Oracle 10g:

A Location-enabled Platform for Enterprise GIS and Core Business Applications

Jim Farley

Introduction

The notion of extending commercial database technology to accommodate the location-based or spatial data that fuels Geographic Information Systems (GIS) is not new. In fact, efforts to integrate robust data management systems with the analytics and the visualization tools common to GIS have been under way in one form or another for nearly as long as these systems for spatial analysis have been in use. There have been many attempts in academia and in both the public and the private sectors to accomplish this integration. However, only a limited number of these initiatives were sustained and even fewer managed to grow and mature over time. This brief discussion will provide an overview of a highly integrated, location-enabled platform from Oracle Corporation, presenting both a sense of its historical development and details of the features that have been introduced in the new Oracle 10g release.

Building Location Infrastructure in the Database

Over the past decade Oracle has sustained a consistent, focused development effort directed at creating robust infrastructure technology with the capacity to support both enterprise GIS requirements and the requirements of those core business applications that can be optimized, enhanced, or extended through incorporating spatial data, visualization, and the notion of basic spatial relationships. The fact that every Oracle database, beginning with Release 9i in 2001, is location-enabled with the capacity to store, index, and perform basic operations against spatial geometries (points, lines, polygons, and their collections) underscores this focus on building highly integrated infrastructure for spatial and location-based applications. This core functionality (available in every database) is referred to as Oracle Locator. To support enterprise GIS applications Oracle Spatial adds high-end infrastructure features to the core functionality of Oracle Locator (**Figure 1**).

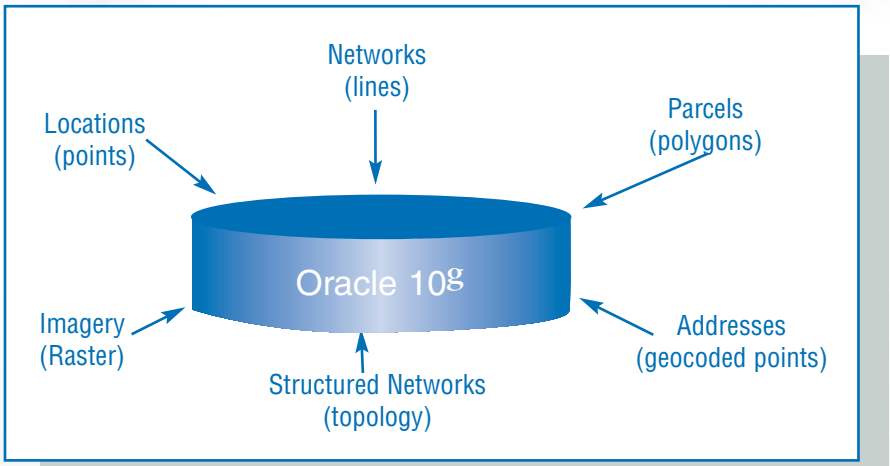

Figure 1 *Oracle10g can store and manage all types of location data for both Enterprise GIS and core business applications.*

Oracle's decade-long development effort has been complemented by input, guidance, and review from a comprehensive cross-section of the geospatial community including the commercial sector, various standards communities, and academia. The sections below provide a summary of the Oracle location-enabled platform that currently supports

an installed base of enterprise applications across government, communications, utilities, transportation, defense, a broad range of land management domains, and many other sectors. This is followed by an overview of the new location-based infrastructure features that are introduced in Oracle 10g.

Geometries and Spatial Referencing

Every Oracle database ships with the Locator feature that supports three basic geometric forms that in turn can be used to represent features such as roads, administrative boundaries, utilities, etc. that typically comprise spatial databases. These spatial primitives include:

- **Points and point clusters:** Points can represent locations such as buildings, fire hydrants, utility poles, oil rigs, boxcars, or roaming vehicles.
- **Lines and line strings:** Lines can represent roads, railroad lines, utility lines, or fault lines.
- **Polygons and complex polygons with holes:** Polygons can represent outlines of cities, districts, flood plains, or oil and gas fields. A polygon with a hole might represent a parcel of land surrounding a patch of wetlands.

Coordinates and Spatial Indexes

Location data can be stored in the database using the whole-earth geodetic model that ensures measurements across the earths surface will be highly accurate. Distance, area, and angular units are fully supported in this context.

To integrate and represent spatial information effectively, Oracle Locator and Spatial provide comprehensive tools for managing coordinate systems and projections. Nearly 1,000 commonly used mapping coordinate systems are supported; users can also define new coordinate systems. Oracle Spatial also provides support for converting data freely between different coordinate systems. These transformations can be on a geometry-level basis or an entire layer at a time.

To optimize the performance of spatial queries, the core database provides R-tree indexing. R-tree indexes perform well and require little in the way of administrative overhead to create and maintain (tuning). R-tree indexes can also be created on two, three, or four dimensions of geospatial data.

