

Oracle Spatial 11g: Advanced Spatial Data Management for Enterprise Applications

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Oracle Spatial 11g, an option for Oracle Database 11g Enterprise Edition, includes advanced spatial capabilities to support geospatial applications, location-based services, and enterprise spatial information systems.

With Release 11g, Oracle Spatial provides significant new functionality that extends its lead as the complete data management platform for the needs of any geospatial or enterprise location-enabled application. Oracle Spatial 11g introduces support for 3-dimensional data and geospatial web services standards. It also provides significant scalability and manageability enhancements for GeoRaster and network data.

INTRODUCTION

Oracle Spatial 11g, an option for Oracle Database 11g Enterprise Edition, provides advanced spatial capabilities to support geospatial applications, location-based services, and enterprise spatial information systems. Oracle Spatial extends the core location features included in every Oracle database with Oracle Locator.¹ Its advanced data manipulation and spatial analysis features include spatial aggregates, area and length calculations, and linear referencing. It also includes a GeoRaster datatype to store and manage image and gridded raster data and metadata, network and topology data models, geocoding and routing engines, APIs for quick and easy deployment of mapping, geocoding, and routing services, and spatial analysis and mining functions. These significant capabilities address business-critical requirements of the public sector, defense, logistics, energy exploration, business geographics, and life sciences domains.

With Release 11g, Oracle Spatial provides significant new functionality that makes it the complete data management platform for the advanced requirements of any geospatial or enterprise location-enabled application. The spatial geometry data type has been enhanced to support 3-dimensional data, and new data types support storage and management of point clouds and terrain models, found in domains such as urban planning, homeland security, or Lidar-based map production. Oracle Spatial now supports geospatial web services standards, to provide a secure, scalable service-oriented architecture platform. The GeoRaster datatype and network data model have been enhanced to handle data sets larger by orders of magnitude with high performance, and are easier to use.

¹ Oracle Locator, a feature of Oracle Database 11g (Express Edition, Standard Edition, Standard Edition One, and Enterprise Edition), provides core spatial features for business applications and partner-based GIS. Features include vector data storage and management, indexing, spatial relationship analysis, coordinate systems support (including support for the EPSG model), and more.

Combined with the performance, scalability, and security of Oracle Database, Oracle Spatial 11g is the most advanced spatial database platform available for enterprise class deployments.

In general, this white paper describes those features included only with Oracle Spatial. Please refer to separate white papers for more information about Oracle Locator features.²

3D DATA TYPE SUPPORT (New with 11g)

Oracle Spatial now provides native storage, querying, and retrieval for 3-dimensional (3D) data including points, lines, surfaces, triangulated irregular networks (TINs - an alternative to rasters), and point clouds. Spatial R-tree indexing now supports 3D data; SQL operators and analysis functions for 3D data are also provided.

Very large 3-dimensional datasets such as urban models, point clouds, and terrain models can now be stored and managed in Oracle Spatial, with security, scalability, high performance, and through an open data type. 3D datasets are often found in urban planning and design, government, homeland security, military, oil & gas exploration, transportation engineering, gaming & simulation, geo-engineering, medical applications, business intelligence (e.g. real estate, advertising), and Lidar-based map production.

SPATIAL WEB SERVICES (New with 11g)

With 11g, Oracle Spatial introduces a web services platform to access, incorporate, publish, and deploy geospatial services, such as for routing, geocoding, business directory, catalog, geospatial feature, and mapping. Because of tight integration with Oracle Database and Oracle Application Server, this is a secure, transactional service-oriented architecture platform with enterprise-class security.

Oracle Spatial supports the following XML-based geospatial web services standards: OGC OpenLS 1.1, Web Feature Service 1.0, Web Feature Service – Transactional 1.0, and Catalogue Service 2.0, on a variety of client technologies and platforms. Oracle Database and Oracle Application Server provide security – including authorization, authentication, and transport confidentiality and integrity. Java and PL/SQL client APIs are provided.

