

Geo-processing using Oracle Spatial Geo Database

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Abstract - In the last two decades, Geographic Information Systems (GIS) has been widely developed and is applied to various fields, which include resources management, environment management, prevention of disaster, planning area, education and national defense etc in many sections and subjects. However traditional GIS application systems can't interact with each other and was considered as an isolated island of information facing problem of interoperability. This is because of different data models adopted by different GIS applications. The spatial data interoperability concept brought forward a huge amount of geospatial information for efficacious management, sharing and increase in value usage. OGC standards are developed in a unique consensus process supported by the OGC's industry, government and academic members to enable geo-processing technologies to interoperate, or "plug and play".

Index Terms – Geo Database, Geo processing, Oracle Spatial, OGC, 3D Rendering, Extrude, GIS

1. INTRODUCTION

Within an enterprise, various software packages are used and in many cases they can't talk with each other. This situation is ubiquitous and also exists between different departments. An Open GIS Consortium (OGC) is an international industry consortium of more than 400 companies, government agencies and universities participating in a consensus process to develop publicly available interface standards. Within a local government or enterprise, the spatial data is centrally stored. Interoperable metadata enables organizations to use the right tool for the job while eliminating complicated data transfers and multiple copies of the same data throughout the enterprise or department. The application server is a mediation system, this model uses oracle application server as the mediation system, and through the application server the application client sends WMS or WFS request and get the map server for background application. The three-tier structure model exposes a GIS portal which is an online GIS for outside of the department. Any client can request the server if it accords with WMS or WFS specification.

standards. However there are other database platforms available like Microsoft® SQL Server 2008, IBM DB2 etc. Open Source database platforms are also available in the realm of proprietary products. MySQL and PostGres with PostGIS extension can server large scale Geo-Database.

3 ORACLE SPATIAL DATA MODEL

Oracle® offers a spatial data model that provides basic enterprise access to geospatial information. This spatial data model provides a standard structure for point, line, and area features. Oracle Spatial 10g XE (Express Edition) is used in this prototype model. This database platform is free to use upto 4 GB of data. However enterprise version has no limit. Basic DDL (CREATE, ALTER, DROP) and DML (INSERT, UPDATE, DELETE) statements can be used for Database Management. With Spatial, the geometric description of a spatial object is stored in a single row, in a single column of object type SDO_GEOMETRY in a user-defined table.

2 DATABASE PLATFORMS

There are several database platforms which provide the spatial support. Oracle® is matured to support OGC

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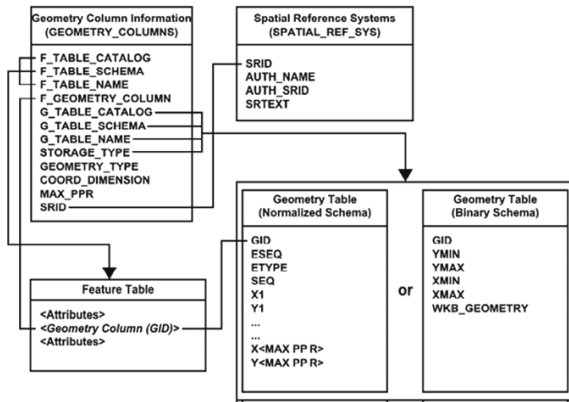


Fig: 1 Schema for feature tables using pre-defined data types

The GEOMETRY_COLUMNS table describes the available feature tables and their Geometry properties. GEOMETRY_COLUMNS table provides information on the feature table, spatial reference, geometry type, and co-ordinate dimension for each Geometry column in the database.

```
CREATE TABLE GEOMETRY_COLUMNS (
F_TABLE_CATALOG CHARACTER VARYING NOT
NULL,
F_TABLE_SCHEMA CHARACTER VARYING NOT
NULL,
F_TABLE_NAME CHARACTER VARYING NOT NULL,
F_GEOMETRY_COLUMN CHARACTER VARYING NOT
NULL,
.....
.....
.....
GEOMETRY_TYPE INTEGER,
COORD_DIMENSION INTEGER,
MAX_PPR INTEGER,
SRID INTEGER NOT NULL
REFERENCES SPATIAL_REF_SYS,
CONSTRAINT GC_PK PRIMARY KEY
(F_TABLE_CATALOG, F_TABLE_SCHEMA,
F_TABLE_NAME, F_GEOMETRY_COLUMN)
)
```

