Proceedings of the 6th AGILE
April 24th-26th, 2003 – Lyon, France

AN OBJECT ORIENTED MODEL FOR DYNAMIC GEOGRAPHICAL INFORMATION SYSTEMS AND LOCATION BASED SERVICES

Oscar Luiz Monteiro de Farias, D. Sc., João Araújo Ribeiro, Dr., Cleber Pereira de Oliveira, M. Sc. student.

Universidade do Estado do Rio de Janeiro - Centro de Tecnologia e Ciências - Faculdade de Engenharia, Departamento de Engenharia de Sistemas e Computação, tel.: (+55) (21) 587-7442, fax.: (+55) (21) 587-7374
{fariasol, araujo, cleber}@eng.uerj.br

1. INTRODUCTION

New technologies in Mobile Communications Systems, Global Positioning Systems (GPS) and Mobile Computers gave rise to a new class of services, the Location Based Services (LBS), applications with characteristics of Dynamic GIS. In this kind of services, users receive, in an automatic and dynamic fashion, according to their position in space, information related to specific services. This paper proposes an Object Oriented Model, that could be thought as a ontology [1] for every kind of application based on Location Based Services, that is, applications that enable devices to exploit their location or mobility, or the location or mobility of other devices in real time [2], [3], and render the information recovered, that depends on the location, to the client(s). These category of application or service includes: News, Navigation Systems, Traffic Systems, Emergency Services, Tracking Freight , Military Applications, etc. The proposed Model adheres strictly to the *Open GIS Consortium (OGC)* recommendations and specifications, in order to incorporate the GIS standards and to boost the dissemination and use of LBSs.

2. AN OVERVIEW OF LBS

In LBS category of services, Information Providers distribute, through the Internet and also through the telecommunication network (eg. cellular network), to some clients, based in their profile and spatial position, information associated with some Spatial Objects, that is objects that are somewhere located in the space. Each of these Spatial Objects owns a given influence area (Fig. 1). For example, when traffic accidents happen in a region near a X-hospital, it would be more probable that the injured people should be attended by this X-hospital. This defines an influence area related to the X-hospital. Specific information is distributed to users/clients that enter some pre-defined influence-area. In the hospital case this information could be, for example, a map showing the hospital location and the shortest (fastest) route from the user actual location to the hospital. Besides that, some information describing the medical services offered by the hospital could be send to the user.

Location Based Services (LBS) are based in the following infrastructure: *i) a Position Determining Equipment (PDE) and some method to compute the location of a mobile device (user or client)* - When the mobile device itself determines its position, it comprises also a GPS; when the determination of the user location is responsibility from the telecommunication network, the PDE itself is located in the switches of the telecommunication company. *ii) Information Providers* – represent companies, organizations or entities aiming to offer some service to the Internet spectrum, based in the user spatial

location. The main characteristics of these LBS should be: web-enabled, in the sense that the service/information is available to anyone, anywhere, anytime and on any device; efficient and easy to use; integrated to the enterprise environment [4]; *iii) Network services* – Comprise all the infrastructure services provided for the Internet and telecommunication companies. In this case fall, for example, the several layers of the Internet network providing reliable information transmission between any two nodes on the network. LBS can trust entirely on these network services and they are fully standardized, and so, we will not consider these services in our model; iv) *An Event Handler* - this logic piece detects when some user enters the influence area of a geographical/spatial object. The corresponding Information Provider is notified, in order it can send the user specific information related to the services offered by the spatial objects managed by him.

Some examples of LBS are listed below [5]:

- Military applications, for example, commandos that have a special target to reach; Typically a soldier in a battle field should have access, via a handheld device, to a small map, where are plotted its position and targets;
- Emergency services that could be drive-oriented according to the user spatial position (eg. *"Help! My ship is sinking at latitude X, longitude Y!* ") [6].
- Vehicle navigation;
- Objects tracking (vehicles, humans and animals). For example, a study about the behavior of some endangered specimen (Panda bear, for instance)
- Service Information, such as tourist Information (*"What are the hotels near here (my current position) and their respective prices?"); ("What are the Italian restaurants near me?"); Delivery Services ("Please send me a Mushroom Pizza");*
- Yellow Page Services, in general;
- Traffic Information, for example, some broadcast information delivered to all vehicles found in a given area *("An accident at Golden Gate between two trucks...").*