Spatial Operators and Other Query Tools

A full range of operators that assess spatial relationships is provided with each database as well. For instance, spatial features can be compared to determine if they touch, intersect, contain, or cover one another. These operators can be used to find all of the schools within a tax zone; locate the zip codes or the area codes that a linear feature like a road or a rail network passes through or to find more general relationships that assess any interaction between spatial features (any interact). In addition to these operators the Locator feature delivered with the database provides methods to query based on distance, proximity, and other basic metrics. This capacity would enable a user to locate all service stations within a kilometer of a highway or to locate all homes within 1.5 miles of a elementary school, etc.

There are other location capabilities that exist in the database as well as database features that enrich basic location capacity. These include:

- **Partitioning for spatial indexes**—Spatial indexes can be partitioned in association with partitioned tables. Partitioning tends to improve performance and improve index management.
- **Linear Referencing (Oracle Spatial only)**—This feature is key to linear networking and dynamic segmentation applications common in street routing, transportation, utility and telecommunications networks, and pipeline management.

Oracle Database 10g

For performance, scalability, and reliability reasons users are increasingly turning to database centric spatial computing to meet the demands of growing data sets and increasingly mission-critical applications. Spatial databases like Oracle Spatial, move spatial processes and operations directly into the database kernel, thereby increasing performance and security. Oracle Spatial 10g supports new spatial features, which extend the range and productivity of application developers, enabling a broader range of applications and improving performance. The focus of the new Oracle Spatial 10g features is to address the requirements of both enterprise GIS customers and to meet the growing requirements of core enterprise business applications that seek to leverage the location-related information they collect (address, city, zip, etc.). To meet these requirements Oracle Spatial 10g introduces GeoRaster and network and topology data models, geocoding, and routing capabilities.

Spatial databases, like Oracle Spatial, move spatial processes and operations directly into the database engine, thereby increasing performance and security. With every release, database vendors incorporate new spatial features that increase performance and broaden range of applications. Recent advances in spatial databases are advancing the concept of spatial platform into broader areas with new features such as:

- **Network Data Model:** A data model is provided to store network (graph) structure in some spatial databases, like Oracle Database 10g. It explicitly stores and maintains connectivity of link-node networks and provides network analysis capability such as shortest path and connectivity analysis. Applications requiring network solutions include transportation, transit, utilities, and life sciences. For transportation applications, the network data model also supports a routing feature.

- **Navigation Routing Engine:** A spatial database now supports navigation routing (driving distances, times, and directions between addresses). Other features include: preference for either fastest or shortest routes, returning summary or detailed driving directions, and returning the time and distance along a street network from a single location to multiple destinations.
- **Topology Data Model:** This is a data model and schema that persistently store topology in a relational database. This is useful when there is a high degree of feature editing and a

strong requirement for data integrity across maps and map layers. Another benefit is that topology-based queries typically perform faster for queries involving relationships such as adjacency, connectivity, and containment. Land management manages georeferenced raster imagery (satellite imagery, remotely sensed data, gridded data). This feature provides georeferencing of imagery, XML schema for metadata management, and basic operations like pyramiding, tiling, and interleaving. Applications in environmental management, defense/ homeland security, energy exploration, and satellite image portals will benefit.

- **Geocoding Engine:** Geocoding is the process of associating geographic references, such as addresses and postal codes, with location coordinates (longitude and latitude). A fully functional geocoding engine is now available as part of the industry's leading database. It provides international address standardization, geocoding, and POI matching by querying geocoded data stored in the spatial database. Its unique unparsed address support adds great flexibility and convenience to customer applications.
- **Spatial Analytic Functions:** New server-based spatial analysis capabilities include classification, binning, association, and spatial correlation—essential for business intelligence applications. This technology enables application developers to deploy spatial data mining operations on a variety of point-based features.

In addition to the functionality in the database server Oracle Application Server 10g includes a component called MapViewer. MapViewer is a JAVA-based visualization tool that uses location information from the database (either Locator or Spatial) to build and display maps in either a browser or in the context of a specific application. MapViewer can be used to:

- Create customized maps that show features such as roads, city areas, waterways, and other transportation networks
- Display map themes such as national, state, and local boundaries
- Visualize business data (*e.g.* population demographics, psycho-demographics, sales metrics, etc.), to portray and explore relationships that can often best be expressed graphically as geographic maps
- Complement an applications workflow, providing interaction with mapped data
- Deliver custom maps over the Internet.