Example 1: Creation of Geometry Table

The SPATIAL_REF_SYS table describes the coordinate system and transformations for Geometry.

```
CREATE TABLE SPATIAL_REF_SYS
(
SRID INTEGER NOT NULL PRIMARY KEY,
AUTH_NAME CHARACTER VARYING,
```

```
AUTH_SRID INTEGER,
SRTEXT CHARACTER VARYING(2048)
)
```

Example 2: Creation of Spatial Reference System

The FEATURE TABLE stores a collection of features.

Metadata is required to store ancillary information about Geo database. Metadata is data about data. It allows common information to be stored at a common level. The attributes like owner name, version number, description of layer, remarks, annotation etc are stored in metadata.

```
CREATE TABLE ANNOTATION_TEXT_METADATA AS
{
F_TABLE_CATALOG AS CHARACTER VARYING NOT
NULL,
.....
.....
.....
A_TEXT_DEFAULT_MAP_BASE_SCALE AS CHARACTER
VARYING,
A_TEXT_DEFAULT_ATTRIBUTES AS CHARACTER
VARYING}

```

```
CREATE TABLE ANNOTATION_TEXT_METADATA AS
{
F_TABLE_CATALOG AS CHARACTER VARYING NOT
NULL,
.....
.....
.....
A_TEXT_DEFAULT_MAP_BASE_SCALE AS CHARACTER
VARYING,
A_TEXT_DEFAULT_ATTRIBUTES AS CHARACTER
VARYING}

```

Example 3: Creation of Metadata

The geometry metadata describing the dimensions, lower and upper bounds and tolerance in each dimension is stored in a global table owned by MDSYS (which users should never directly update). Each Spatial user has the following views available in the schema associated with that user:

USER_SDO_GEOM_METADATA contains metadata information for all spatial tables owned by the user (schema). This is the only view that you can update, and it is the one in which Spatial users must insert metadata related to spatial tables. ALL_SDO_GEOM_METADATA contains meta-data information for all spatial tables on which the user has SELECT permission. Spatial users are responsible for populating these views. For each spatial column, you must insert an appropriate row into the USER_SDO_GEOM_METADATA view. Metadata prototype is given below.

```
INSERT INTO spatial_ref_sys VALUES
(101, 'POSC', 32214,
'PROJCS["UTM_ZONE_14N", GEOGCS["World Geodetic
System 72", DATUM["WGS_72", ELLIPSOID["NWL_10D",
6378135, 298.26]],
PRIMEM["Greenwich", 0], UNIT["Meter",1.0]],
PROJECTION["Transverse_Mercator"],
PARAMETER["False_Easting", 500000.0],
```

```
PARAMETER["False_Northing", 0.0],
PARAMETER["Central_Meridian", -99.0],
PARAMETER["Scale_Factor", 0.9996],
PARAMETER["Latitude_of_origin", 0.0],
UNIT["Meter", 1.0]]);
```

Example 4: Inserting Map Projection parameters

4 RATIONALE OF THE MODEL

This model is scalable to obtain certain objectives. The model implements centralization enterprise spatial data. If database is centralized, it will be more convenient for data manager to update, maintain and distribute. The model enables organizations to use the right tool for the job while eliminating complicated data transfers and multiple copies of the same data throughout the enterprise. The model also helps to implement data sharing between enterprises, especially as data sources for local emergency department. Because emergency department can access and maintain the all data they need. After all, data redundancy can be reduced.