² For descriptions of features in Oracle Locator, please refer to *Oracle Locator: Location-Enabling Every Oracle Database - Technical White Paper* and *Oracle Locator – Feature Overview*. **For complete, detailed listings of Oracle Locator and Oracle Spatial features, please refer to Appendix B of the *Oracle Spatial Developer's Guide 11g Release 1 (11.1)*.**

SPATIAL FUNCTIONS

Oracle Spatial provides functions that perform calculations on geometries, such as area of a polygon and length or perimeter of a geometry. These functions can be used, for example, to determine the total area of all counties around Passaic County, length of an interstate highway, or length of a state border.

Oracle Spatial functions can also generate new geometries such as buffers, unions, intersections, and more. They can be used, for example, to define sales regions by creating a 5 mile buffer around all sales offices, find the geometry representing the union of two sales regions, or find the intersection between two sales regions.

WHOLE EARTH GEOMETRY MODEL FOR GEODETIC COORDINATE SUPPORT

A whole Earth geometry model takes into account the curvature of the Earth's surface when performing calculations on geodetic data. Thus, Oracle Spatial functions return accurate lengths and areas for both projected and geodetic data. Oracle supports over 30 of the most commonly used distance and area units, e.g. foot/square foot, meter/square meter, kilometer/square kilometer, and so on.

LINEAR REFERENCING SUPPORT

Oracle Spatial supports the storage of "measurement" information associated with a linear geometry. This allows many attributes or events to be associated with a specified segment on a linear geometry. Attributes or events are stored in tables separately from the geometry, and the geometry does not have to be duplicated in the attribute tables. Linear referencing is often used by departments of transportation, to model roads or railroads and their attributes; utilities, to model oil or gas pipes and their attributes; and telecommunications providers.

Functions to manipulate linear referenced geometries are also included, e.g. clipping a piece of a linear feature, concatenating a linear feature, and splitting a linear feature.

SPATIAL AGGREGATES

SQL has long had aggregate functions, which are used to aggregate the results of a SQL query. Spatial aggregate functions operate on a set of geometries rather than just one or two geometries. An aggregate function performs a specified aggregate operation on a set of input geometries, and returns a single geometry object. For example, the following statement returns the state boundary of Tennessee generated from all of the counties in Tennessee:

```
select sdo_aggr_union(sdoaggrtype(geom,0.5)) state
from geod_counties
where state_abrv='TN';
```

Other supported aggregate functions include union, centroid, and convex hull; users can also define other aggregate functions. The use of spatial aggregates improves performance and simplifies coding.

GEORASTER SUPPORT

Oracle Spatial includes a data type that natively manages georeferenced raster data, such as satellite imagery, remotely sensed data, and gridded data, in Oracle Database. The GeoRaster feature of Oracle Spatial provides georeferencing of imagery; an XML schema for metadata management; and basic operations like pyramiding, tiling, and interleaving. GeoRaster also supports industry standard compression techniques, including JPEG baseline (lossy) and DEFLATE (lossless) – a key feature that can reduce user storage costs significantly, given the very large sizes of remote sensing imagery data sets. Other proprietary compression techniques are supported through third party plugins. Applications in environmental management, defense/homeland security, energy exploration, and satellite image portals will all benefit from this powerful functionality.

New in 11g:

The current release provides over 30 new subprograms and other enhancements, including advanced mosaic, GeoRaster object or layer union, GeoRaster templates and related functions. GeoTiff, JPEG 2000, and Digital Globe RPC file formats are supported for loading and exporting GeoRaster objects. JPEG files can be loaded without decompression. GeoRaster also supports the use of Oracle SecureFiles.

More metadata and data types are supported. GeoRaster supports a generic polynomial georeferencing model, which includes direct linear transportation and rapid positioning capability georeferencing for rectified and non-rectified airborne photos and satellite images. It also supports multiple NODATA values and value ranges, and has limited sparse data type support.

