Oracle Spatial @ Forestry Tasmania
(from HHEncode to 10g)

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This presentation is about:

- The paradigm shift in GIS data management & processing that Oracle Spatial represents;
- How FT is leveraging Oracle Spatial in:
  - Forest Inventory
  - Land Property
  - Conservation
  - Fire Management
  - Forest Operations
  - General GIS.
- The plans for leveraging the new Oracle Spatial 10g functionality.

I hope that you will be able to see how what we have done could benefit your business/department.

• GIS Review (1998):
  “Forestry Tasmania needs to extend its focus from data capture and specialist analysis to one that integrates operations and business procedures.”

• Objectives for Business-centric computing:
  – Make GIS more accessible by embedding spatial functionality into FT business systems.
  – Integrate spatial and other business data by adopting standardised database technology rather than GIS proprietary formats.

• Objectives endorsed by subsequent IS Vision for FT that recommended the following goals:
  – Integrated data,
  – Easy to use systems,
  – Access to Information (transactional reporting and analytics),
  – Functionally efficient business processes eg capture data at source.
“Enterprise GIS ... cannot be product or vendor driven. Instead, it must be impelled by a clear corporate vision of the key elements which will deliver a truly enterprise solution.”

• This view is represented through a "Spatial Systems Vision" (SSV) with following parameters:
  – Cost (purchase, customisation and ongoing) of product
  – Cost of management
  – IS Vision
  – Experience
  – Diversification/commoditisation of software market especially in area of generic graphics
  – Diverse functional requirements.

• A “Best of breed”, business-centric, focus.
Business Application

Example 1
Inventory & Measurement
Business System: Plot Location Tool

• Business Need: Sustainable Production
  – “Stock on the Shelf” = Inventory
  – Standing volume through measurement using unbiased sampling
  – Stratification

• Solution: Plot Location Tool.
Business System: Plot Location Tool

- Sampling Strata generated within ORACLE (strata are areas of homogeneous forest)
- Sample Points (Plots) located within these strata in a configuration specified by the user
- Readily available to field crews as Mapping products
Business System: Plot Location Tool
Process

Select <geometry> from .... where ....

Sampling Specifications

JTS (Union)

[Diagram showing a process flow with icons and text boxes]
PLT used to locate plot. And a Map is produced.

Navigate to plot with GPS

Locate plot point

A good spot for a plot

Permanent Plots have a metal plot peg to enable easy relocation of the reference point.

Once a crew is within 20m of the plot point they take note of the distance and bearing, and switch off the GPS and chain and compass survey the rest of the way.
Business Process: Inventory

Layout the rest of the plot

Record position of each plot element relative to plot point

Measure a few trees
Data is stored in a spatially enabled database - FIPS

Due to spatial enablement, we can produce mapping products from within the database. No need to export it into GIS systems.
Business System: FIPS2

- Forest Inventory Projection System vn 2.0
- Fully integrated system to store, process and project tree measurement data

GPS Plot Point

Holds reference point for the plot.

Only place where coordinates are stored.

plot_point_easting
plot_point_northing

circle_radius
distance_from_plot_point
bearing_from_plot_point

These materialized views create actual Sdo_Geometry shapes “on the fly” depending on type of section which are consumed by visualisation and mapping systems.

