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Building the Saudi SDI from the Ground Up

Base Map Update Pilot Project in Riyadh

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1 Introduction

Most of the nations in the world have long standing programs to enable the sharing and aggregation of geospatial information. In spite of this fact, it is also true, that real, operational examples of in place systems providing near real time sharing and access to data across multiple organizations are relatively rare.

This paper describes a new approach to the problem of geographic information sharing based on event driven architectures and "conventional" SOA. This approach has minimal impact on the participant's existing databases and client applications, and can readily support pretty much any client application environment.

This paper is organized in two sections. The first describes the general approach to SDI based on event driven architectures. The second part describes the application of these concepts to the Base Map Update Pilot Project for the City of Riyadh.

The approaches described in this paper we believe lay the ground work for a national information infrastructure for the Kingdom of Saudi Arabia. Unlike many national approaches that only deal with the data of the most senior level of government, the propose approach starts at the municipal and utility level. This approach is entirely scalable and thus can grow from the ground up to form a real time national spatial information infrastructure.

Part I – Concepts for an Event Driven SDI

2 The Importance of Accurate & Current Information

Every day, decisions are made respecting urban planning, disaster response, urban development and construction, and civil operations from mail delivery to ambulance dispatch. All of these decisions depend critically on accurate and current geospatial information.

Most such information is created or modified by basic business processes within the various organizations by which manage our society. It is the water company that first knows when a new water main is put in place; the post office when new postal codes are assigned; the city hall when a new street is constructed and named or a land parcel divided. We refer to organizations that have the specific business responsibility in the community for certain types of data as custodians.

While custodians may have business or legal responsibility for specific data types (e.g. land parcel subdivision at city hall), many other organizations will wish to submit their views or to comment on this data. The water company surveyor may determine that a street centerline is

not in the right location according to their "drawing". Such observations are valuable and we don't want this information lost or recorded only for the private use of the water company. Furthermore, the water company may be wrong. There is thus a need to capture and share such observations with the community and in particular with the recognized authority or custodian for that particular feature type.

3 Event Driven Architectures and SOA

If we are to share information across multiple jurisdictions/organizations, open standards are going to be required. It is for this reason that we have seen the evolution of standard data encodings (e.g. GML) and standard interfaces for requesting and modifying data and metadata across the Internet (e.g. WFS, WRS). Today, these standards form the basis of the Service Oriented Architecture (SOA) approach to geographic information aggregation and information. While these standards are clearly necessary, we do not believe that they are either efficient or sufficient to provide the sort of real time data integration that is required. For his reason we have added a component of an event driven architectures to the SOA foundation.

In the typical use of SOA, a client makes a request for data (e.g. WFS. WMS) and the response is returned by the server to the client. This requires that the client application understand the open standard request grammar, and that all of the needed data be fetched in a single or short sequence of requests. While this is a useful approach in some cases we believe it is too open ended, does not perform sufficiently well in general, and makes too great a demand on most of the existing client software developers.

In an event driven architecture, information is moved about not on request by the client but based on data changes or other triggers that occur at the server. For example, the arrival of new land parcel or a change in road location can be the trigger to send the change to subscriber to that event elsewhere in the network. Such an approach greatly reduces the amount of data being transmitted as only items that are changed are sent. In some cases this can even be restricted to sending only the changes themselves. In addition, such change events can be generated and transmitted without requiring any changes to the application that cause the changes. This means that this technology can be deployed with minimal disruption to the data provider.

Since change events are detected as they happen under the control of custodian's business process, they can be communicated to subscribers in near real time, thus assuring a high level of data currency across the community of participants.

This event driven approach can also be made to handle the participation of observers as discussed in Section 2. Observers generate observation transactions "this road has 3 lanes" and these are propagated to the interested subscribers. These can be further captured by the

appropriate custodian which then leads to the generation of official updates using the same even driven mechanism.

4 Advertisements, Publications & Subscriptions

To make the event driven architecture function in practice, there needs to be a means to make known the types of data (and data changes) which a supplier/publisher is willing to provide. We refer to this as an advertisement, and it typically consists of a designation of specific feature types (possibly with additional constraints) that the provider is willing to publish. The other participants in the community can then look at these advertisements and select the ones of interest, again with possible additional constraints (e.g. only roads which fall within a specified polygon) so to define a subscription.

When changes are detected at a provider's site the subscriptions for that provider are examined and the appropriate change events are then sent to all subscribers holding subscriptions that match the provider's change event.

