ENTERPRISE GIS FOR MUNICIPALITIES – A SERVICE ORIENTED APPROACH

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ABSTRACT:

Geographical Information Systems (GISs) provide municipal governments with extraordinary quantitative and qualitative benefits. A municipal enterprise GIS consists of technology, personnel, and other resources to create, maintain, visualize, search, and share geospatial data and services. At a minimum, the municipal EGIS provides these capabilities to all departments of the municipality. Usually the municipal EGIS extends many of these capabilities to the general public, external private entities, and external public agencies as well. EGIS is a fundamental element of e-government because it adds the critical elements of location and visualization to interaction between the municipal departments and the public. Often knowing where a government action or other event in the community is occurring, as well as what is nearby, is essential for achieving informed public participation and timely delivery of services. However, in traditional situation of municipalities, it is not possible for individual standalone services to meet all the service requirements of many users. Such service requests could be met by dynamically chaining multiple services provided by single and multiple service providers. In this paper we propose a Service Oriented Approach for developing an EGIS for Municipalities. The Service Oriented Architecture (SOA) recognizes this and tries to construct a distributed, dynamic, flexible, and re-configurable service system over Internet that can meet information and service requirements of many different users.

1. INTRODUCTION

Planning and management of urban and rural areas generally occur by departments, with each department having its own database where GIS was not a successful tool when decision-making elements of the local government want to use and integrate multi-agency GISderived information. In this respect potential benefit to interoperable GIS, spatial decision support, business intelligence, public information, work flow and operations is clear, but their application has been plagued by high cost and low rate of implementation success especially in extended organization such as municipalities (Halfawy et. al, 2005).

Newly developed technologies have made it possible to create an enterprise GIS for municipalities which combine custom geospatial and attribute data with spatial and non-spatial models and functionality from Geo web services in a service oriented architecture (Farrell, 2006 ; Liuand and Fan, 2007 ; ESRI, 2007). Change in software architecture has led to the emergence of enterprise software that will reduce costs and vastly improve integration. Through the emergence of integrity and interoperability standards, business application vendors no longer need to buy and deploy multiple GIS technologies and maintain multiple versions of the same GIS data to suit specific needs of departmental systems (Figueroa and Stusek, 2001; Tu et. al, 2004; Yang et. al, 2005; ESRI, 2007).

A comprehensive enterprise municipal GIS should provide a common platform for data collection, storage, authorized and secure access to spatial and non-spatial data, harmonize the work flow of respective departments and disseminate information for the benefit of E-Municipalities. One of the main goals of E-Municipalities is improving the quality of public services through the use of information and communication technology (ICT) to their customers. The external customers are considered to be citizens (G2C), businesses (G2B), non-profit organizations (G2N), and public administrations (G2G). The public services are categorized into information, communication and transaction services. Criterion for this categorization is the degree of process automation and interaction. The most services offered belong to the information category like making forms available. The advantage is that citizens don't have to pass to the public office, and as a benefit saving time and money. In addition, a lot of information on how to fill in that form is made available. Information services are not intended to have access to internal data like personal or social information. The platform providing information services are based on content management systems (CMS) (Figueroa and Stusek, 2001).

As a result, public organizations use the structure view of front-offices (FO) and back-offices (BO). The highest level for ICT usage is the transactional level. This level of public service requires an information infrastructure in place to handle a complete workflow based on electronic documents. This starts with in-box handling continues with workflow processing and interoperable interfaces to document management systems (DMS) to out-box processing and all together integrated all public aspects of archiving.

2. CHALLENGES IN ENTERPRISE GIS FOR MUNICIPALITIES

The field that has grown up around reliable among distributed computers in municipalities, especially in municipality of metropolises, is called enterprise application integration (EAI). EAI is both a concept and a group of products. EAI refers to the process of linking large systems together. It is also a label that applies to a number of different software

products, such as Tibco and webMethods, which provide interfaces between the distributed computers (Figueroa and Stusek, 2001). Enterprise GIS model for municipal planning can be best described as a series of activities that focus on common GIS requirements of participating public and private organizations.

