Land Information Management and its (3D) Database Foundation

Han WAMMES, the Netherlands

Key words: Oracle Database, Oracle Spatial, 3D data-types, Oracle Land Information Management Proposition, SOA, Cloud Computing, Interoperability, Security, Information Management, Process Management, e-Government, INSPIRE, LADM/STDM

SUMMARY

From the inception of the Oracle Spatial Engine over ten years ago, Oracle has been striving to make spatial information an integral part of its information management architecture. The Oracle information management architecture includes such areas as GIS, Document Management and Archiving and Business Intelligence. Built initially as disparate solutions on top of the Oracle object-relational / native XML database. It became soon quit clear that taking a more holistic and standardized approach to information management, would create much more value to our customers. By managing spatial databases, document stores and data-warehouses in one database environment taking an unified approach based on open standards, would relief the integration, management and security burden of dealing with such a diversity of structured and unstructured data tremendously. Today these capabilities are an integral part of Oracle's vision on enterprise information management. They also fit naturally in current strategies on SOA, Engineered Systems, Cloud Computing and Big Data, which require not only a unified approach to information management, but also require an unified, on open standards based, approach to process management. The current trends in the GIS domain boil down to exactly these strategies. Especially in the Land Information Management domain, many organizations are re-considering their current systems or implementing new systems if they didn't exist before, like in developing countries, to accommodate new requirements such as open standards based, an integrated approach to managing information, interoperability between systems and support for 3D data-types in the GIS domain. e-Government initiatives and initiatives like e.g. INSPIRE require this open approach towards Land Information Management as land is probably the most important asset, humanity has, to manage our future. In this paper it will be shown how Oracle has been adopting modern technologies as part of its strategy, especially in the 3D area. It will also be shown how e.g. the LADM/STDM application scheme helps in defining Oracle's strategy towards Land Information Management to create a more agile solution based on IT strategies in dealing with current and future requirements.

Land Information Management and its (3D) Database Foundation

Han WAMMES, the Netherlands

1. INTRODUCTION

Ever since Land Information Management systems came into existence, attempts have been made to incorporate GIS capabilities into Land Information Management systems. To be able to manage the geometrical representation of land, together with the descriptive information, many sometimes very artificial solutions were built in linking files containing geometries to relational databases containing the descriptive information. Although many organizations tried to take a more integrated approach, only with the introduction of spatial databases, it became possible to take a truly integrated approach. Oracle was one of first to implement such capabilities in an open way, thanks to the standardization effort of the Open Geospatial Consortium in developing the Simple Feature Specification in which Oracle took a major part. Many of the GIS vendors got rid of their linked file approach, adopted this integrated approach and became a natural technology partner of Oracle. Since then many developments in both the GIS and the IT industry and the standardization effort of OGC® has helped supporting the requirements of Land Information Management systems at least on a technological level. But strangely enough this domain is still characterized as not integrated; deeds are still kept separate from the descriptive and geometrical representation of land and systems are still custom-built. Off course this is a very generalized statement and really dependent on the legal situation, the technical and financial capabilities of the implementing organization and the value it has for society, but in essence though, while the technological capabilities changed drastically, especially in this era of Service Oriented Architecture, Cloud Computing, Sensor Technology (the internet of things), Big Data, Openness (Open Standards and (Linked) Open Data)), organizations dealing with Land Information Management are still very traditional in their approach.

In this paper the following subjects will be covered:

- In chapter 2 the context in which land information is used will be described; managing land information is not self-contained, land information has many stakeholders. Ultimately it is about the value land information can create for society in a sustainable way.
- In chapter 3 the technological developments facilitating Land Information Management systems will be covered; what technologies and what standards are prerequisite to support the context described in chapter 2.
- In chapter 4 it will be shown how we can bridge the gap between technology and value creation; agreeing and standardizing on the semantics of information and processes, like what is being proposed with the LADM/STDM ISO submission, could help minimizing this gap.
- In chapter 5 the Oracle Land Information Management proposition on a conceptual level will be presented.
- In chapter 6 we will cover the current Oracle Spatial 3D capabilities.

- In chapter 7 we will draw a conclusion and resume shortly on the capabilities of the proposed multi-purpose Land Information Management system supporting the required multiple goals.