3. AN OBJECT ORIENTED MODEL FOR DYNAMIC GIS AND LOCATION BASED SERVICES

A common approach to LBS is necessary for the sake of interoperability among different kind of services, allowing the share of information and services from different sources and companies and, also, economies of scale. An Object Oriented Model [7], that follows strictly the recommendations of the Open GIS Consortium [9], [and, in particular, its initiative for reaching a standard for Location Services [8], could boost the dissemination and wide use of LBSs. Notwithstanding, until now, the Open GIS specifications that have a class diagram are restricted to the feature related classes, as is the case for the Geographic Markup Language (GML) Specification [10]. So, we propose in this extend abstract an Object Oriented Model for a generic LBS As the GML presents a well defined class structure, we will use the GMLs *Feature* and *Geometry schemas* integrally. For the other structures of the Model we define a class hierarchy that follows, as close as possible, the definitions found in the Open GIS abstract and implementation specifications. This class structure, together with a data dictionary, can be thought as an ontology for every kind of Location Based Services [11]. People can build new classes derived from the classes proposed is this LBS Object Oriented Model, and, with minimum effort, develop solutions for a particular LBS, thanks to some OO mechanisms, like inheritance and polymorphism.

The classes of the Model are directly mapped from the categories of objects found in the problem domain, briefly described in the first part of this extended abstract. For lack of space, however, is virtually impossible to present in detail, even the main classes of the Model, not to speak in several other classes needed to achieve an efficient implementation

of Location Based Services. In spite of this, a Collaboration Diagram [7] can give us an insight in the Model and in the sort of solution to LBS it advocates (Fig.1). The Collaboration Diagram emphasizes the structural organization of the objects that send and receive messages. These objects are typically named or anonymous instances of classes. It can be useful to illustrate the dynamic view of the model. Other classes not (indirectly) mentioned in the Collaboration Diagram are necessary to represent Web Map Servers [12], features, spatial objects, to geo-code textual information , visualize the maps recovered, etc.

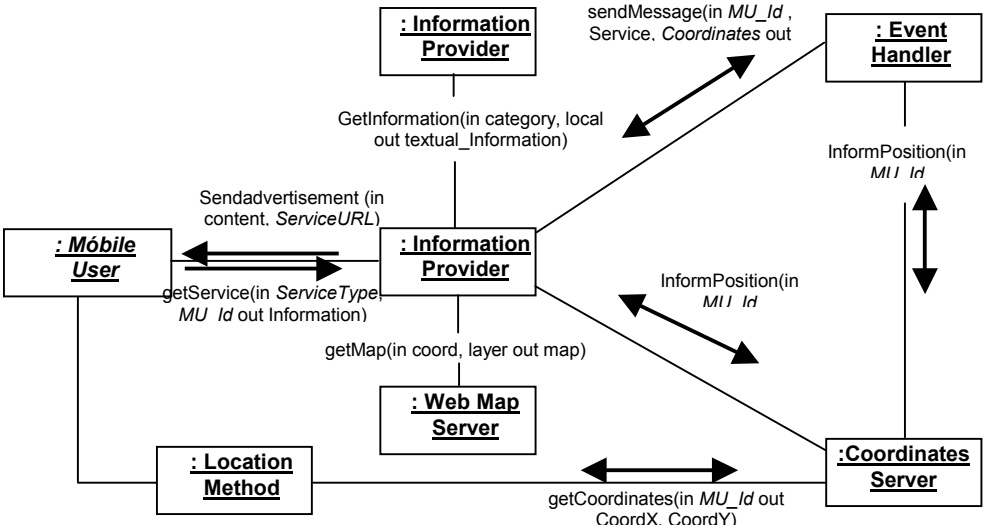

Fig. 1 SBL Collaboration Diagram

The following example shows the several steps needed to furnish a SBL service to a given user:

- Preliminary, the user signs a given Tourist Information Service, for example, according to receive tourist information about cities, when in a given distance of them – eg. 10 Km;
- The user maintains the service inactive for a given period of time. When beginning his holidays trip, for example, he activates the service;
- After that, the signal of the User´s Mobile Device *(Mobile User)* is continuously monitored by the *Coordinate Server*, which inform other components of the LBS system the user position, when asked;
- The *Event Handler* constantly queries the *Coordinate Server*, about the user position and proceeds as follow:
  - Verifies what services are active for that particular user;
  - Verifies what are the *Spatial Object(s)* in whose influence area(s) the user finds himself (this action is done for each *Service Type* defined in the *User Profile)*;
  - Dispatches a message to the In*formation Provider (IP)* that holds information about the *Spatial Object*, in order the *IP* could send the *Mobile User* information about the services offered by that particular *Spatial Object;*
- The *IP* sends to the user´s *Mobile user* a message describing the service and a *Service_URL*. This URL is the Internet address of the In*formation Provider (IP) t*hat