Web services stand to make a significant impact on simplifying EAI and reducing or even eliminating the need for proprietary EAI interfaces. That is not to say EAI platforms themselves cannot still provide useful services, from security to business process modeling, but certainly aspects of the proprietary formats for interface exposure will be commoditized in light of these new GML standards. The interoperation of distributed computers of different systems in different divisions of municipalities that web services enable falls into two primary categories:

- **Invoking Remote Procedures.** Whenever one computer in a municipality division asks another computer to perform a function, that is known as a remote procedure call (RPC). RPCs are a staple of client-server architectures (Figueroa and Stusek, 2001). However, web services make RPCs dramatically simpler to carry out because they eliminate the need for the RPC to travel through any kind of proprietary interface that sits between the computers; and web services make it possible for computers to engage in RPCs even if they are running different operating systems and programming languages.

- **Exchanging Geospatial Data.** Geospatial web services, because they use the universally accepted GML format for the transfer of geospatial data, are very good at helping distributed computers share data. For every transaction, the order-processing software (now itself a consumer of a separate service) sends a SOAP request asking for the exchange rates. In response, the provider computer sends back the exchange rates as another SOAP message.

Traditionally, IT's ability to deliver in metropolis municipalities is hindered by fragmented and complex infrastructures including disjointed legacy systems and packaged applications, a large proportion of which were never designed for information interoperability, integration, and reuse. Consequently, most of the IT budget goes into maintenance of the current infrastructure and only a small percentage is available for supporting new business initiatives (ESRI, 2007). The major portion of budget for new capabilities goes into integrating new functionality into the existing systems.

3. WHY SERVICE ORIENTED ARCHITECTURE?

Traditionally, municipality's information systems have been developed with a functional orientation often resulting in silos of services and information, preventing end-to-end business process visibility (Baptista and de Paiva, 2005). Enterprise application integration (EAI) and other traditional middleware solutions partially address this by enabling systems to communicate with each other, but they don't fully solve the problem as they allow only limited business process adaptability (ESRI, 2007). Moreover, these traditional solutions come at a high cost, relying on proprietary technology and specialized and scarce skills.

SOA helps address the fragmented IT landscape and addresses the difficulties associated with silos of IT infrastructure and applications (Panda D., 2007). There are three main benefits to adopting SOA approach for developing an EGIS for Municipalities (Figueroa and Stusek, 2001):

- **Using existing infrastructure.** In the vast majority of cases, existing (legacy) applications have nothing wrong with them except for the fact that they do not interact easily with other applications, since their interfaces are typically closed and proprietary. Opening up applications with Web services and SOA generally means that the large amount of effort spent over many years enhancing legacy applications to support complex business rules does not need to be lost (Farrell, 2006; Sun, 2007).

- **Reducing integration costs.** Once an application is part of an SOA environment, it can easily be accessed by any other application, generally without change to the application. This allows a substantial savings to be realized in terms of redevelopment and integration costs (Farrell, 2006).

- **Increasing business agility.** A business needs to be able to respond to changing market requirements quickly. SOA, by virtue of its self-defining, standardized nature, allows businesses to adapt by creating composite application functionality quickly (Liuand and Fan, 2007).

However, critical success factors for an SOA implementation that alleviate and mitigate the challenges include defining coarse grained services and agile, loosely coupled business process (Shi, X., 2004). Furthermore, there is a need for SOA governance which provides a set of solutions, policies and practices which enable organizations to implement and manage an enterprise SOA. It is the SOA governance which makes it possible to realize ROI and the business benefits of loosely coupled services. In proposed methodology of this paper, GIS services grouped into three categories (Peng and Tsou, 2003):

- **Data Services:** These types of services are tightly coupled with specific data sets and offer access to customized portions of that data. Web Feature Service (WFS), Web Mapping Service (WMS) and Web Coverage Service (WCS) can be considered in this group. WMS produces maps as two-dimensional visual portrayals of geospatial data. WCS provides access to un-rendered geospatial information. WFS provides geospatial feature data encoded in Geography Markup Language (GML) (OWS2, 2004).

- **Processing Services:** These types of services provide operations for processing or transforming data in a manner determined by user-specific parameters. They provide generic processing functions such as projection and coordinate conversion, rasterization and vectorization. Coverage Portrayal Service (CPS), Coordinate Transformation Service (CTS), and even WMS can be considered in this group (OWS2, 2004).

- **Registry or Catalog Service:** These types of services allow users and applications to classify, register, describe, search, maintain, and access information about Web Services. Web Registry Service, Web Catalog Service, and our implementation of registry catalog service, Fault Tolerant High Performance Information Service, are considered in this group (OWS2, 2004).

