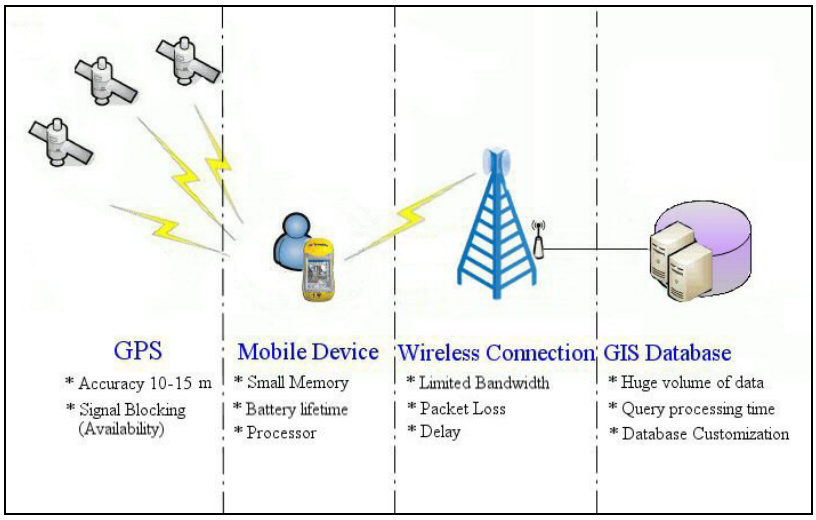


Fig. 1. General LBS Architecture and it problems

In this paper, zone-based update strategy has been utilised in order to investigate its impact on improving the capabilities of LBS system. The idea is to divide the geographical

information and its database into two types of zones; Macro-zones and Micro-zones. Macro-zone is a large geographical area, for instance a town. It is also divided into smaller areas which are called Micro-zones (see fig. 2).

The Macro-zone is a *vector* map. In the Vector maps mode, the spatial objects are referenced to a coordinate system, which consists of coordinates, a datum, and a projection. Spatial objects might be one of the following; a single *point*, which might represent a person, a vehicle or a Pint of Interest (PoI). Or a straight line which is modeled by a link between two points. Or a polyline which is symbolized by a linked list of points (vertices). Or a polygon which is a closed polyline, a polygon is said to be convex if it has no internal angles greater than 180, otherwise it is a concave [1]. Moreover, this Macro-Zone contains detailed information about the micro-zone which the user is located at, and adjacent micro-zones.

The Micro-Zone is a *raster* map. The raster mode is very similar to a bitmap picture, which consists of a grid of pixels ordered in a number of rows and columns. The more number of pixels in the grid is the more quality of raster data [1]. The size of a micro-zone is to be within the walking distance of a pedestrian; for example, a distance of 2 Km. Each micro-zone will be assigned a known update point in order to ease adding any information associated with it. Also each micro-zone will have its unique ID and borders that will enable the system to automatically download the data associated to this zone as the pedestrian approaches it. This will be done either automatically or manually by asking the user to confirm the download process.

