Jorge Arévalo
Internet & Mobility Division, DEIMOS
jorge.arevalo@delmos-space.com
http://mobility.grupodelmos.com
http://gis4free.wordpress.com
First of all...

1 + 1 = 2

1 \times 1 = 1
<table>
<thead>
<tr>
<th>Version</th>
<th>Features</th>
</tr>
</thead>
</table>
| 10gR1 (2003) | First version  
Interleaving  
Georeferencing  
Pyramids  
Raster loader, viewer and exporter |
| 10gR2 (2005) | Raster compression/decompression  
GeoRaster objects in other schemas  
Enhanced GeoRaster tools |
| 11gR1 (2007) | Automatic DML trigger creation  
SDO_GEOR_ADMIN  
Bitmap masks  
NODATA ranges  
Empty raster blocks  
Random blocking size  
New functions, procedures and other features |
| 11gR2 (2009) | Java API  
GCP Support  
Raster reprojections  
Optimized blocking  
Grid interpolations  
Polygon-based clipping in queries  
New functions, procedures and other features |
### PostGIS WKT Raster roadmap

<table>
<thead>
<tr>
<th>Version</th>
<th>Features</th>
</tr>
</thead>
</table>
| 0.1.6d (Feb 2009) | First version  
Type definition  
Canonical input/output  
GiST index support  
Raster loader (gdal2wktraster) |
| 0.1.6k (Aug 2010) | Get/Set raster properties  
*Intersect raster*&*geometries*  
Register out db rasters  
Get metadata for raster and bands  
Convert between world and raster coords.  
Set and know true nodata values  
Get/Set pixel values  
**GDAL r/o basic driver** |
| 0.2.4 (Pred. Nov 2010) | Set raster rotation  
Reproject rasters  
Export raster to standard formats  
Validate raster data  
Topological operators  
MapAlgebra, reclassify...  
Edit raster data on db  
Full GDAL driver |

http://trac.osgeo.org/postgis/wiki/WKTRaster/PlanningAndFunding
Main characteristics: Data type

**Oracle GeoRaster:** 2 related data types

**PostGIS WKT Raster:** 1 data type
Oracle GeoRaster:

PostGIS WKT Raster:
**Oracle GeoRaster:** Creates a spatial index (R-Tree index) on the spatial extent of the GeoRaster object.

**PostGIS WKT Raster:** Creates a GiST index on the raster column, using convex hull.
Oracle GeoRaster: Reduced-resolution versions of rasters can be generated using 5 resampling techniques. The pyramids are stored in the same raster data table as the GeoRaster object, with the same SRS than the original one.

PostGIS WKT Raster: GDAL-provided pyramids are generated on loading time at desired levels. The pyramids are stored in different tables than the original raster.
Oracle GeoRaster: Metadata are part of the SDO_GEORASTER object, and follow a XML schema.

PostGIS WKT Raster: The metadata is packed with the raster data, like the georeference information. Only basic metadata is stored (upper left corner, width, height, pixel size, skew, srid and numbands)
Oracle GeoRaster: The specs for SDO_GEORASTER and SDO_RASTER objects are open. This is really important, to allow third party tools to provide capabilities not implemented in the server, like spatial analysis.

PostGIS WKT Raster: Uses WKT/WKB format for representing data. Is a open specification too.
Oracle GeoRaster. First, ensure raster has accepted format or use `gdal_translate`. Then:

- **PL/SQL API**: `CREATE TABLE`, `SDO_GEOR.init`, `SDO_GEOR.importFrom`. Not very intuitive. Few formats accepted (TIFF, GIF, BMP, GeoTIFF, PNG).

- **Java loader**. Few formats accepted (TIFF, GeoTIFF, JPEG, BMP, GIF, PNG and JP2 for images. ESRI World Files, GeoTIFF and Digital Globe RPC files for georef)

- **GDAL GeoRaster driver (Ivan Lucena)**: Really simple method

```
gdal_translate -of image.tif geor:user/password/SID,table,raster_column
```
PostGIS WKT Raster: All GDAL-accepted formats.

- Use python loader `gdal2wktraster`
  
  > `gdal2wktraster.py" -r C:\orcl_tut\*.tif -t <table> -s <srid> -k 50x50 -l -o C:\orcl_tut\srtm.sql`
  
  > `psql -d <db> -f C:\orcl_tut\srtm.sql`

- In the future: GDAL WKT Raster driver (currently, only support WKT Raster reading).
Oracle GeoRaster:

- Official viewers: GeoViewer (some bugs), MapViewer.
- Lots of Spatial Partners
  (http://www.oracle.com/technology/products/spatial/spatial_partners_sys_integ.htm)
- Tools via GDAL GeoRaster driver (i.e.: QGIS)
PostGIS WKT Raster: Now, is possible to visualize WKT Raster data using **OpenJUMP** and ST_PixelAsPolygons function. Apart from that, there are no tools allowing WKT Raster data visualization. But we have plans for developing support on:

- gvSIG
- GeoServer
- ?
Oracle GeoRaster: As when loading data...

