Geographical Information System-supported Location Based Services: Seamless Content & Functionality Integration Using Web Services

Zanuldin Ahmad, Sellappan Palaniappan, Woon Wei Lee, Yew Kok Han
Malaysia University of Science & Technology (MUST)
Unit GL33 (Ground Floor), Block C,
Kelana Square, 17, Jalan SS7/26
47301 Petaling Jaya, Selangor D.E
Malaysia

Abstract - The rapid growth in mobile internet market worldwide has shown a promising future for the M-Commerce services and applications such as location-based services (LBS). Geographical Information System (GIS) always play an integral role in LBS systems. However, it also introduces high entry cost for LBS developers. This has resulted in slower growth of LBS. The recent emergence of web services technology provides a possible solution to overcome the high GIS's cost issue. This research proposed a GIS web services architecture based on SOAP, XML and HTTP. A prototype is developed to expose GIS functionalities through standard web interface. It is implemented using Microsoft Visual Studio.NET 2003, Oracle Spatial 10g database, Oracle MapViewer, and other supporting tools. The proposed web services approach is found to be practical and promises a lowering of the entry barrier to adopt GIS for LBS development.

Keywords – Location-based services, Geographical information system, Web services, XML, SOAP.

1. INTRODUCTION

The success story of NTT DoCoMo’s i-Mode mobile internet portal since its introduction in 1999 indicated the onset of mobile internet era. It is predicted that by July 2006, there will be about 2 billion mobile phone subscribers worldwide who will be able to access information and services anywhere and anytime through their internet-enabled personal devices [1]. The services and applications that are accessible through internet-enabled mobile devices and conducted through mobile networks are called—M-Commerce [2].

One of the most compelling features of M-commerce is Location-based services (LBS), which is able to track the user’s position and deliver customized services and promotional materials accordingly. LBS is expected to become a major earner of future mobile internet services. It is predicted that location-based services could generate as much as $20 billion a year in revenue by year 2006 [2].

LBS can be defined as the mobile services that use the notion of user’s location information and add values to the mobile services as a whole. Location information (latitude-longitude etc.) is dynamically determined by various positioning technologies such as Global Positioning System (GPS), CELL-ID and Enhanced Observed Time Difference (E-OTD). The location information is then transmitted back to mobile service provider’s server for location-based analysis and integrates location intelligence into their mobile services.

The technical demand to provide location-relevant information to people on the move wherever and whenever required has brought together diverse technologies such as position finding, messaging and spatial analysis. Performing spatial query and analysis has always been an integral part of LBS and it is one of the most challenging tasks in providing LBS. Various problems stemming from these challenges are discussed in detail in section II.

Providing GIS-supported LBS poses high entry barriers such as GIS infrastructure and expertise, database maintenance and expensive mapping datasets. This requires huge initial investment from the service provider and application developer. However, the fast pace of technology changes and nonexistent of standards in the telecommunications industry inevitably leads to plenty of false starts and wasted effort in LBS development [3]. The difficulty, high cost and technical complexity of developing LBS has always been underestimated, which leads to the downright disappointment of pre-bubble promises on LBS deployment [4].

Motivated by the encouraging prospect of mobile internet content, LBS market and the emerging of web services as the next big step in the information technology industry, this research examines the possibility of applying web services approach to achieve seamless content and functionality integration for LBS offering in Malaysia.
The objective of this research is to develop some GIS web services that provide basic spatial analysis and map rendering capability based on the dataset of a small portion of Kuala Lumpur. They can be easily integrated by telecommunications operators and application developers without any platform limitation, using rapidly emerging web services technology (XML, SOAP and HTTP).

This paper is organized as follows: Section II discusses current LBS architecture in and the challenges faced in LBS industry. Section III presents a conceptual design of GIS web services as proposed in this research. Section IV discusses the architecture of the implemented prototype and client test application. Section V concludes the overall achievement and evaluation of the proposed approach in this research.

II. CURRENT LBS ARCHITECTURE

There are five major components that form the high-level representation of today’s LBS architecture: User/mobile clients, application server, mobile positioning center, positioning services and infrastructure, and various databases and applications that provide contents, templates, and information to support the entire LBS system [5].

A. Current LBS architecture

Basically, the LBS system functions as follows:

1. The user accesses the application server that handles all requests, interacts with users, and interfaces with other components.

2. The application server processes a request and issues command to retrieve the user’s position information from the mobile positioning center (MPC).

3. Based on the positioning data retrieved from mobile positioning center, the application server will communicates to content databases and GIS to perform necessary spatial analysis such as proximity searches, buffering, nearest-feature searches etc.