2. THE CONTEXT OF A LAND INFORMATION MANAGEMENT SYSTEM

Egypt was one of the first countries, which over 2000 years ago already implemented a Land Information Management system. The system was used to register, who was growing what crop and where. As such this system could be called the first Land Information Management system if we define a Land Information Management system as a system, which manages information about land and information related to that land. Land shouldn't be restricted to land alone but should include water and infrastructure including buildings as well. There is always a reason why you want to manage information about land, so there should be someone or some organization having an interest in land. This relation could be anything from is 'owner of' through 'grows crop on' to 'preserves'. In general we could say a <subject> has a relation to an <object>, which we call land. In our earlier example, we know that the pharaoh's used this information to collect tax to pay for their expansion strategies. Some people argue this information was actually needed to re-establish land boundaries after the rainy season. People could then reclaim their rights on land when the river Nile washed away the boundaries of the land, but fortunately left a very fertile soil to grow new crop. In any case a Land Information Management system nowadays should serve many purposes, most of them are focused on value creation:

- A land parcel is the basic unit for access and control of land and to make land use decisions
- Currently, reliable land information is necessary for many public programs such as land planning and infrastructure development and maintenance
- Land is a basis for land markets, development, and other economic activity like tax collection

But may be even more challenging though is dealing with the negative consequences of the over utilization of our resources and how to manage this. Sustainable land management has become the central challenge in the sustainable management of earth systems and resources. On the one hand, land management must ensure a growing supply of food and other resources to human populations, which are expected to grow for decades to come. On the other hand, management of land to procure these resources is linked with potentially negative consequences in the form of climate change, biodiversity loss and pollution. Moreover, local alteration of land use and land cover can have global consequences, requiring local and regional solutions to global problems and the cooperation of the world's policymakers, land managers, and other stakeholders in land management at local, regional and global scales.

Though humans have been modifying land to obtain food and other essentials for thousands of years, current rates, extents and intensities of land change are far greater than ever in history, driving unprecedented changes in ecosystems and environmental processes at local, regional and global scales. These changes encompass the greatest environmental concerns of human populations today, including climate change, biodiversity loss and the pollution of water, soils and air. Monitoring and mediating the negative consequences of land change while sustaining the production of essential resources has therefore become a major priority of researchers and policymakers around the world (Article on Land-use and land-cover change, published on the Encyclopedia of Earth by Erle Ellis on April 18, 2010, 3:06 pm and last edited on May 11, 2011, 1:40 pm).

3. THE TECHNOLOGICAL DEVELOPMENTS FACILITATING LAND INFORMATION MANAGEMENT SYSTEMS

From the inception of the Oracle Spatial Engine over ten years ago, Oracle has been striving to make spatial information an integral part of its information management architecture. Built on top of its object-relational / native XML database, Oracle has natively integrated spatial capabilities. This approach resulted in a wide adoption with customers and partners of the Oracle Spatial Engine and its different data models such as the object-relational model for representing (2D) geometries and the native GML implementation, but also the topology model, the network data model, the geo-raster data model and linear referencing. On top of that, with the adoption of service-oriented architectures, (2D) web-services like WFS (-T), were introduced, web-services which can participate in a process flow (BPEL/SOAP), thus providing a standard process management architecture (SOA/BPM), including geo-processing. On top of that viewing capabilities were added (Oracle MapViewer) supporting WMS and also catalog services as CSW and OpenLS services were added. Together, this Open Standards based geo-architecture provides unique basic capabilities to deal with the issues a Land Information Management system encounters in terms of storage, management, security, processing, governance and dissemination. Because the architecture is based on Open Standards it is easily expandable with other 3rd party Open Standards based technologies, like many of the Open Source and vendor supplied GIS tools, thus completing the solution. Currently Land Information Management systems are changing quit rapidly due to the changing data management requirements because of the acquisition of larger amounts of (3D) sensor data, but also because the land information, which needs to be managed has become much more complex due to the complexity of the environment, especially in urban areas. By extending the capabilities of the Oracle Spatial Engine in Oracle 11g, new geo-referenced data types have been introduced to store and manage point clouds, TIN’s and 3D vector geometries. Together with web-services for dissemination of 3D data, the initial 2D geo-architecture has been enhanced to a 3D geo-architecture, thus not only fitting the needs of a modern Land Information Management system, but also fitting (future) SDI requirements (Inspire) and e-Government requirements. Additionally this architecture naturally fits in Oracle’s Cloud strategy, which includes Oracle’s Engineered Systems, the Oracle Database Machine (Oracle Exadata) and Oracle Middleware Infrastructure combined with hardware (Oracle Exalogic Elastic Cloud) and Oracle’s vision on Complex Event Processing and Big Data. Figure 1 shows the Oracle Spatial components and where they fit into this architecture.