distributes information related that particular *Spatial Object*. In this way the user can interact with the *IP* at his will, to know more about the services offered; In the case the User´s *MobileDevice* would have visualization capabilities, a map with the service and user position already plotted could also be sent to the user. Simultaneously the *IP* sends to the *Event* Handler a message for temporarily deactivate the service for that particular user. This is to avoid the continuous repetition of the above cycle, and the reception, by the user, of the same information several times, while he remains in the neighbourhood of the same *Spatia Object.*

In some cases, when the user´s *Mobile Devicer* begins its interaction with the *IP,* it will be necessary that the *IP* takes notice of the user position. This will be reached through requests submited to the *Coordinate Server* using the method *InformPosition (in MU_ID out CoordX, CoordY)*.

4. CONCLUSIONS AND FUTURE WORK

People expect the market-share for LBS and Dynamic GIS will grown exponentially next years, but for this becomes a true fact, it will be necessary a wide dissemination of some standards and/or a common approach to a range of similar problems. The possibility of disseminating a common approach is the primary intention of this article. Our next step is to implement some of these services. The industry itself is already very active in this field. In a recent application, a Palmtop with a GPS offers tourist guide services in Europa [13]. This product - Mobile Tourism Guide – is supported by the European Union and will be tested in Siena, Italy.

The OGC´s recommendations and specifications [14] and especially OGC's Open Location Services Initiative [8] don´t provide a Model for Location Based Services. So, although using some schemas of OGC´s GML – Features and Geomatry – in this paper we present an Object Oriented Model for the wholly LBSs. This Model could be though as a “preliminary Ontology for LBSs” and eventually could help the industry and researches in the efforts for establishing a standard for LBSs, and also to derive solutions to specific location services.

5. BIBLIOGRAPHICAL REFERENCES:

[1] Guarino, N. Formal Ontology and Information Systems. Proceedings of Formal Ontology in Information Systems. First International Conference, Trento, Italy, 6-8 june 1998, Amsterdan, IOS Press, pp 3-15.

[2] Germano Leichsenring, Kazutoshi Sumiya, Kuniaki Uehara. A Location-Aware BBS for Mobile Environments, May 22, 2000.

[3] Leichsenring Germano, Sumiya Kazutoshi, Uehara Kuniaki, A Position-Aware Information Delivery System for Mobile EnvironmentsIPSJ SIGNotes DataBase System Abstract No.121 – 004

[4] Kottman, Cliff. Open GIS: An Introduction and Overview, slides of the speech at the Eighth ACM Symposium on Advances in Geographic Information Systems – ACM GIS 2000, December 10-11, 2000, Washington, D.C., USA.

[5] MAPINFO Corporation. Mobile Location Services: Location-based technology and vision for the next-generation of enhanced services. In: <http://www.mapinfo.com/community/free/library/mobile_location_svcs_whitepaper.pdf>. Access in: 03/12/2002.

[6] Federal Communications Commission (FCC). <http://www.fcc.gov/911/enhanced/>. Acesso em: 30/01/2003.

[7] Grady Booch, Ivar Jacobson & James Rumbaugh. The Unified Modeling Language User Guide. Addison-Wesley Object Technology Series.

[8] Open GIS Consortium. Open Location Services. <www.opengis.org>.

[9] The Open GIS Abstract Specifications, topic 5 – The Open GIS Feature. Open GIS Consortium. http://www.opengis.org/public/abstract/99-105r2.pdf. Editor: Cliff Kottman.

[10] Geography Markup Language (GML) 2.0; OGC Recommendation Paper, 20 February 2001; OGC Document Number: 01-029.

[11] Open GIS Consortium Inc. Open GIS Project Document: OGC 01-068r3: Web Map Service Implementation Specification. Editor: Jeff de La Beaujardière. 16/01/2002.

[12] Oliveira, C.P. Um Modelo para Serviços Baseados em Localização. Dissertação de Mestrado. Programa de Pós-Graduação em Engenharia de Computação – área de concentração Geomática, Universidade do Estado do Rio de Janeiro, Rio de Janeiro, March, 2003.

[13] http://fatorgis.com.br/. Access in 24.10.2002

[14] Open GIS Specifications. <http://www.opengis.org/techno/s