Location-Based Mixed-Map Application Development for Mobile Devices

Hyo-Haeng Lee, Kil-Ram Ha, and Kwang-Seok Hong

School of Information and Communication Engineering, Sungkyunkwan University, 300, Chunchun-dong, Jangan-gu, Suwon, Kyungki-do, 440-746, Korea
hyohaeng@skku.edu, hgr81@skku.edu, kshong@skku.ac.kr

Abstract. This study proposes a Mixed-Map based on a mobile device. The proposed mobile Mixed-Map is designed to download 2-dimensional and 3-dimensional data provided by Google maps and Yahoo maps. It then controls the map data independently. A variety of applications can be implemented. Transferring geographical data from a web geographical information system can improve efficiency by reducing response time. It adopts a tile cache method to provide continuous service when a wireless internet cannot be connected. As an example of the proposed system, we implemented a real-time location tracking system application between mobile devices that obtains current location and GPS information in real-time using GPS. The Mixed-Map can be easily applied to different technologies as the application does not simply rely on API in the ubiquitous environment. The study develops and suggests basic technologies necessary for a ubiquitous geographic information system.

Keywords: Mixed-Map, Mobile, GPS, Map.

1 Introduction

Ubiquitous is a new paradigm in computer systems. It is defined as the effort to enable intelligent services between physical devices and to simultaneously connect diverse objects. Ubiquitous computing is a concept where every object including roads, tunnels, buildings, and other structures are added with computer functions. This creates intelligent objects and targets, enabling sharing of information without limitations of time and space [1]. It is a computing environment that transcends existing home network or mobile computing. Ubiquitous computing entails connection of all computers, where connections are invisible to users and in which information processing has been thoroughly integrated into everyday objects and the environment.

The ubiquitous network allows anyone at anytime to share information without limitations on speed and space [1]. That is, it overcomes various limitations of existing network and service, allowing users to access IT service freely. In particular, by utilizing various sensors in conjunction with a ubiquitous network, it can create a community regardless of time and space. It makes facilitates context-awareness and location awareness of people and objects.

U-LBS (Ubiquitous Location Based Services) service has come to the fore in providing a service based on this model. The location recognition system technology,

M.J. Smith and G. Salvendy (Eds.): Human Interface, Part II, HCII 2009, LNCS 5618, pp. 403–412, 2009.

one of the most important technologies in providing a ubiquitous location service, is actively being researched in many countries.

In this paper, we applied a mixed-map for ubiquitous and propose mobile based location tracking utilizing WiBro and GPS.

This remainder of this paper is structured as follows: In section 2, we introduce related work including Google maps, Yahoo maps services, GPS and WiBro. We describe the proposed mixed mobile map device-based real-time location tracking system using a GPS module, TCP/IP protocol and WiBro in section 3. In section 4, we evaluate performance obtained from experimental observations. Section 5 summarizes this paper; we outline challenges and future directions.

2 Related Work

Research on location-based service has been actively pursued for several years. A number of research projects have experimented with attaching digital information to locations. The mobile generation does not restrict users to a fixed desktop location but allows mobile computing, anywhere anytime. Web map service based applications provide wide functionality to mobile users. Google Maps Mobile [2] and Microsoft Mobile map [3] are prominent examples of mobile geospatial services. PDAs, mobile phones and other portable devices are increasingly provisioned to have location awareness via GPS devices.

Satellite image service offered by Google Map [4] is better than either Microsoft live search maps [5] or Yahoo Map [6] service in terms of sharpness; it fares poorly on map readability compared to Yahoo. The street map service is inconsistent depending on the country. For instance, in case of Yahoo, the signs and colors indicating highways, national roads, country roads, subways and others are similar to actual maps, making it easier for users to use the map services.

Mobile devices have several limitations compared to desktop computers. Consequently web map applications developed for the desktop cannot be easily ported to mobile environments. Limitations on memory size, processor, battery and connectivity further reduce performance, hindering the development of complex applications.

Location positioning for handsets requesting services can use the GPS or the locations of base stations of a wireless network. Location positioning techniques can be divided into network, handset, and hybrid methods, the latter combining the first two [7] [8].

This paper uses Google and Yahoo maps, instead of using API. By saving map information, it increases processing speed and system stability. Using GPS and WiBro, we propose a real-time location tracking service anytime, anywhere between mobile devices.