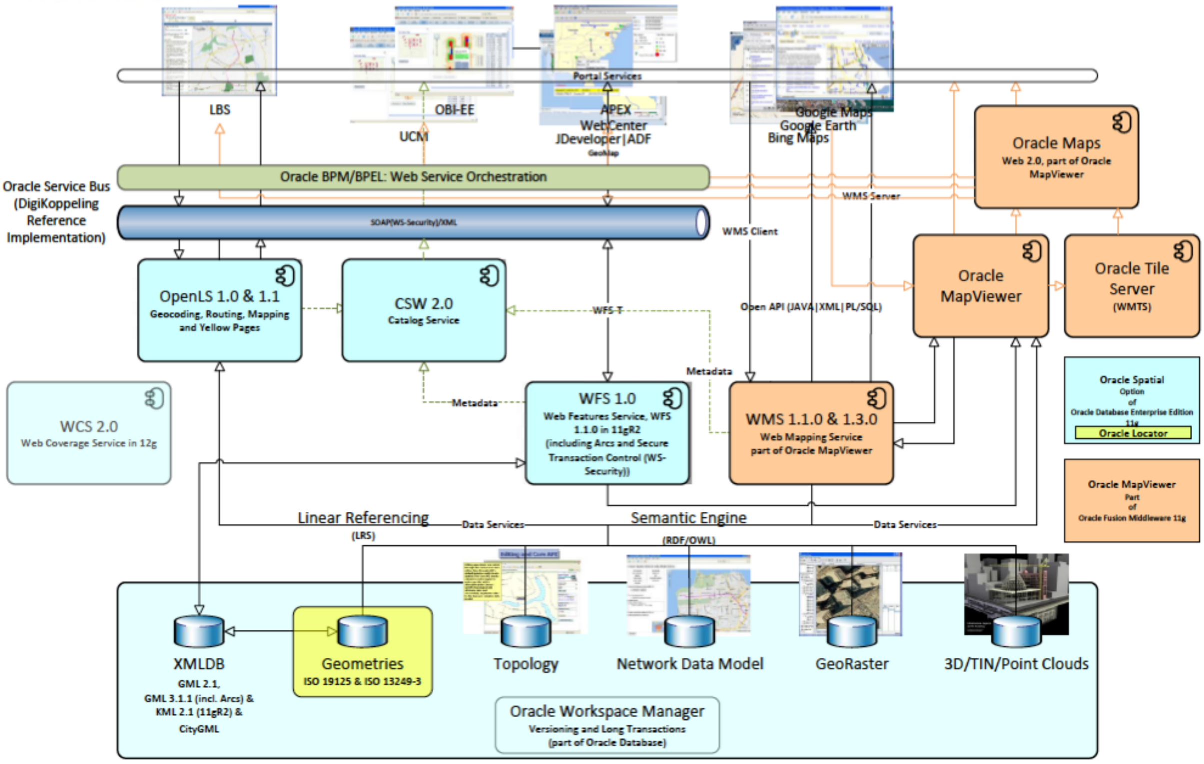
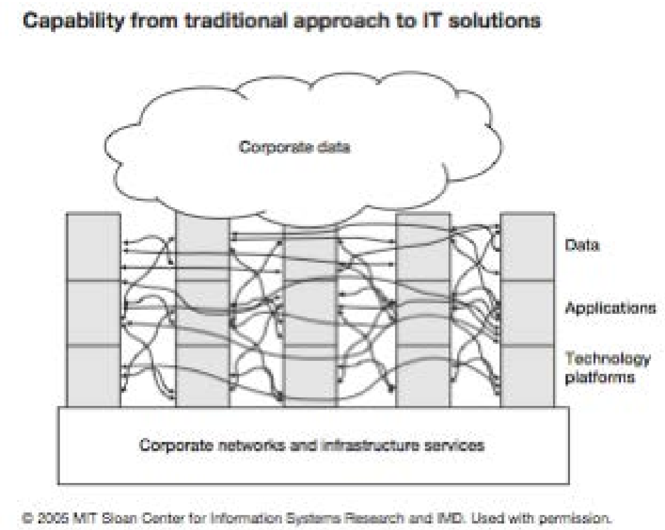


