# Location Based Services: Architecture, Mapping, Transportation GIS

Andreja Samčović, Zoran Bojković

*Abstract* - **Geographic information system is an important element in any of the location applications since it contains all the necessary geographic information of the cities, roads, streets. The information is obtained from sources such as topographic maps as well as satellite images which are then filtered and delivered to the applications. Starting from this point, this paper seeks to provide multimedia location based service architecture together with location based mapping system. The navigation application prototype is regarded as a GIS-based routing solution. Transportation GIS concludes this presentation.**

*Keywords* – **location, GIS, architecture, mapping, routing, Internet.**

## I. Introduction

Geographic information system (GIS) is an important element in any of the ubiquitous location-applications since it contains all the geographical information of the cities, roads, streets. This information is obtained from sources such topographic maps and satellite images which are then filtered and delivered to the applications [1]. Mobile geographic applications are characterized by their ability to support intinerant, distributed and ubiquitous computing. Intinerant means providing computing capability while moving with a person. Distributed means integrating functions that are performed at different places in a way that is transparent to the user. Ubiquitous means delivering the same functionality independent of a user's location [2].

The term location-based service (LBS) has been suggested to describe GIS applications. In these applications geographic data and processing are provided as a type of service over a wireless network connection. This means that simple, low powered devices, such as mobile phones can take advantage of geography. The term "mobile geographic service" is preferred here because of its wider definition and focus on geography and GIS [3].

Many methods of wireless communication are available for mobile geographic systems including radio communication, but commercial cellular telephone systems are increasingly preferred. There are several options available for low and high level communication over cellular telephone networks [4].

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In the last years there have been enormous protocols associated with Wireless Access Protocol (WAP). The WAP specification encompasses a relative simple and compact version of eXtended Markup Language (XML) called Wireless Markup Language (WML) suitable for issuing requests to servers and returning results. WAP also supports the inclusion of wireless bitmap (WBMAP) files. Thus, it is possible to make requests to a geographic service from a WAP phone and returns the results as a display page (called a card) containing a map in the form of an embedded bitmap. As the hardware capabilities of client devices to improve, software applications become more advanced and bandwidth limitations are alleviated, greater interest will focus on using the more, widely accepted Hyper Text Markup Language (HTML) and XML protocols. HTML is concerned with data presentation, whereas the more extensive XML supports data content description and structuring [5].

The Global Positioning System (GPS) offers the highest location data quality. There are some limitations in the use of GPS, especially the requirement for line of sight, added cost and the time it takes to obtain a signal. Some systems may be completed by additional GPS receivers located a fixed position [6]. This improves location calculation from 20-45 seconds to 1-8 seconds. Cellular telephone systems divide geography into base station coverage areas typically of several kilometers in size; although in urban area they can be as small as 10 m. Only the finest resolution of data is of use to mobile geographic service users [7].

This paper presents location-based system architecture, together with location-based mapping system. Transportation GIS is also taken into account. Concluding remarks are given at the end of the presentation.

## II. Location-Based Service Architecture

In designing information systems that support Location-Based Services (LBS) emphasis is given to scalability, distribution and interoperability through the use of broadly accepted information access protocols. Scalability and distribution refers to the capability of autonomous management of separate parts of the available information. The information access protocols when standardized, give the opportunity to the system designer to use already well-defined interfaces. The ontologies used to describe the available information should be based on standards, which allow the easy management of the information. The approach for the architectural design of LBS system is based on those principles.