A Section can be:
- Circle; Point; Line/Transect; Rectangle.
- Actual “shape” is described using particular attributes like radius.
- Spatial position is relative to reference point (bearing and distance)
CREATE MATERIALIZED VIEW Section_C
AS
SELECT
Section.Section_Feature_ID       AS FeatureID,
Section.Plot_No                  AS Plot_No,
Section.Section_ID               AS Section_ID,
Section.LU_Section_Shape_Code     AS Shape_Code,
Section.Circle_Radius            AS Circle_Rad,
Section.Distance_From_Plot_Point AS DstFrom_PP,
Section.Bearing_From_Plot_Point  AS BrgFrom_PP,
Plot.Plot_Point_Easting           AS PP_East,
Plot.Plot_Point_Northing          AS PP_North,
cogo.CreateCircle(
    cogo.PointFromBearingAndDistance(
        plot.plot_point_easting,
        plot.plot_point_northing,
        section.bearing_from_plot_point,
        section.distance_from_plot_point
    ).sdo_point.x,
    cogo.PointFromBearingAndDistance(
        plot.plot_point_easting,
        plot.plot_point_northing,
        section.bearing_from_plot_point,
        section.distance_from_plot_point
    ).sdo_point.y,
    section.circle_radius)         AS Shape
FROM Section,
Plot
WHERE Section.LU_Section_Shape_Code = 'CIRC'
and Plot.Plot_No = Section.Plot_No
and Plot.Plot_Point_Easting is not null
and Plot.Plot_Point_Northing is not null
and Section.Distance_From_Plot_Point is not null
and Section.Bearing_From_Plot_Point is not null
and Section.Circle_Radius is not null
CREATE MATERIALIZED VIEW Tree_C
AS SELECT
  t.Tree_Feature_ID AS FeatureID,
  cogo.PointFromBearingAndDistance(
    p.plot_point_easting,
    p.plot_point_northing,
    t.bearing_from_plot_point,
    t.distance_from_plot_point
  ).sdo_point.x AS Tree_East,
  cogo.PointFromBearingAndDistance(
    p.plot_point_easting,
    p.plot_point_northing,
    t.bearing_from_plot_point,
    t.distance_from_plot_point
  ).sdo_point.y AS Tree_North,
  p.Inventory_Type_No AS Inv_Type,
  p.Inventory_Code AS Inv_Code,
  p.Plot_No AS Plot_No,
  t.Tree_No AS Tree_No,
  tm.Dob_Lower As DBHOB,
  t.Tree_Spp_Code As Spp,
  tm.Measurement_No AS Mmt_No,
  cogo.CreateCircle(
    cogo.PointFromBearingAndDistance(
      p.plot_point_easting,
      p.plot_point_northing,
      t.bearing_from_plot_point,
      t.distance_from_plot_point).sdo_point.x,
    cogo.PointFromBearingAndDistance(
      p.plot_point_easting,
      p.plot_point_northing,
      t.bearing_from_plot_point,
      t.distance_from_plot_point).sdo_point.y,
    (tm.Dob_Lower/200),20) AS Shape
FROM Tree t,
    Tree_Mmt tm,
    Plot p
WHERE p.inventory_type_no = t.inventory_type_no
  AND p.inventory_code = t.inventory_code
  AND p.plot_no = t.plot_no
  AND tm.measurement_no = t.measurement_no
  AND tm.tree_no = t.tree_no
  AND tm.tree_no = t.tree_no
ORDER BY measurement_no DESC

SQL to create a “to scale” circle representing a tree, based on its spatial location and last measured diameter.
Circular Plot and Trees
CREATE MATERIALIZED VIEW Tree_Map_C
AS SELECT
    t.Tree_Feature_ID AS FeatureID,
    tm.Dob_Lower AS DBHOB,
    lt.LU_Cohort_Spp_Group_Code AS Spp_Grp,
    t.Tree_Spp_Code AS Tree_Spp,
    p.Plot_Point_Easting AS PP_East,
    p.Plot_Point_Northing AS PP_North,
    p.Inventory_Type_No AS Inv_Type,
    p.Inventory_Code AS Inv_Code,
    p.Plot_No AS Plot_No,
    t.Tree_No AS Tree_No,
    s.CL_bearing AS CL_Brg,
    tm.Measurement_No AS Mmt_No,
FROM Tree t,
     Tree_Mmt tm,
     Plot p,
     Section s,
     LU_Tree_Spp lt
WHERE p.inventory_type_no = t.inventory_type_no
    AND p.inventory_code = t.inventory_code
    AND p.plot_no = t.plot_no
    AND tm.inventory_type_no = t.inventory_type_no
    AND tm.inventory_code = t.inventory_code
    AND tm.plot_no = t.plot_no
    AND tm.tree_no = t.tree_no
    AND s.inventory_type_no = t.inventory_type_no
    AND s.inventory_code = t.inventory_code
    AND s.plot_no = t.plot_no
    AND s.section_id = t.section_id
    AND t.tree_spp_code = lt.tree_spp_code
    AND p.plot_point_easting is not null
    AND p.plot_point_northing is not null
    AND t.bearing_from_plot_point is not null
    AND t.distance_from_plot_point is not null
    AND tm.dob_lower is not null
    AND ((s.inventory_type_no = 1 AND s.CL_Bearing is not null)
    OR (s.inventory_type_no = 3) OR (s.inventory_type_no = 90))
    AND tm.dob_lower > 0
ORDER BY measurement_no DESC

Field Crews need to view plot rotated to North.