Figure 1. Oracle Spatial components

4. HOW TO BRIDGE THE GAP BETWEEN TECHNOLOGY AND SUSTAINABLE LAND MANAGEMENT

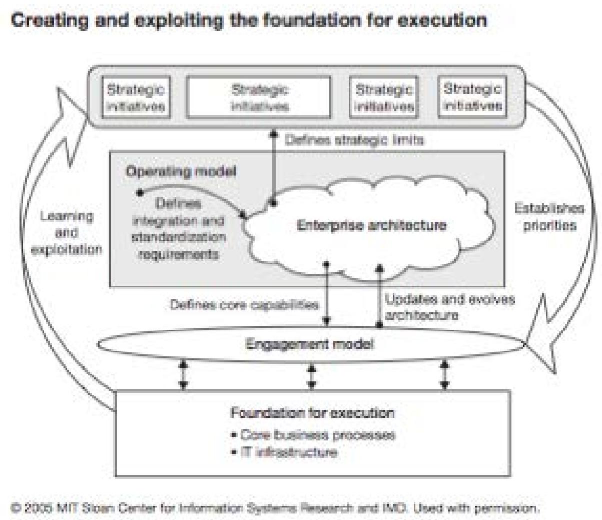
As always with technology, in itself it has no value, but it is required to be able to provide the required information, to help to reach the goals of a sustainable land management solution. To support such a holistic approach, we need to create insight in how to find a balance with nature again, but also between the financial, social and cultural differences. As Egyptian history has shown over and over again, these have been the continuous reason for conflicts.
The conflicts we are dealing with today go completely beyond what happened in Egypt. Some people claim we are already beyond the point of no return, others claim we are close to the point of no return. The only certainty we have is that doing nothing is no option, but doing the right thing is a challenge. Sustainable land management could well be the first step in this challenge and we definitely need systems to support this.

As said the technology is there and the goals are set. Implementing Land Information Management systems has been done before, but not with this holistic, agile approach in mind. Service Oriented Architectures, GIS architectures, Cloud Computing and the wide adoption of open standards provide the proper conditions to make this happen, but also imply a risk if not well architected and governed. It is probably worthwhile to read (Ross, Weill and Robertson, 2006) why this is important. For the sake of this paper, it is important to realize that strangely enough agility is not about complete flexibility, but understanding what the goals are you want to realize with your system and decide on what to standardize and consolidate and fixate specific core functionality which doesn’t change. Ross, Weill and Robertson (2006), call this a ‘foundation for execution’.


Capability from traditional approach to IT solutions

© 2005 MIT Sloan Center for Information Systems Research and IMD. Used with permission.

Figure 2. How traditional systems have been built


Creating and exploiting the foundation for execution

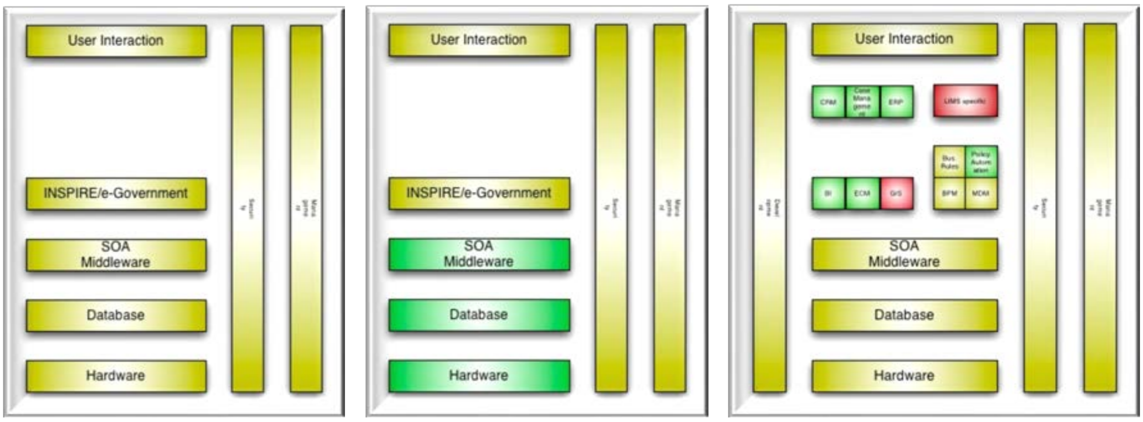
© 2005 MIT Sloan Center for Information Systems Research and IMD. Used with permission.