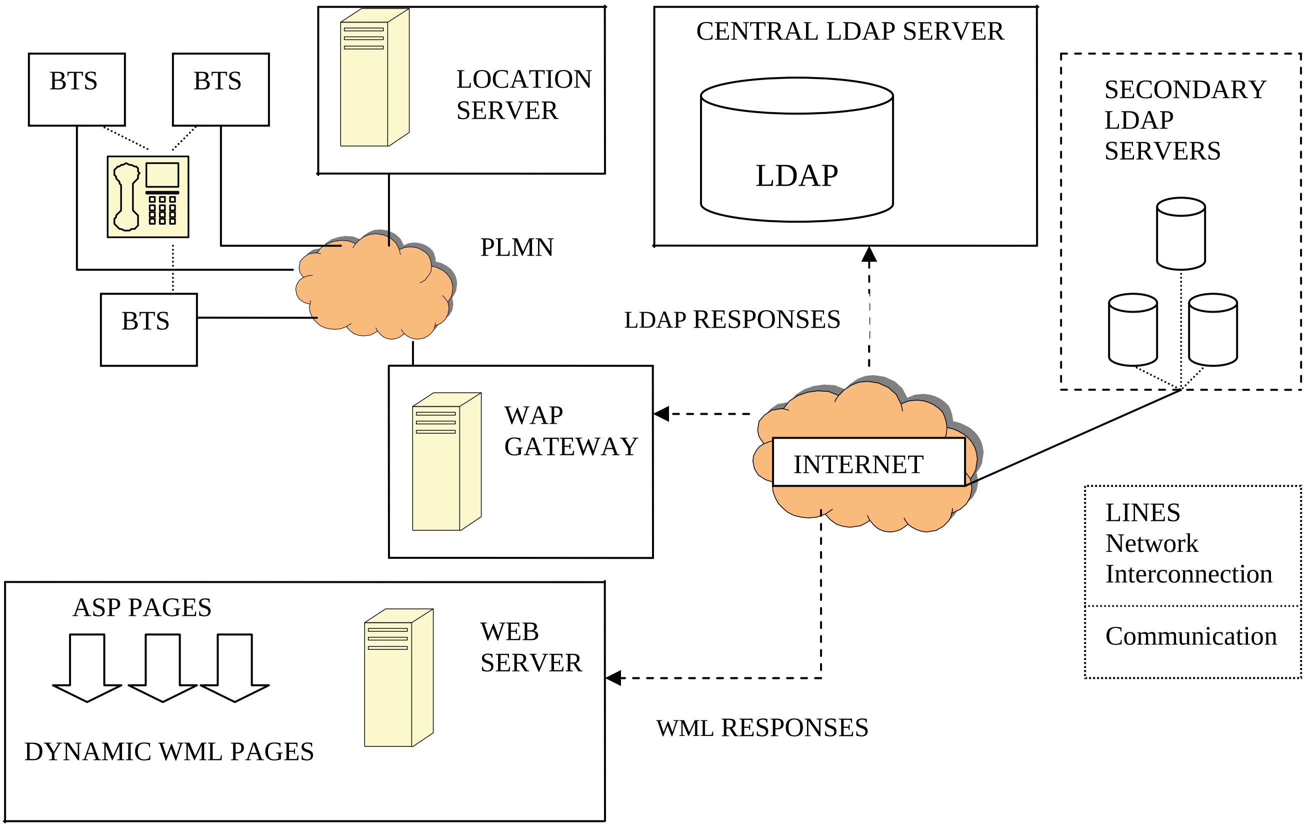


Fig. 1. Location-based services system architecture

LBS system architecture is shown in Figure 1. The user communicates with a Web server over the Wireless Application Protocol (WAP) through a WAP Gateway. The information which is sent to the Web Server upon service initiation is the user's id (identity), password and telephone number. All this information is used by the system for authentication purposes.

In order for the Web Server to grand user access, the information is sent to the Location Server. If the user is in the access lists of the Location Server, then access is granted and the user's current position is recorded and sent back to the Web Server. It informs the user for successful sign in and allows the user to select the product categories in which he is interested. Upon user selection the Web Server communicates with the Lightweight Directory Access Protocol (LDAP) Server in order to create a list with all the available supermarkets located near the user. Let us take an example.

The main building blocks for the proposed system are: Web Server, Location Server, LDAP Server. Note that BTS denotes Base Transceiver Station, while PLMN denotes Public Land Mobile Network [8].

The Web Server acts as a central management unit being responsible for: user interface, communication with the Location Server and communication with the LDAP Server. The Web Server hosts static pages as well as dynamic pages which generate new Wireless Markup Language (WML) pages. ASP represent Active Service Pages. The distinction between static and dynamic pages exists because only a part of the user's interface remains the same (user authentication), while the rest contains pages, while content is dependent on the user's location, the choices he has made and the contents of the product-promotion information base.