Just a View!

No “GIS” programming!
Before Rotate
Rotated to the North!
Advantages of Spatially enabled Inventory Applications for FT.

- All plot management, analysis, growth projection and mapping is contained within the same DB structure.
- No separate “GIS” database
- Data ownership issues clear
- Increased flexibility
  - Powerful views
  - Real circles!
Techno Stuff: Language & Framework

• Plot Location Tool
  – Database Tier: Oracle Spatial
  – Middle Tier: Apache Web Server
    Java Servlets
    Java Topology Suite (JTS)
    Java Server Pages (JSP)
  – Client Tier: HTML (ie JSP)

• FIPS 2
  – Database Tier: Oracle Spatial 10g
    PL/SQL COGO package
  – Middle Tier: C#.NET
    VB6 ActiveX Dlls
  – Client Tier: WinForms

• Both: GIS license & deployment costs: $0
Business Application

Example 2
NewConserve
(Point-based Application)
NewConserve: Data Use

- Strategic planning
  - Management Decision Classification
  - Threatened species management
- Forest Practices Plan preparation:
  - timber harvesting operations
  - roading
  - quarries
- Planning for other activities:
  - fuel reduction/ecological burns
  - reserve design
  - visitor facilities
  - track construction
  - leases/licences
  - land purchase
NewConserve: Data in System

- Aboriginal sites
- Historic sites
- Geoheritage
  - Geoconservation sites (points & polygons)
- Threatened fauna
  - known locations
  - potential habitat
- Threatened flora

Writeable
(Updated by accredited officers in Forest Practices Authority through online, live access to NewConserve.)

Read Only Copy
NewConserve: Menus

**CONSERVE ONLINE**
- Aboriginal
- Historic
- Fauna
- Lookup Tables

- Create an historic site record
- Update an historic site record
- Delete an historic site record
- Browse historic site records
- Browse historic site records (Excel)

**Specify the HISTORIC records**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

**Sdo_Geometry Column**
Created from Easting/Northing (by application)
Example 3

Viewpoints
(Point-based Application)
Business System: Viewpoints

- High value (social, environmental, aesthetic) placed on landscape.
- Key tourism lookouts and other high quality landscape views represented by “viewpoints”.
- Simple Oracle table.
  - Data recorded by typing in northing/easting.
  - Sdo_Geometry (consumed by GIS viewing/mapping applications) constructed by triggers.
  - Other data values (eg district) computed by triggers.
(Same approach is taken for other point datasets.)
Create or Replace Trigger Viewpoints_Bef_Upd
Before Update of Northing, Easting
On Viewpoints
When ( old.northing <> new.northing )
  or ( old.easting  <> new.easting )
Begin
  :new.shape := Sdo_Geometry(2001,NULL,
     Sdo_Point(:new.easting,:new.northing,NULL),
     NULL,NULL);
  :new.district_Code := gis.geography.Which("DISTRICT",
     :new.easting,:new.northing);
...
End;
Techno Stuff: Language & Framework

• **Viewpoints:**
  - **Database Tier:** Oracle Spatial, PL/SQL packages & trigger processing.
  - **Middle Tier:** Apache Web Server HtmlDB
  - **Client Tier:** HTML Adobe Scalable Vector Graphics (SVG) plugin (spatial editing)

• **NewConserve:**
  - **Database Tier:** Oracle Spatial
  - **Middle Tier:** Apache Web Server Java Servlets /JSP
  - **Client Tier:** HTML (ie JSP)
  - **External Access:** Novell iChain

• GIS license and deployment costs: $0
Gratuitous Aside

Performance made easy....
Spatial Autocorrelation

Create Table Lidar
PctFree 1 PctUsed 99
As
Select *
From gis.lidar_tmp
Order By MdSys.HHEncode(easting, 452800, 559800, 8, northing, 5207000, 5283800, 8)
Business Application

Example 4
Wildfire Management
Business Process: Fire Fighting

• Need live reporting of area burnt by a wildfire.
  – Statistic: Area (ha) of Tenure & Vegetation burned.
  – Data must be computed automatically as part of transaction.
  – Output inserted into “Daily Burn” table “attached” to wildfire “operation”
  – Email sent to user to view data in “Fires” application.