Figure 3. How future systems can be built

If we would be able to integrate all these technologies and would able to define a common technical foundation and implement common information and process models like the LADM/STDM ISO submission proposes for the logical foundation, we would be close to the multi-purpose Land Information Management solution, which could serve the different goals we have with this solution and is based on well recognized paradigms as SOA and Cloud Computing and could also be based on new paradigms as Big Data or Engineered Systems.

5. THE ORACLE LAND INFORMATION MANAGEMENT PROPOSITION

Currently Oracle is analyzing whether Oracle should come up with a proposition, which would serve the different configurations needed to support the different requirements for acquiring, managing, analyzing and distributing land information. Recognizing that, although Oracle has a very complete portfolio supporting the foundation for execution strategy discussed in chapter 4, we lack specific components in the Land Information Management domain. Specifically the GIS editing part for manipulating the parcel fabric and the specific applications required for managing the land information are missing. The latter is in many cases still custom built or at least propriety. This is also the part the LADM/STDM domain models comes in, as they define a basis for both a common information model and a process model. This is similar to what Oracle has defined in its AIA (Application Integration Architecture)/MDM (Master Data Management) framework for its suit off applications for people, products and sites (Citizen/Customer hub, Product hub and Site hub), previously known as TCA (Trading Community Architecture) containing both an information model and a process model for trading parties. Combined with Oracle’s unique capabilities of storing and managing both structured and unstructured data (multimedia, text documents, spatial data, semantic data, analytic data) in one and the same database and leveraging Oracle’s so called Engineered Systems for Database and SOA Middleware (J2EE) would drastically relief the management burden, reduce the exploitation cost, increase performance, optimize the utilization of both system memory and storage and would provide the necessary end to end security based on a ‘know your data’ strategy (open versus privacy versus security). These 3 aspects would prepare for Cloud Computing (IAAS and PAAS) and provides the stable platform needed for the ‘foundation for execution’ for supporting a sustainable Land Information Management system.



Figures 4a. Basic Infrastructure, 4b. Optimized Infrastructure and 4c. Land Information Management Architecture

The three step approach to a Land Information Management architecture:

- Provide all the components to be able to act as an INSPIRE node, a (N)GII node or an e-Government hub. Include all Information Models (including LADM/STDM and CityGML) necessary to serve both the data and the semantics to support viewing, distribution of data and participation in e-Government processes (base registrations in the Netherlands). Also include (Spatial) ETL tooling and (Geo) Web Services to ingest (spatial) information from external systems. Optionally include Oracle BI for metadata management, viewing, distribution and analytics (Figure 4a.).

- Same as the 1st, but based on engineered systems (Figure 4b.).
- Full Land Information Management system. Includes the 1st or the 2nd and includes 3rd party GIS editing tools and specific Land Management applications (either 3rd party, custom-built if supporting Open Standards or redesigned and based on LADM/STDM). Include ECM, BI, Case Management, Business Rule Management, … on as needed basis (Figure 4c.).

Needless to say that each and every component should be standards based so they can be integrated or exchanged with other components either of the shelve or Open Source software. Oracle has had and is still having a strong partner strategy, both in the commercial (including ESRI, Intergraph, ERDAS, 1Spatial, Snowflake, SafeSoft (FME), Autodesk, Bentley, …) and in the Open Source community (including Refractions (GeoServer, Udig), ...).

6. ORACLE SPATIAL AND ITS 3D CAPABILITIES
An excerpt of the [Oracle Spatial Developer's Guide 11g Release 2 (11.2)]

Effective with Oracle Database Release 11.1, Oracle Spatial supports the storage and retrieval of three-dimensional spatial data, which can include points, point clouds (collections of points), lines, polygons, surfaces, and solids.

Table 1. Supported (3D) geometry types

Type of 3D Data	SDO_GTYPE	Element Type, Interpretation in SDO_ELEM_INFO
Point	3001	Does not apply. Specify all dimension values (3) in the SDO_POINT_TYPE attribute.
Line	3002	2, 1
Polygon	3003	1003, 1: planar exterior polygon 2003, 1: planar interior polygon 1003, 3: planar exterior rectangle 2003, 3: planar interior rectangle
Surface	3003	1006, 1: surface (followed by element information for the polygons)
Collection	3004	Same considerations as for two-dimensional
Multipoint (point cloud)	3005	1, n (where n is de number of points)
Multiline	3006	Same considerations as for two-dimensional
Multisurface	3007	Element definitions for one or more surfaces
Solid	3008	Simple solid formed by a single closed surface: one element type 1007, followed by one element type 1006 (the external surface) and optionally one or more element type 2006 (internal surfaces) Composite solid formed by multiple adjacent simple solids: one element type 1008 (holding the count of simple solids), followed by any number of element type 1007 (each describing one simple solid)
Multisolid	3009	Element definitions for one or more simple solids (element type 1007) or composite solids (element type 1008)

Table 1 (above) shows the SDO_ GTYPE and element-related attributes of the SDO_GEOMETRY type that are relevant to three-dimensional geometries.