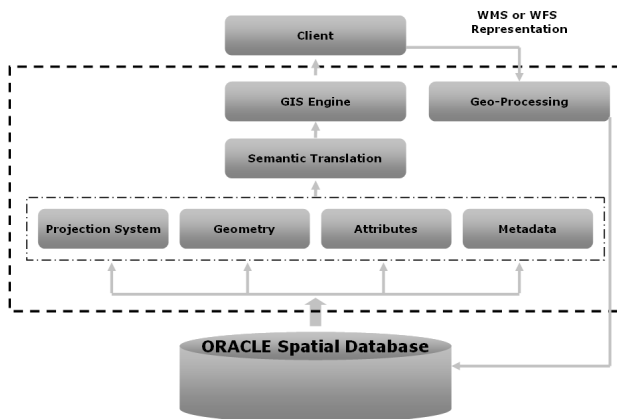


Fig: 2 Data translation component model

The oracle spatial data server can be established at centralized server. Different users can access Geo Spatial information through web browser. The application server is the main tier in internet model, which includes GIS application server, GIS application manager server and application connector. The application in this scenario is developed in Java using NetBeans 6.8 Interactive Development Environment (IDE).

5 GEO PROCESSING

Geo-processing is a GIS operation used to manipulate spatial data. A typical geo-processing operation takes an input dataset, performs an operation on that dataset, and returns the result of the operation as an output dataset. Common geo-

processing operations include geographic feature overlay, feature selection and analysis, topology processing, raster processing, and data conversion. Geo-processing allows for definition, management, and analysis of information used to form decisions. Gujarat state from India is used in this example.

Proposed System is developed in JAVA platform. JAVA SERVER PAGE (JSP) serves the solution in web interface. The Code snippet is given as below for Buffer Analysis using Geo Database.

CODE SNIPPET:

// ASSIGN VARIABLES

```
int sDragx=Integer.parseInt(startDragx);
int sDragy=Integer.parseInt(startDragy);
int eDragx=Integer.parseInt(endDragx);
int eDragy=Integer.parseInt(endDragy);
```

...

```
BufferedImage buffimage1=null;
JGeometry gmtry1,gmtry2;
STRUCT dbobj1,dbobj2;
Graphics2D g11,g22;
Shape sing_sh=null,sh_rect=null;
ResultSet rs1=null,rsbuff=null;
Statement st1=null;
Connection con=newconn();
```

//INITIALIZING MAP

```
st1=con.createStatement(rs1.TYPE_SCROLL_SENSITIVE,rs1
.CONCUR_UPDATABLE);
double
boundingbox[]=boundingBox("TABLE_GUJDISTRICT");
buffimage1 = new
BufferedImage(800,600,BufferedImage.TYPE_INT_RGB);
g11 = (Graphics2D)buffimage1.getGraphics();
g22 = (Graphics2D)g11;
```

```
g22.setRenderingHint(RenderingHints.KEY_ANTIALIASING,
RenderingHints.VALUE_ANTIALIAS_ON);
g22.setPaint(new Color(48,0,0));
g22.fillRect(0,0,800,600);
```

//FIND BOUND BOX VALUES OF A LAYER

```
double
boundingbox[]=boundingBox("TABLE_GUJDISTRICT");
```

//CALCULATE SCALE FACTOR

```
sx = clientwidth / mapw;
sy = clientheight / maph;
```

```
// EXECUTE BUFFER STATEMENT
rsbuff= st1.executeQuery("select
sdo_geom.sdo_buffer(mdys.sdo_geometry(2003,null,null,m
dsys.sdo_elem_info_array(1,1003,3),
mdsys.sdo_ordinate_array(" + Math.min(sDragx, eDragx) +
"," + Math.min(sDragy, eDragy) + "," + (Math.min(sDragx,
eDragx)+Math.abs(sDragx - eDragx)) + "," +
(Math.min(sDragy, eDragy) +
Math.abs(sDragy - eDragy)) + ")), " + dist + ",0.005)
from " + currenttable);
```

```
//DRAW GEOMETRY ON MAP
dbobj2 = (STRUCT)rsbuff.getObject(1);
gmtry2 = JGeometry.load(dbobj2);
sing_sh=gmtry2.createShape();
g11.setColor(Color.blue);
g11.setStroke(new BasicStroke(1));
g11.draw(sing_sh);
```

```
dbobj1 = (STRUCT) rs1.getObject("GEOM");
gmtry1 = JGeometry.load(dbobj1);
JGeometry geomrect = new
JGeometry(2003,gmtry1.getSRID(),arrrect,ordrect);
sh_rect=geomrect.createShape();
```