3 Location-Based Mixed-Map System for Mobile Device

3.1 System Architecture

Fig 1 shows the System Architecture of the Mixed-mobile device based real-time tracking system, proposed in this paper.

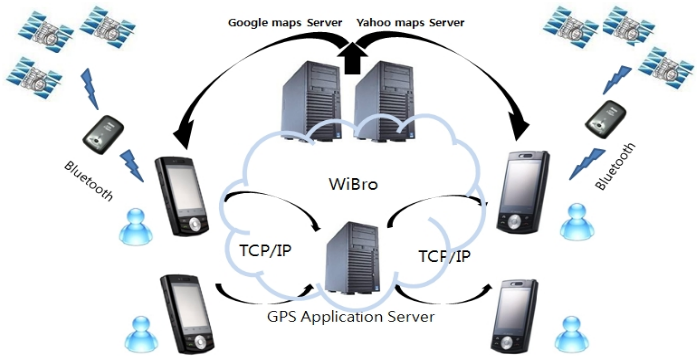

Fig. 1. Mixed mobile map device architecture based real-time tracking system

The user receives the desired information from the mobile device, mounted with a GPS receiver, to access the location-based service. When the client transfers longitude and latitude data received from the GPS receiver to the GPS application server via WiBro using TCP/IP, other mobile client users may convey map data of Google maps and Yahoo maps, accessing the GPS application server.

3.2 GPS

GPS is a satellite-based navigation system consisting of a network of 24 orbiting satellites in six different orbital paths [9]. The satellites are constantly moving, making two complete orbits around the Earth in just less than 24 hours.

The identifier is followed by the sequence of the l data fields, delimited by a comma. The terminal character is an asterisk, followed by a checksum value.

A common NMEA Sentence used for location is:

GPRMC,021708.000,A,3717.6037,N,12658.6239,E,2.07,23.75,280907,,,A
GPGGA,021709.000,3717.6077,N,12658.6237,E,1,04,2.3,77.1,M,19.6,M,,0000
GPGSA,A,3,16,14,07,01,,,,,,,,,5.3,2.3,4.7
GPRMC,021709.000,A,3717.6077,N,12658.6237,E,2.14,17.03,280907,,,A
GPGGA,021710.000,3717.6102,N,12658.6233,E,1,04,2.3,61.1,M,19.6,M,,0000
GPGSA,A,3,16,14,07,01,,,,,,,,,5.3,2.3,4.7
GPRMC,021710.000,A,3717.6102,N,12658.6233,E,2.31,9.15,280907,,,A

The $GPGGA sentence has other information including Latitude, Longitude and Altitude [10].

Most mapping applications require latitude and longitude information to be represented as signed decimal degrees, with negative latitudes for south and negative longitudes for west. This paper converts latitude and longitude information from the "degrees, minutes, and decimal minutes" format to the "decimal degree."

3.3 Map Analysis

The Google maps server and Yahoo maps server contain vast earth image databases. All the major tile-based map interfaces (Google Maps, Microsoft Virtual Earth and Yahoo Maps) map the spherical Mercator system to tiles.

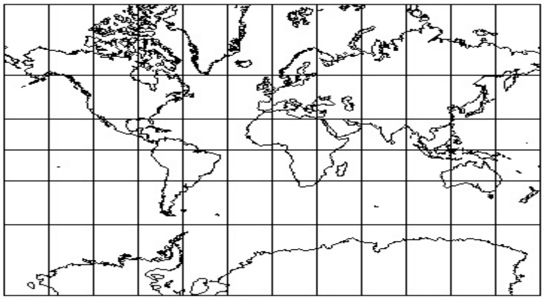

Fig. 2. A Mercator projection map of the earth

Fig 2 is a Mercator projection map of the earth. Equations (1) and (2) determine the x and y coordinates of a point on a Mercator map from its latitude φ and longitude λ (with λ_0 being the longitude in the center of map) [11].

$$TileX = \lambda - \lambda_0 \tag{1}$$

$$\begin{aligned} TileY &= \ln(\tan(\frac{\pi}{4} + \frac{\varphi}{2})) \\ &= \frac{1}{2}\ln(\frac{1+\sin(\varphi)}{1-\sin(\varphi)}) \\ &= \sinh^{-1}(\tan(\varphi)) \\ &= \tanh^{-1}(\sin(\varphi)) \\ &= \ln(\tan(\varphi) + \sec(\varphi)). \end{aligned} \tag{2}$$

The scale is proportional to the secant of the latitude φ, getting arbitrarily large near the poles, where $\varphi = \pm 90°$. The pole's y is plus or minus infinity as seen from the formulae. Google maps and Yahoo maps maximum latitude φ occurs at ±85.05113 degrees when the Mercator y value = π [11].