As shown in Figure 5, the SDO_GTYPE specifies the dimension and shape/type of the geometry. SDO_SRID specifies the spatial reference system, which can be Geographic 3D, Geocentric and Compound or a local coordinate system in case of 3D data. Geographic 3D specifies latitude and longitude and ellipsoidal height, based on a geodetic datum.

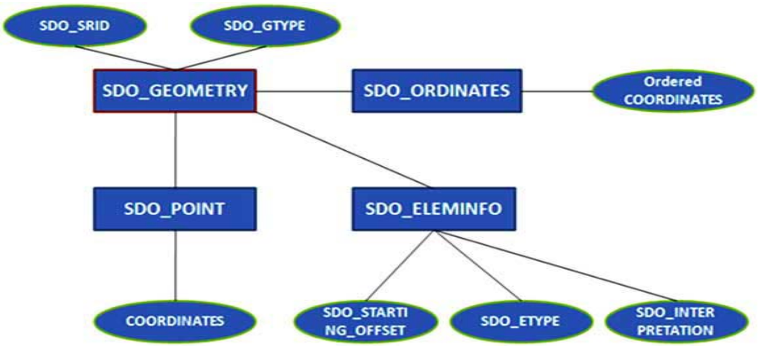


Figure 5. Decomposition of the SDO_GEOMETRY data type

The following Spatial operators consider all three dimensions in their computations:

- SDO_ANYINTERACT
- SDO_FILTER
- SDO_INSIDE (for solid geometries only)
- SDO_NN
- SDO_WITHIN_DISTANCE

For distance computations with three-dimensional geometries:

- If the data is geodetic (geographic 3D), the distance computations are done on the geodetic surface.
- If the data is non-geodetic (projected or local), the distance computations are valid only if the unit of measure is the same for all three dimensions.

For Spatial functions, procedures, and operators that consider all three dimensions, distance and length computations correctly factor in the height or elevation. For example, consider two three-dimensional points, one at the origin of a Cartesian space (0,0,0), and the other at X=3 on the Y axis and a height (Z) of 4 (3,0,4):

- If the operation considers all three dimensions, the distance between the two points is 5. (Think of the hypotenuse of a 3-4-5 right triangle.)
- If the operation considers only two dimensions, the distance between the two points is 3. (That is, the third dimension, or height, is ignored.)

SDO_GEOM (geometry) subprograms, supporting both two-dimensional and three-dimensional geometries:

- SDO_GEOM.RELATE with the ANYINTERACT mask
- SDO_GEOM.SDO_AREA

- SDO_GEOM.SDO_DISTANCE
- SDO_GEOM.SDO_LENGTH
- SDO_GEOM.SDO_MAX_MBR_ORDINATE
- SDO_GEOM.SDO_MBR
- SDO_GEOM.SDO_MIN_MBR_ORDINATE
- SDO_GEOM.SDO_VOLUME
- SDO_GEOM.VALIDATE_GEOMETRY_WITH_CONTEXT
- SDO_GEOM.VALIDATE_LAYER_WITH_CONTEXT
- SDO_GEOM.WITHIN_DISTANCE

6.1 Modeling surfaces

A surface contains an area but not a volume, and it can have two or three dimensions. A surface is often constructed by a set of planar regions. Surfaces can be modeled as surface-type SDO_GEOMETRY objects or, if they are very large, as SDO_TIN objects. The surface-type in SDO_GEOMETRY can be an arbitrary surface defining a contiguous area bounded by adjacent three-dimensional polygons.

Surfaces are stored as a network of triangles, called triangulated irregular networks, or Tins. The TIN model represents a surface as a set of contiguous, non-overlapping triangles. Within each triangle the surface, is represented by a plane. The triangles are made from a set of points called mass points. If mass points are carefully selected, the TIN represents an accurate representation of the model of the surface. Well-placed mass points occur where there is a major change in the shape of the surface, for example, at the peak of a mountain, the floor of a valley, or at the edge (top and bottom) of cliffs.