Working with a Spatial Database

Integrating location-based infrastructure into core database technology makes it possible for both the business and the GIS enterprise to use their baseline information repositories in many productive workflows (**Figure 2**). Typical use-cases might include any of the following:

- **Geographic Information Systems (GIS):** Query topographic data for flood plain and basic land management. Combine with population data in a single database to support disaster preparation and relief.
- **Utilities Infrastructure:** Maintain spatial database of the entire network including individual poles, lines, hydrants, or distribution centers. Overlay road and housing data for "dig safe" queries. Manage "long transactions" through version management.
- **Energy Exploration and Distribution:** Maintain virtual maps of underground oil or gas deposits. Determine where to locate drill sites, refineries, or storage facilities.
- **Supply Chain Management:** Optimize the flow of goods through the supply chain (product mix, inventory, distribution, warehousing, and shipment routes). Add a location dimension to a supply chain so that suppliers can directly review and take action on information that affects them.
- **Customer Relationship Management (CRM):** Enable organizations to understand, anticipate, and respond to their customer needs, in a cost-effective manner. An Internet-centric business model can use electronic storefronts and self-service to expand service delivery, shorten response time, improve efficiencies, and reduce costs for the fastest ROI.
- **Data Warehousing/Business Intelligence:** Analyze all transactions being collected in ERP systems (customer purchasing, sales, asset characteristics by time and place) to derive insight and enhanced decision making.
- **Wireless Location-Based Services:** Enable Internet and wireless service providers to enhance their content offerings with the delivery of geocoded information through a variety of location aware devices. New types of services include looking up addresses, online geocoding, finding travel directions, and identifying the nearest hotels, gas stations, and other places of interest.
- **Field Service/Telematics:** Enhance and/or enable the delivery of diverse multimedia services to a car or fleet. These services include driving directions, real-time weather and traffic (E511), and a range of personalized concierge services enhanced by location data. Intermodal transportation and Intelligent Transportation Systems are relevant, related areas.

Industry Collaboration and Support

The importance of GIS partners and the need for reliable, successful technology integration is instrumental in any industry. In a growing, evolving environment like the geospatial community partnership, collaboration and a commitment to open systems and standards is essential. For a number of years the location-enabled platform technology provided by Oracle has been embraced as a form of reliable infrastructure from tool vendors across the geospatial community. With 10g we expect to see more, deeper integration as providers of GIS and remote sensing solutions adopt the new infrastructure features.

Summary

Clearly, spatial or location-based data are increasingly viewed as integral elements of many core business applications including some advanced business intelligence and decision support applications such as supply chain logistics and enterprise asset management. As these location-based information become integral components of mainstream business applications, the need to effectively man-

age these "special" data with core enterprise information becomes more pressing. Further, because of this closer coupling with mainstream business requirements the need for core database features like security, replication and application clustering, etc., becomes greater. It is this process of mainstreaming location data and location applications that has driven the development of many of the location features in Oracle 10g. With the introduction of Oracle 10g this database platform provides the location infrastructure to support both enterprise GIS and mainstream business application requirements as they exist today and as they are likely to evolve over time.

About the Author

Jim Farley leads Oracle Spatial Product initiatives in raster technology, hosted location-based services, and in the integration of location technologies across Oracle's eBusiness Suite Applications.

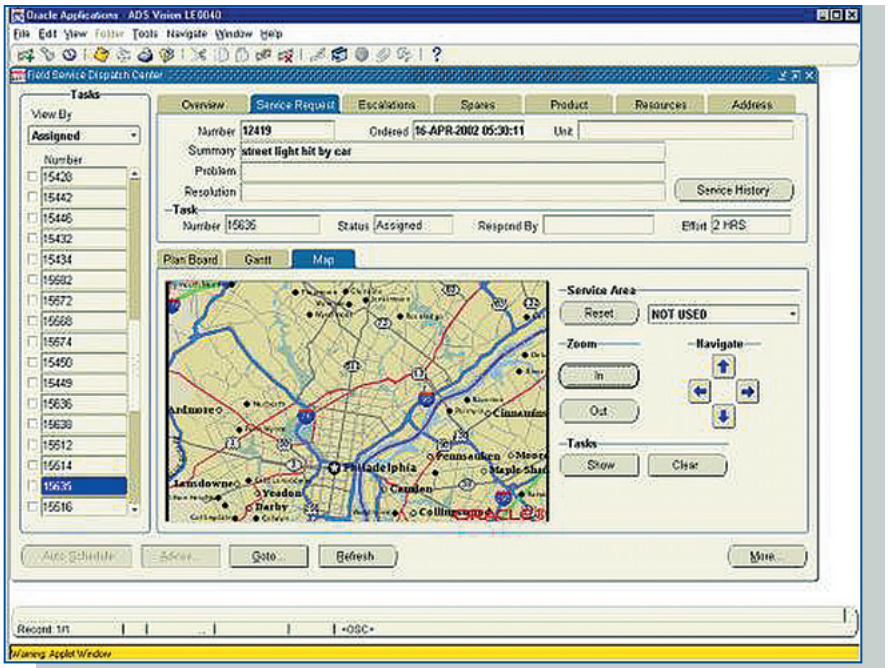

Figure 2 *Core business applications such as Field Service, Asset Management, and Supply Chain are enabled by location-enabled database infrastructure.*