To calculate the PixelX and PixelY coordinates of the tile, the author first determine the latitude and longitude of the upper left and lower right corner of the tile. Since the author knows each tile is 256 x 256 pixels, and the author now have the decimal TileX and TileY coordinates, this is a simple calculation. For the upper left corner:

$$\begin{aligned} PixelX\max &= (TileX + 1)\cdot 256 - 1 \\ PixelY\max &= (TileY + 1)\cdot 256 - 1 \end{aligned} \tag{3}$$

$$\begin{aligned} PixelY\min &= TileX \cdot 256 \\ PixelX\min &= TileX \cdot 256 \end{aligned} \tag{4}$$

The mathematics to calculate the latitude and longitude of the upper left and the lower right corner is a little bit more complicated, since the author has to consider that the tile is a flat object, but the latitude and longitude are in the WGS84.

The formula to calculate the latitude is

$$LatitudeMax = a\sin\left(\frac{e^{(0.5-\frac{PixelY\max}{256\cdot 2^{Zoom}})\cdot 4\cdot\pi}-1}{e^{(0.5-\frac{PixelY\max}{256\cdot 2^{Zoom}})\cdot 4\cdot\pi}+1}\right)\cdot\frac{180}{\pi} \tag{5}$$

$$LatitudeMin = a\sin\left(\frac{e^{(0.5-\frac{PixelY\min}{256\cdot 2^{Zoom}})\cdot 4\cdot\pi}-1}{e^{(0.5-\frac{PixelY\min}{256\cdot 2^{Zoom}})\cdot 4\cdot\pi}+1}\right)\cdot\frac{180}{\pi}$$

The formula to calculate the longitude is

$$LongitudeMax = \frac{PixelX\max\cdot 360}{256\cdot 2^{Zoom}}-180 \tag{6}$$

$$LongitudeMin = \frac{PixelX\min\cdot 360}{256\cdot 2^{Zoom}}-180$$

The author can identify the latitude and longitude coordinates in the tile with the equation stated above. The latitude and longitude coordinates received from GPS were applied to the tile system in this paper.

Google maps and Yahoo maps hold the world in a number of 256x256 pixel tiles. A tile is a raster image, usually a JPEG or PNG file. Tiles form a zoom pyramid with the whole globe covered by one tile, at the next zoom level there are 4 tiles, then 16 tiles, and so on. Zoom level ranges from 18 to 1. Each Yahoo tile has corresponding latitude, longitude and zoom values. Yahoo uses an x, y coordinate system combined with a zoom value to specify the tiles to retrieve from the server.

Fig. 3. Yahoo street map

Fig 3 shows the URL of a tile takes the form of: http://kr.tile.maps.yahoo.com/tl?locale=kr&v=4.1&t=m&x=27948&y=3688&z=3 using x and y for the tile coordinates, and the zoom factor. At factor 17, the earth is divided in 2x2 parts, where 0<=x<=1 and 0>=y>=-1. At each zoom step, each tile is divided into four parts. So at a zoom factor z, the number of horizontal and vertical tiles is 2^ (17-z). The number of map tiles for each zoom level is given by formula [12] [13].

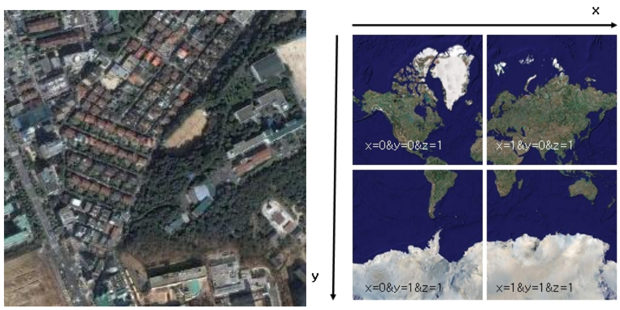

Fig. 4. Google satellite map

Processing Google satellite maps resembles that from Yahoo street maps. Fig 4 is an image of the entire earth retrieved by the web address http://khm1.google.com/kh?v=33&hl=ko&x=55897&y=25390&z=16.