Example 5: A prototype Code in Java Server Page to create Buffer using Geo database

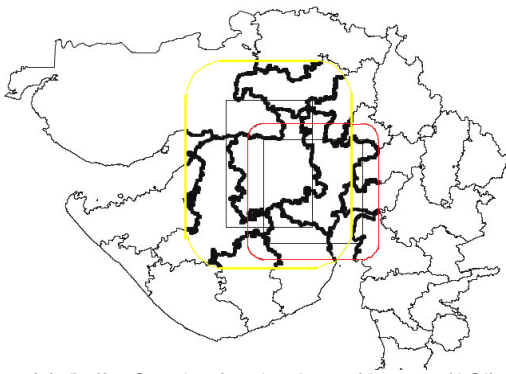


Fig 3(a): Buffer Creation for give Area of Interest (AOI)
Data source: BISAG

DNAME	DNAME	DNAME
AHMEDABAD	AHMEDABAD	AHMEDABAD
AMRELI	AMRELI	AMRELI
BANASKANTHA	ANAND	BANASKANTHA
BHAVNAGAR	BHARUCH	BHARUCH
JAMNAGAR	BHAVNAGAR	BHAVNAGAR
JUNAGADH	GANDHINAGAR	GANDHINAGAR
KACHCHH	KACHCHH	JAMNAGAR
MAHESANA	KHEDA	JUNAGADH
PATAN	MAHESANA	KACHCHH
RAJKOT	RAJKOT	KHEDA
SURENDRANAGAR	SURENDRANAGAR	MAHESANA
		PATAN
		RAJKOT
		SURENDRANAGAR

3 (b) Data

3 (c) Data

3 (d) Union of

inside Yellow
Ring (buffered)

inside Red
Ring
(buffered)

Two Rings
(buffered)

To perform geo-processing in the GIS system, it requires very efficient algorithm and good processing power.

It is required to find the association between two objects in Geo -processing. If two objects are A and B it can be associated like A touches B or A inside B or A equals B etc. Other GIS operations can be performed like difference between two geometries, Union, Intersection.

Difference Operation

Returns the region covered by A that is not covered by B. Function for this operation is SDO_DIFFERENCE



SDO_DIFFERENCE

XOR Operation

Returns the region of A and B that is not shared by both. This function is equivalent to $(A \cup B) - (A \cap B)$. Function for this operation is SDO_XOR



SDO_XOR

UNION Operation

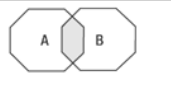
Returns the region of A and B that is covered by both. This function is equivalent to $(A \cup B)$



SDO_UNION

INTERSECTION Operation

Returns the region of A and B that is shared by both. This function is equivalent to $(A \cap B)$



SDO_INTERSECTION

Table 1: Various operations based on Set theory

6 TOPOLOGICAL RELATIONSHIPS

Topology is a major area of mathematics concerned with properties that are preserved under continuous deformations of objects, such as deformations that involve stretching, but no tearing or gluing. It emerged through the development of concepts from geometry and set theory, such as space, dimension, and transformation.

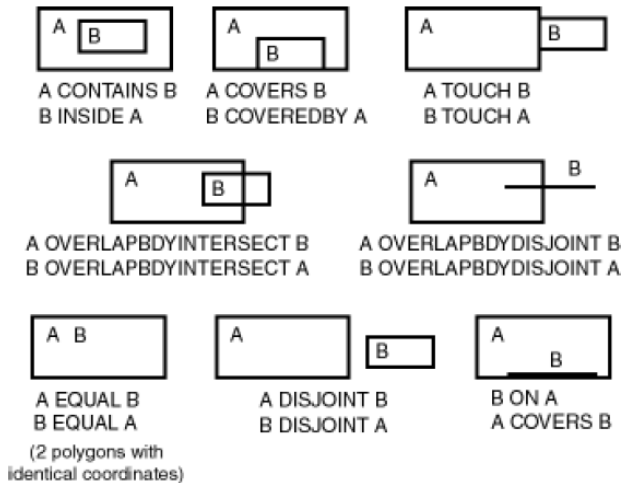


Fig 4 Possible association combinations between objects A and B

7 METHODOLOGY

Use of oracle Geo Database can be utilized by converging Information Communication Technology (ICT). The Geo Database communicates with Web based GIS Map engine. The GIS map engine talks with client with authentication from Java Application Programming Interface (API).