Clearly the information infrastructure must provide the means to display/manage advertisements and subscriptions, as well as to detect provider data changes and propagate these as publication events to the appropriate subscribers. This functionality is provided by the Galdos Hub/Connector SDI framework.

5 Data Staging

What should happen when a new feature, observation or feature update arrives at a subscriber's site? Should it immediately modify the subscribers authorized database?

In most cases the answer to this question is no. All observations do need to be recorded to be sure, but reacting to these observations will depend on the policies of the subscriber organization and these must be accommodated by the information infrastructure.

Our approach has been to provide a data staging capability using the same database (or database technology) as used by the subscriber's authorized database. We call this a staging area or staging data store. All updates obtained through subscriptions are applied only to the staging area, unless a policy is in place (typically part of the subscription) that says to apply the change immediately to the authorized database. The more usual case will be to simply notify a person in the subscriber organization and initiate a workflow to process the change. This workflow will be business process specific and may involve both manual and automated operations.

6 Monitoring Data Flows

So now data is moving about in the community. Publishers send data to subscribers. Publishers create or modify advertisements. Subscribers receive data events driven by their currently active subscriptions.

In such an environment it is important to know what is happening and this requires that the information infrastructure record the various bits of information flowing between the participants as well as providing tools for browsing and examining this information.

These concepts of an event driven SDI architecture are now being deployed using the Galdos Hub/Connector SDI framework. This is happening in a number of different countries, including in particular in the Kingdom of Saudi Arabia. The framework is based on proven components based on existing OGC standards such as GML, WFS, WMS and WRS. We believe this is the appropriate direction for future SDI development.

The next part of this paper looks at these concepts as deployed in the Arriyadh Development Authority (ADA) Base Map Update pilot project.

Part II – ADA Base Map Update Pilot Project

1 Overview

The Base Map Update Pilot system consists of five nodes. The participant nodes in the BMU Pilot System are:

- Arriyadh Development Authority (ADA)
- Saudi Postal Corporation (Saudi Post)
- Saudi Telecom Company (STC)
- Riyadh Amana (Amana)
- Riyadh Water and Sewage (Riyadh Water)

Each participant has an independent GIS system. The goal of the pilot project is to connect these five systems such that they can share information transparently from their respective GIS systems. Moreover, information should not be passed from node to node indiscriminately as this would be wasteful of network bandwidth. The system must have policies for both sender and receiver of information to secure the overall system and govern the publication and subscription of data within it.
The resulting spatial data infrastructure will represent a shared and current information resource used by all participants.

2 Pilot System Concept Description - Benefits

The objective of the ASDI is to enable the ongoing sharing of information amongst all of the municipal agencies (private and public) for the city of Arriyadh. The ASDI will enable ADA to ensure that all of the agencies can work together within a common framework of geographic information. This is expected to have significant economic consequences for Arriyadh and improve the region's ability to deal with planning, development and emergency management activities.

The current situation in Riyadh is characterized by the following:

- Rapidly growing city distributed over a large geographic area (already the size of Greater London). Riyadh is reputed to be the fastest growing city in the world with an annual average growth rate of 4.2%. The projected population for 2021 could be more than 10 million people. Even this number depends on a slowing of the growth rate of the past decade (doubling every 9 years). This population growth will require a major investment in new build structures (mosques, housing, gardens, etc.), as well as the development of comparable built infrastructure (water, sewage, roadways, telecommunications, electricity).

- Riyadh today has no integrated geographic database of information that can be used for planning, construction, security and emergency response. Geographic information is redundantly collected and managed by a variety of agencies, including the main municipality (Riyadh Amana), the ADA, the Saudi Electrical Company, Saudi Post and the Riyadh Water Authority to name only the principal actors.
- There is little or no coordination of the geographic information collected by these agencies, so that in addition to the duplication of effort (e.g. multiple agencies buying and analyzing the same satellite imagery), there are very significant business costs incurred including major and frequent construction delays and the inevitable consequences of planning based on inadequate and conflicting information.
- The key actors in the city are independent, autonomous organizations. Some are private companies (e.g. Saudi Post), while some are independent branches of government. It is highly unlikely that all of these organizations can be required to adopt a single GIS and database solution. Even were this done, it is unlikely that such a decision would survive over a very long time, given the pace of change in Riyadh and the pace of change in the world of software technology. Furthermore, even the selection of a common GIS or database vendor would NOT deal with the key issues of information sharing including data quality, inter-agency access control, and jurisdictional issues respecting particular kinds of data (e.g. Riyadh Water Company can "observe" errors in land parcel surveys, but only Riyadh Amana is the official custodian of this information). Any technology solution must take these important issues into account.
- Most of the key actors in the City of Riyadh have achieved a reasonably high degree of computerization. All of the actors, with the exception of Saudi Electrical Company, are using spatial databases (Oracle Spatial, ArcSDE, MicroStation) for the management of geographic information.
- Riyadh is currently installing a high-speed fibre-optic data communications infrastructure and this should be available in the time frame of the ASDI pilot project. The existing data communications infrastructure appears to be sufficient to support the pilot project in any event.
- The key actors in the city are aware of the impact of the current inability to share geographic information, and appear to be eager to cooperate with one another to provide an information infrastructure for the future of the city.
- Riyadh, like any city, must compete with nearby cities for development investment. An information infrastructure is increasingly an issue in such investment decisions, as it impacts the time frame for investment approval, and the certainty with which a project, once approved, can be completed on time. Developers will take these "information resources" to heart in making a decision to invest in Riyadh or elsewhere in the Gulf.
- Riyadh is a particularly vulnerable city. All of the city's water must come from the Gulf (desalination) or from underground aquifers. Access to energy resources is similarly vulnerable to disruption. This is especially important given the climate, and the rapidly