With 11g, GeoRaster provides enhanced ease of use, reliability, and manageability. GeoRaster DML triggers are created and monitored by the system automatically. Internal changes that monitor DDL events on raster tables and activities on GeoRaster system data enhance the manageability, reliability, robustness, and usability of GeoRaster. Raster data versioning with Oracle Workspace Manager, and raster data row-level security with Oracle Label Security are supported.

For more information about GeoRaster, please refer to separate white papers at oracle.com/technology/products/spatial.

NETWORK DATA MODEL

A data model is provided to store network (graph) structures persistently in Oracle Database. It explicitly stores and maintains network

connectivity and provides network analysis capability such as shortest path, nearest neighbors, within cost, maximum flow and reachability analysis. Applications requiring network solutions include transportation, utilities, social network and life sciences (biochemical pathway analysis).

The network data model also includes: a PL/SQL interface for creating, editing, and analyzing network data; the ability to create and apply network constraints.

New in 11g: Oracle Spatial now supports load-on-demand for partitioned networks, which eliminates memory limitation for in-memory analysis. Large networks can be partitioned into manageable sub-networks and incrementally loaded into memory as needed for performant and scalable analysis. Partitioning utilities are also available for large spatial networks. Thus, users can now analyze very large networks in Oracle Spatial without loading the entire network into memory, to benefit applications that query and analyze such networks.

User or application-specific attributes can be handled at the database level, enabling network data model to manage non-connectivity related information. Users can also selectively extract a subset of a network using SQL-like filters, which speeds up network loading and analysis. Other enhancements include path arithmetic support (such as path addition, subtraction, intersection, comparison) and partial link paths support.

The Oracle Spatial network data model supports multiple concurrent Application Server analysis requests with its thread-safe Java API and supports an XML interface for web services queries. Oracle Spatial network data model provides Java and XML APIs for Service Oriented Architectures and high query volume applications such as field service scheduling and logistics.

For more information about Oracle Spatial network data model, please refer to separate white papers at oracle.com/technology/products/spatial.

TOPOLOGY DATA MODEL

Oracle Spatial includes a data model and schema that persistently store topology in the Oracle 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 (cadastral) systems and spatial data providers benefit from these capabilities.

Application developers and DBAs can version topologies stored in the Oracle Spatial topology data model, using Workspace Manager, a feature of Oracle Database. Feature level spatial transactions against persistent topology in the database are supported. A feature insert or

update occurs as a single operation, simplifying the process of updating and maintaining topology datasets, and keeping code streamlined.

SPATIAL ANALYTIC FUNCTIONS

Server-based spatial analysis capabilities include classification, binning, association, and spatial correlation – essential for business intelligence applications.

For more information about spatial analytic functions, please refer to a separate white paper at oracle.com/technology/products/spatial.

GEOCODER

Geocoding is the process of associating geographic references, such as addresses and postal codes, with location coordinates (longitude and latitude). With Oracle Spatial, a fully functional geocoding engine is provided. It provides international address standardization, geocoding POI matching by querying geocoded data stored in Oracle Database, reverse geocoding, batch geocoding, and other geocoding subprograms.

Its unique unparsed address support adds great flexibility and convenience to customer applications. SQL, Java, and XML APIs for geocoding are provided, and it can be deployed either at the middle tier (J2EE – Oracle Application Server) or at the database server tier.

For more information, please refer to a separate paper at oracle.com/technology/products/spatial.

ROUTING ENGINE

A scalable routing engine provides driving distances, times, and directions between addresses (or locations that have been geocoded in advance). It is provided as a Java client library that can be easily deployed in either Oracle Application Server or standalone OC4J environments. 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. It also provides driving distances, times, and directions between addresses for over a dozen Western European countries, including Germany, United Kingdom, France, and more, to support logistics, transportation, and location-based services applications.