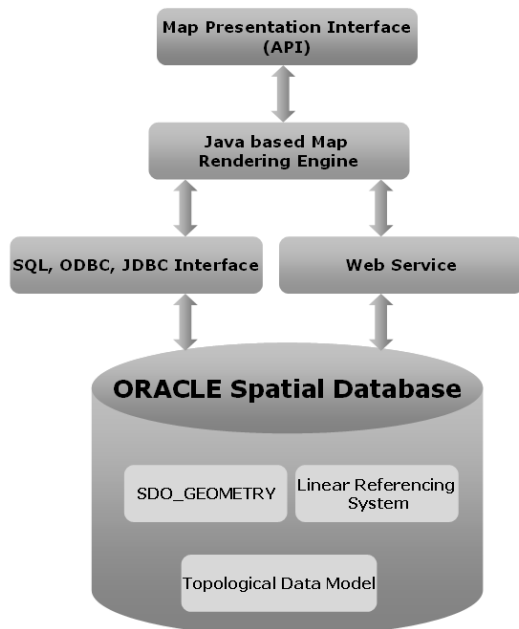


Fig: 5 Interface to access Oracle Spatial Geometry

8 3D RENDERING

Oracle spatial can extrude a Two-Dimensional Geometry to Three Dimension. Two-dimensional footprints of buildings can be extruded using the EXTRUDE function in the

SDO_UTIL package to erect a building on the two-dimensional footprint by specifying the ground height and the top height for each vertex of the two-dimensional geometry.

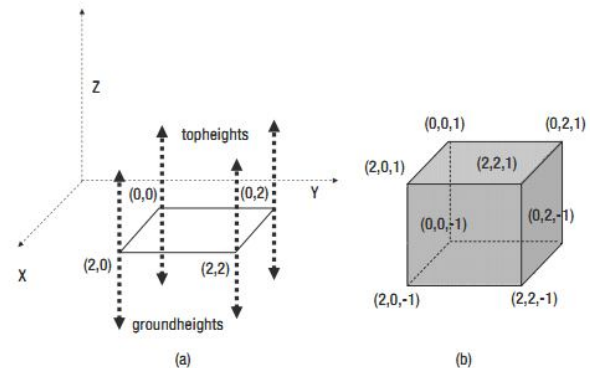


Fig 6(a) Example of a two-dimensional solid with the top heights and ground heights specified and Fig 6(b) the extruded solid object

SDO_UTIL.EXTRUDE

```
(
  geometry          SDO_GEOMETRY,
  groundheights     SDO_NUMBER_ARRAY,
  topheights        SDO_NUMBER_ARRAY,
  result_to_be_validated VARCHAR2,
  tolerance         NUMBER
) RETURN SDO_GEOMETRY
```

Example 6: Extrude schema

The parameters can be interpreted as shown below:

geometry: This specifies the input two-dimensional SDO_GEOMETRY object that needs to be extruded.

groundheights: This is an array of numbers, one each for each vertex for use as the ground height (minimum z value). If only one number is specified, then all vertices get the same value (that is specified here).

topheights: This is an array of numbers, one each for each vertex for use as the top height (maximum z value). If only one number is specified, then all vertices get the same value (that is specified here).

result_to_be_validated: This is a character string that can be set to either 'TRUE' or 'FALSE'. This string informs Oracle whether to validate the resulting geometry.

tolerance: This specifies the tolerance to use to validate the geometry.