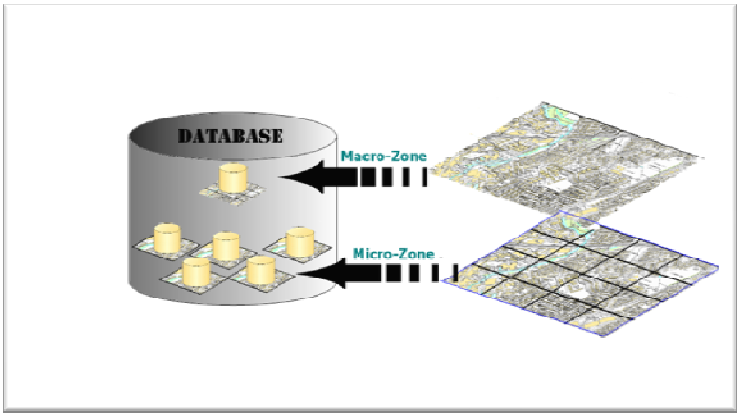


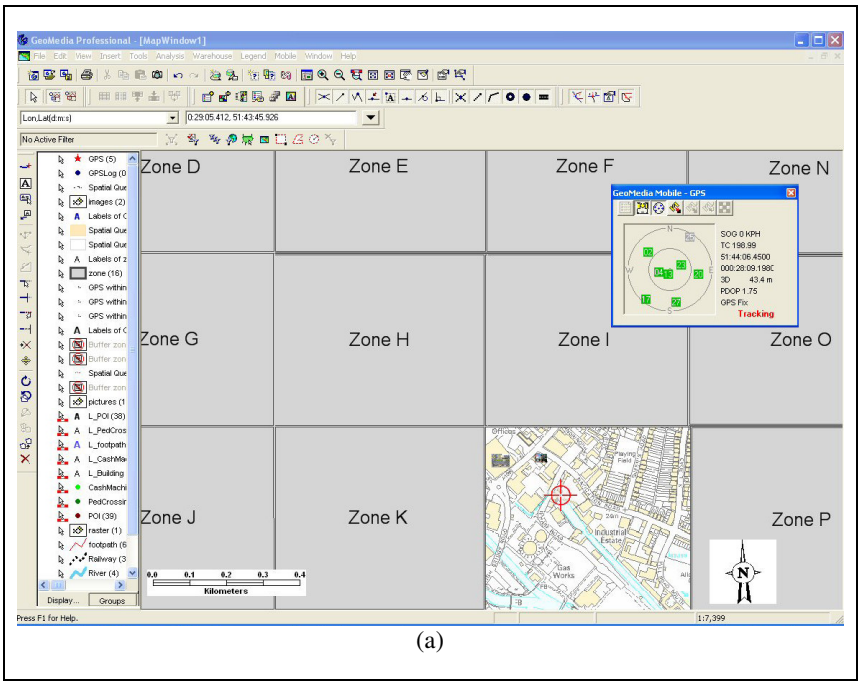
Fig. 2. Zone based Mechanism

2 Initial Implementation and Evaluation

In order to evaluate the proposed mechanism, a simplified scenario was implemented using a master map of Chelmsford UK, and Geomedia Professional GIS system with mobile expansion for GPS (fig. 3). This software tool was installed on a laptop connected to the internet via HSDPA connection, and connected to GPS system via

Holox GPS receiver [13]. During the implementation, Chelmsford vector map was considered as macro-zone and divided into cluster of micro-zones with defined borders. The system was configured to ask the users if they want to upload information when they are getting closer to the adjacent micro-zone, for example, 10m. Moreover, the user can accept or reject the message. If he/she accepts it, then an internet link is established to a remote server to simulate LBS server.
In order to test the Zone-based update Mechanism on the real world, the researcher has used Toshiba Equium laptop that represents the mobile end user. This laptop was connected to a GPS receiver (Holox BT321) via Bluetooth in order to fix the end user physical location. Furthermore, Geomedia Professional software was used as a GIS tool to do the implementation. Geomedia receives the NMEA GPS message string from the GPS receiver and present the location on the Chelmsford master map.

Trial was conducted by the researcher to demonstrate the process. The GPS receiver fix the location of the user which is then matched and placed on the map by Geomedia professional. As shown in fig. 3 (a), the user started to move while the GPS kept updating its new location. By approaching the border of new micro-zone, the system has generated an automatic message asking the user to confirm whether he wants to upload the new zone data (fig. 3 (b)). Once the user has accepted the upload message, the system automatically supplied the new micro-zone data as shown in fig. 3 (c).



(a)