4. The queried result is further processed according to the rules and presentation format in the application (rendering style, map rendering etc.). Normally these tasks will be handled by GIS and map generating engine.

5. Processed spatial data are passed back to application server where they are further integrated with other business-related components such as billing system and other related system that supports the business operations on the telecommunications operator side.

6. Information is sent back to the end user in appropriate presentation format such as downloadable maps, business directory information and mobile coupon.

In this architecture the entire system is an integration of various parties’ products and services which are tightly coupled and highly integrated.

For a LBS to be offered completely to the end users as a whole, the application server in the LBS system would need to interface with all of the other administrative and financial systems beside databases and servers that handle spatial analysis [3]. For example, customer billing, security and privacy are some of the essential sub-systems that made up the telecommunications service and thus a must in LBS offering.

This means that the LBS application has to be physically located within the telecommunications operator’s office, and work behind the telecommunications operator’s firewall. Due to this limitation and coupled with the lack of standards that govern data transfer and interface protocol between GIS and all other sub-systems, each operator will in effect has its own unique, complex and inefficient system solution for LBS offering.

As a result, a lot of efforts are required in initiating LBS offering using today’s LBS industry practice, which poses a high entry barrier to most of the developers and telecommunications operators. Moreover, the telecommunications operators would have to get involved in managing and maintaining the spatial data sets and GIS functionality.

For third-party GIS developers that provide solutions to telecommunications operators they would have to develop LBS systems that were unique and proprietary for each operator. A GIS that is tightly coupled to the telecommunications operator’s administrative and service applications will present problems whenever there is an upgrade, revision or addition of parts in the entire system. This would inevitably require checking and modification in all other parts of the operation, whether the upgrade is related to LBS or not.
B. Challenges faced by current architecture

The key technical and architectural challenges associated with achieving the core business objectives for LBS success are performance, robustness, scalability, easy of implementation & integration, database compatibility and extensibility.

Below are some comments on the challenges faced by LBS industry:

- To provide compatibility among a full range of geospatial databases, high degree of database-independent adaptability to enable seamlessly integration of data and contents from different sources and databases [6].

- Availability and comprehensiveness of spatial content and data is highly desirable [6].

- Standardization to facilitate the development and launch of LBS as this increases the level of compatibility and compliances among different systems in LBS and thus ease up the integration work that takes time, effort and resources using existing industry resources [7].

- Key to success in LBS offering lies on the successful integration of multidisciplinary technologies and contents in LBS system [4].

III. PROPOSED APPROACH

The proposed architecture is intended to introduce a more flexible way in designing LBS system, particularly—to decouple the mapping, GIS and some related content gateway from the current system.

The GIS web services which provide few basic sets of spatial analysis functionalities, such as proximity searches (nearest features, features within a distance etc.) are developed. Also, map rendering capability is included in the service set to provide a means for web services consumer to visualize their spatial query result and generate maps.

All of these services reside in a web services server that acts as the gateway between web services provider and clients. All services are described in WSDL so that the clients will know how to consume the web services. Once bound to the web services, the client can consume GIS web services through the web using XML-encoded SOAP.

At the back end, the GIS web services are supported by few components that made up the entire GIS web services system which include spatial databases, spatial analysis engine and map generating engine. Also, the GIS web services server could consume other services provided by another web services server where necessary (retrieve traffic or weather information). All of the information retrieving process from other web services server is transparent to the GIS web services user, hence introducing seamless content and functionality integration in the entire system.

At the other end, the LBS system can easily communicate to the GIS web services server and performs spatial analysis by just passing in the mobile user’s location, determined through mobile positioning center (MPC). The GIS can be decoupled from the LBS system while the operator will still be able to perform GIS processing in their system through web interface.

By using the proposed web services approach, the emphasis is on the way to decouple the GIS from the entire LBS system architecture. This could be done by standardizing the formats used for communications among GIS, content database and system architecture. Current LBS system architecture is represented by the system labeled “Current Location Based Services system architecture”. All sub-components such as mapping gateway, information gateway, billing gateway, location gateway are tightly coupled to the entire system, hence introducing various limitation and problems as discussed in section 2.1.
LBS application server using XML, SOAP and HTTP.

For telecommunications operators, they no longer need to worry about the effort to implement and maintain GIS in their application server. In fact, they can choose the available GIS web services that suite their business objectives and integrate them into their application server easily without significant investment and effort.

For GIS service providers, they can always concentrate on their core businesses and provide their services through internet using web services. They no longer need to customize their system to meet different operators’ requirement as all of their customers can access the services through a general and standardized web interface. They will be able to offer the same services to any number of operators at the same time and allowing them to grab a larger market with less effort.