In order for SOA to work, interoperability standards related to all aspects of service operations are needed. Our proposed system uses the Open GIS Consortium (OGC) standards for the data finding and access, and OGC and W3C standards for the web services (W3C, 2004). In the geospatial web service area, OGC is modifying and extending W3C standards for the geospatial web services through the OGC web service initiatives (OWS2, 2004).

4. ADAPTED SOA FOR DEVELOPING ENTERPRISE GIS FOR MUNICIPALITIES

EGIS deliver significant benefit to municipalities within the enterprise (intranet and integrated with applications) and among community partners (extranet) using web protocols and web services based on a service bus. In this paper, we develop and implement an EGIS for some part of Tehran (capital of Iran) municipal organizations. Municipality of Tehran has already adopted by various desktop GIS as well as specific software with particular models and functionalities that deliver display of properties and services through web browsers. For this aim SOA can be used by flexible OGS standards and web services to be used in almost all applications and on all devices. SOA is a pattern recognized in applying Geo web service technologies to an application integration problem (figure 1). SOA has a "publish-find-bind" concept, which makes it applicable to a wide variety of Geo web services situations. This opens new opportunities for collaboration with external agencies and interoperability between distributed Geo-DB (Figueroa and Stusek, 2001).

The core focus of this executive master is on the strategies available to managers of urban infrastructure services in densely populated agglomerations, on technological innovations, and on the management of urban network industries more generally (Halfawy et. al, 2005). Such strategies will pertain to (figure 1):

- Energy (electricity, gas, renewable)
- Communications (telecommunications, internet, media, cable)
- Transportation (public transport, roads, railways, airports, and sea ports)
- Environmental Infrastructures (water supply, wastewater treatment & solid waste management)

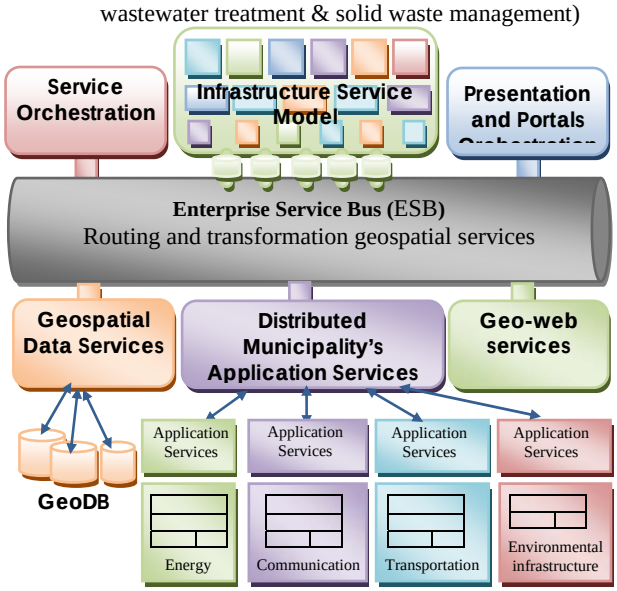

Figure 1. Component of enterprise service bus

In this paper Oracle SOA has been developed to build service-oriented enterprise GIS and deploy them to middleware platform. Oracle SOA includes all components and technologies needed for standards-based building, managing, and optimizing end-to-end business processes and portfolio of services, integrating virtually any existing data or service source (Oracle, 2007). All the Oracle SOA components are illustrated in figure (2). The Service Assembly Framework shown in the center includes the Oracle application server. This solution is used to develop, integrate, and deploy applications, portals, and business services and is designed for grid computing — the ability to present a series of smaller computers as though it was a larger system and SOA. Various component parts intended to enhance collaboration (software to facilitate and manage business process and rules) are integrated within the Service Assembly Framework.

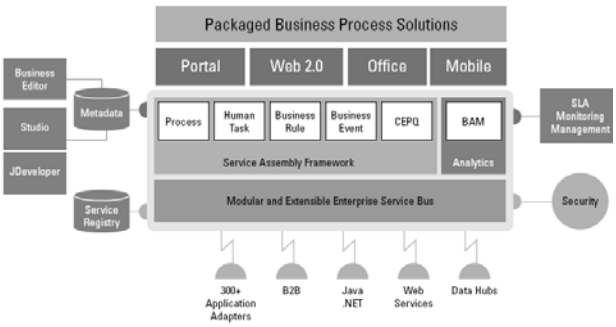

Figure 2. Component of Oracle SOA Collaboration Suite (Oracle, 2007)

The Oracle Business Intelligence Suite covers Analytics, shown adjacent to the Service Assembly Framework in Figure 2. This suite of products includes solutions for dashboard development, proactive intelligence and alerts, real-time predicative intelligence, and mobile analytics, all important for monitoring a SOA environment.