New in 11g: The Spatial routing engine now provides driving directions in Western European languages including German, French, Spanish, and Italian. Generation of turn-specific geometries is now supported, which helps with location services applications that require turn-specific yellow pages data. Computed routes can be returned as a set of edges that can be used for further analysis.

eLOCATION QUICK START

Location service Java and XML APIs (“eLocation Quick Start”) enable application developers to quickly and easily deploy mapping, geocoding, and routing services right “out of the box”, from data stored in Oracle Spatial. The APIs ship with sample HTML interfaces to jump-start the creation of driving directions, mapping, and geocoding applications. The Oracle Spatial geocoding and routing APIs may be used by Oracle Application Server MapViewer, many third party mapping tools, or user-developed applications.

Sample data is available online. Data sets in the format supporting Oracle Spatial 11g are also available from leading data providers.

Visit oracle.com/technology/products/spatial for more information.

ENTERPRISE FEATURES SUPPORTING SPATIAL IN ORACLE DATABASE 11g

Oracle Database 11g provides powerful, reliable support for an organization’s mission-critical applications. These enterprise features enrich Oracle’s spatial capabilities via a flexible Internet deployment architecture, object capabilities, and robust data management utilities that ensure data integrity, data recovery, and data security. This level of support can only exist in the homogenous environment of an enterprise database solution, and cannot be effectively replicated in a hybrid solution that marries an external location-based solution with a traditional enterprise solution, no matter how tightly integrated the two components may appear.

Oracle Spatial takes full advantage of expanded database size limits, high-performance VLDB maintenance utilities, replication, workspace manager (versioning), faster backup and recovery, and partitioning. Only users of Oracle’s native spatial datatype can take full advantage of features such as partitioning, replication, parallel index builds and queries, and spatially-driven multi-level security. These features are not available or limited in functionality when using the LONG RAW or BLOB datatypes. The full range of Oracle utilities (e.g. SQL*Loader) are also available to ease migration and help upgrade applications that use the location-based services features. Some of these key enterprise features are described below.

Partitioning Support for Spatial Indexes

Oracle’s database architecture includes partitioning, in which a single logical table and its indexes are broken up into one or more physical tables, each with its own index. Spatial indexes associated with partitioned tables can be partitioned; range partitioning is the partitioning scheme supported for spatial indexes.

Partitioning offers significant performance, scalability, and manageability benefits, including the following:

- Reduced response times for long-running queries; partitioning can reduce disk I/O operations.
- Reduced response times for concurrent queries; I/O operations run concurrently on each partition.
- Easier index maintenance, because of partition-level create and rebuild operations.
- Ability to rebuild indexes on partitions without affecting the queries on other partitions.
- Ability to change storage parameters for each local index independent of other partitions.

Partitions can also be split, merged, and exchanged.

Parallel Spatial Index Creation

Spatial indexes and index partitions can be created in parallel. R-tree index creation can be subdivided into smaller tasks that can be performed in parallel, making use of unused hardware (CPU) resources. For certain spatial data sets and index types and parameters, parallel index creation can substantially increase index build performance and provide a significant time savings. Large non-point datasets (commonly used in many standard GIS applications) can show dramatic performance improvements.

Parallel Spatial Queries

Spatial queries can now run in parallel on partitioned spatial indexes, improving the performance of "within distance", "nearest neighbor", and "relate" queries. Performance scales with the number of CPUs used to execute a query. This helps location service and land management applications, which need to execute high volumes of spatial queries quickly.

Replication

Oracle's Advanced Replication capabilities can be used for location data. For example, distributed systems that involve geographically dispersed yet logically replicated web sites, can take advantage of synchronized replication of spatial data objects across multiple databases.

Note: Advanced Replication multimaster configuration is offered with the Enterprise Edition database only. Refer to the *Oracle Database Advanced Replication* manual for more information about Advanced Replication features.