A prototype example extruding a Polygon to a Three-Dimensional Solid is given below.

```
SELECT SDO_UTIL.EXTRUDE(
  SDO_GEOMETRY -- first argument to validate is
  geometry
  (
```



```

2003,      -- 2-D Polygon
NULL,
NULL,
SDO_ELEM_INFO_ARRAY(1, 1003, 1  -- A polygon element
),
SDO_ORDINATE_ARRAY (0,0, 2,0, 2,2, 0,2, 0,0) -- vertices
of polygon
),
SDO_NUMBER_ARRAY(-1), -- Just 1 ground height value
applied to all vertices
SDO_NUMBER_ARRAY(1), -- Just 1 top height value
applied to all vertices
'FALSE',      -- No need to validate
0.5           -- Tolerance value
) EXTRUDED_GEOM FROM DUAL;
Example 7: Extruding a sample data using SQL statement

```

```

EXTRUDED_GEOM(SDO_GTYPE, SDO_SRID,
SDO_POINT(X, Y, Z), SDO_ELEM_INFO, SDO_ORDINATE
-----
SDO_GEOMETRY(
3008, -- 3-Dimensional Solid Type
NULL, NULL,
SDO_ELEM_INFO_ARRAY(
1, 1007, 1, -- Solid Element
1, 1006, 6, -- 1 Outer Composite Surface made up of 6
polygons
1, 1003, 1, -- First polygon element starts at offset 1 in
SDO_ORDINATES array
16, 1003, 1, -- second polygon element starts at offset 16
31, 1003, 1, -- third polygon element starts at offset 31
46, 1003, 1, -- fourth polygon element starts at offset 46
61, 1003, 1, -- fifth polygon element starts at offset 61
76, 1003, 1, -- sixth polygon element starts at offset 76
SDO_ORDINATE_ARRAY( -- ordinates storing the vertices
of the polygons
0, 0, -1, 0, 2, -1, 2, 2, -1, 2, 0, -1, 0, 0, -1,
0, 0, 1, 2, 0, 1, 2, 2, 1, 0, 2, 1, 0, 0, 1, 0, 0,
-1, 2, 0, -1, 2, 0, 1, 0, 0, 1, 0, 0, -1, 2, 0,
-1, 2, 2, -1, 2, 2, 1, 2, 0, 1, 2, 0, -1, 2, 2,
-1, 0, 2, -1, 0, 2, 1, 2, 2, 1, 2, 2, -1, 0, 2,
-1, 0, 0, -1, 0, 0, 1, 0, 2, 1, 0, 2, -1))
Example 8: output of Extruded sample

```

Following example shows the satellite image of a building in New York City, USA taken from Google map. The Building ground height and top height are measured in the form of latitude, longitude and altitude with Global Positioning System (GPS). The building corner points are marked and respective co-ordinates are extruded using SDO_UTIL.EXTRUDE method.



Fig: 7(a) Building in a satellite image with edges marked with dark spots.

The extruded geometry vertices returns an array that is plotted as an object as shown in the below figure.

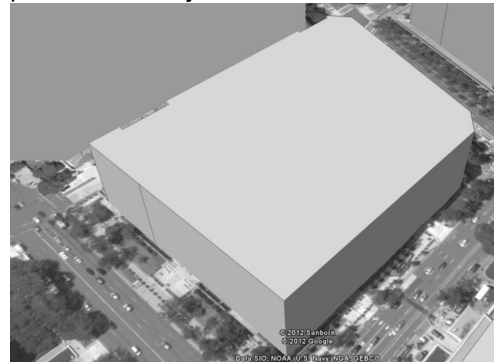


Fig 7(b): Extruded building

9 APPLICATIONS

The proposed method is used to derive new datasets from the data warehouse. The geo-processing kind of tasks that require very efficient algorithms can be effectively carried out by leveraging the potential of Oracle spatial geo database. 3D Elevation Model, Triangulation Irregular Network (TIN) can also be generated from geo database. Moreover, centralized data-centric and secured applications can be developed and scaled at enterprise level.

10 LIMITATIONS

The geo-processing task and extrude task are memory intensive. The proposed methodology can be optimized by introducing cloud based storage and routing mechanism. Parallel Processing can also optimize the performance to render the output in terms of geographical maps.

11 CONCLUSIONS

The proposed solution is scalable to enterprise level. The Spatial Data Infrastructure (SDI) can be established that can be helpful to derive spatial data and attributes from various datasets of different organizations in multiple combinations that can provide near real time information resulting in

efficient and effective decision support system (DSS) to help multiple areas like Health, Defense, Disaster etc.

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