The Web Server constructs positioning requests, forwards them to the Location Server and then accepts the positioning replies from the Location Server. The requests and replies are constructed as eXtensible Markup Language (XML) documents following the Mobile Positioning Protocol (MPP) and the Web Server has the ability to compose and decompose these documents in order to encapsulate or derive information, respectively. The MPP protocol is a kind of implementation of the official prototype Mobile Location Protocol (MLP) which is being developed by Location Interoperability Forum (LIF) and which describes the communication between an application and a Location Server.

The LDAP server waits for LDAP requests, which corresponds to search queries on its content. After processing the request, the LDAP server returns an LDAP response. Using the user's location information and the choices the user has made, the Web Server forms appropriate LDAP requests (following the LDAP v3 protocol specifications) and forwards them to the LDAP Server. Then, based on the LDAP responses received, the Web Server dynamically creates new pages containing the results and offers them to the user.

The Location Server performs two tasks. The first one is to authenticate user access to the system and the second one is to provide user location information. During access control the Location Server checks user credentials (id, password, telephone number). If any of these credentials does not match to the records of an access list kept on the Location Server, then an appropriate message is returned to the Web Server. User credentials are transferred from the Web Server to the Location Server with the help of the MPP protocol. Upon successful authentication, the Web Server constructs a positioning request (in XML) for the particular user and forwards it through an HyperText Transport Protocol (HTTP) request to the Location Server. The Location Server communicates with various network elements and initiates the appropriate positioning methods. When the user's location information arrives to the Location Server, it constructs (in XML) a positioning reply containing this information and returns it to the Web Server. If the user could not be located by the system, the Location Server returns a positioning reply containing a failure notification.

## III. Location-Based Mapping System

The technology of mobile mapping is expanding significantly due to the rising exceptions of consumers. The mobile mapping technology incorporates GIS features. Routing GIS-based solution is becoming very popular and is useful in mobile mapping. The users provide input for the start and the destination point into the mapping mobile system. The system will next display a highlighted route in an image, text or voice format. The navigation application prototype is regarded as a GIS-based routing solution: collecting, storing, searching and retrieving roads and street information, manipulating and calculating the shortest path from one location to another.

The shortest path navigation application is an extension of a larger system known as the “Location based mapping system“. The aim is to develop a mobile mapping system that would serve maps of a requested location to a WAP phone.

Figure 2 shows the conceptual infrastructure of the location based mapping system. There are three major parts of this system, which are the WAP phone, the Web Server and the GIS Server. The WAP phone communicates with the Web Server using WML/WML Scripts and these WMP pages on the Web Server communicate with the GIS Server using the Internet Map Server (IMS). Any search that is carried out on the GIS Server will return the results to the Web Server and WAP phone in WML pages.

The mobile applications could deliver the Map information in different ways such as text (address and phone of nearest bank, driving direction, job dispatch operations based on user’s location), image (the path to the service location, on a map), voice (driving directions, job dispatch operations), video (fly-by movies, traffic congestion status). Such location-based applications could search the map database for locations queried according to the preferences given by the user. The user could request information regarding any facility like hotels, banks, etc. around any given location within certain radius. The user’s location itself can be taken from the GPS device if it is allocated to the mobile terminal.

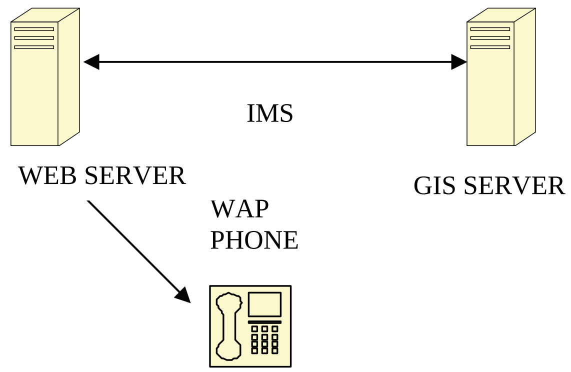


Fig. 2. Conceptual infrastructure of the location-based mapping system

There are certain advantages in which mobile mapping has over traditional map-display systems. Mobile mapping provides access to map related information anywhere anytime. The data itself is being accessed, is current, updated and stored centrally in a single location. Therefore, it is convenient medium of dissipating information. It is a secure and private medium, too. The additional advantage here is the scope of providing Location-based services, as the location of the user would be known by one of the location finding systems. The mobile user would not require much infrastructure/hardware as he would normally require access Map information.