At zoom 0 the entire world is captured in one tile. At zoom 18 the world spreads over 68,719,476,736 tiles. With every increment of the zoom the width/height of the bitmap doubles, so the image area size is multiplied by four each time. At factor 0, the entire earth is one tile where x=0 and y=0. At factor 1, the earth is divided in 2x2 parts, where 0<=x<=1 and 0<=y<=1.

3.4 Tile Image Storage and Display

With Google and Yahoo maps data, there may be frequent disconnections during communication due to prolonged database system manipulation by the users.

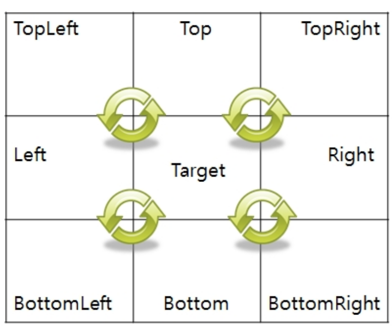

Fig. 5. Tile image storage and display system

Fig 5 shows the focus on the target if we save eight tiles near the target; we could display a map on a screen promptly, as well as using the map without the interruption of map data. Even in a case where Internet connection has been disconnected and we cannot access the Google or Yahoo map service, we can use saved map data.

3.5 GPS Server

This study requires a GPS application server in mobile devices for wireless communication. If a mobile device user acquires GPS location information, the acquired location information is transferred to the GPS application server after transforming the coordinates. Then other mobile device users access the multi-user real-time location information from the GPS application server.

This study designed and implemented mobile device-based real-time location tracking for a mobile web map that can offer real-time location tracking service among multiple users in mobile environments using TCP/IP and a GPS application server.

3.6 WiBro

WiBro (Wireless Broadband Internet) refers to the technology that offers wireless Internet connection at high transmission speed anywhere, anytime, guarantees mobility to the public transportation speed (120 km/h) or higher in downtown areas, and enables broadband multimedia services [7].

WiBro terminals and systems were developed at the end of 2004 by Korean engineers. WiBro was approved as a reference standard for mobile BWA (broadband wireless access) in the general meeting of the ITU-RSG 8 on September 2006 [7].

4 Experiments and Results

The Mobile device was implemented in C# using Microsoft.Net Compact Framework 2.0 and Windows Mobile 5.0 Pocket PC SDK. Two mobile devices were used during the trial, running the Windows mobile Pocket PC 2005 operating system. The Samsung SPH-M8200 mobile devices were used with the GPS module.

Field tests were performed in the WiBro environment by walking at 5km/h and driving at 100km/h speed and receiving GPS data.

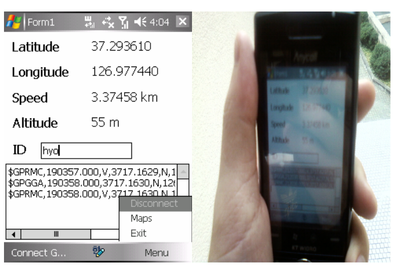

Fig. 6. User interface for GPS information

Fig 6 shows latitude, longitude, speed, and altitude of GPS data in a Samsung SPH-M8200 Mobile device.

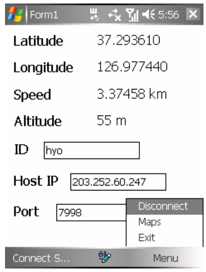

Fig. 7. User interface for login

Fig 7 shows a mobile device for tracking location in real-time, a host address and a port number to login to the server.