LBS providers in Malaysia is standing an advantageous position to adopt this new approach in designing their LBS system as the infrastructure here is still new and open to architectural changes. This is in contrast to other pioneering countries where changes in LBS system architecture might bring huge impact on their current LBS business operation.

By using GIS web services approach, we believe that a lot of false start and unfruitful effort can be avoided at the beginning of LBS development in Malaysia, hence developing the confidence in investors community to grab the highly potential LBS market in the near future. With more confidence in investor community, the LBS industry in Malaysia could gain momentum using the capital acquired from investors to support its growth.

IV. PROTOTYPE IMPLEMENTATION

Figure 2 shows the GIS web services architecture implemented in this research. The web server that is running IIS 5.0 is the mid-tier between web service client and back-end GIS. It hosts sets of GIS web services developed in this research. It is running on the .NET framework and ASP.NET web services architecture.

As the front-end that communicates to the web service client, the web server exposes 2 main web services and plenty of classes and data type as the API. The 2 main web services are FindPlace web service and MapRendering web services.

C#.NET is used to construct application logics that listen to web service request, to retrieve data, perform spatial analysis using Oracle Spatial, and to generate maps using Oracle MapViewer. The complexities of performing spatial analysis are hidden from the web service client and they do not need to know what type of GIS system is running at the back-end. In fact, they do not need to know so in order to perform spatial analysis.

A typical operation of the FindPlace web service prototype is explained below:

1. After binding to the FindPlace web service, application developer develops their client application based on the API described in WSDL. When the client program is executing, a FindSpecification is prepared to describe what kind of information and spatial functionality the application is looking for.

2. The FindSpecification is passed to the GIS web services server by using FindCenterPoint or FindBusiness web method. Upon receiving FindPlace web service request, GIS web services server will process the FindSpecification, and generate appropriate SQL command based on the user’s specified criteria.

3. A connection is established with the Oracle Spatial. The command is sent to Oracle Spatial to perform spatial analysis. As a result, all information requested by the command is sent back to the GIS web services server for further processing.

4. Application logics associated with FindPlace web service will format the result and generate Location object to
encapsulate the data returned from Oracle Spatial in an organized manner. The Location objects are then passed back to the client as response (embedded in SOAP and XML).

5. The client could then manipulate the Location objects that describe the geographical features they requested. They could choose to display the information to the end-user, or apply further processing that makes use of the location and business information embedded in the Location object.

The design of FindPlace web service provides a flexible and programmable way to manipulate the location information. This is in contrast to the limited usage of location information presented by traditional internet mapping system as most of them are presented in plain texts or graphics.

The MapRendering web service works in a similar manner to FindPlace web service. Its main function is to provide a programmable way to visualize location information into a map image.

Figure 3 is a snapshot taken from a client application that makes use of the GIS web services. By passing in simple location information, the web services will perform spatial analysis and returning back appropriate location-enabled information. As in the snapshot, several hotels information (Hotel name, contact no, rating, Latitude-longitude, distance etc.) is presented to the user based on his/her location. Spatial analysis such as proximity searches is performed entirely at server side. Web services client is responsible only for presentation instead of resource-intensive processing.

Figure 4 shows another snapshot where user’s location is pinpointed on a map that visualized the location information presented in figure 3. Map generation is performed at server side without using resources at client side.

From the result shown in this research [8], the proposed GIS web services architecture is able to reduce the development effort in integrating GIS capability into a LBS application. In a nutshell, an application developer just need to locate the URI of GIS web services, bind to them, and start doing simple coding to GIS-enabled his/her application.

Most of the complexities such as GIS software installation, configuration, maintenance, spatial data acquisition, interfacing coding to GIS are all hidden from application developer. This approach also presents a low risk alternative to telecommunication operator. This is because they could integrate GIS capability into their LBS system easily without huge initial investment in GIS.

In summary, the proposed GIS web services architecture presents an alternative to integrate GIS capability into a LBS system with several advantages over the current system architecture.

V. CONCLUSION

In this paper we have presented a GIS web services architecture for LBS development. A GIS web services prototype was developed and evaluated based on Kuala Lumpur datasets using a smart client application (simulation). The result shown that GIS web services prototype greatly reduced the effort and resources required in developing a GIS-supported LBS.
It is concluded from the implementation that a viable solution could be developed where geographical content and GIS functionality are offered as a service through web interface. The geographical content improvement should move towards industry specific content that could serve the niche market. As a result, the GIS web services would mutually compliment for better information integration rather than competing among each other.

Finally, it is hope that this paper will present to reader an understanding of the future direction in developing GIS-supported LBS.

REFERENCES