• Approach:
  – Traditional GIS: Program run within “fat GIS client”.
  – Ours: “Declarative” SQL & database-centric transaction processing....
Example: Live Fire Mapping

- New fire boundary
  - Created by flying a helicopter around the fire edge
  - Inserted into the database as single record transaction.
  - Tenure/Vegetation that has been burned is computed by following “cookie cutter” SQL:

  ```sql
  SELECT /*+ORDERED ORDERED_PREDICATES */
  a.OPERATION_TYPE_ID,
  a.OPERATION_ID,
  a.BURN_DATE,
  b.TENURE_CODE,
  b.VEGETATION_TYPE_CODE,
  ROUND(SUM(MDSYS.SDO_GEOM.SDO_AREA(
    MDSYS.SDO_GEOM.SDO_INTERSECTION(b.shape,c_diminfo,a.shape,c_diminfo),c_diminfo)) / 10000,2)
  FROM ops.burn_daily_incident a,
  ops.fire_tenveg b
  WHERE a.featureid = c_featureid
  AND MDSYS.SDO_RELATE(b.shape,a.shape,'mask=ANYINTERACT querytype=WINDOW') = 'TRUE'
  AND (MDSYS.SDO_GEOM.SDO_INTERSECTION(b.shape,c_diminfo,a.shape,c_diminfo) is not null
  AND ROUND(MDSYS.SDO_GEOM.SDO_AREA(
    MDSYS.SDO_GEOM.SDO_INTERSECTION(b.shape,c_diminfo,a.shape,c_diminfo),
    c_diminfo),2) > 0.0)
  GROUP BY a.OPERATION_TYPE_ID,
  a.OPERATION_ID,
  a.BURN_DATE,
  b.TENURE_CODE,
  b.VEGETATION_TYPE_CODE;
  ```
Live Fire Mapping (cont)

- Actual process:
  - SQL statement is hosted inside an Oracle pl/sql procedure `BurnTenureVegtype()`
  - AFTER INSERT trigger on the fire boundary table places a request to execute procedure for specific record into the Oracle queue:
    ```sql
    job_string := 'ops.BurnTenureVegtype('||to_char(v_featureid)||','''||USER||''');';
    DBMS_JOB.SUBMIT(jobno,job_string,SYSDATE,NULL);
    ```
  - DBMS_JOB After Insert request makes the processing asynchronous to the actual insert of the fire shape.
    - Generation of computed data is separated from transaction data.
      - Because the clip out can take a bit of time when the shape is large... but mostly these clip outs take < a few seconds!
    - When the procedure completes it sends an email to the person who put in the fire boundary with its performance statistics (Yes, straight out of the database!). An example of an email is:
      
      Operation: 12345  
      Description: Burn area computations completed for recently updated burn area shape.  
      Records: 15 written to burn area table.  
      Processing Time: 0 minutes 9 seconds.  
      Action: Please use FIRES application to view tenure/veg/area values.
Techno Stuff: Language & Framework

• Fires
  – Middle Tier: Apache Struts JSP
    Business Components for Java (BC4J)
  – Client Tier: HTML (JSP)
    Adobe Scalable Vector Graphics (SVG) plugin (spatial editing)

• GIS license and deployment costs: $0
Business Application

Example 5

Land

Property
Land Property

- FT creates many dealings over state forest:
  - Leases,
  - Licenses,
  - Easements etc.
- Can have quite complicated spatial rules to enforce legal integrity and validity.
  - Eg they also have some important vertical topological requirements (for example: a dealing of a particular type MUST fall wholly within state forest).

- System built:
  - Property Rights System
Land Property (2)

• Requirement:
  – Rule 1:
    • A Current LES (Lease on State Forest as opposed to a Lease on Other Land) **must be** on State Forest.
• We have implemented this integrity rule via simple SQL statements that are used both in our Property Rights application AND within database triggers.

• No GIS software used other than the Oracle database.
  – However, Radius Topology will improve the computational cost of implementing these rules as a function of creating/editing spatial data
    • Pay cost once (write), reap benefits (read) many times!
Land Property (4)