Database Workspaces

Oracle Workspace Manager, a feature of Oracle Database, provides a virtual environment (workspaces) that allows current, proposed and historical values for data to be managed in the same database. Workspaces can be shared and used to: isolate a collection of changes to

production data until they are approved and merged into production; keep a long term history of changes to data; and create multiple data scenarios based on a common data set for "what if" analysis.

OPEN STANDARDS

Oracle consistently works to help shape, drive, implement and support the latest open standards in the spatial and location services areas. Oracle is a Principal Member of the Open Geospatial Consortium (OGC) and participates actively on the Technical Committee. Oracle is also committed to supporting the new OGC Geographic Markup Language (GML) as well as Open Location Service interfaces. The object-relational model used for geometry storage by Oracle Spatial also conforms to the specifications associated with SQL92 representation of points, lines, and polygons.

Oracle Spatial supports the SQL/MM types and operators, as specified in *ISO 13249-3, Information technology - Database languages - SQL Multimedia and Application Packages - Part 3: Spatial*. Oracle Spatial operators corresponding to those defined in this standard, as well as the SDO_NN and SDO_WITHIN_DISTANCE operators, can be used on data stored in the SQL Multimedia root type.

SUPPORT FROM LEADING GEOSPATIAL AND LOCATION SERVICES VENDORS

Oracle Spatial is directly integrated with the leading geospatial and location services technology vendors worldwide. The breadth of partner support provides developers with their choice of best of breed tools to meet their requirements.

Support from leading systems integrators, both from the geospatial and enterprise IT domains, provides customers with choices for fast deployment of customized solutions to meet their specific requirements.

With Oracle Spatial 11g and partner tools, developers can rapidly deploy scalable, secure enterprise geospatial and location service solutions.

A list of partners is available at oracle.com/technology/products/spatial.

CONCLUSION

The Oracle Spatial option provides advanced spatial capabilities for Oracle Database 11g, addressing the business-critical needs of customers in traditional geospatial domains such as defense, homeland security, land management, transportation, as well as a broad range of domains from finance and retail to life sciences.

Oracle Spatial with Oracle Database Enterprise Edition is the solution for users who have geospatial applications requiring advanced server-side spatial analysis and processing. Oracle Spatial 11g introduces the world's first native support for 3-dimensional data in a database management system. Oracle Spatial now supports storage and management of urban models, point clouds, and terrain models found in domains such as urban planning, homeland security, or Lidar-based map production. Oracle Spatial 11g is also now a geospatially-enabled web services platform, supporting major XML-based standards from OGC.

Oracle Spatial supports all data types found in geospatial and location-enabled business applications. An open GeoRaster format supports the image storage and management requirements from the public sector, defense, and energy exploration domains. Network and topology data models meet the needs of applications in transportation, utilities, land management, life sciences, and location services. A server-side geocoder and routing engine support the deployment of location-based services, and spatial analysis functions enhance business applications. With the "eLocation Quick Start" Java and XML APIs, developers can quickly and easily deploy mapping, geocoding, and routing services. With Oracle Spatial 11g, users can manage larger datasets with better performance than ever before, with less complexity.

In repeated studies, IDC has found that Oracle is the most widely used enterprise spatial database server, with over 80% of the enterprise spatial database market.³ Customers and partners rely on Oracle to deliver performance, scalability, security, and ease of use for their spatial applications. Oracle Spatial is supported by all the leading geospatial and location services vendors and systems integrators.

With every release since its introduction over ten years ago, Oracle Spatial has added advanced spatial data management capabilities to relational database management systems. Oracle Spatial 11g continues this mission. With the unmatched enterprise data management capabilities of Oracle Database 11g, it continues to be the world's leading database management platform for geospatial and enterprise spatial systems.

³ IDC, *Oracle 10g: Spatial Capabilities for Enterprise Solutions*, Sonnen and Morris, Feb. 2005



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