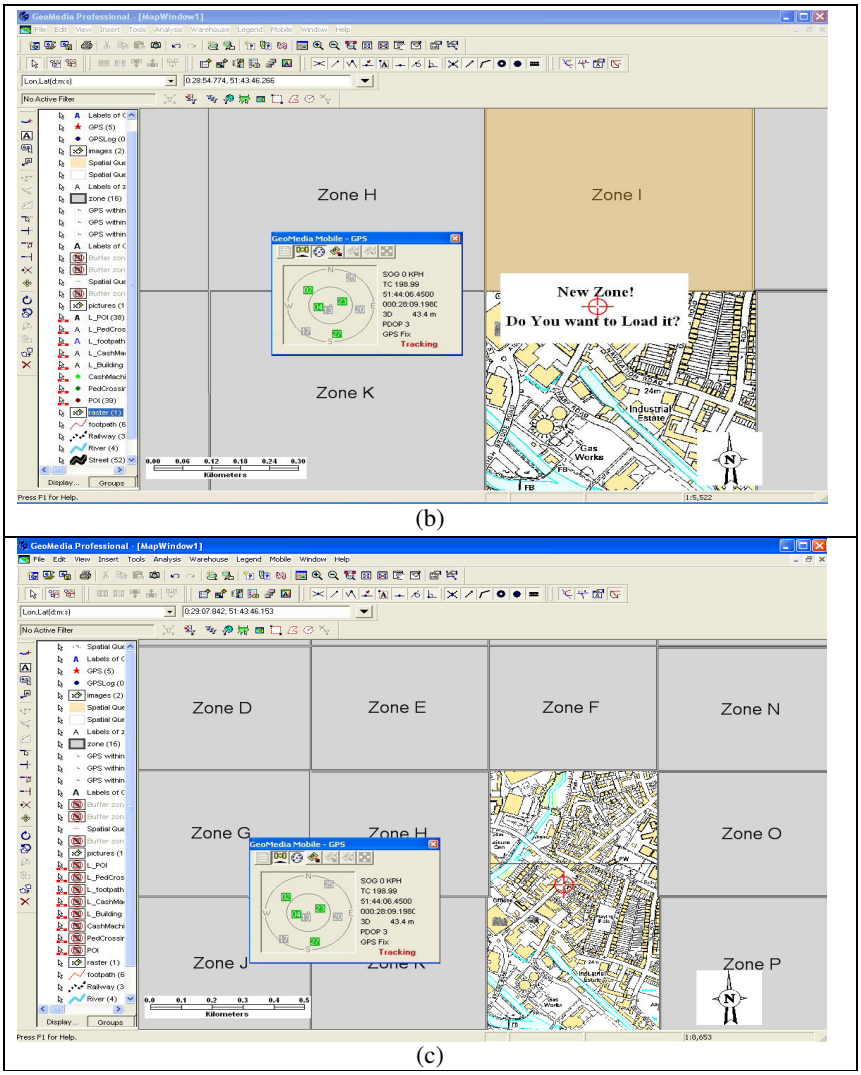


Fig. 3. Implementation of Zone-based mechanism on GeoMedia Professional

The second part of the experiment was to investigate the impact of zone-based update mechanism on the LBS system performance, and to measure the effect of reducing the map size efficiently, a simplified LBS system was built using the network architecture which is already installed at Anglia Ruskin University [11] which can be shown in figure 4. The experiment focused on evaluating this new mechanism on the mobile link (delay, bandwidth …etc) and the mobile device (memory, battery …etc.). During

the experiments, two main connections were used to carry out the test in different scenarios:

a. High-Speed Downlink Protocol Access (HSDPA).

A Toshiba Equium laptop (end user mobile device) was connected to the T-Mobile network through a Web'n'walk PCMCIA data card to establish a live HSDPA (3.5G) wireless connection. T-Mobile Web'n'walk data card supports a theoretical speed of up to 1.8 Mbit/s [10].

b. Wireless Local Area Network (WLAN).

A Toshiba Equium laptop was connected to a Wireless Local Area Network (WLAN) at Anglia Ruskin University network infrastructure (IEEE 802.11b) which supports a theoretical speed of up to 54 Mbit/s. This network is connected to the internet using JANET [14] (a network connecting different educational institutions in the UK) with a speed of up to 100 Mbit/s.

In order to simulate an LBS server, an ordinance survey master map of Chelmsford city was uploaded to the LBS server, in addition to a micro-zone map (small map) of an area within Chelmsford city. This server is accessed via the internet. During the experiments, Ping command was used to send Internet Control Message Protocol (ICMP) to the server to assess the link performance in idle and busy status (Downloading and Uploading). ICMPs packets were used to calculate the Round Trip Delay Time (RTT), in order to estimate the delay experienced in the connection link. Moreover, the time, power and memory utilisation during loading the master map and the zone maps were measured in order to check the difference between the regular system and the Zone-based system.