- Declarative nature of Spatial SQL used in application (Rule 1):

```sql
SELECT CASE WHEN 
    ROUND( MDSYS.SDO_GEOM.SDO_AREA(pr1.shape,a.diminfo)) <> 
    ROUND(SUM(MDSYS.SDO_GEOM.SDO_AREA(
        MDSYS.SDO_GEOM.SDO_INTERSECTION(
            pr2.shape,a.diminfo,pr1.shape,a.diminfo),a.diminfo))) 
THEN 'RULENOK'
ELSE 'RULEOK'
END AS RULE
FROM all_sdo_geom_metadata a, 
    propright.property_right pr1, 
    propright.property_right pr2 
WHERE ( a.owner = 'PROPRIGHT' 
    AND a.table_name = 'PROPERTY_RIGHT' 
    AND a.column_name = 'SHAPE') 
AND ( pr1.property_right_id = :PR1 ) 
AND ( MDSYS.SDO_RELATE(pr2.shape,pr1.shape, 
    'mask=ANYINTERACT querytype=window') = 'TRUE' 
    AND pr2.property_right_id <> :PR1 
    AND pr2.property_right_type = :PT2 ) 
GROUP BY ROUND(MDSYS.SDO_GEOM.SDO_AREA(pr1.shape,a.diminfo)) 
```
Land Property – Cool View

• Database stores polygons.
  – However, is a need to generate title diagrams bearings and distances of sides of polygon.
  – Done with a trivial bit of plsql and a view...
Types and Functions

Create or Replace Type **Coord2DType** As Object (  
    x number,  
    y number );

Create Or Replace Type **Coord2DSetType** As Table Of Coord2DType;

Create Or Replace Type **Vector2DType** As Object (  
    startCoord Coord2DType,  
    endCoord Coord2DType );

Create Or Replace Type **Vector2DSetType** As Table Of Vector2DType;

Create Or Replace **Function GetVector2D**  
    (p_shape in mdsys.sdo_geometry)  
Return Vector2DSetType Deterministic  
Is  
Begin  
  ...  
End;
Create Or Replace View Pr_BearingDistance
As
Select rownum,
    cogo.Bearing( coords.startVector.X, coords.startVector.Y,
                     coords.endVector.X, coords.endVector.Y) as Bearing,
    cogo.Distance( coords.startVector.X, coords.startVector.Y,
                    coords.endVector.X, coords.endVector.Y) as Distance,
    mdsys.sdo_geometry(2002,NULL,NULL,
                        MDSYS.SDO_ELEM_INFO_ARRAY(1,1,1),
                        MDSYS.SDO_ORDINATES ( coords.startVector.X, coords.startVector.Y,
                                                    coords.endVector.X, coords.endVector.Y)) as shape
from propright.pr_a a,
    table(CAST(GetVector2D(shape) AS Vector2DSethype)) coords
Result
Techno Stuff: Language & Framework

- **Property Rights**
  - Database Tier: Oracle Spatial
  - Middle tier: Java Servlets
    Java Server Pages (JSP)
  - Client: HTML (ie JSP)

- **GIS license and deployment costs:** $0
Future Uses
Future

- **Transportation Logistics**
  - Network Analysis functions
- **Integration with Road Asset Package**
  - Linear Referencing (via LRS functions)
- **Orthophotography/Background Photography**
  - GeoRaster + custom/COTS imagery software (eg Verdant PhotoFactory)
- **Lidar**
  - Saga + Manifold -> Kriged surfaces (.5m grid)
    - Ground
    - Tree Heights
  - Loaded into GeoRaster to access manipulation fns
- **Environmental Surfaces**
  - Temperature, Rainfall etc
  - Auto-computation of variables for plantations etc via before insert triggers.
Needs

• Oracle catalog to be fully topological
  Alter table StopValve add constraint PipeFK
  foreign key geometry meet pipe(geometry);

• Oracle designer (data modelling) to support spatial!
• Oracle Lite Mobile synchronisation infrastructure.
• Cross-product integration eg HTMLDB and Spatial and MapViewer out of the box!
• More, better data access APIs for IT developers: eg ADO, OLEDB, Data Provider for VS.NET etc and that the spatial object access is rich and doesn't require user to program up low level access to the geometry!
• Support for geospatial operators within BPEL and therefore...
• ETL support for data warehouse builder
• **Improved Image functionality in SQL**

```sql
select t.[Center Easting (I)], t.[Center Northing (I)], t.[Height (I)],
    HeightMax([testgrid],t.[Geom (I)],3) as GridMax
from testgrid t, surface s
where t.[Height (I)] > 17
    and HeightMax([testgrid],t.Geom,3) = t.[Height (I)];
```

• **Education, Training, User Groups!**

• **Collaboration websites**
Finally

Get “on message” about,

“What's in it for me”.

i.e. not just business customers but we need to get the geospatial professionals to realise that this is their future.