- **PL/SQL API:** `SDO_GEOR.exportTo`. Few formats accepted (TIFF, BMP, GeoTIFF, PNG). Limited data size on 1 operation: 67 MB.

- **Java:** Few formats accepted (PL/SQL plus JPEG and GIF). Memory problems with data size up to 67 MB.

- **GDAL GeoRaster driver.**
PostGIS WKT Raster:

- GDAL WKT Raster driver (all GDAL accepted formats)
- Planned: directly from-db exporting to common formats (tiff, jpeg...
Example: Compute pixel value statistics on areas delimited by vector polygons (http://gis4free.wordpress.com/2010/09/01/oracle-georaster-part-ii/).

**Step 1:** Load vector data (points distribution).

Oracle Spatial only accept SDO format for input geometry data. We have to convert our shapefiles to SDO format using *sdo2shp*

**Tools used:** *sdo2shp* + *sqlplus* + *sqlldr* (possible to use only *ogr2ogr*)

```
C:\orcl_tut>shp2sdo.exe -o cariboupoints cariboupoints -g geom -t 0.5 -v
```
Step 2: Load raster data

Tools used: PL/SQL API

You can use Java loader too, but you should first reformat and reblock data

gdal_translate -of GTiff -a_srs epsg:4326 -anoData -32768 -co “TFW=YES” -co “INTERLEAVE=PIXEL”
-co “TILED=YES” -co "BLOCKXSIZE=50" -co "BLOCKYSIZE=50" image.tif image_new.tif

Insert raster data

DECLARE
geor SDO_GEORASTER;
BEGIN
INSERT INTO span_images values( 1, 'Spain_TIFF_1', sdo_geor.init('span_images_rdt') );
SELECT image INTO geor FROM span_images WHERE image_id = 1 FOR UPDATE;
sdo_geor.importFrom(geor, 'blocksize=(50,50) spatialExtent=TRUE', 'TIFF', 'file', 'C:\orcl_tut\srtm_35_04_new.tif',
'WORLDFILE', 'FILE', 'C:\orcl_tut\srtm_35_04_new.tfw');
UPDATE span_images SET image = geor WHERE image_id = 1;
END;
**Step 3:** Create buffers around points

Tools used: PL/SQL API

```sql
create table cariboupoint_buffers_wgs AS select t.id, sdo_geom.sdo_mbr(sdo_geom.sdo_buffer(sdo_cs.transform(t.geom, 4326), 1000, 1)) geom from cariboupoints t;
```
Step 4: Create indexes

Tools used: PL/SQL API

First, we must update metadata

DELETE FROM user_sdo_geom_metadata WHERE table_name = 'spain_images' AND column_name = 'IMAGE.SPATIALEXTENT';

INSERT INTO user_sdo_geom_metadata VALUES ('spain_images', 'IMAGE.SPATIALEXTENT',
    SDO_DIM_ARRAY(SDO_DIM_ELEMENT('X', -180, 180, .00000005), SDO_DIM_ELEMENT('Y', -90, 90, .00000005)), 4326);

Now, create the index

DROP INDEX spain_images_sidx;

CREATE INDEX spain_images_sidx ON spain_images(image.spatialExtent) INDEXTYPE IS mdsys.spatial_index;

Same operation with vector buffers

DELETE FROM user_sdo_geom_metadata WHERE table_name = 'cariboupoint_buffers_wgs' AND column_name = 'geom';

INSERT INTO user_sdo_geom_metadata VALUES ('cariboupoints_buffers_wgs', 'geom', SDO_DIM_ARRAY(SDO_DIM_ELEMENT('X',
    -180, 180, .00000005), SDO_DIM_ELEMENT('Y', -90, 90, .00000005)), 4326);

DROP INDEX spain_images_sidx;

CREATE INDEX cariboupoints_buffers_wgs_gidx ON cariboupoints_buffers_wgs(geom) INDEXTYPE IS mdsys.spatial_index;
Step 5: Compute statistics. The mean elevation of the raster in areas intersected by vector buffers.

Tools used: PL/SQL API

Time: About 5 mins.