growing population. The need to be able to respond to both planning and other emergencies by having a coherent base of information is thus critical.

It should be understood that the ASDI Pilot System will not address all of these issues. This is the purpose of the ASDI, for which the proposed pilot project is an initial step. At the same time, it is the pilot that addresses the fundamental issues in information sharing, without which, the ASDI cannot deliver on its promises for Saudi society.

The ASDI System in the long run will provide significant benefits to the citizens of Riyadh and to Saudi society in general. In particular, it will provide:

- An integrated, coherent and accurate set of geographic and geographically related information on a variety of scales that will support planning, permitting/authorization, urban security, emergency response, and key operational functions of the city including transit, traffic management, and land development.
- A means of competing with neighbouring jurisdictions (e.g. Qatar, Dubai) by providing a better information base for planning and development, hence providing an incentive investment in Riyadh.
- A means of reducing costs for major construction projects by reducing or eliminating delays through conflicting and incomplete information.
- A foundation for similar systems in major cities and regions across the kingdom.
- A means of significantly reducing the costs of information acquisition (e.g. eliminate multiple surveys, aerial photography and satellite imagery acquisition and compilation by different agencies for the same territory).
- A means of greatly improving the quality of the information base simply because different information sources are integrated with one another.

It is anticipated that the ASDI will be an ongoing investment by the city similar to other types of infrastructure such as telephone, sewage and water. Operation of the infrastructure may begin in government, but may in future be operated in the private sector. The initial phase of the full ASDI will begin with the project already announced by the ASDI. This will focus on issues of metadata management, and provision of a common point of access for geographic information within the ADA. The project did not, in its initial phase, however, deal with the cross jurisdictional sharing of information, something that is essential to a meaningful base of integrated information for the city.

To this end, Galdos has proposed the development of a pilot ASDI system, focused entirely on the subject of distributed data update in a multi-jurisdictional environment. This pilot ASDI system will focus more specifically on a subset of the Arriyadh Base Map, and enable the update of this base map by multiple, different organizations, respecting the particular jurisdictional

authorities of the participants. This pilot system will then be upgradeable to provide cross-jurisdictional information sharing in the context of the full ASDI system.

The ASDI Pilot Project will demonstrate the viability of open standard interfaces, in particular OGC GML, WFS, WMS and WRS to provide cross vendor and cross jurisdictional update of base mapping information for the city of Riyadh. It is intended that the system components installed in this pilot project will be extended in a subsequent phase to form key components of the larger ASDI system.

The ASDI Pilot System will focus only on the distributed update of the Arriyadh Base Map, and for the purposes of the pilot will be restricted to a selected subset of Arriyadh.

The specific benefits of the ASDI Pilot System will include the following:

- Demonstration of real world data sharing between the key actors in Arriyadh. This includes showing that cross-jurisdictional updates, respecting the authority of specific organizations can be achieved in practice.
- Demonstration of policy-base security for geographic data across multiple agencies.
- Establishment of an open-standards based set of components and technology that can expand into the full scale ASDI.
- Builds consensus among multiple organizations (external to the ADA) respecting data sharing and the benefits of the full scale ASDI.
- Reduces the risk for the full scale ASDI deployment by attacking the critical and specific issue of cross-jurisdictional information sharing.
- Provides capacity development in Riyadh through the training of personnel in ADA and at King Abdul Aziz University on open standards (ISO/OGC) and associated technologies.
- Establishes the ADA as a leader in SDI implementation within the kingdom.