## IV. Transportation GIS

Geographic Information System (GIS) is a spatial database. Geographic locations are stored as sets of mathematical coordinates. Information about the location is stored in tables that are linked to the locations. We can use GIS to make maps (for example, maps of street networks, of train lines, of bus routes). Because digital maps can be updated constantly, one can make maps of routes that change from day to day.

Transportation departments use GIS to design and construct highways, taking into account not only the physical realities of slope and drainage, but less tangible qualities like fragile environments and scenic beauties. Safety engineers use GIS to look for places where the same types of accidents occur so they can redesign the roads or change the signs and signals.

Urban traffic engineers use GIS to keep traffic moving smoothly and safely along the streets of their cities. Diagrams of intersections and inventories of signal control equipment are integrated into their system databases. The locations of signals are tied to streets, accident files, and traffic data. GIS is used to predict future congestion and pollution, too, and to solve those problems as well. GIS gives engineers the data-based means to encourage people to reduce their dependence on new roads: to stop driving alone and ride in carpools, use public transit, ride bicycles, stagger work shifts, or even work at home. GIS helps match carpoolers by where they live and work, by the hours they work, and even by whether they prefer to ride or drive. Some times ago, GIS has been incorporated into the emerging area of intelligent transportation systems. Here, traditional basemaps are updated in real time with information on traffic levels, which is then provided to traffic operations, enforcement and emergency response teams.

With GIS playing a larger role in transportation industry, state and local governments, as well as public transport operators have a wider variety of instruments and tools for collecting and processing data.

In movement sensors, red-light cameras, and closed-caption television (CCTV) equipment are being installed at intersections or along highways to help detect the speed and volume of traffic blow and adjust signs and signals accordingly. Global positioning systems (GPS) are being installed in taxis, trains and even snow blows. Onboard computers can collect information from vehicle's operating system and upload it by satellite link, along with the vehicle's position obtained by a GIS receiver. All of the above are examples of data that can be loaded into a GIS.

In computer world, railways around the world use GIS to manage real estate and facility databases to organize data for several different departments: engineering, emergency operations, and railway maintenance among others. They use GIS to keep track of where locomotives are as they run, so any problems (detected with on board sensors) can be required immediately at the nearest service facility. Commuter railways, subways, and light rail operators are starting to provide electronic maps to customers, at stations and over the Internet, showing train positions and arrival and departure times.

Public transport agencies use GIS to plan and analyze bus routes, combining route databases with residential and business demographics to find ways to get more rides and to lower costs.

Airport authorities use GIS to plan runways and parking lots, but they also use its three-dimensional capabilities to look at flight paths and the noise contours generated by passing planes. With this information, they can plan landing and takeoff paths that stay clear of tall buildings and away from residential areas. Airlines use these systems to analyze flight routes and plane capacities to see where they might add a route or change a destination and to plan rerouting when weather forces some airports to close.

## V. Conclusions and Future Applications

Location-based services (LBS) can be defined as any service or application that extends spatial information processing or GIS capabilities to end users via the Internet and/or wireless network. Such services combine scalable GIS technology, easy-to-use browsers, mobile and wireless devices and wireless and Internet infrastructure with Web Servers to provide information and services whenever and wherever they are needed. Thanks to GIS, computer programming and a little intellectual ingenuity, LBS now has the ability to provide a solution to the persisting problem of the intractable incapability of prevalent technology to extend utile spatial information to a user in terms of his/her geographical location.

As wireless Internet access becomes more popular and cheaper, mobile mapping will allow along with Wireless Internet. Providing Map content to the mobile terminal is easy. Many studies indicate that there will be more people accessing Internet through mobile devices than desktop computers. Mobile mapping is a good contender to provide killer applications in this convergent world. As the first truly open standard for intelligent messaging services for digital mobile phones and other mobile terminals, the WAP protocol will lead to a wireless data boom in the mass market.

Finally, GIS has the potential to be the integrating technology for all aspects of the telecommunication industry. Today it is commonly used in typical automated mapping/facilities management applications such as planning, fault tracing, and engineering design. However, there is a greater use of GIS in applications such as demand forecasting, system design, and strategic marketing. GIS will help provide a much better comprehension of market segmentation and the recognition of population distribution patterns. This will allow the industry a greater understanding of their customer base and allow it to better provide optimal products and services.

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