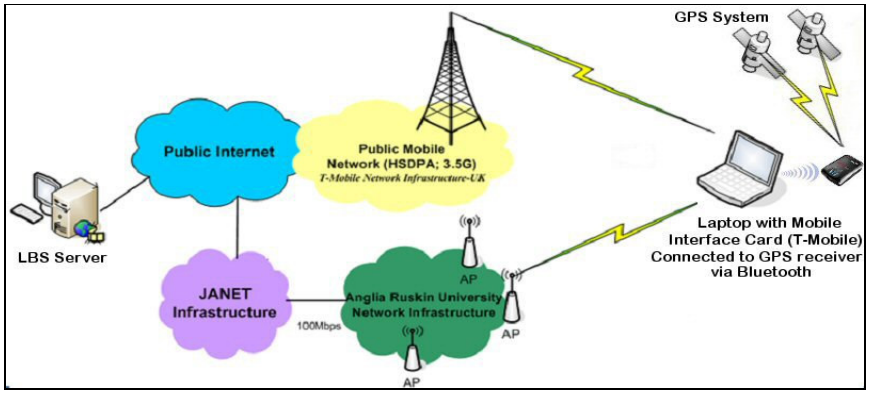


Fig. 4. Network Architected for experimental scenarios

3 Results

Three tasks have been conducted during the experiments, the first one was to measure the time taken to download each file (Chelmsford Master Map and the micro-zone map) using the two types of connections (3.5G and WLAN), the results obtained from this task are shown in figure 5 (a). The time taken to download the whole map in both scenarios (HSDPA and WLAN) was approximately four times the time taken to download the zone map. In the HSDPA connection the master map needs 256.83 seconds to be loaded completely on the user's device while the zone map requires only 62.56 seconds. Also in the WLAN connection the total time needed to load the master map was 183.78 seconds while the zone map took only 46.88 seconds to be loaded. Therefore, the congestion can be reduced. Hence, the performance of the mobile network has been directly affected since the time of accessing the network was reduced using the zone-based update mechanism.

The second task of the experiment was to measure the delay between the mobile device and the LBS server. As shown in figure 5 (b), this test was repeated in four different scenarios:

a. Idle HSDPA link.
b. Loading the master map on the mobile device via HSDPA link.
c. Idle WLAN.
d. Loading the master map on the mobile device via WLAN connection.

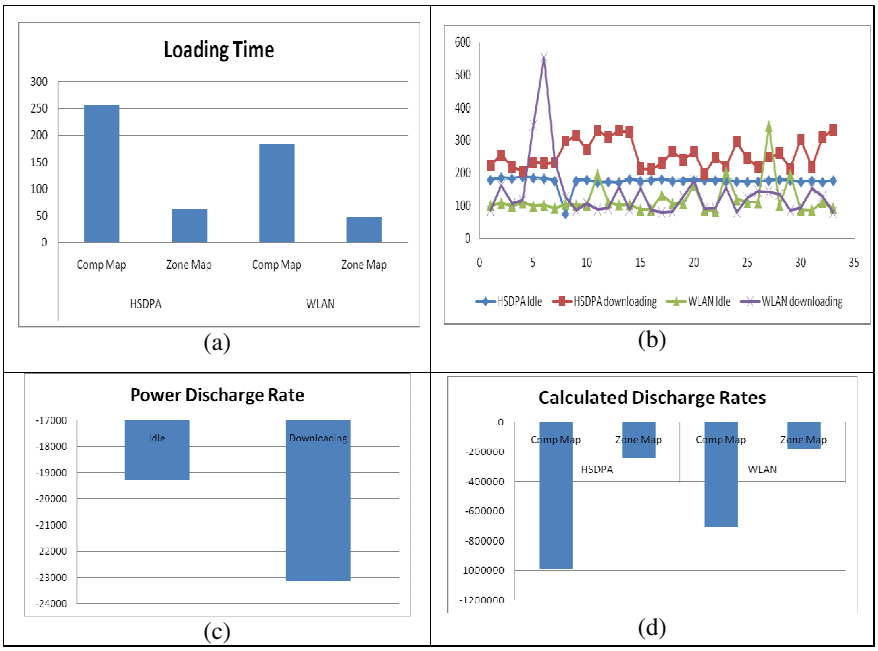


Fig. 5 Experimental Results

The delay was high when the user was accessing the network (map downloading). Whereas, reducing the amount of data transferred between the server and the mobile device using zone-based update mechanism has reduced the demand on the mobile network bandwidth and contributed to the reduction of the cost of accessing the mobile network. As a result of using small size map, the overhead on the network has been reduced significantly.

The third task of the experiment was to measure the discharge rate of the laptop battery (Figure 5 (c)), which was accomplished through monitoring the battery in two cases:

a. Idle mode (no heavy application is running)
b. Downloading mode (downloading the map)

Evidently, from the results obtained, the use of zone-based mechanism can directly affect the performance of the mobile device. This can be seen through comparing the power consumption in each case (whole map and zone-based). The calculated total discharge rate from the whole and small maps can be seen in figure 5 (d). The use of the zone-based mechanism can allow the mobile device battery to last longer, which can be beneficial in case the end user cannot recharge the mobile device in emergency situations. Another benefit is better utilization and management of the storage space. This is important when the mobile device storage capability is limited. Zone-based mechanism allows the user to benefit from LBS server and use the rest of the memory for other applications. Moreover, dealing with a smaller sized database can help in responding to the user's query quicker.

4 Conclusion and further work

At this paper, a zone-based strategy for improving LBS performance has been investigated. A prototype has been implemented and evaluated. The results obtained from this work showed that this mechanism has contributed in reducing the size of information significantly. Moreover, this mechanism has minimised unnecessary cost which might be added due to uploading redundant information by the end users which affected and enhanced the overall LBS performance. Full implementation for this mechanism will be conducted to fully evaluate and test the new system.

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