Data quality is at the core of SOA and of Oracle's SOA strategy. Oracle's Data Hub products are focused on managing data quality. The Oracle Customer Data Hub is used to centralize, update, and clean customer data. It can be used independently of other Oracle applications (Oracle, 2007). On the other hand, metadata works in conjunction with the Service Assembly Framework ensuring that there are common definitions in use throughout the SOA environment. Business Editor, Studio, and Oracle JDeveloper represent the SOA tools available to developers. The enterprise service bus (ESB) is an integral part of the SOA platform. It routes and distributes events between applications and connects existing IT systems with business partners (figure 1). There are many adapters provided to connect services that may be outside of the SOA environment. In a SOA architecture, services are loosely coupled together in a flexible way. The ESB accesses definitions and other important data about the services from the registry to create this fluidity in the SOA environment. In addition, the ESB facilitates the accessibility of security services required to protect the SOA environment.

The SOA Architecture makes allowances for whatever method or technical environment the end user will be using to access applications. This flexibility is illustrated in Figure 3 in the showing Portal, Web, and Mobile as the different types of end-

user access. Oracle Portal is a framework for building, deploying, and managing enterprise portals as referenced in the top layer of the diagram, Oracle and its business partners are building industry-specific business process solutions that are based on Oracle's SOA platform.

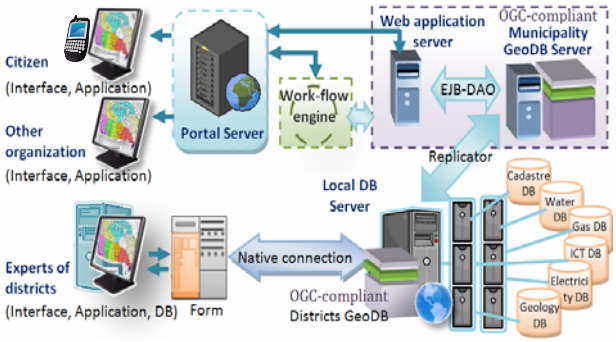

Figure 3. Component of EGIS

In EGIS the administration committee can define what information is to be displayed, how it should look and who can use it through the central management for all the DBs. This process avoids creating multiple copies of data sets and keeping track of what version of the truth shows up in reports and information products. Since most of the preparing, processing and accessing of massive GIS data is done on a server, EGIS offer great opportunity to reduce load on LAN bandwidth, open doors for WAN access, and can deliver GIS to the lowliest, diskless desktop.

The emergence of OGC standards (OGC, 2005) and WMS (web map service) and WFS (web feature service) services allow the application builder and end user to treat an individual service as one layer among many. This means that you can grab aerial photos from one service, lakes and rivers from another, and streets and administrative areas from another. Clearly in these systems, the human resource cost of maintaining and disseminating data can be lowered with web services oriented architecture. Figure 4 shows some of the implemented interfaces in Oracle SOA.

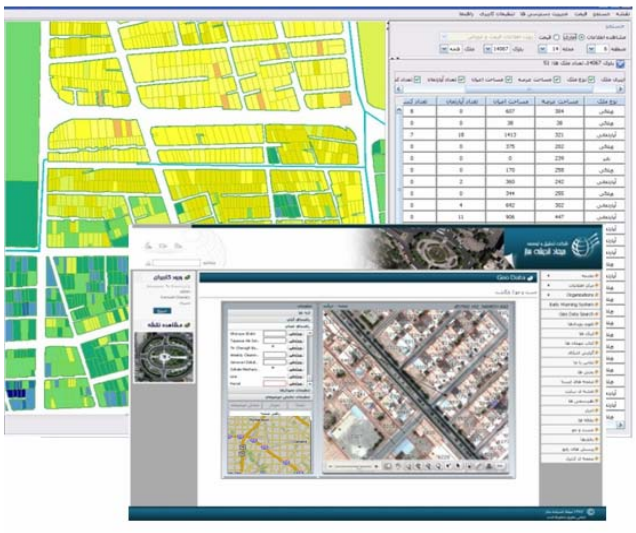

Figure 4. Implemented EGIS samples

The comprehensive enterprise municipal GIS will largely address the needs of various local government departments such as Local Administration, Public Works & Engineering department, Public Health Department, Water supply, Town and Country planning Department, Public Safety, Land records, Tourism Department etc.

