A Platform for Internet GIS

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Abstract
With the proliferation of Internet usage, it has become imperative on the part of Government Agencies and City Planners to publish their data on the web. A lot of this data is GIS related in the form of zoning maps, addresses and traffic patterns. This has led to academic and industry interest in developing technologies to efficiently and aesthetically render maps and map related data onto Internet browsers. But, there has been scant discussion and effort towards detailing all the components that are needed for a production-strength deployment of an Internet GIS system. This paper outlines some of the components needed for such a system. A large North American city is used as a case study to explain how some of these technologies are being used today to serve the city's populace.

Introduction
The ability to access driving directions, housing information and city maps has made our every-day life more convenient. There has been significant work on presentation technologies like JSPs, Applets and SVG, which can be used for GIS but not much on the other technologies needed for a complete Internet GIS system. Let us now outline such a system and study the different components. A typical Internet system consists of 3 distinct tiers. The client tier consists of rendering technologies to display maps on browsers. Techniques to display animation, zoom, and 3D-effects have been studied and detailed. The next tier is the middle tier and capabilities like User Management, Security, Mapping Engines, Caching, Execution Containers and Web Servers dominate this tier. The back tier is the last tier and this is dominated by a scalable data source, typically a relational database. Capabilities like support for spatial data, versioning, indexing schemes and extensibility differentiate one database from another. Let us now look in more detail into the database and middle tiers.

Database tier Support
Databases have been traditionally used for transaction processing. But with the growing demand for a scalable data source to support Internet GIS systems, relational databases have been increasingly used for this purpose. Let us now look at 2 key technologies in Oracle that makes it the platform of choice for Internet GIS deployment

Spatial Support
Any database that aims to provide support for an enterprise wide GIS system should address the following issues –

1. Support for complex data types like lines, points and polygons. In addition, support for operations like intersection and distance on these types.
2. The spatial types and operations supported should be part of the standard query language so that spatial data can be used with non-spatial data seamlessly.
3. The system should also provide performance enhancements such as indexes to process spatial queries (range and join queries) and support for parallel loads.

Workspace Manager
Typical Internet deployments come with a range of workflows that have to be supported without impacting the production environment. Users demand 24/7 access to data on the Internet and as a result data availability becomes a key issue. In addition, GIS projects are usually of long duration (construction of roads, parks, buildings etc) and thus the demands of keeping the as-built state consistent with the "live" state is an ever-present problem.

Workspace Manager is a new feature of Oracle9i Database that enables applications to version database rows, and isolates collections of row versions in database workspaces. It can be used to store both the "live" version of data as well as the as-built version of the data in the same database. Each GIS project can be categorized into a workspace and the data from the workspace can be periodically trickled into the "live" site. Explicit privileges control access to workspace and data. In addition, Workspace Manager supports a history option whereby data can be tagged with a timestamp and users can issue time related queries (example - show me how this land parcel looked 2 years ago?).

Thus native support for spatial type and integrated support for multiple versions in the repository make the Oracle database an ideal back-end tier for an internet GIS system.

Middle tier Support
The 3-tier Internet architecture has some fundamental differences from client-server architecture. The number of users in an Internet system is exponentially higher than the number of clients in a C/S system. As a result, the middle tier in the Internet system should be equipped to handle mass user authentication. Directory support like LDAP is crucial. In addition, support for single-sign-on makes the user experience seamless as the user moves from application to application. Another important requirement in an Internet system is the click-response metric and this requires efficient caching of pages in the middle-tier and the ability to farm out these caches over a geographical area to help local performance. Finally, another important mid-tier requirement is a mapping engine. The mapping engine in the mid-tier takes in data like map name, center location, data source and map size and returns a map image (or a URL for the image) and the minimum-bounding rectangle (MBR) of the map. The Oracle Internet application server has all the features mentioned above and provides and ideal platform for production Internet deployment.

Case Study
Edmonton is the capital of Alberta and Canada's fifth-largest metropolitan area. Greater Edmonton, which encompasses 22 municipalities, is a metropolitan center with a population of more than 900,000. The city has an Internet GIS system titled SLIM (Spatial Land Inventory Management system). The city serves information related to addressing, zoning and land reports to its citizens through the Internet. Edmonton uses Oracle database as its back-end with Spatial and Workspace Manager as one of its key technologies. The extended paper and the presentation will cover more details on the workflows employed in the city and how the features mentioned above complete the system.

Summary
Much focus has been given to map rendering technologies. This paper lays out the blue print for the building of a complete 3-tier Internet GIS system. Attention to the middle and database tier has culled out key requirements for such a system. User case study presented further validates that the technologies are relevant and crucial in the building of an Internet system that can serve its purpose efficiently and productively.