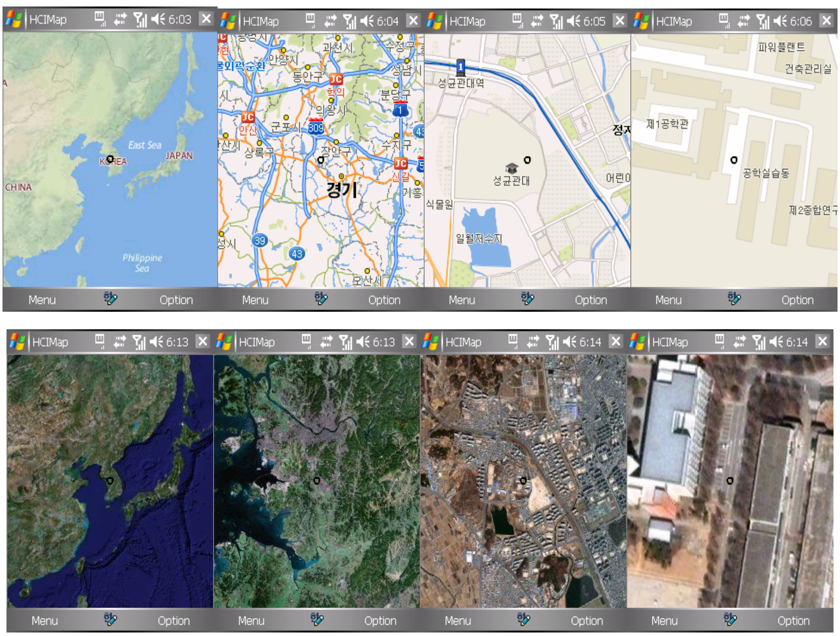

Fig. 8. A Yahoo street map and a Google satellite map

Fig 8 shows a Yahoo street map and a Google satellite map downloaded from the Google map server and yahoo map server.

The latitude and longitude information obtained from a GPS device allows us to display a current location in a mobile device in real-time and transmit the information to the server through TCP/IP.

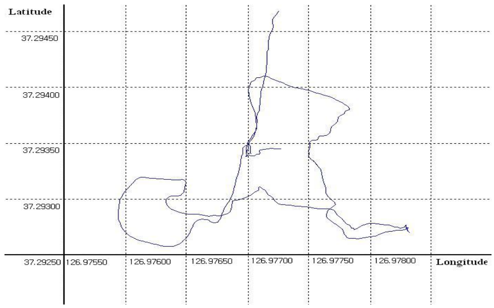

Fig. 9. Location log

Fig 9 shows the GPS location log, received at the campus, representing a five minutes walk at an average speed of 5 km/h. The X-axis is the Longitude and Y-axis is Latitude.

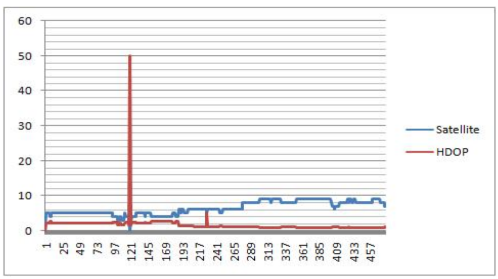

Fig. 10. Number of satellites and HDOP

As shown in Fig 10, the error value increased in the actual test, as the number of satellites decreased, and the HDOP value increased between buildings. Map data of the Google Maps server and Yahoo Maps server were rapidly updated in the mobile devices. Wireless internet communication for real-time location tracking among mobile devices is appropriate for location detection, as confirmed in the experiment.

5 Conclusion

The Mixed-Map can be easily adapted to various technologies, as the application does not rely on the API in the ubiquitous environment. This sharing reduces development cost and time to provide rich functionality and data. The new design exhibits high feasibility in Mixed-map.

The study develops and suggests basic technologies necessary for a mobile HCI (Human-computer interaction). The study will be extended in the future to add functions to improve user convenience.

Acknowledgments

This research was supported by the Korea Science and Engineering Foundation (KOSEF) grant funded by the Korea government (MEST) (No. 2008-000-10642-0).

References

1. Wikipedia, http://en.wikipedia.org/wiki/Ubiquitous_computing
2. Google maps mobile, http://www.google.com/gmm/
3. Microsoft mobile map, http://livesearchmobile.com/windows_mobile.htm
4. Google maps, http://maps.google.com
5. Microsoft live search maps, http://maps.live.com
6. Yahoo maps, http://kr.gugi.yahoo.com/map/
7. Adusei, I.K., Kyamakya, K., Jobmann, K.: Mobile Positioning Technologies in Cellular Networks: An Evaluation of Their Performance Metrics. In: MILCOM 2002 Proc., vol. 2, pp. 1239–1244 (2002)
8. Syrjärinne, J.: Studies of Modern Technologies for Personal Positioning. Doctor of Technology Thesis Work, Tampere University of Technology (2001)
9. GPS, http://en.wikipedia.org/wiki/GPS
10. NMEA data, http://www.gpsinformation.org/dale/nmea.htm
11. Mercator Projection, http://en.wikipedia.org/wiki/Mercator_projection
12. Simple Analysis of Google Map and Satellites, http://dunck.Us/collab/Simple_20Anysis_20of_20Google_20Map_20and_20Satellite_20Tiles
13. Add Your Own Custom Map, http://mapki.com/wiki/Add_Your_Own_Custom_Map