Tins are generally computed from a set of three-dimensional points specifying coordinate values in the longitude (x), latitude (y), and elevation (z) dimensions. Oracle TIN generation software uses the Delaunay triangulation algorithm, but it is not required that TIN data be formed using only Delaunay triangulation techniques.

During and after the generation of TIN’s, you can specify stop lines. Stop lines typically indicate places where the elevation lines are not continuous, such as the slope from the top to the bottom of a cliff. Such regions are to be excluded from the TIN.

6.2 Modeling solids

The simplest types of solids can be represented as cuboids, such as a cube or a brick. A more complex solid is a **frustum**, which is a pyramid formed by cutting a larger pyramid (with three or more faces) by a plane parallel to the base of that pyramid. Frustums can only be used as query windows to spatial operators. Frustums and cubes are typically modeled as solid-type SDO_GEOMETRY objects. Figure 6 shows a frustum as a query window, with two spatial objects at different distances from the viewpoint.

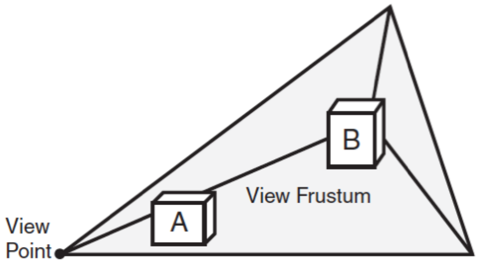


Figure 6. A Frustum as query window for spatial objects

Point clouds, which are large collections of points, can sometimes be used to model the shape or structure of solid and surface geometries. Most applications that use point cloud data contain one or both of the following kinds of spatial queries: queries based on location, and queries based on both location and visibility (that is, visibility queries).

Most applications that use point cloud data seek to minimize data transfer by retrieving objects based on their distance from a viewpoint. For example, in Figure 6, object B is farther from the view point than object A, and therefore the application might retrieve object A in great detail (high resolution) and object B in less detail (low resolution). In most scenarios, the number of objects increases significantly as the distance from the view point increases; and if farther objects are retrieved at lower resolutions than nearer objects, the number of bytes returned by the query and the rendering time for the objects decrease significantly.

6.3 Three-dimensional optimized rectangles

Instead of specifying all the vertices for a three-dimensional rectangle (a polygon in the shape of rectangle in three-dimensional space), you can represent the rectangle by specifying just the two corners corresponding to the minimum ordinate values (min-corner) and the maximum ordinate values (max-corner) for the X, Y, and Z dimensions.

The orientation of a three-dimensional rectangle defined in this way is as follows:

- If the rectangle is specified as <min-corner, max corner>, the normal points in the positive direction of the perpendicular third dimension.
- If the rectangle is specified as <max corner, min-corner>, the normal points in the negative direction of the perpendicular third dimension.

For example, if the rectangle is in the XY plane and the order of the vertices is <min-corner, max corner>, the normal is along the positive Z-axis; but if the order is <max corner, min-corner>, the normal is along the negative Z-axis.

Using these orientation rules for rectangles, you can specify the order of the min-corner and max-corner vertices for a rectangle appropriately so that the following requirements are met:

- The normal for each polygon in a solid always points outward from the solid when the rectangle is part of the solid.
- An inner rectangle polygon is oriented in the reverse direction as its outer when the rectangle is part of a surface

6.4 Using texture data

A texture is an image that represents one or more parts of a feature. Textures are commonly used with visualize applications (viewers) that display objects stored as spatial geometries. For example, a viewer might display an office building (three-dimensional solid) using textures, to allow a more realistic visualization than using just colors. Textures can be used with two-dimensional and three-dimensional geometries.

In the simplest case, a rectangular geometry can be draped with a texture bitmap. However, often only a sub-region of a texture bitmap is used, as in the following example cases:

- If the texture bitmap contains multiple sides of the same building, as well as the roof and rood gables. In this case, each bitmap portion is draped over one of the geometry faces.
- If the texture bitmap represents a single panel or window on the building surface and a geometric face represents a wall with 15 such panels or windows (five on each of three floors). In this case, the single texture bitmap is tiled 15 times over the face.
- If the face is non-rectangular sub-faces such as roof gables. In this case, only a portion (possible triangular) of the texture bitmap is used.

Note: This section describes concepts that you will need to understand for using texture data with Spatial. However, the texture metadata is not yet fully implemented in Oracle Spatial, and a viewer is not yet supported.