To avoid a big amount of PL/SQL code, we remark the important points:

- We use the buffers to intersect the raster data extents.
- We compute raster statistics by `SDO_GEOR.generateStatistics`, using as sampling window the intersecting buffers.
Conclusions

– As we can only intersect vector data with MBR of raster data, not with the raster data itself, we could compute statistics in raster parts with no data.

– The intersection process was really fast, because we don't intersect vector with real data, but with MBR of the data.

Why? Because Oracle GeoRaster was created primarily for raster data storage, not for raster data analysis.
The same example ([http://trac.osgeo.org/postgis/wiki/WKTRasterTutorial01](http://trac.osgeo.org/postgis/wiki/WKTRasterTutorial01))

**Step 1:** Load vector data (points distribution).
PostGIS only accept shapefiles as input data. We use them.
Tools used: shp2pgsql (possible to use ogr2ogr)

```
>"C:\Program Files\PostgreSQL/9.4/bin/shp2pgsql" -s 32196 -I C:\Temp\TutData\cariboupints.shp > C:\Temp\TutData\cariboupints.sql

>"C:\Program Files\PostgreSQL/9.4/bin/psql" -f C:\Temp\TutData\cariboupints.sql tutorial01
```
Step 2: Load raster data
Tools used: `gdal2wktraster, psql`

```bash
>c:\Program Files\PostgreSQL\8.4\bin/gdal2wktraster.py -r C:\Temp\TutData\SRTM.tif.tif -t srtm_tiled -e 4326 -x 50x50 -t > C:\Temp\TutData\SRTM\srtm.sql
```

```bash
>c:\Program Files\PostgreSQL\8.4\bin/psql" -f C:\Temp\TutData\SRTM\srtm.sql tutorial01
```

Step 3: Create buffers around points

```sql
CREATE TABLE cariboupoint_buffers_wgs AS
SELECT id, ST_Transform(ST_Buffer(geom, 1000), 4326) AS geom FROM cariboupoints;
```

Tools used: PgSQL API

Note: The buffers are round, not rectangular. This is because Oracle GeoRaster only accepts rectangular sampling windows. But now, it's not necessary.
**Step 4:** Create indexes

Not needed! Created when loading data.

**Step 5:** Compute statistics. The mean elevation of the raster in areas intersected by vector buffers.

Tools used: pgSQL API

Time: About 10 mins.

Note: We really intersect raster data with vector data. And the raster data is first polygonized to be intersected with buffers.
Conclusions

- Now we can really intersect vector data with raster data, not with the raster MBR. The intersection function is the first one of a set of spatial analysis functions that will work seamless with vector and raster data.
## Evaluation Matrix

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Oracle GeoRaster</th>
<th>PostGIS WKT Raster</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Data Type</td>
<td>SDO_GEORASTER</td>
<td>WKT Raster</td>
</tr>
<tr>
<td>Multidimensional Support</td>
<td>Up to 3</td>
<td>Up to 3</td>
</tr>
<tr>
<td>Georeferencing</td>
<td>Fullfilled</td>
<td>Fullfilled</td>
</tr>
<tr>
<td>Image pyramids</td>
<td>Fullfilled</td>
<td>Fullfilled</td>
</tr>
<tr>
<td>Partitions</td>
<td>Only regular</td>
<td>Only regular</td>
</tr>
<tr>
<td>Raster compression</td>
<td>Fullfilled</td>
<td>Fullfilled</td>
</tr>
<tr>
<td>Scan order</td>
<td>Not Fullfilled</td>
<td>Not fullfilled</td>
</tr>
<tr>
<td>Analysis capability</td>
<td>Not fullfilled</td>
<td>Fullfilled (+ r&amp;v)</td>
</tr>
<tr>
<td>Slicing</td>
<td>Only get 1 layer</td>
<td>Only get 1 layer, planned</td>
</tr>
<tr>
<td>Subsetting</td>
<td>Fullfilled</td>
<td>Not Fullfilled (planned)</td>
</tr>
<tr>
<td>Content-based search</td>
<td>Using vector MBR</td>
<td>Partially (topological planned)</td>
</tr>
<tr>
<td>Spatial Indexing</td>
<td>Fullfilled (over MBR)</td>
<td>Fullfilled (over cells)</td>
</tr>
<tr>
<td>Open specification</td>
<td>Fullfilled</td>
<td>Fullfilled</td>
</tr>
</tbody>
</table>
Screenshots & tutorial: Pierre Racine

Evaluation Matrix: Damon Riga Noktula
(“Server-based Raster Operations for Spatio-temporal Application in Raster Database using Oracle GeoRaster”), based on Peter Bauman's & others criteria.
http://trac.osgeo.org/postgis/wiki/WKTRaster