5. CONCLUSION

In this paper we tried to demonstrate how web based services in an SOA architecture can provide useful tool in enterprise municipal information management for distributed municipality's organization and citizens. This framework makes use of a centralized enterprise-wide shared GIS to significantly improve the availability and consistency of spatial and non-spatial data across different software systems, integrate data across various disciplines, and facilitate the flow and exchange of municipal information based on Oracle SOA. The objective of this framework is to provide the ability of gathering, synthesizing, and reasoning efficiently in order to facilitate municipal management and specific application services.

This approach would serve as a medium for sharing and integrating data across all municipal departments and software systems which will reduce or eliminate inefficiencies of information access and exchange, and thus lead to cost-effective and more efficient operational and strategic decisions. Our expectation is that the Service Oriented Architecture of GIS will grow rapidly over the next few years, having been embraced, cultivated and supported by all the municipal units.

REFERENCES

Baptista, C.d.S., and de Paiva, A.C., 2005. On performance evaluation of web GIS applications. *Proceedings of the 16th* International *Workshop on Database and Expert Systems Applications (DEXA'05).*

ESRI, June 2007, Geospatial Service-Oriented Architecture (SOA), available from www.esri.com/library/whitepapers/pdfs/geospatial-soa.pdf
Farrell T., 2006. Service-Oriented Architecture: Beyond Web Services, available from http://java.sys-con.com/read/44368.htm

Figueroa, R., J. Stusek, 2001. "Regina Enterprise Geographic Information System (REGIS)", *Proc.*, GeoSASK 2001, Regina, SK, Canada.

Halfawy, M, Newton, L, and Vanier, D., 2005. "Municipal Infrastructure Asset Management Systems: State-of-the-art Review", *Proc.*, CIB W78, Dresden, Germany.

Liuand B. and Fan Y., 2007. Research on Architecture and Key Technology for Service-Oriented Workflow Performance Analysis, Lecture Notes in Computer Science, Book Series: *Advances in Web and Network Technologies, and Information Management*, ISBN: 978-3-540-72908-2, Volume 4537/2007, p. 540-545

Oracle, 2007. Oracle Service-Oriented Architecture Suite, Best of Breed SOA Tools and Middleware, White paper, October 2007, available from whitepapers.techrepublic.com.com/abstract.aspx?docid=349355

OGC, 2005. The Importance of Going "Open", An Open Geospatial Consortium (OGC), White Paper, available from http://www.opengeospatial.org/press/?page=papers, July, 2005
OWS2, 2004. OGC Web Service Initiatives, available from http://ip.opengis.org/ows2/

Panda D., 2007. An Introduction to Service-Oriented Architecture from a Java Developer Perspective, Copyright O'Reilly Media, 2007, available from http://dev.aol.com/soa-intro Submitted by Developer Network on February 1, 2007.

Peng Z.-R. and Tsou M.-H., 2003. *Internet GIS*: Distributed Geographic Information Services for the Internet and Wireless Network, New Jersey: John Wiley & Sons, Inc,

Shi, X., 2004. Semantic request and response for standardized Web services, available from http://www-106.ibm.com/developerworks/webservices/library/ws-semantic

Sun, 2007. Assessing Your SOA Readiness, White Paper on the Web: http://www.sun.com/software/whitepapers

Tu, S., Flanagin, M., Wu, Y., Abdelguerfi, M., Normand, E., Mahadevan, V., Ratcliff, J., and Shaw, K., 2004. Design strategies to improve performance of GIS web services. *Proceedings of the International Conference on information Technology: Coding and Computing* (ITCC'04).

W3C, 2004. World-Wide Web Consortium (W3C) homepage, available from http://www.w3c.org

Yang, C., Wong, D.W., Yang, R., Kafatos, M., and Li, Q., Performance-improving techniques in web-based GIS. *International Journal of Geographical Information Science* 19 (3) March 2005, 319–342.