6.5 Validation checks for three-dimensional geometries

The SDO_GEOM.VALIDATE_GEOMETRY_WITH_CONTEXT and SDO_ GEOM.VALIDATE_LAYER_WITH_CONTEXT subprograms can validate two-dimensional and three-dimensional geometries. For a three-dimensional geometry, these subprograms perform any necessary checks on any two-dimensional geometries, within the overall three-dimensional geometry, but also several checks specific to the three-dimensional nature of the overall object.

For a simple solid (one outer surface and any number of inner surfaces), these subprograms perform the following checks:

- Closeness: The solid must be closed.
- Reachability: Each face of a solid must have a full-edge intersection with its neighboring faces, and all faces must be reachable from any face.
- Inner-outer disjointedness: An inner surface must not intersect the outer surface at more than a point or a line; that is, there must be no overlapping areas with inner surfaces.
- No surface patch: No additional surfaces can be defined on the surfaces that make up the solid.
- Orientation: For all surfaces, the vertices must be aligned so that the normal vector (or surface normal, or "the normal") points to the outside of (away from) the outer solid. Thus, the volume of the outer solid must be greater than zero, and the volume of any inner solid must be less than zero.

For a composite solid (one or more solids connected to each other), these subprograms perform the following checks:

- Connectedness: All solids of a composite solid must share at least one face.
- Zero-volume intersections: Any intersections of the solids in a composite solid must have a volume of zero.

For a multisolid (one or more solids, each of which is a simple or composite solid), these subprograms perform the following check:

- Disjointedness: Any two solids of a multisolid can share points or lines, but must not intersect in any other manner.

6.6 Disclaimer

The preceding text states the current 3D capabilities. Capabilities under development are not discussed in this Paper. In combination with experience of the vendors from the CAD world like e.g. Bentley Systems, great 3D solutions can be developed. But it should be recognized that the GIS world is just stepping into the 3D world. In terms of implementations and stable standards, the GIS market is (rapidly) evolving to full 3D capabilities. Land Information Management systems probably would opt in for full 3D topological capabilities as well. To my opinion it is unrealistic to expect operational commercial systems based on 3D topology on a short notice. This on the other hand gives academic institutions the opportunity the work closely together with vendors like e.g. Oracle on this capability, as it would be the next logical step to go into.

7. CONCLUSION

Oracle proposes a Land Information Management proposition based on modern technologies like SOA, Cloud Computing (optionally including Engineered Systems), Open Standards and a foundation like the AIA/MDM framework, which could ingest the proposed LADM/STDM Application Schemes and together could be the ‘foundation for execution’ for serving, Land Information Management applications, the INSPIRE infrastructure or e-Government infrastructures, with the Oracle 3D Spatial Engine as the core of the system serving both 2D and 3D. Thus a basis information system is defined for a (future) sustainable land management.

REFERENCES

Oracle Spatial Developer’s Guide 11g Release 2 (11.2) (2011).

Ross, J.W., Weill, P., Robertson, D. (2006). Enterprise Architecture as Strategy: Creating a Foundation for Business Execution.

Uitermark, H., Van Oosterom, P., Zevenbergen, Lemmen C. (2010). From LADM/STDM to a Spatially Enabled Society: a Vision for 2025.

Worldbank (2006). Sustainable Land Management: Challenges, Opportunities and Trade-offs.

BIOGRAPHICAL NOTES

Han Wammes holds a bachelor’s degree in Surveying Engineering. He studied at the School of Surveying Engineering in Utrecht, the Netherlands. After 10 years at Intergraph and now over 16 years at Oracle, Han gained at lot of knowledge and experience of e-Government IT infrastructures, initially as a Solution Architect and recently as Public Sector Development Manager and has kept a special focus on GIS (Han has introduced Oracle Spatial, in its very early days, in the Netherlands and abroad). Ever since his internship at Dutch Cadastre in 1984, he had a special interest in Land Information Management. Just recently he was re-introduced in the Land Information Management domain, when he was asked to bring in his domain expertise on the subject into a global task force, which is tasked to develop an Oracle Land Information Management proposition.

CONTACTS

Han Wammes
Oracle Netherlands
Hertogswetering 163/167
Utrecht
THE NETHERLANDS
Tel.: +31306698617
Fax: +31306696699
E-mail: han.wammes@oracle.com
Website: http://www.oracle.com/us/products/database/options/spatial/